

## **RRUK DTA PhD Studentships in Railway Research – Summer 2009**

### **GUIDELINES FOR APPLICANTS**

Rail Research UK (RRUK) invites well-qualified graduates who meet the relevant eligibility criteria to apply for a **fully funded studentship** that will allow them to pursue research leading to the award of a PhD.

RRUK, the universities' centre for railway systems research, is a virtual centre established by EPSRC in May 2003. It consists of a core of thirteen research groups from nine universities who support the UK railway industry by providing a focal point for university based world-class research.

Each project is based at one of the consortium's member institutions. Applications should be made to the relevant university; successful applicants will become registered students of that university. An application form from that university must be requested, and submitted in the usual manner. For each project, contact details are given for the supervisor(s), and applicants may find it helpful to discuss the project with the supervisor(s) before making an application. Studentships will be awarded on a competitive basis.

If you make an application, please send a covering letter explaining why you think you would be suitable for the position in question. Please also send a CV.

If you intend to apply, please contact the project supervisor to make yourself known to them.

Applicants who are offered a place by one of the consortium universities are **NOT** guaranteed a funded studentship. Acceptance by a university only means that the applicant will be eligible to be considered for a studentship.

**The studentships on offer are part-funded from EPSRC DTG funds, and as such the following rules apply with respect to eligibility:**

*The part-studentships on offer come from EPSRC DTG funds, and as such the following rules apply with respect to eligibility:*

*Existing criteria on residence and qualifications, based on the Education (Fees and Awards) Regulations 1997, and subsequent amendments continue to apply. An equivalent set of regulations exist for Scotland. This means that a student must demonstrate a relevant connection with the UK (usually established by being ordinarily resident for a period of 3 years immediately prior to the date of application for an award) to be eligible for stipend from a DTG.*

*Students with a relevant connection to an EU country other than the UK continue to be eligible for fees only. Since no stipend is payable, all the fees must be paid from the DTA. However, an EU candidate may be eligible for a full award if a relevant connection with the UK has been established. A relevant connection may be established if an EU national has been in full time education in the UK throughout the three years preceding the start date of the course.*

*If a student does not have a relevant connection with an EU country they will not be eligible for funding from a DTG. Nationality or country of origin is not a criterion for eligibility. Meeting the residence requirement as set out in the Education (Fees and Awards) Regulations 1997 is the test of eligibility.*

In each case, please contact the institution to which you would like to apply to establish your eligibility and fees status.

**Closing date: Friday 28<sup>th</sup> August 2009**

**RRUK DTA PhD Projects – Summer 2009**

<b>No.</b>	<b>Title</b>	<b>University</b>	<b>Supervisor</b>
1	Culture in the railway	University of Nottingham	Wilson
2	Development of GPGPU Algorithms for Analysis of the Wheel-Rail Interface	University of Newcastle	Franklin
3	Enhanced safety and reliability for trains through fault tolerant control	University of Salford	Mei
4	GPR testing of railway trackbed to quantify ballast fouling	University of Edinburgh	Forde
5	Interface design for future UK high-speed rail operations: delivering a user-centred solution	Brunel University	Young
6	Modeling the ACFM response of rails and wheels containing defects	University of Birmingham	Davis
7	National Rail Freight Movement in Great Britain - Lingered Death or Imminent Recovery?	University of Birmingham	Tobias
8	Optimising mental workload for train drivers and signallers	Brunel University	Young
9	Passenger discomfort caused by multi-axis low frequency vibration	University of Southampton	Griffin
10	Prediction of wheelset damage and maintenance costs	Manchester Metropolitan University	Bevan
11	Sensor system optimisation for monitoring and control of railway vehicles	Loughborough University	Dixon
12	The effect of high speed trains on the stability of ballast	University of Southampton or University of Birmingham	Baker / Powrie / Priest
13	The whole passenger journey	University of Nottingham	Wilson
14	Understanding the growth of cracks in new grades of railway rail steel	University of Sheffield	Fletcher

## **1, Culture in the railway**

Institution at which award will be tenable: **University of Nottingham**

Department/School: **Department of Mechanical, Materials and Manufacturing Engineering**

Research Group: **Human Factors Research Group**

Supervisor: **Professor John R Wilson** (with colleagues drawn from Assoc Professor Sarah Sharples, Dr Alex Stedmon, Dr Brendan Ryan, Dr David Golightly)

Supervisor contact details:

**Prof John Wilson**

**Dept of M3**

**University of Nottingham**

**Nottingham NG7 2RD**

**07780 610973**

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Where to request an application form or URL for online applications:

**In the first instance, email and CV to [john.wilson@nottingham.ac.uk](mailto:john.wilson@nottingham.ac.uk), subject marked RRUUK studentship.**

### **Project Outline:**

Until the past few years the railway industry in the UK has tended to see difficulties and need for improvements as being solved largely through new technical systems and operating procedures and safety rules. Now though there is a recognition that organisational culture and the behaviours that it produces are of vital importance. This message is coming from a top level in, for instance, Network Rail, and is of course recognised by RSSB. Whilst the issue of culture is probably considered most in terms of safety culture, and the relationship of this to safe behaviours and performance and to the commission of violations, there is also a much wider interest in organisational culture. In particular at the moment this will be central to achieve the Transformation Programme in Network Rail, through development of consistent and appropriate understandings, expectations and behaviours throughout the management and workforce chain.

Culture, in terms of the types of people needed and the roles they will fill, is also central to systems change. Companies and cross-industry projects are working to further develop and implement new traffic management and related systems for network operations and new approaches to planning for and managing the assets. When successfully implemented, these changes will have a profound effect on the types, knowledge and skills of people needed to make it all work. Therefore the jobs, teams and functions, and particularly the roles and responsibilities of the future, must be planned, assessed and designed alongside design of the technical and organisational systems and the work processes, and within a changed culture.

This project will work closely within the rail industry, following the participant observation approach used very successfully on over 10 other rail human factors PhDs at Nottingham. A socio-technical systems design framework will be used to examine rationally the need for technical and organisational (and cultural) change to be proposed and take place jointly. Methods and approaches based on interview, participant observation, debriefing, subject matter expert enquiry, structured workshops, scenario building and socio-cognitive work analysis will be adapted to investigate and assess culture and its various manifestations currently (across companies, rail sectors and regions and routes) and to propose good future structures and practice. Tools and guidance will be produced of practical use to the rail industry. Connections in, for example, the air traffic control domain will be used to test approaches and outcomes across domains.

Both Network Rail through its Ergonomics National Specialist Team and RSSB through its Human Factors Team have a strong interest in the work and potential outcomes of this proposed PhD project. They will collaborate with us in ensuring that it is embedded in real industry needs as well as in providing access to contacts, information, sites etc.

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## **2, Development of GPGPU Algorithms for Analysis of the Wheel-Rail Interface**

Institution at which award will be tenable: **University of Newcastle upon Tyne**

Department/School: **School of Mechanical and Systems Engineering**

Research Group: **NewRail**

Supervisor: **Dr Francis J. Franklin**

Supervisor contact details:

**Dr Francis J. Franklin**

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Where to request an application form or URL for online applications:

<http://www.ncl.ac.uk/postgraduate/apply/>

**Project Outline:**

Between 1995 and 2005, processor speed in desktop computers increased by a factor of 10. Processor speeds have since levelled out, with a typical top-end system having a speed of 3GHz. While adding extra processors like this adds to the capability of a computer, software needs to be written to take advantage of it. Another area where the parallel processing capabilities of desktop computers has increased phenomenally is graphics processors, which have evolved rapidly into independent computer systems with hundreds of processing cores working simultaneously. This is a massive computing resource that today's programmers are only just beginning to explore using the CUDA and OpenCL GPGPU programming environments.

The research aim is to harness this emerging technology to model two aspects of wheel-rail interface:

(1) Visualization and manipulation of large 3D microstructural models to simulate crack initiation in plastically deforming rails.

(2) Use of Fast Fourier Transforms, Fast Wavelet Transforms and pattern recognition methods for intelligent real-time analysis of high-frequency condition monitoring data to study wheel-rail contact forces.

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### **3, Enhanced safety and reliability for trains through fault tolerant control**

Institution at which award will be tenable: **Salford University**  
Department/School: **School of Computing, Science and Engineering**  
Research Group: **Control and Systems Engineering (CASE) Centre**  
Supervisor: **Professor T X Mei**

Supervisor contact details:

**Professor T X Mei**  
**School of Computing, Science and Engineering**  
**Salford University**  
**Salford M5 4WT**  
**Tel - 0161 2953715**  
**Email – [t.x.mei@salford.ac.uk](mailto:t.x.mei@salford.ac.uk)**  
**Web - <http://www.control-engineering.co.uk/>**

Where to request an application form:

**Prof T X Mei (contact details as above)**

**Project Outline:**

Active controls for railway vehicles can provide much better performance, improve operation efficiency and reduce track damages. However the introduction of additional control system and associated electronics into the traditional mechanical system will have to meet the demanding requirements for safety and reliability in rail industry.

This project seeks to investigate fault tolerant control methods that will be able to ensure the safety and improve the overall reliability of rail vehicles, paving the way for an increased industrial acceptance and a wider application and for advanced active systems. One of the main objectives is to develop practical solutions that do not demand a high level of redundancy and hence reduce the system costs.

The project will be a natural follow up of the leading research work at Salford University in the areas of high-integrity actuation and fault detection methods, and expand the work for railway applications. The research work will include studies into:

- Modelling and simulation of vehicle dynamics and train-track interactions, primarily using Matlab/Simulink
- Establish in-depth understanding of active control systems. A particular emphasis will be on active primary suspensions, although tilting and active secondary suspensions will also be studied.

- Develop fault tolerant electrical architectures suitable for railway applications in terms of system integrity, performance and costs etc
- Development of fault detection and isolation methods and fault tolerant algorithms to take into consideration of different fault conditions.
- Evaluation of the control algorithms through both comprehensive computer simulation and experimental studies. For the latter, a hardware-in-the-loop control system is available at Salford.
- Disseminations of the research findings

Potential Candidate: This project provides an excellent opportunity to carry out a world leading research project and would be particularly suitable for a candidate with a strong interest in one or more of the following subjects – control engineering, mechatronics, vehicle dynamics, or railway engineering.

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#### **4, GPR testing of railway trackbed to quantify ballast fouling**

Institution at which award will be tenable: **University of Edinburgh (UoE)**

Department/School: **School of Engineering**

Research Group: **NDT Research Group**

Supervisors: **Professor Mike Forde & Dr Antonis Giannopoulos, UoE, Dr Peter Woodward, Heriot-Watt University**

Supervisor contact details:

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**E-mail: [m.forde@ed.ac.uk](mailto:m.forde@ed.ac.uk)**

Where to request an application form or URL for online applications:

**Contact Mike Forde - [m.forde@ed.ac.uk](mailto:m.forde@ed.ac.uk)**

#### **Project Outline:**

The overall aim of this project is to relate advanced non-intrusive Ground Penetrating Radar (GPR) to railway ballast fouling, using novel analysis techniques.

The 10-year old University of Edinburgh trackbed [1] will re-visited and the fouling of the ballast re-calibrated following 10 years of environmental changes, using the Ionescu fouling index [2]. A series of GPR experiments will be undertaken on the trackbed using a range of bowtie antennas from 400 MHz to 2.6 GHz. Scatter analyses of the GPR waveforms will extend beyond the simple time domain velocities of Gallagher et al, 1999 [1] to include area analyses, axis crossing analyses and inflexion point analyses. Preliminary work by the nominated candidate G O'Connor predicted the Ballast Fouling Index – in the best case - with a correlation coefficient greater than 0.9. This was obtained by using a 500 MHz bowtie antenna in the parallel orientation - from undertaking a scan area analysis [3].

Whilst the work looks promising at this embryonic stage, more field analysis is needed using a wider range of antennas than the current GSSI systems. Co-operation with IDS Radar, Pisa is expected – access to their advanced radar system. Cooperation with Zetica Rail Ltd (Dr Asger Eriksen) will provide access to their “Zetica Advanced Rail Radar” and their large railway trackbed test site. Radar modelling will be undertaken using Dr Giannopoulos’ GprMax software ([www.gprmax.org](http://www.gprmax.org)).

[1] Gallagher, G. P., Leiper, Q., Clark, M., & Forde, M. C. (2000, February). Ballast Evaluation Using Ground Penetrating Radar. *Railway Gazette International*, pp. 101-102.

[2] Ionescu, D (2004) Ballast degradation and measurement of ballast fouling, *Railway Engineering-2004*, London, Engineering Technics Press, CD-Rom, ISBN 09-47644-55-5

[3] De Bold, R, Morrissey, JP, O' Connor, G & Forde, MC (2009) Aspects of GPR testing of a mixed railway trackbed, *Railway Engineering-2009, Proc 10th Int Conf.*, University of Westminster, London, June 2009, Engineering Technics Press, UK, CD-Rom, ISBN 09-47644-65-2

Industrial Collaboration: Network Rail (John Amore); Holequest Ltd, Galashiels (AJ Batchelor); IDS Radar, Pisa, Italy; Zetica Rail Ltd (Dr Asger Eriksen); GSSI, Salem, NH, USA (Dr A Kathage).

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## **5, Interface design for future UK high-speed rail operations: delivering a user-centred solution**

Institution at which award will be tenable: **Brunel University**  
Department/School: **School of Engineering & Design**  
Research Group: **Human-Centred Design Institute**  
Supervisor: **Dr Mark Young**

Supervisor contact details:

**Dr Mark Young**  
**Tel 01895 266527**  
**Fax 01895 269763**  
**E-mail [m.young@brunel.ac.uk](mailto:m.young@brunel.ac.uk)**

Where to request an application form or URL for online applications:

**Dr Mark Young – contact details above.**

### **Project Outline:**

On the UK rail network, train drivers have traditionally navigated by route knowledge – processing information from trackside signals and familiar landmarks in order to judge braking points and speed profiles. In practice, drivers have to rely on their own expert knowledge in order to maintain performance, increasing their cognitive workload and the concomitant chances of error. Meanwhile, human factors development of the signaller's interface for current and future systems has been relatively neglected in comparison to work focussing on the train cab. To take a true human factors integration approach would involve a bottom-up analysis of future signallers' tasks and requirements, and specification of a complementary interface for signalling operations.

Supporting decision-making by providing predictive information about optimal trajectories and control actions would help promote anticipatory over expectative actions, and assist both drivers and signallers by readily balancing safety and performance goals. Such features are standard interface devices in analogous domains (e.g., maritime navigation, aviation, process control), but are yet to be exploited in rail systems. This project focuses on delivering an enhanced and validated driver's interface, building on previous work in this area. The same model can be adapted to investigate signalling interfaces – although with less prior foundation in this area, the outputs would more likely be development work rather than finished products.

The work would involve three main phases: design – using driver/signaller models and existing research tools to design new enhanced displays; development – prototyping a robust and customisable simulated interface; and evaluation – via empirical testing of the alternative display configurations, using both performance criteria (speed-error, time-keeping, ride quality, fuel use, etc.) and assessment of processing demands (fatigue, workload, etc.) with the Brunel University train driving simulator.

The Human-Centred Design Institute has good links with key players in the rail industry, such as RSSB and Network Rail, and there is every potential to collaborate on this project.

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## **6, Modeling the ACFM response of rails and wheels containing defects**

Institution at which award will be tenable: **University of Birmingham**  
Department/School: **School of Metallurgy and Materials**  
Research Group: **Birmingham Centre for Railway Research and Education**  
Supervisors: **Dr Claire Davis and Dr Clive Roberts**

Supervisor contact details:

**Dr Claire Davis,**  
**School of Metallurgy and Materials,**  
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Where to request an application form or URL for online applications: **On-line applications forms for postgraduate places can be obtained from <http://www.postgraduate.bham.ac.uk/>**

**Project Outline:**

The rail networks across Europe are getting busier with trains traveling at higher speeds, carrying more passengers and heavier axle loads than ever before. The combination of these factors has put considerable pressure on the existing infrastructure, leading to increased demands in inspection and maintenance of rail assets. The rails and railway vehicle wheels both experience wear (resulting in loss of profile) and fatigue (resulting in cracking). One area of concern is the generation of rolling contact fatigue (RCF) cracks in the rails and wheel and the need for early detection. There are a number of non-destructive testing (NDT) techniques used in the rail industry for off-line and on-line (low and high speed) assessment of the steel rails and railway vehicle wheel-sets, including ultrasonics and eddy currents. This project will investigate the use of a different system, alternating current field measurement (ACFM), for defect inspection in both rails and wheel-sets.

RCF cracks in rails and wheel are complex in shape and linking the ACFM signal to the various defect sizes and shapes requires computer modeling. The research team at the University of Birmingham has built up considerable expertise in understanding RCF crack growth, and hence geometries, and practical ACFM measurements. This project will link the two research areas through computer modeling.

The project will involve experimental measurements of real and artificial defects using laboratory test rigs and field-testing using an ACFM sensor. Existing data on crack shapes and sizes, coupled to ACFM measurements, will be provided based on the existing catalogue of rails and railway wheels with defects held in the group. Computer modeling (using COMSOL) will form a substantial part of the project work, with the successful candidate working alongside established researchers with relevant expertise. The computer modeling will investigate the relationship between sensor outputs, the complex geometry of the target components and the numerous defect geometries.

Collaboration with partners across the EU on NDT of railway wheels and rails via existing EU projects is envisaged for the successful candidate.

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**7, National Rail Freight Movement in Great Britain - Lingering Death or Imminent Recovery?**

University: **University of Birmingham**

Department: **Engineering**

Research Group: **Railway Research Centre**

Supervisor Name and E-mail: **Dr Andrew M Tobias – [A.M.Tobias@bham.ac.uk](mailto:A.M.Tobias@bham.ac.uk)**

Where to request an application form or URL for online applications: **On-line applications forms for postgraduate places can be obtained from <http://www.postgraduate.bham.ac.uk/>**

**Project Outline:**

In 2005 the amount of freight moved by rail in the UK reached 22 billion tonne kilometre per year. But this was still far from the level of 1953 (37 billion tonne km) and an increase of only 21.5% compared with 2000, well short of the growth rate required to achieve 80% by 2010 as set in the Transport Ten Year Plan (2000). Forecasts in Network Rail's Strategic Business Plan (2006) now suggest only 48% by 2014 and 69% by 2030. Using data from National Trends Yearbooks and Transport Statistics for Great Britain etc, the aim will be to assess what needs to happen if such targets are to be achieved even in the next fifty years. Are they compatible with the contemporary emphasis on high speed travel between the centres of our major cities? Given the recent decoupling of freight from GDP, how else can it be forecasted? Is there a better measure of rail freight industry performance than freight moved?

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**8, Optimising mental workload for train drivers and signallers**

Institution at which award will be tenable: **Brunel University**

Department/School: **School of Engineering & Design**

Research Group: **Human-Centred Design Institute**

Supervisor: **Dr Mark Young**

Supervisor contact details:

**Dr Mark Young**

Tel 01895 266527  
Fax 01895 269763  
E-mail [m.young@brunel.ac.uk](mailto:m.young@brunel.ac.uk)

Where to request an application form or URL for online applications:  
**Dr Mark Young – contact details above.**

#### **Project Outline:**

Both train driving and rail signalling are complex activities, involving intricate psychomotor skills and drawing heavily on human cognitive abilities such as perception, attention and memory. Ironically, each of these tasks has the potential to impose either overload (e.g., at busy station throats) or underload (on long intercity journeys). Both extremes are equally detrimental to performance, so managing mental workload (MWL) is crucial to optimising performance and safety on the rail network. Yet too little is currently known about the factors influencing mental workload in an operational context, nor about how this may change in the future with the introduction of advanced automatic protection systems such as ERTMS. This project seeks to identify MWL problems in train driving and/or signalling, and propose solutions for job or equipment design to optimise MWL and performance.

Young et al. (2006) warned that MWL would be a major human factors problem with ERTMS, building on groundwork conducted by RSSB (2004). Moreover, there is recognition in the industry that the balance of research and development in this area neglects the signalling task, leaving a significant research gap to be filled. This project aims to measure MWL in a range of scenarios, both current and future (i.e., ERTMS), in order to determine optimal levels of MWL to maintain performance. Its ultimate goal is to attempt a definition of 'redline' thresholds for overload and underload, and identify implications for future system design and performance.

A combination of analytical, fieldwork and lab-based measures will be used. Task analyses of train driving for both conventional and ERTMS operation have already been conducted (RSSB, 2004), and the first step will be to validate and develop these where necessary, as well as to identify or develop similar models for signalling. Field observations, interviews and questionnaire studies will flesh out existing models of MWL using recently developed metrics (e.g., Pickup et al., 2005). Finally, the Brunel Train Driving Simulator can be used to create scenarios for driving with or without ERTMS in order to test MWL demands in a safe and controllable manner.

The Human-Centred Design Institute has good links with key players in the rail industry, such as RSSB and Network Rail, and there is every potential to collaborate on this project.

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## **9, Passenger discomfort caused by multi-axis low frequency vibration**

Institution at which award will be tenable: **University of Southampton**  
Department/School: **ISVR**  
Research Group: **Human Factors Research Unit**  
Supervisors: **Professor Michael J Griffin and Dr Miyuki Morioka**

Supervisor contact details:  
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**Institute of Sound and Vibration Research**  
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Where to request an application form or URL for online applications:  
**In the first instance please contact Professor Griffin – E-mail: [M.J.Griffin@soton.ac.uk](mailto:M.J.Griffin@soton.ac.uk)**

#### **Project Outline:**

Understanding of the factors influencing discomfort caused by low frequency vibration has been limited by the unavailability of multi-axis motion simulators suitable for experimental research with human subjects. In consequence, standardised methods of assessing low frequency vibration do not distinguish between the effect of lateral acceleration and the gravitational component that arises from roll through the gravitational

vector. Measurements of lateral acceleration in trains are influenced by both components, yet recent research has shown that at frequencies associated with vehicle suspensions they cause different discomfort.

Definition of problem to be investigated This project will investigate in laboratory experimental studies the separate and combined effects of lateral and roll oscillation on discomfort in the frequency range 0.5 to 10 Hz. These frequencies do not cause motion sickness but are associated with discomfort. The objective of the studies is to develop an improved means of predicting discomfort for these motions that are common in trains.

The Human Factors Research Unit 6-axis simulator will be used to determine the frequency-dependence of discomfort experienced by seated passengers and a means of predicting the discomfort associated with combined lateral and roll oscillation.

The use of laboratory simulation and associated facilities will be provided from within the existing resources of the Human Factors Research Unit in the ISVR.

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## **10, Prediction of wheelset damage and maintenance costs**

Institution: **Manchester Metropolitan University**

Department: **Engineering and Technology**

Research Group: **Rail Technology Unit**

Supervisor: **Dr Adam Bevan / Prof. Simon Iwnicki**

Contact Details: **Tel: 0161 247 6514 / Email: [a.bevan@mmu.ac.uk](mailto:a.bevan@mmu.ac.uk)**

Application Form: **In the first instance please contact Dr Bevan or Prof. Iwnicki.**

### **Project Outline:**

Current research in to the prediction of wheel damage of railway vehicles has concentrated on the modelling of wear and rolling contact fatigue (RCF). Although these two damage modes account for a high proportion of wheel turning undertaken by train operators, a recent review of wheel turning data (undertaken by MMU and the Vehicle/Track System Interface Committee) has indicated a high incidence of other forms of wheel damage which are not accounted for in the current prediction tools. This includes; wheel flats, tread damage (i.e. cavities, spalling and shelling) and wheel out-of-roundness.

Therefore it is proposed that a research project is undertaken to investigate the potential of predicting other forms of wheel damage, with the overall aim of developing a methodology which can be incorporated within the current simulation tools.

Initially the research will build on the current literature review and gap analysis undertaken by MMU project during a recent project for the Rail Safety and Standards Board (RSSB). This review will identify the current tools and methods available for predicting other forms of wheel damage and the feasibility of linking these methods with the current prediction of wear and RCF damage. A survey of the wheelset maintenance costs associated with each damage mode should also be undertaken to identify the potential cost savings that can be achieved by reducing the incidence of different forms of wheelset damage.

The specific objectives of the proposed research are as follows:

- To carry out a literature review and gap analysis in the field of wheelset damage.
- To determine the costs associated with different forms of wheelset damage.
- To propose a methodology for predicting the incidence and intensity of other forms of wheelset damage.
- To develop a tool for the prediction of wheel damage, possibly using a combination of multi-body system simulation, finite element modelling and more specific programs.

The outputs from the research are intended to assist the rail industry in developing optimised wheelset maintenance regimes to reduce whole life costs, which might include:

- Reduction in the costs associated with wheelset maintenance
- Identify areas at risk from increased wheel damage and suggest potential remediation measures.

Potential Collaborators: It is hoped that industrial support may be obtained, possibly in the form of providing data for use within the project. Lucchini UK, RSSB, Wheelset Maintenance Group (WMG) and ATOC have been identified for potential collaboration and will be contacted if a successful candidate is appointed.

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## **11. Sensor system optimisation for monitoring and control of railway vehicles**

Institution at which award will be tenable: **Loughborough University**  
Department/School: **Electronic and Electrical Engineering**  
Research Group: **Control Systems**  
Supervisor: **Roger Dixon (principal) and Roger Goodall (second)**

Supervisor contact details:  
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Where to request an application form or URL for online applications:  
Everything available at: <http://www.lboro.ac.uk/prospectus/pg/essential/forms/index.htm>

### **Project Outline:**

**Background:** Various developments in the industry mean that there will be progressively increasing requirements to measure the dynamic performance of rail vehicles. Partly this will arise as enhanced condition monitoring techniques<sup>1</sup> are investigated, but also there is an emerging interest in active railway suspensions in general and stability and steering control of the wheelsets ("mechatronic" bogies) in particular.

**Problem description:** Sensing for monitoring these two aspects – monitoring and control – are complementary techniques and are therefore worth considering as a pair<sup>2</sup>: monitoring can help to act as a forerunner to full control possibilities, and is probably key to the achievement of practical, high-integrity active suspensions; introducing control implicitly brings the monitoring function via its sensors, and some of the theoretical techniques developed for modern control are important for effective monitoring algorithms. There are always conflicting demands depending upon whether issues such as low adhesion, suspension components or profile geometry sensing are being monitored; similarly control requirements might relate to whether the secondary or primary suspension is being controlled, and also the associated control objective (e.g. ride quality, structural control, curving performance, stability enhancement, etc.). The project is therefore to establish a scientific basis for determining the optimum sensor system (how many? what type? where?) to meet a particular requirement.

### **Research method:**

Step 1: assess a wide range of control and monitoring possibilities to identify both common and distinct sensing requirements

Step 2: identify established processing approaches and techniques that are relevant to the problem – state estimation, data fusion, etc.

Step 3: investigate suitable optimisation methods that can help to determine the optimum sensor configuration (number, technology, location of sensors) to meet a defined set of requirements

Step 4: test the developed optimisation approach using 2 or 3 examples as case studies

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## **12. The effect of high speed trains on the stability of ballast**

Institution at which award will be tenable: **University of Southampton / University of Birmingham**  
Department/School: **School of Civil Engineering and the Environment (Soton) / School of Engineering (Bham)**  
Research Group: **Geomechanics Research Group (Soton) / Railway Research Group (Bham)**

Supervisors and contact details:  
**Professor William Powrie (University of Southampton)**  
Tel : **02380 593214**  
Email : [wp@soton.ac.uk](mailto:wp@soton.ac.uk)

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<sup>1</sup> IET Conference on Railway Condition Monitoring, Derby, 2008. [ISBN 9780863419270]

<sup>2</sup> Bruni, S., Goodall, R.M., Mei, T.X. and Tsunashima, H., "Control and Monitoring for Railway Vehicle Dynamics", Vehicle System Dynamics, 45(7-8), August 2007, pp. 743-779. [ISSN 0042 3114]

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Where to request an application form or URL for online applications:

For online applications: <http://www.soton.ac.uk/postgraduate/pgstudy/howdoiapplypg.html>

For further information and an application pack please contact:

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### **Project Outline:**

**PLEASE NOTE:** THIS PROJECT MAY BE BASED AT EITHER THE UNIVERSITY OF SOUTHAMPTON OR THE UNIVERSITY BIRMINGHAM, WITH A JOINT SUPERVISOR AT THE OTHER INSTITUTION. PLEASE CONTACT US FOR MORE DETAILS.

#### Background:

Traditional railway lines consist of rails and sleepers resting on a coarse granular material, called ballast. The ballast helps to limit the stresses that are transmitted into the underlying soil to prevent excessive deformation of this soil. The particulate nature of the ballast also allows maintenance work to be undertaken, via tamping to realign the track to its correct geometry. The particle size of the ballast and the inherent speeds of train have insured that the ballast is dynamically stable when a train passes.

#### Definition of problem to be investigated:

The introduction of high speed lines within the UK (CTRL) have caused, under certain conditions, ballast particles to become dislodged and jump or bounce during the passage of a train. This causes damage to the rails of the track and to the running gear of these high speed trains, increasing maintenance costs. At present this phenomena and the fundamentals mechanics associated with ballast particles becoming airborne is not fully understood. One possible suggestion is that the ballast can be dislodged due to ground borne vibrations induced by the displacement of the track during a train passage. These loose, vibrating particles are then propelled along the track under the train by aerodynamic forces. The propelled ballast can then dislodge more ballast as it bounces along under the train. At present though the true mechanism for this phenomena is not understood.

#### Outline of method:

Initially a scoping study will be conducted which will include a literature review and a theoretical appraisal of the phenomena to determine the most probable cause of ballast jumping i.e. dynamic excitation of the particles coupled with wind turbulence brought about by the compression of air under the train. A detailed site investigation would be undertaken to measure the dynamic forces induced into the ballast. This would involve the instrumentation of ballast particles to determine the forces that are experienced by individual particles as well as the use of remote video monitoring to visually assess the behaviour of ballast particles during train passages. Sleeper mounted pressure pads would be installed as well as pitot static tubes to measure near ballast flow velocities. Once the physical processes are identified numerical models will be developed. These models will be used to investigate certain attributes of the system, such as the effects of different ballast sizes, frequency of loading, variation in aerodynamic forces, etc.

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## **13. The whole passenger journey**

Institution at which award will be tenable: **University of Nottingham**  
Department/School: **Department of Mechanical, Materials and Manufacturing Engineering**  
Research Group: **Human Factors Research Group**

Supervisor(s): **Professor John R Wilson** (with colleagues drawn from Assoc Professor Sarah Sharples, Dr Alex Stedmon, Dr Brendan Ryan, Dr David Golightly)

Supervisor contact details:

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**Dept of M3**  
**University of Nottingham**  
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**07780 610973**  
[john.wilson@nottingham.ac.uk](mailto:john.wilson@nottingham.ac.uk)

Applications:

**In the first instance, email and CV to [john.wilson@nottingham.ac.uk](mailto:john.wilson@nottingham.ac.uk), subject marked RRUK studentship.**

#### **Project Outline:**

Providing a service to its customers is one of the keys for the Network Rail Transformation Programme, and passengers are a vital stakeholder group in this. Also within its plans for the 2030 railway the “whole passenger journey” was a key element. Within individual projects also we are seeing increased attention paid to the needs of the passenger, from the home, through travel to the station via various transport means, onto ticket purchase, train identification, boarding and alighting. For instance the current ThamesLink project requires that 24 trains per hour can run through the core stations and this will require passengers having excellent information to enable them to locate their trains quickly and easily and also to board and alight much more rapidly than is possible now.

A key part of supporting the passenger in the future will be innovative information systems, particularly use of mobile and personal computing using location aware and widespread communications networks to enable people once they have started the journey to plan and re-plan their travel by train. This has profound implications for physical and cognitive ergonomics design and also design embedded in real engineering and operational systems of the future. Other questions relating to passenger support and behaviour are concerned with crowd flow at and around stations, during normal situations, perturbations and abnormal situations and during emergency including evacuation and security alerts.

This proposed project concerns design of all organisational, architectural, informational and technical systems for passengers. The research will take a human factors perspective but will be informed by input from engineering and operational experts. The approach will be to develop a fundamental understanding of the needs of passengers including developing a series of scenarios and use cases and prototypical “passenger journeys”, similar to those developed in the health service for “patient journeys”. The research will be a mixture of field observation work on current needs and difficulties for passengers, focus groups and interviews about the present and desired future, and substantial work on developing prototypes and testing interfaces to passenger information systems at various key points in the whole journey. Interoperability with other transport modes will also be considered and integration with other partners within RRUK will greatly aid this. Innovative new ways of expressing and structuring user requirements for large distributed complex systems will build on some early work in EU funded projects.

Both Network Rail through its Ergonomics National Specialist Team and RSSB through its Human Factors Team have a strong interest in the work and potential outcomes of this proposed PhD project. They will collaborate with us in ensuring that it is embedded in real industry needs as well as in providing access to contacts, information, sites etc.

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## **14. Understanding the growth of cracks in new grades of railway rail steel**

Institution at which award will be tenable: **University of Sheffield**  
Department/School: **Department of Mechanical Engineering**  
Research Group: **MERail Railway Research Group**  
Supervisor: **Dr David Fletcher**

Supervisor contact details:

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Where to request an application form or URL for online applications:

**<http://www.shef.ac.uk/postgraduate/research/apply/pgrform.html>**

**Online applications should state they are for Mechanical Engineering**

**Application forms are also available from:**

Admissions Office,  
Student Recruitment and Admissions,  
The University of Sheffield,  
9 Northumberland Road,  
Sheffield,  
S10 2TT, UK.

**Project Outline:**

Background: As new grades of railway rail steel are introduced the mechanisms of failure change, and new research is needed to understand why failure happens, and how it might be prevented. This project is an investigation of crack growth in railway rails, considering the mechanical engineering aspects of crack growth (stress analysis, fracture mechanics) and also materials aspects (influence of steel microstructure).

Definition of problem: Rail steels currently being installed in Europe typically have a higher hardness microstructure than those installed 10 to 20 years ago. Experimental testing in the Rail Research UK project has shown differences in the way cracks form in these harder steels compared to older softer steels, indicating that ductile manganese sulphide inclusions (which are always present even in very clean steels) could be important in rail fatigue cracking. This project will study whether defects associated with inclusions could be the cause of larger cracks. It will do this through a fracture mechanics approach to understanding crack growth from inclusions in the steel microstructure, including how inclusion size and shape influence this growth. Input data will come from experimental testing of steels, and analysis of previously tested samples to understand the observed crack growth.

Methods of investigation: Calculation of stress intensity factors and crack growth rates using analytical solutions, finite element or boundary element modelling. Experimental investigation using small-scale lab based tests.

Keywords: rail, fatigue, cracking, fracture mechanics, modelling, experiments, pearlitic steel