HS2 – Britain’s new high speed railway
Management of Risk

Jeremy Harrison, Director Risk & Assurance, HS2 Ltd
25 January 2018
HS2: the new backbone of Britain’s rail network
HS2 vision: To be a catalyst for growth across Britain
More than double the seats

**2017**

- London Euston: 12,100
- Manchester Piccadilly (Crewe/Stoke Corridor): 3,490
- Leeds (Doncaster Corridor): 1,720

**2033 with HS2**

- London Euston: 31,200
- Manchester Piccadilly (Crewe/Stoke Corridor): 8,620
- Leeds (Doncaster Corridor): 4,860

Evening rush hour total seated capacity
Fast, frequent and reliable

<table>
<thead>
<tr>
<th>Location</th>
<th>Selected Regular Services to/from</th>
<th>Current Fastest</th>
<th>Time Saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONDON</td>
<td></td>
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</tr>
<tr>
<td>Manchester</td>
<td>HS2</td>
<td>2 hrs 07 mins</td>
<td>1 hour saved</td>
</tr>
<tr>
<td>Liverpool</td>
<td>HS2</td>
<td>2 hrs 14 mins</td>
<td>40 mins saved</td>
</tr>
<tr>
<td>Leeds</td>
<td>HS2</td>
<td>2 hrs 11 mins</td>
<td>50 mins saved</td>
</tr>
<tr>
<td>BIRMINGHAM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>York</td>
<td>HS2</td>
<td>1 hr 52 mins</td>
<td>55 mins saved</td>
</tr>
<tr>
<td>Preston</td>
<td>HS2</td>
<td>1 hrs 36 mins</td>
<td>46 mins saved</td>
</tr>
<tr>
<td>Manchester</td>
<td>HS2</td>
<td>1 hrs 28 mins</td>
<td>48 mins saved</td>
</tr>
</tbody>
</table>
HS2 opens up new economic opportunities for:

- Trade & competition
- Local & regional markets
- New exports
- New employment
- New investment
HS2 strategic goals

Catalyst for growth
Value for money
Customer experience
Skills and employment
Capacity and connectivity
World class standards
Sustainable and a good neighbour
HS2 will provide jobs for Britain:

- **25,000** during construction
- **1,200** NCHSR graduates a year
- **2,000** new apprentices
- **3,000** jobs to maintain and operate
- **100,000s** jobs through regeneration/growth
Building HS2

DESIGN & SERVICES
TUNNELS
SURFACE ROUTE
STATIONS
RAILWAY SYSTEMS
ROLLING STOCK
Phase 1 construction statistics

- **230km**  
  ROUTE LENGTH

- **46km**  
  TUNNELS

- **74km**  
  CUTTINGS

- **128 mt**  
  EXCAVATED MATERIAL  
  (90% TO BE RE-USED)

- **145**  
  STRUCTURES OVER BRIDGES

- **152**  
  STRUCTURES UNDER BRIDGES

- **31**  
  MAIN COMPOUNDS FOR CONSTRUCTION

- **299**  
  SATELLITE COMPOUNDS
HS2’s timeline

2009
HS2 Ltd set up

2012
HS2 strategy confirmed by Government

2016
Full HS2 route confirmed

2017
Parliamentary approval for Phase One

2017
Phase 2a Bill to enter Parliament

2019
Parliamentary approval expected Phase 2a

2022
Parliamentary approval expected Phase 2b

2026
Phase One opens

2027
Phase 2a opens

2033
Phase 2b opens
Risk Management Principles

Principle 1: Risk management applies to all aspects of HS2.

Principle 2: Risks derive from objectives and stakeholders

Principle 3: Risk management is undertaken to reduce risk exposure, increase certainty, improve confidence and generate greater value.

Principle 4: Risk is multidimensional and values both soft issues and hard absolutes.

Principle 5: Ensure clear accountability for risk.

Principle 6: Provide the right information to the right people at the right time.

Principle 7: Implement a pragmatic risk management solution.

Principle 8: HS2 Ltd risk management is based on continuous improvement.
Enterprise Risk Management Framework

HS2 Delivery Strategy
“our approach to delivering HS2”

HS2 Risk Appetite Statement
“the amount of risk HS2 is prepared to accept, tolerate or be exposed to”

Wider Integration Risks
Including Secretary of State Retained Risks

Strategic Risks
HS2 Ltd Strategic Risks

HS2 Organisational Risks
HS2 Cross-organisational Functional risks

HS2 Delivery (& Operational) Risks
HS2 Development & Delivery Risks

HS2 Operational Risks
Establish the Context
Baseline info (objectives, goals, stakeholders)

Communication & Consultation

Risk Process

Principles (Clause 3)

Risk Process and Framework based on ISO31000

Risk Treatment

Monitoring & review

Quantitative Risk Analysis

Risk Identification

Quantitative Risk Analysis

Communication & Consultation
Differentiating between Generic and Emerging Risks and Inherent, Current and Target States

**Generic Risks**

*Standard risks for our line of business*

**Emerging Risks**

*New risks – or variants to generics*

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**“Inherent”**

Where we started

**Control Framework**

*Our Policies, procedures, processes and guidance*

**“Current”**

Where we are now

**Management actions**

**“Target”**

Where we hope to get to

---

**Risk Profile**

- **Generic Profile**
- **Emerging Profile**

**Risk Tolerance**

**Risk Appetite**

**Time**

Now
Creating confidence

**Stress Test**
- Worst case
- Risk trigger 30, 70 model
- Wider ranges

**RCF**

**QCRA**
- P95
- ‘Cost to go’

Testing
- Bottom up recalculation

Bottom Up

Outside view

Testing

£

P (X)

Absolute Risk Value
Reference Class Forecasting – in 3 steps

1. Identify relevant reference class of past, similar projects

2. Establish probability distribution for the selected reference class

3. Compare specific project with distribution, in order to establish most likely outcome
Building a Reference Class

* The p-value of statistical tests indicates the strength of the evidence, if $p < 0.05$ the test is significant – here indicating that there is strong statistical evidence that these project types are different from HSR

Source: Oxford Database, August 2015 (Sample of n=361 projects)
Building a Reference Class

- Selecting past similar projects, based on **statistical similarity**
- Testing whether average, median (P50), P80, P90, P95 are statistically significantly different from HSR

<table>
<thead>
<tr>
<th>Is this project type a suitable comparator for HSR projects? (n=39)</th>
<th>Average</th>
<th>P50</th>
<th>P80</th>
<th>P90</th>
<th>P95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conv. rail (n=113)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Fixed link (n=132)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Metro (n=196)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Road (n=658)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

- Only fixed links are comparable for the full range of estimates from P50-P95
- **Final selected reference class included 39 high-speed rail projects and 132 fixed links = 171 projects**
Building a Reference Class for HS2

- Bottom-up QRA estimates the 35% contingency to be a P90
- P90 = 9 out of 10 projects would not exceed this envelope
- RCF shows that 35% contingency is equivalent to P66
Comparison of the Different Reference Classes for Different Points of the Estimate for Levels of Certainty between P20-P80

- 40% contingency covers cost risk exposure of:
  - SBC: P63
  - OBC/FBC: P68
  - Contract control totals: P79

![Diagram showing cost risk exposure and level of certainty for different reference classes.](image-url)
Key Concern is the Tail Risk

Contingency needed vs. P-value
## Causes in the Tail

<table>
<thead>
<tr>
<th>Stated causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Early delays (procurement, political decision making)</td>
</tr>
<tr>
<td>• (Late) design/scope changes, e.g. changes discovered during testing and commissioning; station changes triggered by local government; environmental mitigation</td>
</tr>
<tr>
<td>• Geological risks (sinkholes, archeological finds, water tables, ground levelling, …)</td>
</tr>
<tr>
<td>• “Rare” risks, e.g. contractor bankruptcy, political influence (for example on contractor selection), fraud by contractors (for example using poisonous sealants)</td>
</tr>
<tr>
<td>• Nominal cost increases due to</td>
</tr>
<tr>
<td>• Unforeseen Inflation</td>
</tr>
<tr>
<td>• Reduced number of rolling stock</td>
</tr>
<tr>
<td>• Quality risks and resulting rework</td>
</tr>
<tr>
<td>• Cutting of funding</td>
</tr>
<tr>
<td>• Unknowns in the design (particularly of safety and operations systems)</td>
</tr>
<tr>
<td>• Intermodal integration (long distance bus, commuter rail)</td>
</tr>
</tbody>
</table>
## Responses to Raise Maturity

<table>
<thead>
<tr>
<th>Area</th>
<th>Description</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Late design changes due to external demands</td>
<td>Hybrid Bill process controls scope</td>
</tr>
<tr>
<td>Funding</td>
<td>Problems with funding causing changes to profile. Including excessive interest payments.</td>
<td>Agreed funding profile up front and funding mechanisms including necessary insurance strategy.</td>
</tr>
<tr>
<td>Amplification</td>
<td>Problems on critical path escalate rapidly without ‘damping’</td>
<td>Designing schedule to create higher confidence at critical points eg end of pre-construction. Early contractor involvement in design</td>
</tr>
<tr>
<td>Integration</td>
<td>Failing to appreciate and understand scale of integration required to deliver</td>
<td>Structure of contracts. Assurance approach. Technical specification and assurance</td>
</tr>
<tr>
<td>Quality</td>
<td>Problems with quality of work completed</td>
<td>Assurance design. Hand over points control.</td>
</tr>
<tr>
<td>Archaeology</td>
<td>Significant volumes of archaeology and geology issues</td>
<td>An allowance made and base case is towards the worst case</td>
</tr>
<tr>
<td>Inflation</td>
<td>Inflation greater than expected</td>
<td>Specific recognition and approach to this issue.</td>
</tr>
</tbody>
</table>
Front-End Capability Maturity Model
(Said Business School, Oxford – Prof Bent Flyvbjerg)

1. Benchmarking
- Projects planned with an inside view only
- Optimism bottom-up in estimates unchecked

2. Due Diligence
- No internal capability to challenge cost and schedule forecast of contractors
- No capability to identify 'low balled' bids
- No understanding of the uncertainty of estimates

3. Reference Class Forecasting
- No systematic approach to taking the outside view
- Variability between projects' and sub-projects' ability to reduce bias
- Ignorance of unknown-unknowns
- Incentives to de-risk projects and safeguard contingencies not aligned in supply chains

4. Black Swan Management
- Slow management information leads to predictable surprises
- Biased and narrow management reporting deaf to weak signals
- Overly complex projects (social, political and time complexity) with management of symptoms not causes (ie sources of uncertainty and complexity)
- Tight coupling and interactive complexity make project fragile

5. Master Builder Leadership
- Wide range of capabilities with few pockets of excellence
- Careful balance between individual and organisational capabilities
- High-powered experts lack understanding of way of working
- Lack of empowerment of experts (stifled by process)
- No culture of excellence but a culture of heroes

- Is the project conducting internal and external benchmarks?
- What level of realism does this show?
- Have lessons learned been incorporated?
- How is the procurement strategy and early contractor involvement structured?
- What are the incentives for forecasters?
- Is probabilistic forecasting used consistently?
- Has the project taken a systematic view to compare itself to other projects?
- How mature is the risk management (if any) and other PM disciplines to manage the front-end process?
- Has the project analysed its sources of complexity?
- Have complexities been actively managed or mitigated?
- How compressed is the schedule?
- How confident is the project in the capability of its leaders?
- How mature are the PM processes?
- Do the project and supply chain share understanding of success factors?
## Risk Maturity Level

<table>
<thead>
<tr>
<th>Maturity Level</th>
<th>Area</th>
<th>Problem factors</th>
<th>Potential response (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bench marking</td>
<td>Inside view only with optimism bias unchecked</td>
<td>• Programme of learning from others.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Benchmarking against other projects, industries and sectors</td>
</tr>
<tr>
<td>2</td>
<td>Due diligence</td>
<td>No challenge to cost, schedule forecasts of contractors.</td>
<td>• Internal assessments of costs, schedules.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimal understanding of uncertainty in estimate</td>
<td>• Separate estimating from contractors</td>
</tr>
<tr>
<td>3</td>
<td>Reference Class Forecasting</td>
<td>No systematic outside view. Variability between projects and subprojects ability</td>
<td>• Systematic and ongoing Reference Class Forecasting across different aspects of programme.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to align and reduce bias. Ignorance of ‘unknown unknowns’; lack of exploration.</td>
<td>• Exploration of scenarios to understand ‘unknown unknowns’.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Understand characteristics of tail</td>
</tr>
<tr>
<td>4</td>
<td>Black Swan (predictable</td>
<td>Slow management information communication. Management of symptoms not causes.</td>
<td>• Quick, clean, independent management information reporting</td>
</tr>
<tr>
<td></td>
<td>surprises)</td>
<td>Tight coupled system. Overly complex</td>
<td>• Amplification of weak signals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Recognise complex scenarios and break down</td>
</tr>
<tr>
<td>5</td>
<td>Leadership</td>
<td>High powered experts lack understanding of how to work effectively. No culture of</td>
<td>• Identify necessary pockets of excellence and encourage culture. Continuous learning.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>excellence rather one of heroes. Lack of empowerment of experts</td>
<td>• Focus on ways of working</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Leadership engage in scenario planning</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Increase reliance on ‘qualitative’ (needs more development)</td>
</tr>
</tbody>
</table>
- Based on ISO31000 with reference to other maturity models
- Pushes boundaries for “leading” ERM practice
- Covers enterprise-wide maturity:
  - Document review (25%)
  - Evidence based application (75%)
- Initial qualitative assessment at “Level 1”
- Drill down to L2 and L3 quantitative assessment using weighted scoring
- L4 will be a behavioural questionnaire similar to psychological profiling
Maturity Model

- All orgs all areas score varies between 2 and 4
- Most orgs strong on 3 areas and weak on 2
- Further analysis on particular questions to follow...
Management of Risk in Government (Manzoni & Cheshire, Jan 2017)

Building blocks:
- Creating positive risk management behaviours and culture
- Establishing roles and responsibility
- Communicating risk information
- Building risk capability, including training for risk practitioners

Routine processes:
- Identifying risks, including those responsible for managing them
- Assessing risks and establishing tolerances
- Addressing risks, including contingency arrangements
- Reviewing and monitoring risks, including ‘deep dives’
- Reporting on risk

Periodic activities:
- Assuring the board that risk is being properly managed
- Assuring risks from arm’s length bodies
- Scanning the horizon/environment, including National Risk Register risks
- Building risk maturity
- Peer reviews
- Learning lessons
- Exploiting data and data analytics
- Building and testing resilience frameworks
Thank you

Any Questions?