



Llywodraeth Cymru
Welsh Government

PUBLICATION

Wales: a sustainable space nation

Recommends how to grow the Welsh space sector.

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Ministerial foreword

“ I’m delighted to present the Space Strategy for Wales, which reflects the wealth of capabilities and innovations we have in our nation. Wales has a track record of delivering high value manufacturing and innovation which puts our companies in a prime position to operate in this growing sector. The global space industry is rapidly transforming with space technology getting smaller and entry to space becoming more accessible and affordable. In all our day-to-day lives, we are becoming more reliant on the space sector and the data it provides, from weather forecasting, internet banking and Sat Nav in our vehicles.

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“ In Wales we not only have a strong foundation of companies and institutions operating in these downstream applications, but we also have a vibrant base of companies working in the upstream sector specialising in space hardware and systems. The UK Government has taken the positive decision to support the Space industry in looking to build one of the most innovative and attractive space economies in the world, and grow the UK as a space nation.

“ They aim to protect and defend UK interests in space, shape the space environment and use space to help solve challenges at home and overseas. Through cutting-edge research, they look to inspire the next generation and sustain the UK’s competitive edge in space science and technology. The Welsh Government fully backs this growth and we will work closely with the UK Space Agency to ensure that our national strategy for Wales aligns with the UK’s ambitions” ”

Vaughan Gething MS, Minister for Economy

Introduction

Wales has a population in the order of 3 million people, around 5% of the overall UK population.

In the aerospace sector, Wales has around 10% of the overall UK workforce and arguably punches above its weight.

When it comes to the space sector, Wales has around 1% of the overall UK workforce so there is a huge opportunity for growth in what is itself, a significant growth sector.

The UK space sector has previously set a target of achieving a 10% share of the predicted £400 billion pa global space market in 2030. A 5% share for Wales would equate to £2 billion per year and we believe this is a realisable target that we should aim to achieve and work to exceed.

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The growth of the sector also has the potential to help us address some of the key issues facing Planet Earth and the challenges within Wales itself.

The first mapping of the space sector in Wales was carried out with support from the Aerospace Wales Forum in 2006 and there was also some limited interaction with the then British National Space Centre.

In 2014, there was the first serious engagement between Welsh Government and the UK Space Agency (UKSA) which has since gone from strength to strength.

The first Wales Space Strategy was published in 2015 and the Welsh Government's "Spaceport Snowdonia Wales" brochure followed in early 2017.

The 2019 UK Space Conference was held at the newly opened International Convention Centre in Newport and was the platform for several announcements relating to the award of grant funding to the sector in Wales from UK Space Agency (UKSA) and the Welsh Government. This included a £500,000 award to Snowdonia Aerospace Centre, from the UKSA's Horizontal Spaceport Development Fund, for a Spaceport Snowdonia Development Plan.

Over the last five years, Welsh Government and Aerospace Wales have been working together to develop the space sector network to raise its profile and to develop and enhance its capability.

The Wales Academic Space Partnership (WASP) was established to encourage co-operation between Universities operating in the space sector and to strengthen the links with industry in the so-called "arc of innovation".

Aerospace Wales formed a Space Group to encourage networking between existing sector specialists and an emerging group of disruptive technology start-ups. Welsh Government, Aerospace Wales and representatives from academia and industry have participated in space related events on a regular basis.

The mapping of the sector in Wales reveals several centres of potential growth in upstream and downstream activities contributing to economic growth and the creation of employment across Wales. The exploitation of space data and

space-enabled services has the potential to contribute to meeting some of Wales's key challenges around climate change, connectivity and healthcare.

Since the first strategy was published in 2015, several new players have entered the scene. Snowdonia Aerospace Centre has continued to add to the list of clients using or planning to use its facility, both for future flight and space related operations. Near-space operations have already commenced with flights by the B2Space stratospheric balloon and the Astigan HAPS, taking full advantage of the established MoD/QinetiQ tracking range in Cardigan Bay.

Over £20 million has been allocated for improvements to infrastructure in and around the site, to be completed by 2023. Spaceflight Academy, a Spaceport Snowdonia consortium member, plans to start the development of a spaceflight experience and training facility at Snowdonia's Llanbedr airfield within 18 months. Associated with the Academy is also a plan for a wide-bodied zero-g flight experience aircraft operating from Wales.

A consortium of companies including Black Arrow Space Technologies, Ddiwydiannol, Recurved-Space and the industrial network of the Celtic Space Council are planning to establish a centre of space manufacturing and operations in Port Talbot, linked to a sea-based space launch capability by 2024.

Space Forge has opened a development facility for a returnable manufacturing platform that uses the benefits of space to make new materials that are not possible on Earth. The technology being developed will reduce the cost of re-entry and will enable satellites to be refurbished and reused. The company plans the launch of its first satellite in 2023, return by 2024 and relaunch by 2025.

In 2017, Environment Systems, an Aberystwyth based data company, launched their Satellite Data Services. A cloud-based platform to deliver near real time, always-on metrics to support agricultural supply chains, environmental monitoring natural capital assessments. In 2020, Environment Systems Data Services processed and analysed over 400 million km² of satellite Earth observation imagery around the world.

Three years ago, Aberystwyth University, already a centre of excellence in research and teaching relating to Earth Observation, was awarded funding for

the Living Wales project. Living Wales is a unique and novel world-first concept that aims to capture the state and dynamics of the landscape of Wales in near real time, historically and into the future, through integration of earth observation data, supportive ground measurements and process models. The project has recently been funded for a further two years and the University is working closely with National Resources Wales providing a long term system for understanding, monitoring and planning landscape change that is applicable at a national level and based on historical and near real time earth observations.

The European Space Agency's Business Applications UK Ambassador Network has appointed two regional ambassadors covering Wales: Alan Cross for North West England and North Wales and Andy Williams for South West England and South Wales. Alan and Andy are helping to encourage and nurture potential space applications businesses in Wales. Swansea based Annwen has recently signed up with the ESA BIC UK (Business Incubation Centre) and is creating a voice-activated 'digital companion', providing public information in Welsh or other minority languages, particularly for citizens in remote locations, vulnerable members of society and those not used to using technology. They plan to deliver a satellite and 5G connected monitoring system for Wales.

All this builds on the established foundations of the existing academic and industrial networks in Wales, and links to other key sectors and technologies such as optoelectronics and optics manufacture, compound semiconductors, cyber security, data analytics and advanced manufacturing.

As a result of the UKSA funded cluster development project, we have mapped out the current sector in Wales, identified the key opportunities afforded by the space sector and outlined the key recommendations and actions to be taken. We have established the Space Wales Leadership Group and the Space Wales network, including the Wales Academic Space Partnership.

We face a unique combination of challenges and opportunities. The UK has completed its exit from the European Union, the COVID-19 pandemic is still raging and, above all, humankind is facing catastrophe unless we can succeed in mapping out a more sustainable future for Planet Earth. Space systems and technology and the use of space-derived data have the potential to play a leading role in addressing these broad challenges. Wales has a key role to play

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as a sandpit for both the technological and societal advances enabled by seizing the opportunities provided.

This report sets out our responses against the framework of the UK Space Agency's cluster development project i.e. mapping the ecosystem in Wales, our opportunities and strategy/action plan to realise these and the establishment of the Space Wales Leadership Group and the Space Wales network. We will first consider a brief overview of the market and sources of finance.

The intention is that this document will be shared with our network and other stakeholders and will be further refined and reviewed on a regular basis, becoming the basis of a strategic business plan for the sector in Wales.

Overview of the market and sources of finance

To set the scene for our opportunities and potential actions, we will first consider an overview of the market and sources of finance.

Since 2010, Space has proven to be one of the UK's fastest growing sectors, trebling in size and it now employs 42,000 people and generates an income of £14.8 billion (\$20.5 billion) each year. The global space economy grew by 6.7% on average per year between 2005 and 2017, almost twice the average yearly growth of the global economy of 3.5%. The exosphere is going to get very busy in the next few years. There are around 5000 satellites currently circling the earth in various orbits. Only 2,000 of these are operational. If OneWeb, Starlink and other potential networks have their way, that number could increase by a massive 4,500% in the next five years!

One aspect that has contributed to this growth has been the "New Space" phenomenon, a series of technological and business model innovations that have led to a significant reduction in costs and have resulted in the provision of new products and services that have broadened the existing customer base.

Morgan Stanley estimates that satellite broadband will represent 50% of the projected growth of the global space economy by 2040 and as much as 70% in

the most bullish scenario. Launching satellites that offer broadband Internet service will help to drive down the cost of data, just as demand for that data explodes. Morgan Stanley estimates that the per-megabyte cost of wireless data will be less than 1% of today's levels. The demand for data is growing at an exponential rate, while the cost of access to space and, by extension, data is falling by orders of magnitude. Growth will come from providing Internet access to underserved and unserved parts of the world, and there also is going to be increased demand for bandwidth from autonomous vehicles, the Internet of Things, artificial intelligence, virtual reality, and video.

Reusable rockets and satellites will help drive costs down, and so too will the mass production of satellites and the development of satellite technology. Currently, the cost to launch a satellite has declined to about \$60 million, from \$200 million, via reusable rockets, with a potential drop to as low as \$5 million. And satellite mass production could decrease that cost from \$500 million per satellite to \$500,000.

“The future of the European space sector. How to leverage Europe’s technological leadership and boost investments for space ventures” produced by the European Investment Bank (EIB) in 2018 illustrates the landscape of space business services, business models and segments. The size of total investments into space companies grew by a factor of 3.5 times in 2012 to 2017 compared to the previous 6-year period. Additionally, since 2000, over 180 angel and venture-backed space companies have been founded. Venture capital (VC) firms represent the largest number of investors for space companies, with around 46% of overall investments. Combined with angel investors, these two investor groups comprise around two thirds of the investors in space ventures. In fact, US-based investors account for around two thirds of the 400+ worldwide investors in space companies.

A landscape of space business services, business models and segments

In the global space economy, satellite services represent the largest sector (around 37%), closely followed by ground equipment. Earth observation is

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currently the biggest user of satellite manufacturing and launch services and remains a key driver for the overall industry. Business models predicated on a business-to-consumer (B2C) model, or with a shorter implementation timespan, come with lower risk levels than business-to-business (B2B) models or those with longer implementation timeframes. Compared with the US, Europe has a lower level of involvement in upstream activities, and this reduces the effectiveness of technology transfer into the space sector. The scarcity of scale-up funding in Europe is a critical shortfall, which often leads to a flight of talent and companies to the US, where the financing landscape is currently more favourable.

Over 40 space companies were interviewed throughout the EU and beyond. The majority of companies highlighted the importance of public funds and public sector instruments, which often represent the only accessible source of capital. 40% of interviewees also note that public financing often served as a precondition for accessing private risk capital. The biggest sources of funding within the EU were Horizon 2020 and ESA.

Within the UK there are a range of sector specific and generic funding opportunities, including for example SPRINT, the National Space Innovation Fund and the Space for Smarter Government Programme. The UK will continue to participate in the EU's Horizon programme and continues to contribute to the European Space Agency budget. ESA has established a network of regional ambassadors in the UK to help stimulate business development and link UK companies with ESA funding opportunities. Two ambassadors have responsibility for Wales, one for the north and one for the south.

The Development Bank for Wales (DBW) was established in 2017, replacing its predecessor Finance Wales. The DBW Group is one of the UK's largest regional SME investment companies and provides growth capital for small and medium-sized businesses. DBW contributed to the start-up funding provided to Space Forge when it was set up in Wales. We also have a range of innovation support finance available in Wales under the generic heading of SMART Cymru.

During March 2021 the UK published its "Integrated Review 2021: Global Britain in a Competitive Age, the Integrated Review of Security, Defence, Development and Foreign Policy, describes the government's vision for the UK's role in the

world over the next decade and the action we will take to 2025.” This stressed the importance of both cyberspace and space.

Space is fundamental to military operations, so the success of UK forces greatly relies on control of that domain. The government is investing £5 billion over the next decade in the Skynet 6 satellite communication programme. This will be complimented by £1.4 billion allocated to the new Space Command, National Space Operations Centre, Space Academy and a UK-built intelligence, surveillance and reconnaissance satellite constellation.

Wales has a significant defence infrastructure and industrial capability with the potential to support the UK’s ambitions. Airbus Defence and Space and Raytheon UK are both established in Wales and we have a growing cyber security cluster and capability. There are ongoing dialogues between Welsh Government and other defence primes such as Thales, BAE Systems, Lockheed Martin and Northrop Grumman. The planned ATRC (Advanced Technology Research Centre) which will focus on defence electronics will include a space related element. There will be opportunities for Wales based companies and facilities to bid for MoD related work emerging within the military space domain.

Welsh Government and the UK Space Agency have both made financial contributions to the space sector in Wales, and agreement on further funding is considered essential to support the growth of the sector. In order to develop some of the potential breakthrough opportunities identified in the next section, funding support will also be required from UK Government. It is recognised that in the extraordinary circumstances we find ourselves in, that competition for available resource will be intense and that all parties will need to work together to maximise the return on investment and to ensure alignment with the policies and priorities of UK and Welsh Governments. The Welsh Government has set out the key priorities in documents such as the Economic Resilience and Reconstruction Plan, the Export Action Plan and the Manufacturing Action Plan. All of these are underpinned by the Well-being of Future Generations Act.

The EIB’s report suggested that VC funding is more readily available from the US than from Europe and this is backed up by anecdotal evidence from some of our companies. Asia-Pacific and the Middle East also provide potential sources of finance and export markets. Wales has a diaspora which includes many

wealthy individuals spread around the world and the M4 and M56 corridors contain more local concentrations of high wealth individuals who might be persuaded to invest in the sector.

Mapping of the Wales eco-system

The first stage of the cluster development project was the mapping of the space sector eco-system in Wales. The output from this exercise is represented by a space sector capability matrix and directory and will be accessible via the Space Wales website which will be designed to be updated by individual organisations and be a living document. It is intended that these documents will be used to help promote the sector in Wales and may be issued in printed form, as and when required, to support our presence at events and exhibitions.

A questionnaire was circulated to a wide range of trade organisations including those represented in the Industry Wales group of trade bodies and through various Welsh Government distribution networks. Cross-checks were also made with previous surveys (2006, 2015, 2017, 2019) and records of previous engagement with the Aerospace Wales Space Group and the Wales Academic Space Partnership (WASP). Our experience with similar documents for other sectors suggests the listings will be very dynamic and will continue to grow over time as more organisations enter the market.

The Academic landscape has been surveyed by WASP and is currently being refreshed by the group.

Analysis of the Wales eco-system to identify space sector opportunities

The space sector capability in Wales was reviewed using previous studies, the output from the sector mapping exercise, online workshops and individual discussions with members of industry and academia. The current and potential future space sector in Wales has the following key elements:

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1. Existing advanced manufacturing capability and technology clusters e.g. aerospace, automotive, electronics and software, medical, compound semiconductors, photonics/optoelectronics/optics, life sciences and cyber security.
2. Test and evaluation eco-system based on existing facilities, including Llanbedr and Aberporth Range, Radnor Range and Pendine, open to both military and civil use.
3. Space launch, training and experience capability i.e. Spaceport Snowdonia, Spaceflight Academy and the Port Talbot Space Centre (sea-based launch).
4. An embryonic capability in In-Space Manufacturing and the associated ability to recover space vehicles – Space Forge and Spaceport Snowdonia.
5. A network of research and teaching facilities including WASP and catapult sites – the arc of innovation. The Compound Semiconductor (CS) Applications Catapult is based in Newport and AMRC Cymru at Broughton began operations in December 2019, switching to ventilator production in early 2020 in support of the NHS during the Covid equipment crisis. The Satellite Applications Catapult has operated an outstation at Llanbedr in support of demonstrator programmes and discussions have been held about a potential DISC (Disruptive Innovative Space Capability) facility in Wales. Welsh Government, MoD and DECA are developing a proposal for the creation of ATRC (Advanced Technology Research Centre) based at Sealand and with a focus on defence electronics, including a space related element.
6. Existing and developing strengths in earth observation including sensors, analysis and integration with other data sources e.g. hyperspectral imaging systems at the OpTIC Technology Centre, Living Wales.
7. An environment which poses challenges and opportunities for the downstream application of space data in terms of geography, transportation, communication, health, social inclusion, management of natural resource supported by the resources of a devolved administration, local authorities, NHS Wales, Natural Resources Wales and the Life Sciences cluster.
8. A focus on clean energy, sustainability and the green agenda underpinned by key Welsh Government policies and priorities.

Advanced manufacturing capability and emerging

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clusters

Wales has an extensive advanced manufacturing eco-system with strong capabilities in areas such as aerospace, automotive and electronics sectors. A range of other sectors are also showing strong growth and/or potential technology for use within the space sector.

A compound semiconductor cluster has been established around the CS Applications Catapult (see the Catapult report on Space, July 2020) and Newport Wafer Fab. Optoelectronics/photonics/optics capability is spread across Wales, but there is a key cluster centred on the Glyndwr Innovations OpTIC facility at St Asaph, where there is already a strong track record in space related technology. The cyber security cluster is regarded as a key asset and includes the National Digital Exploitation Centre at Ebbw Vale, established through a partnership of the Welsh Government and Thales. Promising applications sectors in Wales include Healthcare, Life Sciences, FinTech, Agritech, communications and clean energy. Oversight of manufacturing sectors within Wales is shared between Industry Wales and the Industrial Transformation Division of Welsh Government. Many companies that supply multiple sectors already have business in the space sector.

In 2019, Aerospace Wales commissioned a review of advanced manufacturing capability in Wales, with the potential to support the space sector, and this was prepared by Paul Williams of International Space Propulsion. The report analysed both the membership lists of the sector forums and broader databases provided by Welsh Government. The analysis confirmed the potential for the application of this collective manufacturing capability within the space sector.

Within the defence and space sectors, Aerospace Wales has facilitated joint workshops with primes/OEMs (Raytheon UK, Airbus Defence and Space and Qioptiq) to match their needs to the capabilities of potential supply chain companies. This process has worked well and has potential to be repeated with other customers. Raytheon UK is keen to grow its space business and we are discussing plans to engage with potential suppliers in Wales.

The consortium associated with the development of the Port Talbot Space

Centre has developed a network of potential suppliers in Wales, Ireland and the Isle of Man, operating as the Celtic Space Council.

Test and evaluation ecosystem

Wales has several sites suitable for test and evaluation/verification of space system hardware, materials and components, especially those with hazardous products, or the potential for disruptive emissions.

MoD Pendine

Pendine lies at the Western end of the Loughor estuary. The site has several different areas, each with individual capabilities. The shoreline has been used in the past for aircraft landing training sorties, while the large Sea Danger Area stretches into Carmarthen Bay. It also has an Air Danger Area which extends up to 23,000ft.

The facilities mostly consist of prepared, safe areas with permanent buildings and power supplies. The Long Test Track (LTT) facility, suitable for high-speed dynamic trials, is unique in the UK. The Eastern end of the range is most suitable for space related use.

Radnor Range

Radnor Range is a UK MoD accredited independent test house offering a unique blend of capabilities to conduct assessment and trials at the range complex or other facilities.

Radnor conducts fully instrumented testing of armoured vehicles (civilian and military), armoured materials and fully engineered armoured structures to all international test standards and supports the flying of drones and counter-drone activity.

Aberporth

Aberporth Range, located on the west coast of Wales, provides a controlled safe environment for the release of land, air and sea-launched missile firings as well as instrumentation verification, passive and active IR/RF jamming, and the ability to manage supersonic trials activity in its 7,500km² of sanitised airspace from surface to unlimited altitude. The facility is owned by MoD, operated by QinetiQ and since 2003 has been open to civil use.

The Range has a fully instrumented 3D area for Test and Evaluation and space for training activities. It provides both live and virtual environments, real-time data, and deployable systems, all supported by a wealth of expertise.

Recent investment has created the Parc Aberporth Centre of Excellence, securing access for civil UAS to the existing MoD airspace danger areas over Cardigan Bay and the establishment of new segregated airspace, with unlimited height over water, dedicated to UAS testing and evaluation.

Whilst they are terrestrial assets, UAS use satellite communications and remote sensing instrumentation that can create opportunities for the space sector supply chain in Wales through shared products and services.

With the forecast expansion in R&D expenditure on UAS to £7 billion over the next decade, the Wales space sector stands to benefit from this growth.

Llanbedr Airfield

The Welsh Government has invested in developing Llanbedr in Snowdonia to provide infrastructure to support the Wales and UK UAS environment. It is anticipated that there will be further development as a space and aerospace hub. It is also being proposed as a spaceport and a spaceflight experience, training and aeromedical facility (Spaceflight Academy).

The main T&E sites (Pendine, Radnor Range, Aberporth Range and Llanbedr) will require further developments and improvements in support of the projected

growth in the space domain.

Pendine and Radnor Range have existing defence-related facilities however, in order to accommodate high thrust rocket engines or hazardous item tests for space use, ground and environmental assessment studies and civil works will be required to allow enhancement and effective upgrade, where necessary.

The National Space Propulsion Facility (NSPF) in Westcott, Buckinghamshire provides testing sites for engines of lower thrust for use on satellites and cannot accommodate the higher levels required for launch vehicle use. There is currently no secure site in the UK where rocket engine testing at required high thrust (and noise) levels can be performed, and these two Range facilities are ideally suited to provide such services with a suitable investment.

Llanbedr is the home of Spaceport Snowdonia. To fulfil the primary stated space-related objectives of the spaceport (research, development, test and evaluation and Sub-Orbital Flight Training), it will be necessary for the Welsh Government to continue to support the development of the site.

Aberporth Range facilities are owned by the MoD and managed by QinetiQ as part of the Long Term Partnership Agreement (LTPA). The Range supports UAS and IR/RF testing, primarily for defence purposes.

Additional sites

There is commercial and strategic potential for a dedicated civilian avionics and related technologies T&E range, with a possible site in West Pembrokeshire, which will benefit from its remote and easily secured location at the Western end of Milford Haven, within the Haven Waterway Enterprise Zone, and relative proximity to the active IR/RF operations in Aberporth.

Although designed to support civilian IR/RF tracking and avionics development activities related to seaborne launch and Unmanned Aerial/Marine Systems, the facility would have the capacity to act as a potential satellite for the Advanced Technical Research Centre (ATRC) planned for development adjacent to DECA's Sealand site in Flintshire.

The facility could also act as a remote reception base for long-range RF transmission to validate and calibrate avionics systems and protocols for use in the UK space launch and satellite telecommunications sectors, as well as testing laser systems for rapid orbital (satellite to satellite) data exchange – a major benefit for in-orbit manufacturing, navigation, and rapid data downlink transmission.

A dedicated electronics range would attract great interest from various sectors of innovative industry and could provide a base for tracking of space launch operations (sea and air launched). The potential market for this service is growing rapidly.

The growing sector offerings around reusable satellites, returning upper stages and debris mitigation will also benefit from the location of a Plasma Wind Tunnel to allow accurate modelling of material demise on re-entry. Only one such facility exists in Europe, with the DLR (German Space Agency) and this is largely inaccessible to UK business and expensive. The location of this resource could be within Cardiff University's Gas Turbine Research Centre in Port Talbot, or in the Avionics T&E location mentioned above.

Space launch, training and experience

The Spaceport Snowdonia Development plan was produced in March 2020 and was funded by the UKSA's Horizontal Spaceport Development Fund. In 2014, Llanbedr Airfield/Snowdonia Aerospace Centre was identified by the UK Space Agency (UKSA) and Civil Aviation Authority (CAA) as one of the possible candidate sites for a UK Spaceport focused on horizontal launch.

Spaceport Snowdonia is featured in the new UK Space Agency brochure "Launch UK – A guide to the UK's commercial spaceports."

Snowdonia Aerospace Centre lodged a successful application with CAA, creating a permanent danger area around Llanbedr Airfield and has a road map to achieving spaceport certification by late 2022.

The airfield is adjacent to the existing D201 Cardigan Bay Range, which has

substantial existing airspace tracking, control and air/sea surveillance capabilities provided by QinetiQ on behalf of the Ministry of Defence (MoD). It has a long and distinguished track record in supporting experimental test flying in the UK and continues to this day as host to the Snowdonia Aerospace Centre (SAC), providing air and ground services and facilities for the research, development, test and evaluation (RDT&E) of novel aerospace systems and emerging future flight technology, particularly drones, electric aircraft and urban air mobility vehicles.

The report recommends that the site should be mixed use to support a range of non-conflicting aerospace uses, particularly around the emerging aviation technology markets. It is recommended that Spaceport Snowdonia is ideally positioned to be a major research, development, test and evaluation (RDT&E) centre for upstream space-related activities in the UK and to be able to provide spaceflight training and near-space flight experience. The site has also been used for space-enabled BVLOS operations and the mixed use proposal will facilitate the integration of different modes and data sources to support downstream applications.

The proposition is to differentiate Snowdonia from other UK Spaceports by developing the site as a flexible and multi-use campus that supports space related RDT&E, training and (to a lesser extent) satellite launch and to maximise potential across a range of other aerospace uses.

B2Space is already operating its stratospheric balloon capability from Llanbedr.

Founded in 2016, the purpose of B2Space is to provide a reliable, flexible and low cost access to Low Earth Orbit for small and micro satellites, democratise space access and facilitate the development of new technologies and uses of space. The B2Space satellite launch solution is based on the “rockoon” concept (rocket + balloon), and will comprise of a stratospheric balloon that will lift a self-operative platform from which the launcher is deployed. A three-stage solid propellant rocket will deliver the satellites into the required customer orbits (within Low Earth Orbits which are orbits with altitudes ranging from 200km to 1000km, approximately). At the ESA Business Incubation Centre Harwell, B2Space developed a Near Space Testing service: a “flying lab” based on stratospheric balloons to test Space technologies. This flying lab is now

operational with launches taking place from Llanbedr and other sites.

Spaceflight Academy has ambitious plans to start the development of its experience, training and aeromedical facility at the site within 18 months. Spaceflight Academy's vision is "To be the world's leading commercial Spaceflight and aeromedical training provider, motivated by our belief and experts' advice that human factor aeromedical issues associated with commercial Space travel and tourism for the public are no less important than the technological challenges of sending people into Space." Their planned facilities will include a campus building designed to be an impressive gateway attraction for visitors to Spaceport Snowdonia. Spaceflight Academy's cutting-edge facility will include innovative and interactive ways to engage and inspire the public for a 'whole Space experience'. This fully immersive, compelling and exciting environment will support, encourage and promote the development of Space and commercial Space tourism. The facility will include a Desdemona NG, a unique, second generation, all-in-one motion simulator, spatial disorientation trainer and advanced laboratory capable of sustaining advanced G-loads up to 7g. Aeromedical training will be provided for the aviation and spaceflight markets working in close partnership with experts at King's College in London.

Other users are currently in discussion with Snowdonia about their future requirements, and there is an ongoing dialogue between Welsh Government, Snowdonia and a US horizontal launch provider.

All the currently identified vertical and horizontal launch sites in the UK are land based. Black Arrow Space Technologies is proposing an alternative approach - it will launch payloads of up to 500Kg into Polar Low Earth Orbit, or up to 300Kg into Sun Synchronous Orbit, from a seaborne launch vessel.

The benefits of having a seaborne launch capability as opposed to a land-based spaceport include:

- no requirement to develop coastal or remote landscapes to accommodate the launch site and preparation or storage facilities as dockside land is classed as 'brownfield' land.
- when launch activities are performed at sea, there is no noise or other

disruption of the local populace.

- flight trajectories are over the open sea and do not cross or overfly populations or properties.
- may be situated closer to manufacturing centres and airports, shortening the time to deliver payloads to the site for launch.
- unpredictable weather need not be a restricting factor as a mobile facility can find suitable launch conditions.
- operating out of a homeport in South Wales and launching from south west of Ireland, provides a clear trajectory, flying north, to the most popular low earth orbits.

In 2020, the Space Industry Act was brought into law allowing the UK to provide launch services, providing that a set of requirements were met as set down by the Space Industry Regulations,. In the Regulations, the majority of the planned seaborne Concept of Operations (CONOPS) propositions have been accepted, in equity with similar mobile launch modes (e.g. air-launched) and is therefore applicable to UK licensing under the Regulations.

To meet the expectations of providing low-risk space launch services to Polar and Sun Synchronous orbits from Wales, the operations will be performed from a specially converted merchant vessel located in the east Atlantic, southwest of Ireland. Therefore, a homeport in South Wales or South West England was paramount.

A trade-off was performed by Black Arrow Space Technologies and, when all relevant parameters were considered, Port Talbot came out as the ideal solution given its deep-water harbour, local manufacturing and materials heritage, availability of development land at scale, accessibility to UK centres, skilled workforce and proximity to academic and test site institutions.

The Enterprise Zone of Port Talbot Waterfront, owned by Associated British Ports, contains sufficient privately owned brownfield land on which to build a vehicle integration and payload processing centre and storage for parts and propellants and workshops, all within a secure perimeter. It allows for the ambitious growth profile in the development plan and accommodates surrounding space for introduction of related space components manufacturing capacity, hence supporting the establishment of the South Wales space hub in

the area (Port Talbot Space Centre).

Since its inception, Black Arrow Space Technologies has forged several strategic partnerships with Welsh, UK national and international entities, in a diverse range of disciplines, space-qualified products and services, and it is hoped that all will contribute to a successful cooperative economy in South Wales.

The Port Talbot Space Centre was conceived as a suitable designation for the industrial collective and may or may not be exclusive to the launch company. It should become a space manufacturing and T&E hub for South Wales in its own right, and Neath-Port Talbot (Swansea Bay) is an ideal location for that hub, given the existence of a vibrant manufacturing and fabrication capability in the area.

In addition, the Port Talbot Space Centre will incorporate Tracking, Telemetry and Control (T&C) capabilities to support the locally based and UK launch activities. This asset could be included in the PTSC campus (Port Talbot waterfront), or in a separate, suitable remote location, in West Wales.

Such a remote facility would have advantages, including direct Line of Sight of space related launch activities, and a clear communication to other major RF test and evaluation ranges for avionics systems verification. The facility will become a major, perhaps international, asset for electronic testing, evaluation, and system verification for civilian applications, as well as a secure base for development and testing of mobile tracking stations, currently underway in Wales.

In-space manufacturing and recovery of space vehicles

Last year Space Forge received a £600,000 funding package from the Development Bank for Wales, Bristol Private Equity Club and Innovate UK to establish a base in Wales to develop a reusable manufacturing LEO satellite and the capability to return satellites to Earth for repair and refurbishment.

Historically the cost of getting one kilo into low earth orbit was about \$65000

dropping to \$5000 per kilo on Space X's Falcon 9. Its giant Starship rocket has the potential to cut this to \$10 per kilo. Pilot manufacturing activity is already taking place on the International Space Station. In the US, Varda, an in-space manufacturing start-up, announced in December 2020 that it had received \$9m from its investors Space Forge exceeded this, closing Europe's largest ever seed fund round for a space tech company at US\$10.2m in December 2021.

In January 2021, Aerospace Wales and Welsh Government were approached by the Satellite Applications Catapult seeking our support for their bid to the proposed European Space Agency (ESA) Business in Space Growth Network Market Stimulation programme. This is designed to establish a framework for business opportunity identification, implementation and development, leveraging the benefits of the space environment for materials and manufacturing using commercially available space platforms in low earth orbit. We were delighted to give our support and look forward to working with the Catapult to grow the market and relevant capabilities in Wales.

In-space manufacturing and reusable satellites has significant potential as a growth market and the arrival of Space Forge in Wales provides us with a good foundation. The company has ambitions plans:

- 2022: Launch Wales' first built satellite (from a Welsh spaceport if available)
- 2023: Return a satellite to Wales carrying research by Welsh university or for Welsh supply chain
- 2024: Launch a refurbished satellite to commoditise university research for in-space production and use back on Earth, new composites for engines/ semiconductors for telecom/ ceramics for turbines etc.

The potential launch cadence would grow from 4 units in 2023, to 12 units in 2024 to one a week in 2025 to 2026.

Recovery of space vehicles could be managed within the Cardigan Bay MoD/ QinetiQ Danger Area with support from Snowdonia Spaceport.

Space Forge has identified support capabilities which are missing or inadequately represented in the UK: launcher integration practice, payload level cleanrooms more easily accessible for microgravity research - wait times are

long or must be custom built by academics, life-science cleanroom transfer to space cleanroom. The company has been involved in discussions with Welsh Government, Space Wales and the Satellite Applications Catapult about the potential to develop suitable support facilities in Wales. There have also been discussions with the Satellite Applications Catapult about creating a “DISC” (Disruptive Innovative Space Capability) facility in Wales. There is an established DISC facility at Harwell and the facility in Wales is envisaged as potentially filling the gaps and future bottlenecks in terms of facilities for qualification of equipment and the integration of payload packages into space platforms developed to support in-space manufacturing.

There is an opportunity to develop links with the established Life Sciences hub in Wales to explore the potential for pharmaceutical development in orbit.

Research and teaching facilities

Details of space related research and teaching facilities are provided in our Directory and WASP documentation.

In addition to the universities, we have catapult facilities such as AMRC Cymru, the Compound Semiconductors Applications Catapult and the planned ATRC (Advanced Technology Research Centre). ATRC will be located adjacent to DECA (Defence Electronics and Components Agency) at Sealand, Flintshire and will focus on defence electronics including RF and space related activities. The facility is backed by Welsh Government and MoD and all the key defence primes.

We also have privately owned facilities such as TWI’s Port Talbot facility and Radnor Range.

In terms of STEM or STEAM we have existing organisations who could add space to their portfolio and companies such as the Enbarr Foundation and G2G who have already done so.

Discussions have been held with the Satellite Applications Catapult about the establishment of a DISC (Disruptive Innovative Space Capability) facility in

Wales. We have considered various locations and functionality but a link with the Space Forge operation is seen as a strong possibility.

We have also held discussions with the Satellite Applications Catapult about the provision of an Innovation Space Lab in Wales. Building on the rapid development of virtual engagement during the pandemic, Innovation Space Labs will enable the use of the Catapult's gateway network to access its experts, services, and demonstrations, from across the UK.

Earth observation

Over half of future nano/microsatellites will be used for EO and remote sensing. There is great potential for advance manufacturing of instruments in the EO satellite market. The Glyndwr Innovations OpTIC centre and the associated optoelectronics/photonics/optics cluster has already established a significant space related capability. In terms of EO analysis, we have strong capability including Aberystwyth University and specialist companies such as Environment Systems and Geo Smart Decisions.

Environment Systems has a 17 year track record in using EO for addressing environmental and agricultural challenges. This includes everything from natural capital risk assessments in the Caribbean, banana monitoring in Colombia, the development of an agricultural data infrastructure in Turkey to assessing farmer subsidy eligibility in Wales. Most recently, Environment Systems has been using EO analytics as part of the evidence for the Welsh Government national development framework Future Wales: the national plan 2040.

Living Wales is a unique and novel world-first concept, that aims to capture the state and dynamics of the landscape of Wales in near real time, historically and into the future through integration of earth observation data, supportive ground measurements and process models. The project has recently been funded for a further 2 years and Aberystwyth University is working closely with National Resources Wales providing a long-term system for understanding, monitoring and planning landscape change that is applicable at a national level and based on historical and near real time earth observations.

There is an opportunity and a need to move this project beyond research into a longer-term commercial operation or perhaps as part of a National Wales Space Observatory. The volume and quality of data from space is going to grow rapidly and will provide both challenges and opportunities in terms of processing vast amounts of data into useable information for downstream apps. Wales has significant data related capability such as NDEC (National Digital Exploitation Centre) and we need to understand how we can exploit this capability in terms of enhancing our analytical capability.

Wales: challenges and opportunities

Our aim is to serve the people of Wales. It is often said that Wales is a country of many halves. There are geographical challenges in terms of transportation, communications, and the provision of essential services.

We have 3 million people in Wales, mostly located along the north and south coasts with much of the rest of the country living in relatively isolated rural communities. The analysis of social deprivation shows there are pockets of relative poverty across the whole of Wales, both urban and rural.

We should use the technology and services facilitated by the space sector to help grow the economy in Wales and to help deliver enhanced essential services across the nation. We have seen that NHS Wales has been an enthusiastic adopter of technology-based solutions during the current pandemic, including drone and space related elements. Wales is a relatively small country and is well placed to act as a sandpit for both technological and community-based innovation.

Morgan Stanley estimates that satellite broadband will represent 50% of the projected growth of the global space economy by 2040, and as much as 70% in the most bullish scenario. Launching satellites that offer broadband Internet service will help to drive down the cost of data, just as demand for that data explodes.

OneWeb, the Low Earth Orbit (LEO) satellite communications company jointly owned by the UK Government and Bharti Global, has secured total funding of

\$1.4 billion. The capital raised to date positions the company to be fully funded for its first-generation satellite fleet, totalling 648 satellites, by the end of 2022. OneWeb's mission is to deliver broadband connectivity worldwide to bridge the global digital divide by offering everyone, everywhere, access to the Internet of Things (IoT) and a pathway to 5G. Elon Musk's SpaceX has sought approval to deploy as many as 42000 satellites for Starlink, its own space-based internet system. Welsh Government and Aerospace Wales have also opened a dialogue with a potential supplier of airborne 5G services providing the potential for an integrated land, air and space enabled system. Such an integrated network has the potential to overcome the challenges posed to a purely land based system by the topography of Wales.

The radio spectrum is likely to become very cluttered with the rapid expansion of mobile services. Aberystwyth University and QinetiQ are working in partnership to establish the National Spectrum Centre to train the next generation of radio spectrum and systems engineers and upskill current engineers to harness the potential of radio spectrum technologies that enable wireless connectivity between places, people and devices. The centre will also enable industry and government to identify and demonstrate the next generation of innovative wireless applications needed to double the radio spectrum's annual UK economic contribution to over £100 billion by 2025.

In December 2020, the National Infrastructure Commission for Wales published a report expressing concern about the pace of rollout of broadband and mobile services. Without action, the report said, firms could relocate to parts of the UK with fast fibre broadband, good 4G and 5G coverage.

A combination of fibre, land, air and space-based services could transform data and communications services across Wales, particularly in rural areas. It costs about five times more to get fibre connections to Welsh homes and businesses than the UK average.

While the UK government has committed to every home having a fibre broadband connection by 2025, NICW does not think that is realistic and is concerned about "particular challenges" of deploying fibre in Wales. It called on the Welsh Government to make sure that Wales gets equal priority in UK-wide schemes, change planning rules to make it easier for providers to rollout new

services and commit to a 5G strategy, as Scotland has. The report also suggested public money should be diverted from broadband to make it more common to use mobile services for data.

Swansea based company Annwen, provides an excellent example of the innovative use of space data. It is creating a voice-activated 'digital companion', providing public information in Welsh or other minority languages, particularly for citizens in remote locations, vulnerable members of society and those not used to using technology. They plan to deliver a satellite and 5G connected monitoring system for Wales.

Work already undertaken at Llanbedr and the wider area of Gwynedd has demonstrated the potential of combining space and aerospace technology with data analysis and social engagement to support transformation within rural economies. By joining up all the elements of the value chain in upstream and downstream areas, Wales has the opportunity to take a leading role in the development of the space-enabled rural economy, with benefits for both the home market and for potential exports.

Sustainable Wales

In November 2020, the Prime Minister outlined his 10-point plan for a green industrial revolution for 250,000 jobs.

Covering clean energy, transport, nature and innovative technologies, the Prime Minister's blueprint sets out how the UK will achieve its climate change related targets by 2050, particularly crucial following the COP26 climate summit in Glasgow in November 2021.

Wales is already making significant contributions in all areas in the list and our commitment is backed up by legislation. The Well-being of Future Generations Act in Wales gives us the ambition, permission, and legal obligation to improve our social, cultural, environmental, and economic well-being. The Act requires public bodies in Wales to think about the long-term impact of their decisions, to work better with people, communities, and each other, and to overcome the challenges of poverty, health inequalities and climate change.

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Satellites deliver crucial information about the health of our planet. The measurements they provide help us forecast changes in climate, ensure sustainable fishing practices, increase environmental protection and monitor our rising seas. They support the delivery of essential services in areas such as healthcare and crucial services such as navigation, telecommunications and broadcasting. There is an opportunity to develop the links between the clusters and institutions driving the green agenda and the space sector to increase the impact of space driven applications in achieving our sustainability and future generation's goals.

It is also recognised that space missions themselves, at every stage of their design and execution, can also have a negative ecological impact on our planet and outer space too. In 2012, ESA established the Clean Space initiative, creating and adopting new approaches to spacecraft design and technology with the aim of fielding cleaner alternatives to reduce the environmental impact of spaceflight.

There is an opportunity to develop materials and propellants to avoid tropospheric and marine pollution resulting from space launch. This aligns with current and planned developments in Wales concerning materials and future fuels, including the recent funding announcement for the South Wales Industrial Cluster. There is an opportunity to develop green propellants for satellites and upper stages making handling and launch preparation safer.

The management and removal of space debris can be facilitated by space sensor development and retrieval capability. For example, the University of South Wales is working on the development of space surveillance sensors with NORSS (Northern Space and Security). At a UK level, the Astroscale space debris removal demonstration will act as a catalyst for the commercial development of relevant products and services.

Within Space Wales we have a group that is developing a concept to make Wales the world's first sustainable space nation by 2040, leading the way to a greener space.

The vision provides an innovative yet focused space vision that has:

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- leadership in space sector sustainability through the creation of a Sustainable Space Accelerator (SSA). The SSA will promote sustainable practices upstream and stimulate awareness and demand downstream, whilst also driving demand-driven research and development.
- alternative launch and recovery strategies, especially suited to the geography of Wales, to enhance national and sovereign capabilities.
- the establishment of an “Attraction Strategy” to attract “Magnet businesses” in the sector to promote inward investment, showcase Wales’ capabilities in the arena, and generate primary and secondary employment tier opportunities.
- an innovative funding paradigm as a joint venture between the UK Government and the Welsh Government, delivering a novel national capability whilst respecting the benefits of working in a devolved and positive partnership.
- funding governance arrangements that place investment decisions as close to commercial exploitation as possible.
- scope to maintain and develop inter-academia research and development and reinforces a commercial focus to research and development.
- the ability to build on the early investment in space made by the UK Space Agency into Wales.

A strategy for growing the wales space cluster

Much progress has been made since the publication of the Wales Space Strategy in 2015. We have succeeded in raising the profile and awareness of the sector in Wales, but the size of the industry is still small in comparison with many of the other regions in the UK. The cluster development programme has enabled us to strengthen our focus on the sector through the establishment of the Space Wales network and the Space Wales Leadership Group and the re-establishment of WASP. We have also engaged with a range of stakeholders and other “space hubs” funded by the UKSA cluster development programme. Scotland has been particularly helpful in sharing its experience. All the regions we have been engaged with have been happy to share information and ideas and are keen to explore how we can work together.

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We now need to capitalise on the knowledge and material gained by our involvement in the programme. Working in partnership with others, we will develop a programme of engagement through events and participation in sector related exhibitions and conferences. Our new collateral will be used to help promote the sector within Wales, the UK and internationally. We intend to maintain Space Wales and the Leadership Group as an active and dynamic network in Wales and will develop a framework to support its continued future development. It is our intention to develop our proposals in partnership with the UK Government and the UK Space Agency to ensure the necessary alignment of objectives.

- Action: We will a process to measure the size of the industry in Wales to evaluate progress on at least an annual basis. A key role of the Space Wales Leadership Group will be to review progress against our strategic action plan and to support the revision of the plan as circumstances change. Agree measurement framework.

We will now consider each of the main opportunity groupings identified by our study, recognising there will be overlaps between the various elements. Some of what we propose can be considered as incremental, building on the foundations we already have. However, we must also aim for breakthrough activity which will help transform the industrial and societal landscape in Wales.

Our vision is that by 2040 Wales will become the world's first sustainable space nation leading the way to a greener space.

Spaceflight, training and experience

Spaceport Snowdonia

Snowdonia Aerospace Centre has produced a roadmap (February 2021) for the further development of Llanbedr airfield and Spaceport Snowdonia. The key items are listed here:

- A draft site development masterplan has been produced which addresses

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the safety parameters associated with operating the airfield for space related operations.

- Action: Secure funding to enable the Economic Impact Assessment and associated planning work to be undertaken – circa £65,000
- Action: Secure funding to enable further flood defence design works and modelling to be undertaken.
- Action: Establish costs and funding opportunities for the building of new flood defence works.
- Ongoing action: Spaceport operations will require Restricted Airspace/a Danger Area within which to operate. Snowdonia is progressing an application for a new Danger Area scheduled to become effective by Autumn 2021. Funding to support the work has been received from the Welsh Government under an interest free loan to the value of £135,000 (45% of the total project costs)
- Action: To agree with the MoD and QinetiQ procedures and market affordable costs for accessing their existing Danger Area in Cardigan Bay.
- Action: Collaborate with Techniquist Glyndwr who have been appointed by the UK Space Agency under the Spaceport in Communities Programme to undertake extensive local community engagements to illustrate benefits of a Spaceport to the local community. Agree new community engagement schedule with Techniquist Glyndwr.
- Action: Having now joined the UK Spaceport Alliance, take an active role in supporting the group in their engagement with the UK Government, UKSA and the regulatory authorities. – ongoing.
- Action: Deliver an end-to-end demonstrator programme which would aim to illustrate the full scope of facilities, services and operational capabilities of the Spaceport 2023 to 2024.
- Action: From 2025 onwards provide a regular and sustainable low cost / rapid access to near space test capability to UK industry and academia, circa 6 to 10 launches per year.
- Action: Develop costed plan and seek funding mid-2022.
- Action: Complete CAA Licensing and seek Spaceport Licence late 2022.

A Spaceport Snowdonia Strategy Group has been formed chaired by Snowdonia Aerospace Centre and with representation from Welsh Government, Space Wales/Aerospace Wales, Spaceflight Academy, B2Space, Newton Launch

Systems, Space Forge and Deimos Space. The group plan to meet monthly.

Individual schedules are being developed and submitted to Snowdonia by users including B2Space, Newton Launch Systems and Space Forge. Spaceflight Academy wish to start development at the site, for their training, experience and aeromedical centre, by late 2022. They will also be looking within a similar timescale to provide a wide-bodied zero-g aircraft with potential operation from an airfield in Wales (tbc).

Welsh Government and Aerospace Wales have engaged with MoD and potential users to explore the use of the facility for military space. Llanbedr continues to be a development site for future flight concepts and clients have included BAE Systems, Astigan and Vertical Aerospace. Snowdonia Aerospace has already completed a proof-of-concept demonstration for delivery of a mini-defibrillator by drone to a remote rural location in partnership with the Welsh Ambulance Service. The project was funded by the UK Space Agency and Welsh Government under a National Space Technology Programme/Space for Smarter Government Programme to show how satellite-enabled drones could be used as part of a broader satellite-enabled network to support remote healthcare services in rural Welsh communities.

This project provides a bridge between the upstream and downstream elements of the space sector. With its soon to be activated local airfield privately owned danger area connected to the 8500km² of MoD accessible segregated airspace, the airfield has a unique position in the UK in terms of the development of BVLOS flight providing integration opportunities with space data. It is recommended that the newly formed Spaceport Snowdonia strategy group considers the potential offered by this capability and works with potential partners such as NHS Wales and the Welsh Ambulance service to develop integrated solutions for a space-enabled rural economy.

Spaceport Snowdonia has defined the areas in which it wishes to operate and outlined the actions and investment to achieve its ambitions. This will require buy-in from Welsh Government, UK Government and the UK Space Agency. In particular, it is recommended that the degree of engagement is increased with the UKSA Spaceflight team and that Snowdonia makes good use of its new membership of the UK Spaceport Alliance during this critical period of the

development of spaceflight within the UK.

Black Arrow Space Technologies/Horizon Sea-launch/Port Talbot Space Centre

Black Arrow Space Technologies is proposing launch payloads of up to 500kg into Polar Low Earth Orbit, or up to 300kg into Sun Synchronous Orbit, from a seaborne launch vessel. The service will be marketed under 'Horizon Sea Launch' and will be operated out of a proposed Port Talbot Space Centre. The Black Arrow 2 two-stage launch vehicle will be designed and manufactured at their premises in Oxfordshire. The rocket will be powered by proven engine and propulsion technologies, adapted for use in the Black Arrow 2 launch vehicle, comprising innovative 3D printed parts, and using cryogenic Liquefied Natural Gas (LNG) and Liquid Oxygen (LOx) propellants. This is a cost-effective, environmentally friendly system, suited to support reusable systems. Five engines will provide ~450kN thrust to the First Stage, with added reliability and recovery function, with a single-engine propelling the Upper Stage. They plan to establish high thrust test facilities, to support 'stack' tests (initially up to 1MN thrust), and system integration/processing facilities, alongside the spaceport centre. Black Arrow Space Technologies has been developing industrial partnerships to support the project and has created a network of manufacturing companies, the Celtic Space Cluster, with space related capability in Wales, Ireland and the Isle of Man.

Port Talbot Space Centre (PTSC) is planned as a manufacturing and upstream space enabling centre based in Port Talbot's dockside area, redeveloped under the guidance of Neath and Port Talbot Council. The development is alongside the Baglan Energy Park, the Hydrogen Centre and the Gas Turbine Research Centre.

The Port Talbot area has maintained an active and highly skilled manufacturing base with materials support companies and a significant supplier capable of producing a range of air gases directly from the atmosphere.

PTSC offers an ideal home for a seaborne launch operation and related component manufacturers, with dockside space available to build integration,

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storage and processing halls, and workshops within a secure boundary adjacent to the tidal harbour and the inner dock. The railhead is of particular interest in the transport of parts and equipment from farther afield.

A commercial partner is expected to centralise the launch preparation activities in the PTSC, along with parts and propellants storage, to enable the seaborne launch operations to be coordinated and supported in one location. In addition, engines, structures, and propellant tank manufacturing divisions (or subsidiaries) may be introduced within the broader dockside area's confines. Other support facilities may also be introduced, to concentrate the operation and secure the supply chain. Storage facilities will also be introduced to ensure integration can occur rapidly and seamlessly, without obvious obstruction. The operation will create around 350 direct jobs and an anticipated 500 indirect jobs.

- Action: It is recommended that a joint industry/government working group with Welsh Government and Space Wales is formed, similar to that established at Snowdonia, to develop a shared business case and investment profile.

The use of other spaceports

Discussions with Space Forge and their launch requirements and cadence suggest that the UK demand for launches will probably outstrip the UK's short-term readiness to provide launch slots at a competitive price in the international market. We should be working as a network to encourage the growth of both the payload and platform market to exploit our upstream capabilities and drive the development of downstream applications. We will build relationships with other UK and international launch providers to ensure members of the cluster have the necessary and cost-effective access to launch capability and learn from other providers to support the growth of our own domestic capability. Welsh Government, Space Wales and companies within the Space Wales network will engage with potential launch providers at space sector events and exhibitions and through our collective networking activity. We have been approached by the Global Spaceport Alliance and will explore what benefits a relationship might bring.

In-space manufacturing and recovery of space vehicles

Space Forge has received and agreed funding to support the establishment of its development and integration facility in Cardiff. Its current plan is to:

- 2023: launch Wales' first built satellite (from a Welsh spaceport if available).
- 2024: return a satellite to Wales carrying research by Welsh university or for Welsh supply chain e.g. Aston Martin/ GD/ BAE etc.
- 2025: launch a refurbished satellite to commoditise university research for in-space production and use back on Earth, new composites for engines/ semiconductors for telecom/ ceramics for turbines etc.

The potential launch cadence would grow from 4 units in 2023, 12 units in 2024 to one a week in 2025 to 2026.

Recovery of space vehicles could be managed within the Cardigan Bay MoD/ QinetiQ Danger Area with support from Snowdonia Spaceport.

It is in discussion with Welsh Government to explore further funding opportunities. Discussions between Welsh Government and the Satellite Applications Catapult are exploring the establishment of a DISC facility (Disruptive Innovative Space Capability) in Wales and there is potential for synergy between the proposed facilities.

- Action: It is recommended that Welsh Government/Space Wales, Space Forge and the Satellite Applications Catapult work together to develop the DISC concept with firm proposals.
- Action: Plasma wind tunnels provide the capability to simulate atmospheric re-entry conditions, a capability which Space Forge will require in developing its spacecraft recovery proposals. There is an opportunity to develop such a facility in the UK and it is recommended that Welsh Government/Space Wales and Space Forge explore the cost and domestic demand for such a capability and publish their findings.
- Action: The Satellite Applications Catapult is seeking ESA funding to support the demand and capability for in-space manufacturing. Welsh Government/Space Wales have pledged to support this aim. It is recommended that we

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agree a plan for how we will work together.

Test and evaluation ecosystem

The UK Space Agency has tasked the Science and Technology Facilities Council (STFC) to undertake a road mapping survey of proposals for major national space infrastructure and facilities to support economic growth and prosperity and to determine which of these developments may need government support. It is always a challenge to carry out such surveys and the previous iteration required some late intervention to ensure that Wales was adequately represented. The potential growth of the UK launch and launch vehicle capability is likely to expose gaps and bottlenecks in the UK's overall test and evaluation capability. Wales has some excellent facilities, but the collective marketing of our capability is currently ineffective. It is likely because of other priorities and pressures that the collective response to the UKSA/STFC may not have captured all of what we have to offer or require to support future growth.

- Action: seek to review the Wales response with UKSA/STFC and correct any gaps.

We need to develop a better understanding of how our current facilities and needs fit into the overall UK landscape. We should include TWI, ATRC, AMRC Cymru and GTRC in these deliberations. We have discussed the potential for a DISC facility and the possible siting of this adjacent to the planned Space Forge facility in Cardiff.

- Action: review and agree proposals for the development and marketing of facilities in Wales in partnership with UKSA.

We have already covered proposals for the facilities at Llanbedr/Spaceport Snowdonia. We have identified the current MoD/QinetiQ charging regime as an impediment to the greater involvement of SMEs and start-ups in the use of the Cardigan Bay range.

- Action: Initiate discussions with UK and Welsh Governments to seek more commercially attractive rates to encourage the use of this national asset in

support of a growth sector.

The National Space Propulsion Facility (NSPF) in Westcott, Buckinghamshire, provides testing sites for engines of lower thrust for use on satellites and cannot accommodate the higher levels required for launch vehicle use. There is currently no secure site in the UK where rocket engine testing at required high thrust (and noise) levels can be performed and these two Range facilities are ideally suited to provide such services with a suitable investment. Pendine and Radnor Range have existing defence-related facilities, however, in order to accommodate high thrust rocket engines or hazardous item tests for space use, ground and environmental assessment studies and civil works will be required to allow enhancement and effective upgrade, where necessary.

- Action: Welsh Government/Space Wales to work with UKSA and the site owners to agree future potential to support the space sector and to evaluate costs and revenue potential

The proposed Port Talbot Space Centre could incorporate Tracking, Telemetry and Control (T,T&C) capabilities to support the locally-based and UK launch activities or in a separate, suitable remote location, in West Wales. There is a commercial and strategic potential for a dedicated civilian avionics and related technologies T&E range, with a possible site in West Pembrokeshire, which will benefit from its remote and easily secured location at the Western end of the Milford Haven, within the Haven Waterway Enterprise Zone, and relative proximity to the active IR/RF operations in Aberporth.

- Action: Welsh Government/Space Wales to engage with Port Talbot consortium to explore the scope and potential of these facilities.

Advanced manufacturing capability and emerging clusters

We have catalogued our capabilities in the recent mapping exercise supplemented by previous surveys and complementary UK analysis. We have developed collateral in the form of space sector capability matrix and directory.

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- Action: We should seek to engage with key primes and OEMs in the space sector to develop our relationships with them and aim to programme 6 supplier days over the next two years. We could potentially commence with companies with a presence in Wales e.g. Airbus Defence and Space, Raytheon UK.
- Action: we should work with UKSA and other regional hubs/clusters to explore opportunities and potential synergies, first pass analysis.
- Action: within the Space Wales network hold at least two events a year with presentations by potential customers, successful network members and guests from other hubs/clusters.
- Action: Welsh Government/Space Wales prepare a programme of events and exhibitions with respect to the space sector with proposed attendance by “Team Wales”. Apply the normal rigour in preparation and post-event analysis currently standard practice in other sectors. Initial list agreed and refreshed each year.

Earth observation

We have many key elements of an overall earth and space observation ecosystem. We have advanced sensor capability in many of our universities with commercial application through companies such as QMC Instruments and Glyndwr Innovations. The EO capability in Wales and particularly the Living Wales project in Aberystwyth together with commercial companies such as Environment Systems and Geo Smart Decisions provide a strong overall capability in this field. A specific opportunity for the commercial companies is to build on their current export successes to grow the sector further and to further expand existing strong capabilities in the use of artificial intelligence to deliver analytics at scale. In Wales, organisations such as Natural Resources Wales are now established users of EO data. Applications developers such as Annwen Satellites are developing capability to support local communities. We also have growing data analysis capability and growing strengths in such areas as cyber security and artificial intelligence.

- Action: Establish a specialist Earth Observation Group with representatives from the elements identified above to develop detailed proposals for growing

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this activity, including the potential for the establishment of a National Wales Space Observatory.

Research and teaching facilities

WASP (Wales Academic Space Partnership) has been revived and co-chairs Professor Peter Hargreaves of Cardiff University and Richard Hazlewood of Glyndwr Innovations have been elected. The capability audit previously undertaken is being updated. It is planned to meet monthly. Space Wales and Nick Crew of Airbus Endeavr will continue to support WASP and provide linkage with the Space Wales network.

- Action: We will work with the group to formulate proposals to strengthen links between WASP with the rest of the space sector in Wales.
- Action: As previously noted we will publish proposals for a DISC facility and a Plasma Wind Tunnel, assuming the case can be made for these facilities.
- Action: Complete discussions with the Satellite Applications Catapult about the provision of an Innovation Space Lab in Wales.

Wales: challenges and opportunities

- Action: Develop a programme of events and interactions with various communities of interest, in partnership with the ESA Regional Ambassadors covering North & South Wales, Business Wales, and other Forums.
- Action: The public sector is a potential key driver of the take-up of downstream applications. In partnership with Welsh Government agree a programme of events and interactions with Government and Local Government organisations within Wales. Agree a 12 month programme Explore potential funding mechanisms for this activity.
- Action: The roll-out of broadband and 5G services in Wales has been identified as a significant challenge, given the geography of Wales. A working group including Welsh Government, Space Wales, the National Spectrum Centre and providers such as Annwen should be formed to develop proposals for a future potential integrated land, air and space

enabled communications network.

Sustainable Wales

- Action: Develop proposals for a Sustainable Space Accelerator (SSA). This could be based in a university initially, perhaps in partnership with one or more companies. It is envisaged as being distributed rather than in a single dedicated building. The SSA will promote sustainable practices upstream and stimulate awareness and demand downstream whilst also driving demand-driven research and development.

The purpose of the SSA is to address and support nationally committed challenges through the environmentally sustainable utilisation and exploitation of space technologies, reducing pollution and damaging emissions, whilst also delivering growth in vital sectors. The practical manifestation of the SSA in the initial term, will be a project delivery and implementation office that links existing national capabilities in the UK and stimulates the creation of the future supply chain.

Physical and sustainable facilities will only be created in the medium term to develop capabilities that are not currently available in Wales or the UK.

Project deliverables will promote research in sustainable technologies, such as demisable materials, green satellite propellants, clean launcher propellants, and responsible launch/stage recovery operations.

The space wales leadership group

Since 2006, Aerospace Wales has included the space sector as part of its portfolio alongside aerospace, aviation and defence. There are clearly strong synergies between the aerospace and upstream space sector with elements of the UK's industry having evolved from the aerospace side of the business. It was recognised that the growing space sector includes many participants who are disruptors, entrepreneurial start-ups with a very different culture to mainstream

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aerospace. The downstream element of the space sector is by its nature pan-sector bringing together a wide range of potential application areas. For this reason, Aerospace Wales formed a separate Space Group, and has worked with other groups such as Technology Connected and Welsh Government to facilitate engagement with this broader stakeholder community. As part of this project, we have established a new Space Wales brand and a Space Wales Leadership Group (SWLG), the membership of which is drawn from a wide range of organisations recognising the diversity of the sector. This is currently operating under the wing of Aerospace Wales, but it is envisaged that it will transition into an independent organisation. Aerospace Wales is itself a member of the Industry Wales group with similar organisations representing other sectors. During the course of the project, the SWLG has been meeting on a weekly basis and is co-chaired by Helen Swift (Airbus) and John Whalley (Aerospace Wales).

- Action: Continue operation of network and leadership group under the joint sponsorship of Welsh Government and Aerospace Wales. Seek to identify potential funding routes/operating models for continuing operation with proposals.

Conclusions and key recommendations

The UK Space Agency funded space cluster development programme has enabled us to map the space eco-system in Wales, identify opportunities for future growth and draw together key recommendations.

We have also established a Space Wales Leadership Group, which has met regularly during the project, and a Space Wales network.

Recommendations

The Space Wales Leadership Group and Space Wales network will continue to operate and progress the short-term actions identified in partnership with Welsh Government. Space Wales will continue to operate as an arm of Aerospace Wales and discussions will be held with members and Welsh Government to

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determine future funding and governance models.

Space Wales, Welsh Government and UKSA will agree the framework for measurement of the size of the sector in Wales to determine progress toward our goal of £2 billion turnover by 2030.

Working groups will be established to address specific opportunities such as the Sustainable Space Accelerator, National Wales Space Observatory, space enabled broadband and communications system for Wales, public-sector engagement, application of advanced manufacturing to the space sector, and the development and marketing of test facilities.

Key programmes such as the development and use of Spaceport Snowdonia, Talbot Space Centre and in-space manufacturing should continue to be developed through industry and government partnerships.

WASP will be encouraged to develop and grow and work in close partnership with Space Wales and Welsh Government

This report, actions and recommendations will be regularly reviewed by the Welsh Government and appropriate Ministers.

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