



Testing and Commissioning Guidance



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	TESTING AND COMMISSIONING GUIDANCE			LRSSB - LRG - 32.0	
				Issue	1
				Revision	0
				Date	19/10/2022
				Page	1 of 60

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THIS DOCUMENT PROVIDES GUIDANCE IN RELATION TO TESTING AND COMMISSIONING AS PART OF ACCEPTING A TRAMWAY INTO PUBLIC USE					
EXPLANATORY NOTE:					
LRSSB is not a regulatory body and compliance with this guidance document is not mandatory. This document reflects good practice and is advisory only. Users are recommended to evaluate this guidance against their own arrangements in a structured and systematic way, noting that parts of this guidance may not be appropriate to their operations. It is recommended that this process of evaluation and any subsequent decision to adopt (or not adopt) elements of this guidance should be documented. Compliance with any or all of the contents herein, is entirely at an organisation's own discretion.					
SOURCE / RELATED DOCUMENTS:					
LRG 1.0 Tramway Principles and Guidance (TPG) (LRSSB) LRG 30.0 Depot Control Centre Guidance (LRSSB) LRG 31.0 Network Supervision Management Principles Guidance (LRSSB) CENELEC (European Electrotechnical Committee for Standardisation) Standards					
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	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	2 of 60

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TESTING AND COMMISSIONING GUIDANCE

CONTENTS

1. Introduction
2. Scope
3. Network Acceptance
4. Testing and Commissioning Overview
5. Test Types and Purpose
6. Example Testing and Commissioning Programmes
7. Management
8. Responsibilities and Resourcing

Appendices

- Appendix A Example Certifiable List Items
- Appendix B Example Lifecycle Extract
- Appendix C Example Section Proving Test Criteria
- Appendix D Example New Build Tramway Testing and Commissioning Programme
- Appendix E Testing and Commissioning Sequence
- Appendix F Example T&C Programme for Extended Network with New Trams
- Appendix G Example Standard Test Procedure
- Appendix H Example Resource Requirements for the Network Acceptance Process (Extended / Existing Network)

	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	3 of 60

Figures

- Figure 3.1** **Example Tramway System Platform Diagram**
- Figure 6.1** **Example Testing and Commissioning Programme Where a Network Procures New Trams**
- Figure 6.2** **Example 3-stage Validation Strategy**
- Figure 8.1** **Typical High Level T&C Organisation Chart**

Tables


- Table A** **Terms**
- Table B** **Abbreviations**

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	4 of 60

TERMS AND ABBREVIATIONS

Table A – Terms

Term	Definition
Concessionaire	The company to whom a concession has been granted.
Consents	All permissions, consents, approvals, certificates, permits, agreements, licences and authorisations etc., together with all conditions as required for the performance of any of the contracting parties' obligations under procurement agreements.
Contracting Parties	The entities party to the procurement of works and project operations of the network.
Duty Holder	Person in charge of operational activities at a particular time.
Enhanced Existing Services	The services operated under a published timetable which would represent a change to those services operated at the time the procurement agreement is enacted.
Full Service	The provision of public passenger tram services on the final implemented configuration network in accordance with the performance measures and the undertaking of project operations.
Network	The existing system as extended by the carrying out of the works including existing and new trams together with all associated infrastructure, plant, machinery, apparatus, equipment, furniture, street furniture, facilities, track, station and tramstop structures and platforms, depot buildings, control room, P&R sites, electrical sub-stations, overhead line equipment (including bases and poles, building fixings and wiring), CCTV system, network supervision, control (including signalling) system, spares, consumables, administrative offices and office furniture and office equipment in such administrative offices etc.
Operational Readiness	The point at which the network or section is certified as being capable of the enhanced existing services and / or the full services.
Operations Control Centre	The room / area where specific management of the operation of the tram (Light Rail) service is performed.
Operations Control Room	The building where tramway operations are managed.
Operations Control Room Staff	Staff working in the OCC.
Operator	The organisation that has the responsibility (on behalf of the owner) to operate a particular tram system.
Opsco	The contracting party responsible under the procurement arrangements for the project operations, delivery of the services and maintenance of the network after the works and

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	5 of 60

	who supports the design and construction subcontractor during the works period.
Performance Measures	All measures, indicators and output requirements designated to successfully deliver the services and / or project operations.
Term	Definition
Practical Completion	When, excluding any snagging matters, all of the works have been completed in accordance with the procurement agreement(s) in all respects and the works and the network comply with such agreements and all test and commissioning works have been successfully completed in respect of all sections of the works to the reasonable satisfaction of the independent certifier.
Project Operations	The carrying out of the design and the works the implementation / delivery of the services.
Project Operations Staff	Any employees, contractors, consultants or other personnel engaged from time to time in the provision of the project operations.
Safety Management System	A formal management system or framework to manage health and safety.
Services	The provision of public passenger tram services on the network.
Stage Build	Completion of infrastructure works by network section or sections.
Supervisory and Control System	The computerised system used by project operations staff to supervise and manage the project operations and deliver the services.
Test Trams	Trams not carrying passengers and not in service.
Tramway Operator	The operator of the tramway / Light Rail system.
Works	The design, construction, testing, commissioning, completion and bringing into operation of the network, as defined in the procurement agreement(s) including the design, construction, testing, transportation, delivery, commissioning and bringing into operation of the new trams, all necessary modifications to existing network and / or existing trams, any temporary works and any works necessary to gain access to the land and any widening of the highway and the system integration works and obtaining all necessary consents and enable the contracting parties to provide the full services.




	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	6 of 60

Table B – Abbreviations

Abbreviation	Definition
ADC	Assumptions, Dependencies and Constraints
ALARP	As Low As Reasonably Practicable
AVIS	Automatic Vehicle Inspection Systems
AW	Added Weight
CFT	Civils Facilities Tests
CIL	Certifiable Item List
D&C	Design and Construction
DAC	Digital to Analogue Convertor
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FAT	Factory Acceptance Tests
HVAC	Heating Ventilation and Air Conditioning
IC	Independent Certifier
ICP	Independent Competent Person
ILT	Infrastructure Local Test
Km	Kilometres
LRSSB	Light Rail Safety and Standards Board
m²	Square Metres
NIT	Network Integration Test
O&M	Operations and Maintenance
O&S	Operations and Safety
OCC	Operations Control Centre
ORR	Office of Rail and Road
P&R	Park and Ride
PA	Public Address
PIT	Post Installation Tests
PTS	Personal Track Safety
ROGS	Railways and Other Guided Transport Systems (Safety) (ROGS) 2006
RVAR	Rail Vehicle Accessibility (Non-Interoperable Rail System) Regulations 2010
SCS	Supervision and Control System
SCT	Section Commissioning Test
SDLC	Scheme Development Lifecycle
SIT	Site Integration Test
SMS	Safety Management System


	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	7 of 60

Abbreviation	Definition
SPT	Section Proving Test
SS-SAT	Subsystem Acceptance Test
SSC	Safety and Security Certification
STR	Section Trial Running
T&C	Testing and Commissioning
TAT	Tram Acceptance Test
TDAT	Tram Delivery Acceptance Test
TFAT	Tram Factory Acceptance Test
TPG	Tramway Principles and Guidance
TRR	Test Readiness Review
TVM	Ticket Vending Machine
UK	United Kingdom
V&V	Verification and Validation

	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	8 of 60


1 Introduction

- 1.1 This guidance supports the high level principles set out in LRG 1.0 Tramway Principles and Guidance (TPG) published by the Light Rail Safety and Standards Board (LRSSB).
- 1.2 This document provides guidance on testing and commissioning (T&C) for those delegated this responsibility in relation to UK tramways (Light Rail systems) based on 'line-of-sight' operations only. As with all guidance, this document is not prescriptive and is intended to give advice not to set a mandatory industry standard, and it is based upon goal setting principles as best practice.
- 1.3 Much of this guidance is based on the experience gained from existing UK tramway systems and from published documents. It does not prescribe particular arrangements adopted by any existing UK tramway system and is intended to give guidance and advice to those involved in testing and commissioning.
- 1.4 This guidance is not intended to be applied retrospectively to existing tramway systems. However, promoters and operators should consider and assess any implementation of this guidance and / or any subsequent revision, to ensure continual improvement, so far as is reasonably practicable.

	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	9 of 60

2 Scope

- 2.1 A key part of introducing a tramway into public service is to assure that the services can be consistently delivered in accordance with the performance measures and that project operations can be consistently undertaken in an acceptably safe manner. To achieve this, a suitable regime of safety verification and validation (V&V), developed jointly with the Opsco, and O&M subcontractor needs to have been successfully implemented before the commencement of passenger services.
- 2.2 As such, the V&V scheme should form an intrinsic part of the network's implementation plan and correlate with the Safety Management System (SMS). This would include setting out a methodology and approach that demonstrates acceptable safety in turn and underpins the design, implementation of the works and bringing them into public use. These processes will allow the relevant Duty Holder(s) to sign-off the relevant certificates (see Sections 3.11 – 3.18 for further guidance).
- 2.3 This document provides high-level principles and guidance for those involved in the development, design and implementation of new networks and / or modifications to an existing network, whether such modifications are to in relation to infrastructure, trams, and / or project operations.
- 2.4 It is likely that a network will be modified or implemented through a procurement of interrelated contracts with several contracting parties, for example, concessionaire, O&M subcontractor, design and construction subcontractor etc. This guidance is written in relation to such procurement arrangements and as well as suitable to be applied if all project operations are undertaken by a single entity.
- 2.5 This document sets out the methodology, approach and reasoning of appropriate V&V practice including the following:
- Describing the process for accepting the network into service;
 - Identifying and describing appropriate T&C to support network acceptance;
 - Describing the sequencing of tests and test gateways; and
 - Identifying roles and responsibilities of the contracting parties in delivering network acceptance.

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	10 of 60

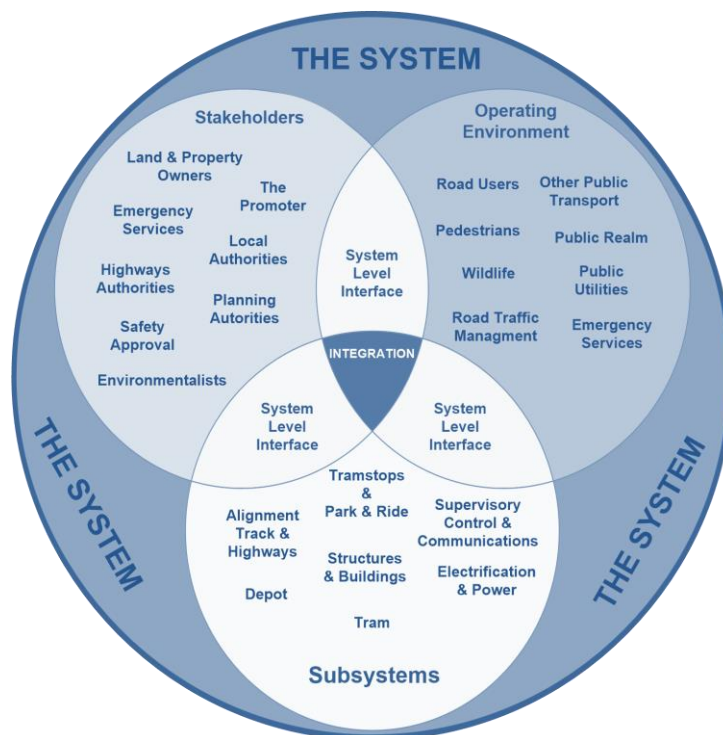
3 Network Acceptance

- 3.1 Network acceptance is the process of V&V that is necessary throughout the Scheme Development Lifecycle (SDLC). It progressively demonstrates and evidences the network, the services and the project operations are enacted in accordance with the performance measures, and that the project operations can be consistently undertaken in an acceptably safe manner. This enables passengers to be carried on the services and means that all parties and elements need to interact to achieve network acceptance so the network and the project operations can operate safely.


Typical Tramway (Network) System Context

- 3.2 A tramway can be described as a system platform containing the tram, trackform, Supervision and Control System (SCS), electrification and power system, communications bearer network and the depot / control centre, as well as its users. This platform then interacts with external factors from within the 'system environment'. These external factors are largely formed of highway users, for example, bus, taxis, cyclist, cars (etc.) and members of the public including passengers, pedestrians and / or householders, businesses etc. adjacent to the network. This is illustrated in Figure 3.1 below.

Figure 3.1: Example Tramway System Platform Diagram



- 3.3 Both the system platform elements and system environment elements should coexist and coordinate to achieve acceptable safety and operational dependability during the period of project operations.
- 3.4 The definition of these relationships will typically be given in the system design specification and / or subsystem design specifications that are developed during the design

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	11 of 60

phases. This will show the interactions and relationships between all technical and non-technical entities that form the system, and are therefore deployed on the network.

Validation of Safety Requirements


- 3.5 In order that that design and implementation of the network and undertaking of the project operations can be assured as being acceptably safe, the scheme development, design and implementation processes need to identify and record any appropriate safety requirements that impact upon the provision of the services and / or the carrying out of the works.
- 3.6 This assurance would typically be achieved through reviewing the existing SMS where the scheme involves modifying an existing network. Safety requirements would also be captured from hazard identification and risk assessment processes as part of early design processes and reviewing / reappraising such as design and implementation progresses. Culmination of assuring acceptable safety is achieved through T&C processes.

Assumptions, Dependencies and Constraints

- 3.7 Understanding the system context (as illustrated in Figure 3.1 above) assists those developing, designing and implementing the network as it demonstrates that the safety of system (network) and its project operations. It is the project operations staff involved with O&M post-handover of the works, who have to deal with the interactions of parties outside their control. Therefore, informed assumptions need to be made during design, development and implementation which place dependencies and constraints on the interfaces between systems, subsystems and the system environment.
- 3.8 Managing these assumptions, dependencies and constraints (ADCs) as part of managing these interfaces and the safety assurance process ensures the following:
- Assumptions will be made about the system environment, including the people and organisations with which the network will interact;
 - Dependencies are put on people meaning that they are required to act before the network can safely be put into service; and
 - Constraints are put in place on people that they must respect after the network is put into operation for it to remain safe.
- 3.9 Good practice is to treat ADCs together as many affect safety. If they are not identified or controlled a hazard may result. ADCs may be dealt with by standards or guidance such as TPG and Rail Vehicle Accessibility (Non-Interoperable Rail System) Regulations 2010¹ (RVAR). Where an ADC is fully dealt within a standard, then proving compliance with this standard will normally be enough to control the ADC.
- 3.10 In addition to any economic benefits, resolving ADCs through standards or guidance will reduce the opportunities for miscommunication and also describe / apply tried and tested solutions.

Safety and Security Certification (SSC)

¹ <https://www.legislation.gov.uk/ukxi/2010/432/data.pdf>

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	12 of 60


- 3.11 Under the ROGS Regulations, certificates or letters of no objection are sought from the Duty Holder at key points within the lifecycle of a scheme. This needs to be embedded within a scheme's assurance and V&V processes, albeit under a self-certification regime.
- 3.12 A letter of no objection may need to be provided by the Office of Rail and Road (ORR) to an aspect of a scheme at certain points within the lifecycle.
- 3.13 Certification for safety and security is taken to mean a series of processes that collectively verify and validate the safety, security and operational readiness of the network and project operations, such that the network can be opened for public use for the services.
- 3.14 Therefore, certification as used in this guidance addresses conditions that could result in harm, whether unintentional (safety) or intentional (security). Application of SSC promotes an informed management decision-making process in the scheme's design, implementation, T&C, bringing into service and the ongoing project operations in that service.

Certifiable Elements

- 3.15 The first step in V&V methodology is to identify from the system context and environment, the elements that need to be certified for the scheme's successful implementation. Safety certifiable elements include those elements of the works and project operations that can affect the safety and security of passengers, project operations staff, emergency service personnel, or the general public and therefore define the scope of a certification programme.
- 3.16 Prior to the commencement of the services or full services, a certificate of compliance for each identified 'certifiable element' will need to be issued. Certifiable elements will be composed of numerous items that make up the whole of the major element of the network and require individual safety and security V&V, including under ROGS where required, before they are validated as safe and secure for use.
- 3.17 It is good practice to produce a listing of these items (a certifiable item list (CIL)). The process of breaking down certifiable elements into CILs occurs simultaneously with the design of the works and in particular, the qualitative and subsequently quantitative hazard identification and risk assessment activities. An example of an assessment of typical certifiable elements and CILs is provided in Appendix A.
- 3.18 Specific certifiable items on the CIL are dependent on the functionality and characteristics of that particular element in the context of the overall system. In addition, the listing of a certifiable item may need to be duplicated a number of times within a certifiable element. For example, each tram requires individual verification, and the wheel / rail interface for each section of the network is tracked as a sub-element of the tram element. Similarly, there are a number of duplicate certifiable items for example line-side signals, traction power, track and other elements. Each element may also be divided into sub-elements equivalent to a particular section of the network being verified.

Important Network Acceptance Stakeholders

- 3.19 The contracting parties are responsible for ensuring that the implementation, T&C and O&M of the network are undertaken in accordance with ROGS. Therefore, a consensus of

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	13 of 60

the network and project operations being acceptably safe needs to be attained from key stakeholders.

The Promoter

- 3.20 The Promoter is the party who is seeking to develop and implement the network or modifications to an existing network and are usually a Local Authority, Combined Authority or Transport Authority and are deemed to be the client.

Independent Certifier (IC)


- 3.21 The role of the IC is to act as agent of the promoter to inspect the works to confirm that the entirety of works that part dependent upon the action point in time are complete in accordance with the implementation plan.
- 3.22 The IC may also be employed by the contractor delivering the altered infrastructure for the promoter. The promoter may then also have an individual / team sampling the evidence to be assured that the works are being delivered and are safe.

Independent Competent Person (ICP)

- 3.23 Where safety verification is required as part of the ROGS process, an ICP is required. They are an integral part of design and implementation safety management process (as set out in the SMS). The ICP provides expert advice, assessment and monitoring of the works and any change to the network from the commencement date by any party deemed to be an infrastructure manager or tramway operator (as defined by ROGS).
- 3.24 Tram operators can also be responsible for managing the contracts associated with infrastructure maintenance.


Office of Rail and Road (ORR)

- 3.25 Professional management of the interface between the concessionaire and the ORR is essential in order to provide the effective and timely introduction of the works as well as in relation to the ongoing working relationship in respect of project operations.
- 3.26 As such, the ORR should be presented with a fully integrated view of any issue across the whole scheme and as such, must be regarded as a key consultee, not an adjudicator on internal conflicts within the contracting parties.

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	14 of 60

4 Testing and Commissioning Overview

- 4.1 T&C represents the final sequence of validation in the network acceptance process. It comprises a suite of physical tests, trials, inspections, reporting and confirmations to demonstrate the following:
- The network is ready to operate the services safely and efficiently in accordance with the timetable, project operations and the performance measures;
 - All systems, equipment and project operations staff are in place to deliver the services and project operations;
 - All necessary consents have been obtained; and
 - The network demonstrates functional compliance with procurement, technical and safety specifications.
- 4.2 The suite of network acceptance tests, undertaken as part of the T&C phase, should underpin the contracting parties' ability to demonstrate internally and externally to the IC, Duty Holder, the ICP and the Promoter that practical completion is achieved. In doing this they would show they have achieved acceptable safety and performance to put the network, or section(s) into passenger service. When devising and agreeing such suite of tests, they will need to reflect the need to certify all certifiable items.
- 4.3 Conducting a series of tests and demonstrations at the most appropriate stages in the SDLC is a valid and proven approach to assuring the above and therefore the operational readiness of the network and the project operations. This improves overall productivity reducing abortive effort and rework and assists to achieve the timescales and sequence of the implementation programme.
- 4.4 Testing and demonstrations are undertaken incrementally and progressively from individual components and assemblies, through to sub-systems and systems and until a suitable section of the network has been commissioned. Once drivers are familiar with that network section, full test running and proving of the network under simulated operational conditions (i.e. Section Trial Running (STR) and Section Proving Tests (SPTs)) is undertaken over that commissioned section. Such approach is diagrammatically represented in Appendix B.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	15 of 60

5 Test Types and Purpose

- 5.1 There are two places where V&V need to be undertaken for network acceptance: off-site at factories, laboratories or simulators and on-site once the works have been constructed and installed. The following sections describe the nature of an appropriate suite of tests to support successful network acceptance.

Off-site Acceptance Tests

Factory Acceptance Tests (FATs)

- 5.2 To prove that there is adequate quality control of systems, components and equipment during the build and manufacture stages of the scheme, an appropriate suite of unit, assembly and final production tests and demonstrations is needed. These tests and demonstrations will be conducted for both infrastructure elements and for the trams to verify the following:
- The systems, components equipment, hardware and software behave and perform as predicted in the design specification(s); and
 - Once subsystems have been successfully tested in isolation that these subsystems when they are incrementally integrated also, holistically, behave as predicted in the design and meet the requirements of the procurement specification(s).
- 5.3 Once the FATs have been concluded satisfactorily then a first article inspection should be undertaken on the first production item. This inspection should verify that the quality of the product is acceptable and that the manufacturers quality control processes and procedures have been implemented.

Tram Factory Acceptance Tests (TFATs)

- 5.4 This element of testing and demonstration will include the functional aspects of the trams and it should also meet any requirements of the promoter's acceptance criteria as set out their procurement specification(s).
- 5.5 In respect of demonstrating that the trams are ready for release to site for commencement of site tests, appropriate tests in accordance with EN50215², as well as the requirements of the latest versions of RVAR, LRG 1.0 TPG (where these are relevant) need to be completed. These tests will normally be undertaken at the tram supplier's factory with the promoter, Duty Holder, ICP and, where appropriate, the IC invited to be present.

On-Site Acceptance Tests

- 5.6 Upon the successful completion of FATs and upon the completion of site construction and installation works for a section or section(s) of the network (as defined in the implementation plan), a series and sequence of site acceptance tests are undertaken. These aim to demonstrate that all certifiable elements, hardware and software etc. are to be incorporated into the works have been implemented, assembled, installed and

² EN50215: Railway applications - Rolling stock - Testing of rolling stock on completion of construction and before entry into service

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	16 of 60

integrated as designed and that they perform according to their specification(s) and the procurement specification(s).

5.7 Whether tests and demonstrations relate to modifications to an existing network, the proving of increased services, new trams, or the section proving of section(s) of a new network, such tests will need to show the integrated operation of the following three key elements of the network:

- Depot, including the Operations Control Centre (OCC);
- Network infrastructure; and
- Trams

5.8 There should be a logical and systematic approach to sequencing such on site acceptance tests. The following subsections suggest a suitable sequencing (see also Appendix B).

Depot Works

5.9 The depot is at the heart of the network. It supports both the maintenance of the trams that will provide the services and the OCC which will be responsible for the management of the network and the delivery of the services in a safe and efficient manner. It is necessary to prove that the depot is fully functional before commencing any test running, proving trials or any enhanced service levels. To achieve this, once the works to the depot are completed, tests and demonstration are undertaken which validate that the depot, inclusive of all buildings and their services, track and formation, electrification and power equipment, the OCC, tram maintenance and cleaning equipment, security and access controls and material stores are completed and compliant with the procurement specification(s).

5.10 To demonstrate the operational readiness of the new or modified depot a suite of integration tests needs to be completed, which validate the items as stated below.

5.11 In relation to tram the test would demonstrate the following:

- Be replenished with sand;
- Be cleaned by the wash plant and internally cleaned on the stabling tracks;
- Be lifted by the provided lifting equipment (incl. overhead crane);
- Draw power from the overhead electrified line; and
- Move under their own power on the depot tracks.

5.12 In relation to depots, tests should demonstrate the following depot equipment performs as designed, and its role in delivering the services and project operations in accordance with the performance measures:

- Wheel lathe including use of calibrated wheelset;
- Battery charging where required;
- Bogie / equipment drops (where installed);
- Underfloor equipment removal be it forklift truck, equipment trolley or other mechanism;
- Roof access platforms interface with tram and end gates;
- Pits;

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	17 of 60

- Portable staging;
- Lubrication filler equipment;
- Windscreen lifting equipment;
- Interface with Automatic Vehicle Inspection Systems (AVIS), for example, tyre measurement, pantograph measurement where installed; and
- Rerailing equipment.

5.13 In relation to the OCC, that it can safely supervise and manage the following:

- All equipment associated with tram movements onto, off and around the depot, including the maintenance workshop;
- Depot protection and isolation systems; and
- The electrification and power equipment.

5.14 In addition, tests also need to demonstrate that sufficient trained project operations staff are available to maintain trams and infrastructure, and carry out the project operations for that particular stage of the implementation plan.

5.15 Tests also need to show that there are sufficient materials and spares available to maintain the trams and depot infrastructure, including the OCC as required for that particular stage of the implementation plan.

Tram Acceptance

Tram Delivery Acceptance Tests (TDATs)

5.16 When new trams have successfully completed their FATs, and are transported to the depot, in line with the implementation plan and programme, each tram will undergo TDATs. This will establish that the tram has not been damaged or affected in any way by the delivery process and that it remains in the condition in which it was inspected prior to despatch from the tram supplier's factory.


5.17 It is worth noting that trams may be split into sections for delivery and will therefore will need to be reconstituted to achieve successful TDAT.

5.18 The ICP will only be required if new or altered trams have been assessed as requiring ROGS safety verification. If the new tram is not significantly different from the existing fleet, then the infrastructure management / transport operator will certify them through their safety change process.

Tram Acceptance Tests (TATs)

5.19 The objective of TATs is to perform a full functional test of the trams, including inspection, examination, witnessing and / or testing all the following to confirm that they are in a suitable condition to operate safely on the network either under test conditions or in delivery of the services:

- Major systems;
- Sections;
- Apparatus;

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	18 of 60

- Equipment;
- Components;
- Internal seating;
- Fixtures and fittings and devices;
- Electrical, hydraulic and other major components and assemblies.

5.20 Part of the above acceptance tests will include validating the interface with the SCS.

5.21 Where the scheme is one which extends an existing network and / or deploys new and / or different trams, TATs must test that both existing modified trams and all new trams will largely be in accordance with the requirements of EN50215. Once completed, further TATs are then needed to prove that all trams are compatible with the final network configuration of the section under test.


5.22 In addition, the ability of one tram of any type used on the network to recover another similar or dissimilar tram at all locations on the network should also be tested / demonstrated.

5.23 To conclude the TATs, the contracting parties will need to provide a certificate signed by the Duty Holder and / or ICP to the IC and the promoter that confirms the following:

- All trams tested have been designed and manufactured in accordance with the procurement specification(s). Such evidence should verify that the trams comply with the standards as stated by the manufacturer in their tender proposal, and in the procurement specification;
- Underrun protection on all trams performs reliably, and is acceptably safe;
- Existing trams have been correctly modified. This would typically be demonstrated through evidencing suitable and satisfactory compatibility tests have been carried out;
- Safety verification has been undertaken in accordance with the SMS and including, where necessary, the requirements of any safety verification scheme as defined by ROGS;
- The trams comply with RVAR; and
- Due cognisance has been taken of the recommendations made by the Duty Holder and / or ICP as a result of such safety verification.

5.24 Upon delivery, all new trams will undergo some T&C. However, the first one or two trams are normally subject to more intensive testing which is generally divided into the following two groups:

- Static: doors, interior and exterior lighting and indication, lighting, air conditioning, heating and ventilation, passenger information, Public Address (PA) system, emergency help points, wheelchair access, radio, rerailing etc.; and
- Dynamic tests: traction and braking both normal and emergency to confirm not only stopping distance but also acceleration and deceleration and jerk rates are within standards, (note loading conditions will be simulated with sandbags), EMC, coupling, multiple working, gauging, platform / stop interface, tram recovery, effectiveness of underrun protection, depot interfaces.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	19 of 60

- 5.25 The requirements of and specification for these tests are normally produced by the manufacturer and reviewed and agreed by the promoter and / or Duty Holder.

Infrastructure Site Acceptance

- 5.26 With regard to the infrastructure works, once site construction and installation is completed, usually by network section or sections (a stage build), a suite of site tests are required to demonstrate the following:
- Construction / installation activities have been completed correctly (i.e. Civils Facilities Tests (CFTs), Post Installation Tests (PITs) , Subsystem Acceptance Tests (SS-SATs)). They should show that the various sub-systems and works, in isolation and before passengers are carried, function and behave at site as designed and tested in the FAT and are in accordance with the procurement specification(s); and
 - Combined tests which demonstrate infrastructure subsystems can be integrated with each other and the trams to prove that they collectively function and behave at site as designed and tested in the FAT and are in accordance with the procurement specification(s).

Civils Facilities Tests (CFTs)

- 5.27 Every certifiable item within the civil Works scope, will need to pass a CFT prior to any combined tests being undertaken. Such CFTs, would typically be confirmatory inspections / examinations, material sampling to prove compliance with appropriate standards, guidance, design and procurement specification(s).
- 5.28 CFTs will predominantly cover the following civil engineering works:
- Architecture;
 - Bridges, tunnels etc.;
 - Depot and sidings;
 - Drainage and Ducting;
 - Embankments;
 - Groundworks;
 - Highways and streets;
 - Structures;
 - Substations;
 - Track and formation;
 - Tramstops; and
 - Utility apparatus.

Post Installation Tests (PITs)

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	20 of 60

5.29 PITs are carried out after installation of equipment, mainly mechanical, electrical and electronic subsystems (including cabling) to determine that such subsystems are:

- Not damaged in any way subsequently to the shipment from the factory or installation process; and
- Installed correctly, and operate properly in accordance with the respective system and subsystem design specifications.

5.30 PIT procedures must reflect the sequence of tests to be performed, such as fixing, cable installation testing, grounding tests, insulation tests and basic subsystem functionality tests. No tram movements are involved at this stage.

5.31 PITs would usually include the following:

- Performed by the contracting party supplying that subsystem / equipment;
- Based on procedures reviewed and approved by the contracting party representative in charge of the SS-SATs; and
- Be witnessed by the contracting party representative in charge of the SS-SATs.

5.32 At the end of the PIT, suitable reports and notices should be sent to the person(s) in overall charge of the testing and commissioning process (T&C management). This notice should be signed by the sub-system representative and also the testing entity if this is different.

Subsystem Acceptance Tests (SS-SATs)

5.33 Once the required CFTs and PITs have been successfully completed, validation of the network and project operations can commence with the thorough testing of each subsystem and certifiable item. These SS-SATs have the primary objective of confirming that the certifiable item being tested performs in isolation as per its own prescribed functionality.

5.34 As such the programming of these tests will follow almost immediately after that item of equipment, subsystem or system is constructed or installed. For example, once PITs have confirmed that electrical and telecoms services have been correctly installed to a tramstop, and a ticket vending machine (TVM) has been correctly installed, SS-SATs would confirm that the relevant tickets can be issued, payments taken etc.

Site Integration Tests (SITs)

5.35 Upon completion of the SS-SATs, a series of tests (SITs) are undertaken on the infrastructure on a location-by-location basis. These SITs incrementally build to form larger predefined geographic areas (as per the stage build process) that are sufficient to allow progression to Section Commissioning Tests (SCTs). The objective of these SITs is to demonstrate that the certifiable items for that section of the network collectively perform according to their prescribed functionality, behave at site as designed and tested in the FAT, and are in accordance with procurement specification(s).

Combined Site Tests


5.36 Following on from the TATs (see Sections 5.19-5.25) and the SITs (see Section 5.35) undertaken on the infrastructure, a series of tests and demonstrations then commence to

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	21 of 60

provide evidence that the network as a whole performs in an acceptably safe and efficient manner. The following sections set out the proposals for such testing.

Section Commissioning Tests (SCTs)

- 5.37 SCTs involve running a tram(s) over a section(s) of the network for which SITs have been successfully completed. This is to validate that the trams and infrastructure successfully interact with each other as well as with the network's environment (as defined in the design specification) and in doing so, behave as predicted / demonstrated as far as practicable in previous tests.
- 5.38 To prepare for the SCTs and also as a fundamental aspect of them is liaison with the operator and tram supplier to ensure that sufficient competent project operations staff (i.e., tram drivers and OCC staff), as well sufficient trams are available to conduct the required test activities.
- 5.39 These SCTs perform a series of exercises including some with the emergency services. The nature of these emergency exercises will require detailed discussion with the emergency services during the implementation stage. They would typically include the following as a minimum:
- Simulated road traffic accident (RTA) at a major road junction;
 - Major tram collision / derailment; and
 - Validate safe and reliable performance of all trams underrun protection systems on all trackforms deployed on the network, i.e. adult male, adult female and child trapped underneath a tram.
- 5.40 The above exercises could be undertaken at the depot, the tram suppliers' factory or suitable location(s) where the required trackforms are located.
- 5.41 SCTs will also include demonstrations that prove the following hazards are As Low As Reasonably Practicable (ALARP) or at worst 'tolerable' as defined in the SMS, such as the following:
- Hazards where the network and / or project operations interact with pedestrians;
 - Collision with another tram;
 - Gauging;
 - The alignment, as constructed, enables acceptably safe line of sight operations to deliver the services in accordance with performance measures;
 - Possible human entrapment in pedestrian areas;
 - Failed tram recovery;
 - OCC and all other project operations safety procedures;
 - Infrastructure and tram maintenance procedures; and
 - RTA.
- 5.42 Where such testing is conducted as part of scheme which modifies an existing network's infrastructure, and / or deploys new or a new type of tram, SCT proposals must not jeopardise the performance of the services and project operations currently executed on that part of the network. In these circumstances, such a SCT programme cannot be undertaken until there is an adequate pool of modified trams and / or new trams available

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	22 of 60


to provide the services on the existing network and project operations staff to resource the SCTs.

Section Trial Running (STR)

- 5.43 The primary objective of this part of the acceptance process is to facilitate the following:
- Training and familiarisation of tram drivers with the newly opened sections of the network, the new and / or modified trams and the network's operating procedures, without passenger pressures;
 - Training and familiarisation of all other project operations staff with the newly opened sections of the network and the operation and maintenance of the new and / or modified systems, subsystems, equipment and trams without passenger pressures; and
 - Accumulation of 'running in mileage / kilometrage' for the new and / or modified trams to ensure that they are fully attuned at the full services commencement date.
- 5.44 In relation to the above, owing to project constraints, it is unlikely that all or even a large part of the mileage / kilometrage accumulation will be achieved in this period as the shadow running period will be compressed, thus it will be extended into the initial operations phase. With regard to the introduction of a new fleet onto an existing or extended system, mileage / kilometrage accumulation will only be achieved during operations albeit some may be accrued in out of hours running.
- 5.45 The primary objective also includes progressively building up the awareness of members of the communities through which the network passes including pedestrians and highway users so they interact safely with the passage of trams.
- 5.46 It is also a primary objective to validate the ride quality criteria as is set out in the procurement specification(s).
- 5.47 Where a scheme modifies an existing network (currently an operational tramway), there will be very limited scope to undertake any trial running after any modifications. All changes need to be fully tested to assure their operational performance and safety. In such cases, STR would likely involve the running of test trams interspersed with in service trams undertaking the services, up to the point at which there is sufficient and accepted evidence that the changes are successful.
- 5.48 STR commencement can occur, once sufficient sections of the network have passed their SCT's. Such stage builds are derived from the optimisation of the network configuration described in the scheme's agreed O&M plan and the scheme's agreed implementation plan.

Section Proving Tests (SPTs)

- 5.49 The objective of the SPTs is to demonstrate the operational readiness of the network of part under such test(s). As with STR, whilst the overall philosophy of the SPTs will be the same, the method and approach will vary slightly depending upon whether such tests are proving modifications to an existing network or new works of a new network. In whichever situation, commencing the SPTs and therefore by default any subsequent Network Integration Tests (NITs) with any new trams or modified trams, this cannot begin until such time as the certificate of conformance in respect of the TATs has been issued to the IC.

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	23 of 60

- 5.50 As with other parts of the acceptance process, appropriate notice of intention to undertake SPTs needs to be given. In this instance, a period not less than 30 days' notice of the date on which such testing will commence is typically given to the IC, Duty Holder, the ICP and the promoter's representative.
- 5.51 Once the STR of the relevant sections of that route have been completed, SPTs can be conducted with the following conditions:
- All Trams being used for the test shall be operated under simulated all seats occupied and standing passengers at 4 persons / m² (AW2³) passenger loading conditions;
 - All trams shall call at each tramstop for a period commensurate with the planned dwell time in accordance with the draft full published timetable and the tram doors are to be opened and closed;
 - All passenger interface equipment shall be operated on all trams being used for the test, and at all tramstops and Park and Ride (P&R) sites on that part of the network being tested, including as a minimum passenger information systems, doors, lighting, heating and ventilation equipment, lighting and facilities at tramstops and access equipment such as lifts;
 - All trams shall run at planned line speed in accordance with the draft full published timetable and trams shall run the entire length of the relevant section of network being tested; and
 - All new trams or modified trams shall, as far as is reasonably practicable, have first completed a minimum of 1000 Km of use in normal traffic, in accordance with the requirements of ISO 3095⁴, before they can be used for SPT tests.
- 5.52 Conclusion of this T&C phase should result in acceptance by the IC, Duty Holder / ICP to confirm that the network has achieved operational readiness and can safely execute the project operations and deliver the services in accordance with the procurement specification(s).
- 5.53 The content of SPTs would typically be as set out in Appendix C. Where a SPT requires the operation of a timetable, such a timetable will represent the draft full published timetable over that part of the network being tested.
- 5.54 The tests, test method / conditions and acceptance criteria set out in Appendix C would be typical across all schemes. However, the durations shown may vary and need to be agreed with IC, Duty Holder, the ICP and the promoter's representative.
- 5.55 At the successful conclusion of the SPTs, the contracting parties need to provide a certificate signed by the Duty Holder and / or ICP to the IC confirming the following for the section of the network tested:
- It has been designed and implemented in accordance with this procurement specification(s);
 - Safety verification has been undertaken for the project operations in accordance with the Network Safety and Security Management Plan and including a safety verification scheme as required by ROGS (where necessary), and as agreed with the

3 The added weight to a vehicle to simulate passenger load. AW2 simulates a load with some seated and some standing passengers.

4 Acoustics — Railway applications — Measurement of noise emitted by railbound vehicles

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	24 of 60

ICP. Therefore, confirming such tested section may be placed into public service without any unacceptable safety risk;

- It complies with ROGS and the RVAR and may be placed in service without any unacceptable safety risk; and
- Due cognisance has been taken of all recommendations made by the Duty Holder and / or ICP as a result of such safety verification.

5.56 For an entirely new network, this would be the point in time where the network and project operations would be handed over to the Opsco, O&M subcontractor and the network put into public operation.

Network Integration Tests (NITs)

5.57 NITs commence upon satisfactory completion of all SPT tests where they have been certified as acceptable. NITs need to clearly demonstrate that the full published timetable can be successfully operated over the whole network for the entirety of the seven day timetable (for example, including weekdays, Saturday and Sunday). These NITs must ensure the following:

- The full network is operated in accordance with the procurement specifications / agreements for seven consecutive days permitting passengers to board and alight trams at all tramstops on the existing modified network;
- The trams call at each tramstop on the new / extended network for a period commensurate with the planned dwell time in accordance with the full published timetable and the tram doors shall be opened and closed;
- All passenger facing equipment is operated on all trams, tramstops and P&R sites, including passenger information systems, doors, lighting, heating and ventilation equipment, access equipment and lifts;
- The network is operated and maintained in accordance with the O&M procedures and instructions; and
- The existing services are monitored in accordance with the existing performance measures against that part of the full published timetable relating to the existing / modified network.

5.58 All performance during this period needs to be recorded, documented and be able to demonstrate the achievement of the following pass criteria that will allow the network to enter public use and commence providing the full services:

- Trams operate over the network for 7 consecutive days in accordance with the full published timetable; and
- The monthly performance for the whole network does not give rise to what would constitute a timetable performance shortfall as defined in the performance measures. Where such are calculated for the period of the test as if the contract month has seven days.

5.59 As well as making available test records to the IC, Duty Holder, and the ICP, they should be invited to witness the NITs and verify that the network complies with the procurement

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/ 2022
		Page	25 of 60

specification(s) and agreements, and is acceptably safe to permit the full services to commence on the agreed full services commencement date.

- 5.60 If the test fails at any time during the seven day timetable proving, then the clock is reset and a further seven days is run until the NIT passes.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	27 of 60

6 Example Testing and Commissioning Programmes

- 6.1 The exact nature and details of a network's T&C programme and scope will vary depending on the nature of each network. However, this guidance sets out example testing programmes to cover the three main scenarios where a tramway scheme is implemented, from the commencement of the SS-SATs premised upon on construction and manufacturing stage inspections, tests and / or examinations being successfully completed.

T&C Applicable to a New Network


- 6.2 This section sets out acceptance proposals for bringing into public use the newly constructed sections of a new tramway (network) as shown diagrammatically in Appendix D. This would in all practicality be essentially a new build and as such there are not the same intricacies placed upon acceptance as is the case for where a scheme modifies an existing network. The following describes an example of a V&V sequence for new build circumstances.

Depot Readiness

- 6.3 Depot Readiness is the first critical stage in network acceptance. The whole SCS and all its subsystems and all certifiable items and facilities necessary for undertaking the depot operations (refer also to LRG 30.0 Depot Control Centre Guidance and LRG 29.0 Guidance on Human Factors in Operations Control Centres), must be successfully tested in their own right, i.e. successful completion of CFTs and PITs. Then all these elements need to come together so that the entire depot facility can be tested and commissioned and brought into use. As such, this sequence would comprise of the following:
- SS-SATs all depot facilities plus all depot and SCS certifiable Items;
 - TDATs (see Sections 5.16-5.18); followed by
 - Full depot T&C tests (see Sections 5.9-5.15).
- 6.4 When the above is completed, this would prove that the OCC is fully functional in respect of the new infrastructure, including track work and traction power, and that there is a sufficiently sized fleet of trams available to perform the suite of tests from section commissioning onwards.

Infrastructure Local Tests (ILTs)

- 6.5 The implementation plan will show construction activities by location. Each location is part of an overall aggregation sequence to form a series of stage builds. Stage builds enable both an efficient construction methodology and means by which the network can be incrementally validated and / or incrementally achieve operational readiness.
- 6.6 Such local tests will comprise of the following:
- CFTs (see Sections 5.27 and 5.28);
 - PITs (see Sections 5.29-5.32);
 - SS-SATs (see Sections 5.33 and 5.34); and
 - SITs (see Section 5.35)

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	28 of 60

- 6.7 Usually, construction of stage builds commences in parallel with the works at the depot(s). So it would be expected that final construction and CFTs, PITs, and SS-SATs of the first stage build would finish at or about the same time as depot readiness is achieved.

Tram Acceptance Tests (TATs)

- 6.8 Depot readiness will see trams pass their TDATs as they arrive from the manufacturer. The next stage is to undertake TATs, (see Section 5.19-5.250), in order that a progressively increasing fleet of trams is available for the successive series of combined tests for each stage build.

Combined Infrastructure and Tram Tests

- 6.9 This represents combined testing of the new infrastructure and new trams for a specified stage build and will cover three aspects. To commence this phase the following is required:
- Depot readiness must have been achieved;
 - ILTs (see Sections 6.5-6.7) must have been successfully completed for the stage build about to enter combined tests; and
 - A sufficient number of trams have passed TATs, and project operations staff must be available to resource the combined tests for the stage build(s) about to enter combined testing.
- 6.10 Once these criteria have been met, the following onward V&V sequence can be invoked:
- SCTs in accordance with Sections 5.37-5.42;
 - Section Trial Running (STR) in accordance with Sections 5.43-5.48; followed by
 - Section Proving Tests (SPTs) in accordance with Sections 5.49-5.56.
- 6.11 The conclusion of these combined tests should result in acceptance that network has achieved operational readiness by the IC, Duty Holder, and the ICP and that it can safely execute the project operations and deliver the services in accordance with the procurement specification(s). This should be true whether the decision is to open the network progressively i.e. upon successful completion of SPTs progressively for each stage build or a series, or whether the network will be opened once all stage builds have successfully completed the SPT stage.

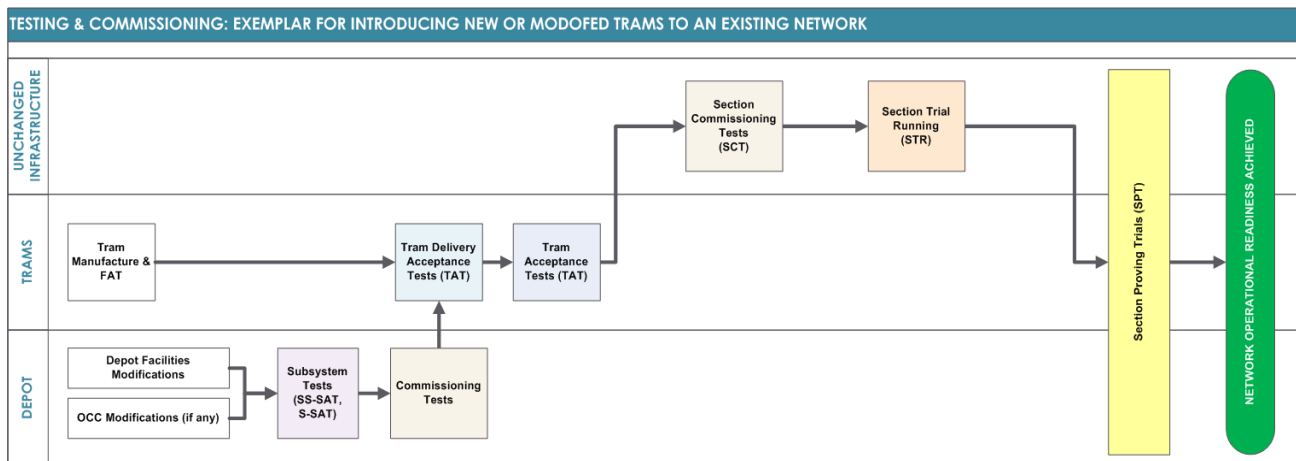
T&C Applicable to New or Modified Trams on Existing Network

- 6.12 This section sets out acceptance proposals whereby a new fleet of trams is procured in addition to, or as a replacement for, existing trams that operate the existing services on an existing network as shown diagrammatically in **Error! Reference source not found.** below. The underlying assumption in this scenario, is that apart from any changes to the depot, there are no changes made to the existing network mainline infrastructure and TLDS.

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	29 of 60

- 6.13 The T&C programme is a very simple one requiring validation of any depot changes, tram acceptance and confirmation that the new trams perform safely and efficiently over the existing infrastructure of the network.

Figure 6.1: Example Testing and Commissioning Programme Where a Network Procures New Trams



- 6.14 The T&C sequence is detailed in Appendix E as outlined below:


- Depot readiness;
- Proving existing as modified network;
- Proving new routes of the network; and
- Proving the final network configuration.

T&C Applicable for New Trams and an Extended Network

- 6.15 This section sets out the acceptance proposals bringing into public operation the newly constructed sections of new routes and infrastructure, new trams, modified existing trams and modified existing infrastructure as illustrated in Appendix F. As such, the following needs to be proven to achieve operational readiness:

- Depot readiness is achieved;
- All trams can operate safely over all parts of the final network configuration;
- All certifiable items and certifiable elements are acceptable safe for use in the project operations and allow the services to be delivered in accordance with the performance measures; and
- All necessary resources and project operations staff are in place for the project operations and allow the services to be delivered in accordance with the performance measures.

T&C Sequence

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	30 of 60

- 6.16 In this scenario the following 3-stage strategy illustrated in **Error! Reference source not found..2** below should achieve network acceptance.
- 6.17 To execute such strategy, the T&C sequence illustrated in Appendix F could be adopted.

Figure 6.2: Example 3-Stage Validation Strategy




- 6.18 Where the implementation plan proposes a phased introduction of services over the existing modified parts of the network prior to the full services, and using existing modified trams and / or new trams to do so, the following is required:
- SPTs 11 – 17 shall be executed on the new or modified certifiable items of the existing network;
 - SPTs 4 -10 and 17 shall be executed on the new or modified certifiable items of the existing network; and
 - Monitoring of the existing services will continue in accordance with the prevailing performance measures.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	31 of 60

7 Management

Management and Reporting of Test Activities

- 7.1 A T&C plan (which should form part of the overall implementation plan) will need to be agreed with the promoters in advance of commencing T&C. Such plan would typically set out the following:
- The process, activity schedule and programme up to full service commencement;
 - The items of equipment (for example, trams, depot) or sections of the network which may be sought to bring into operation or used separately, and how these separate items or sections will be brought together to prove the whole network;
 - The inclusion of approval bodies and other stakeholders and consultees in the process;
 - The specifications for each of the T&C activities to be undertaken including the test objective, the acceptance criteria (inclusive of those stated in procurement specifications) and tolerances;
 - The documentation to control and monitor the T&C process to certify that each test has been passed and that the acceptance criteria have been met and which documentation shall include commissioning programmes, procedures and test reports;
 - A clearly defined process for generating and clearing non-compliance or failures recorded during the T&C;
 - The processes for transfer or handover from those responsible for the implementation of the works to those responsible for the O&M of the works;
 - The documentation that will be provided to show evidence of the satisfactory performance of the tests and, where applicable, of the operating and maintenance procedures by the relevant staff during the acceptance process;
 - The training and safety requirements for each test; and
 - The training regime for staff required to operate and maintain the network, agreed with the Opsco and O&M subcontractor.
- 7.2 Should the pass criteria for the tests and demonstrations not be achieved, the test reports will identify the items that failed and the reasons why. From this, the problem can be identified and rectified and enable that aspect of the test or demonstration to be rescheduled at the earliest possible opportunity.
- 7.3 All network acceptance documentation including plans and records of the tests and demonstration will form part of the justification for the network being acceptably safe to enter public service. As such, all documentation will be appropriately reviewed, scrutinised, endorsed and controlled in accordance with the documentation management process.
- 7.4 The programming of the tests and demonstrations proposed should be set out in the implementation programme. To enable the promoter(s) and relevant stakeholders to witness the tests and demonstrations, prior to the commencement of any test, a notice period of at least seven days needs to be provided.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	32 of 60

Safety Related Tests

- 7.5 Safety studies performed at system and subsystem level (certifiable items) may require justifications that can only be provided by a test. In order to make sure the T&C program will bring the expected evidence of risk closure or mitigation, good practice is to implement the following process at subsystem, system and certifiable item levels, under the overall supervision of the relevant safety management:
- Safety management(s) shall extract their test needs and provide them to the relevant certifiable item T&C management so that verification matrixes and test lists can be produced;
 - Once produced, the verification matrixes and test lists need to be communicated to the safety management for them to identify which tests may cover each justification need; and
 - Following this review, coordination and clarification meetings between T&C management and safety management would be organised in order to freeze the corresponding safety justification / tests, and identify if necessary which tests should be completed or added in order to cover all safety management requirements.
- 7.6 The above steps are concluded by the following:
- Updating of the safety documentation to trace the reference of the test procedure of the test that will allow closing the corresponding risk;
 - Updating of the test list by indicating which tests is safety related;
 - Whenever a safety related test procedure is prepared by T&C management, this procedure will have to be reviewed and validated by the concerned safety management before being officially released;
 - Once the safety related test performed, the test report will have to be reviewed, validated and used by the concerned safety management according to their management plans; and
 - For safety-critical software, validation shall be carried out by a separate team according to the safety management plans.

Regression Tests

- 7.7 The purpose of a regression test (or verification of non-regression) is to check that after a change of certifiable item configuration, the performance has not been degraded or jeopardised. Prior to any configuration change being made to a certifiable item, the performance and parameters have to be base-lined and recorded. This enables a return to the original or known state, if necessary, if the upgrade or fix is proven not to be successful.
- 7.8 The outline strategy to be applied for regression testing would comprise of the following:
- Check that what was specified to be tested has been correctly tested, relevant test step or sequence to be re-performed;
 - Check a representative group of related functions showing that the correction did not generate modifications to the functions which had already been tested; and
 - Resume the test procedure.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	33 of 60


Test Methodology

Test Preparation

- 7.9 The logical sequencing of the main tests may be reflected in a test overview table. This table would give a comprehensive and synthetic view of the overall test program, showing the precedence of the tests and allowing pre-requisite activities to be graphically illustrated.
- 7.10 There may be some tram access training for staff participating in the tests in particularly for an existing network, for example, track PTS (personal track safety), isolation procedures etc.
- 7.11 Typically, preparation processes would include the following:
- Access management:
 - Permit to work management and permit to work template;
 - Tram movement management (temporary operation instructions / restrictions);
 - Traction power isolation;
 - Communication protocols; and
 - Emergency management procedures.
 - Documentation required to perform the tests:
 - Test procedures; and
 - Test schedule.
- 7.12 These documents aim at enabling the works and project operations to be undertaken in a safe and coordinated way under the responsibility of the T&C management and the O&S management.

Test Zones

- 7.13 Network construction will follow a construction programme usually defining construction sites by areas or areas within routes. These are set out in the implementation plan, and will be delivered and ready for testing at different dates within the implementation programme. Therefore, in order to optimise the testing program in relation to the overall implementation programme, it will be necessary to define test zones as a function of zones / areas ready for testing.
- 7.14 Test zones are only related to on-site tests. A zone cannot be considered available for testing if it has not been handed over from civil works and installation works to the T&C management.
- 7.15 The defining of test zones is an important part of the implementation plan and network configuration such that they allow a flexible and safe use of the different available areas for tests in parallel by different teams and for different tests.

	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	34 of 60

- 7.16 It is likely that test zones for CFTs and PITs could be the same as the boundaries of a construction site / area or tramstop. Such granular test zones then build into larger test zones or stage builds to perform testing from SCT onwards.

Testable Configuration

- 7.17 Prior to the start of any tests, the configuration that is going to be tested shall be checked. This configuration should include the following:
- Specified in the test procedure;
 - Checked before the test beginning; and
 - Described in testing reports.
- 7.18 A certifiable Item / sub-system / system is validated for a given configuration. If that configuration changes, the validation process may be done again.

Test Procedures

- 7.19 A specific test procedure shall be issued for each identified test. Each test and its associated test procedure may cover one or several requirements as established in the verification matrix. Test procedures will define all the technical and practical information relative to a specific test and will cover each testing activity step-by-step.
- 7.20 For each test, the test procedure would state the following:
- The certifiable item / sub-system/system configuration to be tested;
 - What will be measured, monitored or / and observed; and
 - The pass / fail criteria.

Test Procedures Standard Content

- 7.21 Standardised content is strongly recommended for the preparation of test procedures, in order to allow their easy review and use. This standard content should be followed as much as possible. Nevertheless, adaptations are not excluded depending on contracting parties' current practice and the appropriateness of the standard content for specific tests.
- 7.22 An example standard test procedure content is described in Appendix G.

Test Readiness Reviews (TRRs)

- 7.23 TRRs need to be organised for all on-site tests. The TRRs are led by T&C management, and assisted by the O&S management, and the T&C management of the certifiable item(s) being tested. TRRs take place after the test procedures have been completed, approved and issued.
- 7.24 The TRR is based on the test procedures and aims at checking the following:
- Test identification: In particular to review the clear objective of the test, the associated requirements, and if the test is safety related;

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	35 of 60

- Test pre-requisites and configuration: In particular to make sure the test configuration is up to date with respect to the associated design configuration and hardware / software configuration. Also, the TRR will confirm that any prerequisite tests have been successfully performed or at least that there are no obstacles to perform the test due to the previous tests performed;
- Test conditions: duration and location will be carefully assessed during the TRR for on-site test in order to ensure good scheduling of the use of test zones and required resources. Test safety information and starting conditions will also be key elements to be reviewed in order to make sure the O&S management can organise properly and safely the logistics of the tests (for example, electrical network configuration, coordination with police, etc.);
- Test means and resources: The TRR will allow review of the entity willing to organise the test is ready in time for the test in terms of means and resources, in order to avoid last minute cancellation of tests;
- Test specification: an overview of the test specification will be done, in particular under the control of the T&C management and of the certifiable item T&C management to check test specification is up-to-date and does not need late adaptation due to previous tests; and
- Test results communication: the test report to be issued by the certifiable item T&C management to the T&C management for review will be agreed.

Conducting the Tests

Test Briefing

- 7.25 Before the test can commence or at the beginning of a testing day a briefing should occur. The briefing is led by the T&C management and aimed at checking that the test can be undertaken in accordance with the relevant test specification, procedure, and schedule.

Test de-Briefing

- 7.26 At the end of the each test a de-briefing should occur. The de-briefing is led by the T&C management or the O&S management, and provides the checks and balances associated with a successful completion, including the following:
- The main result of the test;
 - If non conformity was identified;
 - If any incidents occurred;
 - If parts were damaged or identified as being faulty and therefore if restrictions or constraints had to be applied; and
 - If corrective actions were identified, implemented or need to be implemented.

Configuration and Non-regression Management

- 7.27 The network, and system configurations during tests is very important. Functionalities working in one way for a given configuration, might not be working in the same way in another configuration. Consequently, each test is done with a frozen and known configuration at system or sub-system level. Such configuration shall be named in the test procedure as well as in the test report.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	36 of 60

Definition of Non-regression Procedures

- 7.28 Many sub-systems or certifiable Items may be satisfactorily tested in a given configuration. But it may happen that one component of that sub-system / certifiable item requires to be changed. In this case, the implemented modification to that item may have an impact on the system or the tested item functionality which could invalidate the test result.
- 7.29 In order to ensure such modifications do not require performing the test again, the following steps should be followed for the item to be modified:
- Identify the modifications done and their potential impact on the certifiable item, sub-system and system;
 - Define and perform verification aiming at showing the modifications do not impact the test results; and
 - Submit the results to the T&C management who decides the necessity to perform the test again.
- 7.30 Two examples of modifications that will require non-regression procedures include the following:
- Safety tests while modifying programming code and / or data for software with safety requirements; and / or
 - Some tram tests such as braking tests, while modifying some HW, control system of the tram.

Definition of Tests to be Re-done

- 7.31 Some tests might not provide the expected results indicated in the procedure. For these cases, in agreement with the promoter and Duty Holder / ICP, only those affected parts of the test(s) need be repeated once any other outstanding matters have been solved.

Test Reports

- 7.32 Each test shall be followed by a specific test report presenting the results. The test report shall contain the following:
- Measured parameters;
 - Passed / failed indication;
 - Listing of relevant hazards / risks which have been successfully closed, controlled or mitigated; and
 - Deviations (if any).


Failed Tests

- 7.33 If during a test any parameters have failed their pass criteria, such anomaly must be reported at the end of such test to the following roles / functions:
- T&C management;
 - O&S management;
 - Safety management (when appropriate / necessary);
 - Configuration and anomalies management; and

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/ 2022
		Page	37 of 60

- Certifiable item project management involved in the test.

7.34 Following verification and management's decision and / or after potential modification of the test procedures and / or equipment modifications the test shall be done again.

	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	38 of 60

8 Responsibilities and Resourcing

8.1 The roles, responsibilities and resourcing of the works and associated network acceptance process will vary according to both the procurement method and progression through the network acceptance process. In terms of whichever procurement method is chosen, the contracting parties would typically include the following:

- A contracting party responsible for delivering the works, the D&C subcontractor; and
- A contracting party responsible for the project operations and delivery of the services post operational readiness completion, the Opsco.

8.2 Whilst the above describes a clear delineation in responsibility, the whole design, development and implementation of the works to successfully bring the network into public use requires close interaction between the two parties. No more so than within the network acceptance process, and most certainly within the T&C part of it, albeit that overall responsibility for the network acceptance process up until full services commencement date will usually remain with the D&C subcontractor.

Roles and Responsibilities


8.3 The D&C subcontractor would typically lead and take responsibility for the execution of the works, whether they are new works and / or the modifications to an existing network or trams, and the associated acceptance process.

Example New Routes Added to an Existing Network

8.4 With respect to works associated with design, construction, installation, testing, commissioning and bringing into use of the new routes which form the extension(s) to the existing network, the roles and responsibilities of the D&C subcontractor and Opsco are listed below.

8.5 The D&C subcontractor is responsible for the following:

- Leading, resourcing and completing all build and manufacture activities associated with the supply of new trams and / or all modifications to existing trams;
- Leading, resourcing and completing all construction and installation activities in respect of:
 - Extension works to the depot(s), including such works that need to be in place for the introduction of any enhanced existing services both which are required in advance of full services commencement date); and
 - Infrastructure of the new route(s);
- Leading, undertaking and successfully completing the PITs, and SITs associated with the above elements of the works with such undertaken on the new routes under construction site rules and with such undertaken on existing network (including the depot) as an operational tramway. (After the point of successful completion of SCTs for any and all sections of a network, that section will thence become an operational tramway.);
- Leading, undertaking and successfully completing any 'remedial works' during the STR stages for each section of each new and / or existing network route;

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	39 of 60

- Leading, undertaking and successfully completing any 'remedial works' during the SPTs for each section of each new and / or existing network route; and
- Leading, undertaking and successfully completing any remedial works during the NITs for the entirety of the network (vis a vis new routes, existing network as modified by the works and both new and existing trams).

8.6 The Opsco is responsible for supporting the D&C subcontractor in the following:

- Providing suitable numbers and trained staff to operate the OCC in respect of:
 - Continuing the project operations and delivering the services in respect of the existing network;
 - Supporting the D&C subcontractor with respect to the PIT tests, SS-SATs and SITs, SCTs, STR, SPTs and NITs; and
 - Controlling, and executing the project operations for those sections of the existing and new network which have become operation tramways post their successful completion of their SCTs;
- Providing suitable numbers and trained tram drivers in respect of continuing the existing services on the existing network, as well as supporting the D&C subcontractor with respect to the PITs, SS-SATs, SITs, SCTs, STR, SPTs and NITs; and
- Providing suitable numbers and trained project operations staff in respect of continuing project operations for the existing network as well as supporting the D&C subcontractor with respect to the SCTs, SPTs and NITs.

Example Acceptance for Modifying an Existing Network

8.7 With respect to works associated with design, construction, installation, testing, commissioning and bringing into use of the modifications made to an existing network, acceptance needs to be undertaken without disruption to the existing services which must continue to be delivered in accordance with the existing performance measures. The roles and responsibilities of the D&C subcontractor and Opsco are listed below.

8.8 The D&C subcontractor is responsible for the following:

- Leading, resourcing and completing all build and manufacture activities associated with the supply of new trams and all modifications to existing trams required to operate enhanced services on the existing network;
- Leading, resourcing and completing all construction and installation activities in respect of infrastructure modifications to the existing network required introduction of enhanced services on the existing network and including:
 - Extension works to the existing depot(s);
 - Infrastructure works in respect of electrification and power distribution upgrades;
 - Provision of the full functionality of the new or modified SCS as configured for controlling and managing the existing modified network's project operations;
- Leading, undertaking and successfully completing the PITs, SS-SATs, SITs and SCTs associated with the above elements of the works with such undertaken as an operational tramway; and
- Leading, undertaking and successfully completing any remedial works during the SCTs, STR stages; and SPTs.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	40 of 60

8.9 The Opsco will be responsible for supporting the D&C subcontractor in the following:

- Providing suitable numbers and trained staff to operate the OCC in respect of:
 - Continuing project operations on the existing network in accordance with the performance measures;
 - Supporting the D&C subcontractor with respect to the PITs, SS-SATs and SITs, SCTs, STR and SPTs;
 - Controlling, and executing the project operations for those sections and / or modified systems, trams and / or infrastructure which have become operation tramways post their successful completion of their SCTs; and
- Providing suitable numbers and trained tram drivers in respect of continuing project operations and delivering the services, as well as supporting the D&C subcontractor with respect of SITs, SCTs, STR and SPTs.

8.10 The operator / Opsco will also be operating and maintaining the existing operational network so it can't be assumed resources will be available. For a new system, the operator will be recruiting and training staff often at the time when they may be required to support T&C. This should be considered when producing an integrated T&C plan.

Processes and Procedures

8.11 The D&C subcontractor would be responsible for all processes and procedures in respect of the works including for those T&C activities.

8.12 The following site tests would be carried out under construction site arrangements:


- TDATs;
- TATs;
- PITs;
- SS-SATs;
- SITs; and
- SCTs

8.13 The following site tests would be carried out under operational tramway arrangements, but still under the responsibility of the D&C subcontractor:

- STR;
- SPTs; and
- NITs

8.14 Once any and all section(s) of the network have become operational tramways, the D&C subcontractor will need to arrange access to such parts of the network via the prevailing project operations arrangements, which would include the prevailing procedures for working on and / or near the tramway and permits to work.

Resources

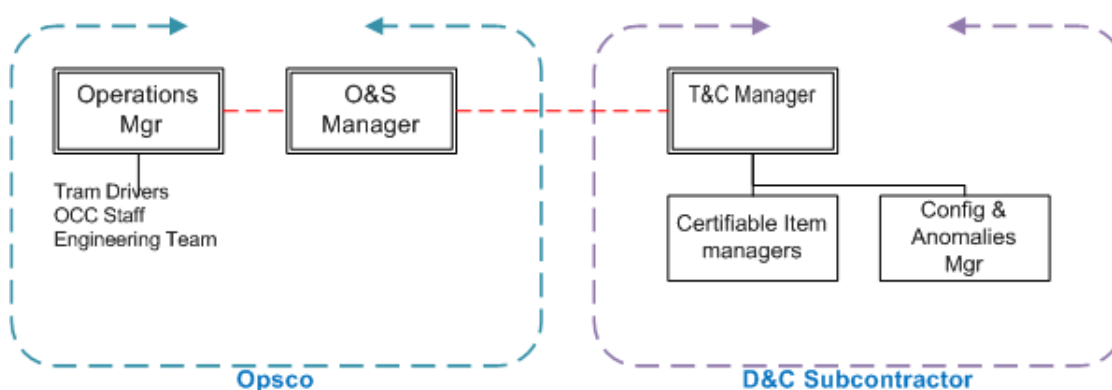
	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	41 of 60

- 8.15 Both the D&C subcontractor and Opsco, O&M subcontractor, will need to provide suitably trained and competent staff in sufficient numbers to undertake the activities of the acceptance process to the durations and time slots set out in the final and agreed version of the implementation programme. Appendix H indicates the types of resources that the two parties would typically need to provide in undertaking the network acceptance tests to an extended existing network.

T&C Organisation Chart

- 8.16 Different procurement methods create different governance structures. It can be typically expected that the promoter(s) and concessionaire / lead contractor will have their own project and senior management teams who will be scrutinising test results and gateway progress. Equally, the D&C subcontractor leading the T&C process, will have a day-to-day relationship with the Opsco, O&M subcontractor for T&C matters. Such, high-level organisation structure, representing the interactions and responsibilities of the D&C subcontractor and Opsco can be illustrated in the organogram in Figure 8.1 below.

Figure 8.1 Typical High Level T&C Organisation Chart



Roles Definition and Responsibilities

Promoters and Representatives

- 8.17 The promoter(s), and / or concessionaire organisation, will have their own teams of suitably qualified people. Members of such teams may well witness some or all of the tests, and be extremely diligent in reviewing the results of the tests, especially those results for TATs, SCTs, SPTS and NITs.

T&C Management

- 8.18 The T&C management coordinates the on-site test and commissioning team and is responsible for the overall consistency of the definition and performance of the T&C activities, in order to obtain the necessary certification to open the network to operate the services. This includes control of the following:
- Test program and schedule;
 - Test procedures / reports;
 - Configuration changes / non conformance; and

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	42 of 60

- All system test levels (SITs onwards).

8.19 During on-site tests the T&C management has delegated authority to decide modifications of the sequence of the scheduled tests, considering results of previous tests, non-conformances or any impediment. Detailed scheduling of the test program shall be coordinated and approved by the O&S management.

Configuration and Anomalies Management

- 8.20 Configuration and anomalies management is responsible for managing the following:
- Definition of the configuration items;
 - Version / configuration of manufactured and / or installed products; and
 - Anomalies follow-up and resolution.

Certifiable Items Management

- 8.21 The certifiable items management is responsible for the overall consistency of the definition and performance of the T&C activities for their respective certifiable item(s), in order to obtain the necessary certification to open the network to operate the services. This includes the following:
- Certifiable item test program and schedule;
 - Certifiable item test procedures / reports;
 - Certifiable item configuration changes / non conformances; and
 - Certifiable item tests realisation according to the schedule.
- 8.22 The certifiable items management shall undertake the following:
- Follow and make sure the certifiable items T&C teams adhere to the safety rules and procedures which apply for on-site tests under the leadership of the O&S management; and
 - Bring support, means and resources to T&C management for system test levels involving its subsystems (SITs onwards).

Operation and Safety (O&S) Management

- 8.23 The O&M management is responsible for the coordination and implementation of the following:
- All safety rules and procedures on test zones; for example; safe electrical configuration, movement of trams, safety trainings;
 - Movements of trams;
 - Permit to work management;
 - Supply of trams, drivers, Opsco support personnel; and
 - Liaising with public authorities to ensure correct and safe test operation.
- 8.24 The O&S management has the explicit delegated authority to authorise start and / or stop any on-site tests they deems is, or may cause, an unsafe event.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/ 2022
		Page	43 of 60

APPENDIX A: Example Certifiable List Items

CERTIFIABLE ELEMENT	CERTIFIABLE ITEM
Tram	Carbody Emergency coupling Doors, door operation controls Bogies and suspension Propulsion and braking systems Saloon layout Driver's cab and controls Telecommunication equipment HVAC (heating, ventilation and air conditioning) Exterior lights Interior lighting CCTV surveillance PA system Passenger Emergency Help Points (PEHPs) Fire / flammability / smoke emissions
Supervision and Control System	Interface to any railway signalling equipment Tramway signalling equipment of single line sections Interlocking circuits / equipment Line-side signals and indicators Automatic vehicle location system OCC Human Computer Interfaces (HCIs) Radio system Supervision and control system Operational data network Telecommunications with emergency services CCTV surveillance

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	44 of 60

CERTIFIABLE ELEMENT	CERTIFIABLE ITEM
Electrification and Power Distribution Infrastructure	High voltage switchgear AC to DC conversion DAC (digital to analogue convertor) switchgear Auxiliary power systems Overhead line electrification (OLE) Traction power substations Line-side power equipment and housings EMC / EMI Stray current protection Touch voltage potential
Track and Structures	Alignment Track Points and crossings Point control, detection and indication Point heating Bridges and supporting structures Embankments and cuttings
Depot	Buildings and associated services Lifts Trackwork Electrification and power systems (as above) Plant and machinery Access controls
Tramstop and P&R sites	Access and egress routes Lifts and escalators Transition zones and concourses Platforms Lighting Electrical systems CCTV surveillance Ticket vending systems PA system PEHPs
Highway Interfaces	Rail / highway surface Traffic signal control Highway layout and signing

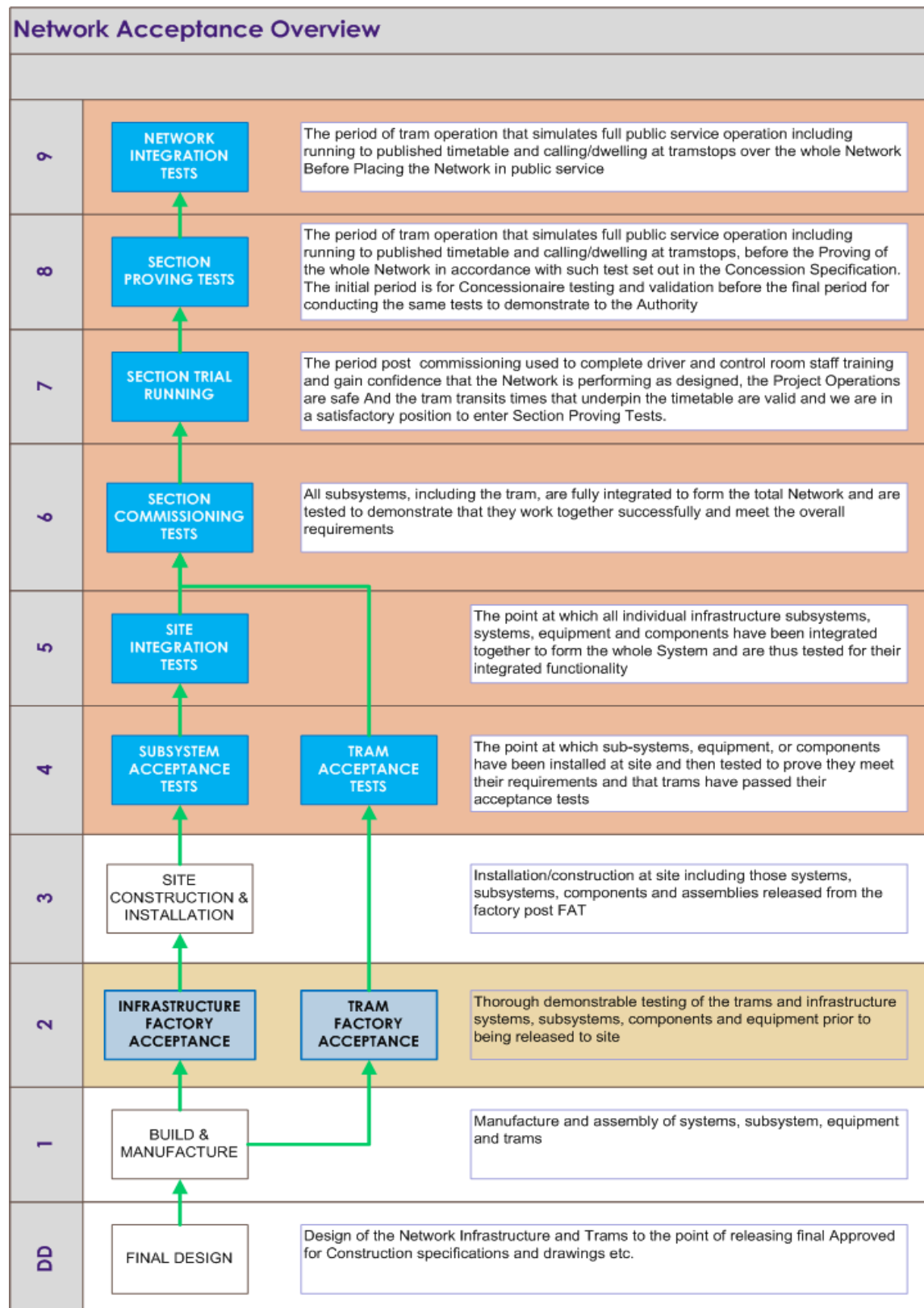
	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/ 2022
		Page	45 of 60


CERTIFIABLE ELEMENT	CERTIFIABLE ITEM
Plans, Procedures and Training	Test Plans: FAT Plans SATs and SIT plans Pre-operational test plans Operating and Maintenance: Standard operating and maintenance procedures Emergency operating and maintenance procedures Manuals and rule books Training and certification where appropriate Emergency preparedness

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	46 of 60

APPENDIX B: Example Lifecycle Extract

Shaded bands are those areas covered by this document.




	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	47 of 60


APPENDIX C: Example Section Proving Test Criteria

Contents and Pass Criteria for SPTs


NO.	TEST TITLE	TEST METHOD / CONDITIONS	DURATION	ACCEPTANCE CRITERIA
1	Timetable Delivery	Full complement of trams operates over the section being tested and any operational sections adjoining the section under test in accordance with the timetable. The timetable shall represent the full published timetable. Each tram shall be used at least once during the test. During the test each traction power substation feeding the part of the network being tested shall be taken out of use for a minimum period of 2 hours to demonstrate that the services continues to operate to the timetable.	7 consecutive days	The monthly performance for the network does not give rise to what would constitute a timetable performance shortfall as defined in the performance measures.
2	Airborne Noise from Trams	Airborne noise from trams shall be measured in accordance with the method of measurement specified in and at the locations specified in the procurement specification(s)	1 day during test number 1 for each location	Noise levels shall comply with measures set out in the procurement specification(s).
3	Ground borne Noise	Ground borne noise shall be measured in accordance with the method of measurement specified in and at the locations specified in the procurement specification(s)	1 day during test number 1 for each location.	Ground borne noise shall comply with measures set out in the procurement specification(s).
4	Tram Internal Noise	Tram internal noise shall be measured in accordance with the method of measurement specified in procurement specification(s) on each tram over all tramstop-to-tramstop sections of the part of the network being tested.	1 round trip for each tram	Noise levels shall comply with measures set out in the procurement specification(s).
5	Ground borne Vibration	Ground borne vibration levels shall be measured in accordance with the method of measurement specified in and at the locations specified in the procurement specification(s)	1 day during test number 1 for each location.	Vibration levels shall comply with measures set out in the procurement specification(s).

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	48 of 60


NO.	TEST TITLE	TEST METHOD / CONDITIONS	DURATION	ACCEPTANCE CRITERIA
6	Ride Quality	Ride quality shall be measured in accordance with the method of measurement specified in the procurement specifications on each tram over all tramstop-to-tramstop sections of the part of the network being tested.	1 round trip for each tram	Ride quality shall comply with measures set out in the procurement specification(s).
7	Tram Passenger Information Display (PID) System	PIDs and audible announcements on the tram shall be continuously monitored. (Note: The contracting parties shall make arrangements for the external destination boards to be covered from public view or the tram identified as being 'out of service' or similar).	3 round trips for each tram over the section being tested.	The PID system complies with the requirements of the procurement specification(s).
8	Tram Saloon Interior	Tram saloon interior environmental conditions shall be continuously monitored for temperature, humidity and lighting within the saloon.	3 round trips per tram per section being tested	Each tram undergoing the test shall comply with measures set out in the procurement specification(s).
9	Tram CCTV System	The CCTV system on the tram shall be continuously monitored and the CCTV recordings reviewed for compliance.	3 round trips for each tram over the section being tested.	The CCTV system complies with the requirements of the procurement specification(s).
10	Tram Passenger Emergency Help Points (PEHP)	Each PEHP on the tram shall be activated twice during the test.	3 round trips for each tram over the section being tested.	The PEHPs comply with the requirements of the Procurement specification(s).
11	Tramstop Passenger Information Display (PID) Availability	The availability of PIDs at or near the tramstops and P&R sites on the part of the network being tested shall be continuously monitored during the test in accordance with the respective performance measures as set-out in the procurement specifications, and the monthly availability calculated for the period of the test as if the contract month has 7 days.	New network: 24 hours a day for each day of test number 1 Existing modified network: 24 hours a day for 7 consecutive days immediately	The availability equals or exceeds the target % set out the performance measures.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	49 of 60


NO.	TEST TITLE	TEST METHOD / CONDITIONS	DURATION	ACCEPTANCE CRITERIA
		<p>During the test, the PID's shall display a free text test message sent from the OCC stating that the "service is not in use. system under test" or similar.</p> <p>During the test, the daily visual inspection shall observe each PID for a period of 15 minutes to confirm that the correct and legible information is being displayed.</p>	upon making any changes to the network	
12	Availability of a Valid Fare to Travel	<p>The availability of the static TVMs (if provided) at or near the tramstops and P&R sites on the part of the network being tested shall be continuously monitored during the test in accordance with performance measure as set-out in the procurement specifications, and the monthly availability calculated for the static TVMs only for period of the test as if the contract month has 7 days.</p> <p>During the test, the daily inspection shall confirm a valid fare to travel can be obtained using each of the permitted methods of payment.</p> <p>On at least one occasion during test, each TVM shall be tested by carrying out the maximum possible number of transactions using each method of payment.</p>	<p>New network: 24 hours a day for each day of test number 1</p> <p>Existing modified network: 24 hours a day for 7 consecutive days immediately upon making any changes to the network</p>	The availability equals or exceeds the target % set out the performance measures.
13	Tramstop Passenger Emergency Help Point PEHP Availability	<p>The availability of the PEHP at or near the tramstops and P&R sites on the part of the network being tested shall be monitored during the period of test in accordance with performance measure as set-out in the procurement specifications, and the monthly availability calculated for the period of the test as if the contract month has 7 days.</p> <p>During the test, the daily manual inspection and check shall activate each PEHP.</p>	<p>New network: 24 hours a day for each day of test number 1</p> <p>Existing modified network: 24 hours a day for 7 consecutive days immediately upon making any</p>	The availability equals or exceeds the target % set out the performance measures.

	TESTING AND COMMISSIONING GUIDANCE		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	50 of 60

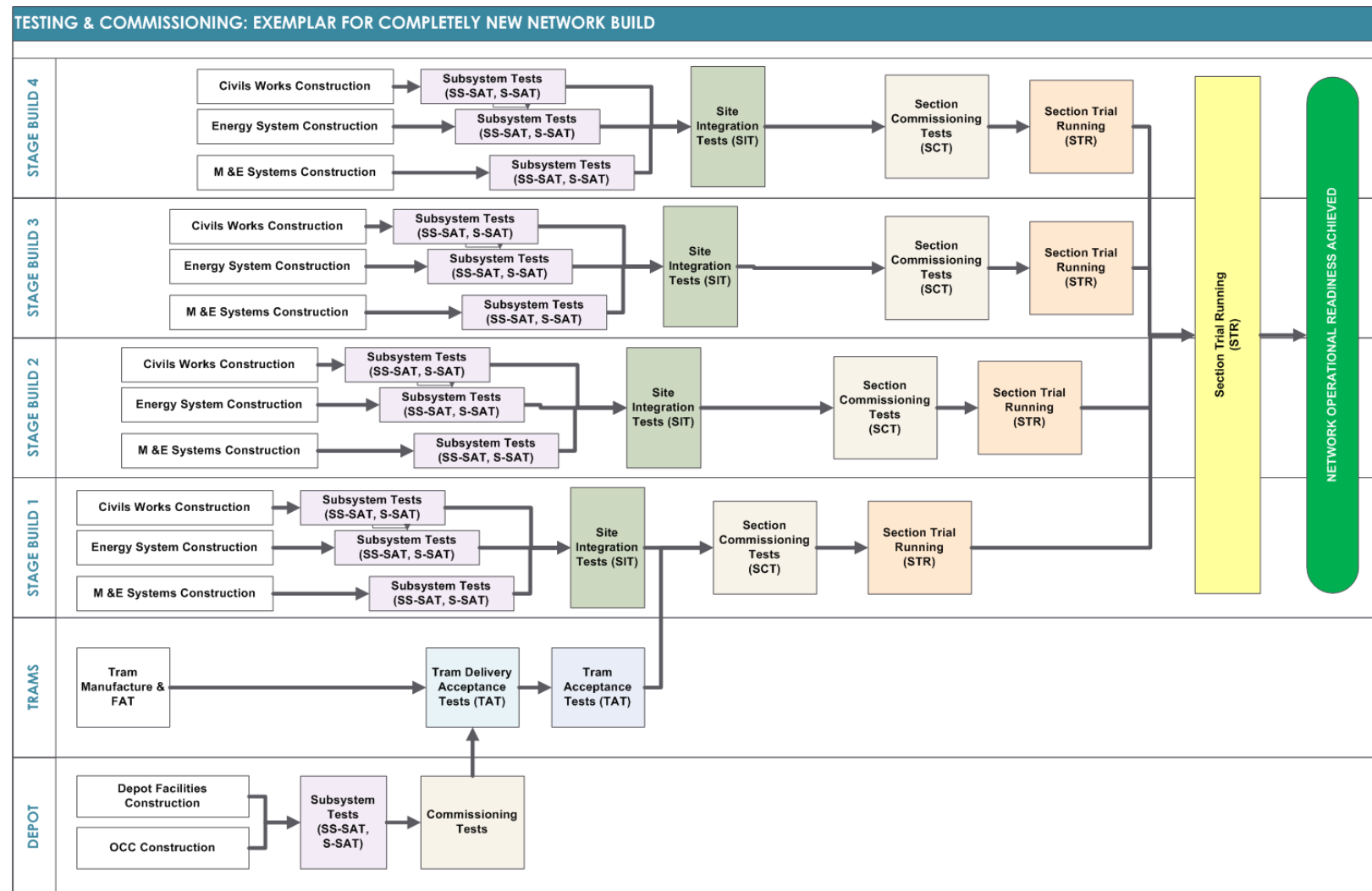
NO.	TEST TITLE	TEST METHOD / CONDITIONS	DURATION	ACCEPTANCE CRITERIA
			changes to the network	
14	Tramstop CCTV Availability	<p>The availability of the CCTV at or near the tramstops and P&R sites on the part of the network being tested shall be monitored during the period of test number 1, and in accordance with performance measure as set-out in the procurement specifications, with the monthly availability calculated for the period of the test as if the contract month has 7 days.</p> <p>During the test, the daily OCC CCTV checks shall be undertaken for each CCTV camera.</p>	<p>New network: 24 hours a day for each day of test number 1</p> <p>Existing modified network: 24 hours a day for 7 consecutive days immediately upon making any changes to the network</p>	The availability equals or exceeds the target % set out the performance measures.
15	Tramstop Public Address System Availability	<p>The availability and performance of the PA system shall be checked daily on each of the tramstops and P&R sites on the part of the network being tested during the period of test number 1.</p>	<p>New network: Daily during test number 1</p> <p>Existing modified network: Daily on each of 7 consecutive days immediately upon making any changes to the network</p>	The PA systems comply with the requirements of the procurement specification(s).
16	Stray Current Monitoring	<p>The stray current monitoring system installed on the network and the section of the network undergoing the test operates continuously for the period of the test in accordance with the requirements of this procurement specification(s).</p>	<p>New network: the duration of test 1 above.</p> <p>Existing modified network: 7 days in service immediately upon making any</p>	The actual stray current levels recorded do not exceed the levels required by the Stray Current Management Plan.


	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/ 2022
		Page	51 of 60

NO.	TEST TITLE	TEST METHOD / CONDITIONS	DURATION	ACCEPTANCE CRITERIA
			changes to the network	
17	EMC	EMC is monitored during the test for compliance with the EMC Management Plan at sensitive receptors on the part of the network being tested.	New network: the duration of test 1 above. Existing modified network: 7 days in service immediately upon making any changes to the network	Compliance with the requirements of the procurement specification(s).

	<h1>TESTING AND COMMISSIONING GUIDANCE</h1>		LRSSB - LRG - 32.0	
			Issue	1
			Revision	0
			Date	19/10/2022
			Page	52 of 60

APPENDIX D: Example New Build Tramway Testing and Commissioning Programme




	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	53 of 60

APPENDIX E: Testing and Commissioning Sequence

STAGE	OBJECTIVE	T&C REQUIREMENTS
1	Depot Readiness	<p>In accordance with Sections 6.3 and 6.4 (New trams will most likely require different maintenance equipment requiring the interfaces to be tested for example, wheel lathe, re-railing equipment and procedures may be different than the existing fleet.)</p>
2	Proving Existing as Modified Network	<p>ILTs in accordance with Sections 6.5-6.7 and Tram Acceptance Tests (TATs) for the new, and / or any existing modified trams, in accordance with Section 6.8, followed by:</p> <p>SCTs in accordance with Sections 5.37-5.42, noting:</p> <ul style="list-style-type: none"> Emergency exercises may be able to limited to: <ul style="list-style-type: none"> Major tram collision/derailment; and Person(s) trapped underneath a tram, i.e. adult male, adult female and child; and ALARP validation may be able to be restricted to: <ul style="list-style-type: none"> Collision with another tram; Gauging; Failed Tram recovery; OCC and all other project operations safety procedures if OCC and / or supervision and control systems modified; and Tram maintenance procedures. <p>Section Trial Running (STR)s in accordance with Sections 5.43-5.48.</p> <p>Upon completion of the SCTs, new and / or modified existing trams will be operated over that section under test conditions and in accordance with an agreed programme. These tests are section trial runs which enable confidence to be gained in the dependability and safety of that network section using the new trams, as well providing training and familiarisation for tram drivers and other project operations staff on the new trams. The duration of this testing phase is mainly driven by the number of new trams, number of tram drivers and project operations staff to be trained.</p> <p>To maintain dependability of the existing services and existing project operations, it is likely that STRs in this scenario are undertaken by means of running test trams interspersed amongst the existing services.</p> <p>Section Proving Tests (SPTs)s over the existing infrastructure in accordance with Sections 5.49-5.56.</p> <p>The implementation plan will set out how the new trams will be introduced to operating the services, for example, phased introduction by route or service pattern or all at once. The latter would be a most unlikely scenario as it would import considerable operational delivery and commercial risk should any or all of the new trams not achieve operational readiness, albeit probably only for a short period.</p>

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	54 of 60

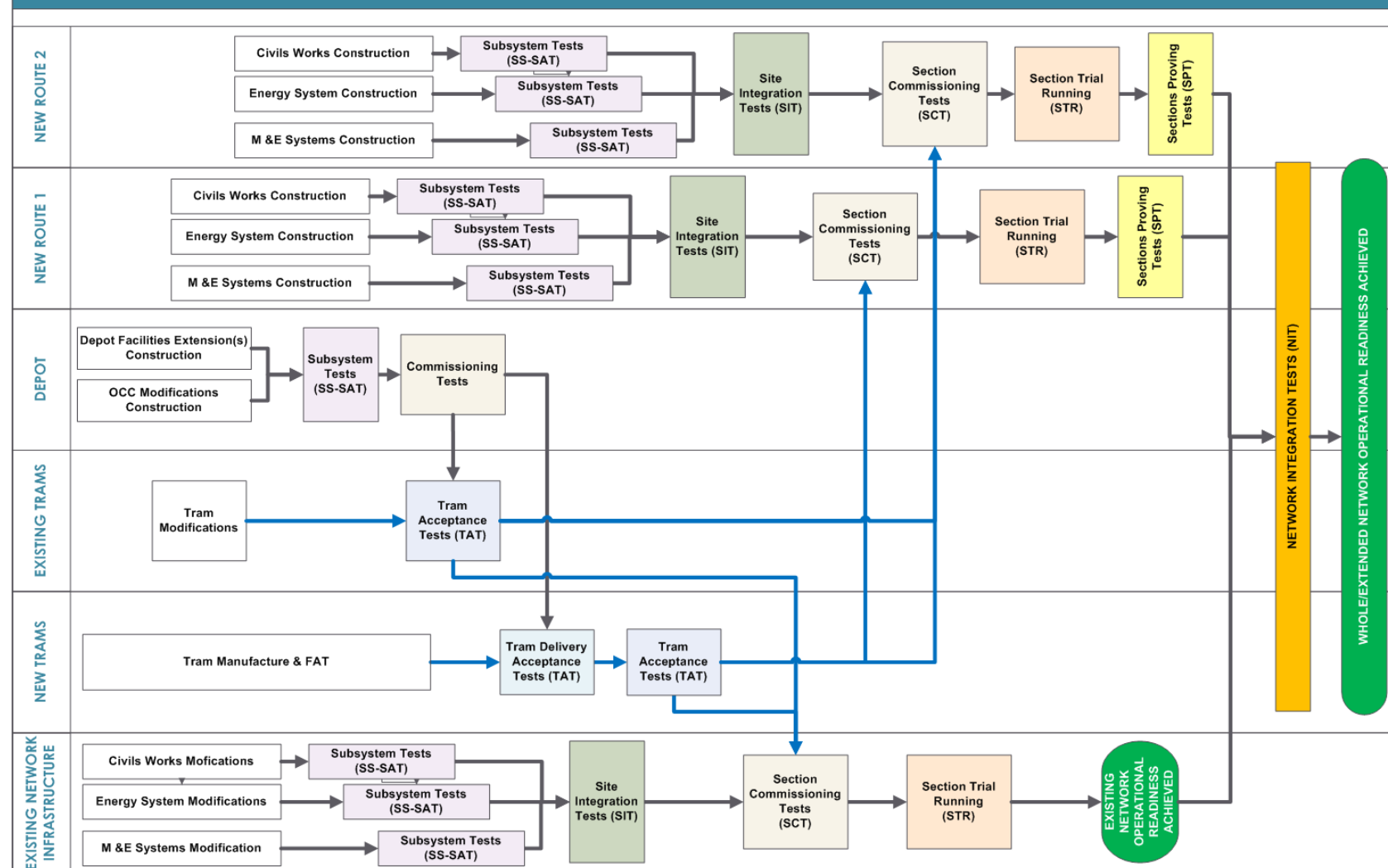
STAGE	OBJECTIVE	T&C REQUIREMENTS
		<p>Such SPTs would typically be conducted on specific sections of the network using the criteria and definitions described in Appendix A, albeit probably only invoking SPTs 1 – 11, 16 and 17. SPTs would more than likely correlate with those route sections operated by a particular service pattern.</p> <p>The conclusion of this T&C phase should result in acceptance by the IC and the Duty Holder / ICP that the network has achieved operational readiness and can safely execute the project operations and deliver the services in accordance with the procurement specification(s).</p>
3	Proving New Routes of the Network	<p>Infrastructure Local Tests in accordance with Sections 6.5-6.7 and Tram Acceptance Tests (TATs) for the new, and / or any existing modified trams, in accordance with Section 6.8 for those trams not delivered or modified at the end of Stage 2;</p> <p>followed by the T&C described below for each stage build of the new infrastructure as defined in the implementation plan.</p> <p>Section Commissioning Tests (SCTs) in accordance with Sections 5.37-5.42.</p> <p>Section Trial Running (STR) in accordance with Sections 5.43-5.48.</p> <p>Section Proving Tests (SPTs) in accordance with Sections 5.49-5.56.</p>
4	Proving the Final Network Configuration	<p>Network <i>Integration Tests (NITs)</i> over the existing infrastructure in accordance with Sections 5.57-5.60.</p> <p>To be in an acceptable position to undertake the acceptance process for the final configuration of the extended network:</p> <ul style="list-style-type: none"> • All the modifications to the existing network have been completed and passed their acceptance process, and the enhanced existing services will be in operation over the existing network; and • SPTs have been successfully completed for the new route(s). <p>As such there will now be confidence of these elements of the network performing safely and in accordance with the performance measures and therefore leave only NITs to be performed by:</p> <ul style="list-style-type: none"> • Operation of the enhanced existing services in accordance with the performance measures as applicable under the full published timetable representing the full services; • Trams continuing empty from the tramstop(s) on the existing network which forms the boundary to the new route(s) to their intended destination and returning from said destination as set out in the full published timetable representing the full services; and • Monitoring of the performance of the entirety of such tests in accordance with performance recording and reporting requirement set out in the procurement specifications, such that it can be demonstrated that: <ul style="list-style-type: none"> ○ Trams operate over the network for 7 consecutive days in accordance with the full published timetable; and


	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/ 2022
		Page	55 of 60


STAGE	OBJECTIVE	T&C REQUIREMENTS
		<ul style="list-style-type: none"> The monthly performance for the whole network does not give rise to what would constitute a timetable performance shortfall as defined in performance measures. Where such are calculated for the period of the test as if the contract month has 7 days.

APPENDIX F: Example T&C Programme for Extended Network with New Trams

TESTING & COMMISSIONING: EXEMPLAR FOR MODIFIED OR EXTENDED NETWORKS



	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/ 2022
		Page	57 of 60

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	58 of 60

APPENDIX G: Example Standard Test Procedure

NO.	NOMENCLATURE	DESCRIPTION
1	Test Identification	
1.1	Test Procedure Title	The test procedure title should be as explicit as possible. The title must give indication of what the test procedure covers and what major components are under test. Test level (FAT-C, SS-FAT, etc.) should be explicitly mentioned in the title.
1.2	Test Procedure Reference	Test procedure reference allows uniquely identifying the test, the test level and the entity involved.
1.3	Test Objective	Test procedure will specify a general test objective.
1.4	Test Method	Test procedure will state the method of the test: inspection, analysis, demonstration or test.
1.5	Requirements Verification	Reference to the contractual requirements, verification covered by the test procedure, in accordance with the verification matrix.
1.6	Safety-Criticality	It has to be indicated clearly if the test is safety related or not (i.e., related to the closure of any requirement identified during the safety process).
2	Test Pre Requisites	
2.1	Applicable Standards	Applicable standards applied to individual tests will be stated in each test specification or procedure.
2.2	Applicable Configuration	The configuration under test will be clearly defined. This will include references to: applicable design specifications; applicable design drawings; and applicable software and hardware configuration.
2.3	Pre-required Tests	The logic of test sequences as defined per the test overview table (for main tests) has to be reflected by indicating the pre-required tests to be completed before performance of the test.
3	Test Conditions	
3.1	Duration	A rough estimate of test duration should be included in order to allow efficient test scheduling and organisation (precision: ½ day).
3.2	Location	Indication of test location should be included; in particular for on-site tests: line (indicating on which test zone if possible), stop, substation, depot workshop, OCC, etc.
3.3	Test Safety	Test procedure for on-site tests will include information regarding the measures to be taken to ensure safety during the tests. This information may be divided in two items:

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	59 of 60

		<ul style="list-style-type: none"> Information to be taken into account in order to ensure safe scheduling of the means and logistics necessary to perform the test on-site; and Test participant safety and competence
NO.	NOMENCLATURE	DESCRIPTION
3.4	Starting Condition	If applicable, test procedure will state the required starting condition of the component or subsystem under test.
4	Test Means	
4.1	Test Equipment List	Test procedure will include details regarding the test equipment to be used during the test.
4.2	Calibrated Test Equipment List	All required calibrated test instruments must be listed (the calibrated test equipment record must be provided with the test report).
4.3	Resources Requirements	List of test personnel required to execute the test, with exclusion of the personnel necessary to ensure the logistics of the test.
5	Test Specification	
5.1	Acceptance Criteria	When applicable (for demonstration test method, acceptance criteria are qualitative). If it can be defined easily, depending on the test complexity, to indicate clearly the acceptance criteria (pass / fail). If the test is more complex or longer, acceptance criteria can be mentioned – but explicitly for each step – directly in the test specification.
5.2	Test Specification	Test specification defines step by step the complete logical sequence of actions / results to be accomplished and checked during the test.
6	Test Results	
6.1	Test Report Reference	Reference to the subsequent associated test report shall be made.
6.2	Results Format	If needed or applicable, test procedure will include the format or schedule template for the submission of results.

	TESTING AND COMMISSIONING GUIDANCE	LRSSB - LRG - 32.0	
		Issue	1
		Revision	0
		Date	19/10/2022
		Page	60 of 60

APPENDIX H: Example Resource Requirements for the Network Acceptance Process (Extended / Existing Network)

TEST DESCRIPTION	DURATION (APPROX.)	D&C RESOURCE	O&M RESOURCE
FATs	Per agreed programme	Suitably trained and competent staff	Contribution to test specification and witnessing of tests
The following tests to be carried out under operational tramway procedures for modifications and under construction site arrangements for construction works			
TDATs	Per agreed programme	Suitably trained and competent staff	Witnessing of tests
TATs	1000 Km per vehicle	Suitably trained and competent staff	Contribution to test specification, tram drivers for the test and staff for witnessing of tests
PITs	Per agreed programme	Suitably trained and competent staff	Contribution to test specification and witnessing of tests
SS-SATs	Per agreed programme	Suitably trained and competent staff	Contribution to test specification and witnessing of tests
SITs and SCT	Per agreed programme	Suitably trained and competent staff	Contribution to test specification and witnessing of tests Provision of suitably trained and competent tram drivers and OCC staff
The following tests to be carried out under operational tramway procedures for both modifications and construction works			
STRs	4-6 weeks per section	Suitably trained and competent staff	Contribution to test specification and witnessing of tests Provision of suitably trained and competent tram drivers and OCC staff
SPTs	8 weeks minimum per route	Suitably trained and competent staff	Contribution to test specification and witnessing of tests Provision of suitably trained and competent tram drivers, OCC and maintenance staff
NITs	2-3 weeks	Suitably trained and competent staff	Contribution to test specification and witnessing of tests; Provision of suitably trained and competent tram drivers, OCC and maintenance staff