Final

Challenges for Space

Harnessing space technologies for the benefit of Scotland

Executive Summary

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London Economics

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Table of Contents

Page

Executive Summary

Objectives

This report presents the results of a study to identify and understand real challenges facing the Scottish public sector and key industries, and opportunities for the Scottish space industry to provide affordable solutions. The study aims to identify the limiting factors for effectiveness and productivity within public services and private industry, with a view to identifying the potential of space-based solutions to address these challenges. It further identifies candidates to initiate a challenge-led approach to address challenges and support the implementation of the best ideas, as demonstrated by the Can Do Innovation Challenge Fund.[1] The purpose of this study is to answer three groups of related questions:

- What are the most pressing challenges that Scottish organisations face? Which challenges could be addressed by space-based solutions that would bring economic growth, and which solutions might lead to increased exports? What current and future strategic, policy, operational, and regulatory challenges are Scottish organisations dealing with, with solutions that could potentially be based in space?
- What are the capabilities of the Scottish space industry?
- Where are the potential matches between Scottish demand and domestic capability? Where is there meaningful overlap between Scottish space industry capabilities and the documented challenges?

Scope and method

To answer these research questions, London Economics drew on a combination of research methods to deliver validated answers to each question. **Primary research** was conducted via 20 stakeholder consultations with representatives from organisations across the Scottish public and private sectors. These consultations provided detailed insight into the specifics of the most important challenges that these Scottish organisations face. They also provided cross-validation between organisations, confirming that some identified challenges were broadly applicable across different organisations. These identified challenges are reported **without consideration as to the maturity of a potential technical solution**, whether space-based or otherwise.

London Economics developed 13 private and public sector **case studies** to highlight a range of public and private organisations that already benefit from space data in their operations. These case studies were shared with stakeholders before the consultations to demonstrate the potential of space-based solutions and to spark ideas about use in their own domain. **Desk-based research** was also undertaken. Relevant literature included academic studies, existing London Economics and space industry studies, relevant space agency projects, and the output of targeted web searches. This research provided inputs for analysis throughout the study.

Alongside the consultation process, promising challenge areas were subject to a **supply side analysis**. This step assessed the extent to which Scottish industry can effectively deliver solutions within a given challenge area. Identified challenges were therefore considered not only in terms of whether space solutions could offer value to Scottish users, but also where Scottish industry could

[1] See CAN DO Innovation Challenge Fund website: https://www.openinnovation.scot/support-and-funding/can-do-innovation-challenge-fund

offer solutions. In this way Scottish industry could benefit from domestic procurement and leverage capabilities developed for domestic needs when looking to export.

Figure 1 Satellite technology

Source: Pixabay

Key findings

A range of challenges across different sectors were identified. These challenges are mostly in the 'downstream' portion of the space industry that utilises existing satellites and ground-based infrastructure to deliver services. Analysis of the challenges allowed the challenges to be classified according to a typology characterised by the type and maturity of the (space-based) solution that would be required:

- **Implementation challenges** that could be addressed through implementation of existing space solutions, such as support to operationalise space solutions for specific contexts. Where a user has a specific challenge or defined need for a product or service that can be addressed using existing technology, support can be provided for implementation. Users may lack **awareness** of a specific solution, so solutions that address implementation challenges can demonstrate what space applications can do.
- **Innovation challenges** that involve supporting the development of either a new solution to fill a gap, or space-based applications that can replace current methods. There is a lack of existing off-the-shelf solutions, potentially creating a need for development of sensors or technical components to deal with technical limitations such as cloud cover and other Scotland-specific issues. **Innovation** is therefore required to establish new solutions. Such challenges could include an innovation that makes space-based data more immediately applicable to the Scottish context, e.g., through calibration to environmental or terrain features common to Scotland. There may also be a need for higher frequency of observations or better resolution than what is currently available, requiring developments in the upstream segment as well as the downstream.
- **Platform challenges** where a solution may exist that can be leveraged across multiple challenge areas, sectors, or organisations. Where users understand their end goal but need help in digestion of data; outputting of data in a useful format; or lower cost of access,

support can be provided to improve **access**. Users may suffer from a lack of ability (technical, financial, etc.), a lack of capacity, or may require a solution with a greater degree of user friendliness.

Filtering of challenges was carried out according to the breadth and strength of stakeholder references to them, as well as the potential for a space-based solution to play a role in tackling the challenge. That is, challenges were prioritised based on their potential impact across a wide range of stakeholders across the Scottish economy and that were of high importance to those that mentioned them.

The specialist team conducting this study has detailed knowledge of the Scottish space sector and has used best practice and best judgement to carry out robust and fair analysis. London Economics has attempted to speak to as wide a range of consultees as possible, from a range of sectors, and with a range of experience in space technologies. However, it is inevitable that the study will not capture every single challenge of relevance facing Scottish organisations today. Furthermore, the weight assigned to potential challenge areas will reflect the biases of those included in the sample of consultees. From a long list of challenge areas, the following key challenge areas were identified:

- **Inefficient allocation of field staff and volunteers**
  - Organisations that perform work via 'boots on the ground' suffer from **inefficiencies in reporting, identifying, and prioritising problems** relevant to their organisation. The optimal utilisation of volunteers, staff members, and limited resources is a significant challenge that constrains the effectiveness of these organisations. Examples include those engaged in environmental protection along Scotland's coastline, or path maintenance in rural settings (e.g., in Scotland's national parks). Many of these organisations could benefit from access to timely information on where the most pressing issues are located and where staff should devote effort, delivered in format that is accessible to volunteers of all backgrounds and technological abilities.
  - One route to improved efficiency is more targeted allocation of resources to monitor potential problem areas, including resource-intensive tasks like monitoring hiking trails and paths. The supply of precise-location and Earth Observation (EO) data to indicate likely areas of concern, using AI or Machine Learning, to these volunteer groups or professional workforces would enable them to ensure early intervention and the avoidance of exceptional costs.
  - The Scottish space sector stands well positioned to respond to the demands of this challenge. Scottish firms demonstrate expertise along both dimensions of the likely technical solution – a combination of Earth Observation and GNSS applications. For example, the Musselburgh based firm, Astrosat[2] possess the necessary expertise in leveraging EO data for environmental monitoring, leveraging machine learning for change detection and time series analysis.
  - Scottish firms also demonstrate the necessary capabilities in GNSS to respond to the second dimension of his challenge's likely solution. For example, Mapix Technologies[3] asserts a unique selling proposition focusing on remote outdoor lone workers with its technology Trackplot[4]. Designed for remote and rural applications in sectors such as forestry, estate and land management, and energy, the company has developed a portal that enables the monitoring of lone workers in real-time.

[2] For more information, visit the Astrosat website at: https://astrosat.net/
[3] For more information, visit the Mapix website at: https://www.mapix.com/
[4] For more information, visit the dedicated Trackplot website at: https://trackplot.com/

Figure 2 The Scottish coastline

Source: Pixabay

- **Inputs into optimal siting of construction projects**
  - Scotland has a significant amount of potential land available for development, with over 11,000 hectares of vacant and derelict land in urban areas alone.[5] More data, used effectively to generate intelligent suggestions to narrow down searches, would enable more successful location decisions for construction projects, such as the identification of appropriate **brownfield sites** and targeting of **green finance** funding. The Scottish Government's Planning Policy introduced a presumption in favour of sustainable development, as well as development that protects and enhances Scotland's natural heritage, including green infrastructure, landscape, and the wider environment.[6] This change highlights the importance of achieving optimal planning and development decisions.
  - Similarly in offshore construction, the efficient siting of energy assets such as windfarms requires the identification of suitable sites before construction and ongoing environmental monitoring of sediment currents after construction to mitigate the potential impact on the local environment.[7]
  - The Scottish space industry demonstrates the necessary expertise to respond to this challenge, as well as significant momentum amongst start-up and early-stage firms. For example, the Glasgow-based firm Digital Content Analysis Ltd[8] or 'D-CAT', positions itself as a digital intelligence specialist, with expertise in EO-driven analysis and the integration of EO with multisource data. They offer products tailored to the construction industry along the full lifecycle of a project, from site assessment to ongoing monitoring of assets.
  - Similarly, the recently acquired Bird.i[9] offers land assessment and build monitoring for the housing industry. There is also evidence of enthusiasm for this application among

[5] Scottish Land Commission (2020), Transforming Scotland's Approach to Vacant and Derelict Land, available at https://www.landcommission.gov.scot/downloads/5f73555fbfe93_VDL%20Task%20Force%20Recommendations.pdf

[6] Scottish Government (2014), Scottish Planning Policy, available at https://www.gov.scot/publications/scottish-planning-policy/documents/. The December 2020 update to the Scottish Planning Policy was removed following a legal challenge at the Court of Session in August 2021.

[7] London Economics (2018), Value of satellite-derived Earth Observation capabilities to the UK Government today and by 2020, available at https://londoneconomics.co.uk/wp-content/uploads/2018/07/LE-IUK-Value-of-EO-to-UK-Government-FINAL-forWeb.pdf

[8] For more information, visit the D-CAT website at https://www.d-cat.co.uk/home

[9] For more information, visit the Bird.i website at https://hibirdi.com/builder/

early-stage firms, with Scottish start-ups such as Hypervine[10] and Omanos Analytics[11] entering the sector. Hypervine leverages satellite based EO in a "tool for tracking people, materials, machines, and carbon emissions on construction and mining sites, helping companies save time, increase profits and reduce waste."[12]

Figure 3 Early-stage construction site

Source: Pixabay

- **Slow, unreliable, or unavailable digital connectivity**
  - Every home and business in Scotland and the rest of the UK has the legal right to request a broadband service with a download speed of 10Mbit/s and an upload speed of 1 Mbit/s. If the cost of connecting a home or business exceeds £3,400, the homeowner or business will have to pay the excess costs.[13]
  - However, the availability of high-quality rural connectivity is patchy, leaving some remote and rural parts of the country underserved. Geographical disparities mean that the speed and quality of internet broadband in rural parts of Scotland lag their urban counterparts: just 72% of the rural population have superfast (>30 Mbit/s) broadband, compared to 98% in urban areas. Considering *commercial* properties, just 59% of rural commercial premises have superfast broadband coverage, compared to 90% in urban areas.[14]
  - Weak provision is a challenge for a number of sectors and acts as a drag on the productivity of businesses, especially those operating in the 'knowledge economy' and in the context of remote working, where fast internet access is fundamental to business activities. It also limits innovative approaches to public service delivery that cannot fully utilise Internet of Things (IoT) solutions. There is a further connectivity challenge in **offshore** sites: these workplaces have a stated requirement for **secure**, **low latency**, **high-bandwidth communications**. From both a cost and safety perspective, a greater level of connectivity would enable greater levels of automation, reducing the need for workers to travel to and spend time at offshore sites. Workers' job satisfaction could

[10] For more information, visit the Hypervine website at https://hypervine.io/
[11] For more information, visit the Omanos Analytics website at https://www.omanosanalytics.org/home
[12] Cemex Ventures (2020), Top 50 Contech Startups 2020, available at: https://www.cemexventures.com/top-50-2020/
[13] See 'Your right to request a decent broadband service: What you need to know', available at https://www.ofcom.org.uk/phones-telecoms-and-internet/advice-for-consumers/broadband-uso-need-to-know
[14] Ofcom (2020), Connected Nations 2020: Scotland Report, available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0021/209442/connected-nations-2020-scotland.pdf

therefore be enhanced through the need to spend less time offshore and greater connectivity during the time spent offshore.

- While the entry of large international firms into the Scottish market is likely to provide a significant share of the solution, domestic firms may also have a role to play in responding to this challenge. For example, the Aberfeldy-based firm TEC Offshore[15] specialises in the provision of satellite communications to the oil & gas industry, remote site operators, and vessel owners. R3-IoT uses smart on-site gateways to connect assets via satellites and support remote monitoring and data collection. This solution is particularly suited for the IoT requirements of several sectors, including aquaculture, energy, environmental monitoring, rural health, and utilities.[16]

Figure 4 Connectivity

Source: Pixabay

- **Need for climate-conscious use of resources**
  - Many organisations would like to monitor the wide-ranging natural assets within Scotland, such as coastal areas (for erosion monitoring), soil moisture, peatland and forests, to name a few. However, despite the value of monitoring, change detection, and verification, most organisations lack baseline data of their current status and a mechanism for gauging progress.
  - In the context of decarbonisation and carbon emissions trading, change detection and verification is crucial to enable private funding of environmental projects. Validation of these environmental protection measures could give private sector investors decision-grade information, while at the same time allowing organisations to meet their environmental targets through verified carbon offsetting.
  - Within the context of Net Zero, the acquisition of novel space-based data, particularly from Earth Observation, could be of high value if integrated into dashboards to help guide organisations as they execute their Net Zero strategies.
  - The relative strength of the Scottish firms in satellite-based Earth Observation analysis and applications suggests this challenge area represents a significant opportunity to deploy expertise and foster further growth in the sector. One example of a company providing solutions for the forestry sector is Edinburgh spinout company, Carbomap[17], which leverages satellite-based synthetic aperture radar (SAR) alongside unmanned

[15] For more information, visit the TEC Offshore website at http://www.tecoffshore.com/
[16] For more information, visit the R3-IoT website at https://r3-iot.com/
[17] For more information, visit the Carbonmap website at https://www.carbomap.xyz/

aerial vehicles (UAVs) and airborne light detection and ranging (LiDAR) for inventory, planning and carbon accounting in forestry and land management.

- Scottish firms have also demonstrated capabilities to contribute towards solutions in natural capital accounting. For example, EOLAS Insight[18] has developed space-based analytical tools to measure biodiversity, monitoring animal populations and changes in their habitats.

Figure 5 Farmland

Source: Pixabay

- **Lack of internal data analysis expertise**
  - Many of the public sector organisations that were consulted would benefit from improved data access, especially to Earth Observation data. The precise details of this varies from greater availability of data to lower cost commercial data, or simply a greater awareness within their organisation of data that is currently available. Few organisations involved in this study have an internal data team with sufficient expertise in geospatial data to conduct original analysis.
  - Many organisations would benefit from a greater awareness of available products, and an understanding of the costs of data. There is likely to be significant interest in a hypothetical suite of interim data analysis tools that sits outside an organisation and provides "**insight-ready**" outputs ('Insight as a service').
  - Numerous firms within the Scottish space sector have recognised the importance of this challenge area and made inroads towards expanding engagement with space-based data. These innovations aim to lower the barriers to entry in terms of inputs such as specialist training and staff time. A prime example of such innovation is the Edinburgh-based firm Earth Blox[19], an Earth Observation company that has developed a user-friendly "no code" interface. The drag-and-drop design of the analytics platform aims to reduce the burden, perceived and actual, of engaging with EO data and thus reduces the need for extensive staff training.

[18] For more information, visit the EOLAS website at https://eolasinsight.com/about
[19] For more information, visit the Earth Blox website at https://www.earthblox.io/

Figure 6 Data analysis

Source: Pixabay

- **Need for improved monitoring of visitor movements and impacts**
  - Within the tourism sector, there is a desire to build capacity to monitor the movements of visitors around historic, natural, and other attractions at tourist destinations. This data could aid organisational planning by supporting optimised resource allocation, such as staffing, to appropriately manage surges at peak times and at peak locations. A solution is likely to hold large potential value for the affected organisations as they benefit from a greater ability to manage (and reduce) bottlenecks and queues; increase visitor capacity and potential revenues; and improve the sustainability of Scottish tourism.
  - The current offering from freely available Earth Observation data providers is not thought to be sufficient to solve this challenge given cloud-cover issues and limitations to temporal and spatial resolution, but future innovation and combination of sources (space-based and on the ground) could lead to an appealing product.
  - Some firms in the Scottish space sector demonstrate the capacity to deliver solutions to this challenge area. For example, R3-IoT[20] has developed a full-stack digital platform, combining satellite communications, cellular, IoT and data analytics, to enable the operation of in-situ sensors in remote areas regardless of the existing infrastructure. This technology and expertise may form a critical input to enabling the improved tracking of visitor movements and the effective deployment of public resources.

[20] For more information, visit the R3-IoT website at https://r3-iot.com/

Figure 7 Car park monitoring

Source: Pixabay

In addition to these six challenges, a wider range of challenges were highlighted, including the immediate challenges around the **economic recovery from the Covid-19 pandemic and restrictions**; **access to skilled labour**; **rising input costs** across the economy; and increasing **demand on energy infrastructure**. This "longlist" of identified challenges is included below, briefly outlining the reason for exclusion from main list of identified challenge areas:

Table 1 Selection of longlist of challenge areas

Challenge	Description	Motivation for non-inclusion
Enforcement of maritime regulation	There is an ongoing need to enforce regulations around illegal dumping at sea; ensure vessels operate within their permitted area; and to combat illegal fishing from "dark" vessels – those with a switched-off Automatic Identification System (AIS) which is used for tracking.	There was less breadth of interest among consultees in this challenge area than in other challenge areas. The multi-faceted issues in maritime regulation include aquaculture, illegal dumping, "dark" vessels, and other issues. There was insufficient interest among consultees in each of these challenges individually. Furthermore, the heterogeneity of potential solutions and the associated regulatory responsibility (local, national, international level), complicated the articulation of this challenge as one for strictly for the Scottish public sector and space-based technology.
Monitoring infrastructure	There is an ongoing need to monitor infrastructure or agreed building projects, including road and rail.	There was less breadth of interest among consultees in this challenge area than in other challenge areas, although elements of this challenge (such as the monitoring of coastal assets) have been captured in the broader "inefficient allocation of field staff and volunteers".
Challenges in farming	Challenges include tracking and locating livestock; identifying pests; predicting yields; and irrigation.	While Scotland has a robust agriculture sector, there was limited breadth of interest for new space-based solutions in this area compared to other potential challenges. Additionally, numerous barriers to adoption of space-based solutions exist in the Scottish context. This includes a significant focus on grazing livestock, for which applications are limited. Furthermore, a relatively old farming labour force, with the majority of Scottish farmers

Challenge	Description	Motivation for non-inclusion
		over 55 years old[21], suggests a potential hurdle to the adoption of new techniques and digital technologies. Finally, a higher proportion of relatively small land parcels compared to those in other countries, such as the United States, suggest reduced economies of scale to recover the fixed costs of the adoption of novel space-based solutions. On the supply side, the proliferation of space-based solutions for agriculture, particularly in Earth Observation, suggests a saturated market with limited growth opportunities for new entrants that might originate in Scotland.
Management of heat loss from public buildings	Management of public buildings (including historic buildings and social housing) for heat loss. This challenge relates to both environmental and fuel poverty concerns.	There was insufficient interest in this topic among consultees to warrant its own challenge area. Consultees who discussed this challenge area suggested that in-house sensor development was a higher priority in, for example, social housing than introducing space solutions. More granular information on energy inputs and a "room-by-room" approach were considered a higher priority for policy delivery than a "whole house" approach delivered from space.
Demand-responsive transport	The need to fill public transport gaps where there is an insufficient critical mass of users, especially in rural and remote areas. This challenge requires digital connectivity, vehicle positioning information, and data analysis.	There was low interest in this challenge area among consultees. The dependence of this challenge on addressing connectivity issues in remote areas suggests that "slow, unreliable or unavailable digital connectivity" is a higher priority challenge, and a prerequisite to considering such technological solutions.
Pollution and poor air quality	There is an ongoing need to understand where and when pollution is happening, and what impact pollution is having on the air people breathe.	There was low interest in this challenge area among consultees. This challenge links to elements of the "need for climate-conscious use of resources", but pollution and poor air quality was not highlighted as a priority by consultees. Additionally, the availability of in-situ air quality monitors suggested a space-based solution may be redundant.
Barriers to adopting new or innovative technologies	Private businesses operating with low profit margins are reluctant to adopt "unproven" new technology or new methods that have not been demonstrated, for example in the farming or construction sectors.	This is a very broad-based and general challenge area, the core of which is an unwillingness for private businesses to take on higher levels of risk where there is a lack of demonstrated benefit. This challenge is considered too general to be useful as a stand-alone challenge area, although elements of this topic are captured in the "lack of internal data analysis expertise" and "inputs into optimal siting of construction projects".

Source: London Economics analysis of responses in stakeholder consultations

Recommendations

To address some of the specific and systemic challenges identified in this report, there are a number of actions that can be undertaken by leaders and stakeholders in the Scottish space industry.

[21] Scottish Government (2020), Scottish agriculture census final report, available at: https://www.gov.scot/publications/scottish-agricultural-census-final-results-june-2020/pages/12/

- **Challenge-led funding**
  - Funding calls could be used to source innovative ideas from the Scottish space industry to address specific challenges and support the implementation of the best ideas. The UK Space Agency's Space for Smarter Government Programme (SSGP) sought to achieve a similar objective and has shown that the successful implementation of useful space applications can be achieved through challenge-led funding that fosters the involvement of users as well as innovators. However, this programme has had limited success in supporting sustainable solutions. At the time of the 2018 economic evaluation of the project, no SSGP had been procured on a commercial basis for national use, and few have been procured on more limited scales once grant funding ended, even though the general effectiveness of solutions could be confirmed. An explanation for this included a lack of user appetite and/or capacity to procure demonstration solutions on a commercial basis at the end of the project. A Scottish challenge-led funding call should consider how best to ensure there is a legacy effect of the grant – for example, limiting support for challenges where users have been screened for their commitment and ability to procure solutions long-term.
  - Regardless of whether supported challenges are procured long-term, a challenge-led initiative should create tangible examples of Scottish space solutions addressing Scottish challenges. These demonstrations can act as beacon of inspiration for potential suppliers and customers of space applications alike – in effect offering a catalytic effect of showcasing the value of space, 'busting myths' about space applications, and demonstrating the capacity of the Scottish space industry to support SMEs and innovation.
- **Centralised resource to match challenges with potential suppliers**
  - The nature of some of the challenges studied in this report suggests matching between challenge setters and potential suppliers could be improved. Scottish space companies already have some products and services that could meet some of the reported challenges, either directly or with limited adaptation. A centralised resource to facilitate matching could expedite the solution to real challenges.
- **Information dissemination**
  - A majority of stakeholders lacked a complete view of available funding mechanisms to seek ways to address challenges. A widely publicised and centralised resource to disseminate information on new grants or funding opportunities, (and potentially user requirements, and existing capabilities) could allow more stakeholders to address challenges through existing mechanisms. Talent, opportunities, and solutions could therefore be matched organically – potentially without a dedicated challenge fund mechanism. While resources such as Scottish Enterprise's Funding Database[22] exist, lack of stakeholder awareness implies a need for heightened focus on dissemination.

[22] Scottish Enterprise. (2022). 'Funding Database'. Available at: https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/business-grants/funding-database

Index of Tables, Figures and Boxes

Tables

Figures

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