



## Centre of Excellence in Infrastructure



Creating high performance, low  
maintenance railway infrastructure  
through research and innovation

Part of the UK Rail Research  
and Innovation Network

# Introduction

## Introduction to the Centre

The Centre of Excellence in Infrastructure (CEI) is led by the University of Southampton and includes fellow Infrastructure experts at the University of Sheffield, University of Nottingham, Heriot Watt University and Loughborough University.

The Centre hosts collaborative research and development by academic and industry partners. It links the primary railway infrastructure research centres and provides a one-stop shop for industry access to leading facilities around the UK, to accelerate innovation from research into practice. The research partner for a project or programme can be selected after considering location, expertise and capacity.

## Our Expertise

The Centre integrates the specialist centres for railway infrastructure research in the UK with the industrial base and network operators. They all have extensive experience of undertaking scientific research and working with the rail industry to turn new discoveries and insights into practical tools for improving the rail network.

Civil engineering infrastructure is largely addressed by the National Infrastructure Laboratory at Southampton and existing and planned facilities at Nottingham and Heriot-Watt. Rail and power infrastructure components are being addressed in the engineering laboratories at Sheffield and, as with rolling stock, hardware-in-the-loop facilities at Loughborough.

The university partners have a very wide science and engineering research base, providing a gateway for access to extensive expertise and facilities that can be explored as the need arises. Taken together with strong links into the wider UK Collaboratorium for Research on Infrastructure and Cities, the Infrastructure Centre will have unrivalled capabilities and worldwide reach.



### Improved performance

Increasing demand for railway capacity means more frequent, faster and longer trains, and increased rates of track deterioration. Longer operating hours and round-the-clock demand for travel mean fewer opportunities for maintenance. The CEI provides practical means to improve track construction and maintenance techniques, leading to longer life and better environmental performance.

### Reduced whole-life cost

To get the best out of railway assets, managers need hard evidence based on a sound understanding of basic principles. Research leads to improved design and specification. Continual improvement of real time, remote monitoring in service enables increasingly accurate measurement and prediction of performance, and optimised timing of maintenance and renewal.

*“UKRRIN brings together key players in UK railway research, across the whole infrastructure / rolling stock / operations spectrum, to provide a coherent interface with industry. Railways are essential to a zero carbon transport future, and personally I am committed to leading and implementing research that will make this vision a reality.”*



**William Powrie**, Professor of Geotechnical Engineering, University of Southampton, and Centre of Excellence in Infrastructure Lead

## The Remit of the Centre

The Centre is focused on the Rail Technical Strategy’s vision for infrastructure. Research is being applied to develop a reliable and resilient seven-day railway with world-class asset management, increased capacity and reduced delays. The vision is to optimise the whole-life, whole system cost of infrastructure, considering investment, carbon and social factors. The Centre integrates associated specialist disciplines such as noise and vibration.

### Expertise and facilities

- Geotechnical engineering
- Track systems
- Metallurgy, tribology and rail/wheel interface
- Noise and vibration
- Structural engineering and materials
- Asset management
- Risk and reliability
- Resilience engineering
- Human factors
- Economic and railway system modelling
- Hardware-in-the-loop
- Fluid dynamics
- High voltage

### Centre locations

- 📍 University of Southampton (lead)
- 📍 Heriot-Watt University, Edinburgh
- 📍 University of Loughborough
- 📍 University of Nottingham
- 📍 University of Sheffield



*“Our facilities at Southampton are compact enough to be agile, versatile and affordable, but large enough to be able to carry out meaningful tests on significant elements of railway infrastructure. They underpin our core philosophy, which is to develop engineering interventions, innovations and enhancements in hardware and processes that are based on fundamental scientific principles and a sound understanding thereof.”*



**William Powrie**, Professor of Geotechnical Engineering, University of Southampton, and Centre of Excellence in Infrastructure Lead

## National Infrastructure Laboratory

University of Southampton

The National Infrastructure Laboratory at Southampton, a new £46 million facility which opened in September 2019, is a major national resource for research into geomechanics, structures, energy and soil mechanics. It houses a new 3m radius, 150 g-tonne centrifuge and a 30m by 15m strong floor on which a range of large scale, highly accurate structural tests can be performed. Its capabilities include facilities for accelerated testing of full-scale sleeper/pad/ballast/subgrade combinations, fully equipped geotechnical laboratories for advanced characterisation of soils and granular materials, materials testing and composite manufacturing laboratories, and world-leading instrumentation and measurement techniques for use in the laboratory and on the live railway.

Associated facilities at Southampton include hydraulics laboratories such as wind tunnels, flumes and a 138m towing tank; high voltage laboratories; advanced x-ray computed tomography systems including large high energy; anechoic and reverberant acoustic chambers and full-size test track for noise and vibration research; advanced tribology; human factors laboratories; prototyping workshops including state-of-the-art 3D metal printing; and significant numerical modelling capability supported by one of the largest university-based supercomputers in the UK. The National Infrastructure Laboratory specifically offers access arrangements for third party researchers. As well as access to world-leading researchers, skilled experimentalists and technical support, it has collaborative desk and meeting spaces for the use of visitors.

# Railway Innovation and Technology Centre

University of Sheffield

The Railway Innovation and Technology Centre at Sheffield undertakes research across a broad spectrum of areas. These include: rail materials and support, new materials and friction management at the rail-wheel interface, power supply infrastructure including overhead line dynamics, and energy storage technology, drainage, platform-train interface and station design for safety, security and enhanced capacity. New investment will enable testing of full sized, unmodified components in real or simulated service conditions in order to reach readiness for deployment. UKRRIN will support purchase of two new twin disc machines at different scales, a high-speed grinding rig, portable rail surface analysis kit and digital image correlation equipment. This will complement and leverage investment by EPSRC and others in Sheffield's new Laboratory for Verification and Validation, a structural dynamics facility featuring a 90m<sup>2</sup> test chamber with control of mechanical, temperature, humidity and wind load on structures.

*“Sheffield’s research support for the railway industry spans a range of academic disciplines, benefiting from world leading expertise in the University’s Faculty of Engineering and Management School. The distributed multi-disciplinary nature of this activity is a significant strength at Sheffield, giving access to a wide range of facilities and expertise.”*



**David Fletcher**, Professor of Railway Engineering, University of Sheffield

*“Settlement of substructure is the main cause of track deterioration and the Heriot-Watt University test facilities help identify how we can address this by accelerated testing. Years of train passages can be simulated in a matter of days.”*

**Omar Laghrouche**, Director of Institute for Infrastructure and Environment, Heriot-Watt University



## Track Infrastructure Research Centre

Heriot-Watt University

Heriot-Watt University focuses on testing track infrastructure, using leading experimental facilities and numerical modelling. Key facilities are the largest of their kind in the UK which are a multi-sleeper full-scale cyclic testing rig for accelerated testing of railway track systems called GRAFT (Geo-pavement and Railways Accelerated Fatigue Testing) facility and a true triaxial test apparatus, capable of simulating complex 3D stress patterns in track materials. These purpose-built facilities and many other full-scale facilities are to test and characterise the short-term and long-term performance (i.e. settlement) of railway track components and infrastructure.



# Control, Mechatronics & ‘Hardware-in-the-loop’ (HiL)

Loughborough University

The Loughborough team brings expertise and capability in control, mechatronics and HiL that does not exist as a primary skill elsewhere in the Network. As part of UKRRIN the aim is to build upon existing capability focused around a ‘full system’ to establish a hardware-in-the-loop laboratory for rail that will be unique in Europe. The capability is focused around a ‘full system’ simulation model and bridges the Infrastructure and Rolling Stock Centres of Excellence. Among other things, it will be available to the CEI for mechatronic switch demonstrators and other advanced vehicle-track interaction concepts.



*“Hardware in the Loop is an excellent means to enable low cost, low risk, accelerated testing of new and innovative concepts”*



**Chris Ward**, Senior Lecturer in Control Systems Engineering, Loughborough University

# Infrastructure Research

## University of Nottingham

Nottingham's railway infrastructure research is carried out across several research groups including Resilience Engineering, Asset Management, Human Factors, Geospatial Engineering, Transport Engineering, Structures and Geotechnics. Key capabilities include: infrastructure asset management, risk and reliability engineering, resilience engineering, networked system complexity, disruption management for the railways, human factors and culture change in autonomous railways, electromagnetic compatibility, wireless communications, stress analysis and mechanics of composite materials, intelligent mobility - positioning and navigation technology, railway trackbed – materials, design & maintenance.

Key facilities include a full-scale ballast test facility and a 50 g-tonne, 2m radius geotechnical centrifuge used to study railway embankment stability.



*“UKRRIN unlocks the opportunity for collaboration between Universities specialising in different areas of railway research”*



**John Andrews**, Professor of Infrastructure Asset Management, Faculty of Engineering, University of Nottingham



# Industrial Partner Testimonial

## Pandrol

“Pandrol have used the opportunity created by UKRRIN to access specialist knowledge and test equipment at the Institute of Sound and Vibration Research in Southampton. The challenge was to investigate how our rail fastening baseplates can be configured to optimise (that is, reduce to a minimum) the wayside airborne noise along track where these are installed, without adversely affecting the baseplate’s capability in reducing transmitted ground vibration. This is a new area of interest. The previous state of the art could be broadly summarised as that you have to choose between controlling noise, or vibration, or to pick a compromise that was adequate in both respects but less than optimal in either.

There are significant advantages to Pandrol in this competitive market sector both in developing the hardware solutions themselves, and also in demonstrating that we have the expertise to develop them. This capability comes about largely through working closely with ISVR on the project. Some initial results from the programme will be presented at the forthcoming International Workshop on Railway Noise in a joint paper between ISVR and Pandrol.”



**Steve Cox**, Pandrol



## Benefits of Collaborating

- ✓ The Centre supports UK industry in developing innovative solutions to improve the performance, efficiency and reliability of the railway network.
- ✓ The Centre saves industry time and effort in finding specific expertise.
- ✓ The Centre provides some of the leading and most up-to-date test facilities anywhere in the world, and access to a broad base of internationally recognised scientists and engineers with significant experience in the rail industry.

## Case Study



### Performance of a cast iron bridge girder reinforced with carbon fibre polymer

Network Rail has some 680 cast iron and 5600 wrought iron bridges and many steel bridges. Over the last 20 years, carbon fibre reinforced polymer (CFRP) composites have been used to reinforce them. The design justification has been largely theoretical with limited testing of small-scale specimens. Older structures present further problems because of their metallurgy and their methods of manufacture. A bridge demolition in Scotland presented a unique opportunity to quantify the benefits of reinforcement at full scale.

Two 9m long, 160-year-old cast iron girders were rescued almost intact from a demolished bridge. They had been reinforced 14 years earlier with carbon fibre polymer composite, but one was effectively unreinforced because the CFRP was damaged.

The reinforced girder carried 43.9% more load and was 30.7% stiffer than the unreinforced girder. These results confirm that CFRP strengthening is a viable process for strengthening cast iron (and by extension also wrought iron and steel).



### Benefits to the rail industry/findings from the research

- ✓ The testing confirmed that CFRP strengthening/stiffening of metallic structural members is a viable technique.
- ✓ The effect of reinforcement has been quantified.

### Next steps for research

- The condition of similar beams in service is bound to be variable, so further tests on beams as and when they are available would prove and refine the results, allowing better estimates of residual life and more cost effective, targeted interventions.



## NOTES

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## Contact us

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