



**London
Underground**

Systems Architecture

Directorate of Line Upgrades

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Business Context

4 million journeys/day,
1 billion journeys/year
20 million customers

800 km of track

5000
signals

402 escalators

13 depots

600 trains

276 stations



Nature of our environment

- Increasing Capacity
- Enhanced Flexibility
- Managing Obsolescence



Electro/ pneumatic / mechanical/ relays
Basic Automatic Train Protection

1900-60



Electro mechanical / Relays / simple discrete component electronics
Automatic Train Operation

1960-80



Train Management Systems for asset management & comms link to control room. Enhanced electronics & SCADA
Enhanced signalling functionality based on solid state technology
DC Cam-shaft controllers & motors replaced by AC drives

1992-96



Capacity enhancements through software ATO \ ATR
Integrated Train Identification and Comms Systems
Integrated ticketing and payment systems

2007



Enhanced Service Control
Partial Automatic Train Regulation
Air Conditioned Train Cars
Auto turnaround
Tunnel Cooling
Mobile Phone and TV services above and below ground

2012

E-ATO

Full Automation. Demand based service management
Auto Dwell Management. Full Automatic Train Regulation
Decision Support
Integrated Signals and Comm Systems
Integrated Real Time Information
Mobile Phone and TV services below ground

2025



System Complexity 2



Stations

Platform
– Train



Track



Trains

Wheel
– Rail



6



EMC



Power

Cooling

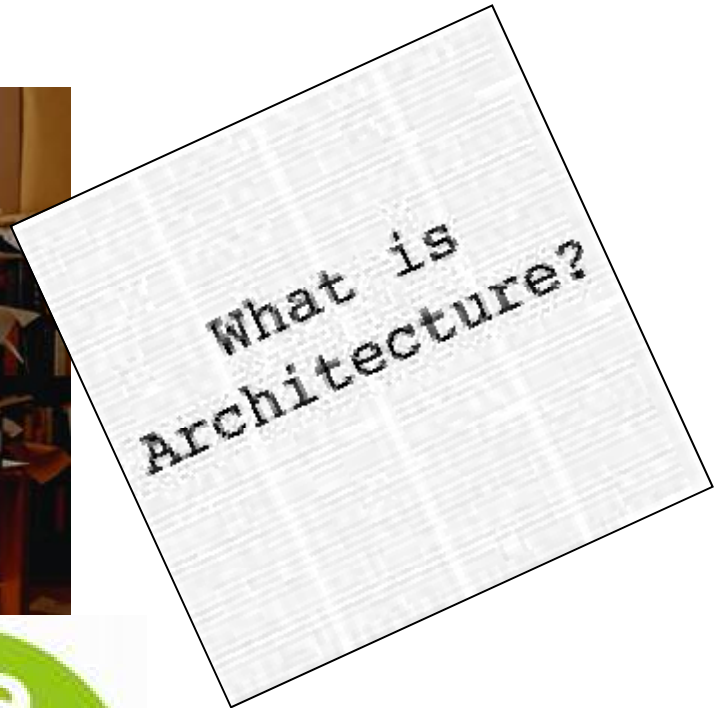


Ventilation



What we need

**Diversity is expensive
.. pragmatic is better**



Share the feast



Its in the contract



Systems Architecture on the SUP

Metropolitan line overview

District line overview

Circle & Hammersmith line overview



- **Phase 1: Roll-out of Eight Car S-Stock Trains**
2007 - 2013
- **Phase 2: Roll-out of Seven Car S-Stock Trains**
2011 - 2005
- **Phase 3: Automatic Train Control**
2010 – 2018

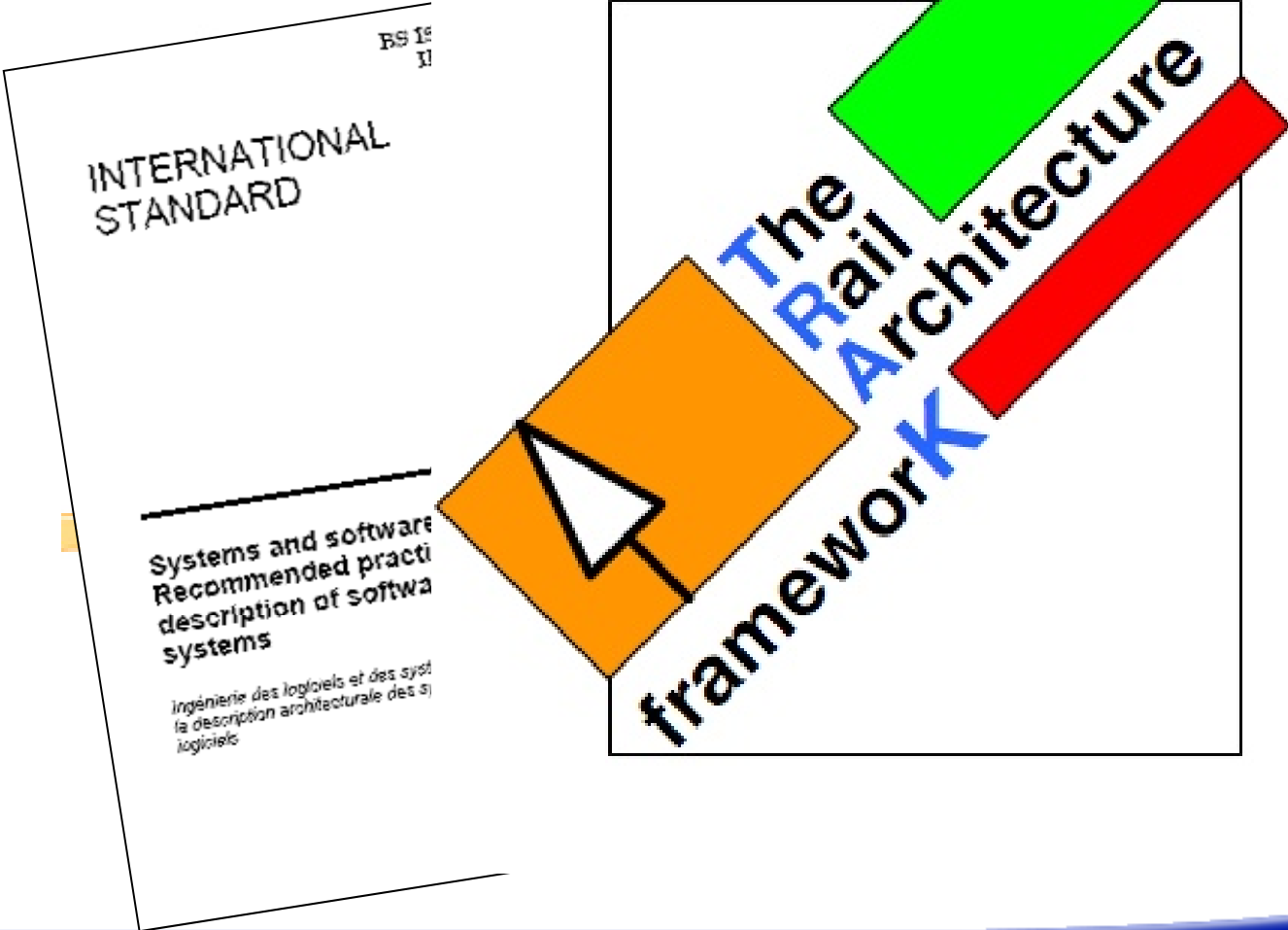


**Architecture
Descriptions**

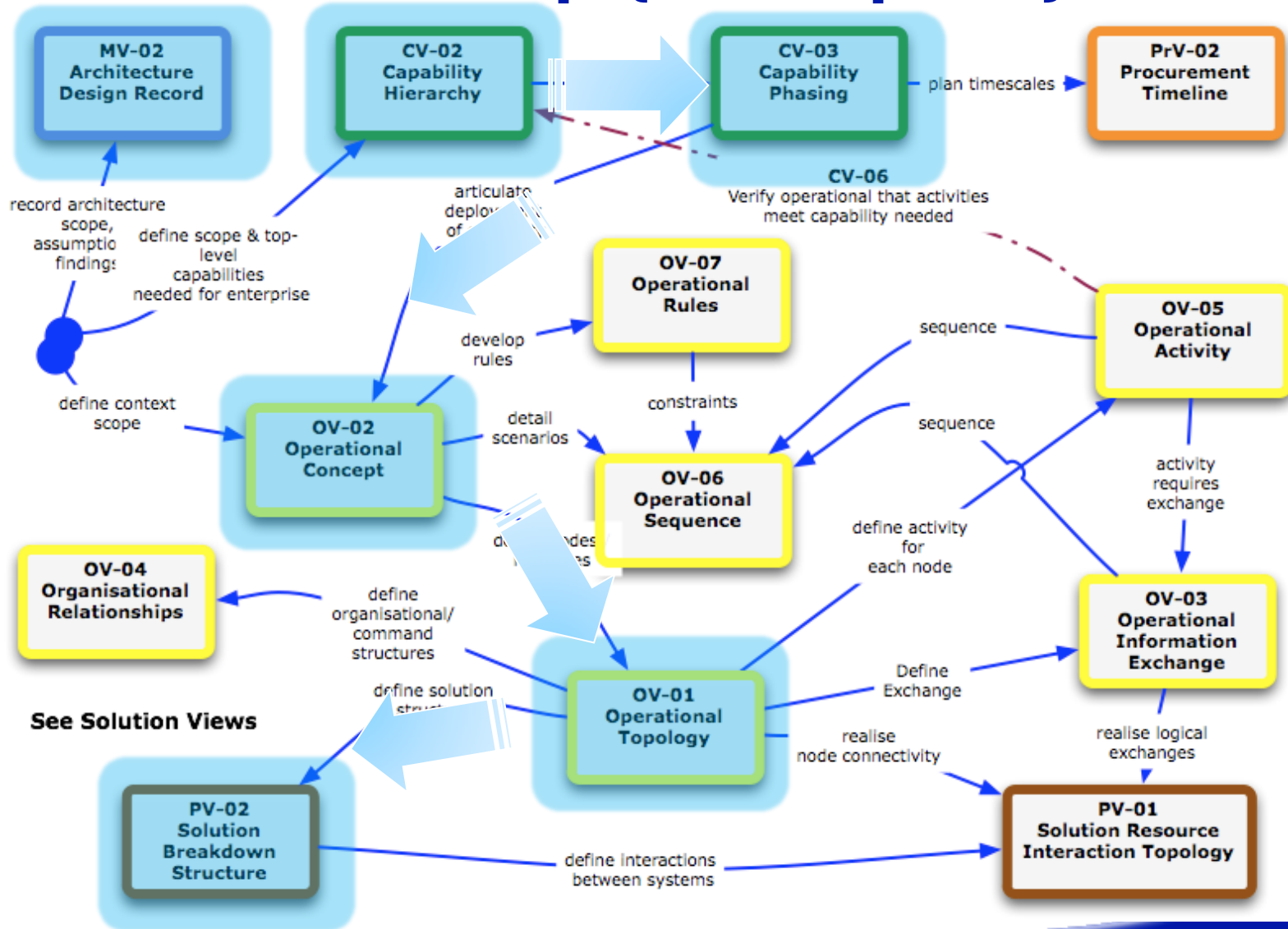


Transition to modelling

Visio 200



TRAK view map {incomplete}



TRAK - in EA Tool

The screenshot displays the EA tool interface with the following components:

- Resources Panel (Top Left):** Lists Favorites, Stylesheets, UML Profiles, and TRAK.
- Diagram Canvas (Center):** Shows a SysML diagram with:
 - Requirement1 and Requirement2 (purple boxes).
 - «Physical» Class2 (orange box) with Port1.
 - «Physical» Class3 (orange box) with Port2.
 - «ArchitecturalConcern» Class7 (purple box).
 - «PortConnection» AB12345 connecting Port1 and Port2.
 - «InteractionElement» Time, «InteractionElement» Timetable.
 - «concernAbout» relationship from Class7 to Class3.
 - «tracesTo» relationships from Requirement1 and Requirement2 to Class2.
- Project Browser (Right):** Shows a tree structure with folders like Standard, View, WholeLifeEnterprise, Projects, Examples, Dummy Model, and Test. The current selection is Dummy Model - FV-02.
- Tagged Values Panel (Bottom Right):** Shows properties for AB12345 (Connector):

Property	Value
PortConnectionID	
exchanges	
exchangedInter...	
- OMG Systems Modeling Language (ML) Logo (Center):** A large watermark logo for SysML.
- Toolbox (Left):** Lists various modeling elements like Capability Configuration, Job, Organisation, Physical, Role, Software, etc.
- Properties Panel (Top Left of Canvas):** Shows details for the selected element: Name: Dummy Model - FV-02, Package: Dummy Model, Version: 1.0, Author: nieplum.



Intelligent client architecting mitigates risk



Model with intelligence

Impose basis for evaluation

«indicative design object» Automatic Train Control
allocatedFrom «requirement» SRS-SSC-3256 Nice cheese, Grommit «requirement» SRS-SSC-4356 Destroy all Aliens «requirement» SRS-SSC-1176 Make my day, punk «requirement» SRS-SSC-6454 Haunting of Molly Hartley

Get what you want

“I want it all.. and I want it now!”



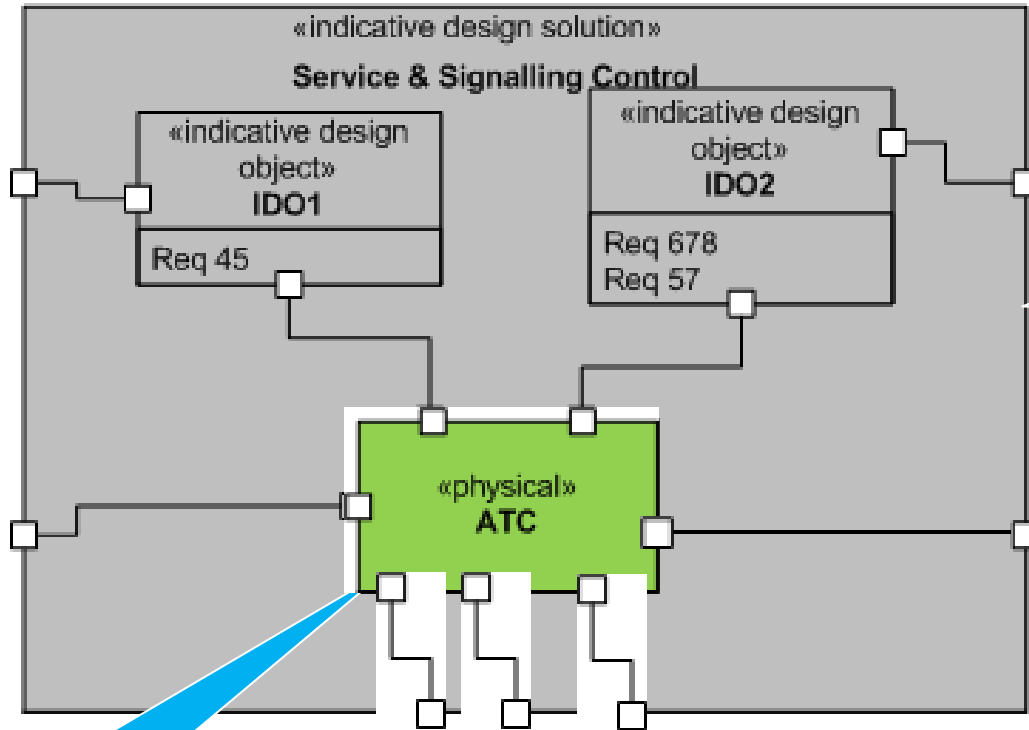
«physical» Alien Signalling System
allocatedFrom «requirement» SRS-SSC-3256 Kill Bill

Requirements in context



Thinking *inside* the box

bdd IDO Interaction Points



requirements mapped to IDOs

know where the interfaces are

know where the solution boundary lies



Problems (unsurprisingly)

1. Run that by me again



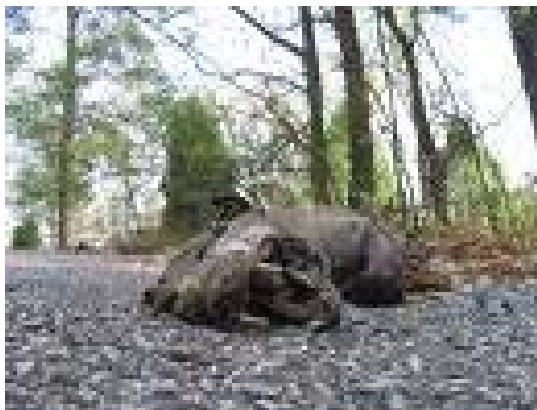
2. Unforgivable



3. 'But we preferred the old pictures'



5. Lack of relevant examples to rail domain



4. system vs view decomposition OMG!



Next steps

- **Modelling tool**
- **Repositories and exchange methods**
- **Support SSR tender and contract assessments**
- **Do more promotion**
- **Strategy for TRAK**
- **London Underground network-level architecting**
- **Ontology**



Question time

- **Q1. If standardising systems architecture is a business no-brainer, how are we to go about achieving this in rail?**
- **Q2. What does your business do today, and where does it need to get to, in systems architecting?**
- **Q3. What rail engineering products do you think of as being systems architecture views?**
- **Q4. What activities can architecting displace, if any?**





tfl.gov.uk

