SUPPORTING COMMERCIAL UK SPACEPLANE OPERATIONS

Consultation on Criteria to determine the location of a UK spaceport

Response to the CAA consultation Questions **06.10.14**

Foster + Partners

XARC
Exploration Architecture Corporation

Mott MacDonald

Contents

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Introduction

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Dear Jeremy,

We have assembled a team to prepare this response to the consultation questions. Our team includes spaceport architects XArc Exploration Architecture Corporation and Mott MacDonald, with whom we have a long standing working relationship on aviation projects around the world. We have provided company credentials as part of this submission.

Foster + Partners has worked with Virgin Galactic at Spaceport America and developed hands on experience of the issues that face spaceport planning and development. Our team consists of Urban Planners, Spaceport Designers and Environmental Analysts. XArc Exploration Architecture Corporation, who consulted with us on the design for the Virgin Galactic hangar facility at Spaceport America has significant experience in the US, particularly with their recent involvement in the Houston Spaceport Study. The Mott MacDonald team has significant local and global aviation experience as well as economic and social planning teams.

We understood the consultation was to review the strategic aspects of CAA's report to help the decision making for the site selection of Spaceport UK. Our approach therefore has been to look at the basis of what the CAA has done to date to get to where they have and to provide some commentary on other possible considerations. We have not formed conclusions on the site selection.

We are very excited and interested to be involved in the growth of the space industry in the UK. We believe we have the credentials and team relationships to further support your teams in the strategic planning process.

We hope you find this response to your consultation useful and please do not hesitate to contact me should you require further information.

Yours Sincerely,

Antoinette Erickson.

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Study Team

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Aviation
Sub-Consultant

TBD

Environmental Impact
Sub Consultant

Beijing International Airport, China
Foster + Partners

Hong Kong International Airport, Chek Lap Kok
Foster + Partners and Mott MacDonald

Queen Alia International Airport, Amman, Jordan
Foster + Partners

Heathow Airport, London
Foster + Partners and Mott MacDonald

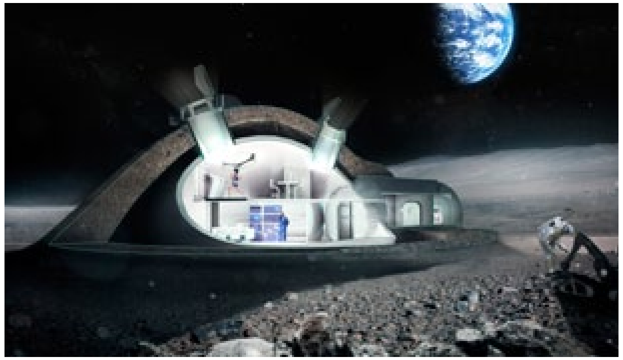
Foster + Partners

Foster + Partners is an international studio for architecture, planning, engineering and design led by its founder and chairman, Lord Foster, together with two heads of design, Spencer de Grey and David Nelson. The practice's work ranges in scale from the largest single building on the planet, Beijing International airport, to its smallest commission, a range of door furniture. The scope of its work includes masterplans for cities, the design of buildings, interior and product design. There is also a strong interest in city planning and the infrastructure of communication. Projects can be found on six continents throughout the world: Europe, North and South America, Africa, Asia and Australasia.

The studio has pioneered a sustainable approach to architecture through a wide range of work, including numerous aviation projects and extensive airport masterplanning experience. Projects include Stansted Airport, England; Chek Lap Kok in Hong Kong; the world's largest airport terminal in Beijing; Queen Alia International Airport in Amman, Jordan; the future Kuwait International Airport and Spaceport America, the world's first private spaceport in New Mexico – all of these projects are based on a design philosophy that establishes a crucial dialogue between scale and clarity. The practice has also recently been involved in a consortium set up by the European Space Agency to explore the possibilities of 3D printing to construct lunar habitations. Addressing the challenges of transporting materials to the moon, the study is investigating the use of lunar soil as building matter. The studio designed a lunar base to house four people, which can offer protection from meteorites, gamma radiation and high temperature fluctuations.

The central concern of the practice is design excellence and a belief that the quality of our surroundings has a direct influence on the quality of our lives. Achieved through active collaboration with clients and specialists this is allied to an acknowledgement that architecture is generated by the needs of people, which are both material and spiritual. Management of cost and time is an important discipline and many of the practice's award-winning projects have resulted from demanding commercial circumstances. A wide range of supporting skills underpins the work of the practice allowing seamless creative integrated solutions.

Established as Foster Associates in 1967 the practice, now known as Foster + Partners, has over 1100 members of staff worldwide. The main studio is in London, with branch offices in Abu Dhabi, Beijing, Buenos Aires, Edinburgh, Hong Kong, Kuala Lumpur, Madrid, New York, Riyadh and Singapore and further site offices in several other locations. Since its inception the practice has worked in over 75 countries, has received more than 600 awards and citations for design excellence and has won over 100 national and international competitions.



Lunar 3D Printing

XArc Exploration Architecture Corporation

XArc Exploration Architecture Corporation was in founded in 2007 as a space architecture consulting firm to provide multi-disciplinary architectural consulting services to the high technology sector of aerospace for facilities utilization and planning of ground infrastructure and architectural systems for space exploration. It provides design and development services for architectural systems in the aerospace domains of: orbital architecture; planetary surface system architecture; and Earth-based space facilities architecture such as spaceports.

For terrestrial architecture projects the company has focused on the design and development of commercial spaceports providing services in Architectural Programming & Program Analysis; Technology Insertion Assessment; Process Flow Modeling and Space Utilization; Infrastructure/Facilities Assessments; Site Assessment Visualization Sequencing Analysis; Risk and Mitigation Assessments; and Spaceport Licensing.

The company has been a member of the Foster + Partners design team responsible for the Spaceport America Terminal and Hangar Facility (THF), and is a current member of the Houston Airport System spaceport development team for Houston Spaceport. It is a current member of the Houston Spaceport Advisory board, and was commissioned by the Houston Airport System to conduct a Houston Spaceport Economics and Business Study and a Concept Design for the spaceport. The study and design concept were completed in November 2013.

Above: Vizualisation images of Houston Spaceport, USA

XArc spaceport consulting experts include a former FAA/AST Associate Administrator and aviation and aerospace professionals that have been associated with spaceport development projects since the inception of the commercial launch industry, and are recognized leaders in promoting the industry. XArc provides full service consulting capabilities for projects endeavoring to seek commercial spaceport licensing and design, including:

- Operational planning
- Economic Analysis
- Program Management
- Facilities analysis
- Masterplanning
- Concept design
- Environmental assessments
- Business case planning
- FAA licensing

As we perform various analyses, assessments, studies, products, and other services in support of the spaceport development, our philosophy is to provide an integrated approach to performing task assignments. Tasking memoranda assigned to the Team are approached within a context of impacting interrelationships between Facilities Planning, Licensing, Environmental Assessments, and Business Planning. The Venn diagram in Exhibit 1 illustrates the interrelationship of these broad categories of support services for an integrated approach in considering all variables when carrying out task directives.

For visualization, marketing, and business development purposes XArc provides spaceport design concepts based on our site assessment analyses and client desires. The opposite page shows examples of the Houston Spaceport concept based on the results of our market driven research process.

Integrated Approach to Scope of Works Tasks

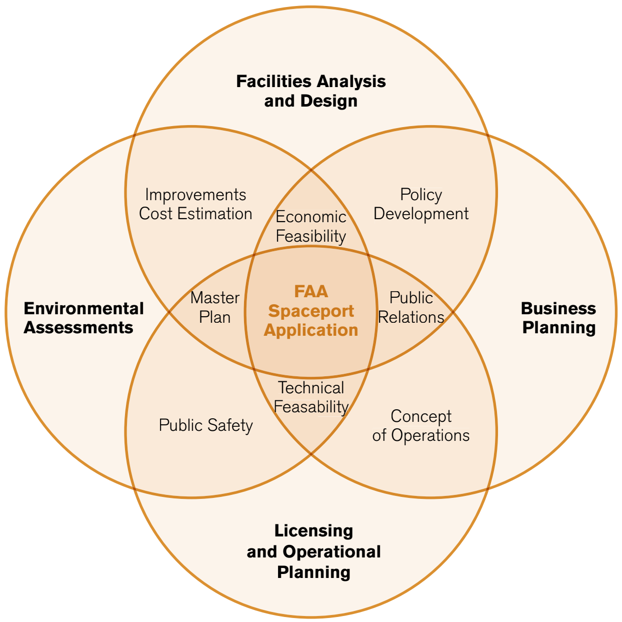


Exhibit 1: XArc Full Service Spaceport Consulting

Mott MacDonald Aviation

Mott MacDonald is one of the world's leading aviation consultancies with an unrivalled track record delivering airport projects. We offer a breadth of aviation-related knowledge and air transport skills including aviation strategy, air traffic forecasting, financial forecasting, fleet planning, airport planning and airport terminal design.

We provide expert airfield and building engineering services, surface access and environmental expertise, capital delivery programmes, asset management and environment management for airports. Our deep understanding of the aviation industry, from all viewpoints, enables us to ensure aviation projects are delivered to the highest standard of quality and safety.

Strategy

Demand forecasting: Our demand forecasting activities cover passengers, air transport, cargo and express mail for airports, airlines, air navigation service providers, business and general aviation worldwide.

Our experienced analysts provide thorough and realistic outcomes whether taking an econometric approach or using Delphi techniques.

Market Analysis: We understand the key issues facing aviation and how they impact on the operating environment – from fuel prices, taxation, deregulation and airline financial performance to market distortion and liberalisation, slot availability, airport capacity, economic growth and propensity to fly.

We combine these skills to provide feasibility studies, market assessment and research that offer sound advice based on experience and market knowledge. This covers analysis of labour supply and training issues, creation of indirect employment, local economic benefits, market growth and contribution to the wider economy.

Regulation and Policy: We have worked for governments, airports and airlines in developing route strategy and aviation policy. This has successfully identified public service obligation routes for regional airports and airlines, helped influence government policy and improved value to users. We advise national and supra-national governments, select committees, lobby groups and learned societies on a range of aviation regulation, policy and strategy issues, and have carried out policy support tasks for the UK and Scottish governments. We also deliver presentations and prepare speeches and presentations for clients to maximise impact of delivery.

Finance

Business Planning: We have provided business cases supporting airport privatisation, concession expansion and investment opportunities for airports and airlines. Our business cases cover the operational and commercial aspects of their business, including debt and equity requirements and risk analysis. We provide financial, operational, commercial, environmental and technical expertise. Our services include reviewing existing airport infrastructure, evaluating the economic and environmental situation surrounding the airport and producing detailed forecasting models that feed into the planning, design and engineering process.

Financial Forecasting: Our master planning and capital delivery teams work together to deliver sound financial information on which to make business decisions. We understand the strategic risks and deliverability issues companies face when delivering capital investment and can give advice at the very earliest stages of airport master planning to mitigate these risks. We enable our clients to make informed investment decisions in the full knowledge of the costs and strategic risks to business.

Technical Advisory: We bring substantial capability and all-round sector experience to technical advisory work – our expertise, knowledge and ways of working set us apart from our competitors. We have leading experience in due diligence having carried out extensive technical, market and environmental due diligence reports for many airports.

We can provide technical advisory services to lenders through to acting as project promoter and lead negotiator for the operating company. Our track record and breadth of experience means that we possess substantial in-house knowledge of the essential components of the privatisation process.

Planning

Masterplanning: We have provided master planning services for airports worldwide, informed by a thorough knowledge of global and local aviation standards and regulations. Our master planning work embraces small and large airports, new greenfield developments and capacity expansion at highly constrained existing facilities.

Facilities Planning: Our facilities planning service minimises risks against changes in market conditions, enabling space to be used as required to meet short- and longer-term needs. To safeguard and maximise operational life, we design to appropriate international standards on the landside, allowing for cost-efficient expansion of terminal buildings while considering access and development opportunities. We also supply risk assessment, emergency planning, construction planning and value engineering services.

Right: Izmir Airport, Turkey

Airspace: We are experts in planning and designing airspace and runways, ranging from airspace assessment and safeguarding to the design of airfield systems. We have expertise in all aspects of aerodrome safeguarding and have advised airports, developers and planners. In the UK we produce safeguarding maps, advise on public safety zones and offer auditing of airport safeguarding teams.

Access: Mott MacDonald understands the demand, capacity and environmental issues concerning surface and sub-surface access. Using multimodal transport modelling we plan and implement efficient and forward-looking systems that can increase efficiencies and minimise impact. One of our key strengths lies in large-scale integrated airport infrastructure developments encompassing all airport surface access projects including road and rail systems.

Design

Buildings: Our expertise and track record in terminal and auxiliary airport buildings design, including identifying the appropriate design and procurement process, helps to minimise risks against changes in market conditions, enabling space to be used as required to meet short- and long-term needs. We develop solutions that enhance quality and meet the highest standards of user comfort and safety – all while keeping a sharp focus on economy, buildability, functionality and sustainability. We are committed to integrating sustainable development into all aspects of our designs.

We use the latest modelling software to increase the accuracy and efficiency of the design process, giving clients greater freedom of input. Our CAST terminal airport simulation software – a custom tailored modelling tool that models highly realistic passenger behaviour – provides instantaneous analysis and 3D visualisation. We employ building information modelling (BIM) on our airport projects. BIM is a co-ordinated set of processes, supported by technology, that add value by creating, managing and sharing the properties of an asset through its lifecycle.

Tunnels/Foundations/Pavement: Our civil engineering expertise also covers development, co-ordination and design of all substructures related to an airport development including basements beneath terminal buildings and underground access tunnels. We have worked on taxiway bridges over airside roads, concrete underground structures for track transit baggage systems and service tunnels and airside roads. We offer the full range of airfield pavement design – structural and geometric – and pavement assessment services. We are fully versed in all major pavement design methods and have applied these to deliver cost-effective pavement and overlays – integrating these with other airport-related infrastructure.

Systems: We tailor our approach, runway, taxiway and apron lighting solutions to ICAO Annex 14 or local standards. Our industry-leading baggage handling solutions comply with the latest airport security regulations. We design and evaluate ICT systems needed by airports and airlines to support their commercial, engineering and maintenance operations.

Proposed expansion and modernisation, Male Airport, Maldives

Terminal 2B, Heathrow Airport, London

Midfield concourse, Hong Kong International Airport, Hong Kong

Construction and Operation

Facilities Management: We help owners and operators to achieve strategic objectives and add long-term value by optimising performance. We plan investment and maintenance so assets are always in appropriate condition and operate to the highest efficiency standards. Our capability covers terminal buildings, aircraft, baggage handling, ICT, refuelling and apron guidance systems, apron floodlighting, and aircraft parking area design.

Monitoring: We work with financial institutions and private clients to provide support in the monitoring of construction and operations at airports throughout the world on a concession contract basis. We report and advise on traffic, revenue and environmental costs, business – particularly commercial – development, environmental aspects and risk management.

Programme Management: Mott MacDonald offers expertise in programme management across a broad spectrum of projects globally. Our services range from high level programme management and business planning for major multinationals to small-scale projects for individual customers. We have a proven track record of delivering major projects and programmes of work in the aviation marketplace.

Sustainability

Environmental Management: Mott MacDonald fully understands the environmental issues that may arise on airport projects and we possess extensive environmental experience gained from airport projects around the world. Our approach to airport planning and design embodies the primary principles of sustainable development following BREEAM and LEED.

Our services include ecology, environmental impact assessments, landscape architecture, climate change, conservation and biodiversity enhancement, pollution monitoring and remediation, carbon footprinting, flood protection, and waste management.

Terminal 5, Heathrow Airport, London

Los Angeles International Airport, USA

Summary

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Key Points Addressed

Prevalent throughout our response to the questions posed by the CAA, is the case for a more comprehensive understanding of economic criteria in site selection when considering the spaceport as an engine to drive long term economic and social health. The CAA criteria determined as necessary for site selection does not enter into the requisite amount of detail required to forecast robust growth of the spaceport. The CAA report seems not to have fully addressed the wider implications of the selection of a suitable location, that sense of scale is reflected in the provided responses. Our response indicates the wider economic and social implications that an infrastructure project of this scale has and the diversity of activity that should ideally emerge around the project.

The CAA consultation paper says at Paragraph 1.3 that the government aims to have a space economy worth £40bn by 2030, equal to about one-fifth of the current size of all UK manufacturing industry. That would mean employing at least 400,000 people – at that level average productivity would be £100,000 per head, a high figure considering that there would be many more workers in manufacturing/maintenance occupations than in technical design and research.

Given its central importance, the spaceport is likely to require local employment of thousands of people even in the early stages and perhaps several tens of thousands by 2030, assuming the £40bn target is to be realised. For this to be feasible, the chosen location should have access to substantial infrastructures, including the social infrastructures of housing, schools, hospitals etc as well as transport and utilities, and to centres of population. Without this, enormous investment would be needed in infrastructure and suitable inducements to encourage people to relocate.

However, none of the eight proposed sites is located close to the science and aerospace industry base of the UK, which is focused in central England, and aerospace industry in South Yorkshire. The current distribution of manufactures and skills suggest that all 8 of the sites would need to attract people and industry.

The key advantage of the CAA's eight locations (as well as runway length) is their coastal position which the safety advantages of which are discussed heavily within the initial CAA document. The 'longlisted' potential spaceport locations shows a numerous sites in eastern England quite close to the coast but excluded primarily because they are not on the coast. However, some, eg RAF Coningsby, are close to the coast and separated from it by very low density areas. A key factor addressed through this report and particular in Q11 is that there are economic advantages of a location such as Coningsby would seem to outweigh the modest safety advantage offered by more remote locations.

Coningsby, using this only as an example, has the key centres of the UK academic and space industry research base within a fairly short travel radius and reasonably good access to population centres (of course many places have better access to population, but low population density is indeed a relevant safety criterion).

Consideration of a wider development for a "UK Spaceport Network" may be a desirable model. Should a spaceport network be established it could be suggested there are remote sites for unencumbered high risk aerospace technology development which can take place, with lesser regulatory processes, where developers are "allowed to fail" with trial and error testing regimes for spacecraft technology development; and other sites developed strictly for early commercial operations; and other sites for vertical launch capability; and other sites for the eventuality of point-to-point travel.

Beyond technical consideration of an aerodrome's feasibility to operate as a spaceport are additional considerations such as the spaceport's competitive advantage for attracting a variety of spacecraft operators without the need to develop significant new infrastructure at the onset, or ability drive economic growth. When comparing these sites it is important to take account of the fact that every criterion is not equally important. Thus, before any sort of quantitative assessment is made between the strengths of one spaceport site versus its competitors, the CAA must separate the characteristics being judged into different weighted categories which we identify as; Competitive Advantage, Investment Advantage, Economic Advantage, Technical Advantage. The weighting assigned to these categories should be dependent on the overarching goals of the government's vision for what defines a UK Spaceport.

Study Components & Process

In responding to the CAA Consultation Questions, our UK Spaceport Consulting Team relied on the combined previous work and experience it has in spaceport development projects.

In particular we placed a heavy reliance on strategies and spaceport planning concepts and findings developed from Foster+Partners detailed knowledge base developed through work on Spaceport America, the world's first purpose built commercial spaceport, XArc work performed on the Houston Spaceport project and Mott MacDonald's extensive aviation consultancy experience. Based on the XArc's body of work we believe the coastal location of the Houston Spaceport together with the City of Houston's vision and plans for converting an existing general aviation aerodrome into a commercial spaceport provides the best benchmark for development of site selection criteria and spaceport model for implementing a successful and economically viable UK Spaceport. "The Houston Spaceport Economics and Business Study", concluded in November 2013, is referenced throughout our response to CAA Questions with examples of exhibits from the study to further illustrate our recommendations as our primary study component. At the request of the CAA, the entire Houston Spaceport study can be made available to the CAA for internal use only.

Our second study component consisted of preliminary sites assessments performed for the eight shortlisted spaceport sites based on an analysis of certain Key Performance Indicators (KPIs), definitions for each indicator can be found under the locations summary. These KPIs were derived from Foster+Partners experience with Spaceport America, these indicators reflect essential decision making question that should be undertaken during feasibility investigations. The results of this process informed our responses for Questions 9-11.

The third study component reassessed a number of airports in the longer list of 26 spaceport site options which were discounted because they were deemed to be not close enough to the coast. Mott MacDonald's global knowledge assisted in expanding the definition of what constitutes a coastal location and the rationale behind location selection. This detailed understanding of wider aviation requirements, as well as that of a commercial spaceport, informed the selection of additional sites identified for Question 11 which may warrant re-consideration.

Potential Locations Summary

The 8 potential spaceport sites have been evaluated against 10 key performance indicators to assist in providing a conclusion for the CAA Q9 and Q10.

Access
The connection to primary existing road, rail and port infrastructure as well as existing localises access to and from site

Existing Facilities
The quality, quantity and use of exiting facilities on the site as well as exiting use in comparison to potential spaceport use, for example large modern aircraft hangers are advantageous

Proximity to Population Density
The distance to large population centres and their relative position to the flight path

Opportunity to Extend Runway
The ability to extent either end of the primary runway and its potential complexity for example; would land need to be reclaimed

Climate
Does the site meet the meteorological criteria outlined by the CAA in Chapter 9 of UK Government Review of commercial spaceplane certification and operations Technical Report

Proximity to Research Facilities
Estimated distance to centres of research and development as well as aerospace company's and university's with aerospace courses

Runway Orientation
Runway orientation in comparison to prevailing wind

Utilities Infrastructure
Where possible identify quality and redundancy of existing utility's connections

Runway composition
Runway surface and time from last resurfacing (if known)

Air Space Intensity
Intensity of commercial flight operations and flight paths in relation to the site location

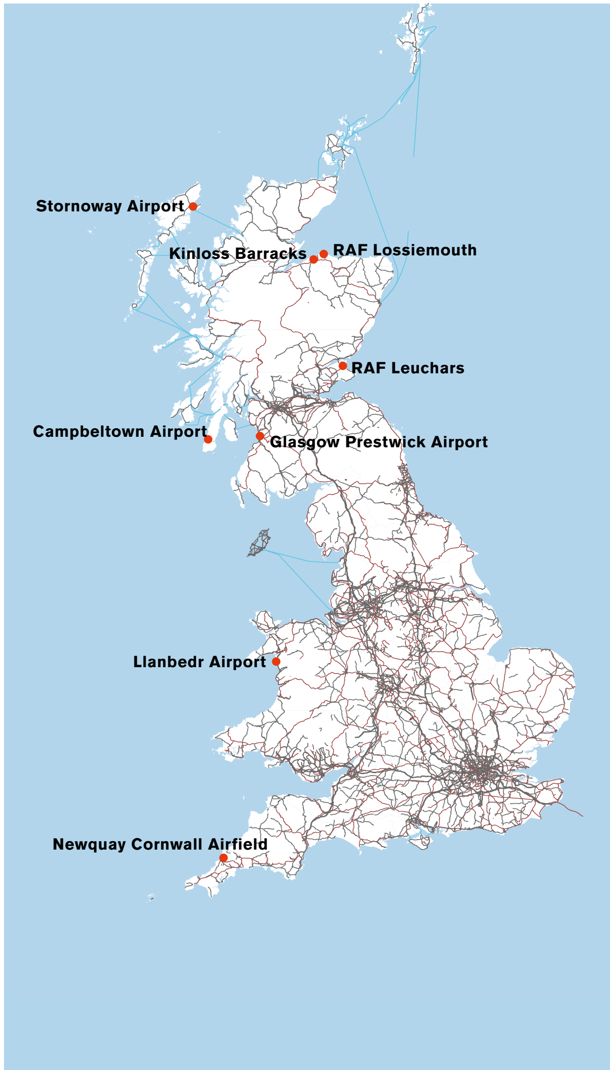
The following pages contains a summary of findings for the 8 potential sites with a detailed analysis for each location evaluating against the 10 key performance indicators

For each location the 10 key performance indicators are given a intenfiers that refelct the following conclutions:

comprehensively fulfils criteria

acceptable fulfilment of criteria with some limitations

significant limiting factors against criteria



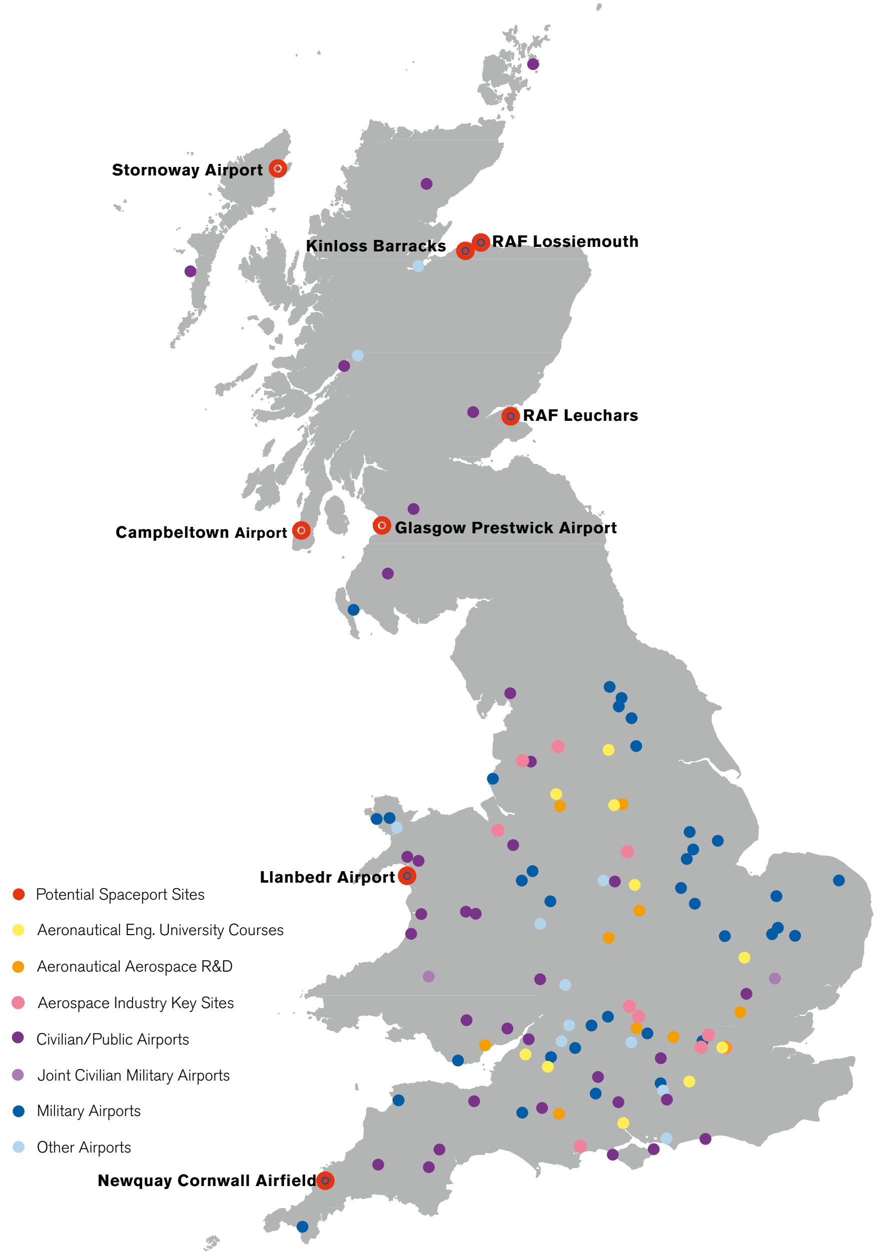
Aerospace Economic Summary

Supports **230,000 jobs** across the breadth of the UK

Every **2.5 seconds** an aircraft takes-off or lands, powered by a Rolls-Royce engine

Potential growth **by 2031** for civil aerospace market is in excess of **$4.4 trillion**

Contributes **£24 billion t**o the economy every year

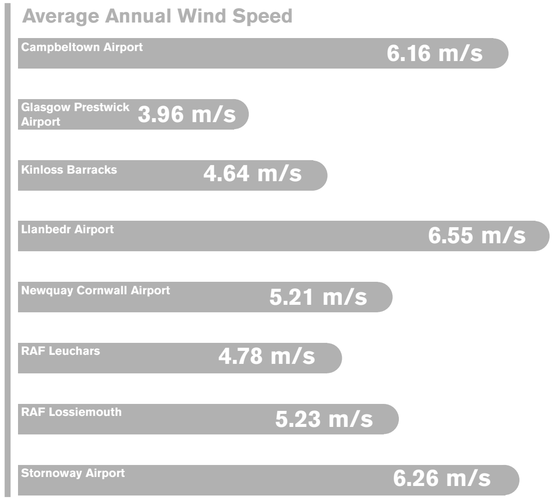


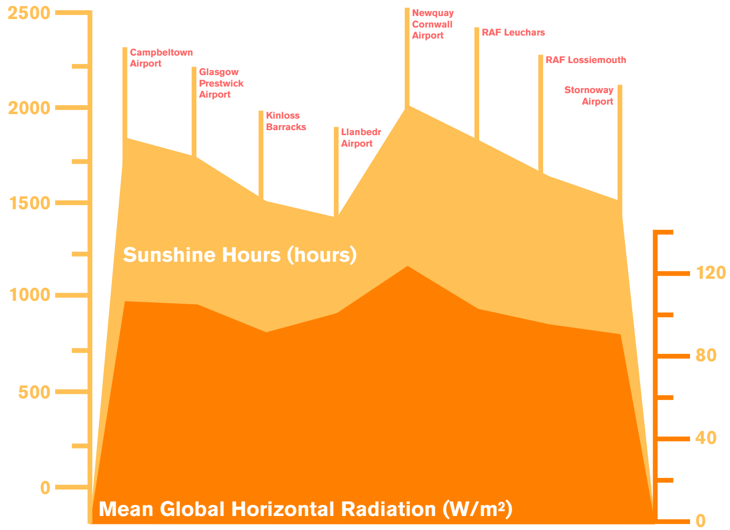
Weather Summary

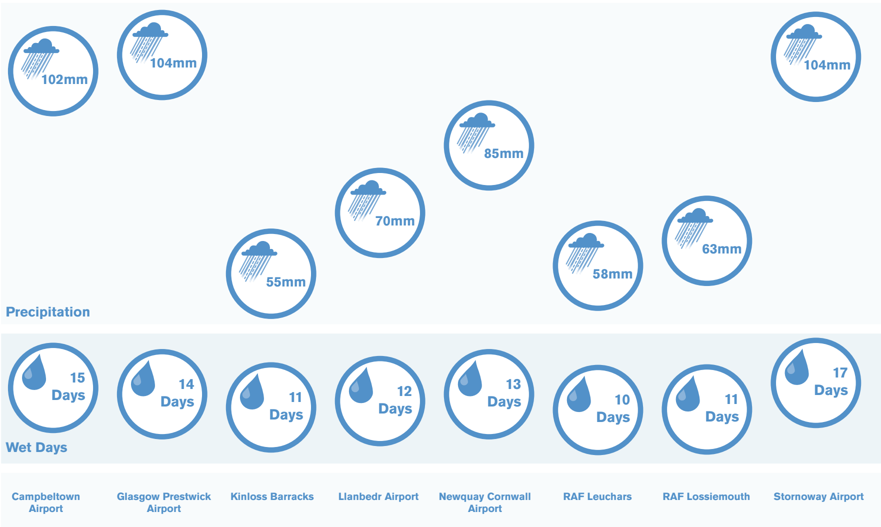
Meteorological Requirements for Airports

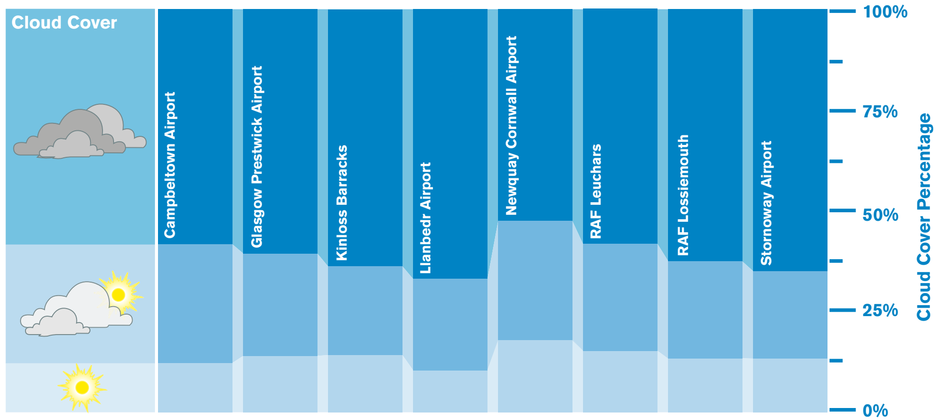
Following the summary of the CAA UK Government Review of Commercial Space plane Certification and Operations Technical Report key performance indicators relating to meteorological factors have been identified for the purpose of selecting a site;

- Average Air Temperature
- Sunshine Hours
- Average Annual Wind Speed
- Precipitation and Wet Days









Summary

There will be differences in the acceptable meteorological conditions for each commercial space operator and their respective launch vehicles, however the following assumption have been made to determine the most suitable location:

Optimum | Suitable | Undesirable

Average Annual Temperature (°C) - the highest average temperature is assumed to be the most suitable

Campbeltown Airport	Glasgow Prestwick Airport	Kinloss Barracks	Llanbedr Airport	Newquay Cornwall Airport	RAF Leuchars	RAF Lossiemouth	Stornoway Airport	Comments
9.7°C	9.7°C	9.1°C	8.4°C	11.1°C	9.1°C	8.9°C	8.9°C	higher temperatures are assumed to be best, although it may not be a significant factor in final selection

Annual Sunshine Hours (hours) - the highest sunshine hours indicate the maximum occasions that launches can take place

Campbeltown Airport	Glasgow Prestwick Airport	Kinloss Barracks	Llanbedr Airport	Newquay Cornwall Airport	RAF Leuchars	RAF Lossiemouth	Stornoway Airport	Comments
1817 hrs	1727 hrs	1518 hrs	1441 hrs	1970 hrs	1806 hrs	1635 hrs	1513 hrs	

Annual Clear Sky Percentage (%) - highest clear sky value suggest optimum sky conditions for take off

Campbeltown Airport	Glasgow Prestwick Airport	Kinloss Barracks	Llanbedr Airport	Newquay Cornwall Airport	RAF Leuchars	RAF Lossiemouth	Stornoway Airport	Comments
12.2%	14.0%	14.2%	10.4%	17.9%	15.2%	13.3%	13.4%	

Average Annual Wind Speed (m/s) - the effect of higher wind speeds at take of can reduced the number of hours that take off can be achieved.

Campbeltown Airport	Glasgow Prestwick Airport	Kinloss Barracks	Llanbedr Airport	Newquay Cornwall Airport	RAF Leuchars	RAF Lossiemouth	Stornoway Airport	Comments
6.16 m/s	3.96 m/s	4.64 m/s	6.55 m/s*	5.21 m/s	4.78 m/s	5.23 m/s	6.26	*wind data for Llanbedr could not be accessed. Data from RAF Valley was used.

Annual Wind Speed less the 1m/s (%) - percentage of time wind speeds are below 1 m/s indicate calmer wind conditions and optimum conditions for take off

Campbeltown Airport	Glasgow Prestwick Airport	Kinloss Barracks	Llanbedr Airport	Newquay Cornwall Airport	RAF Leuchars	RAF Lossiemouth	Stornoway Airport	Comments
1.53	7.38	3.05	0.99	1.64	3.18	4.16	0.42	

Precipitation (mm) and Wet Days average per month- higher precipitation values effect usage of runway, assuming spaceplane launches are limited by rainfall

Campbeltown Airport	Glasgow Prestwick Airport	Kinloss Barracks	Llanbedr Airport	Newquay Cornwall Airport	RAF Leuchars	RAF Lossiemouth	Stornoway Airport	Comments
102mm	104mm	55mm	70mm	85mm	58mm	63mm	104mm	
15	14	11	12	13	10	11	17	

Site Analysis

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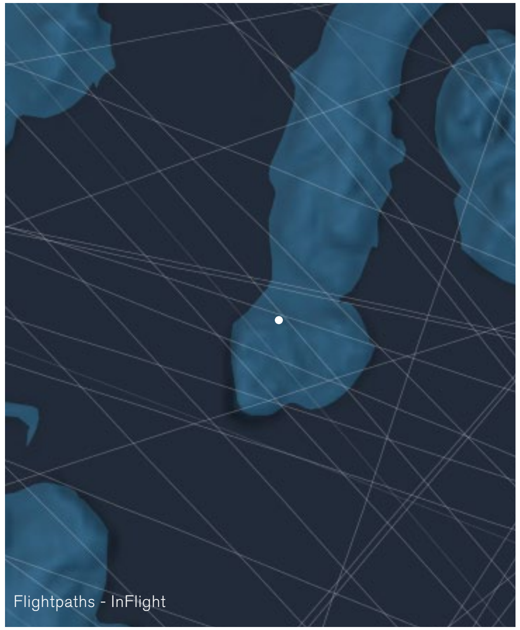
Site Analysis
Campbeltown Airport - Context

Key Facts

Distance to nearest R+D hub	**200** miles
Distance alternate commercial airport	**43** miles
Population density within 5 n.miles	**6,250**
Total sunshine hours	**1817** hours
Total annual precipitation	**1,226** mm
Average wind speed	**6.16** m/s
Prevailing wind	**W**
Runway orientation	**WNW**
Runway length (with potential extension)	**3,049**m (~**3,500**m)
Runway surface	**Asphalt**

- Access
- Existing Facilities
- Proximity to population density
- Opportunity to extend runway
- Climate
- Proximity to research facilities
- Runway orientation
- Utilities Infrastructure
- Runaway Composition
- Air Space Intensity

Site Connections

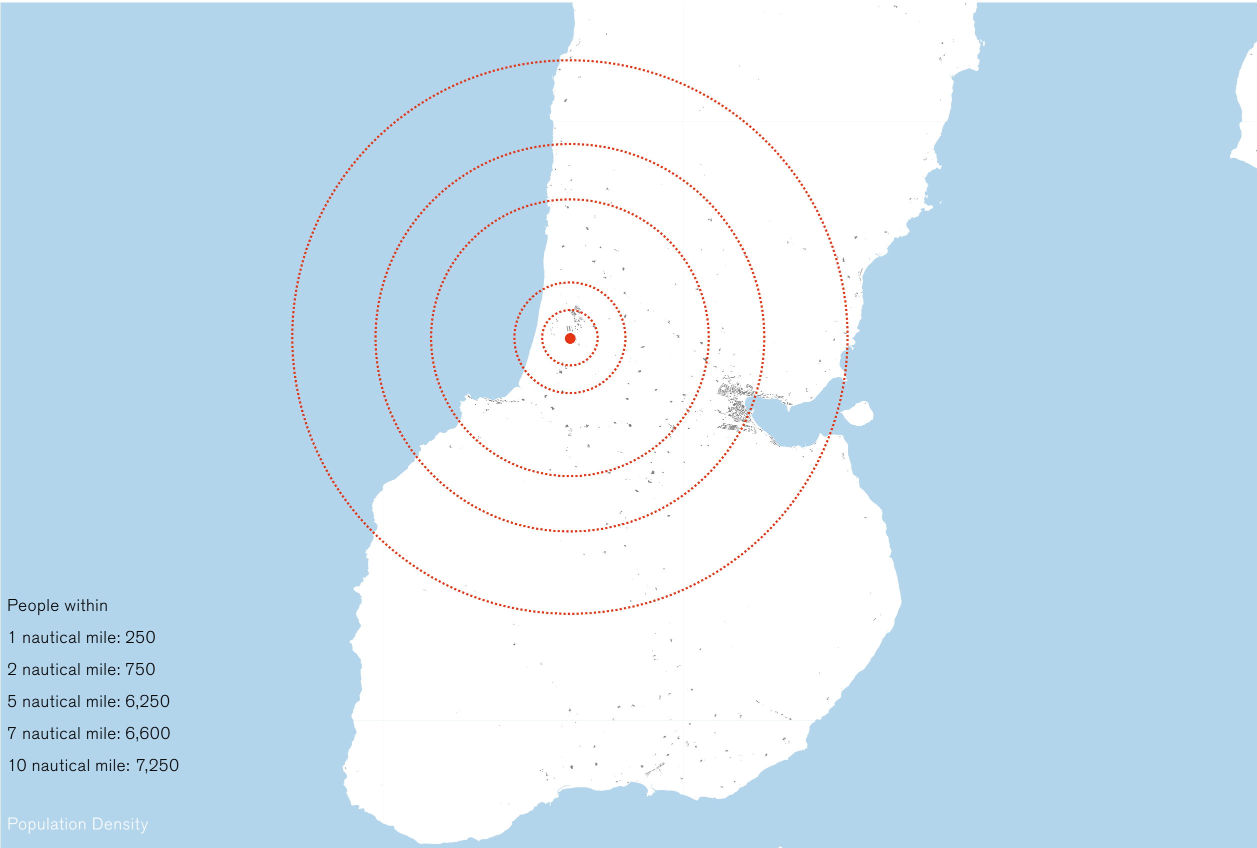

Flightpaths - InFlight

Site Analysis

Campbeltown Airport - Population and Regional Policy

Key Points

- Poor Road Access
- Delivery via sea requires transport through the town
- No rail connection
- Dock in campbeltown larglely transport ferry
- Small barracks to north of site
- Some warehouses
- Moderniation of site required
- Very low air traffic levels
- Large areas of water over which to operate
- Situated near the coast on the Mull of Kintyre
- Very low population density
- Operational length of 1,750m (full length of 3,049m)



Environmental	▪ Noise ▪ Pollution ▪ Renewables

- “opening up” key infrastructure for the Irish Sea and Western Seaboard for offshore renewables e.g. Campbeltown harbour and airport (Argyll and Bute Council's Economic Development Action Plan – 2013 to 2018, p.4)
- Windfarms granted and consturcted north of site (approx 3 miles), coast around airbase protected from windfarm construction (Argyll and Bute Council Wind Farm Policy Map)
- Constrains; Water Capacity, Sewerage Capacity, Nature Conservation and Flood Risk Assessment Required (Argyll and Bute council draft action programme 2014, p.111)

Sustainability	▪ Social ▪ Economic

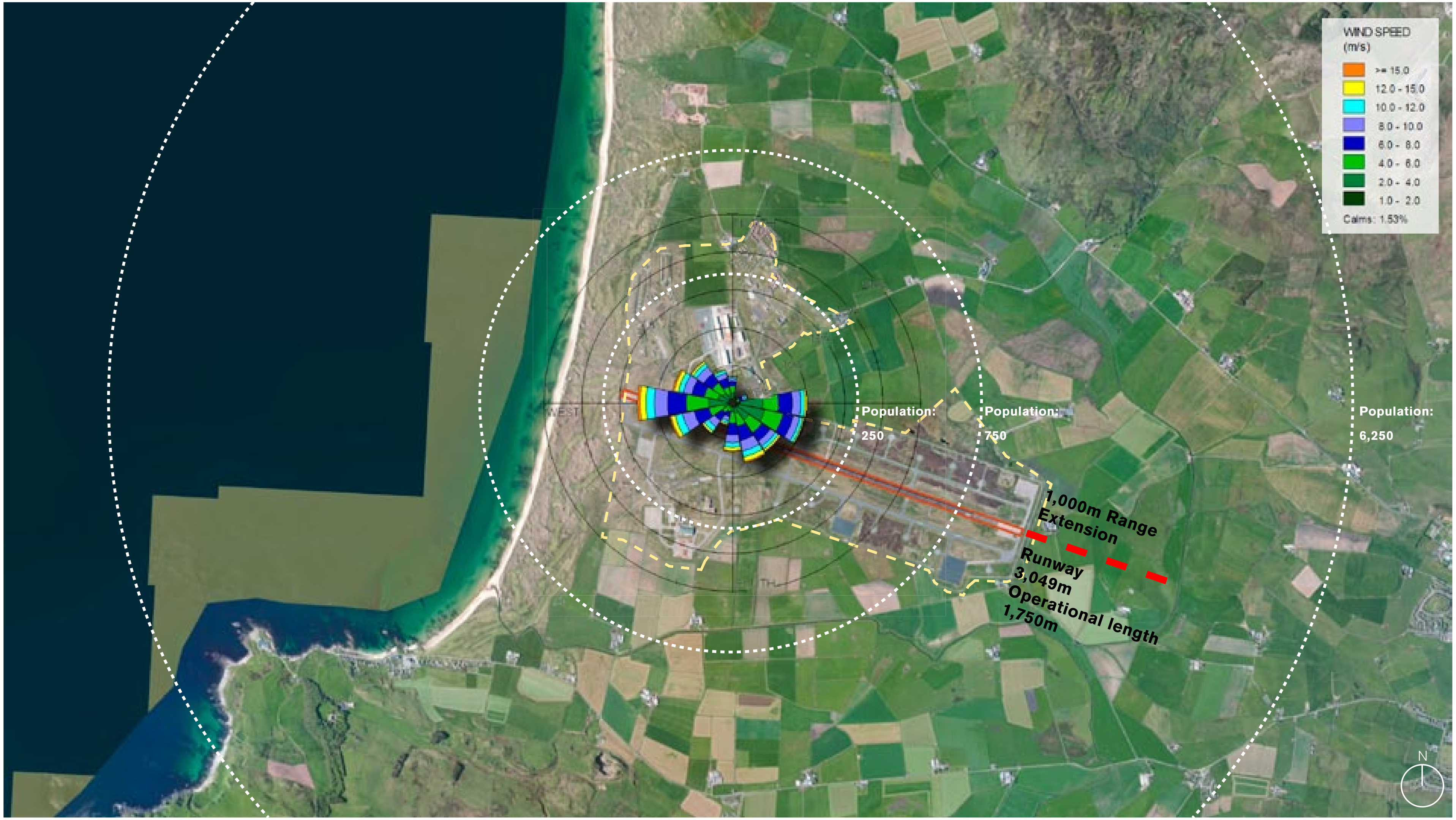
- Prioritise and promote infrastructure investment essential for the area's growth (transport, grid, utilities, broadband, mobile phone coverage) (Argyll and Bute Council's Economic Development Action Plan – 2013 to 2018, p.2)
- Machrihanish Air Base Strategic; redevelopment and inward investment opportunities; green technologies hub (policy AFA 14/7 and MAST 1/10, Argyll and Bute council draft action programme 2014)
- Tourism as a main potential growth sector through high value developments. Argyll and Bute's Economic Development Action Plan promotes the retention and creation of jobs through new and growing enterprises.

Regeneration	▪ Investment ▪ Masterplans

- CHORD: £30million+ regeneration programme in Campbeltown, Helensburgh, Oban, Rothesay and Dunoon (Argyll and Bute Council's Economic Development Action Plan – 2013 to 2018, p.16)
- Masterplan for Machrihanish Airbase by October 2014 (Mid Argyll Kintyre & the Islands Economic Development Action Plan 2013-18, p.6)
- Promoting development of harbour and working with Machrihanish Airbase Community Company (MACC) Limited to realise potential. (Mid Argyll Kintyre & the Islands Economic Development Action Plan 2013-18, p.6)

Site Analysis

Campbeltown Airport - Site Location



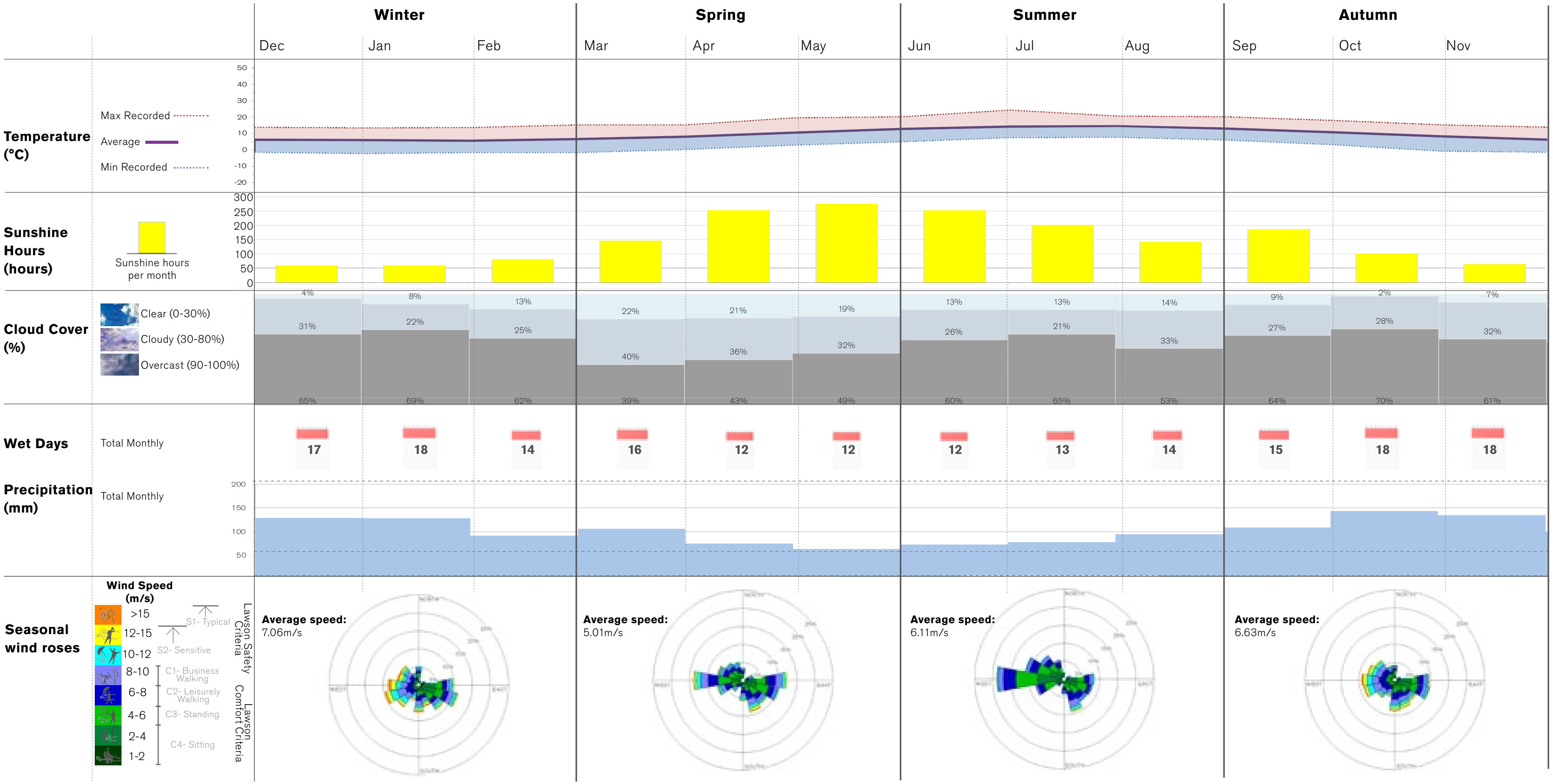
Site Analysis

Campbeltown Airport - Climate

Key Meteorological Factors

- Potential cross winds occurrence
- Moderate ambient air temperature
- Air frost occurrence from October to may
- Spring is likely to provide most potential launch days

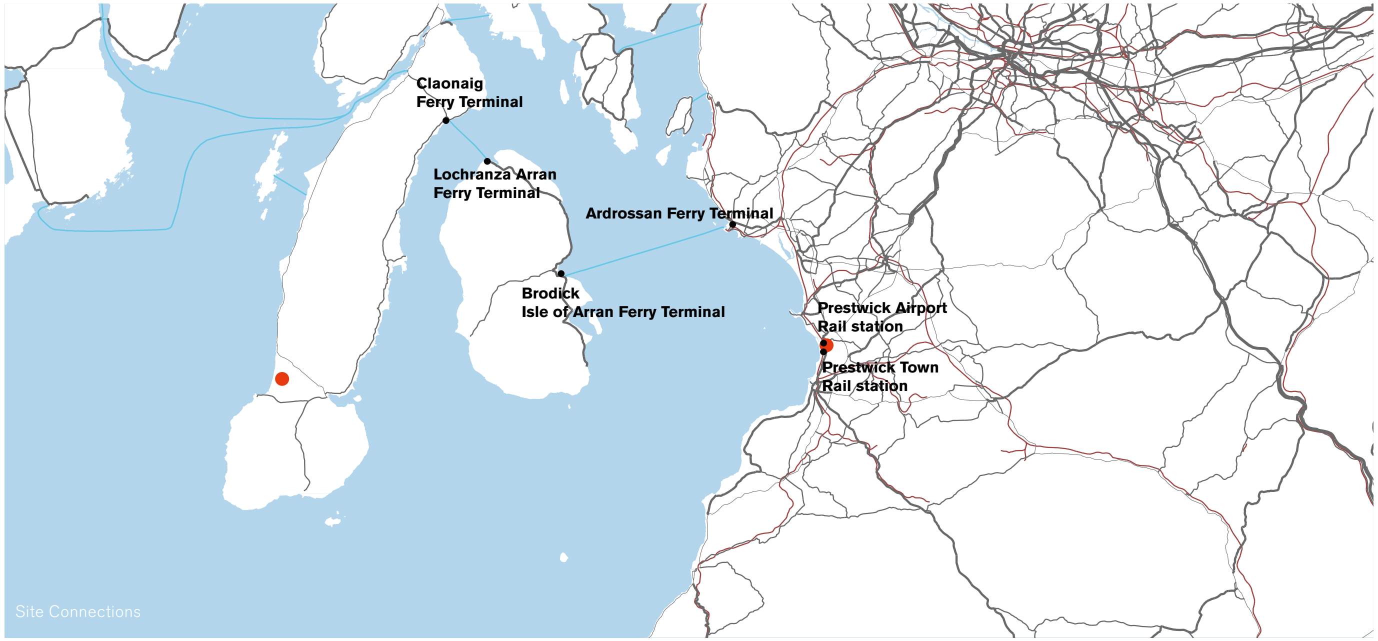
Sources:
Temperature, humidity, solar: MACHRIHANISH RAF (Meternorme)
Wind Data: EGEC - 2001-2012 (mathematica)
Precipitation: Machrihanish - Met Office



Site Analysis
Glasgow Prestwick Airport - Context

Key Facts

Distance to nearest R+D hub	**177** miles
Distance alternate commercial airport	**25** miles
Population density within 5 n.miles	**89,450**
Total sunshine hours	**1727** hours
Total annual precipitation	**1,245** mm
Average wind speed	**3.96** m/s
Prevailing wind	**SW**
Runway orientation	**WNW**
Runway length (with potential extension)	**2,987**m (~**3,500**m)
Runway surface	**Asphalt**



Site Connections

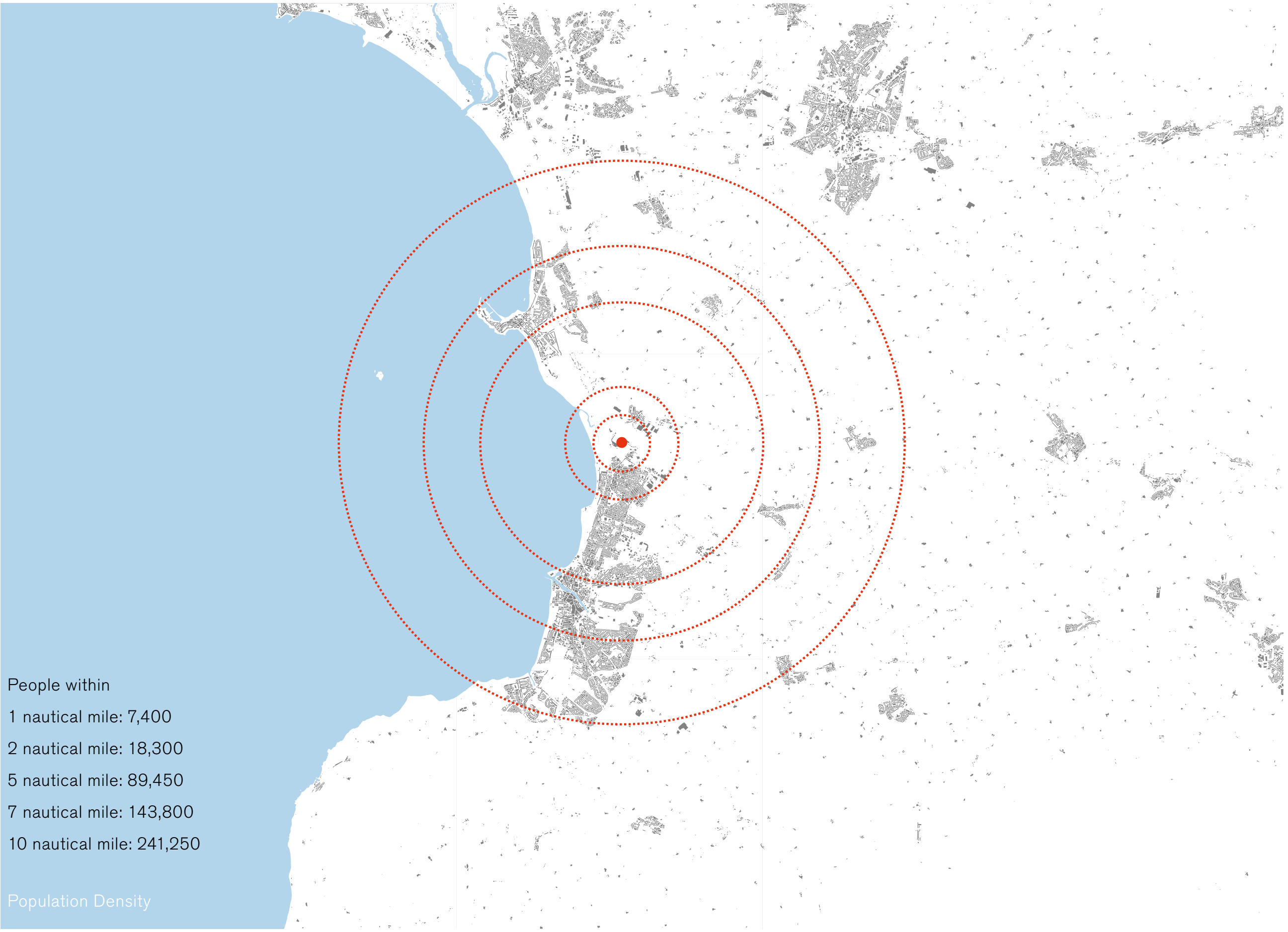

Flightpaths - InFlight

Site Analysis

Glasgow Prestwick Airport - Population and Regional Policy

Key Points

- Good road access
- Prestwick International Airport rail station
- Residential areas immediately adjacent to the airport
- Relatively low population density to the north and east
- High air traffic levels



Environmental	**▪ Noise** **▪ Pollution** **▪ Renewables**

- Employs the principles of sustainable urban drainage and is safe from reasonable risk of flooding without increasing a risk of flooding in other locations (South Ayrshire Local Plan, STRAT5)
- Council will presume in favour of proposals for renewable energy production developments where it is demonstrated (South Ayrshire Local Plan, SERV 3)

Sustainability	**▪ Social** **▪ Economic**

- The Council will safeguard land (surrounding site) for runway related development and will favourably view proposals which are in accordance with the Industrial Strategy (South Ayrshire Local Plan, AIR1)
- Safeguard and promote sites for Airport related development (South Ayrshire Local Plan, AIR 2 &3)
- The plan favors logical extension to existing activities in Prestwick airport. The site falls within the Prestwick Enterprise Area.

Regeneration	**▪ Investment** **▪ Masterplans**

- Key to economy is the continued support to Prestwick Airport recognising the potential that regular links to EU destinations offers in terms of business and leisure travellers. (East Ayrshire Economic Development Strategy 2012-2017, p.9)
- £10m of investment from the Scottish government for Prestwick Airport due to large pre-tax losses over previous years. (BBC News, 18/06/2014)
- Strong support for road improvement schemes on A77 at Maybole, A77 Whitletts roundabout and A77 route action plan. (South Ayrshire Local Plan, RECOMMENDATION 1)

Site Analysis

Glasgow Prestwick Airport - Site Location

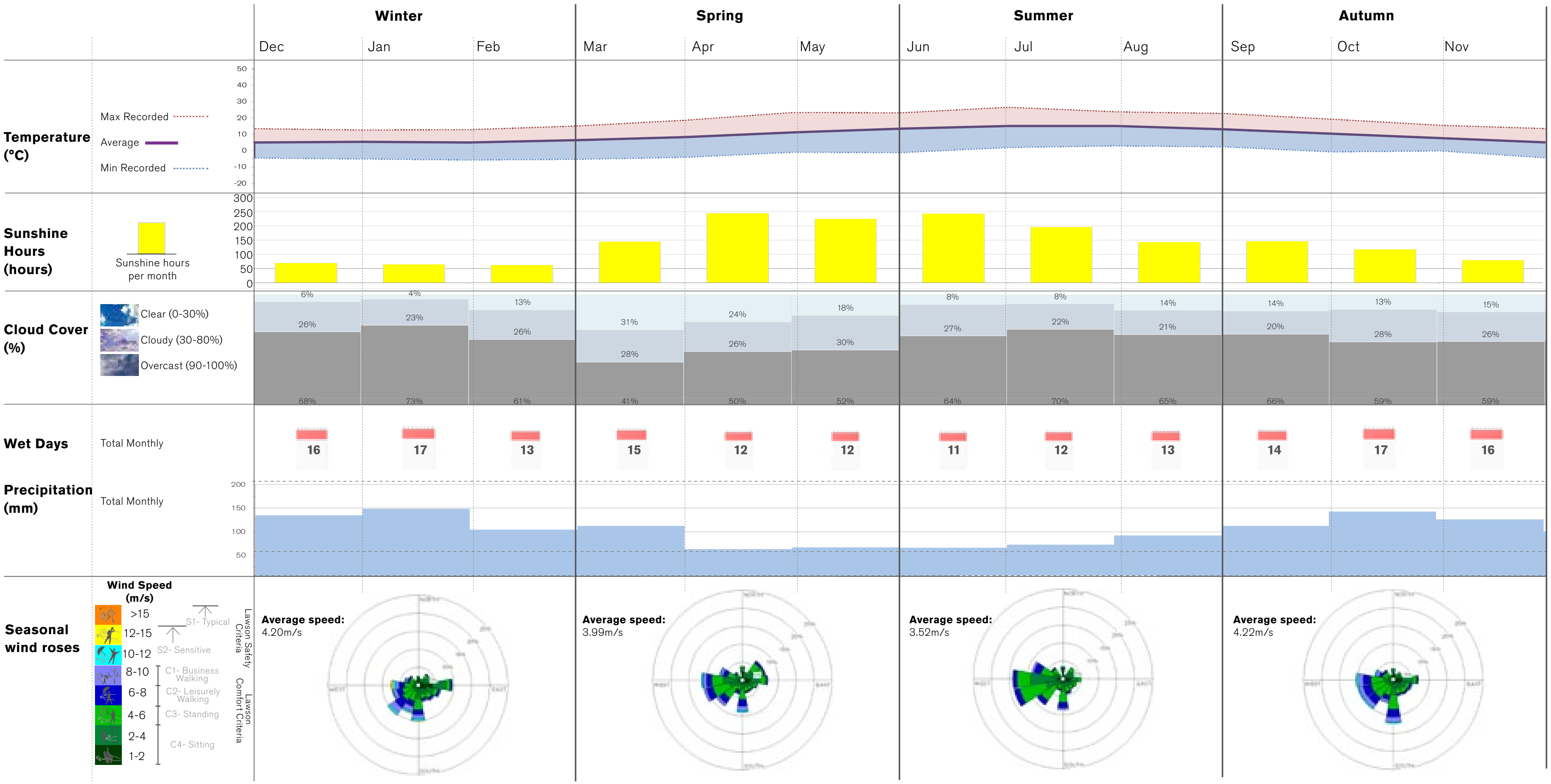
Site Analysis

Glasgow Prestwick Airport - Climate

Key Meteorological Factors

- Potential cross winds occurrence
- Wind speed lower than 1m/s for 7.38% of year
- April to June is optimum period for flight

Sources:
Temperature, humidity, solar: PRESTWICK RNAS (Meternorme)
Wind Data: EGPK - 2007-2013 (mathematica)
Precipitation: Paisley - Met Office

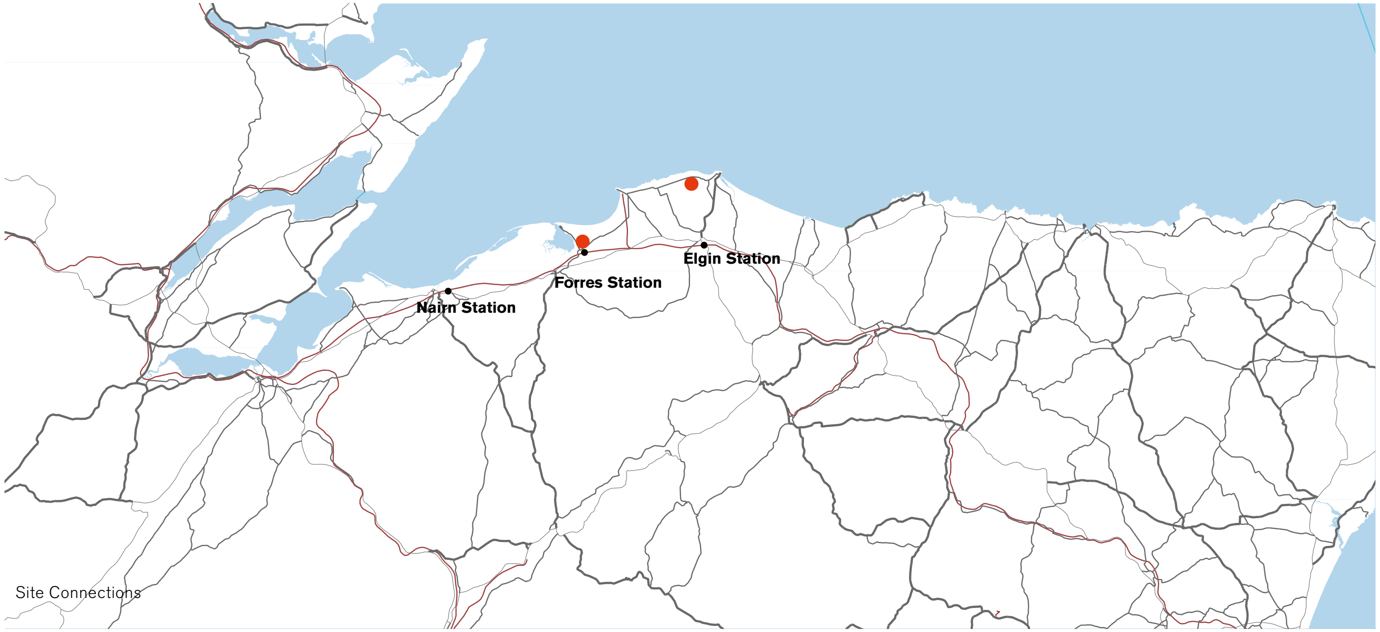


Site Analysisw
Kinloss - Context

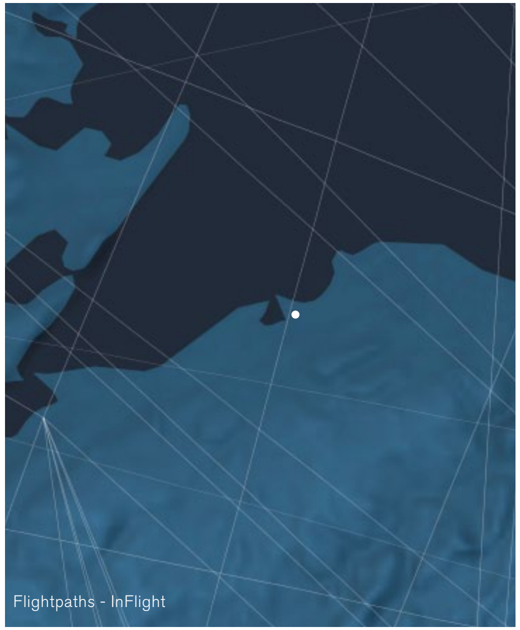
Key Facts

Distance to nearest R+D hub	**300** miles
Distance alternate commercial airport	**19** miles
Population within 5 n.miles	**16,250**
Total sunshine hours	**1518** hours
Total annual precipitation	**664** mm
Average wind speed	**4.64** m/s
Prevailing wind	**SW**
Runway orientation	**WSW**
Runway length (with potential extension)	**2,344**m (~**3,300**m)
Runway surface	**Asphalt**

- Access
- Existing Facilities
- Proximity to population density
- Opportunity to extend runway
- Climate
- Proximity to research facilities
- Runway orientation
- Utilities Infrastructure
- Runaway Composition
- Air Space Intensity



Site Connections

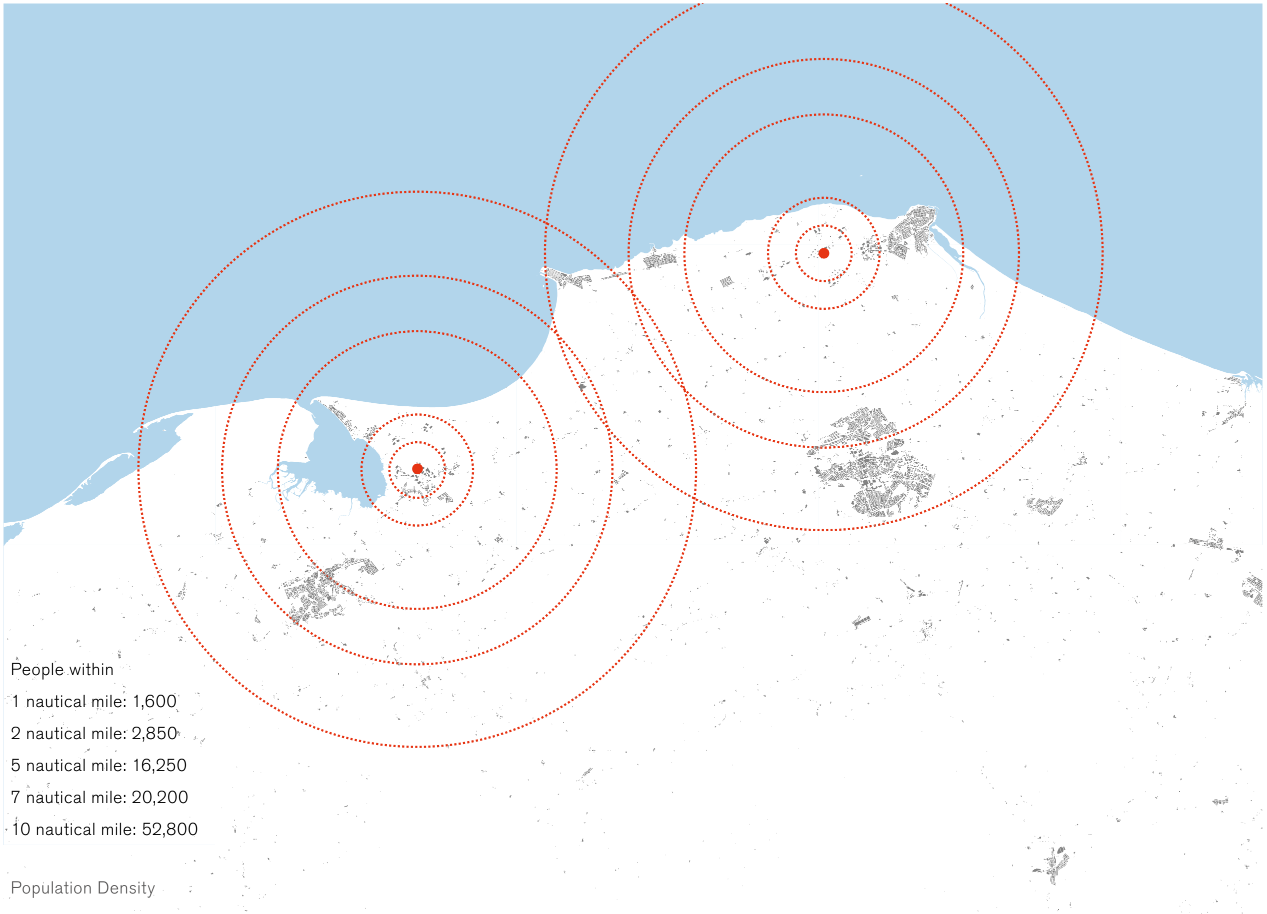

Flightpaths - InFlight

Site Analysis

Kinloss - Population and Regional Policy

Key Points

- Solid Road Access
- Forres is the closest rail station, about 6km away
- No large residential areas adjacent to the site
- Flight path close to RAF Lossiemouth
- Military barracks used as relief landing ground for RAF Lossiemouth.
- Additional airspace protection required
- Low on site facilities
- Two usable runways with potential for extentsion



Population Density

Environmental

- **Noise**
- **Pollution**
- **Renewables**

- Prospective and existing development plans no longer subjected to a need for Noise Impact Assessments (NIA) to mitigate against aircraft noise around Barracks
- To support renewable energy technologies and reduce carbon emissions in new developments. (Moray Local Development Plan, p.7)

Sustainability

- **Social**
- **Economic**

- Economic: 21% of all jobs in Moray from 2 RAF bases (Moray Development Plan, p.12)
- Recuced base utiation has removed the need for a New Housing Allocation Target (Moray Local Development Plan, p.18)

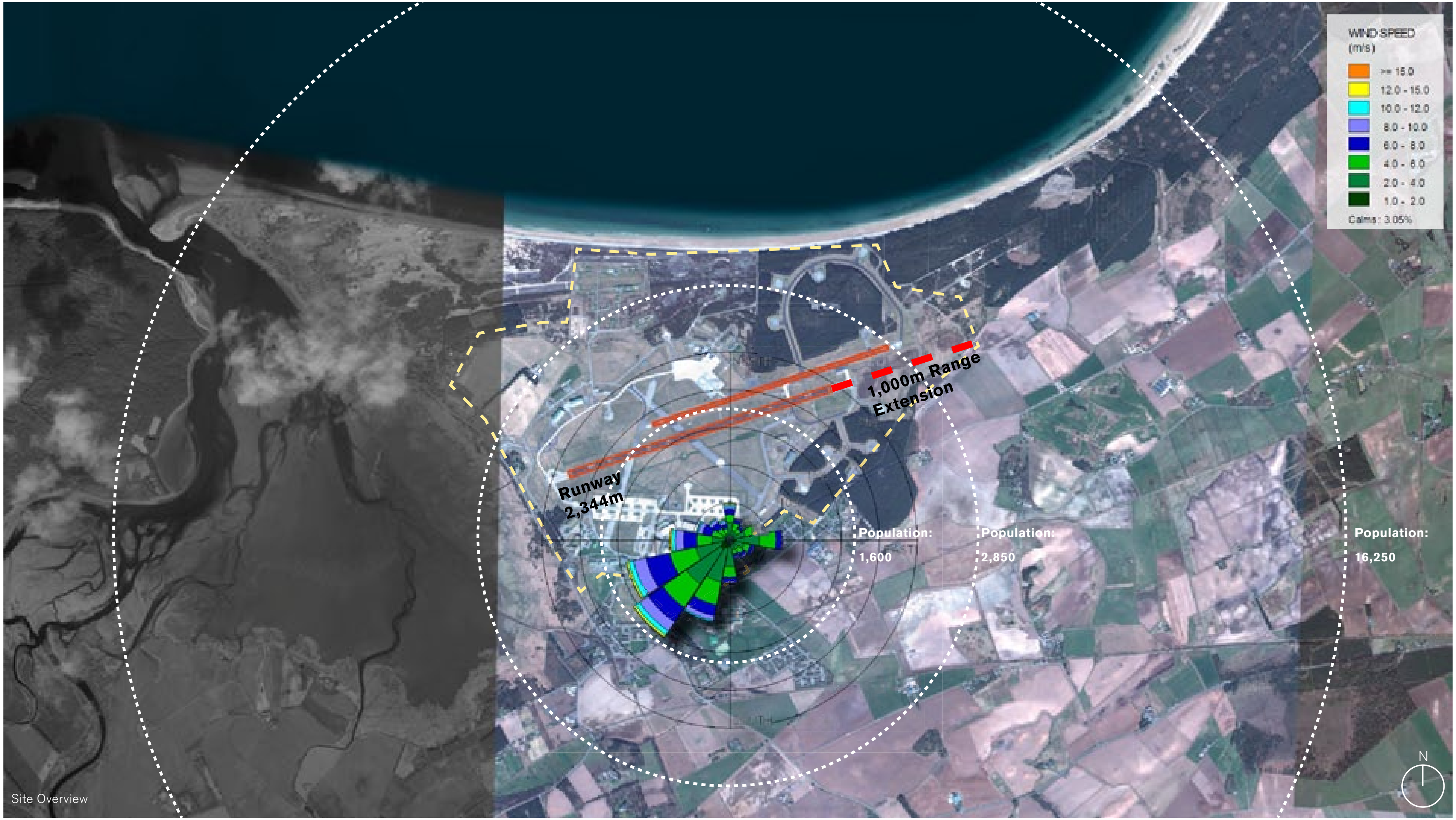
Regeneration

- **Investment**
- **Masterplans**

- to ensure that land and property assets in Moray are used to best advantage to support sustainable economic development and to ensure that infrastructure constraints are minimised (Moray Economic Response Plan, p.7)
- A Moray Economic Strategy was commissioned, with a view to diversifying the economy, and making it less reliant on the Defence and Public Sectors but create 5,000 jobs in the wider economy, with focus on high quality jobs in engineering and science and technology Moray Local Development Plan, p.6)

Site Analysis

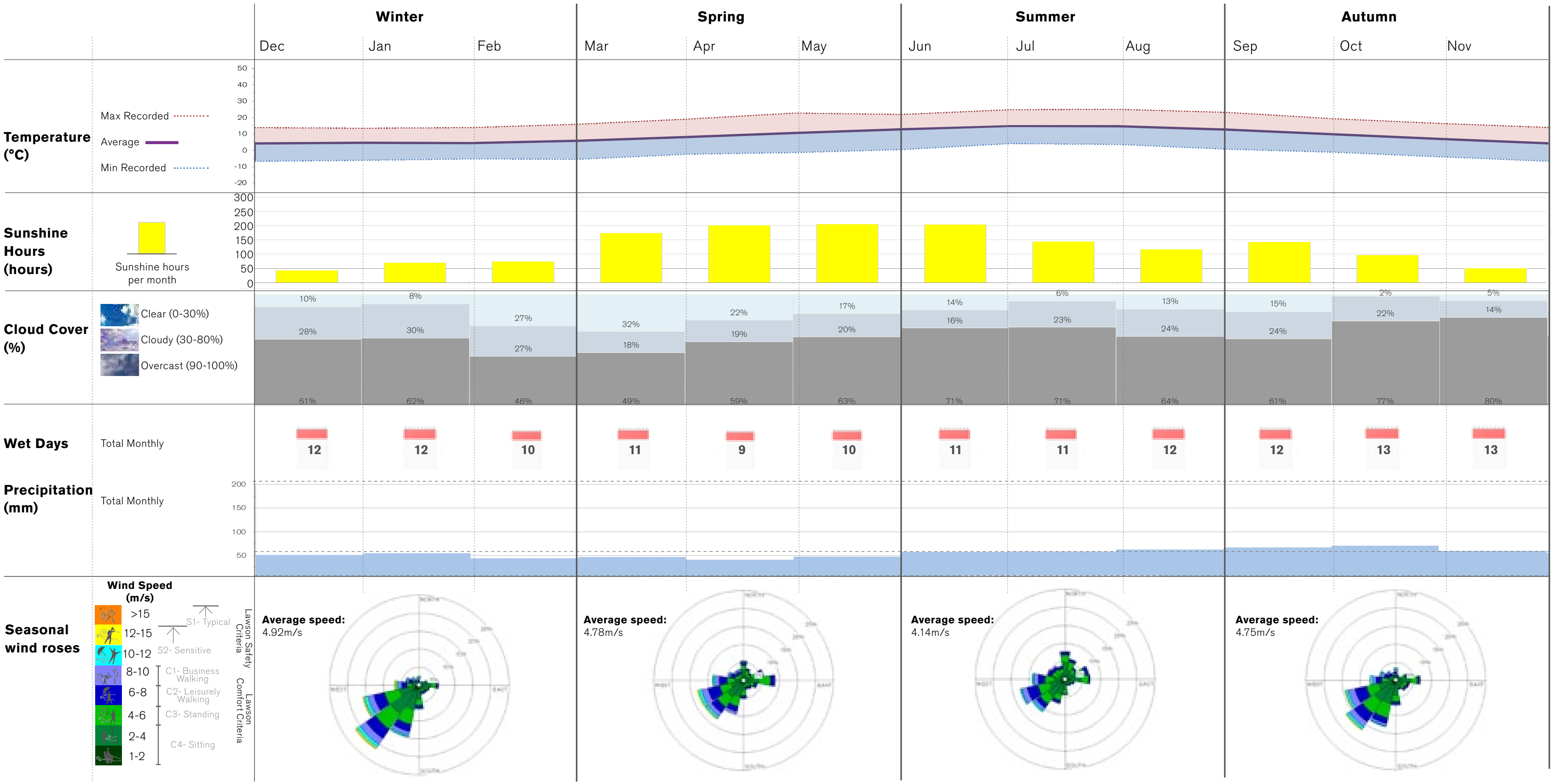
Kinloss - Site Location



Site Analysis
Kinloss - Climate

Key Meteorological Factors
- Limited cross winds occurrence
- Little seasonal variation in wind direction
- Clearest sky in February

Sources:
Temperature, humidity, solar: KINLOSS (Meternorme)
Wind Data: EGQK - 2001-2010 (mathematica)
Precipitation: Kinloss - Met Office



Site Analysis

Llanbedr Airport - Context

Key Facts

Distance to nearest R+D hub	**89** miles
Distance alternate commercial airport	**54** miles
Population within 5 n.miles	**4,550**
Total sunshine hours	**1441** hours
Total annual precipitation	**8,41** mm
Average wind speed	**6.55** m/s
Prevailing wind	**SSW**
Runway orientation	**S**
Runway length (with potential extension)	**2,289**m (~**2,900**m)
Runway surface	**Asphalt**

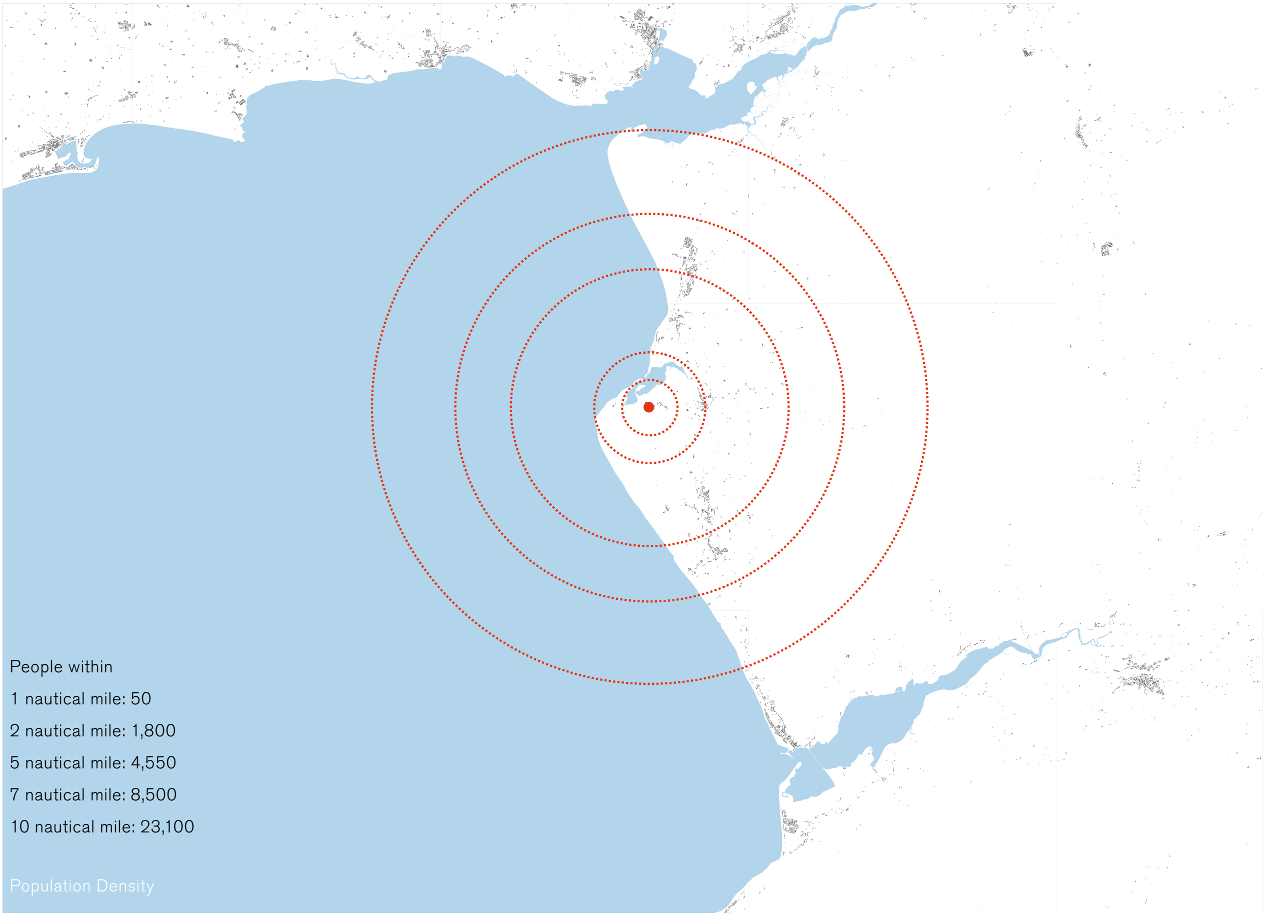
- Access
- Existing Facilities
- Proximity to population density
- Opportunity to extend runway
- Climate
- Proximity to research facilities
- Runway orientation
- Utilities Infrastructure
- Runaway Composition
- Air Space Intensity

Site Connections


Flightpaths - InFlight

Site Analysis
Llanbedr Airport - Population and Regional Policy

Key Points
- Solid Road Access
- Llambedr, Pensarn, and Llandanwg rail stations
- No large residential areas adjacent to the site
- Recently reopened as a civilian aerodrome
- Large area of water to operate
- Located below large number of flight paths from Europe to North America and Dublin to London Airports routes



Environmental
- **Noise**
- **Pollution**
- **Renewables**

- Delivering sustainability and tackling climate change through the planning system. Including planning for renewable energy and sustainable buildings (TAN 22, Planning Policy Wales)
- Gwynedd Werdd Vision and Action Plan commissioned Scoping Renewable Energy
- Opportunities in Gwynedd

Sustainability
- **Social**
- **Economic**

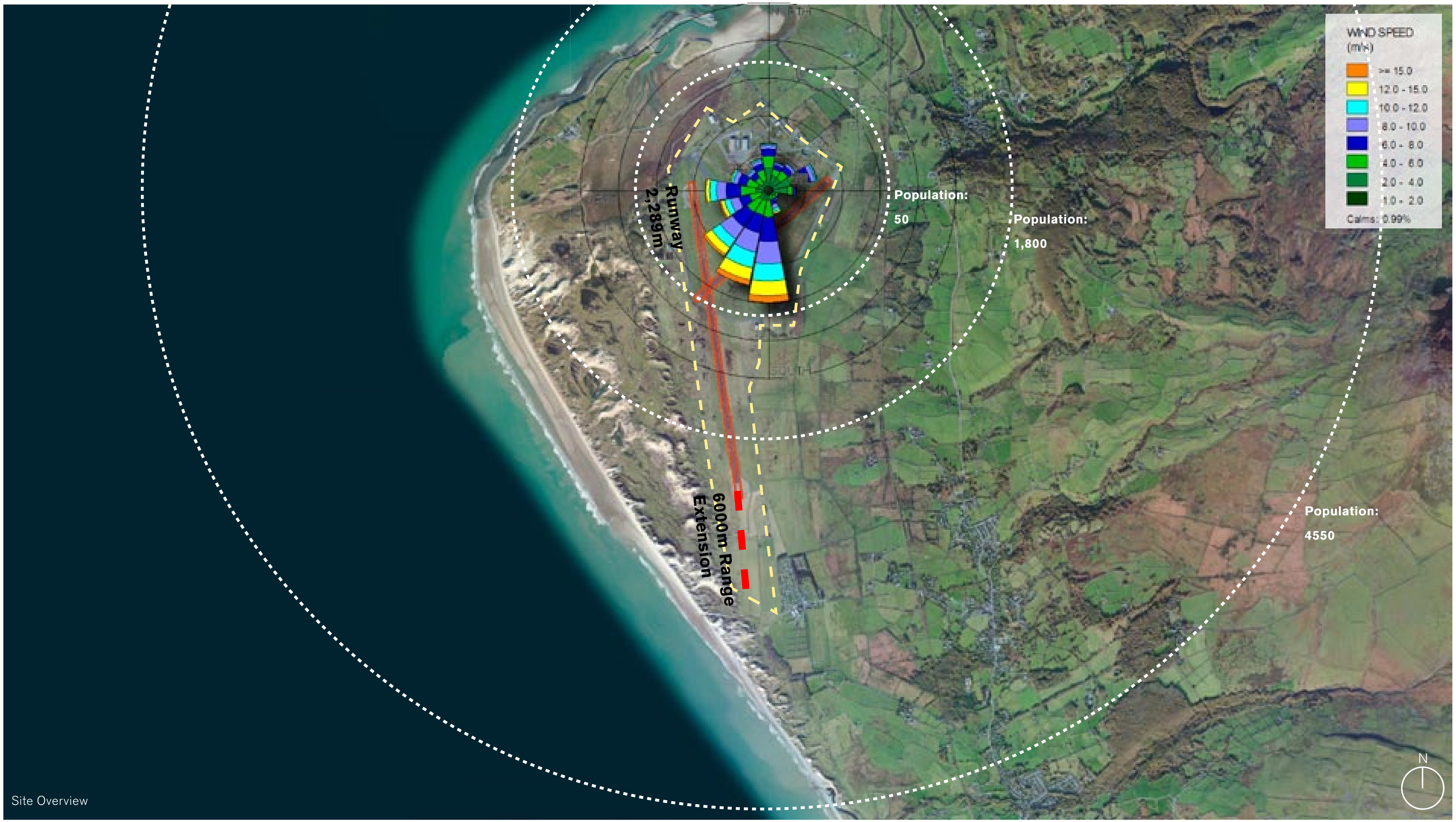
- Policy ECON2 - Improving the Quality of Jobs and Salary Levels; Clarity will be in place on the high value sectors to be targeted for Trawsfynydd and Llanbedr sites, and also the key steps in the work of targeting businesses and jobs. (Gwynedd Council Strategic Plan 2013-2017,, p. 27)

Regeneration
- **Investment**
- **Masterplans**

- QinetiQ and Llanbedr Airfield Estates (LAE) have signed an agreement Unmanned Aircraft System (UAS) base at Llandbedr in 2013 (http://www.qinetiq.com/)
- Llanbedr is one of 2 key sites in the Snowdonia Enterprise Zone, an initiative that provides incentives, support and infrastructure investment. (http://business.wales.gov.uk/)

Site Analysis

Llanbedr Airport - Site Location



Site Overview

Site Analysis

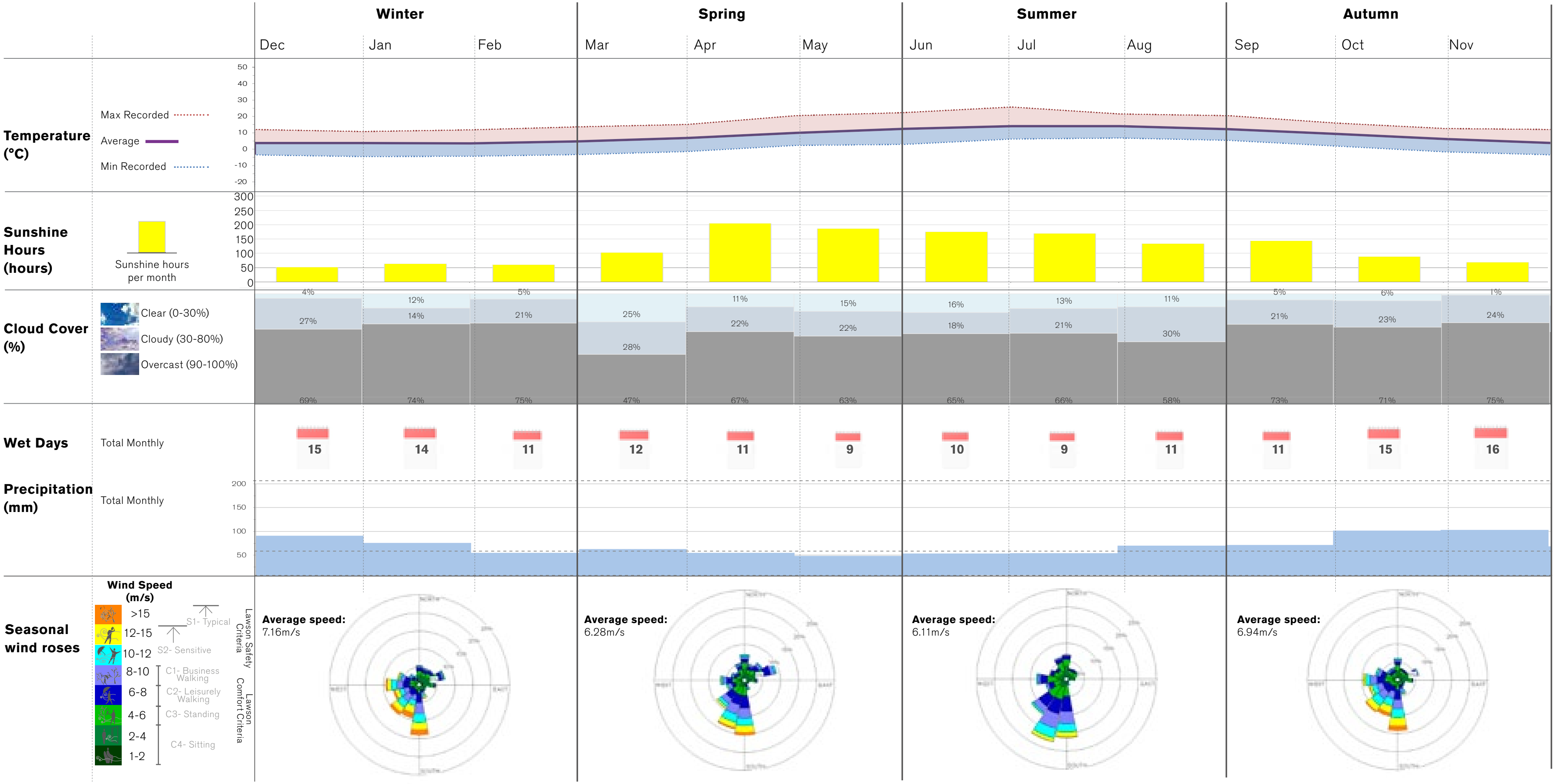
Llanbedr Airport - Climate

Sources:
Temperature, humidity, solar: LAKE_VYRNWY (closest 23 miles) (Meternorme)
Wind Data: EGOV (closest 35 miles) - 2001-2012 (mathematica)
Precipitation: Valley - Met Office

Key Meteorological Factors*

- Potential cross winds occurrence
- Generally very overcast
- Some occurrence of high speed winds in winter, spring and autumn

*Llanbedr Airport weather data could not be attained directly from site. Lake Vyrnwy weather station was used for meteorological data (23 miles East) and RAF Valley was used for wind data (35 miles North)



Site Analysis
Newquay Airport - Context

Key Facts

Distance to nearest R+D hub	**111** miles
Distance alternate commercial airport	**39** miles
Population density within 5 n.miles	**37,200**
Total sunshine hours	**1441** hours
Total annual precipitation	**8,41** mm
Average wind speed	**5.21** m/s
Prevailing wind	**W**
Runway orientation	**WNW**
Runway length (with potential extension)	**2,744**m (~**3,250**m)
Runway surface	**Asphalt**

- Access
- Existing Facilities
- Proximity to population density
- Opportunity to extend runway
- Climate
- Proximity to research facilities
- Runway orientation
- Utilities Infrastructure
- Runaway Composition
- Air Space Intensity

Site Connections

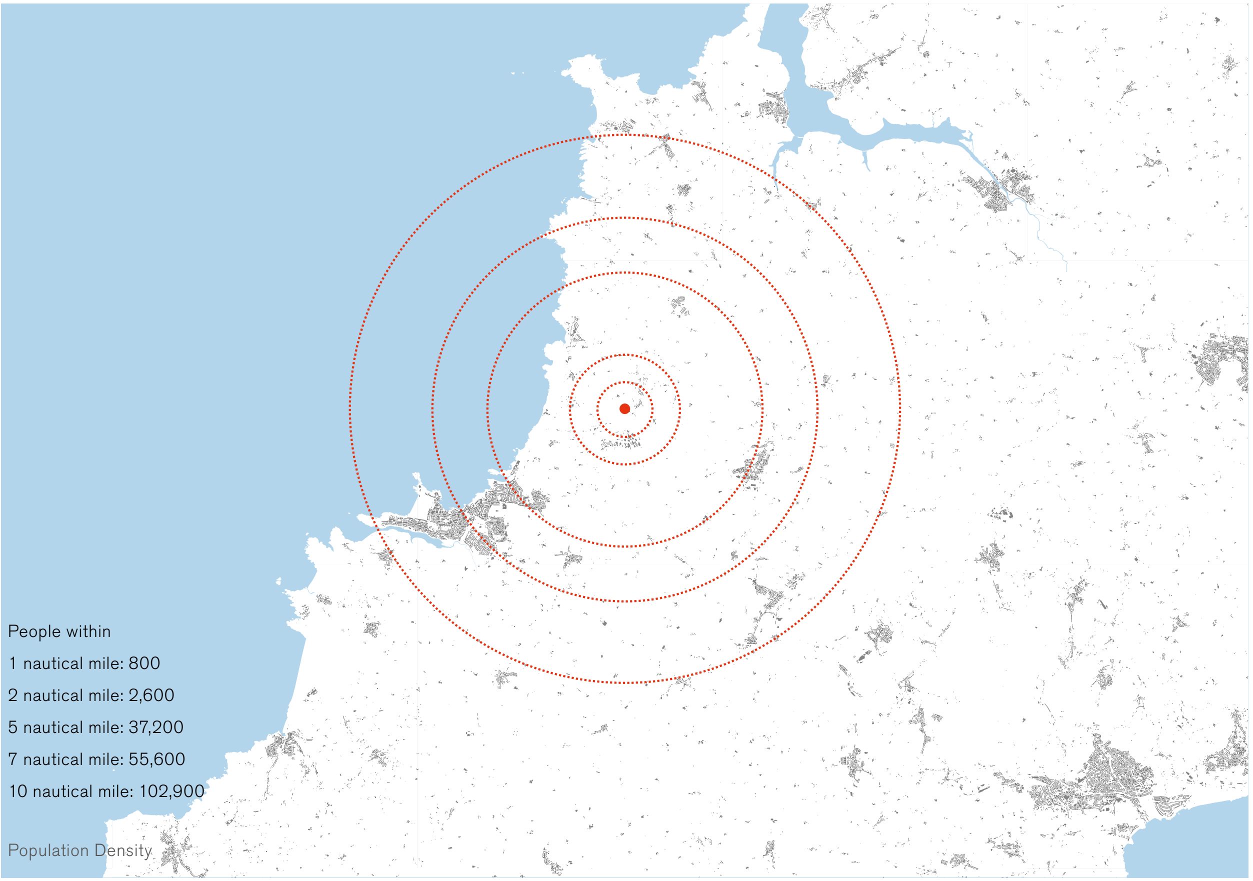

Flightpaths - InFlight

Site Analysis

Newquay Airport - Population and Regional Policy

Key Points

- Good A-road access although not suitable for wide loads around site
- No rail connection
- Good power grid infrastructure (renewable potential)
- Barracks to East of site
- Exiting aerospace maintenance and manufacturing facilities
- Runway length is constrained
- Runoff space confined by major link road
- Newquay town centre 3.3 Miles (noise constraints)
- Located in Class G airspace close to the coast and relatively close to Danger Area
- (DA) 064 complex, which extends up to FL660 (approx. 66,000 feet)



Environmental

- **Noise**
- **Pollution**
- **Renewables**

- Promote low carbon as a business growth catalyst (Cornwall Economy and Culture Strategy, p.15)
- Promote Cornwall and the Isles of Scilly as a 'green' exemplar region (Cornwall Economy and Culture Strategy, p.15)
- Sustainable Energy Action Plan incorporates the Green Cornwall target: 40% CO_2 emissions reduction, 34% GHG Savings, 30% Electricity from RE and 30% Energy Savings (Sustainable Energy Action Plan (SEAP), p.3)
- Cornwall has the Highest level of solar radiation in UK (Sustainable Energy Action Plan (SEAP), p.20)

Sustainability

- **Social**
- **Economic**

- Sustainable movement within and between places throughout Cornwall, to support employment growth (Cornwall Economy and Culture Strategy, p.12)
- Strategic 'gateway' opportunities which promote connectivity between Cornwall and 'the world' to attract and retain high value business (Cornwall Economy and Culture Strategy, p.12)

Regeneration

- **Investment**
- **Masterplans**

- Vision for 2050 advanced aerospace centre (Cornwall Economy and Culture Strategy, p.18)
- Newquay Cornwall Airport - Aerohub Enterprise Zone Order grants planning permission for a 35.5 ha Business Park as part of the now adopted Newquay Cornwall Airport Masterplan 2008-2030 (cornwall.gov, Planning)

Site Analysis

Newquay Airport - Site Location

Site Overview

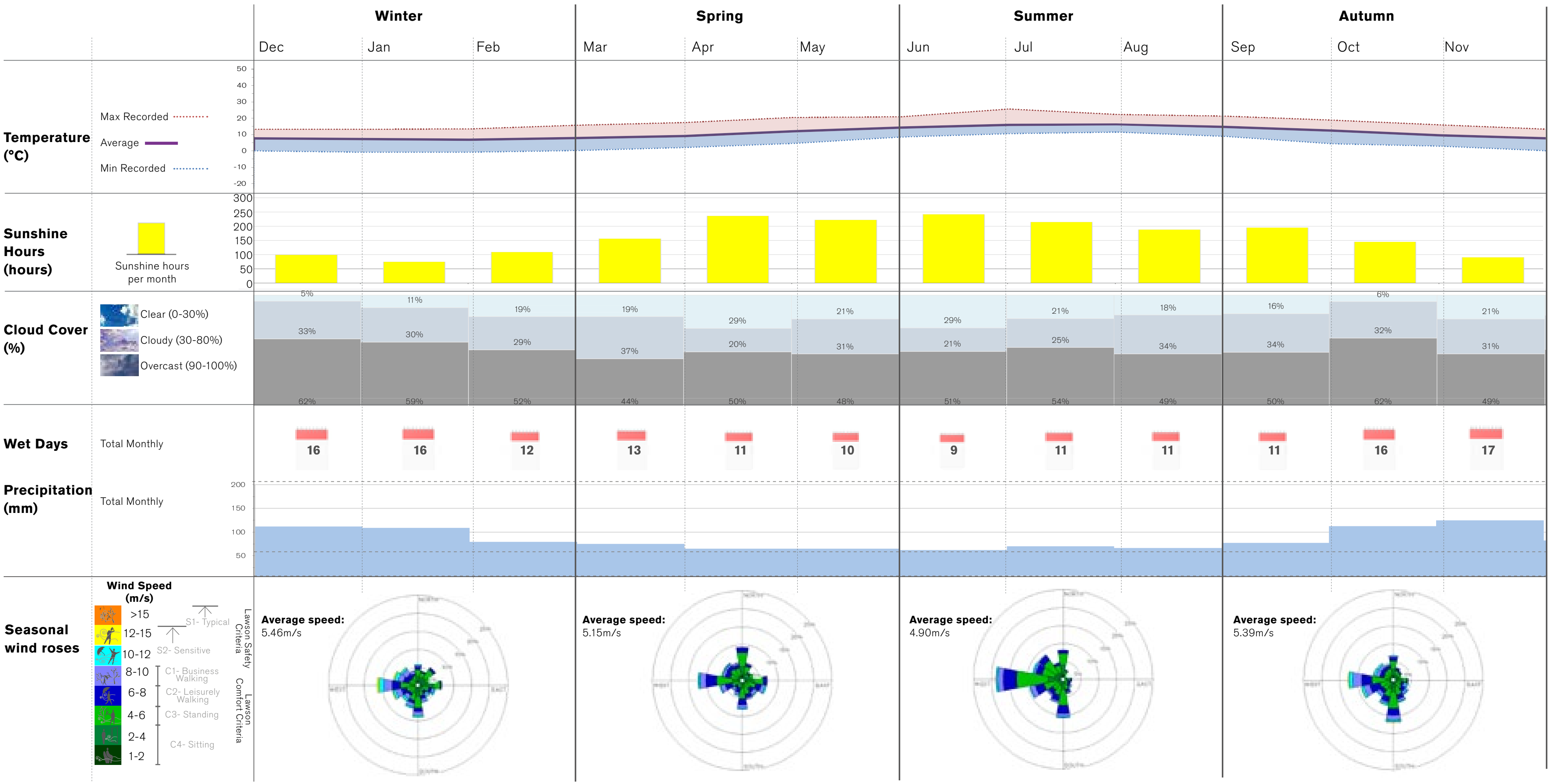
Site Analysis

Newquay Airport - Climate

Key Meteorological Factors

- High potential for cross winds occurrence
- Good sunshine hours April to September
- High occurrence of Westerly winds in the summer, although relatively low speed
- Low precipitation levels April to August

Sources:
Temperature, humidity, solar: SAINT_MAWGAN_RAF (Meternorme)
Wind Data: EGHQ - 2009 - 2013 (mathematica)
Precipitation: St. Mawgan - Met Office



Site Analysis
RAF Leuchars - Context

Key Facts

Distance to nearest R+D hub	**209** miles
Distance alternate commercial airport	**7** miles
Population within 5 n.miles	**34,250**
Total sunshine hours	**1806** hours
Total annual precipitation	**690** mm
Average wind speed	**4.78** m/s
Prevailing wind	**W**
Runway orientation	**WNW**
Runway length (with potential extension)	**2,585**m (~**3,000**m)
Runway surface	**Asphalt**

Site Analysis

RAF Leuchars - Population and Regional Policy

Key Points

- Solid Road Access
- Leuchars rail station next to the site
- No large residential areas adjacent to the site
- Extension of the runway difficult due to rail tracks to the west and the sea to the east
- Active military airfield
- Coastal location
- Close to Scottish terminal manoeuvring area for commercial airports

Environmental

- **Noise**
- **Pollution**
- **Renewables**

- 3 major wind turbine projects off East coast of Fife (directly east of RAF Leuchers), closest is Neart na Gaoithe 64 proposed wind turbine 12 miles off coast. (Renewable Energy Routemap - Fife Delivering Scotlands 2020 Targets, p.20)

Sustainability

- **Social**
- **Economic**

- Target for 2023; The number of businesses in Fife per 10,000 working age adults matches the current Scottish average, an additional 1,900 businesses required (Fire Economic Stratergy 2013-2023, p. 15)
- Fife Youth Job Contract Programme funds 500 - 600 additional Modern Apprenticeships (MA) and jobs by 2017 (Fire Economic Stratergy 2013-2023, p. 17)
- Investment in R&D and development of innovative products and services as a key deliverable for 2017 (Fire Economic Stratergy 2013-2023, p. 21)

Regeneration

- **Investment**
- **Masterplans**

- The Council will work in partnership with the Royal Air Force to review any opportunities to facilitate economic development at Leuchars (Fife Structure Plan 2006 - 2026, p.44)
- RAF Leuchars currently supports 1,260 direct jobs comprising 990 military personnel and 270 MoD civilian employees and is being transfered from RAF to Army with reduced aircraft and RAF presence. (SN06607 - Defence Estate Rationalisation, p.4)

Site Analysis

RAF Leuchars - Site Location

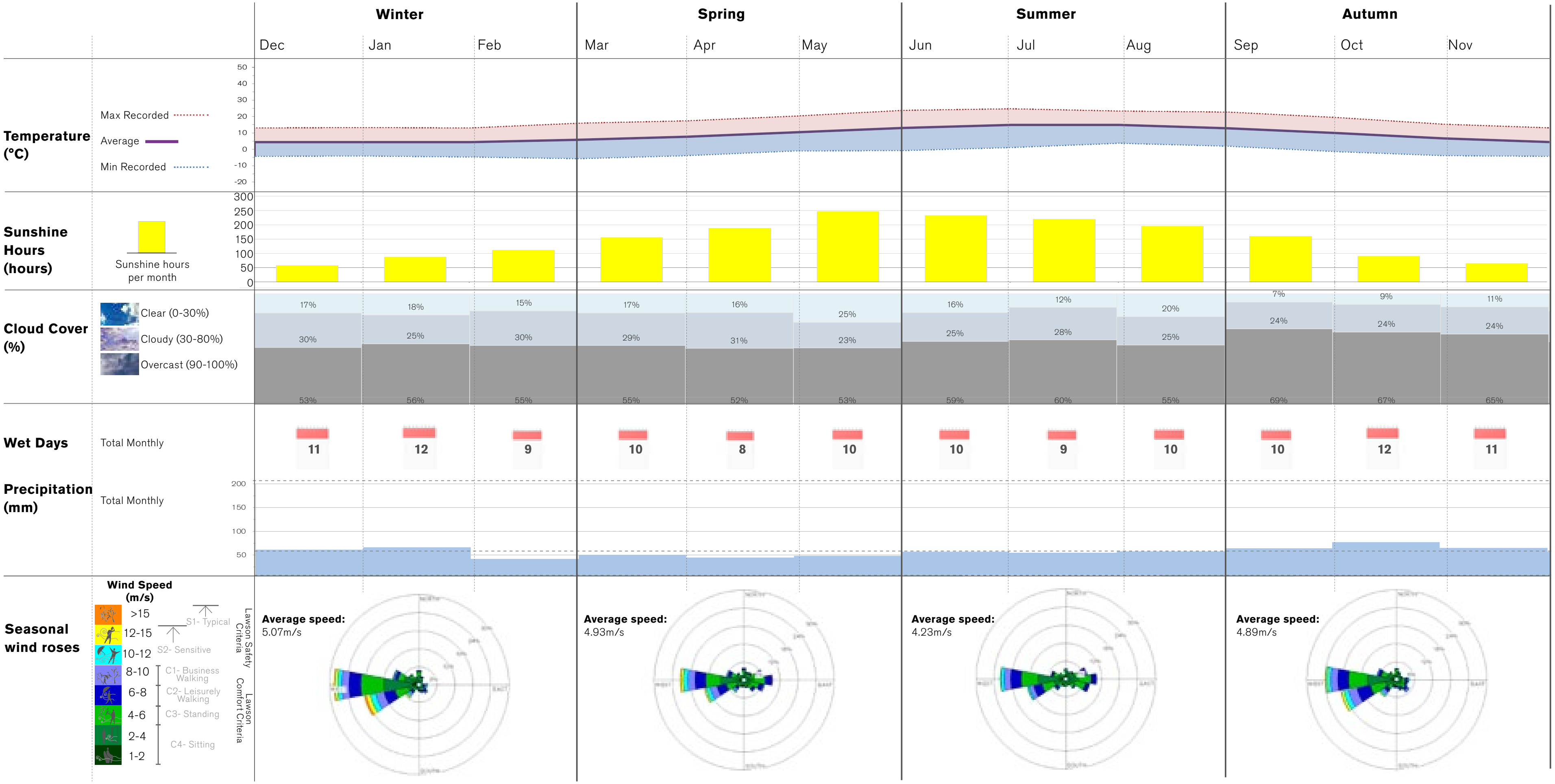
Site Analysis

RAF Leuchars - Climate

Key Meteorological Factors

- low potential for cross winds occurrence
- consistent Westerly prevailing winds
- consistent cloud cover and precipitation in spring and summer

Sources:
Temperature, humidity, solar: LEUCHARS_RAF (Meternorme)
Wind Data: EGQL - 2001-2012 (mathematica)
Precipitation: Leuchars - Met Office



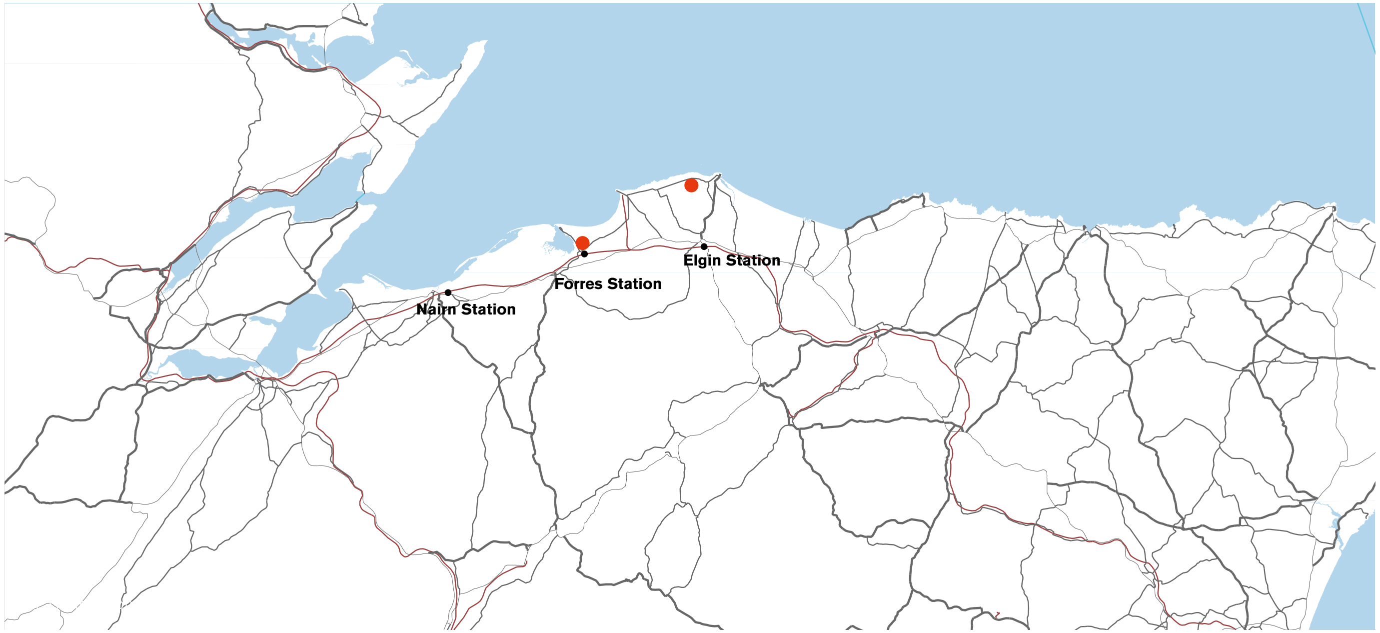
Site Analysis

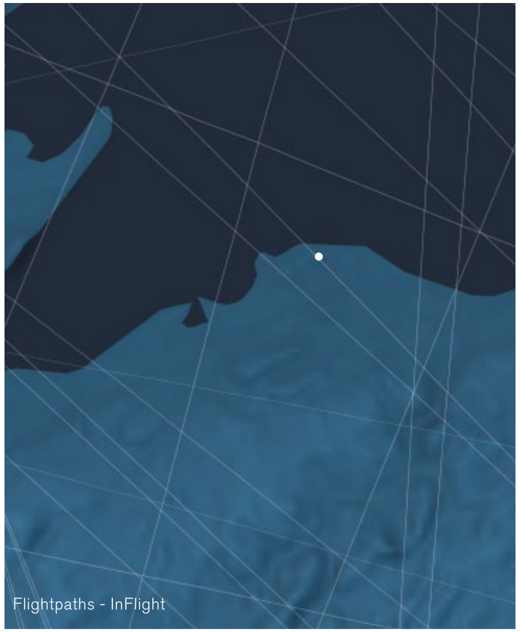
RAF Lossiemouth - Context

Key Facts

Distance to nearest R+D hub	**302** miles
Distance alternate commercial airport	**28** miles
Population within 5 n.miles	**16,250**
Total sunshine hours	**1518** hours
Total annual precipitation	**664** mm
Average wind speed	**5.23** m/s
Prevailing wind	**WSW**
Runway orientation	**SW**
Runway length (with potential extension)	**2,750**m (~**3,000**m)
Runway surface	**Asphalt**

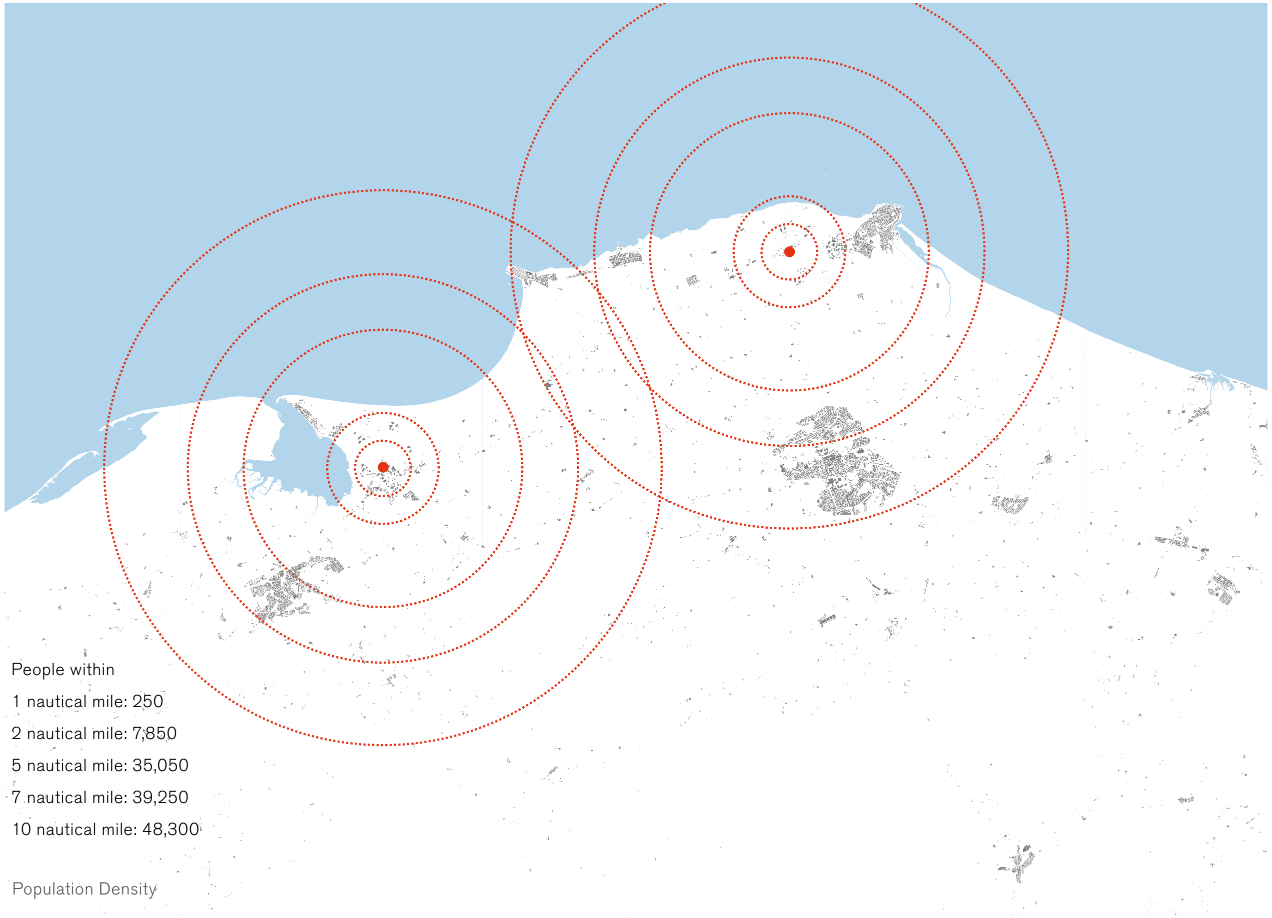
Access
Existing Facilities
Proximity to population density
Opportunity to extend runway
Climate
Proximity to research facilities
Runway orientation
Utilities Infrastructure
Runaway Composition
Air Space Intensity





Site Analysis
RAF Lossiemouth - Population and Regional Policy

Key Points
- Good connection to RAF Kinloss and road network
- The closest rail station 10km away (Elgin)
- Primarily MOD employment locally
- Active military airfield
- Close to large Danger Areas
- Relatively low population density in the vicinity
- Coastal location.
- Previously identified as possible spaceport location
- Road to south may limit extension of runway



Population Density

Environmental
- **Noise**
- **Pollution**
- **Renewables**

- To support renewable energy technologies and reduce carbon emissions in new developments. (Moray Local Development Plan, p.7)
- 400 wind turbines proposed in the Moray Firth, there is potential for Moray to capitalise on this offshore investment (Moray Local Development Plan, p.23)

Sustainability
- **Social**
- **Economic**

- Economic: 21% of all jobs in Moray from 2 RAF bases (Moray Development Plan, p.12)
- Potential for economic growth is identified within Lossiemouth (Excluding MOD): Develop/expand the role of tourism (Moray Local Development Plan, p.13)

Regeneration
- **Investment**
- **Masterplans**

- Virgin Galactic considered site for spaceport prior to New Mexico (Reported by the BBC in July 2006)
- A Moray Economic Strategy was commissioned, with a view to diversifying the economy, and making it less reliant on the Defence and Public Sectors but create 5,000 jobs in the wider economy, with focus on high quality jobs in engineering and science and technology Moray Local Development Plan, p.6)

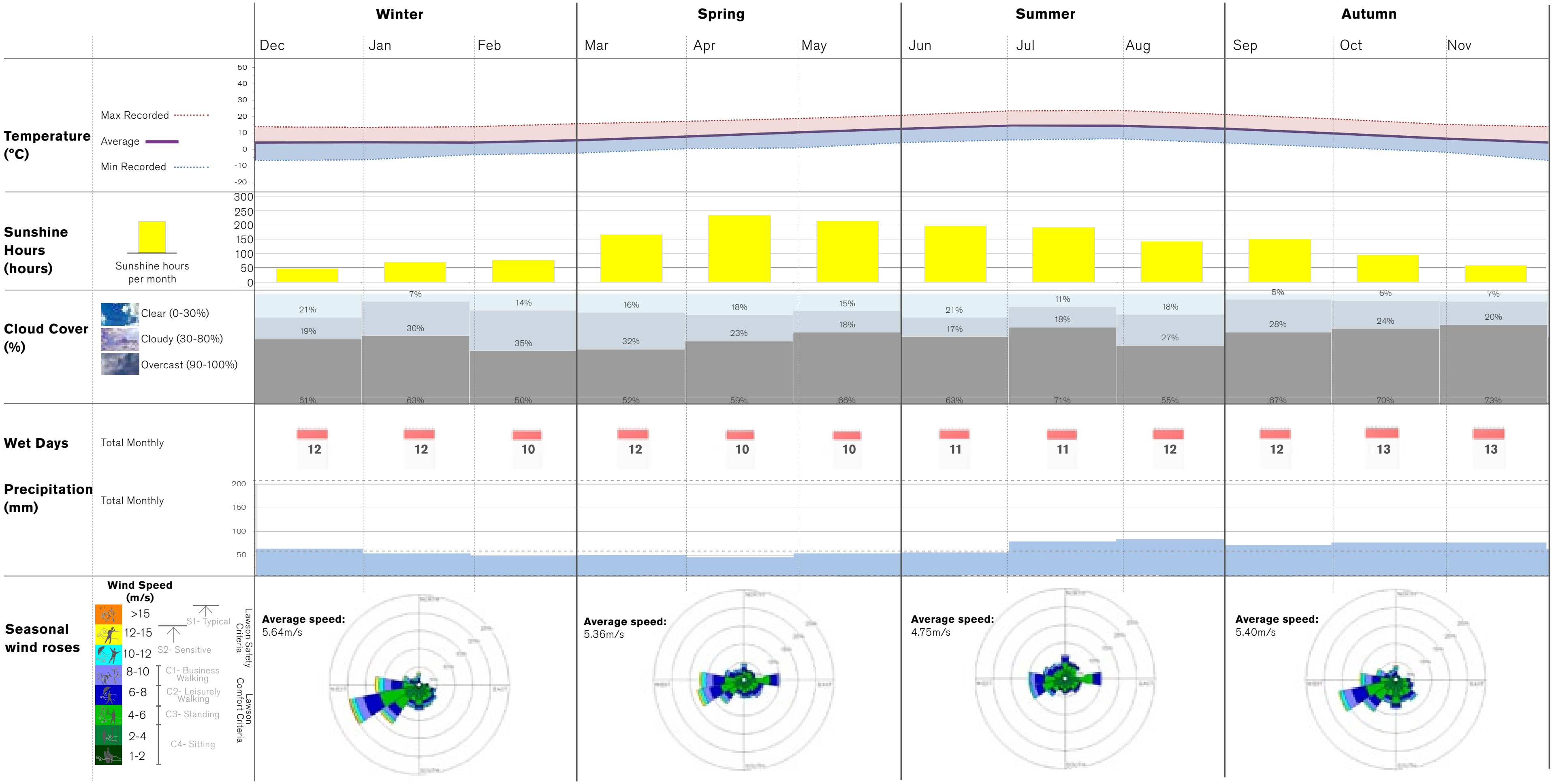
Site Analysis

RAF Lossiemouth - Site Location

Site Analysis
RAF Lossiemouth - Climate

Key Meteorological Factors
- Some cross winds occurrence
- Variable wind direction
- consistent rainfall throughout year
- Spring offers greatest sunshine hours

Sources:
Temperature, humidity, solar: LOSSIEMOUTH_RAF (Meternorme)
Wind Data: EGQS - 2001-2012 (mathematica)
Precipitation: Lossiemouth - weatherbase.com



Site Analysis
Stornoway Airport - Context

Key Facts

Distance to nearest R+D hub	**371** miles
Distance alternate commercial airport	**95** miles
Population density within 5 n.miles	**10,850**
Total sunshine hours	**1513** hours
Total annual precipitation	**1,249** mm
Average wind speed	**6.26** m/s
Prevailing wind	**S**
Runway orientation	**S**
Runway length (with potential extension)	**2,315**m (~**2,500**m)
Runway surface	**Asphalt**

- Access
- Existing Facilities
- Proximity to population density
- Opportunity to extend runway
- Climate
- Proximity to research facilities
- Runway orientation
- Utilities Infrastructure
- Runaway Composition
- Air Space Intensity

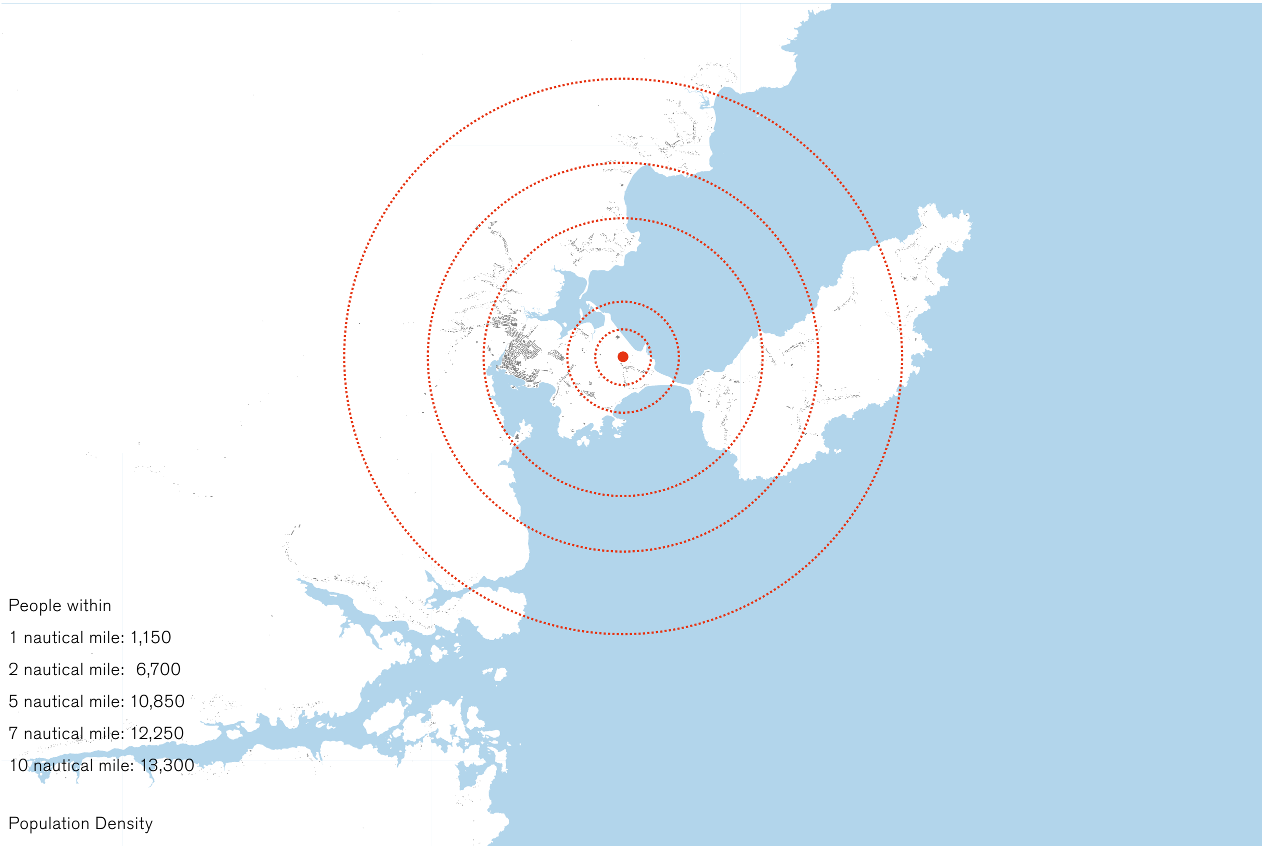
Site Connections


Flightpaths - InFlight

Site Analysis
Stornoway Airport - Population and Regional Policy

Key Points

- Only airport on island
- Good road access
- No rail connection
- Power from mainland
- Limited exiting aerospace maintenance and manufacturing facilities
- Runway length is constrained by link road and beach
- Newquay town centre 2.1 Miles (noise constraints)
- Harbour has direct road link to base (some travel through residential)
- Furthest airport from R+D companies, facilities and university's
- Very low air traffic levels
- Large areas of water over which to operate



Environmental	**▪ Noise** **▪ Pollution** **▪ Renewables**

- Some areas of the site may require a FRA to ensure that the detailed layout and design of a proposed development addresses and proposes measures to remove any risk from flooding.(OHLDP Development Proposals, Prop MU3)

Sustainability	**▪ Social** **▪ Economic**

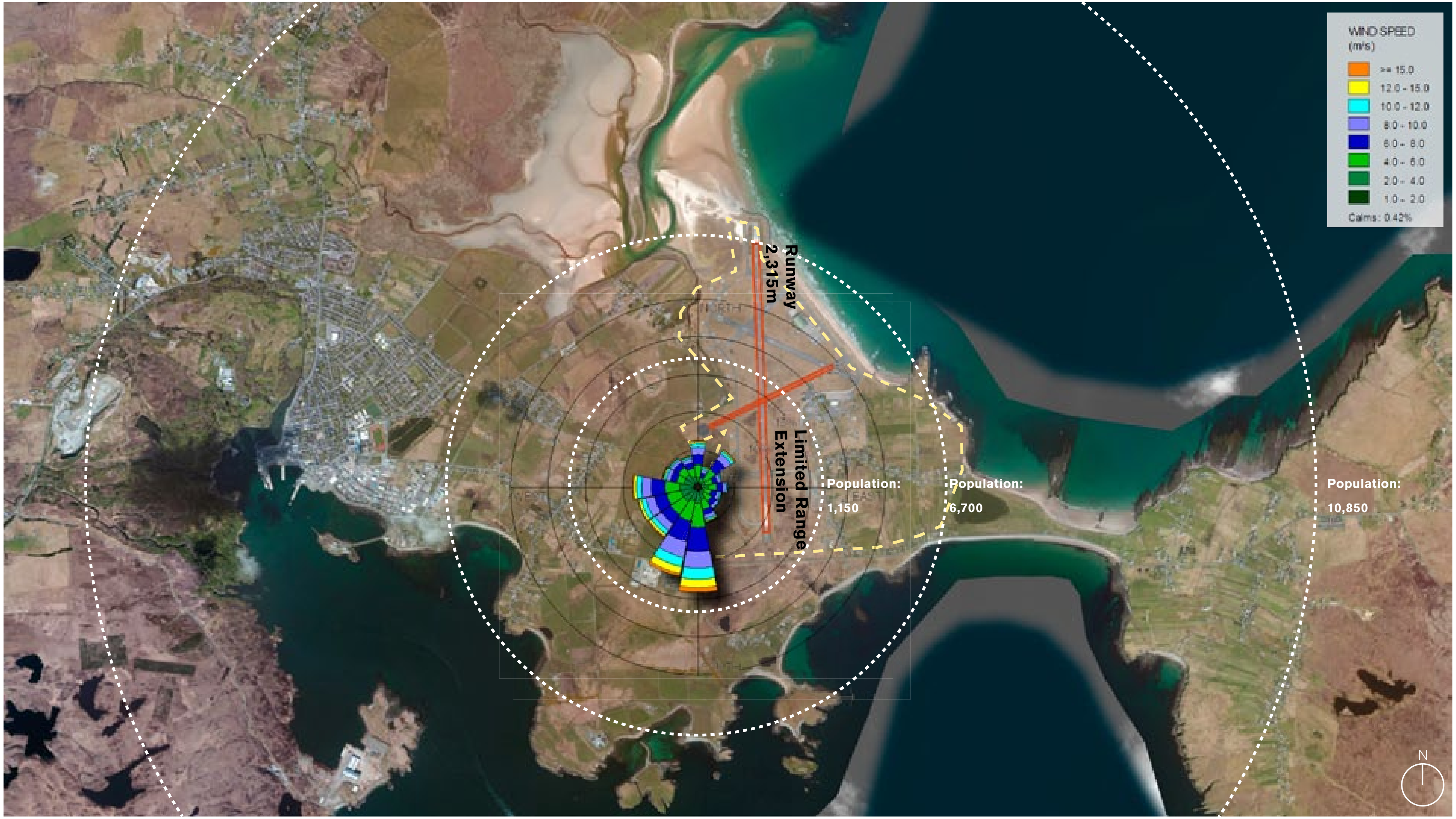
- New or significantly upgraded waste water infrastructure may be required. (OHLDP Development Proposals, Prop MU3)
- In assessing development proposals in and around Stornoway Airport account will be taken of the operational needs of the airport and aerodrome safeguarding requirements

Regeneration	**▪ Investment** **▪ Masterplans**

- In addition to the operational needs of the airport the following uses may be appropriate; business/industry, hotel/conference facilities, where ancillary to the main airport uses, housing (estimated capacity 22 units). (OHLDP Development Proposals, Prop MU3)

Site Analysis

Stornoway Airport - Site Location



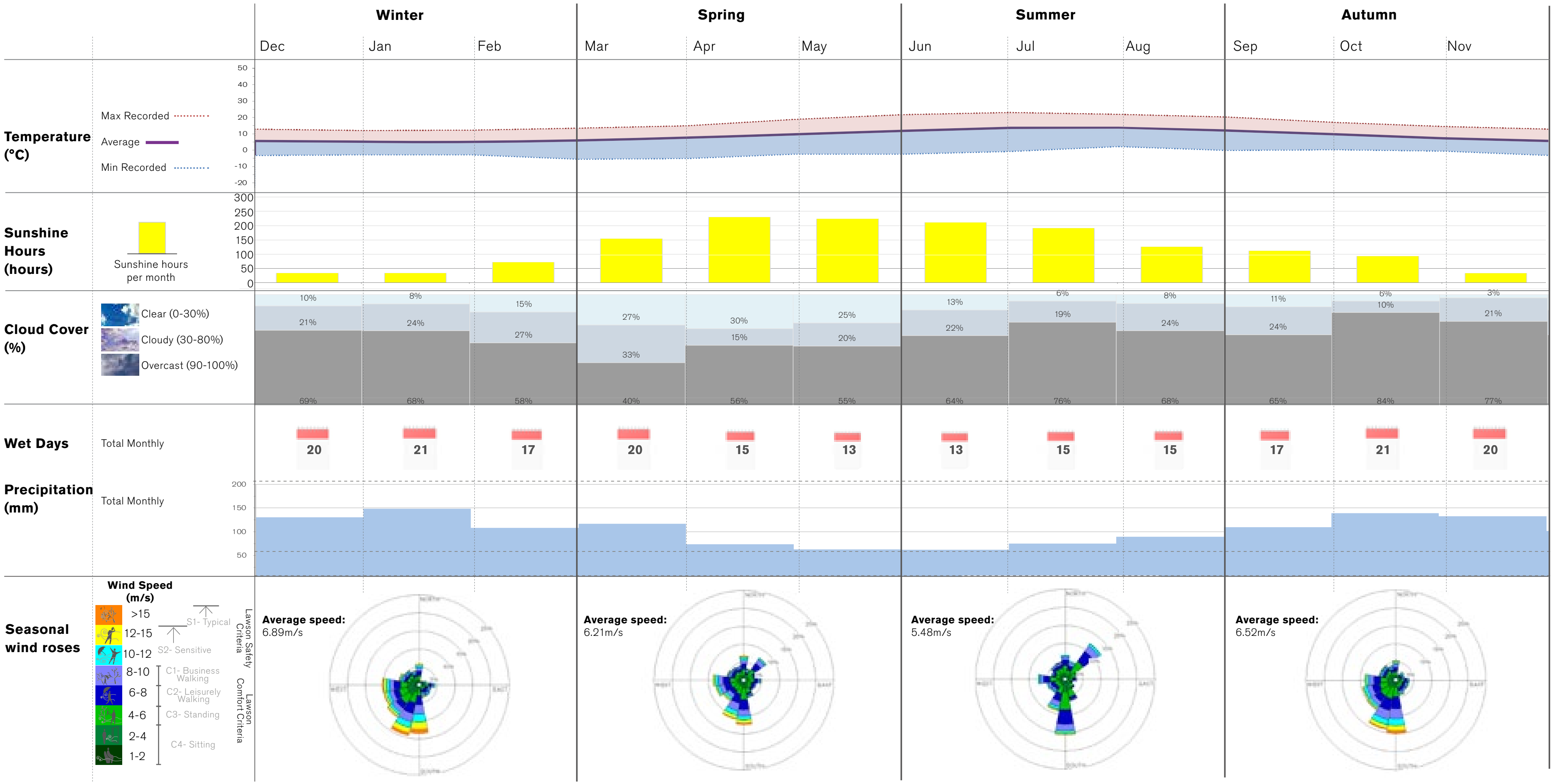
Site Analysis

Stornoway Airport - Climate

Sources:
Temperature, humidity, solar: Stornoway (Meternorme)
Wind Data: EGPO - 2001 - 2012 (mathematica)
Precipitation: Stornoway - Met Office

Key Meteorological Factors

- Potential cross winds occurrence
- Moderate ambient air temperature
- Air frost occurrence from October to may
- Spring is likely to provide most potential launch days



Consultation Questions

4

Consultation Questions

Q1) Do you agree with the CAA's high-level recommendation that, if a decision were taken to proceed, sub-orbital operations should preferably commence, either on a permanent or a temporary basis, from one (or more) of the following:

- **An existing EASA-certificated aerodrome;**
- **An existing UK CAA-licensed aerodrome; and/or**
- **An existing UK military aerodrome, subject to approval from the MOD**

A) An existing EASA-certificated aerodrome

The existing regulatory standards shared between the EASA and the CAA for overseeing bilateral management of commercial and general aviation fleets and airspace must be considered. As additional significant EASA changes to aerodrome regulation in the UK begin to take effect through 2017 , and with a goal of achieving a UK spaceport by 2018, choosing between an EASA-certificated aerodrome and a CAA-licensed aerodrome becomes moot to the extent that both types will have an integrated regulatory framework of well understood oversight processes. An existing EASA-certificated aerodrome may offer added advantage only in the long term when considering Point-to-Point (P2P) transportation aeronautic technologies for suborbital spaceflight advances and the realization of a global spaceport network matures. An EASA-certificated aerodrome could act as a developmental test bed for future regulatory requirements for P2P technologies. However, the time when the commercial spaceplane industry is to integrate into the world's commercial aerodrome network remains unknown.

For now, emerging players in this industry seeking to build a spaceport stand the greatest chance of success by focusing on enabling Research & Development (R&D) efforts at the spaceport site in conjunction with servicing commercial spaceflight operations. Choosing an EASA-certificated aerodrome for initialization of a commercial spaceplane program in the UK is not as crucial in the immediate, because the attraction for the UK should be centered on advanced R&D to take place in domestic airspace. Test flights for prototype aircraft in places removed from urban areas with high concentrations of the uninvolved public would limit risk and regulatory setbacks. Moreover, if the Variable Profile Area (VPA) concept is adopted, non-space air traffic in these remote areas will be easier to manipulate than it would be if spaceplane flights were close to regular aerodromes.

An existing UK CAA-licensed aerodrome

At this point, as long as the CAA guidelines toward commercial space take into consideration the more developed US Federal Aviation Administration (FAA) standards, a CAA-licensed aerodrome is a viable choice. Although EASA regulatory changes to aerodromes are scheduled for implementation through 2017, the future outlook for a codified, bilateral, UK/EU commercial space regulatory framework is as uncertain as the integration of P2P travel into regular aerodromes. Spaceports, such as the one proposed in Houston, TX, or the one to be proposed in the UK, must be put in place today if they are to catalyze the type of technological innovations required to make suborbital passenger flights feasible in the near term. At this point, resources will be managed with the greatest efficiency if focused on national concerns.

An existing UK military aerodrome, subject to approval from the MOD.

Military Aviation Authority (MAA) regulations will govern military aerodrome candidate sites. If features of UK military aerodromes meet the criteria of FAA standards for commercial space regulation, these sites should be adopted into the candidate list of spaceport locations. Moreover, high-level participation between military and private industry typically found in the space industry demands consideration of military aerodromes as part of the UK spaceport network. The following Exhibit 2, taken from the "Houston Spaceport Economics and Business Study" illustrates how an aerodrome's proximity to a government (NASA) R&D facility can leverage the spaceport's R&D activity for economic development of the area. The exhibit illustrates collaboration between industry, academia, and government for enabling P2P technology advancement. The right side of the exhibit identifies FAA areas of R&D needed to advance commercial space transportation. At the top middle of the figure are the FAA's network of academic collaboration partners conducting research in the identified areas, and in particular one university (UTMB) located in Houston, conducting research in aerospace medicine and human spaceflight. Coupling this local capability with the government (in this case NASA) R&D facilities available to the spaceport due to its close proximity to the NASA Johnson Space Center (JSC), enables the spaceport R&D activities to address FAA needed P2P technology advancement. High-level academic collaboration can also be applied to military operations and test facilities.

Point-to-Point Transportation

Future transportation of cargo or humans between different locations

Areas of FAA R&D for Commercial Space Transportation

1 Space Traffic Management & Operation
- 1.1 Orbital
- 1.2 Suborbital
- 1.3 NAS Integration
- 1.4 Spaceport Operations
- 1.5 Integrated Air/Space Traffic Management

2 Space Transportation Ops, Technologies & Payloads
- 2.1 Ground Systems & Ops Safety Techs
- 2.2 Vehicle Safety Analyses
- 2.3 Vehicle Safety Systems & Tech
- 2.4 Payload Safety
- 2.5 Vehicle Ops Safety

3 Human Spaceflight
- 3.1 Aerospace Phys & Medicine
- 3.2 Personal Training
- 3.3 ECLSS
- 3.4 Habitability & Human Factors
- 3.5 Human Rating

4 Space Transportation Industry Viability
- 4.1 Markets
- 4.2 Policy
- 4.3 Law
- 4.4 Regulation
- 4.5 Cross-Cutting Topics

Leverage UTMB Health for P2P Research

- 255 Wearable Biomedical Monitoring Equipment for Human Spaceflight
- 181 Physiological Database Definition and Design
- 182 Human System Risk Management Approach
- 256 Additional NASTAR Centrifuge Testing
- 183 Flight Crew Medical Standards & Participant Acceptance Guidelines

Leverage JSC Intellectual Capital, Test and Lab Facilities for P2P Research



Focus on Enabling P2P Technology Research


Exhibit 2: Positioning Houston Spaceport for point-to-point (P2P) technology research

A sub-orbital operation (permanent or temporary) at an existing UK unlicensed or private aerodrome
This category of spaceport operations was not recommended for consideration. However there may be a role for this particular type of regulatory structure within a UK Spaceport network even though CAA oversight of ground operations would be minimized in this scenario, yet the requirement for restricted or segregated airspace and for third party safety remains the same. The rationale for considering this type of spaceport operations can be seen in the example of the U.S. commercial spaceport model of Mojave Air & Spaceport located at Mojave, California. With its remote desert location it is understood by the commercial spaceflight industry to be the locale where unencumbered, high risk aerospace technology development can take place, where developers are "allowed to fail" with trial and error testing regimes for technology development. A highly regulated spaceport operations regime during early phase technology development can be an encumbrance on entrepreneurial zeal for technology risk.

To protect the uninvolved general public, the dangerous nature of trial and error phases for many of the more mature space technologies still require the seclusion of a remote location. The changing nature of the R&D, as it evolves will find the demographics of stakeholders becoming more varied. Although the current stage of this industry in its infancy dictates that spacecraft developers also act as spacecraft operators. When a product is unveiled to the public at a future date, the operational model of the targeted markets changes the criteria for the spaceport locale. This train of thought should bear a heavy weight on deciding where to begin codifying a spaceport network for the UK.

In the USA, a network of commercial spaceports has emerged such as Cecil Field Spaceport, Colorado Spaceport, and Houston Spaceport with business models for catering to the operations of developed spacecraft. In the case of Virgin Galactic, they have conducted their development and flight testing regime at Mojave with the intent of transitioning operations to Spaceport America.

Recommend Additional Criteria:
1. Weigh candidate aerodrome sites based on proximity to industry, academia, and government institutions with R&D facilities in order to develop a collaborative spaceport operations model for leveraging the spaceport's R&D activity to enable economic development of the area.

2. Within a UK Spaceport network model, consider candidate sites where unencumbered, high risk aerospace technology development can take place, where developers are "allowed to fail" with trial and error testing regimes for spacecraft technology development.

Q2) Do you agree that in order to make maximum use of existing infrastructure, the location should preferably still be active but at a low level of aircraft movements and should have existing and appropriate ground infrastructure/facilities and service provision?

A) Yes, agree. Assessments of candidate ground infrastructure/facilities should also be additional criteria for site selection. It is highly unlikely that modifications to a site with existing facilities will not be required. There are a number of basic facility modifications that will most likely be needed prior to beginning spaceport operations. At the very least, the following facility modifications may be required before spaceport operations can begin:

Runway extension – Increase length to a minimum
- of 2,048m (9,200 ft). A length of 2,804m (10,000 ft) is preferred
- Modify existing taxiways to support oxidizer loading area and specialized fuel storage areas
- Design/construction of Reusable Launch Vehicle (RLV) processing hangar, apron, taxiways
- Allocate/construct office space for RLV operators
- Allocate/construct mission control capabilities
- Provide passenger preparation area

While the minimum recommended facility modifications will be sufficient to support spaceport operations, a long-term vision of the spaceport will drive the development of additional facilities that will provide a complete spaceport experience for all guests. A full-service spaceport would include the following additional facilities:

- Visitor center & passenger terminal
- Spaceflight training facilities
- Payload processing/clean room

Facilities assessments of the candidate sites provide additional criteria for a UK spaceport site selection process. The facilities assessments would provide a general description and inventory of key components of the Aerodrome which could support or integrate with possible spaceport related activities. A typical assessment would include (1) identification of runways, taxiways, and service roads, (2) summary of tenant facilities and services, (3) identification of other Airport facilities and service, (4) description of aircraft storage and parking, and (5) summary of planned future expansion and development.

Gap Analysis: An additional consideration is the spaceport's ability to attract spacecraft operators. It is expected that operators will be able to take advantage of existing pads, runways, hangars, and other facilities, allowing the spaceport to capture a portion of this market without the need to develop significant new infrastructure. Performing a Gap Analysis identifies those facility attributes which require change in order to support or attract operators. Performing a Gap Analysis identifies those facility attributes which must be maintained as well as those requiring modification. Understanding those attributes already supporting operator needs allows the spaceport to avoid inadvertently changing these in the future. The gap analysis will also identify "low-hanging fruit" for the spaceport where minimal changes can result in the attraction of candidate operators. Exhibit 3 illustrates our gap analysis process.

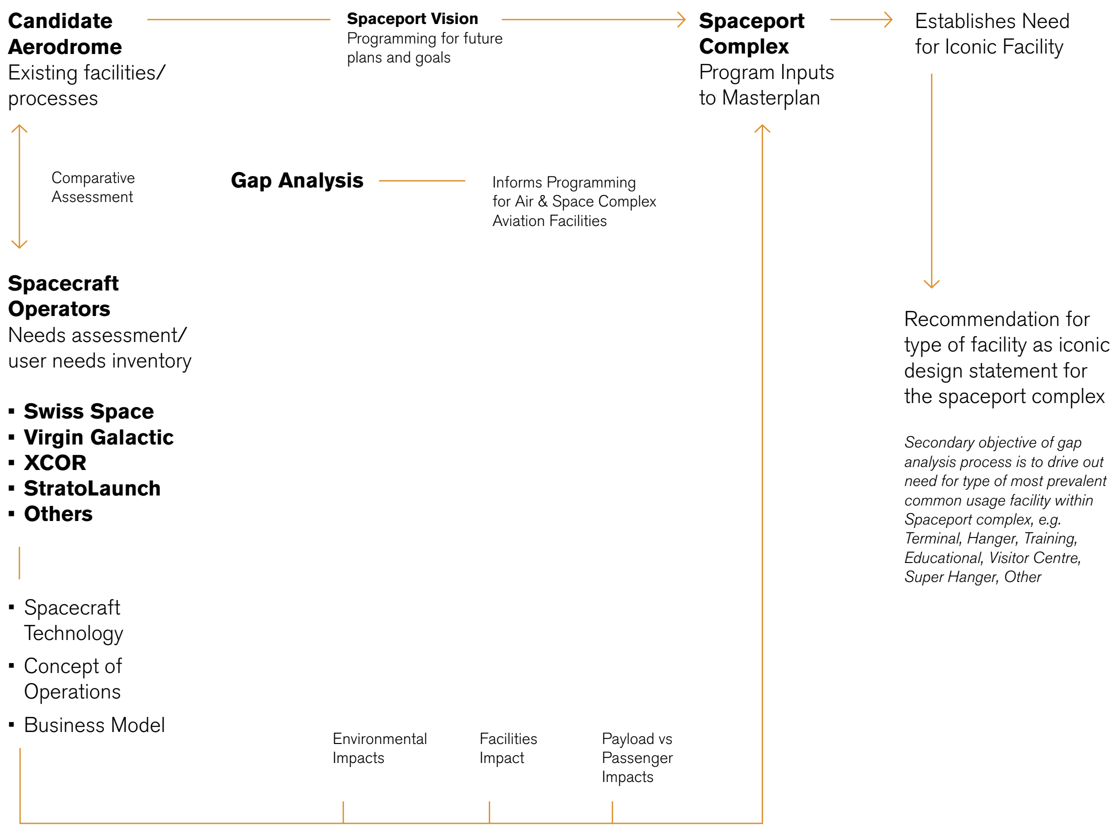
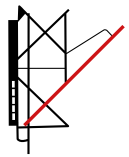
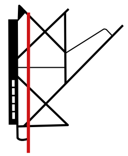
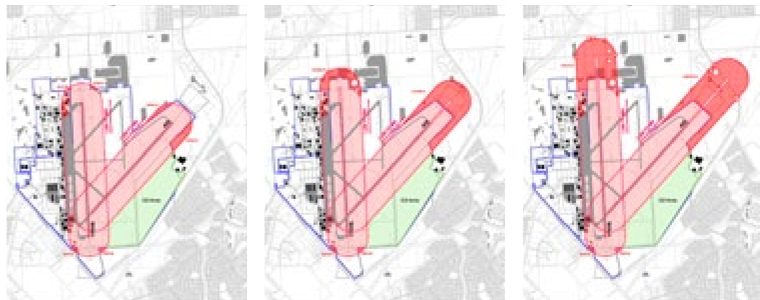


Exhibit 3: UK candidate spaceport site infrastructure/ facilities gap analysis

The analysis can be performed at the micro and macro levels. In the micro analysis, the requirements of each potential operator are evaluated individually. This is expected to result in the list of minimal changes for each site. This allows the spaceport to specifically target individual candidate operators and understand the cost and operational impact of doing so. In the macro analysis, the requirements of the most likely operators will be consolidated. In this case the gap analysis will identify actions necessary to attract the strongest portfolio of operators. The example of Ellington Field Municipal Airport (where Houston Spaceport is to be located), demonstrates in Exhibit 4, how a macro level gap analysis consolidates runway requirements of potential operators in order to inform optimal spaceport investment decisions based on types of spacecraft and markets they serve.

Runway	Wind	Vehicle Class Runway Requirement	Runway	Length m (ft)	Width m (ft)	Added Paving Area m² (ft²)	Paving Cost $/m² ($/ft²)	Paving Total ($m)
17R/35L 	Prevailing winds, prefer-able for glider return	▪ Firehawk - 1070m (trainer) ▪ Lynx II - 2400m ▪ Pegasus - 2420m ▪ Go2 - 2440m ▪ Sidereus - 2590m	Current	2,744 (9,001)	46 (150)	0	$0.00	$0
		▪ VG WK/SS2(maybe) ▪ VG Launcher One(maybe)	Extension 1	3,048 (10,000)	46 (150)	13,922 (149,850)	$8.38 ($90.16)	$14
		▪ Stratolaunch requires 3810m	Extension 2	3,658 (12,000)	61 (200)	97,534 (1,049,850)	$8.38 ($90.16)	$95
4/22 	Glide return problem on cross wind situation	▪ Firehawk - 1070m (trainer) ▪ Lynx II - 2400m ▪ Pegasus - 2420m ▪ Go2 - 2440m ▪ Sidereus - 2590m	Current	2,439 (8,001)	46 (150)	0	$0.00	$0
		▪ VG WK/SS2(maybe) ▪ VG Launcher One(maybe)	Extension 1	3,048 (10,000)	46 (150)	27,857 (299,850)	$8.38 ($90.16)	$27
		▪ Stratolaunch requires 3810m	Extension 2	3,678 (12,000)	61 (200)	111,470 (1,199,850)	$8.38 ($90.16)	$108



Current *Extension 1* *Extension 2*

Exhibit 4: Ellington Airport runway extension options for Houston Spaceport

Transportation

1 Parking Garage
2 Outdoor Parking
3 Metro Station

Retail

4 Hotel & Conference Centre
5 Shops
6 Parks, Buffer Zones
7 Aerospace Museum
8 Visitor Centre

Manufacturing

25 Production Facility 2
26 Manufacturing (lv.4)
27 Production Facility 1

Flight Operations

9 Payload Processing/ CleanRoom
10 RLV Processing Facility
11 Multipurpose Buildings

R&D

19 Conference Area
20 Classrooms
21 Office Area
22 EDGE R&D Centre (lv.3)
23 Makershop (lv.1)
24 Techshop (lv.2)

Spaceport Terminal

12 Visitor Centre
13 Medical Facility
14 Passenger Loading Hanger
15 Admin Offices
16 Passenger Preparation Area
17 Spaceflight Training Centre
18 Mission Control

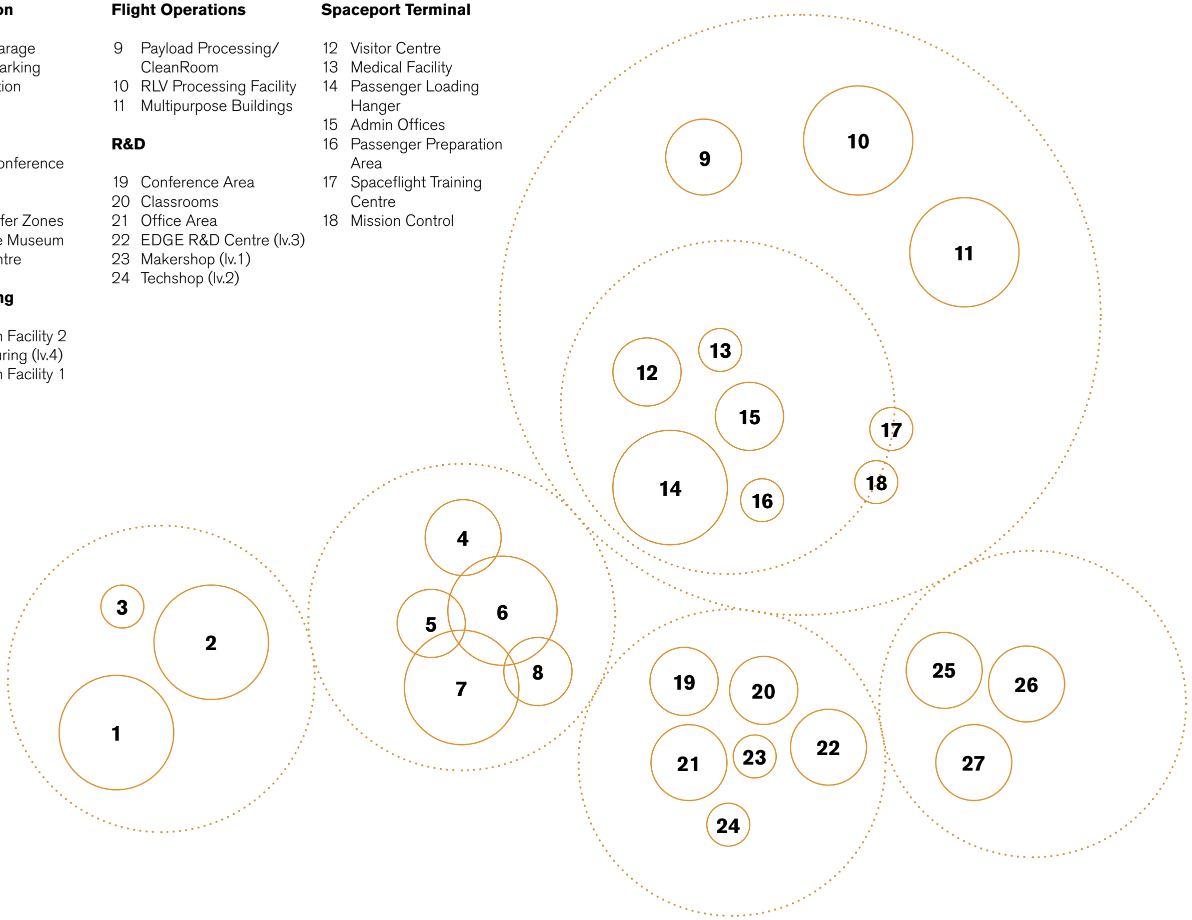


Exhibit 5: Interrelationship of spaceport facilities

Spaceport Organic Growth: When the framework for facility build-out is envisioned as an extension of projected industry growth, interrelationships of components of the spaceport plan blend by how they combine to meet industry needs. The blueprint of Houston Spaceport's market driven design is shown below, expressed as a basic concept for required facilities and infrastructure.

Recommend Additional Criteria:

1. Assessments of a candidate aerodrome site's ground infrastructure/facilities based on ability to meet user needs (i.e., spacecraft developer/operators) should be additional criteria for site selection.

2. Additional consideration is the spaceport's competitive advantage for attracting a variety of spacecraft operators without the need to develop significant new infrastructure at the onset.

Q3) Do you agree that greenfield sites should not be considered?

A) Repurposing an existing aeronautic facility as a spaceport is more practical than fabricating one from scratch. Within the UK, establishing a spaceport at a greenfield site is closely related to a decision for establishing a vertical launch capability. A vertical launch site would have to be built as new, thus causing an unnecessary delay for sub-orbital horizontal launch operations.

The differentiation between a spacecraft developer and a spacecraft operator greatly influence a spaceport's mode of operations. If the initiations of horizontal space launch activities at a UK spaceport is to commerce by 2018, based on support to operators not based within the UK (e.g. Virgin Galactic or XCOR), the direct financial benefit to the local community is greatly reduced. The Pro Forma derived financial implications for operators based elsewhere is irrelevant to UK operations except to the extent that such first-to-market operators will exist and when they will seek alternative points of operations other than their own base.

If the UK spaceport were to cater to a design, development and operational spacecraft firm, it would take depending on the specifics of the systems design that could fly out of the spaceport and based on our prior analyses, 5 to 7 years to bring a system to full scale test. The infancy of the industry under current market conditions make an estimate for the initiation of such an enterprise located at the UK spaceport at least several years in the future. It is probable that the start of such an enterprise would be a few years after other first-to-market operators prove the safety and efficiency of their systems and the size of the market.

Market analysis from our Houston Spaceport Study suggests that in the first years of these initial first-to-market visiting operators, it is likely they will provide their own support equipment and personnel. There will be a requirement for local shelter and access to utilities. If however the horizontal launch market share for the UK Spaceport grows, there will be at some level, activity for transitioning to a local base of operations with local staff, equipment and facilities, but the enterprise will still maintain its main base of operations at its home base. Thus, we predict two scenarios similar to Houston Spaceport are likely for a UK Spaceport operation during its early years:

Scenario 1: For launch event frequencies of once or twice a year the operational scenario for any new spaceport will be to provide shelter and utilities for an outside operator crew and support equipment.

Scenario 2: For launch event frequencies equal to or less than once a week the operational scenario for any new spaceport will be to have locally stationed crew, equipment, offices, hangar space and access to consumables and utilities.

Therefore, we believe development of a greenfield site solely for horizontal launch operations is not justified by current market conditions. To suggest there will be a future candidate viable growing company ready to base operations out of the UK for development of a new system, it would first be necessary to have the first-to-market developers, whether its Virgin Galactic, XCOR or other operator demonstrate the safety of their systems; the efficiency from the standpoint vies-a-vie what ticket prices the market will bear; and that the market is actually there that is being projected. There would have to be a year or two at least of time from first-to-market operations to be able to demonstrate to the investment community that this is a viable industry. In that sense, it will likely be the later part of the decade for when a completely new business might be initiated for operations at the UK Spaceport in the sense of an entity that was going to design, develop, test and operate.

Additional Greenfield Site Consideration

If first-to-market operators commence operational flights in 2015, (current VG projection), the start of a new development system based at a UK Spaceport would not start before 2018. An additional 5 to 7 years of development and test would mean an initial operational capability in 2022 to 2025.


SPEED
LIMIT
30

Q4) Do you agree with CAA's analysis identifying the criteria to be considered in identifying a permanent location for a uk spaceport? If not, please explain why.

A) We agree with the CAA's criteria. The desire among UK leadership for the country to become the European centre for the commercial spaceplane industry requires an approach to site selection which considers various intangible variables as additional criteria. For example, as explained earlier in Section B, Question 1, Houston Spaceport is able to capitalize on Ellington Field's (EFD) close proximity to NASA Johnson Space Center (JSC), shown in Exhibit 6. However, no proposed location for the UK spaceport is able to capitalize on pre-existing space industry activity or technology R&D in the immediate area. This raises the question, "How will the spaceport integrate into the economy?"

By leveraging facilities and talent from local universities and creating a collaborative as well as physical connection to the nearby NASA Johnson Space Center, a spaceport operations model was created for industry/academia/government collaboration at the spaceport R&D technology park.

Additional Criteria Consideration:
A potential site positioned for maximizing integration of the spaceport into the local, regional and national economies offers the best balance between development costs and potential benefits to the UK.

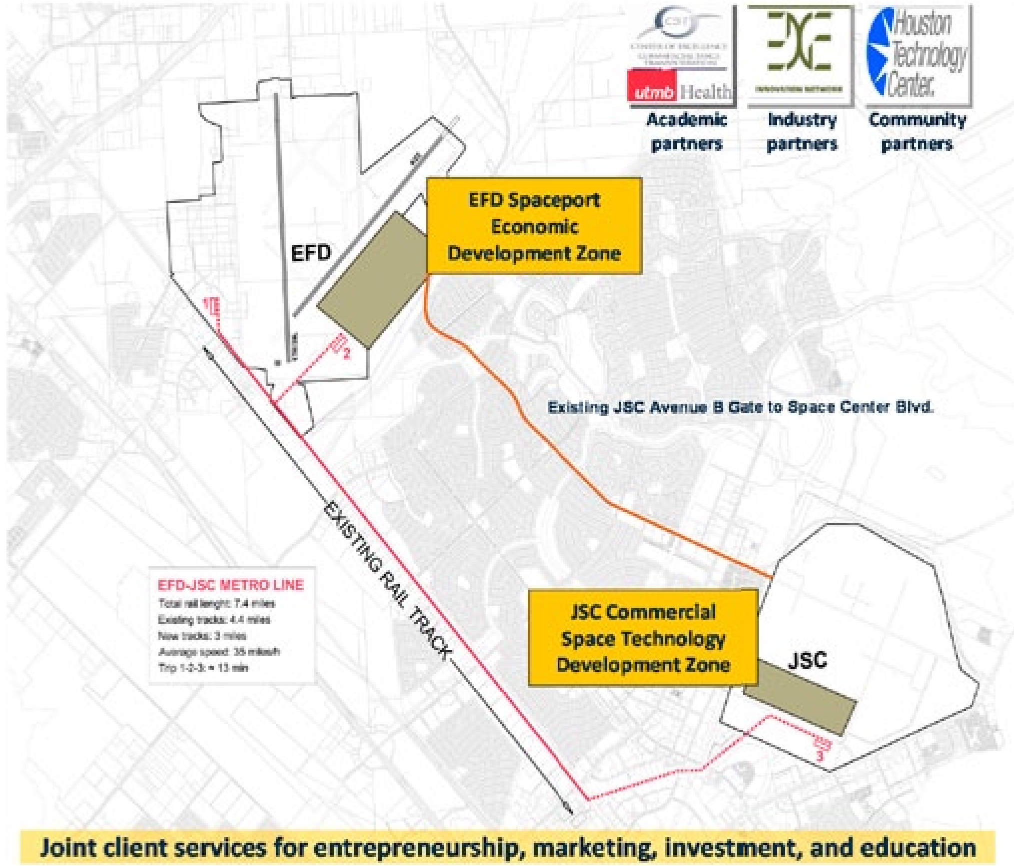


Exhibit 6: Collaborative and physical connections between EFD and JSC

Q5) Do you think there are any other criteria that should also be taken into consideration? If so, please explain why.

A) Refer to previous CAA questions where we have suggested and identified at the end of each question some additional criteria for consideration.

Among safety, regulatory constraints, environmental impact, and other practical technical feasibility concerns, we believe economic criteria should hold substantial weight in the elimination process of determining one site to be more suitable than another. For the spaceport to permeate markets of the larger economy beyond the aerospace sector, providing jobs and delivering productivity across multiple industries, the UK government must seek collaboration as a key objective for the spaceport program.

A spaceport can be an engine that drives creation of a high-tech aerospace industry cluster. Typically, research parks transfer technology from the knowledge source to the external regional community. Technological advancements can trickle down from the aerospace industry to private and consumer markets to boost labor utilization, productivity, and wages. These are all understood and pointed out in the CAA's analysis. What is missing however is discussion of criteria for assessing how local community and regional leaders of a candidate spaceport are evaluated for implementation plans which successfully brand the spaceport as a cluster for aerospace technology innovation to attract talented researchers and entrepreneurs. Such implementation plans will require pioneering models of operation that a new youth generation of scientist and engineers can relate to. Their philosophy is one of openness, sharing, collaboration and communities.

For example, using the Houston Spaceport as a benchmark, once industry needs were identified for the general layout of the spaceport, the goal was to establish the spaceport as an epicenter for innovation and collaboration across multiple segments of society. From industry to academia, it was determined that the value propositions brought to bear by each representative from across this broad spectrum needed to merge in an open forum format where ideas would be allowed to evolve organically. Table 1 identifies the various levels of collaboration facilities envisioned for the spaceport for community participation by multiple segments of society.

Facility type	Environment	Function	Description
Level I	Trial & Error	Grassroots Makerspace at EFD	• Grassroots DIY Community Space • Basic Equipment/Tools/Safety Training • Limited Space, Equipment, Technology • Membership Fees; Community or EFD Sponsored
Level II	Rapid Prototyping	EFD TechShop & JSC Makershop	• Larger Space, Better Equipment/Safety Training • Equipment Owned/Maintained/Floor Plan (well laid out) • Membership & Equip Use Fees (EFD only) • Dedicated Staff Counselors; Training • Owner Operated at EFD; NASA operated at JSC
Level III	Research & Development	General Dynamics EDGE Aerospace Innovation Center A joint EFD-JSC Initiative for Government/Industry/Academia	• Industry/Academia/Government Collaboration • Think Tank; Idea to Implementation (Rapid) • Access to Test/Research Labs • GD Sponsored; Membership Fees
Level IV	Innovative Manufacturing Processes	Aerospace Manufacturing Innovation Institute An Innovative Manufacturing Institute (IMI) within the National Network for Manufacturing Initiative (NNMI)	• $1B Presidential Initiative to Resurrect Mfg. Regions • Legislation to establish 15 Institutes for Manufacturing Innovation & R&D; Competitive selection process • Domestic Products to Market (Rapid) • Training Pipeline • City/State Sponsored

Table 1: Types of facilities for community participation within the spaceport innovation and invention Environment

In coming to life in such a way, the spaceport will be able to adapt quickly to the rapidly changing landscape of space exploration. Exhibit 7 illustrates in a schematic the proposed model of operations for Houston Spaceport.

Houston Spaceport - Economics and Business Care
Defining a Culture of Innovation, Collaboration and Entrepreneurship

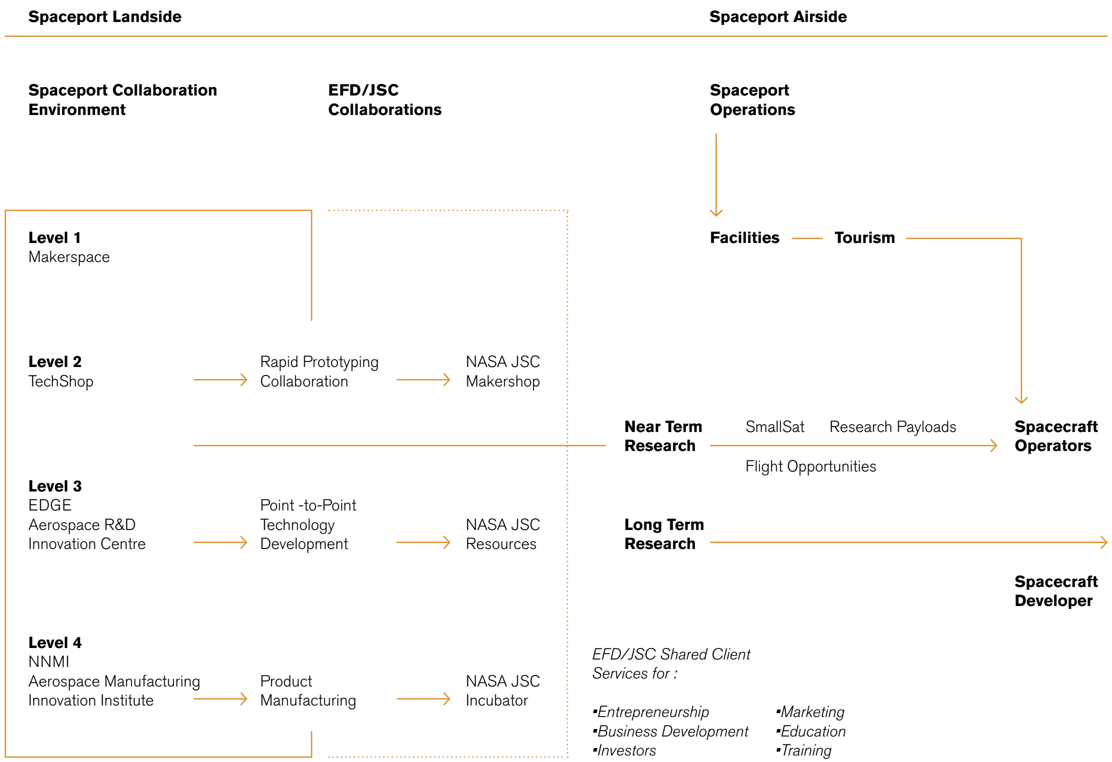


Exhibit 7: Schematic of spaceport operational model for collaboration environment

Instituting a culture of collaboration and innovation within the Research Park will literally be breaking new ground with development of various collaboration facilities, but more so for Houston Airport System management (as well as any UK Spaceport management team operating under a similar model) since it will also be new management territory in understanding how to instill and nurture a collaborative and open culture for the spaceport.

The ability for the spaceport to attract viable participants in its culture of innovation demands that a survey of resources be conducted; various questions soon emerge.

- How close are the nearest research university, and other similar educational institutions?
- How close are industry-related government agencies to the prospective site?
- Are high-tech industries already in place?
- Is the population density of the surrounding area one which would suggest active participation of the general public?
- How intensive will allowable types of “tinkering” be if the R&D center of the spaceport is to be urban?

Additional Criteria Consideration:

1. Economic criteria should hold substantial weight in the elimination process of determining one site to be more suitable than another.

2. Economic criteria for evaluating implementation plans or models of operations for branding and instilling within the spaceport a culture of innovation, collaboration, and entrepreneurship should be part of the site elimination and selection process.

Q6) Do you agree that these are relevant criteria? What weight should be attached to them?

A) All criteria presented in the CAA analysis are relevant. When comparing these sites it is important to take account of the fact that every criterion is not equally important. Thus, before any sort of quantitative assessment is made between the strengths of one spaceport site versus its competitors, one must separate the characteristics being judged into different weighted categories. The relevance of each weighted category would differ however depending the ranking of which categories are more important for site selection. The list below identifies four suggested category groupings for weighing the criteria. (Note: At this point, we have not ranked the listed categories by order of importance.)

Additional Consideration for Attaching Weight to Criteria:

Suggested weighted category groupings for spaceport site selection:

- Competitive Advantage – Ability to attract spacecraft operators
- Investment Advantage – Minimal infrastructure and facilities investment needed
- Economic Advantage – Well positioned for driving economic growth
- Technical Advantage – Optimum environment for flight operations

Q7) If more than one location closely meet the essential operating criteria, safety, meteorological, environmental and economic criteria, do you agree that we should also consider factors around the contribution to local and national growth? If so, what weight should be given to these factors?

A) Local economic growth around one specific site can be an indicator of national growth if the site has a significant level of influence. As the UK spaceport becomes increasingly more important to national objectives, spaceport activities will feed into the national scale in measurable degrees as visible as those seen locally, around the port. This success will trickle across the landscape to educational initiatives that link the spaceport with the promotion of a healthy culture and economic security at the most basic level. The extent of this permeation was examined in the Houston Spaceport project. The Houston Spaceport is envisioned to be an engine that drives creation of a high-tech aerospace industry cluster. The Research Park for aerospace technology research and development, and manufacturing facilities further defines Houston Spaceport as part of its overall spaceport activities and operations.

The business case regarding research aspects of a UK spaceport for spaceflight can be far-reaching and difficult to measure. Continued space exploration and aerospace flight will often present new challenges and opportunities for new, innovating technologies, processes, materials, etc. Typically, research parks transfer technology from the knowledge source to the external regional community. Technological advancements can trickle down from the aerospace industry to private and consumer markets to boost labor utilization, productivity, and wages. Any potential technology transfers from the aerospace and space exploration industry to the commercial consumer markets would have to be qualitatively discussed. At this point it is not technically feasible to determine in advance how material, aerospace, and satellite technology will spillover into the consumer market. Quantification of these far-reaching benefits with the opportunities for technology transfers, entrepreneurship, and cooperation would be extremely challenging prior to the full understanding or implementation of that research. Ultimately however, the success of the spaceport technology cluster could be measured in terms of: a) local industry concentration compared to the nation, b) exports from the region by the industry, and c) the high-tech industry cluster provides higher wages than the local average wage.

If so, what weight should be given to these factors?

These factors should impact the way in which the spaceport is designed to integrate with the general population, to act as an extension of British culture and the will of the nation. A robust planning process and marketing campaign involving local populations at the multiple sites identified for the spaceport's development will aid in assessing the viability of one particular site over another. An assessment of local businesses, land inventory surrounding each prospective site, examination of infrastructure, and even a look at educational performance of local schools, will all aid in understanding exactly what the spaceport will do for the local people, in as far as they represent the entirety of the British population when national economic health is given primary consideration.

To consider the possibilities of multiple sentiments toward the spaceport, it is important to realize that not everyone will support its construction. This is why involvement of people impacted by its construction and eventual operation should be involved in the initial planning stages.

When considering the spaceport as an engine to drive long term economic and social health, the CAA criteria determined as necessary for site selection does not enter into the requisite amount of detail required to forecast robust growth of the spaceport. Assessing the likelihood of a site to generate a ripple effect of new support facilities surrounding the spaceport, new jobs in different sectors, new schools, etc., requires a level of analysis operating at a local, regional, and national scale. Transportation infrastructure, geography, historic trends, and a number of other key indicators need to be weighed when selecting a site for the spaceport.

Consultation Questions continued

The CAA report seems not to have fully appreciated the scale of what they anticipate/propose. The CAA consultation paper says at Paragraph 1.3 that the government aims to have a space economy worth £40bn by 2030, equal to about one-fifth of the current size of all UK manufacturing industry. That would mean employing at least 400,000 people – at that level average productivity would be £100,000 per head, a high figure allowing that there would be many more workers in mundane occupations than in 'rocket science'.

Given its central importance, the spaceport (or spaceport network) is likely to require local employment of thousands of people even in the early stages and perhaps several tens of thousands by 2030, assuming the £40bn target is to be realised.

Table 2 indicates something of this scale and the diversity of the cluster of activity that should ideally emerge when compared to common features of planned developments. The table shows various features of three master-planned technology parks examined side-by-side as benchmarks for the Houston Spaceport project. The first two sites are former U.S. military bases located in San Antonio, Texas, re-purposed as technology parks, and the third site is a research and development park found in Singapore, known as One-North.

	Common Physical Characteristics of Planned Developments	**Port San Antonio (Industrial Park)**	**Brooks City - Base (Hybrid Model)**	**One North (High-Tech Park)**	**Houston Spaceport (Hybrid Model)**
Activities	Workforce Training	✓		✓	✓
	Trade School/College/University	✓	✓	✓	✓
	Built Environment Encourages Collaboration			✓	✓
	Operational Support Encourages Collaboration	✓		✓	✓
	Light Industrial	✓	✓	✓	✓
	Heavy Industrial	✓	✓		✓
	Community Makerspace/Workshops				✓
	Research & Development Centres			✓	✓
	High-Tech Enterprises	✓		✓	✓
	Boutique Retail Store Fronts		✓	✓	✓
	Restaurants/Mobile Food Vendors			✓	✓
	Entertainment/Leisure/Public Activities		✓	✓	✓
	Residential	✓	✓	✓	
	Hotel/Conference Centre			✓	✓
Transport: Rail	Light rail - access to off-site network			✓	✓
	Heavy rail - on-site, or access to off-site network	✓			✓
Mode	Automotive	✓	✓	✓	✓
	Aeronautic	✓			✓
Green Network	Designated Bicycle Lanes			✓	✓
	Interconnected Sidewalk System			✓	✓
	Traditional Parks	✓		✓	✓

Table 2: Common features of planned developments

Consultation Questions continued

For this to be feasible, the chosen location should have access to substantial infrastructures, including the social infrastructures of housing, schools, hospitals etc as well as transport and utilities, and to centres of population. Without this, enormous investment would be needed in infrastructure, and suitable inducements to encourage people to relocate. Ideally too, the location should be close to the science and space industry base.

The importance of repurposing existing infrastructure places extra emphasis on how utilization of existing resources could benefit the Spaceport. When overlaying the process of successful integration of existing resources atop the phased approach of gradual new construction, extra emphasis is placed on the value of long-term planning to achieve objectives. The example in Exhibit 8 illustrates how existing infrastructure of a military base was converted into non-military development of commercial maintenance depot activities for the highly successful Port San Antonio Technology Park which was a benchmarked development analog assessed for the Houston Spaceport Study.

Additional Consideration:
Please refer to our response in Question 5 and recommendation that “economic criteria should hold substantial weight in the elimination process of determining one site to be more suitable than another”.

Commercialisation of Maintenance Depot

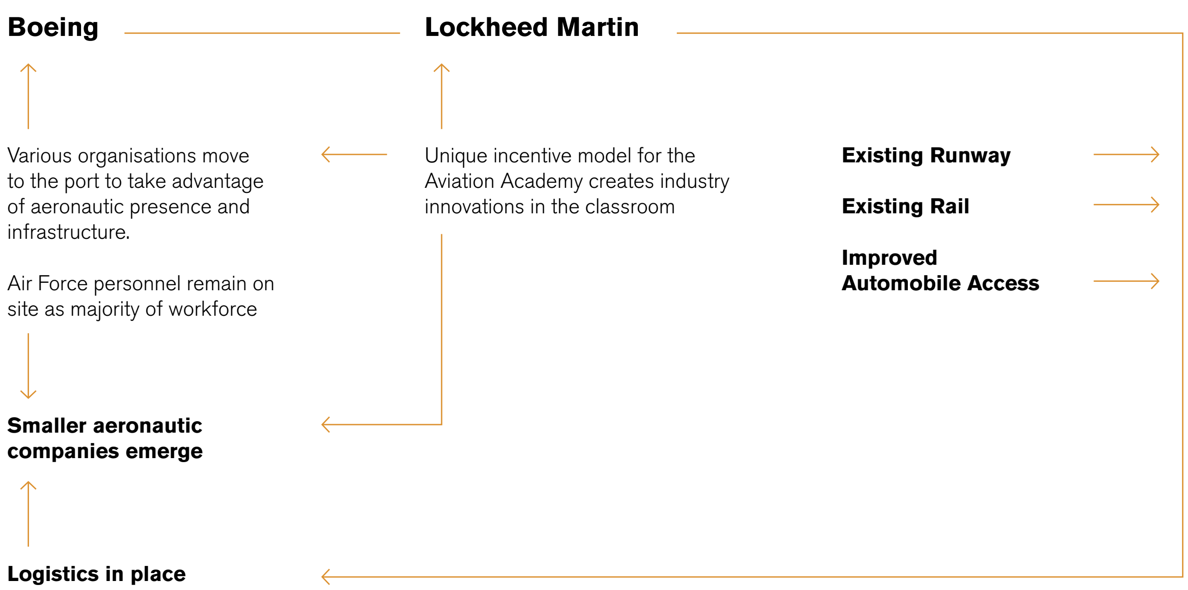


Exhibit 8: Development strategy example for repurposing existing infrastructure


SPACEPORT AMERICA
Virgin
Virgin
GALACTIC

Q8) Do you agree with the CAA's analysis and strong recommendation that until there is a better understanding of sub-orbital spaceplane safety performance, spaceplane operations should only take place in areas of low population density and the resulting view that only a coastal location is suitable to protect the uninvolved general public?

A) Depending on the definition of a coastal location, yes for the most part, we agree, because of safety concerns and the current condition of a nascent industry at a point in time when outcomes of P2P integration into regular aerodrome operation are yet to be understood. However, if the goal for the spaceport is to generate economic growth of the area, or for that matter compete for the space tourism market, it could be a mistake to place the spaceport in an isolated coastal location with no major transportation nodes for access to the spaceport.

In our economics and business study for the Houston Spaceport, a major finding was there is clear competitive advantage to having a spaceport located in close proximity to a "gateway" international airport such as in Houston (or in Denver for Spaceport Colorado, or in Jacksonville for Cecil Field Spaceport). Accessibility for non-local, including international customers will be a strong factor in encouraging growth for a commercial spaceport.

Houston and Cecil Field spaceports have the advantage of a coastal location, so Denver will likely have a tougher go of it initially for overcoming FAA-AST launch vehicle licensing. Houston already has a commitment from Sierra Nevada for landing their Dream Chaser reusable spacecraft there. Licensing and regulatory issues associated with using Houston as a landing site are being worked through with FAA-AST, Sierra Nevada, and Houston. However, these systems are all in their infancy so an FAA "wait and see" approach with vehicle licensing in populated areas is the current attitude, but is not necessarily dismissed out-of-hand for the future. In our opinion, a coastal site as close to a major transportation hub as possible (preferably a gateway international airport) would offer distinct advantages over other sites. The "holy grail" for suborbital spaceflight is point-to-point transportation, (still 20+ years away), and should be built-in with the design of growth capabilities of any spaceport wishing to be part of a global spaceport network, thus proximity to large metropolitan markets is additional insurance for economic viability of the spaceport.

What is interesting about the Houston Spaceport located at the Ellington Airfield Aerodrome is that it is about 30NM from the coast (the low population density area). The flight line for spacecraft operations goes over some of the outer suburbs of Houston. This adds weight to our propositions in Question 11 of adding RAF Coningsby and Marham back into the shortlist for Spaceport UK, which are only about 15NM away from the coast and have some low population density corridors between the airfield and the coast.

Additional Consideration:
Definition of a coastal location: In some instances an airport maybe located near to the coast (e.g. 10-15 miles) and has flight paths which are relatively clear of population centres to and from the coast. Conversely, an airport may be located on the coast, with the coast on one side of the airport, but population centres on the other. The prime objective is to ensure that flight paths into and out of the airport, in both wind directions, have low population densities underneath them.

Q9) What are your views on the CAA's shortlist of eight potential sites?

A) We agree that the shortlist of eight sites all have the potential to become spaceports based upon the CAA's initial filtering and warrant more detailed study and evaluation based upon the CAA's criteria. We believe that there may be additional sites, located relatively close to the coast, which may warrant further investigation. The rationale for doing this is explained in our response to Q8 and the additional potential sites to consider are outlined in our response to Q11.

Of the options that have been shortlisted, a number of them are in remote locations which, whilst reducing the population density underneath the flight paths, make them questionable in accessibility terms for getting cargo and passengers to them. We would recommend that the next stage of evaluation considers attaching a significant amount of importance to that criteria.

Comparision of sites to the assumed KPIs:

Access

Preswick, Kinloss, Newquay, RAF Leuchars and RAF Lossiemouth have access to comprehensive road infrastructure which should allow for supply of materials and equipment to site. Campbeltown and Stornoway have access to local ports although routes to and from go through villages. Stronoway Airport is the islands only airfield.

Existing Facilities

Commercial Airports of Newquay and Prestwick are assumed to have the best passenger handling facilities although RAF Lossiemouth and RAF Leuchars have a variety of suitable storage and maintenance hangers due to their use as "fast jet" stations and RAF Expeditionary Air Wing bases (RAF Kinloss was also part but now stood down).

Proximity to population density

Generally the sites with poorer access had lower population densities however Kinloss and RAF Leuchars have good access as well as have a suitable population density. Locations such has Newquay and Prestwick did not have a significant population in the flight path but adjacent which may be effected by environmental issues. It could be assumed that population proximity is a social and environmental issue rather than safety. Population around RAF Lossiemouth is largely MOD related and therefore primary use as a Spaceport could have an impact on reducing the local population numbers.

Opportunity to extend runway

Prestwick, RAF Leuchars and Stornoway face significant restrictions on extensions due to locations of major roads (A77, A919 and A866 respectively) meaning extensions could require land reclamation. Other locations have significant land that could be topographically acceptable for extension with the exception of Campbeltown. Detailed investigations would be required at all sites to determine detailed ground level variation.

Climate

Newquay has the most appropriate meteorological conditions of the 8 sites with Llanbedr and Stornoway having the worst conditions. Kinloss and RAF Leuchars also have relatively acceptable conditions. Wind speed could be considered one of the more significant factors that affect mothership based aircraft landings; Prestwick significantly outperforms the other sites for the lowest average wind speed.

Proximity to research facilities

Generally most Scottish sites were at a disadvantage in proximity to aerospace R&D, Company bases and Academic institutions although with the exception of Stornoway and Llanbedr there was alternate commercial airports within 50 miles of each site for rapid connectivity (assuming spaceplane only landings at sites). No site is considered to comprehensively fulfil this criteria*.

**The location of Spaceport America is considered remote but firms and research teams have moved to the area to meet the needs of the facility.*

Runway orientation

RAF Leuchars, Stornoway and Kinloss all line up to within 10 degrees of the prevailing wind direction. Sites such as Newquay, RAF Lossiemouth and Prestwick have potential crosswinds that may affect landing although these are of variable frequency and relatively low speed (typically up to 10m/s). Llandbedr has a prevailing wind within 10 degrees of runway but high speed winds (greater than 12m/s) from 10-90 degrees to the runway have potential to impact landings. Campbeltown has variable winds coming from East to West and West to East depending on time of year which has the potential to impact maximum operation hours.

Utilities Infrastructure

Utilities infrastructure reflects existing facilities however sites that have previously been use more intensively such as RAF Lossiemouth may have a greater redundancy in local power, gas and water connections which potentially would not require upgrading. Sites that have been recently expanded or at large capacity such as Prestwich and Newquay are considered to meet the criteria. Remote sites with lower activity for more than 20 years may require significant upgrading of onsite infrastructure for new facilities such as Llandbedr and Campbeltown.

Runaway Composition

All runways are assumed to be Asphalt, which may not be suitable for certain types of fuel such as liquid oxygen use in the XCOR Lynx vehicle but this should be examined with a proposed operator in detail prior to decision making. Based on known age and maintenance investment Prestwich, Newquay and RAF Lossiemouth potentially the highest quality runway surface. Llanbedr Airport, Kinloss Barracks and Campbeltown Airport may not be to the same standard as the larger scale airports/bases on the shortlist.

Air Space Intensity

By analysing commercial flight operations and location of local airbases it is assumed that only the sites of Campbeltown and Stornoway would have the least localised aerial activity. The proximity of RAF Lossiemouth and Kinloss has the potential to affect one another although it is assumed Kinloss has less effect on RAF Lossiemouth. Newquay has a relatively high level impact from transatlantic flight paths.

Observations against KPIs

Based on the 10 key performance indicators it could be observed that sites have a distinct advantage that demonstrate favourable climatic conditions and exiting site infrastructure including good transport connections to R&D facilities. Sites meeting these criteria are most suitable for immediate transition in to an operable spaceport location.

Northern climates were not seen to have a significant disadvantage on the whole, wind speed and runway orientation are favourable at a number of Scottish sites.

Sites that have a proximity to a commercial or military bases may be advantageous in dealing with non-space related air traffic should movement be restricted at the selected spaceport location.

Sites which meet climatic criteria but have poor site infrastructure may still be considered an appropriate choice; potential operators may wish to construct purpose built hangers and facilities prior to commercial flight operations as seen with Ellington Airport in Houston's transition to the Houston Spaceport.


VIRGIN GALACTIC
N348MS

Q10) Are there any locations on the CAA's shortlist which you consider should be disregarded? If yes, please give your reasoning.

A) The eight shortlisted locations look suitable for final assessment, given their strengths in relation to runway length, adjacency to low population areas such as the coast and the potential for segregation of the airspace.

Based on metrological investigation some sites exposed to higher wind speeds and poor runway orientation may be less desirable and may limit spaceport activities during significant proportions of the year. Sites with limited runway extension area as a result of major roads, water bodies or site topography could be limited in their ability to accommodate a number of proposed spacesplanes and their operators.

Our investigation was able to establish relationships to commercial flight paths but detail analysis of military operations and local airport manoeuvring areas surrounding the proposed sites is essential in establishing viability. It should be noted that neighbouring airports and bases does not necessarily put the bases at a disadvantage as stated in Q9, rather air traffic frequency and schedules will affect selection. Acceptable levels of local air movement should be established in detail at the next stage of analysis.

From the assessment of the 8 potential locations based on an analysis against the 10 KPIs it is apparent some sites have performance indicators that could limit their chances to be shortlisted for the potential UK Spaceport site. Although it is not recommend that any of the sites be disregarded from the next stage of evaluation as there may be potential for a wider development of a 'UK Spaceport Network'. Should a network be established it could be suggested that remote sites for high risk aerospace technology development can take place, with lesser regulatory processes, where developers are "allowed to fail" with trial and error testing regimes for technology development; and other sites developed strictly for early commercial operations; and other sites for vertical launch capability; and other sites for the eventuality of point-to-point travel.

Q11) Are there any additional locations that you consider should be on the CAA's short list? If yes, please explain why.

A) There appear to be a number of airports in the longer list of 26 options which were discounted because they were deemed to be not close enough to the coast which may warrant re-consideration. RAF Coningsby and RAF Marham are approximately 15 miles from the coast, have 2750m length runways and appear to have low population densities around them, including some very low density corridors between the airport and the coast. The CAP 1189 report notes that the east of England benefits from lower wind strengths compared to other areas of the UK and it is also relatively dry, albeit it may have slightly less sunshine and more low cloud than other areas. The east of England benefits from being closer to more major population centres of the UK and is much more accessible than northern Scotland, west Wales and south west England. It is also much closer to mainland Europe which may be beneficial if Spaceport UK is competing with other sites in Europe to become Europe's or one of Europe's spaceports of choice. If an agreement with the MOD regarding dual use could be reached (including airspace) and analysis of the population densities are comparable to the 8 coastal sites (taking into account wind direction and the need to operate departures and arrivals over the land side of the airport as well as over the coast) then from an accessibility perspective, these sites could be attractive.

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