ULEMCo

ultra low emission mileage company limited

Document Name	Medium Aircraft Tow Tug Demonstration Report
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Confidentiality Status	**N/A**

Executive Summary

Hydrogen can play a key role in the decarbonisation of all sectors, however it is still not widely accepted and used. ULEMCo, aims to increase the acceptance, trust and implementation throughout the United Kingdom and believe that one of the best ways to do this is to demonstrate hydrogen technology and its abilities in as many different sectors as possible.

The aviation industry, like many others, has ambitious decarbonisation targets and only by using a variety of zero/low emission technology offerings will it be able to meet these targets. Like in all industries, there is no “silver bullet” or single solution for decarbonisation. There has already been an increase in the use of battery-electric vehicles and equipment, however there are many applications in which hydrogen can be a more suitable alternative.

This report outlines ULEMCo’s progress of implementing of hydrogen in ground handling equipment for the aviation industry with the demonstration of a hydrogen-enabled MATT (Medium Aircraft Tow Tug) at Cranfield University in March 2024. The demonstration culminated in what we believe was the world’s first pushback of an aeroplane in a live airside environment by a hydrogen powered vehicle. As well as technology testing, the demonstration helped to develop general acceptance and trust in hydrogen within the community and assisted the development of operating procedures, risk assessments, and training for airports.

The MATT was developed as part of the Teesside Hydrogen Hub, under a project called ZEHyDA (Zero Emission Hydrogen Demonstration for Airport Applications), the ethos behind the project was to produce a hydrogen-enabled piece of ground support equipment to be demonstrated at RAF Leeming to prove the feasibility of hydrogen within the aviation sector.

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Introduction

A fundamental barrier in delivering hydrogen technologies in transport applications is the need to connect the production, distribution and end-use with the right volumes, in the right place and with the right product specification and pressure. With each part of this supply chain working on their separate delivery targets, collective delivery has been overlooked in some of the innovative projects that ULEMCo and its partners have been involved in. Hydrogen is produced using chemical industry technology, using processes that are not currently aligned with the complex storage, dispensing and logistics of supplying fuel for vehicles, off road machines or generators. Having the hydrogen molecule on site or delivered to the refuelling facility, safely, at the right pressure, and in the right volume, for the specific requirements of the vehicle needs to be demonstrated seamlessly. Demonstrating that the benefits of the fast and convenient refuelling of hydrogen can be evidenced over other zero- emission options like battery charging and its related infrastructure is extremely important for the hydrogen industry.

Furthermore, the industry is also challenged by a lack of knowledge and understanding that hydrogen can be used safely in “normal” operational environments, particularly public locations, and highly safety cautious environments like airports, and military sites. There is also a lack of awareness that practical and affordable hydrogen technology solutions exist, now, or in the very near future.

To increase wider use and acceptance of hydrogen as a fuel alternative, it needs to be proven as a safe solution in a variety of transport applications, across multiple industries. The demonstration of different use cases for hydrogen technology can help to establish the required awareness of its availability and viability in real-world scenarios.

This demonstration is the first step in ULEMCo’s plans to develop hydrogen enabled aviation equipment. Alongside the demonstration, further steps are being taken to introduce hydrogen equipment and vehicles airside with the help of various project partners such as: Cranfield University, Connected Places Catapult, Royal Air Force, Exeter Airport, CAA, TUI, and more. This report shares the learnings taken from the demonstration with the industry, with the aim of increasing the acceptance and use of hydrogen within the sector. This demonstration was chosen as the first step in this programme due to the available facilities at Cranfield being the perfect test environment for both hydrogen and the MATT technology.

The work presented in this report was funded by the Department for Transport (DfT) in 2023-2024 however the findings of this report are the views of ULEMCo and do not represent UK Government Policy.

Demonstration Overview

The objective of the demonstration was to showcase a practical and heavy-duty application for hydrogen transport using retrofit drivetrain technology. The demonstration featured an existing medium aircraft tow tug (MATT) used at commercial and military airports which is primarily used to move and position aircraft.

ULEMCo retrofit the MATT with an innovative series-hybrid drivetrain based on the combination of a 100% Hydrogen Internal Combustion Engine (H2ICE) and an electrical powertrain. The H2ICE is a commercially available engine converted to run on hydrogen by ULEMCo. CO2 emissions from the engine are lower than the Ultra Low Emission Standard and it does not emit "harmful emissions" (such as NOx). The vehicle also has a high- voltage electrical powertrain system (from the UK) which is at TRL8/9 having been developed with support of UK R&D funding from Innovate UK and DfT's Tees-Valley Hydrogen Transport Hub [Tees Valley hydrogen transport hub: successful bidders - GOV.UK (www.gov.uk)](www.gov.uk).

Many existing specialist vehicles, such as the MATT used in this demonstration (Figure 1 below) do not meet future emission requirements and therefore cause significant budgetary challenges due to asset replacement requirements. The retrofit technology aims to upcycle existing platforms, helping to address this challenge for existing long-life assets, and extend their commercial viability. By saving the embedded carbon in the original diesel tug, this upcycling method maximises the reduction of greenhouse gas (GHG) emissions.

Figure 1 - MATT (Medium Aircraft Tow Tug)

Cranfield's on-site hydrogen refueller (Figure 2) was used as part of the demonstration to refuel the vehicle. This solution was ideal for the demonstration as it shows the hydrogen refuelling process at a small scale, allowing easy use, but also a direct comparison for the attendees to the process completed at other hydrogen refuelling stations today. The refuelling process simply requires connecting the refuelling nozzle with the vehicle receptacle and pressing "fill" on the refueller's interface. The time taken to refill any hydrogen vehicle is dependent on the refueller and its volume of high-pressure hydrogen storage. For most refuelling stations, the refuelling of the MATT takes less than 5 minutes, comparable to a diesel/petrol vehicle.

Figure 2 - Fuel Cell Systems, Mobile Refueller

Refuelling hydrogen is considered safer than refuelling with other liquid fuels in many ways due to the properties of hydrogen; hydrogen is non-toxic and the fact that it is lighter than air means that it will dissipate rapidly into the atmosphere and not pool like diesel or petrol. There are however other properties of hydrogen that require additional safety measures, such as its lower ignition temperature in comparison to petrol.

Hydrogen refuelling stations adhere to specific standards and legislation to ensure that they are inherently safe to be used by the public, however most providers will also offer safety and use training as an additional service. A high-pressure refuelling station is like any other high-pressure hydrogen system and will include many of the same safety components and systems; these components can be split into both mechanically and electrically controlled systems. The mechanical systems, such as pressure relief valves, solenoid valves, temperature and pressure sensors, regulators, etc. are all manufactured to specific standards making them more than suitable for the high pressures they will experience under regular use. The electrical safety systems work together with the mechanical components and offer an additional layer of safety by automatically monitoring various pressures and temperatures in the system and reacting instantly if there are any abnormalities.

When considering the use of hydrogen at airports, safety concerns are paramount and will be essential to mitigate if it is ever to be considered viable in aviation. Safety concerns often come from a lack of familiarity, a lack of local experience, a lack of knowledge of the risks and mitigation options, and overall awareness of the changes needed to accommodate the use of “new” technologies being applied and adopted. Demonstrations help to address this by taking sites through HAZID (Hazard Identification) and risk mitigation processes for the specific trials. An example of the issues that are specific to aviation, in relation to battery-electric vehicle (BEV) safety in airside operation, is the risk that a BEV will run out of charge and block a taxiway or runway. Hydrogen mitigates this by being a “fast fill” solution and the availability of a Port-a-bull™ (an auxiliary tank capable of completing 350Bar balance fills on hydrogen equipment) offers further risk mitigation for this. Identifying key risks collaboratively like this and learning from real-world experience is of incalculable benefit for accelerated deployment.

The other main risk factors for hydrogen use at airports are largely centred around understanding the designed-in mitigations already incorporated into these pieces of equipment, which already meet relevant standards from road use and are directly transferrable. The "knowledge sharing” this demonstration provided is therefore beneficial for future, wider scale deployment. ULEMCo has already worked with Teesside International Airport, RAF Leeming, and Heathrow on this process, having gained successful approval at both locations for demonstrations to be completed.

Objectives

Through this demonstration ULEMCo aimed to raise the profile of the safe use of hydrogen across the aviation sector and specialist transport sector by:

1. Delivering a real-world demonstration of the MATT in a "representative" airport environment, including towing a functional aircraft and refuelling from a stationary location.
2. Completion of the safety assessments that will provide shared learning throughout the industry.
3. Creating awareness by running the demonstration as a specific event, in collaboration with the Hydrogen Innovation Initiative (HII)[1], which brought together local, regional, and national stakeholders in both the hydrogen supply chain and those interested in aviation decarbonisation.
4. Showcasing a cost-effective solution to decarbonise specialist equipment, by exhibiting our upcycling method to make best use of existing industry assets.

From this work ULEMCo is collaborating with Cranfield University to run a demonstration of the tug doing representative duties including towing aircraft. The demonstration will show the successful supply of hydrogen, and its ability to complete designated tasks by towing an aircraft in a live airside environment, a task representative of usual duty cycles of its diesel equivalent counterpart.

Cranfield University is a specialist postgraduate University, offering world-class expertise and facilities, including its own airport and runway. Making it a perfect location for the development of innovative aviation technologies.

[1] HII is a trusted group of organisations working with Industry, Government, and academia to create an investible, globally competitive hydrogen technology and services sector, here in the UK. For further details, visit hydrogeninnovation.co.uk.

Vehicle Technology

Background

The technology developed for the MATT was a result of available hydrogen engine technology and ULEMCo's understanding of the vehicle requirements. Tow tugs require a large output of torque to push or pull large loads, and this is something that cannot be achieved by hydrogen engines alone using today's technology. To produce a vehicle that is fit for purpose, but that still benefits from the fast refuelling that hydrogen technologies offer, a series hybrid powertrain was designed; allowing the high energy demands to be met by the battery system.

This powertrain makes use of a battery-electric drivetrain utilising two switched reluctance motors (SRMs) and a small battery capacity (only 16kWh) to produce the required torque; in fact, the new, zero-carbon drivetrain has more capacity in terms of torque output compared to the original diesel vehicle. The original Perkins diesel engine was replaced with a Ford V6 petrol engine, converted to run solely on hydrogen. Due to the calibration changes allowing the engine to run on hydrogen, the output is reduced to a constant 25kW. The engine is powered by 2 x 94L hydrogen tanks, pressurised to 350 Bar, and controlled by a specialised ECU developed by ULEMCo.

A layout of the system architecture for the vehicle can be seen below in Figure 3.

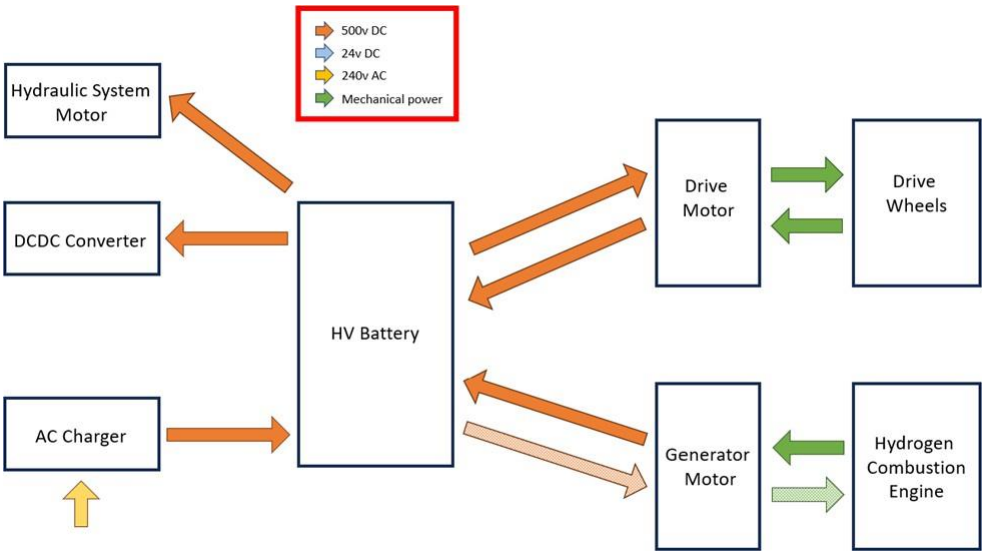


Figure 3 - MATT System Architecture

Estimated Range/Electrical Consumption

Range is often a determining factor when specifying vehicles, this may not necessarily be the most important characteristic for the MATT but is still of use for operational planning. Based on the below assumptions, we have calculated the range for both the hydrogen and the electrical system.

- 48km hydrogen range – 0.95km/kWh unloaded – total train weight 6,000kg.
- 25km hydrogen range – 0.5km/kWh towing – total train weight 20,000kg.
- 5.3km electric range – 0.95km/kWh unloaded – total train weight 6,000kg.
- 2.8km electric range – 0.5km/kWh towing – total train weight 20,000kg.

These figures have been calculated based on the following data:

• Hydrogen storage capacity	188 Litres
• Tank pressure (full)	350 Bar
• Tank pressure (empty)	20 Bar
• Tank mass (full)	4.456 kg
• Tank mass (empty)	0.323 kg
• Useable hydrogen capacity	4.133 kg
• Engine power	25 kW
• Hydrogen consumption at 25kW engine power	0.083kg/kWh
• Electrical equivalent hydrogen capacity	49.8 kWh
• Maximum battery capacity	16kWh
• Minimum battery State of Charge	25%
• Maximum battery State of Charge	60%
• Effective battery capacity	5.6kWh

It should be noted that due to the nature of the vehicle, it is unlikely that it would need to be refuelled multiple times per day, as turnarounds are limited (depending on the airport). As a result, the current range is more than sufficient for the vehicle's duty cycle, however ULEMCo endeavour to complete more, real world testing to prove this.

Real-World Recorded Data

Recording as much real world, relevant data is something ULEMCo always strive to do as it proves the usability of the vehicles and provides confidence in the technology as a result. Prior to the demonstration at Cranfield, the MATT was used for a period at RAF Leeming in which they were asked to use the MATT as they would its previous diesel counterpart. Figure 4 shows how the hydrogen and state of charge percentages change over a period of use. These two quantities are dependent on each other, when the hydrogen engine is in use, the hydrogen percentage will fall, however as the hydrogen engine is used to directly charge the battery, an increase in battery state of charge can be seen.

The control strategy implemented keeps the battery state of charge at an optimal point (40%-60%), to ensure that the life of the battery is maintained as much as possible.

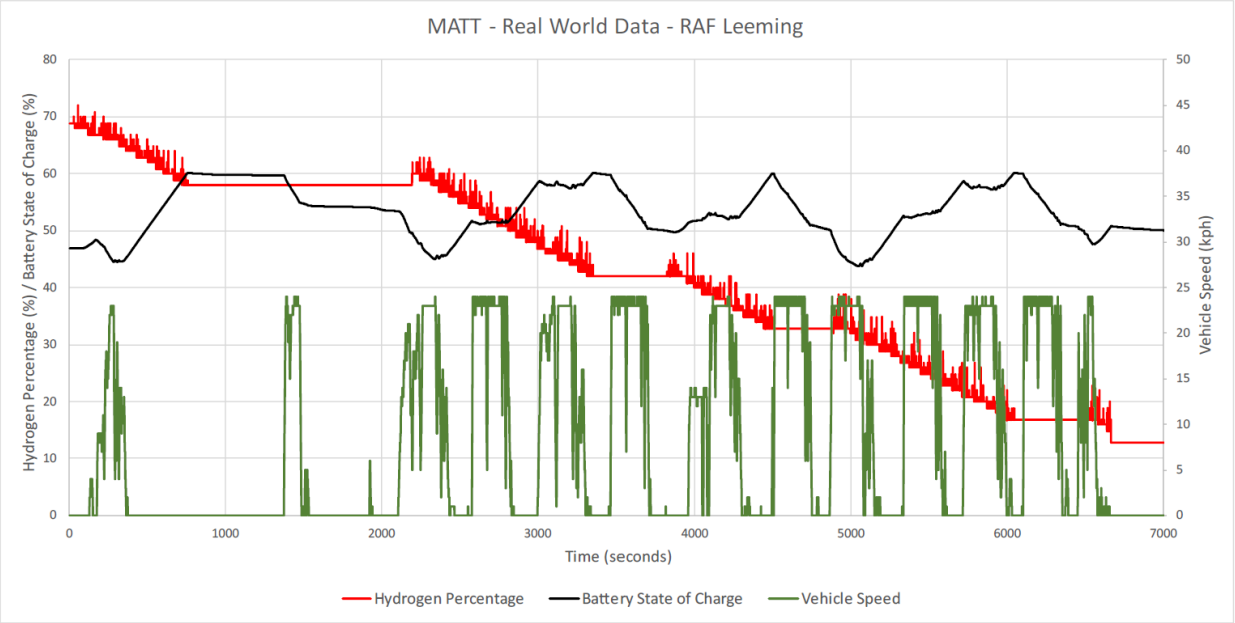


Figure 4 - MATT Real World Data, Recorded at RAF Leeming

Trial Preparation and Approval

This section describes the approvals process to undertake the HII MATT demos and may be useful for other organisations planning hydrogen trials. The process encompassed two stages, airport approval (external) and insurance approval (internal).

Airport approval

To conduct specific R&D activities at Cranfield Airport, a 'Form 301 - Airport Application Form' was required. This is an internal approval conducted by Cranfield Airport and needed to be submitted no later than 30 working days prior to the activity taking place. Had the activity required CAA approval, this would have required 90 days prior notice. Information requested by the airport included:

- Applicant Name.
- Applicant Company.
- Reason for Application.
- Funding Mechanism.
- Budget.
- Consortium Members.
- Summary of Aims and Goals of Activity.
- Regulatory/Licence approvals required.
- Operational/Safety Impact on the airport.
- Airport resources required.

Regarding regulatory approvals, this activity did not require CAA approval. However, it was noted in the application that the activity sat withing the broader framework of a recently awarded CAA sandbox, and that they CAA were engaged and aware of the project.

Regarding the Operational/Safety impacts, ULEMCo detailed the various components and stages of the trial. It was noted that Airport rescue and firefighting services (RFFS) would be briefed in person with the vehicle present ahead of the demo. This was duly conducted the day before the demo took place as planned.

The provision to open and close the access gates was also required from airport operation resources. This activity required funding, which was provided by the project team.

Risk Assessment

A thorough risk assessment-based safety review was completed prior to the demonstration, including feedback from all relevant party members, and engagement with appropriate bodies. ULEMCo has previous experience of this process with the initial TVHH project at Teesside International Airport and RAF Leeming. This allowed various stakeholders to have an input and ensure that all the necessary bases are covered. These assessments were shared with the other sites (RAF) and the UK regulatory bodies (CAA), to ensure that the knowledge and capability gained is transferred throughout the industry.

Insurance approval

Before conducting the demo, the University required approval that the project had the necessary insurance cover. Broadly, this related to insurance covering:

- Damage to buildings/infrastructure.
- Damage to equipment used in the trial.
- Injury to personnel whilst conducting the trial.

This in turn required coordination with the University's underwriter. They required confirmation of the following points regarding the vehicle and the activity. Specifically:

- Does the manufacturer have insurance and if so, what is the maximum level of cover they have?
- Will the manufacturer be onsite to assist with safety training of operatives?
- How long has this prototype been in development?
- Has the vehicle towed other aircraft previously?
- Have there been any safety incidents involving vehicle previously?
- How long will Cranfield have the vehicle onsite before the demo?
- Are Cranfield responsible for the vehicle while it is on site?
- Are there any contractual agreements in place?
- Have Cranfield refuelled similar units before?
- Will any people be on board aircraft during the demo?
- Is the vehicle rated for the size of aircraft?
- Is the power level of the vehicle like standard tugs?

Upon confirmation of the points above, existing insurance cover was confirmed, and final approval was granted.

Summary and reflection

While the approvals process was not particularly complex, the uncertainty around which approvals would be required (if any), the process required to seek these approvals, the type of information that would need to provide, and the associated timelines, meant that navigating this took some time. It also meant that the role of the consortium became more reactionary, in that some unanticipated information requested (for example, from the insurer) was needed at short notice. Prior knowledge ahead of the trial about the information required, and the process for submitting this information, would have allowed the consortium to plan-ahead and prepare the full submission at the outset of the project. This knowledge is something that future demos and activities can now benefit from. A detailed view of the risk assessment completed prior to the trial can be seen in Appendix B.

Cranfield Demonstration

Figure 5 - Setup for Cranfield Demonstration

The MATT demonstration at Cranfield was, we believe, the world's first pushback of an aeroplane in a live airside environment by a hydrogen powered vehicle.

The demonstration was used to highlight the technology, whilst breaking down the barriers in place which are currently restricting use of hydrogen in an airside environment. Invitees to the demonstration included various potential users (Regional and City Airports), partners who assisted with the approvals required to permit this demonstration (Cranfield University, CAA) and other project participants who wish to incorporate hydrogen enabled equipment and vehicles within their fleet in the near future (TUI Airlines).

It was agreed that alongside the physical demonstration of the MATT, there would also be a benefit in demonstrating the ease in which hydrogen vehicles can refuel. Cranfield having a functioning refuelling station (a Fuel Cell Systems HyQube, Figure 6) meant that it was a perfect location to show the whole process of operating a hydrogen enabled vehicle.

Presentations outlining the project were delivered to attendees prior to the demonstrations. Slides from these presentations are included in Appendix A – Presentation Slides from Cranfield Demonstration. This was followed by a question and answer session around the MATT itself, allowing the attendees to see the vehicle first hand.

Figure 6 - Filling the MATT at Cranfield's Refueller

A trip to the refueller followed, where Cranfield University staff were able to talk through the refuelling process with the attendees and complete a live demonstration of the steps required to refuel the MATT.

Figure 7 - MATT Setup with Cranfield's NFLC

After the MATT was refuelled, the push back demonstration commenced. Trained operatives from Cranfield University drove the MATT into place and the gates separating the GOLab (Ground Operations Laboratory) and the live airfield were opened. The aeroplane (National Flying Laboratory

Cranfield, NFLC) was then pushed airside by the tug in a manner resembling an airplane push back at an airport and then pulled back in place. This demonstrated the MATTs ability to move the NFLC with ease both pushing and pulling (Demonstration images shown in Figure 7 above and Figure 8 below).

Figure 8 - NFLC Pushed Airside by MATT

Included at the end of the report in Appendix B – Cranfield Demonstration Risk Assessment, is the risk assessment (RA) completed by Cranfield University prior to the demonstration taking place. This RA was developed by various departments in Cranfield, ensuring that everyone within the University were happy with the way the demonstration would be completed and what would be involved. The main challenge was the use of a hydrogen-enabled vehicle airside and overcoming this challenge was a focus point of the demonstration. The RA has been included to help others in their journey to implement and use hydrogen in an airside environment.

Conclusions and Lessons Learnt

The success of the Cranfield demonstration and the ease in which the MATT refuelled and moved the NFLC sparked interest and confidence from the attendees. ULEMCo received positive feedback and enquiries about the next steps of the project and ULEMCo's plans to utilise the technology in the future. One key point of feedback being that although the MATT proved the capability of the technology, the vehicle itself is rated to only 70T (due to the weight limits of the original diesel chassis), which would rule out many common commercial airline flights taken today. This does however align with ULEMCo's plans to integrate the hydrogen drivetrain technology into a larger, higher capacity tow tug capable of moving much larger aircraft, to meet our customer's needs.

A crucial outcome for the demonstration was the acceptance of the hydrogen technology, particularly the safety aspects of the system. After the demonstration of the safety measures included in the system, the attendees were confident in the measures taken to keep the hydrogen system safe. There were very few concerns with having a hydrogen enabled vehicle or machine as part of their fleet; in fact, there were some discussions over the rental and trialling of the MATT at other airports. A key next step is to work further with the CAA and ensure that hydrogen is an accepted fuel airside.

The Fire Service and Vehicle Operators were able to spend time with the vehicle in a technical capacity to allow them to ask any necessary questions and give feedback. The Fire Services at Cranfield were happy with the inbuilt safety systems and had no concerns about the safety of the vehicle, in fact, it is the high voltage system that they believed would pose the most difficulties if attending a fire incident related to the MATT. Craig Rolfe, the Technical Lead from the NFLC, who drove the MATT for the demonstration said: "The MATT performed well. To be honest it performed no differently to any other tug that I have driven with easy controls, plenty of power able to be applied on and off gradually. I'd be happy to use the vehicle on a day-to- day basis for aircraft and or equipment manoeuvring."

In addition, our previous demonstration completed at RAF Leeming provided further feedback on the refuelling, below is a quote taken from a technician who refuelled the MATT during the demonstration: "Easy to refuel and a lot quicker than refuelling from a diesel pump for the old MATT".

Next Steps

Following the successful demonstration at Cranfield, ULEMCo decided on the appropriate next steps in their hydrogen-aviation programme. A demonstration at a commercial airport (Exeter), using hydrogen-enabled equipment is in the latter stages of planning, and will be a positive expansion of demonstration activity. Using different pieces of hydrogen powered equipment will also allow users to see the versatility of the fuel and show numerous possibilities. The demonstration will also include other partners, allowing the various areas of the supply chain to be covered, including a hydrogen supplier, refueller and other hydrogen equipment providers.

The Cranfield demonstration proved the use of hydrogen airside, as well as building confidence in new technologies and engaging various required partners, such as the CAA. The feedback regarding the MATTs towing capabilities and the lack of commercial aircraft within its weight limits has led to a LATT (Large Aircraft Towing Tractor) to be high on the list of priorities for ULEMCo's next phase of the ZEHyDA (Zero Emission Hydrogen Demonstration for Airport Applications) project.

The wider exposure the demonstration achieved will also benefit ULEMCo in upcoming projects as more players within the aviation industry have witnessed the capabilities of hydrogen technology. Many more contacts have also been made following on from the demonstration, ensuring that ULEMCo will have the ability to call upon new project partners in the future to assist with further demonstrations and work.

Appendix A – Presentation Slides from Cranfield Demonstration

Carbon Zero Turn: objectives

- **Build knowledge** about the safe supply, storage, and delivery of hydrogen for ground operations applications at airports
- **Establish the case** for converting Ground Service Equipment to hydrogen power
- **Inform development** of airport specific standards, regulation skills and training

Regional & City Airports

TUI

ULEMCo
ultra low emission mileage company limited

Cranfield University

UK Civil Aviation Authority

CATAPULT
Connected Places

NEWS

Aircraft turnarounds to be studied at Exeter Airport

16 November 2023 Airports Sustainability UK & Europe

Reducing the environmental impact of aircraft turnarounds will be the focus of a study carried out by Regional & City Airports, TUI and Cranfield University.

Hii MATT Demonstration – Cranfield University

Chris Games – Head of Application Engineering

Background

- The vehicle was produced as part of the ZeHyDA (Zero Emission Hydrogen Demonstration for Airport Applications) project.
- To explore the feasibility of using hydrogen to decarbonize a range of operations within air transport.
- As part of the project the MATT was physically demonstrated at RAF Leeming.

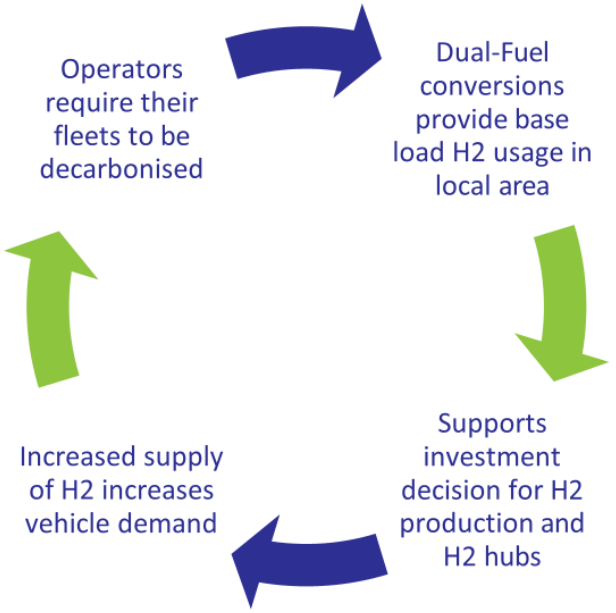
Vehicle Conversion

- The donor vehicle was a diesel SCHOPF F59.
- Perkins engine replaced with a FORD V6 H2ICE.
- 2 x HDSRM300 motors.
- Small battery capacity.
- 2 x 94L H2 tanks.
- ULEMCo developed ECU strategy.

New Vehicle Configuration

H2 Infrastructure Development

- ULEMCo's target is over 5,000 dual fuel conversions by 2030.
- The dual fuel conversions will support the accelerated growth of the H2 sector.



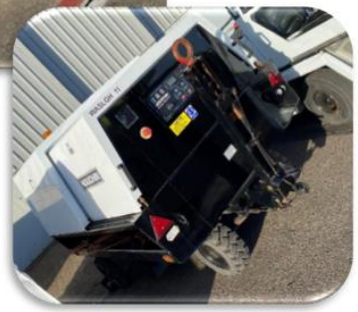
Next Steps

TIAL

- Low floor bus (don't currently own)
- MATT tow tug (don't currently own)
- Ambulift (Good candidate for conversion)

RAF Leeming

- Small Capacity Aircraft Refueller (Awaiting release from RAF)
- AS990 Runway sweeper (To be confirmed)
- LATT – Large Aircraft Tow Tractor (To be confirmed)




The Centre for Air Transport Management (CATM) and the National Flying Laboratory Centre (NFLC)
Cranfield University
Dr Thomas Budd
Senior Lecturer and DARTeC Fellow
Craig Rolfe
National Flying Laboratory Centre (NFLC)
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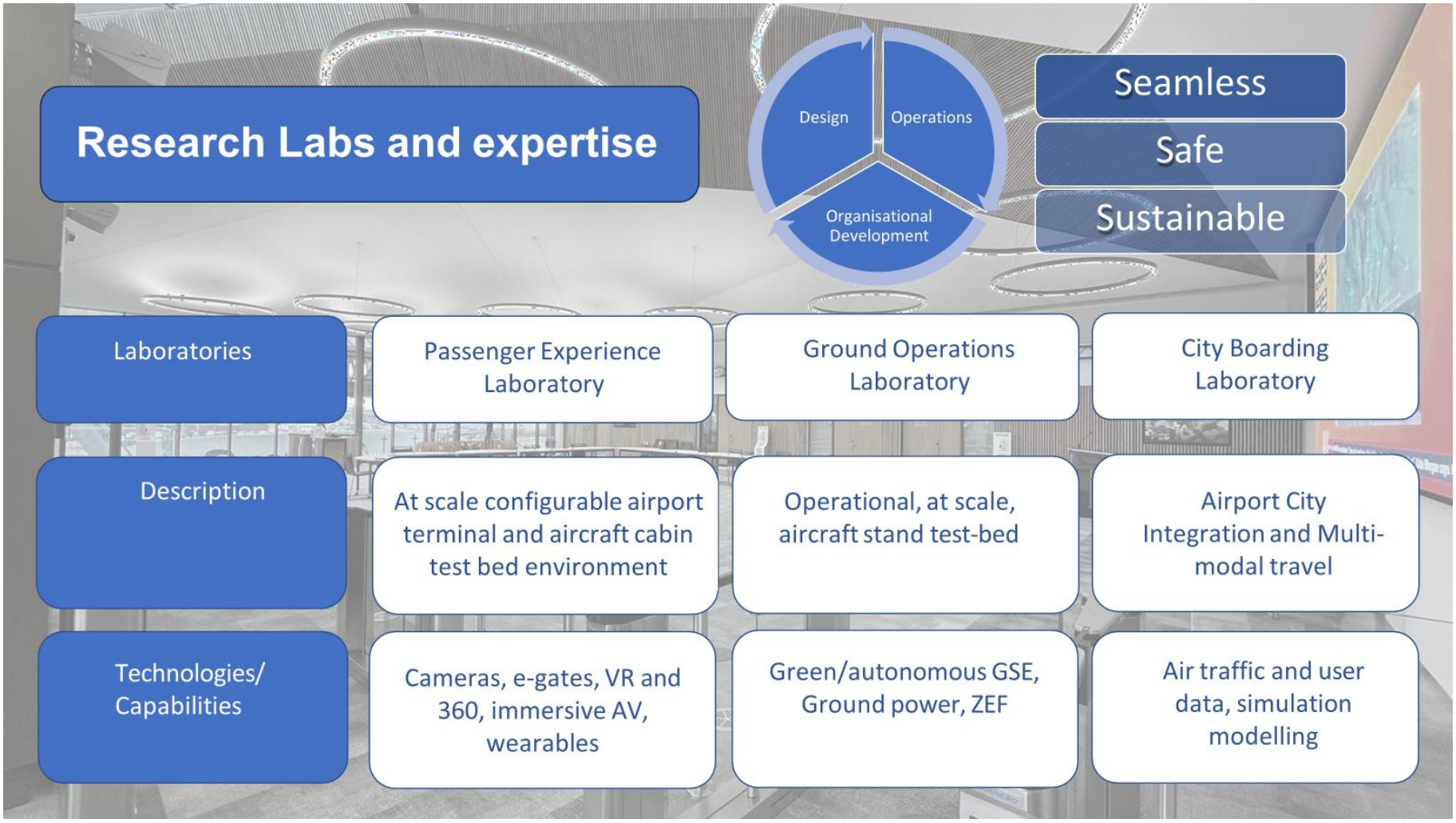
DARTeC- The Seamless Journey
"Harnessing digital transformation to create seamless, safe and sustainable air travel for all"
Seamless
Safe
Sustainable

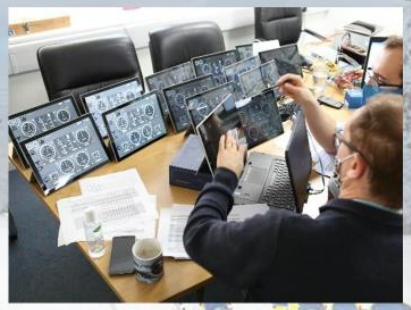

Research Labs and expertise
Design
Operations
Organisational Development
Seamless
Safe
Sustainable
Laboratories
Passenger Experience Laboratory
Ground Operations Laboratory
City Boarding Laboratory
Description
At scale configurable airport terminal and aircraft cabin test bed environment
Operational, at scale, aircraft stand test-bed
Airport City Integration and Multi-modal travel
Technologies/ Capabilities
Cameras, e-gates, VR and 360, immersive AV, wearables
Green/autonomous GSE, Ground power, ZEF
Air traffic and user data, simulation modelling


The National Flying Laboratory Centre: A Unique National Asset
National Flying
Laboratory Centre (NFLC)

The National Flying Laboratory Centre: A Unique National Asset

World-leading research with UK technology companies

Global connected classroom

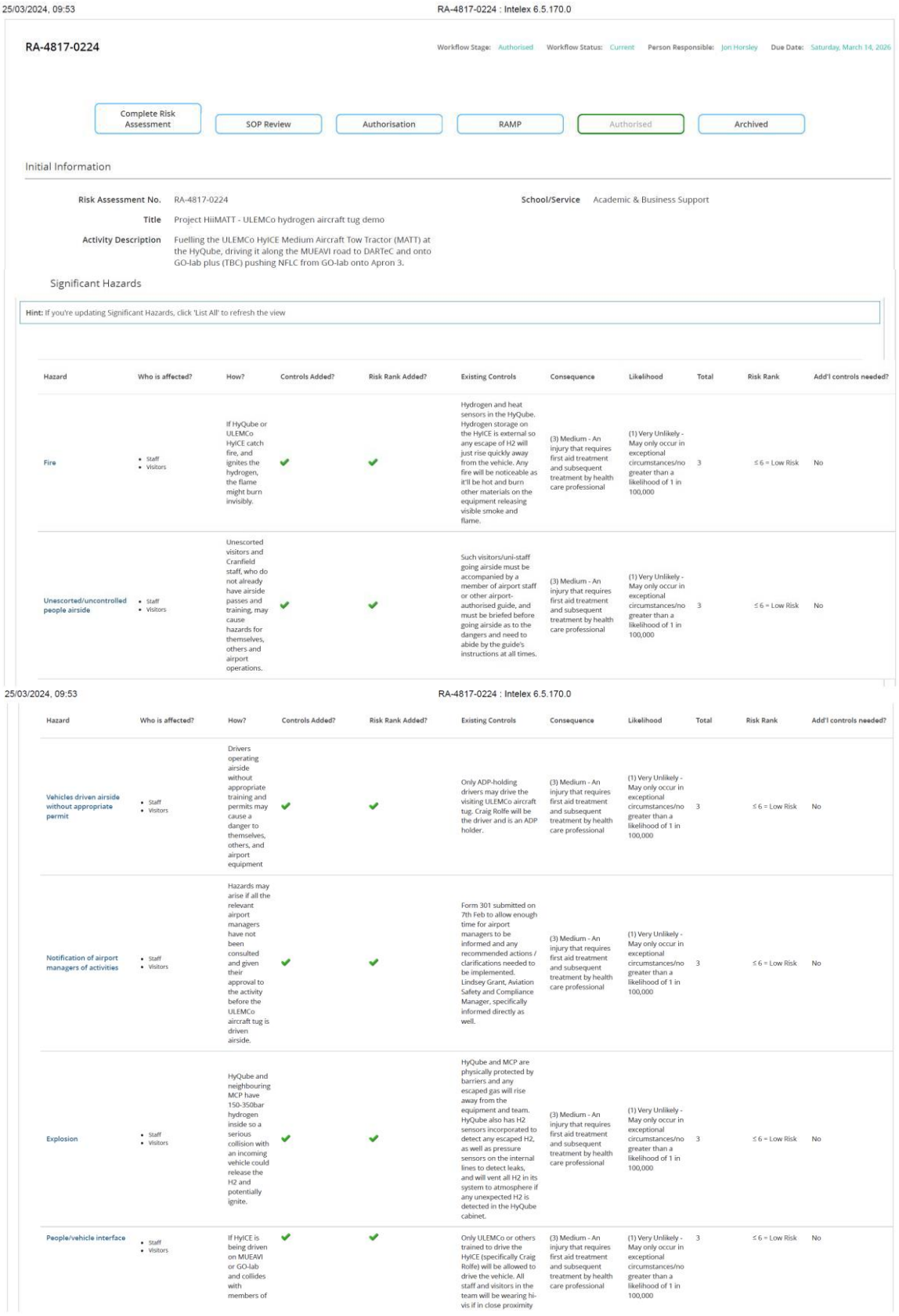


World-leading research with UK Universities

In-flight student experience

STEM outreach for schools and colleges

Appendix B –Demonstration Risk Assessment



25/03/2024, 09:53 RA-4817-0224 : Intelex 6.5.170.0

RA-4817-0224

Workflow Stage: Authorised Workflow Status: Current Person Responsible: Jon Horsley Due Date: Saturday, March 14, 2026

Complete Risk Assessment | SOP Review | Authorisation | RAMP | Authorised | Archived

Initial Information

Risk Assessment No. RA-4817-0224

School/Service Academic & Business Support

Title Project HiiMATT - ULEMCo hydrogen aircraft tug demo

Activity Description Fuelling the ULEMCo HyICE Medium Aircraft Tow Tractor (MATT) at the HyQube, driving it along the MUEAVI road to DARTeC and onto GO-lab plus (TBC) pushing NFLC from GO-lab onto Apron 3.

Significant Hazards

Hint: If you're updating Significant Hazards, click 'List All' to refresh the view

Hazard	Who is affected?	How?	Controls Added?	Risk Rank Added?	Existing Controls	Consequence	Likelihood	Total	Risk Rank	Add'l controls needed?
Fire	• Staff • Visitors	If HyQube or ULEMCo HyICE catch fire, and ignites the hydrogen, the flame might burn invisibly.	✔	✔	Hydrogen and heat sensors in the HyQube. Hydrogen storage on the HyICE is external so any escape of H2 will just rise quickly away from the vehicle. Any fire will be noticeable as it'll be hot and burn other materials on the equipment releasing visible smoke and flame.	(3) Medium - An injury that requires first aid treatment and subsequent treatment by health care professional	(1) Very Unlikely - May only occur in exceptional circumstances/no greater than a likelihood of 1 in 100,000	3	≤ 6 = Low Risk	No
Unescorted/uncontrolled people airside	• Staff • Visitors	Unescorted visitors and Cranfield staff, who do not already have airside passes and training, may cause hazards for themselves, others and airport operations.	✔	✔	Such visitors/uni-staff going airside must be accompanied by a member of airport staff or other airport-authorised guide, and must be briefed before going airside as to the dangers and need to abide by the guide's instructions at all times.	(3) Medium - An injury that requires first aid treatment and subsequent treatment by health care professional	(1) Very Unlikely - May only occur in exceptional circumstances/no greater than a likelihood of 1 in 100,000	3	≤ 6 = Low Risk	No

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Hazard	Who is affected?	How?	Controls Added?	Risk Rank Added?	Existing Controls	Consequence	Likelihood	Total	Risk Rank	Add'l controls needed?
Vehicles driven airside without appropriate permit	• Staff • Visitors	Drivers operating airside without appropriate training and permits may cause a danger to themselves, others, and airport equipment	✔	✔	Only ADP-holding drivers may drive the visiting ULEMCo aircraft tug. Craig Rolfe will be the driver and is an ADP holder.	(3) Medium - An injury that requires first aid treatment and subsequent treatment by health care professional	(1) Very Unlikely - May only occur in exceptional circumstances/no greater than a likelihood of 1 in 100,000	3	≤ 6 = Low Risk	No
Notification of airport managers of activities	• Staff • Visitors	Hazards may arise if all the relevant airport managers have not been consulted and given their approval to the activity before the ULEMCo aircraft tug is driven airside.	✔	✔	Form 301 submitted on 7th Feb to allow enough time for airport managers to be informed and any recommended actions / clarifications needed to be implemented. Lindsey Grant, Aviation Safety and Compliance Manager, specifically informed directly as well.	(3) Medium - An injury that requires first aid treatment and subsequent treatment by health care professional	(1) Very Unlikely - May only occur in exceptional circumstances/no greater than a likelihood of 1 in 100,000	3	≤ 6 = Low Risk	No
Explosion	• Staff • Visitors	HyQube and neighbouring MCP have 150-350bar hydrogen inside so a serious collision with an incoming vehicle could release the H2 and potentially ignite.	✔	✔	HyQube and MCP are physically protected by barriers and any escaped gas will rise away from the equipment and team. HyQube also has H2 sensors incorporated to detect any escaped H2, as well as pressure sensors on the internal lines to detect leaks, and will vent all H2 in its system to atmosphere if any unexpected H2 is detected in the HyQube cabinet.	(3) Medium - An injury that requires first aid treatment and subsequent treatment by health care professional	(1) Very Unlikely - May only occur in exceptional circumstances/no greater than a likelihood of 1 in 100,000	3	≤ 6 = Low Risk	No
People/vehicle interface	• Staff • Visitors	If HyICE is being driven on MUEAVI or GO-lab and collides with members of	✔	✔	Only ULEMCo or others trained to drive the HyICE (specifically Craig Rolfe) will be allowed to drive the vehicle. All staff and visitors in the team will be wearing hi-vis if in close proximity	(3) Medium - An injury that requires first aid treatment and subsequent treatment by health care professional	(1) Very Unlikely - May only occur in exceptional circumstances/no greater than a likelihood of 1 in 100,000	3	≤ 6 = Low Risk	No

Hazard	Who is affected?	How?	Controls Added?	Risk Rank Added?	Existing Controls	Consequence	Likelihood	Total	Risk Rank	Add'l controls needed?
		the team or visitors.			to the HyICE when it is moving.					
FOD being left airside that could interfere with aircraft	• Other • Staff • Visitors	Any Foreign Objects and Debris left airside by visitors / uni-staff could affect airport operations	✔	✔	Craig Rolfe will do a visual check of any areas in which accompanied persons went airside to check for FOD.	(3) Medium - An injury that requires first aid treatment and subsequent treatment by health care professional	(1) Very Unlikely - May only occur in exceptional circumstances/no greater than a likelihood of 1 in 100,000	3	≤ 6 = Low Risk	No

PPE

PPE	Other Relevant Information
Hi Viz	

Associated COSHH

Reference No.	Created By	Location	COSHH Assessment Type	Person Responsible	Types of individuals involved/affected

Emergency Planning

Emergency Planning Arrangements relating to operations/event

1. In the event of collision damage to, fire or explosion on, the HyQube or ULEMCo HyICE vehicle
2. As the vehicle will be going airside (onto Apron 3), this will come under the Airport Emergency Response Plan, which is owned by the Airport Fire Service Manager

Who is affected?

- ☑ Staff
- ☐ Contractors
- ☐ Cleaners
- ☐ Community beyond campus
- ☐ Student
- ☑ Visitors
- ☐ Security
- ☐ Other

How are they affected?

1. Possible injury from vehicle collision or fire/explosion due to hydrogen escape. In any such event, please call 2222 from any Cranfield landline phone or (+44) (0) 1234 752999 from a mobile phone.
2. Lindsay Grant (Aviation Safety and Compliance Manager) has been informed about the event, and to inform Airport Fire.

Safe Operating Procedure

Is an SOP required? No