Systems Engineering Overground

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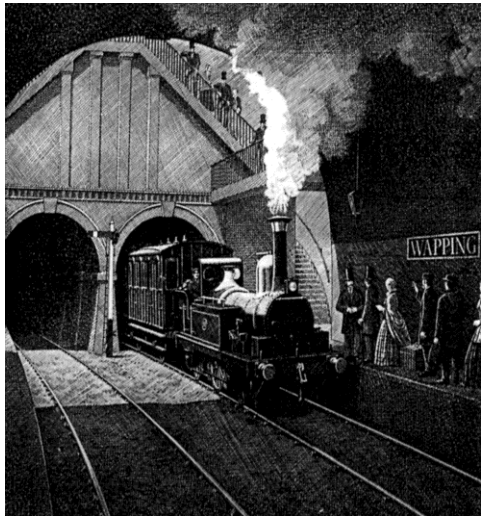
London Overground Infrastructure

Overview

- Integrating SE practices into major procurements
- Convincing of the benefits of an SE approach
- Delegating systems engineering responsibilities down the supply chain
- Using (or not) systems engineering standards
- Ensuring systems assurance is a progressive activity
- Measuring systems integration success
- Commissioning using SE practices

Context & History - ELLP

- East London Line (ELLP) Project concept devised by LU mid 1980's
- TWA planning powers 1997 & 2001
- Project transferred
  - LUL to SRA in 2001
  - SRA to TfL in November 2004
- Benefits
  - Links north and south London
  - First step towards an orbital system
  - Offers congestion relief to central London
  - Catalyst for significant regeneration



ELL Project Scope

Phase 1 (Orange)

Extend the existing line

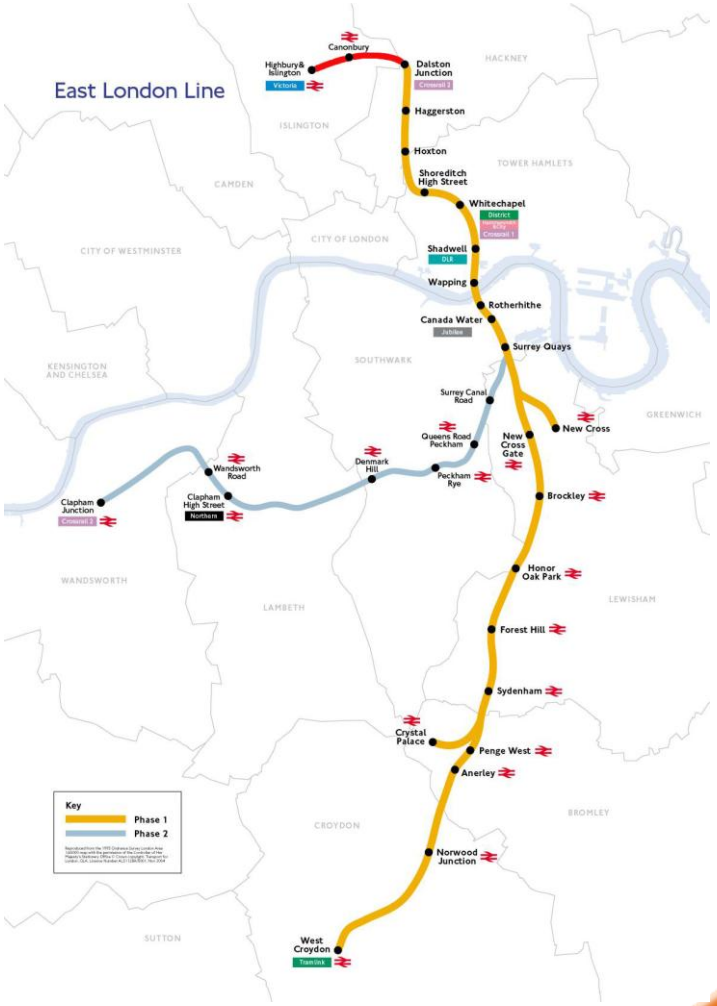
- **North to Dalston Junction**
- **South to Crystal Palace and West Croydon**

Phase 1a (Red)

- **Extend the existing line**
  - **North to Highbury & Islington from Dalston Junction**

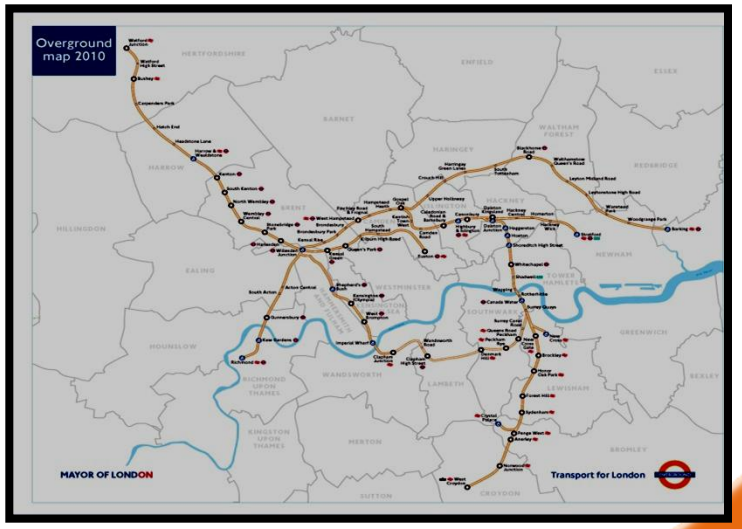
Phase 2 (Blue)

- **Further extend services west to Clapham Junction**



ELR Train Service

- 4 - car trains travelling on national rail infrastructure
- Phase 1 - 12 trains per hour to and from Dalston Junction, one third to New Cross, one third to Crystal Palace and one third to West Croydon
- Phase 1a – 8 trains per hour extended to Highbury & Islington
- Phase 2 - 16 trains per hour through the central section connecting to North London Line and Clapham Junction



Introducing SE into a Major Project

- **Avoid jargon and SE speak**
- **Convince not impose**
- **Integrate SE practices into overall processes**
- **Be pragmatic and persistent**
- **Set out a clear strategy – and then communicate it**

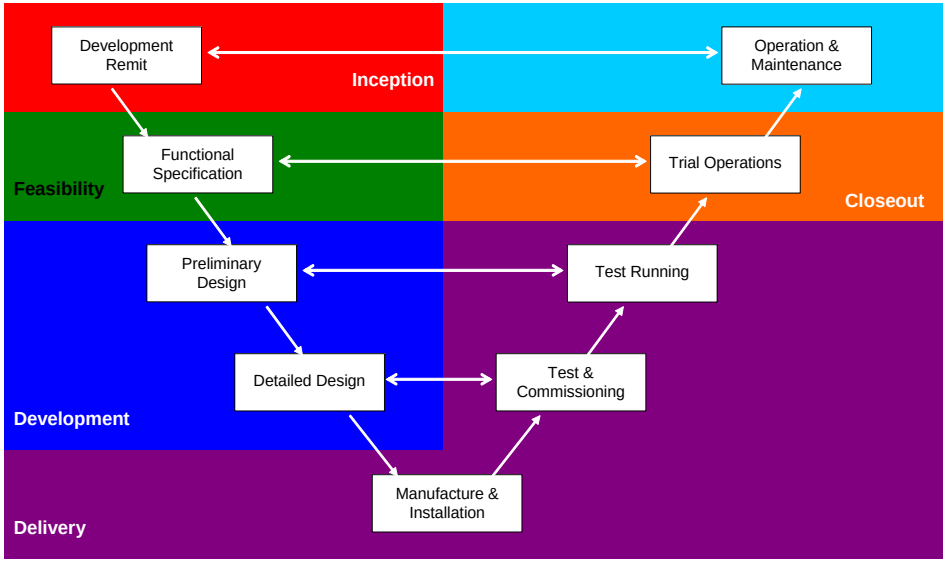
ELLP Engineering Strategy

System Engineering principles applied :-

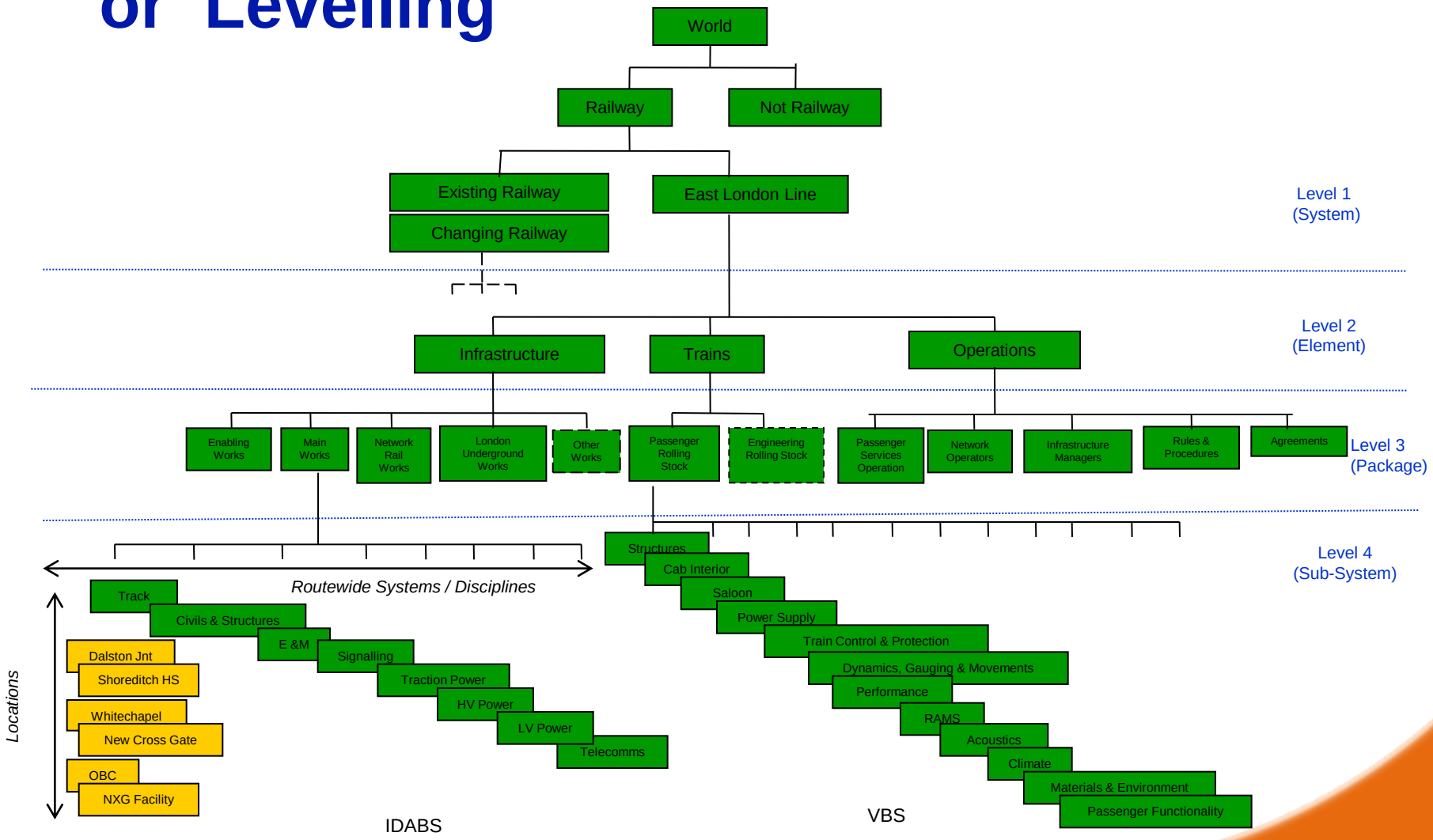
- **System Breakdown Structure (Levelling)**
- **Lifecycle Management**
- **Operational Concept**
- **Modelling**
- **System Definition**
- **Requirement Management**
- **Interface Definition and Management**
- **Configuration Management and Baselines**
- **Progressive Assurance**

Planning the Project - Lifecycle

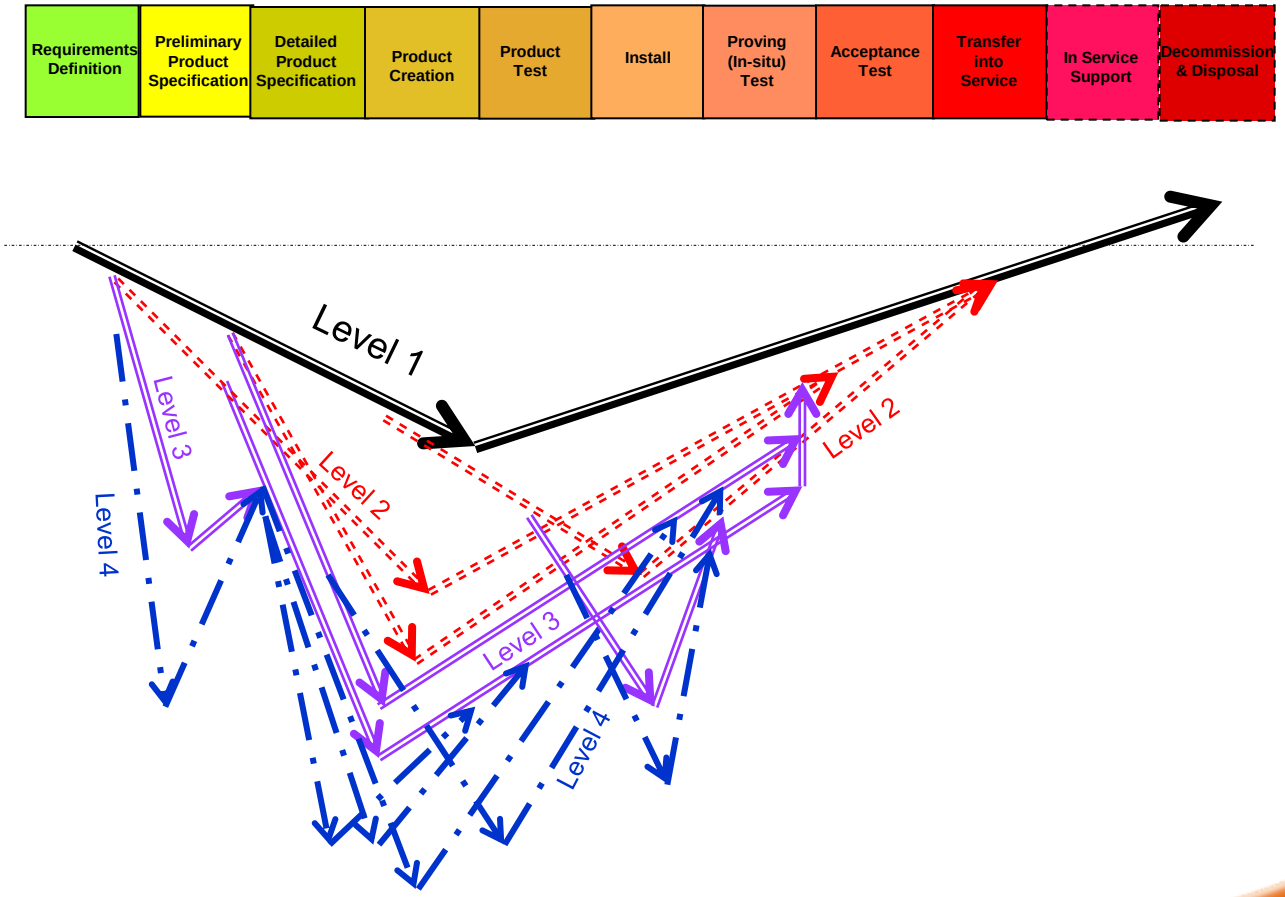
- **Based on EN50126 RAMS standard to use V lifecycle**
- **Other Standards and methodologies considered**
  - **LU E1008**
  - **NR GRIP**
  - **Office of Government Commerce lifecycle**



Planning the Project - System Breakdown or Levelling



The Levelled Lifecycle



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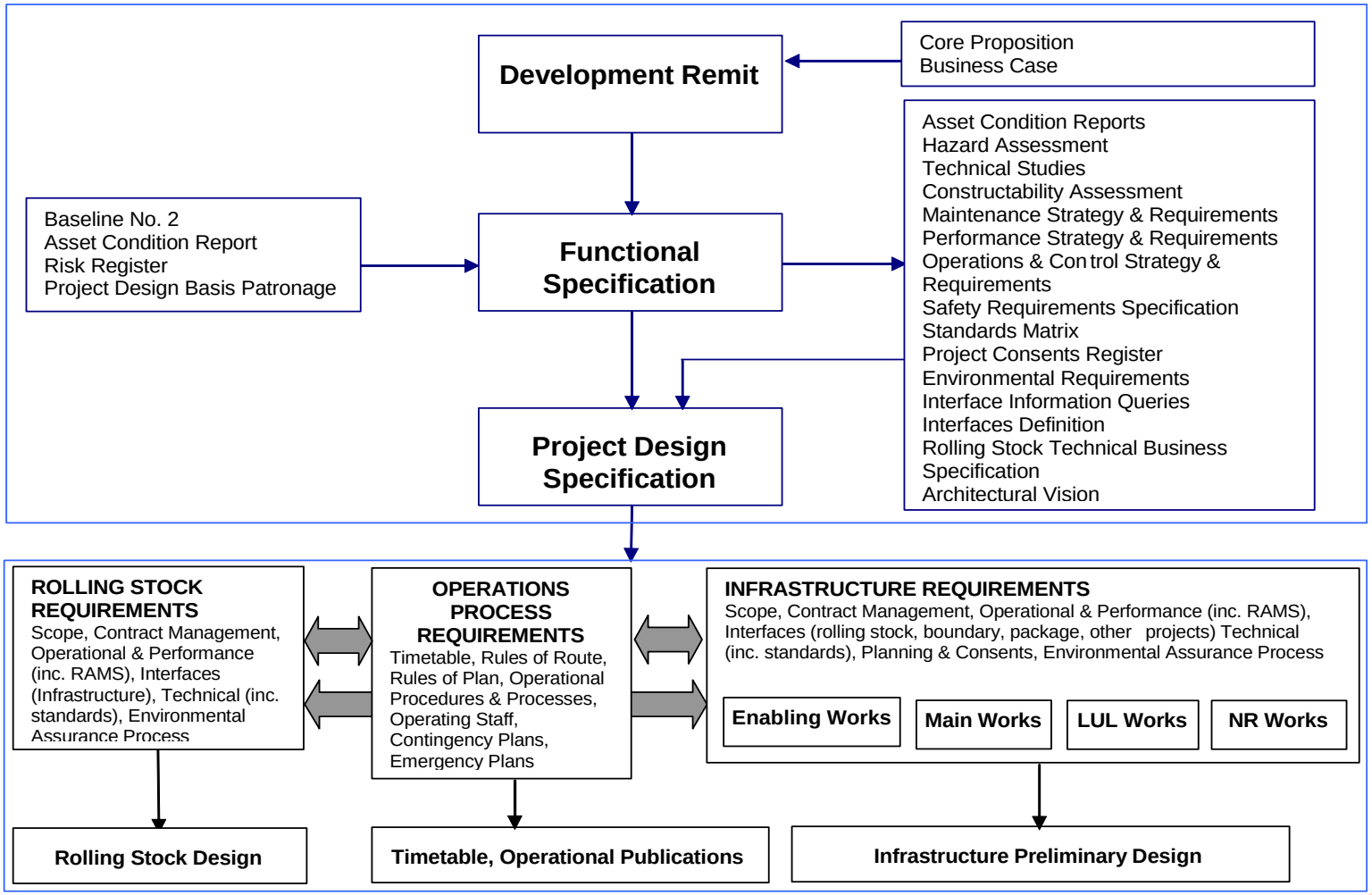
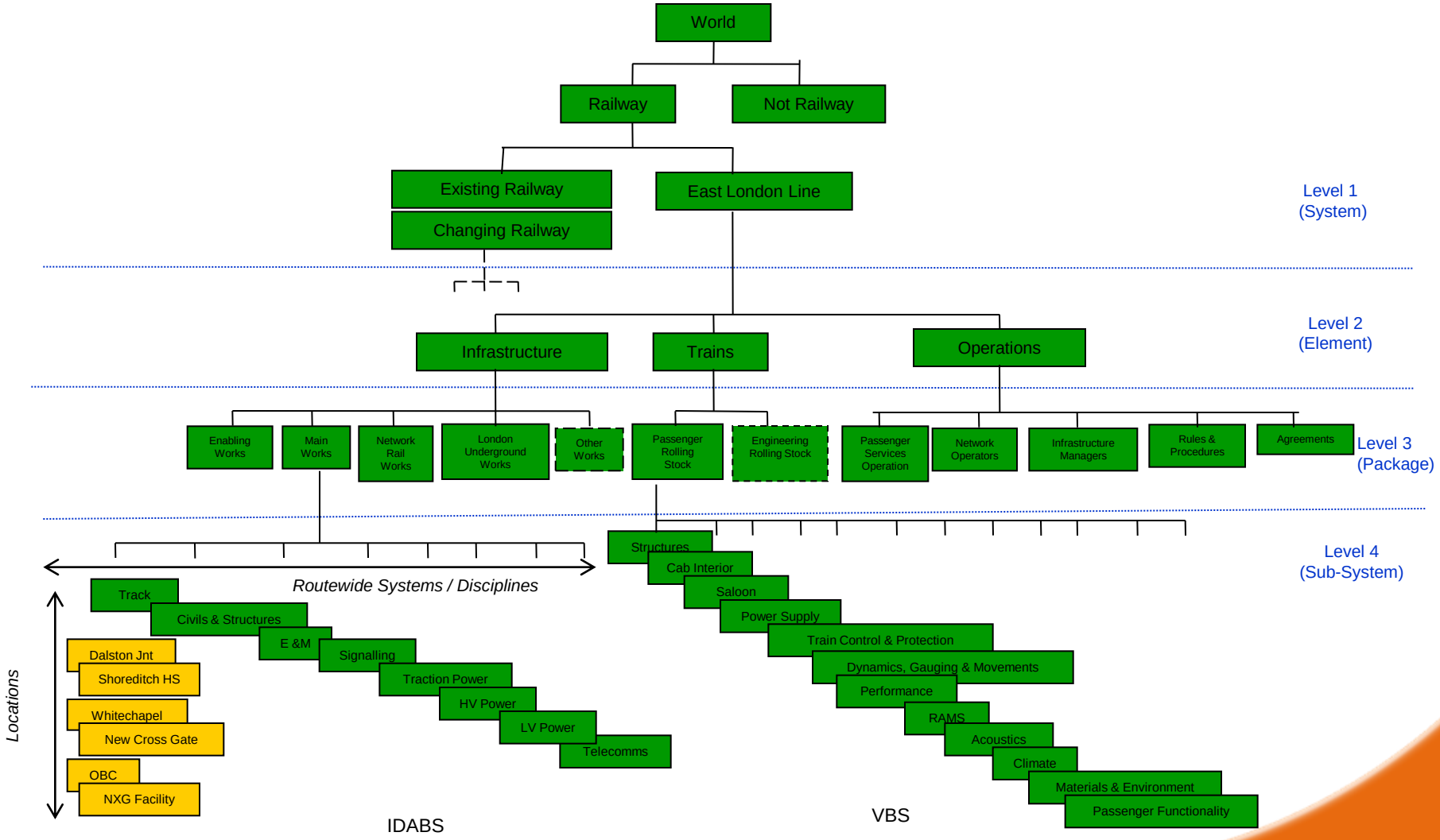
System Definition - 2003



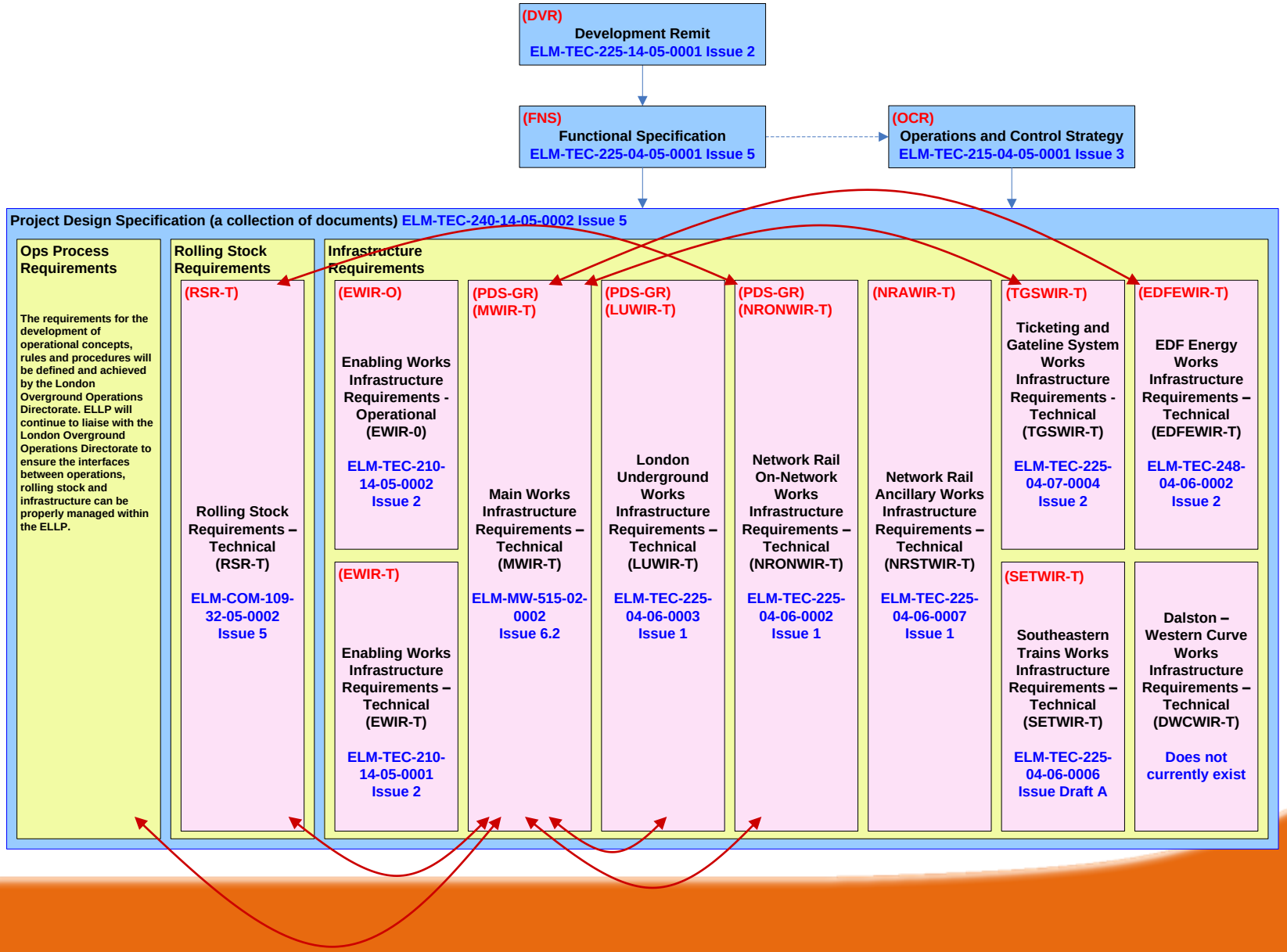
System Breakdown - 2009



Requirements Management

- **Key decisions**
  - **Procurement Strategy**
  - **Operational Concept**
  - **Operational Requirements Capture**
- **Use of Requirements Management Tool**
  - **Tried TeamTrace in 2003**
  - **Migrated DOORS in 2005**
- **Risk based assessment use of DOORS**
  - **Product requirements in DOORS**
  - **Contract requirements specification directly from DOORS**
  - **Process requirements in other Contract documents**

DOORS structure



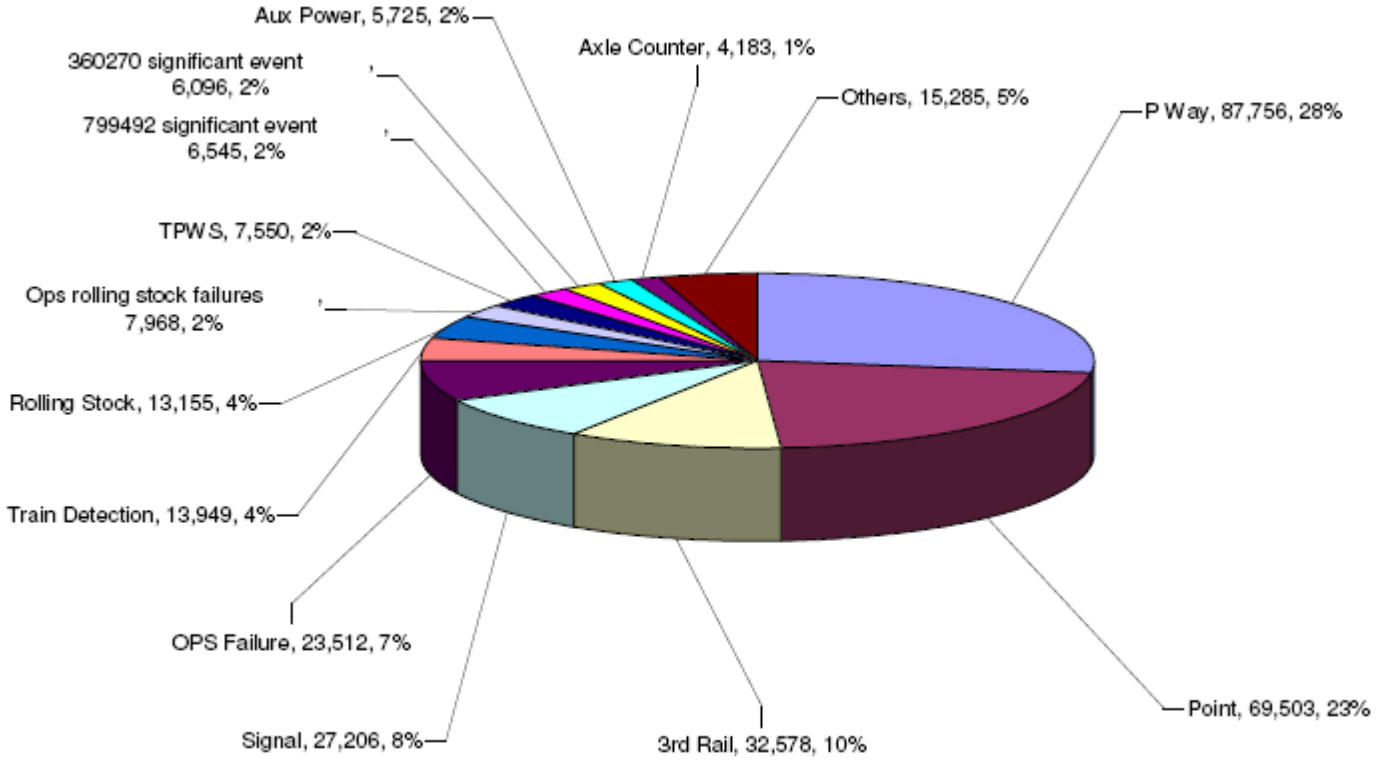
East London Railway System Modelling

- **System modelling to allocate reliability targets**
  - **Concept stage – PPM < 92%**
  - **Preliminary Design stage – PPM 92.9%**
  - **Detailed Design stage – PPM 93.5%**
  - **As built stage – PPM (in 2010)**

- **Infrastructure**
  - **Uses actual data where possible**
  - **Infrastructure reliability is area needing most focus**
  - **Use proven systems to avoid development risk**

- **Rolling stock**
  - **Fleet of 20 trains (18 in service)**
  - **Mean miles to failure event (>2 mins) – circa 38,000**

East London Railway System Modelling



Example of Element Type Delay per Annum (minutes)

ELLP Engineering Strategy

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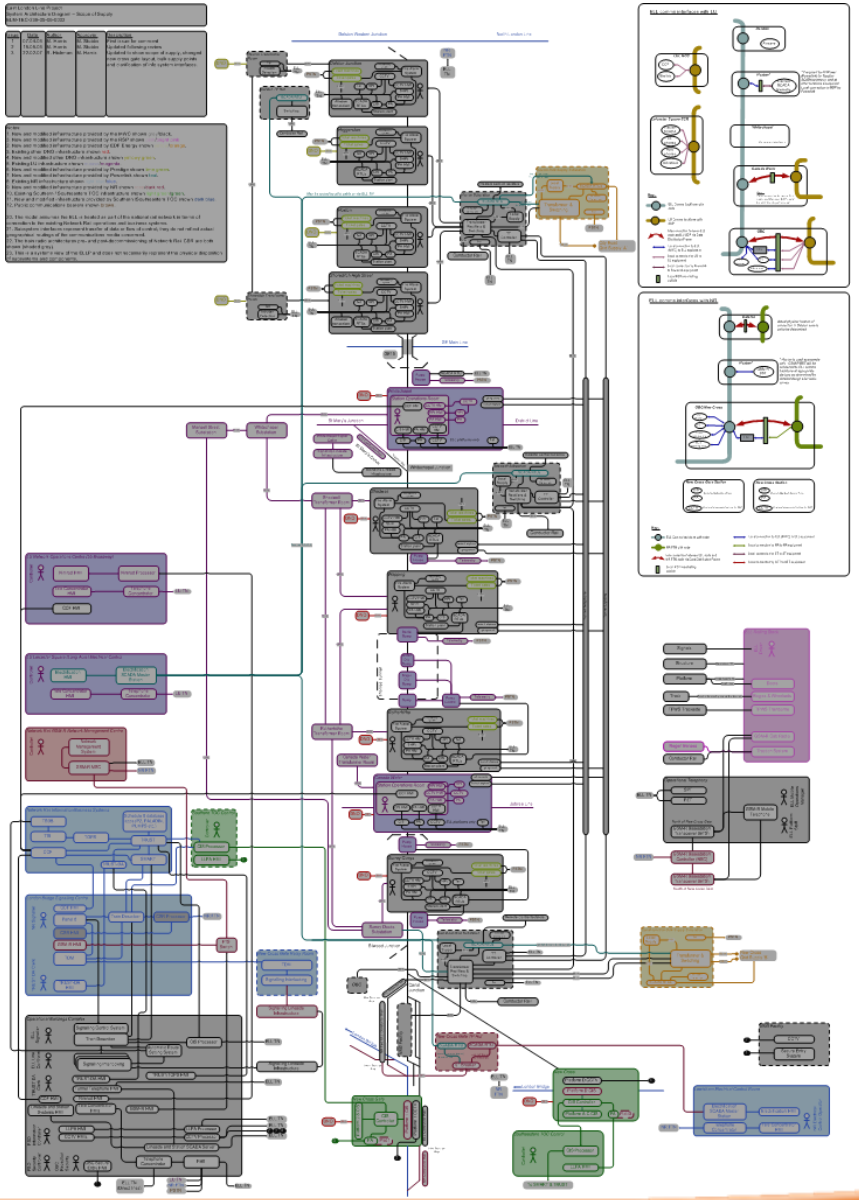
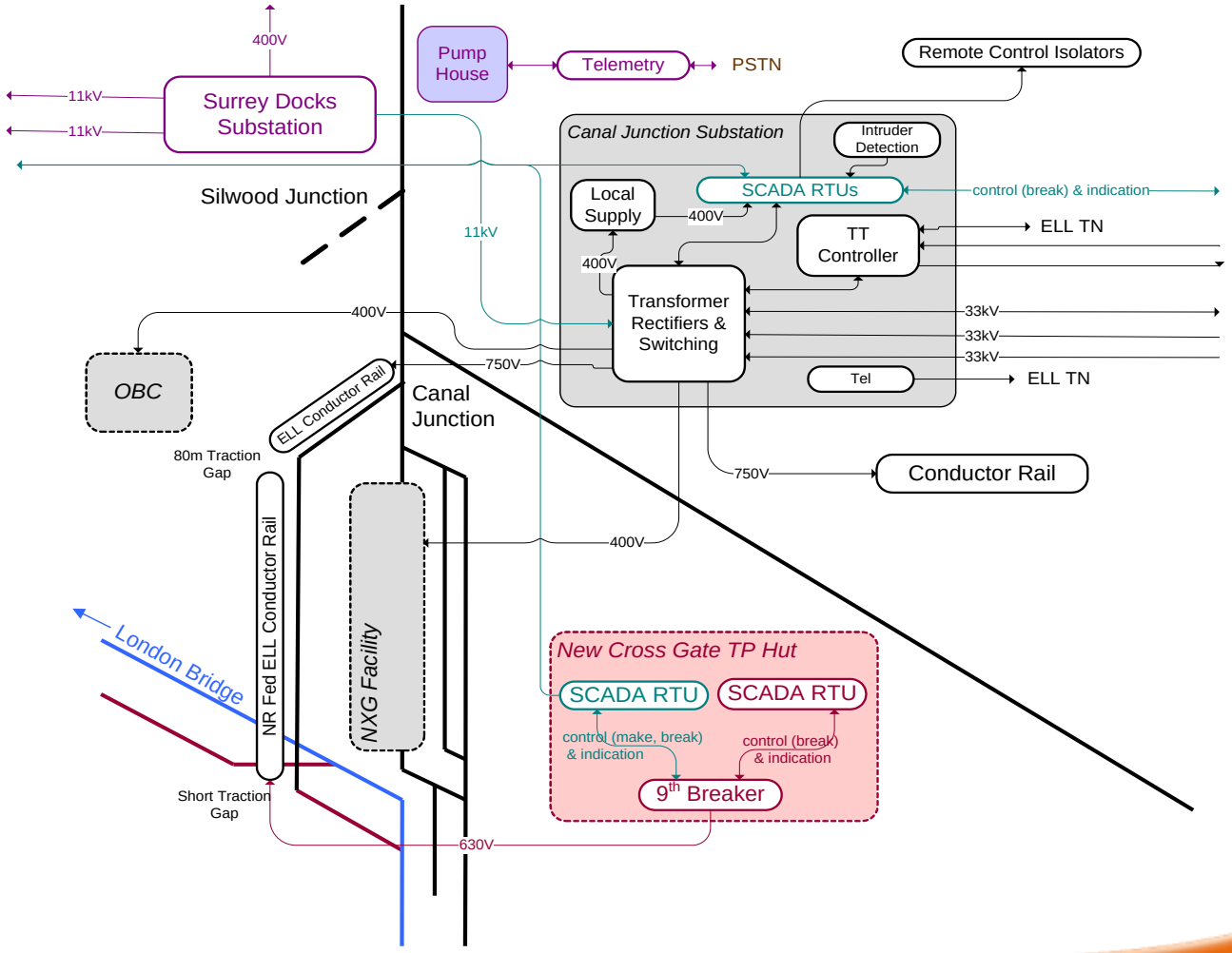
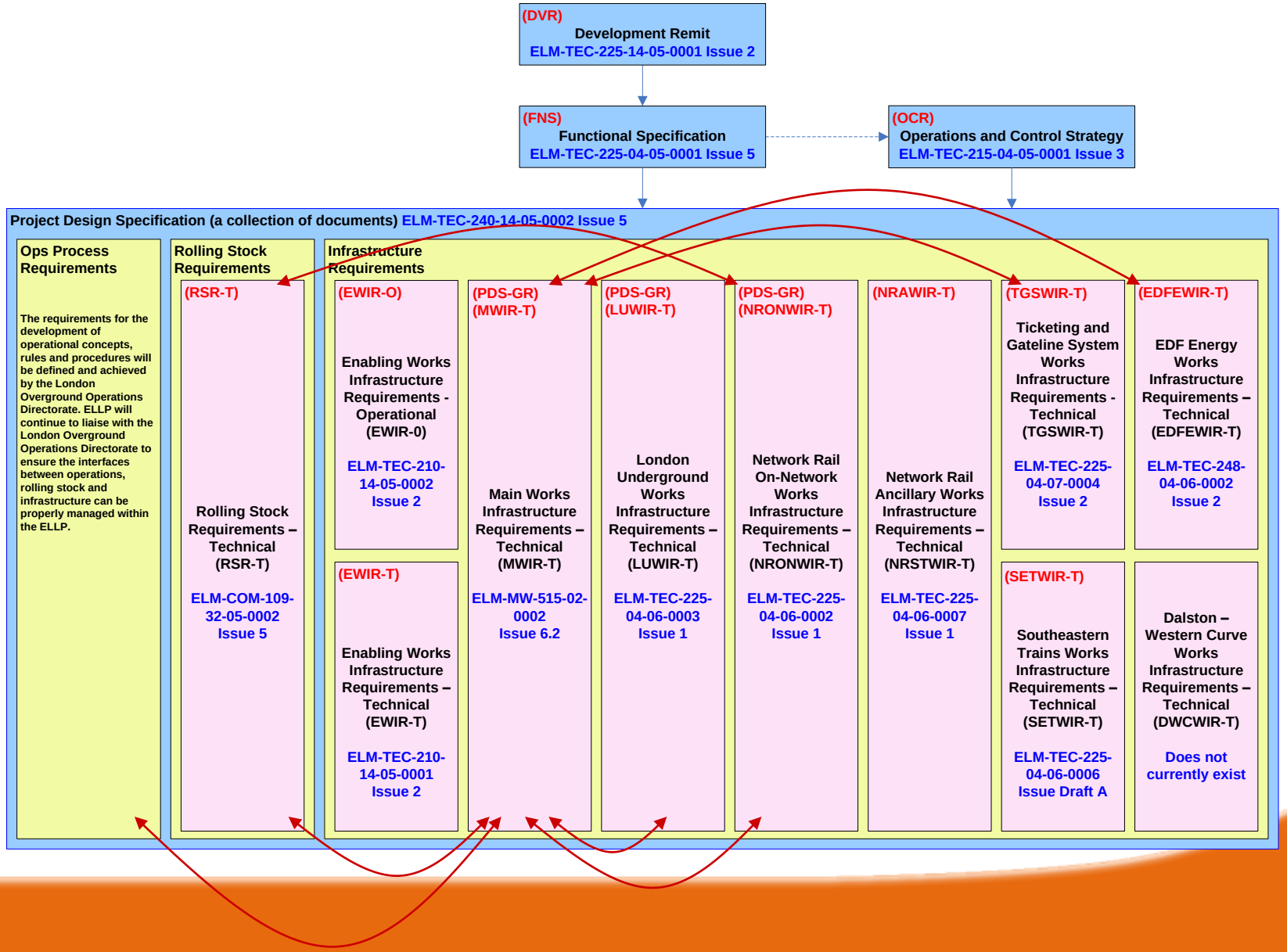
System Architecture



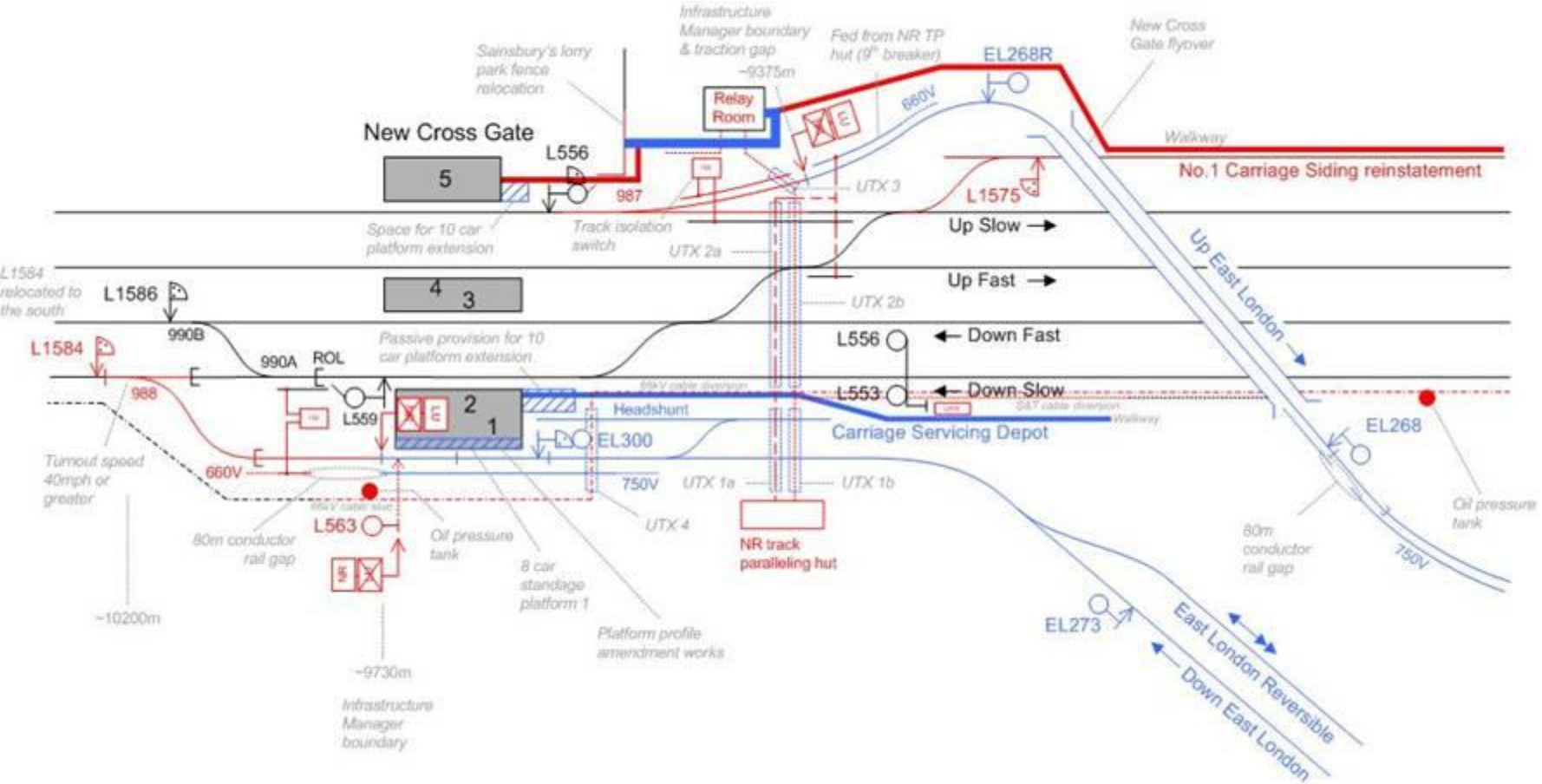
System Architecture (expanded)



DOORS structure



Interface Definition



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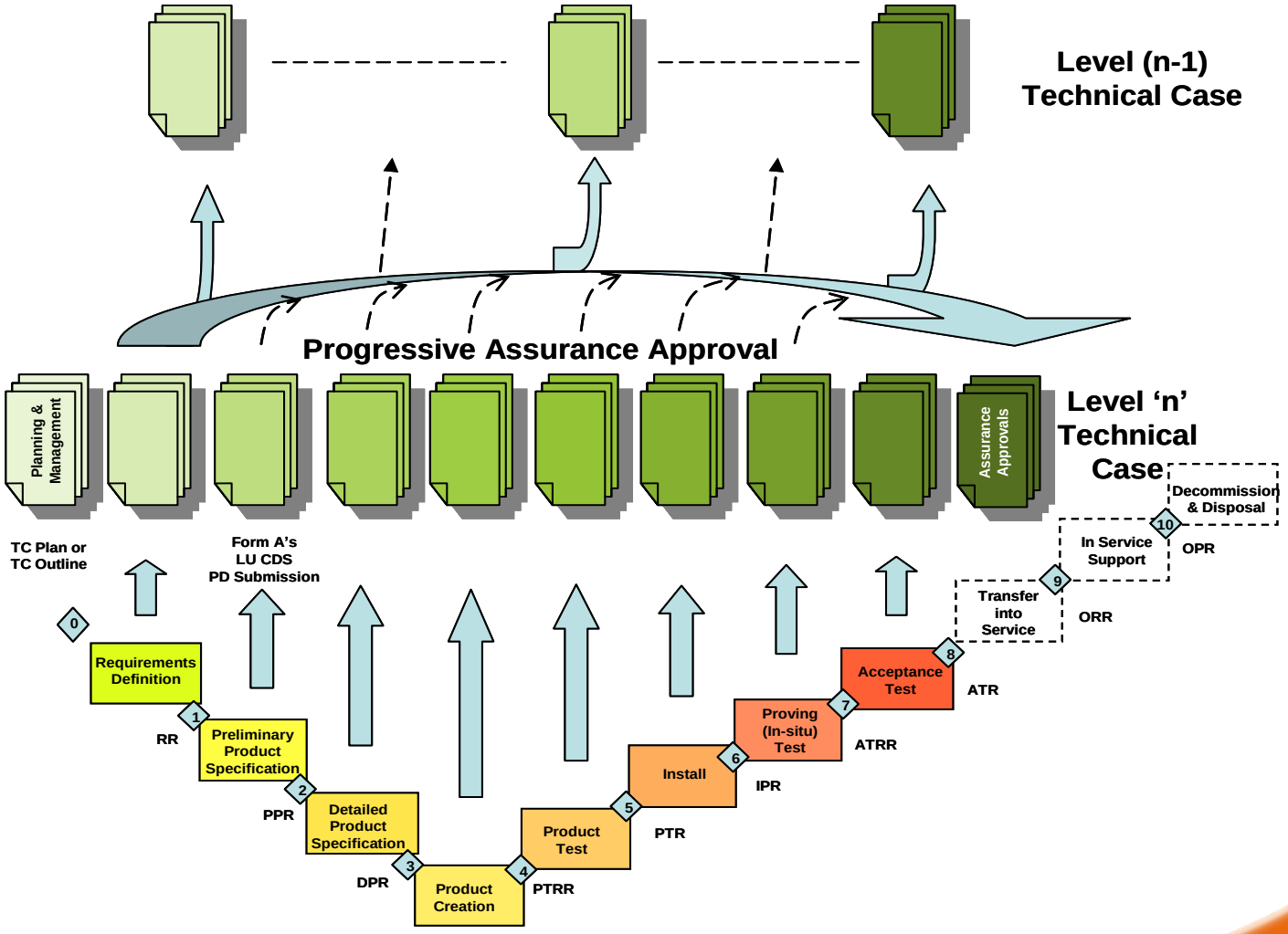
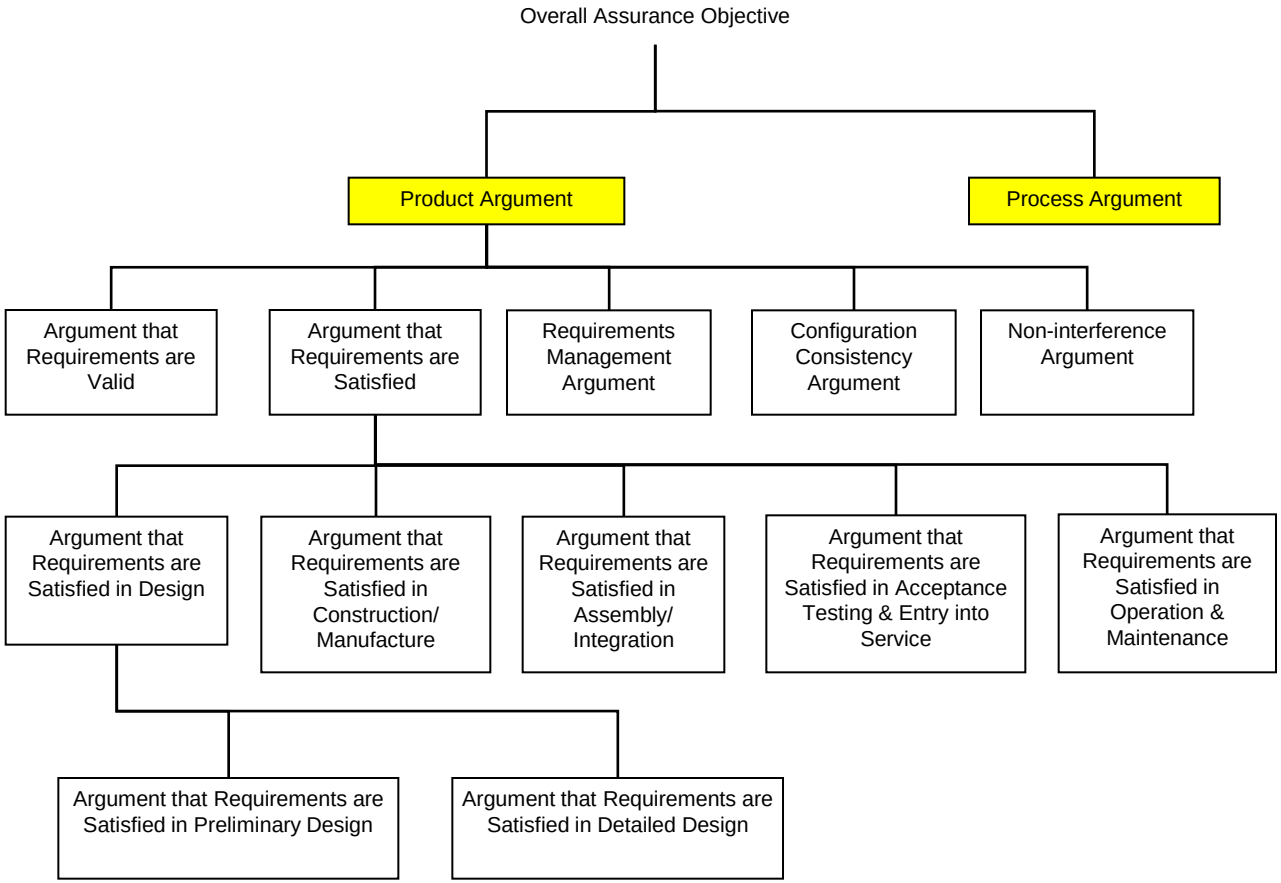
Progressive Assurance



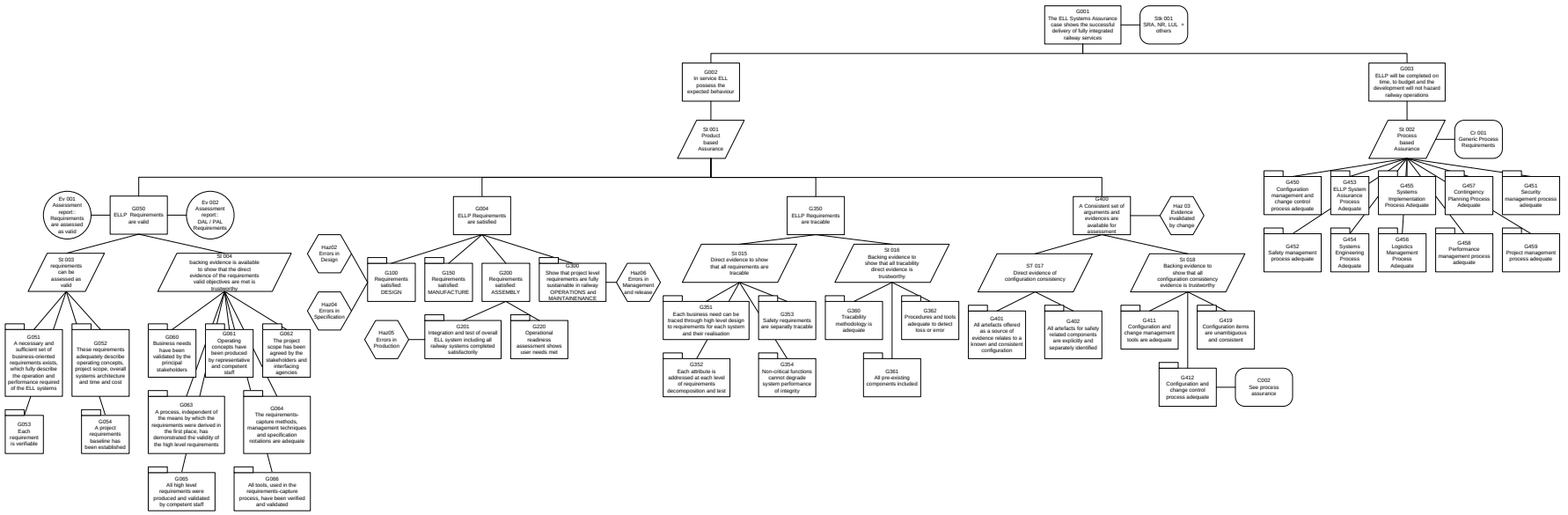
Level 'n' Engineering Product Lifecycle

Progressive Assurance using Technical Cases



Technical Cases and Levelling

Technical Cases – Wood for the Trees



Requirements are valid

Requirements are satisfied

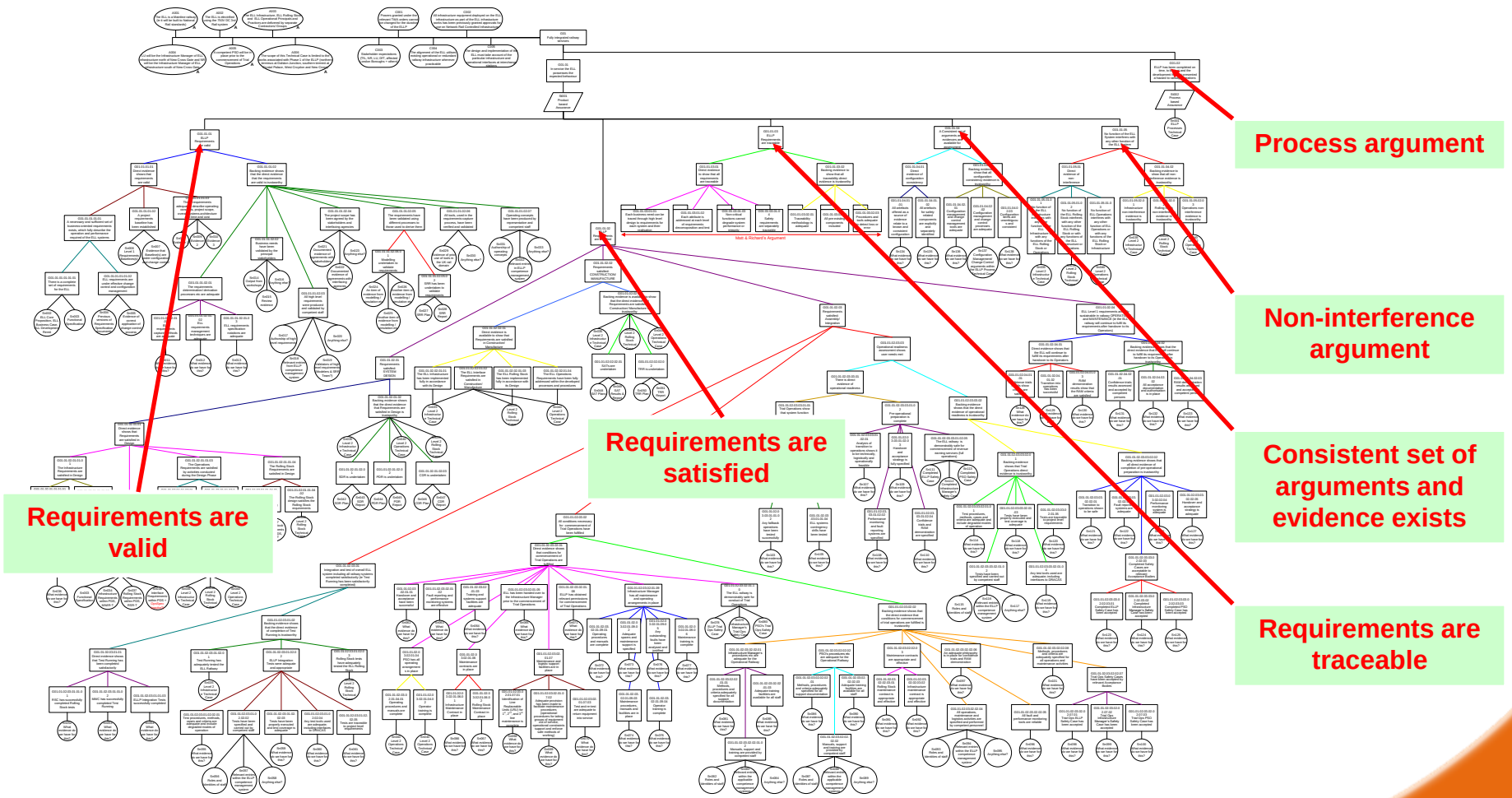
Requirements are traceable

Consistent set of arguments and evidence exists

Process argument

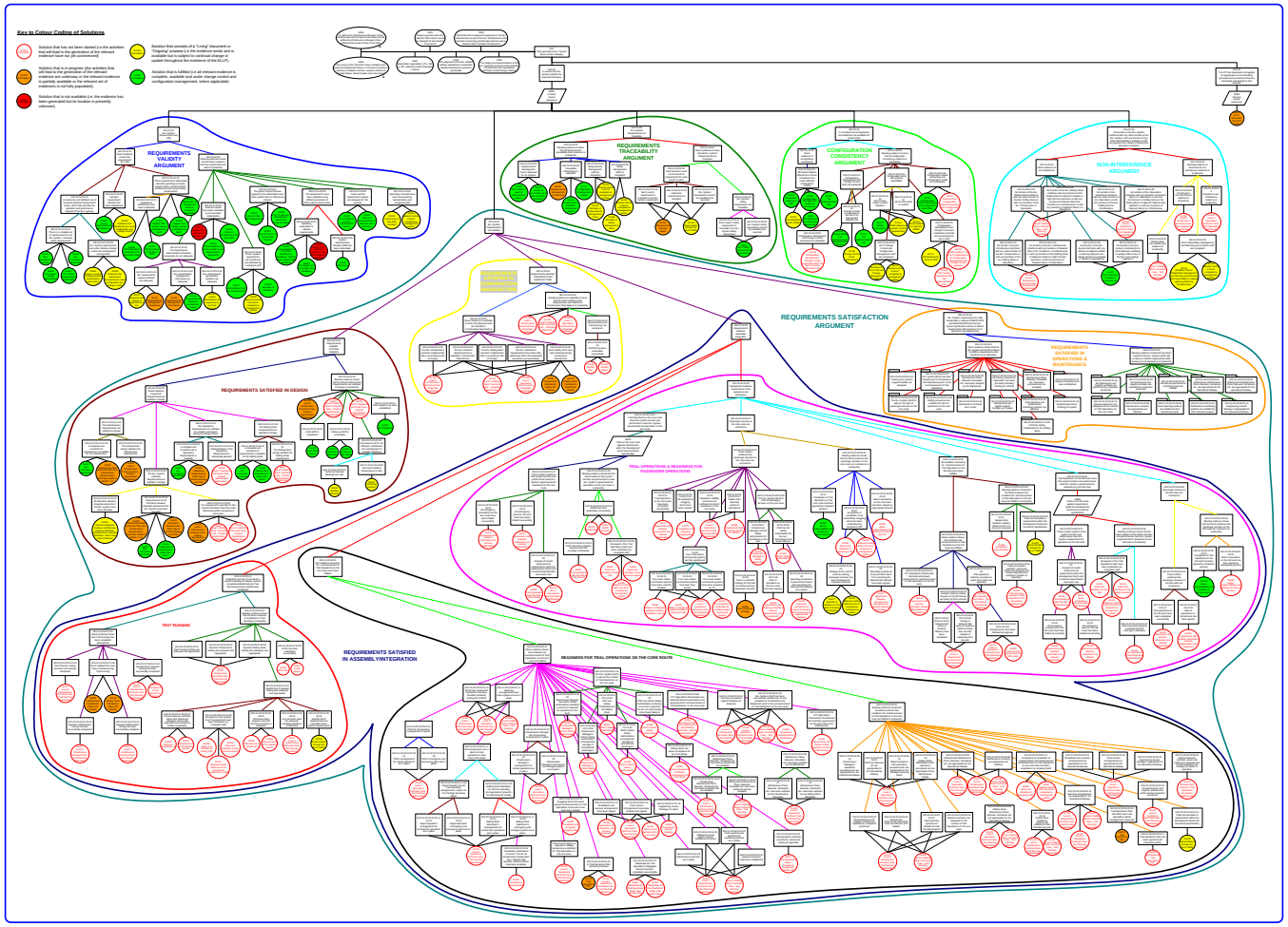
The early Level 1 ELLP GSN argument - 2005

Technical Cases – Wood for the Trees



The developing Level 1 Product GSN argument - 2006

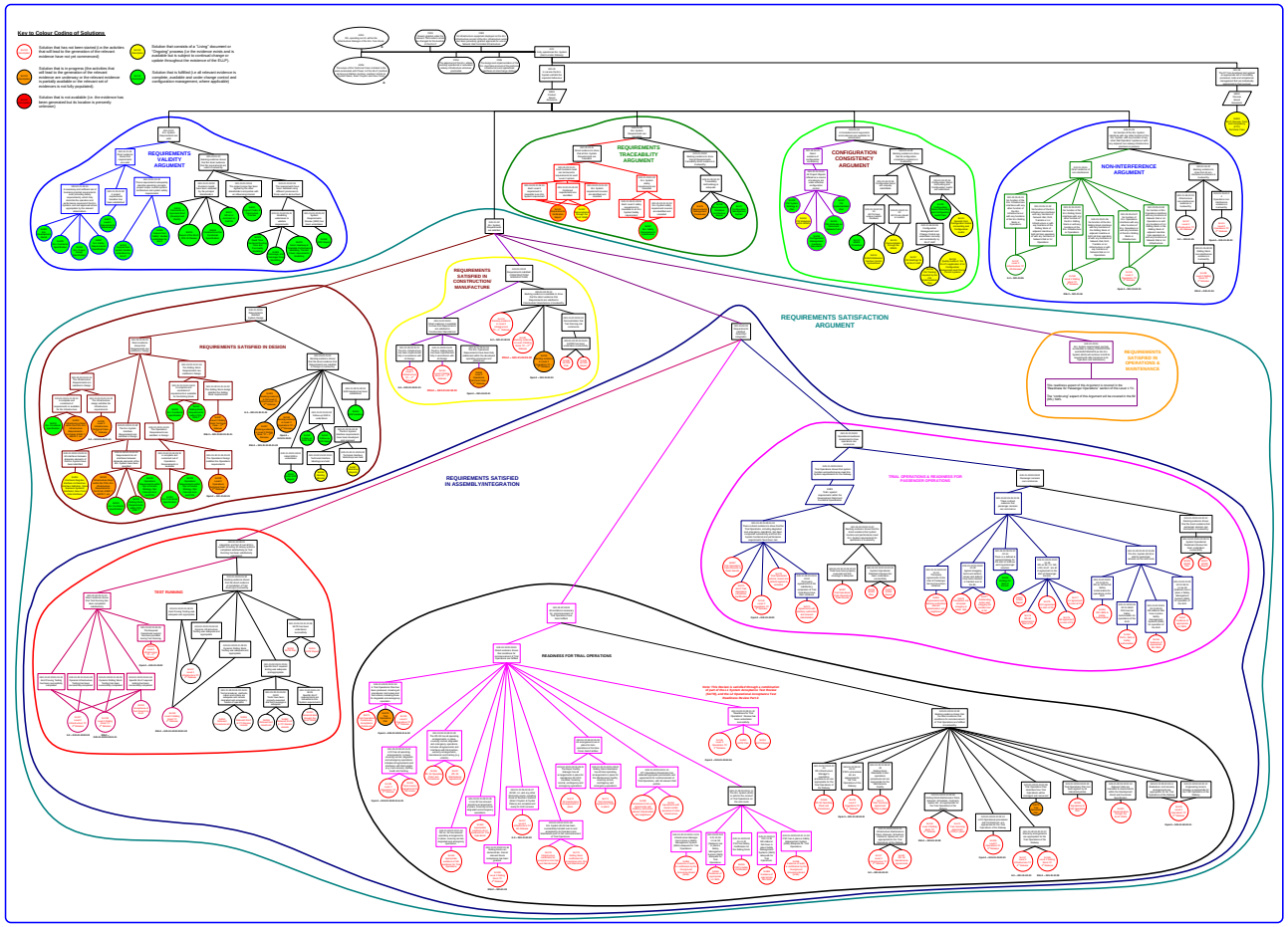
Technical Cases – Wood for the Trees



The developed ELLP Level 1 Product GSN Argument - 2007

Traffic Lights used to monitor progress

Technical Cases – Wood for the Trees

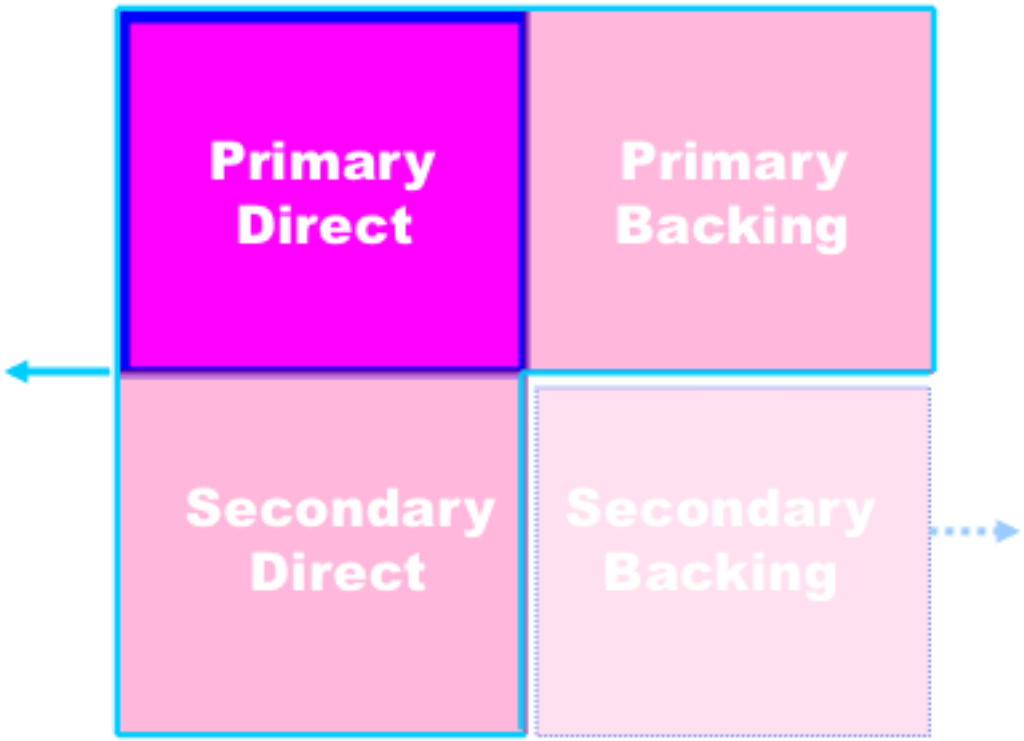


The Rationalised ELLP Level 1 Product GSN Argument - 2008

Technical Cases - The Evidence

- **TfL model TC adopted by supply chain – down through the system breakdown;**
- **Considerable volume of evidence generated for lower level locations and disciplines;**
- **Some evidence essential e.g. legislation, certification required by standards e.g. BS7671;**
- **Evidence needed to be categorised on a risk basis**

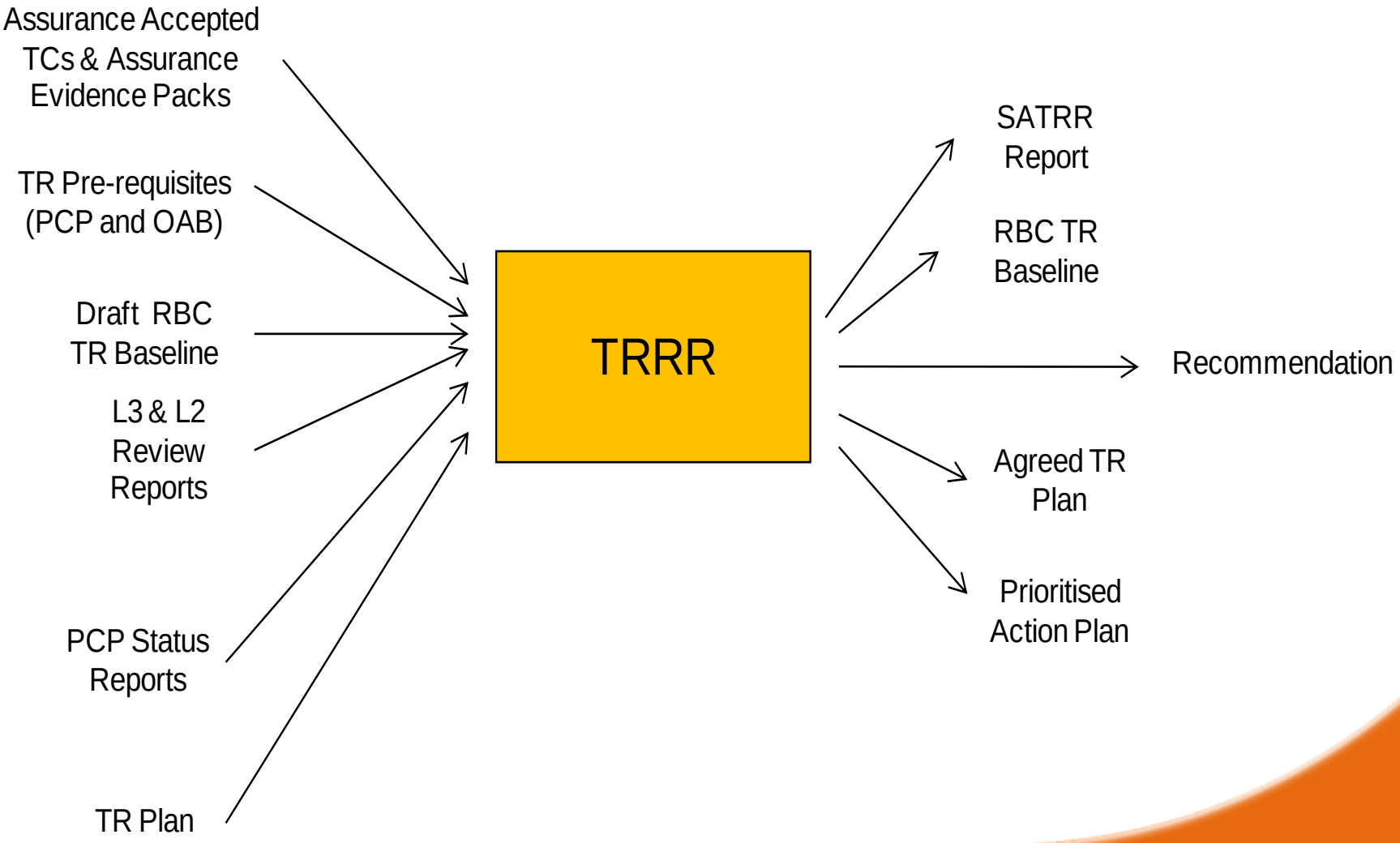
The Evidence Categories



The Evidence Table

Solution Ref. No.	LiveLink Reference Number	Description of Solution (ie of the Product(s) and/or Process(es) that satisfy the Goal)	Responsibility (if not Completed/ Living/ Ongoing)	Status	Ref. Number(s) of the Goal(s) Satisfied by the Solution
Sn 034	ELM-TEC-225-04-06-0001	ELL System Interfaces and Issues Register		Completed (Ongoing)	G01.01.02.01.01.02.01
	ELM-TEC-239-05-06-0002	ELL System Architecture Diagram		Completed	
	ELM-TEC-239-05-05-0002	ELL Systems Context and Interfaces Model		Completed	
	ELM-TEC-225-14-04-0001	ELL Interface Definition		Completed	
	ELM-TEC-225-14-06-0006	NR & TOC Operational & Business Systems Interfaces		Completed	
	ELM-TEC-225-04-06-0004	New Cross Gate Operational Interfaces		Completed	
	ELM-TEC-225-04-06-0006	New Cross Gate Interface Definition		Completed	
	ELM-TEC-225-04-06-0011	Rolling Stock - Infrastructure Traction Interface		Completed	
	ELM-TEC-225-04-07-0002	Bulk Supply Points Interface Definition		Completed	
Sn 035	ELM-TEC-240-14-05-0002	Rolling Stock Requirements within ELM-TEC-240-14-05-0002, ELLP Project Design Specification.		Completed	G01.01.02.01.01.02.02
	ELM-COM-109-32-05-0002	The Rolling Stock requirements within the PDS are currently broken out into ELM-COM-109-32-05-0002, Rolling Stock Requirements-Technical		Completed	G01.01.02.01.01.04.01
Sn 036	ELM-TEC-215-04-06-0006	Start of Service Strategy		In Progress	G01.01.02.03.03.02.01.04
Sn 037		ELLP Level 2 Rolling Stock Technical Case - 2nd Release	System Assurance Manager	Not Started	G01.01.02.01.01.04.02
				Not Started	G01.01.02.01.02
Sn 038		ELLP Level 2 Operations Technical Case - 2nd Release	System Assurance Manager	Not Started	G01.01.02.01.01.03.02
				Not Started	G01.01.02.01.02

SE in Commissioning –TR Readiness



TR Readiness Review Questions

Looking back in time

- What scope of ELL System is to be tested (RBC at TR)?
- Is it integrated, tested and commissioned?
- Does it meet the intention and requirements (V&V)?
- Do we have all the Assurance Evidence (TCs)?
- Is it Safe & Environmentally Compliant?
- Have the correct processes, tools and competences been applied?
- Does it satisfy all the Planning Consents / Orders?

Looking forward

- Is there an approved TR Plan in place?
- Are all SMS's in place?
- Are all Approvals in place?
- Are all participants prepared for TR (IPT, Contractors, O&M parties)?
- Are other Stakeholders informed / prepared for TR?

Prerequisites to Test Running

Rolling Stock	4
Signalling	3
C & C	4
Track	2
Traction Power	2
Stations	2
Statutory Certificates	10
Ops & Procedure	22
TOTAL	49

TEST RUNNING - LIST OF PREREQUISITES

Item #	TITLE	COMMENTS	STAKEHOLDER
1.0	**Rolling Stock**		
1.1	VSSC for class 378 vehicle for ELLP Operation (NR Acceptance)	Commissioning by BT for free run undertaken	NR
1.2	VSSC for class 378 vehicle with test instrumentation (if applicable)		ELLP, BBCJV
1.3	Up to date Maintenance Certificate with associated "snag" list	Required in addition to NR Route Acceptance Certificate	ELLP, BBCJV
1.4	*VSSC is NRAP and EAC Certificates.*		
2.0	**Signalling**		
2.1	Signalling Level 4 Technical Case		ROGS, NR, BBCJV
2.4	Signalling NXG Interface Safety Case (OBC)	Possible Interim submission	ROGS, NR, BBCJV
3.0	**Communications and Control Systems.**		
3.1	Data Transmission Network, SPT, Tunnel Telephones - AC		LOROL, ROGS, NR, BBCJV
3.2	GSM-R valid for use with Test Trains		LOROL, ROGS, NR, BBCJV
3.4	Pway Level 4 Technical Case (include Gauge certificate)	BT to precise their needs	BBCJV
3.5	Tunnel Drainage AC (unless contained in Pway AC)	Part of Pway Level 4 Technical Case	BBCJV

Review of Presentation

- Integrating SE practices into major procurements ✓
- Convincing of the benefits of an SE approach ✓
- Delegating systems engineering responsibilities down the supply chain ✓
- Using (or not) systems engineering standards ✓
- Ensuring systems assurance is a progressive activity ✓
- Measuring systems integration success *?*
- Commissioning using SE practices ✓

Concluding Comments

- Plan at the start and be prepared to develop SE
- Lead by example
- Integrate and balance project and engineering management
- Manage the paper mountain
- Build an integrated team
- Plan for inevitable change
- Be practical and pragmatic

Questions?

www.tfl.gov.uk/overground