

# TECHNICAL DIRECTORATE

## Technical Assurance Plan

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## Contents

<b>1</b>	<b>Background</b>	<b>4</b>
<b>2</b>	<b>Scope and Purpose</b>	<b>4</b>
2.1	Scope	4
2.2	Purpose	5
2.3	Ownership	5
2.4	Relationship to other Crossrail technical and assurance documents	6
<b>3</b>	<b>Technical Assurance Delivery Responsibilities</b>	<b>7</b>
<b>4</b>	<b>CRL Assurance Approach - Methodology</b>	<b>9</b>
<b>5</b>	<b>Crossrail Assurance Reporting Environment</b>	<b>10</b>
<b>6</b>	<b>Duty Holder Roles and Responsibilities</b>	<b>11</b>
6.1	IM(s) Roles and Responsibilities	11
6.2	Transport Undertaker (TU) Roles and Responsibilities	11
<b>7</b>	<b>CRL Assurance Alignment to IM's Assurance</b>	<b>11</b>
7.1	LU Assurance	11
7.2	RfL Assurance	12
7.3	NR Interface Assurance	12
7.4	Design Assurance	12
7.5	Design Management	15
7.6	Engineering Gates Process	15
7.7	Design Review and Acceptance Process	15
7.8	Architectural Assurance and Material Compliance	15
7.9	Requirements Management	16
7.10	V&V Management	16
7.11	Verification Activity Plans	16
7.12	The Design Certification Procedure	17
7.13	Issue of Design Documentation for Construction	17
7.14	Design Change Management Control	17
7.15	Building Control	17
7.16	CRL Competency Assessment	17
7.17	Systems Engineering and Integration	18
7.18	Design Interfaces	18
7.19	Electro-Magnetic Compatibility (EMC)	18
7.20	Engineering Safety Management (ESM) Process	18
7.21	Reliability, Availability, Maintainability (RAM)	19

7.22	Progressive, Collective Design Assurance Deliverables (Infrastructure and Systems) .....	19
<b>8</b>	<b>Construction Assurance.....</b>	<b>20</b>
8.1	Construction Quality Management .....	20
8.1.1	Construction Certification .....	21
8.1.2	Monitoring and Surveillance .....	21
8.1.3	Snagging & Outstanding Works .....	21
8.1.4	Completion & Control of the Works.....	21
8.1.5	Project Technical Request.....	21
8.2	Management of Health & Safety, Environment & Security .....	22
8.3	London Underground Interface.....	22
8.4	Supplier Representative and LUL QUENSH Standard.....	22
8.5	Network Rail Interface.....	23
8.6	Management and Acceptance of Materials .....	23
8.7	Review of Contractor Documentation .....	23
8.8	Transfer of Responsibility between Contractors .....	23
8.9	ESM during Construction .....	23
8.10	Construction Assurance Deliverables.....	23
<b>9</b>	<b>Installation, Testing and Commissioning Assurance .....</b>	<b>24</b>
9.1	Testing and Commissioning Phases .....	24
9.2	Testing and commissioning Certification .....	24
9.3	Safety Justification and Authorisation .....	24
9.4	Testing and Commissioning Deliverables.....	25
<b>10</b>	<b>Handover.....</b>	<b>26</b>
<b>11</b>	<b>Trial Running .....</b>	<b>26</b>
<b>12</b>	<b>Trial Operations.....</b>	<b>26</b>
<b>13</b>	<b>References.....</b>	<b>27</b>
	<b>Appendix A- Crossrail Progressive Assurance &amp; Integration Model.....</b>	<b>31</b>
	<b>Appendix B- Design Assurance V Life-Cycle.....</b>	<b>32</b>
	<b>Appendix C- Design Overview Stages.....</b>	<b>34</b>
	<b>Appendix D- Evidence assessed during IDO/FDO Packages .....</b>	<b>35</b>
	<b>Appendix E- VAP Process Flow .....</b>	<b>37</b>
	<b>Abbreviations .....</b>	<b>38</b>

## **1 Background**

The framework for technical assurance for the Crossrail project as a whole has historically been defined in three key documents which meet the requirements of the Crossrail Project Delivery Agreement (PDA) by providing a plan to achieve progressive technical assurance:

- Crossrail Technical Assurance Strategy [6]
- Crossrail Technical Assurance Plan
- Implementation Plan for Progressive Assurance TAP Ref: 10 [33]

It was recognised in the Project Representative's Report dated March 2013 that an updated version of Technical Assurance Plan would be of benefit to the project in order to:

- provide greater clarity regarding the division of responsibility and relationship between contractors and CRL,
- consolidate the three key Technical Assurance documents (Strategy, Plan, Ref 10) into a single document,
- close out the remaining observations made by the Infrastructure Managers (IM's) and the Project Representative team during the acceptance of TAP Ref: 10 and
- formalise outputs regarding the further development of Handover and Intermediate / Final Design Overview Strategies.

The document has also been restructured in order to provide clarity for each of the key project assurance stages from Design through to Handover.

This document details the key CRL processes, procedures and work streams which generate the necessary evidence to ensure that the delivered railway will be accepted by the IMs.

As assurance evidence is the product of design and delivery activities and other Crossrail processes and plans, this document should sit 'back to back' with other key CRL documents, notably the System Integration Management Plan [41] the Verification and Validation Plan [7] and the Crossrail Handover Plan [34]. Crossrail is committed to updating these documents to reflect a single design-assurance approach.

## **2 Scope and Purpose**

### **2.1 Scope**

This document applies across the whole of the Crossrail Programme and for its duration up to and including the Infrastructure Managers and the Crossrail Train Operating Company (CTOC) obtaining Safety Certification for the necessary authorisations for passenger service on the Crossrail route.

It applies to all areas of Crossrail that deliver, receive, co-ordinate and interface with Technical Assurance; including Industry Partners (including LUL, RfL, NR, Canary Wharf Group, Berkeley Homes, and CTOC), CRL (including Contractors) and the Rolling Stock and Depot Contractor (RSD).

With the exception of interfaces, this document excludes works undertaken for, and by, Docklands Light Railway (DLR) and the also that relating to Over-Site Developments (OSD) as these entities will apply their own assurance regimes and comply with building regulations respectively.

## **2.2 Purpose**

The purpose of this plan is to support the requirements of the CRL Programme Assurance Strategy [42] for delivering technical assurance.

The details including phasing and timing for each assurance stage is referenced later in this document.

This plan presents the activities that will deliver, co-ordinate and manage the technical assurance evidence. This evidence shall be presented to the relevant Infrastructure Managers (IMs) in accordance with an agreed submissions schedule and IM processes.

This document supersedes the Technical Assurance Strategy, the current Technical Assurance Plan and associated TAP Reference 10 document. These documents are forthwith withdrawn.

The document now clarifies the role of CRL (including the definition of supporting processes) in integrating and collating the technical evidence for presentation to the IMs for acceptance, ensuring that the technical assurance of all relevant works is integrated to demonstrate a safe, operable, maintainable, railway that delivers the required levels of performance and capacity. It is intended that the technical assurance requirements that have been previously defined in the relevant CRL Works Information Volume 2B remain unchanged as a result of the formulation of this document, as the Contractors have previously provided individual assurance plans which CRL have accepted.

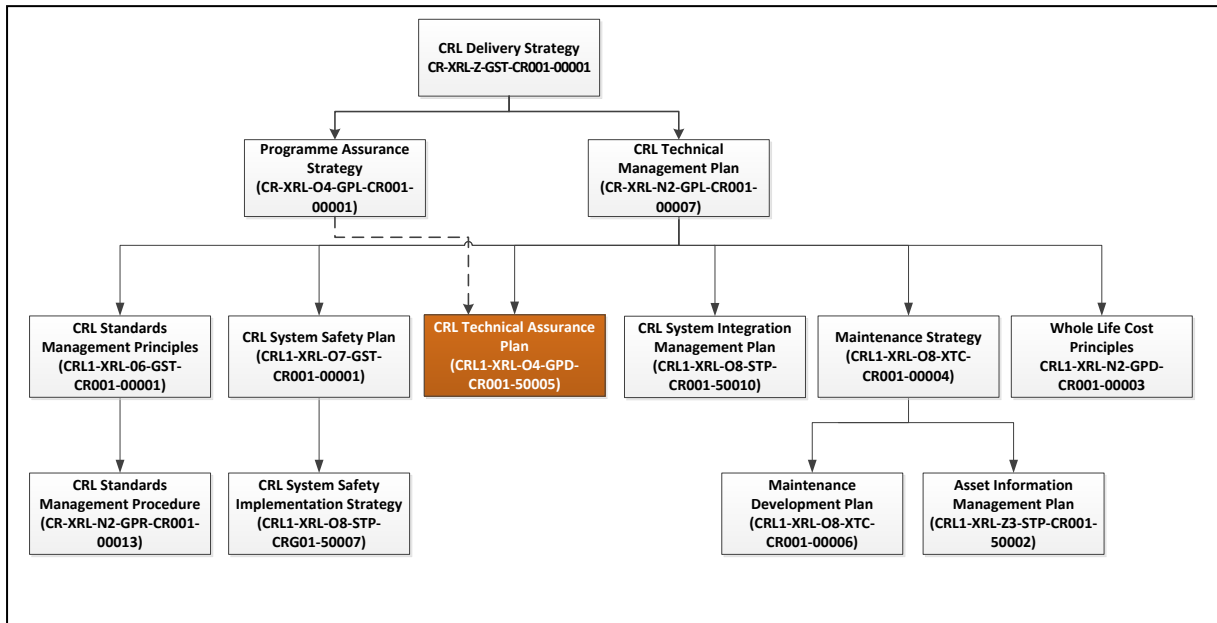
If a gap in assurance is identified either by CRL or the IM's, the necessary evidence will be generated by CRL or the contractors (through instruction) accordingly.

## **2.3 Ownership**

The ownership of this Plan and the accountability for technical assurance rests with the CRL Technical Director.

The overall technical authority for the Crossrail Central Section works lies with the Crossrail Chief Engineer.

## 2.4 Relationship to other Crossrail technical and assurance documents



### 3 Technical Assurance Delivery Responsibilities

Crossrail is accountable for delivering the Crossrail Programme. The Crossrail Delivery Strategy [46] sets out how this will be achieved by the Crossrail Team and Crossrail's industry partners, contractors and stakeholders.

Table 1 below clarifies scope of delivery and associated responsibilities for the delivery of Technical Assurance by Crossrail and its Industry Partners.

<b>Organisation</b>	<b>Technical Assurance Delivery Responsibilities</b>
CRL	<p>CRL is accountable for overall delivery, programme management, design, construction, testing, handover, trial running and completion of the Crossrail Programme.</p> <p>CRL is responsible for delivering an integrated and assured Central Section Railway (1) that will meet the Sponsors' requirements and accepted by the relevant Operators (2).</p> <p>CRL has responsibility for the delivery of the Central Section Works and the integration of this with Network Rail all other relevant works associated with the delivery of the Crossrail project.</p> <p>CRL is also responsible for integrating assurance evidence from NR with COS evidence in order to demonstrate the end to end performance of the railway.</p>
Canary Wharf Group:	<p>Canary Wharf Group (CWG) is responsible for delivering the Canary Wharf Station structure with pre-defined "station MEP systems" which include finishes, escalators (with fire detection), ventilation, heating and lighting but not the systemwide elements (including the Station Operations Room) and connections to the Route Control Centre. CWG has a dedicated technical assurance plan [35] for these works against which the works will be delivered. CWG is responsible for demonstrating the associated assurance evidence meets the relevant project requirements.</p>
Berkeley Homes:	<p>Berkeley Homes (BH) is responsible for delivering the Woolwich Station structure. BH has a dedicated technical assurance plan [56] for these works against which the works will be delivered. BH is responsible for demonstrating the associated assurance evidence to Crossrail.</p>
London Underground (Enabling Works):	<p>London Underground is responsible for delivering specific enabling works (eg station upgrades at Bond Street and Tottenham Court Road Stations). Assurance will be demonstrated through LU Standard S1538</p>

<b>Organisation</b>	<b>Technical Assurance Delivery Responsibilities</b>
<p>London Underground: Delivery of Station Operations Room Integration (SORI) at Bond Street, Tottenham Court Road, Farringdon, Moorgate and Whitechapel Station complexes.</p>	<p>SORI works are undertaken by London Underground in compliance with LU Category 1 Standard – Assurance S1538.</p> <p>A project assurance plan will be produced to detail the key assurance deliverables and the process to be adopted throughout the life of the project to meet the accepted Works Package Plan (WPP) for Station Operations Room Integration.</p>
<p>Network Rail:</p>	<p>1) The Approved Assurance Procedures- This document sets out the arrangements governing NR’s involvement as the adjacent IM for the rail network at the interfaces with the Central Core Area. These do not apply to the On Network Works but require CRL to consult with NR regarding the Central Core Area works that may impact on the rail network.</p> <p>2) Delivery of the On Network Functional Requirements- Crossrail shall validate that NR has sufficiently demonstrated compliance with these requirements throughout the NR GRIP process.</p> <p>3) NR’s Technical Assurance Plan - NR as an Industry Partner has been engaged by CRL to apply its own processes and procedures to develop and deliver the On Network Works. NR has established its own TAP which sets out the method for providing technical assurance during the design, construction and hand back stages of all projects within the ONW. The NR TAP prescribes how NR obtains engineering assurance in accordance with its Safety Management System as regulated by the ORR. This will include acceptance bodies such as Network Rail Acceptance Panel, Competent Independent Person (CIP), NoBo, and Engineering Specification Panel. NR applies both an internal and HQ audit process.</p> <p>4) NR is responsible for delivering the South East (SE) Spur, which is part of the Central Operating Section. Assurance of this will be demonstrated through the NR Technical Assurance Plan [66]</p>



<b>Organisation</b>	<b>Technical Assurance Delivery Responsibilities</b>
Rolling Stock and Depot (RSD):	The Depot and Rolling Stock contractor is responsible for delivering an assured depot and rolling stock, in line with their own technical assurance plan, which will be compliant with the CRL technical assurance requirements. The RSD is also responsible along with CTOC for obtaining approval to run the rolling stock over the Network Rail network in line with standard industry processes (GE/RT8270). The RSD shall also support Crossrail to assure the interfaces to the Central Section works.

**Table 1 - Technical Assurance Delivery Responsibilities**

Notes:

1. Central Section Railway includes the integration, testing and operation of the Crossrail Rolling Stock over the Central Operating Section (as defined in the PDA).
2. Operators means a Transport Undertaking or Infrastructure Manager as defined in the Railways and Other Guided Transport Systems (Safety) Regulations (ROGS)

Each Industry Partner will produce assured designs, and deliver assets compliant with the Crossrail requirements, in line with their own assurance plans.

As the technical authority for the Crossrail programme, it is CRL's responsibility to demonstrate that Crossrail will function as a railway system and demonstrate that the railway is safe, operable, maintainable, and will deliver the required capability and performance. Overall technical authority for the Crossrail Central Section works lies with the Crossrail Chief Engineer.

CRL shall produce additional assurance evidence that all works being delivered by both Crossrail and Industry Partners are both complete and fully integrated to support the relevant Crossrail technical and operational requirements. These activities are described in the CRL Systems Integration Management Plan [41].

## **4 CRL Assurance Approach - Methodology**

As the client for the delivery of the Central Section Works, CRL is the employer of the designers, the design-build contractors and the construction contractors.

The processes that the designers/contractors apply to deliver technical assurance evidence are described in their Design Management Plan or Technical Assurance Plan, which are subject to CRL acceptance for compliance with this CRL Technical Assurance Plan and other relevant project engineering plans and procedures.

Each design organisation assures their design through certifying compliance with the relevant CRL functional, performance, safety & legal requirements for their scope of design works including the interfaces for which they have responsibility. During delivery the construction contractors are responsible for providing self-certified assurance evidence that the works are constructed in accordance with the certified design requirements including testing & commissioning.

This assurance evidence is reviewed and accepted by the CRL's delivery and technical team progressively as per the requirements of the relevant CRL Works Information, this Technical Assurance Plan and other relevant project plans and procedures.

Crossrail will carry out verification activities using a risk based approach during design and delivery in accordance with the published Crossrail verification activity plans (7.11).

In addition to the assurance evidence, including interfaces, that is produced and endorsed by the designers/ contractors engaged by the project, CRL shall also directly produce supplementary assurance evidence where necessary to demonstrate that the rail systems, rolling stock and infrastructure combined with operations and maintenance requirements deliver a safe, operational railway that meets Sponsors' Requirements. To facilitate this outcome Crossrail have established processes whereby the aggregated contractor outputs are tested against four principles:

**Verify that the railway is collectively safe:** CRL management and execution of the hazard identification and review process, railway risk evaluation and demonstration of ALARP principles through generation of engineering safety justifications. Governance provided through the Engineering Safety Steering Group [36].

**Verify that the railway is collectively maintainable:** Use of risk based Maintenance Integration Review Panel workshops to test the alignment and integration of the collective designs with maintenance boundaries, concepts, access, resource, and logistics constraints, including interfaces between IMs. Governance provided through the Maintenance Steering Group [37].

**Verify that the railway is collectively operable:** Use of risk based workshops to test the alignment and integration of the collective designs with the suite of CRL operations concepts. Governance provided through the System Integration Review Panel [53].

**Verify that the railway will collectively perform to required levels of capability:** Delivery of re-aggregated RAM analysis and deployment of agreed suite of simulation / modelling to evidence that the railway shall meet end-to-end performance and capacity targets. Governance provided through the Performance Steering group [54]

Further detail regarding the above is contained within the System Integration Management Plan.

The CRL assurance model (Appendix A) demonstrates how the CRL assurance outputs (above) relate to those produced by the contractors.

## **5 Crossrail Assurance Reporting Environment**

The Crossrail Assurance Reporting Environment (CARE) [50] is a configuration tool which interfaces with eB to package all of the required assurance evidence (to support S1538) using an application interface.

The CARE application facilitates the visibility, structure, inspection and assessment of key assurance evidence that have already been reviewed, approved and filed within eB, the project's document management system.

The CARE system will support the collation and demonstration of design and construction evidence, apposite to the eventual elements by which Crossrail will hand over the railway

to the IMs. The packages of assurance evidence will follow the agreed System Breakdown Structure [55] in determining the totality of assurance evidence required for each asset.

CARE will be the repository for assurance documents generated by Delivery Partners, Contractors and CRL, including all documentation relating to the IDO and FDO processes.

CRL will take full responsibility for the determination of which documents are deposited and how they grouped.

## **6 Duty Holder Roles and Responsibilities**

### **6.1 IM(s) Roles and Responsibilities**

The Infrastructure Managers will ultimately accept the assets that comprise the Central Operating Section of works for future maintenance and operation. They will do this on the basis of the certification issued by CRL, the designers and the constructors, supported by the assurance evidence described in this plan and any other required verification and validation activities as described in the VAPs.

The assurance evidence shall be accepted by CRL who will compile and add to this evidence, where required, to provide the IM with the integrated assurance evidence through the CARE process. IMs will release Letters of No Objection as appropriate to record acceptance.

Notes:

(a) CRL shall regularly submit to the IMs a specific programme and schedule of submissions deemed necessary and sufficient to gain IM approval.

(b) CRL shall make available any project documentation reasonably requested by either the ASBO or by the IM's Competent Independent Person to allow them to undertake their Safety Verification activities as described in Common Safety Methodology (CSM) Regulations or the IM's Safety Verification Scheme.

### **6.2 Transport Undertaker (TU) Roles and Responsibilities**

The Transport Undertaker for Crossrail (otherwise known as the Crossrail Train Operating Company (CTOC)), shall require authorisation from the Office of Rail Regulation (ORR) to place Crossrail into use. To achieve this milestone, CTOC need to demonstrate that their Safety Management System reflects the constraints and function of the assets they will utilise to safely perform their duties.

Therefore, although CTOC do not directly receive Technical Assurance from CRL, they are a customer of evidence generated in line with this Technical Assurance Plan.

## **7 CRL Assurance Alignment to IM's Assurance**

### **7.1 LU Assurance**

In line with the LU Delivery Agreement (51), CRL has developed its technical assurance process for the submission and acceptance of technical assurance deliverables in order to comply with the LUL Assurance Standard S1538 [1]. CRL compliance is as shown in table 2 for Station, Portals, Shafts, Tunnels and Railway Systems.

London Underground Limited accepts CRL staged assurance submissions by releasing a Letter of No Objection (LONO).

The Interface works delivered by LU will be self certified in compliance with LU Assurance Standard S1538 leading to a completion report for Interface works and a staged completion report for permanent works.

Overall certification of the Crossrail Central section works (including LU supporting certification for LU delivered works) will be by CRL following completion of dynamic testing and prior to handover of assets.

## **7.2 RfL Assurance**

CRL compliance is shown in table 2 for Station, Portals, Shafts, Tunnels and Railway Systems. The compliance is aligned with LU Assurance Standard S1-538.

RfL shall accept CRL staged assurance submissions.

For Railway Systems designs wherever the RIR apply, a Notified Body/Designated Body (NoBo/DeBo) will assess the compliance with the Technical Standards for Interoperability(TSIs) and Non-Notified National Rules (NNTRs), and will produce technical files to be incorporated into the relevant engineering safety justifications, part of the overall safety justification to be produced by CRL.

## **7.3 NR Interface Assurance**

It is the responsibility of CRL to demonstrate the assurance of the interfaces with NR, both to NR and to RfL.

For interface works with NR infrastructure, assurance evidence shall demonstrate the compatibility of the Crossrail works with the existing On-Network NR infrastructure. This approach is set out in the NR Group Standard GE/RT8270.

## **7.4 Design Assurance**

The Crossrail Chief Engineer is the technical authority including all engineering matters for the project with design responsibility held by the design organisation (Framework Design Consultants (FDC's) or contractors (where the Contract is specified as Design & Build).

The Chief Engineers Group (CEG) controls the overall engineering design assurance process to its final approval stage for the Central Section and the interfaces of works with the other Industry Partners such as London Underground (LU), Rail for London (RfL), DLR, CWG and Network Rail (NR).

CEG provide overall completion certification for the Crossrail Central Section works in doing this they rely on supporting certification generated through Crossrail Delivery's management of the contracts supplemented by verification activities carried out in accordance with the CEG VAP.

**Technical Assurance Plan  
CRL1-XRL-O4-GPD-CR001-50005**

<b><u>LU Assurance Standard S1538 Term</u></b>	<b><u>CRL Assurance Approach for Stations, Portals, Shafts &amp; Tunnels Submission to RfL &amp; LUL</u></b>	<b><u>CRL Assurance Approach for Railway Systems to RfL &amp; LUL</u></b>
<b><u>Conceptual Design Statements Clause 3.15</u></b>	CRL will submit the CDS to satisfy Assurance Standard S1538 Clause 3.15 in the form of Design Certificates which includes Conceptual Design Overview (CDO), Conceptual Design Statements (CDS's) and Staged Design Compliance Certificates SDCC's/FDS (a) for each LU/RfL operated Station including Portals, Shafts & Tunnels.	CRL will submit Design Statements @ 30% design maturity per elementary systems to satisfy Assurance Standard S1538 Clause 3.15, supported by additional evidence as per the Appendix D- IDO Table.  This Staged Submission will be supported by CRL IDO Certificate for each IDO Packages as per Appendix D.
<b><u>Compliance Submission Clause 3.17</u></b>	CRL will produce and submit a Final Design Overview certificate for acceptance for each LU/RfL operated Station and Portals, Shafts & Tunnels.  The FDO, which is equivalent to LUL compliance submission, will comprise evidence in the form of component FDS's (Civils, MEP/Architectural) and the relevant Systemwide Design Statements at either 60% and 90% gate. Each FDO shall also contain CRL integration activities evidence in line with Appendix D. For LUL Stations this will include the LUL compliance submission for the works on the SOR.  To comply with RIR CRL will submit Interim Certificate of Conformity through NoBo/DeBo.  FDS's and Systemwide Design Statements will be accepted and issued progressively by CRL for each asset group.	CRL will produce and submit a Final Design Overview for the railway systems elements.  The FDO, which is equivalent to LUL compliance submission, shall comprise of evidence in the form of the relevant Systemwide Design Statements at either 60% and 90% gate. Each FDO shall also contain CRL integration activities evidence in line with Appendix D.  To comply with RIR CRL will submit Interim Certificate of Conformity through NoBo/DeBo.  Systemwide Design Statements will be accepted and issued progressively for each asset group.

**Technical Assurance Plan**  
**CRL1-XRL-O4-GPD-CR001-50005**

<p><b><u>Consents to Test/Trial Report Clause 3.18</u></b></p>	<p>CRL will submit Consents to Test/Trial report when testing is either reliant on, or will impact on LU/RfL existing assets or operational railway.</p> <p>To support this report, CRL will (amongst others) provide evidences in the form of Factory Acceptance Tests (FAT), Site Acceptance Test Records (SAT), Installation Release Notices (IRN), integration test evidences- Pre Commissioning Certificates (PCC), Partial Acceptance Certificates (PAC) and Acceptance Certificates (AC)</p>	<p>CRL will submit Consents to Test/Trial report when testing is either reliant on, or will impact on LU/RfL existing assets or operational railway.</p> <p>To support this report, CRL will (amongst others) provide evidences in the form of Factory Acceptance Tests (FAT), Site Acceptance Test Records (SAT), Installation Release Notices (IRN), integration test evidences- Pre Commissioning Certificates (PCC), Partial Acceptance Certificates (PAC) and Acceptance Certificates (AC)</p>
<p><b><u>Staged Completion Report Clause 3.19</u></b></p>	<p>Post dynamic testing and prior to Handover CRL will submit Staged Completion Reports as required by the handover programme to confirm all the certified design requirements have been met during delivery phase including Testing &amp; Commissioning plus any certified changes post design.</p> <p>The report will be supplemented by Final Design Certificate for each Railway elementary system unless already completed.</p>	<p>Post dynamic testing and prior to Handover CRL will submit Staged Completion Report to confirm all the certified design requirements have been met during delivery phase including Testing &amp; Commissioning plus any certified changes post design.</p> <p>The report will be supplemented by Final Design Certificate for each Railway elementary system unless already completed.</p>
<p><b><u>Completion and Consent to Operate Report Clause 3.20</u></b></p>	<p>Following completion of Dynamic Testing and prior to Trial Operations CRL will submit Handover Packages in elements as per Appendix D to satisfy Assurance Standard S1538 Clause 3.20.</p> <p>The details of the CRL processes and requirements for the Completion of the works and handover submissions will be reflected in the CRL Handover Plan [34].</p>	<p>Following completion of Dynamic Testing and prior to Trial Operations CRL will submit Handover Packages in elements as per Appendix D to satisfy Assurance Standard S1538 Clause 3.20.</p> <p>The details of the CRL processes and requirements for the Completion of the works and handover submissions will be reflected in the CRL Handover Plan [34].</p>

**Table 2- CRL Assurance Alignment to Assurance Standard S1-538**

## **7.5 Design Management**

The CRL Design Management Process [2] governs the civil infrastructure and stations approach to design including the mechanical electrical and power (MEP) & architectural designs. The process defines the safe, economic and efficient management of design outputs that conform to the relevant standards and the project requirements delivered for the Central Section Project through FDC's and D&B contractors.

The Systemwide design process is governed through the Systemwide Execution Plan [13] and Works Information to assure the safe, economic and efficient management of design outputs conforming to standards and the project requirements.

All design follows the Design Assurance V-Lifecycle as shown in Appendix B to provide progressive assurance evidence during the design stages to assure the objectives of the project are achieved and that the project can progress successfully to the next stage.

## **7.6 Engineering Gates Process**

CRL Engineering Design Assurance Gates Procedure for Stations & Infrastructure [3] provides a control mechanism to support progressive assurance where evidence is reviewed at defined stages to confirm that the stations and infrastructure meet the project objectives, requirements, obligations and that the risks associated with the engineering are identified and fully understood.

The Systemwide designs are assured through Engineering Design Assurance Systemwide Procedure [32] which defines the railway systems design gates assurance process to its final approval stage for the Central Section along with the relevant interfaces at stations, portals, shafts and to the other industry partners such as LU, RfL & NR.

The above gate procedures also manage the impact of changes to designs post Issued for Construction (IFC) stage.

## **7.7 Design Review and Acceptance Process**

The CRL Design Review Procedure [4] manages and controls the review of the design outputs through CRL for all designs.

Design acceptance is carried out on a risk basis and agreed with each contractor via the CMDL.

This formal review and acceptance is supported by engineering surveillance which shall examine control processes by CRL against submitted plans and procedures and monitoring of the ongoing construction and installations to verify compliance with relevant project standards and specifications on a sampling/risk basis.

## **7.8 Architectural Assurance and Material Compliance**

An 'Acceptance of Samples, Mock-ups, Prototypes & Key Bench Marks Procedure' [11] has been prepared to address how architectural design assurance outputs are accepted for finishes used in the works.

The CRL Demonstration of Material Compliance Procedure [12] manages the process for the review and acceptance of materials through the CRL delivery team Project Field Engineer/ CRL Material Engineer.

For Systemwide assets, the contractors will demonstrate that their materials comply with relevant standards as contained in the package Works Information.

## **7.9 Requirements Management**

Requirements traceability with the Employer's Requirements is maintained in accordance with the CRL Requirements Management Plan [58] which is conducted throughout the project lifecycle.

All CRL designers and contractors are responsible to ensure that at each stage their works meet the relevant apportioned Technical & Operational Requirements through verification and validation of design and delivery evidence. The evidence will be collated in the CRL Dynamic Object Oriented Requirements System (DOORS) tool. The CRL requirements engineer reviews the acceptance of this evidence as part of the CRL gates assurance process. Delivery partners such as CWG and LUL are not mandated to use DOORS software however will demonstrate to CRL through agreed means that their requirements have been discharged.

There are also a number of Employer's Requirements which only CRL can demonstrate have been met, either because each contractor can only demonstrate a pro-rata percentage of evidence (e.g. route performance) or that the requirement has been allocated to CRL to discharge (e.g. project governance commitments).

In these cases, CRL shall take responsibility or a co-ordinating role in demonstrating that requirements have been discharged.

## **7.10 V&V Management**

Verification and Validation activities will be performed in line with the agreed CRL Verification and Validation Plan [7]

## **7.11 Verification Activity Plans**

CRL Verification Activity Plans (VAP's) will describe how CRL is approaching verification activities on a focussed, risk based approach for contractor activities throughout the project lifecycle. Crossrail Verification Activity is detailed in the CRL verification activity plan [TBC].

Each stage of works from design to delivery including testing & commissioning leading into handover of assets shall be verified and recorded to provide evidence of effective and continued control over the executed work.

Demonstration of Compliance and Control during Design: - The Technical Directorate of Crossrail is responsible for setting design standards for the works and to verify that the final design output complies with CRL standards baseline. In order to discharge the responsibility the Chief Engineer's Group, Systemwide & IM(s) will actively participate in the design review process including the attendance at IDR's and SDR's and shall review and accept assurance evidence as work proceeds in accordance with the Engineering Design Review & Gates Assurance Process.

Demonstration of Compliance and Control during delivery: CRL on-going verification and site inspections are carried though the Project Field Engineer, Quality Audit teams and CRL Quality Engineers during the programme of works in order to verify that the contractors are exercising effective control measures in the areas of materials, fitting, finishes, fixtures and any asset related works.

CRL shall verify that the high risk areas are controlled and delivering the requirements of the certified design in the area of materials, fitting, finishes, integration, safety & performance. The record of the verification will be recorded on a Verification Report and Verification certificate. This assurance evidence will record any non-compliance identified during the process for further rectification.



The CRL Assurance team will co-ordinate to avoid duplication of the program of Verification with CRL Audit and Delivery Quality engineer team to address the key risk areas on location basics. The scope of verification through Audit, Quality and CEG/Embedded Engineer will aim to satisfy that the process applied and the end finished product would demonstrate compliance against certified design.

There is a further aspiration for CRL to collaborate with the IM(s) to develop joint Verification Activity Plans covering multi-discipline areas and assets. The CRL/IM(S) joint VAP's would be discipline specific and will involve the multi-discipline area within stations, portals, shafts, tunnels and railway systems. An indicative approach is referenced in Appendix E.

### **7.12 The Design Certification Procedure**

Design Certification Procedure [8] manages the generation of design certificates through the FDC's and D&B Contractor design elements associated with the construction packages. CRL is responsible for accepting the certificates and to provide auditable trail for work packages for assurance evidence.

Systemwide follows a different approach to certification as defined in Part 29 of the Systems Works Information [57]. The Systemwide D&B Contractors self-certify that their design is compliant with the accepted Design Statement generated per elementary systems at 30, 60, & 90% design reviews. A design review release certificate will be issued as part of the review process. The certificate and supporting evidence are subjected to CRL acceptance.

The Design Certificate can only be issued following the end of the testing and commissioning phase as this phase produces some of the evidence of compliance. This is further explained in the Testing & Commissioning process [31]. The completion of works is subject to CRL acceptance.

### **7.13 Issue of Design Documentation for Construction**

Issue of Design Documentation for Construction Procedure [9] manages the engineering governance for handover of completed and gates approved design packages to support construction work packages.

### **7.14 Design Change Management Control**

The Design Change Management Process [10] manages the operation of the Work Order process when the design change has been identified through the Project Technical Request (PTR) procedure [5] and recorded via the Trend and Change Control process. The assessment of design change is monitored through the CRL Design Assurance Gate Review Procedure for evaluating the change and impact against the gated design intent.

### **7.15 Building Control**

The CRL Building Control Procedure [38] addresses how building control issues are managed across Crossrail.

### **7.16 CRL Competency Assessment**

CRL Competency Assessment Guidelines [39] defines the process for assessing the competence for key CRL post-holders whose work has a direct or indirect impact on design assurance, construction, operations or maintenance safety. The process is aligned with the requirements of the London Underground Procedure for Assessment of Crossrail Engineers LUCT-ENG-PRC-00001-001 Rev 2.0.

CRL Delivery Directorate have their own agreed Competency Management Procedure [52]

### **7.17 Systems Engineering and Integration**

The accepted CRL Systems Integration Management Plan [41] shall define the CRL approach to Systems Integration; describing the processes that CRL intends to utilise to ensure that a safe, operational, maintainable railway is delivered that meets the Sponsor's requirements

This will include the integration of all the Crossrail railway systems, electrical and mechanical systems and the civil infrastructure together with the rolling stock to deliver a resilient operational railway.

CRL is responsible for the overall management of systems integration. Both CRL and the contractors monitor and proactively manage Systems Integration to ensure that the interfaces are consistent and deliver the employer's requirements.

### **7.18 Design Interfaces**

The CRL Interface Management Procedure [44] and Interface Control Template [45] manages the integration between the rail systems and the civil and M&E works to confirm that adequate space-proofing and access requirements for systemwide works have been defined and agreed between the interfacing parties.

The interfaces between Systemwide contractors and third parties (such as NR or LU) are specified in the works information for each D&B contract. The contractors in turn describe their interface management processes, Interface Requirements Specification (IRS) for each system- to-system interface in the Design Management Plans subject to review and acceptance through Systemwide. For more complex interfaces, the contractors will produce Detailed Interface Requirements (DIR) which is subject to CRL acceptance at formal design reviews.

For critical third party interfaces – particularly those with NR and the rolling stock contractor, Systemwide has developed interface specifications for inclusion in the works information.

### **7.19 Electro-Magnetic Compatibility (EMC)**

The EMC requirements for each and individual system have been specified in the works information for the contractor in accordance with the CRL EMC Management Plan.

The contractor is responsible for demonstrating at each design stage that these requirements have been met and evidence generated through EMC deliverables which are subject to CRL review and acceptance.

### **7.20 Engineering Safety Management (ESM) Process**

The ESM requirements apply specifically to the design, engineering and provision of railway systems, mechanical systems, electrical systems, fire, public health and architecture. The System Safety Plan sets out the overall strategy and approach mandated by CRL for the reduction of safety risks in the design, construction, testing and potential future operation of the railway to as low as reasonably practicable (ALARP), in compliance with the legal requirements. The Contractors are required to develop a safety management process that meets the requirements of the Crossrail SSP, and undertake (as appropriate);

- Creation of a suitable Safety Plan/Strategy document.
- Hazard identification workshops for the single design option.

- Focussed Quantified Risk Assessments (on an as-required basis or as identified and commissioned by CRL).
- SIL assessments of the safety related functions of proposed E/E/PES.
- Development of a Safety Risk Profile assessment as necessary to demonstrate how safety requirements will be achieved.
- Maintenance of Hazard records in accordance with the Crossrail Hazard Management Procedure [47].
- Progressive development of a Safety Assessment Report to summarise the safety risk assessment activities and present the ALARP justification for the design.
- Collection of safety evidence. The safety evidence may take the form of product, generic and application Engineering Safety Justifications from manufacturers and sub-system and system safety justifications from the Contractors, Conformity Certification, and qualitative/quantitative risk assessments. Where the RIR apply, the NoBo/DeBo will produce a Technical File to contain evidence as mandated by the TSI/NNTR concerned.

System safety requirements are specified in section 2.3 of the SSP [65].

Designers must recognise and contribute to the provision of assurance evidence presented in the form of an Operator's Assurance package that complies with the Concept of Operations to enable Duty Holders to accept the handover of the completed railway.

To ensure progressive assurance and to facilitate the acceptance of future Safety Justifications, Crossrail will draft an Intermediate Safety Justification based on the Design Engineering Safety Justification from Stations and Infrastructure and on the 60% Design Stage Gate ESM report from Systemwide Contractors. This will form part of the Final Design Overview (7.22) and help demonstrate that Systems, Stations and Infrastructure are safely integrated.

### **7.21 Reliability, Availability, Maintainability (RAM)**

The RAM requirements for each and individual system have been specified in the works information for the contractor in accordance with the CRL RAM Requirements for Central Section [14].

The designer/contractor is responsible for demonstrating at each design stage that these requirements have been met and evidence generated through RAM deliverables which are subject to CRL review and acceptance. CRL shall, at the FDO Stage (below) demonstrate that the various design integrate to deliver the system-level targets defined by the RAM requirements.

### **7.22 Progressive, Collective Design Assurance Deliverables (Infrastructure and Systems)**

In order to demonstrate integrated assurance to the IMs, and in doing so, to meet the requirements of S1538 Compliance Submissions, Crossrail intends to carry out a two stage design review of each Element of Crossrail. These reviews, the Interim and Final Design Overviews are comprised as follows:

#### **Interim Design Overview (IDO)**

The Interim Design Overview (IDO) certificate [48] for each handover element captures the Infrastructure design upto RIBA Stage F, MEP & Architectural designs up to RIBA Stage E, Railway Systems Design Statement at 30% gate review and CRL integration evidence as

per Appendix D. This is the initial staged submission, building towards the Final Design Overview. The IDO is planned for completion during 2014 and is timed such that the outputs from the reviews can be fed back into the final MEP, Architecture and Systemwide designs.

### **Final Design Overview (FDO)**

The Final Design Overview (FDO) certificate [40] for each handover element additionally reflects the relevant Systemwide design Interfaces & co-ordination at the appropriate level of maturity to represent the final design (will be at either the 60% or 90% design gate maturity, depending on each system). The FDO is aimed at documenting/assuring that the design provides the required functionality and is compliant to agreed standards - it is not viewed as an opportunity to feedback changes into the design.

The FDO is planned for completion in 2015 once the MEP and Architecture designs are complete and the systems designs are progressed sufficiently to reflect a final position. It is recognised that some elements of the system design will only be completed after the test and commissioning phase (e.g. final software revisions), but this will not impact on the ability to hold a FDO event. This is equivalent to the compliance submission within the LU Assurance Standard S1538.

The interim and final design overview stages are reflected in Appendix C. FDO's will be prepared relevant to each Handover Package. The final contents of these packages are still to be determined however Appendix D contains indicative levels of evidence that will be assessed at each stage.

## **8 Construction Assurance**

All designs assured through the CRL Gates Process will be constructed, tested and commissioned by the Contractor under the governance of CRL Delivery Team (DT). The DT applies a set of approved processes and procedures for the management of construction activities ranging from main works construction, advance works, stations fit-out work, off site production, building control leading to relevant certification and eventual handover.

For Systemwide works the responsibilities of the DT in this section are fulfilled by the relevant Systemwide Project Manager.

### **8.1 Construction Quality Management**

For all construction contracts the DT is responsible for oversight, monitoring and surveillance of the Contractor's activities in accordance with the Construction Management Plan [15] and the Construction Quality Plan [16].

The DT Project Field Engineer (PFE) acting as Supervisor under NEC3 Contract leads the review and acceptance of construction deliverables, observation, inspection and surveillance both on and off site, management and administration of the Non-Compliances Register (NCR) and Snagging/Outstanding Works process and monitoring the compliance and progressive compilation of certificates and quality records.

The Field Engineering Team ensures that appropriate quality related documents are being delivered to programme and being complied with and/or implemented on site through the Contractor. The team also ensures that the sequencing of activities does not impact on product quality.

In addition, the Technical Directorates Quality Team independently monitors performance of the Field Engineering Teams and Contractors through a regime of surveillance, audits and reports on any concerns regarding effectiveness (both DT and Contractor).

Each stage from inception through to delivery is verified and recorded to provide evidence of effective and continued control over the executed work. This evidence comprises all necessary design and construction information, concessions, pertinent communications and change control. The Construction Quality Management Plan contains the following 5 principles procedures, which are as follows:

### **8.1.1 Construction Certification**

The Construction Certification for Structures and Civil Engineering Works [17] procedure requires the Contractor to submit a list of Sub-Construction and Construction Certificates that he intends to produce during the currency of the constructed works.

These certificates lead to the generation of a Whole of Contract Construction Certificate which is issued when all other certificates have been delivered and countersigned by CRL. This final certificate signifies completion of the constructed works.

In addition the records through the Contractor shall be sufficiently detailed to provide assurance of compliance with the Works Information and through the development of the contractor's self-certification shall be signed off by a competent person.

### **8.1.2 Monitoring and Surveillance**

The Monitoring & Surveillance procedure [18] describes the process for the planning and monitoring through the use of inspection, test interventions and surveillance.

### **8.1.3 Snagging & Outstanding Works**

The Snagging & Outstanding Works (Punchworks) Procedure [19] describes the process for the recording and tracking to close out of outstanding works and defects. Construction certificates may be issued subject to agreement with the DT with a Consolidated Outstanding Works List which will be an export from the Punchworks at the time of certificate issue.

### **8.1.4 Completion & Control of the Works**

The Completion & Control of the Works [20] procedure describes the process for establishing that the Works have been completed in accordance with the Contract and the process for managing the Works up until Takeover of the Works by the Employer. A series of Site Surveys take place prior to the contract completion date with a view to the generation of a Consolidated Outstanding Works List (COWL). These surveys will involve the relevant Infrastructure Manager.

### **8.1.5 Project Technical Request**

The Project Technical Request procedure [5] outlines the controlled identification, notification and resolution of:

- Project initiated technical questions,
- Request for Information, between parties under the control or interface management of the Delivery Team (DT).
- Field Change Documents, relating to alterations to the assured design documents issued for permanent and temporary project systems and facilities and non-

conformances found in the Central Section works including those that arose through an audit undertaken by the Quality team.

This procedure applies to the construction and testing phases of the project

## **8.2 Management of Health & Safety, Environment & Security**

The Management of Health & Safety, Environment and Security shall be in accordance with the CRL Health and Safety Manual [21], the Environment Manual [22] and the Crossrail Programme Security Strategy [23].

The Principal Contractor (PC) for each area of the project shall remain responsible for the management of Health, Safety Environment & Security, in accordance with Regulation 22 of the CDM Regulations (2007).

The CRL Project Manager is responsible for the review and allowing the Principal Contractor to put into place robust procedural guidance and direction to demonstrate the responsible discharge of their duty to manage Health & Safety. This is in accordance with CRL Site Mobilisation, Start Up and Critical Readiness Review Procedure [24]

The Project Field Engineer (PFE) is responsible for the technical review and acceptance of Safe Systems of Work, Method Statements / Work Package Plans; and for monitoring compliance against the PC approved documents. This review & acceptance will be in accordance with the CRL Review & Acceptance of Safe Systems of Works Procedure [25]. The Project Field Engineer shall be supported in this by other members of the site team and support functions.

## **8.3 London Underground Interface**

Works which have the potential to impact LU assets (including the operational railway) shall be managed in accordance with:

- CRL/LU Development Agreement [51]
- Infrastructure Protection Plan – London Underground Assets [27]
- Works Package Plan Procedure CRL & LUL [59]
- LU Access and Closures Procedure [60]

The LU Interface Manager is responsible for the overall interface with LU. The project teams are responsible for the interface at the site level, led by the Project Manager.

CRL Interface Works will follow CRL assurance processes. Those works requiring early bringing into use and/or handover to LU will follow the Procedure for Bringing into Use, Completion and Handover to LU of CRL Interface Works [61].

## **8.4 Supplier Representative and LUL QUENSH Standard**

To comply with the LU Cat 1 Standard 1-552 Contract QUENSH Conditions, each project's Project Field Engineer shall act as or nominate a Supplier Representative for their Works. The role of the Crossrail Supplier Representative is defined in [62].

Field Engineers, the Construction Manager or Site Manager may also act as the secondary Supplier Representative to provide additional capacity.

Accreditation shall be performed by LU and recorded formally between the project team and LU by letter. LU is providing training to DT representatives who will receive accreditation as a Supplier Representative to those who have successfully completed the modules. The Field Engineering Manager shall liaise with Crossrail's LU Interface Manager

and LU to coordinate training and maintain the schedule of approved suppliers representatives.

### **8.5 Network Rail Interface**

Works impacting Network Rail (NR) shall be managed in accordance with

- Relevant project procedures and NR standards
- Network Rail Scope Book Procedure [64].
- Crossrail Worksite Possession on Network Rail- Booking and Implementation [63]

### **8.6 Management and Acceptance of Materials**

The Management and Acceptance of Materials during delivery phase will comply with CRL Demonstration of Material Compliance Procedure as per section [7.8] above.

### **8.7 Review of Contractor Documentation**

Before any programmed construction activity can proceed, the activity or activities included shall be clearly proposed and described in the form of proposals, plans, method statements and procedures through the Contractor submittals process as specified in the Management and Acceptance of Field Documentation Procedure [29].

Safe Systems of Work and Method Statements shall be managed through compliance with the Review & Acceptance of Safe Systems of Works Procedure [25]

### **8.8 Transfer of Responsibility between Contractors**

At certain stages of the project, responsibilities will be transferred from one contractor to another prior to take over by the client. This shall be managed in accordance with the Transfer of Possession of the Works from One Contractor to Another Contractor Procedure [30].

### **8.9 ESM during Construction**

Contractors shall update their hazard records, safety evidence, and safety justifications in line with any relevant change that occurs post design.

For the purpose of the 'placing into service' authorisation, evidence of construction conformity must be collected and provided to the relevant Verification or Acceptance Body (Refer to Engineering Crossrail Verification & Validation Plan [7]).

### **8.10 Construction Assurance Deliverables**

The construction assurance deliverables which are generated through the CRL Construction Management Plan and Construction Quality Management Plan are listed below. This evidence supports the Handover packages for each asset. In addition to this assurance evidence other design deliverables are also available for each design contract on their Contractor Master Document Lists (CMDL's).

Construction Evidence

- Construction Work Packages
- Contractor Self- Certification
- Whole Contract Completion Certificates
- As Build Drawings

- Updated CDM Health & Safety File
- Compliance with Requirements/DOORS Report
- Non Compliances, Concessions & Derogations Summary Status Report
- Operations & Maintenance (O&M) Manuals and Updated Engineering Safety Justification Reports/Hazard Logs

## **9 Installation, Testing and Commissioning Assurance**

This section outlines the approach, the key processes and arrangements which will be deployed for the construction, installation, testing and commissioning (T&C) for the Railway Systems and MEP works on Stations, Portals and Shafts works in accordance with CRL Testing & Commissioning Strategy [31]

### **9.1 Testing and Commissioning Phases**

The testing and commissioning phases will be applied appropriately to all elementary systems of the works and all associated interfaces in accordance with the CRL Testing & Commissioning Strategy. The phases 1 to 5 testing will be performed in accordance with specific test procedures prepared by the Contractor in order to prove that the sub-systems and systems meet the requirements of the Works Information in terms of functionality, performance, capacity, safety and fitness for purpose.

- Factory acceptance of each sub-system before delivery to site, or off-site test facility;
- Integration of each sub-system to work with its interfacing sub-systems, making use where appropriate of off-site test facilities;
- Testing of each sub-system and then the integrated system to demonstrate that they meet their requirements;
- Commissioning of each system to form the total railway, and
- Handover to the Infrastructure Managers and Transport Undertakings followed by a period of trial running to prove safe working to enable the transportation systems to be brought into passenger service.

CRL is responsible for management of this process for the Central Operating Section, including bringing into service the interfaces with other industry partners and operators.

### **9.2 Testing and commissioning Certification**

Certification is part of the Assurance process and will be produced at their respective stages of testing. The certificates will be accompanied by the tests reports duly signed off by the Contractor(s) lead testers and further subjected to CEG and Systemwide team acceptance.

### **9.3 Safety Justification and Authorisation**

CRL is responsible for the delivery of the overall justification of the completed works. This will be accomplished by the delivery of top level Safety Justifications integrating the Engineering Safety Justifications supplied by the Contractors. The top level Safety Justifications will cover:

- Systemwide Safety Justification (covers signalling, track, traction power, data transmission systems, communications including radio)



- Tunnels Safety Justification (also covers tunnel systems including ventilation systems)
- Rolling Stock Safety Justification
- Depot Systems Safety Justification
- Station Safety Justifications (one for each station)

The project has carried out extensive modelling of passenger flows for normal, abnormal, degraded, emergency operations, and evacuation, for each station taking into account the LUL Station Planning Standards and Guidelines and the CPFR and this has led to design requirements for each station which have been agreed with the representative of each of the future station IMs. This has also been used as part of the development of the Operations Concept. The Safety Justifications will be checked against the Operations Concept. Once accepted, the Safety Justification will be used to produce an Operator's assurance package to enable the future Duty Holder to adopt the appropriate requirements into its safety management System.

The safety planning and activities concerning this phase of the project will be defined in testing and commissioning plans, or Safety Verification plans, later during the project. The safety activities will be designed to validate the safety requirements and the assumptions, dependencies and caveats in the project safety documentation and to provide the evidence needed for safety authorisation / acceptance.

For the purpose of the 'placing into service' authorisation, evidence of safety in testing must be collected at this stage and provided to the relevant Verification or Assessment Body. Where the RIR apply to a particular subsystem, the NoBo / DeBo will require such evidence and has the right to observe some or all of the tests.

A CRL Data Reporting, Analysis & Corrective Action System (DRACAS) will be used at this stage to report and respond to incidents occurring during this phase of the project

#### **9.4 Testing and Commissioning Deliverables**

The Installation, Testing and Commissioning deliverables which are generated through the CRL Testing & Commissioning Strategy are listed below (non-exhaustive).

##### **Construction & T&C Evidence:**

- Factory Acceptance Tests (FAT); Site Acceptance Test Records (SAT); Installation Release Notices (IRN)
- Pre Commissioning Certificates (PCC); Partial Acceptance Certificates (PAC); Acceptance Certificates (AC)
- Dynamic Test Reports
- Test Reports; Design Certificates per Elementary Systems; Whole Contract Completion Certificate
- Testing & Commissioning Certificates & Reports
- As Build Drawings; Health & Safety File; Compliance with Requirements/DOORS Report
- Non Compliances, Concessions & Derogations Summary Status Report
- O&M Manuals
- Engineering Safety Justification Reports per Elementary System
- Punchlist & Outstanding Work List

- Spare Parts List
- Training
- Systems Maintenance Manuals
- Systems Operational Manuals
- Operational Drawings
- Station Safety Justification Report (each Station)
- Asset Information Models / AIMP

## **10 Handover**

The CRL Handover Process is currently under development for the Central Section assets. The document will contain details regarding the proposed process for handover, certification required and handover arrangements to IM(s). The handover evidence will be collated and demonstrated through the CARE System [50]

For 'placing into service', the safety analysis, compliance evidence, and the safety evidence and arguments that risks are ALARP will be collated by CRL into a series of Operator's Assurance Packages. These will be submitted for acceptance to the relevant Acceptance Body (AsBo) on behalf of the future Infrastructure / Station Operators or to the relevant TOC depending upon the agreement with the relevant Duty holder.

Subsequently, all project safety documentation will be retained by the Operators for maintenance and inspection during the lifetime operation of Crossrail.

## **11 Trial Running**

The trial running period is required to facilitate the Contractors and CRL to carry out their final dynamic tests, where the nature of the tests mandates that they are performed under the aegis of the Operator's rule book and safety management system. The purpose of the trial running period is to demonstrate that the railway is capable of meeting the required levels of performance under normal, degraded, maintenance and emergency modes of operations.

CRL Trial Running Strategy [43] defines the principles for trial running and outlines the types of trials to be performed leading to substantial completion of the railway infrastructure.

## **12 Trial Operations**

On completion of trial running, the operators will conduct trial operations to prepare for and demonstrate that the new railway assets are capable of being operated in accordance with the sponsors' requirements and the operators' safety management systems. CRL and the contractor shall support and assist the operator until the end of trial operations period or as necessary.

## 13 References

Document	Reference
1. LUL Assurance Standard	S1538
2. Design Management Process	CRL1-XRL-O4-GPS-CR001-50002
3. Engineering Design Assurance Gates Procedure	CRL1-XRL-O4-GPD-CR001-50002
4. Design Review Procedure	CRL1-XRL-O4-GPD-CR001-50003
5. CRL Project Technical Request (PTR) procedure	CRL1-XRL-Z-GPD-CR001-50006
6. CRL Technical Assurance Strategy	CRL1-XRL-O-GST-CR001-00001
7. Verification & Validation Plan	CRL1-XRL-O8-STP-CR001-50006
8. The Design Certification Procedure	CRL1-XRL-O4-GPD-CR001-50001
9. Issue of Design Documentation for Construction Procedure	CRL1-XRL-O4-GPD-CR001-50007
10. The Design Change Management Process	CRL1-XRL-O4-GPS-CRG03-50001
11. Acceptance of the Contractor's Architectural Samples, Mock-ups, Prototypes and Key Bench Marks	CRL1-XRL-O7-GPD-CR001-50008
12. CRL Demonstration of Material Compliance Procedure	CRL1-XRL-Z-GPD-CR001-50004
13. The Systemwide Execution Plan	CRL1-XRL-R-STP-CRG03-50001
14. CRL RAM Requirements for Central Section	CRL1-XRL-O8-RRS-CR001-00002
15. CRL Construction Management Plan	CRL1-XRL-N2-STP-CR001-50002
16. Construction Quality Plan	CRL1-XRL-N2-STP-CRG03-50004
17. Construction Certification Procedure for Structures and Civil Engineering Works	CRL1-XRL-O4-GPD-CR001-50006

**Technical Assurance Plan  
CRL1-XRL-O4-GPD-CR001-50005**

18. The Monitoring & Surveillance Procedure	CRL1-XRL-Z-GPD-CR001-50001
19. The Snagging & Outstanding Works (Punchworks) Procedure	CRL1-XRL-O4-GPD-CR001-50010
20. The Completion & Control of the Works	CRL1-XRL-O4-GPD-CR001-50017
21. CRL Health and Safety Manual	CR-XRL-Z7-GMN-CR001-00001
22. Environment Manual	CR-XRL-T1-GMN-CR001-00001
23. Crossrail Programme Security Strategy	CR-XRL-Z7-GST-CR001-00002
24. Site Mobilisation, Start Up and Critical Readiness Review Procedure	CRL1-XRL-Z-GPD-CR001-50007
25. Review & Acceptance of Safe Systems of Works Procedure	CRL1-XRL-Z-GPD-CRG03-50003
26. Procedure for Interface Management	CRL1-XRL-O8-GPD-CR001-50001
27. Infrastructure Protection Plan – London Underground Assets	CRL1-XRL-N2-STP-CR001-50003
28. Crossrail Worksite Possession on Network Rail – Booking and Implementation	CRL1-XRL-Z-GPD-CR001-50013
29. Management and Acceptance of Field Documentation Procedure	CRL1-XRL-N2-GPD-CRG03-50001
30. Transfer of Possession of the Works from One Contractor to Another Contractor Procedure	CRL1-XRL-O4-GPD-CR001-50020
31. Project Test and Commissioning Strategy	CRL1-XRL-O8-STP-CR001-50008
32. Engineering Design Assurance Systemwide Gates Procedure	CRL1-XRL-O4-GPD-CR001-50023
33. Implementation Plan for Progressive Assurance TAP Ref:10	CRL1-XRL-O-STP-CRG03-50001
34. CRL Handover Plan	TBC
35. Canary Wharf Crossrail Station	T142-CPW-N2-RGN-CR143-50161

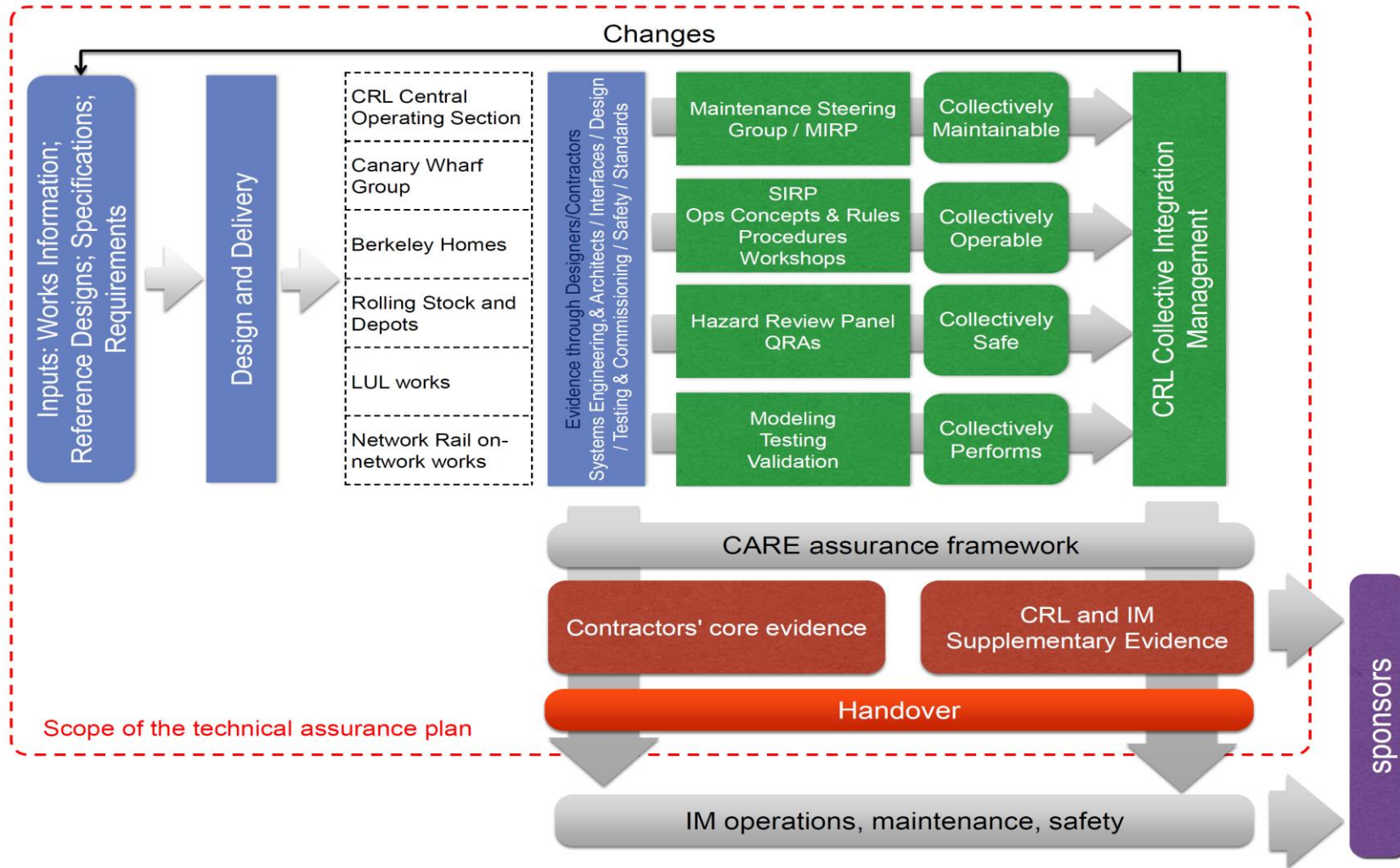
**Technical Assurance Plan**  
**CRL1-XRL-O4-GPD-CR001-50005**

Technical Assurance Plan	
36. Engineering Safety Steering Group	TBC
37. MSG Terms of Reference	CRL1-XRL-O8-LRC-CR001-50006
38. Building Control Procedure throughout the Crossrail Project Lifecycle	CRL1-XRL-O7-GPD-CR001-50007
39. CRL Competency Assessment Guidelines	CRL1-XRL-O7-GPD-CR001-50006
40. Final Design Overview Certificate	TBC
41. CRL System Integration Management Plan	CRL1-XRL-O8-STP-CR001-50010
42. Programme Assurance Strategy	CR-XRL-O4-GPL-CR001-00001
43. CRL Trial Running Strategy	CRL1-XRL-R-STP-CR001-50001
44. Interface Management Procedure	CRL1-XRL-O8-GPD-CR001-50001
45. ICD Template	CR-XRL-N2-ZTM-CR001-00001
46. CRL Delivery Strategy	CR-XRL-Z-GST-CR001-00001
47. CRL Hazard Management Procedure	CRL1-XRL-O8-GPD-CR001-50002
48. Interim Design Overview Certificate Process	TBC
49. CRL VAP Process	TBC
50. CARE	CRL1-XRL-O-RSP-CR001_Z-50001
51. LU Development Agreement	CR-CO-PRW-X-AE-00004
52. Delivery Competency Management Procedure	CRL1-XRL-Z2-GPD-CR001-50001
53. SIRP Workshop Guidelines	CRL1-XRL-O8-GUI-CR001-50001
54. Performance Steering Group	TBC

**Technical Assurance Plan**  
**CRL1-XRL-O4-GPD-CR001-50005**

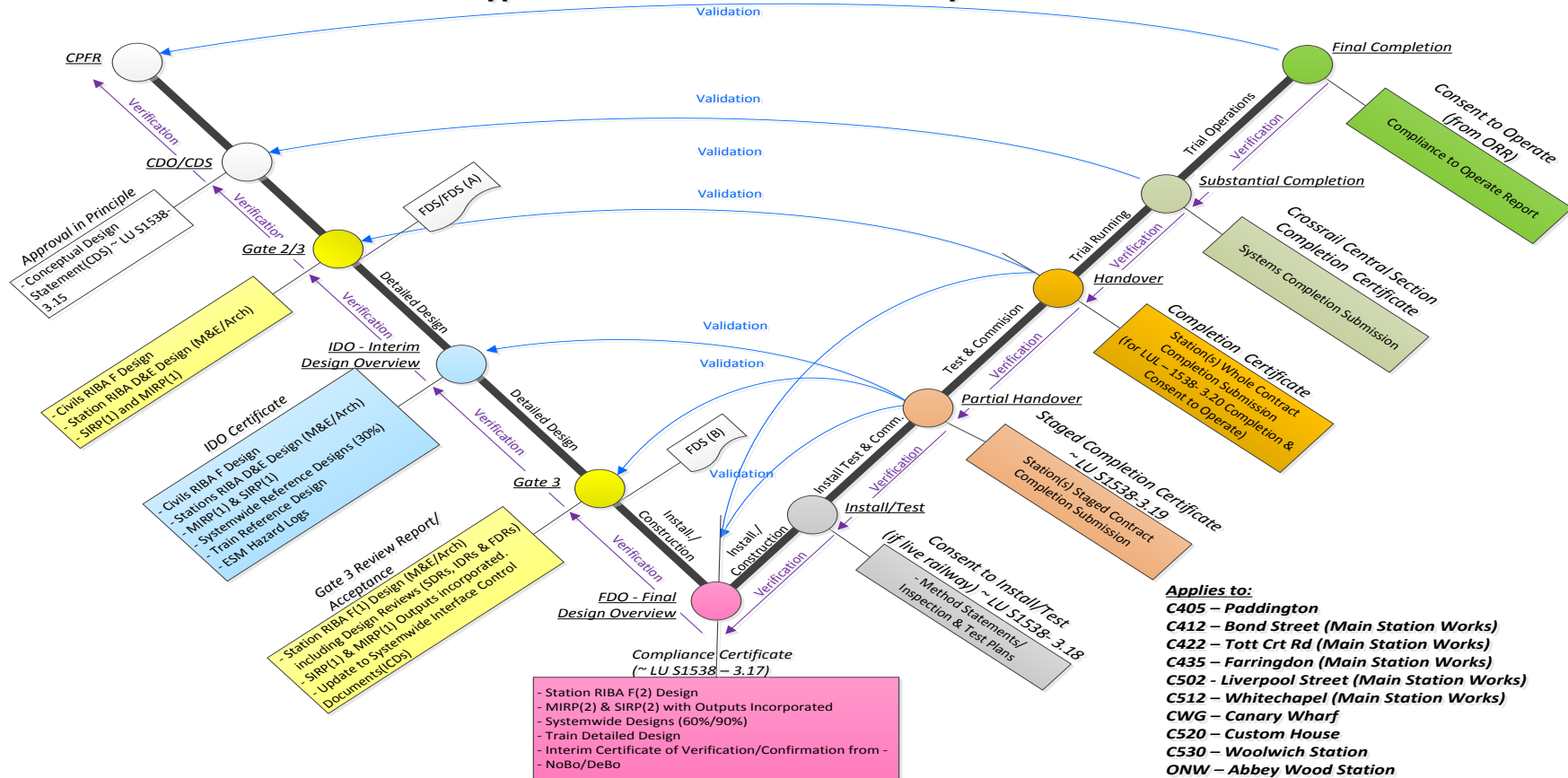
55. Systems Breakdown Structure	CRL1-XRL-R-TSC-CR001-50001
56. Berkeley Homes Technical Assurance Plan	TBC
57. Volume 2B- Part 29- Systemwide Design, Assurance, Record and Certification	CRL1-XRL-R-GPD-CRG03-50001
58. CRL Engineering Requirement Management Plan	CRL1-XRL-O8-STP-CR001-50005
59. Works Package Plan Procedure CRL & LU	CRL1-XRL-O4-STP-CR001-50002
60. LU Access and Closure Procedure	CRL1-XRL-O4-GPD-CR001-50014
61. Completion and Handover to LU of CRL Interface Works	CRL1-XRL-Z-GPD-CR001-50021
62. Crossrail Supplier Representative	CRL1-LU-O4-RSP-CR001-50001
63. Crossrail Worksite Possession on Network Rail- Booking and Implementation	CRL1-XRL-Z-GPD-CR001-50013
64. Network Rail Scope Book Procedure	CRL1-XRL-Z-GPD-CRG03-50008
65. Engineering safety Management System Safety Plan	CRL1-XRL-O7-GST-CR001-00001
66. Network Rail Technical Assurance Plan	CRL1-NRI-N2-STP-CRG04-50016

**Appendix A- Crossrail Progressive Assurance & Integration Model**



## Appendix B- Design Assurance V Life-Cycle

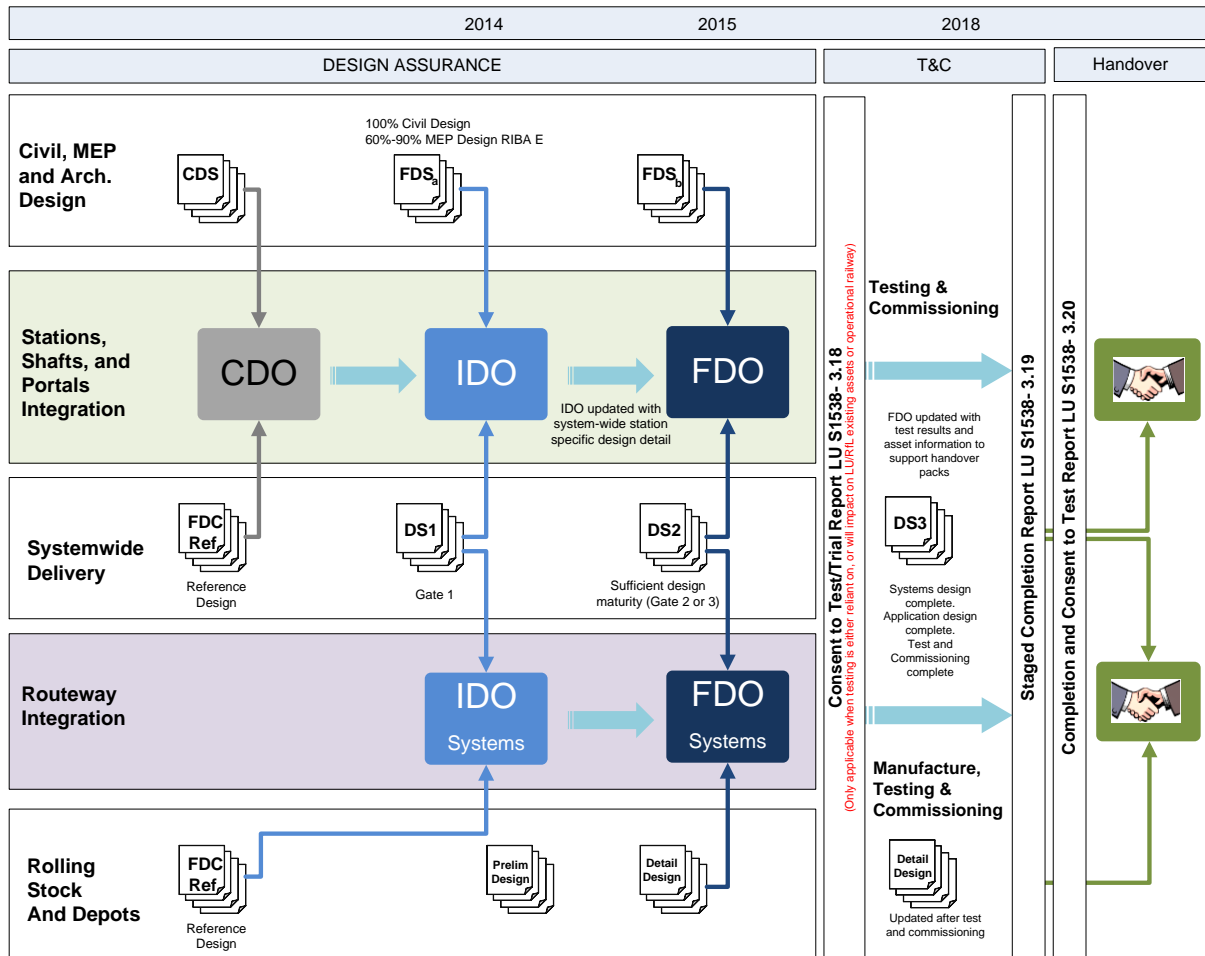
### Typical Station Assurance V-Lifecycle







### Appendix C- Design Overview Stages



**Design Overview Stages**

## Appendix D- Evidence assessed during IDO/FDO Packages

Element	IDO	FDO
<b>Stations Design</b>		
• Civils	FDS	FDS
• MEP	FDS (A)	FDS (B)
• Architecture	FDS (A)	FDS (B)
• Systems Design specifications	DS1	DS2
• Compliance with requirements	Doors report	Doors report
• Co-ordination (Interfaces +)	ICD's, IDR's, IRS's, DIR's	ICD's, IDR's, IRS's, DIR's
• Residual risks / issues	Flag the risks/issues	Flag the risks/issues
• Standards compliance	Non-Compliances, Concessions & Derogations	Non-Compliances, Concessions & Derogations
<b>Systemwide contracts</b>		
• Each Systemwide Contract	30% design	Minimum 60% however will use 90% design where possible subject to programme.
• LU11 SORs	Technical specification to RIBA E	Site specific compliance submission.
<b>Safety</b>		
• Fire safety (within FDSa)	Yes	Yes
• PRM compliance (within FDS(a))	Yes	Yes
• Safety Issues File	Yes	Yes
• Project-wide Hazard Register	Yes	Yes
• Engineering Safety Justifications	Yes	Yes (Design safety Justification)
• Station Safety Justifications	No	Yes (interim)
• CDM health and safety file	Yes	Yes
<b>Performance</b>		
• Passenger movements modelling	Legion model outputs	Legion model outputs
• RAM	RAM demonstration report	RAM demonstration report
• PPM	Trail Model Output	Trail Model Output
<b>Operable</b>		
• SIRP outputs	SIRP 1 review and any open issues	SIRP 2 review and any open issues
<b>Maintainable</b>		
• MIRP outputs	Confirmation of MIRP 1 review and any open issues	Confirmation of MIRP 2 review and any open issues
• Maintenance Boundaries	IM Boundaries Document	IM Boundaries Document
<b>Assurance</b>		
• Evidence for handover	CARE – structure and content	CARE assessment
• Undertakings and assurances	Summary report	Summary report
<b>Whole Life Costing</b>		
• Compliance to CPFR requirements	Evidence of WLC assessment	Evidence of WLC assessment
<b>Quality</b>		
• Construction quality	Certification of works	Certification of works
<b>Rolling Stock &amp; Depots</b>		
• Design	Reference Design	Detailed design

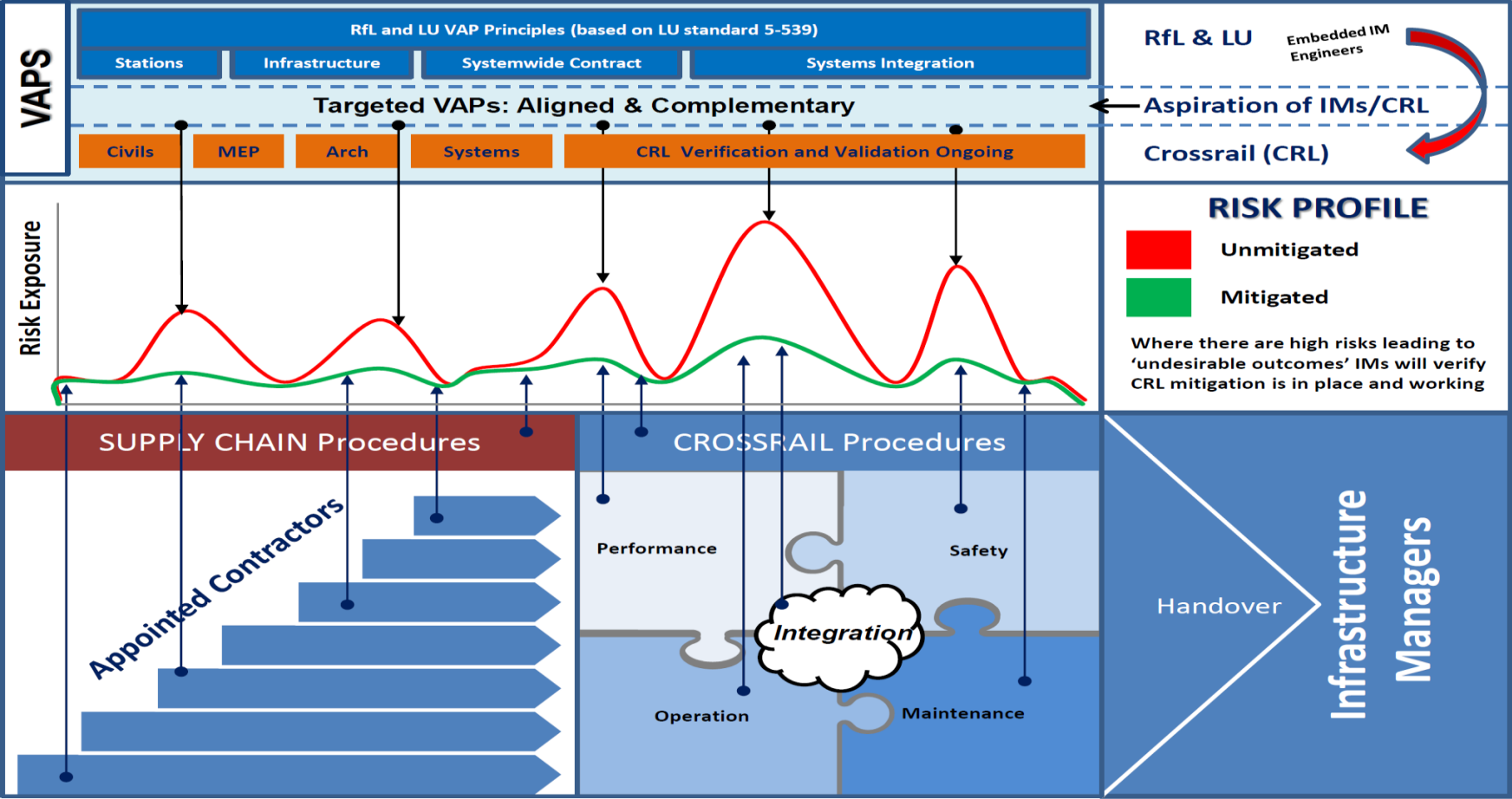
**Technical Assurance Plan**  
**CRL1-XRL-O4-GPD-CR001-50005**

The totality of FDO packages should add up to the whole COS railway (plus interfaces). The intention is to hold IDO and FDO reviews aligned to the handover elements – an indicative plan is shown below:

<b>Element</b>	<b>IDO</b>	<b>FDO</b>	<b>Comments</b>
<b>Stations</b>			
Paddington Station	Yes	Yes	
Bond Street	Yes	Yes	
Tottenham Court Road	Yes	Yes	
Farringdon	Yes	Yes	
Liverpool Street	Yes	Yes	
Whitechapel	Yes	Yes	
Canary Wharf	Yes	Yes	
Custom House	Yes	Yes	
Woolwich	Yes	Yes	
Abbey Wood	Yes	Yes	
<b>Routeway</b>			
Tunnels Portals Shafts C610 Systemwide main works C620 Signalling C660 Comms and Control C650 HV Power	Yes	Yes	It is intended to hold this FDO review as one consolidated event for all tunnels / portals and shafts plus their systems. This is subject to further review between CRL and RfL.
LU11 SORs	Yes	Yes	Will be included in relevant station
<b>Other</b>			
RCC and BUCF	Yes	Yes	Some interfacing / integration evidence needed. The RCC will be installed in an NR building which will not in itself be handed over.
Rolling Stock	No	Yes	Some interfacing / integration evidence needed
Old Oak Common	No	Yes	Some interfacing / integration evidence needed
Plumstead maintenance facility	Yes	Yes	
Yellow Plant	No	Yes	

Appendix E- VAP Process Flow

Verification Activities



## Abbreviations

<b>Word</b>	<b>Explanation / Definition</b>
CARE	Crossrail Assurance Reporting Environment
CPFR	Crossrail Programme Functional Requirements
CRL	Crossrail Limited
CWG	Canary Wharf Group
CSW	Central Section Works
DOORS	Dynamic Object Oriented Requirements System
EMC	Electromagnetic Compatibility
FDC	Framework Design Consultant
FDS	Final Design Submission
FDO	Final Design Overview
LU (L)	London Underground (Limited)
ICD	Interface Control Document
IDO	Interim Design Overview
IM	Infrastructure Manager
IRS	Interface Requirements Specification
ITT	Invitation to Tender
M&E	Mechanical and Electrical
MIRP	Maintenance Integration Review Panel
NNTR	Notified National Technical Rule
NR	Network Rail
ONFR	On Network Functional Requirements
RAM	Reliability, Availability, Maintainability
RfL	Rail for London
RSD	Rolling Stock and Depot
SI	Systems Integration
RIA	Railway Integration Authority
SIRP	Systems Integration Review Panel

**Technical Assurance Plan**  
**CRL1-XRL-O4-GPD-CR001-50005**

<b>Word</b>	<b>Explanation / Definition</b>
T&C	Test and Commissioning
TSI	Technical Specification for Interoperability