Rail Research UK: Management and Research Programme

Professor William Powrie, University of Southampton
Principal Investigator
Background to RRUK

- Nationalised British Rail supported by BR Research, Derby
- Rail industry in the UK was traditionally insular
- On privatisation of the UK railway industry in the 1990’s, BR Research Derby also became a private company
- Emphasis shifted to development and sale of products and services
- Generic rail-focused research base in UK universities was small
- RRUK established in 2003 to enhance the independent research base
RRUK’s Aims

• To facilitate research that will
  • Improve the safety, reliability and capacity of the rail network
  • Reduce the impact of railways on the environment
  • Make rail travel more attractive for passengers
  • Improve industry practice and inform policy development

• By
  • Providing a strong coherent academic community
  • Enhancing the scientific base
  • Working in partnership with industry
What is RRUUK?

• RRUUK’s mission
  - To support the UK railway industry by providing a focal point for world-class, university based research

• A virtual centre
  - Twelve research groups in eight universities
  - Led jointly by the Universities of Birmingham and Southampton

• Multidisciplinary research
  - Engineering, Science, Economics, Human Factors

• EPSRC funding
  - RRUUK1 – £4.2M over 40 months (5/03 – 9/06)
  - RRUUK2 – £4M over 42 months (9/06 – 3/10)
Beneficiaries

- **Universities**: expanded and stable base for scientific railway research and the provision of a career structure for able research staff
- **Industry**: partnerships to expand existing research, develop new knowledge and utilise outputs to solve specific problems that will make a difference to reliability, capacity, comfort and safety
- **Public and customers**: a railway that is more reliable, integrated, comfortable, safe and cost effective and has less impact on its neighbours and the environment
- **Government**: contribution to transport and environmental policy, comparison of the UK with overseas practice, knowledge transfer
Research culture and mode of operation

- **High quality research** that is valued by the industry and makes a difference to railway operation
  - Collaborative research with industry
  - Adventurous scientifically challenging research
- **Feasibility / scoping studies** for new areas of research or new techniques
- **Networks** to encourage dialogue between academics and industry leading to active collaboration
- **Website** to facilitate communication and dissemination of information
- **International support**, contact and collaboration (e.g. EURNEX)
# Original Advisory Board

<table>
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<tr>
<th>Name</th>
<th>Position</th>
<th>Organisation</th>
<th>Project Mentor</th>
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<tr>
<td>Steve Atkins</td>
<td>Assistant Director, Transport Planning, Policy &amp; Research</td>
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<td>B5, C2, C3</td>
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<td>Jol Bates</td>
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<td>Keith Beattie</td>
<td>LUL Director – Crossrail</td>
<td>London Underground</td>
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<td>Chief Executive</td>
<td>CIRIA</td>
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<td>Rob Davis</td>
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<td>WS Atkins Rail Ltd</td>
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<td>Tim Gilbert</td>
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<td>Porterbrook Leasing</td>
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<td>Richard Gosling</td>
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<td>Railway Industry Association</td>
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<td>Ben Harding</td>
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<td>Metronet Rail BCV</td>
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<td>Phil F Heyes</td>
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<td>Health and Safety Laboratory</td>
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<td>Ken Johnson</td>
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<td>Andrew P Lezale</td>
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<td>Nick O’Riordan</td>
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<td>Arup and Partners Ltd.</td>
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<td>Cliff Perry</td>
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<td>Rebeka Sellick</td>
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<td>Andrew Sharpe</td>
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<td>Bill Tyson</td>
<td>Chairman &amp; Managing Director, Transport Management Group Ltd</td>
<td>Greater Manchester PTE</td>
<td>C2, C3</td>
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<tr>
<td>Alan West</td>
<td>Divisional Director</td>
<td>Mott MacDonald</td>
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New Advisory Board Arrangements

• Advisory Board’s modus operandi has evolved…
• Advisory Board remains as a corresponding panel
• Monitoring and Review functions of Advisory Board assumed by AGRRI
• RRUUK = standing item on AGRRI agenda and main item for one meeting a year
Industry Engagement

- Supported by major industry stakeholders
  - RSSB, Network Rail, DfT
- Organisations providing assistance with current projects include:
  - DeltaRail, Arup & Partners Ltd, ATOC, Atkins Rail, Balfour Beatty Rail, Bombardier Transportation, British Geological Survey, Carillion Rail, Central Japan Rail Co, CIRIA, Corus Rail, DfT, DB Systemtechnik (Germany), EWS, Fugro, Gary Davies Associates, Go-Ahead Group, Greater Manchester Passenger Transport Executive, Hitachi, Jarvis Rail, JR Group (Japan), London Underground Ltd, Metronet Rail BCV, Mott MacDonald, National Express Group, Network Rail, Network Rail CTRL, NS (Netherlands), ORR, Pandrol, Porterbrook Leasing, Rail Passenger Demand Forecasting Council, Rail Safety and Standards Board, Railway Forum, Renfe (Spain), SBB Bahnumweltcentrum (Switzerland), Scott Wilson Pavement Engineering, SJ Green Cargo (Sweden), SNCF (France), Spoornet (South Africa), Strategic Rail Authority, TNO-TPD (Netherlands) and UIC (France)
Research Overview
Partners and expertise (1)

- University of Southampton: infrastructure, geomechanics, transport operations, user needs, logistics, train and infrastructure noise, human responses to train environments
- University of Birmingham: aerodynamics, condition monitoring, energy, metallurgy
- Imperial College London: vehicles, high-speed rail, hybrid trains, wheel/rail interface
- University of Leeds: rail economics, passenger and freight demand modelling, cost modelling, regulation/competition, infrastructure charging, international benchmarking
Partners and expertise (2)

- Loughborough University: rolling stock, dynamics, suspension and control, mechatronics, condition monitoring
- Manchester Metropolitan University: vehicle/track interaction – modelling, validation, laboratory testing
- University of Newcastle-upon-Tyne: rail steel microstructure, wear and rolling contact fatigue, wheel-rail adhesion, rail joint inspection
- University of Nottingham: human factors including workload assessment and impacts of automation
Research Themes

• Engineering Interfaces
  - Problems around the wheel-rail interface

• Whole Systems Performance
  - Systems engineering, including human – machine interface

• Users, Community and Environment
  - End-user experience and environmental impacts
Research Projects: Engineering Interfaces

- Appraisal of Track/Sub-base Design using Modern Geotechnical Principles (A1)
- Predicting the Life of Various Grades of Steel Railway Track (A2)
- Railway Noise - Curve Squeal Noise, Roughness Growth, Friction and Wear (A3)
- Ground/Track/Train systems interactions (A4)
- Aerodynamic/Train system interaction (A5)
- Three-Dimensional Microstructural Modelling of Crack Initiation in Rail Steel (A6)
Research Projects: Whole System Performance

- Decision Support System for Dynamic Re-scheduling of Trains under Disturbance (B1)
- Understanding and Integration of Human Factors across the Railway Network (B2)
- Human Factors Models for Integrated Train Operation (B3)
- System Level Cost Framework for the Assessment of Sub-Systems Trade-Off (B4)
- International Benchmarking (B5)
- Human-Automation Interactions in Rail Network Control (B6)
- Rail Industry System Cost Model (B7)
- Advanced Concepts for Condition Monitoring around the Wheel-Rail Interface (B8)
- Optimum Use of CCTV on Railway Systems (B9)
Research Projects:
Users, Community and Environment

- Train Environment Simulator for Optimising Passenger Comfort (C1)
- Delivery of User Needs (C2)
- Future Role of Rail in Integrated Transport Policy (C3)
- Power Futures (C4)
- Passenger and Crew Environments (C5)
- Determining the Costs of Delay to Different Types of Train (C6)
- Strategies for Minimising Railway Energy Consumption (C7)
PhD projects

- A Computation Intelligence Approach to Railway Intervention Planning
- Forecasting the Use of New Local Railway Stations and Services Using GIS
- Development of models for rail vibration and noise radiation including the effects of rail dampers
- Quantifying the Effects of Climate Change on the Railway Network in the UK
- The analysis of information flows as a way to improve the level of resilience of the planning system
- High Speed Train Driving Situation Awareness: An account of Attention and Perception in support of a new cab interface Design
- Optimising Rail Maintenance Techniques
- Track Stability
- Discrete Element Modelling of Railway Ballast
- Enhanced Information Design for High Speed Train Displays
- An Optimised Wheel-Rail Contact Model for Vehicle Dynamics Simulation
Focus on Research and Applications: Projects A1 and A4

Professor William Powrie
Dr Jeffrey Priest
Mr Louis le Pen
Background to projects A1 and A4

- Perception that most methods of sub-base design are empirical and recipe based
- Lack of understanding of how loads are transmitted through track system into the soil
- Lack of appreciation of importance of the sub-base ("ballast memory" and "wet spots")
- Recent advances in soil mechanics and instrumentation should be applied to railways
- Improved understanding of factors affecting sub-base performance for better whole life cost modelling
Outline of projects A1 and A4

Aim: to develop a proper scientific understanding of the load/deformation response of the track foundation

- Instrumented sites – field data
- Advanced laboratory testing
- Numerical modelling
- Modern soil mechanics
- Evaluation of design methods
- More fundamental understanding
- Improved geotechnical approach to design / remedial work
Measurement techniques: remote video monitoring

Webcam captures digital video images of a target, from which displacement is calculated using computer algorithm.

Current webcam records at 30fps
Measurement techniques: geophones (sleeper mounted and in-ground)

Geophones: LF 24, 1 Hz natural frequency, Logged at 500Hz

Mounted on sleeper or positioned in borehole at different depths in formation
Comparison: PIV and geophone data

Geophones and PIV data are in agreement.

Video frame rate of 30fps gives an image every 880mm of travel compared with 53mm for 500 Hz geophones. Both methods capture displacements due to individual axles.
Dynamic displacement during tunnelling under line

8 targets (and geophones) attached to sleepers

Measurements before, during and after tunnelling

All trains Class 373/1 Eurostar sets with near uniform trailer axle load of ~15 tonnes.
Application: Channel Tunnel Rail Link (2)

Left: typical sleeper displacement response

Lower: sleeper No 4 shows greatest deflection and may be hanging
Localised ballast migration is a recent occurrence
Possible causes:
- Mechanical? (ballast moved by sleeper displacement)?
- Vibrational? (“fluidisation” of ballast at certain frequencies)?
- Why localised? (Rail defect? Ground defects?)
Ballast migration over a number of sleepers. Ballast is lost from sleeper ends and builds up against lower rail.

Localised ballast migration: will this spread to other sleepers?

Application: Ballast migration on WCML
Ballast Migration on WCML: instrument layout

Vertical, lateral and longitudinal sleeper velocities measured using geophones
WCML ballast migration: results

Longitudinal

Lateral
WCML ballast migration: results

Vertical: high rail

Vertical: low rail
WCML frequency response

Frequency responses similar both inside and outside affected zone, with displacements dominated by bogie pairs and velocities by individual axles.
WCML displacements for different train types

Class 87 locomotive produces displacements comparable with the Class 390 Pendolino train; displacements for Mk3 coaches are considerably less.
Application: track behaviour at a culvert

Monitoring at a transition zone adjacent to a concrete culvert

Geophones attached to sleepers

Geophones within boreholes at various depths
Response of individual sleepers on approach to culvert

Ground displacements increase in transition zone. Track subject to uplift over transition zone. Also large amplitude feature present near culvert.
Thank you for listening