HS2 Phase One Ground Investigation: Challenges and Requirements

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Head of Ground Investigations, HS2 Ltd

Geotechnica 2015
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Content of presentation

- HS2 Phase One route and timeline
- Geology and ground conditions
- Tunnels and earthworks
- Key statistics and design issues
- The role and scope of the GI
- Resources, procurement, and programme
- Risks
- Health, safety, and welfare
- Current activity
- Summary of challenges
- Future requirements of geotechnical clients
Phase One route:
London - West Midlands
## HS2 journey times (hours: minutes) and route capacity

<table>
<thead>
<tr>
<th>London to/from</th>
<th>Standard journey time before HS2</th>
<th>Fastest journey time before HS2</th>
<th>Standard journey time after HS2 Phase One</th>
<th>Standard journey time after HS2 Phase Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birmingham</td>
<td>1:24</td>
<td>1:12 (1)</td>
<td>0:49</td>
<td>No change</td>
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<tr>
<td>Manchester</td>
<td>2:08</td>
<td>1:58 (2)</td>
<td>1:40</td>
<td>1:08</td>
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<td>Leeds</td>
<td>2:20</td>
<td>1:59 (3)</td>
<td>No change</td>
<td>1:28</td>
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</tbody>
</table>
HS2 operation statistics

- Two phases – first live 2026
- Trains transition to and from Network Rail (but not HS1, nor Heathrow Airport)
- Max speed 360 kilometres per hour (400kph alignment balanced with environmental impact) [Fastest High Speed system in Europe]
- Up to 18 trains per hour, scheduled every three minutes
- European Train Control Systems (ETCS) Level 2 [No signals]
- Automatic train operation
- 400m trains with 1,100 seats
- 200m trains 550 seats
# Timetable (high-level schedule)

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<td>Scheme design</td>
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<td>Civils construction</td>
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<td>Resilience activity</td>
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- ♻: Royal assent
- ‡: Entry to service
Previous projects requiring hybrid Bills

- Used by Government to authorise schemes of national significance
- Examples include:
  - Channel Tunnel 1987
  - Dartford-Thurrock Crossing 1988
  - Severn Bridge 1992
  - Channel Tunnel Rail Link/HS1 1996
  - Crossrail 2008
UK geology
Phase One

- London clay
- Lambeth group
- Chalk
- Rutland formation (limestone/Lias clay)
- Lower Jurassic marlstone
- Mercia mudstone group
- Upper Carboniferous
# Expected ground conditions

<table>
<thead>
<tr>
<th>Ground type</th>
<th>Examples</th>
<th>Properties (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-glacial</td>
<td>Terrace Gravels, Langley Silt, Peat, Alluvium</td>
<td>Weak recent deposits. Often require ground improvement for tunnel construction.</td>
</tr>
<tr>
<td>Glacial</td>
<td>Glacial tiles, Lodgement, Tills/deformation tills (Boulder clay), Glaciofluvial, Glaciolacustrine</td>
<td>Ground properties extremely variable - hard and soft deposits often intermixed.</td>
</tr>
<tr>
<td>Rock</td>
<td>Chalk Group, Gault, Marlstone Rock, Whitby Mudstone, Penarth/Branscombe Mudstone, Upper Greensand, Great Oolite, Dyrrham, Charmouth Mudstone, Mudstone/Merca, Sherwood sandstone, Lenton Sandstone, Edlington, Kidderminster, Tile Hill Mudstone, Coal Measures – sandstone / mudstones / siltstone</td>
<td>Can vary in strength with some acting more like engineering soils. Others are harder rock and stand up for extended periods.</td>
</tr>
</tbody>
</table>
# Tunnels Phase One

## Twin-bored tunnel

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance</th>
<th>Geology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euston</td>
<td>7.4km</td>
<td>London Clay</td>
</tr>
<tr>
<td>Northolt</td>
<td>14km</td>
<td>London Clay/Lambeth/Chalk</td>
</tr>
<tr>
<td>Chilterns</td>
<td>13.4km</td>
<td>Chalk</td>
</tr>
<tr>
<td>Long Itchington Wood</td>
<td>1.5km</td>
<td>Penarth Group/Mercia Mudstone</td>
</tr>
<tr>
<td>Bromford</td>
<td>2.8km</td>
<td>Penarth Group/Mercia Mudstone</td>
</tr>
</tbody>
</table>

## Cut-and-cover

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance</th>
<th>Geology</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Heath</td>
<td>1.1km</td>
<td>Chalk</td>
</tr>
<tr>
<td>Wendover</td>
<td>1.3km</td>
<td>Chalk</td>
</tr>
<tr>
<td>Greatworth</td>
<td>2.1km</td>
<td>Glacial Till/Oolite/Whitby Mudstone</td>
</tr>
<tr>
<td>Chipping Warden</td>
<td>2.5km</td>
<td>Low Jurassic Marlstone/Mudstone</td>
</tr>
<tr>
<td>Long Itchington Wood</td>
<td>0.4km</td>
<td>Penarth Group/Mercia Mudstone</td>
</tr>
<tr>
<td>Burton Green</td>
<td>0.5km</td>
<td>Lower Carboniferous Mudstone</td>
</tr>
</tbody>
</table>
Mass haul and earthworks
Phase One: key construction statistics

- **230km**
  - Total route length

- **53km**
  - Total length in tunnels

- **74km**
  - Total length in cuttings

- **152**
  - Structures under bridges

- **145**
  - Structures over bridges

- **128 mt**
  - Total volume of excavated material (90% to be re-used)

- **31**
  - Main compounds for construction

- **299**
  - Satellite compounds
Key design issues

- Tunnel stability and related techniques/ground movements
- Slope stability: prediction for longer-term stability.
- Heave/settlement: long-term movement beyond five years
- Materials suitability: re-use in mitigation or engineering fill
- Geodynamic control: track foundation stiffness
- Contaminated land: potential for remediation
- Geohazards:
  - Soft ground and/or deep peat
  - Natural landslips
  - Karst
  - Tunnelling in aquifers
  - Landfill and contaminated land
The role of GI: the Geo-Wheel

- Project Management
- Desk Study
- Construction
- Data Base
- Instrumentation & Monitoring
- R & D
- Design and Analysis
- Interpretation
- Factual Data Investigation
- Ground Investigation (Factual Data)
- Contract Management
- Sustainability
- Health & Safety
The role of GI: critical path interfaces

- To address “routine” design and construction-related requirements;
- To address unusual/critical design and construction requirements;
- To provide monitoring data; e.g. groundwater regime;
- To inform utilities and other early works design and construction/implementation;
- To inform mass haul (earthworks) design;
- To inform the employer’s requirements design (“reference” design);
- To inform the Invitation to Tender (ITT) for the main civils works contracts (including geotechnical baseline reports);
- To inform the contractors’ scheme design (“detailed design”)

Overall scope of GI works

- **Boreholes** to investigate ground conditions and groundwater regime, on land and over water
- **Cone Penetration Testing** (CPT) to investigate ground conditions and groundwater regime
- **Trial pits** to investigate ground conditions and groundwater regime
- **Surface geophysics**
- **Borehole and CPT geophysics**
- **Ground Penetrating Radar / investigation pits** for utilities, other buried assets, and existing substructures / foundations
- **Ancillary activities**
  - Traffic Management
  - Forming and maintaining access
  - Hoarding / protection
  - Waste management (arisings, welfare facilities, packaging)
  - Pre-investigation surveys of underground services and other utilities (PAS 128)
- **Installation and monitoring of instrumentation**
- **On Site and laboratory testing**
- **Reporting**
- Works may be on or in close proximity to land under the control of transport and utility owners and operators (e.g. Network Rail; TfL; Highways Agency; National Grid; Water, Sewerage and Electric Companies; Canal & River Trust; and the like)
HS2 resources: GI teamwork

• In the beginning... Technical Directorate and Professional Services Companies (PSCs)
• Preliminary Design: Inform the Hybrid Bill  
  Identify the scale of the GI
• 12,606 GI fieldwork locations!
• March 2014: Mobilisation of a team of geotechnical engineers, engineering geologists, tunnelling engineers, and geo-environmental specialists dedicated to the GI - The GI Core Team
• GI support team - All those at HS2 Ltd who are not members of the GI core team
• Objective: rationalise and divide the overall GI into manageable individual ground investigation contracts
Framework contract basis

The GI Framework is based on the ICC Infrastructure Conditions of Contract – Ground Investigation Version 2011 published by ACE and CECA.

Relevant codes and standards for Ground Investigation include:

- Eurocodes (EC7), British Standards and Codes of Practice (published by BSI) as referenced in the UK Specification for Ground Investigation, 2nd Edition, 2012 published by the Institution of Civil Engineers (Section 17 references and bibliography)
- BS EN ISO 22282-Parts 1-6: 2012 Geotechnical investigation and testing. Geohydraulic testing
- CLR 11 Model Procedures for the Management of Contaminated Land Defra 2004 and RMT Remedial targets Methodology EA 2006
GI parcels and work packages

- The GI work packages represent the smallest division of the Phase One route into individual ground investigation contracts. There are currently 92.

- Work packages can be assembled into GI parcels, aligned to:
  - the division of the Phase One route into Areas South, Central, and North;
  - the division of the Areas into Main Civils Contracts; and
  - those areas with urgent demands for GI data.

- Initially 23 Parcels, currently 10.

- Work packages are divided, by value, into Lots 1 and 2

- Total number of Lot 1 work packages: 38
- Total Number of Lot 2 work packages: 54
### Key GI events and dates

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
<th>Event</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>Return of GI Contractor Pre-Qualification Questionnaires (PQQ) to HS2</td>
<td>9 Dec 2013</td>
<td>Definition of Work Packages for all GI Parcels</td>
<td>30 Nov 2014</td>
</tr>
<tr>
<td>Mobilisation of Interim GI Delivery Manager</td>
<td>Feb / Mar 2014</td>
<td>Mobilisation of long term Phase 1 Infrastructure GI Manager</td>
<td>1 Dec 2014</td>
</tr>
<tr>
<td>GI Peer Review (by Mike Black, Crossrail)</td>
<td>Jun 2014</td>
<td>Framework Awarded</td>
<td>9 January 2015</td>
</tr>
<tr>
<td>Issue of Tender Addendum (Comprising eight Work Packages)</td>
<td>30 Jul 2014</td>
<td>Mobilisation of Contractors</td>
<td>March 2015</td>
</tr>
<tr>
<td>Definition of Work Packages for all GI Parcels</td>
<td>30 Nov 2014</td>
<td>Commencement of GI Fieldwork</td>
<td>April 2015</td>
</tr>
</tbody>
</table>
Phase One GI framework contractors

- Bam Ritchies – A division of BAM Nuttall Ltd*
- Environmental Scientifics Group Limited
- Fugro Seacore Limited (trading as Fugro Engineering Services)*
- Soil Engineering Geoservices Limited*
- Structural Soils Limited
- Allied Exploration and Geotechnics Limited
- RPS
- WYG Environment Planning Transport Limited*

* Awarded GI Contracts as result of Mini-Competition Tranche 1
The programme

• Four years become two!
• Initially thirteen mini-competitions (M-Cs) for work packages at six- to eight-week intervals
• Currently a total of nine tranches of work packages to be launched before the end of 2015, with a maximum of 30 work packages each
• Constraints on initial programme of intrusive fieldwork (primarily as a result of the General Election)
• Slow, measured, start to proceedings....
• Anticipated a rapid acceleration of work beyond the end of May 2015
• Additional GI supervision group resources mobilised accordingly
Key risks

- Changes to HS2 Governance and assurance processes
- Access to land for GI fieldwork before Royal Assent (December 2016) is not granted or is subsequently withdrawn
- An incident occurs during GI works which causes injury or fatality
- Delay of consents bodies
- Changes to locations, scale, and nature of civils works, including utilities and early works
- Requirements for sample and core storage
Health and safety principles

- CDM (Construction and Design Management) regulations [which change in April 2015]
- Leadership and behaviour
- Designing for health and safety
- Workplace health and safety
- Constructing safely
- Performance and improvement
- Engagement
- Occupational health
# Summary of revised GI strategy

<table>
<thead>
<tr>
<th>Type of GI</th>
<th>Approx % of GI</th>
<th>Detail</th>
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<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>Comprehensive, high quality fieldwork and laboratory testing to establish reference conditions for the principal formations along the route of HS2.</td>
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<tr>
<td>B</td>
<td>30</td>
<td>High quality GI appropriate to the engineering element or identified geological anomalies.</td>
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<tr>
<td>C</td>
<td>30</td>
<td>Correlation: Establishing the ground profile and necessary classification tests. Use techniques, where rapidity of construction with good ground profiling may be effected, such as use of CPT and DCP and allied use of NDT techniques such as geophysical survey.</td>
</tr>
<tr>
<td>Supplementary</td>
<td>15</td>
<td>Allows provision of additional information during design development by the PSCs and by the Contractor at main works commencement. This is well-established, industry recognised ground risk mitigation as the project develops.</td>
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Current activity

- Eight GI contracts (work packages) awarded [tranche 1]
- Non-intrusive fieldwork under way at Euston: GPR and topographical surveys
- Intrusive fieldwork under way at Birmingham: Bromford Tunnels and Castle Bromwich... then Curzon Street
- [Intrusive GI fieldwork at Euston and Northolt tunnels on hold]
- Mobilisation for on-network GI at Euston under Network Rail’s direction; expected on site during August 2015
- Evaluation of tenders for work packages tranche 2 completed
- Tranche 3 tenders returned and under evaluation
- Tranche 4 out to tender
- Remaining five tranches in preparation
Summary of challenges

- Scale of the project
- Design of the project
- Design of the GI
- Volume of GI work
- Resources / GI industry capacity
- Impact of design changes
- Impact of Additional Provisions/Third Parties/Stakeholders
- Programme
- Data management
- Health/safety/welfare/risk
- Consistent and reliable factual data, in electronic format
- Access.... **location, location, location**
Future requirements of Geotechnical clients

• Health and safety (and welfare) first
• Collaboration between GI contractors (Joint Ventures non-existent?)
• Paperless? Yes, wherever possible (including site records)
• Document-less? NO! This remains a major task, to be taken seriously. Adequate and appropriate personnel to be assigned to this task
• Effective engagement of British Geological Survey (including the BGS “right of access”?)
• Innovation
• Teamwork
• Co-location of designer and GI contractor personnel
Thank you