national highways

September 2024

The Roads Research Alliance

Annual Report

www.nationalhighways.co.uk

Contents

Foreword

Mike Wilson, Executive Director,
Safety, Engineering and Standards

At National Highways, we know that we need to be laying the groundwork for a future where our roads are safer, more efficient, and more sustainable. We also recognise we have a key role to play in facilitating and driving forward this collective research agenda, to improve operational performance. By working with our academic and industry partners we can build a unique shared perspective that can help inform our respective efforts and deliver better outcomes.

As a sector we know we have to be far better at fostering and adopting innovations to prepare for the future. It is a sign of real progress that as the projects in our initial research portfolio, Future Roads, are starting to mature, they are moving from research towards practical solutions. The long-term impact of the knowledge and recommendations gathered is becoming increasingly evident.

As well as supporting new technologies, the Roads Research Alliance is changing the culture of our industry. We are proud to be building a network where research and collaboration is the main focus, not an addition, and where we are confident about taking risks and pushing boundaries. We hope to be leaders of this approach until it becomes the norm and shapes the roads of the future.

It has been great to see the Roads Research Alliance start to build a bigger profile. Connections are being made between different pieces of research activity and further collaboration has been sparked. Working so closely across our supply chain allows us to ensure our research efforts are best placed across the business.

We have learnt a great deal from the Alliance this year, from the research, and in terms of how to facilitate and manage the Alliance itself. Our industry partner engagement leads have been instrumental in addressing this challenge and I'd like to thank them for providing ideas and constructive feedback on this journey.

Looking ahead, I am excited about further progress in these research projects, realising the value of this activity, and potentially expanding our research portfolio. Your continued support will be crucial to the success of our shared vision.

I would like to thank all our academic and industry research partners for your continued involvement in the Roads Research Alliance this year as we've started to build our portfolio of activities. Likewise, your commitment and support of the Future Roads Fellowship Programme at the University of Cambridge has been invaluable and is starting to produce exciting results.

Executive Summary

The Roads Research Alliance was formally launched as a partnership between academia and industry in 2022. Beginning with the Future Roads Fellowship Programme at the University of Cambridge, the Alliance's purpose has been to collaborate across multiple partners to shape research activity around real industry challenges, to deliver knowledge and insights that can be taken forward by partners, and ultimately deliver better outcomes for the sector.

The Alliance is currently made up of National Highways, the University of Cambridge and 22 industry partners working within the Roads sector. The University of Cambridge received a £2.6m EU Horizon 2020 grant for Marie Skłodowska-Curie Fellowships, which allowed the Future Roads programme to recruit 26 Research Fellows. Of these 26 original Fellows, 20 are currently working on research projects, and 6 are now considered Alumni of the Future Roads Fellowships, working in academia and industry across the globe.

At the beginning of the Future Roads Programme, the industry partners put forward a set of real-world challenges, which were used to advertise the Fellowships and recruit the researchers.

The research projects under the Future Roads Programme are grouped into 5 academic themes, based on this set of key industry challenges.

The Fellows are continuing to collaborate as an academic cohort to develop the synergies between these themes and align their research topics under industry supervision to create greater efficiencies of management effort and output.

The last year has seen numerous academic publications and conferences, cementing the Future Roads Fellows as an impactful community of researchers working for the benefit of the Roads Sector. The industry supervising teams and other technical experts within the partner organisations have had the opportunity to be at the centre of research in Cambridge, with technical training sessions offered by the University in Spring 2024, and other topic-specific workshops taking place.

Alongside this, the Engagement Leads from the industry partners have continued to meet regularly as an Advisory Board to the Alliance, to consider the next steps and opportunities to take the research forward into further development.

Overall, the last year has proved successful for the Alliance in building this research community for the Roads Sector. The overall collaborative value is proving greater than the sum of the individual partner contributions that could be made alone.

The following pages of this report bring this impact to life and illustrate how the momentum being generated by the Future Roads Programme is paving the way for greater research collaboration for the Roads Sector in future.

These themes are:	**Sustainability**	**Smart Materials**	**Automation and Robotics**	**Digital Twins**	**Data Science**

The roads research, development and innovation landscape

Dr Joanna White, Research, Development and Innovation Director, National Highways

National Highways operates, maintains and modernises the strategic road network in England. This 4,500 mile network of motorways and major A-roads spans England and connects the regions and nations of the UK, supporting the economy and wider society through the safe and efficient movement of goods and people. National Highways invests in research, development and innovation to solve the problems we face today and to help prepare us for the future. Our main challenges involve improving safety, creating a more environmentally sustainable network and improving the efficiency of all of our activities.

The Roads Research Alliance is a key piece of our investment in research, development and innovation, bringing together National Highways, the University of Cambridge and 22 members of our supply chain. Through this collaboration, our first research portfolio secured £6.4 million in funding for a five-year Fellowship programme at the University of Cambridge. The programme supports research across digital twins, smart materials, sustainability, data science and automation and robotics.

The role of the supply chain in this alliance is vital, offering practical advice to help shape each Fellow's academic research, and sharing how successful research could be springboarded to innovation trials.

All this helps to connect industry and academia, strengthening our joint value and impact and helping us solve our business challenges.

The joint industry funding alongside the EU Horizon 2020 grant has enabled the University of Cambridge to appoint 26 new Fellows to carry out this research. This includes how to use robots and semi-automation to carry out roadside tasks to keep roadworkers safe, maximise the use of waste materials and low carbon concrete in road construction.

Visibility of our activities is important: sharing knowledge helps to demonstrate our value to the sector. We've been talking about the Alliance and its activities at industry-leading conferences like Highways UK. We've also brought together industry expertise to inform the research, such as the Carbon Management Methodology workshop led by Dr Jinying Xu, facilitated by SAP and hosted by Bentley Systems. All of this demonstrates the ripple effect of excellent collaboration that happens in the Alliance and that will enable us all to deliver greater impact and value over time. We look forward to continuing our work with you as part of the Alliance - watch out for further updates at this year's events.

Gathering research momentum

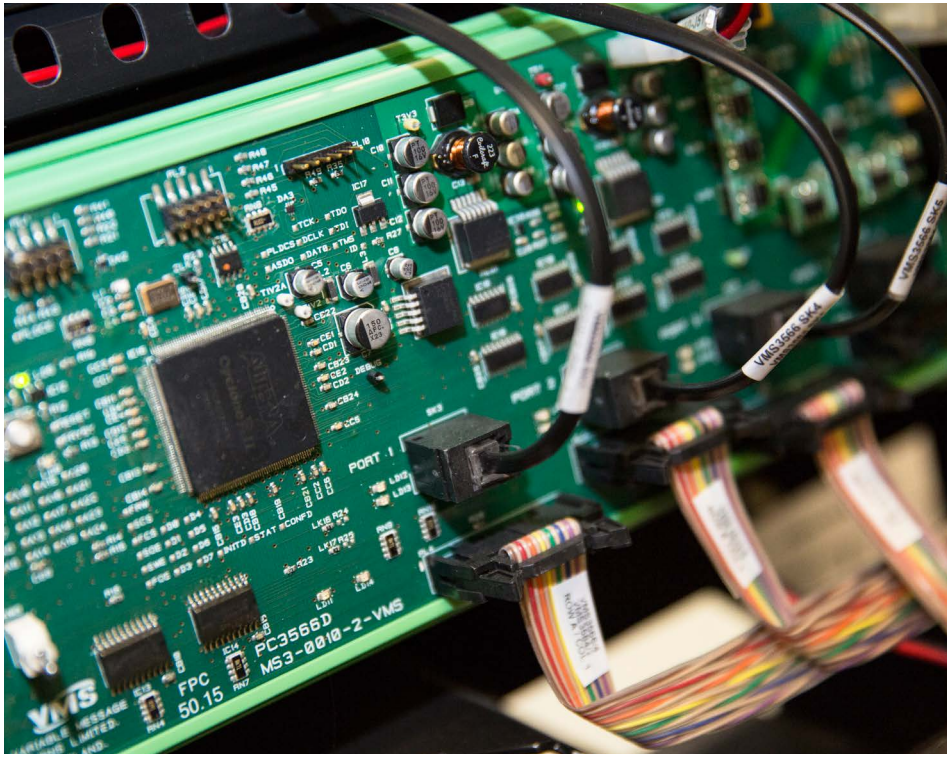
Phillip Proctor, Head of Research
National Highways

The Roads Research Alliance collectively has significant ambition to step up and scale-up the impact of our research activity for the industry. I believe we cannot tackle the complex issues our sector needs to address on our own and that is why collaboration is our top priority. This is what makes the Roads Research Alliance so exciting as it brings together National Highways, our supply chain and academia to collectively focus our efforts.

As well as identifying solutions for the future, our Alliance is supporting the development of the future skills needed in our industry. I'm excited to be part of this, and I'm proud of our track record in attracting external European funding into our industry. This would have gone to other industries if it were not for the commitment of our Alliance partners.

I'm pleased to report that with the appointment of Katherine Ingham as Alliance Manager, we are starting to generate much more momentum. I have taken on the role of chairing the governance board for the Alliance which is enabling a more robust decision-making process as we look to the future.

As you can imagine, a lot of work has also been undertaken by Nick Harris, Mike Wilson and the wider team to raise the profile of the Roads Research Alliance internally within National Highways. But it doesn't stop there. We do have the support and engagement from the Department for Transport (DfT) and are seeking stronger engagement with Local Authorities. We are hoping to make their involvement stronger in the future development of the Alliance.



Strengthening relationships between academia and industry

Professor Ioannis Brilakis, PhD CEng MICE
Laing O'Rourke Professor of Civil
& Information Engineering
Principal Investigator, Digital Roads of the Future
Initiative, University of Cambridge

Building a research and development culture in an industry of low profit margins can be seen as an impossible task. The current difficult economic times have made this task more challenging and catalysed the problem, highlighting the need for greater productivity and efficiency. Research and development (R&D) culture is precisely what is needed to escape the low margins and boost profitability while providing better value for money to clients. This is where I see the role of the Roads Research Alliance coming in.

The past year has been a year of reflection for Roads Research Alliance members. National Highways, first and foremost, is closely reviewing its R&D culture and making a sincere effort to modernise it with support from the University of Cambridge. Others have exploited the opportunity to engage in research via the Future Roads Fellowship Programme.

This has been the first research engagement experience for many, helping them understand the research process and its challenges.

A number of realisations have come about:

(i) R&D is not just about technology: modernising regulations and investing in market maturity are just as important

(ii) R&D is not a product; paying for it is not enough. Active engagement is even more important for success

(iii) R&D is about trying multiple ideas and failing so that one of them can truly succeed and become a game-changer

(iv) There are multiple routes to market and understanding them and their appropriateness for a given project is key to success.

Much of this value is stemming from the Future Roads Fellowship Programme. As we reached the end of 2023 and completed the recruitment of the third cohort of researchers, the programme achieved a significant milestone. Our focus shifted towards effective research management and impactful outcomes. With the active engagement of 20 post-doctoral researchers and 25 industry partners, the full potential of our collaboration is becoming evident, promising great advancements in the near future.

Future Roads Programme - Cohort 2 Industry Partner Day - University of Cambridge

The past year has been marked by increased engagement with our industry partners, highlighting the crucial role of industry supervision within the Fellowship programme. This emphasis has led to a noticeable expansion of established industry supervision arrangements. The exchange of data, site visits, and the invaluable time and expertise of our industry supervisors have significantly enriched our research efforts, ensuring real-world relevance and applicability.

We're committed to continuous improvement and have actively listened to feedback from all stakeholders. In response, we've made changes to supervision arrangements, enhancing relationships with industry partners and ensuring that Fellows' research remains closely aligned with industry needs.

The breadth of research activities at the University of Cambridge relevant to the Roads Research Alliance agenda is expanding beyond the boundaries of the Future Roads Programme, opening possibilities for new collaboration. Our Fellows are engaged in cutting-edge projects that promise to drive innovation and address critical challenges in the sector.

We are proud of our Alumni cohort, composed of former Fellows who have advanced their careers at renowned institutions in the UK and worldwide. This growing network continues to expand our reach and influence, fostering ongoing collaboration and knowledge sharing across the industry.

Roads Research Alliance: management update

Dr Katherine Ingham, Roads Research Alliance Manager on behalf of National Highways

In the last year, the Roads Research Alliance has established its rhythm, operating alongside its portfolio of research activities in the Future Roads Programme. What strikes me most when compiling this report is the sheer scale of what we've managed to achieve – with so many organisations working collaboratively to support the Fellowship Programme at the University of Cambridge. We must take a moment to reflect on this success.

The partners have got to know each other better and contributed a huge amount in terms of research ideas and supervision, data and application suggestions, Alliance governance and constructive challenge on the Alliance's development.

The conversation has turned towards fostering a truly collaborative research environment where industry partners are providing joint supervision of Research Fellows, and challenging each other to consider what next for the projects.

We've established an Interim Executive Board for 2023-24. The Board has supported the Alliance in considering the risks and opportunities presented by the current research programme, decision-making around the membership of the Alliance, and questions about the future Alliance model.

We've raised the Alliance's profile, with representation at Highways UK and in conversation with multiple interested parties – including potential future industry partners and other stakeholders in the roads sector.

Moving into the latter half of 2024, I hope to galvanise activity around building the next phase of the Roads Research Alliance, and support partners in determining where to take their research next, to achieve maximum impact for the roads industry.

There has been a lot of other activity in the background to step-up the maturity of the Alliance's current operation and determine the next step of evolution. One of the central questions within this is how industry partners can take the findings of the research and translate them into meaningful outcomes. Alongside this sits the question of how National Highways will foster the right environment for the Research, Development and Innovation portfolio to flourish.

As the research projects progress over the coming year, it will become easier to see how the outputs will address industry challenges, and how these challenges have morphed to keep pace with innovation and new industry practice since 2022. Inevitably there is a balance to be struck between academic advancement and the practical industry context. We are working to identify which concepts will translate optimally into development and deployment. It is a tricky partnership to maintain whilst these concepts come to the fore, but the last year has proven the commitment of members to pioneering this collaborative effort for the roads industry.

Future Roads Programme: management update

Dr Nevena Vajdic, Future Roads Senior Project Manager, University of Cambridge

The management of the Future Roads Fellowship programme in 2023 focused on several key areas:

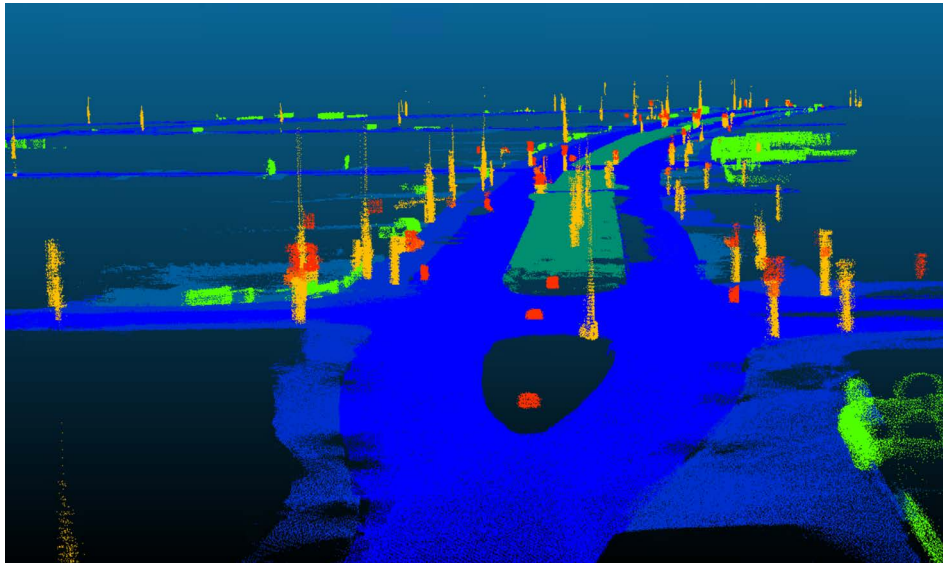
- completing the recruitment of Cohort 3
- inducting and training Cohort 2
- enhancing engagement with industry partners.

The year was marked by the start of Cohort 2, which brought a new set of research projects into the Future Roads portfolio. Notable effort was made to raise the visibility of researchers through social media campaigns, such as #MeetMSCAFutureRoadsFellows, and by updating the website content. The programme's visibility was also enhanced at professional events and through articles in professional journals. Fellows began presenting their work at conferences and publishing their research outcomes.

The introduction of a *Stakeholder management plan* established a systematic approach for managing industry partner engagement and set the framework for communication. A series of one-to-one meetings with industry partners was held to clarify the programme structure and manage expectations on both sides.

The first *Future Roads annual review* marked a milestone in strengthening relationships between researchers and industry partners, opening the door for new engagements and collaborations.

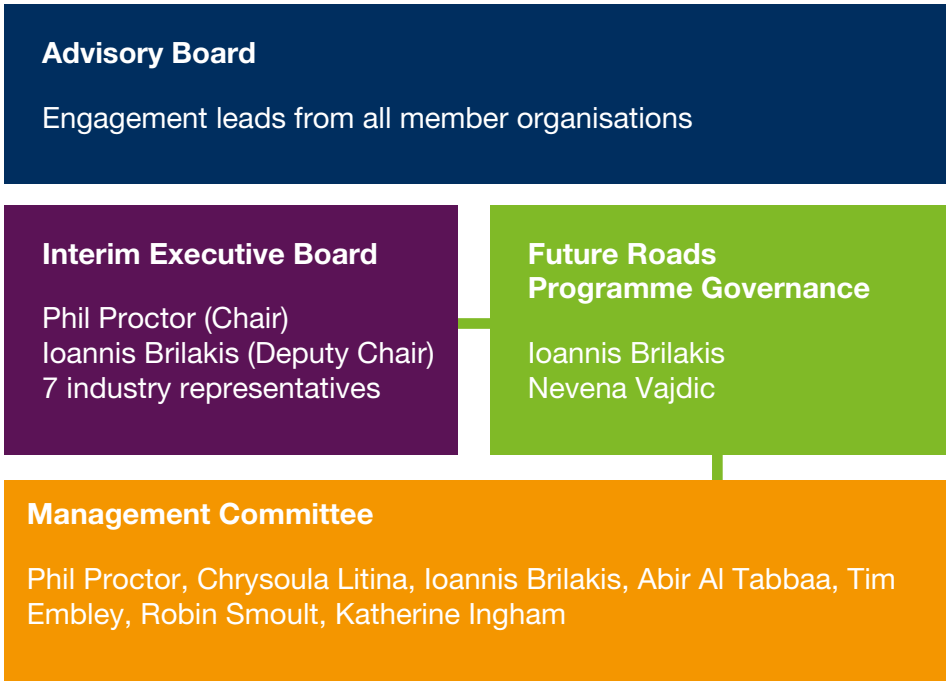
The Future Roads Programme maintains a stable financial outlook based on person-month units as set out in the Grant Agreement with the EU. The distribution of expense categories is shown in the Future Roads Programme budget section later in this report.



Governance overview

Over the last year, the Roads Research Alliance has employed a light-touch governance strategy to sit alongside the governance of the Future Roads Programme.

We would like to thank the members of the Interim Executive Board for volunteering their time to support the governance of the Roads Research Alliance in its formative stages.



Board Members

Chair
Phil Proctor
Head of Research, National Highways

Deputy Chair
Professor Loannis Brilakis
Laing O'Rourke, Professor of Civil and Information Engineering, University of Cambridge

Board Member
Dr David Hynd
Chief Scientist, TRL

Board Member
Greg Weingarten
Head of Inteligent Infrastructure, Jacobs

Board Member
Effrosyni Tzoura
Innovation Manager, Ferrovial Construction

Board Member
Mohammed Dakri
Head of Technology, Lighting and Energy Solutions
SPaTS 2 Framework Market Director, Amey

Board Member
Dr Matt Peck
Director of Innovations, Atkins

Board Member
John Armitage
Technical Director, Ramboll

Board Member
Edward Wells
Infrastructure Head of Digital Construction, Galliford Try

Board Support

Secretary
Dr Katherine Ingham
Roads Research Alliance Manager, National Highways

RRA Management Contract Sponsor
Dr Chrysoula Litina
Principal Research Engineer, National Highways

Sharon Creary
Communications Lead for Research and Innovation
National Highways

Community Support
Becky Franklin
JFG Comms

Critical Friend
Tim Embley
Strategic Innovation Lead, Costain

The Alliance's activity in numbers

£2.6m
Future Roads Fellowship Programme grant from EU Horizion 2020

£3.8m
Total Future Roads Programme Co-Investment from Industry Partners

2026-27
This year in which the current research portfolio ends (pending grant timeline extension)

84 Industry Challenges put forward of which
23 are being address by Research Fellows

20 Future Roads Fellows and Projects

6 Future Roads Fellows Alumni

22 Alliance Industry Partners
+ National Highways
+ University of Cambridge
+ 2 more supervising industry partners supporting Future Roads independently

80 Industry Supervisors supporting Future Roads Fellows at the University of Cambridge

Number of Fellows by Cohort
Cohort 1 (to Sep 25): **2**
Cohort 2 (to Jun 26): **9**
Cohort 3 (to Sep 26): **9**

Number of Fellows by Theme
Sustainability: **4**
Smart Materials: **3**
Automation & Robotics: **5**
Digital Twins: **5**
Data Science: **1**

50 Engagement Leads across all partners driving the Alliance's agenda

Future Roads Programme budget

Overall programme budget: £6.4m

Managed by the University of Cambridge, split proportionally into:

Activity	Percentage of budget
Fellows' salaries and overheads:	78%
Fellows' research costs:	7%
FR management activity:	7%
Fellows' dissemination activity:	4%
Fellows' training:	3%

Progress spend against the grant is measured in person months, assuming a maximum of 27 Fellows, each on 36-month contracts.

Number of person months available	972
Number of person months used (based on actual number of Fellows and duration on projects to March 2024)	235.69
Forecasted person months to be used	780.69
Forecasted unused person months	191.31

The Future Roads Steering Group is currently considering how best to make use of the unused person months, and whether a 'Cohort 4' of Fellows might be plausible.

Management of the Roads Research Alliance activity is provided separately by National Highways through the Specialist Professional and Technical Services (SPaTS2) framework.

Future Roads programme research activity in 2023-24 – geographical coverage

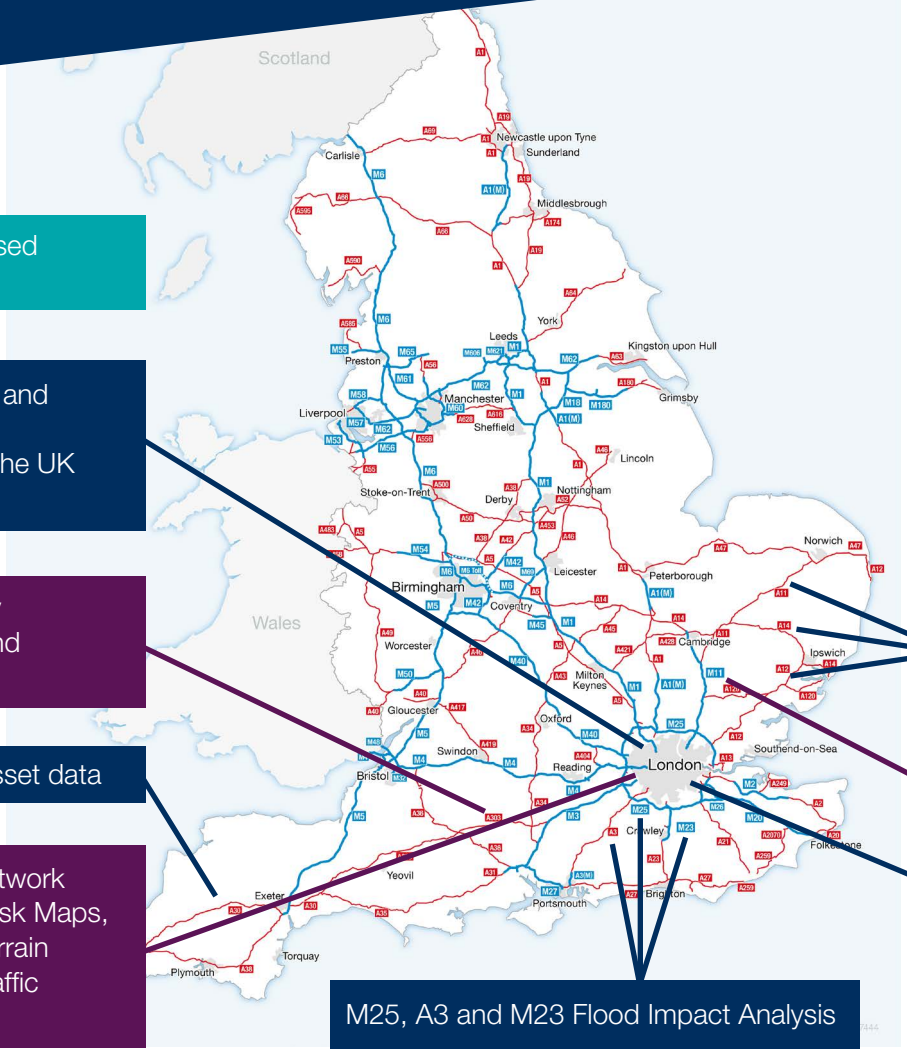
Focus group workshop with UK-based researchers on building regulations

Quantative interviews with Planning and Building Authority departments and consultancies in New Zealand and the UK (Cambridge)

A303 used as a learning case study around carbon process, systems and trusted data sets

A30 Digital Twin provided as built asset data

Greater London Road Transport Network Data: Environment Agency Flood Risk Maps, Digital Surface Model and Digital Terrain Model; Department for Transport traffic counting data



M25, A3 and M23 Flood Impact Analysis

Broader UK Datasets:

RIS2 network data - National Highways

Digital Surface Model and Digital Terrain Model - Environment Agency

Risk of Flood from Rivers and Sea - Environment Agency

Risk of Flood from Surface Water - Environment Agency

Open Roads - Ordinance Survey

Regional and Local Climate Projections - Met Office

A11, A12, and A14 Digital twin research on roadside vegetation

M11 research for Digital Twins

Workshop with 60+ attendees focussed on Carbon Data Collection Methodology - facilitated by SAP and hosted by Bentley Systems in the City of London

Research portfolio – Future Roads programme projects

The Roads Research Alliance's portfolio currently solely consists of the projects within the Future Roads Fellowship Programme at the University of Cambridge. As a requirement of the Marie Skłodowska-Curie Fellowships, the programme has recruited researchers from around the globe. The Fellows are experienced post-doctoral researchers bringing a wealth of knowledge from their extensive research to date.

This provides an opportunity to tap into global research knowledge and networks, ensuring the UK is learning from a wide and diverse network of leading Universities around the world. The Research Fellows and their project titles are listed below under each theme of the programme. Each theme corresponds to a key challenge area for National Highways.

The Future Roads Programme

Theme 1: Sustainability

Cohort	Fellow	Industry challenge addressed	Project title
1	Jinying Xu	How can data science and analytics contribute to sustainability-orientated decision making?	Data science and digital technologies for intelligent carbon management in the whole life of highway assets
3	Khashayar Kazemzadeh	To what extent can an equity, diversification, and inclusion (EDI) agenda change the way we approach road infrastructure planning and design?	Enhancing equity, diversity, and inclusion in active mobility: a study on underrepresented groups' perspectives in road infrastructure planning in Cambridge
3	Zizhen Xu	What strategies could be used to achieve biodiversity (or more broadly ecosystem services) net-gain in managing a national highway network?	Assessing road infrastructure resilience against extreme weather events and fostering climate change adaptation
3	Jie Liu	What strategies could be used to achieve biodiversity (or more broadly ecosystem services) net-gain in managing a national highway network?	Measuring and enhancing the resilience of urban transport infrastructure networks to climate change

Theme 2: Smart Materials

Cohort	Fellow	Industry challenge addressed	Project title
2	Abbas Solouki	Carbon Zero Roads: Decarbonisation of road materials And Zero waste roads: Capitalising on existing pavements and eliminating the mining of natural resources	Zero waste geopolymer pavement
2	Ze Zhou Wang	Maximising road life: Smart materials and sensors to extend the life of existing assets	An innovative zonation-based machine-learning methodology for studying the interactive impacts of traffic, microclimate and natural hazards on pavement deterioration
3	Fengqiao Zhang	Future-proof roads: Data-driven materials for durable and climate resilient pavements	An integrated road asset monitoring system supported by probabilistic models and artificial intelligence

Theme 3: Automation and Robotics

Cohort	Fellow	Industry challenge addressed	Project title
1	Arsen Abdulali	Tele-presence and tele-operation of road construction, monitoring, and maintenance	Human-robot cooperation for maintenance and construction of future roads
2	Kai-Fung Chu	Control of multi-agent systems for traffic Management	Control and implications of mixed autonomous vehicle-infrastructure in a heterogeneous multi-agent system framework
2	Chapa Hewa Sirithunge Pelendage	Safety feedback for autonomous and semi-autonomous heavy machinery usage	A multi-agent system for heavy machinery operation through context aware sensor fusion
2	Yue Xie	Control of multi-agent systems for traffic Management	Highway intelligent traffic control system based on vehicle-road coordination and multi-agent technology
3	Xiang Wang	Road surface monitoring with non-conventional sensors	Explainable artificial intelligence assistant low-cost autonomous-vehicle-mounted inertial measurement unit sensors based road surface condition monitoring system

Theme 4: Data Science

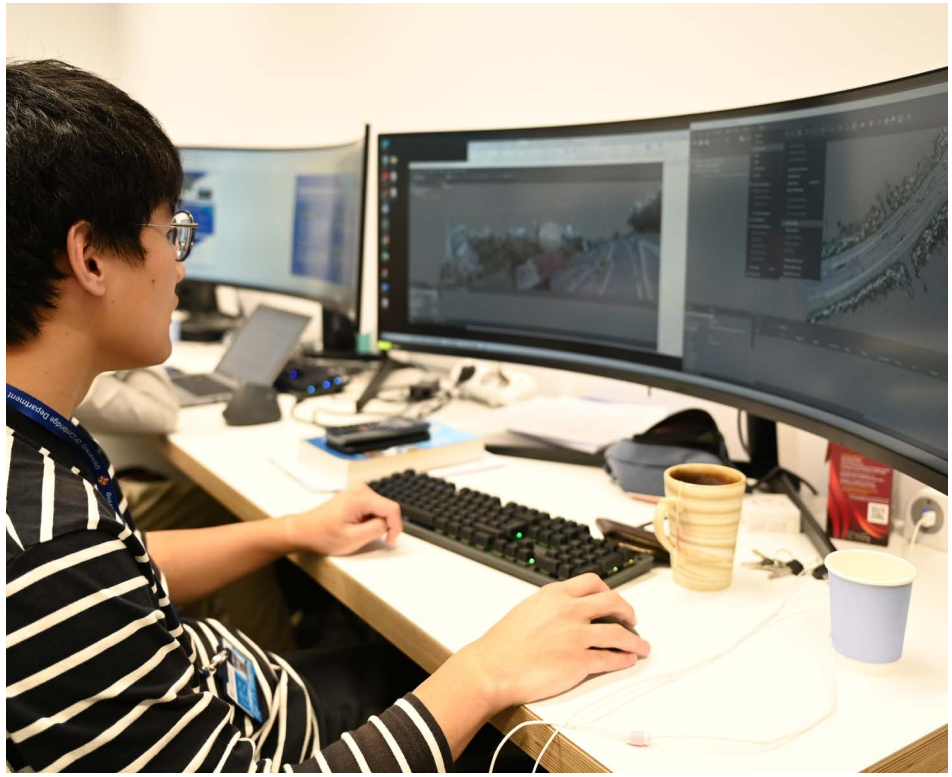
Cohort	Fellow	Industry challenge addressed	Project title
3	Zhaojie Sun	Synthetic data generation for improving automated classification of highway assets and defects	Digital twin-driven structural health monitoring of roads by using physics-based model and machine learning

Theme 5: Digital Twins

Cohort	Fellow	Industry challenge addressed	Project title
2	Linjun Lu	How can we build a trustworthy Digital Twin?	Development of a vision-based method for high-quality traffic data collection in support of building trustworthy digital twins of road network
2	Yuandong Pan	How can a Highway Digital Twin evolve over time?	Data fusion and data structure design in creating and updating digital twins
2	Varun Kumar Reja	What are the minimum data requirements for a valuable Digital Twin?	Towards the development of a resilient highway digital twin: requirements, specifications and standards
2	Mengtian Yin	What are the minimum data requirements for a valuable Digital Twin?	Highway semantic web creation, distillation, and data exchange for unifying digital twin data standards
3	Junxiang Zhu	How can we design a Road Digital Twin?	A graph-based approach for designing road digital twins
3	Shirin Malihi	How can we construct and maintain a road digital twin?	Maintenance of Road Digital Twin Using Multi-modal data
3	Judith Fauth	How can Road Digital Twins generate value from connecting areas?	Advanced planning and building permits through road digital twins

Future Roads Programme Alumni

Some of the Future Roads Fellows recruited by the University of Cambridge have moved on to continue their work for the Roads Sector across industry and academia. This Alumni cohort demonstrates the developing academic network which paves the way for future development of the Roads Research Alliance.



Fellow	New position beyond the Future Roads programme
Dr Vahid Afroughsabet	Concrete and Materials Advisor at National Highways, UK
Dr Daniel Grossegger	Department of Engineering Sciences, Empa, Swiss Federal Laboratories for Materials Science and Technology, Switzerland
Dr Anand Sreeram	Assistant Professor in Transportation Engineering at the University of Nottingham and the NTEC - Nottingham Transportation Engineering Centre, UK
Dr Yiming Zhang	Young Chair Professor, School of Civil Engineering, Southeast University, Nanjing, China
Dr Quentin Adam Felix	Postdoctoral Research Associate at Institute of Highway Engineering Aachen (ISAC), Germany
Dr Munkhbaatar Buuveibaatar	Postdoctoral Research Fellow, Kyungpook National University, South Korea

Impact on a Page

The Future Roads Programme Research Projects were commissioned based on challenges put forward by the Alliance's industry partners. They continue to be shaped by Industry Supervisors to ensure relevance to current practice. To illustrate a sense of the current effort and impact, these projects have been mapped to the key focus areas identified in National Highways' publication, "Connecting the Country; Our long-term Strategic Plan to 2050." Of the 9 key focus areas identified in this strategic document, the current Alliance research portfolio clearly aligns to 5 of these, with a broad range of topics and academic perspectives. Many projects also have a strong focus on Safety, which is another key strategic theme for National Highways.

The collaboration and active engagement in knowledge co-creation between academia and industry illustrates the direct impact currently being felt through the Roads Research Alliance. Through this proximity, there is a greater concerted effort to consider the practical applications of these research concepts to the road network. The outcome of this activity should therefore be framed both in terms of potential improvements for the roads industry, inclusive of the research community the Alliance is fostering for future application.

Digital	**11**	research projects, covering broad topics from multiple angles such as digital twins and human robot cooperation
Customer Experience	**2**	research projects, both addressing the industry challenge of 'control of multi-agency systems for traffic management'
Decarbonisation	**5**	research projects, focused on carbon accounting methodology, recycling materials, geopolymers and self-healing materials for pavement construction
Sustainable Network Development	**3**	research projects, addressing climate change adaptation, and the equity, diversity and inclusion agenda in road planning and design
Asset Resilience	**5**	research projects, exploring the use of sensors, artificial inteligence and smart materials in creating durable and resiliant pavements

Future Roads Programme: Research Fellow case studies

Dr Jinying Xu, Future Roads Fellow in Sustainability, University of Cambridge

I am leading a novel research project focused on carbon data management in the roads industry at the University of Cambridge. The aim of my research is to build trustworthiness in carbon data to achieve net-zero across the life of highway assets. Despite the importance of accurate carbon management, the data we collect on carbon often comes from averages and estimations, and many carbon emissions are not well measured and reported. My research hopes to string the scattered data sets together and leverage new digital technologies to collect carbon actuals following a standard data model.

The collaboration with industry partners has been invaluable in shaping my research. The Roads Research Alliance has provided opportunities to discuss current methods for carbon reporting and shared visions for carbon quantification in the future. Having SAP, Costain, Galliford Try and Ramboll as industry supervisors has been particularly beneficial in providing industry knowledge and ensuring my research creates viable solutions for carbon data management.

I was lucky enough to host a workshop in January this year where over 60 carbon experts from across the roads industry came together to help feed into my research project. This proved the value of the Roads Research Alliance in bringing together subject matter experts from across organisations to create inform and shape practical research.

The potential outcomes of my research is significant. With accurate and trustworthy carbon data, we can better measure our progress towards our net-zero targets and make more informed decisions to achieve this goal. Just as every car has a real-time dashboard for drivers to make prompt decisions, every road should also have a dashboard to help planners, designers, contractors, asset managers, and users be aware of its real-time situation for decision-making underpinning carbon management, and ultimately, sustainability. This research will contribute to the broader scientific community and society as a whole, helping us respond more effectively to the climate crisis.

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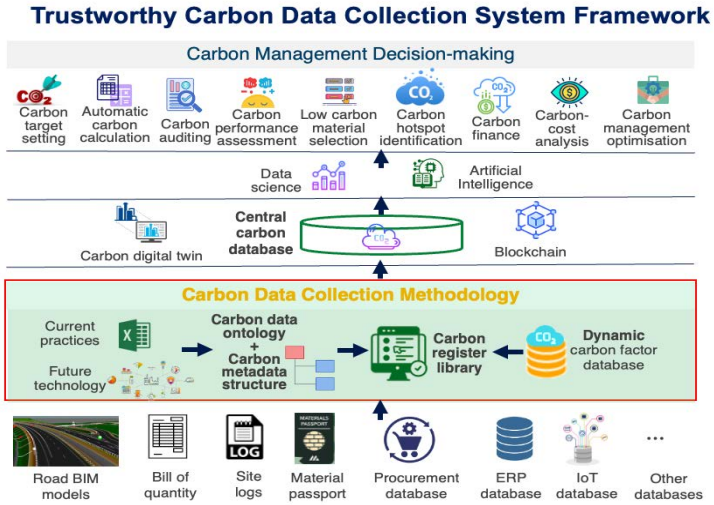


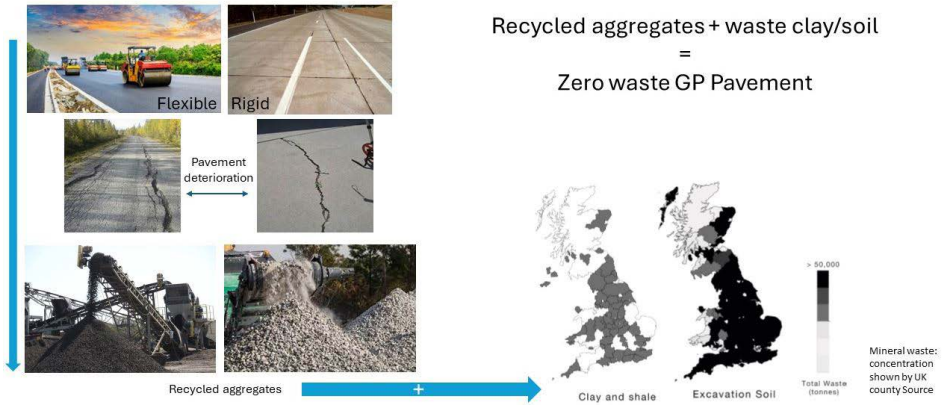
Dr Abbas Solouki, Future Roads Fellow in Smart Materials, University of Cambridge

As a Research Fellow at the University of Cambridge, my research is focused on exploring the use of low-carbon concrete alternatives, such as geopolymer, for rigid pavement production. The aim is to reduce the carbon footprint and provide a sustainable avenue for companies to achieve their net zero and zero waste goals. This will be accomplished by incorporating vast clay waste within the UK, and upcycling it with reclaimed asphalt pavement and crushed concrete. The valorisation of these by-products will considerably reduce waste materials and carbon emissions, offering a more sustainable approach to the paving industry.

My research wouldn't be possible without the close support I've received from the roads industry. I've been fortunate to have several organisations involved as industry supervisors, which has allowed me to shape my research to fit the industry's challenges rather than prescribe a solution from the outside. They've also allowed me to recycle some of their unwanted materials and use their testing facilities to do trials, which have been crucial to progressing my research.

We need to bridge the gap between industry and academia to ensure we create viable and practical solutions that the industry can easily take up. Ultimately partnerships like the Roads Research Alliance are exactly what need to happen to achieve the industry's zero waste and net zero goals.

Looking ahead, over the next five to ten years, I would like to see the industry focus less on developing new ideas and more on advancing and testing existing concepts, while still working on innovative solutions. Unfortunately, there is a lot of exciting existing research on these topics that haven't been picked up or continued. We must start sharing existing knowledge and build on the vast research we already have in this space and support the development of research into real-world innovations. This would be more impactful as it would allow us to create solutions and reach zero waste and net zero goals more quickly.



Dr Yue Xie, Future Roads Fellow in Automation and Robotics, University of Cambridge

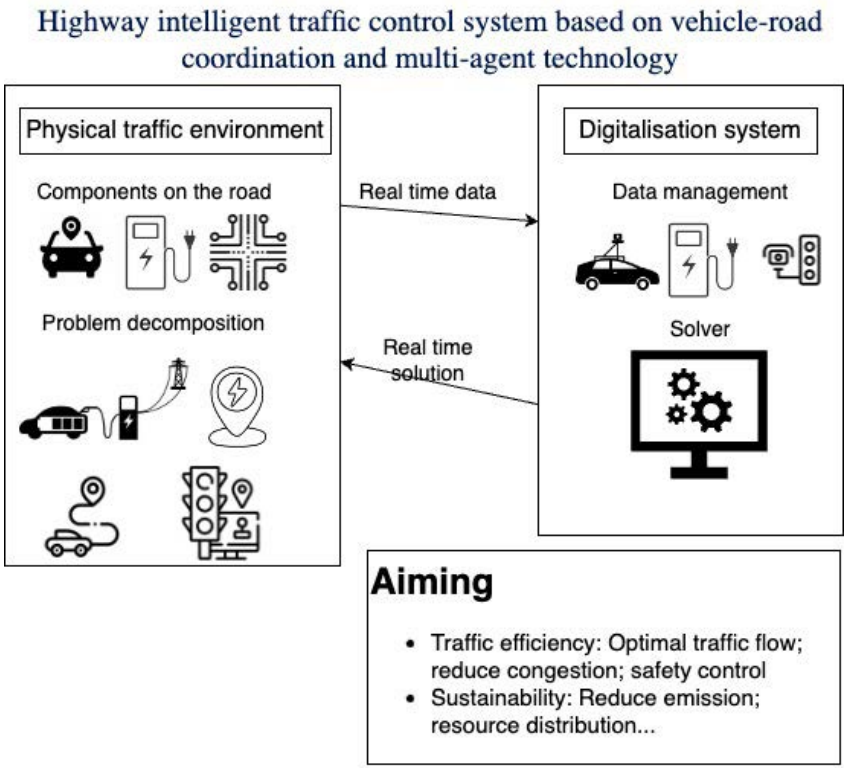
With a background in computer science, I am working on a project that explores the use of autonomous driving technology and intelligent highway systems. The goal is to reduce congestion and commuting times, minimise accidents, and reduce carbon emissions from journeys.

The ultimate vision of my research is for all vehicles on the roads to be autonomous and intelligent. They will be able to decide how to drive and their behaviour on the road, and they will be able to interact with smart highway systems that can adapt and manage the traffic flow. To make this a reality, we need to understand how road construction can guarantee the best management of vehicles by using the technology in autonomous vehicles.

The support I've received from the roads industry through the Fellowship Programme has been invaluable. My industry supervisor, Nicolette Formosa from National Highways, has provided vital and practical real-world applications that have helped shaped my research. As a computer scientist, I started this research project with little domain knowledge of the road sector. Being able to work with National Highways has been crucial in ensuring this expertise is fully understood and incorporated.

Looking ahead, I hope the Roads Research Alliance will continue supporting women in positions across all research levels and STEM subjects. We need greater gender equality in engineering to allow for more diverse thinking and to help us respond to the challenges of the future.

I believe that by supporting rising stars and encouraging more women into junior academic positions, we can make engineering and STEM subjects more inclusive and diverse. This will benefit the individuals involved, the broader scientific community and society as a whole.



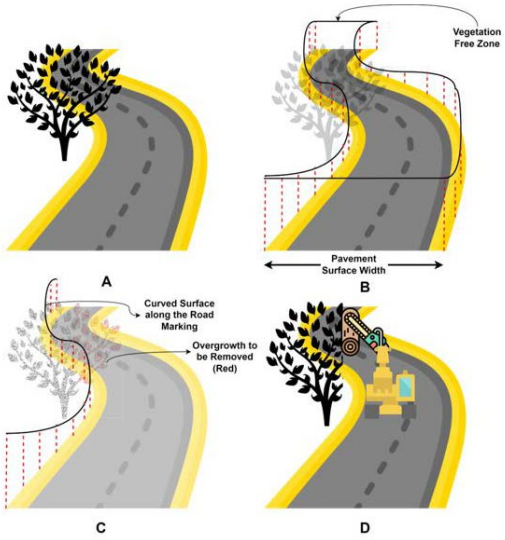
Dr Varun Kumar Reja, Future Roads Fellow in Digital Twins, University of Cambridge

My research project is about transforming the roads industry by digitalising processes in road maintenance, particularly establishing information requirements for all the assets in the road environment. The manufacturing industry has already leveraged digitalisation to a certain extent, and I believe the roads industry can achieve the same. If we can digitalise some of these processes and establish the necessary information requirements to enable this digitalisation, people making manual decisions will have a supportive AI-based service to help them make better decisions on time. This will allow road users to have properly maintained roads and road assets, reduce carbon emissions and allow a smoother traffic flow.

Working with industry partners has been a rewarding experience. Every couple of months, we discuss with our industry partners, and showcase our results to them. There is a lot of support from the partner side to implement the research we are developing onto their projects. I have been invited to give research talks to the industry, have been part of research workshops, and have had discussions with other academics at conferences. These interactions spark interest and help us engage with what the industry is doing and how our research is being applied and can be useful. These are good feedback mechanisms, too.

This relationship is really important as academics can often be more optimistic than industry, and we don't have to operate within the same constraints. However, the industry is much more focused on feasibility and delivery. By working closely together, we can draw on each other's strengths and understand that we both need each other.

The potential outcomes of my research are significant. In the next five to ten years, there will be a major transformation in the autonomous car sector. When there are more autonomous cars on the road, the backbone of having a digital facility will play a huge role in decision-making. This facility can only exist if we figure out the key and unique information requirements for road and road assets. We are moving towards this as we need to make roads safer, less congested and less carbon emitting. My research will enable National Highways to look after road assets much more efficiently.



Future Roads Programme: industry partner case studies

Dr Matt Peck, Director of Innovation, AtkinsRéalis

Matt is the Alliance Engagement Lead for AtkinsRéalis, and is also directly involved in supervising ten Fellows from the Future Roads Programme across cohorts 2 and 3, mainly on the theme of digital twins.

Over the last year I have held regular meetings with the Fellows to discuss the scope of the proposed research, guide their thinking and to ensure the research remains focussed on real world problems that need fixing. Specifically, I have encouraged the researchers to consider the practical application of their research, including how it might be built into a useable product or service.

Each researcher has updated their proposed research to accommodate this input and has a greater understanding of the needs of the UK transportation sector. I have worked alongside the other industry partners to supervise the Fellows' projects and often continue our conversations offline following feedback sessions.

It has been useful to understand the researchers' perspectives on the industry challenges, and how in their view the research might help overcome the difficulties in taking digital twin research from concept to useable capability. Their insight into other global initiatives has been useful to hear, as have their views on how various initiatives might combine to greater effect.

An important dimension of the Fellowship programme is taking the researchers on secondment, and many conversations have been held around how AtkinsRéalis might do this. There is also interest in seeing what practical applications of the research might arise.

The research itself has the potential to form the foundation of future data analysis capabilities that will transform the way in which we manage our roads, especially the way in which we understand how it behaves and how this behaviour is changing due to increasing traffic volumes and changing climatic conditions.

The Alliance has the potential to develop useable products, services and solutions that help take digital twins from being a concept to a practical suite of solutions. This should be a key requirement of its purpose. It will need continued development to take projects beyond proof of concept, and it is therefore important for the Alliance to develop its plans to make this happen.

For the roads industry over the next five to ten years I would like to see the emergence of a massive parallel computing infrastructure (and maybe even quantum computing solutions). This will make the task of undertaking real-time analysis of the travelling public, and the ability to predict their behaviour, an achievable prospect.

I hope that AtkinsRéalis and the wider Alliance can take forward greater insight from the current research portfolio into the issues that need to be overcome to make digital twins a useable capability, as well as emerging solutions that could be licenced for onward development. Over the next year I would like to see an increased focus on the onward development and exploitation of the emerging products, services and solutions.

Luke Winch, Low Carbon Manager, Galliford Try

Luke is an Industry Supervisor on behalf of Galliford Try. He is currently working with Dr Jinying Xu from Cohort 1 of the Future Roads Fellowship Programme on her project around carbon data management.

I have been working with Jinying for the last year, and have fed in current and best practice 'in the field' for carbon data capture and analysis. In particular, we have focussed on scoping the scale of the industry challenge: fragmentation, contractual barriers, resource intensity, data quality, accuracy, completeness, and the transfer of data throughout the project lifecycle.

Working alongside the other supervising industry partners, I have gained a deeper understanding of current best practice and direction of travel, taking this learning back into Galliford Try. I have also been able to better network with relevant carbon colleagues at National Highways.

I helped to frame the Carbon Data workshop that was facilitated by SAP back in January, and from this Galliford Try has gained a greater understanding of how we can contribute to development of the Intelligent Carbon Management System (ICMS) that Jinying is proposing.

Jinying's project has significant potential to impact the roads industry by providing recommendations on the complete and accurate quantification of carbon in real time.

This would allow us to make better informed, data-driven decisions to decarbonise the industry.

My hope is that once this research project has ended, Galliford Try and the other industry partners can take the proof of concept ICMS and develop it into a working model, building outwards on the concepts raised through the research into functional tools. In this case, National Highways also has the potential to benefit from adopting the ICMS recommendations into its own carbon management system. Beyond this, I believe the industry partners have a role to play in translating research findings, acting as the conduit between National Highways and other road sector clients.

Looking ahead to the next year and beyond, I would like to see the Roads Research Alliance pursue further engagement with sector clients to best understand the industry needs and shape the research portfolio around this.

Effrosyni Tzoura, Innovation Manager, Ferrovial Construction Ltd.

Efi is the Alliance Engagement Lead for Ferrovial Construction, a member of the Alliance Interim Executive Board. She is directly involved in supervising Dr Xiang Wang from Cohort 3 of the Future Roads Fellowship Programme on his project around road surface condition monitoring.

Ferrovial Construction joined the Roads Research Alliance in 2023 and I have been actively collaborating with Dr Xiang Wang to help scope his project on road surface condition monitoring within the Automation and Robotics theme. Our guidance is directed towards ensuring that the project's outcomes are both technically sound and commercially viable.

We have already acquired significant knowledge about the latest advancements in monitoring sensors and systems by working with Dr Wang. Within Ferrovial we are exploring opportunities to connect the outputs arising from this programme with other ongoing trials.

Working alongside other industry partners as a supervising team, we are able to extend our collective expertise to the Fellows, leveraging the diverse insights we've gained from our respective organisations, be it contractors, designers, or tech companies. Our focus is on providing constructive feedback on the research project, enhancing each other's contributions based on our diverse experience.

I believe it is this collaborative involvement in the research that will help us to accelerate the project outcomes in the long-term. The Future Roads Programme could serve as the cornerstone for enduring initiatives poised to transform the roads industry.

I hold a position on the Alliance's Executive Board, responsible for supporting standards development based on my personal experience with National Highways. Ferrovial is committed to collaborating with all industry partners and academics to ensure swift and feasible adoption of new technologies and ways of working.

The research that I'm supervising with Dr Wang has the potential to be applied across a multitude of projects. While the current focus is on pavement monitoring, the developed solutions could also be adapted for use in various structural forms, broadening their utility for the wider construction industry.

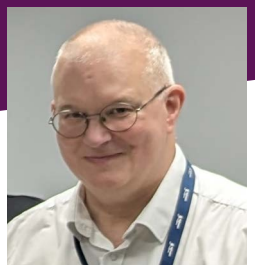
The Roads Research Alliance should focus its efforts on the economic advantages of the research outcomes, ensuring that innovations lead to tangible business improvements. I am also keen to promote a unified information repository: consolidating research findings and data into a single, accessible storage system for streamlined knowledge management.

There are lots of potentially fruitful areas for further research in the roads industry in future, including:

- Sustainable materials: development of new, eco-friendly materials for road construction that reduce the carbon footprint and improve durability.
- Smart roads: integration of IoT (The Internet of Things) and sensor technology to create roads that can communicate with vehicles, manage traffic flow, and detect maintenance needs.
- Data analytics: using big data to optimise traffic management, road safety, and maintenance schedules.
- Public-private partnerships: encouraging collaboration between governments and private entities to fund and drive innovation.
- Policy and regulation: developing frameworks that support the adoption of new technologies while ensuring public safety.

As the Roads Research Alliance continues to develop over the next year, I would like to see a broadening of the research agenda to tackle more of the strategic challenges that we face.

Roads Research Alliance: wider collaboration case studies



Michael Ambrose, Technical Lead - Concrete Roads Programme, National Highways

Mike's position on the Concrete Roads Programme means he regularly interfaces with the research portfolio at the University of Cambridge. He provides an interesting and important perspective on the alignment of research activity for National Highways, even though he is not directly involved with the governance of the Alliance.

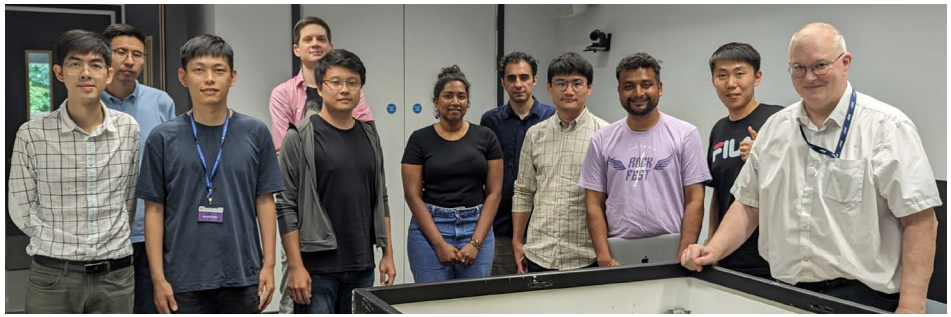
The Centre of Excellence for the Concrete Roads Programme has been able to align its research to the wider portfolio of the Roads Research Alliance, and through this wider association we have been able to combine efforts, share information and disseminate results with our industry partners in key areas such as:

- Materials with lower carbon outcomes, better rates of delivery, increased durability
- Adapting materials for climate change
- Carbon from the bottom up; assemblies of carbon for activities in Operations.
- Upcycling from concrete waste

All Alliance partners, National Highways included, stand to gain from being involved in the wider research portfolio. Being involved in this activity allows us to bring an intellectual rigour to surfacing and proposing solutions to challenges. It informs us of the broader picture of what is possible, speeds up research where there are opportunities, and allows us to apply a different range of perspectives in our thinking, ultimately informing whether we should choose to adopt a change.

For the roads industry more broadly, I am an advocate of the motto, 'Done right, first time, every time, any time'. This moves the problems into focus and provides solutions for the legacy Concrete Roads Programme, which will be running till 2065. As the impact of weather, population and transport changes, so should the answers we have to respond to future challenges.

There is always a degree of uncertainty about the future, and we can't always see the path or be able to focus on the questions we need to answer. In my opinion the Roads Research Alliance has a role to play in providing 'what if?' options, and marshalling industry resources to discover some of the answers we will need for the future.



John Armitage, Technical Director, Bridges and Transport MMC Lead, Ramboll

John is the Alliance Engagement Lead for Ramboll. His wider work on the research and innovation agenda has highlighted the potential for future industry collaborations.

Over the last year, I have been able to maximise the opportunity of Ramboll being involved in this partnership through my involvement as an Engagement Lead within the Roads Research Alliance.

We have offered various experts from across the company to support the research projects. Engagement along the route has been very positive and I have got to know like-minded people in the industry. Forging these relationships has been enormously helpful to our broader R&D efforts.

I have been able to make connections between the Alliance's current research portfolio and other groups that I sit on, such as the Net Zero Bridges Group. The crossover with Dr Jinying Xu's work on carbon management is highly relevant here and evidence of the potential ripple effect that the industry has on the wider roads sector.

Earlier this year we were able to take advantage of the technical training scholarships offered to Roads Research Alliance industry partners by the University of Cambridge. We sent three colleagues on training on the themes of Sustainability, Digital Twins and Data Science.

Ramboll's broader research interests with Laing O'Rourke around alternative reinforcement for pre-cast shells is likely to lead to further innovation activity in the coming year, with the Research, Development and Innovation team at National Highways supporting us in exploring the possibility of a non-location-specific departure from standards.

Various colleagues across the Safety, Engineering and Standards Directorate are supporting us with this, and it's testament to National Highways' wider commitment to the R&D agenda of which the Roads Research Alliance is part.

Ramboll has continued to get involved in wider research activity taking place at the University of Cambridge, such as through the Centre for Doctoral Training in Future Infrastructure and Built Environment: Unlocking Net Zero (FIBE3). As part of this, Ramboll will be delivering a lecture to students in the coming year.

For us, our partnership in the Roads Research Alliance has demonstrable value, not just in the immediate research portfolio but also in the future relationships we are building across the industry. We're excited to see how this develops over the coming years.

Feedback from Sagar Seth on Digital Twin Training

I recently had the pleasure of attending the Digital Twin workshop organised by the University of Cambridge, and I must say it was an enlightening and thoroughly engaging experience. This workshop, which brought together leading experts, researchers, and practitioners in the field, exceeded my expectations in several ways. The workshop opening by Mark Enzer effectively summarised the status of the technology in the civil engineering sector and highlighted some of the challenges and opportunities.

Through the workshop, I was introduced to wider government initiatives such as the National Digital Twin Programme (NDTP) and Cyber-Physical Infrastructure. The university professors went on to explain the application of the technology and the practical considerations such as cloud architecture and data analytics. The workshop was an excellent opportunity to network with some of the leading minds within the field and allowed an insight into the academic developments where we, as those in industry, were able to help explain the practical application of digital twins for consideration.

The Digital Twin Workshop by the University of Cambridge was an outstanding event that provided a wealth of knowledge and inspiration, and I would highly recommend it to anyone interested in the field of digital twins, whether they are researchers, practitioners or policymakers. The insights gained from this workshop will undoubtedly inform and enhance my future work in this exciting domain.

Conclusion

Generating value for the roads industry

The initial success of the Roads Research Alliance should not be underestimated. It is the collective leveraging of a significant proportion of EU Horizon 2020 research investment in transport, a first for this type of investment. As we build the foundations for greater collaboration on fundamental research for the roads industry, the value of the partnership that we have built is significant.

Many of the case studies have referenced the advanced knowledge they have gained from being involved in the research conversations over the last 18 months. The proximity of academia and industry through the Future Roads Fellowship Programme is a particularly special quality, which is acknowledged and deeply appreciated by the Fellows themselves.

As the Alliance raises its profile across partner organisations, including National Highways, further insights and opportunities are presenting themselves, such as links with the Modern Methods of Construction group. This sharing of market insights and positioning is something the Alliance will continue to put at the centre of the agenda.

The investment-in-kind by the industry supervisors, has provided partner organisations with the opportunity to lead the roads sector and steer solutions to industry challenges. It is evident from the numbers quoted in this report, that the sheer volume of activity and expert involvement generates value through connection of people and ideas.

Looking ahead to 2025 and beyond

As the bulk of the research projects begin to develop in the coming year, the Alliance can begin to focus on delivering value from the research outputs. There is a competitive advantage to be had in generating evidence for new concepts working. The work that the industry supervisors are doing to steer the research towards tangible products will intensify as the Future Roads Fellowships draw to a close at the end of 2026. Alongside this, the Alliance can begin to seed conversations around long-term change for the roads sector – steering regulation, industry standards and ways of working.

In the background, the Alliance Management team is working hard to determine the next step in the Roads Research Alliance's evolution. Thank you to everyone who has contributed to this journey so far and we look forward to working with you closely in the coming year.

Membership overview

The Roads Research Alliance consists of the following members.

With particular thanks to the following Alliance Engagement leads from each of our member organisations:

AECOM	Dr Ramesh Perera	Technical Director
AECOM	Joanne Edwards	Technical Director
Amey	Emily See	Highways Market Director
Amey	Mohammed Dakri	Head of Technology, Lighting and Energy Solutions | SPaTS 2 Framework Market Director
Arcadis	Paviter Singh Phull	Technical Director – Design and Construction Health, Safety & Environment
Arcadis	Will Waller	Senior Director - National Highways Account Leader
AtkinsRéalis	Dr Matthew Peck	Innovation Director
Balfour Beatty	Michael Schenk	Head of Demand, Operations & Innovation Planning
BAM Nuttall	Arjun Thirunavukarasu	Innovation Manager
Bentley Solutions	Joe Rice-Jones	Strategic Account Director
Bentley Solutions	Lee Jackson	Product Manager
COLAS	Paul Acock	National Technical Manager
COLAS	Mark Saunders	Client Director
COLAS	Dr Oliver Thomas	Innovation Manager

Costain	Tim Embley	Strategic Innovation Lead
Costain	James Merrett	Consultancy Programme Director - Highways
Ferrovial Construction	Effrosyni Tzoura	Innovation Manager
Galliford Try	Philip Farrar	Innovation Lead
Galliford Try	Edward Wells	Head of Digital Construction
Jacobs	Greg Weingarten	Head of Intelligent Infrastructure
Keltbray	Michael Pelken	Innovation Director, Research and Development
Keltbray	Simon Hayton	Head of Engineering and Performance
Kier	Jordan Flint	Director Kier Highways Design Solutions
Kier	Tom Tideswell	Senior Project Manager
National Highways	Dr Chrysoula Litina	Principal Research Engineer
National Highways	Phillip Proctor	Head of Research
Ordnance Survey	Stefano Cavazzi	Principal Innovation and Research Scientist
Ordnance Survey	Jeremy Morley	Chief Geospatial Scientist
Ramboll	John Armitage	Technical Director

Ringway	Yogesh Patel	Process and Improvement Director
SAP	Frank Omare	Procurement and Supply Chain Specialist
SAP	Francesco de Toma	Transportation Industry Advisor
SAP	Lindsey Rowe	Head of Purpose Programmes & Sustainability - UKI
Telent	Martin Herbert	Head of Contract Services
Telent	Andy Gifford	Director of Highways
Telent	David Taylor	Head of Strategic Planning
Trimble	Marianna Kopsida	Market Development Manager
TRL	Paul Campion	Chief Executive Officer
TRL	David Hynd	Chief Scientist
University of Cambridge	Professor Ioannis Brilakis	Laing O'Rourke Professor of Civil and Information Engineering
University of Cambridge	Professor Abir Al-Tabbaa	Professor of Civil and Environmental Engineering
Versarien	Dr Daniele Annicchiarico	Senior Application Scientist
Versarien	Dr Stephen Hodge	Chief Executive Officer

Future Roads publications

White papers

Building Trustworthiness in Carbon Data to Achieve Net-Zero Across the Life of Highway Assets

Jinying Xu, Kristen MacAskill, and Francesco De Toma

The decarbonisation of the transportation sector is critical to achieving a Net Zero Economy. PAS2080:2023 provides an overarching guidance for carbon management in infrastructure and buildings, but does not extend to covering how the underlying collection, sharing, reporting, and analysis of carbon data takes place. Data trustworthiness issues emerge from stakeholders often relying on obtaining data from others, using different methods and systems. This whitepaper addresses the data trustworthiness issues, identifies its four key pillars and key success factors, and discusses how technology can help. It sets the scene for developing a standardised carbon data model and calls the engagement of value chain stakeholders.

2023 University of Cambridge

DOI: https://doi.org/10.17863/CAM.108074

Journal publications

Bayesian dynamic modelling for probabilistic prediction of pavement condition

Yiming Zhang, Alix Marie d'Avigneau, Georgios M. Hadjidemetriou, Lavindra de Silva, Mark Girolami and Ioannis Brilakis

Engineering Applications of Artificial Intelligence Volume 133, Part F, July 2024, 108637

DOI: https://doi.org/10.1016/j.engappai.2024.108637

A critical review of road network material stocks and flows: Current progress and what we can learn from it

Daniel Grossegger, Kristen MacAskill, and Abir Al-Tabbaa, Resources, Conservation and Recycling, Volume 205, June 2024, 107584

DOI: https://doi.org/10.1016/j.resconrec.2024.107584

Review papers

Soft touchless sensors and touchless sensing for soft robots

Chapa Sirithunge, Huijiang Wang and Fumiya Iida

Front. Robot. AI, 18 January 2024 Sec. Bio-Inspired Robotics Volume 11 - 2024

DOI: https://doi.org/10.3389/frobt.2024.1224216

Conference papers

BG-LoA: A Benchmarking Framework for BIM/GIS Data Integration based on Meta-Modelling Theory

Junxiang Zhu, Ran Wei, Mengtian Yin and Ioannis Brilakis

ISPRS Technical Commission IV Symposium 2024, October 2024, Australia (upcoming)

DOI: https://doi.org/10.17863/CAM.108326

Capturing Reality Changes from Point Clouds for Updating Road Geometric Digital Twins

Diana Davletshina, Varun Kumar Reja and Ioannis Brilakis

2024 European Conference on Computing in Construction, July 2024, Greece (upcoming)

DOI: https://doi.org/10.17863/CAM.107287

How Can Digital Twins Be Used in Highway Maintenance? A Questionnaire Survey for Industry Practitioners

Mengtian Yin, Varun Kumar Reja, Ran Wei, Brian Sheil and Ioannis Brilakis

2024 European Conference on Computing in Construction, July 2024, Greece (upcoming)

DOI: https://doi.org/10.17863/CAM.107921

A Digital Twin Based Approach to Control Overgrowth of Roadside Vegetation

Varun Kumar Reja, Diana Davletshina, Mengtian Yin, Ran Wei, Quentin Felix Adam, Ioannis Brilakis and Federico Perrotta

2024 41st International Symposium on Automation and Robotics in Construction, June 2024

DOI: https://doi.org/10.17863/CAM.107918

Navigating Mixed Traffic: Current State and Future Challenges in Integrating Autonomous and Human-Driven Vehicles

Kai-Fung Chu, Chenchen Fan and Fumiya Iida

2024 IEEE International Conference on Advanced Robotics and Its Social Impacts (ARSO) May 2024, May 2024

DOI: https://doi.org/10.17863/CAM.107292

A carbon data trustworthiness framework for the construction sector

Jinying Xu and Kristen MacAskill, Department of Engineering, University of Cambridge, Cambridge, United Kingdom,

2023 European Conference on Computing in Construction and the 40th International CIB W78 Conference

DOI: 10.35490/EC3.2023.261

Soft robotic tactile perception of softer objects based on learning of spatiotemporal pressure patterns

Tetsushi Nonaka , Arsen Abdulali , Chapa Sirithunge, Kieran Gilday and Fumiya Iida

2023 IEEE International Conference on Soft Robotics (RoboSoft), April 2023

DOI: 10.1109/RoboSoft55895.2023.10121950

Conference papers Cont...

The Xeno-Tongue Gripper: Granular Jamming Suction Cup with Bellow-driven Self-Morphing

Kieran Gilday, Ryman Hashem, Arsen Abdulali, and Fumiya Iida

2023 IEEE International Conference on Soft Robotics (RoboSoft), April 2023

DOI: 10.1109/RoboSoft55895.2023.10121982

Effect of SAPs and polypropylene fibres on the freeze-thaw resistance of low carbon roller compacted concrete pavement

Vahid Afroughsabet, and Abir Al-Tabbaa

SMARTINCS'23 Conference on Self-Healing, Multifunctional and Advanced Repair Technologies in Cementitious Systems, March 2023

DOI: https://doi.org/10.1051/matecconf/202337808006

Research and development - National Highways

Future Roads Fellowships | Digital Roads of the Future (cam.ac.uk)

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