Department for Transport

Transport-Technology Research and Innovation Grants (T-TRIG) 2020 Project Outcomes

September 2021

Department for Transport
Great Minster House
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This publication is also available on our website at www.gov.uk/government/organisations/department-for-transport

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Foreword

This T-TRIG funding call was launched in September 2020 in the midst of a pandemic when our transport system was experiencing massive change. The COVID-19 pandemic has raised many challenges, but it has also highlighted the critical role of research and innovation in developing solutions to tackle them.

This message has been reinforced by the recent publication of the Department for Transport's Transport Decarbonisation Plan. The plan sets out the government's commitments and the actions needed to decarbonise the entire transport system in the UK, and states our intention for the UK to be a hub for green transport technology and innovation.

Research and innovation is at the heart of our post-pandemic recovery, the decarbonisation of our transport system and our strategy for improving transport for the user.

Since 2014, we have invested over £6m in T-TRIG grants, primarily to SMEs and start-ups. The 2020 cohort of T-TRIG projects demonstrates the ingenuity and breadth of UK innovators from academia and SMEs. The cohort features a highly diverse spread of projects, covering all transport modes focussing on DfT's biggest transport priorities.

The 2020 call was the second time we had delivered T-TRIG with the active support of the Connected Places Catapult (CPC). I am delighted to be partnering with them as it allows us to join up DfT's policy needs and expertise with the CPC's understanding of and their broader support to innovators in commercialising their new products and services – so that funding can go further and lead to significant impact on the ground.

I look forward to seeing the 2020 cohort continue on their innovation journey, and to welcoming the next cohort of projects in 2021 as they take their first steps in the programme.

Professor Sarah Sharples

Chief Scientific Adviser, Department for Transport

Introduction

1. Transport – Technology Research Innovation Grants (T-TRIG) enable the Department for Transport (DfT) to fully fund proof-of-concept research projects in support of innovative ideas or concepts that facilitate a better transport system. T-TRIG aims to:

    - Foster innovation to improve UK transport
    - Generate growth in the transport sector
    - Build links between policy teams in DfT and innovators.

2. First launched in 2014, the 2020 call was delivered in partnership with the Connected Places Catapult (CPC) and resulted in £900k of Government grants across 23 six-month projects, covering three themes:

    - Decarbonising the Transport System (12 projects)
    - COVID (7 projects)
    - Open Call (4 projects)

3. This compendium provides one page summaries of the 2020 projects, outlining their aims, activities and impact.

4. You can find out more about T-TRIG through the T-TRIG GOV.UK page, or by getting in contact with the T-TRIG mailbox.

Decarbonising the Transport System

Development of an Innovative AI-Driven Approach to Collect and Deliver Goods with Near-Zero Carbon Footprint

Anteam Ltd.

Real-World Issue

Transport remains the largest emitting sector in the UK, responsible for 27% of all CO2 emissions. 91% of those transport emissions are from road transport: 61% of road transport emissions are from cars and taxis; whilst 35% of road transport emissions are from freight transport. Although the UK freight sector is decarbonising, the pace is outstripped by demand caused by consumers' accelerated adoption of online shopping in recent years.

Proposed Solution

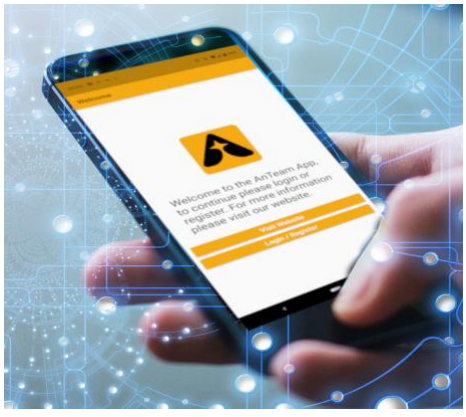
This project focuses on the development of an alternative last mile logistics network that consolidates existing road transport to minimise CO2 emissions, air pollution and the impact on the road transportation network. Customers of this innovative logistics network will enjoy rapid delivery of their goods, at competitive prices, whilst knowing that they have also contributed to the reduction of CO2 emissions by using the service.

Project Activity

- Developed an Artificial Intelligence to enable real-world, optimised solutions against a complex set of constraints inherent in the planning and delivery of goods.
- The AI was initially optimised using simulated data - to test its capability in producing optimised solutions. The AI was shown to be effective in achieving this, with a good balance of computational load.
- Subsequently used real-world data as the input to ensure that the AI algorithm can still produce high quality outputs. This was demonstrated in a case study where a minimum saving of 7 Tonnes of CO2 could be achieved for 20,000 deliveries.
- Conducted customer surveys and interviews to confirm a number of hypotheses resulting in the fine-tuning of our exploitation plan following the completion of the T-TRIG funded project.

What Next?

The development funded by the T-TRIG programme has put Anteam in a strong position to attract further funding for follow-on development and the ultimate launch of a product into the market. We are currently seeking seed funding from venture capital investors and other sources and, if successful, we will be able to make an impact in the reduction of CO2, air pollution and traffic congestion of the logistics sector.



An example of the user interface of the transportation logistics network.

Contact: Dr. Helen Ma helen@anteam.co.uk

Armada Air Lubrication System

Roger Armson, RC, AR & Henrik Utvik

A game changing solution to the shipping sector's looming global challenge

Real-World Issue

The IMO identifies the merchant fleet as the world's 6th largest greenhouse gas emitter. Emission reduction pressure is high due to mandatory decarbonisation & energy efficiency, and increasing social & cost demands. Air Lubrication Systems reduce fuel consumption and emissions but current product efficiency is low and investment payback long according to ship owners.

Project Activity

Initial Development: scaled the concept system to fit with operational constraints of the test facilities.

Computational Fluid Dynamics: verified that the concept would work in the test tunnel conditions and allowed iteration of the design to increase its efficiency.

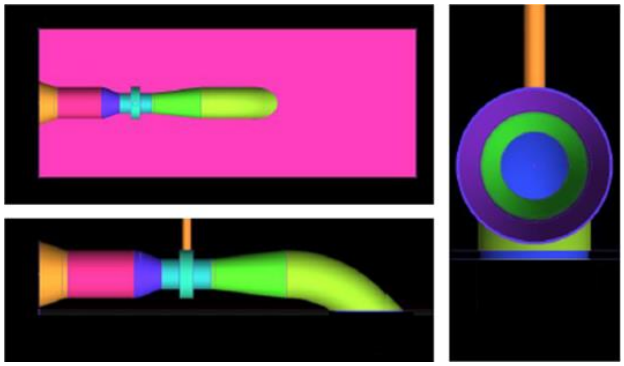
Prototype Fabrication: design development provided dimensions for the physical prototype and HOLTEX Ltd. were subcontracted to make the air injection unit.

Physical Model Testing: model tests were undertaken at the Newcastle University Emerson Cavitation Tunnel verifying the viability of passive aeration of the boundary layer for resistance reduction.

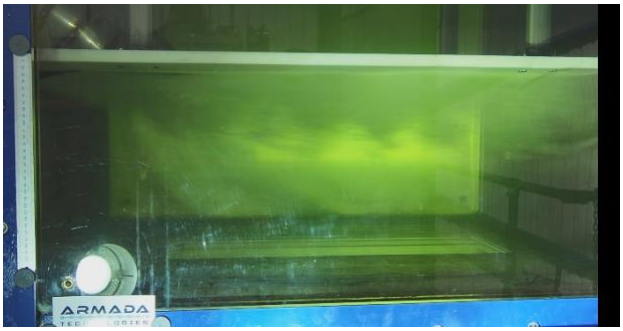
Result Post Processing: analysis of results from the physical model tests have provided ATL with a greater understanding of the system functionality and delivered system credibility. ATL filed a successful patent application in April 2021.

Proposed Solution

This project addresses the low efficiency & high capital cost of current ALS' by designing and testing a "passive" system, estimated to be cheaper to install and deliver greater fuel consumption reduction. Armada Technologies Ltd. (ATL) propose a simple, low cost design that can passively create a boundary layer without the use of compressors, and inject bubbles into the layer to deliver air lubrication under model test conditions.



Initial CFD models (above) and injection of passive micro bubbles into boundary layer (below).



What Next?

ATL are applying for further grant funding to verify and enhance understanding of the ALS performance using CFD and EFD analysis, and to develop tailored ALS designs for four ship owners' selected vessels. Moving forward, it is planned that each of these vessels will be fitted with ALS' for testing and evaluation ahead of commercial product launch. Pay back on ALS investment is estimated at less than two years, with fuel consumption and CO_2 emission reduced by between 10-12%.

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Solar-Hydrogen-Storage Integrated Electric Vehicle Charging Station in Future Cities

Cranfield University, HVSS Ltd, Brunel University London

Live a better life with EVs

Real-World Issue

43% of UK households don't have access to off-street parking, making home charging for all EV owners unfeasible. The solar-hydrogen-storage integrated (SHS-EV) charging stations will address four key challenges in EV charging:

1. Lack of charging infrastructure;
2. Slow charging;
3. Insufficient grid supply;
4. Constrained location of urban EV charging.

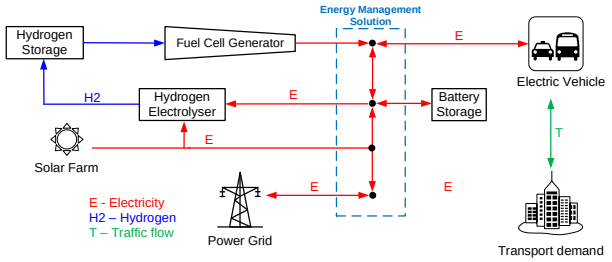
Project Activity

- Designed energy systems for the prototype SHS-EV charging station, and developed the smart energy management solution to coordinate solar, hydrogen, storage and grid to meet the EV charging demand.
- Conducted case studies for the planning and operation of SHS-EV charging stations in four London boroughs, and to investigate future EV charging demand.
- This project made recommendations on the SHS-EV charging station's capacity design, infrastructure costs and operation strategy, aiming to fully charge an EV in 10 minutes in future cities.

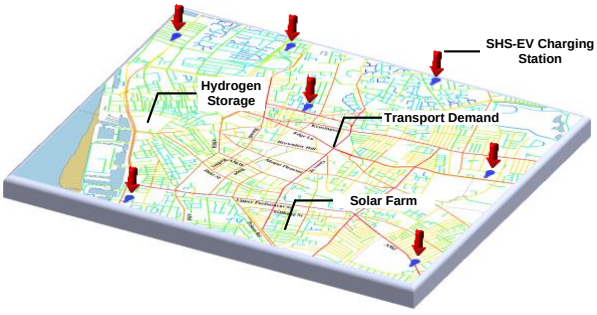
Proposed Solution

A self-generating and multi-energy charging station using both solar and hydrogen to provide:

- Super-fast and off-grid charging to overcome range anxiety of EVs;
- Multi-energy charging system using solar, hydrogen and energy storage;
- CO_2 free power generation at point of charging;
- Retrofitting city's existing petrol stations to meet future EV charging demand.



Energy system design for SHS-EV charging station



Planning and operation of SHS-EV charging stations in city

What Next?

The next step is to conduct laboratory demonstration and site implementation of the project, and seek funding opportunities to progress to a higher technology readiness level. This activity will be supported by building partnerships with HVSS Ltd, research institutes and EV charging infrastructure and manufacturing stakeholders.

Contact: xin.zhang@brunel.ac.uk Brunel University London, Uxbridge, UB8 3PH, UK

TorqueSight™ Duodrive

End to end performance engineering

Real-World Issue

The control, reduction & reporting of marine GHG emissions is only possible with accurate monitoring of all the propulsion parameters including torque & thrust. Lack of 'in-field' performance data already plagues the sector even for basic measures such as operational usage and fuel consumption, especially for older vessels.

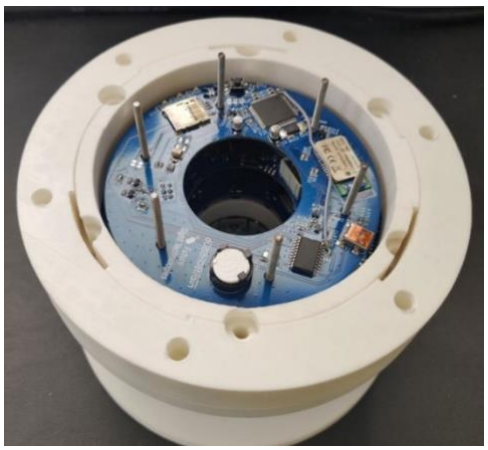
Project Activity

- Optimised the complex 3D bowl shape using finite element analysis, examining multiple options to realise a design on which sensors can be safely mounted.
- Took the first steps to conceive the Wireless Sensor Network (eWSN). The original idea to use piezo-ceramic ultrasonic sensors proved impractical due to vibration, so was switched to a 2.4 GHz Bluetooth carrier with strain gauge sensors. Custom printed circuit board design was required due to the confined space of the bowl layout.
- Developed a new patentable micro generator with battery for use within the TorqueFlange's drum, which is wireless, self-contained, can be environmentally sealed, and has no external stator.

Proposed Solution

Demonstrate that retrofitting of small ships is possible to inform & assist in the transition to zero-carbon propulsion:

- Utilise the TorqueFlange bowl concept to enable remote monitoring of torque & thrust data for vessel carbon footprint reduction and to save energy using automotive-like technology.
- Design an accurate, high speed wireless system that suits standardised installations and is more robust than conventional hard-wired systems, tackling the challenge of data transmission in marine environments.



The TorqueFlange bowl design with sensors mounted. Use the QR code for more info.

What Next?

- Identify opportunities to make use of the TorqueSight™ concept in conjunction with diesel engine control units and develop industrial packaging. First installation planned on Duodrive's demonstrator workboat, using a Hydrogen Transport Hub Demonstrator competition grant. In-situ trialling will support verification of the prototype and optimisation of pre-production hardware with 3D metal printing.
- Mount demonstrations of wireless data recovery for marine and other data streams which require resilient wireless communication. Seek additional funding assistance through InnovateUK competitions and a CrowdFunding project.

Contact: John Carter john.carter@duodrive.com +44 7392 381 276

Decarbonising domestic freight through active travel last mile deliveries

Fernhay Partners Ltd.

Real-World Issue

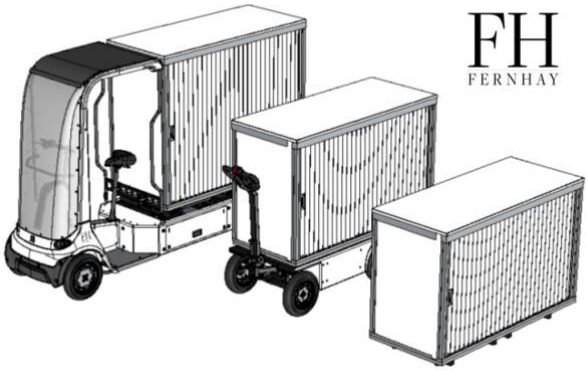
The unprecedented rise in ecommerce and the associated increase in the use of diesel vans to service that need is an issue for Road to Zero ambitions for the UK. Increased van congestion from logistics on roads makes the transition towards cycle infrastructure as well as pedestrianised zones challenging.

Project Activity

- A feasibility study for a novel electric driveline investigated commercial viability and concluded that Fernhay would be able to gain return on investment if the project were developed through to production stage.
- Developed a concept for an innovative electric transaxle coupled to a novel arrangement between pedals and transaxle. Methods used in the project included benchmarking; concept layout design on CAD; automotive project planning; cost analysis; business planning; risk analysis and supplier evaluations.
- Created a value proposition that balanced the planned production volumes, high labour rate and complex electromechanical high value manufacturing driveline.
- Investigated the legality of the design against current EU legislation and concluded our concept was within regulations. There is no prior art that restricts Fernhay progressing the driveline, and we believe that IP can be developed to protect the designs.

Proposed Solution

To transfer freight to active travel solutions and reduce van congestion, managers of large van fleets need commercial grade solutions that compare to vans currently in use. This project takes the engineering from the commercial vehicle market and applying it in novel ways to design commercial drivelines for the cycle freight sector. Our plan is to develop a complete driveline from pedal to wheel that is more robust and durable than anything we have researched while undertaking this work and thus replacing the use of leisure cycle components that is typical in the current market for freight cycles.



Fernhay makes last mile cycling and walking logistics equipment for the based on their unique containerisation system.

What Next?

The feasibility study has proved return on investment should we take the driveline forward to production. Next steps for development are to take the driveline to detailed design, prototype manufacturing, build and then operational testing in the Fernhay eQuad as first trial application and prove out.

Contact: www.fernhay.com enquiries@fernhay.com

Hydrogen as a Combustion Engine Fuel Additive

Meteor Power

Real-World Issue

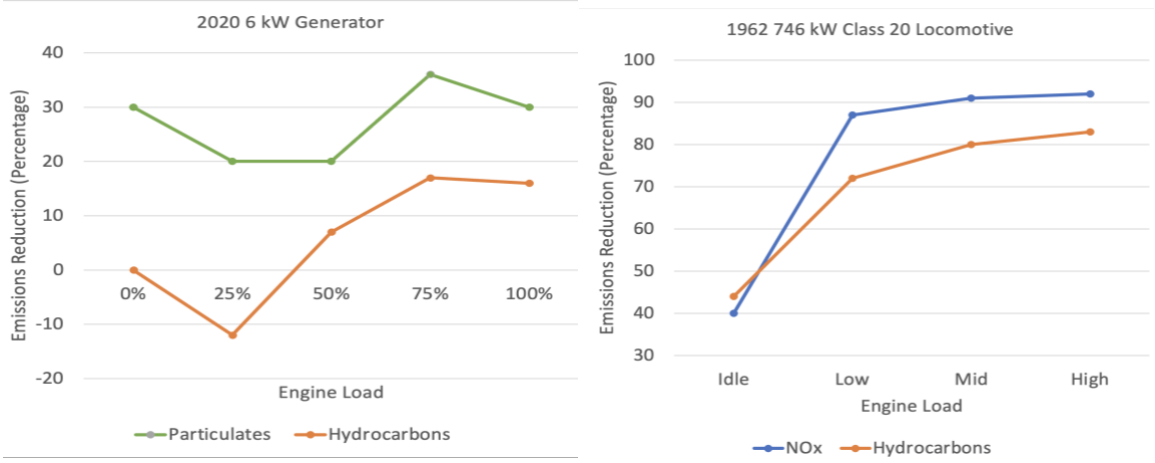
New internal combustion engine sales will end in 2035, yet we will have legacy systems operating for decades to come. There is a need to cut emissions from these existing systems now: our goal is to reduce diesel emissions by over 90% in 2021, saving millions of tons CO_2 and other emissions before the new legislation comes into force.

Proposed Solution

Reducing post-combustion emissions is well proven but what if we could stop them being generated in the first place? Improving combustion results in fewer NOx and particulates. Our solution electrolyses water to create hydrogen and oxygen gas as fuel additives. A relatively low volume of gas provides a dramatic reduction in emissions. This project will investigate multiple designs to reduce fuel consumption and increase output.

Project Activity

- Designed and built a 'wet' electrolysis unit for use in testing emissions from multiple engines, and a series of 'dry' electrolysis units to test different internal configurations to compare gas volume versus electrical power inputs.
- Undertook testing with modern 6kW Hyundai generator and 1960s era 120 litre engine fitted to a Class 20 locomotive. Utilised specialist hydrogen gas measurement devices to accurately differentiate between a range of electrolysis plate designs.
- On older engines the improvements were far greater, which bodes well for improving legacy engine emissions whilst also benefiting more recent engines.



Emissions reduction findings demonstrated a clear benefit from our designs.

What Next?

- Develop new electrolyser electronic control modules to better match hydrogen and oxygen gas production to the optimum combustion for at different speeds and loads.
- Obtain larger, modern diesel engines for further testing before fitting electrolysis units to vehicles to ensure compatibility with the latest engine control units that may be confused by the change in exhaust gas readings.
- Conduct real world trials with industry partners and disseminate findings.

Contact: Mike Edwards mike.edwards@meteorpower.com +44 7775 833 965

Plug & Charge Paua

Helping you find power everywhere

Real-World Issue

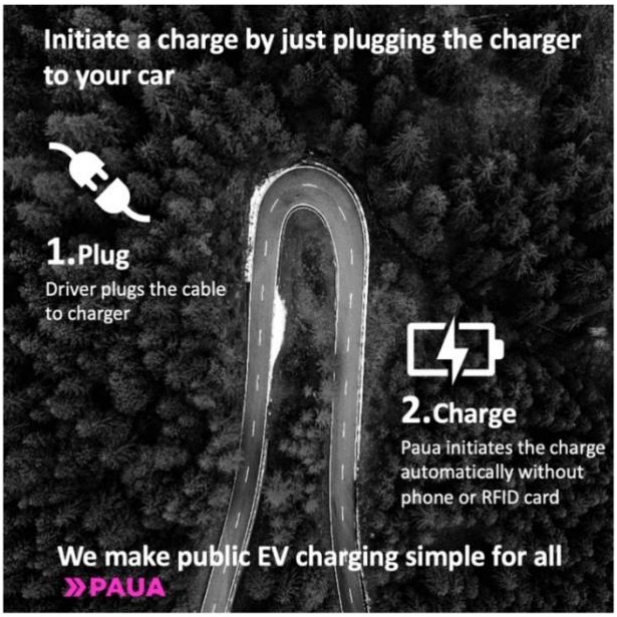
The UK public charging environment is hugely fragmented with over 75 network operators on 25 different software systems and 4 different access methods (RFID, credit cards, apps & ISO 15118). There is not a single method to initiate a charge across all chargepoints making public charging user experience complex for EV drivers.

Project Activity

- Investigated car data and infotainment systems, changepoint network systems, phone, and payments ecosystems to find ways to identify the chargepoint location and a valid payment system: the two key steps needed for the chargepoint operator to initiate a charge.
- Identified a way to enable a "plug & charge" event to be conducted on any chargepoint integrated with Paua and any modern electric vehicle.
- Successfully ran a "plug & charge" session where a driver drove to the charge point, plugged the charging cable to the car and the charging session initiated automatically. Additionally, the session information and receipt were automatically available for the user.

Proposed Solution

The Paua "plug & charge" project aim is to make public EV charging simpler for everyone by enabling drivers to automatically start a charge just by plugging the charging cable to the car. Our vision is that an EV driver can pull up at an electric vehicle chargepoint, plug in their car, the charging will initiate automatically with no need for memberships or apps for each of the networks and payments will automatically be deducted from the drivers pre-set payment method. All history and receipts are gathered, and the driver (and where appropriate their fleet manager) has visibility of the charging session.



What Next?

- Applied for further government funding to commercialise this technology solution. The goal is to fully integrate a "plug & charge" solution into our main product and offer it to our clients. Further investment will allow exploration to resolve possible limitations identified during early testing e.g. when multiple chargers are in the same location, we may need additional logic to understand what charger we will activate.
- We believe that this innovation, when adopted, can save nearly 17,000 hours per year of non-productive time worth £400,000 to the economy based on EV drivers today. This rises to £2.5m by 2026 as more drivers adopt electric cars.

Contact: Niall@pauatech.com Pedro@pauatech.com

Diesel Engine Exhaust Treatment for A3C Carbon Capture Process

PMW Technology and Team

Real-World Issue

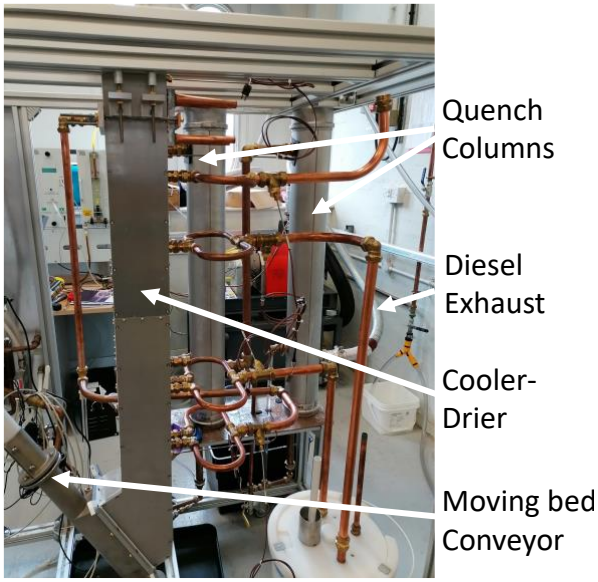
Ship diesel engines generate around 3% of global carbon emissions. Marine exhaust gases are hot and contaminated with particulates, NOx and sulphur oxides. Cryogenic carbon capture offers an important transitional measure to cut shipping emissions from existing engines but needs clean cold gases to work reliably. Conventional clean-up technology is complex and costly.

Project Activity

- Defined the trial application including exhaust gas flows, temperatures and composition. Sized conventional and unconventional elements of the process to handle the thermal and chemical duties.
- Identified and procured components to handle the small gas flows (<10 l/s).
- Designed and manufactured custom components for moving bed heat exchanger process.
- Experienced difficulties and delays in the manufacture of critical gas injectors which introduce the gases into the slow-moving bed of the cooler-drier and other custom components.
- Despite this, the process proved highly effective in cooling and cleaning the gases, reducing inlet temperatures of up to 300°C to -100°C.

Proposed Solution

PMW Technology has developed the compact and economic A3C cryogenic carbon capture process. To enable this to handle hot and dirty marine diesel engine exhaust gases a simple but effective clean-up process has been developed and tested. This involves two stages of scrubbing to cool and clean the gases followed by an innovative moving bed heat exchanger that cools and dries the gases by recycling the cold from the decarbonised exhaust from the A3C process.



The clean-up unit designed to cool and clean gases as part of the wider A3C carbon capture process.

What Next?

- The clean-up unit will form part of a complete end-to-end demonstration of the A3C process scheduled for later this autumn. PMW Technology will be seeking investment partners to support a prototype demonstrator for A3C carbon capture using this clean-up process, first onshore and then onboard for sea trials. The aim is for the prototype to capture carbon dioxide from an auxiliary engine of up to 1000 kW rating.
- The ambition is for the A3C process to support the use of methanol as a hydrogen carrier, capturing carbon dioxide to be returned to the green methanol plant.

Contact: Paul Willson paul@pmwtechnology.co.uk 01422 649404

BAT-Mobile
Pragmatex Ltd

Real-World Issue
Availability of rapid and ultra-rapid Electric Vehicle (EV) charging system (>40kW) across the UK is limited and growing slowly. This is partly because rapid charging systems commonly require a costly grid connection upgrade – which takes time and investment. Government has targets for the roll-out of rapid EV charging facilities, and we need a way to meet them.

Project Activity
- Carried out competitive market analysis and developed concept designs, which were used to produce an initial product specification.
- Developed initial benchtop prototype battery storage and inverter/charger system. From which, designed, built, and demonstrated a small-scale 12.5kWh battery storage prototype charging system.
- Engaged key government officials to understand challenges/priorities for the roll-out of rapid EV chargers across UK.
- Undertook a stakeholder mapping exercise to understand potential end-user customers and routes to market. Interviewed a range of end-user customers to better understand specific use-cases, identify other new potential applications and understand barriers to purchasing systems.

Proposed Solution
Use batteries to provide both AC and DC charging capability for EVs rather than the grid. The battery system would be modular enabling the system to scale quickly and be easily adaptable to any situation by simple connection of further battery packs to reach the desired power requirement. The system would therefore have the capability to be mobile. The system would also connect with the grid (if available) such that the system could charge batteries in off-peak times and supplement the grid connected power at peak times to provide additionally capacity.

Portable and modular 12.5kWh battery storage prototype charging system with both AC & DC charging capability (see display).

What Next?
- Demonstration of prototype system to potential end-user customers from both the public and private sector. Engagement with existing producers to explore potential partnerships that could support further development.
- Explore alternative routes for funding for next stage development, which will demonstrate modular nature of system, by linking multiple battery systems together at operational scale.

Contact: Peter Ainsworth peter@pragmatex.co.uk

Battery Uniform Tab Cooling

Qdot Technology

Enabling Clean Flight

Real-World Issue

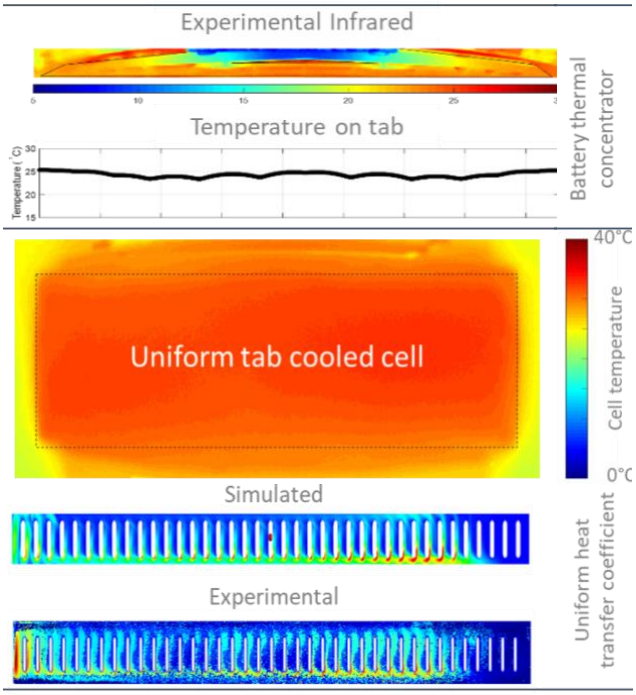
Extremely fast charging and discharging (XFC) of batteries generates significant amounts of heat – left uncontrolled this is detrimental to battery life. Cooling the tabs of a pouch cell-type battery has been proposed as an efficient means of heat extraction but has not been realised in practical application.

Project Activity

- Identified new solutions through analysis of existing data, design and conjugate fluid dynamics simulation, with real-world testing and verification.
- Developed novel solution reducing the number of heatsinks needed by a factor of 6 in the battery pack, while maintaining thermal performance.
- Direct application to Li-ion cells was not possible due to issues in the manufacture of pouch cells. Uniform tab cooling was demonstrated at proof-of-concept level in a cell mock-up system.
- Temperature gradients across cell tabs were decoupled from the coolant flow rate; the gradient for a low-power input system reduced from 5°C to 1.2°C. This gives a cell life improvement of 25% for XFC and a reduction in battery thermal management system parasitic mass to less than 4% of total battery pack; a 55% reduction over Qdot's current design.

Proposed Solution

To fully leverage tab cooling, it is important to ensure that the level of heat extraction across the tab is uniform. This minimises temperature gradients within the cell, promoting extended life – a 5 °C gradient can reduce cell life by 25%. To achieve this uniform cooling, Qdot have leveraged additive manufacturing and novel experimental methods to design and validate an advanced heatsink concept. The heatsink allows reduction of thermal gradients to less than 1.2°C in the cell tab and cell.



Results from analysis of temperature gradients across mock-up system cell tabs.

What Next?

- Continue concept development and experimentally analyse at the multi-cell level.
- Apply new cooling system solution to the next generation battery module to allow XFC.
- Further development will be undertaken to reduce the mass and improve manufacturability for application in the electrification of aerospace, where the cell thermal performance is critical to the system viability.

Contact: Office F20, Atlas Building R27, Harwell Campus, OX11 0QX info@qdot.tech

Diagnosis of Excessive Carbon Emissions from Heavy Goods Vehicles using Digital Twin Technology

University of Cambridge

Real-World Issue

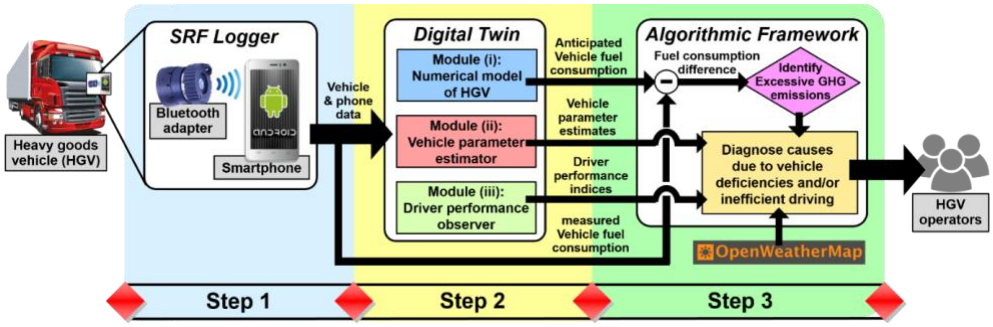
Greenhouse gases (GHGs) generated by heavy goods vehicles (HGVs) account for 5% of total UK GHG emissions, and have remained stable in recent years. HGV deficiencies that occur between regular maintenance checks may not be identified for several weeks, leading to excessive fuel consumption and GHG emissions.

Proposed Solution

Development of a software tool to identify HGVs that generate excessive carbon emissions and diagnose the causes. The foundation of the tool is a digital twin that monitors the operation of a physical HGV and predicts a healthy HGV's fuel consumption, whilst estimating the physical HGV's parameters affecting its fuel consumption. An algorithmic framework will then diagnose vehicle deficiencies such as tyre under-inflation and axle misalignment by fusing HGV measurements and digital twin outputs.

Project Activity

- Developed a numerical model of an HGV incorporating an automatic transmission module to predict an HGV's fuel consumption. The model gives less than 2% prediction error.
- Developed a parameter estimator to estimate an HGVs' mass and rolling resistance coefficient (RRC). Established two mass estimation methods: constant-speed method which applies to HGVs mainly operating on motorways, and gives <6% estimation error; and acceleration method which applies to HGVs mainly operating in cities, and gives <9% estimation error.
- Carried out coast-down tests of an HGV at HORIBA-MIRA proving ground to measure and quantify the influence of tyre under-inflation and axle misalignment on RRC. Developed a multi-level, logic-based algorithmic framework using test results for diagnosing HGV deficiencies including tyre under-inflation and axle misalignment.



Schematic diagram of digital-twin-based method for diagnosing HGV deficiencies

What Next?

- Further development of the proposed digital-twin-based method, including constructing thermal dynamics models for estimating tyre pressure, using additional signals to diagnose misalignment of a single drive axle, and adopting iterative methods to improve mass estimation accuracy.
- Initiate exploitation by providing free trials of the tool to selected HGV operators.

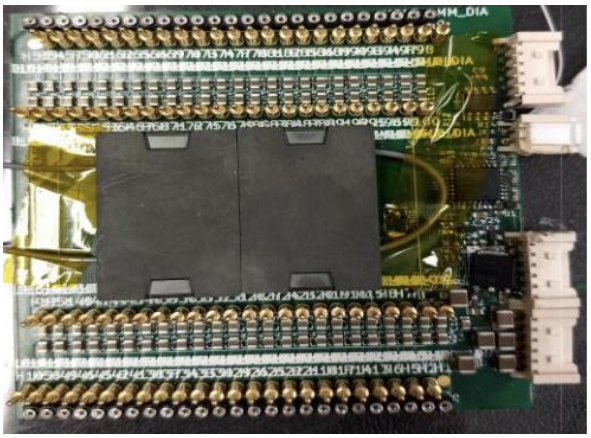
Contact: Xiaoxiang Na xnhn2@cam.ac.uk Department of Engineering

Feasibility study of integrated automotive traction inverters with on-board charging capability for plug-in electric vehicle

Dr Mehdi Baghdadi

Real-World Issue

The government aspires to accelerate the electrification of the vehicle fleet by setting out several measures, including an ambition for up to 70% of new car sales to be ultra-low emission by 2030. Provision of charging infrastructure is a key enabler for the growth of the electric vehicle (EV) uptake.



The proposed power converter module with an integrated gate drive circuitry

Proposed Solution

Modular power electronics offer the ability to operate at substantially higher power density, voltage and switching frequency than those of conventional topologies, leading to significant converter cost and weight reductions, and reliability and efficiency improvements.

Project Activity

- Created the topological model of the reconfigurable automotive inverter and designed a highly optimised 5 kW automotive inverter with built-in ultra-fast charger.
- Fully integrated and validated the reconfigurable inverter by quantifying its performance and economics.
- Optimised gate drive circuit design and controller to achieve ultra-fast switching at maximum 1% losses.
- Optimised inverter design and cooling system to achieve cost and weight reduction targets whilst maintaining specified efficiency and reliability.
- To assess the global converter market size and dynamic and establish the economic benefits of StepWise technology.

What Next?

- Follow-on exploitation utilising the project quantification of the capabilities, potentials and economics of the technology, and the identified potential OEM customers and supply chain players. There is extensive know-how relating to all aspects of proposed technology, in particular the design and control of gate drive, cooling system.
- Electric Propulsion Laboratory (EPL) at UCL have conducted extensive discussions with potential customers, which confirmed the industry's substantial interest. EPL is now in a strong position to raise investment and enter into commercial negotiation with potential customers, aiming to establish key strategic partnerships to develop tailored inverters and commence extensive field testing.

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COVID-19 Recovery

VERTIPROP Carbon ThreeSixty

Next generation Urban Air Mobility composite blades

Real-World Issue

Urban Air Mobility (UAM) is a new, rapid growth, multi-billion pound industry to provide fast, affordable, autonomous, quiet, zero EV air transport in our cities and take congestion off the ground. A new generation of carbon fibre propellers / rotor blades is required to enable this new breed of aircraft to fly.

Project Activity

The project focused on developing a proof of concept blade for a representative UAM vehicle case and involved:

- Market research to understand similar market offerings and their challenges.
- Specification development to determine optimal length, blade number, thrust etc.
- The development of design tools and blades including for a specific demo use case.
- Core design and additive manufacturing.
- Development of fibre placement skeleton, preforming of skeleton and skins, and moulding processes.
- Bend testing to successfully demonstrate a prototype UAM blade.
- Investigation of feasibility of volume scale up.

Proposed Solution

The Vertiprop solution will combine a number of novel, innovative manufacturing processes to enable production of better performing, cheaper carbon fibre blades in a manner that is suitable for scale up to production volumes more often seen in the automotive industry. This includes additive manufacturing, fibre placement technology (to allow internal biomimetic skeleton structure) and resin transfer moulding for fast, accurate moulding of parts.

Fibre placement process (top) and prototype UAM blade (bottom).

What Next?

- Carbon ThreeSixty are committed to developing this blade manufacturing technology further to enable us, as a fast-growing composites technology based SME, to exploit this huge potential market and ensure that high value aerospace manufacturing remains in the UK.
- CTS are already engaged with several major players in the emerging UAM market and are actively seeking further development projects and investment to take these solutions to market.

Contact: Andy Smith andy.smith@carbonthreesixty.com

FAST – Find a Space on a Train

Esoterix

Using how busy the train is now to predict how busy it will be during a passenger's journey

Real-World Issue

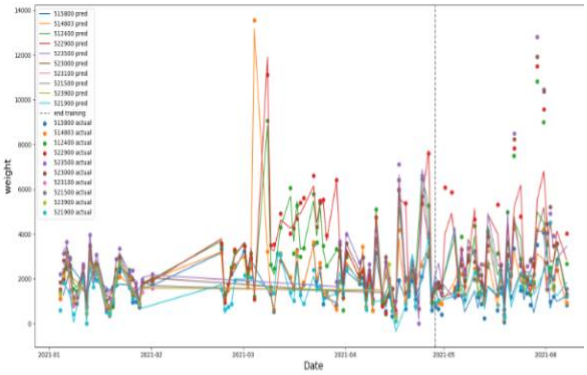
There are inherent uncertainties in rebuilding rail patronage post-pandemic; but accurate crowding information to build passenger confidence is a consistent theme in feedback from consumers. Operators are beginning to offer crowding predictions, but these are based on historical usage and don't account for how busy the train becomes whilst it is running.

Project Activity

- Designed, implemented and optimised the configuration of a Long Short Term Memory (LSTM) Neural Net, which takes historic loading data, real-time loading data from up-line stations and contextual information e.g. weather as input. Detailed historic loading data was provided by train operating company Southeastern.
- Implemented a Last Values predictor, which uses solely historic data, to provide a benchmark for assessing the performance of the Neural Net. Assessed accuracy of all predictors using Coefficient of Determination ($R^{2)}$.
- Found that including up-line loadings significantly improved the Neural Net predictions and that the Neural Net predictor consistently outperformed the Last Values predictor, with or without real-time up-line loadings.

Proposed Solution

The FAST solution predicts how busy a service is likely to be when passengers board and for the duration of their journey. The predictions update in real-time as the train travels down the line, allowing passengers waiting downstream to make informed decisions about their travel. FAST uses a Neural Net to predict how busy a service will be at each station along the line using historic loading data, real-time loading data from up-line stations and contextual information (e.g., seasonality and weather).



Neural net predictions (lines) of loading at 10 stations along a line. Points are actual loadings and the vertical dotted line indicates the transition from training to the test phase. The predictions are highly accurate excepting for the May bank holidays; the net needs more training data to predict these.

What Next?

- Adopt a test-driven approach to enable the team to increase the reliability and scalability of the technology, readying it for commercial application. The technology will be able to help operators manage services in the event of network disruption.
- Promote the technology to all UK operators interested in improving crowding information for passengers, and liaise with the Department for International Trade on potential exploitation overseas.

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Ionising Air to Remove Airborne COVID Particles on Trains

Greenway Innovations

Real-World Issue

Airborne transmission is seen as most likely way to infect people with the COVID-19 pathogen. A crowded train is an obvious location in which this can happen. The threat of contracting COVID-19 and its future variants undermines passenger's confidence that the train and indeed all public transport is safe and hygienic.

Proposed Solution

Use air ionisers on trains to remove airborne COVID-19 virus and create a perception and reality of hygiene and safety for the passenger that will help drive recovery within the transport sector. We will undertake this work by means of data research, physical installation and real-time integrated passenger displays, driven by onboard ionisation sensors.

Project Activity

- Confirmed that ionisation is safe and very effective against airborne and surface virus and bacteria and eliminates unpleasant odour by reviewing online resources.
- Conducted a worldwide search and identified a source of bipolar ionisation devices, typically installed in office air conditioning systems.
- Sourced ionisers and sensors and fitted these (with appropriate design considerations) into the air conditioning ducts on the donor vehicle being completed by sister company Transport Design International (TDI) called "Revolution VLR".
- The mechanical implementation shows good levels of ionisation in the saloon air which corresponds to a full cleaning cycle of less than 5 minutes to near complete viral removal.
- Developed an appropriate and calming message display to support the ionisation system, responding dynamically to the signal from an ion detector which is also installed in the roof of the train.

The donor train: TDI Light Weight train "Revolution"

Installed ioniser & sensor to detect levels of ionisation

AR passenger information system

What Next?

- Market solution through Eversholt Rail Group ,one of the UK's largest train owners and a sponsor of the TDI Revolution Very Lightweight Rail Project. Greenway Innovation is confident the ionisation system is not just a remedy for Covid-19 and future variants but will also enhance general hygiene on any public transport system.
- Continue to work on the displays, looking to Augmented Reality (AR) as a means to reduce the anxiety of, and threat perceived by, the travelling public.

Contact: Adrian Howson CTO adrian@boxclever.digital +44 7747 783189

Lifeband Vibe
Impli

Real-World Issue
COVID-19 has significantly impacted public transport, with UK bus patronage on average having recovered to only 60% of pre-lockdown levels and rail services performing even worse. Vulnerable passenger groups including visually impaired people (VIPs) are particularly adversely affected by the new regime of self-distancing that has been introduced.

Project Activity
- Built first iterations of prototypes that allow people to be traced through a digital environment as well as capture contact with other devices/people. This allowed us to build in haptic controls that can communicate through vibration with the VIPs when the 2m distance has been breached.
- Designed inclusive band that enables easy fastening and versatile usability and selected 3 VIP testers
- Developed a functioning prototype that can be now miniaturised and functionalised with improvements on battery consumption. Tested this in a laboratory environment and in real life.
- Supply chains delays limited testing that could be done with VIPs and this is still be done for completing this project. These issues and identified battery limitations have emphasised the importance of building in alternative energy sources.

Proposed Solution
Build a wearable novel wristband device and software that allows the visually impaired to judge when the 1-2m social distancing measure has not been kept. This will support individuals with difficulties in judging social distance to travel safely on public transport. The LifeBand Vibe project will incorporate “haptic” buzz/vibration capability to provide regular subtle alerts to wearers in circumstances when their safe social distancing may have been compromised without them realising.

Illustration contact tracing with haptics


Wristband design

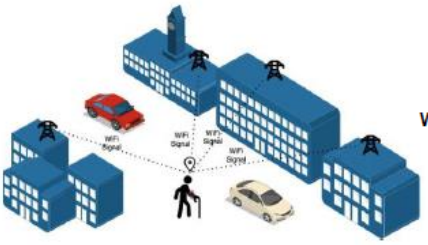


Illustration Wifi location tracing


Press to Play - technology demonstration video

What Next?
- Complete market research with the selected VIP users. We are currently improving the miniaturisation as well as the accuracy of the devices. The aim is to roll out with a commercial solution in spring 2022.
- The team were awarded a larger UKRI grant project that will make this technology available to 20,000 users. T-TRIG has introduced us to further visually impaired charities and association which we will leverage in the next phase of the project.

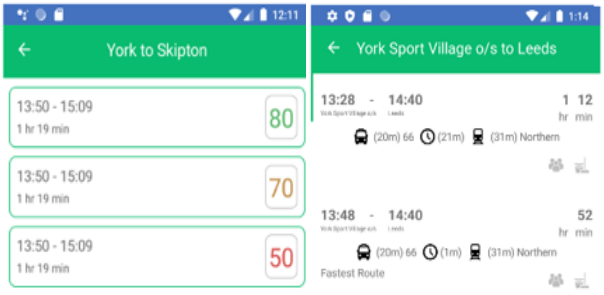
Contact: info@lifebandco.com www.lifebandco.com

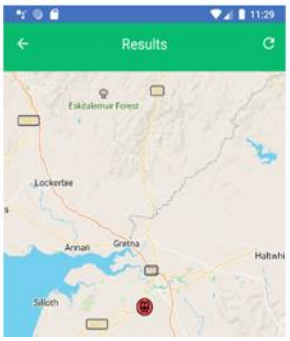
Good to Go
Incremental Solutions

Real-World Issue
Passenger usage of public transport has fallen dramatically in the pandemic; rail journeys down 78% on those made in 2019-20. The impact is due to the combination of restricted movement in lockdowns and increased public wariness of potentially crowded and unclean spaces. The challenge is how to increase public confidence in using public transport as lockdowns were lifted.

Project Activity
The project was split into 3 phases:
Data fusion – collation of all data into an API database, including live bus and train positions and timetables; 'cleanliness' of the trains; 'crowding' of the trains
G2G App – development of the proof-of-concept customer app by way of three, two-week 'sprints'
User Consultation – Proof of concept App shared with TOC customers for feedback.
The key barrier was related to bus data being significantly different to the rail data in which Incremental has deep knowledge and experience. Updates on train cleanliness and crowding were not readily available, but Incremental proposed an extension of its Digital Forms App to allow traincrew to submit reports digitally. Incremental delivered a viable proof of concept App within cost and timelines and demonstrated it to Train Operators customers.

Proposed Solution
A proof of concept App, to provide multi-modal journey planning functionality (bus and train) with live train tracking, passenger loading and train cleaning information for passengers. The Good-To-Go project would collate multiple existing data sources (both open source and those developed by Incremental) to create a unified back-end API for delivery of enhanced journey data, including real-time train position, passenger loading information, train cleaning information, and bus connections.





App screenshots from top left: journey options with score based on cleanliness & overcrowding; breakdown of chosen journey showing bus and train legs; 'live position' of journey.

What Next?
In the time that Incremental created the proof-of-concept App the pandemic led other companies to also respond. In particular, Google Maps now shows cleanliness and crowding information based on live passenger feedback. Given this backdrop, the business case is not strong enough for further development of the successful proof of concept App. An intelligent multimodal journey planner is something that still does not exist today and so further development of those aspects of the App is being reviewed.

Contact: contact@incrementalsolutions.co.uk www.incrementalsolutions.co.uk

Real-time computer vision passenger counting and PPE detection for public transport Route Reports

Real-World Issue

Passengers must comply with social distancing and PPE guidelines to minimise COVID-19 safety risks but transport providers cannot facilitate compliance owing to their inability to access reliable real-time data. This leads to elevated passenger safety risks and inefficiencies in transport operations, leading to potential financial losses.

Proposed Solution

Route Reports' solution, which can be fitted onto any vehicle, uses a small device to analyse vehicle video feeds; counting passengers and identifying PPE. The device analyses vehicle video feeds to detect whether a passenger is boarding and is wearing PPE. The device does not store or stream video, maintaining GDPR compliance and protecting passenger privacy. Instead, the device sends video analysis results in the form of raw data to the cloud. From there, the solution informs transport operators of which services are the most in-demand and have the least PPE compliance through a dashboard.

Project Activity

- Manufactured and tested new devices and firmware specific to the passenger counting use-case.
- Compiled all documentation required for vehicle fitment and compliance.
- Created digital infrastructure and databases for data storage/transmission & geo-fencing programme to enable automated operation.
- Developed and tested passenger counting + PPE detection algorithm.
- Attended multiple industry events to promote the solution in the rail industry - meeting with multiple transport operators within the UK and Europe to discuss the solution's implementation.
- Secured a provisional live trial of the solution with a major UK bus operator.

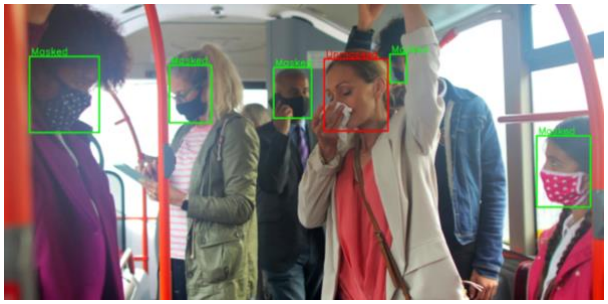
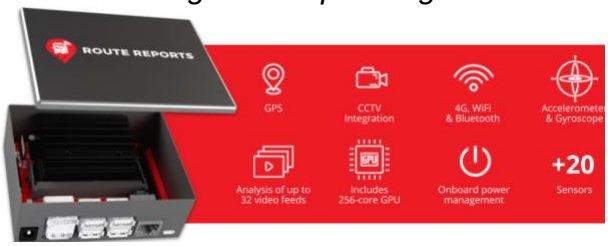


Image of Route Reports' computer vision algorithm operating



Route Reports' device

What Next?

- Pursue a trial with a major UK bus operator - trialling the solution live on their vehicles to further develop the solution.
- Pursue business development in the bus/coach space within the UK and abroad.
- Route Reports will be continuing existing discussions with UK-based rail operators that have expressed interest in the product.

Contact: contact@routereports.com www.routereports.com

Rapid Air Extraction and Decontamination in the Cabin of Public Transport using AC-DBD Plasma Actuation

University of Surrey

Real-World Issue

Airborne transmission is one of the two major pathways of SARS-CoV-2 (COVID19) transmission in indoor spaces and public transport. Currently, there are very few products to tackle airborne virus/bacteria transmission available on the market.

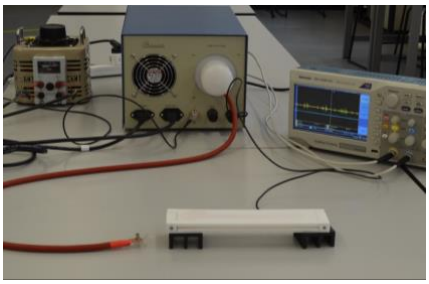
Project Activity

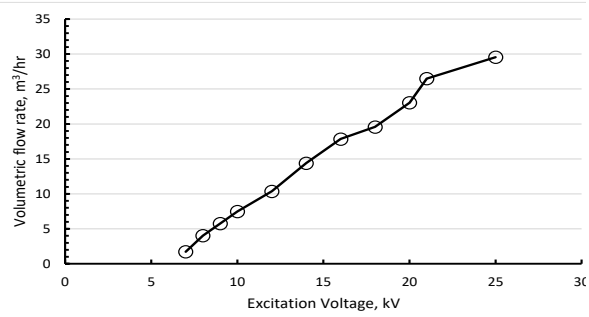
This project investigated capability of the prototype in air extraction:

- Developed a plasma channel-based prototype then conducted Computational Fluid Dynamics (CFD) Simulations to evaluate airflow characteristics in a simplified bus cabin and prototype performance.
- Found that the geometry of the settling chamber and the arrangement of the prototype would exert significant effect on its air extraction capability.
- Built sample prototype and tested performance experimentally via a series of static tests. A volumetric flow rate of 29.6 m^3/hr was generated by the plasma channel. However, the rate dropped by 36% after the plasma channel was coupled with the settling chamber.
- Observed a more significant drop in the volumetric flow rate in the static experiment than that predicted by the CFD simulations. This is potentially caused by the high back-pressure at the outlet of the plasma channel.

Proposed Solution

Recent development of a novel device, known as the Alternate-Current Dielectric Barrier Discharge (AD-DBD) plasma channel can induce a strong directional airflow for air extraction. The side products from its operation include ozone and ultraviolet light which could neutralise any virus or bacteria contained in the extracted air. So, both the air extraction and virus or bacteria neutralisation can be handled by one single device.





From top: Experimental setup; plasma channel in operation; relationship between applied voltage and volumetric flow rate.

What Next?

- Applied for further funding through a 36-month BBSRC Standard Call. The proposed research will expand on this project and investigate the effectiveness of UV-C and ozone in SAR-CoV-2 virus and other pathogens neutralisation. Aim to increase the Technical Readiness Level to 5 by 2024.
- Conduct research to understand the flow physics of the plasma channel actuator and to optimise the geometry and arrangement of the prototype.

Contact: contact@routereports.com www.routereports.com

Open Call

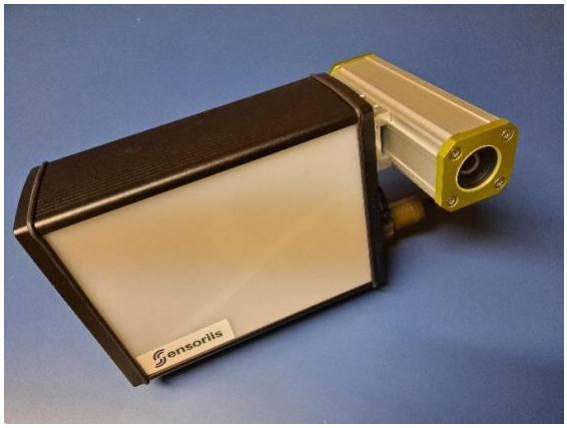
Autonomous Drone Freight Transportation

Cambridge Sensoriis

All weather resilience and safety

Real-World Issue

For the full benefits of drone transportation to be realised, fully autonomous flight in congested, unsegregated airspace is needed. Drones must operate safely in all weather conditions, avoiding obstacles, and navigating beyond visual lines of sight. On-drone sensing is necessary in a package size that does not affect the lift capacity and battery life of the drone.



Radar sensor and camera hardware

Sense-and-avoid concept, for UAS in flight

Proposed Solution

A high-frequency all weather radar, integrated with camera technology, to support the sensing requirements of unmanned aerial systems (UAS) in flight beyond line of sight. Processing data from different but complimentary sensors greatly improves performance across the full range of operational and environmental conditions.

Project Activity

- Researched UAS use-cases and translated these into sensor requirements for obstacle detection and navigation purposes.
- Developed a small weight and power (SWaP) radar, with high resolution camera and programmed to cover the required field-of-view and measurement resolution.
- Adapted processing parameters to detect all obstacle types amongst noise and clutter.
- Detected object relative position/size/ velocity are provided by the radar, along with video. This capability combines all-weather radar detection with the visual references from the camera and provides a useful development interface.
- Demonstrated that SWaP radar, suitable for installation onto commercial UAS, can reliably detect and measure the typical obstacles and waypoints found during flight operations.

What Next?

Further work will see the radar detected object parameters provided direct to the on-board drone flight controller for local sense-and-avoid, and to ground based traffic controllers over 5G or satellite networks for wider situational awareness. Projects are active in both these areas with different UK UAS providers, providing a route to market.

Contact: steve.clark@cambsensoriis.com

SAVAir Claytex

Safe Autonomous Vehicles at Airports

Real-World Issue

To drive airside, a driver must pass a driving test to prove that they are safe and understand the rules. For an AV we also need to prove that they can operate safely in the airside environment under all driving conditions. Physical testing under one set of conditions will not be enough to thoroughly test and prove they are safe, we need to do more.

Proposed Solution

Using simulation, we can create a virtual reality environment for the AV which enables us to test how it performs. With an understanding of the use case for each vehicle we can define the scenarios that form the virtual driving test. The Operational Design Domain (ODD) then provides the limits, such as weather conditions, under which the vehicle needs to be tested and an adaptive test manager runs the process.

Project Activity

- Developed a methodology to derive simulation test cases from scenarios that are linked to the Operational Design Domain (ODD) and vehicle use case.
- Defined test metrics to measure the vehicle performance during the test including metrics to check that the vehicle behaved safely.
- Introduced test automation into our existing AV simulator solution that supports a range of different test methods ranging from sensitivity sweeps through to adaptive test case generation based on past performance and coverage.
- Created proof-of-concept virtual driving test for an autonomous baggage tug that combines tests to assess the vehicles' ability to fulfil its use case and detailed scenarios that are used to check that the vehicle is safe within the limits set in the ODD.

Screenshot from the simulator showing an autonomous baggage tug navigating the airport as part of the virtual test drive

What Next?

- Improve the process of deriving simulation test cases from the ODD and vehicle use case through collaboration with other organisations working on this topic.
- Refine the test automation tools to make them production ready.
- Present the virtual driving test to airports and airlines that are interested in introducing autonomous vehicles into their operations.

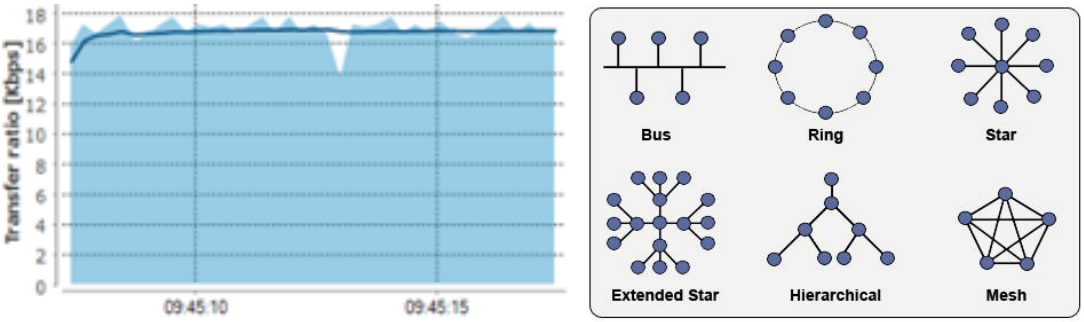
Contact: Claytex Services Limited www.claytex.com

Self Meshing Drone Detection Networks
Houndstooth Wireless

Real-World Issue
Users and installers require the ability to quickly deploy a number of drone detection sensors into an operating environment with minimum effort. Communications between sensors and a central server is vital in order to relay information to the user. Deployable solutions and complex geographies require a resilient networking solution.

Proposed Solution
Self meshing wireless communications technologies are ideal for this requirement and create resilient routes between nodes and servers. This project aims to develop this solution, integrating it with an existing drone detection system. The technology requirements are node to node range, data rate, meshing capability, suitability for integration and absence of reliance on licensed band cellular networks.

Project Activity
- Selected self-meshing wireless network solution from alternative technologies (see image) most suited to a distributed network of drone detection nodes; resilience of the mesh to faults and changes and its setup time were key.
- Tested technology and integrated into the existing hardware enclosure. Produced and tested integration software to allow drone detection information to be sent to a central control station.
- Demonstrated successful interoperability of the mesh networking module with the existing hardware during field tests, and sufficient data rate for drone detection signals, meshing and hardware integration. Maximum range was less than anticipated for a combination of electromagnetic compatibility and antenna specification reasons.



Left: network throughput test shows approx. 16Kbps transfer ratio with little variation, indicating a good quality communications link. Right: alternative network topologies.

What Next?
- Conduct a series of tasks related to radio frequency performance of the mesh module to improve maximum range. Deployment of the technology on an installation is planned for summer 2021.
- Project outputs make rapidly deployable drone detection networks feasible, and significantly improves the economics of achieving fixed installations in large or geographically complex sites and those with less developed infrastructure.

Contact: info@houdndstoothwireless.com

Secure Border-Ready Freight – SysElek

Tracks, controls, and secures freight across borders and customs territories

Real-World Issue

International freight transport will double by 2050. Flexible international trade agreements and changing customs laws increase demands on customs controls and border operations management. There are significant opportunities to enhance UK Customs processes, benefitting business and the public.

Project Activity

- Conducted a review of existing container security locks, digital lock designs, app development tools, cloud database architectures and security approaches, and HMRC's databases and APIs.
- Produced detailed use cases and system requirements, a detailed design for the intended digital lock, a representative prototype of the mobile device app, and an architecture design for the distributed cloud-based database, with a mock up to support the app prototype, along with extensive engineering documentation.
- Challenge found in the dependent link to HMRC's GVMS database; this will be under development until the end of 2021/end of staged customs controls.
- Secured agreements with development partners: a lock manufacturer, a customs declaration software tool developer, and a blockchain security consultancy.

Proposed Solution

Secure border-ready freight leverages digital technology to track and secure freight shipments across different customs territories. It monitors containers during journeys, provides a link to customs declarations, provides information transparently to all parties, and permits customs clearance at any point. The system comprises of digital locks, a mobile device app and cloud-based database linked to customs authorities' IT systems. This innovation benefits custom authorities, shippers, businesses, and the public, ensuring goods are transported efficiently and securely, easing the burden on transport systems and personnel.

What Next?

- Imperial College Business School supported in outlining a plan for future commercialisation, along with an investment forecast to reach full product launch in market in 2022.
- Conduct a field pilot trial involving potential road haulage customers, raising the TRL from 4 to 7.
- Explore funding opportunities from Innovate UK, partners for lock manufacturing, customs declaration software, and blockchain security.

An overview of the flow of information between authorities, traders and operators to enable tracking, control and securing of freight.

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