FUTURE ROADS FELLOWSHIPS (FUTUREROADS)

Call for Applicants

Deadline: 30th September 2022

Photo: Civil Engineering Building, University of Cambridge

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UNIVERSITY OF CAMBRIDGE

CALL FOR APPLICATIONS

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FUTUREROADS-COFUND Marie Skłodowska-Curie Fellowships 2021-2022

The University of Cambridge is pleased to announce that up to 12 Fellowships are available for the second cohort of the FUTUREROADS-COFUND programme. The Future Roads Fellowships Programme (FUTUREROADS) is hosted by the University of Cambridge. The scheme is funded by the European Union's Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie actions (Grant Agreement no 101034337) and cofunded by partners Costain Group Plc and National Highways and industry partners; AECOM Ltd, Amey OW Ltd, Atkins Ltd, Balfour Beatty Civil Engineering Limited, BAM Nuttall Limited, Bentley Systems (UK) Ltd, Keltbray Holdings Limited, L Lynch Plant Hire and Haulage Ltd, Ordnance Survey Ltd, Ramboll U.K., Ringway Infrastructure Services Ltd, SAP (UK) Ltd, Telent Technology Services Ltd, TRL Limited and Cambridge Grapheme Ltd (Versarien).

The programme offers 27 x 36-month fellowships over three recruitment rounds focused primarily in digital twins, smart materials, data science, automation and robotics, and sustainability solutions for the road infrastructure industry. The programme allows applicants to have the freedom to develop their own ideas with access to excellent facilities. FUTUREROADS will enhance fellows' understanding of the methodologies and approaches of other scientific disciplines at the highest level.

The aim is also to establish a multidisciplinary training platform to strengthen researchers' capabilities such that they are capable to work anywhere in Europe and, therefore, attract researchers from around the globe to Europe and contribute to the European goals of increasing the numbers of researchers with innovation skills in Europe.

The programme supports incoming fellowships for postdoctoral researchers on a competitive basis. It aims at high-potential individuals primarily interested in following a career in the transportation infrastructure sector or academia. Awardees will be offered an employment contract with a postdoctoral-level salary and will be entitled to an individual mobility and research budget.

Why apply

The University of Cambridge (UOC) is a collegiate research university in Cambridge, United Kingdom. It was founded in 1209 and is the world's fourth-oldest surviving university. Cambridge is formed from a variety of institutions which include 31 semi-autonomous constituent colleges and over 150 academic departments, faculties and other institutions organised into six schools. UOC provides FUTUREROADS Fellows with a thriving research environment, strong connections to industry and a strong international network. UOC is consistently ranked in the top 10 universities in the world.

The FUTUREROADS programme is for researchers who are looking for an opportunity to pursue research as part of an innovative programme that has international and industry connections. The Fellows will be involved in a unique cohort-oriented programme that is part of a wider initiative at the UOC researching the future of road infrastructure.

Fellows will have access to support via local and international academic supervisors and industry partners. They will have access to career and skills development opportunities as part of the activities directly associated with the FUTURERAODS programme and more widely at the University of Cambridge.

The Fellowship offer

FUTUREROADS offers 36-month fellowships linked to the programme's thematic areas; digital twins, data science, smart materials, automation and robotics, and sustainability, all in the context of the road network. Fellows are offered career development support and training events to develop their non-scientific skills. They are expected to take part in teaching activities at Cambridge and are encouraged to apply for additional competitive funding. The programme is open for all applicants who meet the MSCA mobility rules for fellows.

All Fellows will have their primary base at the Department of Engineering, University of Cambridge. However, they may have supervisors in other disciplines. Fellows also have the opportunity to pursue secondments.

Who can apply

The fellowship is designed to support post-doctoral researchers with up to 2 years of postdoctoral research experience (after completion of the PhD) at the time of applying. Applicants with 3-4 years of postdoctoral research experience will be considered in exceptional cases.

Applicants must comply with the following MSCA mobility rule:

Mobility rule: The researcher must not have resided or carried out his/her main activity (work, studies, etc.) in the host organisation's country for more than twelve months in the three years immediately prior to the call deadline. Make sure you check all specific requirements in the guide for applicants.

How to apply

Applications must be submitted online via the University of Cambridge's job application system at https://www.jobs.cam.ac.uk/.

Applicants can search for the Future Roads Fellowship advertisement (job reference: NM32043) and apply online. The Future Roads website https://drf.eng.cam.ac.uk has a Guide for Applicants – this guide provides essential information about how to correctly supply the required supporting documents for the fellowship posts. Please note that applications that do not meet the criteria regarding mandatory documents will not be considered.

When to apply

The deadline for cohort 2 applications: 23:59pm GMT 30th September 2022

Application timeline for cohort 2:

UNIVERSITY OF CAMBRIDGE

CALL FOR APPLICATIONS

Deadline 30th September 2022

- Opening of call: 1st July 2022
- Deadline for applications: 23:59pm GMT 30th September 2022
- Evaluation period: 11 weeks
- Applicants will receive answers: mid/late December 2022
- Fellowship period begins: April 2023

For more information about the process, guidelines or application system, please get in touch with the Future Roads Programme Managers at DRF-initiative@eng.cam.ac.uk.

Core challenges to be explored by applicants:

1. DIGITAL TWINS Potential applicants should contact the smart materials theme lead, Professor Ioannis Brilakis (ib340@cam.ac.uk), for any queries regarding these challenges.	
What are potential business cases for Highway Digital Twins? As digital twins move from being an experimental concept to a core part of our organisations and societies, it becomes increasingly important to be able to identify ROI and attach value to them. But to realise these values, it is important to see digital twinning as a transformation: people, processes and technology need to be brought together in a holistic manner. And there are numerous hurdles to overcome before this transformation pays off. Therefore, the question arises as to which new business models are needed for the sustainable management of a digital twin. Potential challenges are: - What are potential clients for a Digital Twin? - Why should someone invest in Digital Twins? - What is the return of investment for a Digital Twin? - How to combine businesses (top-down) and technology (bottom-up)? - How to quantify the economic benefits of Digital Twins? - What are suitable financial and business models for Digital Twins? - Who owns the Digital Twin, Data, Models, etc.?	Professor Ioannis Brilakis Industry partner: TRL
How can we build a trustworthy Digital Twin? Digital Twins represent the beginning of a new digital era. With the help of Digital Twin technologies, data is not only collected and analysed automatically but the insights gained are used to control the Physical Twin optimally. To achieve this, novel AI and ML algorithms are being deployed. However, the infrastructure operator is faced with the difficult question of how much trust he can place in the proposed results from the Digital Twin. Frequently, these decisions are associated with high financial costs and, in the worst case, it is a matter of life and death. Accordingly, decisions must be understandable and trustworthy. Which leads to the question, how we can create a trustworthy Digital Twin? Potential challenges are: - How can we trust the analysis and results of a Digital Twin? - How can the results of a Digital Twin be used? - Are provided options and benefits clear? - How to deal with incomplete data?	Professor Ioannis Brilakis Industry Partners: Atkins, OS

How can a Highway Digital Twin evolve over time? The lifespan of infrastructure systems usually extends over several decades. During this period, they must reliably provide the corresponding service. In contrast, digital technology is subject to rapid changes. Technologies that are state-of-the-art today may be obsolete in just a few years. In this area of tension between long-lived infrastructure systems and the rapid development of technology, the question arises of how to design a reliable digital twin that lasts over the lifetime of the infrastructure. This also includes incorporating existing solutions into the design of the Digital Twin to make it backwards compatible. Potential challenges are: - How to future-proof Digital Twins? - How to ensure backwards compatibility? - How to integrate "old" technologies into a Digital Twin environment? - How to deploy a Digital Twin into an existing workflow? - How can a Digital Twin be integrated within existing Software	Professor Ioannis Brilakis Industry Partner: OS
What are the minimum data requirements for a valuable Digital Twin? The idea of a digital twin is based on analysing data from the real world and deriving appropriate courses of action on this basis. This means that a certain amount of data with the corresponding quality forms the basis of a digital twin. The question is, what are the minimum data requirements of a Digital Twin. Or in other words what is the Minimum Viable Product (MVP) of a Digital Twin, which has enough features to attract early-adopter customers and validate a product idea early in the product development cycle. Potential challenges are: - What are unique (data) requirements for Highway Digital Twins? - What data can be shared between different infrastructures Digital Twins (e.g. supply infrastructure)? - What are the standards for Digital Twins? - How to harmonize different Digital Twins? - How to integrate other data sources (e.g. railway, weather, environment data)?	Professor Ioannis Brilakis Industry Partner: OS
2. AUTOMATION & ROBOTICS Potential applicants should contact the automation and robotics theme lead, Professor Fumiya Iida (fi224@cam.ac.uk), for any queries regarding these challenges.	
Safety feedback for autonomous and semi-autonomous heavy machinery usage Operating heavy machinery is stressful and hazardous to operators even if the machine is semi-automated. Detection and prevention of hazardous situations is a challenging task when multiple agents are operating within the same area combined with the uncertainty of human operation. The challenge of this topic is to develop models for these systems and design appropriate sensing technologies that can capture potential hazards and react to them in a safe manner. This investigation includes preliminary lab testing of technological components, prototyping of experimental platforms, and on-site user testing.	Professor Fumiya Iida Industry Partner: BAM Nuttall
Control of multi-agent systems for traffic Management	Professor Fumiya Iida

With the imminent rise of autonomous cars in our highways, new challenges and opportunities are arising for traffic management and maintenance of road infrastructure. This project will investigate the modelling and control of multi-agent systems with partial controllability. The control problems will range from optimal traffic routing, adaptation to traffic blocks, optimal strategies for increasing pavement lifespan, etc. Simulation models will be developed to investigate various control strategies and scenarios. Reinforcement learning will be used to generate the optimal control policies.	Industry partner: Balfour Beatty
Robotic and automated road pavement resurfacing. How can road resurfacing activities be automated and robotised at a commercially viable cost without compromising safety during construction and quality, durability and reliability of the finished road. What underlying conditions (eg data, digital twin models and environmental conditions) are needed to enable such automations. How can road planers, sweepers, pavers and rollers be connected to work seamlessly and autonomously in a continuous flow to maximise productivity. How would other manually operated supporting and enabling activities eg material haulage, deliveries, ironworks, etc be coordinated to work harmoniously alongside the automated activities. How can the plant and equipment be made flexible to operate on different road types and widths?	Professor Fumiya Iida Industry Partner: Ringway
3. SUSTAINABILITY Potential applicants should contact the sustainability theme lead, Dr Kristen MacAskill (kam71@cam.ac.uk), for any queries regarding these sustainability challenges.	
Creating a data model to optimise carbon across the lifecycle of a highway asset. New net zero strategies are shaping planning and operation decisions made by infrastructure asset owners (and their supply chain) towards supporting a lower carbon future. While these plans already specify staged targets, developing transparent and consistently applied protocols for collecting and analysing data to measure progress do not always exist. There are limitations in how the data is collected across projects and how information can be communicated to wider stakeholders in the supply chain. The ambition behind this challenge is to support the creation of a highway-specific data model that solves the business challenges associated with information interoperability throughout the design-to-retire cycle of a motorway/highway and across the value chain (planning, design, construction, operation and maintenance). The underlying aim is to: Enable an efficient, reliable, and secure data collection process along with the ability to ensure user friendly access to the data Facilitate an ability to share sustainability and operational data across stakeholders Ensure compliance with regulatory requirements This would be achieved through developing a model that enables the highway sector's stakeholders to: Assess the environmental impact for scope 1, 2 and 3 emissions Generate regulatory reports Support what-if scenario planning Design maintenance strategies and enable proactive asset interventions Enable operational reviews We encourage applicants to outline how they would respond to this aim. It will be beneficial to demonstrate awareness of current and potential future regulatory requirements for sustainability reporting in the UK, EU and the US.	Dr. Kristen MacAskill Industry Partner: SAP

It is not expected that applicants present a defined solution up-front. Rather, proposals should demonstrate an understanding of relevant concepts and a plan for how a data model might be developed over the course of a fellowship. SAP, a leader in business software and solutions, will provide their expertise in software development to support a Fellow pursuing this challenge.	
How can the sector best manage organisational change to achieve current and future carbon reduction targets effectively and quickly? The highways sector remains relatively traditional in its infrastructure delivery mechanisms covering planning, design, procurement, and construction. It is not generally considered as a leader in technological and organisational innovation. Considering major changes in society that are influencing demands on and expectations of the road network (e.g. population growth, alternative technologies, equity, resource efficiency, climate change), the Future Roads partnership would like to see a shift in the sector's capacity to adapt to new demands. There are emerging solutions to these demands that would help the sector evolve to respond to change. This is being lead via pockets of expertise across the highways sector supply chain. However, there are many barriers to effective adoption. For example, there is a widely held perception that standards are too slow in updating to allow the incorporation of new knowledge and technology. Change is often seen to be in tension with maintenance of safety. The Future Roads partners will support a Future Roads Fellow in exploring this sector ecosystem challenge. Through the partnership network a fellow responding to this challenge will have a unique opportunity to access to stakeholders from across the UK Highways sector to conduct applied research. The ambition is that the fellow will report back to research participants and work directly with partners to develop implementable recommendations and advocate for change. Two key expected outcomes: 1. High quality, publishable research outputs 2. Facilitation of change through engagement with the sector. We welcome proposals that have a primary focus on climate change-related issues, but applicants are welcome to include other considerations. We are keen to see at least one of the following concepts featuring in responses to this challenge: Technological forecasting and social change Business strategy Transition to a sustainable economy Innovation ecosystems Organisational behaviour	Dr. Kristen MacAskill Industry Partner: Keltbray
How to increase national network road capacity without further construction of new roads? At the top of the carbon reduction hierarchy is to 'build nothing', closely followed by 'build less'. At the strategic planning level, an alternative to construction of new lane capacity is to use the existing asset more productively. Increasing the capacity of the existing asset to support more vehicle trips could allow the benefits of a connected country to be achieved in a more construction, and thereby carbon, efficient way. Reduced construction would also support other environmental ambitions. Value for money assessments for new lane capacity schemes currently assume the same flow density and the same peaks for trips for the whole 60 year appraisal period. Confidence that alternative operating models or new	Dr. Kristen MacAskill Industry Partner: Ramboll

<table>
<tr><td>technologies could allow increased flow density could change the value for money case for new lane capacity, and allow a business case to be made for investments to increase capacity that are not traditional civil engineering. Interventions could be targeting behavioural change, be relatively low technology changes to operational procedures or road layouts, or capitalise on digital technologies and connected and autonomous vehicles.
We are keen to see proposals for increasing the productivity of the existing network asset.</td><td></td></tr>
<tr><td colspan="2">4. DATA SCIENCE
Potential applicants should contact the data science theme lead, Professor Sumeetpal S. Singh (sss40@cam.ac.uk), for any queries regarding these challenges.</td></tr>
<tr><td>How can uncertainty quantification be done effectively at scale?

Statistical reasoning about physical engineering systems is essential in this FR endeavour however, even simple uncertainty quantification problems can be very computationally costly. Cloud computing (e.g. Amazon EC2) is an immense resource for Data Science and is potentially an ideally suitable platform for the Machine learning/Bayesian inference algorithms that will be employed to quantify the uncertainty of insights drawn from the noisy and disparate sources of data within the Digital Twin. The pertinent questions are thus how can these algorithms be run effectively at scale, say on the cloud, avoid idling computing resources and deliver timely results via real-time computing budgets? How can these algorithms be designed to be elastic, i.e. seamlessly utilise new computing resources as they come available and be robust to unexpected drop-outs of existing computing resources?</td><td>Professor Sumeetpal S. Singh

Industry Partner: Ramboll</td></tr>
<tr><td>How data can improve safety during Highways Activities?

Highways activities, such as maintenance and replacement, require temporary traffic management. “Live Traffic” delivers real time traffic updates dynamically rerouting vehicles to avoid hold-ups. However, this procedure poses safety risks, such as vehicle incursions into road works. The frequency of Live Traffic is constantly growing, and consequently the safety risks, since the focus of Transportation Authorities is more on updating existing infrastructure than developing new one. The frequency increases even more due to the need for upgrading infrastructure to support electric and autonomous vehicles. The major progress of the last two decades in collecting and processing data, using artificial intelligence, smart materials, automation and robotics, has the potential to significantly improve safety during Highways Activities. The research question is how we can take advantage of data collection and process to improve safety during Highways Activates.</td><td>Professor Sumeetpal S. Singh

Industry Partner: BAM Nuttall</td></tr>
<tr><td>How can we improve Trust in Data and Artificial Intelligence algorithms with highways applications?

Collected data can help us monitor and predict traffic, assets condition and weather. Consequently, there is a great potential to improve highways monitoring, maintenance, traffic delays users’ comfort and safety. However, to what extent do we trust the data, i.e. its veracity, and the results coming from the artificial intelligence algorithms? For instance, road users do not always follow instructions related to the path that they need to follow to reach their destination. Road managers do not completely trust automated techniques for asset condition monitoring and they combine automated with manual monitoring. How can we define trust in data and artificial intelligence? How can we measure it? How can we improve it?</td><td>Professor Sumeetpal S. Singh

Industry Partner: Atkins</td></tr>
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5. SMART MATERIALS Potential applicants should contact the smart materials theme lead, Professor Abir Al-Tabbaa (aa22@eng.cam.ac.uk), for any queries regarding these challenges.	
Nano-inspired Roads: Role of Nanomaterials in the delivery of future roads Nanomaterials and nanotechnology will play a vital role in delivering future smart, sustainable and resilient roads and pavement materials. For example, graphene-asphalt and graphene-concrete composites were recently demonstrated in full-scale field trials as viable pavement materials for significant enhancement of the life of road surfaces. Potential areas for applicants to consider: exploring the potential for graphene in the delivery of low carbon pavement materials, including concrete, asphalt, fibres and other reinforcement, coatings, and road markings; the development of application of graphene-waste composites in pavements to maximise the use of wastes and recycled materials; the development and deployment of 3D printing with graphene, including concrete with graphene reinforcement for tailored applications; graphene for condition sensing in roads; durability enhancement of pavements with graphene, e.g. resistant to chlorides or enhancing the wear performance. How can we accurately quantify the environmental credentials, carbon reductions, cost savings and longevity enhancement of those materials and products? How can such additives and new materials be better integrated into the standards? There is also scope to explore impacts on a project or scheme level and explore refinements to existing life cycle software and commercial carbon calculators.	Professor Abir Al-Tabbaa Industry Partners: Balfour Beatty, Versarien
Maximising road life: Smart materials and sensors to extend the life of existing assets The UK's strategic road network is valued at more than 128 billion pounds, and it is expected that this amount will increase with the majority of the assets still being in service in 2050. The assets that make up the network are ageing and it is now acknowledged that the maintenance and repair of the existing assets (as opposed to demolishing and rebuilding) is the most sustainable approach to maintaining its services. Potential areas for applicants to consider include: can smart materials be developed that can significantly enhance the life of existing assets? Can we deploy sensors to assess the current state of pavements? Can sensor data help us make smarter decisions? Can smart materials and sensors be combined to enable the pavement to report its state of health to help with the proactive maintenance of the assets and lengthen their operating life? Can smart materials inform efficient design, whereby we design with less materials and reduce overdesign in the maintenance of assets? Can we use this body of data to model the performance and deterioration of these materials and, ultimately, their whole life performance to inform intervention needs? Can we capitalise on the sizable body of existing data (owned by National Highways and others) to improve our knowledge of the current state of the assets? Can we employ car sensors, e.g. on Royal mail vehicles, to help in this regard? Can we use sensors and data extracted from sensors to eliminate disruptions and enhance traffic flow? Can we integrate data from multiple sources and produce information and knowledge to inform strategic decisions in terms of cost, carbon and environmental benefits.	Professor Abir Al-Tabbaa Industry Partner: Telent and Galiford Try

Oil-free asphalt for future roads: Sustainable materials for flexible road pavements Asphalt is mainly composed of bitumen mixed with aggregates of crushed stone. Bitumen is a by-product of crude oil distillation and contributes hugely to emissions and environmental impacts. In a future not reliant on fossil fuels, can we develop asphalts from alternatives to crude oil bitumen that deliver the same or better performance? For example, can asphalts be developed from waste biomass, including cooking oils and sewage? Or can they be developed using biopolymers like lignin or alginate? Can these oil-free asphalts have increased resistance to damage and deterioration? Can the chemistry of these oil-free asphalts be tailored to improve their properties and performance? Can the performance of these oil-free asphalts be improved by adding fibres, and can they self-heal? If commercialised, what will the cost be of these oil-free asphalts? Will they be cheaper than current asphalts? What will their whole life performance be? Can we develop suitable accelerated tests to provide confidence on their longevity and performance. What will the material and resource flow for their production look like? How sustainable will they really be? How will they performance in a life cycle analysis look like and what would their end of life look like? Can we balance the environmental impact, cost, performance and longevity? Can we accelerate their adoption into the standards?	Professor Abir Al-Tabbaa Industry Partner: Ringway and Versarien
Zero waste roads: Capitalising on existing pavements and eliminating the mining of natural resources The construction and maintenance of our highways consume huge volumes of natural resources and generate vast quantities of waste. Can future roads use minimal to zero natural resources, and when we maintain and repair existing roads, can the removed material be used as a quarry for these operations? Can we up-cycle "waste" materials, creating roads of higher quality and value? Potential areas for applicants to consider include: the development of additives or rejuvenators to improve the performance and functionality of recycled materials? Can we do all of this on-site, reducing transport costs? Are we able to do this with the currently available technologies? What technologies will be required in the future? How can we address the barriers to the adoption of such materials and products? Can we develop accelerated ageing tests to test these materials and foster adoption? How can those new materials be better integrated into the standards? Can we in addition, use recycled materials, waste-based materials and locally sourced materials, and if so, how much? What and where are the most relevant and compatible national waste streams and where can we simultaneously help solve certain pressing waste and pollution problems? What are the cost, carbon and environmental impacts of such activities and is there a convincing and meaningful business case to make?	Professor Abir Al-Tabbaa Industry Partner: Amey and TRL
Carbon Zero Roads: Decarbonisation of road materials The UK Net Zero Highways document has set a target of net zero for maintenance and construction by 2040. However, current road construction and maintenance projects are far from being carbon neutral, and road materials significantly contribute to carbon emissions. Half of all infrastructure carbon is associated with the maintenance and repair of assets. Can suitable low carbon or ultra-low carbon road materials be designed, validated and rolled out to contribute to carbon reductions in construction and maintenance? Where within the different road materials and components can we make the quickest and largest impact, and how? What are the opportunities for carbon capture and storage/sequestration within the road materials and the wider	Professor Abir Al-Tabbaa Industry Partner: Keltbray and Galiford Try

road infrastructure network materials and assets? Where are the low-hanging fruit in the decarbonisation of road materials, and do they address capital or operational carbon? Can we continue to reduce the carbon footprint of roads throughout their service life? How do we quantify those benefits in whole life carbon calculations and life cycle analyses? Can we develop sufficiently accurate carbon calculators? Can lessons be learnt from existing or past projects? What is the best way to balance cost, carbon and longevity? How can we accelerate the validation of new low carbon materials and products to assist with their implementation into specifications and standards?	
Future-proof roads: Data-driven materials for durable and climate resilient pavements Roads are usually damaged well within their design life. This is highly inefficient and significantly costly, not only financially but also in terms of carbon. With the highly intensive carbon footprint of road materials, an important pathway towards net zero carbon highways would be to maximise the use of more durable pavement materials. The focus of this challenge is on the generation of the much-needed evidence-based relevant data and the creation of suitable data models to enable the assessment, optimisation and integration of durability performance and carbon impact. How can a model be created to optimise carbon across the lifecycle of a highway asset, to understand the carbon impact through the use of more durable materials? We know that data plays a fundamental role in enhancing our understanding of material and structural behaviour, providing knowledge, insights and predictions that were not possible before. How can currently available data, e.g. weather and traffic data, or data generated on-demand, e.g. from road conditions sensors, be used to deliver the data-driven smart pavements of the future that is durable and low carbon? This challenge covers understanding the available road data, material performance and ensuring resilience against future climate- and loading- related actions. How can we design digital roads with materials and sensors that enhance the life span, longevity and durability of this critical infrastructure? How should design specifications be updated for resilience? What will be the most relevant failure criteria to design for in a changing climate? In a changing fleet and increased demand, what are the relevant failure mechanisms and detections for pavements that will impact material durability? We need to understand the modes of failure and the failure mechanisms in different types of physical and digital assets to help us arrive at the mitigation measures and inform maintenance approaches.	Professor Abir Al-Tabbaa Industry Partner: Amey and Telent