



Department
for Transport

Transport-Technology Research and Innovation Grants (TRIG) 2021 Project Outcomes

Delivered by

CATAPULT
Connected Places

Foreword

Professor Sarah Sharples, DfT Chief Scientific Adviser

DfT has a clear role to play in seeding the transport innovation ecosystem with new ideas and new leaders, supporting economic prosperity and enabling the recovery of the transport system post COVID19. Our Transport Research and Innovation Grants (TRIG) provide many small grants to innovators to address the challenges and respond to the opportunities of our transport system today. TRIG allows DfT to support a broad portfolio of projects and help innovators take sensible risks - ones which they could not afford to take on their own. This is an important role for Government and ensures that we have a healthy pipeline of new solutions coming through to support DfT's Strategic Priorities.



2021's TRIG Competition is the largest DfT has funded and it has been my great pleasure to see this programme grow, to get a chance to meet some of the exciting innovators who TRIG supports and to see how they are working to bring beneficial novel technology ideas to life. This competition has encompassed projects across the whole breadth of the technology and application spectra in transport and projects were delivered by innovators from across the whole United Kingdom: from Exeter to Shetland; from Glasgow to Swansea; and from Northern Ireland to Kent. This cohort also enjoys great levels of diversity, with growing numbers of female and under-represented black and minority ethnic innovators.

At a recent Innovation Panel event, hosted by our colleagues at the Connected Places Catapult, I was delighted to present the TRIG Chief Scientific Adviser Awards to some inspirational projects from the TRIG 2021 cohort, and would like to again take the opportunity to highlight these inspirational teams: Makesense; Malakoff (and their partners Ecomar); Hypermile; Fishbone; and the University of Surrey. I am very much looking forward to seeing how each of these 51 projects grow and mature over the coming months and am delighted to see TRIG continuing to forge ahead as a flagship support mechanism within the transport innovation ecosystem for SMEs and University teams.

Congratulations again to all of our 2021 projects! I look forward to seeing your teams and your projects flourish and deliver vibrant innovation in all parts of the transport system.

A handwritten signature in blue ink that reads "Sarah Sharples". The signature is written in a cursive style and is positioned below the main text of the foreword.

TRIG 2021

TRIG 2021 totals 51 projects. 45 of these projects cost £30k each whilst 6 Future Freight projects were awarded grants of up to £100k. 2021 themes included Maritime Decarbonisation, Future of Freight (both £30k and £100k projects), Covid-19 Recover and Transport System Resilience and the Open Call. Summaries were prepared by recipients.

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Department
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Maritime Decarbonisation

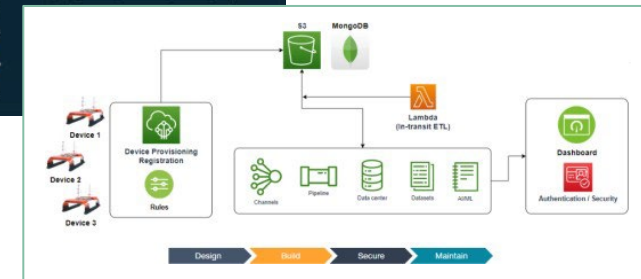
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ACUA Ocean

Increased Automation of Hydrogen Battery Powered Systems for USVs

The complexity of hydrogen-powered battery systems for autonomous systems requires smart automation and optimisation of operational and safety systems. This can minimise operator burden and identify vessel performance anomalies in near real-time. This project takes the next step in the automation of maintenance by capturing critical vessel data and distributing it securely to a Remote Operation Centre. This project demonstrates an end-to-end (from source to cloud-based analytics pipeline including a notification service) solution. The solution also uses an algorithm that models and identifies asset failures and raises alarms, e.g. hydrogen-related alarms from the fuel cell and fuel tank.



Activities

- Integration of hardware redundancy for safer operations.
- A digital platform for monitoring and anomaly detection for H-USV systems.
- Control and monitoring of electrical and propulsion equipment including sensors.
- Data analytics and sensor correlations and anomaly detection using the digital platform.
 - a. Removing the need for human intervention in non-routine operations
 - b. Automate control and environmental monitoring of vessel compartments
- Workshops and engagement with electrical suppliers.

Conclusions and Impact

The TRIG project allowed us to continue the development of our software and hydrogen systems monitoring and control taking the monitoring and hydrogen safety system capability to TRL4. AcuaSight™ development continued and we carried out tests with multiple vessels (in a synthetic environment) publishing vessel data in real-time to a hybrid cloud-based C2 system. Both these capabilities are TRL5 ready.

Although we do not have access to a representative test environment, AcuaSight™ (running on a remote machine) was tested robustly with the hydrogen-powered vessel operating in a simulation.

Next Steps

Future work will focus on AI algorithms that can predict changes in the state of the vessel (including engine performance) using historical data along with sea state and weather station data.

Our predictive maintenance works aim to collect vessel data over time and expand the operator's awareness of the vessel by introducing a performance metric, the *safe mobility score*. The score, computed by onboard computers will feed into wider strategic and mission planning tools such that the vessel state is stable and optimised for its mission entirety. End-user engagement is ongoing with an aim to complete vessel integration and testing by September 2023.

Armada Technologies Limited:

Passive Air Lubrication: Merchant Ship Carbon Emission Reduction

Merchant ship carbon emissions account for roughly 3% of global output. Current cost effective solutions to delivering double digit fuel consumption & carbon reduction are limited to cutting speed & engine power which reduces shipping capacity & frequency. Air Lubrication can cut drag & fuel consumption by 15% but incumbents deliver less than 7%, using large compressors, which can require seven years to payback investment. Armada Technologies' air lubrication system (PALS) passively injects bubbles under a ship's hull reducing drag using a simple venturi, commonly used in gas cookers & fish tanks. TRIG 21 supported design, fabrication & testing of PALS Mk3 in a pressurised cavitation tunnel simulating drafts & speeds up to 6.5m & 20 knots at HSVA's Hamburg test facility. Testing demonstrated passive drag reduction over 10% at 4.0m (max tank pressure) draft & 20 knots observed by bubble dynamics experts from Liverpool John Moores University (LJMU), a venturi engineer, naval architect & HSVA's test team. They concluded that after modification, PALS could be the "perfect air lubrication system".



Activities

Concept Design. Venturi and injector. Delivered by Armada Technologies March 2022.

Detailed design. Iteratively improved utilising computational fluid dynamics (CFD) software over four cycles. Delivered by SimFwd & Friendship System June 2022.

System fabrication. PALS Mk3, based on above design and integration into 'HYKAT' cavitation tunnel. Delivered by HSVA end August 2022. Test Matrix, detailing 42 activities to be carried out over days in September. Delivered by Armada Technologies & LJMU August 2022.

Test Program. Delivered as planned, however at drafts <1m, venturi produced over aerated water causing turbulence & increased drag. Swapped for pump to simulate venturi. Final Report. Detailed test data, analysis & report delivered by HSVA mid September 2022.

Conclusions and Impact

Proof of Concept - Achieved.

PALS successfully introduced aerated water to simulated boundary layer. Under realistic ferry operating conditions an average 'on plate' >10% drag reduction was recorded, with significantly higher drag reductions measured in other tests.

A 'sweet spot' can be achieved where hydrodynamic phenomena are balanced to match operating conditions.

Tests demonstrated beneficial impact of the active injection of water alone in all operating conditions tested.

We also showed that PALS can deliver fully passive aeration under targeted operating conditions.

These results significantly increased owner interest throughout customer discussions held during the project.

Next Steps

Installation: Subject to contract, PALS installation planned for a passenger freight ferry and a large bulk carrier in Q4 2023. Owner investment £34K. Scale up HYKAT results using HSVA's in-house CFD code to estimate drag reduction if PALS were installed on a passenger freight ferry. November 2022. EU Horizon. Armada is a part of Retrofit55 consortia which won a grant to develop PALS and other systems to deliver 35% emission reduction during a 2-year project starting December 2022.

Other Grand Funding: Armada won a 'FastStart' grant to develop a PALS performance optimisation control system and a Liverpool City Region grant to design PALS installation for a passenger ferry. Commercial Funding. Armada is currently raising a second round of commercial funding to finance its operations throughout 2023.

Canal & River Trust

Oxfordshire Waterways Electrification Transition (OxWet)

The Oxfordshire Waterways Electrification Transition (OxWet) was developed to provide a route map to help those living and operating on the inland waterways to contribute to achieving national decarbonisation targets including those set out in the Clean Maritime Plan and UK Clean Air Strategy.



Activities

The project used mixed-methods research to better understand those who use the waterways and how electrification might take place in a sector that has so far seen little transition away from conventional energy systems.

There were five core project activities:

- Desk-based research
- Stakeholder interviews
- User survey
- Location-identification tool
- Full Report and recommendations

Next Steps

Research from the OxWet project provided recommendations for planning and delivery of electrification of the inland waterways framed around a need for both 1-year and 25-year roadmaps to deliver a power infrastructure network and to support growth of an electric boat industry.

Commercial opportunities are present in power network technology along with the supply of parts and development of industry skills to build battery electric vessels and/or convert conventionally powered boats.

Conclusions and Impact

There is no need to develop both a power network and a userbase of electric propulsion vessels to generate a functioning market and confidence in the use of battery technology on the waterways.

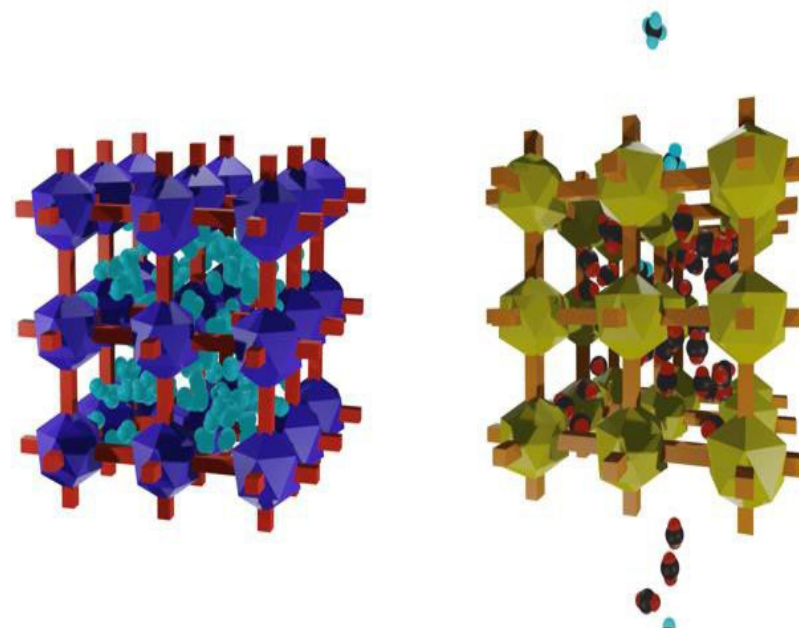
Vessels have long and complex operational lifecycles, relying upon natural lifespan models to achieve change will take decades.

The technology to transition to battery electric exists within the market today, however targets, investment or other incentives may be needed to drive a shift at the pace that will be needed to meet 2050 ambitions.

C-MAT TECHNOLOGIES LTD.

SEFAD – Ship emission filtration and decarbonisation

The SEFAD project aims to develop a solution to reduce polluting GHG's in shipping. The objective is to create a Metal Organic Framework (MOF) that filter will be installed at quaysides or jetties either permanently or semi-permanently to capture ship's CO₂ exhaust gases. SEFAD's specialist filtration technology has the possibility to capture a number of other marine pollutants emitted from the vessel's exhausts; however, this project will focus specifically on the capture of CO₂.



Activities

- Adsorption tests carried out at a range of temperatures.
- Molecular simulation tests run for adsorption of N₂, CO₂ AND water.
- Identification of a number of promising MOFs for CO₂ capture, based on stability and capture potential.
- Carried out an economic feasibility study into the viability of further developing MOF filtration processes, for carbon capture in shipping.

Conclusions and Impact

The ideal adsorbent should possess several excellent properties, such as (i) high CO₂ adsorption capacity; (ii) high CO₂ selectivity vs water and (iii) excellent water & temperature stability. In this work, we successfully developed systematic approach for the identification of promising MOF materials for CO₂ capture. There is a strong economic case for further development and this could have significant impact on speeding up de-carbonsation within the UK maritime sector.

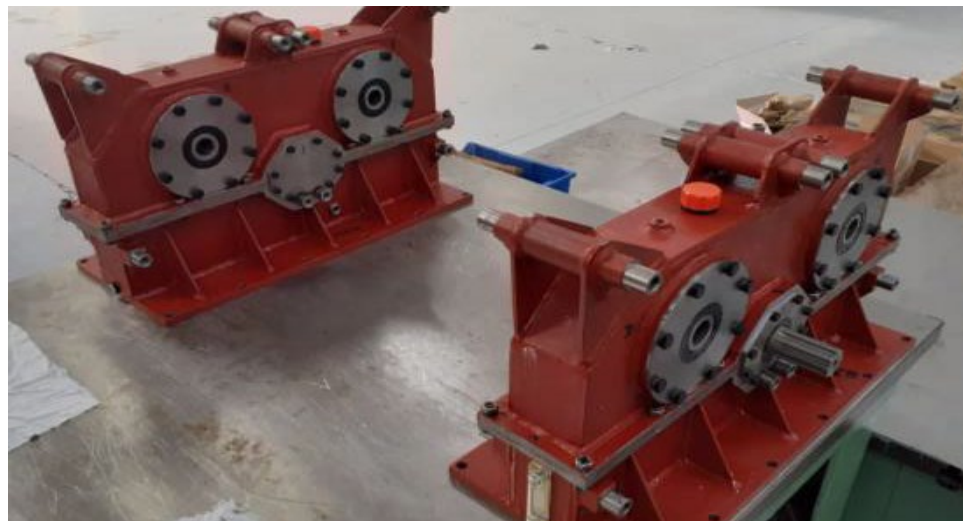
Next Steps

C-MAT is now actively looking for UK ports with existing carbon storage facilities to collaborate on the future of this project. The knowledge obtained here will be applied to a pre-test design simulation process. This focus on the most promising process methods for CO₂ capture in the MOFs, in tandem with exploring how to integrate that with existing UK port infrastructure. Pending the success of that collaboration. Thereafter we would expect to build and deploy a working prototype CO₂ filter.

Ecomar Propulsion Limited

Marine Clean Energy Multi Motor Feasibility Project

The project was a feasibility study to define operational parameters and design characteristics for a unique gearbox that delivers clean electric propulsion for use in large marine sea-going vessels.



Activities

- Project Management and Exploitation
- Desk Level Definition of Design Parameters
- Desk Level Initial Gearbox Assembly Drawings
- Fabricate Gearbox with Ecomar Motors – This exceeded the planned project activities

Conclusions and Impact

It is viable to produce a multi motor gearbox for clean marine vessels.

Provides evidence that advance control systems are required to operate successfully.

Synchronisations of motors is essential and that advanced techniques such as a field weakening need to be incorporated into electrical operating design.

This project opened new technical opportunities in advanced clean electric propulsion.

Next Steps

Archive successful completed system hardware bench tests.

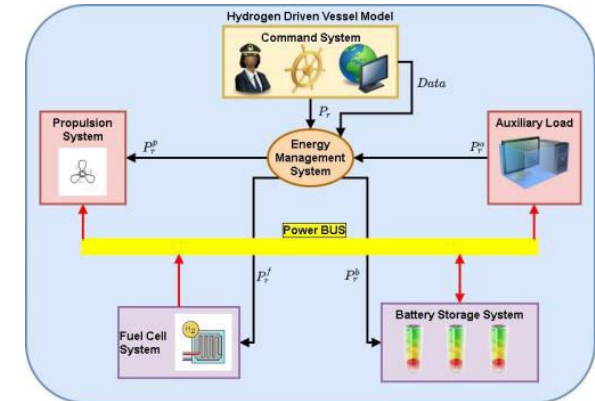
Design and implement a more advanced control system.

Multipower trains for commercial workboats up to 1MW which means we can pursue a much wider market for bigger vessels than our current clean propulsion systems can achieve.

Industrial Systems and Control Ltd., Glasgow

Optimal Control of Hydrogen Driven Marine Vessels

This project involved the design of the Energy Management System (EMS) for a hydrogen driven marine vehicle fuelled by both hydrogen fuel cells and electric batteries. The proposed Model Predictive Control (MPC) based EMS combined with an Artificial Intelligence (AI) based predictor represents a proof of concept of hydrogen-fuelled vessel power management software. The effectiveness of the EMS was illustrated by the results obtained using simulation software representing the ship models within a MATLAB/Simulink environment.



Activities

Task 1:

- Analysis of fuel cell vessel specifications
- Design and validation of the vessel simulator

Task 2:

- Design and validation of the MPC-based EMS
- Design and validation of the AI predictor
- Integration and validation of MPC-based EMS with AI predictor

Conclusions and Impact

Relative to a to a baseline rule-based (RB) control a basic MPC provides real improvements, since degradation can be tuned via the cost weightings. The MPC with AI results in even better fuel cell degradation and hydrogen consumption. With respect to a baseline rule-based (RB) policy, the MPC with AI prediction reduces fuel cell degradation by 99% and hydrogen consumption by 16%. With respect to a basic MPC the MPC with AI prediction reduces fuel cell degradation by 62.5% and reduces battery stress by 2.32% and hydrogen consumption by 2.5%. The battery degradation is somewhat worse for both MPC designs but economically this is not so important as the improvement in fuel cell degradation.

Next Steps

Initial contacts have been made with potential future partners and customers. The next steps are:

- A prototype should now be produced which requires investment we must secure, and testing in controller in the loop simulations ideally followed by ship trials.
- Further contacts with potential user companies and presentations of the results.
- Submission of a paper to attract support at an exhibition, workshop or conference.
- Include the material in ISC training courses that can be provided at company premises.

JET Engineering Systems Solutions

5G Smart Connected Port Data Dashboard

It is estimated port operations account for 5% of total shipping emissions, producing 18.9 million tonnes of Greenhouse Gases (GHG) and CO₂/year per port. Much of this is due to lack of communications between operators and port authorities during port-weather delays. The anticipation of these delays via real-time and fine-scale data is presented in a port data dashboard aimed at improving efficiency in response time and thus aiding in the decarbonisation of the porting industry, which needs to be cut by 75-85% to meet Net-Zero UK targets.



Activities

This project focused on the creation of a 5G enabled data dashboard, which presents the data acquired from Port-specific sensor packages hosted on our innovative mesh network of data buoys deployed at sea.

The dashboard delivers real-time data pipeline development for collecting, transmitting, storing and visualisation of data. The data dashboard was graphically designed for fast interpretation of weather, met-ocean data and warning events to increase response time of operations to port-weather delays.

Conclusions and Impact

The outcomes of this project was successful and noted as scalable given further funding for sensor package development and sea- testing, enabling real-time data throughout to the dashboard. Utilisation of port data dashboards has been proven to provide fine-scale weather warnings in real-time based on buoy-localised data. This has the potential to improve monitoring and response times for port operations. On a wider scale the outcomes will reduce GHG emissions associated with idling ships & port-weather delays.

Next Steps

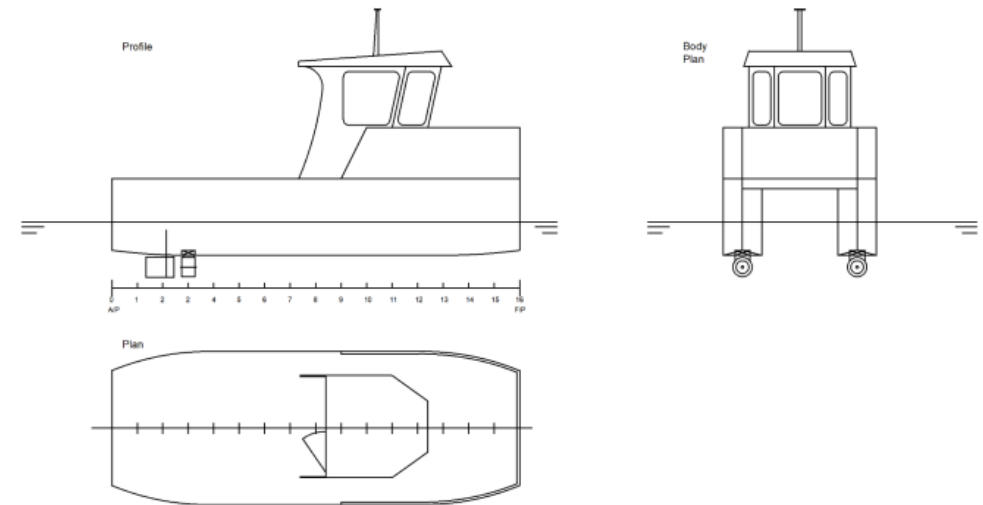
Construction and integration of sensor packages into the buoy platforms. Following this, a deployment in a test bed environment, with designed sensor packages to test real-time data capture potential. The integration of AI technologies will also improve data and communication rates via machine learning.

The dashboard itself has, and will, generate opportunities for collaborations with port authorities. In addition, it has generated interest for other use cases that require fine- scale, real-time data for decarbonisation.

Malakoff Limited

Small Zero Emission Vessel

Production of a fully electric small commercial vessel design. Due to the utilisation of a fully electric propulsion system the vessel will produce zero emissions during operation. The project included detailed design and production of a trial vessel.



Activities

- Concept design
- CFD analysis
- Stability analysis
- Structural assessment
- Structural design
- Propulsion system design/integration (based on existing technologies)
- Production of trial vessel
- Trials (ongoing)

Conclusions and Impact

- Development of commercial and technical expertise
- Significant interest in project from local area and marine sector
- Project approaching TRL 6
- Clear path adopted to move project through TRL 7, 8 and 9 and onto commercialisation

Next Steps

- Vessel trials
- Assessment of vessel by certifying authority to achieve commercial vessel coding
- Use of vessel in commercial setting by Malakoff
- Use of vessel in commercial setting by prospective adopters (trials/tests by prospective purchasers)
- Commercial adoption of vessel design
- Development of additional design to produce range of commercial solutions

Materials Nexus

Project SmoothSurf

Project SmoothSurf aims to use the innovative new material modelling capability developed by Materials Nexus to predict the next generation of anti-foul materials to limit build-up of fouling – bacteria, algae and shellfish. Improved materials are urgently needed to reduce reliance on ecotoxic materials and to reduce the dramatic rise in fuel use and CO₂ emissions that fouling causes.



Test substrates being immersed in sea

Activities

Work was divided into three work-packages:

1. Modelling to predict best fillers and surface groups to optimise bio-adhesion, strength and flexibility.
2. Synthesis and testing of physical properties. Outsourced to London South Bank University.
3. Literature synthesis unexpectedly needed updating to prevent toxic reagent interfering with results
4. Testing of biofoul accumulation in seawater, outsourced to Plymouth Marine Services.

Work packages were completed successfully.

Conclusions and Impact

- Modelling successfully identified one material that was confirmed to be most effective in antifoul trials.
- Other predicted trends could not be verified due to significant spread in biological data.
- Changing filler surface groups gave small impact to anti-fouling properties and no significant difference in physical performance.
- New (unoptimized) materials performed less well than commercial controls.

Project results support Materials Nexus efforts to work with paint developers for next-gen materials.

Next Steps

Potential commercial opportunities identified include antifoul paints for shipping, off-shore energy (wind and tidal) and aquaculture.

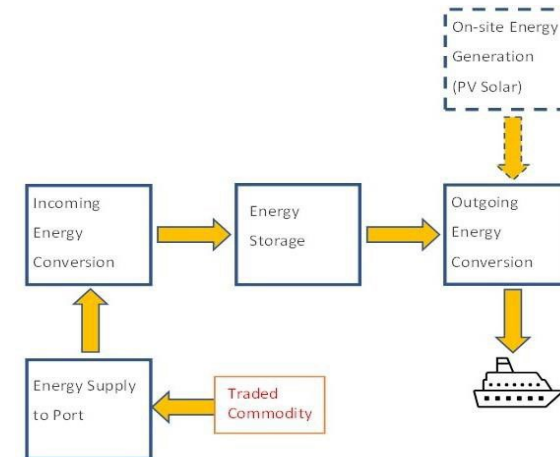
The technical developments of interest will be reviewed for potential patent filing, in particular the new filler surface group identified.

Opportunities to continue to develop the material prediction and development capability will be evaluated. This could involve partnerships with tier 1 paint manufacturers.

MSE International

ModOPS – Modular Onshore Power Supplies for ships

When in port, ships generate power using on-board generators which produce pollution and carbon emissions. Shore power systems can solve this problem but it is unclear what system would be most cost-effective for the port. ModOPS has modelled different options to highlight their relative merits. This will accelerate port investment in shore power, to improve air quality and carbon footprint.



Activities

ModOPS has surveyed over 100 third-party reports to extract latest knowledge on shore power and energy systems.

This formed a basis for a modular OPS model that analysed the cost and carbon performance of OPS systems for five different use cases.

12 different source energy options were compared for all use cases. Results were analysed to draw key conclusions to guide port decision-making on OPS. These were discussed with selected end-users. A white paper has been created for publishing the work to MSE's 3,400 subscribers.

Conclusions and Impact

Preferred OPS solutions for ports depend very much on the port's proximity to energy resources and the needs of its visiting vessels. For most ports, all-electric OPS systems with some battery storage are likely to be a good option to consider first.

Where the required grid connection capacity is unavailable, in-port generation using a liquid fuel is likely to be a good option to consider. HVO fuel is a good short-term option, whilst green methanol fuel may become more attractive, especially if methanol becomes a mainstream net-zero bunker fuel.

Next Steps

MSE plans to take ModOPS to the next stage in three ways:

1. Perform more specific analysis of OPS options for some early-adopter ports. Several such ports have expressed interest in this approach, leading to accelerated investment in OPS.
2. Explore options for refining the ModOPS model architecture to make it a commercial software product. This would require further finance and collaboration with a software specialist.
3. Build a pilot containerised OPS to demonstrate in-port generation using a green methanol fuel.

Unitrove Innovation

Further Development of the World’s First Liquid Hydrogen(LH₂) Bunkering Facility for Zero-Emission Ships

On 05 November 2021, Unitrove unveiled the world’s first liquid hydrogen bunkering facility for fuelling zero-emission ships at COP26 in Glasgow.

This project enabled further advancement of the technology towards commercialisation with the development of a safety-critical PLC control system through procurement of critical liquid hydrogen components.



Activities

- Design review and technical specification of liquid hydrogen facility, optimising for safety, performance and cost.
- Procurement of critical liquid hydrogen components and instrumentation for system monitoring (e.g. cryogenic couplings, hoses, temperature sensors, and flowmeter).
- Development of a safety-critical PLC control system to ensure safe and functional operation of the bunkering facility.

Conclusions and Impact

- TRIG 2021 was invaluable in helping the project to move forwards to the next stage. The impact of the programme extended far beyond financial support of £30k.
- TRIG 2021 helped to create new opportunities such as video production, pitching, and networking without administrative burden.
- Unitrove was able to accelerate development and procure critical pieces of equipment, which otherwise would have been unaffordable.

Next Steps

Unitrove is looking to push the development towards a live pilot project for implementation of the liquid hydrogen ship-fuelling facility. Unitrove will be collaborating with cohort member, ACUA Ocean, which is developing an autonomous liquid hydrogen powered ship. The two companies have been awarded a [CMDC2 grant](#) as part of a Unitrove-led consortium and will collaborate in the next CMDC3 competition.

The University of Birmingham

Coordinated Energy Storage Systems for Electric Vessels

The project focusses on the application of short-term energy storage systems, namely ultra-capacitor (aka supercapacitor) and super-conducting magnetic energy storage systems and their coordinated control and operation to battery-powered electric vessels. The main aims of the project are to design the DC-microgrid architecture of a prototype vessel, the power-electronic converters and the control of the vessel's power system. The design has been verified with a bespoke hardware-in-the-loop platform.



Activities

- Developed an efficient controller that reduces thermal stresses on batteries and has the potential to increase battery lifetime by 20%.
- Developed a hardware-in-the-loop platform to test shipboard power systems of electric vessels with batteries and short-term energy storage.
- Verified with hardware-in-the-loop simulations that DC grids reduce the power losses of electric vessels in comparison with traditional AC grids.
- Verified that a further gain of efficiency of 2-3% can be obtained using Silicon-carbide devices.
- Disseminated results at the NIST-CS workshop and prepared a technical paper for the international conference on Clean Electrical Power.

Conclusions and Impact

We have validated the proposed concept of short-term energy storage systems in electric vessels, which can increase the service life of the vessel's battery, increasing the TRL from 3 to 4. Batteries can be downscaled by 25% whilst the vessel still delivers peak power for dynamic positioning.

The hardware-in-the-loop platform has given the University the knowledge on energy storage to support the marine industry to decarbonise water transport through new research projects and consultancy. We had interest from several companies: Fincantieri, Vard Electro, Vard Design, Skeleton, ASG Superconductors, MSE International, Bibby Marine, Malakoff.

Next Steps

- The project outcomes have been used as seeds for a larger collaborative EU Horizon Europe project on innovative energy storage systems on-board vessels – to start at the beginning of 2023 in collaboration with academic and industrial partners from 5 EU countries.
- We are also planning to collaborate with other academic and industrial partners in the UK on propulsion projects (Bibby Marine, Malakoff) and MSE International (port cranes). We will engage with our industrial partners in the railway sectors through our UK Rail Research and Innovation network, with initial discussions with Hitachi Rail.

The University of Strathclyde

A toolkit to evaluate shore-side electrical infrastructure requirements for rural islanded communities

(Enabling net-zero water-based transportation for rural and islanded communities)

Decarbonisation of lifeline and tourism vessels servicing remote communities will likely be limited by the available electricity network capacity in an area for likely net-zero transition pathways.

An interactive toolkit has been developed to inform harbour and vessel operators about the different infrastructure choices available to the sector to support the transition towards net-zero operation.



Activities

This project has established an interactive toolkit, supported by an open engineering methodology, to help inform enabling stakeholders about the different infrastructure choices required to support their future operation over the short, medium and long term.

Additionally, the project interviewed several key stakeholders to understand the operational requirements and obligations they would expect future net-zero vessels to meet.

Conclusions and Impact

Different stakeholders have engaged in initial studies to investigate the technology parameters required to meet their operational needs.

The developed toolkit provides much-needed evidence to support 'ahead-of-need' electrical distribution network upgrades for this sector.

A range of different investment timescales exist that vary with demand estimates, spatial features, and the utilisation of existing infrastructure.

Next Steps

1. Research dissemination through conference and impact sessions
2. Continue tool development to cover a wider region of the UK
3. Feasibility study to support qualification of outputs
4. Deployment trials to inform characterisation and commercials
5. Collaboration on next stage research activities



Department
for Transport

Open Call

Delivered by

CATAPULT
Connected Places

AKREON Technology Ltd

EcoCool

EcoCool is a mobile, modular, solar-powered refrigerator designed for complex environments where components and spares are not readily available. EcoCool provides a sustainable means of cold storage in underdeveloped/off-grid locations.

This could enable a more resilient freight and logistics system both in the UK and abroad, especially in places with less developed infrastructure.



Activities

Prototype Design:

The team worked collectively on the technical specifications required for EcoCool. We analysed the engineering design and components needed. Hence the conclusion is to use a Thermoelectric chiller over conventional compressors.

Procurement:

We worked closely with our manufacturing partners on negotiations and quality checks for all materials needed for prototype development.

Prototype development and testing:

This took place in Glasgow, Scotland, with our partner over 16 weeks.

Conclusions and Impact

We are pleased to say the project was successful because we have been able to develop from TRL1 to TRL4, which was the projected milestone for the project phase. We were able to advance from basic principles to developing and testing a working prototype.

The positive impact of the project was identified in overall team development, gaining new skills and training and creating new technical partnerships for future projects.

Next Steps

- Conduct more testing for the prototype.
- Rewrite the business plan and develop and business model for the product.
- Conduct market research and test demonstrations.

Commercial opportunities have been generated from prospective clients as we have built relationships with stakeholders in hospitals in Nigeria and Ghana. We received a positive response from them and plan to conduct live tests in the two countries in 2023. This would help us understand our prospective customers and how well we can solve their needs.

Calyo

Novel Ultrasound Navigation & Collision Avoidance Sensor

We have designed, tested and characterised a small footprint, ultra- low power ultrasound navigation and collision avoidance sensor that will broaden the environmental and performance envelope of autonomous vehicles in challenging environments. We have assessed the potential of the sensor and made plans on how to take the work further.



Activities

The main goal of the proposal was to develop a novel, fully embedded, sensing architecture which enables 3-D perception for autonomous mobility applications in challenging environments using ultrasound. The work was based around three inter-linked objectives:

1. To develop a fully embedded sensing architecture
2. To fabricate a second-generation plug and play prototype sensor
3. To explore commercial opportunities

Conclusions and Impact

The ability to perceive and interact with surrounding objects and the environment is critical to autonomous mobility.

Our sensors will improve the safety of autonomous vehicles by providing a low-cost, alternative source of information on environmental interaction.

This project has enabled Calyo to move into the autonomous mobility sectors much more quickly and hence drive growth in the UK economy.

Next Steps

We've demonstrated several applications and attracted interest from a number of industry partners.

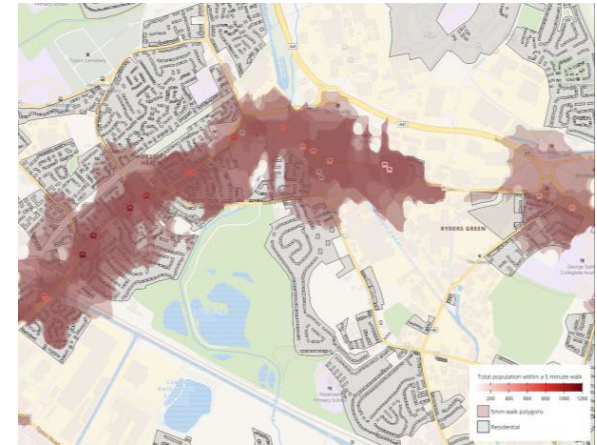
This includes multinational technology companies for application on unmanned systems across defence, and civilian applications including the automotive, mobile robots, and consumer electronics sectors.

The company is now looking for early adopter partners and clients.

City Science

Interactive Bus Performance Reporting & Analysis Tool

The National Bus Strategy led to Local Transport Authorities (LTA) setting out their ambitions for improved bus services, and reporting progress every 6 months. This tool is designed to support these LTA's by providing a web-based interface to access, analyse and map bus performance, connectivity, coverage and demographic data, ensuring reporting is more insightful and consistent.



Activities

1. Undertook a literature review of best practice in bus performance reporting.
2. Outlined potential outputs and streamlined these to most relevant and with quality data.
3. Recorded bus performance information for selected LTAs.
4. Engaged with LTAs and presented to industry conferences to understand needs and wants.
5. Streamlined and standardised data analysis for significantly faster processing speeds.
6. Developed web-based analysis and outputs to better represent the catchments and performance of bus services.

Conclusions and Impact

Considerable progress was made to bridge a known technology gap in the transport industry. Feedback also made us aware of other products adjacent to this space, improving our awareness of what is available and therefore where the outstanding gaps remain.

The software module developed as part of this solution is now live on our web-based software cadence, for Kent and Oxfordshire. We continue to record data for these two regions, increasingly increasing the value of insights from the tool.

Next Steps

- Promoting our product to local authorities to adopt.
- Identifying further funding streams to deliver further enhancements to the product, including identification of potential bus priority schemes, standardised BSIP evidence base reports, analysis of revenue and mapping fleet emissions.
- Continuing to collate bus data to enhance our monthly and annual reporting outputs.
- Applying this tool to our ongoing consultancy offering to Local Authority clients.

To support these next steps, we will seek to engage in future finding opportunities as well as through engaging with potential clients and/or collaborators.

Digital Signs For Transport Ltd T/A PassageWay

Personal Digital Signs For Remote Train Stations In Wales

Across Wales many rural stations display inaccurate train arrival data on CIS screens, because information is based upon a train passing a fixed geographic trigger and in rural areas the distance between triggers can be extreme. Our project leverages real-time information on the trains 3G geolocation and provides customers with a personal digital sign for viewing on their smartphone.



Activities

We worked with TfW to identify four trial stations for the proposed trial. Working with TfW we produced sign mock-ups and then integrated them with the live data feed from SignalBox (the data supplier). The digital signs update automatically every 30 seconds, displaying the latest service information in both English and Welsh. We provided TfW with QR codes for each of the trial stations digital sign for them to display on customer information posters

Example sign: Conwy <https://signs.mysign.live/tfw/station/CNW>

Conclusions and Impact

We have extended the live deployment for the digital signs for an additional three months free of charge as TfW were delayed in producing the posters and deploying them at the stations.

The feedback received from TfW internally is that they believe the innovation to be excellent and that it will be a very useful service across over 100 of their stations.

Next Steps

TfW have asked for us to quote for a longer extension to the project at the trial stations and also to roll it out at several other stations closer to Cardiff where there are known issues with the CIS information.

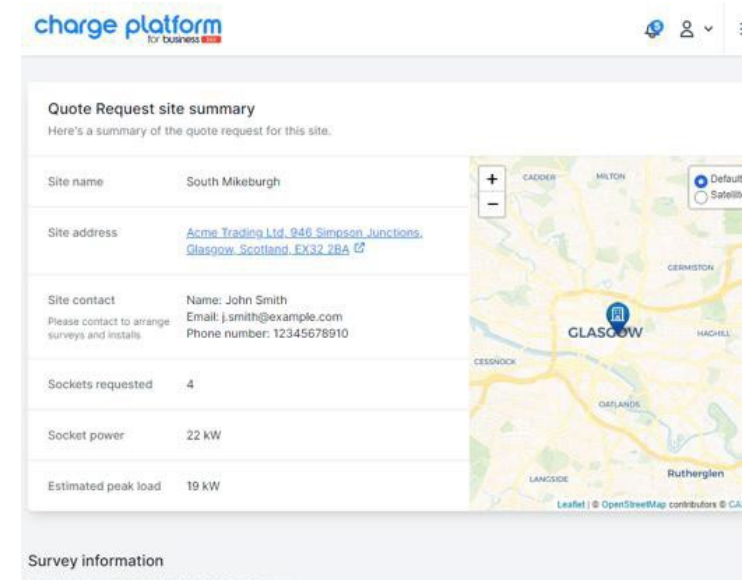
We expect there to be significant additional development work involved for a wide-scale deployment as we migrate from a trial environment to widescale deployment.

Diode

Shared Survey Platform

The Shared Survey Platform is designed to streamline the survey bottleneck that currently exists for workplace charge point installations.

Shared Survey allows installers to produce a workplace charge point quote from one single electrical and site survey.



Activities

Our project was developed and tested in the following six steps:

1. Identified and onboarded two installers from our existing network
2. Designed the Shared Survey prototype
3. Feedback loops
4. Tested the final survey prototype with a real customer
5. Designed the user interface and built the back-end software
6. Built the user interfaces and back-end processes

Conclusions and Impact

The conclusion of this project is we've delivered against our best-case scenario, meaning we have a fully developed software product ready for a live test environment and commercialisation.

It has been estimated that the UK will require 1.2m workplace charge points by 2023 – that's 2500 per week. Shared survey will allow efficient use of our installation capacity and eliminate the burden of site surveys, which will give us the best chance of ensuring sufficient charge points are installed in time for 2030.

Next Steps

1. Live testing environment across a variety of installation types with the following installers: Scottish Power, Mr Charger and ChargedEV.
2. Create a suitable commercial model which makes the realised savings transparent, whilst passing a portion onto the surveyor.
3. Establish an operations strategy. Surveyors could be from our existing network of installation partners, specialist surveying companies, an in-house team or a blend of all three.

Esitu Solutions

Developing HGV driver Training Materials in Virtual Reality

- Recent driver shortages have led to a raft of changes in training and licencing HGV drivers. These changes are likely to increase the road risk of HGVs, especially in regard to the time required to develop vehicle-specific hazard perception skills.
- We created a novel training intervention using 360-degree footage to improve HGV drivers' hazard perception skills in an attempt to mitigate any increase in risk due to changes in legislation.
- These materials were tested on HGV drivers. The training was received well by drivers, though future iterations of the training are required.



Activities

- We reviewed previously filmed 360 video footage from an HGV to identify suitable clips for training purposes.
- An HGV driver trainer was hired to review the clips to understand critical incident points.
- These points were then scripted by our team of Traffic and Transport Psychologists.
- An extensive video-editing phase took place to add animations and annotations to the clips, to demonstrate where drives should look, while an expert voiceover provided an explanation of why they should look in these places.
- We evaluated the training using a randomised control trial with 31 HGV drivers.

Conclusions and Impact

- Drivers gave positive feedback on the training intervention, rating it as comfortable, realistic, immersive and engaging. Written responses also suggested the training module was well received.
- They particularly like the VR approach, though we did not demonstrate a positive behaviour improvement for the trained drivers compared to the control group. This was potentially due to the small sample size.
- We have achieved success in creating VR training clips that HGV drivers find acceptable. It is clear, however, that the content needs to be iterated, or perhaps refocused primarily on novice or learner HGV drivers/

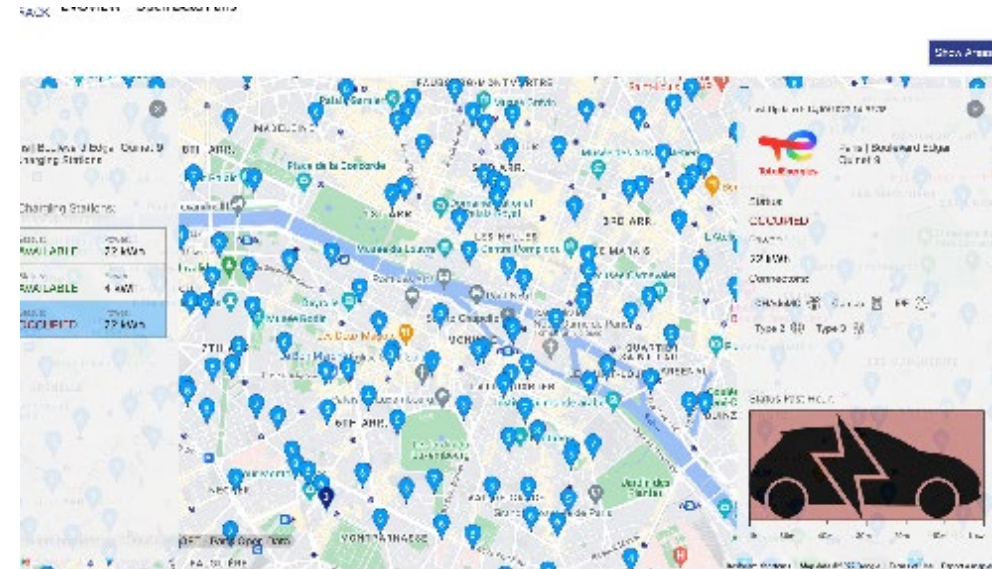
Next Steps

- The positive feedback is sufficient justification to persevere with further development of the training.
- We are actively seeking further funding to continue its development, as well as working with clients who will assist us in the evolution of our products.
- As this product continues to evolve, we should see benefits to HGV companies, e.g., through the reduction of collision-related costs.
- There is the potential for national economic benefits, as saving a single life represents a significant economic saving. Trained drivers will also reduce harsh acceleration/ braking, cutting fuel emissions and combating air pollution. Efficient fuel usage also reduces vehicle wear and tear.

Evotrack

Delivering real-time forecast of electric vehicle charging demand to support the life cycle of public charging infrastructure and better investment decisions

We developed a comprehensive cloud service that runs our prediction algorithm on cloud architecture. Our prediction algorithm is a learning-based algorithm to identify factors affecting the charging demand and deliver charging station usage predictions. These predictions allow analysis to determine ideal future spots for deploying additional charging stations as well as implementing new practices to operate existing stations such as dynamic pricing for charging stations.



Activities

This project helped us transform our early-stage technology into a minimum viable product. We developed our existing prototype further and integrated a cloud architecture services. We developed the testing environment and analysis tools to benchmark our prediction algorithms. Through the TRIG 2021 programme we carried out system-wide tests using publicly available data. We tested our prediction algorithm against real-time data published in this database. We now share these predictions on our cloud user interface, where users can access freely and interact with our demo.

Conclusions and Impact

We strongly believe that delivering a good public charging infrastructure requires all relevant stakeholders to work together. In this regard, our intelligence that we generate through our cloud platform aims to help reducing the amount of charging infrastructure on the ground whilst ensuring reliable, resilient and convenient charging access by drivers. UK is expected to deploy up to 200,000 more chargers in the next 10 years. Based on the trials we ran during the TRIG 2021 programme, we estimate that our algorithm could save up to 24,000 chargers from being deployed unnecessarily.

Next Steps

We are gearing up to launch a stand-alone prototype for our first product in late 2022. We have been receiving great feedback and enthusiasm about this product and we are looking forward to demonstrating the value of our technology to our stakeholders and future customers later this year.

We have been speaking with various stakeholders including prospective customers and investors. The evidence we collected through our talks suggests there is a clear interest in our product both from potential users and potential investors.

Flit (Cambridge) Limited

Circular Economy Battery for ebikes and e-scooters

FLIT has developed a prototype battery for ebikes and e-scooters that is easy to refurbish and recycle. This addresses the problem that the most common manufacturing method for batteries used in these devices, spot welding, makes batteries difficult and expensive to refurbish or recycle.

This means that currently most of these batteries are currently disposed of, resulting in loss of valuable materials and possible environmental damage.



Activities

After conducting initial calculations and tests which confirmed the viability of this project, FLIT developed a first prototype which showed the concept of having cells that are easy to access for refurbishment or recycling was feasible.

These calculations and tests also showed that careful consideration would have to be given to the structure of the battery pack, exposure to debris entering the pack during assembly or refurbishment, and the reliability of the contacts.

The second prototype improved on the structural design and addressed the reliability of the contacts by using the compression of each battery structure itself to connect each cell to the circuit.

Conclusions and Impact

This project demonstrated that the concept generated is feasible, but further development is required to commercialise it, for example by developing the battery to the standards required for international certification.

If this battery concept can be fully commercialised, then it has the potential to greatly impact how efficiently battery cells and materials are used in the micro-mobility sector across Europe and globally.

Next Steps

Having successfully demonstrated the feasibility of this concept, we will now seek further funding to develop more advanced prototypes that advance the project to higher TRL levels, and assess the feasibility of the operating environment.

This will require both assessing how this type of battery might be integrated into e-bikes and e-scooters already in widespread use, and more thoroughly understanding the practicalities of how manufacturing, logistics, and maintenance processes work for the companies that we wish to collaborate with.

Go Eve

DockChain: Rapid EV charging at scale. Prototype device project

Our innovation, DockChain, allows multiple electric vehicles to plug into a single charge point. Our project was to build a prototype system that applied this concept to rapid DC chargers. With a set of our DockChain terminals a single rapid charger can now serve multiple vehicles, or a whole car park, instead of just two spaces. We remove the cost and operational challenges of choosing rapid DC chargers for fleet operators and destination car parks.



Activities

- Go Even built a physical daisy-chain system with a connector box (which attaches to a standard DC charger) and 6 rapid charge point terminals. Tested successfully on multiple electric cars and powered up to 200 amps.
- The microelectronics (inside each terminal) and our software gave visibility of the battery status of all vehicles plugged into the chain. They safely managed the charging sequences. Each vehicle remained in a happy hold state until we passed it to the source rapid charger to take their turn in the 'queue'.

Conclusions and Impact

- The prototype worked as planned. A true DC charge point multiplier.
- DockChain can be added to most existing rapid chargers already installed.
- Through the project we discovered new safety considerations, user/ design/ install considerations, new applications and features that can aid fleet operators.
- The impact of DockChain can be enormous, removing the investment dilemma for many operators presented with the current constraints of rapid chargers and comparing them to slow charging solutions.

Next Steps

The TRIG project has opened a range of commercial opportunities for Go Eve. We have customers wanting to pilot DockChain in public transport, distribution, car retail, office and apartment buildings.

We will be designing a compact DockChain with higher power capabilities. For which we will obtain both European and US certification then move to mass production and taking orders.

Our software will evolve to give new ways to manage the charging on a chain. E.g. prioritise specific EVs or reacting to power price changes.



Honeycomb Network

Project Nectar: Retrofitted, Universal Smart-charging Infrastructure for e-bikes

Transport currently accounts for 27% of the UK's greenhouse gas emissions. Privately owned e-bikes are an ideal solution to decarbonise commutes and last-mile delivery. Having already created a universal e-scooter charger, Honeycomb Network set out to adapt their technology to produce a universal e-bike charger with the intention of establishing public charging hubs scattered across cities to eliminate range anxiety.



Activities

Honeycomb began by exploring and testing various e-bike batteries and building a database of properties and characteristics. The team modified their existing electronics and software to enable charging of e-bikes alongside e-scooters and designed a control unit to package the electronics, allowing stand-alone installation and retrofitting for existing bike storage.

Alongside product development, Honeycomb surveyed 479 UK e-bike users with 70-75% of respondents expressing that an app-accessed, public universal charging solution would be either 'really wanted' or a 'necessity'.

Conclusions and Impact

The project was successful, a universal e-bike charger was built, culminating in a demonstrator of the easy-to-use, resilient and aesthetic public e-bike charging.

If a public infrastructure network is established, it would eliminate range anxiety and reduce barriers to entry (for example: having to carry around a charger). This would boost cycling uptake, which as a form of active travel, improves mental and physical health, reduces greenhouse gas emissions, congestion and noise pollution.

Next Steps

Further R&D is required to allow the technology to include proprietary batteries (Bosch and Shimano) and to produce a product that is adaptable for all kinds of location (off-grid, renewables solution).

Upon completion of R&D and compliance, Honeycomb will roll out the app accessed e-bike charging at bike storage facilities starting with SpokeSafe. This allows Honeycomb to enter into the estimated – £155M UK e-bike infrastructure opportunity and then into the >£2.5Bn global opportunity. There are also opportunities in parallel markets such as last mile delivery logistics.

MakeSense

Shape-changing Haptic Navigation Technology for Visually Impaired Persons

The TRIG grant enabled us to develop a unique human-machine interface which **non-visually communicates 3D spatial information which can be derived using computer vision**. Our device resembles a small flashlight, with a camera in place of the lightbulb. The camera locks-on to targets/directions in 3D space, called a *vector*. The device then **physically bends** to aim along the target vector whilst held in the hand. e.g., if the target is up- and-to-the-left then the device bends up-and-to-the-left. **Sensing the bending direction via touch**, the user follows the curvature to point the device, and hence their hand. By *pointing*, the user ‘feels’ target directions. The device shape continuously updates, responding to user/target movements, thus providing closed loop feedback with respect to the local environment. This innovation reduces an **intractable problem of describing 3D navigation** with audio cues or vibration sensations, into an **intuitive and straightforward** experience.



Activities

- Design, manufacture and testing of a series of prototypes.
- Establishment of a permanent laboratory space and technology benchmarking set up.
- Securing IP protection via a patent filing.
- Building the development team.

Conclusions and Impact

- Determined that our shape-changing vector deliver technology is effective.
- Significant follow-on funding has been secured including £150k from angel investors, and a £500k grant from Innovate UK.
- We’ve secured three letters of support/intent from big industry players.
- TRIG has transformed MakeSense from a one-person start-up into a company with three full-time employees.
- We’ve advanced the technology from TRL2 to TRL3/4.

Next Steps

- Large scale trials with blind volunteers in collaboration with Blind Veterans UK.
- Further development and refinement of the haptic interface technology.
- Integration of our computer vision interface with other technologies such as multi-constellation GPS.
- We intend to have a marketable product in late 2024. The price point is likely to be around £4000, which is <90% cheaper than a guide dog. We anticipate that consumers will pay for the device, like they do for competing products i/e/ Orcam, Envision etc.

Wordnerds

All Passengers Travel Equally | Eliminating AI bias from customer communications in UK public transport

Wordnerds has developed its text analytics platform to offer two unique features: a sentiment analysis model that is specifically optimised to minimise bias in the UK; and a comprehensive bank of AI themes trained on public transport passenger data (tweets and survey responses). To our knowledge, this is the first time anywhere in the world that a commercial AI delivers either of these two criteria.



Activities

Reduction of gender, location, class and other bias on the Wordnerds platform through:

- A sentiment model to better handle short content
- Removal/neutralisation of words that can attract bias before sentiment processing, e.g. pronouns, names and entities

These developments are now in full deployment live on the platform and in use by customers.

Also the creation of a public transport theme bank offering operational, customer journey and segmentation methodologies to customers.

Conclusions and Impact

This project is allowing public transport providers to hear the voices of all their passengers with unprecedented clarity.

Providers are able to quickly understand the issues facing passengers and take action to improve passenger experience, confident that they are making those decisions on data that contains minimal bias:

- Bias reduced to around a quarter of original levels, from avg. 3.45% to avg. 0.93%.
- Average platform set-up time for new transport customers reduced by 70%, from 35 to 10.5 hrs.

Next Steps

We intend to fully capitalise on the commercial opportunities provided by this project, by expanding further in the UK public transport market - starting at World Passenger Festival.

We will continue to develop our methodologies work in adjacent sectors, and hope to explore other European languages next year.

Our dedicated work on bias has already contributed to TOC contract renewals and led to a report commissioned by the Connected Places Catapult.

Queen's University Belfast

Human Centred Pedestrian Avoidance System: Modelling and testing (HUMANPAS)

In this project, we aimed to study the interactions between drivers and pedestrians. We have recorded driver and pedestrian behaviour in a virtual reality environment where they are free to safely interact with each other. The data collected in the study has been used to develop a pedestrian model that can predict human crossing when interacting with a single vehicle.



Activities

1. **Data collection:** We developed a Driving-Pedestrian Distributed Simulator based on Unreal Engine 4.26. The driver and pedestrian interaction data were collected in the virtual urban road environment.
2. **Development of a pedestrian model:** To predict the future behaviour of the pedestrian based on our car behaviour, we developed a pedestrian model based on a probabilistic graphical model.
3. **Optimisation of automated vehicle controller:** With the developed pedestrian model, we optimised our automated vehicle control system.

Conclusions and Impact

1. **Conclusions:** The developed pedestrian model and vehicle controller can predict pedestrian motion, quantify the uncertainty in their future trajectories and improve automated vehicle's motion behaviour when interacting human road users.
2. **Potential impact:** The developed automated vehicle control algorithm has the potential to improve human road users' acceptance and significantly contribute to road safety by improving motion behaviour of the automated vehicle when interacting with road users.

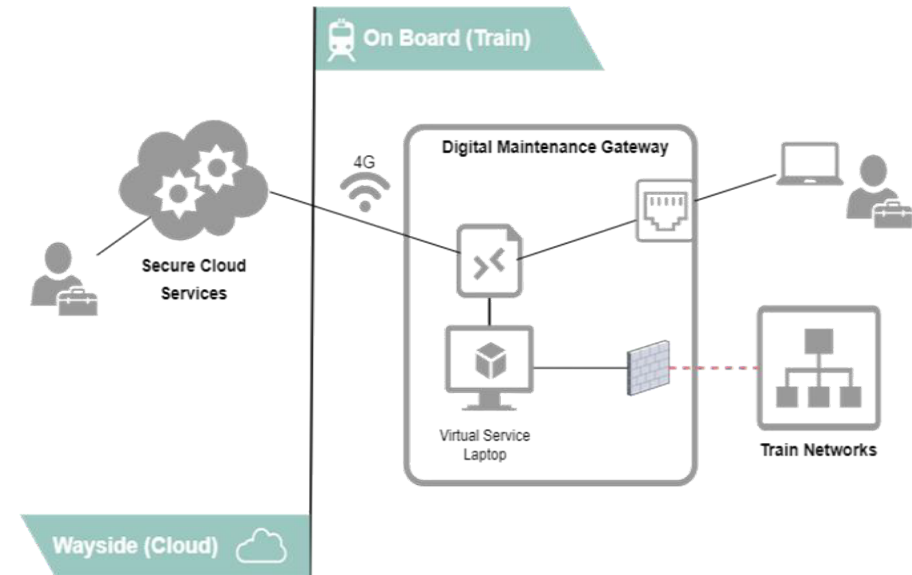
Next Steps

1. Improve the human-vehicle interaction test system
2. Multi-agents interaction test, i.e. multi-vehicle and multi-pedestrians
3. Engage with some industrial partners to explore the potential deployment of our control algorithm
4. Many technological challenges are existing for the interaction modelling, interactive decision-making and control as well as human factor analysis, we will continue to address the existing challenges.

RazorSecure

A Digital Maintenance Gateway for Secure and Reliable Maintenance and Safe Operations of Digital Assets

RazorSecure and Birmingham Centre for Rail Research and Education (BCRRE) have developed and tested a proof of concept for a managed access Digital Maintenance solution to provide a 'secure overlay' for maintenance operations, capable of integration with legacy and new build rail vehicles. The project delivery was enhanced by use of deaf awareness principles.



Activities

We demonstrated and validated the solution against three safety related application controls using Birmingham Centre for Rail Research and Education cyber labs. The solution was deployed using virtual machines and RazorSecure's Security Gateway platform. Data was collected via an industry survey, advisory board and site visits across rolling stock leasers, rail and freight operator depots and manufacturers. All results are publicly available through Railway Industry Association, Rail Delivery Group Board and Rail Safety and Standards Board etc. Our project manager has been nominated for two awards for deaf awareness implementation in the project.

Conclusions and Impact

There is deep variation in digital maintenance practices, and security vulnerabilities in existing processes and hardware are common. This makes asset management and audit challenging and has the potential to risk unsafe operational conditions.

Remote secure access through one system with checks and balances on user access, asset ID and tasks can be achieved using existing infrastructure and our proof of concept. This has the potential to be deployed wherever network or remote access connectivity is available.

Next Steps

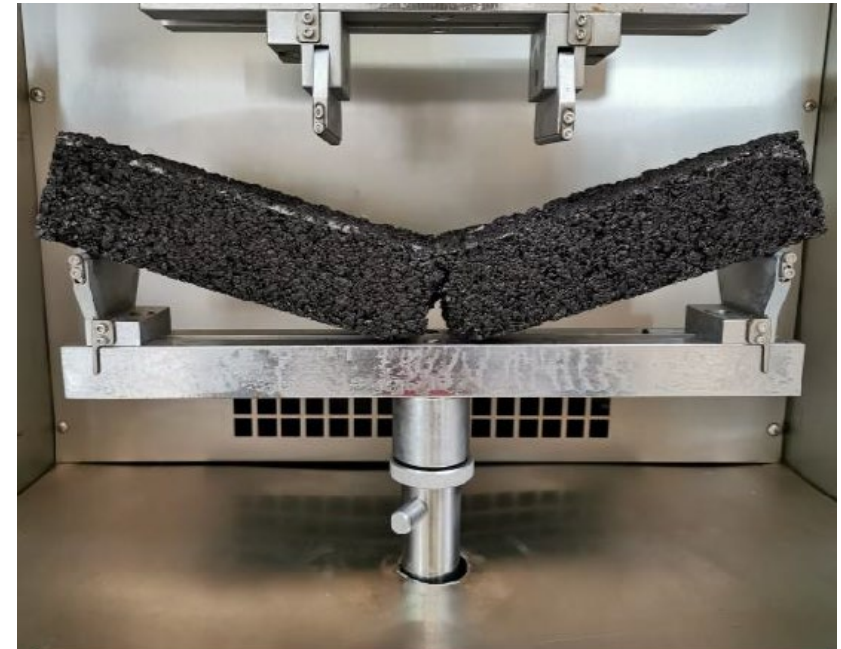
The commercial potential of our proof of concept has been recognised across RazorSecure's global operations, and proposals for in-situ trials have been made in the EU and US. BCRRE are committed to further work, other partners will be invited to contribute to next stage development with a total potential market sales to £4 million by end 2023. Product alignment with emerging US and EU NIS2 regulations and standards is informing our next stage of development.

Robotiz3d Ltd

Seal-It – Rigorous testing of crack sealing materials and procedures for preventative road maintenance

The aim of this project is to fill a market gap and build an integrated thermo-mechanical rig for crack repair quality assessment.

There are currently no standardised ways for testing quality of crack repairs, and available lab testing is too simplistic to simulate real-world conditions, often limited to qualitative testing. Shape-It fills this gap by developing a robust and comprehensive testing technique for materials commonly used for crack sealing.



Activities

Through this project, an innovative testing facility containing a custom-made rig in a climate/temperature-controlled was built to deliver more objective, quantitative assessments of crack repair qualities.

Tests were successfully completed and showed the high dependency of the ultimate stress to the temperature. Moreover, tests on the repaired samples showed that the repaired crack is the last point of failure in the sample.

Conclusions and Impact

Seal-it achieved its goal of designing and manufacturing a tensile testing machine capable also of thermal cycling for temperature-controlled static and fatigue tests on asphalt samples.

This advanced testing rig will allow Robotiz3d to improve its repair technology via continuous assessment of the structural performances of the cracked slab of asphalt once repaired.

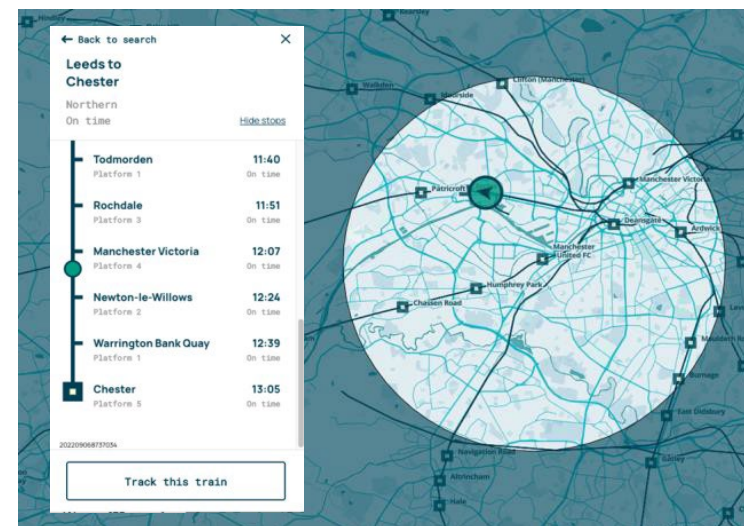
Next Steps

Tests with more specimens and with different combinations of repair materials and processes are initially needed to fully assess the performance and reliability of the Seal-it platform. Once such tests are completed, tests with real-world specimens coming from the existing roads will allow this technology to climb the TRL scale and finally meet the specification of a fully-fledged commercial product. We believe that only relatively minor changes will be needed in the machinery itself to go from the current TRL4 to full commercialisation.

Signalbox

Improving Incident Response on Britain's Rail Network with Automatic Train Identification

Signalbox's incident response application offers a novel solution for train operating companies, control rooms, and emergency services to match location data (latitude and longitude) from a mobile with the live location of a passenger train. This simple application – the first of its kind – draws upon Signalbox's existing train detection technology to empower incident response teams with quicker access to accurate real-time data for trains.



Activities

- We carried out an assessment of user needs to determine the ideal user experience and related technical requirements.
- We did research and market analysis to inform a longer-term commercial and technical roadmap.
- We focused on improving and testing Signalbox algorithms that precisely match a snapshot of location data to a specific train in a railway environment.
- We designed, built and iterated a minimum viable product (MVP) that was launched online for beta testing.

Conclusions and Impact

We released an MVP to map.signalbox.io to demonstrate the feasibility of using a snapshot of location data to search for a live train and refine results by filtering with simple questions.

We carried out internal testing and found that the technology and algorithm matched location data to a train in 98% of instances, and converged on a single train without ambiguity in 79% of tests.

This demonstrates that Signalbox can be used to enhance incident response on Britain's rail network by saving call handlers time when callers on a train are unable to describe their location.

Next Steps

We will demonstrate to the product potential users to gather feedback from key stakeholders.

We will secure a visit to a control room environment where Signalbox staff can use the application alongside existing applications to optimise the usefulness, reliability and permanence of the application in a real-world test environment.

We will create a product development roadmap (front and back-end) to improve coverage and reliability, and respond to feedback from stakeholders.

Swansea University

Safety Assessment for Urban-Air-Mobility (UAM) System in Metropolitan Areas

A modelling method and a universal safety assessment for UAM have been developed from this. Those methods will enable the high- accuracy simulation of novel UAM configurations. Also, the advanced inverse simulation method will be developed for the autonomous system development and safety assessment.



Activities

1. Deliver a novel uncertainty quantification-based modelling method and an improved inverse simulation algorithm.
2. A new inverse simulation method, which can significantly improve it's feasibility in multiple scenarios.
3. An incorporated flight simulation system is developed from this project to verify the modelling and simulation methods.

Conclusions and Impact

The advanced inverse simulation algorithm and high-accuracy modelling method are significant milestones for future research. This development allows the inverse simulation algorithm to extend its applications to:

1. Aircraft safety investigation
2. On-board autonomous and autopilot systems
3. UAM-based flight simulator development
4. UAM preliminary design optimisation

Next Steps

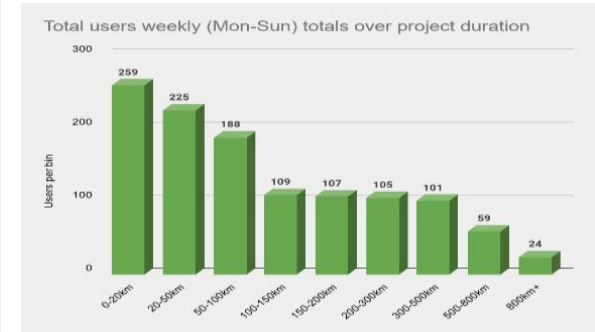
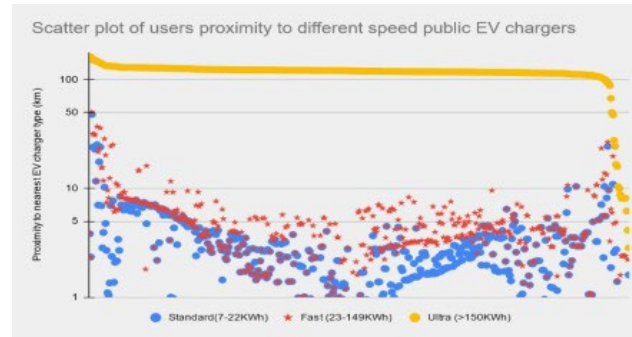
During the development of this project, multiple funding and mark opportunities have been developed:

1. Aerodynamics investigation of the multi-rotor vehicle (the Royal Society)
2. Design optimisation for future vehicle development (with Samad Aerospace)
3. UAV flight intension identification (With Cranfield University)

TravelAi Ltd

Accelerating the ICE-to-EV Transition

Decarbonising transport is critical, and in 2030 new ICE cars sales will end. But consumers are anxious about EV range, ownership costs and EV charging deserts. Meanwhile the EV industry lacks the data to battery rightsize and prioritise new EV sites. EVCurious sets out to answer this trifecta with data, deeptech automation, mass personalisation and the scale of smartphones.



Activities

- Milestone and project planning with partners
- Prep of recruitment material & users
- Validating ICE trip and battery analysis tech
- Iterative software development
- Final report findings and exploitation

Successfully launched EVCurious app on Apple and Google. Cardiff Uni and Glasgow are studies provided over 500 users generated 91K trips, 5K by public transport and 25K by car. Invaluable engagement with leaders in EV space (inc. manufacturers, vehicle leasing, battery experts, public EV networks, home EV installers).

Conclusions and Impact

Impact: Successfully validated with EV industry, field tested with consumers and advanced IP from TRL2/3 to TRL 5/6/7. Analysis of test users:

- 90% total daily car trips <100km (76% drivers)
- 64% total weekly car <150k, 71% <200km
- Fast chargers just <24% radius of 7km
- Ultra-fast just <2% within 7km, 95% >150km

Conclusion: Big gaps with rapid and ultra EV chargers; more EV battery sizes should be encouraged; users were happy to leave EVCurious app running in the long term.

Next Steps

Research: Consumer ready interface to make TRL7/8 ready, and launch direct to B2C.

Feasibility Study: How payload impact Light Commercial Vehicle (LCV) EV range. Simulation feature a request from SME financing co. Serves new segment analyses to expand market size.

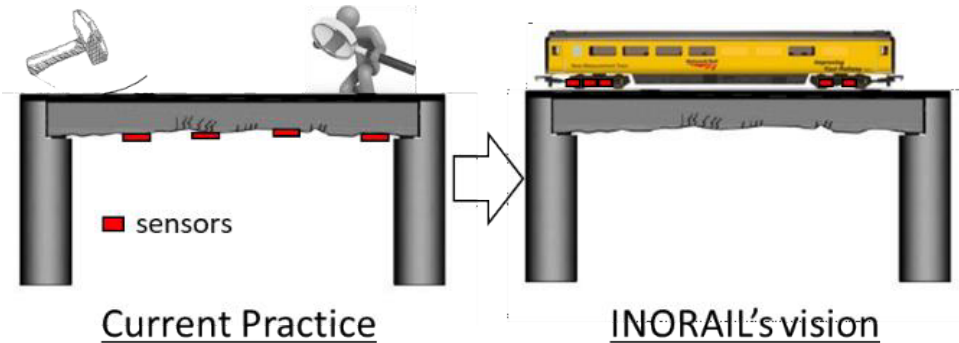
Commercial: In next 3-5 months find a commercial sponsor, and Pilot with a target commercial client (EV manufacturer, vehicle leasing, EV Battery makers, public EV networks, home EV installers).

Need to consider how industry can engage with data, create dashboard. Also secure investment.

University of Surrey

INORAIL: Indirect Inspection of Railway Bridges Using Train-Borne Monitoring System

In this project, we aimed to produce an indirect damage inspection mechanism for railway bridges using an instrumented train that can inspect bridges on the network while travelling at operational speed. In this system, a bridge is monitored by analysing the data collected on a moving train while crossing the bridge.



Activities

- Building, training and testing data-driven damage detection and classification algorithm.
- Conducting scaled testing using a model bridge and an instrumented model train.
- Conducting a practice-based feasibility investigation using an over 100-year-old bridge using an operational instrumented train.



Conclusions and Impact

- Achieving an unprecedented accuracy of 100% in detecting and classifying damage using the developed data-driven damage system using an instrumented model train.
- Demonstrating the viability of the concept for a case study bridge by demonstrating over 75% accuracy in detecting the change in the riverbed and 85% in age classification of train-borne signals.
- Building the practice-based core and foundation for the follow-up activities that will lead to an automated data-driven, drive-by damage inspection system.

Next Steps

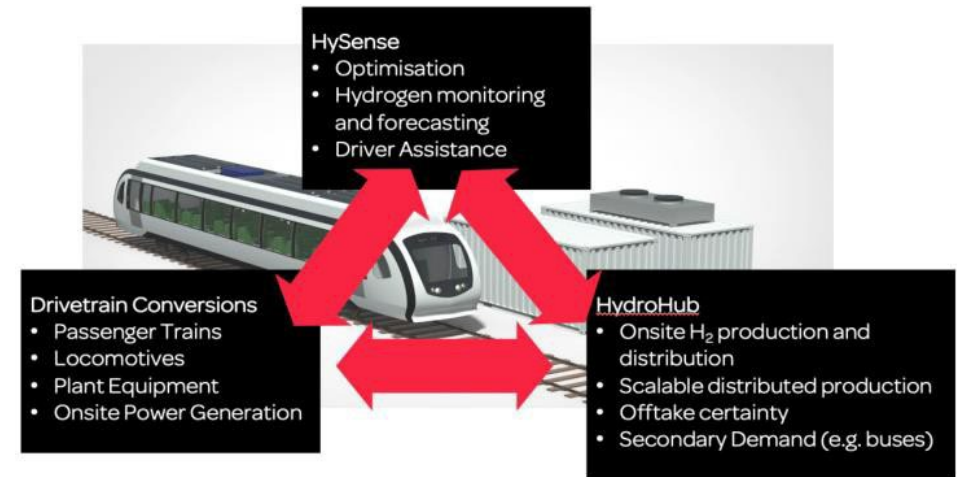
- Expanding the application of the system for other types of bridges using the additional train measurements for two different instrumentation systems and surveys covering approximately 200 mile of track, for 2-5 year period.
- Automating bridge numerical modelling through 3D scanning and climbing robots.



Vanguard Sustainable

HySense: Intelligent interface between infrastructure and rolling stock/end user designed to manage, monitor, maintain and optimise hydrogen use, demand and supply across a transport network.

Build upon the initial HySense concept to establish what data sources are available and needed to successfully manage Hydrogen supply, data analysis and manipulation and also a review of what key stakeholders require to be encouraged to switch to hydrogen as a fuel.



Activities

- Engagement with potential system end users
- Definition of system architecture
- Development of a limited functionality prototype to be tested in a controlled environment
- Creation of a development and exploitation plan for further activities

Conclusions and Impact

- Prototype is capable of calculating fuel consumption for a given route and information hydrogen system design and best practice.
- Hysense is a viable product for ongoing development within the Vanguard.
- Development required additional investment from Vanguard or an external source to maintain the current pace.
- Functionality is key to end users.
- The uptake of hydrogen powered vehicles is key to the success of HySense as otherwise there's no suitable end users.

Next Steps

- Further development of the pilot system to incorporate functionality identified by stakeholder engagement.
- Test Hysense in a live environment.
- Secure investment to develop the system into a commercially secure setup.
- Continue to promote the uptake of hydrogen as a fuel in the rail and heavy transport industries.

Zipabout Limited

Why do they all come at once? Improving Bus Information Accuracy to Increase Confidence, Satisfaction and Usage

This project has supported the development of a new approach to bus arrival predictions, extending earlier research into Machine Learning models targeted at predicting rail delays during disruption. This new approach is intended to automatically predict delays based on a number of 'features' including weather, time of day and traffic delays – and to increase passenger confidence through the provision of more timely and accurate information. We use an iterative approach supported by both qualitative and quantitative research through a 'real-world' demonstrator, ensuring the output of the new model is useful to passengers.



Activities

- Specification and development of a predictive model for bus arrivals and departures, based on data from DfT BODS.
- Qualitative user research into personalised messaging and alerts for bus services through the existing Zipabout platform.
- Design and initial implementation of a real-world demonstrator allowing for quantitative research into messaging effectiveness.

Conclusions and Impact

- Successfully created simple predictions based on DfT BODS SIRI-VM and GTFS data for the majority of services.
- Analysis for applicability of Random Forest Machine Learning (ML) model to bus predictions undertaken – previous approach for rail delays shown to be valid.
- Country-wide deployment of technology with Oxfordshire County Council (OCC) confirmed – supporting the Local Authority with net-zero targets and commitments.

Next Steps

- Further development of ML model with UoB through wider R&D partnership.
- Launch of Zipabout Local product with OCC in Q4'22, enabling further research into effectiveness of predictions, and iterative development of solutions.
- Integration of new prediction capability for bus services into Zipabout's existing, national deployment with major rail operators (including National Rail Enquiries).



Department
for Transport

Covid 19 and Transport System Resilience

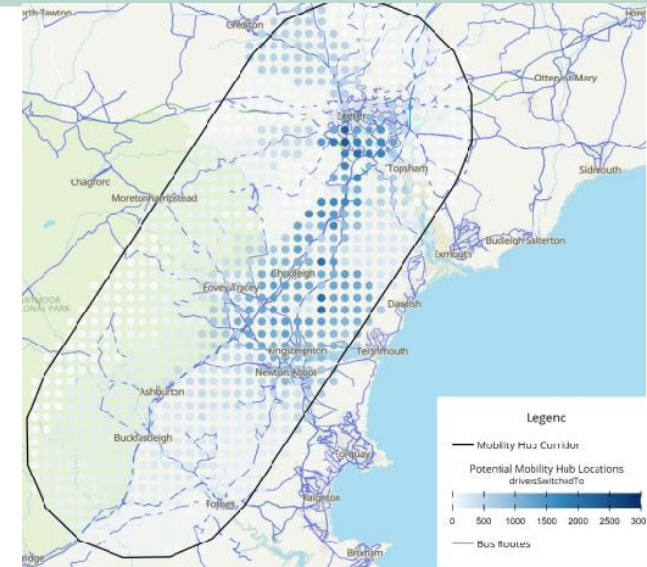
Delivered by

CATAPULT
Connected Places

City Science

Optimal Planning for Mobility Hubs

This project developed a tool to aid in the determination of the location of a Mobility Hub. A Mobility Hub is a space which brings together multiple modes of transport and supporting services. Examples include, train stations and park and ride sites. There is comprehensive guidance on what can be provided at a Mobility Hub but limited on their location, which is what we aimed to address in this project.



Activities

Literature Review of national policies and guidance on the planning of Mobility Hubs.

User Engagement session with multiple local authorities to gauge their current and desired approach to Mobility Hub planning.

Tool Development, developing the location finding tool which assesses mode shift depending on a Mobility Hub's location.

Conclusions and Impact

Mobility Hubs are a focus of local and national governance to help increase the use of sustainable transport in the future.

There is a lack of consistent or evidence led planning of a Mobility Hub's location across the guidance and local authorities.

The tool developed in this project will help local authorities make better decisions on a Mobility Hub's location. Some validation has been carried out on the tool, but more is needed for it to be market ready.

Next Steps

- Develop the generative design of a Mobility Hub based on the location selected by the tool
- Incorporate walking/cycling/wheeling/scooting into the potential mode choices of the tool
- Integrate the tool outputs with wider data sources
- Engagement with future funding opportunities to support the above
- Engagement with a local authority to provide test data to better validate the tool

Stormchain® Rapid Impact Assessment

A collaboration between JLES Ltd. and HD Research Ltd.

Stormchain® is the state-of-the-art in highway-asset Rapid Impact Assessment technology. Comprising a Web-browser based Geographical Information System (GIS) and the in-field mobile App, Stormchain supports defensible decision making during major incidents. It equips council frontline teams and managers to be genuinely 'prepared for their worst day instead of an average day'.



Activities

Stormchain 1.0 went into TRIG as a level 2 proof-of-concept system requiring testing and editing to progress to prototype stage.

The testing and refinement of the system in Cumbria and East Riding within the TRIG timeframe provided an invaluable opportunity to develop and integrate significant new features and functions into the system.

We also presented the system at numerous key sector events, including [PIARC World Winter Congress](#) (Calgary) and both [UK Cold Comfort](#) conferences and to UKRLG.

See the project video: [here](#)

Next Steps

Our objective is to commercialise the product as Software as a Service (SaaS) as soon as possible. This will directly support and be part of the 'new approach' to sector resilience.

With support from the Local and Regional Programmes Team we will be testing Stormchain with up to 10 councils during the major east coast flood exercise in September (FloodEx22). Our target is to deploy Stormchain across at least 30% of the 210 UK Highway Authorities by month 36 (June 2025), whilst also continuing to explore opportunities to offer the system to potential international customers.

Conclusions and Impact

With these changes embedded Stormchain was operationally tested in East Riding. The system worked exactly as expected, creating a tangible buzz in the operations room as live data was fed in from the operative's apps in the field directly to the manager in the control room.

The Director summarised this experience:

'Stormchain gives us the ability to survey, assess, prioritise and archive information in a matter of minutes and hours what took us days and weeks'.

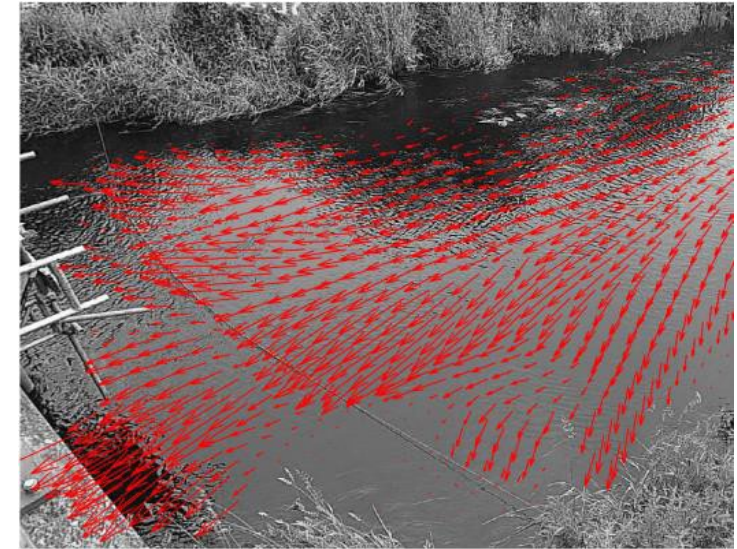
Stormchain has successfully attained and surpassed the TRIG target TRL4.

University of Strathclyde

Low-cost sensor system for enhanced bridge flood resilience

Bridge scour, the removal of soil surrounding bridge foundations due to water flow, is the most common cause of bridge failure in UK and worldwide, resulting in significant disruptions to road and rail transport infrastructure networks and major costs for risk mitigation.

This project aims to develop a tool for early warning and real time scour risk assessment of bridges exploiting information from low-cost flow sensors and reliable models for evaluating the scour.



Activities

WP1: Evaluation of the accuracy of existing scour formulae using available laboratory and field data and quantification of the statistical parameters based on the observed scatter between the predicted and measured pier scour depths.

WP2: Use of data-driven machine learning such as Artificial Neural Network for an accurate prediction of the bridge scour depth.

WP3: Development of a tool for assessing in real time the risk of exceedance of critical scour levels using low-cost equipment (IP camera).

Conclusions and Impact

The tools proposed and tested in this project allow to continuously and remotely monitor some critical hydraulic features of the flow (surface, velocity, depth) that are strongly correlated to those controlling bridge scour. The monitoring data, combined with advanced, time-dependant hydraulic and scour models, permit to achieve near real-time estimates of bridge scour.

The developed tools can help Transport Agencies and Operators to make measured-informed decisions concerning bridge scour risk management, thus improving current practice.

Next Steps

- Apply for funding to develop a digital platform based on the proposed tools and models
- Submit a larger research proposal on digital twin models for bridge flood risk assessment
- Disseminate the obtained results to the scientific community and Transport Agencies and Operators
- Engage with Strathclyde Inspire to explore commercialisation of the technology
- Test the developed tools under more extreme flood events, start continuous monitoring at the case study bridge.



Department
for Transport

Future of Freight (£100k)

Delivered by

CATAPULT
Connected Places

3Squared

Levelling up Freight

This project sets out to make sure that freight trains are more profitable to run by helping to fill empty wagons before they depart ports at short notice. The project builds on the additional capacity that Network Rail's £17m upgrade programme delivered at Southampton to run longer trains, and the £3m investment now being undertaken by Solent Stevedores to increase their capability to take longer trains into their loading platform.



Activities

We undertook a high level of stakeholder engagement to fully understand the issues faced when trying to move container freight by rail at short notice.

The insights enabled us to create a straw man for the overall solution and the data required to facilitate the development of the PoC.

Several software iterations were demonstrated to members of the supply chain and the feedback went into further development, with the resultant solution getting a firm thumbs up.

Conclusions and Impact

We have proven that by having access to the right data and the right time, it is possible to create the right conditions to help promote modal shift.

We have achieved this by: giving visibility of available space on a freight train before it leaves and providing a mechanism for customers to book their containers to fill that space.

The impact on the freight market is significant as it enables customers who would have historically transported their goods by road, to transfer their movement onto the railway.

Next Steps

We have been awarded funding from Innovate UK's First of a Kind programme to further develop our solution, mainly around the creation of Machine Learning algorithms that will help identify paths that aren't used; therefore, opening capacity to run additional trains.

We are in discussions with Network Rail and the GBR Transition Team to determine how we take the Capacity Management solution forward and having conversations with the Google team who sponsor the Interchange UK Programme.

Anteam

Development of “Sharing Logistics” with Embedded Trust Models for Near-Zero Carbon Delivery

This project focuses on progressing Anteam’s sharing logistics concept by building upon an advanced AI-based matching algorithm, focusing on the human element of the equation. The project also tested the proposed concept within a controlled environment to provide an early understanding of the potential challenges that could be faced during implementation. The testing allows Anteam to adjust and optimise its operating models and underpinning technologies to mitigate some of the challenges faced.



Activities

The project attempts to identify key barriers to adoption that could impact the successful deployment of the proposed logistics concept. A number of hypotheses were initially generated and a survey was conducted to get an early indication on any mitigations that could be implemented. These mitigations were incorporated into the trial and a trial with selected businesses were conducted. The trial confirmed a number of hypotheses but also provided additional learning that could not have been obtained otherwise.

Conclusions and Impact

Human-centric features are critical to the successful adoption of an innovative concept, especially one that attempts to create a change in human behaviour. The human-centric features need to be manifested in the operating model, business model as well as the App technology (both front-end and back-end).

If the proposed logistics concept can be widely implemented in the UK, it could decouple the linear correlation between the growth of logistics capacity with the generation of additional CO₂ emissions, air pollution and traffic congestion.

Next Steps

The next steps is to expand the testing and ensure that the trial is even more representative (TRL 5 and TRL 6). The legal and insurance frameworks also need to be defined to support a more commercially oriented trial.

The trial within this project has also highlighted an opportunity to redefine the reward mechanism for our users, in order to make it more attractive for users to continuously participate in the innovative logistics network.

CGA Simulation

LMFHub – Last Mile Freight Hub Planner

LMFHub is a tool for predicting the best place for infrastructure that will enable radical developments in logistics. Placing 'micro-consolidation' hubs in the correct place, and smoothing the road routes from it, means goods can be distributed efficiently by low energy use modes like Cargo-Bikes. LMFHub is a predictive digital environment for the unknown future of logistics in the context of the overall transport system.



Activities

Building a mock-up to show to end users in industry and local government to refine a prototype digital tool which includes:

- A site optimizer that uses a combination of statistical and agent-based modelling
- A comparative tool for different areas of a digital environment
- A back-and-forth iterative process between human and machine testing out different options with statistical results to compare the options
- Spider heat graph showing journey times out of a potential site

Conclusions and Impact

- Industry, local government and transport authorities confirm such a tool is needed and not currently available
- CGA has been able to build an appropriate tool on an existing platform with TRIG funding
- The only equivalent tool identified is an early prototype within a very large logistics company
- Cargo Bikes and new modes of delivery are cheaper and more efficient
- LMFHub is the right tool to plan now for the future of logistics

Next Steps

To take LMFHub to market CGA needs to:

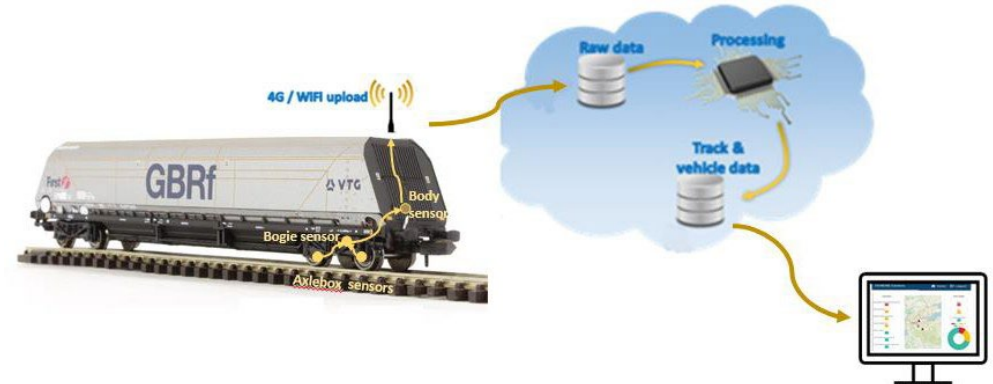
- Refine the prototype based on feedback on this round of user trials
- Make it available as a Beta test product for potential users on a national and global scale
- Identify first customers and work with them on a number of ground-breaking implementations of LMFHub
- Build a marketing team for the product

To do this CGA Simulation needs to source funding, include exploring Private Investment.

Fishbone

Freight Wagon Condition Management System (FWCOMS)

FWCOMS provides operators and wagon owners, with a remote condition monitoring system that identifies existing or impending component or system failures, through usage of machine learning analysis to identify harmonic profiles of individual components of the wagon bogie.



Activities

- Non mainline testing trials took place, alongside development of data analytics and algorithms that can be used to train machine learning models, enabling the prediction of bogie or wagon component failure.
- Testing was conducted on two VTG owned hopper type wagons with varying mileage on a heritage railway track, to baseline vibration signatures of the wagons.
- Pilot signal processing and machine learning exercises were conducted to produce analytics for the vibration datasets.

Conclusions and Impact

- Using the acquired baseline vibration data from the various wagons, the project results demonstrated the ability to assess component health.
- This can be used to enable the transition to on condition maintenance of wagon components, allowing us to avoid vehicle down-time for unnecessary maintenance.
- By having an accurate real-time reading of the vehicle's health, we can reduce safety incidents on the railway, such as vehicle failures or de-railing.

Next Steps

- Seeking further funding for mainline testing trials on hopper wagons in early 2023.
- Train simulations to test specific fault scenarios.
- Seeded fault testing at Perk Rail Heritage Railway.

Opportunities

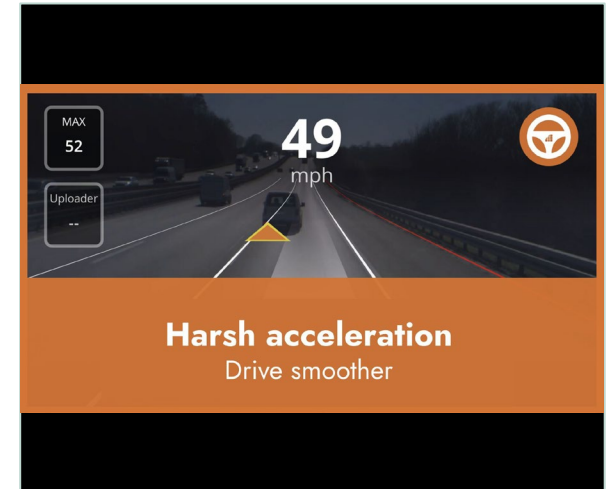
- Further collaboration between Fishbone and MoniRail.
- FWCOMS is designed to be modular. This makes the system easily transferable to different wagon types.
- Proven concept shows there is the potential to fit this system across the UK rail network.

Hypermile

Future of Freight Challenge: Machine Learning-Based Intelligent Driver Platform to Make Diesel & Electric Commercial Vehicles More Energy Efficient

Challenge: Driver Behaviour is the biggest factor affecting a truck's energy consumption yet existing solutions either provide only temporary results (e.g. training centres) or do not account for the driving environment (e.g. telematics).

Solution: Support drivers' changing skills requirements by leveraging Hypermile Co-Pilot hardware and AI technologies to assist them in being more energy efficient operators of commercial vehicles.



Activities

- **Artificial Intelligence (AI):** Developed AI model, based on road environment data and vehicle telemetry, which detects inefficient driving manoeuvres to reduce energy costs.
- **Product:** Deployed Co-Pilot, a retrofittable software & hardware solution with camera/screen, into diesel truck and electric passenger vehicle.
- **Efficiency:** Delivered Co-Pilot efficiency improvements via real-time feedback to drivers when inefficient driving manoeuvres are detected, alongside updates to AI cruise control system.
- **Testing:** Tested Co-Pilot on private/public roads.
- **Data:** Built web dashboard for fleet managers.

Conclusions and Impact

- **Fuel Savings:** Achieved 6.80% fuel savings versus an experienced driver of a diesel truck on public roads (*Project Goal: 5%*).
- **Range Extension:** Achieved 7.85% energy savings versus an experienced driver of an electric passenger vehicle (*Goal: 7%*).
- **Expanded Functionality:** Integrated driver training platform with Hypermile's AI cruise control, creating a unified Co-Pilot product for fleet managers & drivers (*Goal: unify product*).
- **TRL:** Successfully evolved Co-Pilot integrated product from TRL-2 to TRL-5, having tested in relevant environment (*Goal: TRL-5*).

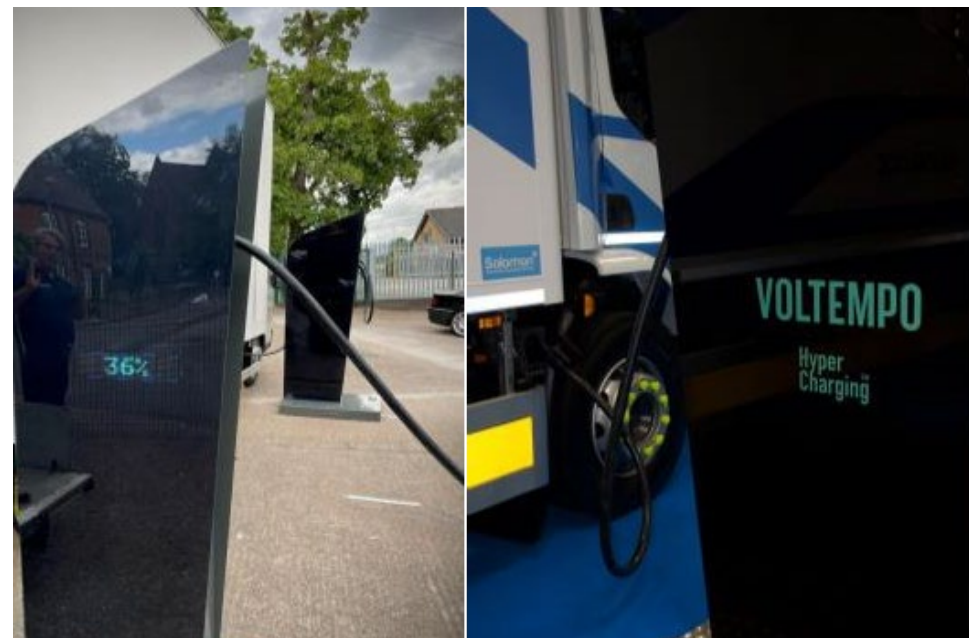
Next Steps

- **OX Electric Trucks:** Despite having to withdraw due to vehicle readiness challenges, our original TRIG partner, OX (vehicle OEM), intends to continue the partnership on a commercial basis with Co-Pilot deployments across their diesel & electric trucks.
- **Tier-1 Suppliers:** Hypermile is also in advanced discussions to begin pilots with two tier-1 suppliers.
- **Leasing Firms:** Co-Pilot has also been demoed to two major truck leasing firms at Millbrook testbed, and discussions ongoing.
- **Investors:** On track to raise seed+ round.

Voltempo

Heavy Goods Vehicle Charging

- Optimising EV charging around the needs of Heavy Goods Vehicles
- Creating an EV charger that can charge at 350kW plus for extended periods of time without derating due to overheating
- Creating a rapid EV charging hub capable of charging multiple vehicles simultaneously



Activities

- Development and build of a charging system that can charge 1,000A without derating for over an hour.
- Design and build of a transportable HGV-ready charging system, capable of charging three vehicles simultaneously, installed into a hybrid truck.
- Demonstrated with Renault Trucks in a controlled environment at Tyseley Energy Park in Birmingham.

Conclusions and Impact

- Creating a charging system that can charge HGVs at 350kW of higher requires a significant redesign over current state-of-the-art charging systems.
- New cables and new internal design is required to get high enough efficiency to avoid costly cooling systems that only provide a 'sticking plaster' solution to the root problem.
- We have had considerable interest from Renault Trucks, Scania and DAF.

Next Steps

- Voltempo charging system to be used as a cornerstone of our ZERFT funding consortium bid for providing 1MW ready charging.
- We expect to close three orders for HyperCharging systems by the end of this year:
- Phillips 66: petrol station forecourts (£450k)
- Zevhub: Fleet charging solutions (£285k)
- Additionally, we are offering charging-as-a-service for XPO using our current prototype.



Department
for Transport

Future of Freight (£30k)

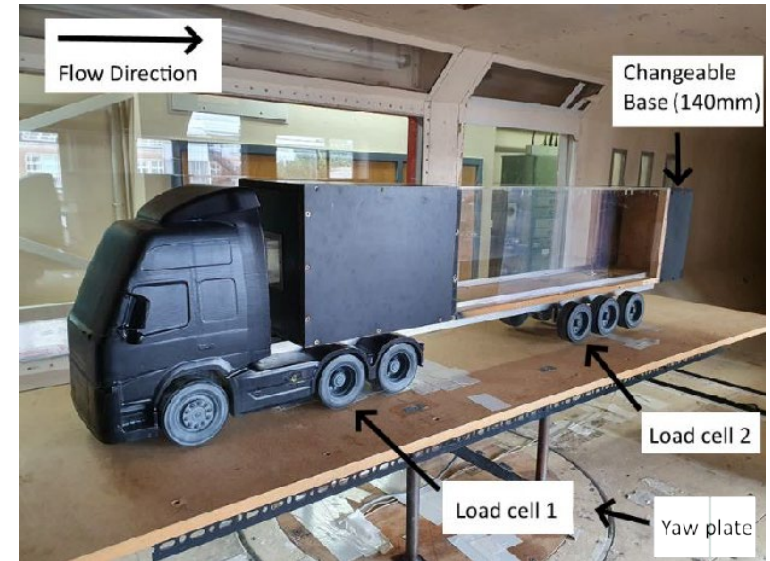
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CATAPULT
Connected Places

Brunel University London

Non-linear boat-tails: A pathway to realising future heavy goods vehicle aerodynamic performance

Heavy goods vehicles make a significant contribution to greenhouse gas emissions within the UK and globally. This project investigated and validated a new and novel drag reduction technology denoted as the non-linear boat-tail. Unlike traditional boat-tails, this concept employed a unique non-linear reduction in rear trailer cross-sectional area to provide comparable performance benefits.



Activities

- Redesign of existing 1/10th wind tunnel model to integrate concept
- Design and manufacture of components to evaluate multiple configurations
- Load cell and surface pressure instrumentation integration
- Raw data collection from wind tunnel test programme
- Data analysis to narrow optimum design parameters
- Retest, refine and define optimal configuration
- Preliminary full-scale design exercise

Conclusions and Impact

- Maximum reduction in total vehicle drag of 8%
- Corresponds to approx.. 3-4% fuel reduction
- Estimated 110 tonnes/vehicle/year CO₂ saved
- Sub-optimal configurations also remain effective
- Performance benefits increase with flow misalignment
- Optimal configuration bias towards the top of the trailer
- Integration within full-scale vehicle cost-effective, beneficial, feasible and realistic
- Full-scale redesign requires only minor modifications to existing design

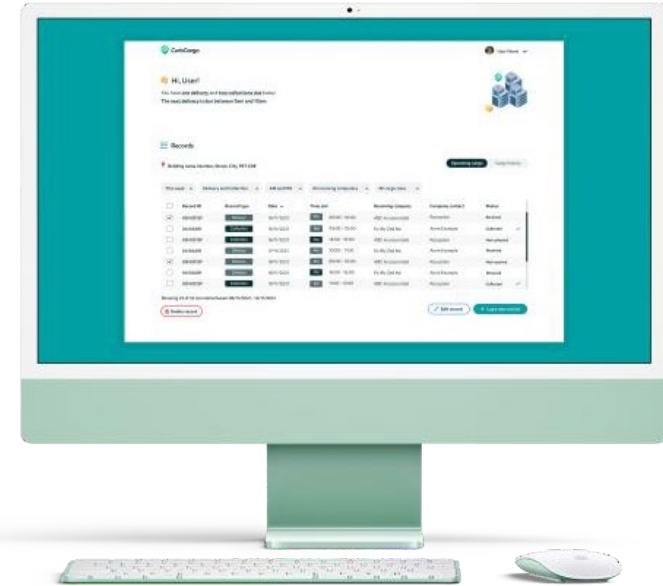
Next Steps

- Secure follow-on funding to provide resources to realise full-scale prototype
- Employ dedicated engineer to conduct and finalise full-scale detailed design exercise
- Manufacture first prototype
- Install and integrate test and performance evaluation instrumentation
- Engage suitable commercial customer to assess overall operational performance
- Produce new line of low drag trailers for commercial marketplace

CurbCargo

Curbing Pollution & Congestion in Cities

Put simply, users of CurbCargo see the environmental impact of freight deliveries into their business premises and are prompted to make targeted interventions that reduce vehicle movements to improve air quality and reduce congestion. CurbCargo connects these like-minded businesses and fosters collaboration to further reduce environmental damage and healthcare costs.



Activities

- **Data Collection** – Operational data collection at our selected pilot sites.
- **Environmental Impact Methodology** – Developing and validating the approach to emissions and environmental impact assessment.
- **User Experience (UX)** – design and validation working.
- **Customer Engagement** – interviews and feedback sessions.
- **Minimum Viable Product (MVP)** – detailed design and ‘full stack’ development.

Conclusions and Impact

- **Proven concept and approach** – validated the concept with real world data and confirmed potential to reduce vehicle movements and the associated pollution / congestion.
- **Increased customer engagement** – good customer feedback and involvement in the programme and support / commitment for next phase.
- **New Commercial opportunities** – demonstration of the concept and approach, combined with TRIG/DfT support have helped to unlock commercial discussions with potential partners.

Next Steps

- **Implementation** – go live at the pilot site and create marketing case studies.
- **Commercial** – develop / finalise the commercial partnership with Connected Places Catapult and Property Manager partner.
- **Funding** – secure additional funding to support the live pilot sites and subsequent commercial scale-up.

Cyth Limited

Investigating the feasibility of scavenging sufficient energy from freight wagon sway to power predictive maintenance sensor platforms

A high-fidelity ruggedized data acquisition system with accelerometers and inclinometer were deployed on a rail freight vehicle to perform quantitative and spectral analysis of wagon sway motion. Analysis of the acquired data has given valuable insight into the types of electromechanical systems that will be necessary to convert wagon sway energy into electrical power for on-board predictive maintenance IIOT equipment. Two concept electro-mechanical systems have been designed to exploit sway motion, and a numerical simulation tool was created to assist in the design and analysis of harvesting systems.

Activities

Creation of ruggedized packaged autonomous data acquisition equipment to capture high speed signals from 3-axis accelerometers and inclinometer during operation of rail freight wagons was deployed on rolling freight wagon and shunt locomotive.

Post processing of acquired data was performed to characterise temporal and spectral content of available vibration/motion of the freight wagon.

Creation of two candidate energy harvesting mechanical systems concepts to harness rail sway.



Conclusions and Impact

Characterisation of amplitude and frequency characteristics of freight wagon sway has given very good insight into the fundamental design requirements of candidate energy harvesting devices suited for this application.

Scavenging of even modest power budgets from rail freight wagon sway will allow FOCs to perform 'always-on' monitoring of rolling assets with IIOT sensor systems. This will answer some of the digitalisation challenges identified by the FOCs, and should enable the adoption of predictive-maintenance strategies to optimally manage maintenance of rolling stock.

Next Steps

Because of legal and availability challenges, system of deployed only at low speed. Data from full-speed operations must be obtained.

A working mechanical prototype of two concept design candidates will be produced and tested.

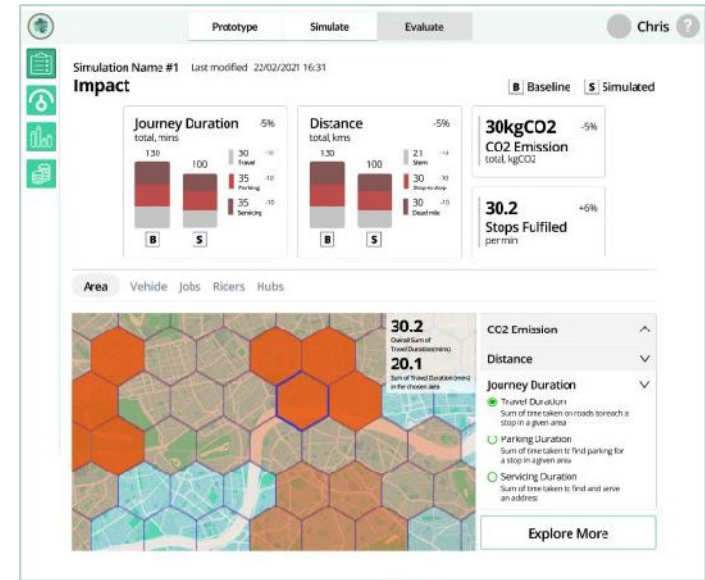
We have received strong expressions of interest from a number of UK FOCs who recognise that application of predictive maintenance capability on their rolling stock fleets represents a potentially disruptive capability for them. Tens of thousands of unpowered rail freight vehicles currently operate in the UK alone.



Kale Collective

AI Infrastructure for Cargo Bike Logistics Transition for Last Mile of Urban Freight

The project delivered by Kale Collective for the TRIG grant consists of a tool for urban logistics operators to quickly understand how they could improve their business by adding electric cargo bikes to their vehicle fleets and what additional depot infrastructure needs to be invested in. The tool uses the operators' own historical data and a simulation engine to accurately predict the optimal fleet composition and consolidation hub.



Activities

A user interface was designed as a proposal for a complete user-facing application. The user interface allows operators to get an overview of their costs and revenue, identifies the optimal vehicle and depot investment strategy, and provides tools to further reduce costs and tweak their revenue model.

The core simulation and optimisation technology was developed as an API allowing operators to integrate the tool into their own technology stack.

Conclusions and Impact

Our simulation engine provides a quick and inexpensive way for logistics operators to understand how they can reduce costs and carbon emissions by replacing fleet vehicles with electric cargo bikes and vans.

Our platform accurately quantifies the speed and efficiency gains cargo bikes will provide operators by analysing their historical operational data. The wider impact is faster adoption of low-emission, low-congestion delivery vehicles to make our cities more liveable.

Next Steps

Algorithm Refinement

We are currently exploring the use of advanced machine learning methods such as embeddings (compressing all the relevant urban features to a small vector space) to have models that can generalise to multiple cities and urban contexts.

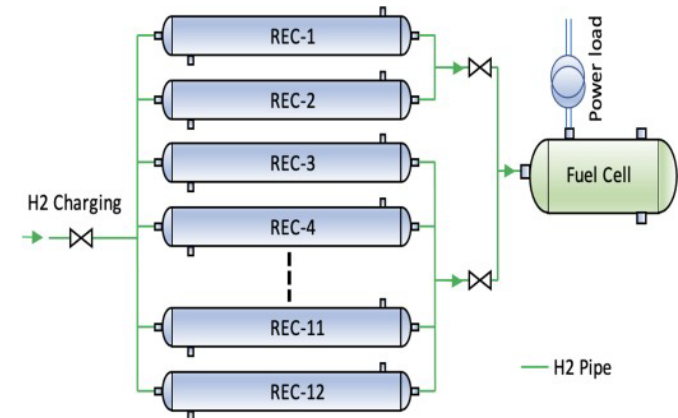
Commercial Partnership

We are exploring a possibility of entering a commercial partnership with one of the mid-sized cargo bike operators for the further product development.

London South Bank University

Low Carbon Food Transport Refrigeration Trucks with Hydrogen Fuel Cell and Metal Hydride Reactors

A hydrogen fuel cell (H2FC) food transport refrigeration truck energy system with metal hydride (MH) hydrogen storage and simultaneous refrigeration capability has been designed and investigated. The MH alloy and MH hydrogen storage tank have been selected and designed respectively. The market opportunity for the proposed system is reviewed and analysed. Future steps are outlined.



Activities

- A hydrogen fuel cell (H2FC) food transport refrigeration truck energy system with MH hydrogen storage and refrigeration was proposed and designed;
- The MH hydrogen storage tank with 12 MH reactors was designed for a 32-ton H2FC food transport refrigeration truck;
- The MH alloy used in the MH hydrogen storage tank was selected and characterised;
- Market opportunity and route for the proposed system and vehicles were reviewed and analysed.

Conclusions and Impact

- The proposed hydrogen fuel cell food transport refrigeration system with NH hydrogen storage and refrigeration capacity is feasible;
- A new approach has been developed for the MH alloy selections in different applications;
- A model has been developed for the characterisations of MH alloys based on measurement data;
- The MH alloy selection and MH hydrogen storage tank design are applicable;
- The development of the proposed system has significant impact on environment, society and government policy on zero emission target.

Next Steps

The proposed H2FC food transport refrigeration system will be further developed with a number of essential steps. These include:

- MH alloy optimisation;
- MH alloy characterisation with experiment;
- Initial test and validation for a single tube-in-tube MH reactor;
- Test rig development to measure the H2FC truck performance of hydrogen refuelling, storage, releasing, refrigeration and FC power generation;
- Model development and system scale-up;
- Future field test and commercialisation.

Mole Solutions

Module for intermodal operations on innovative Underground Freight Transport System (UFT)

UFT is an emerging innovative transport concept using the subsurface to mode shift freight from road-based HGV to electrically powered capsules travelling autonomously on rail tracks in low-cost tunnels.

A key parameter is the intermodal load / unload operational efficiency and its interfaces. This project develops a TRL4 status module that monitors and controls that integrated material handling and capsule movement with a target exemplar 33 second transfer duty cycle.



Activities

1. System modelling to specify exemplar case, design parameters, predict performance and optimise and measure results.
2. Specify, select and design material handling equipment and layout for a range of Material Handling Units. Do this using DEMO 3D digital twin design software tool with its illustrative features.
3. Design Capsule special intermodal features avoiding onboard power sources. Use CAD tools of Sketch up and Alive with illustrative features.
4. Prepare timing and logic diagrams as the basis for subsequent coding of the station controller.

Conclusions and Impact

The evidence presented in the final report concludes that TRIG project 1260 was efficiently completed on time and within budget. The project outcomes and learnings have enabled TRL progression not only individually for the two key work areas of logistical 'Material Handling Aspects' and for the 'Capsule unload /load features' but, significantly and importantly of how these areas work together physically and with control systems to provide an integrated intermodal operation. A transfer cycle of 33 seconds on a UFT transporting 5,200 pallets per day impacts by enabling a reduction of 400 equivalent HGV movements.

Next Steps

Technically, further development and testing beyond the currently achieved TRL4 status. This project progress has enabled and supported a UFT exploitation route based upon a regional approach as recommended by DfT. This currently envisaged as being in the West Midlands with its progressive approach to solving the effect of freight transport efficiency and environmental Issues. A collaboration with the Dudley based 'Black Country Innovative Manufacturing Organisation (BCIMO)' for future testing and focus on 'Very Light Rail Freight' advancement is welcomed as a vision for the future.

University of Cambridge

Brake-Actuated Steering to Reduce the Carbon Emissions of HGVs

This project aims to develop and test a novel, low-cost, and lightweight active rear-steering system, Brake-Actuated Steering (BAS), to improve the manoeuvrability of a wide range of HGVs. This will unlock the use of higher capacity vehicles in many urban and rural areas, improving efficiency, reducing emissions and operating costs. The system also eliminates tyre wear during cornering, enabling the use of fuel-efficient tyres.



Activities

- Developed HGV model of a tractor-semitrailer with multiple brake-actuated steered axles.
- Modified brake prototype hardware and controller to use for the steering actuation and to emulate the behaviour of commercial brake actuators.
- Carried out controlled testing at HORIBA-MIRA of the full-scale prototype system for a variety of road surfaces, vehicle speeds, and a number of steered axles.
- Assessed system performance with comparison to a conventional vehicle with fixed axles.

Conclusions and Impact

The technology has successfully reached TRL 5.

- The BAS system is a viable technological solution that uses individually controlled brake actuators to steer the vehicle axles without any additional components.
- Reduces swept path width by 25%, tail swing by 60% and trailer cut in by around 70%.
- Reduces carbon emissions and tyre wear emissions, allowing operators to use fuel-efficient tyres and increase payload capacity, improving efficiency through the use of much more productive higher capacity vehicles.

Next Steps

- Live demonstration of the prototype BAS system to potential technological partners.
- Develop control strategy can CAN bus network to control commercial brake actuators for the steering actuation. Three EBS units have been supplied to Cambridge University from ZF group.
- Further testing of the system with commercial brakes and in reverse manoeuvring.
- License the technology to a industrial partner and disseminate findings.