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OLRT CONSTRUCTORS CONSTRUCTEURS

OTTAWA LIGHT RAIL TRANSIT PROJECT

Confederation Line Phase 1
Engineering Safety and Assurance Case

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OLRT CONSTRUCTORS This document may contain confidential and commercially sensitive information.		16 August 2019

J Bergeron aug 20TH 2019

LICENSED PROFESSIONAL ENGINEER
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REVISION HISTORY

Rev	[redacted]	[redacted]ription	Prepared by	Reviewed by	Approved by	Authorised by	Accepted by
0	17 April 2019	Initial Issue	SA Team	John Blowfield / Stuart Gilbey	Mary McGrath	Derek Wynne	Sean Derry
1	05 July 2019	Amended document sequencing in line with feedback from the City of Ottawa & SA-TUV & corrected various reference errors. Address of ISA comments.	SA Team	Stuart Gilbey	Mary McGrath	Derek Wynne	Sean Derry
2	05 August 2019	Amendments to table of owners. Reference updates	SA Team	Stuart Gilbey	Mary McGrath	Derek Wynne	Sean Derry
3	16 August 2019	Updated in preparation for RSA	SA Team	Stuart Gilbey	Mary McGrath	Derek Wynne	Sean Derry

ALS0084164

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3.2.5- Threat & Vulnerability	Florica Nye	Technical Director	OLRT-C
3.2.6- Cyber Security	Florica Nye	Technical Director	OLRT-C
3.2.7 - Electromagnetic Compatibility (EMC)	Florica Nye	Technical Director	OLRT-C
3.2.8- Grounding	Steve Nadon	Test & Commissioning Director	OLRT-C
3.2.9- Human Factors & Ergonomics	Florica Nye	Technical Director	OLRT-C
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4.0 – Process Argument	Mary McGrath	Systems Assurance Lead	SEMP

ALS0084164

EXECUTIVE SUMMARY

This Engineering Safety and Assurance Case (ESAC) sets out to determine that the Confederation Line Phase 1 is 'Fit for Operation', through evaluation of the product and process arguments in line with the risk based assurance approach to Systems Engineering and Systems Assurance as presented to the City of Ottawa on 14 May 2018 [1].

The product and process arguments are supported by eight pillars of assurance, which in turn are evidenced by achievement of the pillars supporting objectives, as represented within this document.

Having assessed the objectives and evaluated the associated assurance activities together with the conclusions identified for each, it is evident that significant assurance was implemented and achieved

With the evidence available it was possible to determine that the highest level Systems Engineering and Systems Assurance argument, namely that Confederation Line Phase 1 is 'Fit for Operation, could be made.

The Assurance arguments presented in this ESAC were determined to collectively derive that when satisfied, the Confederation Line Phase 1 works were sufficiently assured to enable entry into service operations in accordance with Revenue Service Availability (RSA) subject to adherence to any Restrictions, Conditions and Limitations identified in the in Confederation Line Phase 1 Operational Restrictions Document [2] and resolution of issues identified in the ESAC Outstanding Items List [378].

This ESAC and the argument(s) it presents are only valid for Revenue Service if the following caveats are satisfied;

- All remedial works to resolve identified deficiencies that have been designated as 'prior to Substantial Completion' that have been determined to be Safety related by the Systems Engineering and Systems Assurance Team must have been completed.
- All remedial works to resolve identified deficiencies that have been designated as 'prior to Revenue Service Availability' that have been determined to be Safety related by the Systems Engineering and Systems Assurance Team must have been completed.
- All conditions detailed on OBC Certificates must be satisfied.
- All conditions detailed on OFS Certificates must be satisfied.
- All outstanding SIT/SAT Reports must be issued confirming each test has passed.
- Any deficiencies identified within the SIT/SAT Reports, and that have been determined to be Safety related by the Systems Engineering and Systems Assurance Team, must have been completed.
- Confirmation that no safety related events occur during the Trial Running period as a result of the Infrastructure/ LRV.
- The railway is correctly maintained throughout the pre-revenue service period;
- The as-built configuration baseline that underpins this ESAC and Safety Justification documents does not change.

Typically an ESAC would be developed at the outset of the project, reflecting all project lifecycle stages, using a structure established through appropriate development workshops or a recognised industry standard model. This ESAC is bespoke to the Confederation Line Phase 1 project, developed from the Detailed Design stage through to Handover and therefore cannot be directly used for any other

ALS0084164

project, without development by appropriate skilled and competent persons. Use of this document for anything other than its intended purpose on Confederation Line Phase 1 would be at the users risk.

ALS0084164

CONTENTS

1. INTRODUCTION

1.1 PURPOSE

This ESAC lays out the main lines of reasoning and argument to support delivery of the Confederation Line Phase 1 Railway.

Having ascertained such reasoning and argument, it proceeds to identify necessary evidence to substantiate such arguments in order to support the decision to migrate the Confederation Line Phase 1 Railway from delivery into operation to RSA.

This ESAC presents the outcome of Assurance activities and objectives conducted in accordance with the Ottawa Light Rail Transit-Constructors (OLRT-C) Systems Assurance Management Plan (SAMP) [3].

For the purposes of this document, the term Systems Assurance is defined as:

'The planned and systematic set of activities that assure the technical integrity of a product, process, or system.'.

Where assure means:

"to give confidence"

This ESAC is the top level document in the suite of Engineering Safety and Assurance submissions as shown in Figure 1. It summarises the assurance arguments and supporting evidence presented within lower level documents.

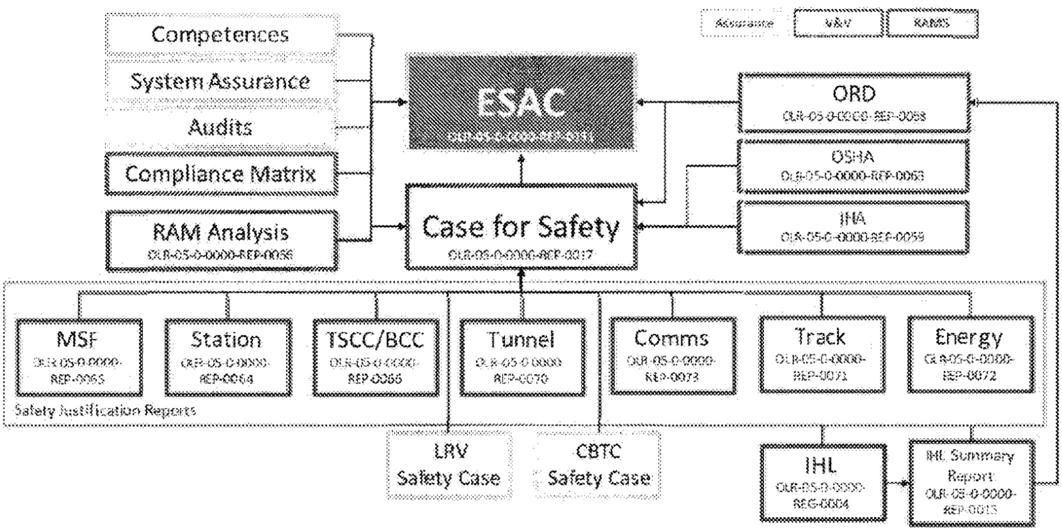


Figure 1: Hierarchy of Deliverables

Typically an ESAC would be developed at the outset of the project, reflecting all project lifecycle stages, using a structure established through appropriate development workshops or a recognised industry standard model. This ESAC is bespoke to the Confederation Line Phase 1 project, developed from the Detailed Design stage through to Handover and therefore cannot be directly used for any other project, without development by appropriate skilled and competent persons. Use of this document for

ALS0084164

anything other than its intended purpose on Confederation Line Phase 1 would be at the users risk.

1.2 STRUCTURE

The structure of this ESAC has been defined in line with the arguments and sequencing as shown in the Assurance Arguments Diagram (Figure 2) below.

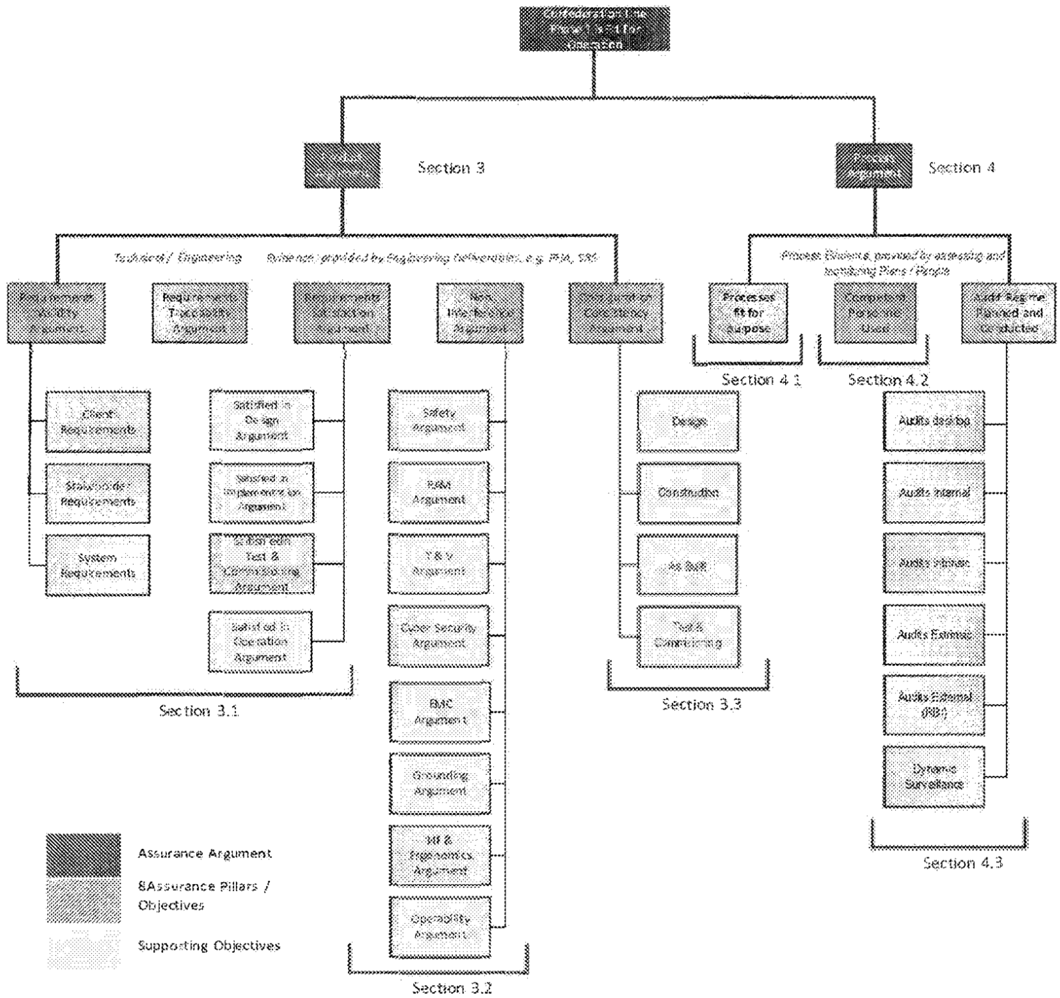


Figure 2: Assurance Arguments Diagram

The Assurance arguments presented in Figure 2 were determined to collectively derive that when satisfied the Confederation Line Phase 1 works were sufficiently assured to enable entry into service operations in accordance with RSA.

ALS0084164
ALS0084164

In line with accepted Assurance methodologies and best practice, there are 8 fundamental pillars underpinning the Product/Process Assurance Argument. Five of which were associated with the Product Argument and a further three associated with the Process Argument, as highlighted in Figure 3 below.

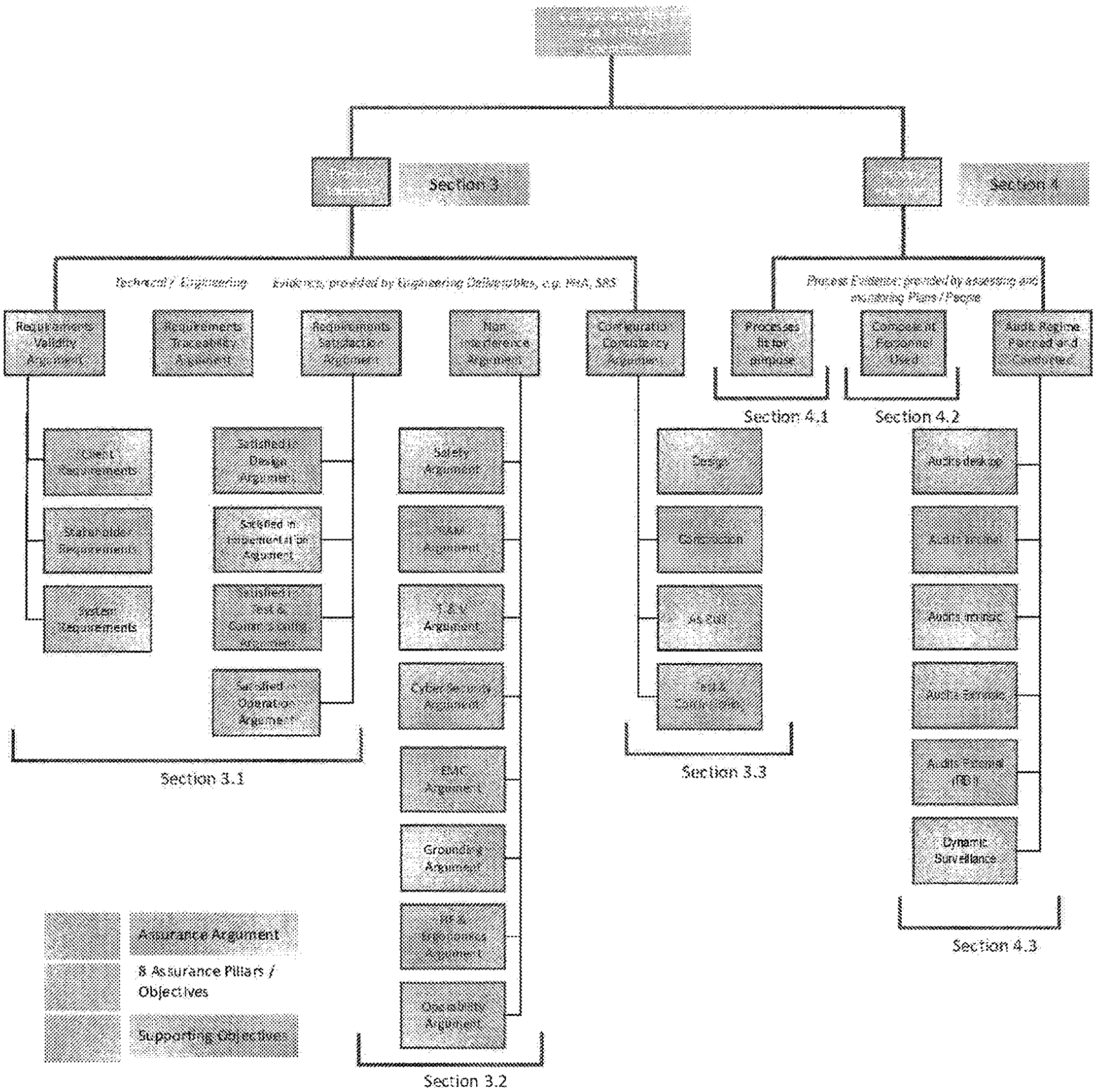


Figure 3: The 8 Pillars of the Assurance Argument

Each of the above highlighted pillars represents an objective to be met in support of the all up Assurance Argument, Confederation Line Phase 1 is 'Fit for Operation', these are in turn underpinned by a set of supporting objectives (see Figure 2). Aggregated supporting objectives which when successfully made determines that an assurance argument can be considered to be fulfilled.

ALS0084164

In recognition of the Assurance Argument approach and to ensure consistency of process this document is structured into the following sections:

Section 1 Introduction	Introduces the purpose of the Engineering Safety and Assurance Case and outlines the structure & scope of the document.
Section 2 System Definition	Provides a high-level overview of the Phase 1 Confederation Line Railway.
Section 3 Product Argument	Provides the Product Argument demonstrating that the delivered System possesses the required properties as satisfied by the five fundamental product assurance pillars.
Requirements Arguments	Pillars of the Product Argument, provides the arguments to demonstrate that the requirements objectives used to describe the Confederation Line Phase 1 System have been validated, are traceable and have been satisfied.
Test and Commissioning	Supporting objective to the requirements pillar, provides the argument to demonstrate that enough Test and Commissioning activities have been performed to support requirement satisfaction.
Non-Interference Arguments	As a pillar to the Product Argument, provides the arguments as satisfied by the Non-Interference objectives, to demonstrate that Individual System Components will not interact with other systems, people and external components in an unacceptable manner and in such a way as to degrade the required properties of the overall Ottawa Light Rail Transit (OLRT) Railway.
Reliability, Availability, Maintainability, Safety (RAMS)	Supporting objective of the Non-Interference Pillar, provides the argument to demonstrate that the overall safety risk is managed to a level that is considered to be tolerable and As Low As Reasonably Practicable (ALARP) and that the Reliability, Availability and Maintainability (RAM) aspects have been adequately translated into the final system such that OC Transpo and Rideau Transit Maintenance (RTM) are able to operate and maintain the Confederation Line Phase 1 in the required System configuration.
Threat Vulnerability	Supporting objective of the Non-Interference Pillar, provides the argument to demonstrate that Threats and Vulnerabilities have been adequately addressed.

ALS0084164

Cyber Security	Supporting objective of the Non-Interference Pillar, provides the argument to demonstrate that the system is considered acceptably electronically secure and that Cyber Security threats and vulnerabilities have been identified and appropriate ongoing monitoring, review and countermeasures are in place.
EMC	Supporting objective of the Non-Interference Pillar, provides the argument to demonstrate that the system is adequately protected against Electromagnetic Interference.
Grounding	Supporting objective of the Non-Interference Pillar, provides the argument to demonstrate that compliant protection against Grounding and Bonding has been achieved.
Human Factors and Ergonomics	Supporting objective of the Non-Interference Pillar, provides the argument to demonstrate that adequate consideration of Human Factors has been achieved.
Operability	Supporting objective of the Non-Interference Pillar, provides the argument to demonstrate that the system Standard Operating Procedures (SOPs), Limitations and Operational Conditions are in place for the Operation of the Confederation Line Phase 1 as baselined in the System configuration.
Configuration Consistency Argument	As a pillar to the Product Argument, provides the argument to demonstrate that appropriate configuration control processes have been followed, are in place, and, being adhered to.
Section 4 Process Argument	Provides the Process Argument demonstrating that the appropriate series of processes have been correctly executed by trained, experienced and competent personnel.
Process	As a pillar to the Process Argument, provides the argument to demonstrate that appropriate processes have been utilised in the development of the OLRT Management System.
Competency	As a pillar to the Process Argument, provides the argument to demonstrate that competence of personnel has been managed.

ALS0084164

Audits	As a pillar to the Process Argument, provides the argument to demonstrate that a robust Risk Based Intrusion (RBI) audit management regime and audit process has been used to confirm that processes, plans, competence, requirements, Validation & Verification and RAMS have been managed on the Project.
Section 5 Quality	Although not part of the Assurance Argument as defined in figure 2, this section has been included for thoroughness and in support of the arguments to demonstrate that appropriate Quality Assurance measures have been employed and enacted. Thus, aiding overall completeness of the strategy and approach taken with the assurance activities.
Section 6 Supporting Tools	Although not part of the Assurance Argument as defined in figure 2, this section has been included for thoroughness and completeness of the approach taken. It provides evidence of the supporting tools used and how they have been utilized to progressively manage and monitor Systems Assurance in support of the Completeness Argument.
Section 7 Conclusions	Provides overall conclusion of the argument the Confederation Line Phase 1 is 'Fit for Operation' and aggregation of the supporting argument conclusions.

In presenting the product and process arguments each associated section is based on structure as follows:

- Objectives – objectives are set to determine what needs to be achieved to satisfy the argument
- Approach - the approach is the strategy employed in order to satisfy the argument
- Activities – the activities are the physical entities carried out in achieving the objectives, in line with the approach defined and therefore satisfying the argument
- Outputs – the outputs being the result of the activities undertaken
- Evidence – the evidence is proof of approach, activities and outputs being achieved
- Limitations – observations which are relevant to the section and considered within the argument
- Conclusion – the findings of the approach, activities and evidence validating the argument.

1.3 SCOPE

The scope of the ESAC is shown in Figure 4 and as conveyed in the System Breakdown Structure (SBS) [4].

ALS0084164

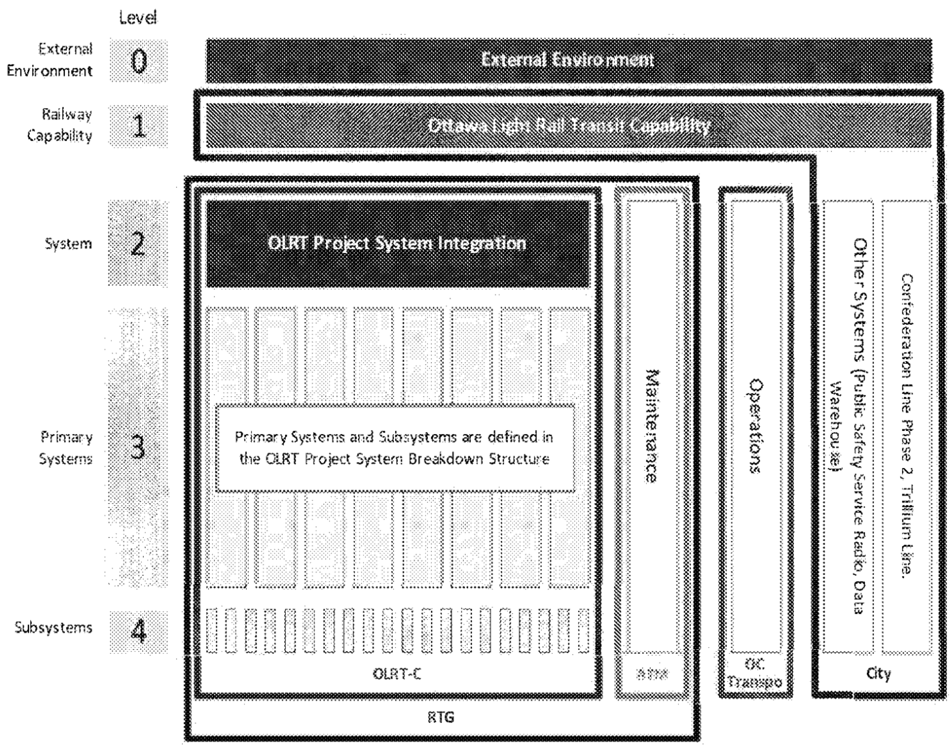


Figure 4: OLRT Project Levels and Scope Boundaries

The scope of the ESAC **EXCLUDES**:

1. Any health and safety risk on site during installation, commissioning, maintenance and decommissioning.
2. Contract to provide power to run the Confederation Line Phase 1.
3. Changes to passenger flows and loading on platforms shared with O-line as this change is not within the remit of OLRT-C.
4. Operation of the Confederation Line Phase 1 other than provision of SOPs for systems within OLRT-C scope.
5. Maintenance of the Confederation Line Phase 1 Asset Data Management.

As depicted in

Figure 4, this ESAC is part of the suite of Level 2 documentation, delivered by the OLRT Project. As such this ESAC should only be used to determine that the OLRT infrastructure is Fit for Operation from an Engineering Safety perspective and in support of the decision by the City to operate the Confederation Line Phase 1 Railway System and grant a Revenue Service Availability Certificate (RSAC).

The Railway System can only be determined to be 'Fit to Operate' by holistically considering the Level 2 documentation of the OLRT Project. This ESAC cannot be used in isolation of the Project contract organisations safety documentation to determine that the OLRT Confederation Line Phase 1 is 'Fit for Operation' and safe to take into operation.

ALS0084164
ALS0084164

2. SYSTEM DEFINITION

Ottawa Confederation Line Phase 1 provides a Low Floor Light Rail Vehicle (LFLRV) Light Rail Transit (LRT) service between Tunney's Pasture and Blair stations. The 12.5km line includes a 2.5km mined tunnel beneath downtown Ottawa and an LRT Maintenance and Storage Facility (MSF) located at Belfast Road, shown in Figure 5.

The works include provision of thirteen stations, three located in the underground section with Blair, Hurdman and Tunney's Pasture Stations integrating with the Bus Rapid Transit system. The Confederation Line links up with the north-south running O-Train at Bayview Station.

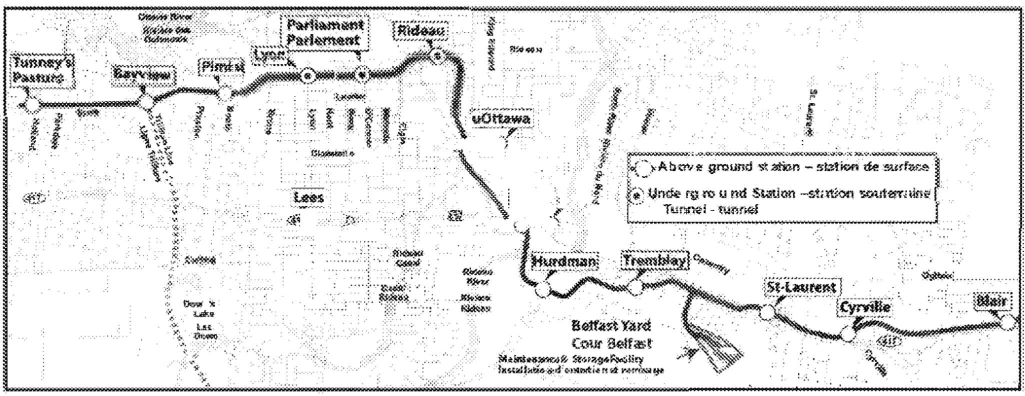


Figure 5: Confederation Line Phase 1

A portion of the existing Bus Rapid Transit system (BRT) has been converted into the LRT and existing roads widened to accommodate the remaining buses. A THALES Computer Based Train Control (CBTC) system has been installed and trains, supplied by Alstom, can function in Automatic Train Operation (ATO) mode. This is being opened through a 30-year Design-Build-Finance-Maintenance agreement with Rideau Transit Group (RTG).

Phase 1 creates the central section of the Confederation Line. East and West extensions have been planned for 2022 and 2023 respectively. These extensions will see the line continue from Trim Road to Moodie and Baseline Stations adding over 27-kilometres of new rail to the Phase 1 scheme.

Specifically, the Phase 1 works to which this ESAC applies consists of:

1. Bringing into use 34 new trains with the inclusion of on-board CBTC equipment.
2. Introduction of a CBTC signalling system controlled from a single location at 875, Belfast Rd (Train Service Control Centre (TSCC)), capable of ATO, Automatic Train Regulation (ATR) complete with Automatic Train Protection (ATP).
3. Provision, replacement and upgrade of power infrastructure required to run the trains and signals effectively.
4. Provision of 12.5-kilometres of guideway from Blair Station to Tunney's Pasture.
5. Provision of a depot MSF located at Belfast Yard.
6. Provision of 3 Underground stations (Lyon, Parliament and Rideau), one enclosed station (St. Laurent) and a further 9 At Grade stations.

ALS0084164

7. Provision of a Backup Control Centre (BCC) located at Belfast Yard (MSF) within the Yard Control Centre.

8. Combining these new assets to deliver a quality service, with timetable changes throughout the migration to progressively improve passenger journey times as Phase 2 new assets become available.

ALS0084164

3. PRODUCT ARGUMENT

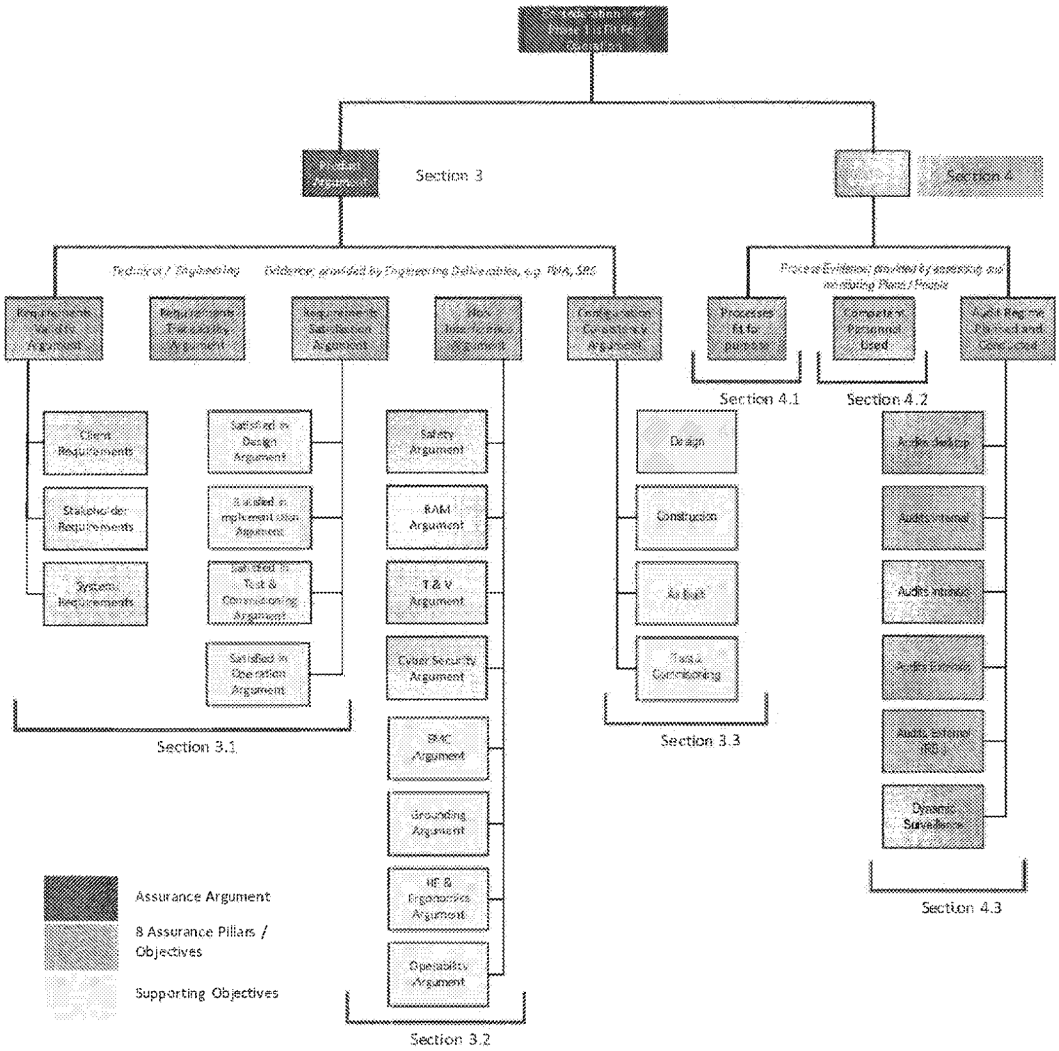


Figure 6: The 5 Pillars of the Product Argument

'A System must possess the required properties for it to be 'Fit for Operation' and this can in part be achieved through satisfying the Product Assurance objectives'

This section provides the Product Argument demonstrating that the delivered System possesses the required properties as satisfied by the five fundamental Product Assurance pillars and their supporting objectives as depicted in Figure 6 above. For clarity these are:-

- Requirements Validity
- Requirements Traceability
- Requirements Satisfaction

ALS0084164

- Non Interference
- Configuration Consistency.

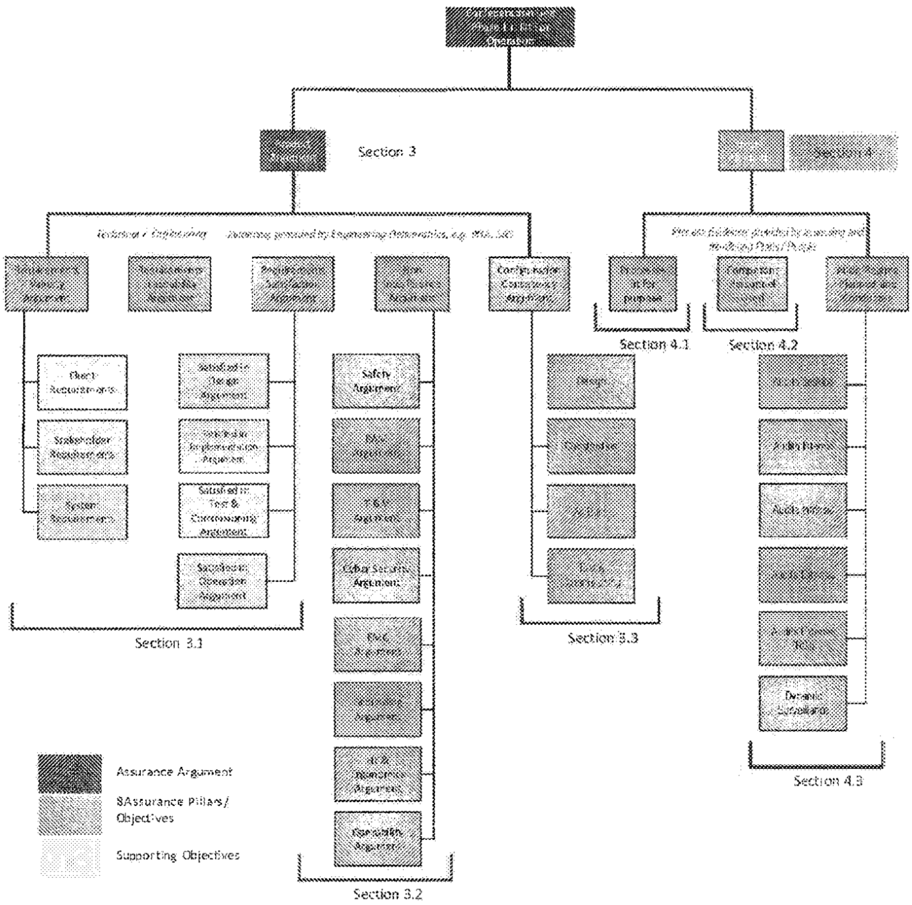
These assurance arguments have been used to deliver OLRT Engineering Safety and Systems Assurance.

The following sections document that the Product Argument can be satisfactorily made and that Product Assurance has been successfully achieved. This is determined by setting out the approach taken, the specific activities carried out in accordance with that approach, identifying and stating any limitations in meeting the objectives and by presenting evidence obtained which demonstrates the successful conclusion.

3.1 REQUIREMENTS –VALIDITY, TRACEABILITY & SATISFACTION

This section of the ESAC addresses the Requirements pillars of the Product Assurance Argument as depicted in Figure 7.

ALS0084164



Section 3
Stakeholder Requirements
System Requirements
Section 3.1
Safety Argument
Cyber Security Argument
Section 3.2
Section 3.3
Section 4.1
Section 4.2
Dynamic Surveillance
Section 4.3
Assurance Argument
8Assurance Pillars/ Objectives
Supporting Objectives

ALS0084164

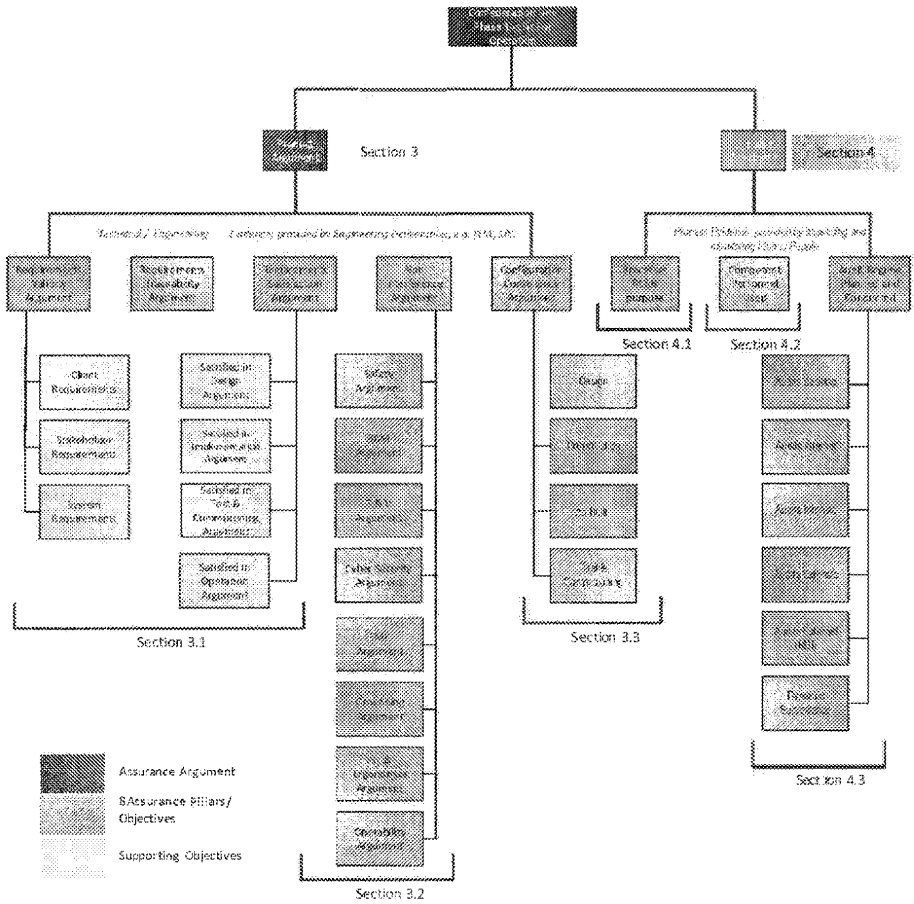


Figure 7: The 3 Pillars of the Requirements Argument

For clarity of the evidence presented and conclusions drawn in this document the requirements pillars are described as:-

Requirements Validity is the determination that Requirements at Railway/ System/ Sub-system are complete and correct in order to develop the solution and satisfy the Client.

Requirements Traceability is a sub-discipline of Requirements Management; it records relationships between many kinds of development artefacts, such as requirements, specification statements, designs, tests, models and developed components.

Requirements Satisfaction is evidenced through employing a robust Verification and Validation process.

3.1.1 Requirements Objective

In order to ensure the Requirements pillars are clear, concise and fully aligned to the desired Assurance outcomes, it is necessary to represent these in terms of objectives to be achieved. The objectives for the 3 Requirements Pillars of the Product argument are:

Requirements Validity Objective

ALS0084164

The objective of the Requirements Validity pillar is to demonstrate that a complete and consistent set of requirements was available, assessed and under effective change control.

Requirements Traceability Objective

The objective of the Requirements Traceability pillar is to capture and demonstrate that requirements were linked and traceable to their sources and their solutions. This requirements relationship capture was present at multiple levels, such as Railway, System & Sub-System and as such linkage exists both within and between the aforementioned levels.

Requirements Satisfaction Objective

The objective of the Requirements Satisfaction pillar is to demonstrate that requirements were fulfilled throughout the project lifecycle, to include the design stage through to system development, construction, testing and commissioning and finally into operation.

3.1.2 Approach

In order to determine Requirements Validity and ensure Requirements Traceability OLRT-C implemented an OLRT-C Requirements Management Plan [5] which defined the requirements structure and processes for the OLRT Project. The Requirements Management Plan [5] focused on the activities that needed to be performed to deliver and demonstrate a defined, traced and validated set of requirements to enable effective system integration, Verification and Validation.

The objectives of the requirements process were to:

- Capture existing requirements sets into a single repository and establish a consistent baseline
- Derive new requirements sets where these are necessary
- Implement traceability between requirements and other artefacts and address identified gaps.

In address of and to ensure Requirements Satisfaction OLRT-C implemented an OLRT-C V&V Management Plan [6] which defined the Verification and Validation (V&V) strategy and activities for the OLRT Project.

The primary objectives of the V&V processes were to ensure that the OLRT system, as designed, built and installed, met the specified requirements of the Project Agreement (PA) [7].

3.1.3 Activities

In demonstrating achievement of the respective objectives as previously defined above, the following key activities and analysis were performed to underpin the approach and ensure a satisfactory outcome to the Requirements Validity, Traceability and Satisfaction objectives.

Project Agreement

ALS0084164

The PA [7] has been imported into the Dynamic Object Oriented Requirements System Next Generation (DOORS NG) requirements management tool and analysed to identify requirement clauses, responsible organisations, assurance arguments and related elements from the System Breakdown Structure [4].

Post-contract changes to the PA [7] have been analysed and incorporated where agreed including variations, Project Agreement Design Integration (PADI) log, Site Change Request (SCR)s and Request for Information (RFI) which impact requirements.

Railway Requirements

A set of Railway Level Functional Requirements [16] and a set of Railway Level Operational Scenarios [15] has been developed. The Railway Level Functions have been used to validate the Railway Level PA [7] requirements by creating satisfaction links.

Derived Safety Requirements

Safety Requirements have been derived from the Confederation Line Phase 1 Integrated Hazard Log (IHL) [8] by the RAMS team. Safety requirements have been derived for each hazard and its mitigation actions.

Both the IHL [8] and Derived Safety Requirements (DSRs) have been imported into DOORS NG. Each DSR has then been linked back to its associated hazard and linked to applicable requirements in the PA [7].

Verification and Validation evidence against the PA [7] requirements were used to demonstrate that linked DSRs have been satisfied.

NFPA 130

NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems, has been imported into DOORS NG. A subset of requirements as identified by the Authority Having Jurisdiction (Ottawa Fire Service) via RFI-O-269 have been assessed for compliance.

Verification, Validation and Compliance

The Technical Compliance Report [9] covers design compliance and product compliance of the technical schedules in the PA [7], applicable safety related variations and NFPA 130:

- Design compliance is the compliance of the OLRT Project design packages to the requirements
- Product compliance is the compliance of the configured OLRT System [313] to the requirements.

Primary compliance data inputs to this process were:

- Design Compliance Returns from Engineers of Record (EoR)
- Design Conformance and Construction Certification Letters
- Test Reports
- Non-Conformances Log – OLR-04-0-0000-REG-0004 [10]
- Minor Deficiencies List – OLR-90-0-0000-CMP-0004 [19a]
- Alstom Compliance Matrix – see PA Technical Compliance Matrix [11]
- Thales Compliance Matrix –see PA Technical Compliance Matrix [11].

NFPA 130 & Threat and Vulnerability Assessment (TVA) requirements have undergone additional product compliance assessment through inspection and survey.

Verification and Validation of Derived Safety Requirements is contained within the Safety Requirements Matrix [12] and is evaluated as part of the safety process.

Process requirements have undergone a risk-based assessment of compliance focussing on safety and security related processes. Other process requirements that impact the quality of the delivered OLRT System have been considered on a case by case basis.

Non-technical schedules are excluded from the Technical Compliance Report [9] and are instead covered by the Non-Technical Compliance Matrix [13].

3.1.4 Outputs

The primary outputs of the Requirements Management process were:

- PA Analysis and Allocation [14]
- Railway Operational Scenarios [15]
- Railway Functional Requirements [16]
- Railway Requirements Traceability Matrix [17]
- Safety Requirements Matrix [12].

ALS0084164

The primary outputs of the Verification, Validation and Compliance process were:

- Technical Compliance Report [9]
- PA Technical Compliance Matrix [11]
- NFPA 130 Compliance Matrix [18].

3.1.5 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Requirements activities and analysis are identified in Table 1.

Table 1: Requirements Evidence

Ref	Title	Number
[4]	System Breakdown Structure	OLR-09-0-0000-DIA-0001
[5]	OLRT-C Requirements Management Plan	OLR-50-0-0000-MPL-0007
[6]	OLRT-CV&V Management Plan	OLR-50-0-0000-MPL-0006
[7]	Project Agreement	TORO 1; 4868348: v55
[9]	Technical Compliance Report	OLR-05-0-0000-REP-0054
[11]	PA Technical Compliance Matrix	OLR-90-0-0000-CMP-0002
[12]	Safety Requirements Matrix	OLR-05-0-0000-REP-0053
[13]	Non-Technical Compliance Matrix	OLR-90-0-0000-CMP-0001
[14]	PA Analysis and Allocation	OLR-05-0-0000-REP-0009
[15]	Railway Operational Scenarios	OLR-05-0-0000-REP-0011
[16]	Railway Functional Requirements	OLR-05-0-0000-REP-0010
[17]	Railway Requirements Traceability Matrix	OLR-05-0-0000-REP-0055
[18]	NFPA 130 Compliance Matrix	OLR-05-0-0000-CMP-0002
[19a]	Minor Deficiencies List	OLR-90-0-0000-CMP-0004

3.1.6 Limitations

The following limitations have been noted in preparation of the Technical Compliance Report [9] and PA Technical Compliance Matrix [11].

- Due to the lag time in processing data to generate the compliance matrix, evidence received after 14th August 2019 has been included in the Notice of Revenue Service Availability but may not be included in the Technical Compliance Report [9] and PA Technical Compliance Matrix [11]
- Where a design compliance matrix has not been received from the EoR, the V&V team have made a limited assessment of compliance based primarily on Final Design Reports and Design Conformance Letters. The evidence in the areas

ALS0084164

assessed by the V&V team should be considered as providing a lower level of assurance than data provided by an EoR

- Where a design compliance matrix has not been received from the EoR, the mapping of Design Certification Letters (DCL) and Construction Certification Letters (CCL) to requirements has been implemented by the V&V team
- The agreed strategy for declaring product compliance relies on the EoRs to assess lower level V&V evidence, such as Factory Acceptance Tests, Certificates of Conformance and inspections, in the process of issuing Construction Certification letters. The completeness of the lower level evidence has not been checked by the V&V team
- Any requirement changes which have been agreed informally outside of the variation and PADI process have not been considered
- Any open variations or PADI items which do not have an approved status have not been considered
- Any deficiencies which were added to the Minor Deficiencies List or existing deficiencies which have changed status after 14th August 2019 have not been reviewed for their impact on compliance.

3.1.7 Conclusion

Requirements Management, Verification and Validation activities have been performed in accordance with the OLRT-C Requirements Management Plan [5] and OLRT-C V&V Management Plan [6].

The Technical Compliance Report (TCR) [9], summarises the compliance of the OLRT project to the technical schedules of the Project Agreement [7] as at 14th August 2019. The PA Technical Compliance Matrix [11] provides the full clause-by-clause listing of compliance statements.

A design compliance statement (full, partial or non-compliance) has been declared for 99.0% of applicable requirements. Where a compliance statement has been declared, 98.7% have been declared as compliant.

A final product compliance statement has been declared for 90.7% of applicable requirements. Where a compliance statement has been declared, 97.2% have been declared as compliant. A further 8.3% of applicable requirements have a product compliance statement of “Compliant Pending”. These requirements are pending an item of evidence to be received or an open NCR or deficiency to be closed.

The Technical Compliance Report [9] and PA Technical Compliance Matrix [11] may be updated after the Revenue Service Availability submission to reflect data that has been received since 14th August 2019. Evidence outstanding as at 14th August is listed in the Technical Compliance Report [9].

As the Minor Deficiencies, are resolved post Revenue Service Availability, any updated report will reflect the improved compliance position.

Through the Requirements Management and Verification and Validation approach taken and demonstrated activities undertaken it can be proven that:

Requirements Validity was demonstrated and a complete and consistent set of requirements was produced, assessed and under effective change control.

Requirements Traceability was established and requirements were linked and traceable to their sources and their solutions. These requirement relationships were present at multiple levels, and such linkage exists both within and between these levels.

Requirements Satisfaction was demonstrated to prove that requirements had been fulfilled throughout the project lifecycle, including the design stage through to system development, construction and testing and commissioning.

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it has been proven that the Requirements Validity, Traceability and Satisfaction arguments can be satisfactorily made. This statement is based upon OLRT having evidentially, traceably and defensibly met the three objectives of Requirements Validity, Traceability and Satisfaction in support of the Product Argument 'A System must possess the required properties' and Confederation Line Phase 1 being 'Fit for Operation'.

This conclusion can be used in aggregation to positively support the Product Assurance argument.

3.1.8 Test & Commissioning

To demonstrate that sufficient Test and Commissioning activities have been performed to support requirements satisfaction.

3.1.8.1 Objectives

In contribution to the Requirements Satisfaction objective, demonstrate that sufficient Test and Commissioning activities have been performed to support requirement satisfaction in the testing and commissioning stage of the project lifecycle.

3.1.8.2 Activities

A Testing and Commissioning programme was developed to address the requirements of:

- PA Schedule 14 Testing and Commissioning
- ISO/IEC 15288 – Verification Process.

The Testing & Commissioning Management Plan [277] covered activities that started in the factory, followed by installation and Post Installation Checkout (PICO), Site Acceptance Testing (SAT), Systems Integration Testing (SIT), System-Wide Commissioning and Trial Running testing.

Functional Tests

Once equipment had been installed at site and Post Installation Check Out (PICO) had been performed, the functional test phase was initiated. Successful completion of PICO enabled SATs to be performed by the equipment supplier or OLRT-C.

Once the OLRT-C Testing and Commissioning (T&C) Team was satisfied with the SAT results, that system or equipment was turned over to T&C and incorporated into the SIT program.

The T&C team executed the SIT procedures and performed System Wide Commissioning. System and equipment suppliers supported the testing as required to ensure that any issues with their system or equipment were addressed and to complete any tests that cannot be undertaken without other systems.

Successful completion of functional testing was documented in T&C's Test Management System (TMS).

Specific Functional Tests

Site Acceptance Testing

Following satisfactory PICO and static train testing, the installed components, Subsystems or Primary systems were then tested against an agreed set of SAT procedures which were captured in the Requirements and V&V Test Traceability Matrix [19].

The Site Acceptance Procedures complemented those performed in the factory but were also focused on requirements that could not be verified in the factory. SAT testing of a System included some level of integration with other systems but was intended to primarily test each system independently.

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

Systems Integration Testing

Once two or more systems had completed SAT, they were brought together to commence SIT.

At this point all testing was:

- Led by the Suppliers with an OLRT-C Project Representative monitoring the tests, thereafter
- Testing was led by an OLRT-C Project representative with Supplier support.

SIT procedures included tests prepared by the equipment supplier and an OLRT-C Representative. This reflected that some system suppliers were expected to be unable to demonstrate all technical requirements without integration with other suppliers systems.

SITs therefore concentrated on intersystem functionality and performance under normal, abnormal and emergency scenarios.

Simulation and Test equipment was needed to carry out some SITs as the final system will integrate into a working revenue environment which may not be made available for test purposes.

Vehicle and CBTC Testing

Vehicle and CBTC Testing was largely performed by Alstom and Thales respectively, with OLRT-C oversight.

Alstom Testing is described in Alstom Test and Commissioning Plan.

ALS0084164

Thales testing is described in the Thales Quality Assurance Plan [373], System Verification and Validation Plan [374] and System Test Plan [375].

TypeTesting

Type testing was done on a small sample of vehicles (or even just one vehicle) that were representative of the fleet. Type tests were thorough, detailed and sometimes destructive tests that were intended to verify that a production-standard vehicle met its requirements as intended by the design. The results of type testing were read-across to the entire fleet on the proviso that all vehicles were built to the same design and had sufficiently rigorous quality processes applied throughout production to assure a consistent build standard.

Serial Testing

Serial tests were performed on every vehicle and were part of the quality assurance process that ensures that every vehicle was built correctly and consistently in accordance with the design. The scope of serial testing was less comprehensive than type testing and focused on functionality that was critical to safety and / or operation of the vehicle.

Revenue Vehicles were signed off via Car History Books (CHB). Each of the 34 LRVs has a CHB containing all documentation for that vehicle.

Each vehicle went through a number of stages and was formally signed off at each handover.

- Firstly, the vehicle was manufactured and underwent a serial test by Alstom before handover to Thales
- Thales then integrated the CBTC system onto the vehicle and performed integration testing to ensure that the integrated system functioned and performed as designed
- The integrated vehicle with CBTC was then handed over to OLRT-C.

Car History Books for each vehicle were collated within the Vehicles Commissioning Manual and were also available for inspection from the OLRT-C Integration Manager.

Trial Running

A 12 day period of Trial Running was planned to be performed following achievement of Substantial Completion.

ALS0084164

Regression Testing

Regression tests may be required when a hardware or software component is to be changed and/or upgraded, or, where functionality or performance may be impacted by the change.

The extent of regression testing required was determined by the members of the Configuration Change Control Board (CCCB) as described in the Configuration Change Control Recovery Plan [310].

A regression test shall / has been conducted for each new version of the Confederation Line Phase 1 Primary Systems installed, to detect unexpected impact resulting from program modifications. Regression test report(s) identified any variation between current and previous test results revisions.

Punchlist Resolution

All test failures were treated as Punchlist items and tracked with their resolutions recorded in Unifier.

Each failure was recorded in the test report and a full description of the failure was raised as a Punchlist item in Unifier. The Punchlist item was assigned to a System Subject Matter Expert for review.

The System Subject Matter Expert assigned the Punchlist item to one of their team members or Supplier for resolution.

Punchlist Verification

When the Punchlist item had been resolved the Punchlist item together with the corrective action details was released to T&C for verification. If the Punchlist item resolution passed the regression test of the test procedure, the Punchlist item was closed. If the resolution did not fix the problem, the Punchlist item was re-assigned to the system Subject Matter Expert.

If the system Subject Matter Expert and/or the T&C Manager decided the Punchlist item should be reported as a nonconformity, a Non-conformity Report (NCR) was generated. The Confederation Line Phase 1 OLRT-C Quality Manager maintained a Non-Conformance Log [10] and issued NCR numbers as required. The nonconformity was tracked and corrected by the formal Management of Non Conformances process [275].

Test Management System

A Test Management System (TMS) was used by the T&C team to store information relevant to T&C results.

The TMS had four parts:

- Test Tracking
- Deficiency Tracking
- Configuration Tracking
- Work Authority Tracking.

ALS0084164

Test Tracking

Detailed information about the test list (name, number, document status, test stage, results, associated deficiencies, and others) were entered in the Test & Commissioning database (Unifier). The database enabled the T&C Manager to accurately identify which tests had passed, which tests needed to be repeated and those that had not been performed.

Punch list Tracking

The T&C Team tracked deficiencies resulting from tests and other T&C activities. These deficiencies were entered, organized and managed through Unifier. Deficiency reports were extracted and downloaded from Unifier on a daily basis.

Configuration Tracking

A configuration management tool (PDMPlus from CMStat) was used to build an asset list of hardware and software. These configuration items include data such as serial numbers, software numbers, firmware numbers and dates of installation/replacement. This process was governed by the Configuration Management Recovery Plan [279].

Work Authority Tracking

Access was allowed into a test area through the T&C Work Authorization Process as defined in the Testing and Commissioning Work Authorization Procedure [308]. Contractors requested access into a test area by completing a Work Authorization Application and submitting to the T&C Team. If the work could be accommodated the application was approved and returned to the applicant with relevant information.

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

3.1.8.3 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Test & Commissioning activities and analysis are identified in Table 2.

Specific evidence associated to the Test & Commissioning activities and outcomes can be found in the Test Traceability Matrix [19], PA Technical Compliance Matrix [11] and Technical Compliance Report [9].

Table 2: Test & Commissioning Evidence

Ref	Title	Number
[308]	T&C Work Authorization Procedure	OLR-16-0-0000-PRC-0002
[277]	Testing & Commissioning Management Plan	OLR-16-0-0000-MPL-0001
[19]	Test Traceability Matrix	OLR-03-0-0000-REP-0352
[10]	Non-Conformance Log	OLR-04-0-0000-REG-0004
[275]	Management of Non Conformances Process	OLR-QMS-GP4 01
[279]	Configuration Management Recovery Plan	OLR-09-0-0000-MPL-0004

ALS0084164

Ref	Title	Number
[9]	Technical Compliance Report	OLR-05-0-0000-REP-0054
[373]	Thales Quality Assurance Plan	3CU 05018 0019 QMZZA
[374]	Thales System V&V Plan	3CU 05018 0043 VCZZA
[375]	Thales System Test Plan	3CU 05018 0041 QTZZA

3.1.8.4 Limitations

A number of Test Reports are outstanding. These are listed in the ESAC Outstanding Items List [378] along with the status of Engineer of Record signatures outstanding for any reports.

3.1.8.5 Conclusions

Test & Commissioning requirements have been satisfied as considered and evidenced in the Test Traceability Matrix [19] and Technical Compliance Report [9].

In conclusion through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that sufficient Test and Commissioning activities have been performed to support requirement satisfaction in the testing and commissioning stage of the project lifecycle.

This conclusion can be used in aggregation to positively support the Requirements Satisfaction objective.

3.2 NON-INTERFERENCE

This section of the ESAC addresses the Non-Interference pillar of the Product Assurance Argument as depicted in Figure 8.

ALS0084164

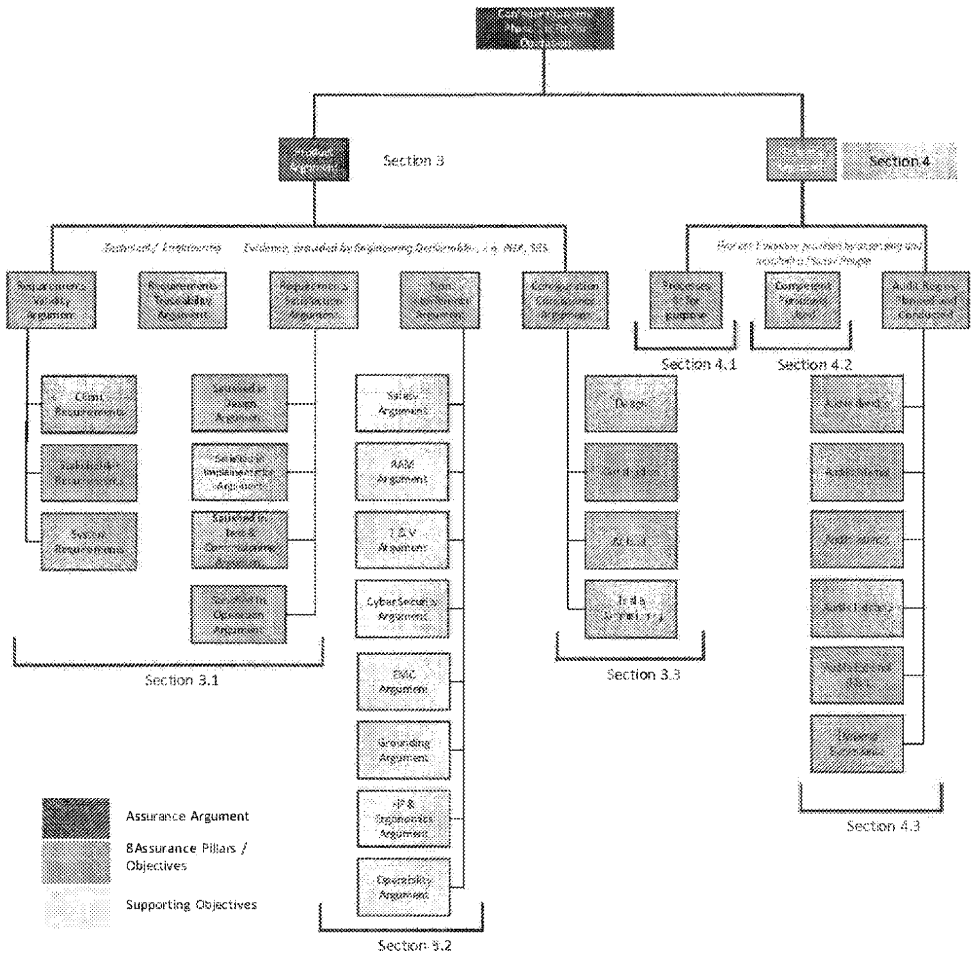


Figure 8: The Pillar of the Non-Interference Argument

For clarity of the evidence presented and conclusions drawn in this document the Non-Interference argument is described as:-

Demonstrating that Individual System Components will not interact with other systems, people and external components in an unacceptable manner and in such a way as to degrade the required properties of the overall Confederation Line Phase 1 Railway.

3.2.1 Non Interference Objective

In order to ensure the Non-Interference pillar is clear, concise and fully aligned to the desired Assurance outcomes, it is necessary to represent it in terms of an objective to be achieved. The objective for the Non-Interference pillar is:

"To demonstrate that no component of the integrated system shall interfere with or be interfered with by any other function of the integrated system or surroundings. In achieving this the railway can be deemed to be both Safe and Available in a Reliable manner providing appropriate Maintenance is undertaken"

ALS0084164

3.2.2 Approach

In order to satisfy the Non-interference pillar's objective a number of supporting objectives needed to be considered. Successful conclusion of the Non-Interference pillar is met by demonstrating a positive outcome to the 8 supporting objectives as shown in figure 8 above.

The remainder of this section explains in more detail the activities undertaken to develop the Non-Interference assurance pillar through to a conclusive position and in addition to the various activities it also describes and encompasses the outputs and evidences produced and considered.

The aggregation of the conclusions to the supporting objectives will determine that the Non-Interference objective has been achieved.

3.2.3 Activities

In demonstrating achievement of the respective objective as previously defined above, the following key activities and analysis were performed to underpin the approach and ensure a satisfactory outcome to the Non-Interference objective. These areas of activity were as follows:-

- RAM & Safety (see section 3.2.4)
- Threat & Vulnerability (see section 3.2.5)
- Cyber Security (see section 3.2.6)
- EMC (see section 3.2.7)
- Grounding (see section 3.2.8)
- Human Factors and Ergonomics (see section 3.2.9)
- Operability (see section 3.2.10).

3.2.4 RAM & Safety

To demonstrate that the overall safety risk was managed to a level that was considered to be tolerable and As Low As Reasonably Practicable (ALARP) and that the RAM aspects had been adequately translated into the final system such that OC Transpo and RTM will be able to operate and maintain the Confederation Line Phase 1 in the required System configuration.

3.2.4.1 RAM & Safety Objective

In contribution to the Non-Interference assurance pillar; demonstrate that the overall safety risk was managed to a level that can be considered to be tolerable and ALARP and that the RAM aspects were adequately translated into the final system such that RTM are able to operate and maintain the Confederation Line Phase 1 in the required System configuration.

ALS0084164

3.2.4.2 Approach

The approach of the RAMS assessment of the Primary Systems undertaken was to provide a railway level body of evidence that demonstrated the OLRT infrastructure and its constituent Primary Systems provided the necessary availability and correct functional performance to allow safe operation of the Phase 1 Confederation line Railway, that it is 'Fit for Operation' and ready for RSA subject to limitations identified in the Confederation Line Phase 1 Operational Restrictions Document [2].

RAMS analysis was conducted to ensure that the reliability, availability and maintainability are sufficient to support safe operation of the railway for all stakeholders, operators, maintainers, neighbours and the public in general and importantly, the fare paying passengers who will travel on the Confederation Line Phase 1, Railway.

The aims of the RAMS approach were to:

- Identify activities that were to be undertaken to ensure RAMS performance was inherent in the design
- Identify evidence in order to determine that PA [7] requirements were realised in the design and where necessary new RAMS requirements were derived
- Provide data to inform maintenance, Operations and City of Ottawa stakeholders how to uphold safe and reliable operation
- Provide confidence in the operational performance of the infrastructure
- Demonstrate that the integrated railway primary system and sub-system designs were acceptably safe and that risks had been identified, managed and controlled.

3.2.4.3 Activities

This section of the ESAC addresses all RAMS activities that were undertaken in support of the overall Confederation Line Phase 1 Case for Safety [20].

System Safety assessments were conducted in accordance with the OLRT-C Systems Safety Programme Plan [23] in which Hazard analysis in line with OLRT-C Hazard Management Procedure (HMP) [24] formed a critical element of safety assessment.

The outputs from the Safety Assessments were concluded in the Confederation Line Phase 1 Case for Safety [20] which resides in the document hierarchy as shown in figure 1.

RAM Analysis

RAM analysis utilised sub-system parts-count analysis sourced from Engineering Joint Venture (EJV) RAM reports and developed into a railway Primary Systems level RAM, risk and performance assessment using Reliability Block Diagram (RBD) and Failure Modes Effects and Criticality Analysis (FMECA) for those critical areas.

Engineering Safety Management

Engineering Safety Management (ESM) activities were undertaken in line with the OLRT-C Systems Safety Programme Plan [23] to demonstrate that the Confederation Line Railway is fully integrated (compatible) and safe to operate. The approach was based

ALS0084164

upon the requirements of EN 50129 and tailored to the specific requirements of the OLRT-C Confederation Line Project.

EN 50129 is based upon the implementation of IEC 61508 as applicable to the railway sector and accordingly Safety Integrity Levels (SILs) have been applied to the railway functions as detailed in Safety Integrity Level Allocation Report [25].

Hazard Identification and Analysis

Hazard identification, analysis and implementation of control measures was a fundamental Principle of the system safety assessment. These were conducted in line with the processes and risk ranking criteria defined in the OLRT-C Hazard Management Procedure [24] based upon the safety management processes identified in the OLRT-C System Safety Programme Plan [23].

The principle Safety risk management methods included implementing engineering processes compliant to the codes and standards mandated in the PA [7], comparison to the demonstrated performance of analogous reference systems, and the identification of further risk reduction measures ALARP.

Hazard Review Panel

A process of Safety risk analysis and review by stakeholders in the form of the Hazard Review Panel (HRP) was applied and where applicable Safety Related Application Conditions were transferred to the appropriate party to manage, whether City of Ottawa, the Infrastructure maintainer (RTM) and/or Operator (OC-Transpo) as appropriate. The HRP was established in accordance with the HMP and assembled in accordance with the HRP Terms of Reference [26].

Hazard Analysis was undertaken through each stage of the project lifecycle and in line with the OLRT-C Hazard Management Procedure [24] culminating in the overall Confederation Line Phase 1 Case for Safety [20]. This was supported by an IHL Summary Report [27] which wrapped up the final stages of the hazard closeout and transfer process. This included the transfer of hazards from EJV, Thales and Alstom, primary systems, signalling & control and rolling stock respectively.

EJV produced an Interface Hazard Analysis (IHA) [44] based upon analysis obtained from sub-system Preliminary Hazard Analyses (PHA) and developed this into a comprehensive programme level OLRT-C Interface Hazard Analysis [28]. A systematic approach was employed in evaluating the consequences of failure and associated controls, finding safety risks to be ALARP. This was particularly the case when compared to similar railway undertakings, according to the findings of the IHL summary Report [27].

The Confederation Line Phase 1 Operations and Support Hazard Analysis (OSHA) [29] was produced based on OSHAs carried out by EJV on the most critical of the Primary Systems, Stations, as defined within the Station Operations & Support Hazard Analysis Report (O&SHA Report) [30], OCS as defined within the OCS Operations and Support Hazard Analysis Report [31] and Tunnel Ventilation System (TVS) as defined within the Tunnel Ventilation System OSHA [32]. Thales produced an OSHA for the CBTC[33]. The remaining Primary Systems, Comms, track and Traction Power Sub-stations (TPSS) were analysed in the OLRT-C Interface Hazard Analysis [28] and the Track Assurance Reports [34], [35] & [36], Confederation Line Phase 1 Reliability Availability and Maintainability Report [37]

ALS0084164

and Day in The Life Of (DITLO) Report [38]. The outputs from these activities were uplifted into the EJV Hazard Log [39] and assimilated into the overall project IHL [8] which formed the basis for hazard transfer and HRP discussions and ultimately a formal acceptance by the appropriate party, City, Maintainer and/or OC-Transpo.

The output from the hazard analyses were identified in the Thales Hazard Log [40], Alstom Rolling Stock Hazard Log [41], EJV Hazard Log [39] and IHL [8]. Derived safety requirements output from the hazard analysis activities were agreed with HRP and transferred to the appropriate party.

Any operational limitation or constraints identified during the safety analysis process are detailed in the Confederation Line Phase 1 Operational Restrictions Document [2].

RAMS assessment was reinforced by extensive certification provided by a range of independent safety assessments and certification by the appropriate Engineers of Record.

3.2.4.4 Outputs

Outputs are covered as discussed in this RAMS section, referenced in Table 3 below and Appendix 2 of this ESAC.

3.2.4.5 Evidence

To provide evidence of satisfactory achievement of the safety objectives the key documents generated throughout the RAMS activities and analysis are identified in Table 3.

Table 3: RAMS Evidence

Ref	Title	Reference
[8]	Confederation Line Phase 1 Integrated Hazard Log	OLR-05-0-0000-REG-0004
[20]	Confederation Line Phase 1 Case for Safety	OLR-05-0-0000-MPL-0017
[21]	Ottawa Light Rail Transit Project Specific Application Safety Case Report	3CU 05018 0247 DUZZA
[22]	Ottawa LRV Project Consolidated Safety File	ADD0000939280
[23]	OLRT-C System Safety Programme Plan	OLR-50-0-0000-MPL-0012
[24]	OLRT-C Hazard Management Procedure	OLR-50-0-0000-MPL-0009
[25]	Safety Integrity Level Allocation Report	REJ-05-0-0000-REP-0327
[26]	HRP Terms of Reference	SEMP-DOC-0002
[27]	IHL & HRP Summary Report	OLR-05-0-0000-0015
[28]	OLRT-C Interface Hazard Analysis	OLR-16-0-0000-REP-0059
[29]	Confederation Line Phase 1 Operations and Support Hazard Analysis	OLR-05-0-0000-REP-0063
[30]	Station Operations & Support Hazard Analysis Report (O&SHA Report)	REJ-05-0-0000-REP-0370
[31]	OCS Operations and Support Hazard Analysis Report	REJ-05-0-0000-REP-0371
[32]	Tunnel Ventilation System OSHA	REJ-05-0-0000-REP-0369

ALS0084164

Ref	Title	Reference
[33]	CBTC OSHA	3CU 05018 0032 DUZZA
[34]	Track Assurance Report 1	OLR-22-0-0000-REP-0001
[35]	Track Assurance Report 3	OLR-22-0-0000-REP-0004
[37]	Confederation Line Phase 1 Reliability Availability and Maintainability Report	ORT-05-0-0000-REP-0056
[38]	Day in The Life Of (DITLO) Report	OLR-05-0-0000-REP-0050
[39]	EJV Hazard Log	REJ-05-0-0000-REG-0006
[40]	3CU 05018 0033 DUZZA	Thales Hazard Log
[41]	Alstom Rolling Stock Hazard Log	ADD0000939629
[42]	Maintenance & Storage Facilities (MSF) Safety Justification Report	OLR-05-0-0000-REP-0065
[43]	TSCC and BCC Safety Justification Report Case	OLR-05-0-0000-REP-0066
[44]	EJV Interface Hazard Analysis	OLR-16-0-0000-REP-0302
[45]	Communications System RAM Report	REJ-05-0-0000-REP-0334
[46]	OCS RAM Report	REJ-05-0-0000-REP-0335
[47]	TPS RAM Report	REJ-05-0-0000-REP-0336
[48]	Tunnel Ventilation and Electrical System RAM analysis	REJ-05-0-0000-REP-0337
[49]	EJV STA System RAM Analysis (Station System) Report	REJ-05-0-0000-REP-0338
[50]	Trackwork System RAM Analysis	REJ-05-0-0000-REP-0339
[51]	Communications System FMECA Report	REJ-05-0-0000-REP-0340
[52]	Overhead Catenary (OCS) Failure Modes and Effects Analysis	REJ-05-0-0000-REP-0341
[53]	Traction Power Supply (TPS) Failure Modes and Effects Analysis	REJ-05-0-0000-REP-0342
[54]	TVS FMEA	REJ-05-0-0000-REP-0343
[55]	Station (STA) Failure Modes and Effects Analysis Report	REJ-05-0-0000-REP-0344
[56]	Track Failure Modes and Effects Analysis	REJ-05-0-0000-REP-0345
[57]	Communications (COM) Sub-systems Hazard Analysis	REJ-05-0-0000-REP-0354
[58]	Tunnel Ventilation and Electrical System SSHA	REJ-05-0-0000-REP-0355
[59]	TPS Sub-System Hazard Analysis	REJ-05-0-0000-REP-0356
[60]	OCS Sub-System Hazard Analysis	REJ-05-0-0000-REP-0358
[61]	Station (STA) Sub-System Hazard Analysis (SSHA)	REJ-05-0-0000-REP-0359
[62]	Trackwork Sub-System Hazard Analysis (SSHA)	REJ-05-0-0000-REP-0357
[63]	OCS Preliminary Hazard Analysis	REJ-05-0-0000-REP-0332
[64]	Communications Systems PHA	REJ-05-0-0000-REP-0325
[65]	Power Supply Distribution System (PSD) Preliminary Hazard Analysis	REJ-05-0-0000-REP-0324
[66]	Mainline Preliminary Hazard Analysis	OLR-05-0-0000-REP-0003

ALS0084164

Ref	Title	Reference
[67]	Thales Ottawa Light Rail Transit Project, Preliminary Hazard Analysis	3CU 05018 0025 DUZZA
[68]	TVS and Electrical Systems PHA	REJ-05-0-0000-REP-0326
[69]	Thales Ottawa Light Rail Transit Project System Hazard Analysis	3CU 05018 0026 DUZZA
[70]	CBTC RAM Analysis (Signalling)	3CU 05018 0109 BCZZA
[71]	Tunnel Safety Justification Report	OLR-05-0-0000-REP-0070
[72]	Track Safety justification Report	OLR-05-0-0000-REP-0071
[73]	Energy Safety Justification Report	OLR-05-0-0000-REP-0072
[74]	Communications Systems Safety Justification Report	OLR-05-0-0000-REP-0073
[376]	Stations Safety Justification Report	OLR-05-0-0000-REP-0064
[75]	Track Assurance Report 2	OLR-22-0-0000-REP-0002
[371]	Safety Certification –Additional Vehicles (LRV# 1102 & 1108)	OLRT-THALES-1077 Safety Cert – LRV # 1102 & 1108
[377]	Preliminary Hazard Analysis (PHA) Gap Assessment Report	OLR-05-0-0000-REP-0008

Table 3 is a comprehensive list of RAMS evidence used throughout various reference documents, as such it contains more than has been referenced in this summary section of the ESAC.

3.2.4.6 Limitations

Any limitations or constraints associated with the OLRT infrastructure are identified in the Confederation Line Phase 1 Operational Restrictions Document [2] in support of the overall Confederation Line Phase 1 Case for Safety [20].

3.2.4.7 Conclusions

It can be concluded by reference to the Primary Systems Safety Justifications [20], [42], [43], [71], [72], [73], [74], Ottawa Light Rail Transit Project Specific Application Safety Case Report [21] by Thales and Ottawa LRV Project Consolidated Safety File [20] by Alstom that the Confederation Line Railway is 'Fit for Operation' subject to limitations identified in the Confederation Line Phase 1 Operational Restrictions Document [2].

In consideration of the above the Confederation Line Phase 1 Railway has been demonstrated to be capable of safe operation by a comprehensive review and analysis of the system and hazards against the principles of EN50126 & EN50129. The evidence to support this is provided by the Case for Safety and documents listed above, subject to the limitations and control stated in the Confederation Line Phase 1 Operational Restrictions Document (ORD) [2].

ALS0084164

The principle safety arguments supporting the RAMS objective and Non-interference pillar are:

- The System meets the requirements of the Project Agreement [7] and requirements that have been derived whilst mitigating the hazards raised during the safety analysis of the works
- A robust hazard management procedure has been applied in which all parties have been involved, including City, OC Transpo and RTM and all Safety Related Control Measures associated with the hazards have been transferred to and accepted by the respective parties
- Hazard identification, analysis and mitigation processes have been undertaken in which evidence is presented that all hazards have been reduced to acceptable levels in accordance with the HMP [24] hazard ranking criteria
- Systems Integration Testing has been conducted to demonstrate correct functional operation and safe integration. Thus, further demonstrating safety requirements are satisfied
- Correct installation of equipment has been inspected and endorsed by an Engineer of Record as demonstrated by CCLs
- RAM analysis has been undertaken to the extent necessary to demonstrate that the necessary RAM performance inherently meets the safety requirements in the design
- Safety risks have been reduced by using mature and proven systems that have been integrated using processes that have been demonstrated to be robust and traceable.

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that the overall safety risk has been managed to a level that is considered to be tolerable and As Low As Reasonably Practicable (ALARP) and that the RAM aspects have been adequately translated into the final system such that OC Transpo and RTM are able to operate and maintain the Confederation Line Phase 1 in the required System configuration.

This conclusion can be used in aggregation to positively support the Non-Interference pillar.

3.2.5 Threat & Vulnerability

In contribution to the Non-Interference assurance pillar depicted in Figure 8; to demonstrate that Threats and Vulnerabilities have been adequately addressed.

For clarity aspects related to Cyber Security are described in Section 3.2.6.

3.2.5.1 Objectives

In contribution to the Non-Interference assurance pillar; demonstrate that Threats and Vulnerabilities were adequately addressed.

3.2.5.2 Approach

This section of the ESAC summarises the activities undertaken and evidence obtained in relation to the mitigation of Threat and Vulnerability (security) threats to the Confederation Line Phase 1 Railway.

The Ottawa Light Rail Transit Project System Security Certification Plan (SSeCP) [76] defined the process for certification of TVA[77] on the Ottawa Confederation Line Phase 1 Project. The SSeCP [76] described the systematic, explicit, and comprehensive process for managing Threat and Vulnerability risks by performing Threat and Vulnerability certification tasks, culminating in the issuance of Threat and Vulnerability Certificates of conformance to ensure that:

- The agreed-upon Threat and Vulnerability Requirements for all certifiable elements of the Project Agreement [7] had been met or exceeded
- The agreed-upon design countermeasures identified within the TVA [77] and the corresponding Threat and Vulnerability Log [78] had been satisfied or complied with.

3.2.5.3 Activities

The Threat and Vulnerability Certification process includes 5 steps:

1. Identification of Certifiable Elements and Sub-Elements. These elements and sub-elements are major components of the Ottawa Confederation Line Stage 1 system which, due to their design and function, have a material impact on the security of the Railway.
2. Identification of Security Requirements for each Certifiable Element and Sub-Element.
3. Both Verification and Validation of Security Requirements.
4. Tracking, review, update and documentation of certification tasks in the Security Certification Checklists.
5. Issuance of Certification for Certifiable Elements or Sub-Element's conformance to all associated and relevant Security Requirements.

ALS0084164

3.2.5.4 Outputs

The Confederation Line Phase 1 Railway was assessed and divided into discrete Certifiable Elements and Sub-Elements, identified within the Ottawa Light Rail Transit Project System Security Certification Plan (SSeCP) [76].

Through the TVA [77], Security requirements were identified for each certifiable element and sub-element and incorporated into the Design Criteria Conformance Checklists and Construction Specification Conformance Checklists.

Verification and Validation of Security requirements were performed and the evidence recorded on Design Criteria Conformance Checklists and Construction Specification Conformance Checklists.

Design Conformance Letters and Construction Conformance Letters were issued to certify those elements and sub-elements where the Verification and Validation of Security requirements was completed.

3.2.5.5 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Threat & Vulnerability activities and analysis are identified in Table 4.

Table 4: Threat & Vulnerability Evidence

Ref	Title	Number
[76]	[redacted]	
[77]		
[78]		
[79]		
[80]		
[81]		
[82]		
[83]		
[84]		
[85]		

ALS0084164

Ref	Title	Number
[86]	[redacted]	
[87]		
[88]		
[89]		
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[107]		
[108]		

ALS0084164

Ref	Title	Number
[109]	[redacted]	
[110]		
[111]		

3.2.5.6 Limitations

The content of the outputs of the Security Certification process contain security sensitive information, hence protocols have been applied to control the dissemination and storage of the Security documents. The Safety Assurance team did not have visibility of the outputs resulting in a heavy reliance on the Security Certificates provided by the Security Certification professional. Those that were available in 4P and are referenced were used although those not available, such as the TVA assessment report could not be accessed, and is therefore not referenced.

A list of deficiencies resulting from site visits by the Security Certification professional were assessed by authorised OLRT-C Project personnel.

3.2.5.7 Conclusions

A systematic process for identifying threats to the security of the Ottawa Confederation Line Phase 1 Railway & mitigation of those threats was implemented. Upon completion of the certification, a Threat Vulnerability Tracking and Resolution Conformance Certificate (Document: OLR-05-0-0000-CER-Se1000) was issued.

All Security Design and Security Construction Certificates have been issued. A covering Letter, Statement of Compliance has been issued for Substantial Completion.

Any deficiency that is not resolved is identified as a restriction in the specific Security Certificate.

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that Threats and Vulnerabilities have been adequately addressed.

This conclusion can be used in aggregation to positively support the Non-Interference pillar.

3.2.6 Cyber Security

[redacted]

3.2.6.1 [redacted]

ALS0084164

3.2.6.2 Approach

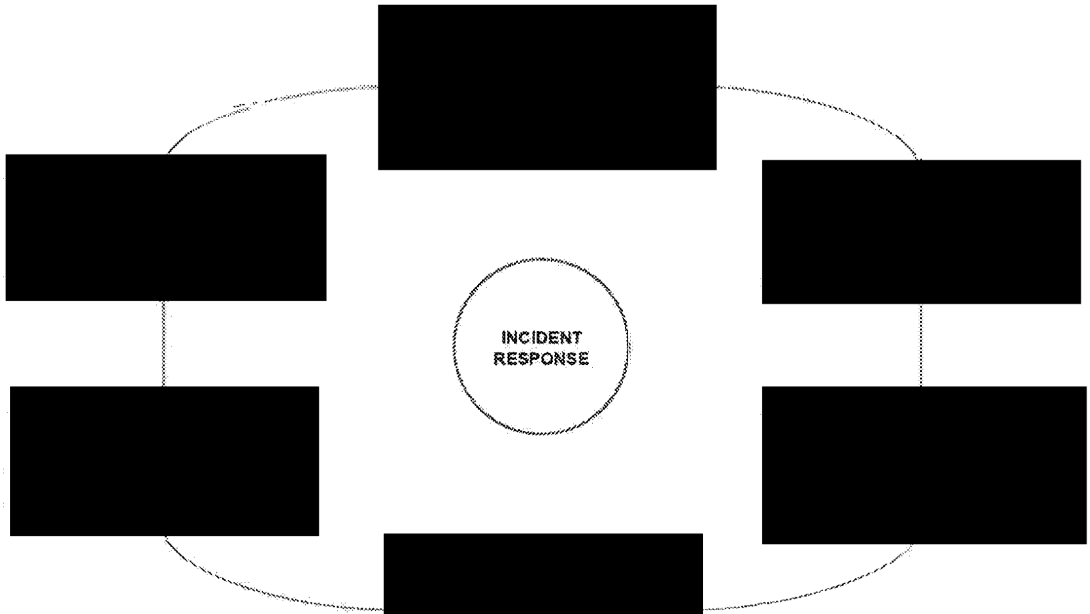
[redacted]

3.2.6.3 Activities

[redacted] weaknesses and new threats that require vendors to release security mitigation updates.

ALS0084164

[redacted]



[redacted]

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[redacted]

3.2.6.4 Outputs

[redacted]

3.2.6.5 Evidence

[redacted]

Table 5: Cyber Security Evidence

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Ref	Title	Number
[112]	[redacted]	
[113]		
[114]		
[115]		
[116]		
[117]		
[118]		
[119]		
[120]		
[121]		
[122]		
[123]		
[124]		
[372]		

3.2.6.6 Limitations

No Limitations Identified for Cyber Security to date.

3.2.6.7 Conclusions

Compliance to the best practice and contractual obligations, determined in the approach section above, were achieved through application of a structured approach to Cyber Security and mitigation of any Cyber Security hazards and vulnerabilities in accordance ISO 27001.

It is considered that the Projects identified counter measures were all implemented and the final Penetration Test Readiness Hardening Scope has been realised. Therefore, there is no reason to suggest that the system is not secure from external or internal electronic threats.

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that Cyber Security threats and vulnerabilities have been identified and mitigated and the system has minimal risk from accidental and deliberate electronic interference.

This conclusion can be used in aggregation to positively support the Non-Interference pillar.

ALS0084164

3.2.7 Electromagnetic Compatibility (EMC) and Electromagnetic Interference (EMI)

To demonstrate that the System, it's neighbours and persons are adequately protected against Electromagnetic Fields (EMF) and Electromagnetic Interference (EMI). The interoperability of the installed system must be assured to confirm Electromagnetic Compatibility (EMC) of the system and its environment.

3.2.7.1 Objectives

In contribution to the Non-Interference assurance pillar; demonstrate that the System is protected against EMI and will not cause Electromagnetic Interference to neighbouring Systems or expose persons to unsafe levels of non-ionising radiation.

3.2.7.2 Approach

The purpose of the EMC/EMI approach was to determine that:

1. The Railway System is not causing any EMI which can adversely affect humans.
2. The Railway System is not causing any EMI which can adversely affect equipment or systems internal or external to the Confederation Line Phase 1 system and
3. All equipment that has been provided to the Confederation Line Phase 1 project has been considered to be sufficiently immune from externally radiated EMI (whether generated externally to the railway system or by other equipment within the railway system itself)

The EMC Management Plan [128] for the Confederation Line Phase 1 System considers the operation of the primary systems within an electromagnetic environment.

The EMC Management Plan identifies test evidence that demonstrates LRV performance. It is proven that the LRV does not develop an EMF which exceeds that maximum exposure levels that could adversely affect human health [131].

The EMC Management Plan requires a risk assessment which considers the potential harmful effects of EMF on humans, including persons with embedded electronic medical devices.

An analysis of a model of a generic railway power architecture has been performed to consider whether the system presents a potential risk of harm.

This analysis is presented in the OLRT EMI / EMC Systems Assurance Report [381]. The analysis concludes that EMF associated with the railway is within the limits required by the Project Agreement.

To validate this analysis it is recommended that measurements are taken around the operating railway near to the Tunnel Ventilation System (TVS) and Traction Power Sub-Stations (TPSS).

The city assessment of the Final Survey Report [127] identified one intolerable disturbance which is being managed Through Non-Conformance Report (NCR) 0878.

The Main works included installations along the alignment such as:

ALS0084164

- Interfacing railways
- University of Ottawa (uOttawa)
- Canadian Broadcasting Corporation (CBC)
- National Resources Canada (NRCan), local hospitals
- Factories and other receptors/transmitters of EMI

The Confederation Line Phase 1 railway is comprised of the following Primary Systems:

DC Electrification System – TPS Traction Power:

This system provides 1500VDC supply to the Confederation Line Phase 1 Overhead Catenary System (OCS). The OCS is powered from 8 sub-stations spaced along the 12.5km route. Each is fed from the 60Hz grid and is equipped with a 12 pulse rectifier to produce 1500 VDC (full wave rectified) supply.

Low Voltage Trackside System:

The Low Voltage (LV) track side distribution system provides 3 phase 208 VAC to wayside electronic equipment such as Signals, switch machines and Data Communication Systems.

Light Rail Vehicles:

Light Rail Vehicles comprise 49m long vehicles with four integral car sections; LMC1 (motor bogie), IMC (trailer), LCC (trailer) and LMC2 (motor).

There is one traction unit with each motor bogie. The traction unit consists of a dual inverter configuration, with one inverter driving each of the two motors on the motor bogie.

There are two auxiliary power systems on the LRV, each supplying a variable voltage and frequency 3 phase converter, which supplies 45-60 Hz power varying from 350 to 480 V.

Each APS has a 120 V inverter for convenience outlets, 120 V loads, and an LVPS and battery charger for the 28.5 VDC supply.

Signalling System:

The Signalling System is a CBTC 2.4 GHz Wi-Fi radio based system. The Radio communications are achieved by LOS antennas located along the alignment and on the Light Rail Vehicle.

The Wayside Radio Unit (WRU) communicate CBTC information, received via the Light Rail Vehicle to the wayside network backbone (fibre optic), and to the train via LOS antennae.

In each zone, ATP is provided by Computer Based Interlocking (CBI). CBI is contained within the Zone Controllers, located in Station Equipment Rooms (SERs) that operate/manage switch machines, signals and intrusion detection systems.

The Zone controllers communicate with the TSCC, MSF, BCC and Yard Control Centre (YCC) via the CBTC DCS backbone.

Communication Systems:

ALS0084164

The Communication Systems provide vital and non-vital support to daily operations and emergency services. Communication systems are designed to be integrated throughout the Confederation Line Phase 1 Railway including; Stations, Tunnels, MSF, TSCC, Traction power sub-stations etc.

The Confederation Line Phase 1 Communications infrastructure includes CTS, PIS (PA, PID), CCTV, IAC, telephone and intercom, radio communication system, train to wayside wireless and SCADA.

The SCADA system comprises TPSS, Building Management Systems (BMS) and the Building Automation Systems (BAS).

Track (surge arrestors):

Lightning protectors are positioned along the alignment on either side of the DC connecting feed and at all mid-point anchor assemblies. Arrestors have a minimum energy rating of 2.6kJ/kV.

Building Services: Electrical and Mechanical services and Maintenance and Storage Facility.

Generally, equipment within the framework of building services meets the following EMC standards:

- Equipment within 3m of the track complies with EN50121-4.
- Equipment within 10m of the track complies with industrial immunity requirements equivalent to EN61000-6-2.
- Equipment in light industrial areas such as the TSCC complies with light industrial requirements equivalent to EN61000-6-1.
- In all cases, apparatus complies with product specific standards as well as the requirements specified in EN50121-4 and EN61000-6-2.

3.2.7.3 Activities

To ensure the electromagnetic spectrum was suitably charted and managed EMC activities were delivered in three phases.

Phase 1 – An initial EMC Field Survey: provided the baseline electromagnetic spectrum and electromagnetic signature of ten (10) specifically selected measurement locations along the Confederation Line Phase 1 alignment.

Phase 2 – An EMC Simulation combined the baseline measurements and vehicle signature information to create a simulation of the system. The EMC Simulation considered information regarding sensitive equipment (provided by stakeholders) for more accurate results.

Phase 3 – A Final EMC Field Survey repeated the measurement taken at the same locations as the Initial EMC Field Survey and compared the EMC measurements.

In addition to EMC Field Survey measurements, the EMC Management Plan [128] requires that the electrical/electronic EMC/EMI reports and/ or the Certificates of Compliance for identified sub systems are collated and assessed.

ALS0084164

The procurement specifications identified in section 3.2.7.4 require that the suppliers of the sensitive EMI/EMC sensitive systems and equipment should demonstrate compliance to the EMC standards, regulations and requirements identified by the specifications.

It is generally recognised that this evidence can be provided as the actual test report or, as is usual for commercially available electronic equipment, a certificate or signed declaration.

To assure the EMI/EMC sensitive systems identified by the EMC Management Plan, the certificates and declarations for the EMI/EMC sensitive systems should be collated. The Configurable Items Database [313] identifies the installed part numbers and this data source should be used to identify the part numbers that require certification.

The equipment installed is often commercially available from reputable manufacturers and suppliers. It is likely that the installed equipment complies with the requirements of the procurement specifications however the expected certification and declaration documentation is not currently referenced by the EMC Management Plan.

Additionally, the EMC Management Plan requires the performance of static and dynamic integration testing to demonstrate the interoperability of the installed sensitive sub-systems.

The Test and Commissioning team have performed the Systems Integration Test activity described in section 3.1.8.2 as part of the Requirements Validation and Traceability.

Following achievement of the Substantial Completion milestone, the 12-day Trail Running activity described by section 3.1.8.2 has been undertaken by the Test and Commissioning team.

The Systems Integration Test and the 12-day Trail Running activities are functional tests which are not referenced by the EMC Management Plan.

The Systems Integration Test and the 12-day Trail Running activities do provide a degree of confidence for the interoperability of the system.

ALS0084164

3.2.7.4 EMC Requirements and Procurement Specification Extracts

Table 6: EMC Requirements and Procurement Specifications

Document Number	Document Name	EMC/EMI Requirements
RES-53-0-0000-SPE-274219	Fixed Facilities Passenger Information System (PIS) Procurement Specification 27 42 19	Section 3.7
RES-53-0-0000-SPE-275116	Fixed Facilities Public Address (PA) System Procurement Specification 27 5116	Section 3.7
RES-53-0-0000-SPE-274216	Fixed Facilities Passenger Information Display (PID) System Procurement Specification 27 42 16	Section 3.7
RES-53-0-0000-SPE-282300	Fixed Facilities CCTV System Technical Specification Standard Specification 28 23 00	Section 1.4
RES-53-0-0000-SPE-281300	Intrusion Access Control Procurement Specification 28 13 00	Section 1.4
RES-53-0-0000-SPE-273000	Fixed Facility Telephony Equipment Standard Specifications 27 30 00	Section 1.5
RES-53-0-0000-SPE-255010	Fixed Facilities SCADA System Procurement Specification	Section 4.5
RES-53-0-0000-SPE-0001	Vehicle Interface – High Speed Radio System Functional Description	Sections 9.1, 9.3, 9.4
RES-56-0-0000-SPE-342123	Transformer Rectifier Unit Specification	Sections 1.2, 3.1, 4.2
RES-53-0-0000-SPE-275100	Communication Transmission System Network Equipment Standard Specification 27 51 00	Section 1.4
RES-56-0-0000-SPE-260917	Supply of Programmable Logic Controllers (PCL's) for Tunnel Ventilation Systems	Section 1.6
RES-52-0-0000-SPE-233400	Supply of Tunnel Ventilation Packaged Fan Units	Section 2.1(V)
RES-53-0-0000-SPE-281643	Fence Intrusion Detection System Procurement Specification 281643	Section 1.5, 2 (h)

3.2.7.5 Outputs

The primary outputs of the EMC process were:

1. EMC/EMI Environmental Measurement Initial EMC Field Site Survey Report [125].
2. EMC Simulation Report [126] (due date 7th July 2019.
3. Final EMC Field Report [127].
4. Light Rail Vehicle and CBTC EMC/EMI Reports.
5. EMC/EMI Fixed Facilities Reports/Certificates [134].

3.2.7.6 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the EMC activities and analysis are identified in Table 7

Table 7: EMC Evidence

Ref	Title	Number
[125]	EMC/EMI Environmental Measurement Initial EMC Field Site Survey Report	VIC-74-0-9009-REP-0001
[126]	EMC Simulation Report	VIC-74-0-9009-REP-0002
[127]	Final Survey Report	VIC-74-0-9009-REP-0003 16/04/19
[128]	EMC Management Plan	OLR-74-0-0000-MPL-0002
[129]	EMC Test & Measurement Plan	OLR-74-0-0000-MPL-0003
[130]	Alstom N90-EMI Conducted Calculation	ADD0000938885
[131]	Alstom EMC Radiated EMC Type Test Procedure	ADD0000938969
[132]	Alstom EMC Radiated EMC Type Test Report	ADD0000938971
[133]	Thales: Ottawa Light Rail Transit Project Hardware Environmental and EMC Qualification Report	3CU 05018 0117 QZZZA
[134]	EMC/EMI Fixed Facilities Reports/Certificates	Pending
[135]	Vican Corporation – Statement of Compliance Letter dated April 8, 2019 on Final EMC Survey results	8th April 2019
[381]	OLRT EMI / EMC Systems Assurance Report	OLR-05-0-0000-REP-0076

3.2.7.7 Limitations

EMC Simulation Report [126] not yet issued (due date 7 July 2019).

Observations have been made by the OLRT EMI / EMC Systems Assurance Report [381].

3.2.7.8 Conclusions

The measurement results included in the Final EMC Field Site Survey Report are similar to the Initial EMC Field Site Survey Measurement. No significant anomalies were observed during the final survey. There were no significant (>1V/m) EM emissions observed.

It is therefore considered that the Confederation Line Phase 1 has complied with the requirements specified in the EMC Test and Measurement Plan Section 8.0 [128].

ALS0084164

It is recommended that the observations from the OLRT Interim EMI EMC Systems Assurance Report [381] are considered and addressed to positively support the Non-Interference pillar.

3.2.8 Grounding

To demonstrate the compliant protection against Grounding and Bonding has been achieved.

3.2.8.1 Objectives

In contribution to the Non-Interference assurance pillar; demonstrate that compliant protection against Grounding and Bonding was designed and implemented, including the management of stray current.

3.2.8.2 Approach

This section of the ESAC addresses the design and assessment of provisions that were implemented for Grounding of the Overhead Catenary System (OCS), Trackwork and to detect stray currents.

Stray current refers to negative traction return currents that return to the traction power sub-station via unintended, low resistance paths rather than the running rails. This can cause corrosion and potentially lead to premature wear out of metallic equipment in the vicinity of running rails such as civil structures and building services.

A grounding strategy was implemented in order to achieve the following:

- Ensure safety of personnel, passengers, and general public
- Development of a solution capable of stray current mitigation and control
- Ensure safe permissible step limits and touch potentials in accordance with IEEE 80
- Ensure compliance to the grounding aspects of the PA [7]
- To ensure codes of practice (See Table No.7 below) had been fully addressed and that adequate grounding provisions had been incorporated into the design

The grounding strategy implemented for this project was derived from the PA [7] requirements, associated standards, recommendations, and experience acquired from previous transit projects.

3.2.8.3 Activities

Engineering governance was critical to ensuring adequate grounding provisions were incorporated into the design. Processes identified in the Systems Engineering Management Plan [176] highlight how requirements captured from the PA [7] have influenced the design by specifying design provisions that were released in the design and Codes of Practice implemented to ensure that necessary standards were achieved. Compliance to PA [7] requirements is evidenced in the DOORS verification module and the Technical Compliance Report [9].

ALS0084164

Industry standards adhered to in the development and implementation of the OLRT grounding solution are shown in Table 8 below.

Table 8: Codes of Practice

Title	Reference	Revision
Bonding and Grounding of Electrical Equipment (Protective Grounding).	CAN/CSA C22.2	4
General Grounding Requirements and Grounding requirements for Electrical Supply Stations	CAN/CSA C22.3	2
Railway Electrification Guideline Standard No.8	CAN/CSA C22.2 – M91	-
Guide for Safety in AC Substation Grounding;	IEEE 80	-
IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System	IEEE 81	-
Railway Applications, Fixed Installations – Protective Provisions Relating to Electrical Safety and Grounding	EN 50122-1	-
Effects of Current on Human Beings and Livestock – Part I General Aspects	IEC 60479	-
Canadian Electrical Code Part 1	CSA C22.1	-
Ontario Electrical Safety Code	-	25th Edition

The grounding system provides a critical safety function in protecting passengers, maintainers and physical assets, structures, equipment and systems from the risks associated with electrical power sources. Engineering safety management was conducted in line with the OLRT-C Systems Safety Programme Plan [23] to ensure that hazards were identified, assessed and mitigated.

Hazard analysis pertaining to grounding was shown in the PHA and Sub-System Hazard Analysis (SSHA) for the Traction Power Supply (TPS) [59], [65] and Overhead Catenary System (OCS) [60], [63] and provided evidence that risks had been reduced by design and the development of SOPs.

This was supplemented by Failure Modes Effect and Criticality Analyses for the TPS [53] and OCS [52] that illustrated how prevalent failures and their consequences had been adequately managed. Reliability, Availability and Maintainability Reports for the TPS [47] and OCS [46] provided confidence that the grounding solution delivered acceptable levels of performance.

OLRT Project design, build and maintenance was undertaken in the context of an ISO 9001:2008 Quality Management System (QMS). Key aspects of the approach adopted included the involvement and oversight of Engineers of Record in the design and construction processes and acceptance within DCL and CCL.

ALS0084164

This was backed up by a rigorous inspection and audit regime in which physical assets and systems were inspected for conformity and quality. This was further supplemented by Stray Current Testing – July 2017 [143] that showed there was no evidence of LRT induced stray current upon the City's water-mains

3.2.8.4 Outputs

Extensive design provisions were implemented to ensure that adequate grounding was incorporated and that the risks associated with stray currents were adequately managed.

Features of the design were implemented to minimise the potential for the release of stray currents at each location as described below:

TPSS

- Copper conductor grid and ground rods at junction points have been used along the perimeter and bonded at intervals to ground rods or the TPSS building enclosure
- Contact resistance between the soil and personnel have been maximised with >300mm layer of clean crushed rock above the ground grid
- The TPSS ground grid is connected to the Utility Neutral Conductor
- DC Switchgear is insulated using 12mm highly insulating epoxy coating
- Each TPSS incorporates a Rail Grounding Switch (RGS) (or negative grounding device) to prevent a "floating" potential of the rail relative to earth. The RGS shorts to ground upon detection of 50V or greater with status/event reported via SCADA.

OCS

- OCS Poles, supports and structural equipment are grounded using local ground rods or buried ground loops to achieve a resistance <25 ohms and compliance to the PA [7]
- OCS poles are grounded via a ground rod and secured with rebar within the OCS pole foundations at two locations
- OCS poles and supports that are installed on structures are bonded to the main grounding conductor or tied to the structural rebar
- OCS supports in tunnels are grounded using a bare copper grounding conductor
- Lightning strike arrestors are connected to dedicated ground rods whether on OCS feeder poles and at the incoming feeder circuit breaker compartment of buildings, substations, and stations.

ALS0084164

Stations

- Stations have been designed to include a buried ground grid and ground rod design to achieve safe step and touch potential in line with the requirements of IEEE 80
- There are continuously bonded structures in which power carrying equipment and supporting metallic infrastructure are bonded to the main system ground as per CEC, OESC, and IEEE
- Structural rebar is bonded to the main ground grid at set intervals to maintain continuity.

Tunnels

- Main insulated ground conductor in cable trench of tunnels
- Structural and expansion joints bonded to the main slab and both sides at 50m intervals.

Civils

- New civil structures are bonded with rebar on both sides with the use of wire ties along the length of the structure to achieve electrical continuity
- Legacy structures have been modified to incorporate conducive material along the length of the structure on both sides by bonding to exposed rebars for continuity, where possible.

Track

- Running rails use insulated rail fasteners for the tracks on the mainline and for the MSF yard tracks
- Equipment connected to the rail, such as switch controllers and heaters, are electrically isolated to ensure there're is no path to ground
- MSF Shop tracks are electrically isolated from the MSF Yard tracks using Insulated Rail Joints (IRJ) and fed from a dedicated TPSS
- Rail-to-Rail and Track-to-Track cross bonds and return cables are used to connect conductive parts of the return circuit.

Miscellaneous

- Non-current-carrying-conductive parts such as conduit, cable trays, handrails, and non-coated metallic guideway fencing, are electrically bonded and permanently grounded
- Equipment such as switch machines, switch heaters, wayside radio units, are grounded locally using a ground rod or via a common grounding point if available nearby
- Track-side fencing is grounded at 100m intervals using a ground rod
- Fencing has been PVC coated or non-metallic materials have been used, where appropriate
- Localised grounding of equipment where no common ground is available.

ALS0084164

In order to detect stray currents and build in necessary protections, monitoring capabilities were incorporated as described by the Mitigation and Monitoring of DC Stray Current Interference Effects [136] which was incorporated into the design

- Monitoring test points on new structures and in the vicinity of utilities along the main guideway parallel to the track
- Temporary and permanent monitoring test points on key structures such as tunnels, overpass and bridges
- SCADA detection of RGS and TPSS Rectifier Inverter trip event of fault condition
- Rail resistance testing and twenty-four hour assessment and monitoring at vulnerable structures will be conducted at various stages of the project development and operational lifecycle as baseline, construction completion, revenue service and ad-hoc follow-up testing.

3.2.8.5 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Grounding activities and analysis are identified in Table 9.

Table 9: Grounding Evidence

Ref	Title	Number
[23]	OLRT-C Systems Safety Programme Plan	OLR-05-0-0000-REP-0055
[65]	Power Supply Distribution System PHA	REJ-05-0-0000-REP-0324
[59]	TPS Sub-System Hazard Analysis	REJ-05-0-0000-REP-0356
[63]	OCS Preliminary Hazard Analysis	REJ-05-0-0000-REP-0332
[60]	OCS Sub-System Hazard Analysis	REJ-05-0-0000-REP-0358
[53]	Traction Power Supply (TPS) Failure Modes and Effects Analysis	REJ-05-0-0000-REP-0342
[52]	Overhead Catenary (OCS) Failure Modes and Effects Analysis	REJ-05-0-0000-REP-0341
[47]	TPS RAM Report	REJ-05-0-0000-REP-0336
[46]	OCS RAM Report	REJ-05-0-0000-REP-0335
[73]	Energy Safety Justification Report	OLR-05-0-0000-REP-0072
[136]	Mitigation and Monitoring of DC Stray Current Interface Effects	REJ-56-0-0000-REP-0125
[137]	Construction Quality Management Plan	OLR-04-0-0000-MPL-0017
[138]	OLRT Constructors Stray Current Monitoring (Apex Corrosion)	APX-55-0-6187-REP-0001
[139]	TSCC Grounding and Bonding Results – SCHNEIDER	List of Grounding Tests – see [145] to [150]

ALS0084164

Ref	Title	Number
[140]	Rail Isolation and Stray Current Impact on Practical Completion	APX-55-0-6187-LET-0001
[141]	Grounding and Bonding Design Report	RES-56-0-0000-REP-0261
[142]	Rail Grounding Switch Specification	RES-56-0-0000-SPE-2628162
[143]	Stray Current Testing – July 2017	RES-OLR-56-3-LET-0228
[144]	Ground Fault Calculations – TPSS 01	RES-56-1-TP01-DBC-0131
[145]	Ground Fault Calculations – TPSS 02	RES-56-1-TP02-DBC-0136
[146]	Ground Fault Calculations – TPSS 04	RES-56-3-TP04-DBC-0132
[147]	Ground Fault Calculations – TPSS 05	RES-56-3-TP05-DBC-0133
[148]	Ground Fault Calculations – TPSS 06	RES-56-4-TP06-DBC-0114
[149]	Ground Fault Calculations – TPSS 08	RES-56-5-TP08-DBC-0116
[150]	Ground Fault Calculations – TPSS 09	RES-56-4-TP09-DBC-0117
[151]	Grounding Test Report, Segment 5	SDE-55-0-9056-PIC-0006
[152]	Grounding Test Report, Segment 4	SDE-55-0-9056-PIC-0012
[153]	Grounding Test Report, Segment 3	SDE-55-0-9056-PIC-0011
[154]	Grounding Test Report, Segment 2	SDE-56-0-9056-PIC-0014
[155]	Grounding Test Report, Segment 1	SDE-56-0-9056-PIC-0014
[156]	Grounding report for TPSS6	SDE-55-0-9056-PIC-0005
[157]	Soil Resistivity Measurements for TPSS10	SDE-55-0-9056-PIC-0004
[158]	Grounding report for TPSS7	SDE-55-0-9056-PIC-0003
[159]	Grounding report for TPSS9	SDE-55-0-9056-PIC-0002
[160]	Grounding report for TPSS5	SDE-55-0-9056-PIC-0010
[161]	Grounding report for TPSS4	SDE-55-0-9056-PIC-0009
[162]	Grounding report for TPSS8	SDE-55-0-9056-PIC-0001
[163]	Grounding report for TPSS2	TCC-55-1-1014-REP-0003
[164]	Grounding report for TPSS1	SDE-55-0-9056-PIC-0008

3.2.8.6 Limitations

Grounding system design, development and construction has been conducted in accordance with defined and controlled processes including the Construction Quality Management Plan [137].

ALS0084164

There is considered to be no limitations associated with the grounding system design or associated design approach; however, a number of grounding related safety risks or points of clarification have been identified in the Energy Systems Safety Justification, as follows:

- Switch machines present a touch potential issue to maintenance personnel between the outer case of the machine and any component connected to the rail. This presents the risk of injury through shock or arcing, or possible reliability issues associated with switch control and detection. It is recommended that switch machines are insulated from ground and bonded to the running rails
- Rail Grounding Switches at substations do not deal with increased touch potential between substations that may occur due to resistance to the return current in the event of broken rail or cross-bond. This can lead to a risk of increased touch potential to maintenance personnel when responding to perform corrective maintenance. It is recommended that checks for rail and bond discontinuities conducted with sufficient frequency that the risk of dangerous touch potentials is maintained at an acceptable level
- Lightning arrestors may incur damage in response to lightning strike. It is recommended that lightning arrestors are tested in response to a lightning strike event to determine correct functionality and to replace on-condition
- Depot rails are grounded whilst running rails are insulated from ground. The different grounding configurations of running rails to MSF shop mean that IRJs are required at the interface. Significant current flow and arcing can occur during train pass. It is recommended that safe methods of working in the vicinity of IRJ are developed to prevent arcing in the event that the track sections are bridged, e.g. due to tooling, machinery, etc. It is also recommended that a regular maintenance test is performed confirm integrity of the IRJ.

3.2.8.7 Conclusions

The Grounding activities undertaken and evidence produced have demonstrated that the following were achieved:

- Safety of personnel, passengers, and general public
- A solution was provided capable of stray current mitigation and control
- Safe permissible step limits and touch potentials in accordance with IEEE 80
- Compliance to the grounding aspects of the PA [7]
- Codes of practice (See Table No.7 below) were fully addressed so that adequate grounding provisions were incorporated into the design.

Based on the evidences presented for Grounding, it can be seen that design reports, hazard assessment analysis, base line surveys and test reports have been provided in accordance with the project requirements and show a methodical, engineered approach to grounding.

A review of the provided evidence demonstrates that in accordance with the Project Agreement, Project Requirements, and relevant industry standards, that a

ALS0084164

comprehensive grounding strategy has been implemented on the Confederation Line Phase 1 project.

Where limitations have been identified with grounding design and its implementation, they were mitigated by work safe procedures and best practices in the maintenance and operation of the Confederation Line Phase 1.

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that compliant protection against Grounding and Bonding and management of stray current has been achieved.

This conclusion can be used in aggregation to positively support the Non-Interference pillar.

3.2.9 Human Factors & Ergonomics

To demonstrate that adequate consideration of Human Factors has been achieved.

3.2.9.1 Objectives

In contribution to the Non-Interference assurance pillar; demonstrate that Human Factors was incorporated into the design, operation and maintenance of the System.

3.2.9.2 Approach

The approach undertaken was to define the process (strategy) necessary to have met the PA requirements and to have been cognisant with best practices in the industry for ensuring that the knowledge of human capabilities and limitations were incorporated into the Design, Operation and Maintenance of the Confederation Line Phase 1 system.

The objective of the approach was to identify the entire scope of work and apportion the necessary responsibilities.

Project Agreement Requirements

- Schedule 10: Identification of human factors required
- Schedule 10: Cab layout/ergonomics
- Schedule 10: Passenger seating/stanchions/level of comfort
- Schedule 15-2 Part 4, various requirements for driver cab, vehicle seats, consoles, etc.

Additional Agreed or Formalized Requirements

- VC-80, Driver Alertness – As defined in Variation Confirmation 80, Vehicle Deadman's Handle Function-Additional Alertness Function in ATO
- Simulations/ replication of the environment and on the job training.

3.2.9.3 Activities

This section of the ESAC summarises the status of activities and evidence relating to Human Factors and ergonomics (HF).

The activity undertaken first defined all potential Human Factors issues associated with Operations of the Confederation Line Phase 1 Railway and allocated analysis and resolution to one of the main project participants namely: OLRTC (RTGEJV, Alstom, Thales), RTM – Maintainer and The City of Ottawa/ OCT.

HF Areas of and associated responsibility assignment are as follows:

- Review of the features of the cab environment – Alstom
- Undertaking the review of driving – City
- Reviewing the tasks of other 'train crew' – City
- Reviewing the HF aspects related to design of MSF and TSCC
- Reviewing the task of maintaining and preparing trains for service – RTM
- Reviewing the HF aspects associated with the control including management of screens and authorising the movement of trains – RTGEJV.

The following steps described below were taken to perform the HF analysis:

- Engagement of Human Factors Consultancy
- Document review of the technical specifications, project correspondence, the background of the project and any emergent design issues
- From these findings and measurements, a proposed conceptual design was developed
- Site visits were conducted – including a tour of the control room and meeting with the bus controllers and superintendents
- Interviews were conducted to gain an understanding of their job roles, equipment usage and the operational concept for bus control to help inform any design changes required to include the LRT control consoles, and overview display
- Workshop was held to meet with Project Stakeholders; review and identify the equipment requirements and to establish where possible the operational concept for those consoles and the extent of LRT control
- A project Human Factors Issues Log (HFIL) was created
- A wrap-up meeting was held which reviewed the way forward on the HF issues and delivery of recommendations
- An ergonomic assessment was produced where conclusions and recommendations were described
- The verification and validation process involved the following tasks analysis:
    - a full operational concept detailing the intended operations of the functional equipment for the LRT consoles,
    - a new overall integrated transit control centre where the functional links, roles of all the controllers throughout the control room and OVD and console design were reviewed for both buses and trains on the network, in order to

ALS0084164

achieve a more integrated approach to transit management in the City of Ottawa

3.2.9.4 Outputs

The primary outputs of the Human Factors Management process were conclusions and recommendations of the HF and ergonomics analysis which were implemented in the design. These were evidenced and formalized in the reports as listed in the evidence table below.

Stratification and prioritisation of Alarms has been provided to the City of Ottawa.

3.2.9.5 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Human Factors activities and analysis are identified in Table 10.

Table 10: Human Factors Evidence

Ref	Title	Number
[165]	TSCC Final Human Factors Report	REJ-50-0-0000-REP-0089
[166]	Ergonomics Support for the Confederation Line	REJ-50-0-0000-REP-0089
[167]	MSF YCC/BCC Ergonomic Report	REJ-50-0-0000-REP-0280
[168]	Driver Display	ADD0000939551
[169]	Cab Layout/Ergonomic	ADD0000939495
[170]	2nd Pre-Final Design Review Cab layout/ergonomics	ADD0000939544
[171]	Driver's Seat Ergonomic Study in Cab	ADD0000939261
[172]	HMI Design Document	3CU050180044DSZZA
[173]	SCADA – Operator Interface Style Guide	WGS-53-0-S069-PDS-0007
[174]	SCADA – Operator Interface Library Specification	WGS-53-0-S069-PDS-0006
[175]	Driver Alertness Study	INT-58-0-0000-REP-0001

3.2.9.6 Limitations

Number of hours of Controller Training and Operator Certifications now being issued.

Validated with OLRT-C experienced resources and based on a prioritisation / similar railway (e.g.: Canada Line).

This ESAC excludes Operations and Work Instructions of the City and any Alarm strategy OCT chose to implement.

A strategy will evolve when the Railway is in Operation and when the Railway is extended.

ALS0084164

3.2.9.7 Conclusions

The minimum requisite Human Factors and Ergonomics analysis was undertaken. For the purpose of this report it has been assumed that both Alstom and Thales managed their own Human Factors and Ergonomics requirements.

A systematic process for identifying the human factors and ergonomic requirements for the Confederation Line Phase 1 Railway system and the implementation of the recommendations within the design and installation was implemented.

A number of Human Factors and ergonomic reports were issued to provide evidence that due diligence was applied.

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that Human Factors was incorporated in the design, operation and maintenance and therefore adequate consideration of Human Factors has been achieved.

This conclusion can be used in aggregation to positively support the Non-Interference pillar.

3.2.10 Operability including conditions and limitations

To demonstrate that the system SOPs, Limitations and Operational Conditions are in place for the Operation of the Confederation Line Phase 1 as baselined in the System configuration.

3.2.10.1 Objectives

In contribution to the Non-Interference assurance pillar; demonstrate that the System SOPs, Limitations and Operational Conditions were in place through identification of operational principles of the railway having been incorporated or that appropriate measures were put in place in readiness for Revenue Service Availability.

3.2.10.2 Approach

This section identifies the activities that were carried out to support the key operational principles used in the development of the railway system for start-up, operation and stopping of the Confederation Line Phase 1.

Throughout this section reference is made to SOPs. SOPs is used as a general term to cover all available rules and procedures (e.g. Standard Operating Procedures, Work Instructions & Rule Books).

To identify that operational principles of the railway were incorporated or that appropriate measures were put in place in readiness for RSA.

3.2.10.3 Activities

With respect to Confederation Line Phase 1 the operational elements are production and distribution of the SOPs.

ALS0084164

As part of the activities undertaken to identify the operational principles of the Confederation Phase 1 Railway System and to ensure that appropriate measures are in place to operate a safe and reliable passenger rail service, a series of scheduled DITLO workshops were undertaken.

The purpose of the DITLO workshops was to:

- Identify appropriate measures had been implemented for typical operational railway scenarios

  Highlight any gaps in the Standard Operational Procedures
- Map the activities required to minimise delays to the customer
- Cross reference these activities with the design and functionality of the Railway System.

DITLO workshops were held over three days to identify any complete, incomplete or missing operator requirements. The workshops considered the full extent and limitations of the railway in normal & degraded modes and under emergency conditions, to identify and determine what operational procedures are needed to minimise risk and delays during normal, degraded and emergency operation.

3.2.10.4 Outputs

Day in The Life Of (DITLO) Report [38].

The surveillance and monitoring activities provided a good indication of the actions performed for operational readiness at Primary System level and are documented as internal reports to support this ESAC.

3.2.10.5 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Operability activities and analysis are identified in Table 11.

Table 11: Operability Evidence

Ref	Title	Number
Documents		
Standard Operating Procedures		
[178]	Activation of Back-Up Control Centre	OLR-05-0-0000-RGL- 104022422
[179]	Ad Hoc Station Cleaning	OLR-05-0-0000-RGL- 104022501
[180]	Belfast Yard Level Grade Crossings CBTC System – Wayside and Central Equipment Failures	OLR-05-0-0000-RGL-1040232 OLR-05-0-0000-RGL- 104022412
[180a]	CBTC System – Wayside and Central Equipment Failures	OLR-05-0-0000-RGL-104022412

ALS0084164

Ref	Title	Number
[181]	Communications System Faults and Failures	OLR-05-0-0000-RGL- 104022415
[182]	Driver Vigilance System Activations	OLR-05-0-0000-RGL- 104022423
[183]	Elevator Failure	OLR-05-0-0000-RGL- 104022502
[184]	Emergency Alarm activations	RTM-17-0-0000-SOP-0040
[185]	Emergency Event – Station Procedures	OLR-05-0-0000-RGL- 104022427
[186]	Emergency Events – Mainline	OLR-05-0-0000-RGL- 104022426
[187]	Emergency Management Plan	OLR-05-0-0000-RGL-1060100
[188]	Emergency Response Procedures	OLR-05-0-0000-RGL-1060200
[189]	Escalator Failure	OLR-05-0-0000-RGL- 104022503
[190]	Guideway Intrusion Procedures	OLR-05-0-0000-RGL- 104022424
[191]	In Service Track Failures	OLR-05-0-0000-RGL-104022410
[192]	Inclement Weather Procedures	OLR-05-0-0000-RGL- 104022420
[193]	Line of Sight Operations	OLR-05-0-0000-RGL- 104022419
[194]	LRV Door Fault Procedures	RTM-17-0-0000-SOP-0013
[195]	LRV Event Recorder Download Procedure	RTM-18-0-0000-SOP-0031
[196]	LRV Faults and Vehicle Minimum Operating Standard	OLR-05-0-0000-RGL-104022403
[197]	MSF Power Failures	OLR-05-0-0000-RGL-1040241
[198]	OCS Failure and Damage	OLR-05-0-0000-RGL- 104022421
[199]	Working on the Confederation Line Procedures	OLR-05-0-0000-RGL-1040211
[200]	Planned Vehicle Coupling and Uncoupling	OLR-05-0-0000-RGL-1040233
[201]	Removal of Defective Trains from Service	OLR-05-0-0000-RGL- 104022404
[202]	Station Power Failure	OLR-05-0-0000-RGL- 104022504
[203]	CBTC Target Point Overshoot Procedure	RTM-17-0-0000-SOP-0020
[204]	Track Obstructions	RTM-17-0-0000-SOP-0041
[205]	Traction Power Supply and Distribution Alarms, Faults and Failures	OLR-05-0-0000-RGL- 104022413
[206]	Train to Train Evacuations	OLR-05-0-0000-RGL- 104022425

Ref	Title	Number
[207]	Vehicle Brake System Failures	RTM-OP-PRO-249
[208]	Weather Monitoring, Reporting and Alert Level	OLR-05-0-0000-RGL- 104022205
Work Instructions		
[209]	Assault or Threat of Violence	OTRC-S200-13-WI
[210]	Bomb Threat	OTRC-S200-18-WI
[211]	CBRN- Chemical, Biological, Radiological or Nuclear	Confidential
[212]	Civil Unrest on the Confederation Line	OTRC-S200-34-WI
[213]	Vigilance Systems Activations	OTRC-S200-01-WI
[214]	Degraded Adhesion	OTRC-S200-02-WI
[215]	Disturbance on the Confederation Line	OTRC-S200-29-WI
[216]	Docking Issue	OTRC-S200-03-WI
[217]	Door Fault Recovery	OTRC-S200-12-WI
[218]	Door Procedure for Revenue Service	OTRC-Q200-05-WI
[219]	Employee Emergency Alarm	OTRC-S200-04-WI
[220]	Evacuations on the Confederation Line	OTRC-S200-28-WI
[221]	Fire and Smoke at a Station	OTRC-S200-05-WI
[222]	Fire and Smoke at the Maintenance and Storage Facility	OTRC-S200-08-WI
[223]	Fire and Smoke in a Traction Power Substation or on the Guideway	OTRC-S200-06-WI
[224]	Fire and Smoke on a Train	OTRC-S200-09-WI
[225]	Fire and Smoke in a Tunnel	OTRC-S200-07-WI
[226]	Fire and Smoke Monitoring, Systems and Equipment	OTRC-Q200-06-SD
[227]	Hijacking on the Confederation Line	OTRC-S200-35-WI
[228]	Joint Region of Authority Transfer	OTRC-S200-10-WI
[229]	On-Board CBTC Faults and Failures	OTRC-S200-15-WI
[230]	Person with a weapon on the Confederation Line	OTRC-S200-32-WI
[231]	Radio Protocol	OTRC-S200-16-WI
[232]	Rail Controller Duty Transfer	OTRC-S200-17-WI

Ref	Title	Number
[233]	Rail Log	OTRC-Q200-04-WI
[234]	Removing Non-Communicating Trains from Service	OTRC-S200-11-WI
[235]	Rules Deviation Procedure	OTRC-S200-20-WI
[236]	Scheduled Station Opening and Closing	OTRC-S200-22-WI
[237]	Seismic Events	OTRC-S200-23-WI
[238]	Suspicious Activity or Mischief	OTRC-S200-30-WI
[239]	Suspicious Package on the Confederation Line	OTRC-S200-36-WI
[240]	Sweep Trips	OTRC-S200-24-WI
[241]	Temporary Speed Restrictions	OTRC-S200-25-WI
[242]	Track Failures and Obstructions	OTRC-S200-26-WI
[243]	Traction Power Isolation	OTRC-S200-27-WI
[244]	Train Event Recorder Download	OTRC-Q200-02-WI
[245]	Train/Human Contact	OTRC-S200-37-WI
Safety Management System		
[246]	Environmental Management	OLR-05-0-0000-RGL-1080000
[247]	Public Education and Outreach	OLR-05-0-0000-RGL-1150000
[248]	Safety Management System	OCT-S230-03-PROG
[249]	Training and Certification (Transit Services & RTM Employees)	OLR-05-0-0000-RGL-105000
[250]	Verification of Regulatory Compliance	OLR-05-0-0000-RGL-1040900
Rules		
[251]	LRV Safety and Inspection Rules	OLR-05-0-0000-RGL-104070000
[252]	Electric Light Rail Operating Rules Rule Book	OTRC-S100-00-RUL

3.2.10.6 Limitati ons

A review of the rules and procedures was not undertaken at a formal level and the list supplied in Table 11 is not intended to be definitive, however during the series of DITLO workshops it was clear that the attendees from the various organisations all had a good understanding of the individual tasks expected of them during normal, degraded and emergency conditions. The suite of rules and regulations contained in Table 10 is a good indication that Operational Preparedness was approached in a practical and efficient manner.

The DITLO workshops were considered to be a huge success, both for the collection of evidence regarding the competencies of the participants and the identification of areas where more clarification was required.

It was agreed at the onset of the DITLO Workshops that the PA [7] Requirements would not be mapped against the actions detailed in Appendix A of the Day in The Life Of(DITLO) Report [38].

There are over 7000 technical requirements that could be attributed to the outputs from the Workshops. It was mutually agreed that it shall be the responsibility of the participants of the workshops which identified the owner's actions as detailed in Section 1.2 and Appendix A of the Day in The Life Of (DITLO) Report [38], to link the PA [7] requirements where necessary.

3.2.10.7 Conclusions

The workshops and field investigations carried out indicate a good level of operational preparedness.

The DITLO workshops defined that staff knowledge of operating principles & supporting equipment and systems was satisfactory.

As a result of the DITLO workshops the operator and maintainer were strongly recommended to carry out further workshops to explore more demanding scenarios and ensure close out of the recommendations made in the Day in The Life Of (DITLO) Report [38].

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that the System SOPs, Limitations and Operational Conditions are in place for the Operation of the Confederation Line Phase 1 and that identification of operational principles have been incorporated or appropriate measures put in place in readiness for RSA.

This conclusion can be used in aggregation to positively support the Non-Interference pillar.

3.2.11 Non-Interference Conclusion

For the Non-Interference objective, it can be concluded that each of the supporting objectives have satisfactorily been achieved. Therefore, through aggregation of the conclusions of the Non-Interference supporting objectives, which are:

- RAM & Safety
- Threat & Vulnerability
- Cyber Security
- EMC
- Grounding
- Human Factors and Ergonomics
- Operability.

ALS0084164

That through the approaches observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that no component of the integrated system shall interfere with or be interfered with by any other function of the integrated system or surroundings. In achieving this the railway can be deemed to be both Safe and Available in a Reliable manner providing appropriate Maintenance is undertaken.

This conclusion can be used in aggregation to positively support the Product Assurance argument.

3.3 CONFIGURATION CONSISTENCY

This section of the ESAC addresses the Configuration Consistency pillar of the Product Assurance Argument as depicted in Figure 10.

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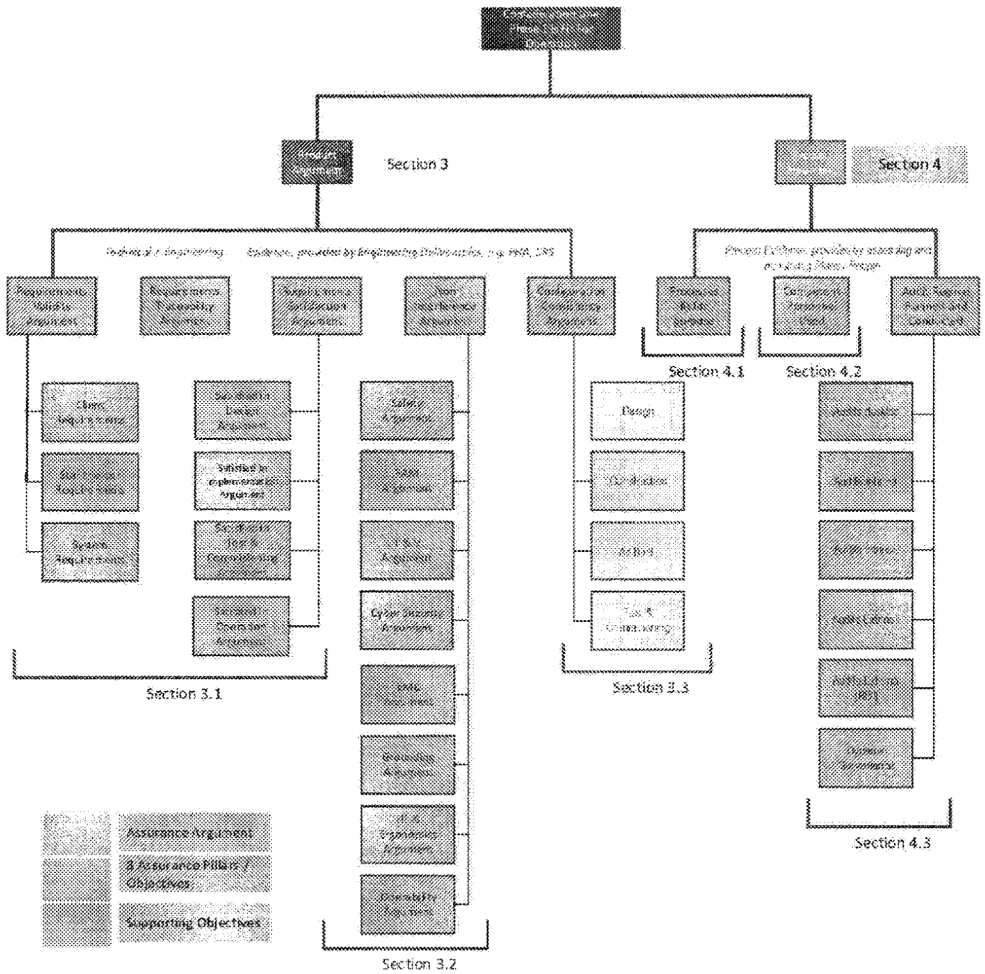

Section 3
Section 4
Section 3.1
Section 3.2
Section 3.3
Section 4.1
Section 4.2
Section 4.3
Design
Assurance Argument
3 Assurance Pillars / Objectives
Supporting Objectives

ALS0084164

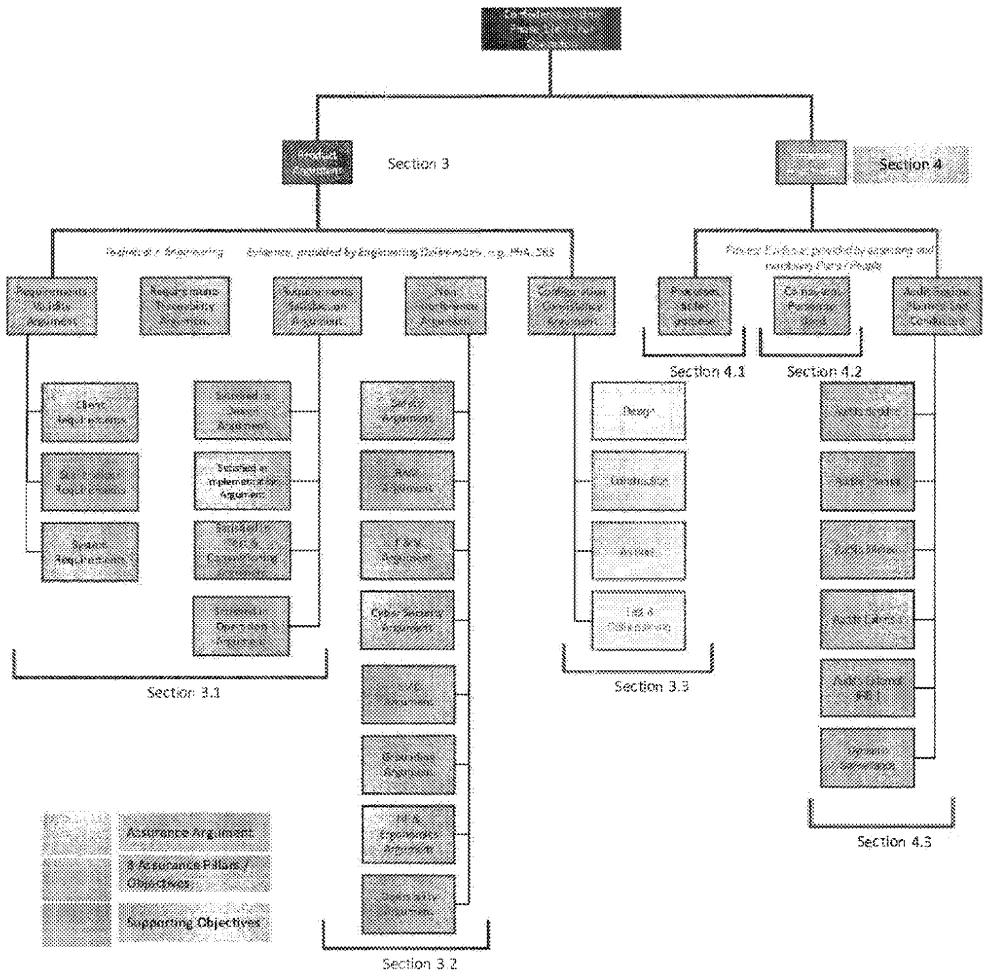

Figure 10: The Pillar of the Configuration Consistency Argument

For clarity of the evidence presented and conclusions drawn in this document the Configuration Consistency argument is described as:

Demonstrating that appropriate configuration control processes have been followed, were in place, and being adhered to.

3.3.1 Configuration Consistency Objectives

To demonstrate that appropriate configuration control processes were followed, were in place, were being adhered to and through this establish that sufficient As Installed data existed to support a stable As Installed baseline configuration.

ALS0084164

3.3.2 Approach

Configuration Management establishes and maintains consistency of a product's performance, its functional, and physical attributes with its requirements, design, and operational information throughout its life.

Configuration Management is the top-level methodology applied to the Confederation Line Phase 1.

As-Installed Baseline

This part of the ESAC considers the As-Installed configuration [313] of the Confederation Phase 1 Railway System and whether the As-Installed data is sufficiently complete (all data related to critical elements/Minimum Operating Requirements received) in order to support the decision to migrate the Confederation Line Phase 1 from delivery into operation to meet RSA.

Minimum Operating Requirements define the scope of the 'As Installed' baseline to support the Confederation Line Phase 1 Case for Safety and supporting Safety Cases'.

The objectives of the Configuration Management process were to:

- Identify the Configuration items as detailed in the systems breakdown structure – SBS [4]
- Set its first baselines to reflect the As Installed state of each asset
- Ensure the design requirements for systems were recorded and conformed to the PA [7] requirements
- Test results were recorded
- Redline drawings (packages) were identified to support achievement of As Commissioned status.

The **Configuration stages** covered:

- Construction
- As Installed
- Test and Commissioning (operational configuration).

The **Configuration Management process** included:

- Procedures for the authority to make organisational changes.
- Processes for incorporating the changes into project documentation.
- Processes for ensuring all relevant management units including System safety were made aware of the changes.

On the Confederation Line Phase 1 this covered design documentation, redline drawings, maintenance manuals, testing regimes, operating manuals and procedures.

ALS0084164

Configuration management detailed the process of how change to the system configuration was managed and controlled through all pertinent project management groups (e.g. Safety Management) and the associated project documentation.

3.3.3 Activities

Configuration Baseline Recovery

In the absence of any Configuration Management and Change Control management for Configuration baseline during the Design Stages of the Confederation Line Phase 1, a requirement for a rapid recovery action was identified and addressed through the production and implementation of the Configuration Management Recovery Plan [279] and Configuration Change Control Recovery Plan [310] in August 2018.

The Configuration Management Recovery Plan and Change Control process was rolled out and implemented in October 2018, audited by internal and external entities in order to examine its implementation progress, effectiveness of the recovery plans and to measure the status (completeness) of the Configuration baseline. Those reference audits were:

- SEMP-RSL-P0050-2018-2004 – 17th August 2018 – Configuration Recovery Plan
- OLR-04-0-0000-ARI-0068 – 30th August 2018 – Configuration Department Internal Audit report
- SEMP-RSL-P0050-2018-2016 – Implementation of the Change Control Process – November 2018
- RTG-OLRTC-SA-020 –City Audit dated 17th Jan 2019.

Change Control Board

A Change Control Board (CCB) was established in October 2018, as a result of the production of a Configuration Change Control Recovery Plan [310] and Configuration Management Recovery Plan [279]. A change control process was produced and together with signed formal terms of reference for the Change Control Board. The roll out completed through a formal workshop on 12th October 2018.

A Change Control Board team, comprising of Engineering Safety, Configuration and Change Representatives, Quality, Installation, Test & Commissioning, Integration Personnel (including the designers) was established and the quorum took place every week. Change Control Board – Configuration Management Meetings were documented.

Sixteen (16) RFI-CMs were reviewed by the change control board since its inception in October 2018 – there have been Fifteen (15) RFI-CMs closed out and One (1) which remains Open, at the time of this report.

In addition to the Railway System Level activities identified above, formal; Risk based Intrusion Audits [345], [346] and [347] were performed on the Alstom and Thales processes and plans to evidence the implementation of Configuration Control and Configuration Change Management [315] and [314].

Alstom and Thales baselines are not included in the Confederation Line Phase 1 Configuration Database.

ALS0084164

Minimal Operational Requirements (MORs)

The Minimal Operational Requirements (MOR) for Primary Systems as identified in the Configuration Management Recovery Plan [279], as Priority 1 configurable items, were fully captured in the Configuration Database. Details of the Configuration Database, PDM Plus tool are included within section Supporting Tools, PDM Plus.

The MOR represent the critical elements for which data is required to support operation and maintenance of the Confederation Line Phase 1.

Testing and Commissioning Data

The testing results and reports available were captured and inputted into the Confederation Line Phase 1 Configuration database.

As Commissioned Baseline

All redlines (100%) have been incorporated into the Configuration Management database including those related to Safety Critical Items to form the As Commissioned Baseline.

Redline drawings (packages) were identified to support achievement of the Configuration baseline. The baseline used the redline drawings of which the revision numbers were the same as the IFC revisions. The receipt of redlines were identified through submittal (unique number drawing submittals) and are reliant on the production of timely submissions of Redlines in readiness for handover to enable an Operational System.

3.3.4 Outputs

The Configuration Items database [313] system is built and functional.

The Configuration database was greater than 98% complete as of 30th May 2019, awaiting closure of RFI and final test results to achieve 100% completion.

Training Sessions for the use of the Configuration database were completed as part of the handover readiness to RTM Operations and Maintenance in August 2018, November 7th, 2018 and March 12th, 2019.

The Full content of the database, at the time, was handed over to RTM in March 2019 by means of a full download of all data into an excel format. The Operators and Maintainers were provided with full access to the Configuration database from May 2018.

3.3.5 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Configuration Consistency activities and analysis are identified in Table 12.

Table 12: Configuration Consistency Evidence

Ref	Title	Number
[279]	Configuration Management Recovery Plan	OLR-09-0-0000-MPL-0004
[310]	Configuration Change Control Recovery Plan	OLR-05-0-0000-MPL-0036

Ref	Title	Number
[311]	At Grade Station Condition Assessment Report (Hurdman)	OLR-05-0-0000-REP-0061
[312]	Underground Station Condition Assessment Report (Lyon)	OLR-05-0-0000-REP-0062
[313]	Configurable Items Database	OLR-09-0-0000-REG-0002
[314]	Thales Configuration Management Plan	3CU 05018 0020 QMZZA
[315]	Alstom Configuration & Change Management Plan	ADD0000939450
[316]	RTGE Joint Venture. CTS & Subsystems CM Plan	RES-53-0-0000-REP-0299
[262]	Design Change Management Procedure	OLR-QMS-GP700-SP02
[273]	Ottawa Light Rail Transit Project Specific Procedure: Field Directives	OLR-QMS-GP700-SP03
[274]	Ottawa Light Rail Transit Project Specific Procedure: Site Instructions	OLR-QMS-GP700-SP04
[317]	System Integration Program Plan	OLR-50-0-0000-MPL-0003
[306]	Red-Line and As-Built Procedure and Guidelines	OLR-QMS-GP700-SP13
[318]	REJ. Safety Certification Support Plan	REJ-05-0-0000-REP-0308
[255]	Design Quality Management Plan (DQMP)	REJ-04-0-0000-MPL-0022
[76]	Ottawa Light Rail Transit Project System Security Certification Plan (SSeCP)	OLR-05-0-0000-MPL-0005
[319]	Systems Engineering and Assurance Governance Document Tree Railway Level	OLR-05-0-0000-WBS-0002
[4]	Systems Breakdown Structure	OLR-09-0-0000-DIA-0001
[292]	OLRT-C. Documents & Records Control and Security Protocol	OLR-QMS-GP100-SP01
[263]	Request for Information Procedure	OLR-QMS-GP-700-SP06
[320]	PDM Plus User Guide	OLR-09-0-0000-REG-0003_D
[321]	PDM Plus and Scrape Tool	OLR-09-0-0000-REG-0004

3.3.6 Limitations

A Configuration baseline had not been established at the Design Stage of the Confederation Line Phase 1 Project therefore the production of As Commissioned drawings in timely fashion for Handover and Configuration baseline completion was not achieved.

ALS0084164

Configuration site surveys and associated reports were approximately 98% complete, the balance 2% were awaiting SIT results and IP addresses to be identified and incorporated into the configuration database for all database users.

As Commissioned drawings were not included in the Configuration Database at time of writing of this ESAC, however this does not impact the assessment of the 'As Installed' baseline [313] pertinent to this ESAC and consideration of the objective of appropriate configuration control processes being followed and in place.

Formal audits to prove maturity and completeness have not been performed on the Configuration database. Status reports, drawing registers and management reports can be run/ extracted from the configuration module as required.

3.3.7 Conclusions

It is can be seen that individual documents and drawings are controlled and managed and definition of overall technical baselines for the project are evidenced.

An OLRT design integration review has been undertaken and actions implemented, and configuration baselines of the OLRT Requirements for Design, have been established. Configuration change is demonstrated to have been implemented and under control, with configuration being maintained within a managed configuration database, which will be handed over to the client.

In conclusion, through the approach observed, activities recorded, evidence obtained and limitations considered it can be demonstrated that appropriate configuration control processes were followed, were in place, were being adhered to and through this established that sufficient As Installed data existed to support a stable 'As Installed' baseline configuration [313].

This conclusion can be used in aggregation to positively support the Product Assurance Argument.

ALS0084164

3.4 PRODUCT ARGUMENT CONCLUSION

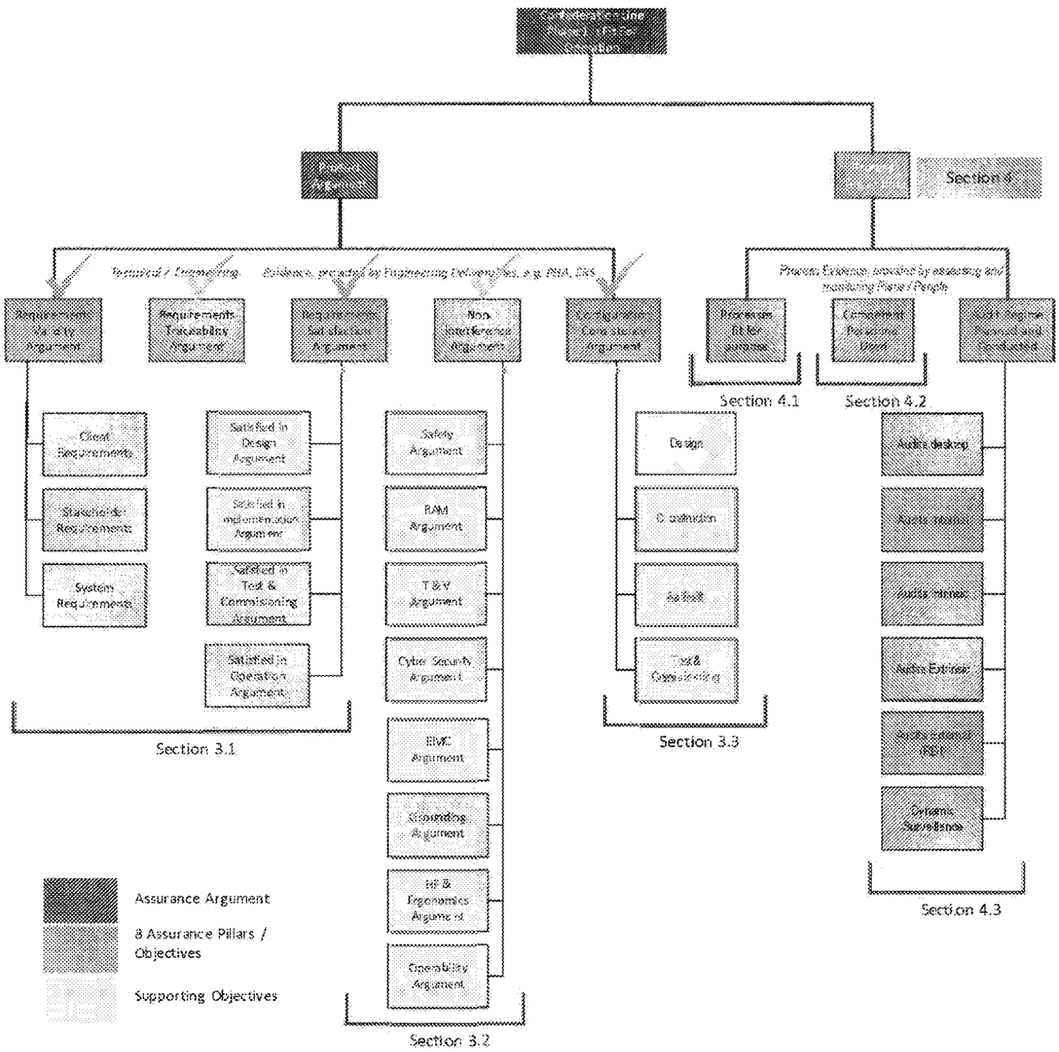

Figure 11: The 5 Pillars of the Product Argument

As previously stated, 'A System must possess the required properties for it to be 'Fit for Operation' and this can be in part achieved through satisfying the Product Assurance objectives' for Requirements – Validity, Traceability & Satisfaction, Testing and Commissioning.

Non Interference – RAM & Safety, Threat & Vulnerability, Cyber Security, EMC, Grounding, Human Factors & Ergonomics, Operability (SOPs) including conditions & limitations and Configuration Consistency.

The supporting objectives identified above have been analysed to stress test the argument, demonstrate and provide additional evidence that the objectives have been achieved and the product assurance argument can be made.

ALS0084164

Requirements Validity, Traceability and Satisfaction have been demonstrated and concluded with requirements and verification and validation having been effectively managed and delivered and therefore positively support the Product Assurance argument.

Non-Interference has been demonstrated through satisfaction of its supporting objectives RAMS, Threat and Vulnerability, Cyber Security, EMC, Grounding, Human Factors and Ergonomics and Operability and each in turn demonstrated that System Components will not interact with other systems in an unacceptable manner that may degrade the Confederation Line Phase 1 Railway and therefore positively supports the Product Assurance argument.

Configuration Consistency has been demonstrated through satisfaction of appropriate configuration and change control processes being established, implemented and adhered to and therefore positively supports the Product Assurance argument.

Each of the Product Assurance pillars and their supporting objectives has therefore been considered with each objective analysed. When these supporting objectives and their conclusions are aggregated it appears evident that there is no significant reason why the OLRT Product Argument cannot be made and that the Confederation Line Phase 1 'System possesses the required properties'.

This argument can be used in aggregation to positively support the overall argument that the Confederation Line Phase 1 is 'Fit for Operation'.

ALS0084164

4. PROCESS ARGUMENT

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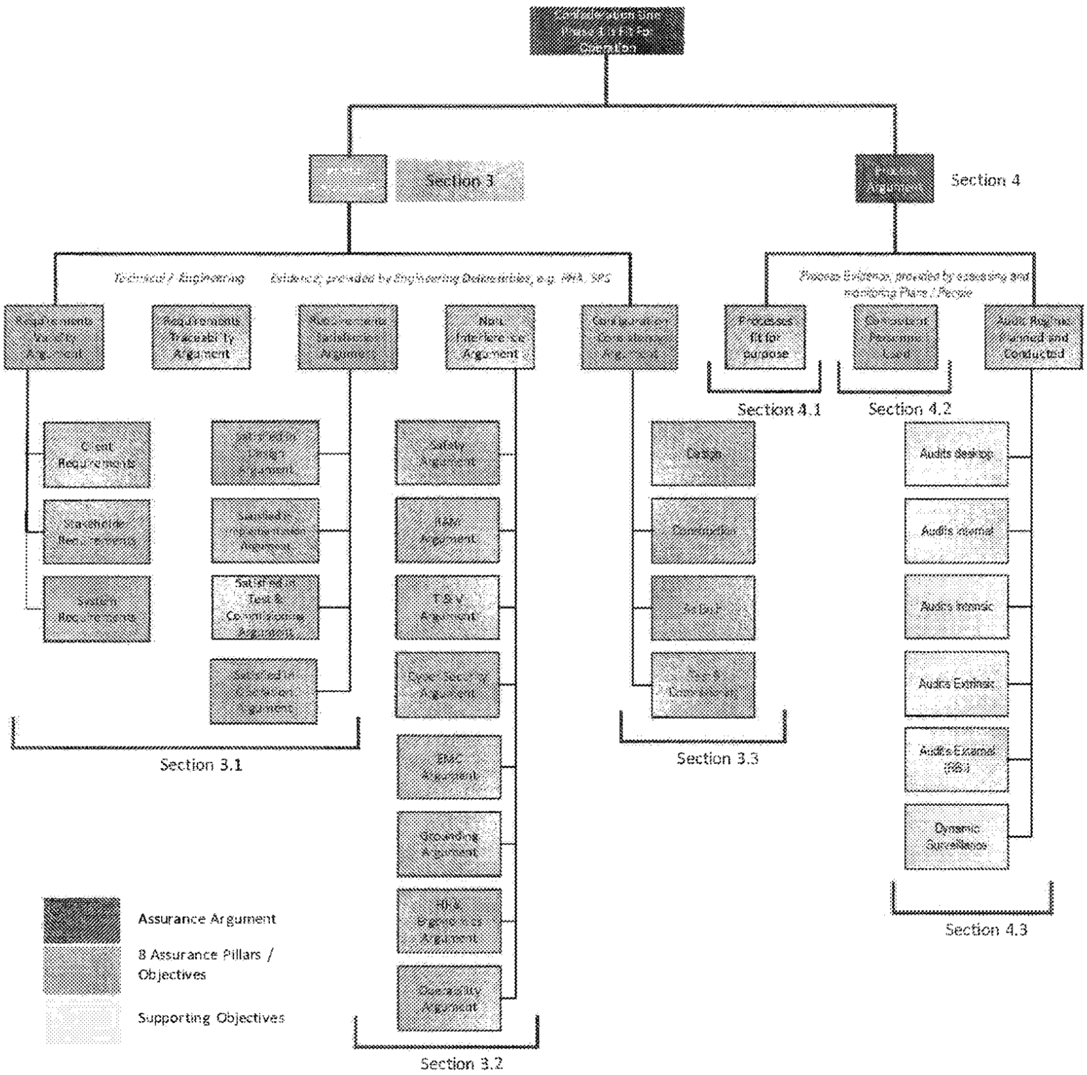

Section 3
Section 4
Requirements Traceability Argument
Non Interference Argument
Processes fit for purpose
Safety Argument
Design
Construction
Audits desktop
Audits internal
Audits Intrinsic
Audits Extrinsic
Dynamic Surveillance
Section 3.1
Section 3.2
Section 3.3
Section 4.1
Section 4.2
Section 4.3
Assurance Argument
8 Assurance Pillars / Objectives
Supporting Objectives

ALS0084164

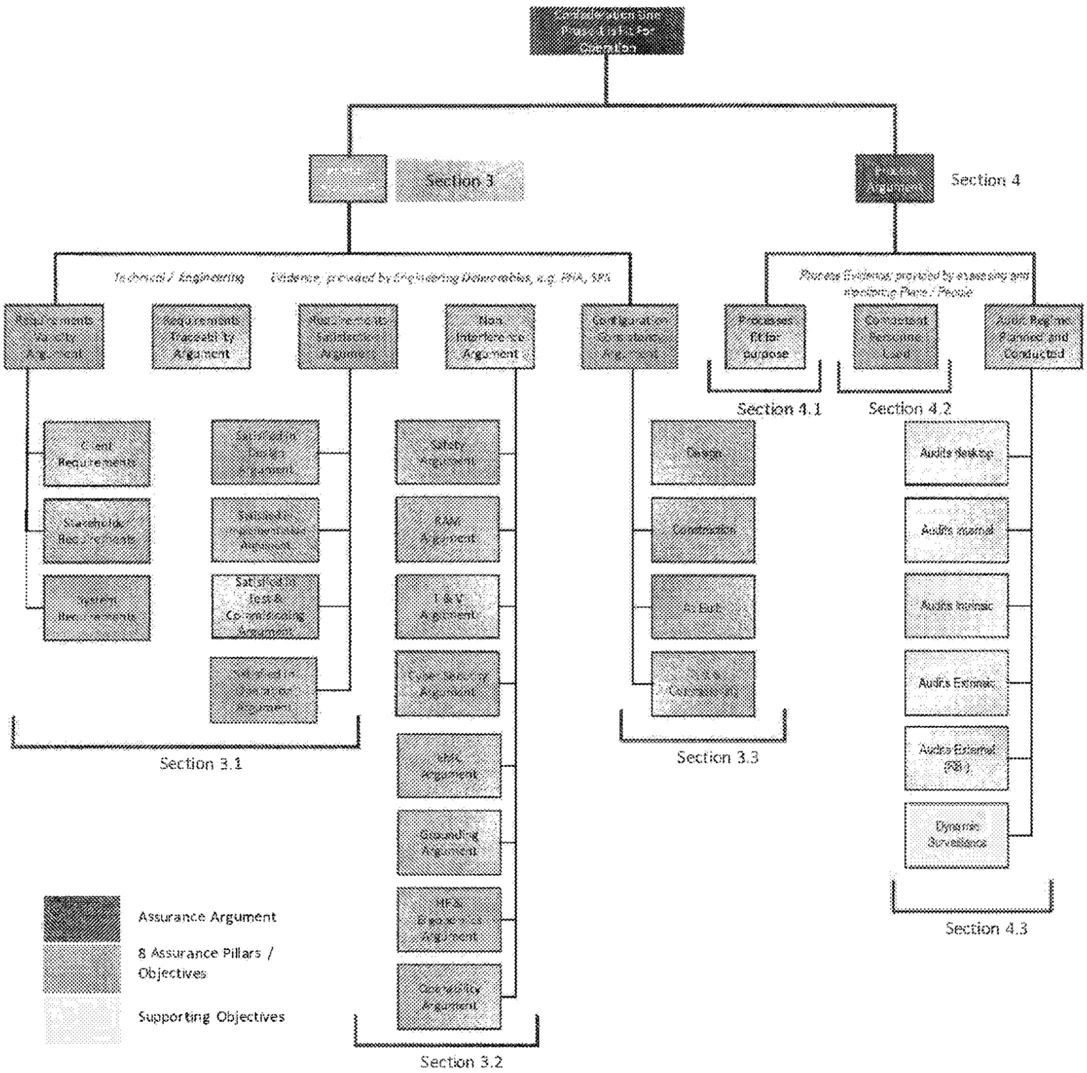

Figure 12: The 3 Pillars of the Process Argument

Provides the Process Argument demonstrating that the 'appropriate series of processes have been correctly executed by trained, experienced and competent personnel' for the System to be 'Fit for Operation' and this can be achieved through satisfying the Process Assurance objectives'.

This section provides the Process Argument demonstrating that the delivered System has been achieved through the application of appropriate processes, correctly executed by trained, experienced and competent personnel as satisfied by the three fundamental Process Assurance pillars and their supporting objectives as depicted in Figure 12 above. For clarity these are:

- Processes are fit for purpose
- Competent Personnel Used

ALS0084164

- Audit Regime Planned and Conducted.

These assurance arguments have been used to deliver OLRT Engineering Safety and Systems Assurance.

The following sections document that the Process Argument can be satisfactorily made and that Process Assurance has been successfully achieved. This is determined by setting out the approach taken, the specific activities carried out in accordance with that approach, identifying and stating any limitations in meeting the objectives and by presenting evidence obtained which demonstrates the successful conclusion.

4.1 PROCESSES FIT FOR PURPOSE

This section of the ESAC addresses the Processes Fit for Purpose pillar of the Process Assurance Argument as depicted in Figure 13.

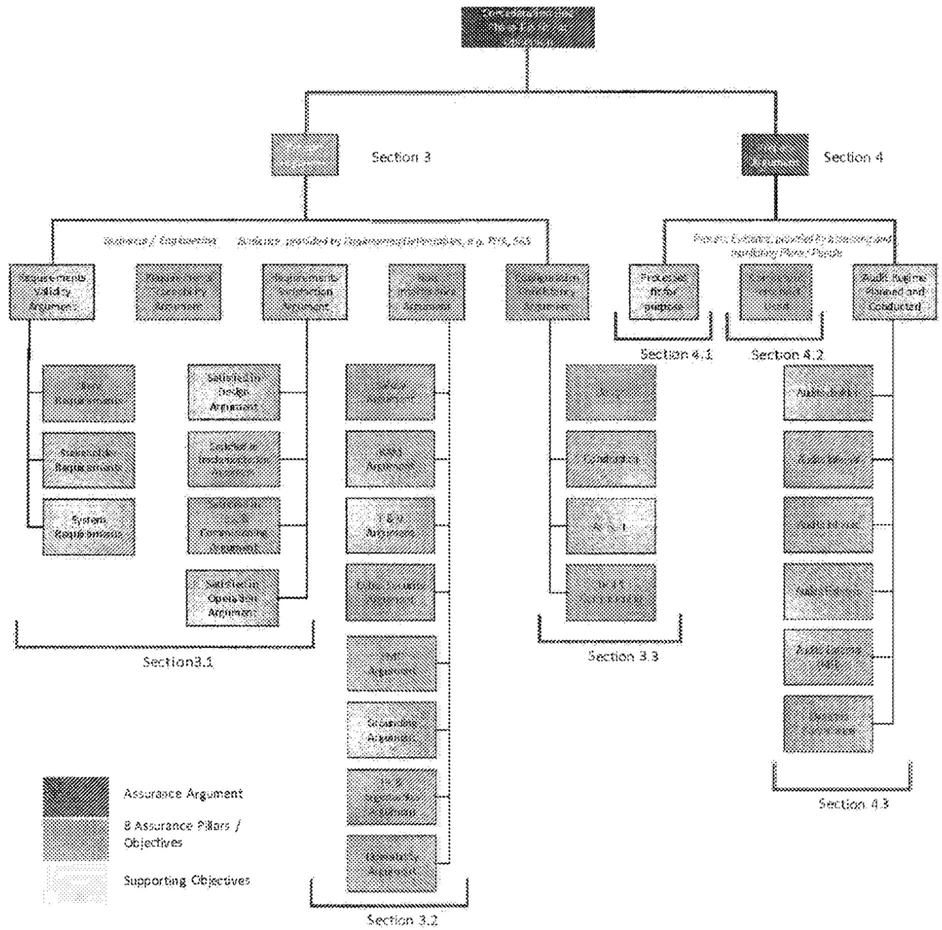

Figure 13: The Processes Fit for Purpose Pillar of the Process Argument

For clarity of the evidence presented and conclusions drawn in this document the Processes Fit for Purpose pillar is described as, providing the argument to demonstrate

ALS0084164

that appropriate processes have been utilised in the development of the OLRT Management System.

4.1.1 Objectives

Demonstrate that appropriate processes have been utilised in the development of the OLRT Management System and that the processes created and undertaken have been fully assessed and deemed to be acceptable for the purpose for which they were intended.

4.1.2 Approach

Across the Confederation Line Phase 1 and in line with Systems Assurance best practice, all activities were performed in line with processes that were appropriate and sufficient for the purpose for which they were intended. By confirming the processes were fit for purpose it facilitated an effective platform to ensure staff were sufficiently competent in such process related activities.

The processes referred to in this section covered both those introduced at Railway level as well as those employed to ensure the Systems Assurance activities were managed and effective.

Process creation and implementation played a significant role in ensuring a consistent approach was taken to the Systems Assurance activities associated with the Confederation Line Phase 1 project.

4.1.3 Activities

To achieve the objective the following were developed, implemented and monitored:

- Tracking of Statement of No Objection (SONO) and non SONO requiring deliverables via the Responsible, Accountable, Consult, Inform – Statement of No Objection (RACI-S) [323].
- Derivation and Determination of Assurance Requirements through planned workshops, meetings, correspondence and reports
- Audit Follow Up and Close Out – Terms of Reference for the Risk Based Intrusion Audits on EJV, Thales & Alstom [325] – for additional details see Section 4.3
- Identifying, monitoring and close out of System Assurance Hazards, RAM and Safety related issues identified in 2017 and early 2018
- Comments Resolution (CRE) Monitoring and Close Out
- Creation and Implementation of OLRT-C Hazard Management Procedure [24]
- Set Up, Management and Delivery of a SEMP OLRT-C Data Requests
- The development, implementation (roll out) of SEMP OLRT-C Project Management System Folder Structure (Assurance) (PMS)
- Creation and Implementation of Project Assurance Plans (MSF, At Grade Stations, Underground Stations and Primary Systems Level) [336], [337], [338] and [333]

ALS0084164

- Conducting of Design Integration Review (DIR) and issue of actions report [339]
- DITLO process.

4.1.4 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Processes Fit for Purpose activities and analysis are identified in Table 13.

Table 13: Process Evidence

Ref	Title	Number
[319]	Systems Engineering and Assurance Governance Document Tree Railway Level	OLR-05-0-0000-WBS-0002
[323]	RACI-S	SEMP-P0050-PLA-0020
[325]	Terms of Reference for the Risk Based Intrusion Audits on EJV, Thales & Alstom	
[326]	SAA Monitoring and Close Out Process SAA Register	SEMP-PRO-00012 SEMP-REG-0008
[24]	OLRT-C Hazard Management Procedure	OLR-50-0-0000-MPL-0009
[329]	Data Request Process	SEMP-P0050-PRS-0005
[330]	Design Certification	OLR-00-0-0000-REG-0012
[331]	Construction Certification Log	OLR-00-0-0000-REG-0012
[332]	Thales PICOs Tracker	OLR-04-0-0000-REG-0026 (Thales only)
[333]	OLRT-C Primary Systems Level Project Assurance Plan	OLR-05-0-0000-MPL-0017
[334]	OLRT Authority Approval Process Plan	OLR-05-0-0000-MPL-0008
[137]	Construction Quality Management Plan	OLR-04-0-0000-MPL-0017
[263]	Request for Information Procedure	OLR-QMS-GP700-SP06
[275]	Management of Non Conformances	OLR-QMS-GP4 01
[91]	HRP Terms of Reference	SEMP-DOC-0002
[336]	OLRT-C Maintenance Storage Facility Project Assurance Plan	OLR-05-0-0000-MPL-0039
[337]	OLRT-C At Grade Stations Project Assurance Plan	OLR-05-0-0000-MPL-0032
[338]	OLRT-C Underground Stations Project Assurance Plan	OLR-05-0-0000-MPL-0033
[339]	Design Integration Review Meeting Minutes	OLR-05-0-0000-MOE-DIR-0001

ALS0084164

Ref	Title	Number
	Design Integration Review Presentation	OLR-05-0-0000-PRE-0004

4.1.5 Limitations

Not all the processes identified in the plans were audited due to time constraints and therefore focus was given to those relating to Safety, RAM and Compliance.

4.1.6 Conclusions

Having evaluated these key areas and Systems Assurance activities together with the conclusions identified within the competency and audits sections, it is evident that significant Assurance has been implemented and achieved and a reasonable level of processes and procedures had been established to ensure a robust approach was taken and processes being Fit for Purpose.

The approach and activities undertaken supported by the evidence obtained and presented demonstrates that appropriate processes have been utilised in the development of the OLRT Management System and that the processes created and undertaken have been fully assessed and deemed to be acceptable for the purpose for which they were intended.

This conclusion can be used in aggregation to positively support the Process Assurance Argument.

ALS0084164

4.2 COMPETENT PERSONNEL USED

This section of the ESAC addresses the Competent Personnel Used pillar of the Process Assurance Argument as depicted in Figure 14.

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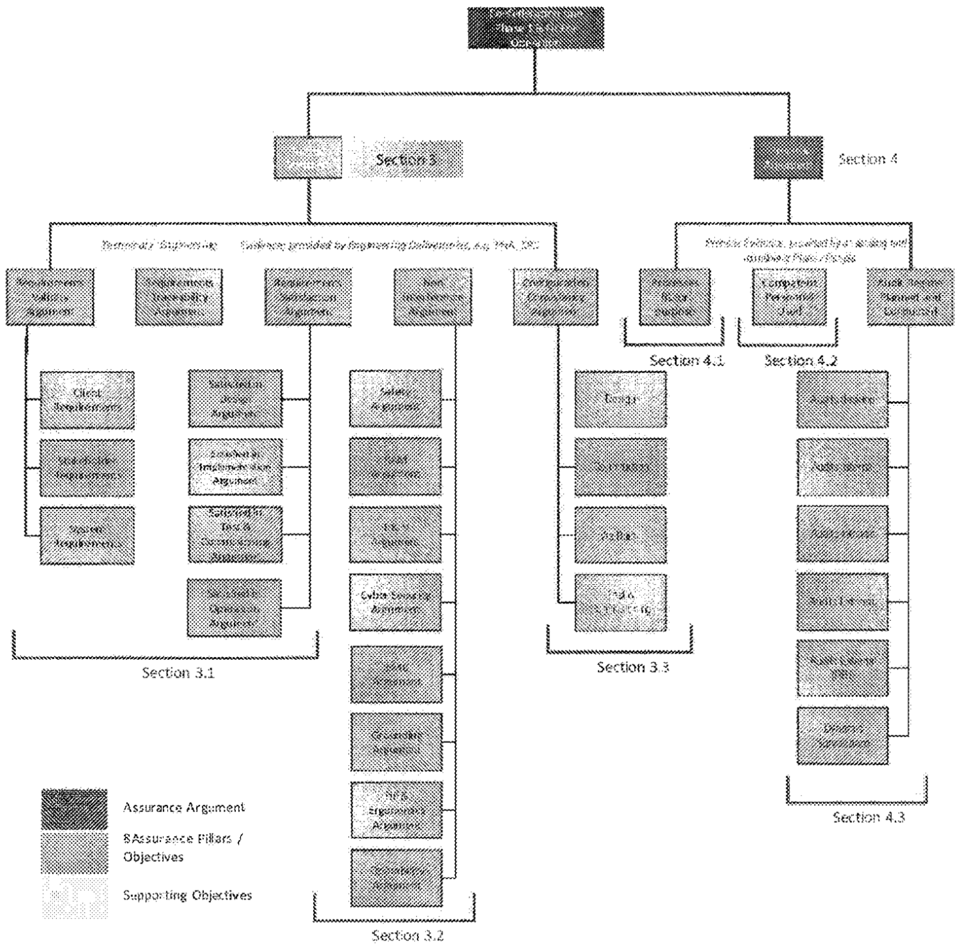

Section 3
Section 4
Section 3.1
Section 3.2
Section 3.3
Section 4.1
Section 4.2
Section 4.3
Design
Assurance Argument
8Assurance Pillars / Objectives
Supporting Objectives

ALS0084164

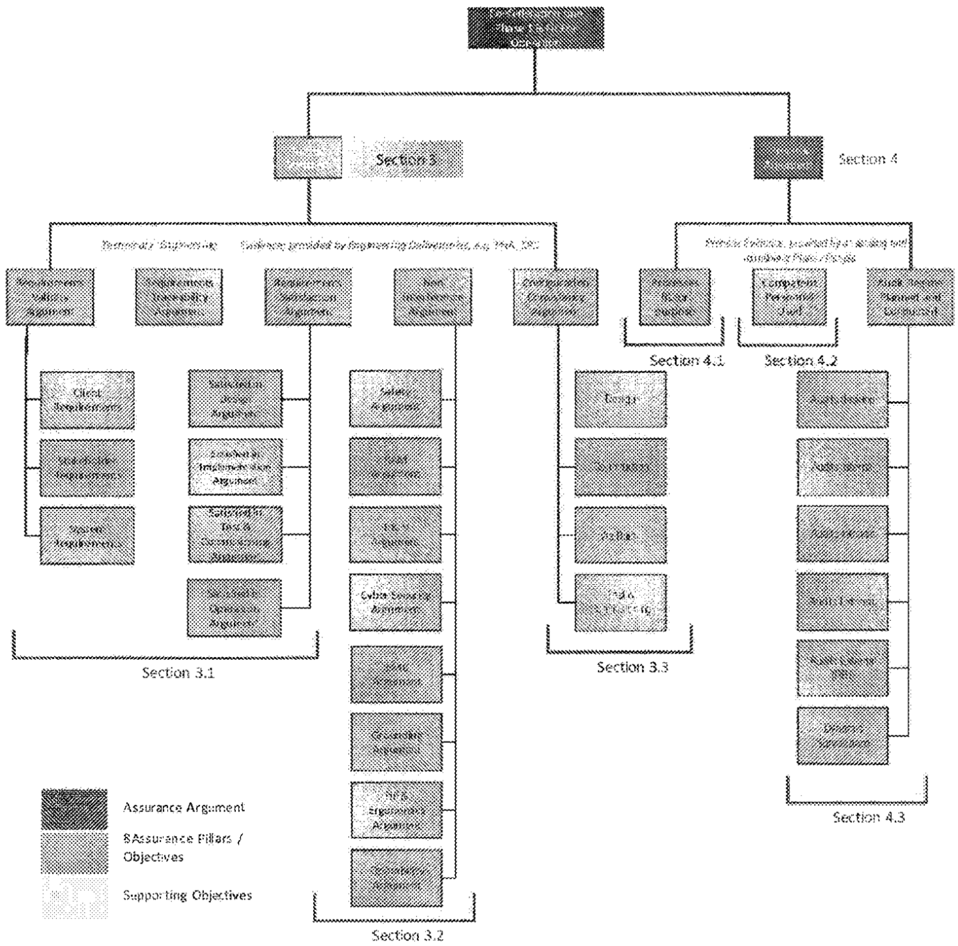

Figure 14: The Competent Personnel Used Pillar of the Process Argument

For clarity of the evidence presented and conclusions drawn in this document the Competent Personnel Used pillar is described providing the argument to demonstrate that competence of personnel has been managed.

4.2.1 Objective

Demonstrate that the processes have been executed by personnel with competency that meets the requirement and that appropriate Competency arrangements are in place with relevant staff having been assessed against these controls.

4.2.2 Approach

The Competency Management Regime applied to the scope of work contracted to OLRT-Constructors for the Primary Systems as specified within the PA [7] and as detailed in

Figure 4 – OLRT Project Levels and Scope Boundaries –detailed in Section 1.3 Scope above.

For the purposes of Competency Management, the scope of Competency included the systems of Signalling, Train Control and Light Rail Vehicles, but excluded Operations and Maintenance.

The main area of focus was on the Primary Systems associated with the Minimum Operating Requirements (MOR) as defined in the Configuration Management Recovery Plan [279].

For all Engineering activities concerning the Primary Systems for MOR, the Confederation Line Phase 1 Project adhered to the requirements of the Professional Engineers Act – 1980. In the province of Ontario, these requirements are controlled by a Professional Engineer Ontario (PEO) governing body.

Competency is based upon the requirements of:

'The Professional Engineers Act – 1980

- Licensing requirements shall be to the requirement R.S.O. 1990, c.P.28, s.12(1):2001, c.9, Schedule B, s.11(16).

  No persons shall engage in the practice of professional engineering or hold himself, herself or itself out as engaging in the practice of professional engineering unless the person is the holder of a licence, a temporary licence, a provisional licence or a limited licence.

Certificate of Authorisation

- Shall be in accordance with R.S.O. 1990, c.P.28, s.12 (2).

  No person shall offer to the public or engage in the business of providing service to the public services that are within the practice of professional engineering except under and in accordance with a certificate of authorisation.'

The rigorous assessment carried out (by law) of all engineers who hold the PEO 'seal' ensures that the competency requirements laid out in the OLRT-C Competency Management Plan (CMP) [340] were fully satisfied. The PEO license holder is referred to as an EoR.

4.2.3 Activities

A controlled listing of PEOs and EoR s together with their disciplines utilised was held on record and used to validate DCL, CCLs, Integrated Certification Letters (ICL) and Test Certification Letters (TCL). These documents represented the primary demonstration and application of competence, for works completed within each project lifecycle stage.

To ensure within the project, traceability and control of competency to discipline the 'RTG EJV DCL number assignment log' was created as a managed document that aligned individual EoRs with products and associated DCLs / CCLs / ICLs / TCLs. This document was managed by Technical Director of the Confederation Line Phase 1 and contained within the Project (4P) Document Management Database.

In addition to EoR's, specialist engineering professionals were engaged on Confederation Line Phase 1, such as (but not limited) to EMC specialists, Cyber Security specialists,

ALS0084164

Threat and Vulnerability – Security specialists and were documented in the EoR EJV Competency Matrix [341] which was managed and maintained by the Confederation Line Phase 1 Technical Director.

ENGINEERS OBLIGATIONS ON THE CONFEDERATION LINE PHASE 1 PROJECT

Design Certification Letters

- The EoR shall sign and seal the relevant DCL's to confirm that the PA [7] requirements (including, but not limited to, all codes, standards and specifications) have been satisfied in design. Any exceptions shall be detailed and, if applicable, subject to the OLRT-C Non Conformance management process [275].

OLRT-C established the Design Certification Log [330] to evidence production of DCLs, signed by the respective EoR and associated with the specific area of work. The log defined all design packages required to deliver the OLRT-C scope of works and therefore supported demonstration of completeness.

Construction Certification Letters

- The EoR shall sign and seal the relevant CCL's to confirm that the design requirements detailed in the relevant DCL have been satisfied in Construction. Any exceptions shall be detailed and, if applicable, subject to the Management of Non Conformances process [275].

OLRT-C established the Construction Certification Log [331] to evidence production of CCLs, signed by the respective EoR and associated with the specific area of work. The log also defined all design packages required to deliver the OLRT-C scope of works and therefore supported demonstration of completeness.

Test Certification Letters

- The T&C Director and Systems Integration Director shall sign the TCL to confirm that all test scripts have been successfully carried out. All test failures shall be detailed and, if applicable, subject to Management of Non Conformances process [275].

OLRT-C have established and stored the TCL signed by the T&C Director and Systems Integration Director, within the Project (4P) Document Management Database.

Integration Certification Letters

- PEO Guidance – Section 6.3 'Use of the professional Engineer's Seal stated: For a project covering work within several engineering disciplines, all documents within a particular engineering discipline must be sealed by the engineer taking responsibility for work within that discipline, with an indication or qualification of which discipline is implied by the seal. The supervisory or co-ordinating engineer (if available) should also apply his or her seal to indicate that the work of the various disciplines has been coordinated. If only one signature and seal is used, it should be that of the engineer taking responsibility for the work, generally the coordinating engineer.
- These requirements apply to systems that are comprised of different engineering disciplines and as a consequence have a number of different DCLs/CCLs applicable to them.

ALS0084164

- The responsible coordinating engineer has evaluated all relevant supporting data and has applied their seal to the Integration Certification Letter (ICL) confirming that all systems have been integrated satisfactorily.

OLRT-C, using a risk based approached considering, system criticality, interface type and complexity, established a suite of ICL to ensure that the most significant areas of integration were targeted to support engineering safety and assurance, as shown in Figure 15 below.

Name	Revision	Description
OLR-53-0-0000-ICL-0005	0	Integrated Conformance Letter – SCADA Server to CCTV Server
OLR-53-0-0000-ICL-0006	0	Integrated Conformance Letter – SCADA to PA
OLR-53-0-0000-ICL-0007	0	Integrated Conformance Letter – Overhead Catenary System (OCS)
OLR-53-0-0000-ICL-0010	0	Integrated Conformance Letter – Train Operations Control Centre (TOCC)
OLR-53-0-0000-ICL-0009	0	Integrated Conformance Letter – Traction Power to Medium Voltage
OLR-53-0-0000-ICL-0001	0	Integrated Conformance Letter – Network Management System
OLR-53-0-0000-ICL-0002	0	Integrated Conformance Letter – SCADA to CBTC
OLR-53-0-0000-ICL-0003	0	Integrated Conformance Letter – SCADA to Tunnel Ventilation System (TVS)
OLR-53-0-0000-ICL-0004	0	Integrated Conformance Letter – SCADA to Traction Power

Figure 15: Nine Targeted ICL with in 4P

Aggregation of Certification Letters and Certificates of Authority

OLRT-C Competency Management Plan [340] Section 2.3 detailed the aggregation methodology for Primary System Level and Railway System Level Certification Letters and Certification for Authority application.

OLRT-C established the Design and Construction Certification Log [330/331] to evidence aggregation of Certification Letters, signed by the respective EoR and associated with the specific aggregated packages of work.

ALS0084164

SUPPORTING ENGINEERS (NONE PEO)

- Evaluation Methodology:

  For supporting engineers roles that fell outside of the PEO requirements, a number of alternative evaluation methods were implemented. These included the use of:

  - A Competency Framework
  - Review of CVs
  - Intrusive Audits.

The scope of evaluation used a risk-based approach, at the discretion of the Systems Assurance Lead, to determine which main suppliers would be subjected to assessment.

Systems Engineering

- The SEMP Competency Framework was used to assess all Systems Engineering and Systems Assurance functions. Scoring to confirm the adequate competency of the engineer and / or identify areas of development and increased supervision. This was Primarily applicable to the SESA Engineers:
- The retention of records such as CVs, Training, Professional membership, experience, theoretical and practical knowledge
- Verifying by audit the Competency Management regime
- Review and feedback report.

ALS0084164

4.2.4 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Competent Personnel Used activities and analysis are identified in Table 14.

Table 14: Competency Evidence

Ref	Title	Number
[340]	OLRT-C Competency Management Plan	OLR-05-0-0000-MPL-0040
[341]	Cross reference of EoR Against Activities	EoR EJV Competency Matrix – OLR-00-0-0000-REG-0014
[342]	SEMP Competency Framework	OLR-04-0-0000-MPL-0001
[343]	Professional Specialists Engineers listing	See [341]
[344]	Professional Engineers Act	90p28_e
[3]	OLRT-C System Assurance Management Plan	OLR-05-0-0000-MPL-0020
[345]	Systems Engineering and Assurance Technical Audit (Alstom) Report	SEMP-PSL-AUD-2018-2003
[346]	Systems Engineering and Assurance Technical Audit (Thales) Report	SEMP-PSL-AUD-2018-2002
[347]	Systems Engineering and Assurance Technical Audit (EJV) Report	SEMP-PSL-AUD-2018-2001

4.2.5 Limitations

There were no Competency Audits performed on the OLRT-C personnel / workforce organisation.

Evidence of competency and competency management systems being in place was requested and recorded within the respective audit reports [345], [346], [347], however in some cases evidence was not provided by the third party. Therefore, it has not been possible to demonstrate competency for all third parties such as Thales and Alstom. It is to be assumed that these organisations have their own competency arrangements in place.

4.2.6 Conclusions

Although it is not possible to certify that all staff can be considered competent due to the condition identified in Section 4.2.5 above, it is considered that appropriate measures have been implemented to ensure as far as possible, that all staff involved in the Confederation Line Phase 1 project do have sufficient competency to carry out their specified tasks and furthermore this has been underpinned by the competency of the EoRs as regulated by the Professional Engineers Act – 1980.

ALS0084164

The approach and activities undertaken supported by the evidence obtained and presented demonstrates that the processes were executed by personnel with the required competency and that appropriate Competency arrangements were in place with relevant staff having been assessed against these controls, therefore competency has been managed.

This conclusion can be used in aggregation to positively support the Process Assurance Argument.

4.3 AUDIT REGIME PLANNED AND CONDUCTED

This section of the ESAC addresses the Audit pillar of the Process Assurance Argument as depicted in Figure 16.

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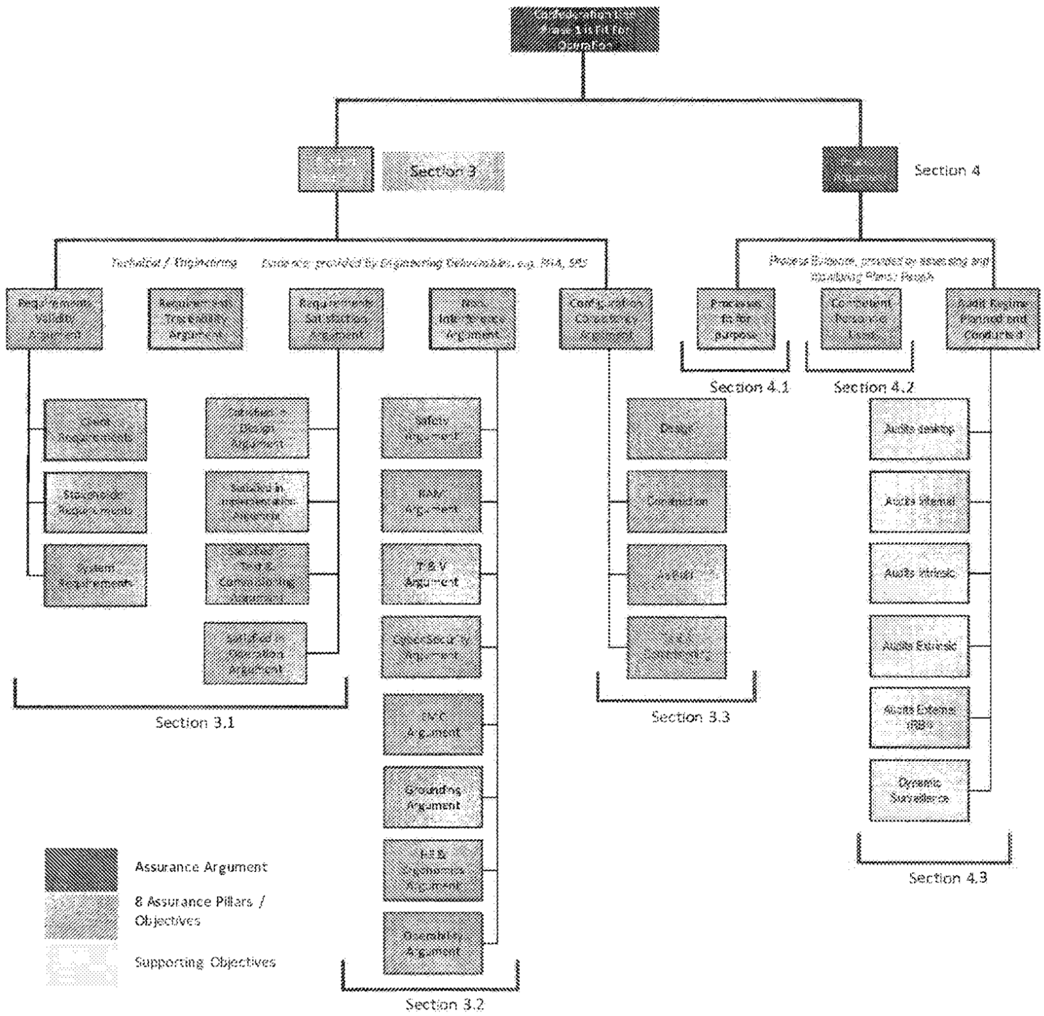

Section 3
Section 4
Requirements Validity Argument
Requirements Traceability Argument
Requirements Satisfaction Argument
Configuration Consistency Argument
Processes fit for purpose
Competent Personnel
Audit Regime Planned and Conducted
Client Requirements
Stakeholder Requirements
System Requirements
Satisfied in Design Argument
Satisfied in Operation Argument
Safety Argument
RAM Argument
T & V Argument
CyberSecurity Argument
EMC Argument
Grounding Argument
Operability Argument
Design
Construction
Audits desktop
Audits Internal
Audits Intrinsic
Audits Extrinsic
Dynamic Surveillance
Section 3.1
Section 3.2
Section 3.3
Section 4.1
Section 4.2
Section 4.3
Assurance Argument
8 Assurance Pillars / Objectives
Supporting Objectives

ALS0084164

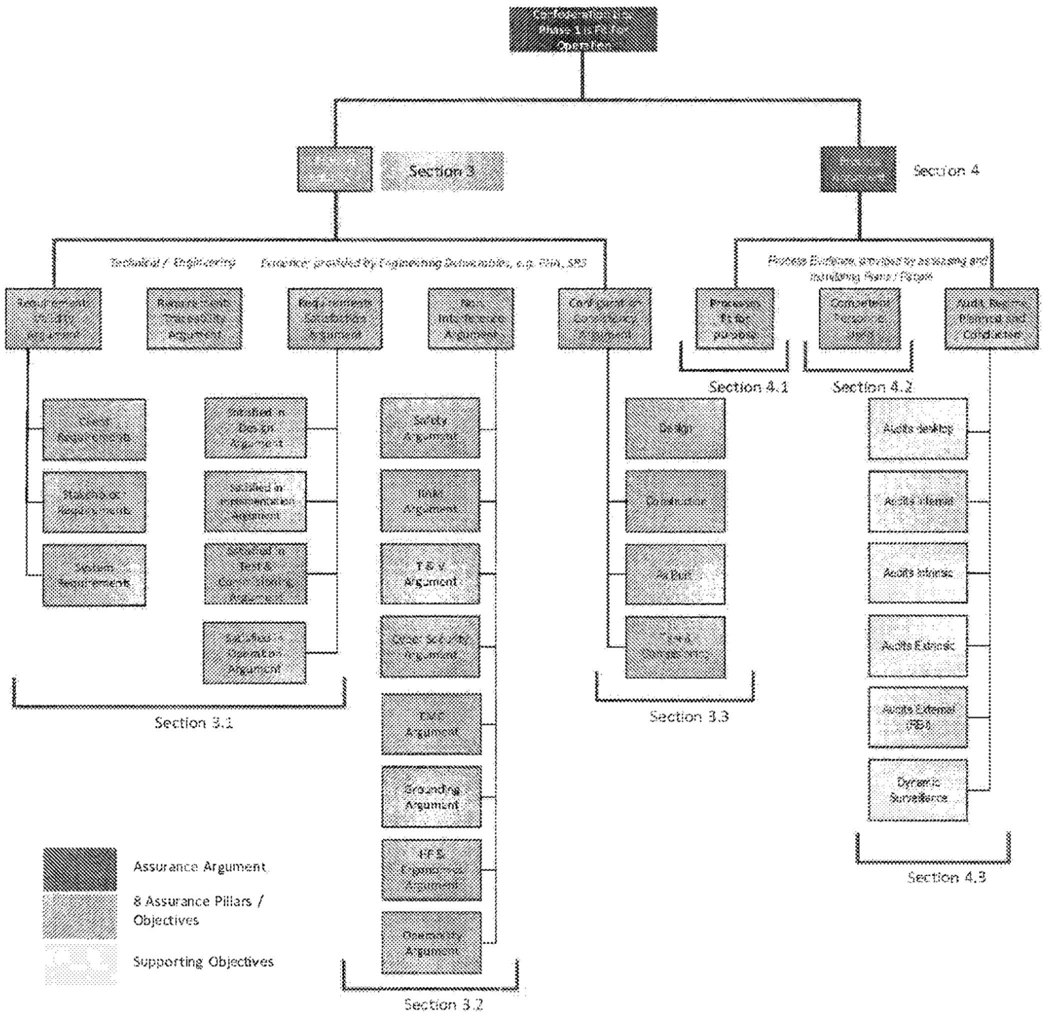

Figure 16: The Audit Regime Planned and Conducted Pillar of the Process Argument

Provides the argument to demonstrate that a robust Risk Based Intrusion (RBI) audit management regime and audit process has been fully implemented (all audit stages) to confirm that processes, plans, competence, requirements, Validation & Verification and RAMS have been managed on the Project.

4.3.1 Objective

Demonstrate that a robust Risk Based Intrusion (RBI) audit management regime and audit process was used to confirm that processes, plans, competence, requirements, Validation & Verification and RAMS were managed on the Project.

4.3.2 Approach

This section of the ESAC summarises the status of activities and evidence relating to Systems Assurance and Systems Engineering audits (all types) that were performed in support of the Process Assurance argument for the Confederation Line Phase 1.

ALS0084164

Quality Management audits are addressed under Section 5, the Quality Management section of this ESAC.

Systems Assurance applied to Safety Assurance, Product Assurance, Process Assurance and People Assurance and was primarily concerned with providing confirmation that plans, processes and procedures were established, implemented and maintained and that they were effective. In support of these requirements the key activities undertaken were Systems Assurance audits.

4.3.3 Activities

A schedule of audits was applied; the depth and application of the process (Audit) was based on the level of risk involved.

These audits addressed all aspects of the Design Management Plan, Systems Engineering Management Plan and their subordinate plans and was aligned with the identified scheduled project Systems Engineering audits documented in SEMP-P0050-0-0000-REG-0003 – Audit Status Report Log [348].

The Systems Assurance Lead and designated Lead Auditor (Assurance) was supported by specialist representatives with the necessary competence and experience to perform the scheduled audits using scope and audit criteria to meet the elements of ISO 15288; ISO 50126; ISO 9001. RBI Audits were performed using the principals of ISO 19011:2011.

Planned Surveillance and Monitoring (Audit) – Field Assurance

The surveillance of the Confederation Line Phase 1 Project was an inherent element for ensuring that processes were being complied with in support of the Process Assurance Argument.

Surveillance and Monitoring was performed to confirm that Systems Assurance compliance had been achieved by the Confederation Line Phase 1 project. A schedule of surveillance, in-process inspection and monitoring was and continues to be applied.

Key operations were surveyed, inspected and monitored to confirm that operational controls were effective. The surveillance and monitoring programme activities were fully completed and with no further surveillances planned.

EJV (RBI) Audit – External Audit – SEMP-PSL-AUD-2018-2001 [347]

An External audit of the EJV organisation producing the OLRT-C design was performed, to ensure that they had competent persons and were applying appropriate processes and procedures as a party with recognised significant risk to the delivery of a viable, useable, operational and maintainable product.

In support of the audit and demonstration of Assurance data was requested from EJV regards competency and process known as follow up and close out of audit as detailed and documented in the Intrusive Audit Action Tracker [350].

The audit was performed by the Head of Systems Engineering and Systems Assurance and the Systems Assurance Lead.

Thales (RBI) Audit – External Audit – SEMP-PSL-AUD-2018-2002 [346]

ALS0084164

An External audit of the Thales organisation producing the OLRT Signalling and Train Control System which interface with the infrastructure and systems OLRT-C deliver, was performed to ensure that they had competent persons and were applying appropriate processes and procedures as a party with recognised significant risk to the delivery of an integrated viable, useable, operational and maintainable product.

In support of the audit and demonstration of Assurance, data was requested from Thales regards competency, process and provision of their safety case known as follow up and close out of audit as detailed and documented in the Intrusive Audit Action Tracker [350].

The audit was performed by the Head of Systems Engineering and Systems Assurance and the Systems Assurance Lead.

Alstom (RBI) Audit – External Audit – SEMP-PSL-AUD-2018-2003 [345]

An External audit of the Alstom organisation producing the OLRT Vehicles which interface with the infrastructure OLRT-C deliver, was performed to ensure that they had competent persons and were applying appropriate processes and procedures as a party with recognised significant risk to the delivery of an integrated viable, useable, operational and maintainable product.

In support of the audit and demonstration of Assurance data was requested from Alstom regards competency, process and provision of their safety case known as follow up and close out of audit as detailed and documented in the Intrusive Audit Action Tracker [350].

The audit was performed by the Head of Systems Engineering and Systems Assurance and the Systems Assurance Lead.

Dynamic Audits

Various dynamic audits were performed including:

- Configuration and Change Control
- Document Control Procedures and Document Numbering in 4P
- Engineering Safety Assurance Case Readiness
- Non-Conformance, RFI, Variations, SVR, Site Issues and Data Requests
- Track Assurance Report 1 – Tunneys Pasture to Tunnel Portal West [34]
- Track Assurance Report 2 – Tunnel Portal West to uOttawa – Limit of Slab [75]
- Track Assurance Report 3–Limit of Slab (uOttawa) to Blair [35]
- OLRT Stations Accessibility Review [349]
- Track Assurance Report- Derailment Management [36].

Surveillance and Monitoring

A variety of surveys, inspections, condition assessments and observations were carried out as part of Systems Assurance to determine compliance, verify mitigations, monitor processes, corroborate design, observe good practice/compliance and ascertain information; these included:

- Threat and Vulnerability Requirements Compliance Inspections

ALS0084164

- NFPA 130 Requirements Compliance Inspections
- City of Ottawa Accessibility Design standard (COADs) requirement compliance inspection
- Hazard Review Panel Hazard mitigation action confirmation inspections
- Integrated Hazard Log Hazard mitigation action confirmation inspections
- Condition Assessments of Hurdman and Lyon Stations
- Observation survey at MSF for implementation of good practice
- Observation surveys to corroborate design is as-built
- Observation surveys to conform NCR/SVT/site issue actions implemented
- Observation surveys to identify potential issues and non-compliance
- Observation surveys for implementation of good practice
- Desktop surveys to identify safety issues within change logs (NCR/SVR/Variations).

Many repeat observation surveys were carried out and confirmed that reported issues from the observation surveys were being satisfactorily rectified.

Dynamic Surveillance

Where engineering management practices and processes were considered to be high risk to the Project there was an increased level of surveillance, inspection and audit which was applied to satisfy the risk-assessed mitigation. This requirement was expanded to capture subcontractor processes as required.

4.3.4 Outputs

A number of audit and surveillance reports were produced as defined in the SEMP Audit Status Report Log [348].

Follow Up audits and close out activities were scheduled and documented on weekly basis to address the findings in each risk based intrusion Systems Assurance and Systems Engineering Audit.

Findings in the risk based intrusive audits were addressed and closed out.

The condition surveys on Hurdman & Lyon stations were completed in March 2019 by the Systems Assurance Fieldwork Engineers.

Ottawa City performed scheduled audits in parallel with the SESA Audit programme. These are not documented in this ESAC.

Table 15: Audit Outputs

Ref	Title	Number
[348]	SEMP Audit Status Report Log	SEMP-P0050-REG-003
[347]	Systems Engineering and Assurance Technical Audit (EJV) Report	SEMP-PSL-AUD-2018-2001

ALS0084164

Ref	Title	Number
[346]	Systems Engineering and Assurance Technical Audit (Thales) Report	SEMP-PSL-AUD-2018-2002
[345]	Systems Engineering and Assurance Technical Audit (Alstom) Report	SEMP-PSL-AUD-2018-2003
[350]	Intrusive Audit Action Tracker	OLR-05-0-0000-REG-0013

4.3.5 Evidence

As proof of satisfactory achievement of the objectives the key documents generated throughout the Audit Regime Planned and Conducted activities and analysis are identified in Table 16

For a full listing of audits and their types of audit performed during the project delivery see the SEMP Audit Status Report Log [57]

Table 16: Audit Evidence

Ref	Title	Number
[34]	Track Assurance Report 1	OLR-22-0-0000-REP-0001
[75]	Track Assurance Report 2	OLR-22-0-0000-REP-0002
[35]	Track Assurance Report 3	OLR-22-0-0000-REP-0004
[349]	OLRT Stations: Accessibility Review	OLR-22-0-0000-REP-0005
[36]	Track Assurance Report- Derailment Management	OLR-22-0-0000-REP-0003
[351]	Audit Programme	SEMP-P0050-0-0000-SCH-0003
[352]	Guideway Station and MSF Observation Register	OLR-OLR-05-0-TRA-0077
[353]	Assets – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1000
[354]	Escalators – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1001
[355]	Fire – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1002
[356]	Comms and CCTV–TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1003
[357]	Evacuation – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1004
[358]	Civils & Construction – TVA and NFPA 130 requirements	OLR-05-0-0000-REP-1005

ALS0084164

Ref	Title	Number
[359]	Electrical – TVA and NFPA 130 requirements	OLR-05-0-0000-REP-1006
[360]	Mechanical – TVA and NFPA 130 requirements	OLR-05-0-0000-REP-1007
[361]	Signage – TVA and NFPA 130 requirements	OLR-05-0-0000-REP-1008
[362]	Hydro Ottawa – TVA and NFPA 130 requirements	OLR-05-0-0000-REP-1009
[311]	At Grade Station Condition Assessment Report (Hurdman)	OLR-05-0-0000-REP-0061
[312]	Underground Station Condition Assessment Report (Lyon)	OLR-05-0-0000-REP-0062

4.3.6 Limitations

Due to the timescales involved it was not practical to schedule Process and People type audits across all areas of the Project together with topics which featured in the OLRT-C Systems Assurance Management Plan [3].

The risk-based intrusion approach was utilised on crucial activities to meet ESAC requirements.

The timely availability of design drawings to support surveillances and monitoring.

Limited involvement with the testing and commissioning programme to witness and observe live testing; reliance on test results only.

Access limitations due to construction works being carried out, security restrictions/restricted access and adverse weather.

Restricted access to the TSCC.

4.3.7 Conclusions

Desktop and scheduled internal assurance system audits were performed on the Systems Engineering Assurance Management regime.

Follow Ups on Risk Based Intrusion Audit were completed for close out of Observations raised during the time of audit. The Intrusive Audit Action Tracker [350] demonstrated that all observations were closed out far as practicable. There are no adverse or safety related observations open.

There are no further Systems Assurance or Systems Engineering audits planned for 2019.

It can be concluded that the Systems Engineering and Assurance Audits are now satisfactorily closed.

The approach and activities undertaken supported by the evidence obtained and presented demonstrates that a robust Risk Based Intrusion (RBI) audit management

ALS0084164

regime and audit process was used to confirm that processes, plans, competence, requirements, Validation & Verification and RAMS were managed on the Project.

This conclusion can be used in aggregation to positively support the Process Assurance Argument.

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4.4 PROCESS ARGUMENT CONCLUSION

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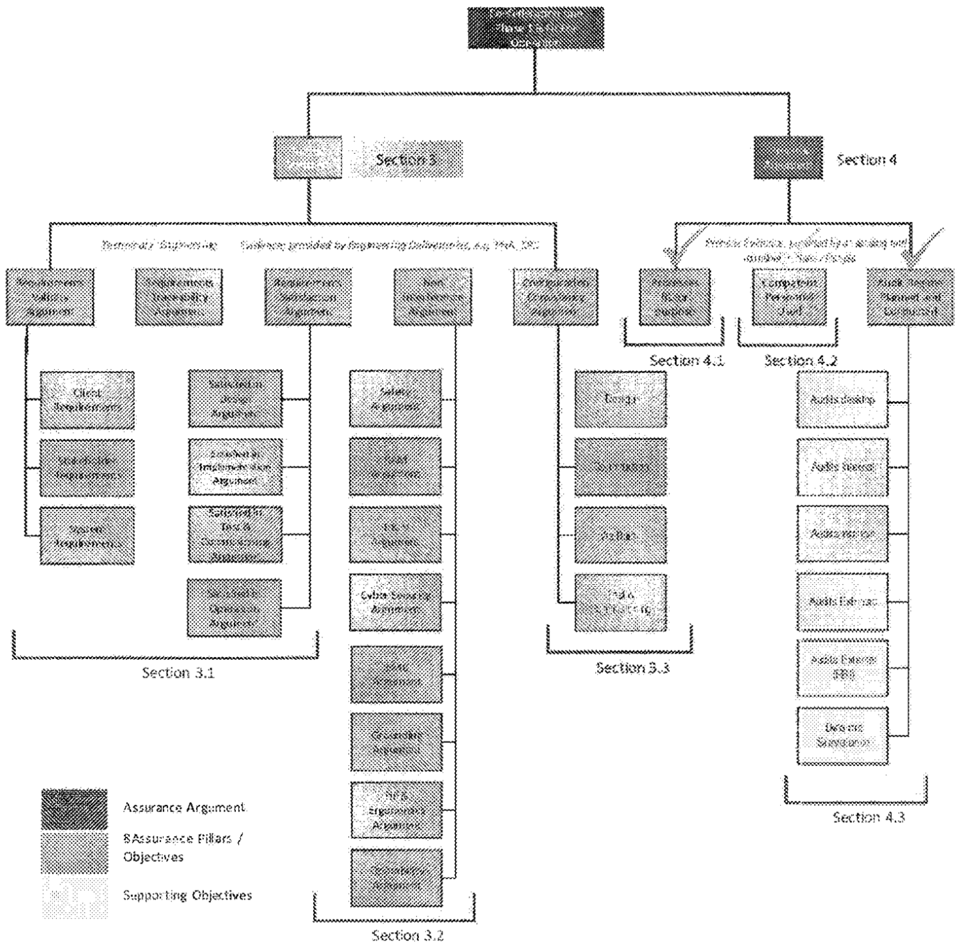

Section 3
Section 4
Section 4.1
Section 4.2
Section 3.1
Section 3.3
Section 4.3
Section 3.2
Assurance Argument
8Assurance Pillars / Objectives
Supporting Objectives

ALS0084164
ALS0084164

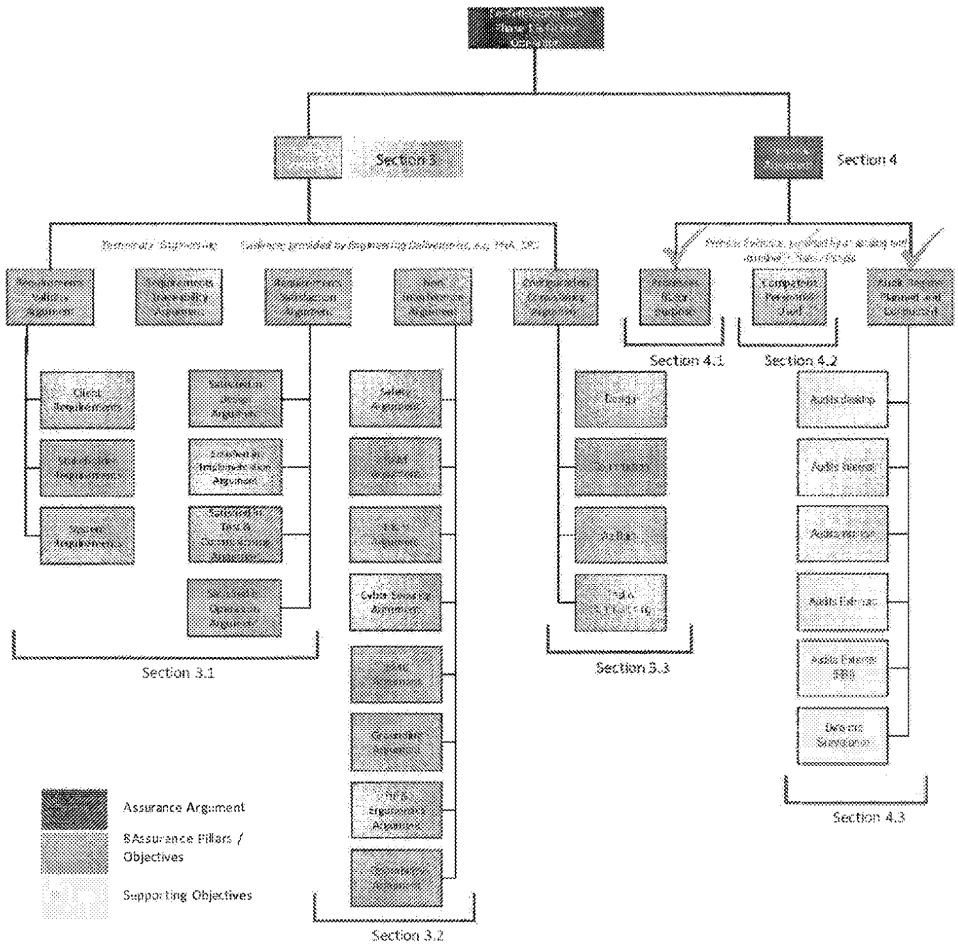

Figure 17: The 3 Pillars of the Process Argument

As previously stated, 'A System must possess the required properties for it to be 'Fit for Operation' and this can be in part achieved through satisfying the Process Assurance objectives' for:

- Processes are Fit for Purpose
- Competent Personnel Used
- Audit Regime Planned and Conducted.

The supporting objectives identified above have been analysed to stress test the argument, demonstrate and provide additional evidence that the objectives have been achieved and the process assurance argument can be made.

Processes Fit for Purpose has been demonstrated and concluded that appropriate processes have been utilised in the development of the OLRT Management System and that the processes created and undertaken have been fully assessed and deemed to be acceptable for the purpose for which they were intended therefore positively supporting the Process Assurance argument.

ALS0084164

Competent Personnel Used has been demonstrated and concluded that processes were executed by personnel with the required competency and that appropriate Competency arrangements were in place with relevant staff having been assessed against these controls, therefore competency has been managed, thus positively supporting the Process Assurance argument.

Audit Regime Planned and Conducted has been demonstrated and concluded that a robust Risk Based Intrusion (RBI) audit management regime and audit process was used to confirm that processes, plans, competence, requirements, Validation & Verification and RAMS were managed on the Project, therefore positively supporting the Process Assurance argument.

Each of the Process Assurance pillars and their objectives has therefore been considered with each objective analysed. When these objectives and their conclusions are aggregated it appears evident that there is no significant reason why the OLRT Process Argument cannot be made and that:

- The Confederation Line Phase 1 demonstrated 'Appropriate series of processes have been correctly executed by trained, experienced and competent personnel'.

This argument can be used in aggregation to positively support the overall argument that the Confederation Line Phase 1 is 'Fit for Operation'.

ALS0084164

5. QUALITY

Although Quality as a set of activities is not specifically identified as an Assurance Pillar or part of the Assurance argument within Figure 2, it has been purposefully included in this document to demonstrate overall completeness and further support the 'Fit for Operation' argument.

5.1.1 Objectives

Demonstrate that appropriate Quality Assurance measures have been employed, enacted and support argument for completeness and coordination.

5.1.2 Approach

The Confederation Line Phase 1 QMS was implemented at outset of the Project to address all applicable requirements relating to Quality Management on the Project, and to document the means and methods to be used in order to satisfy:

- Project Agreement Schedule 11- Part 2
- Meet Customer/Client expectations and compliance with regulatory requirements and specifications; focus on schedule, costs and construction targets.

Quality System Hierarchy

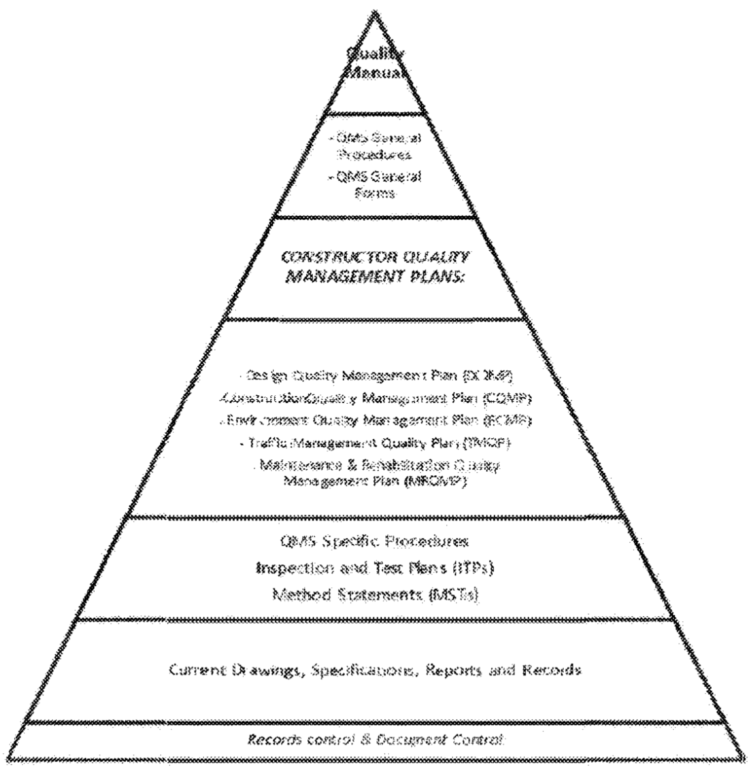

Figure 18: Hierarchy of the QMS

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The QMS System consists of the Project Quality Manual (RTG-04-0-0000-QMS-0001) [253], all related quality sub-plans, procedures, and other supporting quality documents to meet the requirements of ISO 9001:2008. The QMS structure is illustrated in Figure 18 above.

5.1.3 Activities

Quality Management Plans

Quality Management Plans (QMPs) were produced for each area identified in the QMS hierarchy in order to obtain measurable targets consistent with the Quality Policy (see Project Quality Manual -RTG-04-0-0000-QMS-0001 [253] – section 4) and measure the performance across the Joint Venture.

Detailed targets were identified in each of the individual QMPs for their specific area of responsibility, or, under an individual process for each of the parties, taking into account, the following:

- Mitigation of significant environmental impacts identified in the Environmental Quality Management Plan [254]
- Training personnel, subcontractors and subconsultants involved in the project so they can help minimise the environmental impact of their work
- Demonstrating compliance by ensuring inspection, monitoring, tracking and documentation procedures are in place
- Defining measurable targets and documentation procedures to promote continual improvement
- Addressing any non-conformance issues in a timely manner and update the plan and training programs as required to mitigate future non-conformance events
- Maintain customer confidence in the project quality management system

The OLRT Project design, build and maintenance was undertaken in the context of an ISO 9001:2008 QMS. The main purpose of this QMS was to provide products and services that consistently met client requirements. The OLRT Project QMS is described in the Project Quality Manual [253].

RTG, OLRT Constructors, RTM and RTGEJV were governed by the same Quality Policy Statement, included in the Project Quality Manual [253].

The documents contained within the QMS were:

- Quality Policy Statement (see Project Quality Manual -RTG-04-0-0000-QMS-0001 [253] – section 4)
- Project Quality Manual [253]
- General procedures documented as specified in ISO 9001:2008
- Quality Management Plans to ensure the conformity of any works and materials for the Project:
    - Design Quality Management Plan (DQMP) (by RTGEJV) [255]

ALS0084164

- Construction Quality Management Plan (CQMP) (by OLRT Constructors) [137]
- Ottawa Light Rail Transit Project Traffic Quality Management Plan (TQMP) [256]
- Maintenance & Rehabilitation Quality Management Plan (M&RQMP) (by RTM) [257]
- Environmental Quality Management Plan (EQMP) (by OLRT Constructors) [254]
- Quality Records
- Specific procedures for each Quality Management Plan
- Inspection and Test Plans (ITPs)
- Method Statements (MSTs).

Submission of Project Quality documentation as per Schedule 11 Part 2 of the Project Agreement commenced in March 2013.

ISO 9001:2008 QMS– Requirements

The Confederation Line Phase 1 Project QMS was deemed compliant to ISO 9001:2008 – QMS Requirements. British Standard Institute (BSI) performed inspections and produced reports [258] from several surveillance visits to determine that the Project QMS system was being maintained and improved upon to meet the requirements of the ISO 9001:2008.

Evidence of this ongoing activity was recorded in audit reports produced by BSI entitled "3rd Party Assessment to assess the degree of compliance of OLRT's QMS against the ISO 9001:2008 Standard".

Systemwide Contractors (Supply Chain)

Systemwide contractors followed their own QMS as described in their respective safety plans to meet Confederation Line Phase 1 Contract reference documents.

Risk Management

Risk Management on the Confederation Line Phase 1 Project was conducted according to requirements laid out in the Project Risk Management Plan, OLR-09-0-0000-MPL-0002 [259]. The plan established detailed responsibilities and procedures for the Management of Risk on the project, including:

- Risk Identification
- Quantitative Risk Analysis and Prioritisation
- Risk Response and Mitigation
- Residual Risk
- Schedule and Cost Contingency, and
- Opportunity.

As established in the Risk Management Plan, a Risk Register was maintained to log all identified risks, and for the various risk management elements and activities described

ALS0084164

above. The Risk Register was attached as an appendix to the Project Monthly Works Report document [260].

DESIGN

Design Reviews

The full details of the process for carrying out design reviews can be found in document OLR-QMS-GP700-SP01 "Design Review Interface Protocol" [261]. Flowchart of process is shown in Figure 19. This aspect was particularly pertinent in the early stages of the project when major design decisions were being made on a regular basis but was carried through whenever substantive changes were needed.

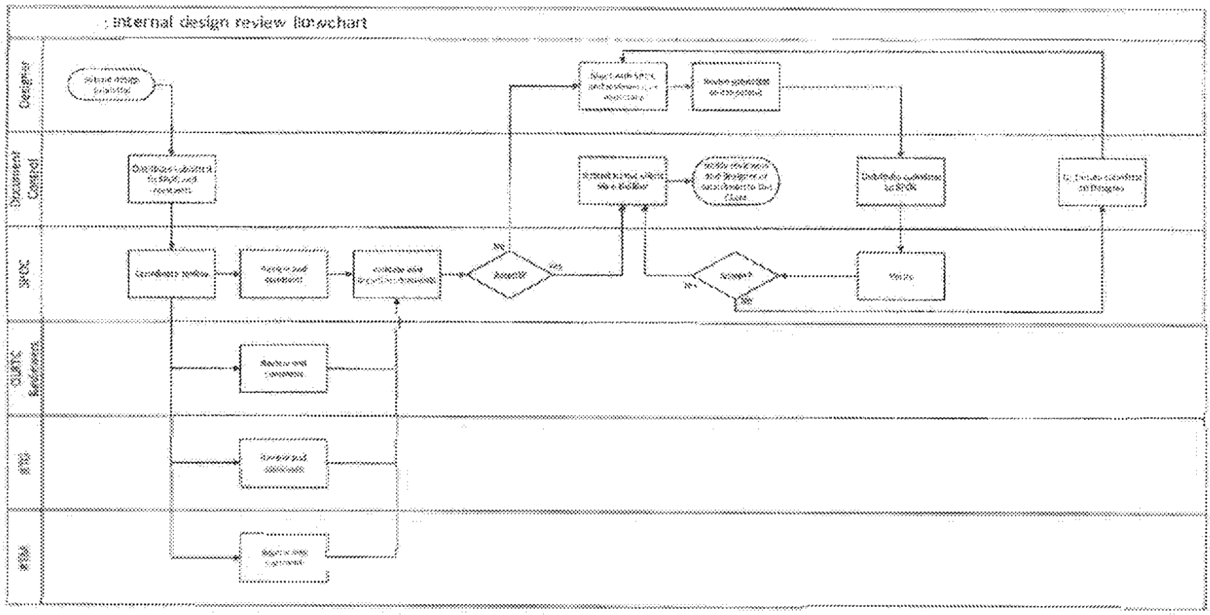

Figure 19: Design Review Process

Design Changes

Whenever a design needed to be changed because of on-site issues or urgent updates it was necessary to implement consistent and robust management of the change; this process was controlled under OLR-QMS-GP700-SP02 "Design Change Management Specific Procedure" [262] which covered:

Requests for Information (Design)

Requests for Information concerning Design management were managed using procedure OLR-QMS-GP700-SP06 [263]. An RFI was both an internal and an external process used to request information from another group or organisation. As they pertained to design management, RFIs were only a means of clarifying the design.

ALS0084164

Procurement

In 2013, the client awarded the contract to design, build, finance and maintain the Confederation Line to the Rideau Transit Group, a consortium that included SNC-Lavalin Constructors (Pacific) Inc., Dragados Canada Inc., and EllisDon Corporation. The project was one of the largest public-private partnership transit initiatives ever undertaken in North America.

Due to the complexity and geographic dispersion of the Confederation Line (13 stations, trackwork & systems, trains, a maintenance facility, and tunnel) the task of Procurement Management was split into two distinct and separately managed entities; a centralized pre-award procurement management group, and locally managed post-award subcontracts administration.

The centralized pre-award procurement process was managed by a team that reported to a Procurement Manager. This team operated out of the Confederation Line main office located at 1600 Carling Avenue.

Essentially at a summary level, this group was responsible for the following activities:

- Maintenance of the Master Bidders List
- Participation in the preparation of scope documents for required works or equipment
- Mapping of potential scope awards (Procurement & Contract Packages) against budget forecasts
- Obtaining approvals for the issuance of Invitations to Bid
- Prequalification of Bidders
- In instances where multiple bidders were not utilized (usually due to unique technical expertise, schedule demands or for low-value commitments), the issuance and obtaining approvals of a bid waiver
- Receipt and vetting of vendor bids
- Negotiation and subsequent award of subcontracts and purchase orders
- The creation of subcontract files in project management systems.

A more detailed explanation of pre-award procurement management is available in the Confederation Line Project Procurement Plan (OLR-QMS-GP301-SP01 Rev. 02) [264].

Due to the nature of the Confederation Line scope (essentially, multiple mini projects, or stations), a decision was made at the time of project formation to treat each individual station as a stand-alone sub-project, where all activities were managed by one or more Project Managers located at each station site. These individuals were responsible for all PM related activities, including post-award subcontract management.

At a high level, these Subcontract Coordinators (with direct feedback from PMs) were charged with the day-to-day administrative tasks such as:

- Negotiation and receiving agreement for subcontract changes

ALS0084164

- Entering subcontract changes in project approvals system (Unifier, or in some instances manual paper approval system)
- Receipt, vetting, and initial approval of vendor progress billings and invoices
- First line of contact for vendor claims, liens, and other commercial disputes.

To further supplement these activities, the project created a centralised subcontracts specialist group to provide higher-level analysis and support.

Quality Audit Management

Confederation Line Phase 1 – Requirements – Quality Audit Programme

Quality Audits on the Confederation Line Phase 1 Project were planned, scheduled, performed and delivered to satisfy the requirements in Project Agreement 11 Part 2.

The Confederation Line Phase 1 Quality Audit Programmes (Schedules) were produced each year by OLRT-C identifying which quality audits were to be performed in each period. Quality (Plans) Audit Programmes are detailed in the OLRT-C Quality Audit Plan, document numbers OLR-04-0-0000-SCE-0003 to 0007 inclusive [265].

Internal and External Type Audits

Project Quality Manual – RTG-04-0-0000-QMS-0001 [253], Construction Quality Management Plan (CQMP) – OLR-04-0-0000-MPL-0017 [137], and the Internal and External Audits procedure – OLR-QMS-GP4.03 [266] identifies the requirements and the management process for required audits. The Quality Audit Programme Status was documented and tracked through the OLRT-C Internal & External Audits Register [267].

Ottawa City Audits

Document OLR-QMS-GP4.03 [266] details the requirements and responsibilities relating to planning for and responding to City Audits.

Quality Audit Reporting and Management Review

The status of all audit reports, findings, and audit responses (close out status) was summarized in the OLRT-C Internal & External Audits Register– document OLR-04-0-0000-REG-0027 [267]

QMS Monthly Reports were submitted each period. See OLR-04-0-0000-REP-0001 and upwards (currently to 0078) [268]

Continual Improvement

Continual Improvement, Corrective and Preventive Action on the Confederation Line Phase 1 Project was required to satisfy Project Agreement [7] and ISO 9001:2008 standard. The planning to effectively manage these aspects of the QMS was detailed in the Project Quality Manual – document RTG-04-0-0000-QMS-0001 [253] and further described in Project procedure documents Continual Improvement OLR-QMS-GP-4.04 [269], and Corrective and Preventive Actions OLR-QMS-GP-4.02 [270].

All identified Continual Improvement initiatives, Corrective Actions and Preventive Actions were logged in their associated registers for tracking of initiation, assessment, and implementation. These registers were reported as appendices in each of the QMS Monthly Reports – documents OLR-04-0-0000-REP-0001 to 0080 [268].

ALS0084164

CONSTRUCTION

Preparatory Works

Preparatory Works (detail covered by OLR-QMS-GP700-SP05 [272]). Preparatory Works are works that the OLRT-C Construction Project Team considered necessary to construct in advance of the full multidiscipline IFC package submission.

Site Instructions

Site Instructions were managed in accordance with the process OLR-QMS-GP700-SP04 [274]. A Site Instruction Notice (SIN) describes an internal process used to introduce new, additional and /or revised Issued for Construction (IFC) documents to the field. Site instructions were Issued by EJV or Designer's with full drawings and specifications.

The signed Site Instruction cover sheet was supplied to Project Document Control function for uploading into 4Projects.

The entire package, together with the CRE associated with the initial design package, was then uploaded toe-Builder for the Client's review.

Field Directives

Field Directives were managed in accordance with the process detailed in OLR-QMS-GP700-SP03 [273]. A Field Directive (FDR) was issued for any changes that did not include revised or new drawings, typically they included sketches or hand-marked drawings and documents. Field Directives were applied to capture any changes to an issued IFC package that were required quickly. These were issued by EJV or the designer for minor changes.

Non-Conformances, non-conformance control and mitigation

Non-conformances were managed through the Management of Non Conformances Process – OLR-QMS-GP4 01 [275]

A Non-Conformance Report (NCR) is described by the RTG Project Quality Manual [253] as being a document issued by the Client or RTG that details the description of an identified non-conformance (i.e. non-conformity), and the proposed rectification and action taken, or to be taken.

Design changes may be required in response to a non-conformance. Any NCR that resulted in a design change, revision or additional drawing was authorised through a Field Directive or a Site Instruction, as appropriate.

Deficiencies

Deficiencies on the Confederation Line Phase 1 Project were managed in accordance with the Deficiencies Management Plan – OLR-90-0-0000-MPL-0001 [276]. Deficiencies on the project were identified by various parties both internal and external to the Confederation Line Phase 1 project team, including:

- Project Quality & Construction Team
- Project EJV
- City of Ottawa Construction Monitors, and
- Building Occupancy Inspection reports.

ALS0084164

Internal project deficiencies were managed using the Unifier Software, which allowed management of deficiencies, and generated output reports summarizing status. Deficiencies from external sources were summarized in the Master Deficiencies List, which was maintained and shared regularly with the stakeholders.

Requests for Information

The RFI management process is fully defined in OLR-QMS-GP700-SP06 [263]. RFIs were initiated by:

- The Client
- RTGEJV, RTG and RTM
- Subcontractors including information requests from Prime Suppliers
- OLRT-C Project Management personnel.

Site Inspections (Quality, Health and Safety)

The site inspection process is defined in Specific Procedure: Inspection and Testing Plans [295]

Informal Site inspections were/are defined as:

1. Start of Shift Inspections.
2. Project Personnel Inspections.
3. Maintenance department inspections.

Formal site inspections are defined as:

1. Management Inspections.
2. Project Safety Manager or T&C Safety Coordinator Inspections.
3. JHSC Committee Inspections.
4. Speciality Site Inspections.
5. Regulatory Agency Site Inspections.
6. Client Site Inspections.

Site Inspections – Health and Safety

Site inspections included (d) but were not limited to such Health and Safety –safe working:

- Evaluation of the hazards and control measures with the objective of confirming the hazards was identified and the intended safeguards were put in place and functioned properly. The Inspector(s) remit was to review the area to confirm that the hazards had been properly identified and controlled, and, to identify if any new hazards had been introduced into the area since the last inspection
- The general conditions/layout of the work area including housekeeping, storage of materials, access routes, ground conditions, overlapping work activities, illumination, sanitary facilities.

ALS0084164

Non-conformance(s) identified through Quality / Health and Safety Site Inspections resulted in the generation of non-conformance reports resulting in the rectification and corrective action of on-site modifications as identified above.

Systems Assurance – Monitoring and Surveillance

Planned Monitoring and Surveillance was undertaken by the Systems Assurance Engineering Team (Dynamic Surveillance performed by SEMP). These surveillances were performed to mitigate identified Engineering Safety Hazards, Workmanship, Condition reporting, follow up of identified and analysed non- conformance reports deemed to be engineering safety issues.

Further details of these types of Systems Assurance Process Audits are contained in Section 4.3 of this ESAC.

Document Control

Documentation Handover

The majority of project documentation that will be included in the handover has already been provided to different organizations during project realisation. Project documentation was provided to the Operator and Maintainers (RTG and RTM) through the Viewpoint for Projects (4P) system and to the City through e-Builder system.

Handover documentation to RTG, RTM and the City is in electronic format and copied into three password protected external hard drives. RTG, RTM and the City will each receive a hard drive containing the handover documentation.

Handover documentation will be in electronic file formats such as .pdf, .xis, .doc and .dwg. It should be noted that there are hardcopy requirements for the handover of as-built drawings.

The revisions and versions of handover documentation shall be the latest revision numbers found in 4P.

An excel file containing the metadata of documentation will be included in the handover. Metadata will include document number, description, revision, status, date created and organization.

The handover of documentation from the Confederation Line Phase 1 Document Control function to RTG will take place within 4 months after the substantial completion date.

The handover of documentation from RTG to the City and RTM will take place within 6 months after the substantial completion date.

The issuance of documents to the City's e-Builder system and 4P system will continue during handover activities.

There are additional handovers at regular intervals for documents issued after the main documentation handover until Project Final completion. Any and all additional documentation handover will be submitted on USB flash drives.

The required conditions to end Confederation Line Phase 1 documentation handover and activities to RTG and City are:

- Letter confirming final completion achievement

ALS0084164

- RTG and City letter confirming completion of documentation handover

All documentation identified in List of Documents for Handover [271] have already been handed over.

5.1.4 Evidence

As proof of satisfactory achievement of the objectives through the completeness argument approach the key documents generated throughout the Quality activities and analysis are identified in Table 17.

Table 17: Quality Assurance Evidence

Ref	Title	Number
[253]	Project Quality Manual	RTG-04-0-0000-QMS-0001 R3
[254]	Environmental Quality Management Plan (EQMP)	OLR-04-0-0000-MPL-0010 R3
[255]	Design Quality Management Plan (DQMP)	REJ-04-0-0000-MPL-0022 R1
[137]	Construction Quality Management Plan (CQMP)	OLR-04-0-0000-MPL-0017 R3
[256]	Ottawa Light Rail Transit Project Traffic Quality Management Plan (TQMP)	OLR-04-0-0000-MPL-0032 R4 OLR-04-6-H417-MPL-0005 R0
[257]	Maintenance & Rehabilitation Quality Management Plan (M&RQMP)	RTM-04-0-0000-MPL-0044 R2
[258]	BSI Audit of QMS	BSI-04-0-0000-ARP-0001 R0 BSI-04-0-0000-ARP-0002 R0 BSI-04-0-0000-ARP-0003 R0 BSI-04-0-0000-ARP-0004 R0 BSI-04-0-0000-REP-0001 RB
[259]	Project Risk Management Plan	OLR-09-0-0000-MPL-0002
[260]	Project Monthly Works Report	OLR-00-0-0000-MWR-0074
[261]	Design Review Interface Protocol	OLR-QMS-GP700-SP01
[262]	Design Change Management Procedure	OLR-QMS-GP700-SP02
[263]	Request for Information Procedure	OLR-QMS-GP700-SP06
[264]	Project Procurement Plan	OLR-QMS-GP301-SP01
[265]	OLRT-C Quality Audit Plan	OLR-04-0-0000-SCE-0003 to 0007 (April 2018)
[266]	Internal & External Audits	OLR-QMS-GP-4.03 R2

ALS0084164

Ref	Title	Number
[267]	Internal & External Audits Register	OLR-04-0-0000-REG-0027
[268]	OLRT-C QMS Monthly Reports	OLR-04-0-0000-REP-0001 to 0080 (Feb 2019)
[269]	Continual Improvement	OLR-QMS-GP-4.04 R0
[270]	Corrective and Preventive Actions	OLR-QMS-GP-4.02 R1
[271]	OLRT-C List of Documents for Handover	OLR-QMS-GP100-SP06
[272]	Ottawa Light Rail Transit Project Specific Procedure: Preparatory Works	OLR-QMS-GP700-SP05
[273]	Ottawa Light Rail Transit Project Specific Procedure: Field Directives	OLR-QMS-GP700-SP03 R2
[274]	Ottawa Light Rail Transit Project Specific Procedure: Site Instructions	OLR-QMS-GP700-SP04 R3
[275]	Management of Non Conformances	OLR-QMS-GP4 01
[276]	Deficiencies Management Plan	OLR-90-0-0000-MPL-0001 R0
[277]	Test and Commissioning Plan	OLR-16-0-0000-MPL-0001
[279]	Configuration Management Recovery Plan	OLR-09-0-0000-MPL-0004
[280]	Control of Documents	OLR-QMS-GP-1.00 R1
[281]	Control of Records	OLR-QMS-GP-1.01 R2
[282]	Management Review	OLR-QMS-GP-2.00 R2
[283]	Objectives & Targets	OLR-QMS-GP-2.01 R1
[284]	Planning of Product Realization & Internal Communications	OLR-QMS-GP-3.00 R0
[285]	Procurement (Subcontracts & Pos) & Verifications	OLR-QMS-GP-3.01 R1
[286]	Monitoring & Measurement of Product	OLR-QMS-GP-3.02 R1
[287]	Project Execution & Traceability (Product & Services)	OLR-QMS-GP-3.03 R1
[288]	General Procedure: Management of Non-Conformances	OLR-QMS-GP4.01 R3
[289]	Customer Satisfaction & Complaints Procedure	OLR-QMS-GP-4.05 R2
[290]	Resources & Training	OLR-QMS-GP-6.00 R1

ALS0084164

Ref	Title	Number
[291]	Design	OLR-QMS-GP-7.00 R1
[292]	OLRT-C. Documents & Records Control and Security Protocol	OLR-QMS-GP100-SP01 R1
[293]	Documents Naming Procedure	OLR-QMS-GP100-SP02 R3
[294]	Work Submittals Flow Chart	OLR-QMS-GP100-SP03 R0
[295]	Specific Procedure: Inspection and Testing Plans	OLR-QMS-GP302-SP01 R0
[296]	Specific Procedure for Environment – Permits, Licences, Approvals and Agreements (PLAA)	OLR-QMS-GP302-SP02 R1
[297]	Specific Procedure for Environment – Monitoring, Reporting and Deficiencies	OLR-QMS-GP302-SP03 R2
[298]	Specific Procedure: Running tunnel – Rock Bolts Pull Test	OLR-QMS-GP302-SP05 R2
[299]	Specific Procedure: Materials Control, Product Identification and Traceability	OLR-QMS-GP302-SP06 R2
[300]	Specific Procedure: OLRTC Submittals	OLR-QMS-GP302-SP08 R0
[301]	Specific Procedure: CADD Submissions	OLR-QMS-GP700-SP07 R0
[302]	Specific Procedure: Comment Resolution Sheets	OLR-QMS-GP700-SP08 R0
[303]	Specific Procedure: Technical Coordination Groups & Other Groups	OLR-QMS-GP700-SP10 R1
[304]	Specific Procedure: Enclosure Form	OLR-QMS-GP700-SP11 R1
[305]	Specific Procedure: Technical Tender Evaluation	OLR-QMS-GP700-SP12 R0
[306]	Red-line and As-built Procedure and Guidelines	OLR-QMS-GP700-SP13 R1
[307]	Systems Final Design Review and Issued for Construction Package Preparation Procedure	OLR-QMS-GP700-SP14 R0
[309]	Documentation Handover Plan	OLR-QMS-GP100-SP05 Rev A

5.1.5 Limitations

None identified, affecting the Quality section of this ESAC.

ALS0084164

5.1.6 Conclusion

Quality Management Plans (QMPs) were produced for each area identified in the QMS hierarchy in order to obtain measurable targets consistent with the Quality Policy (see Project Quality Manual -RTG-04-0-0000-QMS-0001 [253] – section 4) and measure the performance across the Joint Venture.

The demonstration of Quality Assurance supports conclusion that the areas of the ESAC and the work carried out by OLRT-C represent the complete project and therefore positive argument of completeness.

Governing the organisation under a single Quality Policy Statement, included in the Project Quality Manual supported coordination across the organisation.

The approach and activities undertaken supported by the evidence obtained and presented demonstrates that appropriate Quality Assurance measures have been employed, enacted and support argument for completeness and coordination.

This conclusion can be used in aggregation with the Product and Process Argument conclusions to positively support the overall Argument of Confederation Line Phase 1 being 'Fit for Operation'.

ALS0084164

6. SUPPORTING TOOLS

Although Supporting Tools as a set of activities is not specifically identified as an Assurance Pillar or part of the Assurance argument within Figure 2, it has been purposefully included in this document to demonstrate overall completeness and further support the 'Fit for Operation' argument.

This section provides evidence of supporting tools and how they have been used to progressively manage and monitor Systems Assurance in support of the Completeness Argument. For clarity these are:-

- Goal Structured Notation
- Integrated Design Area Breakdown Structure
- IBM Rational Collaborative Lifecycle Management (CLM)
- Test Management System (TMS)
- PDM Plus
- Document Management

This section of the ESAC considers the main toolsets utilised within the Systems Assurance activities in support of demonstrating the Systems Engineering & Assurance Completeness argument.

6.1 OBJECTIVE

Demonstrate the use of effective tools within the delivery of the project that provide evidence and support of completeness.

6.2 GOAL STRUCTURING NOTATION (GSN)

Several tools were utilised in order to identify and determine the completeness of the artefacts required as evidence and in order to prove the Confederation Line Phase 1 project had reached sufficient maturity for Revenue Service Availability enablement.

One such tool was a comprehensive GSN [369 & 370]. This was introduced to identify suitable evidential artefacts that were required against the Systems Assurance product and Process arguments. Introduction of the GSN occurred at a point in the Project lifecycle that it was not possible for it to be used as a single, definitive method of assurance tracking of assurance evidence(s) as they became available.

6.2.1 Approach

GSN was a graphical notation for presenting the structure of arguments. Primarily it acted as a communication means to describe how a particular claim had been shown to be true by means of evidence. For Confederation Line Phase 1 the argument demonstrated how a set of evidence items combined together to demonstrate the top claim that the railway is fit to be taken into Operation. Items of evidence included process information, product information, qualitative data, quantitative data, subjective information, analysis, testing, verification and validation.

6.2.2 Activities

GSN was designed such that it modelled the system in question as a series of sub goals and subsequent evidential arguments, which when satisfied achieve the top-level objective of "The railway is fit to be taken into operations"

Below is a pictorial representation of the top-level goals associated with the product and process arguments.

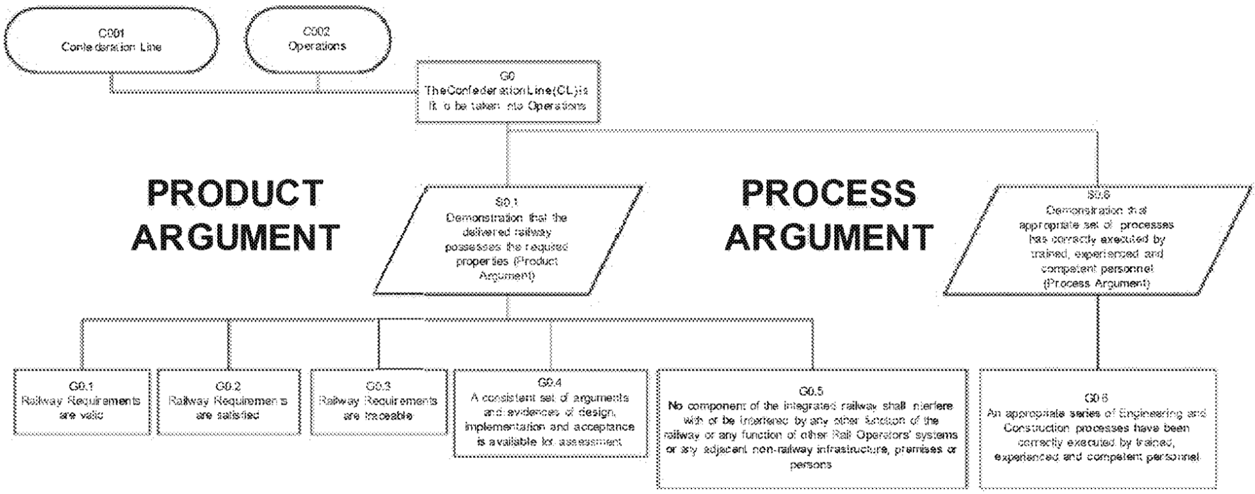

Figure 20: Overall GSN model for OLRT

Individual goals to be realised are therefore as follows:

Product based goals:

- G0.1 Railway requirements are valid – this aspect looked at the Project Agreement, determining the scope of the requirement set and the requirements validity by examining whether:
  - A complete set of requirements is available
  - Interfaces have been identified and allocated
  - Railway requirements assessed for completeness, viability & practicability
  - Established requirement baseline encompasses railway requirements
  - Railway requirements under effective change control & configuration management and
  - Supporting evidence shows that direct evidence is trustworthy.
- G0.2 Railway requirements have been satisfied – this aspect looked at the defined requirement set and considered how they were addressed across the lifecycle of the project, covered by four lower level goals:
  - Requirements satisfied in railway design – it is noted that due to when SEMP were engaged it was not possible to commence from preliminary design and only detailed design was able to be assessed

ALS0084164

- Requirements satisfied in construction/ manufacture
- Requirements satisfied in railway system acceptance
- Requirements fully sustainable in operations & maintenance.

- G0.3 Railway Requirements are traceable – this aspect looked to ensure that everything required has been delivered and that everything delivered was required. In addition is looked at the trustworthiness of this requirement.
- G0.4 A consistent set of arguments and evidence of design, implementation and acceptance is available for acceptance. This aspect looked at the maintenance of a configurable solution
- G0.5 No component of the Confederation Line Phase 1 shall interfere with or be interfered with by any other function of the Confederation Line Phase 1 or surroundings. Whenever individual items are connected within a system the potentiality for interference of one type or another is feasible. This aspect covers all types of potential interference
- G0.7 The CBTC enabled railway is acceptably electronically secure. In the current climate the potentiality for electronic interference is always present. This aspect looks looked at how this is was mitigated.
- G0.6 An appropriate set of Engineering and Construction processes have been correctly executed by trained, experienced and competent personnel. This aspect looked at whether an appropriate set of processes had been identified and correctly executed by appropriately competent personnel.

6.2.3 Outputs

The output of the GSN approach was a Confederation Line Phase 1 GSN model depicting specific evidences mapped to their respective goals and objectives to support demonstration of Engineering Safety and Assurance for the project. This was captured in the GSN Visio Model SEMP-P0050-PLA-0028 [369] and the interactive PowerPoint version of the GSN model – SEMP-P0050-PRE-0001 [370].

The GSN is an internal document used as a toolset only and as such is not an external deliverable.

6.2.4 Evidence

The evidence is contained within the GSN methodology presentation and the supporting objective evidences such as plans, processes, documents, test results, test reports and compliance reports are available in 4P.

Table 17: GSN Evidence

ALS0084164

Ref	Title	Number
369	GSN Visio Model	SEMP-P0050-PLA-0028
370	GSN model	SEMP-P0050-PRE-0001

6.2.5 Limitations

A GSN would typically be introduced at the outset of a given project to help define and plan the System Assurance activities and evidences that would ultimately demonstrate Engineering Safety.

In this instance GSN was introduced during the latter part of the construction delivery phase of the project (circa 3rd quarter 2018) to assess the available Systems Assurance evidence as having met the defined goals and objectives for the Confederation Line Phase 1. The GSN was therefore limited by the data that was available from the project from that point in time.

In addition, as the GSN was only constructed to recognise the scope of the Confederation Line Phase 1 activities it does not consider the full Engineering Safety and operational activities of RTM & OC Transpo.

6.2.6 GSN Conclusions

The GSN as a toolset was utilised throughout the development of the ESAC to identify suitable evidences that were required and available commensurate with the project lifecycle stages, as such it was not a toolset utilised to determine a conclusion regarding engineering safety.

The Systems Assurance evidences received and considered and included within the GSN were suitable to support the overall ESAC conclusion (see Executive Summary).

The use of the GSN has demonstrated that assurance evidence has been produced by the project at each lifecycle stage and supporting each aspect of the Product/Process argument, therefore providing a robust picture of completeness.

The GSN and ESAC are aligned under the Product/Process Assurance Argument structure this concludes that the evidence contained within the ESAC presents a picture of completeness and can be relied upon.

6.3 INTEGRATED DESIGN AREA BREAKDOWN STRUCTURE – (IDABS)

In addition to and in support of the GSN, an IDABS [355 & 356] was introduced. The main purpose of IDABS was to track and demonstrate the maturity of the evidential artefacts produced for Confederation Line Phase 1 both by System Breakdown Structure and geography, thus a complete visualisation of the project.

The objective of the IDABS was to provide a visible means of breaking down the contractual design elements into manageable design areas by System Breakdown Structure and geography. In doing so, a visual toolset for tracking design element progress & maturity was achieved.

ALS0084164

6.3.1 Activities

The IDABS applies to the scope of work contracted to OLRT-Constructors (OLRT-C) as specified within the PA [7]. As such it recognized and captured the design elements that sit below the Railway Level (that being the whole of the Infrastructure & Trains) as defined in the OLRT-C Systems Assurance Management Plan (SAMP) OLR-05-0-0000-MPL-0020 [3].

These hierarchical System Levels are identified as:

- Railway System Level
- Primary System Level
- Sub-system Level

For the purpose of creating the IDABS, a design area was either a geographical area or a line-of-route Primary System of the infrastructure.

6.3.2 Outputs

The output of the IDABS was an OLRT-C plan depicting specific assurance evidences mapped to their respective geographical locations and their Primary Systems. This was captured in the IDABS Plan – OLR-05-0-0000-MPL-0050 [367] and the IDABS Spreadsheet OLR-05-0-0000-SCE-0004 [368].

The IDABS is an internal document used as a toolset only and as such is not an external deliverable.

6.3.3 Evidence

Below is a list of the evidences identified in the IDABS:

Table 18: IDABS Evidence

Ref	Title	Number
[369]	GSN Visio Model	SEMP-P0050-PLA-0028
[370]	GSN Model – PPT	SEMP-P0050-PRE-0001
[367]	IDABS Plan	OLR-05-0-0000-MPL-0050
[368]	IDABS Spreadsheet	OLR-05-0-0000-SCE-0004
[3]	OLRT-C System Assurance Management Plan	OLR-05-0-0000-MPL-0020
[330]	Design Certification	OLR-00-0-0000-REG-0012
[331]	Construction Certification Log	OLR-00-0-0000-REG-0012
[332]	Thales PICOs Tracker	OLR-04-0-0000-REG-0026 (Thales Only)
[353]	Assets – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1000

ALS0084164

Ref	Title	Number
[354]	Escalators – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1001
[355]	Fire – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1002
[356]	Comms and CCTV–TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1003
[357]	Evacuation – TVA and NFPA 130 Requirements Compliance Inspections	OLR-05-0-0000-REP-1004
[320]	PDMPlus User Guide	OLR-09-0-0000-REG-0003_D

Table 19: Sources of Additional IDABS Data

Additional Supporting Evidence
All other PICOS within 4P up until 25/01/19
System Acceptance Test Documents – contained within 4P
Site Integration Test Documents – contained within 4P
Surveillance and Monitoring Inspection Logs – Various

6.3.4 Limitations

The limitations of the IDABS were the availability of the inputs required at any point in time, up until all work within the project was complete. Only at this final point can IDABS be considered complete. However, the progressive population of IDABS can be used in assessing the maturity of the Systems Assurance evidence at any given point in time and therefore facilitate effective decision making and management of the project.

In addition, as IDABS is only constructed to recognise the scope of the Confederation Line Phase 1 activities it does not consider the full scope of assurance evidences of RTM & OC Transpo.

6.3.5 IDABS Conclusion

The IDABS summarises the availability and maturity of Systems Assurance evidence of the Confederation Line Phase 1 project incorporating all available source data up to 5th April 2019.

Systems Assurance evidences have been made available across greater than 85% of the Confederation Line Phase 1 route areas and Primary Systems shown within the IDABS. In addition, greater than 22% of the route areas and Primary Systems have multiple assurance evidences types available.

ALS0084164

Supporting tools (DOORS, GSN, IDABS) have been utilised as the methodologies to determine progressive Assurance across multiple Assurance disciplines and achievement of completeness.

The use of the IDABS has demonstrated that assurance evidence has been produced by the project at each lifecycle stage and supporting each Primary System, Sub-System and Geographical area of the project, therefore supporting a robust picture of completeness.

The IDABS and ESAC utilise the same assurance evidences as are presented to satisfy the Product/Process Assurance Argument. This concludes that the evidence contained within the ESAC presents a picture of completeness and can be relied upon.

6.4 IBM RATIONAL COLLABORATIVE LIFECYLE MANAGEMENT (CLM)

IBM Rational Collaborative Lifecycle Management (CLM) provides a set of integrated applications for Requirements Management, Change and Configuration Management, Quality Management and supporting services such as reporting.

For the Confederation Line Phase 1 Project, the following Rational CLM applications have been used to support the System Engineering and System Assurance process:

- Rational DOORS NG – Requirements Management, Verification and Validation
- Rational Quality Manager (RQM) – Test Planning and tracking
- Jazz Reporting Service and Report Builder – Report generation and dashboards.

Figure 21 below provides the high level data model used for the OLRT Project.

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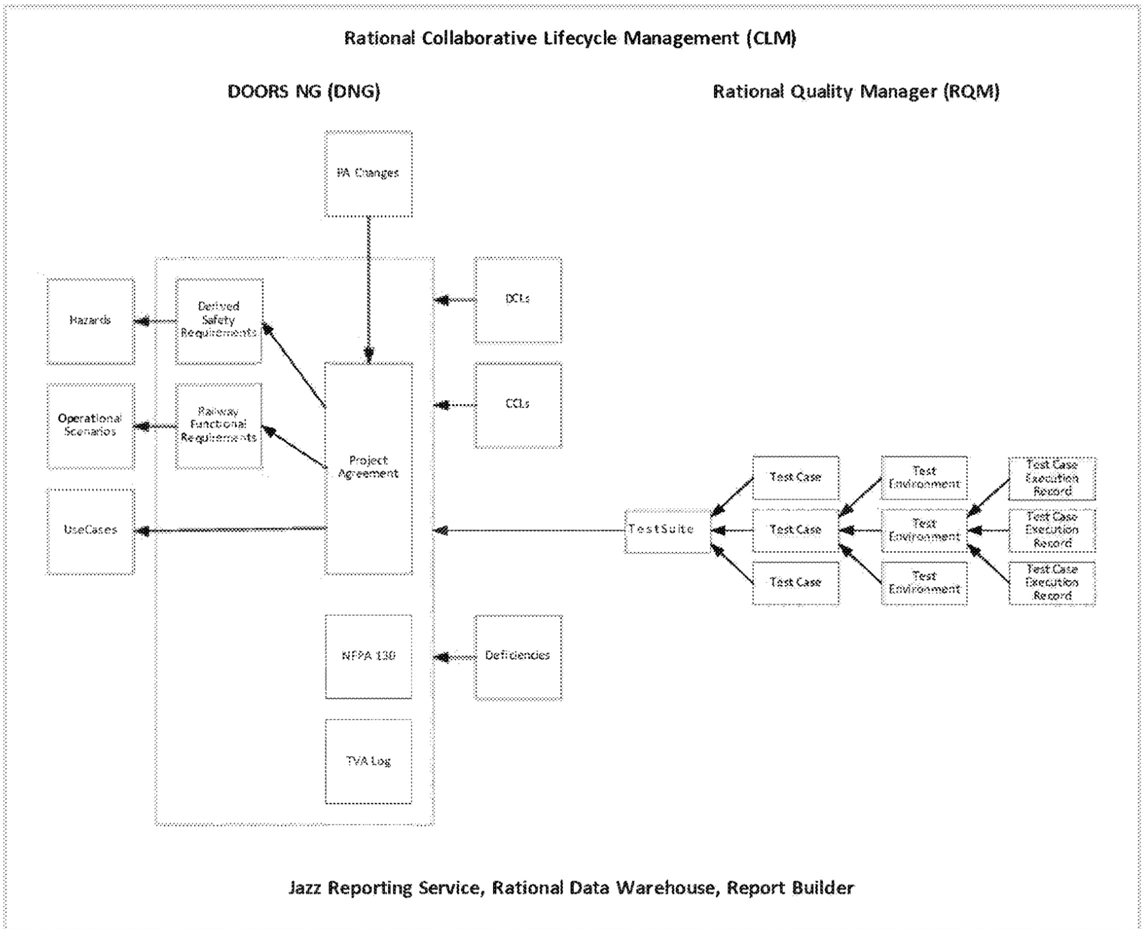

Figure 21: Rational CLM Data Model Implemented for the OLRT Project

DOORS NG was used to capture, link, trace, analyse and manage changes to information to ensure the project's compliance to specified requirements and standards. In addition to the primary requirements products, traceability was implemented to the Integrated Hazard Log, PA changes including contract variations, Use Cases, DCLs, CCLs and deficiencies (including non-conformances).

Rational Quality Manager was used to identify SATs and SITs, implementing traceability between test cases and relevant requirements. This traceability enabled test coverage of requirements to be confirmed and supported declaration of compliance against contract requirements. For each test procedure, the data structure enabled test results to be recorded for each test case at each geographical location and for each run of the test.

6.5 TEST MANAGEMENT SYSTEM (TMS)

A Test and Commissioning Database was used by the T&C team to store information relevant to T&C results. This forms the backend of the Test Management System (TMS).

The TMS had four parts:

- Test Tracking

ALS0084164

- Deficiency Tracking
- Configuration Tracking
- Work Authority Tracking

The detail of the TMS is covered within section Test & Commissioning 3.1.8.

6.6 PDM PLUS

PDM Plus is a SQL Server Database Client. The version used for this project was Version No 6.2.7.120. This database was used for the Configuration and Change Management Control & recoding of data and identification of Redline drawings. (See Configuration Section 3.3 in this ESAC detailing the scope of the configuration and change management).

The PDM Plus System automated the processes, elements, and activities required to perform accurate Configuration Management (CM) of a product and its configuration documentation. The PDM Plus System provided intelligent product information by maintaining the relationships between product items, configuration documentation, change activities, baseline status information, as-configured information, as well as action items, certifications, packaging information, warranty details, data items, and the data vault.

The PDM Plus product structure, workflow management and baseline management capabilities provided accurate real-time status reporting of products being built, delivered or maintained. The System's integrated architecture cross referenced all products to the exact revision or version of configuration documentation used to build, test, or maintain a product. PDM Plus also provided a consolidated central point location for release, storage, change management, accounting, and audit records of product information within the PDM Plus "Database-of-Authority."

6.7 DOCUMENT MANAGEMENT

4Projects is a secure, web-based collaboration solution enabling a project team to share and manage information with internal and external partners. 4Projects provided a central repository for the upload of files of any type and size, which were then available for other users to view, edit, or download. The drawings and documents in 4P were managed and controlled by Confederation Line Phase 1 – OLRT-C Project Document Control.

e-Builder is the City of Ottawa's electronic document management system wherein they receive document submissions. This system contains the workflow processes for RFIs, Variations and submissions.

Unifier is the repository of supplier documents for the Confederation Line Phase 1 project. This system contains the workflow processes for the exchange and review of supplier documents.

ALS0084164

6.8 SUPPORTING TOOLS CONCLUSION

To demonstrate overall completeness and further support the 'Fit for Operation' argument the project implemented the use of the following key tools:

- Goal Structured Notation
- Integrated Design Area Breakdown Structure
- IBM Rational Collaborative Lifecycle Management (CLM)
- Test Management System (TMS)
- PDM Plus
- Document Management.

GSN: The use of the GSN has demonstrated that assurance evidence has been produced by the project at each lifecycle stage and supporting each aspect of the Product/Process argument, therefore providing a robust picture of completeness.

IDABS: The use of the IDABS has demonstrated that assurance evidence has been produced by the project at each lifecycle stage and supporting each Primary System, Sub-System and Geographical area of the project, therefore supporting a robust picture of completeness.

IBM CLM, PDM Plus, TMS and Document management: The use of these tools has supported specific areas of Systems Engineering and Quality Management throughout the project, ensuring consistency, control and management to essential elements of the project.

Therefore it can be concluded that the Confederation Line Phase 1 has effectively utilised 'Supporting tools to progressively manage and monitor Systems Assurance in support of the Completeness Argument'.

This can be used in aggregation to positively support the overall argument that the Confederation Line Phase 1 is 'Fit for Operation'.

ALS0084164

7. ESAC CONCLUSION

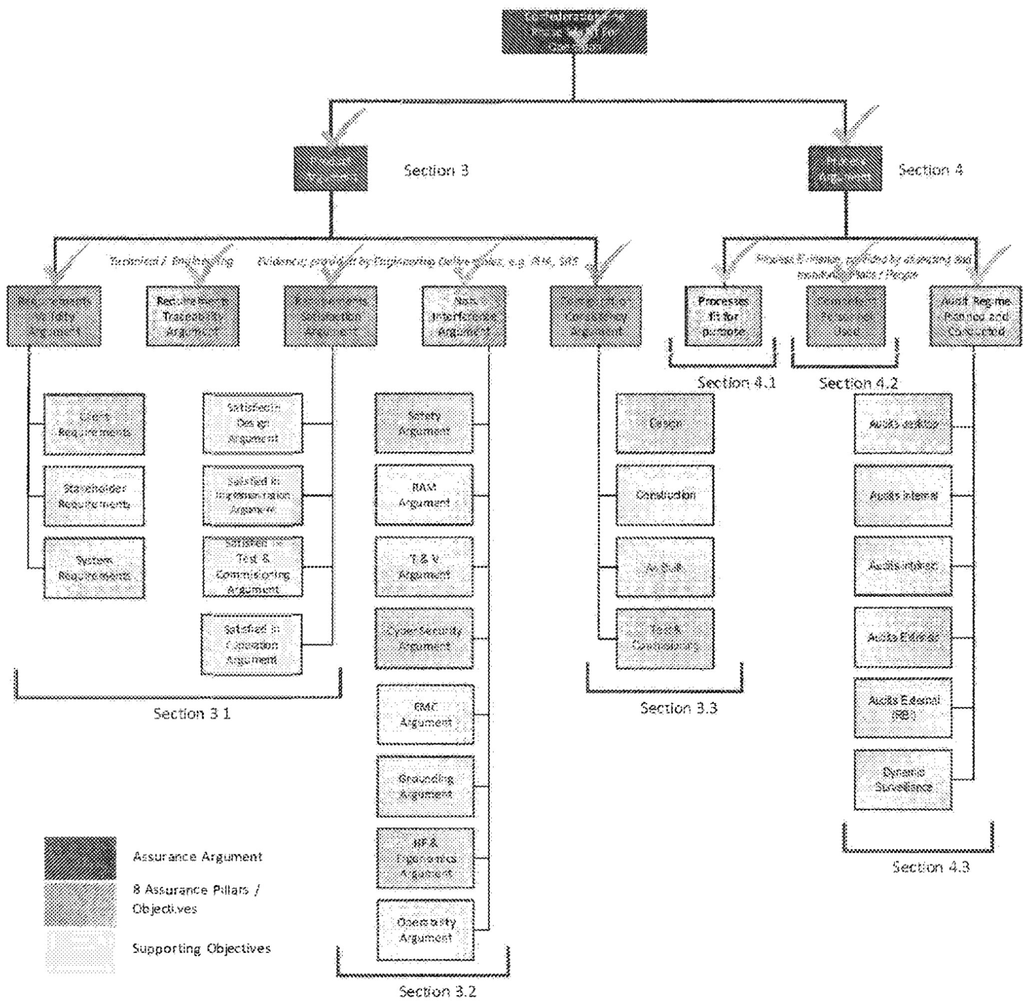

Figure 22: The Assurance Argument Diagram

In order for the Confederation Line Phase 1 to be 'Fit for Operation' it must be demonstrated that the 'System must possess the required properties' through satisfaction of the objectives defined to form the Product Argument and that 'Appropriate series of processes have been correctly executed by trained, experienced and competent personnel' through satisfaction of the objectives to form the Process Argument.

In addition a demonstration of Quality Management 'Appropriate Quality Assurance measures having been employed and enacted' and use of Supporting Tools 'Evidence of the supporting tools used and how they have been utilized to progressively manage and monitor Systems Assurance' provides demonstration of completeness.

Each of the Product Assurance pillars and their supporting objectives has been considered with each objective analysed. When these supporting objectives and their conclusions

ALS0084164

are aggregated it appears evident that there is no significant reason why the OLRT Product Argument cannot be made and that:

- The Confederation Line Phase 1 'System possesses the required properties'.

Each of the Process Assurance pillars and their objectives has been considered with each objective analysed. When these objectives and their conclusions are aggregated it appears evident that there is no significant reason why the OLRT Process Argument cannot be made and that:

- The Confederation Line Phase 1 demonstrated 'Appropriate series of processes have been correctly executed by trained, experienced and competent personnel'.

The use of supporting tools has been considered and analysed and in conclusion it is evident they have been used to progressively manage and monitor Systems Assurance in support of Completeness, therefore:

- The Confederation Line Phase 1 demonstrated 'Supporting tools have been used to progressively manage and monitor Systems Assurance in support of the Completeness Argument'.

Each of the Product and Process Assurance pillars and consideration of Supporting Tools and their supporting objectives has been considered with each objective analysed. When these objectives and their conclusions are aggregated it appears evident that there is no significant reason why, it cannot be stated that:

- The Confederation Line Phase 1 is 'Fit for Operation'.

The Assurance arguments presented in Figure 22 above have been determined to collectively derive that when satisfied the Confederation Line Phase 1 works are sufficiently assured to enable entry into service operations in accordance with RSA.

ALS0084164

APPENDIX 1 – ACRONYMS AND ABBREVIATIONS / DEFINITIONS

Acronym	Definition
ALARP	As Low As Reasonably Practical
APTA	American Public Transportation Association
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATR	Automatic Train Regulation
BAS	Building Automation System
BCC	Backup Control Centre
BMS	Building Management Systems
BRT	Bus Rapid Transit
BSI	British Standard Institute
CBC	Canadian Broadcasting Corporation
CBTC	Communications Based Train Control
CCCB	Configuration Change Control Board
CCL	Construction Certification Letter
CCTV	Closed Circuit Television
CHB	Car History Books
CLM	Collaborative Lifecycle Management
CM	Configuration Management
CMP	Competency Management Plan
COADs	City of Ottawa Accessibility Design standard
CQMP	Construction Quality Management Plan
CRE	Comments Resolution Sheet– External
CTS	Communications Transmission System
DITLO	Day in The Life Of
DCL	Design Certification Letter
DOORS	Dynamic Object Oriented Requirement System
DSR	Derived Safety Requirements
EJV	Engineering Joint Venture
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EoR	Engineer of Record

ALS0084164

Acronym	Definitions
EQMP	Environmental Quality Management Plan
ESAC	Engineering Safety and Assurance Case
ESM	Engineering Safety Management
FDR	Field Directive
FMECA	Failure Modes Effects and Criticality Analysis
GSN	Goal Structured Notation
HAZID	Hazard Identification
IHA	Interface Hazard Analysis
HF	Human Factors
HFIL	Human Factors Issues Log
HMP	Hazard Management Procedure
HRP	Hazard Review Panel
IAC	Intruder Access Control
ICL	Integration Certification Letter
IDABS	Infrastructure Design Area Breakdown Structure
IHA	Interface Hazard Analysis
IHL	Integrated Hazard Log
IRJ	Insulated Rail Joints
ISO	International Organization for Standardization
ITP	Inspection and Test Plans
LFLRV	Low Floor Light Rail Vehicle
LRT	Light Rail Transit
LRV	Light Rail Vehicle
M&RQMP	Maintenance & Rehabilitation Quality Management Plan
Mgr	Manager
MOR	Minimal Operational Requirements
MSF	Maintenance and Storage Facility
MSTs	Method Statements
NCSC	UKs National Cyber Security Centre
NCR	Non-Conformity Report
NRCan	National Resources Canada
OCS	Overhead Catenary System
OLRT	Ottawa Light Rail Transit

ALS0084164

Acronym	Definition
OLRT-C	Ottawa Light Rail Transit - Constructors
ORD	Operational Restriction Document
OSHA	Operations and Support Hazard Analysis
PA	Project Agreement
PADI	Project Agreement Design Integration
PEO	Professional Engineer Ontario
PHA	Preliminary Hazard Analysis/Analyses
PICO	Post Installation Checkout
PIDS	Passenger Information Display System
PMO	Project Management Office
QMP	Quality Management Plan
QMS	Quality Management System
RACI-S	Responsible, Accountable, Consult, Inform – Statement of No Objection
RAM	Reliability, Availability and Maintainability
RAMS	Reliability, Availability, Maintainability and Safety
RBD	Reliability Block Diagram
RBI	Risk Based Intrusion
RFI	Request for Information
RGS	Rail Grounding Switch
RQM	Rational Quality Manager
RTG	Rideau Transit Group
RTM	Rideau Transit Maintenance
RSA	Revenue Service Availability
RSAC	Revenue Service Availability Certificate
SA	Systems Assurance
SAA	Safety Assurance Actions
SAMP	Systems Assurance Management Plan
SAT	Site Acceptance Testing
SBS	System Breakdown Structure
SCADA	Supervisory Control and Data Acquisition
SCR	Site Change Request
SIL	Safety Integrity Level
SIN	Site Instruction Notice

ALS0084164

Acronym	Definition
SIT	Systems Integration Testing
SOPs	Standard Operating Procedures
SSeCP	System Security Certification Plan
SSHA	Sub-System Hazard Analysis
T&C	Testing and Commissioning
TCL	Test Certification Letter
TCR	Technical Compliance Report
TMS	Test Management System
TQMP	Traffic Quality Management Plan
TMS	Test Management System
TPS	Traction Power Supply
TPSS	Traction Power Sub-stations
TSCC	Train Service Control Centre
TVA	Threat and Vulnerability Assessment
TVS	Tunnel Ventilation System
V&V	Verification and Validation
WRU	Wayside Radio Unit
YCC	Yard Control Centre

DEFINITION

Ottawa Confederation Line Phase 1	The Ottawa Confederation Line Phase 1 consists of Guideway, Stations and Line of Route systems (such as CBTC, Track, OCS) between Tunney's Pasture and Blair Stations, MSF Connector, LRV Phase 1 Fleet (as per the RTG – City of Ottawa Project Agreement), MSF buildings and Yard Phase 1 scope (as per the RTG – City of Ottawa Project Agreement), TSCC and BCC Phase 1 scope (as per the RTG – City of Ottawa Project Agreement). It excludes systems/ equipment supplied by the City of Ottawa such as Fare Gates and P25 Radio. It excludes certification and subsequent delivery of Operations and Maintenance activities instructed by O&M Manuals and/ or Transferred Safety Hazards recorded by agreed Hazard Management Forms.

ALS0084164

APPENDIX 2 – REFERENCES

Ref	Document Number	Document Description	Rev
Section – Executive Summary			
1	SEMP-P0050-PRE-0002	SEMP 14th May 2018 SESA Presentation	0
2	OLR-05-0-0000-REP-0058	Confederation Line Phase 1 Operational Restrictions Document	0
378	OLR-05-0-0000-REG-0025	ESAC Outstanding Items List	0
Section 1 – Introduction			
3	OLR-05-0-0000-MPL-0020	OLRT-C System Assurance Management Plan	0
Section 1.3 –Scope			
4	OLR-09-0-0000-DIA-0001	System Breakdown Structure	1
Section 3.1 – Requirements Verification & Validation			
5	OLR-50-0-0000-MPL-0007	OLRT-C Requirements Management Plan	0
6	OLR-50-0-0000-MPL-0006	OLRT-C V&V Management Plan	0
7	TORO1; 4868348: v55	Project Agreement	v55
8	OLR-05-0-0000-REG-0004	Confederation Line Phase 1 Integrated Hazard Log	4
9	OLR-05-0-0000-REP-0054	Technical Compliance Report	4
10	OLR-04-0-0000-REG-0004	Non-Conformances Log	270
11	OLR-90-0-0000-CMP-0002	PA Technical Compliance Matrix	35.0
12	OLR-05-0-0000-REP-0053	Safety Requirements Matrix	4
13	OLR-90-0-0000-CMP-0001	Non-Technical Compliance Matrix	Al
14	OLR-05-0-0000-REP-0009	PA Analysis & Allocation	1
15	OLR-05-0-0000-REP-0011	Railway Operational Scenarios	1
16	OLR-05-0-0000-REP-0010	Railway Functional Requirements	2
17	OLR-05-0-0000-REP-0055	Railway Requirements Traceability Matrix	0
18	OLR-05-0-0000-CMP-0002	NFPA 130 Compliance Matrix	3
19	OLR-03-0-0000-REP-0352	Test Traceability Matrix	2
19a	OLR-90-0-0000-CMP-0004	Minor Deficiencies List	P
Section 3.1.8 – Test & Commissioning			
308	OLR-16-0-0000-PRC-0002	T&C Work Authorization Procedure	0
373	3CU 05018 0019 QMZZA	Thales Quality Assurance Plan	
374	3CU 05018 0043 VCZZA	Thales System V&V Plan	
375	3CU 05018 0041 QTZZA	Thales System Test Plan	

ALS0084164

Ref	Document Number	Document Description	Rev
Section 3.2.4 - RAMS			
20	OLR-05-0-0000-REP-0017	Confederation Line Phase 1 Case for Safety	2
21	3CU 05018 0247 DUZZA	Ottawa Light Rail Transit Project Specific Application Safety Case Report	0
22	ADD0000939280	Ottawa LRV Project Consolidated Safety File	D
23	OLR-05-0-0000-MPL-0012	OLRT-C Systems Safety Programme Plan	0
24	OLR-05-0-0000-PRC-0001	OLRT-C Hazard Management Procedure	0
25	REJ-05-0-0000-REP-0327	Safety Integrity Level Allocation Report	1
26	SEMP-DOC-0002	HRP Terms of Reference	N/A
27	OLR-05-0-0000-REP-0015	IHL Summary Report	0
28	OLR-05-0-0000-REP-0014	OLRT-C Interface Hazard Analysis	0
29	OLR-05-0-0000-REP-0063	Confederation Line Phase 1 Operations and Support Hazard Analysis	1
30	REJ-05-0-0000-REP-0370	Station Operations & Support Hazard Analysis Report (O&SHA Report)	0
31	REJ-05-0-0000-REP-0371	OCS Operations and Support Hazard Analysis Report	0
32	REJ-05-0-0000-REP-0369	Tunnel Ventilation System OSHA	0
33	3CU 05018 0032 DUZZA	CBTC OSHA	3
34	OLR-22-0-0000-REP-0001	Track Assurance Report 1	0
35	OLR-22-0-0000-REP-0004	Track Assurance Report 3	0
36	OLR-22-0-0000-REP-0003	Track Assurance Report – Derailment management	0
37	OLR-05-0-0000-REP-0056	Confederation Line Phase 1 Reliability Availability and Maintainability Report	2
38	OLR-05-0-0000-REP-0050	Day in The Life Of (DITLO) Report	0
39	REJ-05-0-0000-REG-0006	EJV Hazard Log	6
40	3CU 05018 0033 DUZZA	Thales Hazard Log	2
41	ADD0000939629	Alstom Rolling Stock Hazard Log	C
42	OLR-05-0-0000-REP-0065	Maintenance & Storage Facilities (MSF) Safety Justification Report	0
43	OLR-05-0-0000-REP-0066	TSCC and BCC Safety Justification Report	01
44	REJ-05-0-0000-REP-0302	EJV Interface Hazard Analysis	1
45	REJ-05-0-0000-REP-0334	Communications System RAM Report	1
46	REJ-05-0-0000-REP-0335	OCS RAM Report	1

ALS0084164

Ref	Document Number	Document Description	Rev
47	REJ-05-0-0000-REP-0336	TPS RAM Report	1
48	REJ-05-0-0000-REP-0337	Tunnel Ventilation and Electrical System RAM analysis	1
49	REJ-05-0-0000-REP-0338	EJV STA System RAM Analysis (Station System) Report	1
50	REJ-05-0-0000-REP-0339	Trackwork System RAM Analysis	1
51	REJ-05-0-0000-REP-0340	Communications System FMECA Report	0
52	REJ-05-0-0000-REP-0341	Overhead Catenary (OCS) Failure Modes and Effects Analysis	0
53	REJ-05-0-0000-REP-0342	Traction Power Supply (TPS) Failure Modes and Effects Analysis	0
54	REJ-05-0-0000-REP-0343	TVS FMEA	1
55	REJ-05-0-0000-REP-0344	Station (STA) Failure Modes and Effects Analysis Report	0
56	REJ-05-0-0000-REP-0345	Track Failure Modes and Effects Analysis	0
57	REJ-05-0-0000-REP-0354	Communications (COM) Sub-systems Hazard Analysis	2
58	REJ-05-0-0000-REP-0355	Tunnel Ventilation and Electrical System SSHA	3
59	REJ-05-0-0000-REP-0356	TPS Sub-System Hazard Analysis	2
60	REJ-05-0-0000-REP-0358	OCS Sub-System Hazard Analysis	3
61	REJ-05-0-0000-REP-0359	Station (STA) Sub-System Hazard Analysis (SSHA)	1
62	REJ-05-0-0000-REP-0357	Trackwork Sub-System Hazard Analysis (SSHA)	1
63	REJ-05-0-0000-REP-0332	OCS Preliminary Hazard Analysis	0
64	REJ-05-0-0000-REP-0325	Communications Systems PHA	1
65	REJ-05-0-0000-REP-0324	Power Supply Distribution System (PSD) Preliminary Hazard Analysis	1
66	OLR-05-0-0000-REP-0003	Mainline Preliminary Hazard Analysis	B
67	3CU 05018 0025 DUZZA	Thales Ottawa Light Rail Transit Project, Preliminary Hazard Analysis	03
68	REJ-05-0-0000-REP-0326	TVS and Electrical Systems PHA	1
69	3CU 05018 0026 DUZZA	Thales Ottawa Light Rail Transit Project System Hazard Analysis	01
70	3CU 05018 0109 BCZZA	CBTC RAM Analysis (Signalling)	01
71	OLR-05-0-0000-REP-0070	Tunnel Safety Justification Report	2

ALS0084164

Ref	Document Number	Document Description	Rev
72	OLR-05-0-0000-REP-0071	Track Safety Justification Report	1
73	OLR-05-0-0000-REP-0072	Energy Safety Justification Report	1
74	OLR-05-0-0000-REP-0073	Communications Systems Safety Justification Report	0
75	OLR-22-0-0000-REP-0002	Track Assurance Report 2	0
376	OLR-05-0-0000-REP-0064	Stations Safety Justification Report	0
Section 3.2.5 – Threat & Vulnerability			
[redacted]			
		Reference removed	

ALS0084164
ALS0084164

Ref	[redacted]	Document Description	Rev
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ALS0084164

Ref	Document Number	Document Description	Rev
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Section 3.2.6 – Cyber Security			
[redacted]			
Section 3.2.7 - EMC			
125	VIC-74-0-9009-REP-0001	EMC/EMI Environmental Measurement Initial EMC Field Site Survey Report	2
126	VIC-74-0-9009-REP-0002	EMC Simulation Report	4
127	VIC-74-0-9009-REP-0003	Final Survey Report–To be Provided by OLRT-C EMC Manager	2
128	OLR-74-0-0000-MPL-0002	EMC Management Plan	4

Ref	Document Number	Document Description	Rev
129	OLR-74-0-0000-MPL-0003	EMC Test & Measurement Plan	2
130	ADD0000938885	Alstom N90-EMI Conducted Calculation	A
131	ADD0000938969	Alstom EMC Radiated EMC Type Test Procedure	A
132	ADD0000938971	Alstom EMC Radiated EMC Type Test Report	C
133	3CU 05018 0117 QZZZA	Thales: Ottawa Light Rail Transit Project Hardware Environmental and EMC Qualification Report	2
134	Pending	EMC/EMI Fixed Facilities Reports/Certificates	N/A
135	Vican Corporation - Statement of Compliance Letter dated April 8, 2019 on Final EMC Survey results	Ottawa LRV Confederation Line FINAL EMC FIELD SITE SURVEY, April 8 2019	N/A
[381]	OLR-05-0-0000-REP-0076	OLRT EMI / EMC Systems Assurance Report	0
Section 3.2.8 – Grounding			
136	REJ-56-0-0000-REP-0125	Mitigation and Monitoring of DC Stray Current Interference Effects	C
137	OLR-04-0-0000-MPL-0017	Construction Quality Management Plan	3
138	APX-55-0-6187-REP-0001	OLRT Constructors Stray Current Monitoring (Apex Corrosion)	0
139	TSCC Grounding and Bonding Results – SCHNEIDER	List of Grounding Tests –see [144] to [150]	N/A
140	APX-55-0-6187-LET-0001	Rail Isolation and Stray Current Impact on Practical Completion	0
141	RES-56-0-0000-REP-0261	Grounding and Bonding Design Report	0
142	RES-56-0-0000-SPE-2628162	Rail Grounding Switch Specification	0
143	RES-OLR-56-3-LET-0228	Stray Current Testing – July 2017	N/A
144	RES-56-1-TP01-DBC-0131	Ground Fault Calculations – TPSS 01	0
145	RES-56-1-TP02-DBC-0136	Ground Fault Calculations - TPSS 02	0
146	RES-56-3-TP04-DBC-0132	Ground Fault Calculations - TPSS 04	0
147	RES-56-3-TP05-DBC-0133	Ground Fault Calculations - TPSS 05	0
148	RES-56-4-TP06-DBC-0114	Ground Fault Calculations - TPSS 06	0

ALS0084164

Ref	Document Number	Document Description	Rev
149	RES-56-5-TP08-DBC-0116	Ground Fault Calculations - TPSS 08	1
150	RES-56-4-TP09-DBC-0117	Ground Fault Calculations - TPSS 09	0
151	SDE-55-0-9056-PIC-0006	Grounding Test Report, Segment 5	0.1
152	SDE-56-0-9056-PIC-0012	Grounding Test Report, Segment 4	0.1
153	SDE-56-0-9056-PIC-0011	Grounding Test Report, Segment 3	0.1
154	SDE-56-0-9056-PIC-0014	Grounding Test Report, Segment 2	0.1
155	SDE-56-0-9056-PIC-0014	Grounding Test Report, Segment 1	0.1
156	SDE-55-0-9056-PIC-0005	Grounding report for TPSS6	1.1
157	SDE-55-0-9056-PIC-0004	Soil Resistivity Measurements for TPSS10	1.1
158	SDE-55-0-9056-PIC-0003	Grounding report for TPSS7	1.1
159	SDE-55-0-9056-PIC-0002	Grounding report for TPSS9	1.1
160	SDE-55-0-9056-PIC-0010	Grounding report for TPSS5	0.1
161	SDE-55-0-9056-PIC-0009	Grounding report for TPSS4	0.1
162	SDE-55-0-9056-PIC-0001	Grounding report for TPSS8	1.1
163	TCC-55-1-1014-REP-0003	Grounding report for TPSS2	0.1
164	SDE-55-0-9056-PIC-0008	Grounding report for TPSS1	0.1
176	OLR-50-0-0000-MPL-0005	Systems Engineering Management Plan	0
Section 3.2.9 – Human Factors & Ergonomics			
165	REJ-50-0-0000-REP-0089	TSCC Final Human Factors Report	0
167	REJ-50-0-0000-REP-0280	MSF YCC/BCC Ergonomic Report	A
168	ADD0000939551	Driver Display	0
169	ADD0000939495	Cab Layout/Ergonomic	A
170	ADD0000939544	2nd Pre-Final Design Review Cab layout/ergonomics	B
171	ADD0000939261	Driver's Seat Ergonomic Study in Cab	C
172	3CU 05018 0044 DSZZA	HMI Design Document	3
173	WGS-53-0-S069-PDS-0007	SCADA - Operator Interface Style Guide	0
174	WGS-53-0-S069-PDS-0006	SCADA - Operator Interface Library Specification	0
175	INT-58-0-0000-REP-0001	Driver Alertness Study	2
Section 3.2.10- Operability			

ALS0084164

Ref	Document Number	Document Description	Rev
178	OLR-05-0-0000-RGL-104022422	Activation of Back-Up Control Centre	B
179	OLR-05-0-0000-RGL-104022501	Ad Hoc Station Cleaning	B
180	OLR-05-0-0000-RGL-1040232	Belfast Yard Level Grade Crossings	A
180a	OLR-05-0-0000-RGL-104022412	CBTC System – Wayside and Central Equipment Failures	E
181	OLR-05-0-0000-RGL-104022415	Communications System Faults and Failures	B
182	OLR-05-0-0000-RGL-104022423	Driver Vigilance System Activations	B
183	OLR-05-0-0000-RGL-104022502	Elevator Failure	E
184	RTM-17-0-0000-SOP-0040	Emergency Alarm activations	B
185	OLR-05-0-0000-RGL-104022427	Emergency Event – Station Procedures	A
186	OLR-05-0-0000-RGL-104022426	Emergency Events - Mainline	B
187	OLR-05-0-0000-RGL-1060100	Emergency Management Plan	A
188	OLR-05-0-0000-RGL-1060200	Emergency Response Procedures	C
189	OLR-05-0-0000-RGL-104022503	Escalator Failure	B
190	OLR-05-0-0000-RGL-104022424	Guideway Intrusion Procedures	B
191	OLR-05-0-0000-RGL-104022410	In Service Track Failures	B
192	OLR-05-0-0000-RGL-104022420	Inclement Weather Procedures	C
193	OLR-05-0-0000-RGL-104022419	Line of Sight Operations	A
194	OLR-05-0-0000-RGL-104022405	LRV Door Fault Procedures	B
195	OLR-05-0-0000-RGL-104022102	LRV Event Recorder Download Procedure	B

ALS0084164

Ref	Document Number	Document Description	Rev
196	OLR-05-0-0000-RGL-104022403	LRV Faults and Vehicle Minimum Operating Standard	D
197	OLR-05-0-0000-RGL-1040241	MSF Power Failures	B
198	OLR-05-0-0000-RGL-104022421	OCS Failure and Damage	B
199	OLR-05-0-0000-RGL-1040211	Working on the Confederation Line Procedures	B
200	OLR-05-0-0000-RGL-1040233	Planned Vehicle Coupling and Uncoupling	D
201	OLR-05-0-0000-RGL-104022404	Removal of Defective Trains from Service	B
202	OLR-05-0-0000-RGL-104022504	Station Power Failure	C
203	OLR-05-0-0000-RGL-104022408	CBTC Target Point Overshoot Procedure	C
204	OLR-05-0-0000-RGL-104022409	Track Obstructions	B
205	OLR-05-0-0000-RGL-104022413	Traction Power Supply and Distribution Alarms, Faults and Failures	A
206	OLR-05-0-0000-RGL-104022425	Train to Train Evacuations	D
207	OLR-05-0-0000-RGL-104022406	Vehicle Brake System Failures	E
208	OLR-05-0-0000-RGL-104022205	Weather Monitoring, Reporting and Alert Level	B
209	OTRC-S200-13-WI	Assault or Threat of Violence	0.2
210	OTRC-S200-18-WI	Bomb Threat	0.2
211	Confidential	CBRN- Chemical, Biological, Radiological or Nuclear	0.1
212	OTRC-S200-34-WI	Civil Unrest on the Confederation Line	0.2
213	OTRC-S200-01-WI	Vigilance Systems Activations	0.3
214	OTRC-S200-02-WI	Degraded Adhesion	1.0
215	OTRC-S200-29-WI	Disturbance on the Confederation Line	0.3
216	OTRC-S200-03-WI	Docking Issue	0.4

ALS0084164

Ref	Document Number	Document Description	Rev
217	OTRC-S200-12-WI	Door Fault Recovery	0.2
218	OTRC-Q200-05-WI	Door Procedure for Revenue Service	0.3
219	OTRC-S200-04-WI	Employee Emergency Alarm	0.4
220	OTRC-S200-28-WI	Evacuations on the Confederation Line	0.3
221	OTRC-S200-05-WI	Fire and Smoke at a Station	0.5
222	OTRC-S200-08-WI	Fire and Smoke at the Maintenance and Storage Facility	0.5
223	OTRC-S200-06-WI	Fire and Smoke in a Traction Power Substation or on the Guideway	0.6
224	OTRC-S200-09-WI	Fire and Smoke on a Train	0.5
225	OTRC-S200-07-WI	Fire and Smoke in a Tunnel	0.5
226	OTRC-Q200-06-SD	Fire and Smoke Monitoring, Systems and Equipment	0.6
227	OTRC-S200-35-WI	Hijacking on the Confederation Line	0.2
228	OTRC-S200-10-WI	Joint Region of Authority Transfer	0.4
229	OTRC-S200-15-WI	On-Board CBTC Faults and Failures	0.5
230	OTRC-S200-32-WI	Person with a weapon on the Confederation Line	0.3
231	OTRC-S200-16-WI	Radio Protocol	1.0
232	OTRC-S200-17-WI	Rail Controller Duty Transfer	0.5
233	OTRC-Q200-04-WI	Rail Log	0.5
234	OTRC-S200-11-WI	Removing Non-Communicating Trains from Service	0.3
235	OTRC-S200-20-WI	Rules Deviation Procedure	1.0
236	OTRC-S200-22-WI	Scheduled Station Opening and Closing	0.3
237	OTRC-S200-23-WI	Seismic Events	0.5
238	OTRC-S200-30-WI	Suspicious Activity or Mischief	0.2
239	OTRC-S200-36-WI	Suspicious Package on the Confederation Line	0.2
240	OTRC-S200-24-WI	Sweep Trips	1.1
241	OTRC-S200-25-WI	Temporary Speed Restrictions	0.3
242	OTRC-S200-26-WI	Track Failures and Obstructions	1.1
243	OTRC-S200-27-WI	Traction Power Isolation	0.4

ALS0084164

Ref	Document Number	Document Description	Rev
244	OTRC-Q200-02-WI	Train Event Recorder Download	0.4
245	OTRC-S200-37-WI	Train/Human Contact	0.2
246	OLR-05-0-0000-RGL-1080000	Environmental Management	A
247	OLR-05-0-0000-RGL-1150000	Public Education and Outreach	A
248	OCT-S230-03-PROG	Safety Management System	1.0
249	OLR-05-0-0000-RGL-1050000	CONFEDERATION LINE SAFETY MANAGEMENT SYSTEM 5.0 Training and Certification	A
250	OLR-05-0-0000-RGL-1040900	Verification of Regulatory Compliance	A
251	OLR-05-0-0000-RGL-104070000	LRV Safety and Inspection Rules	A
252	OTRC-S100-00-RUL	Electric Light Rail Operating Rules Rule Book	1.1
Section 3.3 – Configuration			
279	OLR-09-0-0000-MPL-0004	Configuration Management Recovery Plan	3
310	OLR-05-0-0000-MPL-0036	Configuration Change Control Recovery Plan	2
313	OLR-09-0-0000-REG-0002	Configurable Items Database	02
314	3CU 05018 0020 QMZZA	Thales Configuration Management Plan	04
315	ADD0000939450	Alstom Configuration & Change Management Plan	D
316	RES-53-0-0000-REP-0299	RTGE Joint Venture. CTS & Subsystems CM Plan	A
317	OLR-50-0-0000-MPL-0003	System Integration Program Plan	A
318	REJ-05-0-0000-REP-0308	REJ. Safety Certification Support Plan	0
Section 4 – Process			
319	OLR-05-0-0000-WBS-0002	Systems Engineering and Assurance Governance Document Tree Railway Level	C
320	OLR-09-0-0000-REG-0003	PDMPlus User Guide	D
321	OLR-09-0-0000-REG-0004	PDMPlus and Scrape Tool	N/A
323	SEMP-P0050-PLA-0020	RACI-S	Nov-18

ALS0084164

Ref	Document Number	Document Description	Rev
325	TBA	Terms of Reference for RBI Audit Follow Up & Close Out (minutes of meeting)	N/A
330	OLR-00-0-0000-REG-0012	Design Certification Log	N/A
331	OLR-00-0-0000-REG-0012	Construction Certification Log	N/A
332	OLR-04-0-0000-REG-0026	Thales PICOs Tracker	N/A
333	OLR-05-0-0000-MPL-0017	OLRT-C Primary Systems Level Project Assurance Plan	0
334	OLR-05-0-0000-MPL-0008	OLRT Authority Approval Process Plan	1
336	OLR-05-0-0000-MPL-0039	OLRT-C Maintenance Storage Facility Project Assurance Plan	0
337	OLR-05-0-0000-MPL-0032	OLRT-C At Grade Stations Project Assurance Plan	2
338	OLR-05-0-0000-MPL-0033	OLRT-C Underground Stations Project Assurance Plan	1
339	OLR-05-0-0000-MOE-DIR-0001	Design Integration Review Meeting Minutes	0
339	OLR-05-0-0000-PRE-0004	Design Integration Review Presentation	0
Section 4.2 – Competency			
340	OLR-05-0-0000-MPL-0040	OLRT-C Competency Management Plan	0
341	EoR EJV Competency Matrix	Cross Reference of EoR Against Activities	N/A
342	OLR-04-0-0000-MPL-0001	SEMP Competency Framework	0
343	N/A	Professional Specialist Engineers Listing	N/A
344	90p28_e	Professional Engineers Act	N/A
Section 4.3 – Audits			
345	SEMP-PSL-AUD-2018-2003	Systems Engineering and Assurance Technical Audit (Alstom) Report	1
346	SEMP-PSL-AUD-2018-2002	Systems Engineering and Assurance Technical Audit (Thales) Report	1
347	SEMP-PSL-AUD-2018-2001	Systems Engineering and Assurance Technical Audit (EJV) Report	1
348	SEMP-P0050-0-0000-REG-0003	SEMP Audit Status Report Log	N/A
349	OLR-22-0-0000-REP-0005	OLRT Stations Accessibility Review	0

ALS0084164

Ref	Document Number	Document Description	Rev
350	OLR-05-0-0000-REG-0013	Intrusive Audit Action Tracker	N/A
351	SEMP-P0050-0-0000-SCH-0003	Audit Programme	N/A
352	OLR-OLR-05-0-TRA-0077	Guideway Station and MSF Observation Register	C
353	OLR-05-0-0000-REG-0015	Assets – TVA and NFPA 130 Requirements Compliance Inspections	0
354	OLR-05-0-0000-REP-1001	Escalators – TVA and NFPA 130 Requirements Compliance Inspections	0
355	OLR-05-0-0000-REP-1002	Fire – TVA and NFPA 130 Requirements	0
356	OLR-05-0-0000-REP-1003	Comms and CCTV–TVA and NFPA 130 Requirements Compliance Inspections	0
357	OLR-05-0-0000-REP-1004	Evacuation – TVA and NFPA 130 Requirements Compliance Inspections	1
358	OLR-05-0-0000-REP-1005	Civils & Construction – TVA and NFPA 130 requirements	1
359	OLR-05-0-0000-REP-1006	Electrical – TVA and NFPA 130 requirements	2
360	OLR-05-0-0000-REP-1007	Mechanical – TVA and NFPA 130 requirements	1
361	OLR-05-0-0000-REP-1008	Signage – TVA and NFPA 130 requirements	0
362	OLR-05-0-0000-REP-1009	Hydro Ottawa – TVA and NFPA 130 requirements	0
Section 5–Quality			
253	RTG-04-0-0000-QMS-0001	Project Quality Manual	3
254	OLR-04-0-0000-MPL-0010	Environmental Quality Management Plan (EQMP)	3
255	REJ-04-0-0000-MPL-0022	Design Quality Management Plan (DQMP)	1
256	OLR-04-0-0000-MPL-0032	Ottawa Light Rail Transit Project Traffic Quality Management Plan (TQMP)	4
256a	OLR-04-6-H417-MPL-0005	Ottawa Light Rail Transit Project Traffic Quality Management Plan H417 – Segment 6	00
257	RTM-04-0-0000-MPL-0044	Maintenance & Rehabilitation Quality Management Plan (M&RQMP)	2
258	BSI-04-0-0000-ARP-0001	BSI Audit of QMS	N/A
258	BSI-04-0-0000-ARP-0002	BSI Audit of QMS	N/A

ALS0084164

Ref	Document Number	Document Description	Rev
258	BSI-04-0-0000-ARP-0003	BSI Audit of QMS	N/A
258	BSI-04-0-0000-ARP-0004	BSI Audit of QMS	N/A
258	BSI-04-0-0000-REP-0001	BSI Audit of QMS	N/A
259	OLR-09-0-0000-MPL-0002	Project Risk Management Plan	1
260	OLR-00-0-0000-MWR-0074	Project Monthly Works Report	N/A
261	OLR-QMS-GP700-SP01	Design Review Interface Protocol	1
262	OLR-QMS-GP700-SP02	Design Change Management Procedure	0
263	OLR-QMS-GP700-SP06	Request for Information Procedure	1
264	OLR-QMS-GP301-SP01	Project Procurement Plan	01
265	OLR-04-0-0000-SCE-0003 to 0007	OLRT-C Quality Audit Plan	7
266	OLR-QMS-GP-4.03	Internal & External Audits	2
267	OLR-04-0-0000-REG-0012	OLRT-C Internal and External Audit Register	N/A
268	OLR-04-0-0000-REP-0001 to 0080 (Feb 2019)	OLRT-C QMS Monthly Reports	8
269	OLR-QMS-GP-4.04	Continual Improvement	0
270	OLR-QMS-GP-4.02	Corrective and Preventive Actions	01
271	OLR-QMS-GP100-SP06	List of Documents for Handover	0
272	OLR-QMS-GP700-SP05	Ottawa Light Rail Transit Project Specific Procedure: Preparatory Works	2
273	OLR-QMS-GP700-SP03	Ottawa Light Rail Transit Project Specific Procedure: Field Directives	2
274	OLR-QMS-GP700-SP04	Ottawa Light Rail Transit Project Specific Procedure: Site Instructions	3
275	OLR-QMS-GP4 01	Management of Non Conformances	0
276	OLR-90-0-0000-MPL-0001	Deficiencies Management Plan	0
277	OLR-16-0-0000-MPL-0001	Testing & Commissioning Management Plan	3
279	OLR-09-0-0000-MPL-0004	Configuration Management Recovery Plan	3
280	OLR-QMS-GP-1.00	Control of Documents	1
281	OLR-QMS-GP-1.01	Control of Records	2

ALS0084164

Ref	Document Number	Document Description	Rev
282	OLR-QMS-GP-2.00	Management Review	2
283	OLR-QMS-GP-2.01	Objectives & Targets	1
284	OLR-QMS-GP-3.00	Planning of Product Realization & Internal Communications	0
285	OLR-QMS-GP-3.01	Procurement (Subcontracts & POs) & Verifications	1
286	OLR-QMS-GP-3.02	Monitoring & Measurement of Product	1
287	OLR-QMS-GP-3.03	Project Execution & Traceability (Product & Services)	1
288	OLR-QMS-GP4.01	General Procedure: Management of Non-Conformances	3
289	OLR-QMS-GP-4.05	Customer Satisfaction & Complaints Procedure	2
290	OLR-QMS-GP-6.00	Resources & Training	1
291	OLR-QMS-GP-7.00	Design	1
292	OLR-QMS-GP100-SP01	OLRT-C. Documents & Records Control and Security Protocol	01
293	OLR-QMS-GP100-SP02	Documents Naming Procedure	03
294	OLR-QMS-GP100-SP03	Work Submittals Flow Chart	0
295	OLR-QMS-GP302-SP01	Specific Procedure: Inspection and Testing Plans	0
296	OLR-QMS-GP302-SP02	Specific Procedure for Environment – Permits, Licences, Approvals and Agreements (PLAA)	1
297	OLR-QMS-GP302-SP03	Specific Procedure for Environment – Monitoring, Reporting and Deficiencies	2
298	OLR-QMS-GP302-SP05	Specific Procedure: Running tunnel – Rock Bolts Pull Test	2
299	OLR-QMS-GP302-SP06	Specific Procedure: Materials Control, Product Identification and Traceability	2
300	OLR-QMS-GP302-SP08	Specific Procedure: OLRTC Submittals	0
301	OLR-QMS-GP700-SP07	Specific Procedure: CADD Submissions	0
302	OLR-QMS-GP700-SP08	Specific Procedure: Comment Resolution Sheets	0
303	OLR-QMS-GP700-SP10	Specific Procedure: Technical Coordination Groups & Other Groups	1
304	OLR-QMS-GP700-SP11	Specific Procedure: Enclosure Form	1

ALS0084164

Ref	Document Number	Document Description	Rev
305	OLR-QMS-GP700-SP12	Specific Procedure: Technical Tender Evaluation	0
306	OLR-QMS-GP700-SP13	Red-Line and As-Built Procedure and Guidelines	1
307	OLR-QMS-GP700-SP14	Systems Final Design Review and Issued for Construction Package Preparation Procedure	0
309	OLR-QMS-GP100-SP05	Documentation Handover Plan	A
310	OLR-05-0-0000-MPL-0036	Configuration Change Control Recovery Plan	2
311	OLR-05-0-0000-REP-0061	At Grade Station Condition Assessment Report (Hurdman)	0
312	OLR-05-0-0000-REP-0062	Underground Station Condition Assessment Report (Lyon)	0
Section 6 – Supporting Tools			
367	OLR-05-0-0000-MPL-0050	IDABS Plan	0
368	OLR-05-0-0000-SCE-0004	IDAB5 Spreadsheet	0
369	SEMP-P0050-PLA-0028	GSN Visio Model	0
370	SEMP-P0050-PRE-0001	GSN PowerPoint Model	0

End of Document