CATAPULT
Transport Systems

ACADEMIC ENGAGEMENT STRATEGY

Fostering relationships between academia and industry helps the UK be a world leader in Intelligent Mobility – to grow faster, create better products and services, and gain access to new markets

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EXECUTIVE SUMMARY

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Imagine a world where journeys are seamless, transport is smart and connected, and delays and congestion are a thing of the past. The Transport Systems Catapult is working to make this vision a reality.

Faced with the combined challenges of an ageing global population, rapidly increasing urbanisation and the corresponding strain on the environment, policy makers are beginning to realise that current approaches to transport will not be sufficient for our future needs.

Inventive and skilled thinkers from academia and industry are helping to create intelligent, integrated transport systems that work across multiple forms of transport. Bringing that expertise together, aligning goals and facilitating collaboration are key to what we do – and essential for making the new world of transport a reality.

Academic Engagement is at the heart of the Transport Systems Catapult (TSC) and is one of our strategic initiatives.

Academia delivers innovation, knowledge and thought leadership, but it must evolve its connections with the commercial world if it is to have social and economic impact and deliver better transport outcomes for the UK.

By continuing to meet the changing needs of both academia and industry, and partnering with both, our strategic approach is designed to bring innovations to market faster, as well as understand and unlock new opportunities for exploitation.

LEVERAGING ACADEMIA FOR DISRUPTION

We are in a strong position. UK universities are among the best in the world, and are progressing and pursuing innovative research that could disrupt the norm and solve global problems. Without the commercialisation and implementation of that knowledge, however, the UK risks losing out on the immense benefits offered by Intelligent Mobility (IM). Connection between academia and industry is crucial to this disruption and innovation.

UK universities leverage over £10 billion per year[1] in research and teaching funding for the development of early Technology Readiness Level (TRL) research and education projects. By merging the considerable research power of the UK's universities with the TSC's targeted knowledge of global transport system challenges and opportunities, we can focus academic research more efficiently for even better impact. These early TRL projects form a pipeline of innovation that runs from academia to industry, resulting in a faster route to market for mobility solutions – for people and goods.

MORE THAN THE SUM OF THE PARTS

Professor Sir Mark Walport, Chief Executive Designate of UK Research & Innovation (UKRI), gave a speech in July 2017 outlining the vision for the newly announced organisation and commented, "We are building on component parts of the funding landscape which, individually, are very strong, but there is considerable untapped potential for the whole to be much more than the sum of the parts. We need to stimulate and reward audacity, ambition and agility, where imagination and innovation are actively encouraged and important proposals do not fall foul of artificial divides." [2]

[1] Department for Business Innovation & Skills (March 2016): The allocation of science and research funding - 17/18: £4.89bn; 18/19: £4.99bn; 19/20: £5.09bn
[2] Sir Mark Walport shares a vision for UK Research and Innovation https://www.gov.uk/government/news/sir-mark-walport-shares-vision-for-uk-research-and-innovation

Connecting academia with industry is complicated, especially when organisational structures and models are complex and often come with legacy issues. Yet the future of transport depends on this multidisciplinary connection. Two influential groups – academia and industry – have the potential to unlock this future. While Sir Mark's speech refers to funding divides, he also pointed out that universities, companies and funding agencies often work in isolation. Through neutral facilitation across disciplines, the TSC bridges silo thinking for communication and collaboration that brings disruption and progress.

WHY ACADEMIC ENGAGEMENT IS AN IMPERATIVE

With a clear focus on linking with universities to help them transmit and share insight, information and progress, the TSC can connect thought leadership with commercial and practical reality. This practical reality has huge potential and, as our wider organisational strategy identifies (see page 6), the Academic Engagement Programme is foundational for the overall success of making the UK the world leader in IM. The opportunity sits particularly within the commercial sphere. By acting as an IM accelerator, we attract disruptive start-ups with high-growth potential to the UK transport industry and help them grow into world-leading companies. And when companies are motivated and fuelled by exciting new opportunities, they are enabled to deliver tangible advancement in the transport sector.

If academic engagement is a dependency for success, it is essential that we put an academic engagement strategy into action now, to ensure that this crucial part of our economy is given sufficient focus and funding. As Jo Johnson pointed out, "The analysis of the 2016 Higher Education Business and Community Interaction (HEBCI) survey […] shows that wider economic engagement is growing more slowly than the economy as a whole, at one per cent, and from a low base. It is also highly uneven, with parts of the country benefiting from it more than others." [3]

Measuring the collaboration that comes from academic engagement and the resulting knowledge exchange is fundamental to this. By advising Research England "to consult with the sector and advise on the development of a new, public Knowledge Exchange Framework (KEF)" the government seeks "a comprehensive range of measures of impact". Ultimately, this supports the government's goal that the KEF "will become an important public indicator of how good a job universities are doing at discharging their third mission, just as the REF rewards excellence in research and the TEF rewards excellence in teaching and student outcomes."

£10 billion per year

UK Universities leverage in research and teaching funding for the development of early Technology Readiness Level projects.

[3] DBEIS: Jo Johnson speech at HEFCE Conference 2017 (12 October) HM Government - Speeches - Department for Business, Energy and Industrial Strategy 12/10/2017

FIVE STRATEGIC INITIATIVES FOR RAPID PROGRESS

It's important to contextualise our Academic Engagement Strategy with our wider organisational strategy. The TSC has identified five strategic initiatives that will help us deliver rapid progress in the commercialisation of transport innovation, and make the UK the world leader in IM.

ACADEMIC ENGAGEMENT PROGRAMME	SME PROGRAMME	CONNECTED AND AUTOMATED TRANSPORT (CAT)	NEW MODELS FOR TRANSPORT	OPEN DATA PLATFORM FOR TRANSPORT
1	2	3	4	5
Connect industry with outstanding UK university teams	Includes business accelerator and growth programmes	Growth in new market entrants delivering CAT product and service innovations	National framework for exploitation of new business models	Enable critical infrastructure and sector-wide analysis for data sharing

FIVE STRATEGIC ROLES

Based on the five strategic initiatives for rapid progress the TSC's key roles for academic engagement are to:

1. Create new collaborations among IM stakeholders in universities, industry (especially SMEs) and government, helping them align their plans and roadmaps.
2. Connect a diverse range of organisations, break down barriers and silos, and bring together large consortia.
3. Ensure IM has presence in research budget planning and allocation by working with universities and research councils to highlight opportunities for research exploitation and making it a priority.
4. Support universities to engage with transport policy and influence policy makers.
5. Act as an agent for UK and global opportunities by understanding, collecting, maintaining and developing our knowledge of the IM sector.

INTRODUCTION

In the UK we are perfectly positioned to make the most of academic opportunities for the advancement of Intelligent Mobility (IM).

The UK is home to three of the top ten universities in the world: Oxford, Cambridge and Imperial College London. Of Europe's top five universities, four are in the UK: Oxford, Cambridge, Imperial and UCL[4]. We have a thriving academic community, generating innovative research that is capable of solving global problems

BARRIERS TO ADVANCEMENT

The UK is well placed to take advantage of these momentous changes and should aspire to be at the forefront of the global IM market, which will be worth an estimated £900 billion by 2025. However, if industry cannot or does not connect with our thriving academic community and commercialise its knowledge, the UK risks losing out on the huge benefits offered by IM. Equally, if UK universities want to maintain their world-leading position, increasing their level of industry income – which currently lags far behind that of US universities – is essential.

Overcoming any barriers that slow the flow of knowledge and innovation between academia and industry is crucial to everyone's future success. The TSC has identified four key barriers:

1. A gap between research output and commercialisation
2. Industry's lack of knowledge about universities' capabilities and assets
3. Silos between transport modes, sectors, universities and research groups
4. No shared language between academia and industry

PURPOSE OF THIS STRATEGY

Designed to maximise the potential impact of academic research on industry and enable the sector to grow faster, this Academic Engagement Strategy has been created for industry, universities, national and local government, sister Catapults and further Research and Technology Organisations. By evidencing the TSC's success through case studies of work, this strategy intends to build relationships within the IM ecosystem, both immediately and long-term – to bring thinkers, innovators, leaders and business owners together to benefit each other, the community and the UK.

[4] Times Higher Education World University Ranking 2018

THE ROLE OF THE TRANSPORT SYSTEMS CATAPULT

As a neutral, independent integrator, the Transport Systems Catapult (TSC) connects key players in industry with academic leaders to develop solutions that would otherwise not have come about.

A NATIONWIDE NETWORK

Catapult centres, established by Innovate UK, are a network of world-leading hubs designed to transform the UK's capability for innovation in specific areas and help drive future economic growth. Each Catapult centre specialises in a different area of technology; however, all offer a space with the facilities and expertise to enable businesses and researchers to collaboratively solve key problems and develop new products and services on a commercial scale.

In his 2010 report that was instrumental in setting up Catapults, Hermann Hauser wrote, "We must continue to invest in, and support, research excellence; ensure we support areas of UK industry which have the ability and absorptive capacity to capture a share of high value activity; and close the gap between universities and industry through a 'translational infrastructure', to provide a business-focused capacity and capability that bridges research and technology commercialisation." [5]

In 2014, he went on to say, "Catapults should develop a stronger, more coherent engagement model for working with universities (national and international), building on best practice, with a view to drawing on and commercialising knowledge to help UK industry gain competitive advantage."[6]

BRINGING THE FUTURE FORWARD

As an independent and neutral integrator, the TSC can connect organisations and sectors to deliver the future of transport. By aligning thinking and incentives, and by facilitating the meeting of stakeholder needs, the TSC boosts the UK's knowledge of, and activity in IM. When thinking is aligned, the IM community moves forward in the same direction to create maximum efficiency, success, innovation and commercial benefit.

SOLVING INDUSTRY CHALLENGES

As a neutral and trusted body in the IM community, the TSC is uniquely placed to foster relationships between academia and industry players whose objective is to grow the UK economy in transport. Ultimately, this fostering helps the UK grow faster and solve industry challenges, create disruptive, groundbreaking products and services and open up new markets.

FIVE INITIATIVES FOR RAPID PROGRESS

Our work brings growth and creates jobs in the UK IM sector. At the TSC, we have identified five strategic initiatives that will help us make rapid progress, of which one is academic engagement. Each of these initiatives is vital – advancement depends on every one of the five, as they are so closely interconnected.

1. **Build on and deepen our relationships with academia,** connecting industry with outstanding UK university teams that are working on transport.
2. **Help small businesses with comprehensive programmes and support,** including an accelerator to help those who want to turn an idea into a business, and a programme for growth.
3. **Ensure the UK is the premier place to develop and test Connected and Automated Transport.** Connected and Automated Transport (CAT) is a major focus of the UK's Industrial Strategy.
4. **Provide new ways to discover, pay for, use and deliver transport.** The New Models for Transport initiative aims to develop a national framework for exploitation of new business models such as MaaS and support MaaS ecosystem developments.
5. **Improve our ability to share data between organisational silos.** This initiative underpins and enables all the others.

[5] Hauser H (2010) "Hauser Report of Technology and Innovation Centres in the UK (2010) https://www.catapult.org.uk/documents/10582/221284/pdf/328e5fa1-b16b-4e16-ae64-40119918e4d3

[6] The Current and Future Role of Technology and Innovation Centres in the UK Hauser H (2014) "Review of the Catapult Network" https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/368416/bis-14-1085-review-of-the-catapult-network.pdf

BENEFITS AND BACKGROUND OF ACADEMIC ENGAGEMENT

The TSC's history of contributions and benefits to academia and industry is encouraging. To date, our academic programmes and initiatives have brought both national and global advancement in the IM sector.

THE DIRECT IMPACT OF OUR STRATEGIC FOCUS

As well as the transformative effect of working with the TSC on research that will have a direct impact on the world around us, there are wider benefits to academic and industry engagement. This engagement is crucial for progress, and also depends on connection with government.

FURTHER BENEFITS FOR UNIVERSITIES:

FOR RESEARCHERS

A series of case studies demonstrate the impact of the TSC acting as a neutral integrator, working with academia and industry. As defined by the Research Excellence Framework (REF), impact is an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia.

Each Higher Education Institution (HEI) submits a selection of impact case studies for assessment in the REF. An impact case study is a four-page document, describing the impact of research undertaken within the submitting department. It also contains information about the research that underpins the impact that took place.[7]

FOR FUNDING

Universities can benefit from working with the TSC when it comes to their Higher Education Business and Community Interaction Survey (HE-BCIS). The work we do together can provide valuable evidence that can positively affect the industrial and Higher Education Innovation Fund (HEIF) income and influence Research England.

As creating and maintaining dynamic and trusted relationships with universities is a top priority, some of our recent projects have included:

- Working with 33 national and three international universities (Denmark, France and Italy)
- Managing 35 placements and internships at the TSC
- Organising over 100 workshops and events in partnership with academics
- Leading more than 30 joint projects with academia

[7] http://impact.ref.ac.uk/CaseStudies/FAQ.aspx

IMOVATION CENTRE OUTCOMES

The TSC created placements for academic staff and students at the Imovation Centre, where research and events were held. Regular workshops, forums, conferences and networking events at both the universities and Imovation Centre resulted in the development of IM concepts, research and partnerships with commercial partners, particularly SMEs. With IM at the core of educational programmes – from apprenticeships to postgraduate education – work with industry partners also enabled us to identify IM skills needs.

THE UNIVERSITY PARTNER PROGRAMME

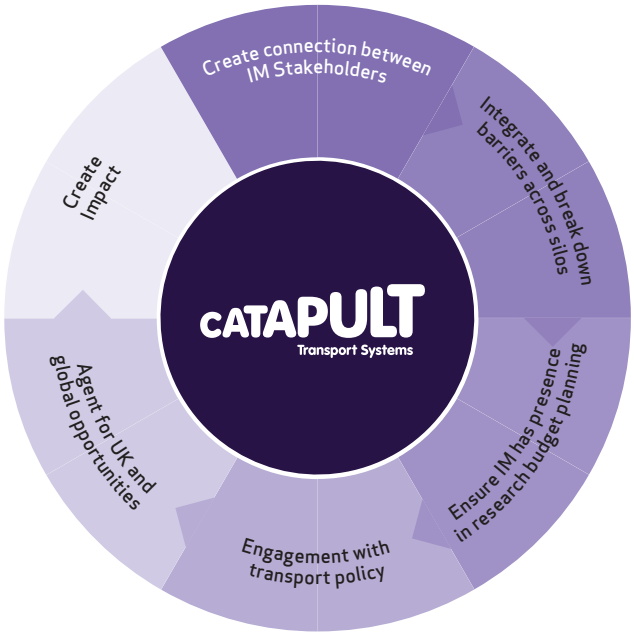
Established in 2014, the TSC's University Partner Programme (UPP) developed a network of long-term university partners, and assisted the maximisation of measurable economic benefit of UK research into IM. Research needs and market opportunities were shared between all partners, promoting inter-university knowledge exchange.

University partnerships applied for collaborative project funding. The University of Aberdeen and Heriot-Watt University, Coventry University, De Montfort University, Loughborough University and Nottingham Trent University, the University of Leicester and University of Nottingham, University of Sheffield and Sheffield Hallam University, University of Southampton, Cranfield University and University of Leeds were the participating universities. The UPP will conclude in March 2018 and be succeeded by the new Academic Engagement Programme (see page 13).

THE ACADEMIC ENGAGEMENT STRATEGY

Our vision is to use our role as a trusted and neutral partner and critical friend to support the acceleration of collaboration and the sharing of IM knowledge between academia and industry. By increasing the impact of IM-related research, making it easier for industry to commercialise it and put it into action in the world, our support will benefit universities, businesses and consumers alike.

Our neutral position puts us at the heart of the IM community and means we are ideally suited to increase the flow of knowledge and ideas. The TSC will fulfil the following strategic roles through the new Academic Engagement Programme:



Implementing our Academic Engagement Strategy is highly dependent on the Academic Network and the strategic initiatives of TSC.

OUR ACADEMIC ENGAGEMENT STRATEGY: THE TSC'S FIVE STRATEGIC ROLES

1. Create new collaborations among IM stakeholders, helping them align their plans and roadmaps.
2. Connect with a diverse range of organisations and break down barriers between silos.
3. Ensure IM has presence in budget planning and allocation by working with universities and research councils.
   a. Influence research councils in advisory boards and committees to focus on IM-related opportunities by emphasising the needs of industry.
   b. Grow the UK academic focus on IM and enable the development of educational services.
   c. Support the development of more IM-related Master of Science courses.
4. Support universities to engage with transport policy and influence policy makers.
5. Act as an agent for UK and global opportunities by understanding, collecting, maintaining and developing our knowledge of the IM sector.

THE ACADEMIC ENGAGEMENT STRATEGY'S NETWORK

Commencing in 2018, the new three-year Academic Engagement Network has been developed based on the TSC's wider organisational strategy and the five strategic roles of Academic Engagement. It is designed to help participating universities gain recognition for international excellence in research fields that are relevant to our vision of IM.

By establishing the Academic Network, which includes academics from former UPP partners and other UK universities, we will be working with academics in a number of different ways, always ensuring that we are quick to adapt to business needs. This Academic Network will also reach out to the wider UK science and technology academic community and will establish Deep Academic Alliances (DAA) with a number of universities.

TIER ONE

THE WIDER BASE

The wider base will be an ongoing open network of entrepreneurial academics and researchers from UK universities who will contribute to the creation of an environment that will make the UK a world leader in IM. We will define the future big ideas and challenges with the Academic Network, local authorities and LEPs, SMEs and corporates, so that we can best support and facilitate research projects. We will share the knowledge gained from this activity with stakeholders in an annual statement.

TIER TWO

DEEP ACADEMIC ALLIANCES

We will undertake more focused activity with universities whose research has significant overlap with our capabilities. This will be to create significant knowledge and capabilities relevant to the key markets, influence important stakeholders and ensure that all our strategic partners are working towards a common goal through the partnership. Much of this approach is driven by Hermann Hauser's review of the Catapult system published in 2014, mentioned earlier, which demands a "stronger, more coherent engagement model" if the UK is to gain competitive advantage in this sector.

THE ACADEMIC ENGAGEMENT STRATEGY'S PROGRAMME

Integral to the success of the TSC fulfilling its five strategic roles for Academic Engagement is a programme of initiatives. Each of the five collaborative and connected ideas are designed to build on our strength as a neutral facilitator and connector, linking academia with industry:

1. **Placement programmes** to help drive seamless collaboration by addressing a specific industry need.
2. **Collaborative research and development** activities that connect projects across academia and industry.
3. **Deep Academic Alliances** (DAA) that create key partnerships between universities, industry and TSC.
4. **Hackathons** organised in partnership with universities to rapidly solve real IM industry problems.
5. **Events and publications t**hat share knowledge and develop a network of IM leaders.

ACADEMIC ENGAGEMENT PROGRAMME ELEMENTS

Through academic engagement and together with industry and government, the IM community can positively impact the UK by driving transport innovation and boosting commercial competitiveness. To bring this strategy to life and to realise the purpose of academic engagement, the TSC will initiate a new Academic Engagement Programme with anticipated benefits.

PLACEMENT PROGRAMME

To help drive seamless collaboration between industry and academia we enable and offer different types of placements that directly address a specific industry need and support the TSC strategy. The programme's four main activities are:

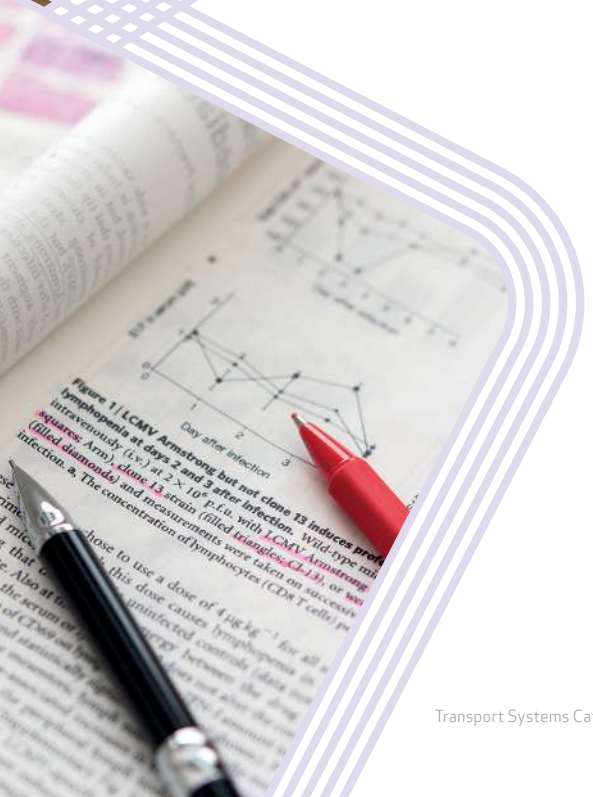
1 PLACEMENTS	2 INTERNSHIPS	3 SECONDMENTS	4 RESEARCHERS IN RESIDENCE
For university staff seeking to access support from the TSC or expertise to validate a proof of concept (research project shall be around TRL 4).	For university students who want to apply their skills and knowledge to a specific IM area within an existing industry-led project at TSC.	Market-led opportunities offering the chance for academic staff to spend time within an SME and solve a specific problem. The expected impact is to boost growth and job creation within micro enterprises.	For academic staff looking to explore selected capability areas while working with catapult centres. The purpose is to establish a long-term relationship between catapults and universities.[8]

By exploring and trialling new methodologies and data for the IM sector, academic staff and students are integral to the exciting move towards full adoption of Connected and Automated Transport (CAT) and New Models for Transport. With access to TSC's state-of-the-art facilities, tools and data, such as the Modelling and Simulation Platform, the Visualisation and CAV Lab and the IM Data Hub, the opportunity to apply knowledge is expedited.

Working with the TSC brings tremendous benefits for universities. Students and researchers have the opportunity to develop their skills and expertise, supporting them with their future career goals and, at the same time, helping the IM sector bridge a future skills gap. Over the past three years, access to our facilities and expertise has contributed to boosting research in IM within the partner universities, which has led to many collaborative research and development projects, proof of concepts, joint events and papers.

As a thought leader in IM, the TSC is ideally positioned to create and optimise placements. We can steer research in the IM market and help participants create a shared vocabulary – something that is currently missing in this relatively new sector. To date, staff and students from over 30 universities have taken part in the TSC placements, secondments and internships. The demand to access these activities is ever growing, as is the appetite to test new ideas and work together, for a brighter, even more successful future in IM.

[8] https://catapult.org.uk/work-with-us/researchers-in-residence/



COLLABORATIVE RESEARCH AND DEVELOPMENT ACTIVITIES

As part of our role as a facilitator of collaboration, the TSC leads programmes and joint projects across academia and industry. We respond to Innovate UK and research council requests and broker the creation of consortia to support industry-led challenges with pioneering academic research.

DEEP ACADEMIC ALLIANCES (DAA)

DAAs are key partnerships between universities, industry and TSC that align IM research and educational roadmaps and strategies. They play an important role in maximising the potential of SME networks and creating a strong group of universities who can lobby for funding for IM and develop enabling capabilities with industry for the benefit of UK PLC. To ensure we are always working with the most relevant academic organisations, we review the status of our university partners every two years.

HACKATHONS

The spirit of innovation and collaboration that is central to our ethos is perfectly embodied by Hackathons. Organised in partnership with universities to rapidly solve real IM industry problems, Hackathons trigger new start-ups and potentially encourage them to join the IM Accelerator.[9]

Expected benefits for the sector:

- Creation of prototype solutions to specific challenges
- Accelerated business growth and innovation
- Data exploration
- Application of leading research capabilities to industry problems
- Cementing partnerships between transport bodies, corporates, SMEs and academia

Improved efficiencies:

- Using existing academic knowledge, expertise and research outputs as 'quick wins' to solve industry problems
- New academic partners for industry
- Better aligned research in universities, driven by industry challenges

EVENTS AND PUBLICATIONS

Sharing knowledge and developing a network of IM leaders is fundamental to establishing a common vocabulary and collaborating on cutting-edge work. We run events in tandem with the SME Programme, delivering on-site Transport Café events at partner universities, increasing academic focus during the Imagine Conference and developing joint papers and publications with universities.

Our comprehensive series of networking events offers academics, industry leaders and funders the chance to discuss IM themes at a regional, national and international level. This is a great opportunity for all of us to share our knowledge, experience and goals, and to develop the common vocabulary that is so essential to the smooth flow of information and ideas.

[9] https://wayra.co.uk/intelligentmobility/

ACADEMIC ENGAGEMENT PROGRAMME OUTCOMES AND BENEFITS

The TSC Academic Engagement Programme is a broad initiative that involves activities and projects that produce end results for the benefit of universities and businesses, individuals and organisations. Some of the many outputs that we expect include:

1. Aligned strategies and roadmaps so that universities and the TSC can work seamlessly together.
2. The formation of a shared IM vocabulary through our events, publications, presentations and papers.
3. An opportunity for students to gain an award for the best IM-related project of the year.
4. The production of an Academic Capability Map in IM. This will help us all gain a clearer picture of the key capabilities and assets of UK universities. We will work with partners such as the National Centre of Universities and Business on an IM related platform to connect academia and industry.
5. Academic start-ups and spinouts deriving from innovative work done during activities such as Hackathons.
6. A dynamic and thriving Academic Network that:

- Helps the UK become a role model in driving innovation through academia.
- Enables our academic partners to contribute to the delivery of the Industrial Strategy, bringing together the UK's world-leading research with business to meet major industrial and societal challenges.
- Helps universities and research communities to write clear business cases for IM support and funding.
- Minimises silos across the industry and in research communities.
- Runs an open Transport Café with universities.
- Supports clusters and grows partnerships in IM.
- Works efficiently with other networks and clusters, such as the Midlands Engine and University Transport Study Group (UTSG).
- Shares ideas at Imagine Conference academic day.
- Runs productive, interactive open days with SMEs.

STRATEGY IN PRACTICE:
CASE STUDY 1

FIELD TRIALS LEAD TO GREATER UNDERSTANDING OF WHAT MAKES PEDESTRIANS TRUST CAVS

Student researching pedestrian-pod interactions secures key role at the Knowledge Transfer Network

ABOUT THE PROJECT

It is crucial that pedestrians trust CAVs to be safe and reliable. To look into this important area, the TSC supported George Filip, a Nottingham University PhD student, as he undertook a three-month placement exploring pedestrian interactions with CAVs. George observed how pedestrians and other traffic participants interacted with the LUTZ Pathfinder automated pod during field trials in Milton Keynes. He also interviewed TSC staff to further explore the theme and took part in two Imagine Festivals. Mark Westwood (Chief Technology Officer), Alan Nettleton (Senior Technologist) and Dave Barnett (Senior Technologist) at TSC supervised his placement.

PROJECT HIGHLIGHTS

Understanding trust between people and CAVs

The observational studies and interviews offered significant insights into what makes pedestrians and other road users trust CAVs to be safe, such as the need for automated vehicles to acknowledge pedestrian presence. The internship also gave George the opportunity to directly observe how exposure to CAV technology increases its acceptance by the public – transitioning from novelty to normality, with a majority of users being willing to use the pods.

OUTCOMES

Taking new knowledge to the CAV community

Following his internship, George successfully applied for an Impact Grant from the Horizon CDT to further explore cyber security and transparency issues in CAVs. He then secured the role of Knowledge Transfer Manager for the Knowledge Transfer Network, where he is helping businesses innovate in the area of CAVs.

His internship offered solid quantitative data to support qualitative theories, which are currently being translated into a journal paper that George is writing. It also led to another placement, and collaboration on a journal paper with Professor Sarah Sharples, non-executive director for TSC and Associate Pro-Vice Chancellor for Research & Knowledge Exchange at University of Nottingham.

> **The access, support and mentoring offered by the Transport Systems Catapult have proven to be one of the best experiences of my PhD, while also offering me a chance to network and gain insightful knowledge into my topic. It has also helped me secure a research grant as well as a new position.**

George Filip, Researcher at University of Nottingham and Knowledge Transfer Manager for CAVs at Knowledge Transfer Network

CASE STUDY 2

VR SIMULATION PROJECT REVEALS HOW PEDESTRIANS REACT TO AUTONOMOUS VEHICLES

Autonomous vehicle VR simulation project leads to a first class degree

ABOUT THE PROJECT

As autonomous vehicles begin to populate our roads, it is important to consider how pedestrians will behave around them. Stuart Mould, a University of Nottingham Master of Engineering student, decided to investigate how pedestrians react to autonomous vehicles using his two-month placement at the TSC. Supervised by Professor Sarah Sharples, he developed a project that focused on improving pedestrian safety by examining their interactions with autonomous vehicles. Stuart used the TSC's virtual reality system, created by the visualisation team, to run his experiments in Nottingham.

PROJECT HIGHLIGHTS

Real world applications

The simulation involved virtual cars approaching a pedestrian crossing under various conditions. Results showed that pedestrians felt more confident that they had been seen and that the vehicle would stop when a non-linear deceleration pattern was used. As a result, Stuart's study recommended that non-linear deceleration should be incorporated into the braking of autonomous vehicles, particularly when they are approaching at high speed.

OUTCOMES

Putting UK students at the heart of innovation

Participant feedback provided data for Stuart's Masters project and helped him gain a first class degree in 2017. He went on to secure a job with Romax Technology – a global leader in software and services for rotating and electric machinery. His placement at the TSC enabled him to produce an innovative yet robust Masters project, with useful insights for the development of autonomous vehicles and associated infrastructures.

Since finalising his project, Stuart has been invited to present his findings at the Transport Technologies Showcase, hosted by the University of Nottingham, and is collaborating on a journal paper with another PhD placement and Professor Sarah Sharples of the IMPETUS project.

> **The aid given by the TSC dramatically enhanced the fidelity of the simulation that was used for my experiment. Ultimately this gave a high level of immersion for the participants, providing far more accurate results and was a real benefit to the experiment.**

Stuart Mould, Master of Engineering graduate, University of Nottingham

CASE STUDY 3

VR EXPERIMENT MAPS MACRO TRENDS FOR PEOPLE, PODS AND PUBLIC TRANSPORT

ABOUT THE PROJECT

University of Sheffield PhD students, John Charlton and Luis Montana Gonzalez, and undergraduate George Baron, combined a large-scale pedestrian simulation model developed using FLAME GPU with the Unreal Engine. They were able to further extend their simulation by collaborating with the TSC to produce a virtual reality implementation based on a 3D representation of the area around Milton Keynes train station.

PROJECT HIGHLIGHTS

Learning how crowds interact with CAVs

The simulation enabled users to walk among virtual characters and pods. Pedestrians and vehicles could interact with each other and with the user. As users walked around the lively, populated area, using the TSC's Omnideck it was possible to clearly see the effects of incorporating the TSC's automated vehicles with crowds.

OUTCOMES

Opening up new research avenues

The students' research opens the door to more projects in the future, for example, incorporating FLAME GPU with the Unity Engine, examining pedestrian data to extract macroscopic variables that describe crowd movements, and more testing of state-of-the-art simulations with the Omnideck treadmill.

CASE STUDY 4

UNDERSTANDING CYBER SECURITY IMPLICATIONS FOR IM OVER THE NEXT DECADE

As we innovate and drive change in IM, one topic continues to raise its head: cyber security. Today in the UK, the average annual cost of cyber crime to transport companies is £2.4 million[10] – a figure that's set to rise with increasing connectivity.

Together with academic partners, the TSC explored this threat in order to offer recommendations on the way forward, ensuring a leading role for the UK as a secure IM market. We gathered evidence from reports, white papers, policy documents and academic research, along with interviews and workshops with key stakeholders and thought leaders. Using the networking capability of the TSC, research from over 70 sources gave the report significant credibility and influence. The academic lead, Siraj Ahmed Shaikh, Professor of Systems Security at Coventry University, commented;

> **I found the collaboration with the Transport Systems Catapult highly valuable. They have adapted the knowledge of cyber security and applied it successfully to the Intelligent Mobility industry with context of cyber threats to transport systems. The industry and policy insights resulting from this work are highly valuable as we invest nationally in modern transport systems that need to be connected, secure, safe and resilient.**

ACTION POINTS FOR A SECURE IM FUTURE

Together with our academic partners, we clearly identified that a strategic approach is required, beginning with five critical steps:

1. Review established security principles and their suitability for IM.
2. Accelerate and adopt technology and research roadmaps for securing all aspects of IM, with emphasis on the convergence with other mobility technologies.
3. Upskill the mobility sector workforce, with cyber security positioned as an essential skill for those working in IM.
4. Ensure transparency as standard across mobility domains. Cyber security is not just an automotive or aviation problem, it is for all of mobility.
5. Accelerate cyber security innovation for IM.

With established capability in cyber security, the UK is well positioned to respond to these challenges. What is needed now is a robust strategy to bring together innovation and expertise from all areas – academic, industrial and political.

[10] Ponemon Institute (2015) Cost of Cyber Crime Study. Ponemon Institute

CASE STUDY 5

COLLABORATING IN A CALL TO ACTION – THE IM SKILLS STRATEGY

New technology is bringing about a new age in transport that offers vast opportunities for jobs and economic growth. All sectors of the transport industry are competing for skills sets that are in short supply. What we do today determines how successful we will be in the years to come. Our Intelligent Mobility Skills Strategy is a call to action for government, academia and industry. Following months of collaborative research, with significant input from a wide range of stakeholders, we published our perspective on the challenges surrounding IM skills in the workforce.

The TSC was commissioned by IM-pact UK to develop a detailed understanding of the skills required to support growth of the UK's IM market. It was made possible through sponsorship by the Centre for Connected and Autonomous Vehicles (CCAV).

OUR APPROACH TO THE PROBLEM

The global IM market is estimated to be worth about £900 billion by 2025. To make the most of this opportunity as a leading force in the field, the UK must quickly build the skills of the nation. Our report on this vital issue was undertaken to give impetus and direction to the national plan for bridging the IM skills gap.

Collaboration between industry and academia was essential to this project. The review and evaluation of skills demand, supply and interventions required has been informed by the following academic partners:

- Dr James Brighton, Prof Graham Braithwaite and Ian Chapman, Cranfield University
- Dr Alan Wong, Karen Ghali, Chris Osowski and Dr Ben Waterson, University of Southampton
- Dr John Arthus, Dr Yuri Vershinin, University of Coventry
- Dr Jenifer A. Holden and Dr Caitlin D. Cottrill, University of Aberdeen
- Peter Barton, Adrian Solomon, Dr Michael Le Lerre and Prof Lenny Koh, The University of Sheffield
- Dr Teresa Maria Raventos and Teresa Smith, University of Leicester
- Clare Collins, De Montfort University
- Dr Paul Edwards and Dr Jenny Illingsworth, University of Birmingham

Industry experts who provided insights and expertise included Jo Lopez, Jaguar Land Rover, Guy Wilmshurst Smith, Network Rail, Neil Franklin, NSAR Limited, Russell Goodenough, Fujitsu and Dr Rhys Morgan from the Royal Academy of Engineering. We gathered robust evidence from over 30 reports, interviewed 40 key stakeholders and ran an IM skills industry workshop attended by over 20 industry participants including SMEs and large corporates.

We also examined industry-specific skills initiatives, such as the Department for Transport (DfT) Transport Infrastructure Skills report and the Automotive Council report on skills. We worked as a key stakeholder with the Centre for Connected and Autonomous Vehicles (CCAV), the joint policy unit between Department for Business, Energy and Industrial Strategy (BEIS) and the DfT. This inter-agency approach has led to a cross-sector IM skills matrix and skills gap assessment that identifies the IM skills demand forecast up to 2025, and recommends ways to solve the skills-gap problem.

> **Cranfield University has participated in the development of the Catapult's IM Skills Strategy. The knowledge we have gained has been valuable in shaping our proposals for a new technical MSc targeted at the Intelligent Mobility (IM) sector.**

Ian Chapman, Head of Regional Engagement and Corporate Projects, Cranfield University

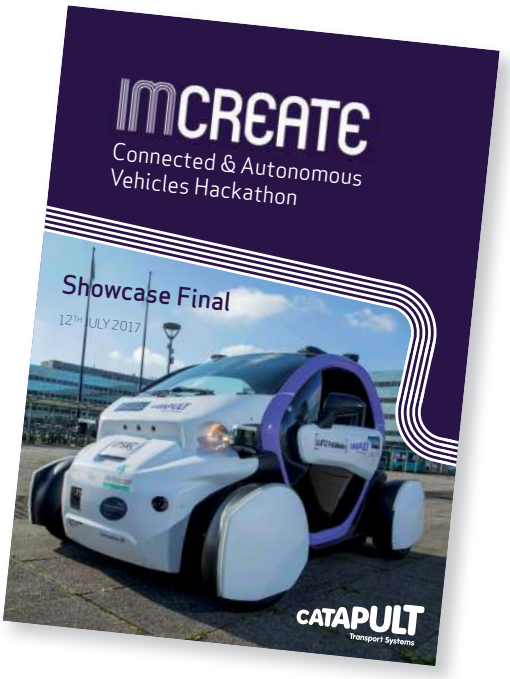
CASE STUDY 6

PROMISING INNOVATION SPRINGS FROM CAV HACKATHON

Hackathons are a great way to bring together innovative brains from across industry and academia to trigger new thinking and ideas.

In July 2017, the TSC hosted the 3rd IMCreate Hackathon. The focus of our thinking on this occasion was CAV. Teams of data scientists, coders, creatives and business thinkers from the worlds of academia and business attempted to solve transport CAV challenges over a 26-hour period. The event was co-organised by IMPART[11] and sponsored by Tech Mahindra.

The day was equal parts demanding and exhilarating, but as the clock ticked down, Team Rostek, Team Sim IQ and Team Space Scanners emerged as our three finalists. They all took part in the final of the Hackathon, just over a week later at the London Transport Museum. Team Sim IQ were the ultimate victors, receiving the £2,000 prize. We are now helping them assess their options for the development of their innovative solution, including the formation of a start-up company and incubation at the Digital Engineering and Test Centre, hosted at the London campus of LoughboroughUniversity – one of our IMPART partners



Hackathons are a great way to bring together innovative brains from across industry and academia to trigger new thinking and ideas.

CASE STUDY 7

THE FUTURE OF MARINE AUTONOMY WITH THE UNIVERSITY OF SOUTHAMPTON

In January 2017, academics at the University of Southampton worked in association with the Government Office for Science in a high-level workshop. Its aim was to influence government and the TSC strategy on marine autonomy. This included recommending a plan for the acceleration of marine autonomy technologies in different contexts, identifying key drivers of change and the key decision points for technology accelerators and public policy.

[11] Partnership project between Loughborough University, De Montfort University, Nottingham Trent University and Coventry University supported by the Transport Systems Catapult (TSC). http://impart-upp.co.uk/about-impart/

THE FUTURE OF ACADEMIC ENGAGEMENT

> **...our investment in and support of research excellence helps us close the gap between universities and industry – between research and commercialisation – through a 'translational infrastructure'**

Hermann Hauser – Catapult review, 2014

What we do is pivotal to creating a successful, dynamic and innovative IM environment for the future of the UK. By bringing together the best thinking from academia and industry, we make an important contribution to solving economic, social and environmental issues. Together, we impact change in a way that none of us could do in isolation.

This is why our strategic approach is designed to be collegiate and dynamic. We know we must be nimble enough to adapt to internal and external change, while basing our priorities on the trending areas in IM and staying highly focused on connecting the academic world with the commercial. As Professor Sir Mark Walport of UKRI has reminded us, success depends upon us all coming together to become more than the sum of our parts. The work we do together, today, will determine the outlook for IM in the UK for decades to come.

By continuing to think and work flexibly, always ensuring that we adopt the methods and approaches that will best benefit the transport sector and the UK as a whole, the IM community has the agility to adapt when change comes – from Brexit or any other external influences.

As Hermann Hauser recommended, our investment in and support of research excellence helps us close the gap between universities and industry – between research and commercialisation – through a 'translational infrastructure'.

This is an exciting time to be at the leading edge of a new world of transport. When we work together, sharing our skills and insights, we can drive change at an astonishing rate, bringing real innovation to the lives of people around the UK, and around the world.

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