




# ASSURANCE ENGINEERING SAFETY MANAGEMENT

## System Safety Plan Addendum For Stage 5 and CRL Close Out

Document Number : CRL1-XRL-07-GST-CR001-00001

### Current Document History:

Revision:	Effective Date:	Author(s)	Reviewed by:	Approved by:	Reason for Issue:
0.1		H Zerkani			Internal review
1.0	1 June 2022	Hayat Zerkani 	Stephen Turner 	Phil Clayton 	Issue

## Table of Contents

<b>1</b>	<b>INTRODUCTION .....</b>	<b>3</b>
1.1	BACKGROUND .....	3
1.2	PURPOSE .....	4
1.3	SCOPE .....	4
<b>2</b>	<b>ESM ACTIVITIES - STAGE 5B MINUS TO CRL CLOSE OUT.....</b>	<b>5</b>
2.1	ESM ACTIVITIES .....	5
2.2	CRL INCREMENTAL CHANGES .....	6
2.3	COMPLETION OF CRL SAFETY ASSURANCE.....	9
2.4	INDEPENDENT ASSESSMENT .....	11
2.5	ORR AUTHORISATION AND TECHNICAL FILES .....	12
2.6	CONFIGURATION CONTROL.....	12

## 1 INTRODUCTION

### 1.1 Background

- 1.1.1 In April 2019 Crossrail Ltd (CRL) announced its strategy for Revenue Service known as the Earliest Opening Programme (EOP).
- 1.1.2 The Handover Strategy and Plan [CRL1-XRL-K1-STP-CR001-50001] was then produced to outline the EOP approach and describe the delivery detail for the successful transfer of the Crossrail Project Elements to the relevant Infrastructure Managers (IMs) in line with the Crossrail Project Development Agreement (PDA). Successful transfer was defined as delivering the Central Operating Section (COS) to Revenue Service as early as possible with a plan in place to complete any outstanding works.
- 1.1.3 The transfer of the Routeway to Rail for London Infrastructure (RFLI) in March 2021 allowed RFLI to stand up as an Infrastructure Manager under the Railway and Other Guided Systems (ROGs) regulations.
- 1.1.4 Completion of the railway has been progressive with several stages spanning from Trial Running to Stage 5c representing the End State when all works are complete with a full service from Reading and Heathrow through the Central Section to Shenfield and Abbey Wood. These stages are given in the table below (staged highlighted in green have been completed).

Stage	Description
1	Progressive introduction of new Crossrail rolling stock on existing suburban services into Liverpool Street by substitution - complete
2a	Crossrail Services running from Paddington High Level to Hayes & Harlington - complete
2b	Crossrail Services running from Paddington High Level to Heathrow Airport- complete
3a	Crossrail Services running from Paddington Low Level to Custom House/Abbey Wood (excluding Bond street Station) - complete
3R	Inclusion of Bond street Station in passenger service.
4a	Crossrail Services using the CL345 FLU on GEML between Liverpool Street Station High Level Platforms and Shenfield Station.
5a	Crossrail services Reading & Maidenhead to Paddington High Level.
5b-	Crossrail Services to operate at 10tph Peak Service Abbey Wood to Reading and Heathrow and 12tph Peak Service Shenfield to Paddington. 22 tph peak service through the Central Operation Section, 16 tph interpeak service.  Auto-transition at the GW interface and Manual transition at Stratford for the GE interface  Signalling System configuration: ELR210, Comms & Control System configuration: CMS4.30.0, PSD System Configuration: V12(R-0). Train onboard software configuration: H5.9
5b	Crossrail Services operating at 10tph Peak Service Abbey Wood to Reading and Heathrow, 12tph Peak Service Shenfield to Paddington. 24 tph through the Central Operation Section,

Stage	Description
	<p>20 tph interpeak service</p> <p>Automatic transition at GW interface. Manual transition at Stratford platform for the GE interface until ELR 300 commissioning. Automatic transition following ELR300 commissioning at GE interface.</p> <p>Auto-reverse implemented at Westbourne Park</p> <p>Signalling System configuration: ELR220 (updated to ELR300 on 28/12/22, Comms &amp; Control System configuration: CMS4.31.3 (update to CMS4.32.1 on 28/12/22), PSD System Configuration: V12(R-0). Train on board software configuration: H5.10 (upgrade to H5.15 on 28/12/22),</p> <p>Stations' configuration: All stations fully handed over and complete.</p>
5c	<p>Final timetable pathing, to be confirmed.</p> <p>Any infrastructure change from Stage 5b will be carried out and assured by others (not CRL)</p>

**Table 1: Elizabeth Line COS Stages**

1.1.5 The current CRL ESM System Safety Plan [CRL1-XRL-O7-GST-CR001-00001], referred in the rest of the document as CRL SSP, addresses the ESM activities required to achieve End State. It does not address in detail the engineering safety management for stages 3R to 5b. Especially given that the railway is already handed over and that the acceptance process moved from the CRL Project to the IM (RFLI for routeway assets, RFLI/MTREL for RFLI stations and LU for Lu stations).

## 1.2 Purpose

1.2.1 The purpose of this document is to describe the engineering safety management (ESM) activities and risk assessment process, documentation and approvals required for Stage 3R to 5c. These activities will apply the principles outlined in the Common Safety Method for Risk Evaluation and Assessment (CSM-RA):

- a) System definition
- b) Hazard identification
- c) Risk evaluation and risk acceptance
- d) Safety requirements
- e) Hazard management
- f) Independent assessment

## 1.3 Scope

1.3.1 This document focuses on the incremental changes to the COS infrastructure being delivered by CRL to the relevant Infrastructure Manager/Operator (RFLI/MTR-EL/LU/NR). It also details the CRL ESM activities up to final handover to the IMs.

## 2 ESM Activities - Stage 5b minus to CRL Close out

### 2.1 ESM Activities

2.1.1 Stage 5b minus covers the integration of services from the east and west into the COS, with trains running from Reading and Heathrow through to Abbey Wood and trains running from Shenfield through to Paddington, with a peak service in the COS of 22 trains per hour (no Auto-reverse) to allow maximum service levels with no Auto-reverse. Later stages will provide a service of 24 trains per hour with auto-reverse at Westbourne Park.

2.1.2 The CRL ESM activities are:

- Establish the System Definition for 5b minus with the CRL outstanding works, seen as incremental changes to the operational railway, required for completion of 5b minus identified, see outline in section 2.2. The system definition for 5b- and CRL close out is covered in the COS SJ Central Operating Section Stage 5 Safety Justification.
- Apply the RFLI Change Assurance Framework process (CAF) [RFLI-GEN-HS-PRO-0006] summarised in Figure 1 to the incremental changes to the operational railway.
- Produce assurance deliverables for these changes as agreed by CAP filter, see section 2.1.5
- Complete the CRL safety assurance, see section 2.2.

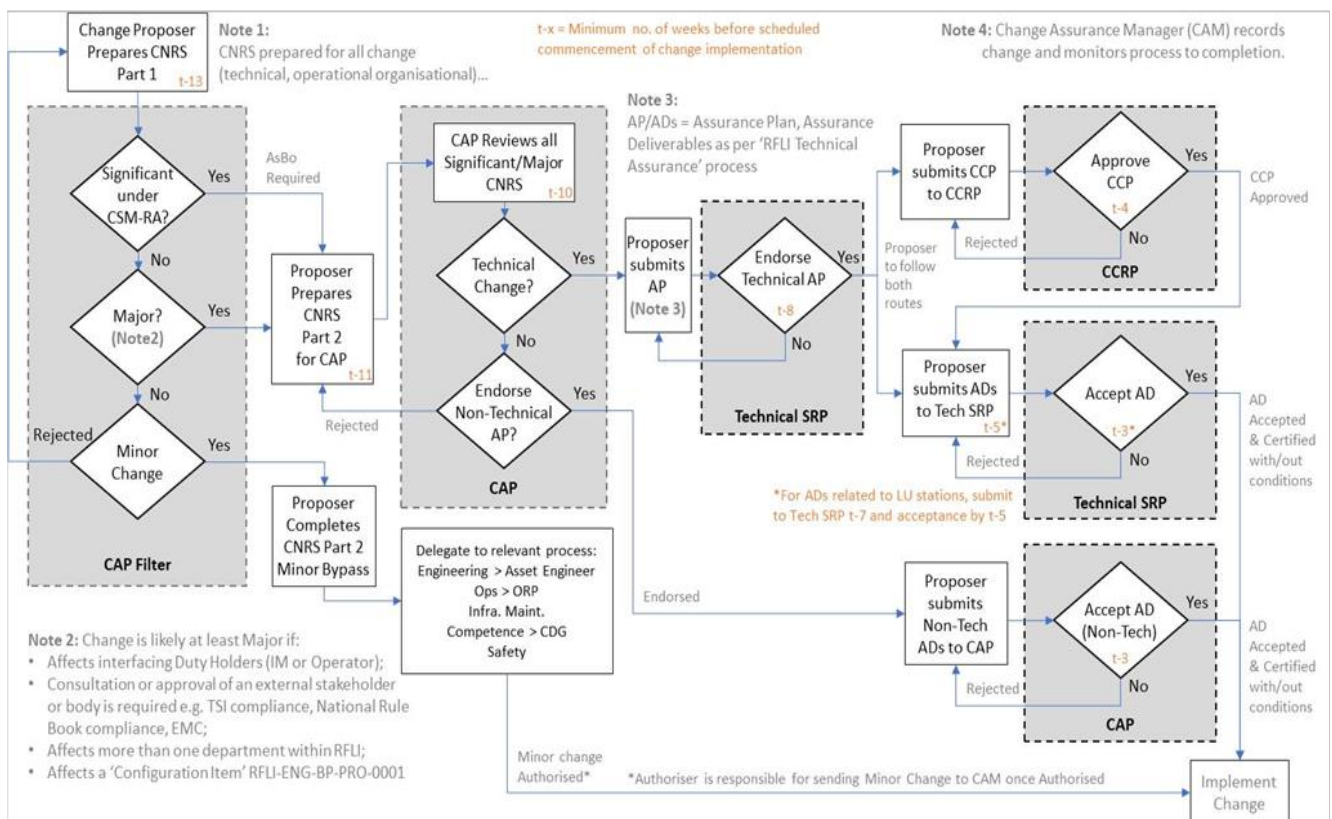


Figure 1: CAF Process

## 2.2 CRL Incremental Changes

2.2.1 The incremental changes to the COS operational railway are:

- Signalling system reliability and performance upgrades
- Communication & Control (C&C) system changes, including modifications to the in-tunnel boundaries between LFEP Channel 5 cells (around LU stations only)
- Tunnel Ventilation System (TVS) changes
- Completion of Bond Street Station (under Stage 3R)
- Platform screen doors changes
- Auto-reverse in tunnel and open areas
- Completion of Element Outstanding Works List (EOWs) relevant to the appropriate programme milestone (3R, 5b- etc.)

## 2.2.2 Assurance Deliverables to Support Incremental Changes

The items highlighted in red are significant changes that require independent assessment from the Assessment Body (AsBo).

No	Element/System/ function	Works to complete (Stage)	Significance under CSM RA	Change classification			CRL Assurance Deliverables (TBD with project)	Acceptance/Certification		
				Significant Change	Major	Minor		CAP	Asset Engineer	TSRP
1	Platform Screen Doors	Closed & Lock switch modifications on all PSD platforms, and other minor changes (Digital Advertising Display trials and echo software change)	Change is reversible and is a modification to optimise performance. However, Major under CAF (see Fig. 1)	No <sup>1</sup>	Yes	No	<ul style="list-style-type: none"> <li>CNRS</li> <li>CRL C&amp;L Assurance Plan</li> <li>C631 C&amp;L Change Impact Assessment (addendum to ESJ)</li> <li>S1538 compliance covered in Railway Systems and Non-Traction Power (RSNTP) Element Completion and Handover Report (ECHR)</li> </ul>	CNRS	-	Assurance Plan, C631 Impact Assessment
2	Signalling	ELR 210 (5b-) ELR220 (5b) ELR300 (5c)	Software changes to achieve originally expected functionality. Not considered a Significant change under CSM but Major under CAF (see Fig. 1)	No <sup>1</sup>	Yes	No	<ul style="list-style-type: none"> <li>CNRS</li> <li>CRL Signalling Change Assurance Plan</li> <li>C620 ESJ (or addendum where applicable)</li> <li>CRL Stage Completion Report (S1538 compliance)</li> </ul>	CNRS	-	Assurance Plan, C620 ESJ for ELR 210 and 300, ESJ addendum for ELR 220
3	Auto Reverse	AR in Tunnel areas and open areas (WBP)	Novel operation for UK mainline railways. Lack of vigilant driver in leading cab.	Yes	-	-	CRL Safety Statements	CNRS	-	'Generic Use of AR in COS Safety Justification' and Location specific AR Safety Statements (such as in tunnels, unplanned AR and Open areas)

No	Element/System/ function	Works to complete (Stage)	Significance under CSM RA	Change classification			CRL Assurance Deliverables (TBD with project)	Acceptance/Certification		
				Significant Change	Major	Minor		CAP	Asset Engineer	TSRP
4	Comms and Control	CMS/SCADA software upgrades and LFB radio change	Enhancements to achieve the expected functionality is not considered to be a significant change.	No <sup>1</sup>	No	Yes	<ul style="list-style-type: none"> <li>CNRS</li> <li>CRL C&amp;C Change Assurance Plan</li> <li>Telecomms Configuration Change Form (TCCF)</li> <li>Software Configuration Release Certificate (SCRC)</li> <li>O660 ESJ (Routeaway and BOS)</li> <li>S1538 compliance covered in RSNTTP ECHR</li> </ul>	CNRS	<ul style="list-style-type: none"> <li>TCCF</li> <li>SCRC</li> </ul>	-
5	Tunnel ventilation	TVS fan speed and mode table changes for Bond Street Station	Software changes to achieve originally expected functionality.	No <sup>1</sup>	No	Yes	<ul style="list-style-type: none"> <li>CNRS</li> <li>CRL TVS Assurance Plan</li> <li>CRL TVS Assurance Statement</li> <li>S1538 compliance covered in RSNTTP ECHR</li> </ul>	CNRS	SCRC	TBD
6	Bond Street	Completion of BOS station works	New use of the station: open to passengers.	Yes	-	-	<ul style="list-style-type: none"> <li>BOS SJ</li> <li>BOS ECHR</li> </ul>	CNRS	-	BOS SJ
7	EOWLS	Outstanding Works								

Table 2: Changes Introduced by CRL (Classification, Deliverables and Acceptance/Certification)

1: Note that CRL contractors still work in line with CSM as per the CRL works information.

Note that the assurances deliverables above are subject to the CAF process and CAP filter agreement.



## 2.3 Completion of CRL Safety Assurance

### 2.3.1 Safety Justifications

Most CRL Safety Justifications were written and accepted for End State. However, some were only accepted for Stage 3a Revenue Service but not all will be updated for CRL COS End State configuration. For efficiency, it is proposed that the incremental changes will be referred in the COS SJ. Table 3 describes the rationale of Safety Justifications update or otherwise.

Safety Justification	SJ Update required?			Rationale
	5b-	5b	5c*	
Shafts & Portals	N			SJs accepted for End State  Dependencies status in Risk Statement Summary for Stages 5b- and 5b
RFLI Stations including ABW	N			SJs accepted for End State  Dependencies status in Risk Statement Summary for Stages 5b- and 5b
LU Stations (FAR, TCR, LIS)	N			All dependencies closed
LU Station WHI	Y			Update to reflect all dependencies closed. Not linked to any stage 5 milestones. Now complete
LU Station (BOS)	Y			New SJ for passenger service. Not linked to any stage 5 milestones. Inked to stage 3R milestone
Civils, Track, Traction Power, Non-traction Power, Plumstead Sidings & Maintenance Facility, EMC, and E&B	N			SJs accepted for End State  Dependencies status in Risk Statement Summary for Stages 5b- and 5b
Tunnel Systems	N			SJ accepted for End State.  Incremental changes via CAF process and acceptance by relevant RFLI Asset Engineer. Update to TSS safety argument will be covered in the updated Stage 5b-/5b COS SJ
Platform Train Interface	N			SJ accepted for End State.  Incremental changes via CAF process and acceptance by TSRP of Close & Lock Impact assessment (ESJ addendum). Update to PTI Safety argument will be covered in the updated Stage 5b-/5b COS SJ
Signalling	N			SJ Accepted for Stage 3a. However, incremental changes subject to CAF process and ESJ acceptance by TSRP. Signalling safety argument will be covered under Signalling SJ section in the updated Stage 5b-/5b COS SJ. Updated certification required following acceptance of COS SJ (to be agreed by TSRP)
Route Control Centre	N			SJ Accepted for Stage 3a. However, main change is related to Human Factors and Operability and some work at BUCF which does not warrant the update of the RCC SJ. The RCC safety argument will be covered under RCC section in the updated Stage 5b-/5b COS SJ. Updated certification required following acceptance of COS SJ (to be agreed by TSRP)

Safety Justification	SJ Update required?			Rationale
	5b-	5b	5c*	
Communications and Control	Y			SJ needs updating because of the number of open hazards (related to BOS not being complete previously) and the new C660 BOS ESJ as well as other minor changes and software upgrades. Document will be produced for CRL COS End State configuration and accepted for Stage 5b- and 5b ( <b>Error! Reference source not found.</b> ).
Great Western Interface	Y	N	N	SJ needs updating because it currently refers to Empty Coaching Stock. No physical change to the interface. Will not be submitted to TSRP but delegated to RFLI Signalling Asset Engineer (As Signalling is the main change). Note that the argument for Auto reverse is covered by a dedicated Safety Statement.
Great Eastern Interface	Y	N	N	SJ needs updating because it currently refers to Empty Coaching Stock. Will not be submitted to TSRP but delegated to RFLI Signalling Asset Engineer (As Signalling is the main change)
COS SJ	Y	N	N	The COS SJ is updated for End state Stage 5 once but is subject to acceptance through the risk statement TSRP acceptance to support the Stage 5b- then other stage 5 milestones ( <b>Error! Reference source not found.</b> ).
Risk Statement Summary	Y	Y	Y*	Will be updated for Stages 5b- and 5b milestones. This document will provide the argument for the acceptability of risk for these milestones by showing that all ESM activities have been completed and where not complete, risk has been mitigated.  * The Risk Statement at this stage (CRL COS End State configuration) will give the final status of all ESM activities

Table 3: Rationale for SJs Update

### 2.3.2 Dependencies

All dependencies at EiRS Stage 3a were closed or mitigated through the Structured Engineering Judgement (StEJ) with many StEJ items limited to Stage 3a or time limited as a route to closure. These dependencies have been reviewed and grouped in the following categories:

- Dependencies that require closure by Stage 5b-
- Dependencies that require closure by Stage 5b
- Dependencies that require closure by CAW Maintenance of Behalf of (MoBo) contract end
- Dependencies that require closure by BOS completion
- Dependencies that require closure by CRL close-out
- Dependencies that will be closed by other than CRL Post CRL close-out

This will allow CRL to focus on milestone-specific dependencies requiring closure by the CRL Project.

A document giving the outcome of the categorisation above 'CRL Dependencies Assignment to CRL Milestones' [CRL1-XRL-O7-RGN-CR001-50143] is being produced and will be submitted to Stakeholders and TSRP for endorsement. The document will constitute a baseline of dependencies

status. It will be managed by CRL ESM team and status reported through the Risk Statement Summary for each milestone.

CRL close-out and Post CRL close-out dependencies will be risk reviewed in a timely manner for applicable closure in accordance with RFLI processes.

The previously used CRL Structured Engineering Judgement (STEJ) process will then be retired except for Bond Street Station where CRL is still the System Design Authority.

The dependencies Master Tracker – Stage 5, reference [CRL1-XRL-O8-LRG-CR001-50019] will be managed by CRL ESM team, and the status of dependencies will be recorded in the CRL Risk Statement Summary at Stage 5b-. The final status of dependencies will be recorded in a Risk Statement Summary at CRL COS End State configuration.

### 2.3.3 Project Wide Hazard Record (PWHR)

All identified hazards for the COS Operational Railway against the End State railway have been captured within the Project Wide Hazard Record (PWHR). Most hazards have been closed. The currently open hazards (which have been mitigated for Stage 3a) are largely related to completion of outstanding works such as Bond Street Station.

Like dependencies, hazards have been categorised by milestones. Any mitigation used for Stage 3a will be reviewed for its applicability for 5b- and any dependencies that are addressed by others or Post Crossrail Closeout will be transferred and tracked by Duty Holders.

PWHR baseline at Stage 5b- will be submitted to RFLI/LU. Stage 5b- is the significant railway change of joining up the Elizabeth Line services, with passenger services starting across the COS fringes that, when coupled with Stage 3R for BOS station, will represent the 'final completion' stage under the CRL PDA. The final version will be handed over at CRL Project close-out.

## 2.4 Independent Assessment

### 2.4.1 Independent Safety Assessment

2.4.1.1 Any incremental change affecting functions with a safety integrity level (SIL) will be subject to independent safety assessment (ISA) as per the standard CRL contractor engineering safety management process.

### 2.4.2 Assessment against CSM and Interoperability Compliance

2.4.2.1 CRL has appointed Ricardo Rail as the Assessment Body (AsBo) as well as the Approved Body (ApBo) for the COS Railway.

2.4.2.2 AsBo activities included the safety assessment of all safety justifications outlined in Table 3 for Stage 3a. AsBo assessment will continue to be applied but their assessment for Stage 5 and Stage 3R will be limited to:

- Assessing BOS SJ and producing BOS Safety Assessment Report (SAR)
- Review of updated SJs to make sure dependencies have been closed or mitigated
- Assessing auto-reverse safety statements and providing Letters of Support (LoS)

2.4.2.3 ApBo activities will include the following:

- Completing review of BOS TSI requirements compliance and updating BOS Technical File
- Assessing evidence of APIS conditions of previously authorised systems.

2.4.2.4 ApBo/AsBo will also provide Letters of Closure (LoCs) when conditions in the TFs/SARs have been closed. This will permit the relevant duty holder to inform ORR when conditions are closed.

#### 2.4.3 External Audits

2.4.3.1 In support of maintaining CRL ISO9001 certification, an external audit of CRL quality management system by Lloyds Register has taken place on 11 July 2022. This is the quality management system that underpins all CRL's delivery schedule and the assurance of all CRL activities. The audit which included a site visit to the Bond Street site was successful with no non-conformances raised. So, ISO9001:2015 Certification is still maintained for the final stages of the CRL programme.

### 2.5 ORR Authorisation and Technical Files

2.5.1 The role of System Design Authority (SDA) and System Integrator to ensure these works are integrated into the whole system is with the Technical Authorities of the Duty Holders (RFLI and LU) except where delegated to CRL.

2.5.2 Under the Railway Interoperability Regulations (RIR), following receipt of the ORR Authority to Place into Service (APIS) for the Elements/Sub-systems, CRL are required to transfer the Technical File, Certificate of Verification and Verification Declaration to the owner of the subsystem with that owner becoming the project entity for that Element/Sub-system. In conjunction with the transfer of each Technical File, CRL will confirm the return of the SDA (previously delegated to the CRL Chief Engineer) for the Element/Sub-system to the IM. On confirmation of acceptance of the SDA the full responsibility for the associated Element/Sub-system will rest with the receiving party e.g., RFLI or LU. The CRL RFLI Technical Transition Accountability Tracker [CRL1-XRL-O-LRG-CR001-50011] details the changes in accountability for the technical assurance responsibilities as CRL progress through the process of transferring the SDA to the IMs. As this progresses the IM processes and procedures will take precedence over CRL processes and procedures for any change made to the associated Element/Sub-system.

2.5.3 All Systems/Elements have been authorised for Revenue service, except BOS which was authorised for evacuation and will require authorisation for Passenger Service.

2.5.4 Some Systems/Elements were granted APIS by ORR with conditions. These conditions are being tracked, and upon closure, a letter of condition closure supported by AsBo/ApBo will be issued to ORR by the relevant duty holder.

### 2.6 Configuration Control

2.6.1 The process for safely managing changes to the configuration of RFLI engineering assets and railway infrastructure from the point in time that RFLI became the Duty Holder under ROGS is described in 'Configuration management of changes to RFLI Elizabeth Line engineering', [RFLI-ENG-BP-PRO-0001].

2.6.2 Under the auspices of RFLI's Change Assurance Framework procedure RFLI-GEN-HS-PRO-0006, any proposal for change must be submitted in accordance with the assurance framework arrangements in the CAF procedure.

- 2.6.3 Any RFLI party or contracted entity intending to make a technical change to the Elizabeth line railway system as part of their function, or scope of supply, shall assume the role of the 'Change Proposer' at the point in time when an intention is identified.