The Railway as a System: Woking to Waterloo case study

James Hardy FutureRailway Programme, RSSB
Professor Clive Roberts, University of Birmingham
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Introduction

A case study – doubling capacity at Waterloo

• Why we did the study (JH)
• The Rail Technical Strategy context (JH)
• The Case Study (CR)
• Next steps (JH)
Rail Technical Strategy 2012
Vision Case for W2
Woking to Waterloo
Study Background

A 4 week study to:

• Help to prioritise the RTS portfolio initiatives by showing how they could be brought together to deliver a step change in capacity for existing lines

• Develop a systems-thinking approach to solving capacity challenges

• Use the W² (Woking-Waterloo) route as a case study to show the potential benefits of the approach – can we **double capacity** without major track works **in 30 years** using some combination of RTS innovations?

• This will lead to the prioritisation of innovations and importantly the functional requirements for those innovations
Overview of planned approach

Methodology

**Doubling capacity:**

– double the number of people that can be carried into and out of Waterloo in the peak hour”

– Assume 2043 demand levels on end-CP6 infrastructure

Estimate the key **capabilities** of a railway system that could deliver the required capacity, for example:

– Reduced headways
– Increased train capacity
– No maintenance

Vary capabilities to deliver alternative “**visions**” for the system (e.g. “customer-friendly” or “24-hour operations”)

Identify **combinations of RTS portfolio initiatives** that can provide the necessary capabilities and importantly, develop the key functional requirements
Systems Thinking: What Drives System Capacity?

Station Capacity
- Ingress / Egress Points, Ticketing, Barriers etc
- Customer Info

Line Capacity (Passenger Carrying Capacity)
- Timetable
- Margins & slack
- Reliability and Recovery

Train Paths
- Train Capacity
  - Floor Height
  - Length of car/articulation/double decker?
  - Gauge
  - Platform length
- Dwell-times
  - Train layout (no. of doors, standing/seating
  - Station layout
- Journey Time
  - Train speed
  - Acceleration
- Signalling Headway
  - (Emergency) Brake Rate & Adhesion
  - Size of signalling blocks - Junctions - Straight Line
  - Is train in front treated as a brick wall? (true moving block?)

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Customer Info

Ingress / Egress Points, Ticketing, Barriers etc

Reliability and Recovery

Line Speeds

Platform length

Termi
- Minimum Reversing Times, Cleaning

Train Paths
The Systems V

Stakeholder Requirements (Mission)

Option Development

System Requirements

Functional Decomposition

Physical Decomposition

Design and Development

Verification Process

Integration Process

Test of Subsystems

Test of System

Validate to Requirements

End of Life Processes

Reliability Process

Project Management Process

Use of Systems Engineering Tools
**IDENTIFICATION OF KEY TECHNOLOGIES**

**A Systems Approach**

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**01** Identify the case study and system boundary, high level objectives of the study and time frame (e.g. double capacity, Woking to Waterloo line, fast lines, 2043).

**02** Expert knowledge elicitation, data gathering and baseline simulations to quantify current capability of the line.

**03** Identify the future likely operating concepts (e.g. "passenger friendly", "comfortable standing").
This will set the capability gaps between the baseline and future vision.

**04** Simulation of the operational concepts to define the functional requirements that will need to be met by the different significant activities in each portfolio.

**05** Identify set of technologies that have the potential to meet the functional requirements using the matrix selection tool.
The functional requirements can be used to specify the undeveloped technologies.

**06** Develop option and test business benefits to home in over iterations at optimised solution.
Identification of key constraints/variables
Baseline simulation and expert knowledge elicitation

Static simulations to understand current

- Train capacity
- Platform capacity
- Train turnaround
- Station capacity
- Passenger handling
- Dwell times
- Headway
- Train performance
- Variability
- Complexity
- Availability
- Reliability
Future Operational Scenarios

What operational concepts are plausible for the line in the future?

Different future operational concepts will be based on different assumptions

– the Woking to Waterloo line is focused more on passenger comfort: ‘passenger friendly’ operating scenario

– the Woking to Waterloo line is operated more like a metro: ‘comfortable standing’ operating scenario
Selection of operational concepts

What operational concepts are plausible for the line in the future?

Selection of the most appropriate operational concepts for the line
Alignment of the required capabilities for these operational concepts
Functional improvement

Assessment of which operational concepts deliver the desired improvements (and in which ways)
Functional improvement

Assessment of which operational concepts deliver the desired improvements (and in which ways)

Baseline
- Current timetable - 23tph
- All trains assumed to be 12-car Class 450s

![Diagram showing passenger capacity and demand improvements over time for various operational concepts.](image-url)
Comfortable standing

- Woking
- Clapham Junction
- Throat: 23 tph
- Stabling
- Waterloo

54,538
Functional improvement

Assessment of which operational concepts deliver the desired improvements (and in which ways)

**Comfortable Standing**
- Operations as *Baseline*
- Maximise train capacity by removing all seating

![Graph showing passenger capacity/demand for different operational concepts](image)

- **Baseline**
- **Comfortable Standing**
- **Optimised Operations**
- **Passenger Friendly**
- **More Connected Railway**

**50-year Benefit (£bn)**
- **Seats (First Class)**
- **Standing (4pax/m2)**
- **50 Yr Benefit with 2043 Demand (£bn)**
- **2014 Demand**
- **Double 2014 Demand**
Optimised Operation

Woking

Clapham Junction

Throat 45 tph

Waterloo

52,245
Functional improvement

Assessment of which operational concepts deliver the desired improvements (and in which ways)

- £4bn
- £2bn
- £bn
- £2bn
- £4bn
- £6bn

Baseline

Comfortable Standing

Optimised Operations

- 45tph, 60s headway, 125mph
- 5-8min. turnaround at WAT
- 40% lighter train, 8MW power

Passenger Friendly

More Connected Railway

50-year Benefit (£bn)

- Seats (First Class)
- Standing (4pax/m2)
- 2014 Demand
- Double 2014 Demand

Seats (Standard)

50 Yr Benefit with 2043 Demand (£bn)

2043 Demand
Functional improvement

Assessment of which operational concepts deliver the desired improvements (and in which ways)

- Optimised Operations plus
- 50% train capacity increase
- 30tph

![Diagram showing passenger capacity and demand improvements for different rail concepts: Baseline, Comfortable Standing, Optimised Operations, Passenger Friendly, More Connected Railway. The diagram illustrates the 50-year benefit (€bn) with different demand scenarios including 2014 demand, double 2014 demand, and 2043 demand.](image-url)
Passenger Friendly

Woking

Clapham Junction

Throat 30 tph

Waterloo

52,245
Functional improvement

Assessment of which operational concepts deliver the desired improvements (and in which ways)

- Optimised Operations
- Stop at Clapham Junction
- Fewer seats (34tph)
- More standing

### 50-year Benefit (£bn)

- **Baseline**
- **Comfortable Standing**
- **Optimised Operations**
- **Passenger Friendly**
- **More Connected Railway**

#### Passengers Capacity/Demand

- **Baseline**
- **Comfortable Standing**
- **Optimised Operations**
- **Passenger Friendly**
- **More Connected Railway**
Identification of technologies

Use matrix of portfolio initiatives to identify technologies that may improve capability

Simple models to understand the likely improvement that technology may achieve

Develop detailed requirements for technologies

Further studies on other lines to identify common benefits of technologies

<table>
<thead>
<tr>
<th>Capability</th>
<th>Initiatives</th>
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<tbody>
<tr>
<td>Station capacity</td>
<td>SPU02-U05 Innovative modal interchange</td>
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<tr>
<td></td>
<td>SPU04-U02 Personal/wearable IT</td>
</tr>
<tr>
<td></td>
<td>SPU04-U04 Balance of timely/accurate</td>
</tr>
<tr>
<td></td>
<td>SPU05-U01 Modernising physical tickets</td>
</tr>
<tr>
<td></td>
<td>SPU05-U02 Cloud ticketing</td>
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<tr>
<td></td>
<td>SPU05-U03 Ticketless travel</td>
</tr>
<tr>
<td></td>
<td>SPU06-U04 Reduce slips, trips and falls</td>
</tr>
<tr>
<td></td>
<td>SPU07-U03 Improving ticketing</td>
</tr>
<tr>
<td></td>
<td>SPM04-U05 Useful intelligence to customers</td>
</tr>
</tbody>
</table>
Optimised Operations

- Variability: 4x (+3)
- Signalling Headway: 60 secs (-60)
- Waterloo Capacity: 200% (+100)
- Track Speeds: 125 mph (+25)
- Operating Margins: 15 Secs (-15)
- Train Power: 8 MW (+4.6)
- Reliability: 4x (+3)
- Train Mass: 300 Tonnes (-210)
- Dwell-times: 45 secs (-15)
- Train Capacity: 100% (+0%)
Building on Waterloo to Woking Modelling
Relationships between Portfolios, Concepts of Service and Trade-offs

The Railway

Service Element Solutions

SPW07-A: Terminal Station Capacity
SPW07-C: Maintenance Free railway

SPW07-B: Operating Trains Closer Together
SPW07-E: Electric Railway

SPW07-D: Intelligent Trains
SPW07-F: Double Deck Trains

SPW07-G: Station Transit
SPW07-I: Future Train

SPW07-H: Light Freight
SPW07-I: Rapid Electrification

Significant Programmes

CoS6 Concepts of Service

CoS.1 The Passenger Focussed Railway
CoS.2 The High Capacity Railway
CoS.3 The Simple Railway
CoS.4 The Freight Focussed Railway
CoS.5 The All Day Running Railway
CoS.6 The Right Time Railway

Cost

Capacity

Performance

The Low Cost Railway
The High Capacity Railway
The High Performance Railway
The Optimised Railway

Cost

Capacity

Performance

The Railway

RTS Enablers

Cross Cutting Themes

Whole System Approach

Whole System Reliability, Rolling Stock Status, Resilience, Safety; Security; Risk mitigation; Sustainability; Automation; Flexibility

People

Innovation

Capability Development, Technology Development, Capability Delivery, Technology Delivery, Service Delivery, Capacity Delivery

Level 5

Level 4

Level 3

Level 2

Level 1
Next steps

• A routemap for W2W
• Other challenges and concepts of service to support industry challenges
• Federated model to support wider application of this approach
• Develop the next iteration of the RTS in September 2016
Thank you