OTTAWA LIGHT RAIL TRANSIT PROJECT

Ottawa Confederation Line Phase 1

Operational Restrictions Document

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LICENSED PROFESSIONAL ENGINEER J. BERGERON PROVINCE OF ONTARIO

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REVISION HISTORY

Rev	Date	Description	Prepared by	Reviewed by	Approved by	Authorised by	Agreed by
0	17-Apr-19	Initial Issue	S Forster	S Leonard	J Blowfield	D Wynne	S Derry
1	09-Jul-19	Amended in response to CRE comments	M Williamson	S Leonard	J Blowfield	D Wynne	S Derry
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EXECUTIVE SUMMARY

This is the Operational Restrictions Document for the Ottawa Confederation Line Phase 1 Railway System. It has been prepared in accordance with the requirements of the Confederation Line Phase 1 Systems Safety Certification Plan [6], Confederation Line Phase 1 Systems Safety Programme Plan [5] and the Confederation Line Phase 1 Authority Approval Process Plan [1]. It identifies any Restrictions, Conditions and Limitations which must be observed to ensure validity of the Confederation Line Phase 1 Engineering Safety and Assurance Case [7] and subordinate Case for Safety [4]. The Restrictions, Conditions and Limitations identified herein are applicable to any person or party, irrespective of any prevailing commercial arrangements, involved in operating and/or maintaining and/or renewing/upgrading/extending Confederation Line Phase 1.

A thorough hazard identification, analysis and mitigation process has been undertaken in accordance with the Confederation Line Phase 1 Hazard Management Procedure [2]. The outcome of this process is recorded in the Confederation Line Phase 1 Integrated Hazard Log [3] and various subordinate Hazard Logs associated with the Primary Systems Safety Justification Reports .

Correct design, construction and integration has been verified by Engineers of Record and recorded in Design Certification Letters (DCL), Integration Certification Letters (ICL) and Construction Certification Letters (CCL). Safety Assurance is further supported by Ontario Building Control (OBC) Certificates, Ottawa Fire Service (OFS) Certificates and Technical Standards and Safety Authority (TSSA) approvals. Furthermore, Systems Integration Testing (SIT) and Systems Acceptance Testing (SAT) have been successfully completed. The Confederation Line Phase 1 RAM Report [8] underpins these Safety Analyses and Assurances confirming the infrastructure can deliver long term availability.

Based upon evidence presented in the Confederation Line Phase 1 Engineering Safety and Assurance Case [7] and subordinate Case for Safety [4], and subject to the Restrictions, Conditions and Limitations described herein being adhered to, the Ottawa Confederation Line Phase 1 Railway is considered fit for safe operation.

Based upon the evidence presented, it is considered that Ottawa Confederation Line Phase 1 Railway is acceptable for revenue service subject to adherence to any Restrictions, Conditions and Limitations identified in this document and resolution of issues identified in the Engineering Safety and Assurance Case Outstanding Items [14].

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1. INTRODUCTION

This document presents the Restrictions, Conditions and Limitations for the Ottawa Confederation Line Phase 1 and supports the Confederation Line Phase 1 Case for Safety [4], collectively these provide Safety Justification for Revenue Service.

Project Agreement, schedule 13, section 5.1.5 "Safety Certification and Regulatory Matters" provides the following instructions:

Safety Case

The Safety Case will be based on the composite of all SSCP documents and will provide links to the disposition of all hazards, and to the status of Safety Certificates. The Safety Case will be a composite of both the Generic Safety Case and Application Specific Safety Case, as outlined in both EN 50126 [20] and EN 50129 [22]. These include the following:

- An overview of the OLRT as a system
- A summary of reference to the safety requirements
- Evidence that the OLRT, as designed, installed and tested, meets all safety requirements
- Adequacy of compliance with the safety requirements
- A summary of the safety assessment and safety audit tasks
- A summary of the safety analysis tasks
- An overview of the safety engineering techniques employed
- A Quality Management Report, providing a summary of the quality and safety management controls adopted
- Related Safety Cases for any subsystems on which the main Safety Case depends
- A summary of any limitations or constraints, and how these may be lifted

Restrictions, Conditions and Limitations for the Ottawa Confederation Line Phase 1 have therefore been identified by Engineering Safety Management processes implemented in accordance with the Confederation Line Phase 1 Systems Safety Certification Plan [6] and Confederation Line Phase 1 Systems Safety Programme Plan [5] in accordance with the requirements of EN 50126 [20], EN 50128 [21] and EN 50129 [22] to ensure safety is inherent in the design, implementation and operation.

It should be noted that the Restrictions, Conditions and Limitations identified herein are applicable to any person or party, irrespective of any prevailing commercial arrangements, involved in operating and/or maintaining and/or renewing/upgrading/extending Confederation Line Phase 1.

1.1 PURPOSE

When a complex system enters service for the first time, there will be constraints on its usage; this can be likened to not exceeding a certain number of revs during the initial ownership period of a new car. Hence, usage constraints do not necessarily constitute failure or defect of the railway.

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Restrictions, Conditions and Limitations enable effective, efficient and safe utilisation of the railway in normal, degraded and emergency degraded modes. Harmonisation and optimisation of Restrictions, Conditions and Limitations is best achieved by 'learning' obtained during both Trial Running and Revenue Service.

Hence Operational Restriction, Condition or Limitation take many forms and do not necessarily constrain safe Revenue Service, such as running at reduced speed or reducing headway. They can specify exceptional or additional monitoring of systems, people or processes to monitor how the railway is normally used daily, and how it must be used in exceptional circumstances.

The objective of this document is therefore to inform the City of Ottawa, Operator (OC-Transpo) and Maintainer (Rideau Transport Maintenance (RTM)) of any constraints which must be observed to ensure safe Revenue Service.

- Restriction – describes what the City of Ottawa, Operator (OC-Transpo) and Maintainer (RTM) can't do
- Condition – describes what the City of Ottawa, Operator (OC-Transpo) and Maintainer (RTM) can do but only like this
- Limitation – describes what the City of Ottawa, Operator (OC-Transpo) and Maintainer (RTM) can do but only this much

For completeness and convenience this document also presents a consolidated list of all recommendations recorded in the Confederation Line Phase 1 Engineering Safety and Assurance Case [7], the Confederation Line Phase 1 Case for Safety [4] and any subordinate Safety Justification Reports or Safety analyses.

1.2 SCOPE

This Confederation Line Phase 1 Operational Restrictions Document covers the whole integrated railway systems defined by the Confederation Line Phase 1 Configurable Items Database [15] within the following categories:

- Tunnel Systems
- Track Systems
- Signalling & Train Interface
- Trains
- Energy
- Communications and Control
- Stations
- Transit Service Control Centre (TSCC) and Backup Control Centre (BCC)
- Maintenance and Storage Facility (MSF).

This Operational Restrictions Document also considers the interfaces and interactions of between the Confederation Line Phase 1 Railway Systems and the Infrastructure and Rolling Stock Maintainers, Operators and the environment.

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1.3 DOCUMENT STRUCTURE

This Operational Restrictions Document is structured as follows:

- Section 1: Defines the purpose, scope and approach to the safety analysis and management and the relationship of this document to other key safety documentation.
- Section 2: Provides a holistic system description including geographic locations, equipment, key parties, design criteria and environmental and operating context
- Section 3: Description of Restrictions applicable to the Ottawa Confederation Line Phase 1 Railway
- Section 4: Description of Conditions applicable to the Ottawa Confederation Line Phase 1 Railway
- Section 5; Description of Limitations applicable to the Ottawa Confederation Line Phase 1 Railway
- Section 6: Description of Recommendations applicable to the Ottawa Confederation Line Phase 1 Railway
- Section 7: Conclusions

1.4 DOCUMENT HIERARCHY

The Confederation Line Phase 1 Operational Restrictions Document supports the Confederation Line Phase 1 Engineering Safety and Assurance Case [7] and subordinate Ottawa Confederation Line Phase 1 Case for Safety [4].

The Confederation Line Phase 1 Safety and Assurance framework is shown in Figure 1.

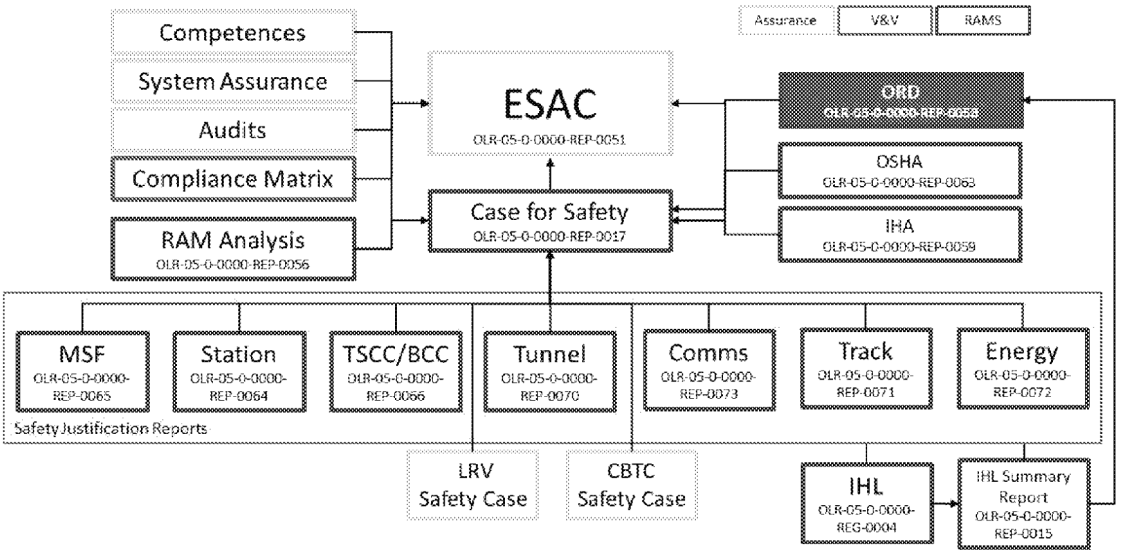

Figure 1 - Document Hierarchy

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1.5 GLOSSARY

Table 1: Glossary

Abbreviation	Meaning
BCC	Backup Control Centre
CBTC	Communication Based Train Control
CCL	Construction Certification Letter
CCTV	Closed Circuit Television
COADS	City of Ottawa Design Standard
DCL	Design Certification Letter
DRACAS	Data Recording and Corrective Action System
DSR	Derived Safety Requirements
DWA	Designated Waiting Area
EB	Emergency Brake
EJV	Engineering Joint Venture
ETEL	Emergency Telephone
ESAC	Engineering Safety Assurance Case
FDAS	Fire Detection and Alarm System
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HRP	Hazard Review Panel
IRJ	Insulated Rail Joint
LRU	Line Replaceable Unit
LRT	Light Rail Transit
LRV	Light Rail Vehicle
MSF	Maintenance and Storage Facility
NDT	Non-Destructive Test
OFS	Ottawa Fire Service
OBC	Ontario Building Control
OCS	Overhead Catenary System
OLRT	Ottawa Light Rail Transit
OLRT-C	Ottawa Light Rail Transit – Constructors
RAMS	Reliability Availability Maintainability Safety
RCF	Rolling Contact Fatigue
RM	Restricted Manual
RTM	Rideau Transit Maintenance
SAT	Systems Acceptance Test

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Abbreviation	Meaning
SCADA	Supervisory Control And Data Acquisition
SIL	Safety Integrity Level
SIT	Systems Integration Test
SOP	Standard Operating Procedure
SRV	Slip Resistance Value
TPSS	Traction Power Substation
TSCC	Transit Services Control Centre
TVS	Tunnel Ventilation System
UTO	Unattended Train Operation
VOBC	Vehicle On-board Controller

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1.6 REFERENCED DOCUMENTS

1.6.1 Referenced Project Documents

Table 2: Reference Documents

No.	Document Title	Document No.
[1]	Confederation Line Phase 1 Authority Approval Process Plan	OLR-05-0-0000-MPL-0008
[2]	Confederation Line Phase 1 Hazard Management Procedure	OLR-05-0-0000-PRC-0001
[3]	Confederation Line Phase 1 Integrated Hazard Log	OLR-05-0-0000-REG-0004
[4]	Confederation Line Phase 1 Case for Safety	OLR-05-0-0000-REP-0017
[5]	Confederation Line Phase 1 Systems Safety Programme Plan	OLR-05-0-0000-MPL-0012
[6]	Confederation Line Phase 1 Systems Safety Certification Plan	OLR-05-0-0000-MPL-0003
[7]	Confederation Line Phase 1 Engineering Safety and Assurance Case	OLR-0-05-0000-REP-0051
[8]	Confederation Line Phase 1 RAM Report	OLR-05-0-0000-REP-0056
[9]	Tunnel Ventilation – Signaling Criteria Report	REJ-52-2-000-REP-0071
[10]	MSF Shop OCS Safe Work Procedure	OLR-15-4-MEAB-PRC-0003
[11]	TSCC Final Human Factors Report	REJ-50-0-0000-REP-0089
[12]	HRP Meeting Minutes 09, dated 10.04.2019	-
[13]	Project Agreement	TORO J; 4868348: v55
[14]	Engineering Safety and Assurance Case Outstanding Items	OLR-05-0-0000-REG-0025
[15]	Confederation Line Phase 1 Configurable Items Database	OLR-50-0-0000-REP-0058
[16]	Confederation Line Phase 1 System Breakdown Structure	OLR-09-0-0000-DIA-0001
[17]	Safety Requirements Matrix	OLR-05-0-0000-REP-0053
[18]	Confederation Line Phase 1 Integrated Hazard Log Summary Report	OLR-05-0-0000-REP-0015
[19]	PA Technical Compliance Matrix	OLR-90-0-0000-CMP-0002

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1.6.2 Referenced Codes and Standards

The Confederation Line Phase 1 Railway System has been developed in accordance with the requirements of the Codes and Standards identified in Table 3. Reference is made to the either the version/issue cited in the Project Agreement [13] unless where otherwise stated.

Table 3 - Applicable Codes and Standards

	Title	Document No.
[20]	The specification and demonstration of reliability, availability, maintainability and safety (RAMS)	EN 50126
[21]	Functional safety of electrical/electronic/programmable electronic safety-related systems	EN 50128
[22]	Communication, signalling and processing systems. Safety related electronic systems for signalling	EN 50129
[23]	Standard for Fixed Guideway Transit and Passengers Rail Systems	NFPA 130
[24]	Standard for Lightning Protection Systems	NFPA 780
[25]	Bonding and Grounding of Electrical Equipment (Protective Grounding)	CAN/CSA C22.2
[26]	General Grounding Requirements and Grounding requirements for Electrical Supply Stations	CAN/CSA C22.3
[27]	Railway Electrification Guideline Standard No.8	CAN/CSA C22.2 – M91
[28]	Guide for Safety in AC Sub-Station Grounding	IEEE 80
[29]	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System	IEEE 81
[30]	Railway Applications, Fixed Installations – Protective Provisions Relating to Electrical Safety and Grounding	EN 50122-1
[31]	Effects of Current on Human Beings and Livestock – Part I General Aspects	IEC 60479
[32]	Canadian Electrical Code Part 1	CSA C22.1
[33]	Ontario Electrical Safety Code	-
[34]	Common Safety Method Design Targets (CSM+DT), Guidance on the Common Safety Method for Risk Evaluation and Assessment	GEGN8646
[35]	City of Ottawa Accessibility Design Standard	-
[36]	Protection against corrosion by stray current from direct current systems	EN 50162

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2. SYSTEM DESCRIPTION

2.1 PROJECT DESCRIPTION

Ottawa Confederation Line Phase 1 provides a low floor Light Rail Vehicle (LRV) Light Rail Transit (LRT) service between Tunney's Pasture and Blair stations. The 12.5-kilometre line includes a 2.5km mined tunnel beneath downtown Ottawa and an Maintenance and Storage Facility (MSF) at Belfast Road, shown in Figure 2.

Phase 1 includes thirteen stations, with three considered as Under Ground Stations, one considered as an Enclosed Station, and Blair Station, Hurdman Station and Tunney's Pasture Station integrating with the Bus Rapid Transit system. The Confederation Line links up with the north-south running O-Train at Bayview Station, and with VIA rail at Tremblay.

The Ottawa Confederation Line Phase 1 scope comprises Guideway, Stations and Line of Route systems between Tunney's Pasture and Blair Stations and delivery of the MSF, Yard, TSCC/BCC and LRV Fleet as defined by the RTG - City of Ottawa Project Agreement [13].

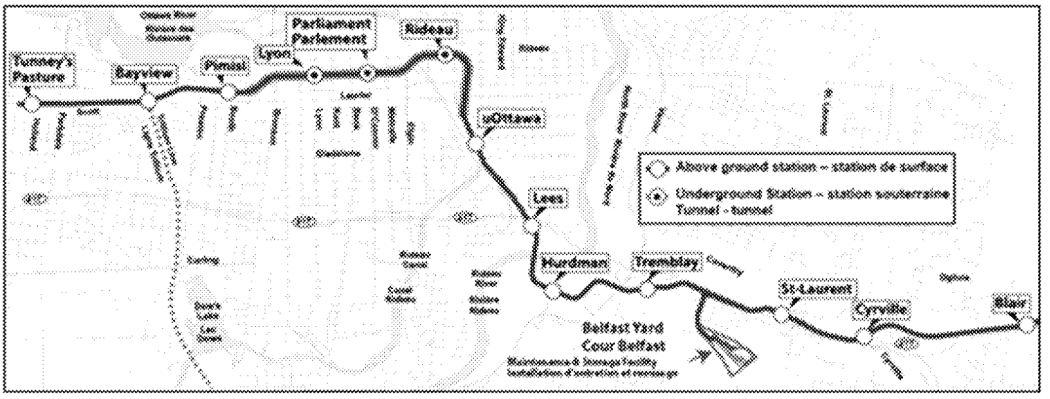

Figure 2 - Confederation Line Phase 1 Route Map

2.2 KEY PARTIES

Design of the majority of Ottawa Confederation Line Phase 1 infrastructure was the responsibility of an Engineering Joint Venture (EJV) partnership between SNC Lavalin, Dragados and EllisDon.

Alstom Citadis Spirit low floor articulated rail vehicles are used to provide up to 300 passengers per LRV unit.

Communications Based Train Control (CBTC) moving block train control systems has been provided by Thales.

Transit Services (OC-Transpo) provide all main line control staff, LRV Drivers, transit law and other customer service personnel.

Rideau Transit Maintenance (RTM) are responsible for maintenance of all systems and infrastructure including the LRV fleet.

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2.3 ENVIRONMENT

Two and a half kilometres of the Ottawa Confederation Line Phase 1 is underground, passing through the core of Ottawa. Three stations, Lyon, Parliament and Rideau are in this tunnel section, in addition St Laurent station is an "enclosed Station" and considered to be below grade.

In certain areas enhanced track systems have been provided for noise and vibration attenuation.

Part of the railway is under the Ottawa Canal and below the rising water table, requiring appropriate waterproofing and flood protection measures.

The external environment presents a range of challenges:

- Extremes of heat, cold and relative humidity
- Average temperature -15°C to +15°C
- Extreme temperatures - 38°C to +39°C
- Effect of dust (e.g. equipment with appropriate IP protection)
- Snow and ice on exposed sections including tunnel mouths (e.g. point heaters for points in the open areas) and with a risk of build-up of ice on the catenary
- Wind which can deflect the overhead catenary and put sideways forces on the support posts
- Shock and vibration
- Seismic activity
- Electromagnetic Interference.

2.4 OPERATING CONTEXT

Overall performance and cost effectiveness of the Ottawa Confederation Line Phase 1 Railway has been enhanced by embedding Supervisory Control And Data Acquisition (SCADA) as a fundamental feature of the design solution and operations concept. This approach automates equipment monitoring, many operating functions and facilitates enhanced operator decision-making. SCADA benefits RAMS performance through the provision of an accurate and complete data set relating to performance and health of equipment that can be used to inform maintenance scheduling.

The Ottawa Confederation Line Phase 1 infrastructure has been designed to minimise the maintenance burden and logistic footprint. Maintenance has been rationalised to repair by LRU replacement at first line as far as is technically feasible, and preventive maintenance minimised by design and widespread implementation of SCADA monitoring capability. This approach reduces safety risk to on-track personnel by minimising the exposure to hazardous environments whilst maximizing benefits to passengers through on-time running and cost effectiveness.

Systems were selected for their inherent ease of maintenance whilst the infrastructure layout was designed to permit necessary access, walking routes and provision for human factors.

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3. RESTRICTIONS

3.1 CONTEXT

The Ottawa Confederation Line Phase 1 was developed as the City of Ottawa Stage 1 Rail Plan. Rail network expansion plans are now being pursued under City of Ottawa Stage 2 Rail Plan;

- Trillium Line that connects at Bayview Station that is within the Ottawa Confederation Line Phase 1 scope; this includes provision of Service Control Centre features in TSCC that will need to be expanded.
- Confederation Line Phase 2 / 3 comprising extensions to Confederation Line Phase 1 scope in both Easterly and Westerly directions; these include provision of Service Control Centre features in TSCC that will need to be expanded in addition to placing further demands on existing infrastructure.

3.2 STANDARDS

The standard Railway applications — The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) – Part 1: Basic requirements and generic process, EN 50162 [36], section 4.4.2.2 states:

> 4.4.2.2 At a high level, the factors that influence system RAMS are generic, applying across all industrial applications. Figure 5 includes some generic factors which influence transport system RAMS. This figure also shows the interaction between these factors. To identify detailed factors which influence the RAMS of railway systems, each generic influencing factor shall be considered in the context of the specific system.

Section 4.4.2.2 references the figure that is included here, Figure 3

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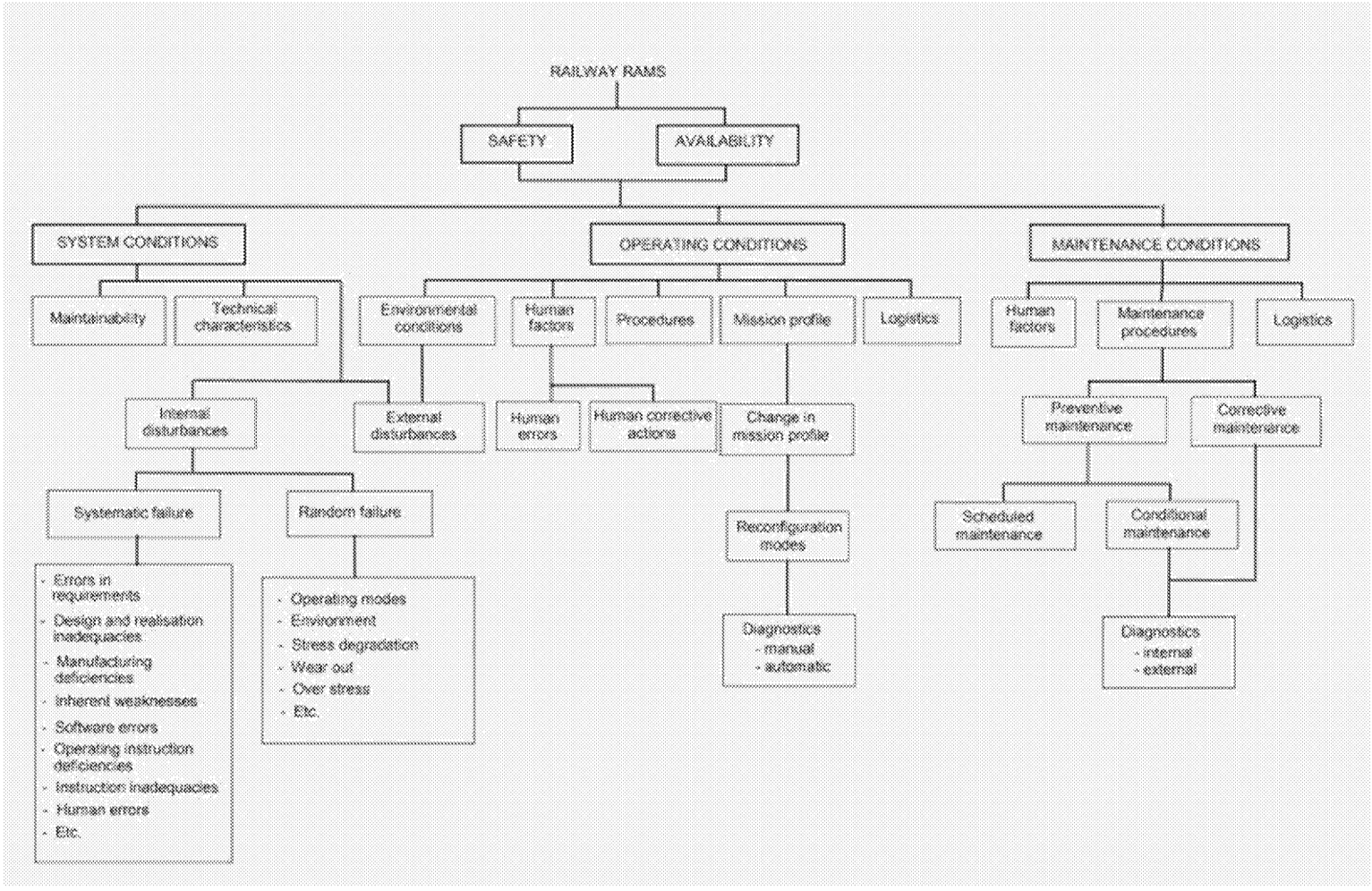

Figure 3 - Sourced from EN 50126 Factors Influencing Railway RAMS

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3.3 POLICIES

In order that the Confederation Line Phase 1 Engineering Safety and Assurance Case [7] and Ottawa Confederation Line Phase 1 Case for Safety [4], and all supporting Safety Justifications and Analyses are valid, the following must be adhere to:

- There **must be no** Safety, RAM, Performance, Functionality or Assurance impact on the Ottawa Confederation Line Phase 1 Railway as a result of other works.
- To utilise the Ottawa Confederation Line Phase 1 Railway infrastructure as a constituent part of an enlarged scope, any existing Safety, RAM, Performance, Functionality and Assurance justifications, analyses and evidences **must be** revalidated within the enlarged railway scope.

3.4 RESTRICTIONS

To comply with the policies defined in section 3.3 the following Restrictions must be enforced for Confederation Line Phase 1 Railway:

- Communications System
  - No equipment shall be physically or otherwise installed in or connected to the existing Communications Primary Systems unless the appropriate Threat & Vulnerability Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing Communications Primary System unless the appropriate Cyber Security Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing Communications Primary System unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].
- Signalling
  - No equipment shall be physically or otherwise installed in or connected to the existing CBTC Primary Systems unless the appropriate Threat & Vulnerability Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing CBTC Primary System unless the appropriate Cyber Security Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing CBTC Primary System unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].
- TSCC/BCC
  - No equipment shall be physically or otherwise installed in or connected to the existing TSCC or BCC systems unless necessary Cyber Security Certification has been obtained.

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- No equipment shall be physically or otherwise installed in or connected to the existing TSCC or BCC Primary System unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].

- Stations
  - No equipment shall be physically or otherwise installed in or connected to the existing Station Primary Systems unless the appropriate Threat and Vulnerability Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing Stations Primary System unless Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].
- Guideway
  - During any Stage 2 works, any worksites adjacent to the Confederation Line Phase 1 Guideway shall ensure that public access is controlled preserving the existing Threat and Vulnerability Certification.
  - No equipment shall be physically or otherwise installed in or connected to the existing Guideway unless the appropriate Threat & Vulnerability Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing Guideway unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].
- Track
  - No equipment shall be physically or otherwise connected to the existing Track Primary System unless the appropriate Grounding and Bonding analyses have been obtained.
  - No extension of the track shall be physically or otherwise connected to the existing Track Primary System unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].
- Energy
  - No equipment shall be physically or otherwise installed in or connected to the existing Energy Primary System unless the appropriate Grounding and Bonding analyses have been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing Energy Primary Systems unless the appropriate Threat & Vulnerability Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing Energy Primary System unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].

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- MSF
  - No equipment shall be physically or otherwise installed in or connected to the existing MSF Primary Systems unless the appropriate Threat & Vulnerability Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing MSF Primary System unless the appropriate Grounding and Bonding analyses have been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing MSF Primary System unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].
- LRV
  - No equipment shall be physically or otherwise installed in or connected to the existing LRV Primary Systems unless the appropriate Threat & Vulnerability Certification has been obtained.
  - No equipment shall be physically or otherwise installed in or connected to the existing LRV Primary System unless the appropriate Grounding and Bonding analyses have been obtained.
  - No equipment shall be physically or otherwise installed in, connected to or added to the existing LRV Primary System unless the Systems Engineering and Systems Assurance has been applied in accordance with ISO 15288, EN 50126 [20], EN 50128 [21] and EN 50129 [22].
  - Ottawa Confederation Line Phase 1 LRVs are not permitted to operate on Stage 2 extension works until necessary gauge clearance and kinematic envelope validation has been provided.

It should be noted that, whilst every effort has been made to identify all applicable restrictions of this type, the reader must at all times consider any proposed works or actions to ensure compliance with the policies set forth in this document and an up-issued Case for Safety [4].

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4. CONDITIONS

4.1 TUNNEL VENTILATION SYSTEM

4.1.1 Light Rail Vehicle/Tunnel Ventilation System Interface

In the event that a fire is detected onboard a Light Rail Vehicle (LRV), the incident train notifies the Vehicle On-board Controller (VOBC) of the adjacent trains on the same line via the SIL4 CBTC backbone of the emergency condition. The incident train continues to the next platform and evacuates passengers and Tunnel Ventilation System (TVS) directs the airflow away from the fire.

CBTC only notifies trains on the same line that are travelling in the same direction and not those on the adjacent track. This could potentially lead to trains stopped at stations being exposed to the fire.

Thales are modifying the CBTC software to automatically notify the operator of a non-incident train on the adjacent track to do one of the following in the event that a fire is detected onboard a train travelling in the opposite direction:

- Emergency Brake (EB) to stop prior to the station and evacuate passengers in the away from the incident train
- If already approaching the station in the opposite direction to the incident train then to operate in reversionary manual, accelerate and travel past the station and incident train and stop at the next station aft of the incident train.

Prior to implementation of this software upgrade, a temporary Standard Operating Procedure (SOP) has been put in place for a TSCC Operator to relay the above instructions to the Operator of an LRV travelling in the opposite direction in the event of fire emergency. Coupled Incident Train / Active VOBC / TVS – LRV Operator contacts TSCC / BCC – confirm where onboard the coupled train the incident has occurred.

Non-incident Train / CBTC / TVS – TSCC / BCC contacts LRV Operator – instruct an EB / Drive Through.

4.1.2 CBTC/TVS Interface

Confederation Line Phase 1 LRV sets have been designed to be capable for being deployed in multiple configurations of train length. LRV cars are currently configured as 4 units but could be expanded to 5 units. LRVs can comprise a single car (of 4 or 5 units) or 2-car coupled pairs (of 8 to 10 units).

The standard configuration is typically a 4 car LRV comprising a driving cab at the front, 2 non-driving cabs and a rear cab or an 8-car train comprising 2 LRVs of 4-cars coupled together.

When operating in the 8-car LRV configuration, either the VOBC in the front LRV or the VOBC in the rear LRV can be active. Hence, either the VOBC in either the front or rear LRV that is responsible for alerting the TSCC Operator via the Safety Integrity Level 4 (SIL4) CBTC network in the event of fire on-board train.

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In the event of fire onboard train, the LRV Operator should continue to the next station and evacuate the LRV, or where this is not possible, undergo immediate evacuation in the tunnel.

This can have a detrimental effect upon TVS performance in the event of a fire under some circumstances. A fire in the front LRV of an 8-car configuration when the rear VOBC is active could cause the TVS to direct the airflow towards the fire and evacuating passengers.

This anomaly is considered to be associated with the interface in coupling the front and rear trains.

Prior to implementation of this software upgrade, a temporary SOP has been implemented as follows:

When notified of a fire onboard train, the LRV Operator must communicate verbally with the TSCC Operator to confirm LRV location, direction, train set configuration and whether the front or rear VOBC is active. The TSCC Operator verifies the VOBC message by comparison with the driver status report and instructs TVS Fans and Dampers accordingly.

4.1.3 Downtown Tunnel

Tunnel ventilation – Signalling Criteria Report [9], for interfacing with the TVS Systems, the following operating conditions are applied:

Downtown Tunnel: Station Ahead Clear must be used when moving a train through the Downtown Tunnel. In ATO mode this is achieved by the automatic maintenance of minimum headway. In all other driving modes the LRV Operator must receive permission to proceed from the TSCC Operator.

4.1.4 MSF Connector

Tunnel ventilation – Signalling Criteria Report [9], for interfacing with the TVS Systems, the following operating conditions are applied:

MSF Connector Tunnels (complete system): only one train (total) is permitted into the TVZ at any given time.

4.1.5 TVS Testing

The following TVS Maintenance conditions are applied:

- For first six months of Revenue Service an end to end (TSCC to Fan actuation) test to be performed every month
- After first six months of Revenue Service the following actions:
    - Cycle each fan every month
    - End to end (TSCC to Fan actuation) test to be performed every three months.

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4.2 TRACK

4.2.1 Ultrasonic Testing Frequency

Due to the concerns about rail hardness and the lack of any technical methods of detecting rail breaks, it is a condition on the approval of the system that the ultrasonic testing regime is amended to once every 3 months for the first 2 years.

The MSF connector and yard should be tested every six months for the initial two years. The frequency of all ultrasonic testing may then be changed based on findings and a risk-based approach.

4.2.2 Grinding of Rails in Downtown Tunnel

The condition of all the railheads in the Downtown Tunnel between Parliament Station and the East portal are contaminated. This contamination has the potential to mask the effectiveness of ultrasonic testing equipment, as the signals will either fail to return or will give false indications.

A condition on the approval of the system that rail grinding is undertaken within two months of the commencement of Revenue Service.

4.3 STATIONS

4.3.1 Station Minimum Operating Standard (SMOS)

An SMOS has been prepared, based on the Rule Book / SOPS and the City / OCT Safety Management System, that specifies the Station Minimum Operating Standard.

Any Confederation Line Phase 1 Station that falls short of the SMOS shall not be opened for / immediately removed from Passenger Service until the necessary remedial / maintenance works and testing have been satisfactorily undertaken.

4.3.2 Rideau Escalator

Rideau station is the deepest Ottawa Confederation Line Phase 1 station. Escalators support safe evacuation in the event of emergency. Compliance to NFPA 130 [23] can be only achieved if at least one of the escalators is operational. The station should be closed in the event of loss of all escalators.

4.3.3 Station FDAS

All Stations are equipped with fire detection and alarm capability that is monitored via SCADA and periodically tested. Detectors and alarms have been positioned in order to provide adequate coverage and resilience. Minimum response times to Fire Detection and Alarm System (FDAS) equipment failures must be established.

4.3.4 Emergency Telephones

After each use of an Emergency Telephone (ETEL) the TSCC operative must reset the annunciating alert, confirming that the event has been responded to and thus making the system available again.

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4.3.5 Station CCTV

The Closed-Circuit Television (CCTV) system has been designed to provide adequate coverage across the station and backup in specific areas.

Security personnel must be deployed to site in the event of prolonged outage.

In the event of outage of multiple simultaneous CCTV cameras failures at a station at an unprotected station then consideration must be given to station closure.

4.4 MSF

The following conditions shall apply to mitigate the impact to safety as the MSF moves from its current Phase 1 Operations to Phase 2 and beyond:

Yard functionality is being delivered in stages, from initial Revenue Service, until Alstom vehicle production is complete, and the MSF is at its final configuration. All stages need to be identified and the configuration of each stage documented, analysed and the impact to the safety case determined. In each case, attention should be paid to which parts of the yard are dedicated to vehicle production, which parts are dedicated to maintenance and storage, the interfaces between these two activities.

The LRT train movements for the MSF Yard, in addition to that of the handover platforms, are not yet controlled by CBTC. Future upgrades are planned to introduce CBTC and Unattended Train Operation (UTO). The impact to safety of this transition shall be subject to HAZID/HAZOP workshops to identify new risks and associated mitigations.

Maintainers are vulnerable and at significant safety risk if the Stinger Cable is attached whilst working on the roof of an LRV:

Whenever the Stinger Cable is attached to an LRV no person(s) shall be allowed to work on the roof of the connected LRV; appropriate warning signage shall be used to notify maintainers when a Stinger Cable is attached (irrespective of whether it is energised or not) in order to reinforce this condition of use.

Delivery Drivers attending the MSF are required to cross the track via a Level Crossing:

CBTC / Level Crossing Barrier functionality is not yet commissioned: the barriers are to remain chained / locked and drivers / pedestrians wishing to cross the track must make contact with the Yard Controller who will provide access in a controlled / safe manner.

4.5 CYBER SECURITY

Cyber Security for the railway must be regularly re-assessed and correctly updated throughout Revenue Service in order for the Case for Safety [4] and subordinate Safety Justifications to be valid.

4.6 MAINTENANCE

The railway must be correctly maintained throughout Revenue Service in order that the Case for Safety [4] and subordinate Safety Justifications to be valid.

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4.7 LIGHT RAIL VEHICLE

Prior to departing a station platform, the LRV Operator is required to view the Platform Train Interface to ensure that persons embarking / disembarking the train are clear of the doors.

The Platform located CCTV imagery is currently being displayed on the LRV Operators Display Unit, however the system is subject to some undesirable deficiencies. Until these deficiencies are satisfactorily resolved A Temporary SOP, RTG-OTT-58-0-LET-0865 - Alternative Plan for Platform Edge Cameras, must be used.

4.8 CBTC

LRVs are fitted with on-board CBTC equipment so that they can be managed with safe separation by the CBTC system.

Any vehicles that are not CBTC-fitted can only be used once all LRVs are stabled in the MSF or subject to implementation of Procedures that must be adhered to in order to maintain safe separation through manual process / permissions.

4.9 ENGINEERING GOVERNANCE

The Confederation Line Phase 1 Case for Safety [4] and Confederation Line Phase 1 Engineering Safety and Assurance Case [7] are predicated on the following caveats being 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 has 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 has been completed;
- All conditions detailed on OBC Certificates are satisfied;
- All conditions detailed on OFS Certificates are satisfied;
- All outstanding SIT/SAT Reports are issued confirming each test has passed as listed in the ESAC Outstanding Items [14];
- Any deficiencies that have been determined to be Safety related by the Systems Engineering and Systems Assurance Team identified within the SIT/SAT Reports and listed in the ESAC Outstanding Items [14] have been rectified and resolved;
- 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 identified in the Confederation Line Phase 1 Configurable Items Database [15] that underpins the ESAC [7], Case for Safety [4] and subordinate Safety Justifications, does not change.

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5. LIMITATIONS

5.1 CBTC

In the event of a disturbed switch condition a LRV operator must confirm with the TSCC that it is safe to proceed in Restricted Manual (RM) Mode; proceeding in the mode over a disturbed switch must be achieved with Driver Vigilance and is therefore limited to the LRV operators judgement.

In the event of a disturbed switch the Service Controller communicating with LRV operatives must confirm LRVs by their Train Number and should maintain a safe service level that reflects the increased workload and is therefore limited to the Service Controllers judgement.

5.2 TUNNELS

The only limitation identified relates to the walkway on the eastbound side of the west end of St Laurent Tunnel. Due to the lack of structural clearance to the supporting wall, no walkway path has been installed for approx. 100m.

If an incident train cannot proceed to the next platform and stops adjacent to the east bound side of the west end of St Laurent Tunnel, safe evacuation requires all trains to be stopped until passengers reach an appropriate place of safety.

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6. RECOMMENDATIONS

6.1 CONFEDERATION LINE PHASE 1 RAILWAY - GENERAL

6.1.1 DATA RECORDING AND CORRECTIVE ACTION SYSTEM

Data Recording and Corrective Action System (DRACAS) should be implemented in order to detect the precursor events that may lead to a safety-related incident and to promote continuous improvement in the management of safety and performance of the infrastructure.

6.1.2 MAINTENANCE SCHEDULING

Corrective maintenance tasks should be prioritised according to the operational criticality of the function delivered by the failed asset in order to determine an acceptable "time at risk" and inform corrective maintenance scheduling, spares inventory levels and supply-chain setup arrangements.

An analysis should be undertaken that builds upon the assessment presented within the Confederation Line Phase 1 RAM Report [8] to determine the tasks that must undergo immediate response and those that can be scheduled according to the convenience of the maintenance organisation.

6.1.3 DATUM PLATES RECORDING

No evidence has been found that there are procedures to ensure the track cannot be moved relative to the overhead conductors leading to possible de-wirement or collision with electrification posts. The provision of Datum Plates recording the correct rail position relative to the plate would be a means of achieving this.

Provision of structural clearance datum plates, including the Overhead Catenary System (OCS) masts, to enable monitoring of track position. Provision of annual checks of structural and platform clearances to ensure safe operation of LRV. Validation of gauge clearance acceptance for all platform end gates and any secondary glazing systems installed along the platform edge needs to be demonstrated.

6.2 STATIONS

6.2.1 STAFF ON TRAINS/PLATFORMS DURING INITIAL SERVICE

It is recommended that for the initial running period that additional staff are placed on the platform or on the LRV to help ensure passengers do not move towards the train until it is stopped at the platform correctly. This should continue until such time that OC-Transpo are sure that the LRV Operator have obtained sufficient skill/competence in stopping the train in the correct place.

6.2.2 CCTV SMART SOFTWARE

It is recommended that that Video Analytics software capable of detecting and alerting the Line Controller to a person or object on the guideway. This is already a feature of the

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CCTV system functionality that should be activated in the event that frequency volume of incidents is indicated by DRACAS. This would entail modification to the CCTV and SCADA functionality and installation of more PTZ cameras.

6.2.3 INSTALLATION OF OCS ANTI-CLIMB GUARD

Anti-climb guards should be installed on OSC poles within the Stations to minimize the risk of electrocution in the event of passengers climbing and misbehavior.

6.2.4 DIAGRAMS INTO FIRE SAFETY PLANS

Diagrams and fire evacuation route maps should be provided within station-specific Fire Safety Plans to inform Fire Fighters and Emergency Responders in line with the requirements of section 5.6.1 of the City of Ottawa Accessibility Design Standard (COADS) [35].

It has been noted that diagrams highlighting Designated Waiting Area (DWA) and elevator locations are not included in station fire safety plans. This could potentially lead to the prolonged exposure of disabled passengers to hazardous conditions for in the event of emergency and represents a non-compliance to section 5.6.1 of COADS [35].

It is recommended this be incorporated into DWA and elevator locations be incorporated into station fire safety plans.

6.2.5 STROLLER/BUGGY WARNING SIGNS

Warning signs to raise the awareness hazards associated with strollers/buggies rolling or being blown should be installed on all above ground station platforms.

6.2.6 PASSENGERS WITH REDUCED MOBILITY

Processes should be put in place for the LRV Operator to inform mobility impaired passengers of elevator faults that may reduce their ability to exit a station during normal operation or evacuation in the event of emergency.

6.3 COMMUNICATIONS

There are no specific recommendations associated with the Ottawa Confederation Line Phase 1 Communications Systems

6.4 TRACK

6.4.1 WHEEL & RAIL WEAR

Establish a working group to monitor wheel and rail wear data. From this, specific remedial actions can be identified and agreed, such that they do not cause any worsening to one asset of the other.

Remit of wheel-rail working group to cover:

- Increasing rail wear visual inspections on all sharp curves to measure side wear rates

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- Ultrasonic testing and visual rail inspection results
- Monitor wheel profile wear rates through increased visual inspection or Non-Destructive Test (NDT)
- Monitor effectiveness of LRV mounted lubricator performance, linked to rail wear locations, and evaluate the potential to install rail mounted lubricators and friction modifiers. Increase the preventative rail grinding frequency across the whole system to reduce the risk of Rolling Contact Fatigue (RCF) growth in the harder 310 Brinell rail
- Review the switch blade profile of No.8 switches to reduce the wear rate.

6.4.2 OCS

The installation of protective troughing to all main line OCS bonds, to prevent damage during tamping operations.

6.5 ENERGY

6.5.1 RAIL AND BOND DISCONTINUITY MAINTENANCE

No broken rail detection has been provided. Apart from derailment considerations, broken rails and broken cross-bonds increase the resistance to the return current, increasing touch potentials.

As the Rail Grounding Switches are at Sub-Stations, these do not deal with raised touch potentials between Sub-Stations.

Maintenance tasks are needed to regularly to check for rail and bond discontinuities with sufficient frequency that the risk of dangerous touch potentials is maintained at an acceptable level.

6.5.2 LIGHTENING STRIKE MAINTENANCE

After a lightning arrestor has absorbed a strike, it may require replacing to ensure that it remains effective. A maintenance task is required following lightning strikes to the OCS to inspect/replace arrestors.

6.5.3 RAIL JOINT SAFE WORKING METHODS

The depot rails are grounded whilst the running rails are insulated from ground. The insulation is provided by an Insulated Rail Joint (IRJ) in the running rails.

As a train crosses these joints, the running rails of the main line are shorted to ground. Large currents can flow leading to arcing.

Staff working on these joints could be subject to arcing if any tools bridge the two rails. Safe methods of working at or near these joints need to be developed.

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6.6 TUNNEL

6.6.1 WALKWAY MAINTENANCE

During the winter months the Tunnel Walkway should be de-iced as and when required to prevent slips, trips, falls in event of emergency.

6.6.2 WATER MANAGEMENT

A tunnel leak inspection and repair strategy must be developed to ensure the long-term tunnel structural integrity. Tunnel water management arrangements are required to protect vital tunnel assets from water damage and corrosion.

6.6.3 CABLE ROUTES

Tunnel cable routes should be kept free from excess water and suitable drainage of the cable troughs should be maintained.

Periodic inspection of the cable troughs should be implemented to ensure the integrity of cables and adequate drainage is maintained.

6.7 MSF

6.7.1 OCS

RTM should conduct a HAZOP to ensure the isolation process and procedures are robust and complete.

The MSF Shop OCS Safe Work Procedure [10] has been used for the construction phase. This document contains safe operating procedures for the both the OCS and the stinger supply. This report recommends the procedure be reviewed/amended as necessary to cover relevant MSF Operations

Management of the residual risk associated with the hazard is mitigated by the operation procedures introduced and by the acceptance of RTM for hazard transfer.

6.7.2 MOBILE LIFTS / PLATFORMS

If mobile scissor lifts are introduced into the MSF, full training and safe ways of working must be adopted.

6.7.3 SANDING WASH AND INSPECTION BAY

Adjustment of the spray nozzles shall be maintained so that wash spray does not come into contact with the OCS.

6.7.4 EMERGENCY POWER

The emergency generator is located on a solid concrete foundation with no bunded drains observed. Spill kit/absorbent materials were not observed in the area. It is advised these be provided.

Fire extinguishers were not observed in the area. It is advised these are provided.

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6.7.5 SIGNAGE

It is recommended that a regular periodic audit of all signage is carried out to include but not be limited to:

- Fire Safety Signs, Fire Door, Fire Exit, Fire Extinguisher, Fire Zone
- Hazardous Substance Safety Signs
- General Safety Signs, No Smoking, Hard Hat, Pipeline, Roof Hazard, Flammable Materials Bin, Ear Defenders, Eye Wash, First Aid Box, Electricity at Work poster
- Electrical Safety Signage, Safety Labels and Notices provided at all locations connected with HOL power supply and distribution systems including sub-stations, switch rooms, transformer rooms
- External Traction Power Substation (TPSS) and Electrical Room, Signage, Information, displaying location details, warnings and emergency contact information where appropriate at boundary gates and entrances to buildings at agreed specified locations
- Internal electrical information sign displaying location details, normal contact numbers and emergency contact information installed adjacent to first aid points and telephones at agreed specified locations
- Signage shall be kept clean and legible. Signage that is damaged, illegible, or faded shall be replaced immediately
- Signage shall be kept free of vegetation growth or any other obstruction which may reduce required visibility.

6.7.6 FLOOR FINISH

It is noted that the floor finish throughout the storage shed and maintenance bays etc. is self-finished concrete. This could be difficult to keep clean in the long term and may not offer the adequate Slip Resistance.

It is recommend hardwearing epoxy paint finish with a granular additive be incorporated to increase the Slip Resistance Value (SRV) and cleaning potential.

Floor paint that is colour differentiated for walkways, would offer an opportunity to provide clear demarcation to indicate the safe walking routes to patrons.

6.8 TSCC

The TSCC Final Human Factors Report [11] makes several recommendations for further Human Factors validation studies to be conducted and validated under trial operating conditions.

These actions were communicated to the City as referenced in HRP Meeting Minutes 09, dated 10.04.2019 [12].

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7. CONCLUSIONS

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 EN 50126 [20], EN 50129 [20] and [22], respectively.

The principle safety arguments supporting this claim are as follows;

- The Confederation Line Phase 1 meets the requirements of the Project Agreement [13] as evidenced by the PA Technical Compliance Matrix [19].
- All Derived Safety Requirements (DSR) identified in the Confederation Line Phase 1 Integrated Hazard Log [3] have been agreed and accepted by the Hazard Review Panel (HRP) and transferred to respective recipients as evidenced by the Safety Requirements Matrix [17].
- Hazard identification, analysis and mitigation processes have been undertaken in which evidence is presented that all Confederation Line Phase 1 hazards have been reduced to acceptable levels as evidenced by the Confederation Line Phase 1 IHL Summary Report [18].
- RAM analysis shown in the Confederation Line Phase 1 RAM Report [8] provides confidence that failures and the consequences of failures have been adequately managed and the Confederation Line Phase 1 is capable delivering long term safe, reliable and cost-effective performance.
- 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.
- Assurance of correct design has been provided in the form of DCLs by Engineers of Record that confirm the electrical, structural and mechanical design has been generated in accordance with applicable Codes, Standards and Requirements as evidenced by the PA Technical Compliance Matrix [19].
- Assurance of correct construction has been provided in the form of CCLs by Engineers of Record that underwrite the general conformity of construction to the DCL as evidenced by the PA Technical Compliance Matrix [19]. Systems Integration Testing has been conducted to demonstrate correct functional operation and safe integration of Confederation Line Phase 1. Thus, further proving safety requirements are satisfied
- SITs for Primary Systems have been successfully completed as evidenced by the PA Technical Compliance Matrix [19].
- Restrictions, Conditions and Limitations have been defined to ensure bullets 1-7 are and remain valid.

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