H2 Fuel Cell UAV Refueling Demonstration Project

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1. Executive Summary

This report summarises the outcomes of the H2 Fuel Cell UAV Refueling Demonstration Project, which explored the practical application of hydrogen technologies in unmanned aerial systems through two complementary activities: the demonstration of a novel hydrogen generation and refueling setup, and flight testing to assess the endurance and operational behaviour of a hydrogen-powered UAV. The project focused on evaluating hydrogen refueling concepts and verifying the endurance potential of the UAV system on an existing platform rather than developing a new aircraft platform.

Figure 1.1: Hydrogen-powered UAV in flight during flight testing

During flight testing, the system demonstrated stable behaviour, predictable and near-linear hydrogen consumption, and effective hybrid power management, with the fuel cell providing continuous energy and the onboard battery supporting transient peak loads during higher-demand flight conditions. The recorded data provided a credible basis for assessing endurance-related performance and for estimating longer-duration operation under alternative hydrogen storage configurations. Internal analysis carried out during the project indicated that, within the available airframe volume, a larger hydrogen tank configuration could support flight durations of up to approximately seven hours.

The project also demonstrated a practical hydrogen refueling concept relevant to field operations, based on an off-grid hydrogen generation and refueling approach developed by Tactical Edge Systems. The system architecture supports both on-board and off-board refueling approaches, as well as rapid access to the fuel system for inspection, maintenance, or tank replacement. The project identified several practical considerations relevant to future application, including refueling turnaround time, thermal effects during tank filling, platform integration trade-offs, and the influence of logistics on demonstration scope.

Overall, the demonstration shows that hydrogen technologies can support longer-endurance, lower-emission UAV operations and offer clear potential for applications where long duration, reduced downtime, and flexible field logistics are important, such as infrastructure inspection, environmental monitoring, and other remote operations. At the same time, the project highlights the importance of system-level optimisation, refueling concept selection, and operational planning in enabling wider adoption of hydrogen-powered unmanned aviation.

2. Introduction

2.1. Purpose of the report

The purpose of this report is to document the H2 Fuel Cell UAV Refueling Demonstration Project and provide a structured overview of the activities undertaken, the results obtained, and the key technical and operational insights generated during the demonstration. The report covers both the hydrogen generation and refueling demonstration activities and the flight testing carried out to assess the endurance potential and operational behaviour of a hydrogen-powered UAV.

The report is intended to describe what was demonstrated during the project, what was learned through testing and analysis, and which observations are relevant to future hydrogen-powered UAV operations. In particular, it captures practical considerations associated with hydrogen refueling, hybrid power system behaviour, endurance assessment, and the operational constraints that influenced the scope of the demonstration. It is intended to provide project partners, stakeholders, and wider industry participants with a clear understanding of the project outcomes and their relevance to the further development and deployment of hydrogen technologies for long-endurance unmanned aerial applications.

2.2. Background of the technology

Hydrogen fuel cell technology is increasingly being explored as an alternative power source for unmanned aerial vehicles, particularly in applications where longer flight endurance and improved operational flexibility are required beyond what conventional battery-powered systems can typically provide. In a hydrogen fuel cell system, hydrogen is used as an energy carrier. Within the fuel cell, hydrogen reacts electrochemically with oxygen from the air to generate electricity, water, and heat. The electricity produced is used to power the UAV propulsion system and onboard electronics. Unlike internal combustion engines, fuel cells generate electricity without combustion and produce no direct CO_2 emissions at the point of use.

Compared with lithium-ion batteries commonly used in UAVs, hydrogen fuel cell systems can offer significantly higher energy density, making them particularly attractive for missions such as infrastructure inspection, environmental monitoring, mapping, surveillance, and other operations where extended flight duration is important. In practice, hydrogen-powered UAV systems typically combine a fuel cell, compressed hydrogen storage, power management electronics, and, in many cases, a battery used to support transient peak loads and operational flexibility.

As interest grows in hydrogen as a clean energy carrier for transport and aviation, hydrogen-powered UAVs are increasingly being considered as a practical early use case where the benefits of hydrogen can offer clear operational value. At the same time, the practical deployment of such systems depends not only on flight performance, but also on factors such as hydrogen storage, refueling approach, turnaround time, and system integration. This project considered these factors through a demonstration focused on hydrogen refueling concepts and endurance-related flight testing using an existing UAV platform.

2.3. Objectives of the demonstration

The key objectives of the demonstration were

- to demonstrate the practical setup and operation of a hydrogen generation and refueling configuration relevant to UAV deployment,
- to assess the endurance potential of a hydrogen-powered UAV through flight testing and analysis,
- to demonstrate stable and controlled UAV operation across all flight phases, including take-off, transition, cruise, and landing,
- to assess the stability and reliability of the hydrogen fuel cell system throughout the mission,
- to evaluate the operational practicality of the hydrogen solution, including refueling-related considerations, system handling, and preparation for continuous operations,
- and to capture technical and operational lessons relevant to future hydrogen-powered UAV demonstrations and deployments.

3. Project Description

The H2 Fuel Cell UAV Refueling Demonstration Project was undertaken to assess the practical application of hydrogen technologies in unmanned aerial systems, with particular emphasis on hydrogen refueling concepts and the endurance potential of a hydrogen-powered UAV. The project was not focused on the development of a new aircraft platform, but on demonstrating relevant hydrogen generation and refueling arrangements and evaluating how an existing UAV system performs when operated with a hydrogen fuel cell power architecture.

The hydrogen technology considered within the project combined two closely related elements. The first was a portable hydrogen generation and refueling concept developed to support field-based UAV operations. This system was based on hydrogen generation through a chemical reaction between aluminium and water and was intended to demonstrate a practical approach to producing hydrogen on demand for refueling purposes. The second element was a hydrogen-powered UAV configuration using an Intelligent Energy SOAR fuel cell, a hydrogen storage tank, a hybrid battery, and associated power management and monitoring systems. Together, these elements formed the basis for assessing both refueling practicality and endurance-related flight behaviour.

The UAV platform used in the project was an existing airframe originally designed and optimised for battery-powered operation. For the purposes of the demonstration, it was operated in a hybrid configuration in which the fuel cell provided the primary continuous power supply, while the onboard battery supported transient peak loads and operational flexibility. This was an important feature of the project, as it allowed the team to assess endurance-related behaviour and practical operational considerations on a representative platform without presenting the work as the development of a new hydrogen UAV.

Figure 3.1: Hydrogen tank installation and securing mechanism

Figure 3.2: Fuel cell system installed within the UAV fuselage

The project was delivered through collaboration between Sky-Drones Technologies Ltd and Tactical Edge Systems, with Connected Places Catapult supporting the wider initiative. Sky-Drones Technologies Ltd was responsible for the UAV platform, flight testing, and technical reporting, while Tactical Edge Systems provided the hydrogen generation and refueling system, relevant hydrogen system components, and associated technical input. The project was conducted within the framework of the Hydrogen Innovation Initiative and formed part of a broader effort to explore practical hydrogen applications in emerging transport and aviation use cases.

The demonstration activities took place across two closely connected workstreams. One workstream focused on commissioning and demonstrating the hydrogen generation and refueling setup, including the associated fueling workflow and operational configuration. The second workstream focused on flight testing of the hydrogen-powered UAV, including an initial validation sortie, a controlled endurance-related sortie, and the collection of system and performance data for subsequent analysis. Together, these activities were intended to provide a practical basis for understanding how hydrogen refueling concepts and hydrogen-powered flight performance could support longer-endurance UAV operations.

In terms of project timeline, the work included preparation and commissioning of the hydrogen refueling system, rehearsal and demonstration of the refueling setup, flight validation and endurance-related testing, analysis of the resulting technical and operational data, and preparation of project outputs for final presentation and dissemination. The final outcomes of the project were presented at the Royal Aeronautical Society in London.

4. Demonstration Activity

The demonstration activities were structured around two closely related workstreams: the commissioning and demonstration of a hydrogen generation and refueling setup, and the flight testing of a hydrogen-powered UAV to assess endurance-related performance and operational behaviour. Together, these activities were intended to examine both the practicalities of hydrogen refueling and the feasibility of longer-endurance UAV operation using a hydrogen fuel cell power system.

4.1. Equipment used

The hydrogen refueling demonstration involved a portable hydrogen generation system developed by Tactical Edge Systems, together with associated refueling hardware and system components. The commissioning and fueling setup included a reactor vessel, a hydrogen tank, pressure regulation equipment, pressure monitoring instrumentation, manual valves, over-pressure relief devices, and associated hose and connection interfaces required for controlled fueling operations. The setup also included the hardware used to demonstrate the hydrogen generation and tank filling workflow.

Figure 4.1.1: Hydrogen Tank and Fuel Cell Commissioning Test Setup

The flight testing activities used a hydrogen-powered UAV configured with an Intelligent Energy SOAR fuel cell, a hydrogen storage tank, a hybrid battery, and the associated electrical power management and monitoring systems required for operation. The UAV platform itself was an existing airframe originally designed for battery-powered use and adapted to operate in a hybrid hydrogen-electric configuration for the purposes of the demonstration. Supporting infrastructure included software-based diagnostics, power output monitoring, and flight data recording tools used during pre-flight checks and demonstration sorties.

Figure 4.1.3: Hydrogen-powered UAV on the ground prior to flight testing

4.2. Methodology and procedures

The demonstration began with commissioning activities for the hydrogen generation and refueling system. These activities were carried out to verify that the system could be prepared, operated, and monitored under demonstration conditions. The commissioning work included setup of the hydrogen generation system, connection of the fueling hardware, observation of pressure behaviour during tank filling, and verification of the operation of the principal system elements integrated into the architecture.

Figure 4.2.1: Setup of the Edge Refueler Hydrogen Generation System

Following commissioning, a demonstration of the hydrogen refueling workflow was carried out to illustrate the practical setup, operation, and teardown of the refueling system. This work demonstrated the operational concept for hydrogen refueling in a UAV context, including the handling of the hydrogen tank, the use of the regulator and pressure gauge to monitor fill status, and the overall sequence required to support field deployment. The demonstrated setup also reflected the intended integration of hydrogen refueling into UAV operations.

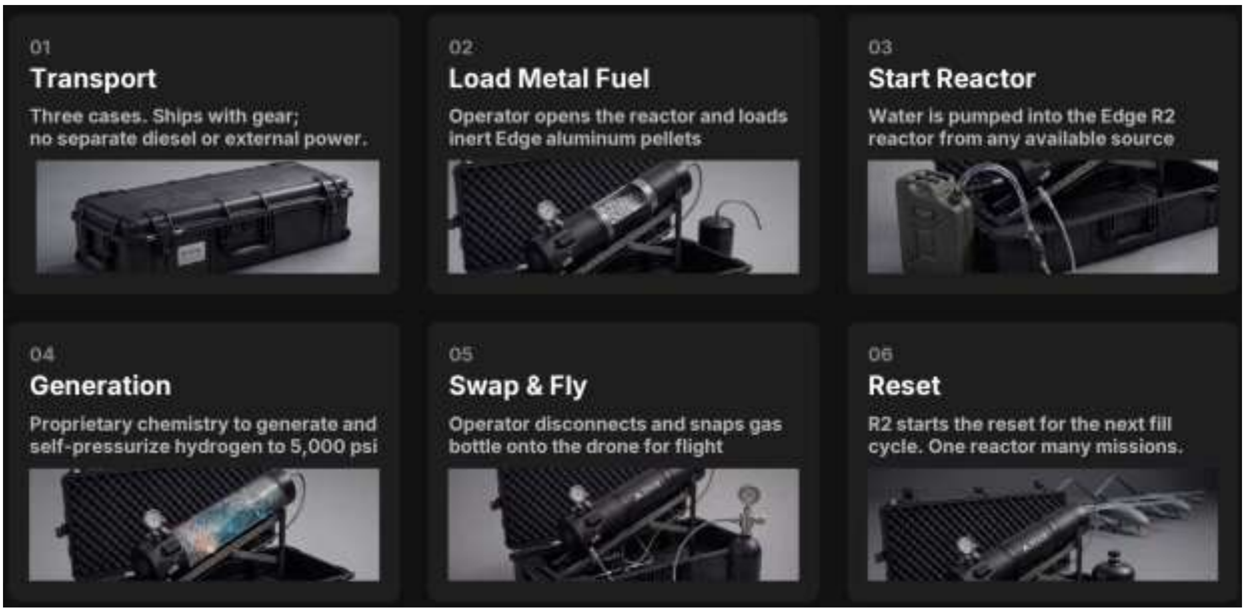

Figure 4.2.2: Edge R2 Refueling Process

Figure 4.2.3: Tank Fueling by the Edge Refueler

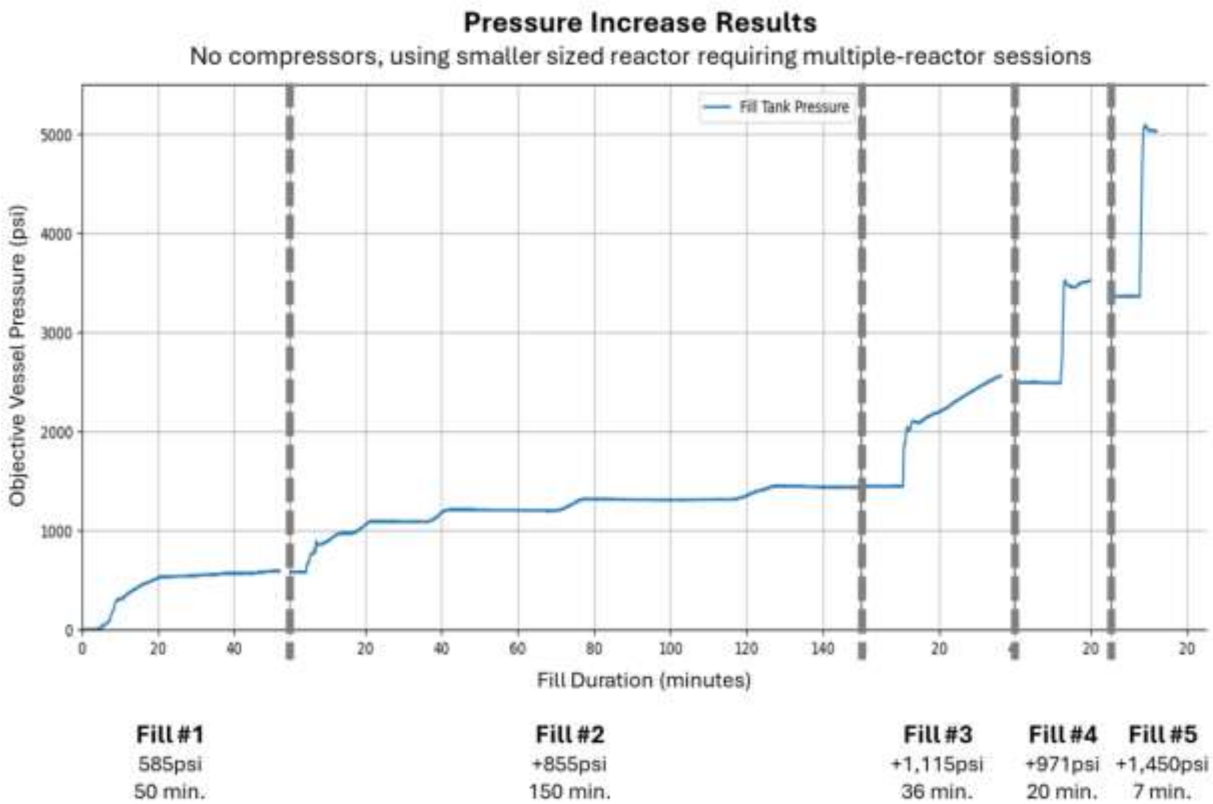

Figure 4.2.4: Tank Fill to 5,000 psi (350 bar). Final stage, 3,526–5,000 psi: 7 min.

The flight testing programme included an initial low-risk validation sortie followed by an endurance-related demonstration sortie. Before flight, the UAV system underwent visual inspection and software-based diagnostics to confirm readiness for operation. These checks covered the hydrogen fuel cell system, hydrogen supply parameters, electrical output stability, temperature monitoring, and supporting subsystems. Once the system had been confirmed to be operating within expected parameters, the validation sortie was conducted using a controlled flight pattern designed to confirm stable operation under representative dynamic conditions.

After successful completion of the validation flight, an endurance-related sortie was conducted to collect representative operational data on hydrogen consumption, current draw, battery behaviour, and general system performance during sustained flight. This provided the basis for subsequent analysis of endurance potential, hybrid power behaviour, and the practical implications of hydrogen operation on the existing UAV platform.

Figure 4.2.5: Flight trajectory and mission profile during the initial validation sortie

4.3 Data collection and monitoring methods

Data collection formed an important part of the demonstration, particularly during the flight testing activities. During hydrogen system commissioning and fueling demonstration, pressure behaviour was monitored using instrumentation connected to the regulator and tank system. This made it possible to observe filling progress, confirm pressure performance, and assess the behaviour of the refueling setup under demonstration conditions.

During flight testing, the UAV system recorded operational and performance data relevant to endurance assessment and system evaluation. These data included hydrogen consumption over time, system current draw, battery voltage behaviour, and flight trajectory information. Together, these measurements supported assessment of fuel consumption trends, hybrid power interactions between the fuel cell and the battery, and the overall stability of the system during different flight conditions.

The collected data were subsequently consolidated and analysed to identify representative consumption behaviour, evaluate the consistency of fuel cell power delivery, and estimate endurance potential under alternative hydrogen storage configurations. In this way, the demonstration activity provided not only operational evidence from the flights themselves, but also a structured basis for the analytical conclusions presented later in the report.

5. Results and Analysis

5.1. Performance of the technology

The demonstration showed that the hydrogen-powered UAV system could operate in a stable and controlled manner under representative flight conditions and provide a sound basis for assessing endurance-related performance. Across the completed flight activities, the fuel cell delivered consistent baseline power, while the hybrid battery supported transient peak loads during manoeuvres and other higher-demand conditions. No critical system failures were observed during the mission, and the overall behaviour of the power system indicated that the hydrogen fuel cell architecture was suitable for sustained UAV operation on the existing platform.

The recorded hydrogen consumption profile showed a near-linear decrease in tank level over the duration of the endurance-related flight. This is a significant result, as it indicates predictable fuel usage and supports straightforward estimation of hydrogen requirements for longer missions. The recorded current profile also showed that electrical demand increased during manoeuvres and in the presence of wind, while the battery voltage remained stable throughout the flight, confirming that the battery was used mainly to support short-duration peak loads rather than to provide the primary energy source. Together, these results demonstrate effective hybrid power management and stable energy delivery throughout the test campaign.

In addition to the flight performance results, the refueling workstream also provided evidence of refueling performance under the demonstrated conditions. The filling results showed that the Tactical Edge refueling approach was capable of supporting tank filling to 350 bar, providing a useful basis for assessing the practical performance of the refueling concept alongside the endurance-related performance of the UAV system.

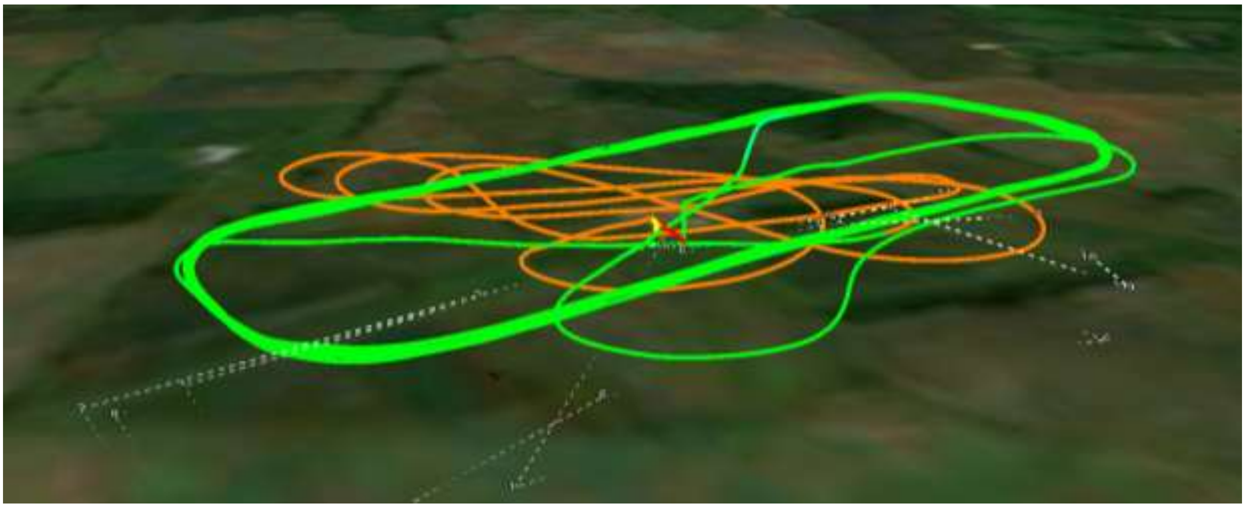

Figure 5.1.1: Flight trajectory and operational profile recorded during the demonstration sortie

Figure 5.1.2: Hydrogen Tank Level (%) – Consumption profile over the duration of the flight

Figure 5.1.3: Electrical Current (A) – System current draw throughout the flight

Figure 5.1.4: Battery Voltage (V) – Battery voltage over time

5.2. Validation against design or models

The demonstration provided supporting evidence of several key assumptions underlying the project. First, the measured hydrogen consumption behaviour confirmed that the system could deliver predictable endurance-related performance under sustained operating conditions. This allowed the project team to use the recorded flight data as a credible basis for projecting longer endurance under alternative hydrogen storage configurations. Second, the observed behaviour of the hybrid power architecture supported the intended operational concept in which the fuel cell provides the primary continuous power supply and the battery supports temporary peak demand.

The project also drew on supporting analytical and engineering inputs beyond the flight data itself. In the hydrogen refueling workstream, the system engineering gas model referenced in the report supported the conclusion that the Edge Refueler system could provide fuel cell-grade hydrogen without additional scrubbers or purge stages. In the endurance analysis, the measured consumption rate and available installation volume within the airframe were used to estimate the endurance potential of a larger hydrogen storage configuration. These elements do not constitute a full model-versus-test validation programme, but they do provide a reasonable engineering basis for linking demonstrated behaviour with projected future performance.

5.3. Economic analysis

The demonstration provided several useful observations regarding cost and operational efficiency in the context of hydrogen-powered UAV systems. Battery-powered UAV systems currently benefit from lower upfront and operational costs, supported by a mature supply chain and established charging practices. The report notes that a typical UAV battery set costs approximately $800 and requires replacement after around 200 charge cycles. By comparison, hydrogen systems currently involve higher initial costs, including fuel cells at approximately $10,000 and storage tanks at around $250, reflecting the earlier stage of technology development and the more limited maturity of the supporting ecosystem.

At the same time, the results indicate that hydrogen systems may offer potential operational value in long-endurance use cases where frequent battery replacement, repeated charging cycles, or operational downtime materially affect mission efficiency. The demonstration showed that hydrogen-powered operation can support longer endurance potential and that operational concepts such as rapid tank replacement can reduce interruptions between flights. The report therefore supports the view that, although hydrogen systems are currently more expensive in upfront terms, they may become increasingly attractive in applications where long mission duration and reduced downtime are operationally more important than minimum acquisition cost.

5.4. Environmental impact

The demonstration confirmed several environmental advantages associated with hydrogen-powered UAV operation. At the point of use, the fuel cell generates electricity electrochemically, with water as the primary by-product and zero direct CO_2 emissions during operation. This provides a clear advantage over conventional combustion-based systems and supports the broader case for hydrogen as a lower-emission option for unmanned aviation applications. The report also places these findings in the context of wider UK and international decarbonisation initiatives, including the UK Hydrogen Strategy and Net Zero targets.

From an acoustic perspective, the report notes that the fuel cell system itself produces continuous operating noise associated with internal components such as compressors and cooling systems, typically in the range of approximately 55–65 dB at close proximity for small UAV fuel cell systems. However, during flight the dominant noise source remains the propulsion system, with the installed propellers typically generating approximately 75–85 dB depending on thrust and operating conditions. As a result, the environmental profile of the demonstrated system is improved primarily through emissions reduction rather than a major reduction in overall flight noise.

5.5. Comparison with other existing or alternative technologies

The most direct comparison in the report is with battery-powered UAV systems. The demonstrated platform was originally designed and optimised for battery operation, which makes it a useful basis for understanding the benefits and constraints of hydrogen propulsion. The report notes that battery-powered UAVs of a similar class are typically limited to approximately four hours of flight time, whereas the measured hydrogen consumption data from this project indicates that a hydrogen-optimised configuration with increased storage volume could support flight durations of up to approximately seven hours. This comparison is particularly important because it highlights that the advantage of hydrogen lies not in the current hybrid configuration alone, but in the endurance potential that can be realised when the platform is better aligned with hydrogen storage and system integration requirements.

The report also highlights a difference in design constraints between battery and hydrogen systems. Battery-powered UAVs are primarily mass-limited, whereas hydrogen-powered systems are more strongly constrained by available volume for tank installation. This changes the optimisation logic of the platform and creates opportunities for different airframe integration approaches, especially in fixed-wing configurations where hydrogen storage can be distributed more flexibly. In addition, hydrogen systems appear less sensitive to low ambient temperatures than battery systems, since battery performance can degrade significantly in cold conditions while the fuel cell produces heat during operation and can maintain more stable performance.

Compared with conventional combustion-based systems, the report does not present a full quantitative side-by-side operational comparison, but it does identify a key advantage of hydrogen in the form of zero direct CO_2 emissions at the point of use. The report therefore supports the conclusion that hydrogen is particularly relevant where long endurance and emissions reduction are both priorities, even though further work would be required to establish a more complete cost and performance comparison across all possible UAV propulsion approaches.

6. Challenges and Solutions

6.1. Technical issues encountered

The project identified several technical challenges associated with the practical use of hydrogen technologies in a UAV context. One of the most important was that the demonstrated UAV platform was an existing airframe originally designed and optimised for battery-powered operation rather than for hydrogen propulsion. As a result, the demonstrated configuration provided a useful basis for endurance assessment and operational evaluation, but did not represent an optimised hydrogen platform. This introduced system-level trade-offs in terms of packaging, energy utilisation, and overall endurance efficiency. The project therefore highlighted that the observed performance should be understood in the context of a non-optimised installation rather than as the maximum achievable capability of hydrogen-powered UAV operation.

A further technical issue related to the behaviour of the hybrid power architecture under varying load conditions. Although the fuel cell provided stable baseline power, additional power demand arose during manoeuvres and in the presence of wind, requiring short-term support from the onboard battery. This was not treated as a failure of the system, but it was an important technical observation because it confirmed that transient peak loads must be accounted for in the design and operation of hydrogen-powered UAV systems, especially where a non-optimised hybrid configuration is used.

Another significant technical issue concerned the thermal effects associated with compression-based hydrogen refueling. The report notes that refueling using compressed hydrogen, such as from a compressor or high-pressure cylinder, can increase tank temperature to approximately 40–60°C. A cooling period is therefore required before flight operations can begin. However, this effect is specific to compression-based refueling methods. In the case of the Tactical Edge system, this thermal effect does not occur, and an alternative operational approach is also possible through replacement of the tank rather than waiting for cooling after compression-based filling.

6.2. Mitigation strategies and solutions

The project adopted several approaches to mitigate these technical and operational challenges. In relation to the non-optimised UAV platform, the team treated the existing airframe as a representative demonstration vehicle and used measured performance data to establish a credible basis for analysis of future hydrogen-optimised configurations. Rather than presenting the demonstrated system as a final product, the project used it as a practical platform for endurance assessment, system behaviour evaluation, and identification of improvement opportunities.

To address the operational demands of hybrid power management, the system architecture combined the fuel cell with an onboard battery, allowing the fuel cell to provide continuous baseline power while the battery absorbed short-duration peak loads. This approach proved effective during flight testing and helped maintain overall system stability across different operating conditions. The battery was then recharged during steady-state operation, supporting continued mission performance without interruption.

To reduce operational constraints associated with refueling and maintenance, the project incorporated a system design that supports both on-board and off-board refueling, together with accessible installation of the fuel cell and quick-release mounting features. This provides flexibility for inspection, maintenance, and tank replacement, and supports operational concepts such as rapid replacement of a pre-filled unit rather than reliance on a single refueling method in all circumstances. These design features represent an important mitigation strategy for improving practical deployability in future operations.

In response to the thermal effects of compression-based refueling, the project identified cooling time as a factor that must be incorporated into operational planning. The report also notes that these thermal effects are specific to compression-based methods and are not expected to occur with the Edge Refueler approach. This distinction is important because it indicates that the choice of refueling method can itself serve as a mitigation strategy when planning field operations and turnaround cycles.

7. Key Learnings

The project showed that hydrogen technologies can provide a practical basis for longer-endurance UAV operation when applied through an appropriate system architecture and operational concept. A central technical learning from the demonstration was that the hydrogen fuel cell system was able to provide stable baseline power throughout flight, while the hybrid battery effectively supported transient peak loads during manoeuvres and other higher-demand operating conditions. This confirmed that the demonstrated hybrid configuration was suitable for endurance-focused flight testing and that the interaction between the fuel cell and battery could be managed in a stable and predictable manner.

A further important learning was that hydrogen consumption during the endurance-related sortie followed a near-linear profile. This is significant because it provides a reliable basis for mission planning and for estimating endurance under alternative storage configurations. The project therefore demonstrated not only that the system could operate successfully in flight, but also that the recorded data were sufficiently consistent to support engineering analysis of longer-duration operation.

The demonstration also highlighted the importance of considering platform configuration when interpreting performance results. The UAV used in the project was an existing airframe originally optimised for battery-powered operation rather than for hydrogen propulsion. As a result, the project confirmed that useful endurance-related insights can be obtained from a non-optimised hybrid installation, while also showing that substantially greater performance is likely to depend on platform-level optimisation, including tank integration, system layout, and the balance between fuel cell and battery roles.

The project also highlighted several lessons about how hydrogen demonstrations should be run. It showed the importance of capturing the right operational data, of distinguishing clearly between directly demonstrated outcomes and projected future performance, and of treating refueling operations, flight testing, and analysis as closely linked but separately manageable workstreams. These lessons are especially relevant where project logistics affect how much of the intended operating concept can be demonstrated live within the available timeframe.

Finally, the work reinforced that the practical value of hydrogen in UAV applications depends not only on aircraft-level endurance, but also on operational practicality. Refueling method, accessibility of the installed system, handling procedures, and turnaround planning all influence deployability and should therefore remain central considerations in future demonstrations and future operational concepts.

8. Implications for the Hydrogen Industry

The project is closely aligned with current industry interest in practical hydrogen applications that can deliver clear operational value in sectors where conventional battery-based solutions face endurance limitations. Within unmanned aerial systems, one of the most promising near-term roles for hydrogen is in missions requiring long duration, reduced downtime, and deployment in locations where repeated battery charging or replacement is operationally restrictive. The results of this project therefore support a broader industry trend toward evaluating hydrogen not only as an energy source, but as part of a complete operational concept involving storage, refueling, turnaround planning, and field deployability.

The project is also relevant to the growing focus on advanced aerial mobility and the use of hydrogen in transport applications that contribute to decarbonisation goals. By demonstrating both a hydrogen refueling concept and endurance-related flight performance on an existing UAV platform, the project provides practical evidence that hydrogen technologies can move beyond conceptual discussion and be examined in operationally meaningful settings. In this respect, the project contributes to the wider industry effort to identify viable early use cases for hydrogen in aviation and transport.

The demonstration reinforces the role that hydrogen can play in supporting lower-emission aviation and transport applications. At the point of use, the fuel cell system generates electricity electrochemically and produces water as the primary by-product, resulting in zero direct CO_2 emissions during operation. In UAV applications, hydrogen also offers the prospect of combining low-emission operation with extended endurance and reduced interruption between missions, which can make clean-energy solutions more practical in real operational settings. For sectors such as infrastructure inspection, environmental monitoring, and remote surveying, this combination of operational utility and reduced emissions is particularly important.

From a commercial perspective, the project indicates that hydrogen-powered UAV systems have meaningful potential in applications where endurance, mission continuity, and field flexibility are more important than minimum upfront cost. At the same time, the demonstration also shows that commercialisation and scalability will depend on more than flight performance alone. Progress toward wider adoption will require practical refueling pathways, safe and repeatable operating procedures, suitable storage integration, and system architectures that are optimised for hydrogen rather than adapted only from battery-based designs. The project therefore suggests that future commercial progress will depend on coordinated development across the wider operational ecosystem, including hydrogen supply methods, refueling equipment, aircraft integration, and field maintenance concepts.

The findings also suggest several implications for future industry work. Hydrogen development efforts are likely to be most effective where they remain focused on use cases with clear endurance and deployment advantages, and where equal attention is given to refueling concepts, storage integration, and operational procedures rather than to aircraft endurance in isolation. Additional demonstration programmes that more directly integrate refueling activity and flight operations within a single field campaign would strengthen the evidence base around turnaround time, mission continuity, and operational practicality. Wider progress in this area will also depend on continued collaboration between UAV platform developers, hydrogen technology providers, operational users, and public innovation bodies.

9. Conclusion

The H2 Fuel Cell UAV Refueling Demonstration Project provided practical evidence that hydrogen technologies can support longer-endurance UAV operations through a combination of hydrogen refueling concepts and endurance-focused flight testing. The project demonstrated that a hydrogen-powered UAV system based on an existing airframe can operate in a stable and controlled manner, while also generating useful technical and operational data on hydrogen consumption, hybrid power behaviour, and system practicality.

A key conclusion from the project is that the demonstration successfully established a credible basis for assessing endurance potential and operational deployment considerations, even though the UAV platform used was not optimised specifically for hydrogen propulsion. The recorded flight data showed predictable fuel consumption and stable system performance, while the refueling workstream highlighted the practical factors that must be taken into account when applying hydrogen technologies in field conditions, including refueling configuration, handling procedures, turnaround time, and thermal effects associated with compression-based filling.

The project also confirmed that the practical value of hydrogen in UAV applications depends on more than flight performance alone. Safe and effective deployment requires attention to system integration, refueling method, maintainability, and operational planning. In this respect, the project contributed not only technical results, but also broader operational insight into how hydrogen-powered UAV capability can be demonstrated and assessed in a realistic project setting.

More broadly, the demonstration supports the future development of hydrogen-powered unmanned aviation by showing that hydrogen can offer meaningful advantages in applications where extended endurance, lower direct emissions, and reduced operational interruption are important. At the same time, the project highlighted that further progress will depend on continued optimisation of platform integration, closer coupling of refueling and flight operations, and continued demonstration of practical deployment concepts under representative field conditions.

The next steps suggested by the project include further work on hydrogen-optimised UAV configurations, continued refinement of practical refueling approaches, and additional integrated demonstrations that combine refueling operations and endurance-focused flight activity more directly within a single operational campaign. Taken together, the outcomes of this project provide a strong foundation for future technical development, operational validation, and wider industry adoption of hydrogen technologies in long-endurance UAV applications.