



**London  
Underground**

**INCOSE UK RIG**  
**2nd Railway Systems Engineering Workshop**

**22nd June 2010**

# **From Business Requirements to System Performance Requirements by Railway Engineering Simulations**

**Catherine Norris**

**Modelling Delivery Manager**

**Department of Systems Integration**

# Overview

- **Review of Simulating Capability Paper**
- **Systems Engineering as an integral part of the SSR Upgrade & SSR ATC Contract**
- **Modelling and Simulation within the SSR ATC Contract and Beyond**
- **The Simulation Tool**
- **Ongoing Challenges**
- **Conclusions**



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# Review of Simulating Capability Paper

- **Summary**
- **Conclusions**
- **What has happened since**

Simulating Capability on the London Underground Catherine Roberts & David Dobson

## Simulating Capability on the London Underground

### Abstract

The paper begins from an LUL viewpoint, discussing the measurement of capability as defined by LUL's contracts with its Infrastructure companies. An outline of the advantages and disadvantages of using simulation to measure and test capability follows, together with thoughts on the benefits of the entire supply chain using the same simulator suite. The viewpoint is then switched to that of Metronet Rail SSL Ltd. Their answer to capability simulation, the Railway Engineering Simulator, is introduced and examples given of methods used and results obtained using the tool. Mention is made of the use of the tool in order to demonstrate sub-optimal contract compliances as well as the other fringe benefits of owning and maintaining such a tool. The paper concludes that simulation is an essential tool for measuring capability.

### Capability and the use of Simulation Tools for Capability Testing

#### Introduction

The first sections of London Underground opened in 1863, today it has 408km of track, 275 stations and approximately 3 million passenger journeys are made per day. The infrastructure needs modernising and improving to take London Underground forward into the 21<sup>st</sup> century and enable it to cope with increasing customer demand.

In March 1998 it was announced that the Public Private Partnership (PPP) would be the way forward for the maintenance and renewal of the London Underground Infrastructure. Under the PPP London Underground remains the railway operator and the infrastructure is leased to an Infrastructure Company (Infraco) for a period of 30 years. Infracos are to provide, maintain and improve the infrastructure throughout this period and in return are paid an Infrastructure Service Charge (ISC).

The ISC paid to the infraco per period depends on the performance of the infrastructure. The payment to Infraco depends on the Capability of the assets provided and the Availability of those assets. In this way the PPP incentivises infraco to improve performance and abates them if their performance is poor.

Capability is a measure of the ability of the infrastructure to deliver customer service. Availability is a measure of the impact of delays on the customer due to infrastructure failure.

### The Capability Concept

Capability is intended to be an output based, non-prescriptive measure. The PPP uses the measure of Customer Journey Time to determine the level of infrastructure capability provided by the infraco. Customer Journey Time is a measure of the time taken for the average customer journey, measured from the time they arrive at the arrival platform to alighting from the train at their

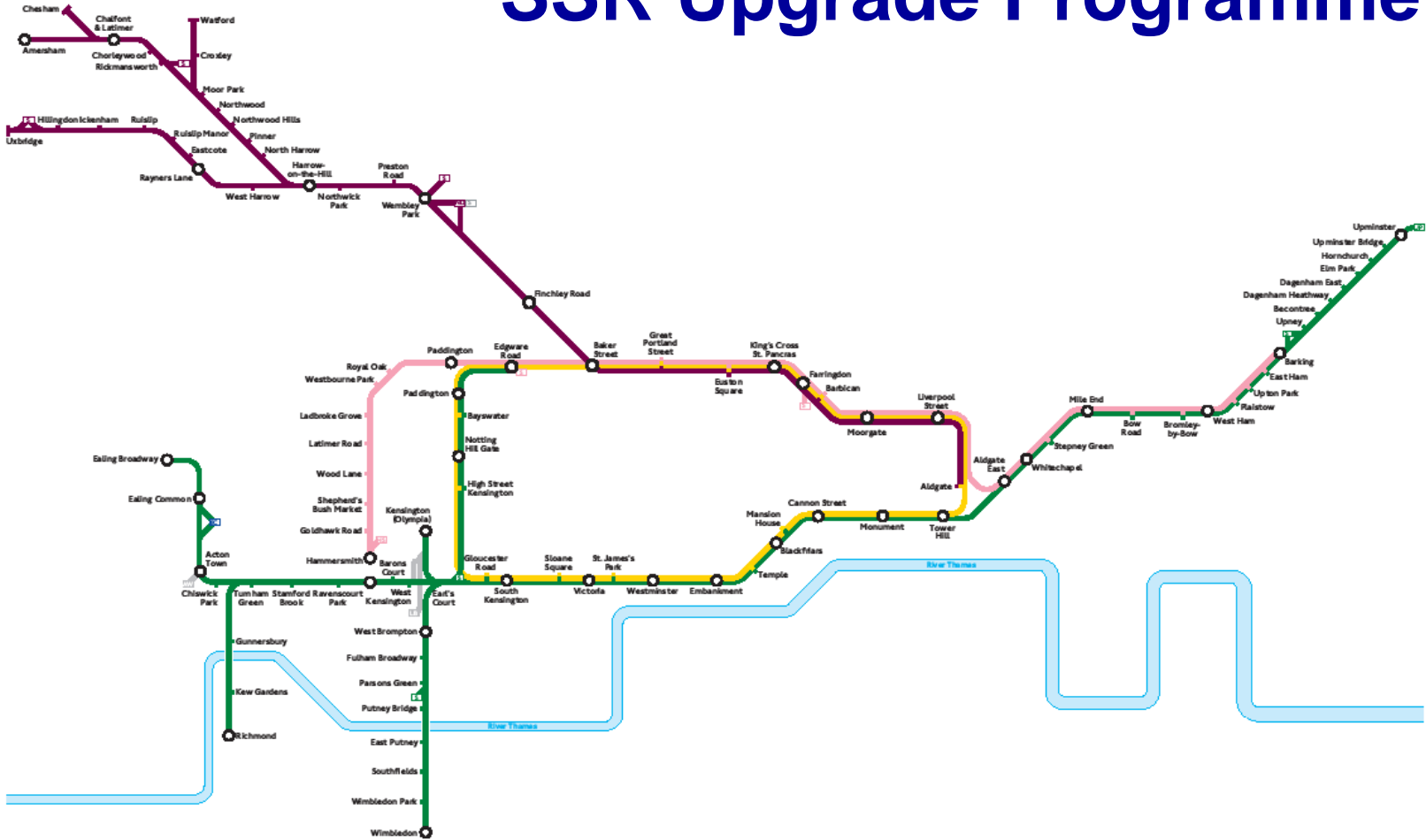


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# SSR Upgrade Programme



 SSR Tube Map  
(with depots and sidings)

Transport for London

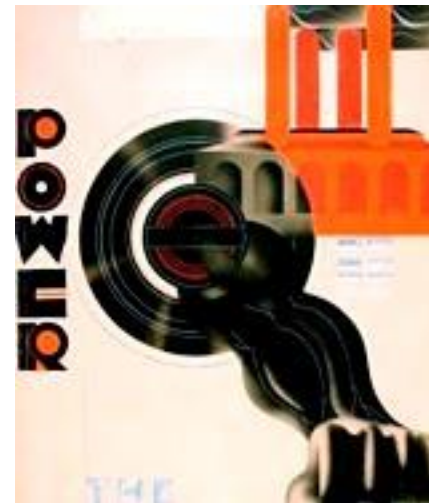
Key to depots		Key to lines	
EC	Ealing Common		Circle
HS	Hammersmith		District
ND	Neasden		Hammersmith & City
UP	Upminster		Metropolitan
W	Waterloo		
	Stabling Sidings		
	Engineering Depot		

December 2008





# Sub- Surface Upgrade Programme Assets



# Sub- Surface Upgrade Programme Integration Challenge



# Systems Engineering Focus: Sub-Surface Upgrade Programme



# Systems Engineering Focus: Automatic Train Control Contract

- Performance Targets
- Remove Ambiguity
- Improve Bid Evaluation
- Reduced risk in Contract
- Capped targets
- Performance margins



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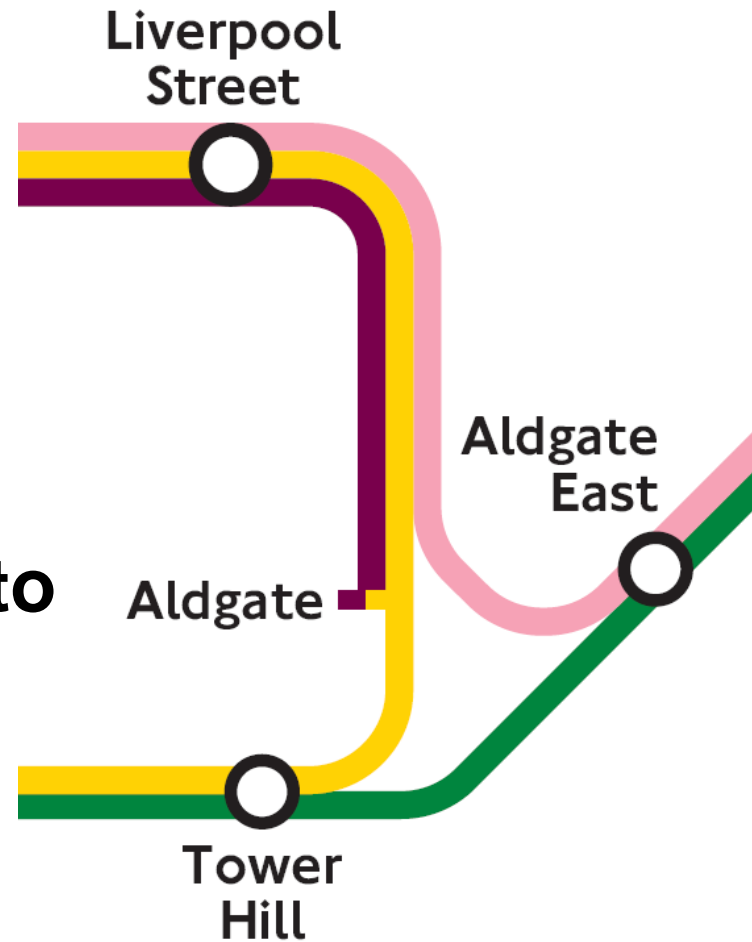
# **Modelling and Simulation: Automatic Train Control Contract**

- **Setting realistic and achievable performance targets**
- **Bid Evaluation**
- **Parallel Virtual Worlds**
  - **Understanding the integrated system**
  - **Understanding the contribution of the ATC System**
- **Convergence**
- **Agreed method for Performance Measurement**
- **Modelling ATR Systems and Strategies**



# Setting Performance Targets

- **Specify Performance Targets**
  - Trains per hour
  - Junction Capacity
  - Reoccupation Times
- **Compare performance to targets**
- **Achievable Targets**



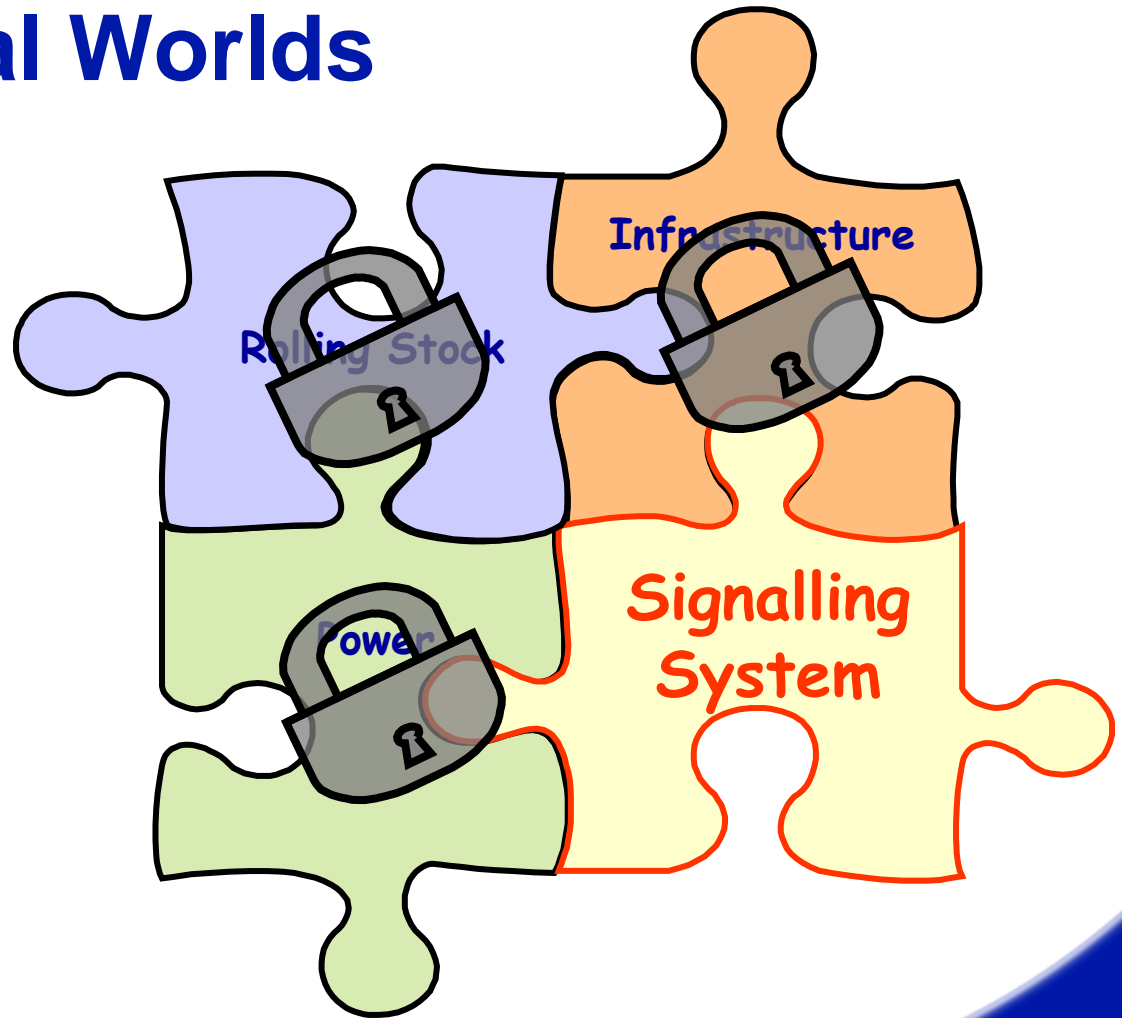
# Bid Evaluation

- **Modelling used by supplier to determine performance of their system on our infrastructure**
- **Design application exercise to demonstrate performance**
- **Simulation Strategy Document**

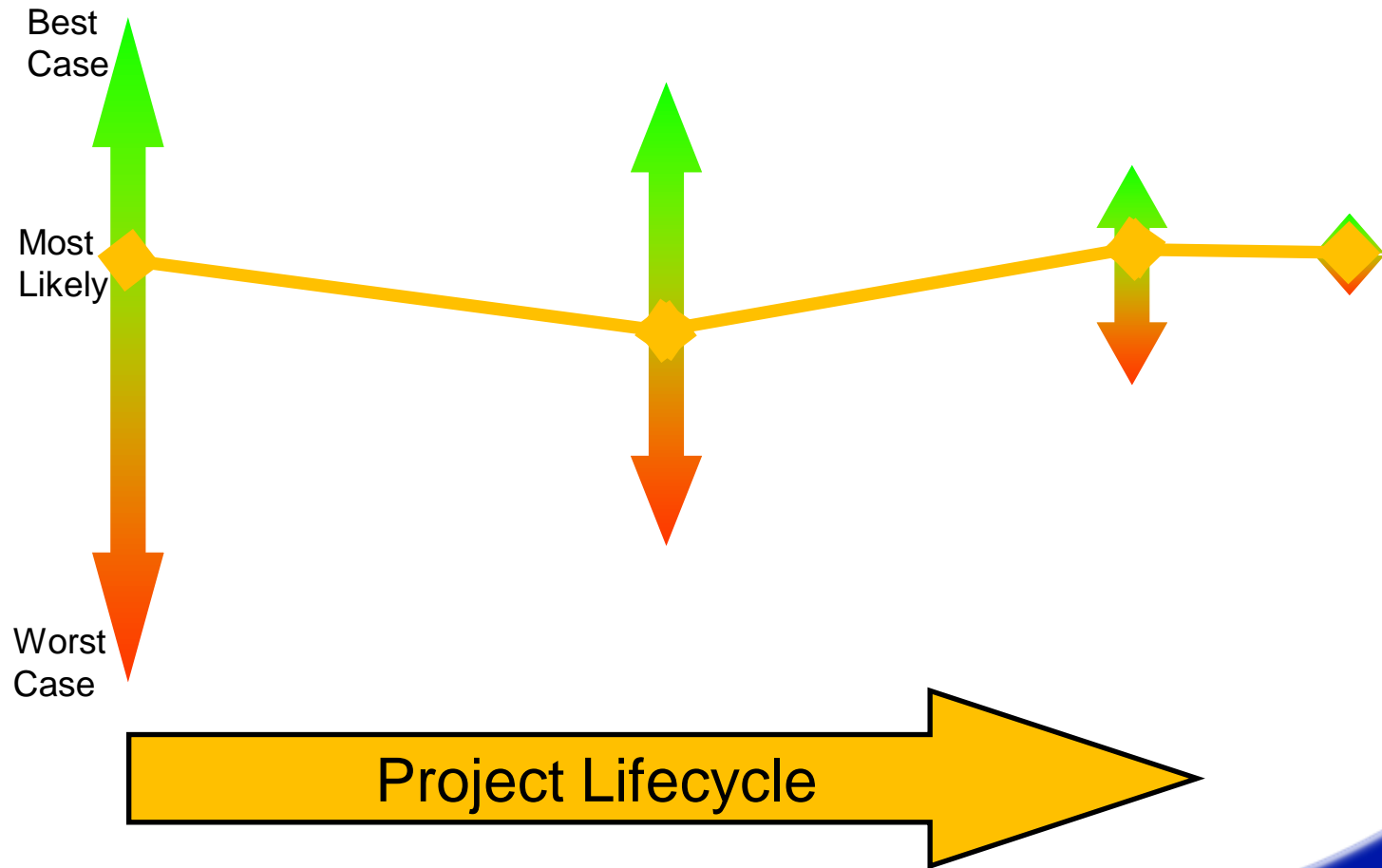


# Parallel Virtual Worlds

- **Static World**
- **Real World**

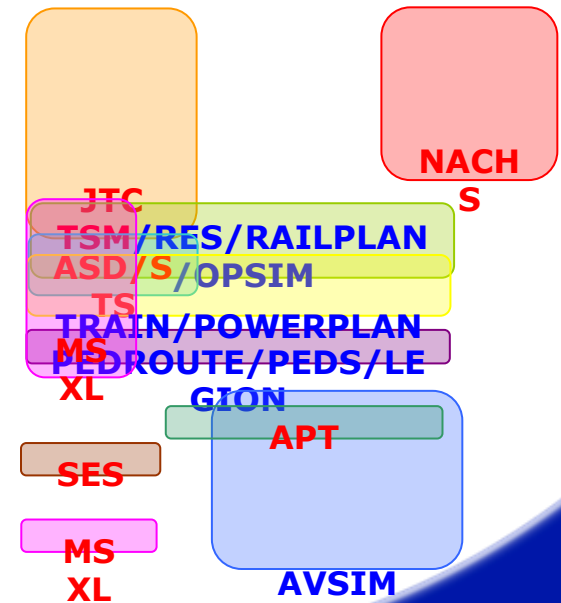


# Convergence



# Performance Measurement

- **Required to:**
  - Predict performance through the life of the contract
  - Measure the final delivered performance
- **Engineering Management**
  - Agreed testing, measurement and calibration activities
  - Planning, programming and resourcing
  - Agreed simulation tool



# **Modelling and Simulation: Beyond the Automatic Train Control Contract**

- **Verification of the integrated SUP performance**
  - Power, track, signalling and rolling stock
- **Operational and Timetabling Strategies**
- **ATR Systems and Strategies**
- **Energy Saving Strategies**



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# Simulation Tool Management

- **Tasks**
- **Tool modifications**
- **Access & Logistics**
- **Programme**



# Railway Engineering Simulator

- **Models the railway system - rolling stock, signalling, track and power to a high level of detail**
- **Used extensively on London Underground Lines**
- **Data driven**
- **In-house training, support and development**



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# Modelling a Complex System

- **Determine level of abstraction**
- **Calibration**
- **Sensitivity analysis**
- **Tool development**
- **Support**
- **Skills retention and development**



# Managing data

- Independent preparation and check
- Data Control and traceability
- Managing several scenarios

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6	ACTW Acton Town West
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8	AGR Arnos Grove
9	AGR1 Arnos Grove
10	AGRS Arnos Grove Sidr
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13	ALP Alperton
14	AM Amersham Siding
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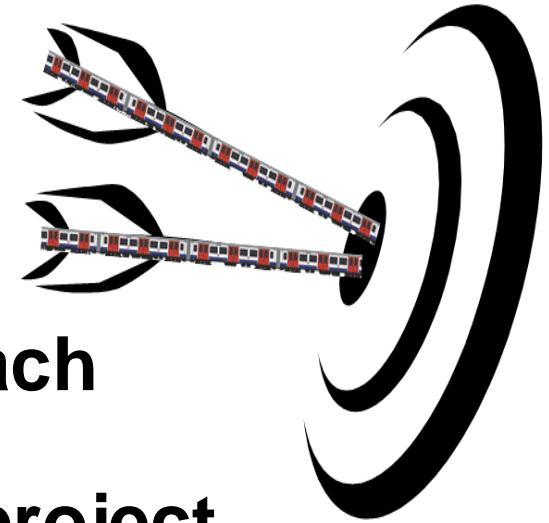


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# Conclusions



- **New Systems Engineering Approach**
- **Use of Modelling throughout the project lifecycle**
- **Clarity on delivery responsibilities**
- **Build confidence in the delivery of the Sub-Surface Railway Upgrade**
- **Supports the vision to reduce access**





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