The universities' centre for railway systems research

Rail Research UK

Rail Research UK:

Management and Research Programme

Professor William Powrie, University of Southampton
Principal Investigator

Rail Research UK

Organisation and Management

Background to RRUK

Rail Research UK

- 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-focussed research base in UK universities was small
- RRUK established in 2003 to enhance the independent research base

RRUK's Aims

Rail Research UK

- 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 RRUK?

Rail Research UK

- RRUK'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
  - RRUK1 – £4.2M over 40 months (5/03 – 9/06)
  - RRUK2 – £4M over 42 months (9/06 – 3/10)

Beneficiaries

Rail Research UK

- **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

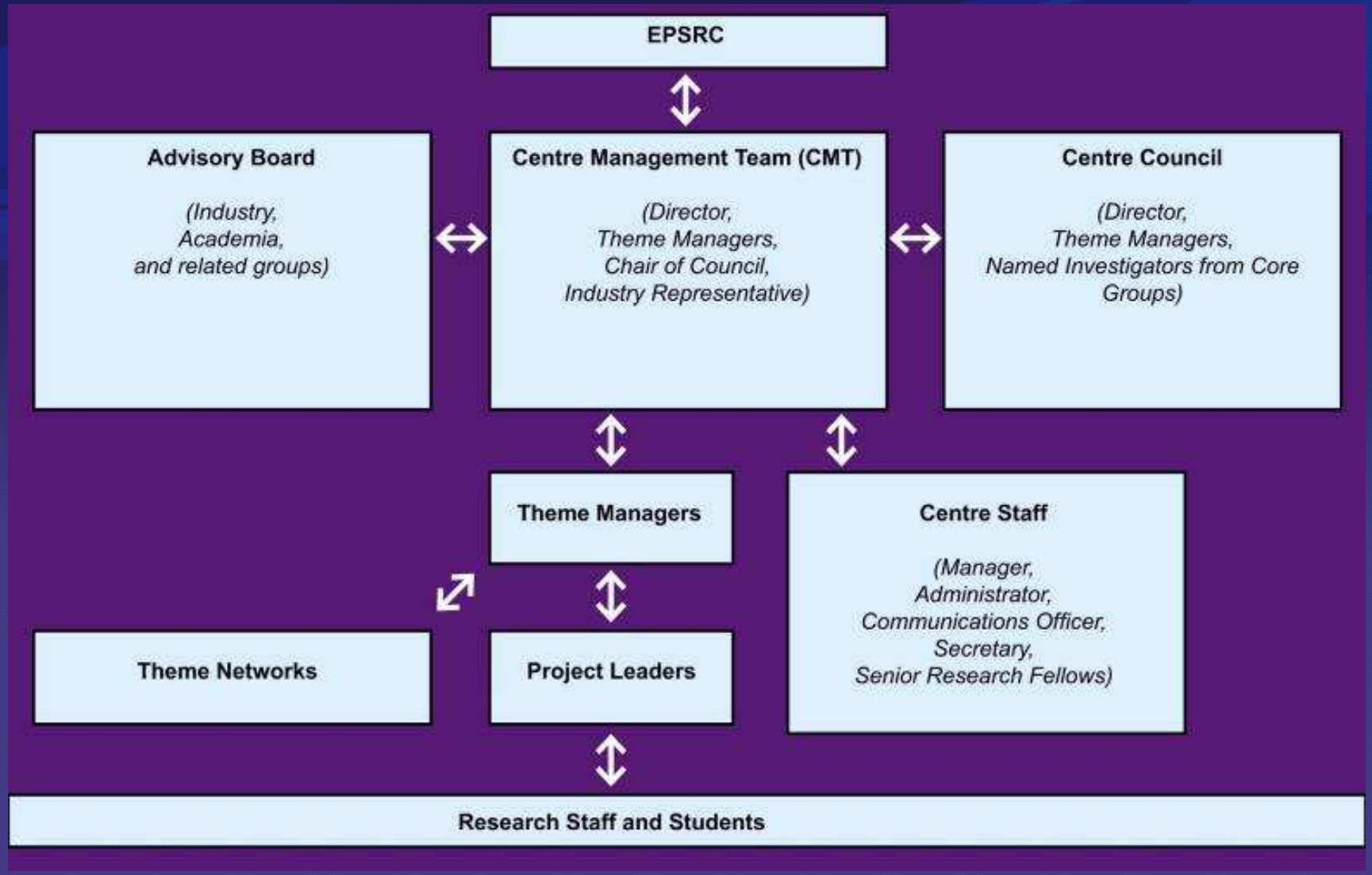
Research culture and mode of operation

Rail Research UK

- **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)

Management Structure

Rail Research UK



Original Advisory Board

Rail Research UK

Name	Position	Organisation	Project Mentor
Steve Atkins	Assistant Director, Transport Planning, Policy & Research	Strategic Rail Authority	B5, C2, C3
Jol Bates	Operations Director	Carillion Rail	
Keith Beattie	LUL Director – Crossrail	London Underground	A3
Tim Broyd	Chief Executive	CIRIA	A1
Rob Davis	Engineering Director	WS Atkins Rail Ltd	B1, B4
Tim Gilbert	Engineering Director	Porterbrook Leasing	A3, C1
Richard Gostling	Technical Director	Railway Industry Association	
Ben Harding	Director of Safety and Assurance	Metronet Rail BCV	B4
Phil F Heyes	Head, Engineering Control Group	Health and Safety Laboratory	A2
Ken Johnson	Emeritus Professor, Department of Engineering	Cambridge University	
Andrew P Lezala	Chief Executive	Jarvis Rail	A2
Andrew McNaughton	Chief Engineer	Network Rail	B2, B3
Nick O'Riordan	Director	Arup and Partners Ltd.	A1
Cliff Perry	Deputy Chairman	AEA Technology Rail	B1, C1
Rebeka Sellick	Engineering Director	Association of Train Operating Companies	B4
Andrew Sharpe	Head of Research and Development	Rail Safety and Standards Board	
Bill Tyson	Chairman & Managing Director, Transport Management Group Ltd	Greater Manchester PTE	C2, C3
Alan West	Divisional Director	Mott MacDonald	

New Advisory Board Arrangements

Rail Research UK

- Advisory Board's modus operandi has evolved…
- Advisory Board remains as a corresponding panel
- Monitoring and Review functions of Advisory Board assumed by AGRRI
- RRUK = standing item on AGRRI agenda and main item for one meeting a year

Industry Engagement

Rail Research UK

- 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)

Rail Research UK

Research Overview

Partners and expertise (1)

Rail Research UK

- 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)

Rail Research UK

- 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

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- 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

Rail Research UK

- 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

Rail Research UK

- 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

Rail Research UK

- 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

Rail Research UK

- 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

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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

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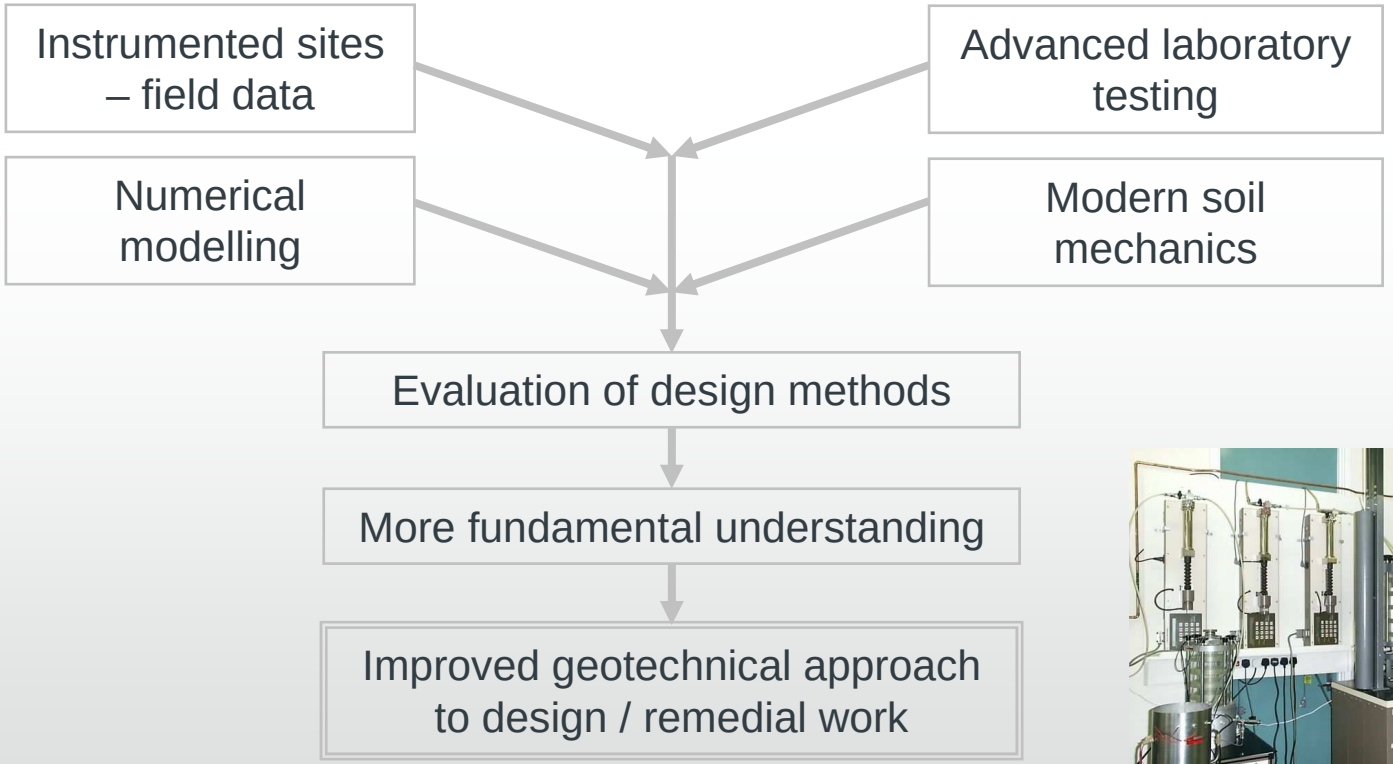
Aim: to develop a proper scientific understanding of the load/deformation response of the track foundation



Measurement techniques: remote video monitoring

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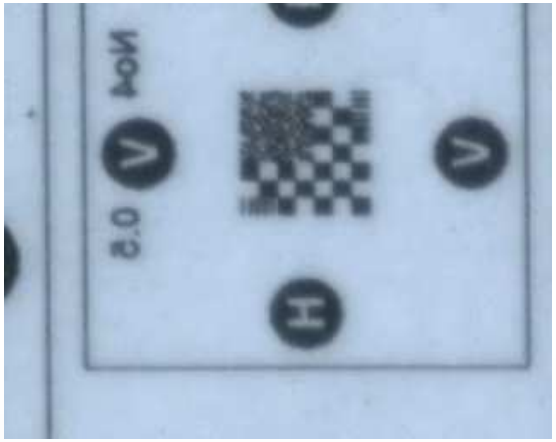

Webcam captures digital video images of a target, from which displacement is calculated using computer algorithm.

Current webcam records at 30fps

Measurement techniques: geophones (sleeper mounted and in-ground)

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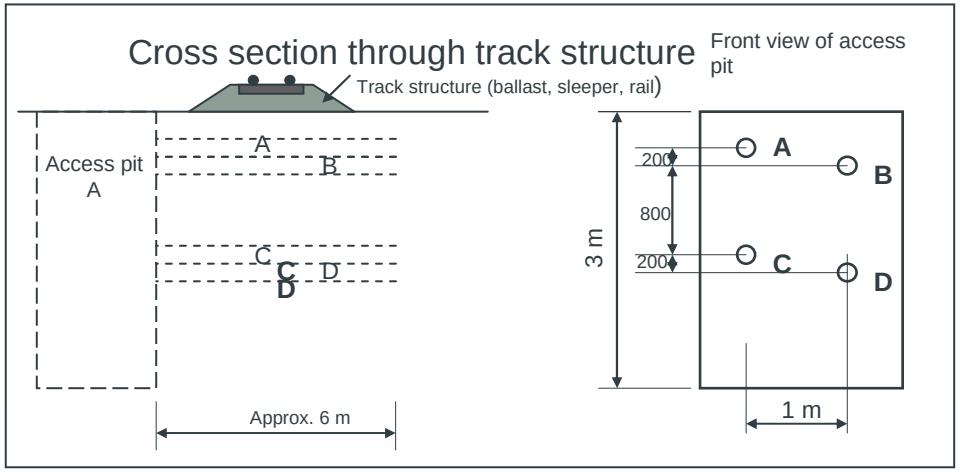

Geophones: LF 24, 1 Hz natural frequency, Logged at 500Hz

Mounted on sleeper or positioned in borehole at different depths in formation

Comparison: PIV and geophone data

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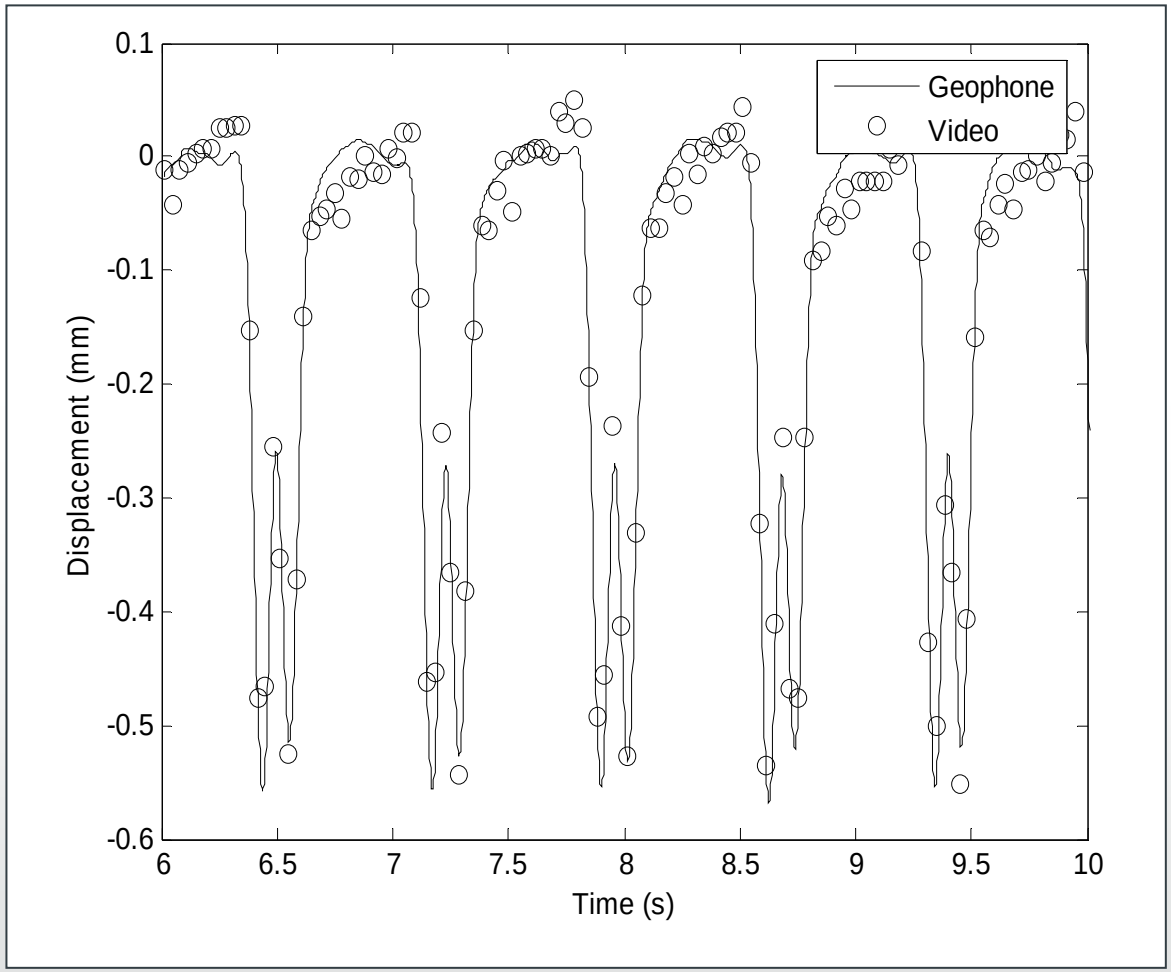

Geophones and PIV data are in agreement.

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.

Application: Channel Tunnel Rail Link (1)

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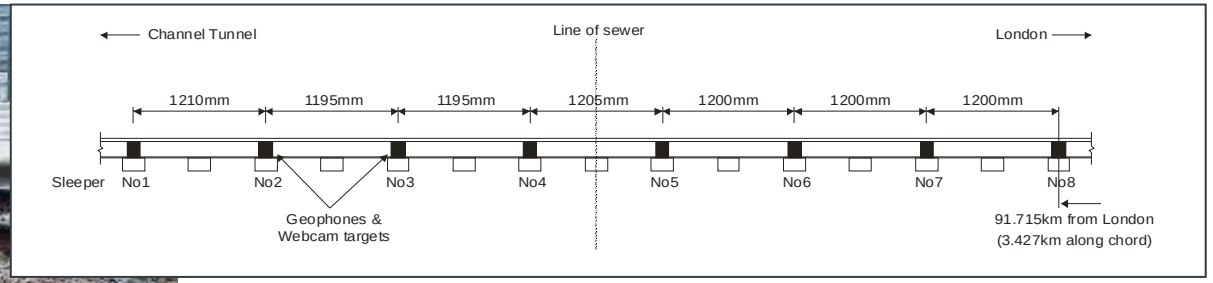

Dynamic displacement during tunnelling under line

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)

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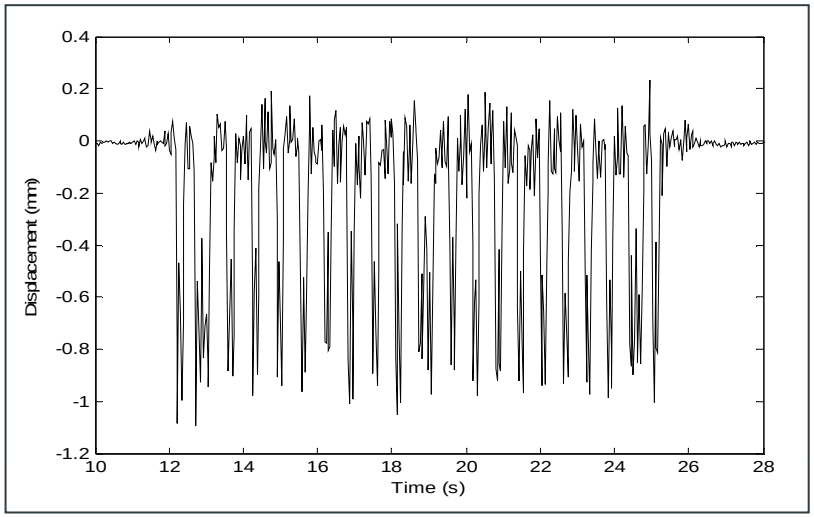
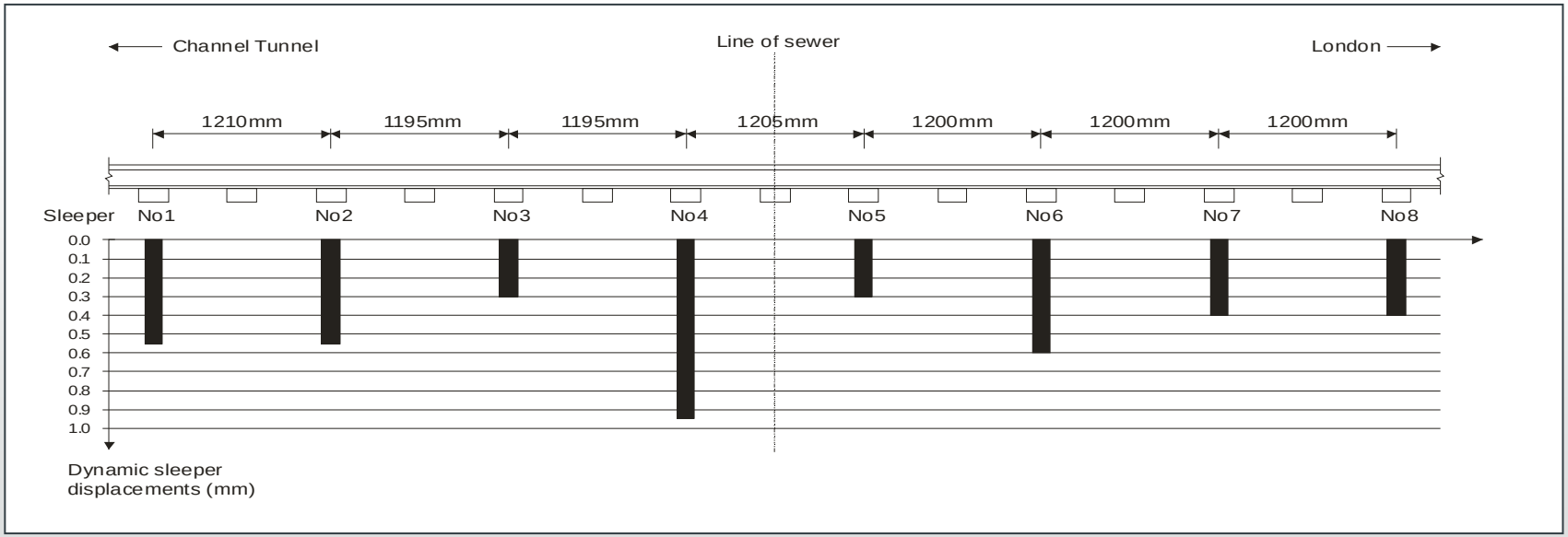


Left: typical sleeper displacement response

Lower: sleeper No 4 shows greatest deflection and may be hanging



Application: Ballast Migration on WCML

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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?

Application: Ballast migration on WCML

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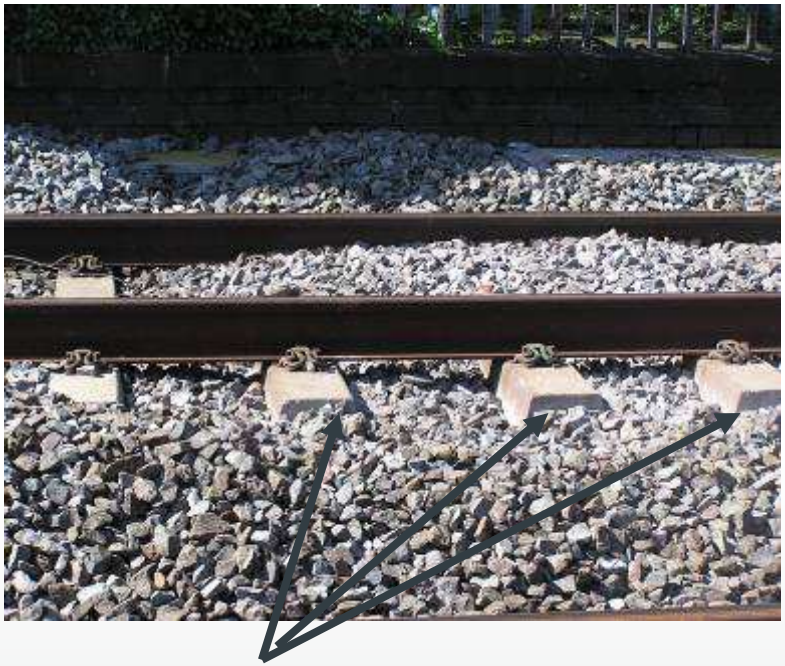

Ballast migration over a number of sleepers. Ballast is lost from sleeper ends and builds up against lower rail

Localised ballast migration: will this spread to other sleepers?

Ballast Migration on WCML: instrument layout

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Vertical, lateral and longitudinal sleeper velocities measured using geophones

WCML ballast migration: results

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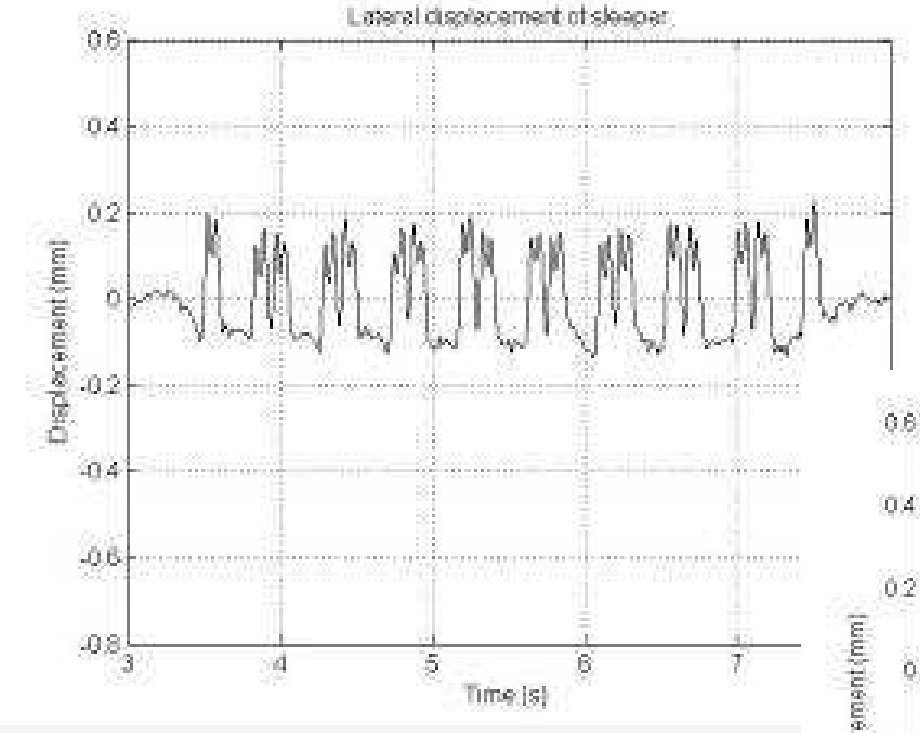
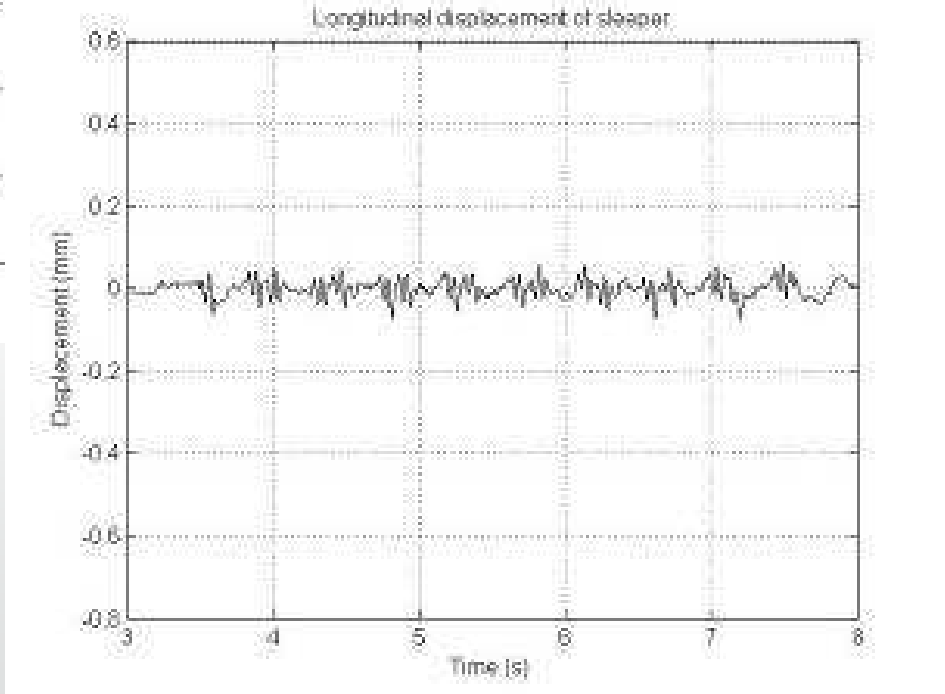


Lateral

Longitudinal



WCML ballast migration: results

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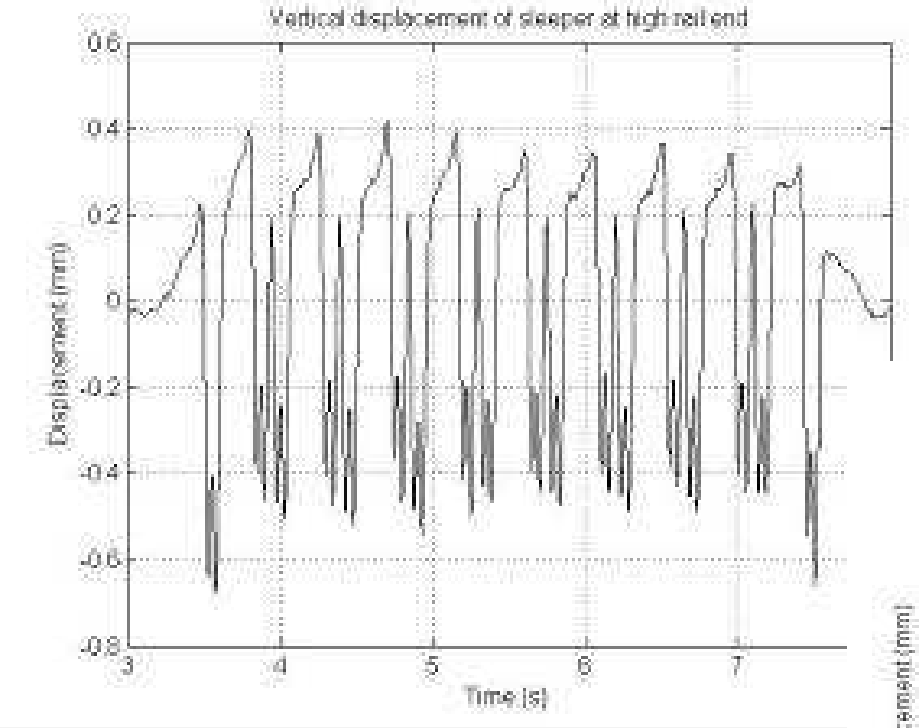
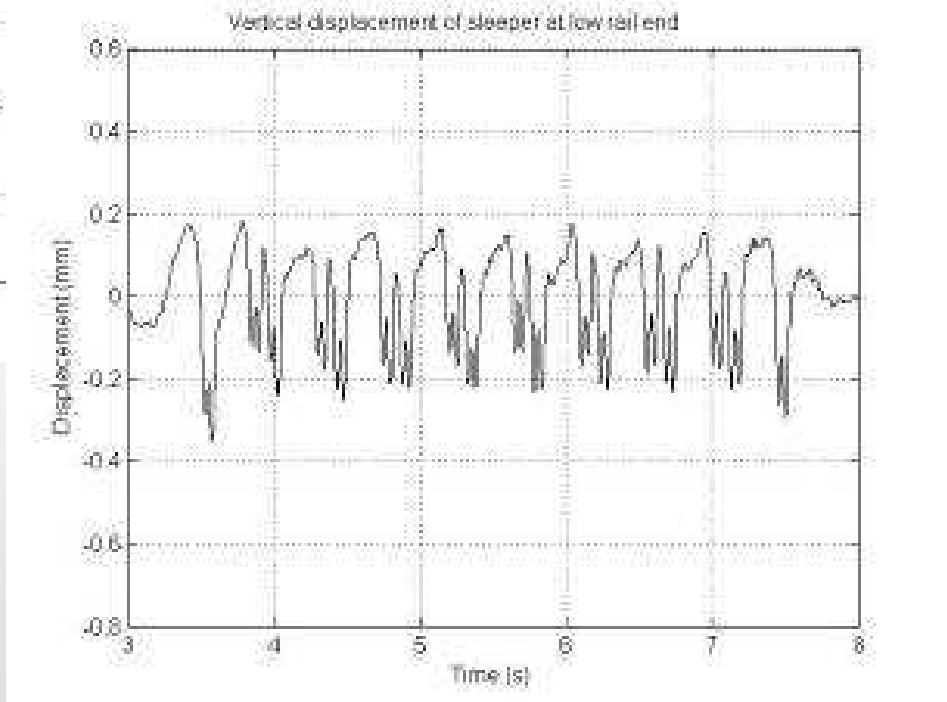


Vertical: high rail

Vertical: low rail



WCML frequency response

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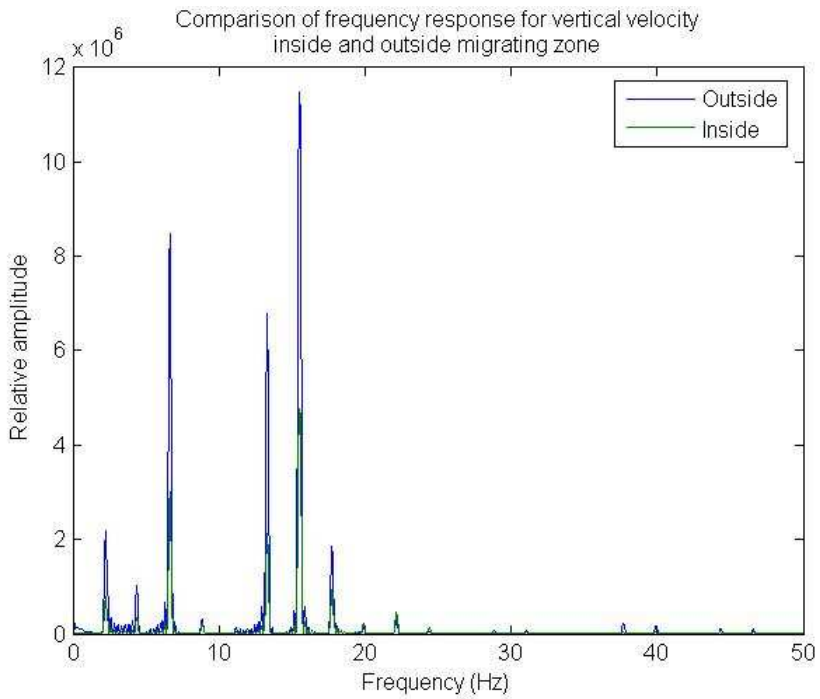

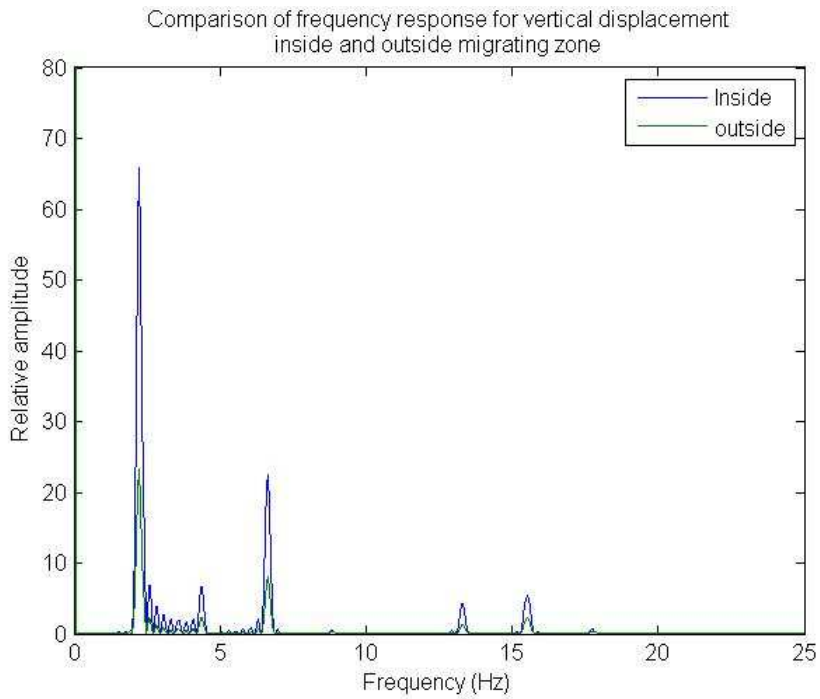

Frequency responses similar both inside and outside affected zone, with displacements dominated by bogie pairs and velocities by individual axles

WCML displacements for different train types

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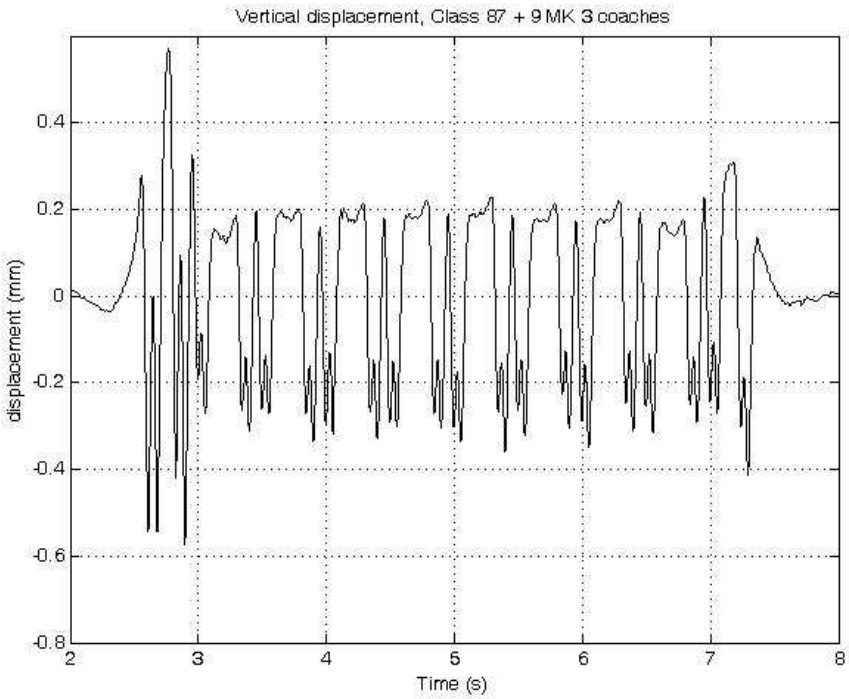

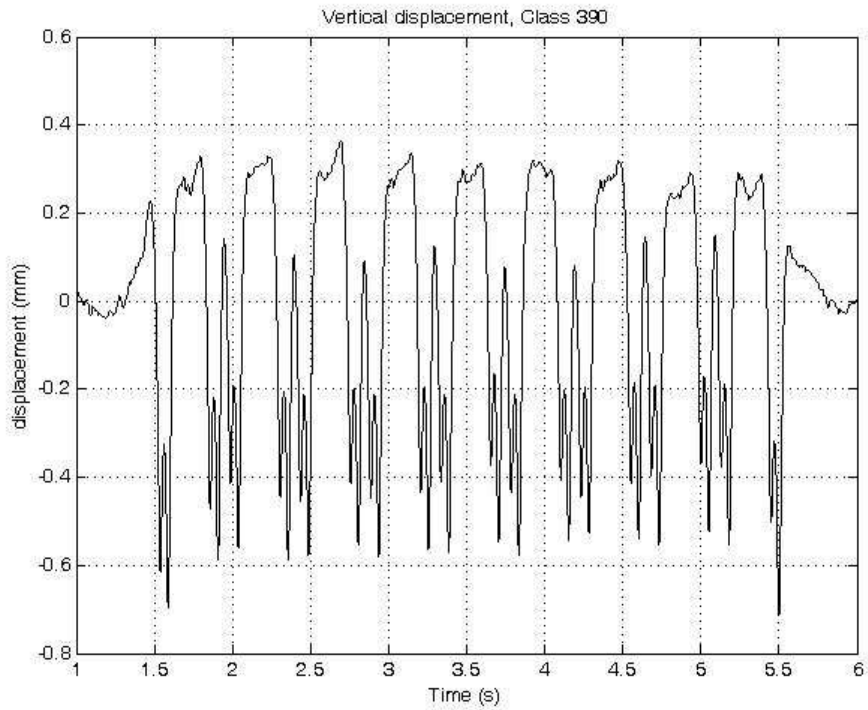

Class 87 locomotive produces displacements comparable with the Class 390 Pendolino train; displacements for Mk3 coaches are considerably less.

Application: track behaviour at a culvert

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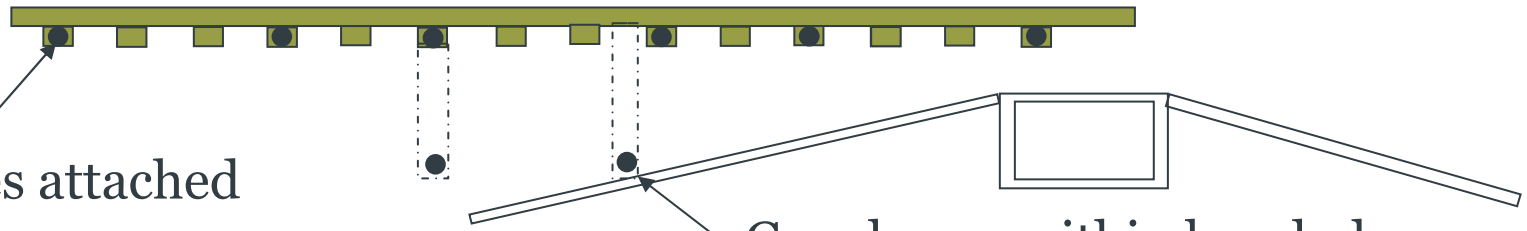

Geophones attached to sleepers

Geophones within boreholes at various depths

Monitoring at a transition zone adjacent to a concrete culvert

Response of individual sleepers on approach to culvert

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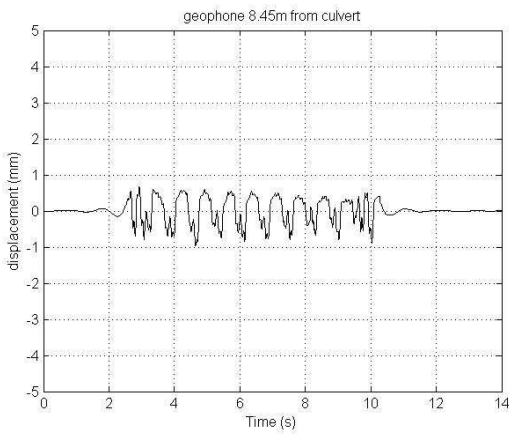

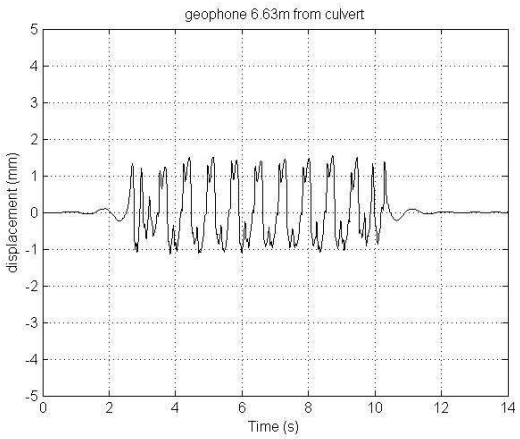

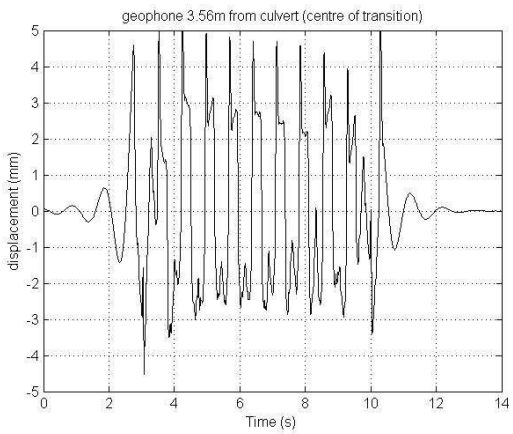

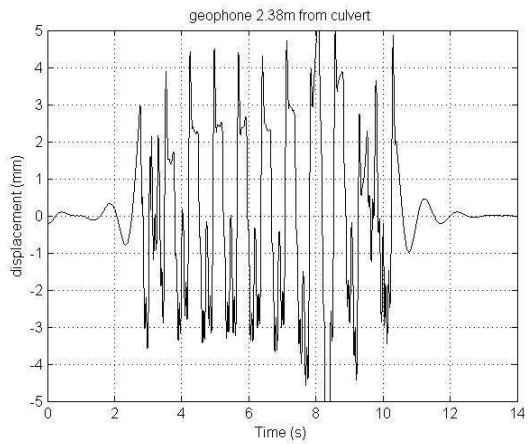

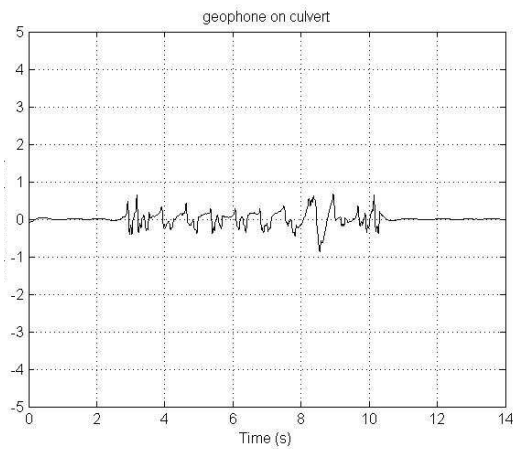

Ground displacements increase in transition zone. Track subject to uplift over transition zone. Also large amplitude feature present near culvert

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Thank you for listening