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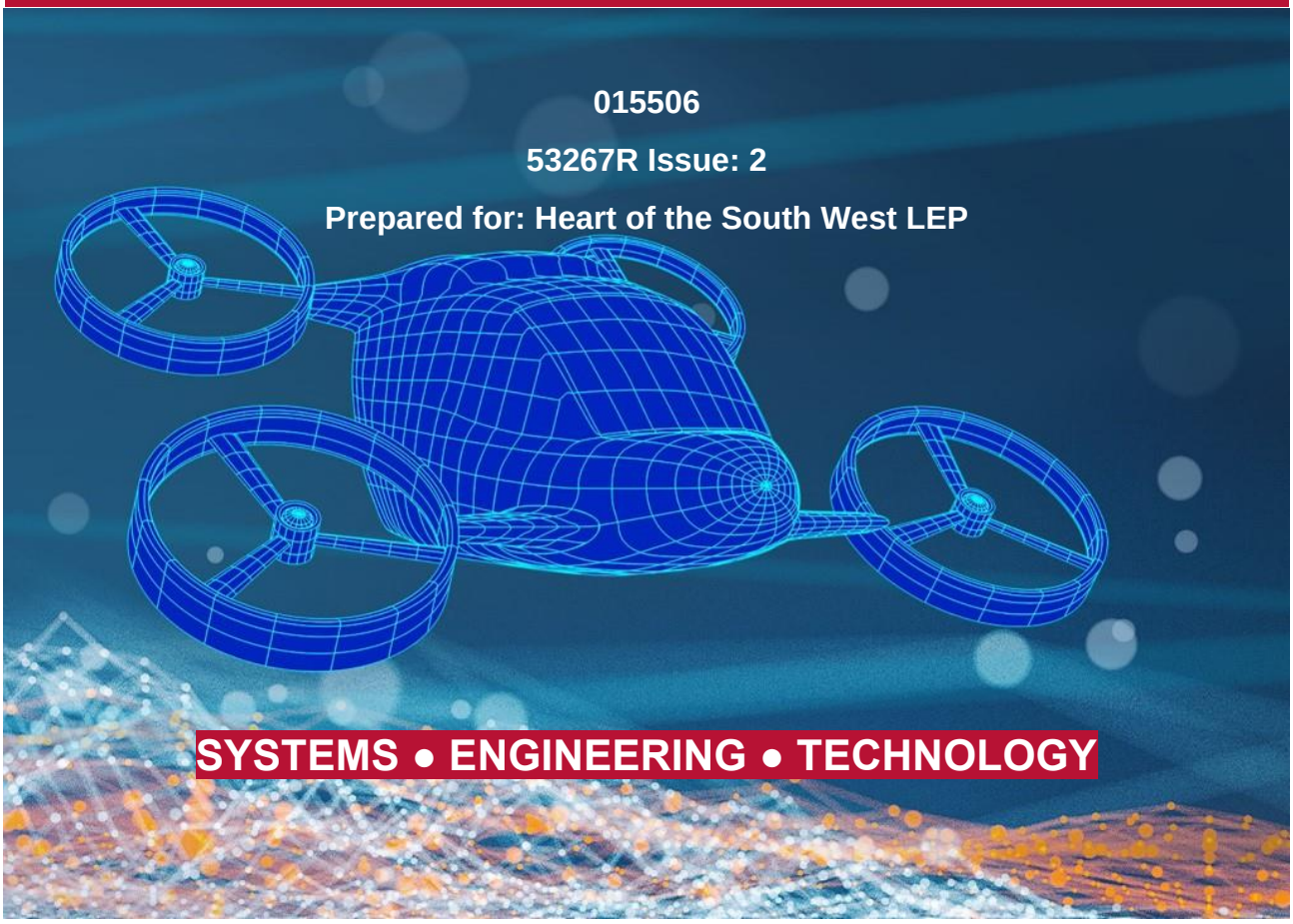
Smart and Sustainable Aviation Feasibility Study

Sustainable Aviation Testing and Demonstration in the South West

April 2022



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Smart and Sustainable Aviation Feasibility Study

Sustainable Aviation Testing and Demonstration in the South West

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Executive Summary

The aerospace industry is at a critical stage of development. We are starting to unlock the full potential of drones, we are beginning to see the emergence of a whole new class of electric Vertical Take-Off and Landing (eVTOL) air vehicles, and we are doing this in the face of a climate crisis that poses significant risk to social, economic, and environmental stability. Additionally, we are seeing developments in new aircraft architectures and new propulsion systems centred around electrical and hydrogen powertrains as the industry moves towards achieving Net Zero.

In order to enable and later certify these new aircraft and safely integrate drones into UK airspace, the aerospace industry will need to conduct a significant amount of testing and demonstration. This report is an initial exploratory feasibility study into the test and demonstration assets, facilities, and capabilities in the Heart of the South West (HotSW) region, i.e. Devon and Somerset, but with connections to other key areas such as Bristol. Some certification activities will only require minor facilities, whereas others will require more specialised infrastructure and facilities, such as alternative fuel storage and transport. When considering development in the HotSW, it will be important to make best use of existing assets and improve cohesion between different sectors using similar infrastructure, to allow for a more streamlined and cost-effective route to technology exploitation. To reach UK government targets like Net Zero by 2050, and support flourishing local, national, and international economies that are more connected, the aviation and aerospace industries will need to evolve in line with the rapid pace of development.

Organisations tend to focus on individual systems or sub-systems, but with the new classes of air vehicles pushing the requirement for a more interconnected airspace, it will be important to take a more holistic view of the whole air system and supporting ground infrastructure. All elements of the puzzle need to come together to enable the smart and sustainable future of aviation. Whilst the South West has capability in each of the necessary areas to enable testing and demonstration, it needs a strong and ambitious vision for the future that a critical mass can get behind to spark innovation, collaboration, and critically, investment. This could become the tipping point to scaling up the testing and demonstrating of hydrogen or electric aviation.

The South West Region's Potential Future Aviation Test & Demonstration Environment

The organisations in the South West region would benefit from a 'grand vision', which would be focused around a Future Aviation Test Environment as described in Section 4.1 of this report. This would expand on existing test environments to include integrated mobility through drones, eVTOL air vehicles, and commercial air traffic. Exeter is ideally situated to act as a hub for this test environment with spokes out to the key assets and expertise of Bristol, Yeovil, Newquay, Plymouth, and beyond. Exeter has direct access to a great talent pool, existing flight test areas, ground testing facilities, and energy infrastructure; all of these elements will be key for enabling the future of smart, sustainable aviation (See section 4.1 of this report). Having lost test flight capability at Filton (sold for development), an option may be to conduct test flights in a corridor between Exeter and Yeovil as illustrated by the map in Section 4.2 of this report. Such an ambitious project needs to be collaborative and inclusive; no single organisation will be able to achieve this in isolation. Investment and knowledge sharing also needs to be deconflicted across sectors to avoid repeated investment into existing assets. The project needs to scalable and open to different platforms with consideration of the whole platform lifecycle so that it can be operationalised following successful test and demonstration.

A critical piece of the decarbonised aviation jigsaw is ground infrastructure, and Exeter airport could be an ideal location to trial this infrastructure for both hydrogen and electric aviation like a 'living lab demonstrator'. This is due to its central location in terms of energy distribution, less busy airspace in comparison to neighbouring airports, levels of existing infrastructure already in place, good access to engineering talent, and close access to all aspects of new aircraft development. The future of airspace is likely to be integrated with no segregation between drones, eVTOLs, General Aviation (including light aircraft and business jets), and other scheduled commercial flights – this flight test corridor could be a way to test this in a way similar to

a physical embodiment of the CAA regulatory sandbox. Exeter has close access to all aspects of aircraft development – this differentiates the region from other national clusters that are only focused on individual systems rather than whole aircraft platforms. Another unique selling point for the region is the vertical take off and landing expertise that doesn't exist elsewhere in the UK.

Due to current levels of technology readiness, the South West should initially consider battery electric, hybrid-electric and hydrogen fuel cell aircraft. Longer haul aircraft using cryogenic liquid hydrogen, like those considered by the FlyZero project likely won't arrive until the mid 2030s so this is less of an immediate focus for the region, but future infrastructure requirements for liquid hydrogen should still be kept in mind to avoid missing out when it does arrive. Other sectors will likely require hydrogen too which further highlights the need to be collaborative and inclusive in approach. There may be a useful exercise in understanding how an airport can operate multiple fuel types in the future in an effective and safe manner. This could include exploring efficient airport layouts, understanding operational practicalities, as well as testing these using emerging aircraft technologies.

This report sets out what a grand vision project could look like for the region as well as some recommended actions for enabling it. A more detailed study into the practicalities of achieving this vison will likely be needed. A consortium like the Sustainable Aviation Programme board that represents different stakeholder groups are well placed to coordinate the necessary actions described in this report. These views have been informed by the interviews with stakeholders and subsequent analysis described in the annex of this report.

Contents

1 Project Overview 7
1.1 Background Context 7
1.2 Objectives of the Study 8
1.3 Structure of this report 8

2 Understanding the Future of Decarbonised Aviation 9
2.1 Hydrogen Powered Flight 9
2.2 Electric Aviation 9
2.3 Regulatory Requirements 10

3 Approach Towards Stakeholder Interviews 11
3.1 Summary of Study Methodology 11
3.2 Stakeholders & Overview of Organisations Interviewed 11

4 Key Recommendations for Sustainable Aviation Growth 15
4.1 The South West Needs An Ambitious Vision 15
4.2 Development of a Smart, Sustainable Aviation Test Environment 16
4.3 Summary of Key Findings 18
4.4 Recommendations For Enabling The Future Of Sustainable Aviation Testing And Demonstration In The South West 18
4.5 Recommendations by Stakeholder Group 24

5 References 27

ANNEX A - INTERVIEW NOTES 30

Introduction to Interview Notes 31
A.1 Ampaire 32
A.2 Catapult Network 35
A.3 Devon County Council 41
A.4 East Devon DC 42
A.5 Exeter Aerospace 44
A.6 Exeter Airport 46
A.7 Exeter College 49
A.8 University of Exeter – Centre for Future Clean Mobility 51
A.9 GKN Global Technology Centre 55
A.10 Hydrostar / Emerald Green Power 58
A.11 IAAPS 59
A.12 Leonardo Helicopters 61
A.13 Rigby Group 63
A.14 South Somerset District Council 64

A.15 Transport Lead LEP 65
A.16 Vertical Aerospace 67
A.17 WEAF 70
A.18 Yeovil College 72
A.19 YEW Research & Consultancy 74

1 Project Overview

The Heart of the South West Local Enterprise Partnership (HotSW LEP) has appointed Frazer-Nash Consultancy to undertake a feasibility study into the potential for smart and sustainable aviation and aerospace testing and demonstration facilities within the Heart of the South West (Devon and Somerset). The Sustainable Aviation Programme board vision provides useful context towards the aims and objectives of local stakeholders, and is discussed below in Section 1.1.

1.1 Background Context

The Heart of the South West LEP (HotSW LEP) is a business-led partnership between the private sector, local authorities, universities, and colleges, which aims to raise productivity and ensure prosperity for all through clean and inclusive growth.

To sustain and grow the South West's aerospace industry, the HotSW wants to ensure that the sector is fit for purpose and prepared to embrace a decarbonised future. This study aims to identify potential opportunities and risks associated with the necessary move towards decarbonised aviation.

1.1.1 Sustainable Aviation Programme Board Vision

To provide context for this study, the Sustainable Aviation Programme Board Vision, Aims, and, Background have been included here. Collaboration between HotSW LEP and organisations across the South West region will support the aviation and aerospace industry to prepare for the next generation of smart and sustainable flight specifically around Test & Demonstration facilities.

> *"The Sustainable Aviation Board will position the Heart of the South West to take advantage of the global ambition to decarbonise aircraft, ensuring that we exploit new markets in electrical and hydrogen propulsion and accelerate opportunities to become the centre for sustainable aviation for regional flights thus building back better."* [1].

1.1.2 Sustainable Aviation Programme Board Aims

1. To **promote** and raise the profile of the Heart of the South West's sustainable aviation opportunity nationally and internationally.
2. To **secure investment** in the sector to lead the way in innovation and technical excellence.
3. To **deliver** projects and programmes to unlock the economic potential of the sustainable aviation industry.

1.1.3 Sustainable Aviation Programme Board Background

Who are the Sustainable Aviation Board?

> "A collaboration of industry players, academia, skills providers, supply chain integrators, place makers and innovation partners convened by the Heart of the South West Local Enterprise Partnership." [1]

Why is Sustainable Aviation important to us?

> "Pre-Covid the South West Aerospace industry was valued at over £7 billion supporting 98,000 high value jobs, being recognised as the UKs most capable and diverse Aerospace region. Leonardo Helicopters based in Somerset has a unique UK specialism in rotorcraft and is the only industry prime in the UK with a complete end-to-end capability. Just in Somerset 4,300 people are employed (2,800 with Leonardo). Advanced Manufacturing employs a further 6,000 people in the County. Exeter Airport contributed £162.4 million annually to the local economy with 2,700 jobs (direct and indirect) and served just over 1 million passengers annually. It also has a significant Maintenance, Repair and Overhaul (MRO) engineering facility. The training academy previously operated by Flybe trained 651 pilots, 873 cabin crew and 120 apprentices per annum and is now leased by Exeter College.
>
> The area has an important eco-system with significant assets and institutions including the Met Office, the Centre of Future Clean Mobility, the iAero Innovation Centre as well as the proposed France – Alderney – Britain interconnector. If we are to sustain and grow this important industry for the South West we need to ensure that it is fit for purpose as the aviation sector embraces decarbonisation, or we risk losing our business competitiveness and number one ranking within the UK as the strongest aerospace sector. " [1].

1.2 Objectives of the Study

The objectives of this study are detailed below:

- Exploring the test, demonstration, facility, and technology requirements of the HotSW region;
- Identifying existing assets;
- Identifying the risks and opportunities; and
- Providing recommendations and immediate/future priorities for the region.

The recommendations included in this report aim to provide a useful guide in helping organisations in the South West understand their strategic priorities. This report is not intended to give a full literature review or study of what individual companies have to offer. Instead the focus is on developing options for the region as a whole; to identify what is missing, what people need, when people need it, and what actions need to be taken. The region can then capitalise on the assets they have, in order to attract talent and investment while contributing to the decarbonisation of this important sector. This study aims at identifying options where the best value for money strategic options may lie for the region so that in turn people want to work and invest here.

1.3 Structure of this report

This section of the report is intended to signpost the reader to the key areas of interest for the report with the expected main area of interest being the recommendations in Section 4. The general structure of the report is included below, showing the topics covered in each section. More specific page numbers can be found on the Contents Page:

- Section 1: Introduction, Context & Objectives
- Section 2: What does smart and sustainable aviation look like?
- Section 3: Methodology & Stakeholders involved
- Section 4: Key recommendations for sustainable aviation growth
- Annex A - Detailed interview findings from each stakeholder

2 Understanding the Future of Decarbonised Aviation

Upon initial analysis of the future of decarbonised aviation, the technologies involved might seem to create a more fragmented ecosystem, as aircraft will use more diverse propulsion methods such as hydrogen or electric power depending on the use case. However, the entire aviation ecosystem is expected to become more integrated, unified, and dynamic. The aviation network will likely provide an end-to-end solution, encompassing ground transport and new short-distance transport solutions (eVTOL aircraft) as part of the 3rd aviation revolution, as travel becomes increasingly connected and intermodal. There are three key system elements required to unlock this future aviation ecosystem, these are detailed below.

2.1 Hydrogen Powered Flight

The introduction of sustainable alternative fuel sources will be vital for the aviation industry to move towards Net Zero, and hydrogen powered aircraft are poised to be a solution for zero-carbon medium and long-haul flights. Within hydrogen powered flight there are two emerging methods of propulsion that are most likely to be utilised:

- **Fuel Cells** – Electrochemical generators that combine hydrogen and oxygen to produce electricity, with just water and heat as by-products.
- **Direct Hydrogen Combustion** – Burning hydrogen in a combustion engine in the same way conventional fuels are used can produce power.

There are challenges with both of these options, and in the short-term, direct combustion is more likely to be implemented, with modified gas turbines and hydrogen storage development required for use. Whereas there are greater technological barriers to using fuel cells including durability and reliability. Whilst direct hydrogen combustion enables the achievement of a gross net-zero carbon target, of the two technologies, only fuel cells achieve true zero emissions aircraft [2], as combustion with air leads to the production of Nitrogen Oxides.

As part of the move towards hydrogen powered flight, it is anticipated a comprehensive production and supply chain system will need to be fully embedded within the aviation network. Airports with a large amount of available space will likely take advantage of on-site production, electrolysis, liquefaction, and storage capabilities, whilst a robust logistics network that contains pipelines, shipping routes, trains, and trucks will need to be built up to ensure liquid hydrogen can be delivered to airports which cannot accommodate production facilities [3]. Further to this, ground support equipment (forklifts, refuelling vehicles, etc.) are expected to be decarbonised through use of hydrogen or electric power, with a medium sized airport requiring around 15 fuel trucks per day [4].

The development of supporting infrastructure network will be one of the key enablers to facilitating the widespread uptake of hydrogen technologies. The impact is that widespread implementation will be required before the technology becomes truly viable. However, different aircraft types will have varying entry into service (EIS) dates, allowing a more phased approach for the introduction of hydrogen and its associated infrastructure network. For example, local airports / airfields hosting smaller aircraft could develop hydrogen infrastructure first (due to a closer EIS date) with larger airports accommodating hydrogen passenger airliners further down the line.

2.2 Electric Aviation

A second key technology that will see significant widespread use is electric aircraft. This will encompass everything from small autonomous drones to regional and international aircraft and the rise of what is known

as Advanced Air Mobility (AAM). Due to the challenges around low power density of battery technologies at present, it is unlikely that medium and long-haul aircraft will become electrically powered in the near future.

AAM encompasses short range eVTOL aircraft that provide a new urban air mobility dimension to the aviation network. This technology is approaching the latter stages of technology readiness, with companies as Vertical Aerospace, Joby Aviation and Archer, all creating AAM solutions with significant backing from the aerospace industry, with Vertical Aerospace having a pre-order book worth $5.4bn [5]. AAM technologies will be integrated into some existing airport systems, but also into new vertiports that open up a truly urban aviation network. A key anticipated issue of a more active urban network with both drones and AAM technologies is how the airspace will be managed. This requires a more dynamic and unified traffic management network to allow for interoperability. AAM systems will also be sharing the airspace with other electric aviation technologies including Uncrewed Air Systems (UAS) being used for a wide range of applications such as middle and last-mile logistics.

As with hydrogen propulsion, infrastructure network improvements are required in order to enable widespread use of electric aircraft. There are several options for charging electric aircraft: fixed charging infrastructure, mobile charging vehicles to supply electricity without needing to install any infrastructure, and battery hot swapping to eliminate the need to wait whilst the batteries recharge. Whilst battery hot-swapping may give electric aircraft a very quick turn-around, all these approaches have the issue of integrating charging stations into airports, with current ground infrastructure and power management within airports not being sufficient to support a large electric fleet [6].

Whilst a well-developed power distribution network exists, in its current form it is ill-equipped to provide power for an entire fleet of electric aircraft so adjustments will need to be made. In a similar way to hydrogen power, there is the potential for airports to have their own on-site renewable energy production facilities in the form of solar or wind farms [6]. Not only does this reduce load on the grid but allows for excess energy to be sold back to the grid and enables better peak load management. One further area that may be explored to tackle this issue is vehicle-to-grid storage where the vehicle batteries are used as additional grid storage when not being used for flight [6]. There is however some scepticism about this option as this limits the usable battery life for flight operations which has raised safety concerns from aircraft manufacturers.

2.3 Regulatory Requirements

Finally, the development of regulations is an essential enabler to decarbonised aviation. New airworthiness standards that enable rapid introduction of new technologies in a safer and assured manner need to be created, with a supportive policy and regulatory environment, consistent with key focuses on Safety, Environment, and Security being critical to success.

One example is with urban aviation regulation and legislation regarding noise levels and safety of use cases of autonomous drones and AAM. Other aspects where appropriate regulation is necessary include safety when interacting with these new technologies, for example, hydrogen poses different hazards to ground crew than conventional aviation fuel due its cryogenic nature. Furthermore, the fire risks it poses are not the same as for Jet A-1 aviation fuel [3]. This adds a whole new dimension to airport and airfield safety. To account for this, a step change in safety understanding is required, which needs to be reflected in relevant regulations. Standardisation of regulations on an international level could improve and accelerate regulatory development in this area.

It is worthwhile noting that it would be highly beneficial for the stakeholders of the Sustainable Aviation Program Board to research and explore each of the above mentioned themes further so that the region is equipped with the most up to date knowledge when decision making. There is a vast quantity of readily available information on each of these topics that would be useful in developing the understanding of the future of aviation testing and demonstration.

3 Approach Towards Stakeholder Interviews

3.1 Summary of Study Methodology

Following attendance at a Sustainable Aviation Programme board meeting, Frazer-Nash worked with the HotSW LEP to down-select a suitable set of stakeholders. An initial correspondence was sent out to confirm that each of the groups were willing to be part of the study. After receiving notice back from the organisations that had been contacted, interviews were set up lasting approximately 1 hour each to discuss the testing and demonstration proposition in the South West. A set of interview summaries at the end of this report are not intended to give a full detailed record of the interviews held, and instead provide a high-level overview of the key challenges and opportunities identified and discussed.

Each interview also provided the opportunity to identify any additional organisations in the region that had been omitted the initial list that could contribute to the study.

To inform the study, Frazer-Nash engaged key stakeholder groups to collect their views on existing capabilities and assets, as well as identify capability gaps and opportunities. These conversations allowed the identification of potential actions (or inactions) to help keep the region on track in line with the Sustainable Aviation Program board goals. The study has collected views from key stakeholder groups including:

- Aerospace Manufacturers & Industry;
- Further Education Institutions, STEM students & Training Providers;
- Academia & Research Groups;
- Airports;
- Local Government including district and county councils with planning authority;
- National Research & Development Networks (e.g. Catapult Network);
- Independent Aerospace Specialists; and
- Maintenance Repair and Overhaul (MRO) organisations.

It is important to note that through discussions with the above stakeholder groups, there was a significant variation in the levels of understanding of current and future technologies or projects. If the South West region is to promote aerospace and support job creation, it would be beneficial to bridge this gap and baseline the levels of understanding the key challenges and opportunities. The Sustainable Aviation Programme Board would be the ideal platform to enable this.

3.2 Stakeholders & Overview of Organisations Interviewed

The stakeholders (listed in Table 1 below) represent views from: Aerospace Manufacturers & Industry; Further Education Institutions, STEM students & Training Providers; Academia & Research Groups; Airports; Local Government; National Research & Development networks; Independent Aerospace Specialists and Maintenance Repair and Overhaul (MRO) organisations. These stakeholders were chosen from an initial list identified by the Sustainable Aviation Programme board. The list is representative of several different perspectives in the aerospace and aviation sectors and as such the interviews with these organisations capture many of the risks and opportunities in the region. Each of the stakeholder groups will play an important role in the future aviation system of systems; it is important to take a holistic view when concerned with the future of mobility.

Views from the Civil Aviation Authority (CAA), Air Navigation Service Providers (ANSPs), and Energy Distribution Networks have not been included in this study, but it is worthwhile exploring these further in the future. It is worthwhile collecting a view from an ANSP like NATS and a regulatory body like the CAA to

understand their views on the challenges and more importantly the opportunities for testing and demonstration in the South West. It may also be worthwhile engaging with other sectors like the automotive and energy industries to ensure work isn't repeated as there are likely options for mutual benefit and knowledge sharing across industries. There needs to be a cross-sector deconfliction of effort and investment if the region is to reduce any unnecessary cost or delay. It will be important for most stakeholder groups to gain an understanding of the specific energy requirements, energy supply, and distribution infrastructure needed for the future aviation system of systems as this is a critical piece of the puzzle that must not be overlooked.

Table 1 - List of Stakeholders engaged in this study

Stakeholder Group	Name	Brief Description	Location	Interview Date
Aerospace Manufacturers & Industry	Ampaire	Ampaire is developing high performance, zero emission aircraft to transform the landscape of aviation. They are part of the Future Flight Challenge projects 2ZERO and SATE.	UK & Global	21/03/2022
	GKN Aerospace	GKN Aerospace is a multi-technology Tier 1 aerospace supplier. GKN are leading the H2GEAR project.	Bristol	28/02/2022
	Hydrostar / Emerald Green Power	Hydrostar are primarily concerned with Electrolyser and Electrolyte development while Emerald Green Power's focus is developing green power sites.	Global	18/03/2022
	Leonardo Helicopters	Leonardo Helicopters is based in Yeovil, with ~2,800 employees producing helicopters on site such as the Super Lynx 300, AW159 Wildcat, and AW101 Merlin.	Yeovil	22/02/2022
	Vertical Aerospace	Vertical Aerospace are an electric vertical-take-off-and-landing (eVTOL) aircraft developer.	Bristol	28/02/2022
Further Education Institutions, STEM students & Training Providers	Exeter College - Future Skills Centre	Further Education College based in Exeter.	Exeter	15/03/2022
	Yeovil College	Further Education College based in Yeovil.	Yeovil	28/02/2022
Academia & Research Groups	University of Exeter - Centre for Future Clean Mobility	Developing new hybrid and electric powertrain technology for cleaner mobility.	Exeter	18/02/2022
	IAAPS	As a subsidiary of the University of Bath, IAAPS focuses on advanced propulsion systems.	Bristol / Bath	24/02/2022
Airports	Exeter Airport	An international airport located in East Devon.	Exeter	18/02/2022
	Rigby Group	The Rigby Group is a parent company of several companies working in technology, finance, real estate, aviation, hotels and more. They own Bournemouth Airport, Coventry Airport, Exeter Airport and Norwich Airport, and operate Blackpool Airport and Solent Airport Daedalus on behalf of their owners.	UK & Global	14/03/2022 & 17/03/2022

Stakeholder Group	Name	Brief Description	Location	Interview Date
Local Government	Devon County Council	Devon County Council is the county council administering the English county of Devon. The council covers the non-metropolitan county area of Devon.	Devon	23/02/2022
	East Devon District Council	District Councils provide core local services, including economic development, planning, housing, leisure, wellbeing and environmental services for local communities.	Devon	23/02/2022
	South Somerset District Council	District Councils provide core local services, including economic development, planning, housing, leisure, wellbeing and environmental services for local communities.	Somerset	28/02/2022
National R&D networks	Connected Places Catapult	The Connected Places Catapult is focused on accelerating innovation in cities, transport, places and connectivity. They work across a diverse set of projects, providing 'innovation as a service'.	UK Wide	25/02/2022
	National Composites Centre	The National Composites Centre is one of the centres that form the UK's High Value Manufacturing Catapult. It works globally to accelerate the adoption of high-value, sustainable engineering solutions in composites.	Bristol	16/03/2022
Independent Aerospace Specialists & Other	Transport Lead LEP	The Heart of the South West Local Enterprise Partnership (LEP) is a business-led partnership between the private sector, local authorities, universities and colleges. Frazer-Nash interviewed the transport lead for the LEP.	Devon & Somerset	24/02/2022
	YEW Research & Consultancy	Frazer-Nash interviewed an independent aerospace sector specialist from YEW Research & Consultancy. They are supporting projects aiming to improve the competitiveness and productivity of the aerospace sector, particularly driving innovation. YEW Research & Consultancy works with a broad range of stakeholders, including industry representatives, local governments, universities and other partners.	Bath	04/03/2022
	WEAF	The West of England Aerospace Forum (WEAF) is a membership trade association that champions and supports the interests of the aerospace and defence industry in the South West of England.	Bristol	21/03/2022
Maintenance Repair and Overhaul (MRO) organisations	Exeter Aerospace	A subsidiary of Dublin Aerospace, Exeter Aerospace performs Base Maintenance services on a variety of aircraft from their facilities at Exeter Airport.	Exeter	16/03/2022

4 Key Recommendations for Sustainable Aviation Growth

This section of the report is split into 5 sections. Section 4.1 describes the grand future aviation test environment project idea. Section 4.2 outlines the proposed development of a potential Sustainable Future Aviation Test Environment. The Section 4.3 summaries the key findings followed by Section 4.4 outlining short, medium, and long term recommendations for the HotSW LEP. In Section 4.5, the report provides details on recommendations broken down by stakeholder groups. These recommendations have evolved from analysis after the interviews.

4.1 The South West Needs An Ambitious Vision

The organisations in the South West region would benefit from a 'grand vision' project, which could be along similar lines to the Sustainable Aviation Test Environment (SATE) that is in Scotland. This ambitious project could be a South West replication of the SATE but developed to include integrated mobility with drones, eVTOL air systems, and commercial air traffic. This could be centred around Exeter airport as it is ideally located as an energy hub, it has access to a good talent pool, and has existing flight test areas. Test flights could be conducted in a corridor between Exeter, Newquay, Yeovil, and beyond, as illustrated by the map in Section 4.2. Further exploration of a business case, investment and action plan will be needed to refine the requirements of such an ambitious project like this.

An important piece of the puzzle is ground infrastructure and Exeter airport could be an ideal location to trial this infrastructure for both hydrogen and electric aviation like a 'living lab demonstrator'. This is due to its central location in terms of energy distribution, relatively quiet airspace, levels of existing infrastructure already in place, good access to engineering talent, and close access to all aspects of new aircraft development. The future of airspace is aiming towards a non-segregated approach between drones, eVTOLs, General Aviation, and other commercial flight vehicles. A flight test corridor could be a way to test this similar to a physical embodiment of the CAA regulatory sandbox. Exeter is also ideally placed with close access to all aspects of aircraft development detailed in the lists below:

Aerospace & Aviation

- Wing Design
- Fuel Systems
- Landing Gear
- Avionics
- Thermal Systems
- Whole Aircraft Design & Test
- Air/Gas systems
- Electrical Systems
- Flight Trials
- Composites
- Gas Turbines
- Advanced Propulsion
- Digital technologies
- Simulation
- Ground & Flight Testing

Electrical Power

- Solid state Control
- Actuation
- Battery Storage use
- Electrical motors
- Marine Propulsion
- Auto and Land power systems
- Ground & Flight testing

Emerging Zero Emission Clusters

- Hydrogen
- Production and transmission
- Aircraft Fuel cell systems
- Storage
- Ground support
- Transport

This test hub could be in the form of a 'living lab demonstrator'. It would also be an ideal location to support apprentices, undergraduates, and PhD students. They would be able to work with industry professionals to upskill on new technologies. To do this, the airport would need technology partners with cross-sector experience to aid them in understanding the technical challenges and specific requirements. The benefits described here are not intended to form an approach to implementing an ambitious project but could serve as a useful indicator alongside the recommendations to develop a robust investment strategy and action plan.

The benefits such a 'grand vision' would bring include:

- A test location for sustainable aviation including hybrid, electric and hydrogen flight
- A test location for integrated airspace
- A location for developing skills and training engineers on future flight technologies
- Job creation and improved public perception of new technology
- First mover advantage – other areas can then replicate and join up to form a network
- A regulatory testing ground to help aircraft developers certify their systems
- Encouraged innovation and sustainability. As well as increased opportunities for collaboration between universities, engineering design hubs, MRO, airports, energy
- Development and proving of ground infrastructure that is critical to enabling the future of flight
- High profile projects like this could attract talent and investment to the region
- Demonstration of air and ground integration
- Facilitates potential options for later commercialisation, manufacturing and upscaling

This 'grand vision' project suggestion is ambitious, and as such, comes with associated risks. Some of the key considerations would include:

- Cost
- Technically challenging
- Available resource to coordinate and deliver a project of this scale could be limited
- A project of this scale will likely take a long time to implement
- Other areas may look to do similar projects meaning the South West receives less investment, though there is benefit to different areas replicating a blueprint to eventually join up into a connected system of systems

4.2 Development of a Smart, Sustainable Aviation Test Environment

Figure 1 demonstrates how Exeter can act as central hub in the development of a sustainable test environment in the South West. This hub at Exeter must not act in isolation, it may need to be connected to nodes at Yeovil and Bristol etc to leverage the full capabilities and assets that exist in the region. Exeter has close geographical links to local industry, skills centres, and academia, allowing for local talent to be used effectively, whilst promoting economic growth in the region. It is well supported by local and future infrastructure, including airports, motorways, energy production and distribution infrastructure, and the future space port. The potential land and sea flight corridors provide access to the identified flight-testing areas from each of the key locations in the South West, and utilise a less busy airspace. These areas could be used for both uncrewed and crewed vehicle testing.

Exeter has good intermodal transport links and the close proximity to Bristol also allows for enhanced national and international links. The close links to Bristol also provide a good feedback loop to the existing engineering knowledge and assets that exist there such as the GKN GTC, IAAPS, NCC and Airbus. The region as whole has capability to develop each aspect of a whole aircraft platform.

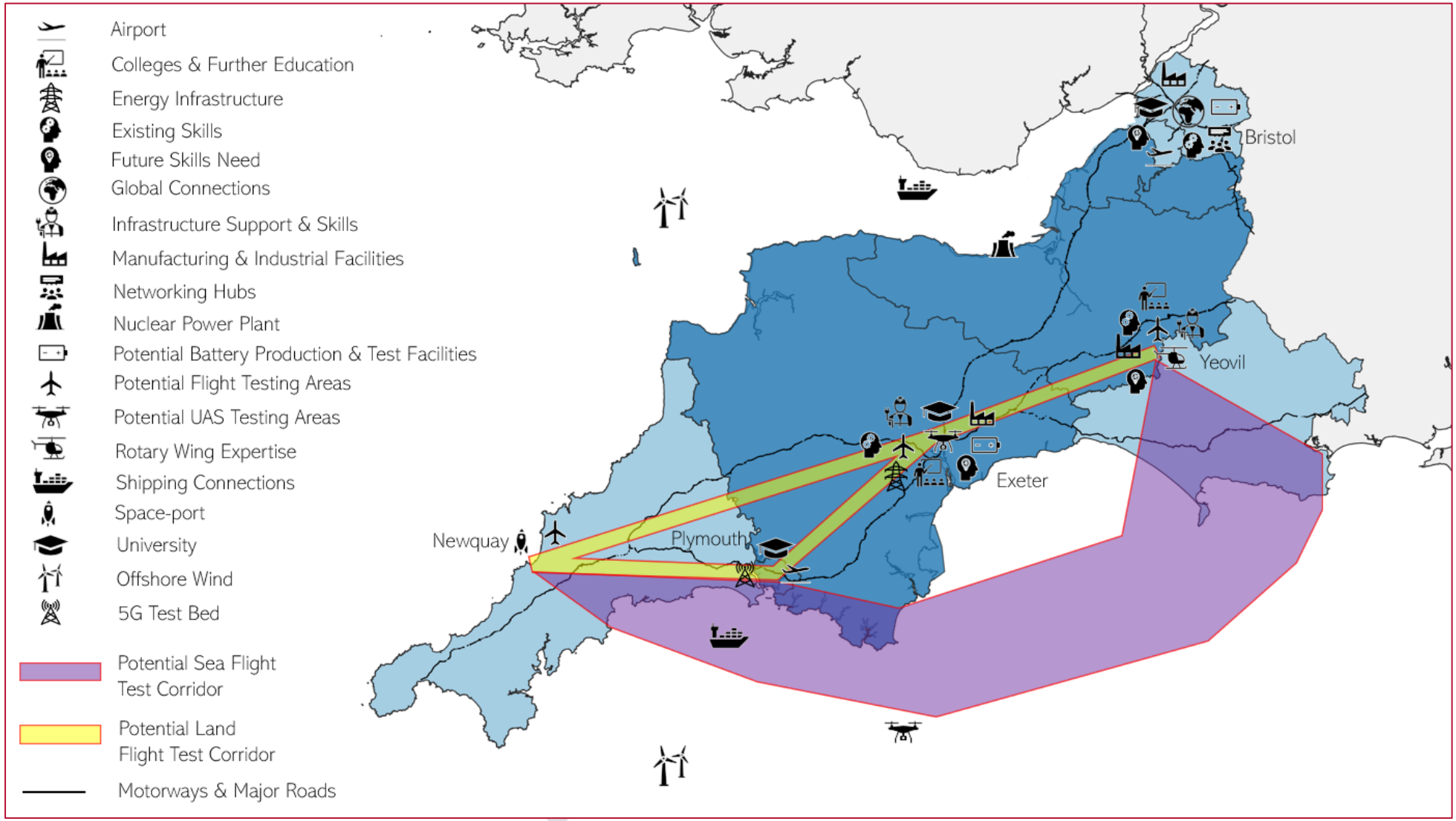

Figure 1. Key infrastructure in the South West highlighting the potential for a sustainable test environment.

4.3 Summary of Key Findings

This section of the report outlines the key findings from the stakeholder engagement and supporting research. They have been broken down into Short-, Medium-, and Longer-Term suggestions that will help enable the South West's ambitions to stimulate regional economic productivity. As a guideline, the short-term suggestions are generally considered to be feasible within 6 to 11 months, the medium-term suggestions within 12-30 months, and the longer-term recommendations around 31+ months. There will likely be exceptions to these guide timeframes as certain technologies get accelerated and plans expedited. This is broadly in line with guidance for EIS dates for certain technologies like hydrogen demonstrators and an estimation of the implementation challenges associated with each recommendation. These are framed as recommendations for the HotSW LEP and Sustainable Aviation Programme Board but some may apply to other groups as well as indicated in Section 4.5 of this report. It is worth noting that the longer-term recommendations tend to carry more risk due to the longer timescales and higher costs involved.

It is important for the region to think ambitiously in order to secure investment and talent but also to ensure successful delivery of sustainable aviation testing and demonstration programmes and later operationalisation of those aircraft. The South West is a recognised hub for aerospace and these recommendations aim to build on that status to cement the region at the forefront of innovation and development. Now is a perfect time to capitalise on the region's assets. The challenges to overcome are all parts of a complex system of systems and often this means they cannot be tackled in isolation – every piece needs to come together in the right way to achieve the sustainable transition. The aerospace sector within the Devon and Somerset region would benefit from calling on complimentary support from areas like Bristol.

4.4 Recommendations For Enabling The Future Of Sustainable Aviation Testing And Demonstration In The South West

Table 2 summarises the recommendations for implementation by Heart of the South West LEP and the Sustainable Aviation Programme board, to enable sustainable aviation growth in the region. These recommendations were informed by each of the interviews detailed in the Annex of this report. The recommendations can generally be grouped into those affecting the grand vision project, air and ground infrastructure, skills pipeline, management, further technical research, and financing. We have assessed the relative ease of implementation with a red, amber & green scale. Red suggests that it is relatively harder to implement while green is assessed as relatively easier low hanging fruit and amber is in the middle. Recommendations marked as red often require inputs from other sources like investment whereas, green or amber items tend to have less external dependencies. The recommendations highlighted as red still present significant opportunity to the region and though challenging to implement are worthwhile doing.

Table 2: Short-, Medium-, and Long-Term Recommendations for HotSW – Red, Amber Green (RAG) Assessment

Timeframe	Code	Recommendation	Relative Ease of implementation (RAG)
Short *Further research, securing investment and collaboration*	**S1**	**Explore and understand energy provision, distribution & supply.** ▸ Engage organisations like Western Power, National Grid and UK power Network Services to understand the energy challenges for scaled up testing and demonstration. ▸ Engagement with technology partners such as Emerald Green Power to under practicalities of what is possible against what is required in terms of energy supply and distribution. ▸ Understand Demand and Distribution potentially through modelling. This includes understanding the demand for individual aircraft as well as for whole fleets of mixed aircraft types. ▸ Identify the skills needed for the energy sector and how this affects integration with aviation.	
	S2	**Develop communications between technical, economic, local government and energy supply partners to better understand the requirements and commercial business case.**	
	S3	**Coordinate technology and engineering partnerships with airports to allow knowledge sharing and development of a robust understanding of the technical requirements for testing electric and hydrogen aircraft.** ▸ It would be useful for the Sustainable Aviation Programme Board and other stakeholders in the South West to get up to speed with latest industry developments, for example the outputs from the recently published Aerospace Technology Institute and CPC Zero Emission Flight Infrastructure reports [6], [3], [7], [8] & [9]. ▸ Facilitate workshops or learning sessions on future flight technology to upskill key decision makers. ▸ This should capture testing of different scale platforms including large and small as well as the ability to support multiple platform types e.g. hydrogen vs electric.	

Timeframe	Code	Recommendation	Relative Ease of implementation (RAG)
	S4	**Identify potential funding routes, e.g., UKRI, Innovate UK, CPC, ISCF, EPSRC, Faraday Challenge.** ▸ Help organisations to seek and apply for this funding. ▸ This should include commercial opportunities and not just government grant funds. ▸ It is worth noting that the Aerospace Technology Institute and the National Aerospace Technology Exploitation Programme (NATEP) have both recently announced new funding [9] [10].	
	S5	**Continue to engage industry and academia across the region to promote cross-sector collaboration and avoid repeated investment.**	
	S6	**Explore how drones can be used to fill the gaps in capability today.**	
	S7	**Explore collaboration options with the Plymouth 5G test bed for drone or sustainable aviation testing.**	
	S8	**Potential further work to explore the Economic Impact of the existing assets in the region.**	
	S9	**Explore the new potential hydrogen clusters in the South West** ▸ Such as at Bristol Airport.	
	S10	**Close Engagement with NATS and CAA to understand their views on test flying in the area.**	

Timeframe	Code	Recommendation	Relative Ease of implementation (RAG)
	S11	**Identify and further explore an ambitious 'grand vision' project that the region can rally behind** – this should be focused around the region's cross-disciplinary capability by developing something like a sustainable flight test hub including vertical lift with integrated airspace. It should consider both the aircraft and ground infrastructure aspects but could also be extended to include manufacturing and more. Further more detailed research is needed here. ▸ This will also help to inform a robust business case. ▸ It will also help to inform the necessary stakeholders to bring into a potential consortium to deliver the project with coordination from the HotSW LEP or other authorities. ▸ This also includes identification and continued development of new aircraft platforms to support electric or hydrogen aviation.	
	S12	**Continue to promote STEM subjects particularly those associated with future flight technologies at schools, colleges and universities in the region.** This will help to build a future workforce pipeline.	
	S13	**Develop an action plan or strategy for securing investment and then implementing the grand vision project in Recommendation S11.**	
	S14	**The HotSW LEP should work with local government and regulatory bodies to promote sustainable aviation, Advanced Air Mobility, support agile regulation.**	
Medium *Getting the skills and plans in place*	**M1**	**Continued refinement of the business case developed for the grand vision project in Recommendation S11.**	
	M2	**Develop a refreshed regional industrial strategy that focuses on hydrogen and electric across sectors.** ▸ Review the documents here: [6], [3], [7], [8] & [9].	

Timeframe	Code	Recommendation	Relative Ease of implementation (RAG)
	M3	**Develop a regional strategy for upskilling and training people from apprentices, through to PhDs in the 'future proof' skills like Electrical, Control & Instrumentation, Data, Hydrogen, Simulation etc.** New platforms will have more complex avionics systems than previous platforms – this will require more software assurance and certification. ▸ Development of university sponsored courses or applied training courses at colleges that are focused on future flight technologies like urban air mobility and uncrewed air systems. Cranfield University is a good example of this. ▸ Coordinate Further Education colleges, universities and students to get exposure of future flight technologies in industry or research centres across the South West. These education providers should aim to incorporate collaborative elements of learning from other providers in their curriculum to promote cross-discipline working. ▸ This should incorporate learning from experienced engineers too so that traditional skills and knowledge isn't lost.	
	M4	**Continue engagement with students early on to promote and encourage STEM subjects.**	
	M5	**Conduct a detailed exploration of the requirements for this grand scale project** ▸ This will help to down-select the most feasible options thereby maximising return on investment. ▸ This includes identification and potential allocation of land for things like the development of flight testing, electric or hydrogen testing facilities, hangars, offices, employment land or energy production near Exeter airport.	
	M6	**Explore the impact of and demand for Sustainable Aviation Fuels in the region.**	
	M7	**Identify potential options for a manufacturing facility ideally co-located with a test flight facility.**	
	M8	**Explore feasibility and options for developing an Environmental Test bed for cryogenics etc.**	
	M9	**Develop understanding of inter-modal transport links** ▸ e.g. what is already being done for road and rail? Is there an existing hydrogen production and test facility?	

Timeframe	Code	Recommendation	Relative Ease of implementation (RAG)
Long *Further implementation and action*	**L1**	**Develop and implement a longer-term resourcing plan focused on electric and hydrogen aviation skills.** ▸ Collaborate with universities, colleges, industry and government to do this.	
	L2	**Bring together a consortium to start implementing the grand vision plan identified in Recommendations S11, M1) and S13).** This ambitious project should consider the need for a shared flight test facility and integrated infrastructure. Initially it could be in the form of a living lab demonstrator where skills can be taught, and innovation can be proved.	
	L3	**Explore further requirements for transitioning long-haul aviation to a more sustainable solution through liquid hydrogen and other enabling technologies.** Entry into service for liquid hydrogen aircraft is expected to be around 2035 so the majority of the efforts before this will be focused on fuel cells and battery or hybrid electric aircraft.	

4.5 Recommendations by Stakeholder Group

As detailed in Section 3.2 of this report, the stakeholders that were interviewed have been grouped into categories that represent different aspects of the future aviation system of systems. This section of the report details a quick headline summary view on the actions and recommendations from each particular group based on the analysis after each interview.

4.5.1 Aerospace Manufacturers & Industry

The aerospace and aviation sectors need to continue to push towards developing zero emission aircraft and supporting infrastructure. This means promoting innovation and collaboration for the mutual benefit of all parties. They should aggressively strive towards decarbonisation in everything they do; this includes reduction of their Scope 1, Scope 2, and Scope 3 emissions[1]. Specific to testing and demonstration, they need to accelerate the development of technology solutions and understand the route to certification. Organisations that understand this well should help to encourage knowledge sharing in the wider engineering community. This will require significant investment and fundamental understanding of the challenges faced. Knowledge needs to be shared to overcome the barriers and to ensure investment is optimised and not repeated. The future of smart and sustainable aviation will require high level systems thinking to integrate a diverse set of skills and solutions. It will become increasingly important to draw on skills from outside of aerospace e.g. from the automotive and energy sectors.

- ***Example organisations, assets, experience and facilities in the region that support these recommendations are: Leonardo Helicopters including their flight test telemetry facility; GKN Aerospace's Global Technology Centre; Airbus's Wing Testing Facility, the National Composites Centre, Exeter Aerospace, Ampaire and Vertical Aerospace. For more information on each of these please refer to the annex of this report.***

4.5.2 Further Education Institutions, STEM students & Training Providers

The education challenge is significant – it is difficult to teach skills that don't yet exist. New aircraft platforms are being built with more sophisticated avionics and propulsion systems than ever. This will require a different set of skills to engineers from the past. There will be more focus on electrical control and instrumentation, power electronics, batteries, cryogenics, fuel cells, whole aircraft systems thinking, assurance, cyber security, digital, Industry 4.0, and more. Manufacturing, mechanical, and materials engineering will remain critical to enabling smart aviation, but most of these skills already exist in the area. It is essential for schools and colleges to engage students with STEM subjects early on and give them exposure to industry. They also need to continue to work closely with universities and industry to effectively 'future proof' the curriculum. There needs to be financial incentives to attract teachers to deliver the right courses, and investment to equip these teachers with the tools and facilities they need to deliver the high standard of training required.

- ***Example organisations, assets, experience and facilities in the region that support these recommendations and the region's proposition include but are not limited to: Yeovil College, Exeter College, the GW4 University alliance (Bristol, Bath, Cardiff & Exeter), the South West Institutes of Technology, Weston College, Bristol UWE and more. For more information on each of these please refer to the annex of this report.***

4.5.3 Academia & Research Groups

Universities and research groups need to continue to push decarbonisation as a priority on their agenda. They need to play the supporting role of offering highly skilled engineers for simulation, modelling, assurance, analysis, design, and testing of new air vehicles. The facilities available at research centres will be a highly valuable resource to developers looking to do ground testing and de-risk their flight programmes. The intangible

[1] https://www.carbontrust.com/resources/briefing-what-are-scope-3-emissions

assets that universities bring to the table is significant and global collaboration amongst their networks and the region should be leveraged to deliver a sustainable flight testing hub. Research facilities may need investment to ensure they have all the necessary equipment to understand and model the future aviation system of systems. University curriculums should be updated to include future of flight technologies like hydrogen and electric propulsion. There are emerging MSc courses in Advanced Air Mobility and future technologies that are endorsed by the aerospace and aviation sectors. Academia in the South West should look to replicate these types of courses.

- ***Example organisations, assets, experience and facilities in the region that support these recommendations and the region's proposition include but are not limited to: the University of Exeter's Centre for Future Clean Mobility, the Institute for Advanced Automotive Propulsion (IAAPS), the National Composites Centre, the South West Institutes of Technology, The GW4 University alliance (Bristol, Bath, Cardiff & Exeter) and national networks like UKRI or the Connected Places Catapult, For more information on each of these please refer to the annex of this report.***

4.5.4 Airports

Airports are enablers to the green aviation revolution; they have the space and willingness to adapt but are constrained by cost and limited understanding of the practicalities of integrating future solutions with existing systems. They need financial and technological backing or partnering to meet the decarbonisation challenge. Developing appropriate supporting ground infrastructure is as important as improving the airspace. Airports will need to facilitate upgrades to this infrastructure with support from energy networks, airline operators, and technology providers. It will be important to get views from air navigation service providers and regulators to understand their perspective on testing and demonstration.

- ***Example organisations, assets, experience and facilities in the region that support these recommendations and the region's proposition include but are not limited to: Exeter Airport, Leonardo Helicopters flight test area at Yeovil, the Rigby Group, Bristol Airport and Exeter Aerospace. For more information on each of these please refer to the annex of this report.***

4.5.5 Local Government

Councils and local authorities will provide a pivotal role in supporting organisations access and develop employment land for future flight purposes. They should continue to support businesses in softer ways with enterprise packages and knowledge sharing networks. It would be beneficial for the government and authorities to help organisations seek and apply for funding. Promoting sustainability and smart aviation across their communities will be key to helping improve public perception of things like drones, eVTOLS, or hydrogen aircraft. By developing a better understanding of the challenges and solutions in aerospace and aviation the authorities would be able to coordinate infrastructure and energy projects across multiple sectors better. Councils can effectively act as the touchpoint between the aerospace industry, airports, colleges, other industries and national critical infrastructure organisations. Support from councils to help reduce the skills shortages will be essential to ensuring the right people are in the right place to work on testing and demonstration in the South West.

- ***Example organisations, assets, experience and facilities in the region that support these recommendations and the region's proposition include but are not limited to: Somerset & Devon District and County Councils and The Heart of the South West LEP. These should also be supported by central government and industry bodies like the West of England Aerospace Forum (WEAF). For more information on each of these please refer to the annex of this report.***

4.5.6 National R&D networks

Research and development organisations like the Catapult network need to continue promoting innovation and collaboration. They can help to fund key technical programmes as well as help to address current skills and knowledge gaps. These networks could also help to coordinate the necessary consortia required to deliver the cross-disciplinary challenge of sustainable aviation. The organisations looking to drive testing and demonstration in the South West should look to these R&D networks for examples of technology, innovation, knowledge pools and collaborative working. These networks can help to accelerate key technology projects in line with testing and demonstration programmes. There will likely also be a role for them to support with economic and demand modelling later down the line.

- ***Example organisations, assets, experience and facilities in the region that support these recommendations and the region's proposition include but are not limited to: the Connected Places Catapult, the National Composites Centre, the Advanced Manufacturing Research Centre, the GKN Global Technology Centre, universities, iAero and more. For more information on each of these please refer to the annex of this report.***

4.5.7 Maintenance Repair and Overhaul (MRO) organisations

For testing and demonstration purposes, the maintenance and repair requirement will be relatively small but as aircraft start to be commercialised MROs will play an ever-important role. Their facilities will need upgrading in line with future flight technology development and likewise their staff will need upskilling to meet updated regulation.

- ***Example organisations, assets, experience, and facilities in the region that support these recommendations and the region's proposition include but are not limited to: Exeter Airport, the Rigby Group and Exeter Aerospace. For more information on each of these please refer to the annex of this report.***

5 References

[1] Sustainable Aviation Programme Board, “Sustainable Aviation Strategy,” 2021.

[2] Airbus, “Airbus Hydrogen Future Aviation,” 2021. [Online]. Available: https://www.airbus.com/sites/g/files/jlcbta136/files/2021-07/airbus_hydrogen_future_aviation_1P%20%281%29.pdf. [Accessed 2022].

[3] ATI FlyZero, “FlyZero Reports,” 2022. [Online]. Available: https://www.ati.org.uk/flyzero-reports/ . [Accessed 2022].

[4] “Integration of Hydrogen Aircraft into the Air Transport System: An Airport Operations and Infrastructure Review,” Aerospace Technology Institute, Cranfield, 2021.

[5] “Avolon exceeds pre-order,” Vertical Aerospace, 29 March 2022. [Online]. Available: https://vertical-aerospace.com/wp-content/uploads/2022/03/VerticalAerospace_PressRelease_220329.pdf. [Accessed April 2022].

[6] Connected Places Catapult, “Blueprint for Zero Emission Flight Infrastructure,” 2022. [Online]. Available: https://cp.catapult.org.uk/news/blueprint-for-zero-emission-flight-infrastructure/. [Accessed 2022].

[7] ATI, “ATI Publications,” 2022. [Online]. Available: https://www.ati.org.uk/resources/publications/ . [Accessed 2022].

[8] HM Government, “UK Hydrogen Strategy,” 2021. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf. [Accessed 2022].

[9] FlyZero, “Workforce to Deliver Liquid Hydrogen Powered Aircraft,” 2022. [Online]. Available: https://www.ati.org.uk/wp-content/uploads/2022/03/FZO-IST-PPL-0053-Workforce-to-Deliver-Liquid-Hydrogen-Powered-Aircraft.pdf. [Accessed 2022].

[10] FutureFlight.Aero, “FutureFlight - The Future of Advanced Air Mobility,” 2021. [Online]. Available: https://www.futureflight.aero/news-article/2021-08-12/ampaire-starts-uk-hybrid-electric-flight-trials-scotland . [Accessed 2022].

[11] HM Government, “Green aerospace tech to receive record government funding,” 2022. [Online]. Available: https://www.gov.uk/government/news/green-aerospace-tech-to-receive-record-government-funding. [Accessed 2022].

[12] Connected Places Catapult, “Catapult Network,” 2022. [Online]. Available: https://catapult.org.uk/our-work/our-impact/. [Accessed 2022].

[13] Connected Places Catapult, “Future of Air Mobility Accelerator,” 2021. [Online]. Available: https://cp.catapult.org.uk/opportunity/future-of-air-mobility-accelerator/#:~:text=In%20partnership%20with%20the%20Future,and%20testing%20of%20disruptive%20innovations.. [Accessed 2022].

[14] Knowledge Transfer Network, “KTN Future Flight Cafe,” 2021. [Online]. Available: https://ktn-uk.org/events/future-flight-cafe-uks-first-remote-low-carbon-aviation-test-centre/ . [Accessed 2022].

[15] SATE Project Team, “Public Summary: SATE (Sustainable Aviation Test Environment),” 2021. [Online]. Available: https://custom-eur.cvent.com/1EEE3F7178EC486E8926B23F55A0B125/files/204895468c6344bcb10bcbc7d68b66bb.pdf?_ga=2.94136733.1280856492.1648462290-802649050.1611225882. [Accessed 2022].

[16] Aerospace Testing International, “Lilium to start high speed testing of eVTOL aircraft in Spain,” 2022. [Online]. Available: https://www.aerospacetestinginternational.com/news/drones-air-taxis/lilium-to-start-high-speed-testing-of-evtol-in-spain.html . [Accessed 2022].

[17] National Composites Centre, “National Composites Centre,” 2022. [Online]. Available: https://www.nccuk.com/ . [Accessed 2022].

[18] Airbus, “U.K. Secretary of State launces the joint-funded Aerospace Integrated Research and Test Centre,” 2021. [Online]. Available: https://aircraft.airbus.com/en/newsroom/press-releases/2021-06-secretary-of-state-to-launch-the-joint-funded-aerospace-integrat . [Accessed 2022].

[19] Bristol Airport, “Bristol Airport joins forces with easyJet to trial a range of initiatives,” 2021. [Online]. Available: https://www.bristolairport.co.uk/about-us/news-and-media/news-and-media-centre/2021/8/bristol-airport-joins-forces-with-easyjet-to-trial-a-range-of-initiatives . [Accessed 2022].

[20] British Aviation Group, 2021. [Online]. Available: https://www.britishaviationgroup.co.uk/news/bristol-airport-joins-consortium-tasked-with-developing-hydrogen-fuel-infrastructure/. [Accessed 2022].

[21] Plymouth City Council, “Use cases announced for world's first 5G marine-focused testbed,” 2022. [Online]. Available: https://www.plymouth.gov.uk/newsroom/pressreleases/usecasesannouncedworldsfirst5gmarinefocusedtestbed. [Accessed 2022].

[22] East Devon DC, “Road improvement work starts at Exeter airport long lane to boost East Devon's economic recovery,” 2021. [Online]. Available: https://eastdevon.gov.uk/news/2021/01/road-improvement-works-start-at-exeter-airport-long-lane-to-boost-east-devon-s-economic-recovery/ . [Accessed 2022].

[23] Dublin Aerospace, “Exeter Aerospace Approvals,” 2022. [Online]. Available: https://dublinaerospace.com/exeter-aerospace-approvals . [Accessed 2022].

[24] Dublin Aerospace, “Exeter Aerospace Services,” 2022. [Online]. Available: https://dublinaerospace.com/exeter-aerospace-services . [Accessed 2022].

[25] University of Nottingham, “2ZERO Project - Towards Zero Emissions in Regional Airline Operations,” 2021. [Online]. Available: https://www.nottingham.ac.uk/aerospace/projects/2zero-project/index.aspx . [Accessed 2022].

[26] BBC, “The epic attempts to power planes with hydrogen,” 2022. [Online]. Available: https://www.bbc.com/future/article/20220316-the-epic-attempts-to-power-planes-with-hydrogen?ocid=ww.social.link.linkedin . [Accessed 2022].

[27] Exeter College, “About - Exeter College,” 2022. [Online]. Available: https://exe-coll.ac.uk/about/. [Accessed 2022].

[28] Exeter College, “Exeter College Students to Study at World-Leading Aeronautical University in Florida,” 2022. [Online]. Available: https://exe-coll.ac.uk/exeter-college-students-to-study-at-world-leading-aeronautical-university-in-florida/ . [Accessed 2022].

[29] University of Exeter, “Our Research,” 2022. [Online]. Available: https://emps.exeter.ac.uk/research/ourresearch/#a2. [Accessed 2022].

[30] University of Exeter - Centre for Future Clean Mobility, “What We Can Do - Our Capabilities,” 2022. [Online]. Available: https://futurecleanmobility.com/what-we-can-do/. [Accessed 2022].

[31] GKN Aerospace, “About GKN Aerospace - Global Technology Centre,” 2022. [Online]. Available: https://www.gknaerospace.com/en/about-gkn-aerospace/global-technology-centre/ . [Accessed 2022].

[32] GKN Aerospace, “GKN Aerospace Our Technology - H2GEAR,” 2022. [Online]. Available: https://www.gknaerospace.com/en/our-technology/2021/H2Gear/ . [Accessed 2022].

[33] Heathrow, “Future Flight Challenge NAPKIN,” 2021. [Online]. Available: https://www.heathrow.com/company/about-heathrow/future-flight-challenge/napkin. [Accessed 2022].

[34] IAAPS, “IAAPS,” 2022. [Online]. Available: https://iaaps.co.uk/ . [Accessed 2022].

[35] Oxford Economics, “The Contribution of Leonardo to the UK Economy 2020,” 2020. [Online]. Available: https://uk.leonardocompany.com/documents/64103/12187431/The+Contribution+of+Leonardo+to+the+UK+Economy+2020.pdf. [Accessed 2022].

[36] Rigby Group, “Airports - Rigby Group,” 2022. [Online]. Available: https://www.rigbygroupplc.com/divisions/airports. [Accessed 2022].

[37] Peninsular Transport, “Peninsular Transport,” 2022. [Online]. Available: https://www.peninsulatransport.org.uk/. [Accessed 2022].

[38] Gov.UK, “NATEP helping SMEs innovate in aerospace: Spring 2022,” 2022. [Online]. Available: https://apply-for-innovation-funding.service.gov.uk/competition/1144/overview. [Accessed 2022].

[39] ATI, “Status update on ATI Programme funding,” 2022. [Online]. Available: https://www.ati.org.uk/funding/. [Accessed 2022].

Annex A - Interview Notes

Introduction to Interview Notes

This section of the report provides summaries of the individual engagements of the study team and the stakeholders through interviews during the project timeframe. The detail of these conversations assists in providing context and meaning to the recommendations proposed in Section 4 of this report. One of these recommendations includes the suggestion for discussions with additional stakeholders, such as Air Navigation Service Providers and the Civil Aviation Authority (who were not included in the interviews under this study), which would be expected to add additional context to the proposition for testing and demonstration in the South West region.

The following interview summaries are presented alphabetically by organisation name and indicate no order of preference nor prioritisation.

In general, these interviews were conducted in a structured manner with time allocated to discuss technical and skills requirements, risks and opportunities. The fluid, organic and diverse nature of the conversations mean that some of the interview summaries do not follow a set structure. These interview summaries are not intended to give a ‘meeting minutes’ style record of each discussion but instead provide the reader with a view of the key themes, assets, risks and opportunities identified.

The purpose of the interviews was to inform the recommendations, presented in Section 2 of this report. To show the link between the interview discussions and the recommendations, some sections of each interview summary have been highlighted in green font with a corresponding recommendation reference number(s) into which they feed.

A.1 Ampaire

Ampaire is developing zero emission electric aircraft and converting existing aircraft to hybrid-electric propulsion. They have been involved in two high profile UKRI Future Flight Challenge projects: Towards Zero Emissions in Regional Aircraft Operations (2ZERO) and Sustainable Aviation Test Environment (SATE). Their Electric EEL technology demonstrator has successfully flown from Kirkwall in the Orkney Islands to Wick on the Scottish mainland. The converted six-seat Cessna 337 Skymaster is being used for trials intended to demonstrate the feasibility of using hybrid-electric propulsion to support regional airline services.

These flight trials are being supported by funding from the UK government's Industrial Strategy Challenge Fund for a project called SATE that is being led by Scotland's Highlands and Islands Airport Limited. The Ampaire team are using the Electric EEL in the South West of the UK, for conducting further demonstration flights between Exeter and Cornwall as part of the 2ZERO project. The second EEL prototype now flying in the UK has previously been used for trials conducted in Hawaii with Mokulele Airlines. Its longest flight to date was a 341-mile trip from Ampaire's headquarters in Los Angeles to San Francisco [10].

Ampaire is aiming to develop hybrid-electric powertrains for existing regional airliners and utility aircraft in the 9- to 19-seat category. This could include aircraft types such as the Cessna Grand Caravan and Twin Otter.

The Ampaire team are developing a copperbird for their aircraft in partnership with the University of Nottingham where they have access to good facilities including powerbanks and dynos. The university also comes with a wealth of aerospace engineering knowledge that the team can draw on. An ironbird is also being developed in Scotland where the team's Maintenance, Repair and Overhaul organisation (MRO) partner resides. The MRO team will be responsible for retrofitting the aircraft with the hybrid-electric propulsion systems. Some of the initial testing of the propulsion system could be replicated at places like IAAPS (Bristol) or possibly the Centre for Future Clean Mobility (University of Exeter).

Ampaire are currently in the process of applying for Phase 3 funding of the UKRI Future Flight Challenge, this funding will be critical to enabling the next phase of the project. University of Nottingham are the natural partner for Ampaire during phase 3 of the project but a full directory of facilities across other regions of the UK could have been useful to the team when they were identifying suitable partners. The nature of applying for grant funding is time limited, as such it is often difficult to identify and successfully engage potential collaborators. With more time Ampaire could have spoken to more potential partners. This is particularly difficult in the case of electric propulsion where a lot of the skills for challenges such as battery sizing or motor selection lie outside of the aerospace world and sit in the automotive sphere. Again, this highlights the usefulness of a full directory of cross sector facilities that companies can refer to when applying for grants and looking for partners (Rec S5).

A.1.1 Requirements / Facilities for enabling the future of flight

For Ampaire and other SMEs to thrive with the development of smart and sustainable aviation solutions it would be beneficial to have access to:

- Hangar space – companies designing aircraft or aircraft subsystems will likely need access to some form of hangar space where they can store, build, maintain and repair their aircraft.
- Airfield – somewhere the aircraft can take off and land with supporting infrastructure is critical to allowing flight test.
- Airspace – flight test corridors and permission to fly are essential.
- Innovative start ups or collaborators will likely need some form of collaborative environment – the iAero centre (Yeovil) has great potential for this.

- This collaborative environment also needs to be a space which is useful for industry in the sense that it is 'more than just desks'. It needs to have facilities for hardware and software development, design work, or smaller scale testing. It is also important to foster a collaborative environment with other people and organisations in the space to promote innovative thinking and knowledge sharing.
- Funding is critical – this should not just be government funding streams as these are often time consuming and win rate is low which presents challenges, particularly to SMEs. Business accelerators or incubators which develop routes to product exploitation are ideal.

One challenge associated with collaborative working spaces is the ability to build an effective team, ideally with a mix of students, undergraduates, postgraduates, and more experienced personnel. To build this team it is important to have good access to the engineering talent pools centred in Bristol or other big cities. There needs to be some incentive for the people with the right skills to come to the area, including raising awareness of the social value, local environment or relatively lower house prices. To meet the future skills demand there may also be a requirement for fishing in the talent pools from other industries, e.g. energy or automotive.

Flight test is not a key worry for Ampaire as they have already conducted some initial flight tests and have access to the Sustainable Aviation Test Environment (SATE) in Scotland. Even if the South West already had great facilities, they may still have chosen Scotland as a test location, in part due to their Future Flight Challenge funding, plus the relative remoteness and how well established they are with supply chain partners North of the Border. There is a strong advantage to having test flight facilities co-located with a production or assembly facility. It allows an organisation to fly more regularly and collect more data to support the engineering development, route to certification and also the commercial sales pitch.

A.1.2 Scale Up, Manufacturing and Operationalisation

When it comes to scaling up and commercialising electric aircraft, cost of a manufacturing or assembly facility is a big factor. Having access to the right workers for manufacturing is also critical. The facility needs to be the right type of space for the specific manufacturing.

With Ampaire's current pod design (Ampod), the pods can be retrofitted to aircraft so the final assembly line for electrical pod could be attached to an assembly line for the aircraft. Co-location makes the process more lean but alternatively the pods could be shipped out to other sites to be fitted later. Ideally, the Ampod manufacturing facility should be close the engineering team to allow for efficient feedback loops and a shorter supply chain. The 2ZERO project is not focused on just a single aircraft system, it covers a system of systems and this needs to be considered during any scale up.

A.1.3 Testing in Exeter

Ampaire are planning to take a fleet leader approach to testing – do ground testing, prove it is safe to fly, then a short hop, gradually build the flight envelope, gain a permit to fly (~100 hrs) and continually add endurance to aircraft by demonstrating through test.

For small scale testing of one or two small aircraft, Ampaire can plug directly into the existing 3-phase electricity network at Exeter Airport for charging etc. The next aircraft will have similar requirements to the current one under development but larger aircraft in the 9-15+ seat range or some of the new eVTOL designs will likely need upgrades to the electrical infrastructure at the airport. Cost becomes a dominant factor once substations need to be bolstered or more cables need to be run across or under the apron to reach the aircraft. It is recommended that research is conducted into the details of aircraft size vs energy demand and how much can feasibly get supplied (Rec S1, S2, M6).

A.1.4 Next Steps for Ampaire

A critical factor Ampaire is funding. They are doing some work within the Connected Places Catapult Transport Research and Innovation Grants (TRIG) and are hopeful of Future Flight Challenge (FFC) Phase 3 funding. It would be beneficial to identify other potential funding options like the Faraday Challenge but also more commercial opportunities because grant funding can be particularly unreliable. The Aerospace Technology Institute funding has been on hold but an additional £685m of government funding over the next three years was announced on 29th March 2022 [11]. This could be a huge potential opportunity for the South West as more project funding calls are opened up. The HotSW LEP could potentially help to provide businesses with support in identifying and applying for funding (Rec S4).

Ampaire will be formalising Exeter College as a partner for FFC Phase 3; this will allow students/apprentices from the college to work directly on some exciting future flight projects giving them valuable skills before their full transition to work. Additionally, if Ampaire is successful with their FFC Phase 3 funding they will likely need new hires across the board including aerodynamics and structures engineers. As the business model currently works around retrofitting aircraft with their electric pods, a wider skill set is needed including aerospace, modelling, electric propulsion from automotive, battery sizing, motor selection, electrical engineering, re-engine aircraft engine swap, structural integration and more. The structures recruitment drive is likely to be based in Scotland close to where the MRO capability resides.

For the permit to fly and alignment with the full type certification, Ampaire will additionally need people to produce assurance evidence to meet their safety arguments. Though it presents a significant challenge, it was suggested in the interview that if Ampaire or other organisations like Vertical Aerospace were looking to conduct test flights they could use their own assurance and certification experts trusted with sign off from the regulatory bodies to approve certain testing and demonstration within pre-defined limits. If this was implemented in a suitable framework supported by the HotSW LEP and other bodies it could act to boost innovation whilst remaining safe. The assurance is provided by trusted experts but it allows for more flight testing this is almost like a physical embodiment of the CAA Regulatory Sandbox seen for the FFC.

A.2 Catapult Network

The Catapult Network supports businesses from the research and development phase towards industrialisation or market exploitation of their products and ideas. It is a network made up of leading technology and innovation centres established by Innovate UK helping to deliver technical and economic benefit across the UK and globally. The network aims to bridge the "valley of death" between Technology Readiness Levels (TRLs) 4 and 6; from academic research to industrial commercialisation. Catapult centres accelerate research and help organisations to scale technologies up. The network is comprised of nine Catapults with a national presence (40+ locations).

From 2013 to 2020 the Catapult Network supported 8,332 SMEs, had 14,750 industry collaborations and a further 5,108 academic collaborations. They also managed over £1.3 billion of research and demonstration facilities in this period [12].

Of particular interest to this work are the Connected Places, High Value Manufacturing, Energy Systems, Digital and Satellite Applications Catapults. Each of these centres provides unique expertise that is valuable to understanding the future aviation system of systems and adapting to the challenges faced.

A.2.1 Connected Places Catapult

For this study we spoke to a representative from the Connected Places Catapult (CPC). CPC works on accelerating innovation for cities, transport, and places. This means they don't 'do' traditional aerospace but do have some overlaps with aerospace particularly around infrastructure, intermodal transport, drones and electric vertical take-off and landing (eVTOL) aircraft.

CPC plays a key role in understanding and overcoming issues associated with public perception; this will be critical as drones and eVTOL aircraft become more widely adopted. Their engagement with small and medium enterprises (SMEs) is also highly valuable; it gives them unique insight and access to the latest innovation.

Through the interview it was highlighted that the Connected Places Catapult have a Future of Air Mobility (FAM) Accelerator aimed at identifying and leveraging innovative digital solutions to tackle challenges in the fast-moving aviation industry landscape.

> *"In partnership with the Future Flight Challenge from UK Research and Innovation (UKRI), the accelerator selected 11 SMEs to join a 6-month programme, where they received support from a consortium of industry, academic and regulatory partners on the trialling and testing of disruptive innovations.*
>
> *Connected Places Catapult delivered the programme in partnership with Plus X who supported the SMEs through a bespoke programme roadmap tailored to their requirements, including investment readiness, technology and product development support, alongside introductions to aviation stakeholders and potential customers. These activities were co-designed with the SMEs in order to grow their businesses and adapt propositions to programme partner requirements."* [13]

The FAM accelerator programme is primarily looking for SMEs of Technology Readiness Level of 6+ though it will still consider applications from earlier stage businesses if they are closely aligned with the key challenge themes set out below:

- **Data-Driven Aviation**: The CPC programme is looking at how organisations can better capture and utilise data to improve operational and commercial efficiencies within the aviation and aerospace sectors. This could be with the collection of on-aircraft, airside operations or customer data, we would like to see how data gathered can enhance decision-making [13].

- **Smart Airports**: The CPC programme is investigating how autonomous solutions could be integrated into airport management and security operations. The programme will also check out disruptive technologies that will support the aviation industry in reaching Net Zero targets [13].

- **Advanced Air Mobility**: The CPC programme is exploring how the development of Advanced Air Mobility can be expedited through investigation of the systems, infrastructure technologies and modelling and simulation tools required for commercialisation [13].

"Connected Places Catapult is delivering the programme in partnership with Plus X who will support the SMEs through a bespoke programme roadmap tailored to their requirements, including investment readiness, technology and product development support, alongside introductions to aviation stakeholders and potential customers. These activities will be co-designed with SMEs in order to grow their businesses and adapt propositions to programme partner requirements.

SMEs will have the opportunity to access funding through the accelerator programme, which will be used for the testing and trailing of live demonstrations. However, funding is not guaranteed and will be reviewed on a project-by-project basis by the programme partners."

Even though the applications for the CPC FAM are now closed, the HotSW LEP could help to coordinate and encourage SMEs across the region to apply for future accelerator programmes like this. By securing funding the SMEs would then be enable to conduct the necessary testing and demonstration of their systems to move forwards towards smart, sustainable aviation (Rec S4).

Through the interview with CPC it became clear that the CPC's national view on various engineering and technology clusters would be of significant benefit to the Devon and Somerset. The South West has a big aerospace cluster but these are generally larger, traditional aerospace companies; there are few SMEs. It was suggested that it could be beneficial to get more small, innovative, and agile companies. Therefore, it is likely worthwhile spending some more time speaking to CPC to fully understand the national networks and clusters that exist already, to further explore any potential collaborations or to identify agile SMEs that may want to come to the South West for mutual benefit. An SME from the HotSW region could engage with the CPC who in turn could set up further conversations with organisations from across their UK wide network. For example, drone companies may want to come to the South West to conduct testing and demonstration of their air platforms. The iAero centre could be an ideal location for SMEs to collaborate with each other and with larger aerospace primes.

The HotSW LEP could also play a role in encouraging and supporting any existing companies in the region that have products or ideas at the mid-low technology readiness levels to work with the CPC or wider catapult network to accelerate their development and route to market. Securing funding is critical to organisations across the South West and engagements with the CPC or similar R&D networks could help provide SMEs in Devon and Somerset the exposure they need to seek and apply for funding.

It was recommended that the aerospace and aviation industries shouldn't try to do everything. Knowledge and experience gained in the automotive, manufacturing or other industries should be leveraged to provide cross sector benefit (Rec S5). The future of mobility will be multi-modal transport and so the aerospace and aviation industries need to work closely with other transport groups like rail and highways when designing, developing and demonstrating the transport systems of the future in line with the levelling up agenda.
Future electric aviation will also likely move away from operations solely at existing airports in a traditional hub and spoke model to a more distributed aviation system. This will require important consideration of the connections with other transport networks and ground infrastructure.

A.2.1.1 Ground Infrastructure vs Flight Test Corridors

The development of testing and demonstration facilities will be critical to enabling electric and/or hydrogen aviation but perhaps upgrading ground infrastructure will be relatively more important than defining flight test corridors. Aircraft need places to take-off, land, recharge, refuel and repaired before they can become

operationally viable. Once the necessary ground infrastructure is developed it can then be replicated and joined up with other existing transport infrastructure across the UK.

Future Flight projects like the Sustainable Aviation Test Environment (SATE) at Kirkwall Airport in the Orkney Islands are already working towards a low carbon aviation test centre like this [14].

> *"The project will trial a range of alternatively fuelled and alternatively piloted aviation technologies This includes low-carbon aircraft that utilise electric, hydrogen or sustainable aviation fuel to replace conventional fossil fuels. In addition, the project will demonstrate the benefits of the use of Unmanned Aerial Vehicles (UAV) on several routes and user case studies. The SATE project presents an opportunity for partners to utilise the dedicated test facility complex at Kirkwall airport, which includes Office, Hangar, Apron, Taxiway and access to 100% renewably sourced Electrical charging, Hydrogen and Sustainable Aviation Fuels.*
>
> *Kirkwall offers an operational airport in uncontrolled "Class G" airspace with a network of island and mainland routes that can be flown. The SATE facilities are flexible and will also be used to trial and demonstrate opportunities to decarbonise the airport infrastructure. Kirkwall is one of 11 Airports managed by HIAL (Highlands and Islands Airports). The sister airport at Wick (31nm SW) as well as other airports in Orkney offer meaningful trials to be undertaken within a rural transportation system. Finally, the SATE project will contribute to the decarbonisation of the Aviation sector and look to improve regional air connectivity. This innovative project will stimulate job creation and use local renewable energy, supporting Orkney's net zero ambitions. The project will also examine the socio-economic impact of these new technologies and services along with the skills and training needed to support them."* [15]

A test environment capable of trialling different fuels and aircraft platforms like this doesn't yet exist in the south of the UK. Perhaps replication of a test environment demonstrator like this could be a good option for the Devon and Somerset (Rec S3). The environment should also consider interconnectivity with drones, eVTOL and other transport systems like rail or highways. A suitable ground location would need to be identified. Following this, test flight corridors could be set up providing links between Exeter, Newquay, or Plymouth for example (Rec S10). Once the initial air corridors are defined, they can be replicated. In this way they can be gradually set up and joined up to provide a connected air transport system.

There are over 500 airfields in the UK and many of these could present the ideal location for a 'living lab' demonstrator. Support from government and local authorities would likely be needed to manage and connect these airfields into usable sites. An example of flight testing that is being conducted by Lilium (an eVTOL developer) is at the Air Traffic Laboratory for Advanced Systems (ATLAS) Flight Test Centre in Andalusia [16]. This is a potential model worth looking to replicate in the UK.

Some core questions around the specific requirements for sustainable aviation infrastructure and new generation air vehicles remain unanswered. Airports and many industrial groups have little to no understanding of the practical details of implementation of electric or hydrogen infrastructure.

- What do we need?
  - Will it be hydrogen or electric or a mix of both?
  - What skills do our people need to deal with these new systems?
- When do we need it?
- How do we pay for it?

The CPC have recently published a 'Blueprint for Zero Emission Flight Infrastructure (ZEFI)' document that reveals a lot of information on what airports will need to do to prepare for sustainable aviation [6]. It is good starting point for further research into answering some of the above questions. It is worth noting that different

airports won't need to reach the same capability/capacity levels at the same time. Likewise, the Aerospace Technology Institute (ATI) has released several publications detailing topics like hydrogen fuel cells, integration of hydrogen into the air transport system as well as other manufacturing themes [3] [7]. These reports are a highly valuable source of information that we encourage the stakeholders of the Sustainable Aviation Program board to explore further (Rec S3). It is also worthwhile reviewing the ZEFI project reports and recent ZEFI demonstrations [6]. There is possibly going to be follow on work to the catapult's ZEFI programme that Exeter Airport or others in the South West region could potentially get involved with; these options are worth exploring.

A.2.1.2 Hydrogen Economy

Hydrogen for small scale testing and demonstration of aircraft will be relatively easy to obtain and handle. The challenge comes when we look to scale up these aircraft into viable transport solutions. It is worth considering the longer-term opportunities and challenges associated with producing, storing and distributing hydrogen before establishing a test and demonstration facility. By considering these challenges it will help to future proof and de-risk the agreed solution. However, there is a still a significant amount of uncertainty including but not limited to when airports will be ready for using hydrogen, when hydrogen aircraft will be ready, and when will the rights skills and facilities be in place. Ideally, the aviation and aerospace industries and academia need to answer as much of this uncertainty as possible before heading the wrong path.

Will there be a wider hydrogen economy that supports all industries? Further work is being conducted by the Department for Transport to identify and understand options for potential hydrogen hubs like Teeside. It is recommended that the HotSW LEP works to encourage collaboration and deconfliction for hydrogen production in region by speaking to stakeholders from nuclear, rail, road, maritime, renewables, automotive etc. A coherent view of where major and minor hydrogen hubs should be and what areas they will service needs to be developed [8] (Rec S1, S9, M2). Further research would likely be needed to identify this coherent view for the South West – what infrastructure is being developed and what needs to be develop to have the capacity to service sustainable aviation as well as other sectors in the region.

A.2.1.3 Skills

The Catapults are doing some ongoing work to identify skills gaps and skills shortages. The High Value Manufacturing catapults, Aerospace Technology Institute (ATI) and other organisations have also published skills reports that identify risks and opportunities – these are primarily focused on manufacturing and less on aviation but are still very relevant to this study. It is recommended that the HotSW LEP read the ATI FlyZero project's latest 'Workforce to Deliver Liquid Hydrogen Powered Aircraft' report [9] (Rec S12, M3, L1).

There will be a struggle to recruit the right people in the next 5yrs to keep sovereign capability. Ideally the route to certification needs to happen now for new eVTOL aircraft and very soon for hydrogen fuel cell and electric aircraft. If these aircraft do not get certified, investors may pull their money which would significantly delay or stop hydrogen or electric powered flight from becoming reality. There will be a drive towards more testing within the digital environment; for approvals, and for proving/verifying flight tests with a digital twin. This should and will likely become part of the approval process and as such organisations looking to flight test their sustainably powered aircraft will need to understand digital testing. This will require skilled engineers and researchers that are familiar with both simulation and the certification process.

SMEs want a route to market for their products and systems. Leonardo and others like GKN or Airbus can potentially offer this. The SMEs and wider supply chain could benefit from linking up with some of the larger companies who have more resources, more people and sometimes more experience. This also includes linking up to other centres of excellence nationwide. The future of aviation needs to be innovative and agile but needs to backed by the fundamental understanding of safety, manufacturing, maintenance and operations.

A.2.2 National Composites Centre

The National Composites Centre (NCC) is an independent, open-access technology centre delivering world-class research and development of composites. As part of the UK's Catapult Network, they offer their partners access to the latest technology, provide technical expertise and the business support they need to overcome barriers to innovation and accelerate their growth [17].

The NCC are perfectly placed to support new aircraft development programmes.
They have capabilities in [17]:

- Advanced Composites
- Digital Engineering
- Hydrogen
- Sustainability
- Technologies
- Engineering Services
- SME Support
- Skills, Training and Workforce Development

For example, they are supporting Vertical Aerospace with some Design and manufacture of fuselage of their demonstrator aircraft with GKN and other partners doing other sections of the airframe.

As eVTOL manufacturers, new aircraft developers and industry incumbents like Leonardo start to look towards ramped up production of new aircraft, the high value manufacturing catapult can support with design and engineering expertise. The NCC can produce certifiable parts.

The NCC is doing a significant amount of work on the Airbus Wing of Tomorrow technology demonstration programme. Airbus remains the design authority for this programme, but the NCC can influence the design – a critically valuable skill for other programmes looking to gain knowledge from the catapult.

The NCC can test the quality of the parts they're making but can't test finished products. They don't have the facilities to test whole structures but up the road at Filton, Airbus formally opened the Aerospace Integrated Research and Test Centre (AIRTeC) representing a £40m investment.

> *"Filton, 3 June 2021 - Kwasi Kwarteng, Secretary of State for Business, Energy and Industrial Strategy, will today formally launch Airbus' Aerospace Integrated Research and Test Centre (AIRTeC) in Filton, Bristol. AIRTeC is a £40 million, state-of-the-art research and testing facility jointly funded by the Government's ATI programme and Airbus. Covering more than 10,000m2 of gross internal floor space - the equivalent of two football pitches - the Centre is designed to undertake structural testing of large-scale aircraft assemblies, from full-size wings down to the individual components and materials used in aircraft design. It provides the most advanced working environment and tools for Airbus alongside external suppliers, partners, and academia, to deliver the next generation of aircraft wing, landing-gear systems and fuel system designs.*
>
> *Furthermore, the facility is a key asset in helping industry accelerate the design, manufacture, testing, certification, infrastructure, and commercial operation of zero-emission aircraft through sustained investment in R&T and R&D and fostering greater collaboration across sectors. Companies in other sectors, such as maritime and nuclear, along with universities can also utilise AIRTeC's innovative, highly flexible, and easily adaptable environment, which includes 65,000m² of state-of-the-art specialist test space, a 40-metre-long strong floor, and a 14 x 10 metre strong wall capable of testing full-size wings - with a force equivalent to the weight of 240 cars – using a 25MN high-capacity loading test machine.*
>
> *The facility also includes labs, collaborative office space, and reconfigurable testing areas. This combination of test assets is unique in Europe. "* [18]

Additionally, the NCC are supporting Rolls Royce with development of composite fan blades and use of ceramic matrix composites. In wider aerospace the catapult centre is working on landing gear and interior cabin seats.

A.2.2.1 Hydrogen

The NCC are looking into hydrogen storage including cryogenic tanks, pipes and other pressure vessels up to 700 bar. There is a gap for a hydrogen test facility in the South West and it would be worthwhile linking up with other groups like WEAF or WECA as well as other industries to address this gap (Rec S3).

Though not as relevant to the NCC, it was also noted in the interview that there are some ongoing initiatives at Bristol Airport with easyJet and others to work towards decarbonisation [19] [20]. This includes consideration of:

- Electric Ground Power Units
- Sustainable Aviation Fuels
- Waste Management
- Supply chain carbon reductions
- Development of hydrogen fuel infrastructure
- and more.

A.2.2.2 Skills

The NCC takes on ~15-18 graduates per year. They also take on apprenticeships, who spend most of their time of working but then get assessed by the Further Education colleges or Institutes of Technology. The NCC delivers high quality composite training courses to varied levels – this could be highly valuable to other organisations across the region like Exeter Aerospace for example.

There are also likely to be significant opportunities for NCC staff to do secondments out to other organisations in the South West or alternatively other organisations' staff to second into the NCC. Or less formally the NCC staff could make use of collaborative working spaces like the iAero centre to help encourage knowledge sharing for the mutual benefit of the region and industry. Leonardo has ~4 seats at the NCC. The Sustainable Aviation Programme Board could consider setting up some form of collaborative working agreement with the NCC and its member organisations (Rec S5).

In the interview, it was highlighted that Plymouth Smart Sound have recently set up a 5G marine test bed [21]. For now this is focused on marine applications but there is significant opportunity for aerospace testing here. A 5G test location would be ideal for test flying drones and potentially eVTOL aircraft. The HotSW LEP could explore this potential opportunity to work with Plymouth Smart Sound to understand any potential options for collaboration (Rec S7).

A.3 Devon County Council

Local government authorities will be an important part of the jigsaw for enabling smart and sustainable aviation both in the early testing phases but also in the eventual commercialisation of systems. The support will primarily be around capacity building. In other words, providing workspace, work skills and business support. There is two tier local government in place with District Councils looking after business rates and planning applications while the County Councils are responsible for highways, education and employment land etc. Both tiers here will be important for the testing and demonstration of smart, sustainable air vehicles but also later as they look towards commercialisation and ramped up production and operationalisation.

As identified by many of the stakeholders we have spoken to as part of this study, organisations will need access to some sort of testing and demonstration space including hangar and office space. They may need space for energy production, storage or distribution (hydrogen or electric). The councils will be pivotal in supporting organisations access this employment land and building the necessary facilities on that land. There is employment land adjacent to Exeter airport which could be use for future flight purposes to augment any additional air side infrastructure. Purchase and effective management of this employment land could provide space for high quality jobs which could contribute to the test and demonstration proposition in the region (Rec M5).

An important element of the future aviation systems of systems will be sufficient energy provision. This will require close engagement with energy providers and regulators like Western Power Distribution, National Grid, UK Power Networks or other producers/distributors of hydrogen. As planning authorities, the councils tend to have a better view of ongoing or proposed infrastructure developments. This knowledge should sometimes be shared with wider stakeholders to provide them with visibility. The local authorities and councils often underpin the core proposals for infrastructure development. If the South West wants to strive to be a sustainable aviation testing and demonstration hub it will need sufficient and appropriate ground infrastructure; organisations will need approval from councils to make this happen. Though less critical to the testing and demonstration phase, consideration of more electric decarbonised ground vehicles will be an important part of the future of mobility. Electric vehicles and their associated infrastructure is a key interest to the local councils and will become really important in the longer term goals of reaching a decarbonised aviation sector.

The councils could provide a central coordination role to encourage collaboration and promote discussion of key risks and opportunities. This could also involve marketing or promotion of key sites and job roles to attract people to areas.

There is a significant difference between the salaries of engineers working in industry and those working in teaching roles. To meet the future skills need it will be important to retain and upskill existing teachers but also attract new teachers. Through close collaboration with local colleges and the South West Institutes of Technology, the councils could act to support this pipeline of skills (Rec S12, M4, L1). This could be with the adult education budget and careers advice with a focus on the high demand skills. The development of a skills plan that captures the transition from traditional skills to other ‘future proof’ skills such as digital and electrical engineering as well as consideration of energy and sustainability will be important. This skills plan will likely need to be developed in partnership with industry and colleges; the Sustainable Aviation Program board is well placed to take on this role in a timely fashion (Rec S12, M4, L1).

Through this interview it was reiterated what an important role that Exeter College and the Future Skills Centre play here.

A.4 East Devon DC

East Devon District Council has a similar offering to the other councils we have spoken to. They are focused on growth, development and prosperity in the region. They are supporting the Long Lane, access road upgrade near Exeter Airport.

> *"The new access will help to boost economic recovery from the Covid-19 pandemic, support new employment and provide opportunities for clean and inclusive growth. The enhancements to Long Lane will unlock development of the new 19 acre AirPark site in the Exeter and East Devon Enterprise Zone which is expected to create around 1,000 jobs.*
>
> *Valued at £3.7 million, the scheme will also facilitate a bus loop and cycleway, substantially improving access to the new Future Skills Centre and the maintenance hangars which have recently been taken over by Exeter Aerospace. The scheme will also improve the access to Exeter Airport, a major gateway to the region, and help to facilitate the construction of key infrastructure for the forthcoming France-Aldernay-Britain interconnector project."* [22]

In this interview some key organisation in the region were highlighted:

- Exeter College & the Future Skills Centre
- Exeter Aerospace
- Exeter Science Park
- City Science

It was suggested that Exeter airport would be an ideal location for testing and demonstration of smart, sustainable aviation. Particularly as its quieter than the airspace around Bristol airport and has more appropriate infrastructure connections than Newquay.

East Devon DC will play an important role in coordinating infrastructure projects, land allocation and skills promotion. They can also support businesses, help to improve public perception of test flights and help organisations seek out and apply for funding. A key recommendation is to identify additional funding routes aside from UKRI FFC, CPC/DfT TRIG, Faraday Challenge, Jetzero, Green Skies etc.

There is lots of work looking into infrastructure in the region presently including but not limited to:

- Heating and decarbonisation,
- Buildings + roads
- Potential proposals for large scale offshore wind
- Potential proposals for green hydrogen
- Potential proposals for large scale solar
- Proposals for ~50MW battery storage and Exeter Smart Grid
- Reviewing local plan – updates to existing infrastructure too
- Science park & district heating

To enable a sustainable aviation cluster centred around a test hub located at Exeter, there will be need for early buy in from the planning authority for land allocation. The land allocation should consider other industries not just aerospace & aviation – this could benefit the aerospace sector as other companies may have skills that add to the aviation skills mix. It is important to deconflict between different sectors working to achieve the same thing so that capability isn't unnecessarily duplicated.

Some key recommendations were suggested:

- In the short term, organisations will need some sort of flight test location and suitable hangar space (Rec M5). There should be a focus on future skills and continued engagement with Exeter College,

Exeter Aerospace, Exeter Airport University of Exeter, NATS, the Turing Institute and other similar institutions to develop and deliver a future proof curriculum.

- In the short term it would also be useful to down select and identify the specific requirements for testing aircraft, electric or hydrogen aviation (Rec S3). Knowledge sharing and collaboration in this space should be encouraged. It would even be useful for non-technical organisations to get a better basic understanding or mental model of what the future of aviation looks like so they know how to prepare for it better.
- In the medium to long term, it will be important to explore the best options for upgrading ground infrastructure, energy provision and distribution and green hydrogen planning (Rec S1, S9).
- Further exploration of national projects like 2Zero and the JetZero council would be useful to aid the understanding of SMEs in the region (Rec S4). This would help to give organisations an awareness of the key issues surrounding sustainable aviation test and demonstration which would enable them to make better informed decisions and action plans.
- A Skills agenda and plan that closely aligns with the key technical requirements needs to be developed and shared (Rec S12, M4, L1).

A.5 Exeter Aerospace

An important part of the future aviation system of systems will be through life maintenance, repair, and overhaul (MRO) of aircraft. This is less relevant for non-commercial testing and demonstration but should definitely be considered early on to ensure that the appropriate MRO infrastructure and skills are available when needed. This is particularly important as new classes of air vehicles with new hydrogen or electric powertrains start to be tested and eventually enter service. The maintenance of airframes will also be affected as new materials including composites are introduced.

Therefore, as part of this study we spoke to Exeter Aerospace, an MRO organisation set up in October 2020 at the previous Flybe site at Exeter Airport. They are a subsidiary of Dublin Aerospace who effectively act as the complimentary sister company focusing on the narrowbody segment of the market. Exeter Aerospace presents maintenance organisation approval capabilities from both the CAA and EASA [23] [24]. Exeter Aerospace currently offers Base Maintenance services on the following aircraft:

- ATR 42-200/300 Series,
- ATR 42-400/500/72-212A,
- ATR 72-100/200 Series,
- BOMBARDIER DHC-8-100/200/300,
- BOMBARDIER DHC-8-400,
- EMBRAER ERJ 170 Series &
- EMBRAER ERJ 190 Series.

These aircraft are traditional platforms with traditional maintenance programmes. The current level of understanding around hydrogen or electric systems is very limited and will need to be improved to meet the next generation demands.

This presents a significant resourcing challenge for MRO organisations; they are already struggling to attract the right talent and they are seeing workforce shortfalls. This is in part due to the Covid-19 pandemic where many maintenance engineers left aviation to work in other industries. The current skills shortage is challenging for organisations, but this is separate to the future skills gap and future skills shortage. It may be easier to attract people to roles like this if it is highlighted that the technology focus will be the future of flight (Rec M3).

Working closely with Exeter College on apprenticeships etc will be highly valuable. Today's training curriculum needs to consider the future of flight and future skills requirements. The training process needs to have new skills for new platforms embedded into it. Many people are unsure of what this syllabus will look like so close interaction and engagement with technology partners, universities and industry will be essential to ensure it is robust/rigorous enough (Rec M3, L1).

There should be more focus on electrical, hydrogen and composites skills as these become increasingly important with new aircraft types. With limited options for investment only limited training can take place on site, but Exeter Aerospace is happy to send staff out to training courses to upskill them but understanding the right courses to attend is not always straightforward. This skills gap will likely keep widening unless it is addressed now. There is a skills shortage at the moment but not a skills gap.

Some of their onsite assets are detailed below:

- They have plenty of space available. This means there is a need to understand the optimum utilisation of this space better. By understanding this utilisation, they can start to build better business cases. The space could be used for anything within reason including more facilities focused on future aviation systems, providing it made practical business sense to do so.

- Onsite battery workshop (~10ft by ~10ft) where they can charge batteries for test. It is worth noting that this is older style 28V aircraft batteries and the power supplies need to be upgraded considerably for new batteries and as there becomes a higher volume of batteries to work on. The workshop would likely need expanding as electric aviation demand increases. There is no maintenance of lithium batteries presently. There needs to be investment in charging and maintenance infrastructure coupled with a better understanding of new electric aviation requirements (Rec S2, M2).

- They have a Composites workshop on site including a wet lay-up controlled environment facility but this shop could be bigger. Demand for composites is likely to increase with new aircraft programmes but this is less relevant to the scope of testing and demonstration of aircraft.

As a relatively new organisation focused on current delivery it is difficult to look forward at the future pipeline of skills needed. They will likely need assistance from technical partners or information from regulatory bodies like the CAA to help them understand the technical requirements going forward. Being part of Dublin Aerospace could be of benefit here as they can collaborate and share knowledge.

MRO organisations are heavily legislated, documented, and require strict sign off in accordance with manufacturer's instructions, flight cycles, flight calendars and scheduled maintenance. Operators will instruct the MRO organisation to perform a particular package of work, i.e., the MRO requirement is driven by leasing requirement of operator and then the MRO certify against the work. This means that for maintenance, repair and overhaul of new aircraft types with hybrid-electric, electric or hydrogen propulsion systems, the requirement will be driven by the operators and flowed down to the MRO organisations later. MROs will need to be considered at the point of commercialisation – it will be the last piece in the smart, sustainable aviation puzzle. It is still a very important piece of the puzzle though and regulating bodies like the CAA will need to consider these future aircraft requirements within their guidelines to ensure they are robust against future needs.

It was suggested that it is likely worth engaging with Wales Aerospace, West of England Aerospace Forum, Midlands Aerospace Alliance or other industry groups to understand their approach to tackling sustainable aviation (Rec S2, S5).

A.6 Exeter Airport

UK Airports will play a critical role in enabling the future generation of smart and sustainable aviation. They will not drive the hydrogen or electric aviation requirements as these will generally come from the platform providers, however, they will be the key to enabling the fulfilment of the requirements. Ultimately, the airports represent the locations that these future aircraft will be located and operated from so will play a vital role in supporting infrastructure development. Many airports have developed sustainability and decarbonisation strategies but these seem to be relatively immature with a lot of unknowns. Exeter has 'sister airports' at Bournemouth and Norwich. They do a lot in-house in terms of airport core services and capability with the aircraft being primarily fixed wing at present. They've got an air ambulance and a police unit but no commercial rotary operation.

Exeter Airport is a stakeholder of the 2ZERO project alongside Ampaire, University of Nottingham, HotSW LEP and others.

> *"The 2ZERO project uses a holistic systems approach to simulate and physically demonstrate the viability of electric aircraft in regional air transport operations and the changes needed to achieve a scalable ecosystem with demonstrable economic and environmental impact. The 2ZERO project will carry out flight demonstration of a novel 365KW initial prototype of 6-seat hybrid electric (HE) aircraft to assess performance capabilities and operational requirements.*
>
> *The project will also integrate a hybrid-electric powertrain and novel battery pack energy system to scale up to a larger passenger aircraft in preparation for flight demonstration in Phase3. This would be the largest passenger capacity for which HE flight is demonstrated. Modelling and simulation will be used to optimise flights based on this class of HE aircraft. This research will uncover the system-wide changes necessary for future operations of HE aircraft, including new standards and certification, airport infrastructure, demand management for renewable ground power (storage, distribution, and charging), optimisation of ground operations and air traffic route systems. Significantly, reduced operating costs and the Point to Point route structure will dramatically improve flexibility for airline operators and ease congestion at major hubs by creating viable routes from smaller regional airports."* [25]

One of the key challenges for Exeter Airport, that also resonates with other industrial groups, is the lack of specific and detailed understanding around the future aviation system of systems.

- What do the aircraft of the future look like?
- What does the associated infrastructure look like?
- How much capacity is needed to service a certain volume of aircraft?
- What will the airport need to do to adapt to these changes?
- What are the new skills needed?
- Do the economics stack up?

The airport and other stakeholders like MRO organisations will likely need to partner with a technology organisation to build the necessary understanding around hydrogen and electric aviation. There needs to be a business case in place before the airport can do anything, but they are unlikely to be able to invest in a new generation of sustainability projects without backing from government or grant funding from groups like UKRI.

A.6.1 Energy Requirement

For sustainable aviation at the airport to be commercially successful for low cost and regional/short-haul carriers the aircraft will need to have a quick turnaround time (~25-30 minutes). The airport doesn't have current capacity to support significant volumes of hydrogen or electric aircraft. The ability to meet turnaround

demand will be linked to how much capacity there is or will be in the wider energy networks whether that energy is in the electrical or hydrogen form. If the supply can be generated it will also need to be stored. To meet this energy demand there will need to be significant investment in the energy production, supply and storage infrastructure. The airports can help facilitate this i.e. they have the space and willingness to support these projects but the large capital expenditure requires dictates that the airport cannot do it alone, it will need technology partners and financial support (Rec S1, S4).

The airport has land and space and are happy for developers, like Vertical Aerospace, Ampaire or Leonardo, to build and test their aircraft there but beyond the testing and development phase it comes to a question of scale and economics, i.e., does it make business sense. The airport is also happy to have test flights providing the necessary approvals are in place – it just can't invest in infrastructure changes etc for the small scale.

A.6.2 Skills Requirements

For testing and demonstration and later commercialisation the whole aviation industry will need to further upskill on electrical powertrains. Classical mechanical engineering skills will still be important, but the skills agenda should now include more electronic and electrical engineering as well as understanding of other technology bricks such as hydrogen combustion, hydrogen fuel cells, electrical propulsion, thermal management and aerodynamic structures (Rec S12, L1).

The talent pool and skills market are highly competitive and it will be critical to ensure that people with the rights skills are brought in and retained. Alternatively, engineers and apprentices will need to be trained to meet this skills gap and skills shortage. These future skills are also becoming increasingly expensive; salaries are becoming more competitive making it harder to retain talent. There is pressure to match salaries with other locations. The airport has been able to recruit successfully so far but this will be a significant challenge in the near term. The Covid-19 pandemic wiped training and upskilling staff off the priorities list as airports across the world felt the effects of reduced air traffic.

This where Further Education colleges and training providers like Exeter and Yeovil colleges will be critical to ensuring a robust future proof workforce. Engineers currently working at airports and MRO organisations should also be encouraged to attend training courses etc to upskill themselves to meet future challenges (Rec M3). The airport has suggested they're happy to take people with little to no training and upskill them through training courses etc where appropriate.

A.6.3 Barriers

Batteries, electric charging, hydrogen and other sustainable aviation technologies currently do not feature in the airport's 10 year plan currently. The airport is still looking to be sustainable through the use of solar, LEDs and other green initiatives – but this will only take them so far. The aircraft is the critical piece to decarbonise. The airport and airline operators need better technical understanding and the technology needs momentum to get it higher on their agenda after the 2ZERO initially introduced it to the conversation. Once the technology is ready and viable, the airlines need to be bought into it before the airports have the funding to adapt. Without the buy in from airline operators, the airports won't be able to invest – cost is a key constraint particularly given the impact of the Covid-19 pandemic. This also makes 50% matched funding grants a challenge. The other key constraint being sufficient Suitably Qualified & Experience Personnel (SQEP) that meet the CAA's regulatory standards. Some key challenges for developing a test and demonstration proposition in the South West that were identified in the interview have been detailed here:

- Battery and hydrogen technology isn't mature enough to enter into service yet. Size, weight, refuelling/recharging, storage, production, distribution, cost and availability are all project related challenges that need to be addressed. These challenges are generally for the developers not for the airports though.

- Future skills gap and skills shortage. More workers are needed from technicians through to engineers trained in future technologies. Exeter College and other FE training providers can help here with refined training programmes and a 'future proof' curriculum.
- Airports can't invest without knowledge and a solid business case.
- Operational support isn't an issue at the moment but if things stepped up there could be a problem. Air Traffic in particular will struggle as a discipline if the amount of operations up-ticks significantly, but they could scale from their own 'build your own' capability.
- The airport sometimes has real issues with getting airspace use cases agreed by the regulator for normal use cases so they're not confident in terms of more challenging uses of airspace. This is why it will be worthwhile engaging NATS and the CAA as a follow on to this study.

It was recommended that the region needs to coalesce around one big initiative, ideally funded in part by government. This initiative needs to have a focus on action rather than just conversation (Rec S11). This fits with the 'grand vision' recommendation of a sustainable aviation test hub that is detailed in Section 4 of this report.

Exeter Airport wants to understand the core customer requirements around test and demonstration so that they can have the required supporting infrastructure in place at the right time. The technical feasibility is very close to being proven but the airports and operators need an industrial strategy to enable the industrialisation of new transport modes.

> *"Even though an estimated $500bn (£370bn) is going to be spent globally on hydrogen infrastructure, not every problem… ..has been solved, and some – including whether the hydrogen is produced locally or centrally, how it is distributed and how it is stored at the airport – are far too big for an aircraft manufacturer or airline to solve on its own. Then there is the matter of how aircraft will be refuelled with passengers nearby (robotic arms are one idea), and what the safety regulations will be. "That's a big bit of work," says Captain David Morgan, director of flight operations at budget airline easyJet. "And that's something we're going to start doing long before the first aeroplane arrives on the scene." Crucially, commercial aviation will have to learn from other industries that work with hydrogen every day. "One of the reasons why we brought Zeroe to public attention early was because we need to work as an ecosystem to make it happen," says Bentall. Conversations between airports, airlines and manufacturers have started."* [26]

A.7 Exeter College

Exeter College provides tertiary education for around 10,000 – 12,000 students. The college was established in 1970 as the first tertiary college in the UK, bringing together the former grammar schools' sixth forms and Exeter Technical College [27].

Today, the college is forging a path as a college of the future, offering learners a variety of ways into industry or further study. The college offers A Levels, BTECs, Apprenticeships and, from 2020, the government's brand new T Levels; a technical-based qualification that prepares students for industry with practical skills and knowledge. Exeter College is a recognised leader in the provision of Science, Technology, Engineering and Maths (STEM) subjects.

Exeter College has the Future Skills Centre which has focuses on aviation, engineering, travel and tourism. They have strong relationships with industry, including working with Exeter Aerospace to meet the future skills need. They're partnering with the 2ZERO project and funding for phase 3 lands and is successful, they will be the first college in UK to be part of such a project.

There are around 90 full time engineering students studying for a mix of Level 3, Level 4, and foundation degrees. They're also about to bring their apprentice program back after it was wiped out when the airport lost an airline carrier. Previously there was around 35 apprentices. The college is hoping for ~6 next year and a further ~18 the year after. The curriculum is being developed by the college but it is recognised that this needs to be immersed in industry. Some college staff are attending a Future Aviation Day in October 2022 to help encourage knowledge development and upskilling in the future of aviation technologies. This will improve the teaching capabilities at the college.

The college is making use of the Turing program and in the summer ~25 students will be going to Florida for some future flight experience [28]. Some staff are also going as part of their continual professional development.

> *"Exeter College is delighted to have secured government funding to be able to offer students studying the National Diploma in Aeronautical Engineering the chance to learn at a world-leading university in Florida.*
>
> *The Embry-Riddle Aeronautical University is a specialised Aeronautical University based in Florida with several campuses across the globe. The university offers associate, bachelor's, master's and PhD degree programmes in arts, sciences, aviation, business, and engineering. This summer Exeter College students will have ten days to fully immerse themselves in university life and participate in core learning activities linked to aviation. "* [28]

The college are looking at future labour needs but there needs to be a joined-up strategy in place to allow Further Education colleges to deliver the right people with the right skills today and tomorrow and in the future. This means taking on value-add programmes for the benefit of the students (Rec S12, L1). The college staff need to understand the issues around decarbonisation in aviation and the college needs resource to be able to deliver that teaching.

The college is very well supported with strong governance aimed at preparing students for life. Their working links with airlines, operators, industry etc is constantly evolving. They have great college resources but are looking to expand and improve these due to high demand. The aviation resources are growing in line with the post-covid recovery funds – this allowed the college to buy an 18-seater Jetstream aircraft for teaching purposes. The college is well funded but the teaching resources they can afford are platforms from ~25 years ago, not the platforms or systems that will enter into service 2 years into the future. The college needs to be able to replicate future systems to prepare students for both theoretical and practical aspects of sustainable aviation. Currently, 4th year students are exposed to real working environments at Exeter Aerospace, but the college should also be forward looking – i.e. the curriculum should be futuristic not current state.

There is currently a team of ~7 aviation specialists including 6 lecturers plus a business development lead with experience in the aviation sector. There are sometimes challenges with retaining staff wanting to go to industry because of higher salaries or other opportunities. The majority of staff come to the college in their 'twilight era' wanting to give back to the community. They present great aviation experience, but their experience of future flight technologies is more limited, as it is a new field. This means it is a challenge to deliver teaching unless they get support from industry etc.

The current curriculum is based on the current national agenda and focuses mostly on mechanical skills, these are important but other skills need to be added to the mix as well. Exeter college needs to deliver value-add programmes for digital skills, simulation, electrification and more. The college has lots of good will with industry and an engaged college community. They are well supported by the board but need to continue to look for investment and capital injections to deliver the best possible programmes. The Institutes of Technology that are in the region should ensure the curriculum is balanced and knowledge shared. The college is part of the Colleges Aviation Network – this allows for joined up thinking and sharing of best practice. The key is to remain connected and collaborative – for example there should be knowledge transfer between Yeovil's rotary wing expertise and Exeter's fixed wing expertise. This extends to maximising the collaboration with universities too (Rec S5). The 2ZERO project has given the college some links to Nottingham and Brunel. There is a roughly even split between students leaving the college to go on to higher education and leaving for jobs in industry. If the college had access to centres like the GKN GTC or IAAPS it would give the students real insight to R&D and industry, secondments should also be encouraged.

Exeter Aerospace and ither companies in the area will need support as air traffic increases during Covid-19 recovery. Exeter college can help fill these roles but it needs to be a real offer with real job prospects for the students. If the demand is there, Exeter college can work to fill the roles to help reduce the skills shortage.

A.8 University of Exeter – Centre for Future Clean Mobility

The University of Exeter is a well-respected Russell Group university with high quality research outputs. It consistently ranks highly in UK and International League Tables. In the 2021/22 academic year the university supported over 30,000 students made up of both undergraduate and post-graduate students. A key interdisciplinary area of research for the university is climate change and sustainable futures. There are several research centres and groups at the university that are highly relevant to aerospace engineering and the future of sustainable aviation [29]. These research centres include but are not limited to:

- Digital Engineering
- Evolutionary Computing and Optimisation
- Centre for Energy and the Environment
- Centre for Future Clean Mobility
- Exeter Technologies Group (Materials and Manufacturing)

Devon, Somerset, and the wider ecosystem can directly benefit from the world class research facilities and experience produced by the University of Exeter. As part of this study we explored this further by speaking to representatives from the Centre for Future Clean Mobility.

The Centre for Future Clean Mobility (CFCM) specialises in developing new hybrid and electric powertrain technology for cleaner mobility of humans and goods. The Centre partners with organisations to develop low-emissions, high-efficiency integrated power systems for applications in the marine, off-highway, rail, defence, and energy sectors. Much of this can be readily adapted to test and development of aerospace applications too. More than 30 companies have invested in CFCM to accelerate innovation towards future clean power.

They have expertise in the following areas:

- **Powertrain design, assembly and test:**
  The CFCM has expertise in design, assembly and test of hybrid and electric powertrains optimised for fuel efficiency, range and cost. These capabilities extend across a wide range of vehicles from passenger ferries to road-rail vehicles, to all-terrain military vehicles and more. The onsite facilities allow the team to test powertrains up to 0.5MW [30]. Some of the testing depends on the extent of the existing hardware and control systems design.
- **Government funding leveraging:**
  The CFCM has experience with leveraging government funding from supply chain development, through to bid writing, consortium partnering, and regulatory compliance. The centre often leads and writes multi-partner bids applying for funding from Innovate UK, ISCF, EPSRC, MarRI-UK and others [30]. These types of funding streams will be critical to other organisations across the South West as they look to develop their systems through grant funding. The experience that the CFCM has in this area is invaluable. The HotSW LEP could help organisations to seek out and apply for different funding streams and commercial opportunities.
- **Battery pack design and test:**
  The centre has experience designing, building and testing battery packs, this includes repurposing old batteries for clean mobility applications [30].
- **Control system design and implementation:**
  The researchers have expertise in system modelling, optimisation, and implementation. They also use other advanced AI functionalities [30].
- **Engineering into retrofit or OEM vehicles and vessels:**
  They have experience designing battery storage arrangements and motor installation based on the existing vehicle's architecture. Retrofitting vehicles and vessels that already exist can often be the most sustainable option [30].

- **Autonomous systems:**
  Autonomous systems are a key research area for the CFCM; they have experience in the development of autonomous behaviours, robust and adaptive controllers, and monitoring schemes, for a wide range of applications [30].
- **Instrumented test facilities for full-scale or near full-scale powertrains:**
  The CFCM, based at Exeter Science Park, hosts facilities for design, build, test in-lab and in-service of large electric and hybrid powertrains. This allows the researchers to test for emissions amongst other things [30].
- **Access to partner facilities:**
  The research group is part of the South West & Wales DER Centre of excellence. This offers a wide variety of open-access equipment for developing the next generation of Power Electronic Machines and Drives. The centre also collaborates with other Devon based projects/groups like the Marine Business Technology Centre and IMPACT lab offering various access to equipment for Devon based SMEs [30].

In addition to the above-mentioned capabilities, the centre has wider reach back into other teams at the University of Exeter.

The research team at the centre is made up ~6-8 cross-discipline leads with supporting researchers, admin and business development staff. The work is mostly focused in early to mid TRL R&D support in the 'TRL valley of death' but the CFCM can support up to TRL 7/8 if required. The CFCM are keen to transfer and share knowledge, this could be in the form of secondees, Knowledge Transfer Partnerships, exchange programmes or PhDs. The HotSW LEP could help to promote this kind of knowledge sharing (Rec S5, L1). Currently the centre is focused primarily on marine applications, but a lot of this research knowledge is directly transferrable to work in the aerospace or automotive sectors. Part of the reason that the centre hasn't done Aerospace work previously is that Aerospace companies are generally more established with good existing R&D capabilities so they need less external support from places like the CFCM. Alternatively, some aerospace companies will already be collaborating with centres like Cranfield. In the future it is possible that smaller, more agile companies make a bigger impact on the industry and so will need more additional support from academia etc. The centre has worked with the maritime industry on a roadmap for clean maritime mobility in the South West and nationally but Aerospace is probably slightly ahead on this.

The dyno that the centre has currently is relatively small in comparison to some of the larger civil engine test set ups but there will likely be a role for smaller scale powertrains in test and development. For example, if Leonardo needed an electric tail fan, the CFCM could help with this. Testing for full engines shouldn't be repeated loads as it gets expensive and time consuming. It is possible to test distributed powertrain architectures for the smaller stuff.

The researchers at the centre come from different backgrounds with diverse experiences and skills including safety critical systems, modelling & simulation, mechanics etc. They also have a drone lab where they are doing more aerospace specific R&D – this is worth exploring further. The facilities as they stand could be used for aerospace applications but as aerospace tends to be more mature in this type of testing there has been less interest to date – this could change with the introduction of hydrogen and electric aviation. Collaboration with centres like iAero could be mutually beneficial to the CFCM and other innovative companies looking to develop green aviation (Rec S5).

They are confident that at the minute they have a UK and Continental Europe USP in terms of the clean combustion powertrain test capability they have. They're running on a mix of direct industry funding and innovate UK funding. They're focusing more on the industry side where they can and as a University, they're there to provide R&D and early to mid-stage TRL support. They don't do much in automotive. For niche sectors they can get to prototype and then it's up to industry and market to scale up from there. They have UK and international partners. The centre is growing rapidly with plans to expand.

The sectors they're in have skill, innovation and capability and funding gaps so getting higher up the TRLs is a real challenge so they've bridged that gap. You need digital techniques and optimisation to bridge the gap been clean fuels and hydrocarbons. The centre is focused on testing clean powertrains and links closely with industrial partners for different applications of those powertrains. The university also has autonomy experience including a project for a fully autonomous 6-wheel drive vehicle. There could be potential to continue work on autonomy with iAero and other collaborators.

They have no fluid modelling and simulation capability – the CFMS at Bristol and Bath Science Park could support this if it was required. The research centre doesn't see any overlap with CFMS. The centre does have some capabilities in simulation and modelling for control systems and electric motors. There is a crossover with the work that IAAPS are doing – this is seen as a collaboration opportunity rather than competition. They are happy to share knowledge between the GW4 universities (Bath, Bristol, Cardiff and Exeter) – this could be through secondments or project partnering. Both IAAPS and CFCM are keen for engagement and collaboration.

A.8.1 Skills

- The centre is working very closely partners with to identify and recruit the right skills
- There is a struggle getting electrical powertrain and control systems engineers (EC&I)
- Many electrical engineers are recruited from places like India but this can have associated VISA issues
- The centre has been asked by blue chip businesses to provide Electric Vehicle training
- There should be a 'pyramid ratio' making up the future workforce from unskilled workers through to skilled experts. The new generation need to be upskilled and capable of working at 1000V and above.
- The pyramid should include apprentices, graduates, PhDs but there are skills gaps and skills shortages across the board therefore, we need more people trained everywhere at every level.
- There should be top down pressure on universities from government and industry to be teaching the right skills that are in demand. Financial incentives or other initiatives would also be beneficial here.
- Colleges and universities need to coordinate with industry to understand the future requirements – this should in turn influence the curriculum.
- There needs to be huge levels of investment to train thousands of people to meet the skills shortages and narrow the skills gap.
- There is a move towards electrifying engineering courses at universities (similar to the data science / software and digital transformation that occurred in the 2000s) but they need to hear more demand from industry and hence their customers.
- Training programs are needed to deliver – 1000s of graduate skills in mechanical, control systems, power electronics and more. These training programs should also start with 16-18yr olds, giving them exposure to technical projects because they represent the future work force.

A.8.2 Enablers & Infrastructure

- They can get to a demonstrator, and can help with integration, build and test.
- For example, Network Rail will have a demonstrator from quattro on a real site so they're in that space.
- There is a UK gap in mass production, manufacturing, and upscaling.
- The Council control the land around Exeter airport – it has potential for full scale airport flight test, particularly given the decrease in commercial air traffic in the area.
- The infrastructure required for green hydrogen needs to be funded by a public / private mix.

Across all mobility sectors there is no hydrogen infrastructure and high power electrical infrastructure is also lacking. Investment in infrastructure needs to be large scale and cross-sector so that we can have green hydrogen production at point of requirement, this is a priority (Rec S1, S2, S9, M2). It was suggested that there needs to be a joined up industrial strategy beyond the feasibility being proven – the strategy needs to bring in

users, operators, distributors and producers. In the South West they have all the capability for clean mobility and powertrains but the missing piece is batteries at an industrial scale.

A.8.3 eVTOL

- It was suggested that there is ability to do flight test in the airspace around Exeter (Rec S10).
- Leonardo would likely need to undergo a challenging transformation for them to fit with the eVTOL market. An ageing workforce would also add to the challenge. They need to train and upskill a new generation of workers.
- It will be important to understand the requirement for Yeovil compared to Italy. Yeovil has less of a focus on new build presently – financial levers would be needed for the business case of eVTOLs to make sense.

A.9 GKN Global Technology Centre

The GKN Global Technology Centre (GTC) is a 10,000m^2 'Open access' collaborative R&D centre located in Filton, Bristol. It is one of 4 GKN Global Technology Centres. It represents a joint £32M investment between GKN Aerospace and the UK Government through the Aerospace Technology Institute. The centre is part of an ecosystem of Universities, Research and Technology Organisations, Catapults, Government Organisations and Industrial Partners. It also provides support to start-ups and SMEs [31].

A.9.1 Hydrogen

The GTC supports key programmes like Wing of Tomorrow and H2GEAR. They are also supporting Vertical Aerospace with some of the manufacturing for their initial demonstrator aircraft.

> *"GKN Aerospace will lead a ground-breaking UK collaboration programme, called H2GEAR, to develop the company's first hydrogen propulsion system for sub-regional aircraft. Hydrogen is expected to play a key role in the decarbonisation strategy of aviation as it can power aircraft efficiently, leaving water as the only by-product. H2GEAR puts GKN Aerospace at the heart of the technology developments needed for the future of more sustainable aviation. The technology will first focus on significantly improving sub-regional aircraft hydrogen powered performance, in turn enabling applications on larger aircraft and longer journeys. The programme is supported by £27M of ATI funding, matched by GKN Aerospace and its industrial partners.*
>
> *H2GEAR aims to develop a liquid hydrogen propulsion system for sub-regional aircraft that could be scaled up to larger aircraft. Liquid hydrogen is being converted to electricity within a fuel cell system. This electricity efficiently powers the aircraft, eliminating CO2 emissions. This would create a new generation of clean air travel, eliminating harmful CO2 emissions."* [32]

The H2GEAR project will be a big step forward in the development of a hydrogen drive train, power unit and fuel cell integration. How we develop a liquid hydrogen supply chain or hydrogen hubs remains a large uncertainty though. This includes uncertainty around fuel storage and distribution – the same challenges faced by airports apply to multiple industries too. No one size fits all solution will work, different regions will require different power levels. Developing this capability in the South West would firmly put the region at forefront of development and it could have huge cross-sector benefits (Rec S11, M2). GKN are looking to enable hydrogen aircraft not develop an off the shelf platform. This means they're focused on the propulsion system, agnostic of the eventual platform.1-5Mw+ of green hydrogen capacity is certainly on the wish list for GKN and others in the region.

It was suggested that Exeter could be a good location for flight test (Rec S10). A key enabler for this is an airframe that can embody the hydrogen powertrain for demonstration (Rec S11).

GKN is also supporting Heathrow, Rolls Royce, Cranfield Aerospace Solutions and others with Project NAPKIN. This is a Future Flight Challenge funded consortium aimed at establishing a blueprint for zero carbon aviation by modelling the introduction of low or zero emissions aircraft into regional and short-haul aviation, such as those with hydrogen or electric propulsion. Some useful findings from the Project NAPKIN interim report have been included here:

- *The first ZEF flights will most likely operate from small airports operating short hops, such as those in the Scottish Highlands and Islands and to and from the Isles of Scilly and the Channel Islands. They will use gaseous hydrogen, which can be delivered by truck using existing supply chains, with liquid hydrogen used for longer routes.*
- *Ultimately major new infrastructure will be required at larger airports potentially involving pipeline, liquefaction, storage, and upgraded delivery to aircraft, but at the point of introduction, a small number of deliveries by road will be sufficient to support core routes.* [33]

The full findings from the consortium will be published in April 2022, it is worthwhile keeping an eye on the release of these reports as they will be highly applicable to the region, particularly if Exeter becomes a hub for sustainable test flight.

As well as aircraft systems and hydrogen, GKN Aerospace are also interested in noise, wind tunnels, materials testing and cryogenic materials. They can lean on their Fokker heritage for some of this, a lot of data sits outside of the UK though. There are a lot of questions and challenges around composites testing and can these materials perform at cryogenic temperatures. Something that has been identified as missing for the South West area is an environmental test facility for testing structures and rigs at extremely low temperatures (Rec M8).

It was suggested that the South West still has a lot skilled engineers but it can sometimes become a cash flow problem to lock those skills in to stop them moving away for promise of higher salaries. There needs to be some capability built around sustainable powertrain for uncrewed air systems. GKN itself can act as a systems integrator if needed and has a huge reachback of skills and capabilities globally. It would be beneficial to the region if they could tap into this knowledge. GKN could perhaps work as a satellite team down at the iAero centre like an exchange program. To get urban air mobility to take off the key challenge is around certification, this means there will be more skills requirements focused on assurance, simulation, testing and regulation (Rec M3).

The GKN GTC are Tier 1 members of the National Composites Centre (NCC) and the Advanced Manufacturing Research Centre (AMRC), they are also Tier 2 members of the Manufacturing Technology Centre (MTC). They are fully signed up members of The Welding Institute and also have connections to the National Graphene Institute (NGI) in Manchester. There is also consideration of working with the Royce Institute as a satellite site. There is huge potential for the iAero centre and other organisations across the South West to engage with GKN and tap into this UK wide network of R&D expertise. The HotSW LEP could help to coordinate this engagement (Rec S5).

The GKN GTC site collaborates with Weston College, University of Bristol, Bath Universities, UWE, Exeter and PhDs on in-service work as well as professors conducting R&D. Weston College has apprentices on the site which provides great engagement for the students to work in a real industry environment. The other colleges across the Devon and Somerset region should also look to collaborate and gain exposure to sites like the GTC. The HotSW LEP should promote the capabilities of the region but check the area isn't saturated with projects like Fresson or ZeroAvia (Rec S11).

During the interview we asked what the biggest gaps in sustainable aviation were, i.e. what are we missing in industry. Some suggestions are detailed here:

- Materials Technology – evaluation and understanding of materials will unlock their potential
  - Following that understanding comes the capability to apply the materials to the next generation of platforms
- Short of engineers, H2Gear employed ~50 people but more people are needed industry wide
- Cryogenic skills, materials & manufacturing skills, EC&I skills, digital skills, Industry 4.0

There are some aspects of hydrogen infrastructure that Aerospace should focus on and others that they may get for 'free' from other industries. This Hydrogen economy needs to be better understood. The hydrogen infrastructure needs to be adaptable so that all industries are welcome, not just aerospace. This will save cost and improved connectivity. There is a need for green hydrogen and the magnitude of hydrogen infrastructure required to meet demand is huge. Aerospace needs to upscale and invest in hydrogen networks but it is unclear at this stage what those networks look like (Rec S1, S2, S9, M2).

Table 3 - Requirements table provided by GKN Aerospace

No.	Project or Horizon (H1, H2, H3)	Requirement	Timescale (In Approx Years)
1	H3	Liquid hydrogen supply chain capability	1-2yrs
2	H3	Liquid hydrogen test facility - Fuel Storage & delivery	2-3yrs
3	H3	Cryogenic material test facility - material characterisation	Now
4	H3	1-5MW power ground test facility	2-3yrs
5	H3	LH2 Aircraft refueling test capability	3-5yrs
6	H3	Aircraft platform for flight demonstration of LH2 Hydrogen Electric Aircraft capability	1-2yrs
7	H3	Aeroacoustics wind tunnel testing facility (3m+ proprotors)	2-3 yrs
8	H3	eVTOL propulsion systems fatigue testing facility	2-3 yrs
9	H3	Battery systems and fire safety testing facility	2-3 yrs
10	H3	Bonding pilot line - UK Capability and knowledge	Now
11	-	Material testing UK Database/Investment	Now
12	-	Off cuts that can be used to create new objects - E.g Containers Near Net shape	Now

A.10 Hydrostar / Emerald Green Power

For initial testing and demonstration purposes the logistical challenges around producing sufficient energy (hydrogen or electric) and transporting it to an aircraft are relatively minor as the volume will be low. As soon as testing and demonstration starts to ramp up towards more commercialised operation the energy challenges will be significant, ground infrastructure will likely become the dominant factor holding back or accelerating clean aviation. Therefore, if the South West wants to become a hub for sustainable aviation in the long term it needs to consider energy (Rec S1).

We spoke with a representative from Hydrostar and Emerald Green Power. Hydrostar are mainly concerned with Electrolyser and Electrolyte development while Emerald Green Power's focus is developing green power sites. Emerald has grown rapidly and now employs ~15 people. These organisations provide a complimentary mix of focus on product and focus on application while considering how we can produce enough green hydrogen to meet demand.

Most organisations and people including airports, airlines and manufacturing sites don't have a clear and detailed understanding of how much hydrogen they will need and what that will look like in a practical sense. Emerald Green Power's products Romulus (smart city net zero digital twin) and Remus (remote monitoring utility system) can help to answer some of these uncertainties. Building a digital twin of Exeter can help to answer how much energy is needed and where (Rec S1). It could go further and look at identifying how much carbon is being produced and how much green hydrogen is needed to offset that. Do we build a single 100MW electrolyser or is that unfeasible or do we have a distributed network of smaller electrolysers? Modelling and simulation can help to solve some of these uncertainties. Digital twins would also be really valuable for modelling how many aircraft are likely to be operating at given times to de-risk the energy demand/supply challenge. Hydrogen production likely needs to be more distributed to allow for better integration with the national grid infrastructure. Opposite the airport in Exeter there are a host of distribution centres, these could help to play a key role in the distribution of sustainable aviation technology parts and systems etc

A process should be put in place to work out how technology partners like Hydrostar or Emerald Green Power advise various councils, boards and groups to inform their requirements (Rec S2).

A.11 IAAPS

The Institute for Advanced Automotive Propulsion Systems (IAAPS) is a world-leading centre of excellence for research, innovation, enterprise, and education, supporting the future direction of propulsion. Designed to drive research investment, deliver economic impact and address the skills shortage, IAAPS is a catalyst for sustainable economic growth [34].

Primarily, the institute has focused around automotive, but it is looking to pivot towards other sectors including aerospace. The funding received by IAAPS is also shifting to more hybrid propulsion systems away from internal combustion engine work. Additional new funding calls are being seen in aerospace and this is starting to gain traction.

At the time of writing this report, the IAAPS centre is yet to be opened though most of the cells and components are in place. It is perfectly placed next to the NCC which has a national agenda but supports the local region too – the stakeholders within the HotSW region would likely benefit from links to these national centres of excellence. Once opened and operational IAAPS are keen to be part of any education, training, and collaboration with neighbours at the Bristol and Bath Science Park. There is a unique capacity and scale at the site.

A.11.1 Hydrogen Propulsion and Hydrogen Systems Testing

In our interview with a representative from IAAPS it was recognises that there is a huge shortage of testing systems particularly around hydrogen. It will be important for IAAPS to go out to market to understand what opportunities exist and what industry projects they can support.

As a short-term priority, the centre wants to get grant funding for a green hydrogen project. PV solar cells at the site could run an electroliser to give hydrogen production capabilities on site. The centre will look to get hydrogen on site within a year anyway, but it would be ideal if this was sourced through green electrolysis rather than bought in. In other words, even if the centre does not get funding they will invest in hydrogen anyway. This will give the centre the ability to combine hydrogen with the testing of propulsion systems – IAAPS would be able to offer all aspects. Many other groups are doing work with electric propulsion in aerospace, but IAAPS suggested that the addition of hydrogen sets them apart globally.

As part of their short-term plan, IAAPS are proposing to work with a tier 1 company in Bristol to develop a hydrogen propulsion system – this will mark their first hydrogen contract but they have plans to expand in this area.

IAAPS can support fuel cell and electric motor development using their own test cells. With further testing of individual components in parallel. Novel battery design is relatively immature but their emulation systems can assess real time performance of batteries. Additionally, they can simulate workloads and propeller cycles, air pressure for air management of hydrogen fuel cells and more.

The 4WD system could be suitable for a copper/iron bird facility where the dynos are arranged to effectively simulate the power loads in an aircraft. There is further potential to use the chassis space for more hydrogen and hydrogen for aerospace applications.

There are lots of organisations doing proof of concept – but not much further – there aren’t many places that can sustain 1-1.5MW capability. IAAPS can review thermal management, run simulations, develop and use digital twins, verification & validation, develop component models, review cooling systems and integrate with third party systems. They can work in the full range from early TRLs to higher TRLs of systems.

A key feature of the IAAPS centre is that the projects don't need to be managed by the IAAPS staff; organisations can just use space to run these tests. They have state of the art facilities, and open to engagement, collaboration and commercial opportunities across multiple sectors.

IAAPS has good reachback into the University of Bath as well as other PhDs and post-doctorate researchers. The centre can draw on this expertise if required for specific technical challenges. Once fully operational they will likely have students, academics, and other staff on secondment in the centre. They need more industry experience than academic though, particularly industry experience relevant to Aerospace.

It was recognised that the Aerospace approval process is long and the future requirement will need to be more agile. The starting point needs to make business sense too. The development cycle for innovation needs to be quicker too. This has led them to be interested in some automotive simulation software adapted for aerospace that give them 6-7 design options early on which can be prioritised quickly to save time and cost. The university is doing projects on charging infrastructure whereas IAAPS focuses on the systems and propulsion. It is possible to collect loads of data using AI techniques but eventually you need to test the platform. IAAPS have the ability to validate simulated data with physical and simulated environments. The IAAPS centre won't validate things against CAA certification, they're more focused at the early stage development and initial testing. These facilities can be rented out to interested parties and aircraft developers looking to run tests without the cost of buying a dedicated site.

They have received 2nd stage planning permission for the building – so there is no problem with developing an aerospace specific area. The business model changing is rapidly and so robust business cases would need to be in place to for any specific developments. There is an initial plan for using gaseous hydrogen on site and having a storage facility based on consumption. IAAPS neighbours the NCC who also have a strong requirement for hydrogen.

Initially IAAPS will open with ~30-40 people but will look to expand to ~100 staff over the next few years. Staff can be kept at a minimum as projects bring their own staff. Initially the staff mix is made up of ~13 operations staff with the rest coming from engineering backgrounds.

A.12 Leonardo Helicopters

Leonardo Helicopters, based in Yeovil, is clearly of huge importance to the South West and the UK. They want to become a 'centre of gravity' for the region and build momentum from there as the UK vertical lift experts. What sets Leonardo apart is their experience in vertical lift, rotary wing integration, vertical lift dynamics backed up by a vast wealth of certification experience. This is what differentiates them compared to Cranfield or other aerospace nodes or clusters across the UK. The Leonardo site at Yeovil contributed £360m directly to GDP in 2018. The site employed 3100 people with 5000 total employments supported in the local area. Leonardo spent £62m with the local supply chain in 2018 [35]. Continuation of this social and economic benefit relies on continued new platform development by Leonardo.

They are the incumbent helicopter designer and manufacturer in the UK. Though they are not involved with Advanced Aerial Mobility (AAM) aircraft directly, a lot of the skills and experience are highly transferrable particularly around the route to the certification end game and eventual release to service. This knowledge of the certification process is and what success looks like is directly transferrable to new digital systems and new aircraft architectures.

Leonardo also have significant experience in planning flight test campaigns in a cautious and progressive manner; they are experienced in how to execute this safely and effectively. They have the ability to run a large electric ground test rig but no hydrogen test facility exists yet. Close collaboration with centres like IAAPS or CFCM could help to bridge this gap (Rec S5). At their site in Yeovil, they also a Whirl tower for testing rotary wings – this could be rented out to academic partners to use day to day but then it could also be used by eVTOL companies like Vertical Aerospace during qualification testing.

The transmission and electric motors required for tilt rotor aircraft and eVTOLs are effectively the same as those used for helicopters as the architecture is very similar. Leonardo has the expertise of how these operate and how they are designed and manufactured, this knowledge is invaluable to the advanced air mobility (AAM) sector. Leonardo also has a telemetry mast which is highly valuable during the testing phase of an aircraft, particularly when coupled with their experience of development flying. Leonardo has significant tilt rotor experience having developed the AW609 tilt rotor aircraft – this experience is highly valuable to the advanced air mobility market.

There will be a hangar requirement for any aircraft developer in the region as they need to maintain and repair their aircraft. The Leonardo site in Yeovil has plenty of space, the key is to understand the best use of the existing buildings and optimisation of any future site developments. Electric or hydrogen aircraft will also need energy specific infrastructure like electric charging or hydrogen storage and fuel cell facilities. This highlights the need to integrate the different elements of ground and air transport – a testing hub could demonstrate this integration.

Leonardo is great at developing iterative products that go from Version A to Version B to Version C. They aren't as good at disrupting straight from Version A to Version C. Airworthiness and innovation often don't mix well and for good reason but this needs to change for testing and demonstration of future platforms. Development of new platforms whether its drones, AAM or regional air mobility with hydrogen or electric power will need to be developed in more agile and innovative ways (Rec S11). New programmes will need new ways of working. Enablers like automation, simulations & digitals twins and training need to be used as much as possible – Leonardo brings significant experience of these and other enablers to the region. Digital twins in particular should be used to avoid as much expensive rig testing as possible, testing in this manner can also help to de-risk any future ground or flight testing (Rec M3).

It was suggested that the development of a flight test corridor between the Yeovil site and Exeter airport and beyond for both uncrewed air systems testing and testing of electric or hydrogen aviation would be of great benefit to the region and to the UK (Rec S10). It would help to keep the UK as a leader in aerospace and

aviation globally. A key enabler to this is funding. Leonardo could seek and apply for more funding though Innovate UK, the Catapults and other grant schemes – the HotSW LEP could help to coordinate some of these funding attempts. Any investment for a test corridor and supporting infrastructure should be deconflicted between industries, the investment needs to be cross sector so that things are repeated between aerospace and automotive for example. This also means that any existing developments in other sectors should be leveraged to their full potential for aerospace.

A.12.1 Skills

Leonardo is looking to recruit significantly more people in the next few years. This will be made up a wide range of experience levels so colleges and universities need to be able to deliver the right teaching to enable graduates of those institutions to fill the future roles (Rec M3, L1). The curriculum should be expanded to included future flight technologies like hydrogen and eVTOL aircraft. Currently, there isn't much exposure to this in education or in the wider engineering community – this needs to be addressed. This means the vision needs to be articulated to students to inspire them to join roles that are in demand to meet the future engineering challenges (Rec S12, M4). This won't be a one size fits all solution and the future requirements by their nature aren't always that clear so it will also be a case of where institutions and industry can put their best 'bang for buck'.

The existing engineering skills also need to be practiced or there is a risk of losing them. This means there needs to be some succession planning for experienced personnel, upskilling new staff and knowledge transfer from old programmes to new (Rec M3).

A.13 Rigby Group

Regional airports are crucial to the economic development of regions in which they are located and this will become even more true as we move towards the future of mobility. Regional & City Airports (RCA)'s vision is to help regional airports to prosper through effective management and collaboration, enabling them to benefit from the economies of scale. This also enables knowledge transfer and sharing of best practice between regional airports. RCA is a major player in the UK regional airport sector. They own Bournemouth Airport, Coventry Airport, Exeter Airport and Norwich Airport. The group also operates Blackpool Airport and Solent Airport Daedalus on behalf of their owners [36].

The Rigby Group are following the Airports Council International combined approach to sustainability with mentoring from Schipol airport. The Rigby Group are committed to the journey towards electric flight. The need for transitioning to more sustainable, decarbonised aviation is well known but the challenge lies in understanding exactly what this looks like.

It was suggested in the interview that the priority requirement is an infrastructure that can produce batteries or energy systems to support aviation and other sectors. Batteries should be produced near the point they will be operated from. One suggestion was that the South West needs a battery focused infrastructure that can be a focal point for all industries looking to decarbonise (Rec M2, L3). Once that is in place, the focus can shift to electrifying flight. The skills agenda for batteries and electric flight can then be built on to support this.

In terms of facilitating flight test for Ampaire from Exeter airport very little needed to be done. Ampaire filed the normal flight plans and cleared the safety aspects with the CAA. The airport is just the supporter and facilitator but the funding for Ampaire's required infrastructure for 2ZERO was funded through the UKRI grant. There is a fuelling facility at each of Rigby Group's airports including for private planes but they don't have any green refuelling facility yet – this understanding will come from Ampaire or other sustainable aircraft developers.

It was suggested that preparing for hydrogen or electric flight is a bit of a waiting game for the Rigby Group's airports. They need to better understand the requirement and because Rigby Group are the enablers not the drivers, they will need technology partners or some investment guarantees to support this. This could include a business case with a down-selection of hydrogen vs electric. The transition to and away from Sustainable Aviation Fuels (SAF) also needs to be considered (Rec M6). The airline operators need to be ready for these changes and they can then flow down their requirements to ensure the airports are ready to facilitate sustainable flights.

Exeter airport has a 1MW electricity supply but generally the baseload doesn't tick over 350kW. Some areas of the airport can be covered in solar panels. This energy needs to be captured and stored once its generated. Batteries are expensive and relatively immature. It is worth exploring whether an electrolyser could be efficient enough if it draws from the peak of renewable energy. Exeter airport's supply can't handle a large 10MW electrolyser. This suggests that the airport stakeholders need to engage with Western Power Distribution etc to understand the energy supply and demand logistics. The HotSW LEP could help to facilitate these discussions (Rec S3).

Does the electricity grid have the capacity and capability to meet demand for electric aviation while in parallel other industries decarbonise and increase their demand too? Can the use of batteries or electrolysers help to stabilise the grid? This likely presents its own integration challenges.

The airport uses no gas so new pipelines would be required if hydrogen was to be piped into the airport.

A.14 South Somerset District Council

The District Council has no major financial incentives available, but they can provide smaller support to businesses and support around the 'softer side' of inward investment. This could be through 'landing packages' ensuring that businesses can tap into the right talent pools. For example, they could support Leonardo, or Vertical Aerospace or an advanced manufacturing facility from an economic development perspective. They are also the local planning authority so would need to be engaged early on if any proposed testing and demonstration facilities were to be built.

It was recognised that there is a communication gap between industry and local government – this should be addressed to ensure stakeholders are both on the same page in terms of requirements, business cases and implementation of smart, sustainable aviation (Rec S2).

The District Council can encourage business to be more sustainable, but their impact and influence is limited. Generally, they take their lead from industry players like Leonardo and the wider supply chain. The economic development team at the council are developing an action plan report with an employment skills agenda closely aligned with Yeovil College. They recognised it would be good to be more proactive in terms of government support mechanisms and funding options but they have limited experience in this area which adds to the challenge.

It was recognised that as we transition towards the future of flight the existing supply chain in the region may need to diversify. There a few key sites around Yeovil that could be developed for High Value Manufacturing sites (Rec M7). There are also potential plans to develop transport links like the A303. Bundford Park (~500m from the iAero centre) is a large site that could be used for mixed use employment land. This could be a valuable asset for companies like Vertical Aerospace looking to identify a suitable test and manufacturing location.

They are looking to do more work with universities but this is sometimes challenging as there is no formal funding process in place. They have a series of business support programs, including from the county council renewal fund to support local businesses. Their Full Pathways Programme is aimed at getting engagement from businesses and from schools and encouraging businesses to sponsor undergraduates, placement students etc to give them more of a tie to local areas to retain that talent. They also have softer programmes like the Yeovil next generation programme which is about community regeneration. A further strategy for encouraging more experienced hires with the right skills is also needed. Currently they are relying on quality-of-life assets (countryside, house prices, market towns, schools, fresh air etc).

The council has no technical understanding of large-scale hydrogen production, energy infrastructure or of the business requirement for green hydrogen. They do have plans to reach net zero though, they just need some knowledge transfer from technology partners. It was also suggested that it would be beneficial for the council to explore better use of drones for levelling up, particularly where the use cases fill current gaps in capability. A number of smaller airfield sites like Henstridge, RNAS Merryfield and RNAS Yeovilton were identified as potential options to explore further for testing and demonstration purposes (Rec S6).

A.15 Transport Lead LEP

For this feasibility study we spoke to the Transport Lead at the Local Enterprise Partnership whose background in transport planning, road & rail, civil engineering and land use provide to give valuable insight into some of the broader issues facing decarbonised aviation. Testing and demonstration of sustainable aircraft is a stepping stone towards the fully decarbonised aviation system but it is often important to start with the end in mind so that money and time doesn't get wasted testing the wrong systems in the wrong way. It was suggested that Exeter is becomingly increasingly important in the region and further afield – it is an ideal growth location. Exeter has a long runway suitable for testing and importantly, test operations are often more viable in relatively rural areas where airspace is less busy (Rec S10).

It was recommended that we must be interested in whatever technology will decarbonise transport as whole and which technologies will get us there quickest. A holistic view of mobility must be taken. Airports cannot decarbonise in isolation and will need to be supported by a hydrogen economy and or a battery economy (Rec M2, L3). Perhaps this means a focus on battery technology with rapid charging initially then a phased transition towards hydrogen as that will likely lag and take a while to arrive. It is also worth noting that central government's efforts for green hydrogen are mostly located in the Northeast of the UK – the government's recent hydrogen strategy should be considered here. The available supply and demand of hydrogen in the South West doesn't seem to be well understood by many stakeholders – this needs to be addressed before too much time or money is invested. Hydrogen storage, energy infrastructure and grid capacity are also key concerns to address to enable green aviation (Rec S1). To answer these types of questions it will be important to engage people across sectors like Nuclear and Renewables as well as distribution networks. It was noted that Green hydrogen should be a priority if/when there is a production facility available.

The local councils and HotSW LEP can help to transfer knowledge between industries by acting as the coordinating partner (Rec S2, M3). The region needs plans in place to better understand the technical and commercial viability of hydrogen vs batteries for testing and demonstration but also for the longer term as well. Then there needs to be better understanding of how drones can safely benefit society to fill capability gaps in the health sector or emergency services in rural areas for example.

It was suggested that Exeter Airport is well located in terms of surface transport though not as close to rail connections. The airport is situated adjacent to the A30 just off Junction 29 of the M5 – so it is very well connected by road to the engineering hub up at Bristol. The connections by road across from Exeter to Yeovil on the A303, or from Bristol to Yeovil are less convenient. Peninsula Transport is a shadow sub-national transport body, that represents the five lead transport authorities in the South West peninsula; Cornwall, Devon, Plymouth, Somerset and Torbay [37]. At the time of the interview with the LEP Transport Lead, Peninsular Transport were writing their long term strategy – this needs to be understood in the context of the future aviation system of systems. It should give insight as to where the best, most connected sites are for potential testing and demonstration hubs.

Exeter airport needs more patronage and the range of flights is relatively limited, perhaps being a first mover for testing of sustainable aviation through electric or hydrogen technologies could benefit the airport commercially (Rec S8). It was suggested that Exeter could possibly be the best location within the region for a hydrogen distribution hub. There is significant potential for electricity-based industries to be located at Exeter. There is also a proposal for an intermodal freight terminal close to Exeter Airport with scope for express logistics type facilities. This could be beneficial for companies looking to test sustainable aircraft in the region particularly if they need to quickly transport aircrafts parts around and also have quick links for staff to join up with other engineering hubs.

During the interview it was suggested that Yeovil and Exeter should have a really solid starting point in terms of engineering skills. There should be a focus on more electrical skills and energy/hydrogen integration. The

universities in the region could be a valuable resource to draw on to help address these challenges (Rec S12, M3, L1).

A.16 Vertical Aerospace

Vertical Aerospace are an eVTOL platform provider based out of Bristol. Their approach to development of a new electric aircraft is to act as integrator with key technology partners like Microsoft, GKN, Honeywell, Rolls Royce, Solvay. Vertical Aerospace has also partnered with operational or leasing partners including Virgin Atlantic, American Airlines and Avolon. They recently floated in the New York Stock Exchange where they raised ~$300M.

Following the launch of the company in 2016, Vertical Aerospace have flown their VA-X1 and VA-X2 eVTOL aircraft and are looking to certify and fly their VX4 aircraft by 2024. To reach this ambitious certification goal, the team at Vertical Aerospace will need to conduct extensive ground and flight test campaigns.

The GKN Global Technology Centre is supporting Vertical Aerospace in the development of two demonstrator aircraft which will be used for the necessary ground and flight testing. This testing will need to be incremental and progressive yet cautious; covering all aspects of operation including but not limited to thrust requirements, battery requirements and transition from vertical to horizontal flight (and vice versa). The use of eVTOL aircraft represents a step change risk for the CAA because they are new platforms operating in different environments with different use cases. This makes testing and successful demonstration of eVTOLs critical to their success.

A.16.1 Technical Requirements

A key requirement for electric aircraft manufacturers including Vertical Aerospace is having a suitable runway location to allow for test flights and post-production demonstration. Sole usage or close to sole usage of the runway facilities is also highly desirable as it mitigates risk from conflicting air traffic scheduling though this is likely unachievable unless Vertical Aerospace owned the site. This requirement comes from the fact that the development batteries are heavier than the anticipated operational aircraft batteries meaning they need to test as soon as they’re airborne with limited flight time. This makes testing at civil commercial airports more difficult but not impossible.

An appropriate runway facility has not yet been identified and down selected by Vertical Aerospace yet but a close proximity to the Bristol base would be ideal. Finding the right patch of runway to use is a key challenge for Vertical Aerospace; this presents a potential opportunity for the South West region, if a suitable site can be located there (Rec S10).

No manufacturing facility defined yet – this could ideally be situated in the South West (Rec M7). It is preferrable to have this close to the head office. Ex-military establishments or unused civil aerodromes are potential options, but they also bring their own complications due to the lack of supporting infrastructure. There is a need for a low volume manufacturing site with post-production flight test facility on hand, i.e., they do not want to build the demonstrator then ship it away for flight test. The demonstrator aircraft used for the certification campaign will need a flight test location. Later, if the flight tests prove successful then Vertical Aerospace will need a higher volume manufacturing site. It is worth aiming for this to start with to avoid development of two separate sites.

Vertical Aerospace keep partnering at the heart of the way they operate, this is likely to be their way forward when it comes to manufacturing automation and industrialisation. Though they’re not necessarily going to take over a production site that has already been built.

A dedicated simulation facility (with mobile aspects) is being planned and set up. This will be an important tool to help de-risk flight test but it requires close interaction with the CAA to understand how much credit can be taken from simulation. It will be important to answer how data is managed within synthetic environments and how this is transferred to the real world safely. The simulation environment will need to be of sufficient fidelity but not too computationally expensive.

It is possible that Vertical Aerospace may look to build somewhere themselves, this is in part dependent on any economic incentives from local government, councils, other investors and central government. A manufacturing facility for Vertical Aerospace could possibly be in South Wales or in the South West beyond Bristol in Devon and Somerset. From a levelling up perspective, Vertical Aerospace will look at all options but access to a good talent pool of engineers including graduates is essential. Therefore, it is necessary to invest in the education of the future workforce (Rec S12, M3, L1).

Testing over water is not ideal for Vertical Aerospace initially suggesting that a flight test corridor over land between Exeter, Newquay, Yeovil and Bristol could be a good potential option (Rec S10). Vertical Aerospace will need hangarage but this and other maintenance aspects are likely to be solved relatively easily. The electrical power challenge may be harder to resolve. They are unlikely to overload the substations with just two demonstrator aircraft but as they scale up this will become a risk and there will become a need for upgrading substations and the general electricity infrastructure (Rec S1). The substations could become overload if there was around 6 aircraft being demonstrated. This will come at a cost so there needs to be incentive from local authorities and deconfliction with existing infrastructure projects. Good communications infrastructure will be needed as a huge amount of data will be collected during flight test. There needs to be good connections to severs and telemetry stations, ground based fibre and 5G will be beneficial here (Rec S7). Leonardo has an existing telemetry mast that could prove useful to Vertical here. Plymouth has just opened a 5G marine test bed that could open up other options for testing once Vertical's platform has matured. Flight test turnaround times will be key, by flying twice in a day it could effectively halve the length of the test campaign dramatically saving on cost. To be able to do this Vertical Aerospace would need relatively quiet airspace – Exeter has this (Rec S10).

A.16.2 Skill Requirements

The resource requirement for testing and demonstration of Vertical's aircraft will be relatively small but as they look towards ramped up production of 50-100+ vehicles in the longer term they will need lots of engineers and technicians on hand quickly.

As the first clean sheet aircraft design in the UK in a generation, Vertical's aircraft has huge potential for Inspiring STEM students. The HotSW LEP could work with local schools and colleges to help inspire students to take engineering and technology subjects, this would benefit engineering as a whole while also helping to form a talent pipeline (Rec S12, M4).

As Vertical Aerospace grows, they will want to take on graduates and vocationally trained engineers like apprenticeships. The talent pool available in Bristol is a great resource for Vertical but as they need a great volume of engineers they can look further afield to the South West. Close collaboration with the Further Education providers and Institutes of Technology in the region would likely be of huge benefit to both parties (Rec M3, L1).

Some suggestions were identified through this conversation:

- There needs to be incentives from the HotSW LEP to attract people to the area. These could be financial, for example, can the HotSW provide support to organisations seeking and applying for funding (Rec S4).
- Local government will needs to be agile with legislation, politics, with more technical understanding of the challenges and opportunities compared to other councils and authorities (Rec S4, S14). Bureaucracy can stifle innovation.
- There are some barriers to Advanced Aerial Mobility (AAM) including but not limited to public perception, noise & visual pollution. Local authorities need to be proactive in promoting AAM and dispel myths (Rec S14).
- There is a strong aviation capability in the South West, but the organisations there cannot rest on their laurels and need to be aggressive and ambitious to attract the right skills and assets to the region – particularly in new markets like eVTOL (Rec S11).

- Intermodal transport and delivery routes are critical – to enable testing and later on production of new aircraft the logistical infrastructure needs to be in place to support this. The HotSW LEP could work with infrastructure organisations and the councils to explore this further (Rec M9). The current test area at Llanbedr is ideal for flying but a long way away from the engineering team with poor road connections – bypasses could be needed.
- The region needs to be willing to go first, there will be a significant first mover advantage for AAM and hydrogen or electric aviation (Rec S11).

A.17 WEAF

We spoke to a representative from the West of England Aerospace Forum (WEAF) who suggested that the key differentiator between the South West and other aerospace clusters across the UK is the ability to develop every aspect of an aircraft not just a small focus on one system or sub-system (Rec S11).

The key challenge or threat is around the fact that Filton has been lost as a suitable flight test location. So how do we keep aircraft testing in the South West?

The answer lies in the regional capability as a whole, not just in one city. The South West as a collective including Exeter, Yeovil, Newquay, Boscombe Down, Poole, Bristol, Yeovilton, Culdrose and others have a vast wealth of experience to be tapped in to. Comparatively other regions do not have such a diverse and complete range of skill sets.

The barriers to developing smart and sustainable aviation here will always be financial ones. A lot of the technology is starting to be demonstrated, it needs to be industrialised and commercially viable. A solid business case needs to be put forward to attract talent and investment. A robust business case will also help to identify the necessary actions for protecting jobs in the region. There is threat of competition from organisations like QinetiQ in places like St Athan but this threat dwindles as you move further North because moving further North takes you away from the core skills base. It's a different era for Aerospace now; we're no longer looking at incremental design changes, it's whole aircraft systems. A lot of capability has been lost in this area, particularly having lost Filton's runway, therefore it is important to protect jobs and capabilities associated with whole aircraft flight test.

Exeter has strong potential for a flight test corridor (Rec S10), some flights have been conducted already e.g. Ampaire's flight to Newquay. This could be backed up by a flight area that follows the A303 to Yeovil. Military aircraft already use this route.

Another part of the future aviation puzzle that is missing is the capability to conduct environmental test (Rec M8). Fuel cells and electric motors are often tested in automotive environments, but these will have completely different operating profiles to the aerospace industry, particularly if there is a move towards cryogenic liquid hydrogen. The Centre for Future Clean Mobility at the University of Exeter is looking to invest in environmental test capabilities which would be a huge differentiating advantage.

There is a high demand for hydrogen testing, this puts on a lot of pressure for there to be appropriate hydrogen test rigs. This is challenging and likely needs to be done in remote areas due to Health and Safety. Many R&D centres won't be geared up for hydrogen propulsion testing. The safety implications point towards using a more rural area for testing. For these reasons the FlyZero program suggested Scotland as a possible location for remote hydrogen testing. The area around Exeter and the science park could be a suitable alternative (Rec M5). IAAPS also has great potential for hydrogen testing, but it will need a good business case to support this. It is worth exploring this topic further. Appropriate training for dealing with hydrogen safely will also be paramount. It is worth investigating whether Honeywell's oxygen / pressurised gas side of their business could be translated into pressurised cryogenic hydrogen experience.

Further North around Bristol and beyond the skills are focused on design, Exeter on the other hand is about operationalisation and flight test. Significant certification experience exists in the South West including but not limited to Boscombe Down and Yeovil. It is important to not lose this capability to other areas like Cranfield, Wharton, the Solent or abroad. A lean feedback mechanism needs to exist between the engineering hub and the test and operations hubs to allow a more connected, efficient and holistic approach to decarbonising (Rec S2).

The skills needed to support Exeter in the near term are present, the challenge comes with ensuring the people with the right skills are ready for the future demand. There should be progressive building of skills and

collaboration between Exeter College, Yeovil College, Weston College, the IoTs – each of these skills bases need to be complimentary (Rec M3, L1). If Exeter Aerospace could attract a hydrogen developer such as Universal Hydrogen for the conversion Dash-8 or ATR aircraft to hydrogen then this would greatly benefit the region. Exeter Aerospace could then tie in with colleges and IoTs even more than they already are to develop hydrogen apprenticeships to train the skills of the future. The social values and house pricing in the region relative to other areas should also help to retain talent once it has been developed (Rec S11).

It was suggested that Exeter isn't likely to be a great production hub for hydrogen but has huge potential as a storage and distribution hub (Rec S1, S9). It will be important to understand what are happening in the wider mobility sectors, for example will we see hydrogen fuel cells used in road and rail transport? Will there be enough charging capacity for all vehicles to move towards electrification in a given timeframe? There are lots of benefits to having Exeter as hydrogen hub for mobility – they key is to develop a business case to attract investment here and get over any inbuilt resistance of it being developed in the region.

A.18 Yeovil College

During this study we met with and interviewed some representatives from Yeovil College.

Yeovil college has a mix of students, apprentices, degree apprentices and prescribed adult learners.

Their apprentices work across a range of companies including Leonardo, BAE Systems, Honeywell, Thales and other SMEs. It is small-medium sized college with a mixed economy in engineering mostly centred around aerospace, with fabrication & welding and Level 3 design engineers.

Yeovil College has submitted several bids for grant funding for hybrid test rigs but haven't met success with them all. Grant funding for particular equipment would be a valuable resource for the college.

This focus on new equipment would ideally be centred around:

- The interest in hybrid propulsion systems and energy cells
- The need for a hydrogen cell centre, the college needs the right facilities in place to train the skills to meet future demand. Both physical resources and people are needed, a lot of the information is there but can't be applied without the right tools.
- Substantial Investment (in the order of millions) for hydrogen propulsion testing / teaching
- A modular drivetrain rig – with potential to future proof it with integration of different energy sources

The college has submitted several bids to the DfE for hybrid test rigs but their applications for grants have been rejected. It was suggested that it is very difficult to secure funding through consortium bids and flexibility for employers isn't embedded in funding mechanisms yet. Often there are rules around funding received that means it can pay for buildings but not the equipment inside them needed for teaching – this resents additional challenges.

Even as aerospace grows, there should still be sufficient capacity to recruit enough apprentices. Yeovil College is part of the of 14-19 partnership (made up of ~11 institutions / secondary schools.) Every year around 2500 leave those schools –and Yeovil College picks up around half of them). In Yeovil ~21% of students progress on to Higher Education. This is compared with ~29% in the wider HotSW region and ~49% nationally. This means that there are proportionally higher numbers of students available to fill jobs straight out of school in roles like technicians, aircraft maintenance and repair etc when compared with other areas of the UK. The perception of companies like Leonardo is generally very good for the community – they are considered high value stable jobs.

It is important to engage students early on at ~11, and give them exposure to the 'stepping off points' where we need the future workforce in areas like Digital, Health, Construction and Aerospace. To bolster the teaching capability around hybrid propulsion systems and ensure that the right skills and knowledge is being taught it will be important to upskill the teachers and staff through additional courses / training (Rec S12, M4, L1).

The college has no problems with using assets at collaboration spaces, giving their students exposure to different aspects of industry. They're not keen on operating across multiple sites but students working part time at centres like IAAPS or the GKN GTC could be beneficial.

It was suggested in the interview that everything needs to be deconflicted across industries and within the same industry, i.e., any testing and demonstration facilities need to be sufficiently differentiated from other facilities across the South West. The college has a focus on aerospace but there is a slight overlap to aviation that may need deconfliction too.

In the interview it was recognised that Yeovil's expertise is rotary wing, vertical lift flight. Yeovil College aspires to become the best rotary aerospace training facility in world – delivering beyond somerset through connections to other education providers globally. The college is looking into strategic and operational partnerships with

prospective partners to better understand the curriculum of the future. The HotSW LEP could play a role in helping to encourage these strategic partnerships (Rec S2). They need to get their talent academies rolling to build capacity for rotary wing expertise.

It was suggested that there seems to be a lack of joined-up thinking between government, local strategy and industry (Rec S2, S3). The local skills improvement plan for the West of England could help to start join this thinking up adding resilience to the region's capability. There is a need to think longer term in 5, 10 and 25 year timescales; many of the challenges seen by the college and by industry can't be solved within 2 years.

The college and South West region as a whole needs more educators with aerospace experience (Rec L1). The college is already amongst the highest paying Further Education institutes for advanced manufacturing so this could be challenging to raise salaries further. They will need to rely on the region's social assets like lower house prices etc to attract people. The college will continue to utilise the place leadership program to get is needed for South Somerset. They will also continue to bid for hybrid propulsion technology and equipment to teach with so that they can strive towards the ambition of developing and delivering the best rotary wing curriculum globally. The college wants to develop more hybrid learning spaces so that they can connect with other colleges and industry worldwide to add value to their students.

A.19 YEW Research & Consultancy

YEW Research & Consultancy assisted this study as an independent aerospace specialist. Their background and extensive knowledge of the sector helped to guide the remaining conversations we had with the other stakeholders. They also highlighted key organisations to consider and research further.

The cross cutting recommendations from YEW Research & Consultancy included address the existing and future skills gaps, identifying funding sources, identifying a 'grand vision' test project similar to a living lab demonstrator, identify a suitable location for this test hub and explore hydrogen and electrical infrastructure requirements.

During this interview, it was made clear that if the region doesn't have what Vertical Aerospace, Ampaire and others need now to help them develop and certify their aircraft, they will go elsewhere. The region needs to be able to signpost developers to the right capability within the region (Rec S2, S11) or quickly adapt and come up with something. Funding is critical though and local areas don't tend to have large pots of money available for developing projects, if they do have money it is usually intended for building something rather than delivering a project or capability.

Further to testing and demonstration of hydrogen and electric aircraft, airports will need to look at decarbonising ground vehicles and be proactive in doing so (Rec M9).

Airports are already targeting to be carbon neutral by 2030 following the Airports Council International model but they have limited consideration of the air vehicles – they need this perspective from airline operators and manufacturers. Airports can take a more proactive role in decarbonisation of air-side ground vehicles. It is difficult to define a test hub without picking a specific platform or use case but the future of mobility will need to consider all use cases and platform sizes. As such a test hub aimed at different scales of operation and different platforms with different use cases could be an opportunity for the region to differentiate themselves (Rec S3). Ampaire is already doing flight tests in the region so there will be a lot to learn from them.

It became clear through speaking to YEW Research & Consultancy that the HotSW LEP needs to be ambitious (Rec S11). The project outcomes should be as iconic as projects such as the Coventry Verti-port. The region needs to demonstrate something, not just talk about it. The Sustainable Aviation Programme board recognises this so needs to do the next level of thinking around how to achieve that. The project vision won't work unless it gets buy-in from key stakeholders like Exeter Airport and Leonardo. It needs to reach that critical mass where it will attract funding and people. A replication of a sustainable aviation test environment with integrated airspace is one option.

The 'grand vision' needs to be targeted at the optimum point though. It shouldn't try to aim for test and demonstration of large commercial aircraft like those being developed under the FlyZero programme but likewise it shouldn't be solely focused on development of small uncrewed air systems (UAS). It should be a balanced mix of UAS, eVTOL, AAM, regional mobility and larger aircraft. A proposed testing hub should consider several different classes of aircraft, with supporting ground infrastructure and integrated airspace.

It was also noted that a significant number of UKRI Future Flight Challenge Phase 2 projects involved or were led by organisations based in the South West region. This highlights that the region has a strong capability and could act in a leadership capacity for developing a future aviation test environment. This expertise helps set the South West apart from other organisations or clusters nationally.

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