

PhD Studentship in Plant and Machinery Safety in Highways Construction – Highways England and Birmingham City University (BCU)

Faculty of Computing, Engineering and the Built Environment, BCU / Health and Safety Division, Highways England

- Location:** BCU, City Centre Campus (Millennium Point) and Highways England offices, Birmingham with potential travel to other sites throughout England
- Bursary:** Up to £17,500 per annum, with a potential incremental annual increase subject to satisfactory performance over a fixed term of up to 42 months
- REF CODE:** All candidates to state that “Highways England - *Eliminating asset and personal risk associated with operating vehicles and construction machinery on highway work sites.*”
- Fees:** All fees are paid.
- URL to apply:** <https://www.bcu.ac.uk/courses/bsbe-research-degrees-phd-2020-21>
- Closing Date:** 12 noon, 30th October 2020
- Interview Date:** November 2020 (exact date to be confirmed)
- Commencement date:** 1st February 2021 (notification to the successful candidate made in December 2020)
- Supervisory team:** **BCU Academic Team:** Professor David J. Edwards, Professor Mark Shelbourn and Dr Christopher Roberts
Highways England Team: Dr Iain Rillie and Mr Stewart Evans.

INTRODUCTION

Highways England (previously known as the Highways Agency) is a government-owned company charged with operating England's motorways and major trunk roads. They exist to connect the country and achieve this by building, operating, maintaining and improving the strategic road network in England so their customers can travel safely and efficiently.

Current levels of investment in road infrastructure in this country have not been seen for a generation. The government's Road Investment Strategy for the first Road Period (known as 'RIS1') from 2015 – 2020 saw £15.2 billion invested to enhance, renew and improve England's motorways and major roads. The ambition for the second Road Period (RIS2) from 2020 – 2025 is even greater, with £27.4 billion to be invested in making England's strategic roads even safer, faster and more reliable, revolutionising the network with innovative design and smart technology whilst minimising impact on those who live alongside it. Fifty major schemes including the Lower Thames Crossing, the A303 around Stonehenge, the A66 from Scotch Corner to Penrith and the A46 around Newark reflect the sheer scale of investment planned to fulfil the government commitment to create a road network that delivers for our customers and the country.

These investments require Highways England to undertake major construction work and maintenance schemes, utilising many hundreds of people who work with, or alongside, works vehicles and construction machinery. This work is carried out both day and night, in all weather conditions and often in close proximity to traffic flowing at high speed.

These conditions create risk of incidents occurring, which can affect peoples' health, safety and wellbeing. Highways England believes passionately that every worker has the right to return home safe and well from their job. This applies to all the people who work to build, operate, maintain and improve the road network and to keep Highways England's customers safe.

Collectively, highway authorities and construction scheme clients like Highways England and the major civil engineering contracting organisations have worked hard, together, to eliminate risk of harm from accidents and incidents. Understanding incidents, including those that involve people working with or alongside vehicles and construction machinery, is key to taking effective action to keep people safe. Yet despite collective best efforts incidents continue to occur and cause harm.

It is essential for Highways England to understand how and why these incidents happen with the aim of initially identifying why incidents happen and so enable design of effective countermeasures, but with the longer term goal of preventing incidents using countermeasures that work holistically with vehicles, people and the working environment to eliminate risk of harm.

Project Summary – *Eliminating asset and personal risk associated with operating vehicles and construction machinery on highway work sites*

Context

Incidents involving construction machinery and vehicles have the potential to cause life-changing injuries to those working with or alongside them. Sadly, these incidents occur regularly within the highways sector and although some do not result in harm to road workers, many do result in serious or in some cases fatal injuries. Such incidents therefore have a huge impact upon the lives of those who work to build, operate and maintain our roads and also our other national linear infrastructure assets.

The incidents also have a huge impact on the work being undertaken to deliver an improved highway network, as each incident rightly results in a safety stand-down, where work stops while investigations are started and safety measures reviewed. This impacts on delivery by delaying completion of work, prolongs the inconvenience experienced by customers using the road and increases the amount that the work will cost.

As a client, Highways England believes that no-one should be harmed while working or travelling on the strategic road network. They want everyone to go home safe and well every day, which means no accidents or incidents that result in harm. Yet incidents involving vehicles and construction machinery continue to occur despite the best efforts of Highways England and members of their supply chain (including contractors, original equipment manufacturers (OEMs) and hirers) to stop them.

The interface between people and vehicles (including mobile plant and construction equipment) has persistently been a cause for concern to clients and contractors alike. In response, a comprehensive range of advanced digital technological solutions have been developed by OEMs and third parties that claim to (and could, in theory) ‘engineer-out’ incident occurrence. Systems have also been created that claim to reliably locate and identify underground and overhead services or structures, to prevent risk of harm from hitting them with plant, whilst others solutions have been developed that utilise wearable technology which claims to monitor personal safety and raise an alarm in the case of unsafe behaviour.

Yet despite such attempts to create machinery and/or site safety systems that are ‘safer by design’, accompanied by proof that these systems work on a technical or functional level, ongoing evidence suggests that the rate of incidents, accidents and fatalities remains fundamentally unchanged and unacceptably high. Accidents continue to happen with life-changing results, despite the efforts of all involved to eliminate or reduce worker risk. Of particular concern is the regularity with which construction machinery strikes underground services and also overhead

services/structures, both of which have a high lethality potential and at the very least cause disruption to power networks and asset damage.

Scope of the research

This research will investigate how to eliminate asset and personal risk associated with operating vehicles and construction machinery on highway work sites, with the aim to determine what changes an amended approach could achieve with regard to safety.

The research work conducted will investigate the socio-technical interfaces that occur between the three elements (environment, vehicles and people) to understand how they interact. This will enable understanding of where weaknesses within these elements and/or in their interactions give rise to safety risks and hence provide understanding of why some risks are realised as accidents or incidents whereas others are not.

With this knowledge, it will be possible to determine why technology-based safety solutions do not appear to be delivering the intended benefit and outcome in these situations. This will then allow Highways England to determine what requirements should be implemented to deliver the intended benefit and outcome, ultimately requiring its supply chain to use techniques and technologies that are proven effective.

This research approach will require seeking the active involvement of members of Highways England's supply chain as well as the use of operational data (qualitative and quantitative) to understand the problem. Hence, participant action research (PAR) will be used to work with supply chain members, in order to understand the underlying strengths and weaknesses of current operational models and to co-develop new evidence-led vehicle, construction machinery and working environment specifications and *modus operandi*.

PAR will triangulate between extant literature, case study evidence gathered from field trials and secondary data (held by Highways England and participating members of the supply chain). An accumulation of evidence accrued and disseminated will be used to propose options for human behavioural change throughout industry, the redesign of project layouts and redesign of functional and ergonomic features inherent within machinery design or retrofit design. These features and options will be tested against pre-defined hypotheses to determine what changes an amended approach could achieve with regard to safety.

This research will provide an evidence base regarding how the three core elements of environment, vehicle and people could be changed such that they can (or should) work together holistically to eliminate worker risk. This will direct development of countermeasures and indicate whether Highways England should change its approach to the elimination of worker risk. It will also ensure that the research results and findings are applied so that the research delivers real-world practicable outcomes that improve safety and so should be widely adopted throughout industry.

THE STUDENTSHIP

The PhD studentship is funded (under a partnership arrangement) by Highways England and the Faculty of Computing, Engineering and the Built Environment, Birmingham City University. The fully funded studentship is for a three-and-a-half-year tenure and provides an excellent opportunity for a self-motivated researcher to work with leading academics and practitioners within the multidisciplinary areas of health, safety and wellbeing related to construction plant, machinery and vehicle operation. Anticipated topics of investigation will include vehicle and construction machinery safety, workforce behavioural safety, operational safety and risk and incident data analysis.

The successful candidates will be based in Birmingham, Britain's second largest city. They will primarily work at Birmingham City University, Millennium Point or (subject to Covid-19 restrictions and gaining appropriate security clearance) at Highways England's Birmingham office (B1 1RN) as required. In addition, there will be a need to visit locations such as construction sites and/or other Highways England offices, depending upon the nature and stage of research work undertaken. Consequently, this studentship will involve field research and collaboration with members of Highways England's supply chain (including civil engineers, plant hire companies, original equipment manufacturers and construction contractors). It will also involve collaboration with Highways England personnel working in the areas of health, safety and wellbeing; behavioural change; operational maintenance; major project delivery, incident data management; and safety standards.

The research required will provide exciting opportunities for the successful candidates who should bring passion to this subject area in order to develop high quality evidence-led research in the important area of health, safety and wellbeing. Subject to success, this research offers the opportunity to gain a PhD in an important, yet highly novel, area with transferrable skills that will enhance the candidates' employability prospects.

APPLICATIONS FOR THE STUDENTSHIP

Highways England and Birmingham City University (BCU) share a common commitment to equality, diversity and inclusion. The opportunity to study for this fully funded PhD at BCU is an open competition; applications are invited from students from all backgrounds and each fully completed application will be assessed solely on merit during the initial review, to ensure equality of opportunity and freedom from discrimination.

We welcome applications from candidates who can provide evidence of the following essential and desirable attributes and requirements:

ESSENTIAL:

Personal attributes

- Interest or involvement in workforce safety, operational safety, or road safety;
- Good self-management and planning skills that make optimum use of time;
- Accountability for own work, learning from mistakes and the work of others;
- Ability to maintain focus on defined goals and persevere, even in the event of failure;
- Enthusiasm for applied scientific research, with considerable self-motivation;
- Attention to detail, taking time, pride and care to deliver scientifically credible research;
- Trustworthy with the ability to engage individuals and industry, and to build trust in others through open and honest dialogue;
- Respect for others, especially those with conflicting or contradictory views or opinions;
- Willingness to listen to alternative arguments and understand opposing hypotheses;

- Ability to work effectively in an interdisciplinary and geographically distributed team; and
- Good communication skills, enabling ideas to be shared via oral, graphical and written channels.

Core academic requirements

- Sufficient academic acumen to support preparation of written materials such as research publications in academic journals, reports to Highways England and working papers;
- Willingness to travel within the UK in support of collaborative discussions with Highways England staff and supply chain and to visit construction sites as required by the research;
- Understanding of qualitative and quantitative analytical techniques and their application to multi-disciplinary research; and
- An appreciation and understanding of statistical and modelling software that can be used to analyse large sets of both quantitative and qualitative data.

Specific academic requirements

- Proven qualification or competence in at least one of the core areas of research and working knowledge of the remaining core area(s) of research. The core areas of research are: construction equipment / vehicle safety; safety behavioural change; operational health, safety and wellbeing;

DESIRABLE:

Personal attributes

- Possession of a driving licence for Category B vehicles (cars) is beneficial, as many construction sites are not easily accessible via public transport.

Academic requirements

- Knowledge of health and safety legislation, regulations, approved codes of practice and other guidance applicable to highway construction;
- Knowledge of the highway construction environment, including the types of vehicles and construction machinery used;
- Knowledge of behavioural or cultural change applied to achieve health, safety and wellbeing improvement in operational high-risk environments;
- Knowledge of operational environments and the challenges associated with working within them to deliver highway schemes;
- Knowledge of relative safety theories, current approaches to achieving safety improvement and contemporary safety management practices;
- Awareness of technology solutions, devices and working practices intended to improve safety for those working with or around construction machinery and vehicles; and
- Experience of working within or with the construction and civil engineering industry.

PACKAGE:

The successful candidate will receive an initial bursary of up to £17,500 per annum, depending on experience. The bursary will be subject to annual review and increment, subject to satisfactory performance.

Additional resources will be available to support the practical aspects of the research work, for example via pilots or trials on the network, with the potential (subject to benefit case approval) for the successful candidate to request funds for attendance at appropriate national or international conference events.

HOW TO APPLY:

Applicants should complete an application form here <https://www.bcu.ac.uk/courses/bsbe-research-degrees-phd-2020-21>

Applicants are invited to explore our webpages to find more information about the course entry requirements (<https://www.bcu.ac.uk/courses/bsbe-research-degrees-phd-2020-21>) and our Research Community (<https://www.bcu.ac.uk/research/our-phds>)

Overseas application must submit a valid International English Language Test System (Academic IELTS) or equivalent, with overall score 6.5 with no band below 6.0 or equivalent (<https://www.bcu.ac.uk/international/your-application/english-language-and-english-tests/accepted-qualifications>)

RECRUITMENT PROCESS:

Applications should be submitted online through BCU's application portal before 12 noon on 30th October 2020. All fully completed applications will be considered.

Following initial review of all fully completed applications, successful candidates will be invited to interview for the studentship. All unsuccessful applicants will be advised in writing; unfortunately we cannot provide feedback on applications that were unsuccessful at the initial review stage.

Competence-based interviews will take place via video conference during November 2020 – dates and venue to be confirmed. Interviews will be conducted by an interview panel drawn from Highways England and BCU. For any candidates with a disability, we will provide reasonable adjustments for the interview to allow full participation in our recruitment interview process.

Candidates will be notified of an interview appointment time via email.

CONTACT DETAILS

For further details on this opportunity please contact:

Telephone: +44 (0)7722 521846 (Professor David J. Edwards, Birmingham City University)

E-mail: david.edwards@bcu.ac.uk; and drdavidedwards@aol.com

Telephone: +44 (0)7803 442278 (Dr Iain Rillie, Highways England)

E-mail: iain.rillie@highwaysengland.co.uk

PhD Studentship in the Predictive Modelling of Safety Risk for Highways Operation – Highways England and Birmingham City University (BCU)

Faculty of Computing, Engineering and the Built Environment, BCU / Health and Safety Division, Highways England

Location:	BCU, City Centre Campus (Millennium Point) and Highways England offices, Birmingham with potential travel to other sites throughout England
Bursary:	Up to £17,500 per annum, with a potential incremental annual increase subject to satisfactory performance over a fixed term of up to 42 months
REF CODE:	TBA – All candidates to state that “ <i>Predictive modelling of accident risk to pre-empt risk through use of combined knowledge of past incidents and current conditions.</i> ”
Fees:	All fees are paid.
URL to apply:	https://www.bcu.ac.uk/courses/bsbe-research-degrees-phd-2020-21
Closing Date:	12 noon, 30 th October 2020
Interview Date:	November 2020 (exact date to be confirmed)
Commencement date:	1 st February 2021 (notification to the successful candidate made in December 2020)
Supervisory team:	BCU Academic Team: Professor David J. Edwards and Dr Yahya Al-Saeed Highways England Team: Dr Iain Rillie and Mr Stewart Evans.

INTRODUCTION

Highways England (previously known as the Highways Agency) is a government-owned company charged with operating England's motorways and major trunk roads. They exist to connect the country and achieve this by building, operating, maintaining and improving the strategic road network in England so their customers can travel safely and efficiently.

Current levels of investment in road infrastructure in this country have not been seen for a generation. The government's Road Investment Strategy for the first Road Period (known as 'RIS1') from 2015 – 2020 saw £15.2 billion invested to enhance, renew and improve England's motorways and major roads. The ambition for the second Road Period (RIS2) from 2020 – 2025 is even greater, with £27.4 billion to be invested in making England's strategic roads even safer, faster and more reliable, revolutionising the network with innovative design and smart technology whilst minimising impact on those who live alongside it. Fifty major schemes including the Lower Thames Crossing, the A303 around Stonehenge, the A66 from Scotch Corner to Penrith and the A46 around Newark reflect the sheer scale of investment planned to fulfil the government commitment to create a road network that delivers for our customers and the country.

These investments require Highways England to undertake major construction work and maintenance schemes, utilising many hundreds of people who work with, or alongside, works vehicles and construction machinery. Once strategic roads have been constructed, Highways England has the responsibility to operate them on behalf of the Secretary of State for Transport. This involves regularly inspecting the roads, directing work to maintain them in good condition as well as managing the traffic and responding to incidents on the roads that affect the expeditious movement of traffic. These operational functions are carried out 24/7/365 by Highways England's Traffic Officer Service on-road and control room staff and teams of highway inspectors.

Operational work is carried out both day and night, in all weather conditions and often in close proximity to traffic flowing at high speed. These conditions create risk of incidents occurring, which can affect peoples' health, safety and wellbeing. Highways England believes passionately that every worker, inspector or traffic officer has the right to return home safe and well from their job. This applies to all the people who work to operate, maintain and improve the road network and keep Highways England's customers safe.

Collectively, highway authorities and construction scheme clients like Highways England and the major civil engineering contracting organisations have worked hard to eliminate risk of harm from accidents and incidents. This has used traditional analytical techniques based on past data, using this to capture lessons-learned and introduce new safety controls to mitigate risks from incidents that have already occurred or risks that are foreseeable. The scale of data available that can advise on safety risk is growing every year, but Highways England is passionately determined to use all its data, knowledge and information as effectively as possible to understand incidents and so take effective action to get people home safe and well.

This ambition is essential for Highways England and indeed other client organisations and their suppliers to understand how and why incidents happen that involve their people. Without this insight it will not be possible to identify what happened, how it happened and so design effective countermeasures. The objective has to be prevention of incidents rather than reaction to them, which directs towards the use of past data, information, knowledge and experience alongside present real-time data to predict incident risk in real time. This would allow incidents to be predicted and hence pre-empted to eliminate risk of harm.

Project Summary - *Predictive modelling of accident risk to pre-empt risk through use of combined knowledge of past incidents and current conditions*

Context

Highways England seeks to become a world class proactive learning organisation that uses all data that are available to it such that it is possible to carry out introspective analysis of activities in real time. The aim is to ensure that the health, safety and wellbeing for employees and others affected by their work activities is assured so everyone goes home safe and well every day. A core part of this is to move from a reactive, historical focus on past incidents leading to post-incident corrective action towards a learning approach that provides for predictive and pre-emptive incident prevention. As an example of this shift to proactive management of safety, Highways England has just launched a set of leading indicators for health, safety and wellbeing, which though still in development, represent a paradigm shift in approach.

As an organisation, Highways England is data-rich; this project will explore how use of the broad range of data sources that are either held by Highways England, held by third parties on behalf of Highways England or are in the public domain can be used to predict and pre-empt undesirable circumstances which may lead to harm. These data must include not just those that relate to safety or risk as there are many other factors which influence risk of harm. To facilitate this transformational process, Highways England needs to better understand previous work undertaken in predictive modelling of safety (and then by agreement health, safety or wellbeing risk), as a tentative first step towards developing a bespoke, interactive and pre-emptive 'early warning' indicator predictive model of risks posed.

Such 'blue skies' research work will also provide a robust basis for evidenced identification of risk areas for improvement on-road and in Highways England premises during work-related activities. Such evidence is essential if the principle of 'do no harm' is to be applied successfully, as a 'black

box' approach to predictive risk intervention may result in increased risk rather than increased safety. This work will therefore demonstrate how sound applied scientific thinking and hypothesis testing can be used to underpin much-needed innovation using predictive modelling to improve health, safety and wellbeing.

Scope of the research

At this early stage of conceptual development, it is envisaged that a broad four-stage process will be undertaken in achieving this work. It is anticipated that while the focus will remain on change that supports improvement in health, safety and wellbeing within Highways England the successful candidate will have some latitude to shape the approach taken during the course of study as the research unfolds.

Stage One will conduct a bibliometric review of extant evidence, including (but not necessarily limited to) literature, practitioner/professional body literature and practitioner/professional experience. This will aim to: i) identify similar studies previously undertaken and critically appraise the success or otherwise of these, with an emphasis on studies in relevant and related fields; and ii) investigate the levels of success of similar predictive and classification modelling approaches (applied within safety literature or related topics).

The outcome of Stage One will be quantification of feasibility for developing a predictive model for operational risk, along with suggested proof of concept model parameters to be included in a predictive risk model.

Stage Two will match the parameter list identified in Stage One with available sources of internal, third party and public domain data available for use in a predictive or classification model. This will be supported by other work being carried out within Highways England around data use which will advise the available data for this work and its quality. Using these data along with the previous research and/or starting from first principles, the research will develop a first-generation prototype model focused on a defined and discrete topic of interest. This topic is anticipated to be operational risk for a defined cohort of Highways England personnel, for example traffic officers or highway inspectors, but will be further elucidated upon by the supervisory team subject to data availability.

The outcome of Stage Two will be the first-generation prototype model, together with the underpinning research that demonstrates the validity and robustness of the proposed approach.

Stage Three will involve testing the performance of the first-generation prototype model using real-world data and undertaking sensitivity analysis on the model. This will demonstrate whether the new innovative approach produces accurate and valid results that can be used to predict and hence pre-empt potential incidents; secondly it will determine which parameters within the model are of greatest importance and hence most value. Additionally, this Stage should advise what additional parameters could provide greatest value for further functional development of the model and thus are worthy of further investigation / potential integration into a second-generation model.

The outcome of this Stage is evidence of model performance, along with understanding of the value of model inputs in terms of output accuracy and precision, thus directing where further effort should be expended in improving existing or adding new data.

Stage four will explore the development of the first generation model into a prototype real-time risk assessment mechanism, using live data to predict high risk situations. This digital approach to risk assessment will demonstrate as a proof of concept application whether real-time risk

prediction is a viable technique to increase awareness of incident risk, modify personal behaviours to reduce incident likelihood and if so what limitations such a system would face.

The outcome of Stage Four will be a demonstration of whether live data can be used to predict risk using a first- or second-generation predictive model in a way that could be further developed working in partnership with independent programmers or follow-on researchers.

Candidates should note that this proposed work is part of a larger project to deliver improvements in health, safety and wellbeing within Highways England and that other opportunities to extend the project or collaborate with other research groups are likely.

THE STUDENTSHIP

The PhD studentship is funded (under a partnership arrangement) by Highways England and the Faculty of Computing, Engineering and the Built Environment, Birmingham City University. The fully funded studentship is for a three-and-a-half-year tenure and provides an excellent opportunity for a self-motivated researcher to work with leading academics and practitioners within the multidisciplinary area of digital modelling analysis of health, safety and wellbeing. Anticipated topics of investigation will include operational safety and risk, workforce behavioural safety and incident data analysis.

The successful candidates will be based in Birmingham, Britain's second largest city. They will primarily work at Birmingham City University, Millennium Point or (subject to Covid-19 restrictions and gaining appropriate security clearance) at Highways England's Birmingham office as required. In addition, there will be a need to visit locations such as road work and construction sites and/or other Highways England offices, depending upon the nature and stage of research work undertaken. Consequently, this studentship will involve field research and collaboration with members of Highways England's supply chain (including civil engineers, scheme designers and construction contractors) to identify and learn from any similar work in their field of experience. It will also involve collaboration with Highways England personnel working in the areas of health, safety and wellbeing; behavioural change; operational maintenance; asset management; major project delivery, incident data management; and safety standards.

The research work required will provide exciting opportunities for the successful candidates who should bring passion to this subject area in order to develop high quality evidence-led research in the important area of health, safety and wellbeing. Subject to success, this research offers the opportunity to gain a PhD in an important, yet highly novel, area with transferrable skills that will enhance the candidates' employability prospects.

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- Understanding of qualitative and quantitative analytical techniques and their application to multi-disciplinary research; and
- An appreciation and understanding of statistical and modelling software that can be used to analyse large sets of both quantitative and qualitative data.

Specific academic requirements

- Proven qualification or competence in at least one of the core areas of research and working knowledge of the remaining core area(s) of research appropriate to the studentship applied for. These core areas of research are: safety data analysis; qualitative/quantitative modelling; health, safety and wellbeing risk

DESIRABLE:

Personal attributes

- Possession of a driving licence for Category B vehicles (cars) is beneficial, as many construction sites are not easily accessible via public transport.

Specific academic requirements

- Knowledge of pertinent risk management models, algorithms and theories published within scientific literature;
- Knowledge of big data management tools, techniques and basic programming skills;
- Knowledge of computational intelligence techniques and software;
- Knowledge of modern machine learning techniques including deep learning (e.g. Recurrent Neural Networks (RNN) for sequence models)
- Knowledge of bibliometric mapping tools such as Vos Viewer, Gephi, CiteSpace or SciMat;
- Awareness of deterministic modelling validation procedures and processes; and
- Experience of working either within construction and civil engineering industry or information technology sector.

PACKAGE:

The successful candidate will receive an initial bursary of up to £17,500 per annum, depending on experience. The bursary will be subject to annual review and increment, subject to satisfactory performance.

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CONTACT DETAILS

For further details on this opportunity please contact:

Telephone: +44 (0)7722 521846 (Professor David J. Edwards, Birmingham City University)

E-mail: david.edwards@bcu.ac.uk; and/or drdavidedwards@aol.com

Telephone: +44 (0)7803 442278 (Dr Iain Rillie, Highways England)

E-mail: iain.rillie@highwaysengland.co.uk