

Completing the Elizabeth line

5 April 2023



Design Overview & Integration

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Scheme Development

Business Case and Pre-Bill Consultation

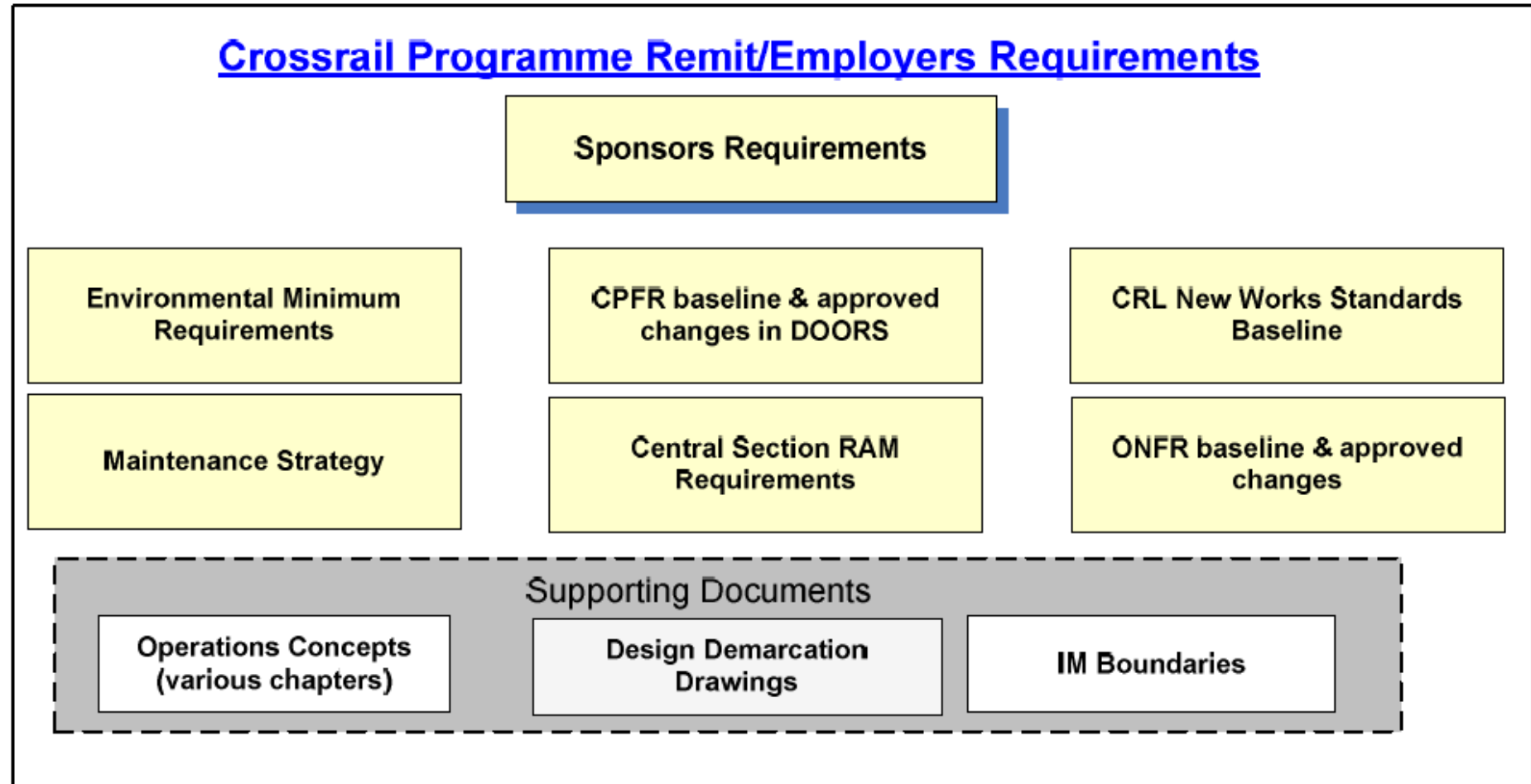
Crossrail (Hybrid) Bill and Reference Designs

Sponsor's Requirements

Stakeholders and Programme Partners Consultation

Crossrail Programme Functional Requirements (CPFR)

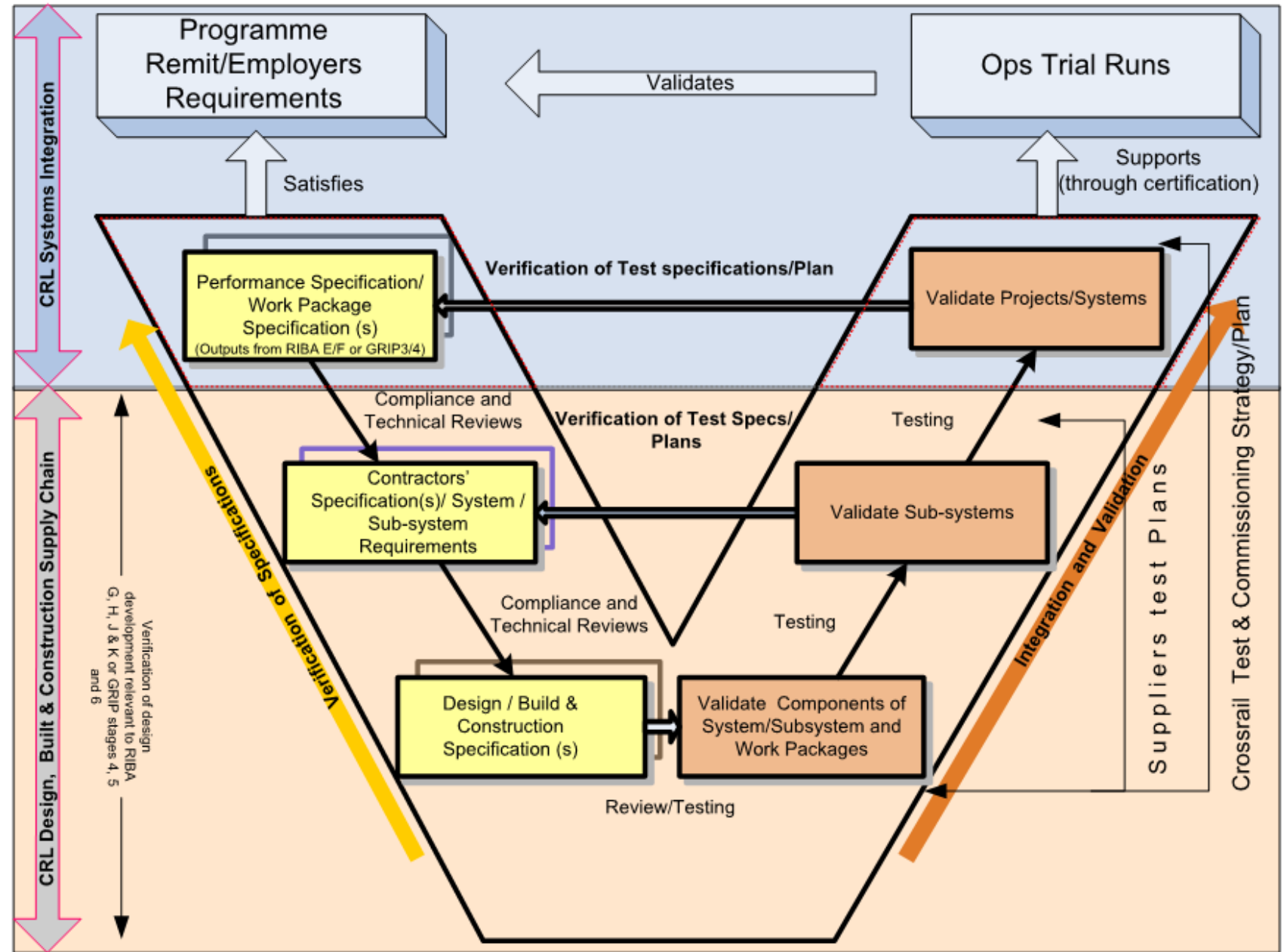
Requirements Management established from the outset



Requirements

DOORS Implementation

A clear engineering lifecycle was developed, implemented and built into the overall programme schedule

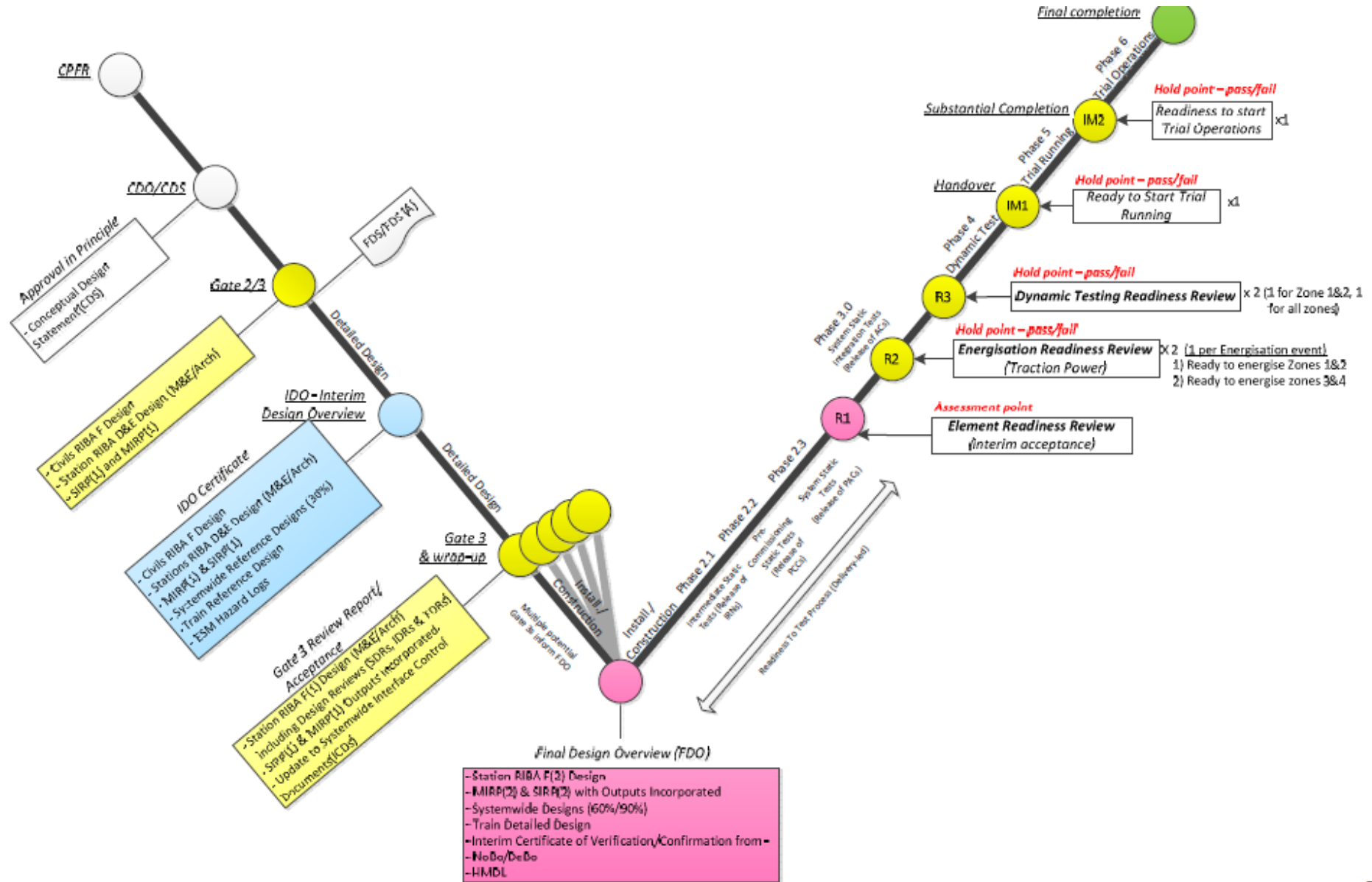


Engineering Foundation

Design Gates 1, 2 & 3 leading to:

- Concept Design Overview
- Interim Design Overview
- Final Design Overview

Design baselines updated as details were worked, with Final Design Submission Addenda produced all the way through the life-cycle up to As-Built status.

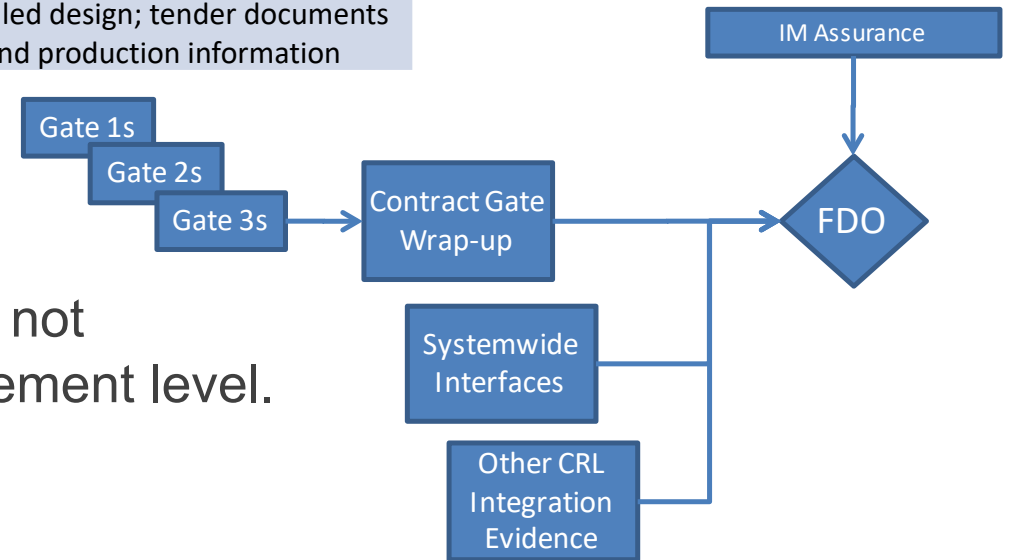


Design Gates and the Final Design Overview

- ▶ During design phase the Contractors presented design assurance to CRL at 3 ‘Gates’
- ▶ The following table provides details of the Crossrail Gates 1, 2 and 3 and the equivalent stages under other familiar processes:

Crossrail Gate	RIBA Stage	GRIP Stage	LU Stage	% completion	Description
Gate 1	C or D	3	Conceptual Design Statement Ref Clause 3.15 – S1538	20% Design	Final Scheme design
Gate 2	E	4		60% Design	Development of single option
Gate 3	F	5	Compliance Submission Ref Clause 3.17 - S1538	100% Design	Detailed design; tender documents and production information

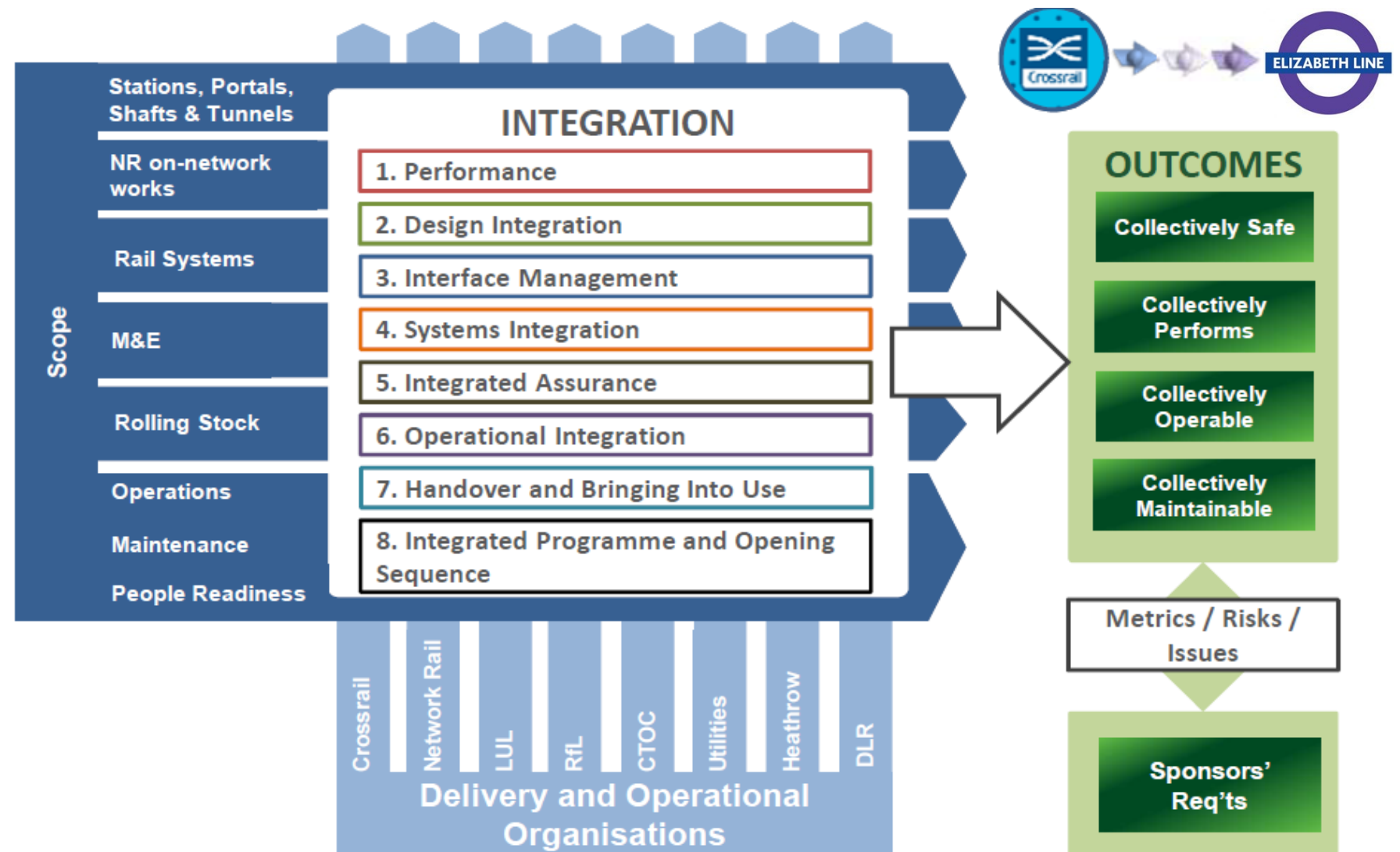
- ▶ Wrap-up Gate was used to bring together a Contractor’s Gate 3 submissions to demonstrate a complete design.
- ▶ The Handover strategy was based around Elements, and not Contracts, so CRL needed to test the Designs from an Element level.
- ▶ This led to the Final Design Overview Process



Integration Model

Four Pillars

- Collectively Safe
- Collectively Performs
- Collectively Operable
- Collectively Maintainable



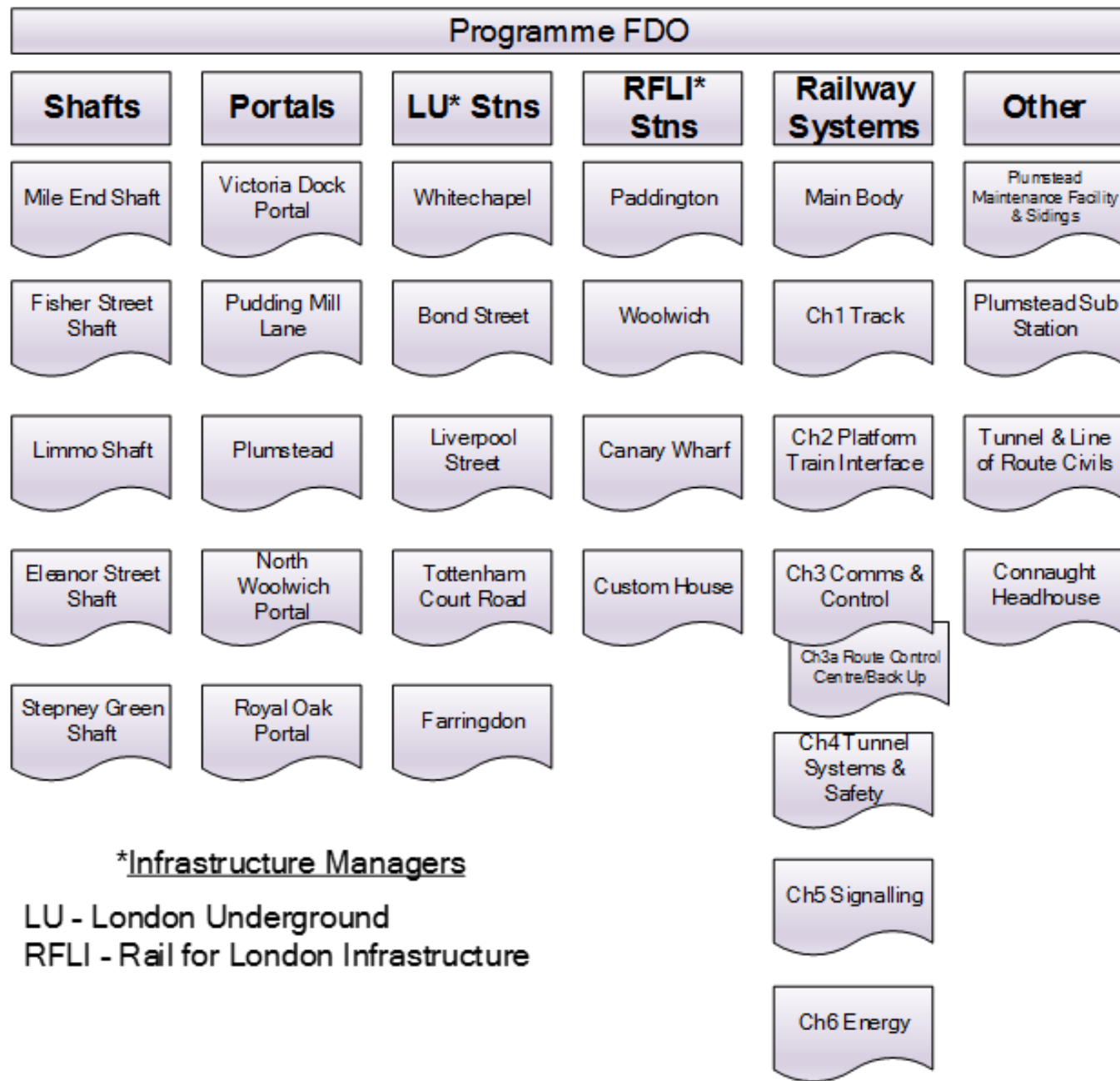
FINAL DESIGN OVERVIEWS (FDO)

Outputs:

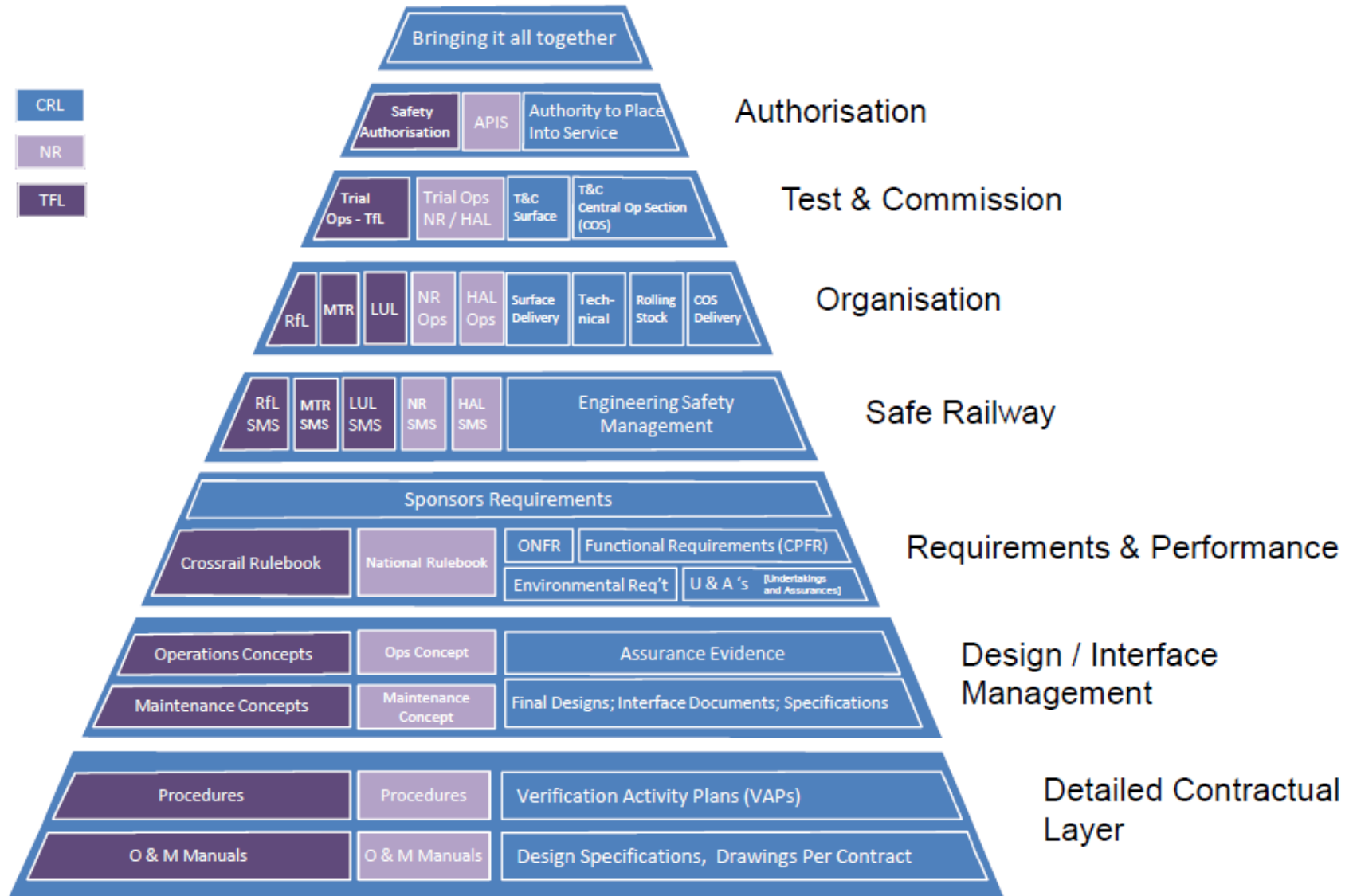
Completion and acceptance of 32 FDO Reports

Completion and approval of over 1,000 FDO evidence documents

Close out of over 2,000 FDO issues raised during the review process



Systems Integration – Many Layers of Integration



Processes supporting Integration

Four Pillars

Collectively Safe

Collectively Operable

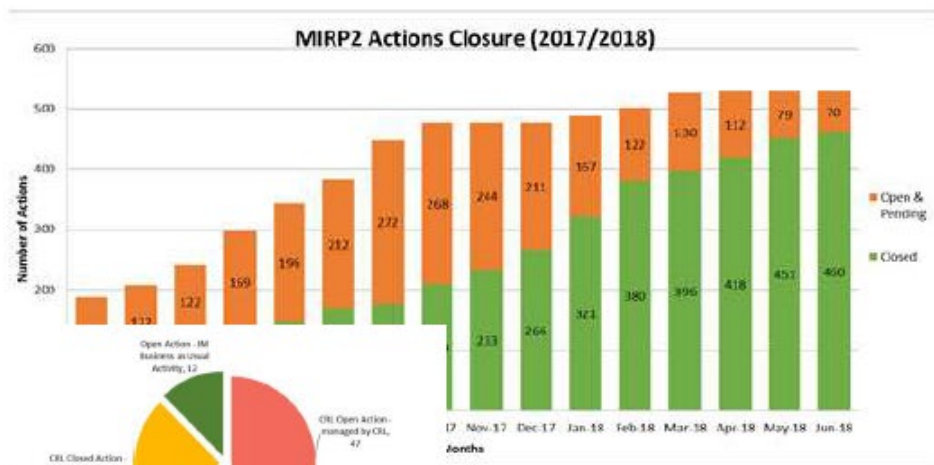
Collectively Maintainable

Collectively Performs

► These are the key processes that provide CRL with the “four pillars”

Integration Activity	Performance	Operations	Maintenance	Safety	Contractor Involvement?
Collectively Safe					
• Hazard management process				X	X
• Design and Engineering safety justifications (DESJs and ESJs)				X	X
• Focussed Quantified Risk Assessments				X	CRL
• Interoperability - TSI Compliance (NoBo) and NNTRs				X	X
• CSM compliance – AsBo reports				X	X
• Interface Hazard Analyses				X	X
• Safety Justifications (per Element)				X	CRL
• Overall end to end railway safety justification (one line-wide)				X	CRL
Collectively Operable					
• System Integration Review Panel Outputs		X			X
• CPMR requirements compliance	X	X	X		X
Collectively Maintainable					
• Maintenance Integration Review Panel Outputs			X		X
• Maintenance boundaries definition			X	X	CRL
• Maintenance Plan (per station and system)			X		CRL
• RAM analysis	X	X	X		X
Collectively Performs					
• Simulation / modelling	X				X
• Test & Commissioning certificates (integration, dynamic testing, trial running)	X				X
Technical Assurance					
• Design Assurance outputs	X	X	X	X	X
• Architectural assurance	X				X
• Materials Compliance	X			X	X
• Requirements Management	X	X	X	X	X
• EMC Management	X			X	X
• IDO and FDO reviews	X	X	X	X	CRL
• Progressive Assurance (inspections)	X				CRL
• Test & Commissioning certificates (integration, dynamic testing, trial running)	X				X

Operations & Maintenance Integration



SIRP and MIRP workshops brought project and operational personnel together for facilitated scenario-based discussion

SIRP 2

- 64 workshops run 2016/7
- Emphasis on operability
- Actions tracked and subject to rigorous closure process

Earlier SIRP O&1 series similarly managed

- Emphasis on design alignment with Operational Concepts

MIRP 1 and 2

- 61 workshops run
- Similar closure tracking process

Statements of Operability Assessment and Holistic Maintenance Plans represent the final outputs, and act as a condition to design approval at FDO

The workshops served also as an input for operator preparation of procedures

Crossrail Engineering Safety and Assurance Case (CESAC)

Marshalling the Evidence:

The CESAC was the top level summary assurance case

Complete argument drawn from CRL, RFLI, MTR-EL, LUL, BT and NR to demonstrate that:

- The minimum scope and functionality conditions for each stage had been met
- The delivered scope and functionality was sufficiently integrated and assured for the subsequent stage
- The IM's and Operators were ready

