ANNEX F

SSAC REPORT – Scotland's Space Sector: Exploring potential future opportunities

Brief overview of Scottish academic landscape

A review and mapping exercise on the strengths of academic R&D in Scotland relevant to the Space Sector. This should include directly relevant R&D such as space structures and systems, as well as indirect relevant R&D such as data analytics. Analysis completed for:

Universities	
N/A	Abertay University
X	Edinburgh Napier University
X	Glasgow Caledonian University
X	Heriot-Watt University
N/A	Queen Margaret University
N/A	Robert Gordon University
X	University of Aberdeen
X	University of Dundee
X	University of Edinburgh
X	University of Glasgow
X	University of St Andrews
X	University of Stirling
X	University of Strathclyde
X	University of the Highlands and Islands
N/A	University of the West of Scotland

Supporting Institutions	
X	Fraunhofer Centre for Applied Photonics
X	National Manufacturing Institute for Scotland (NMIS)
X	CENSIS
X	The Data Lab

☒	Royal Observatory Edinburgh
☒	The Satellite Applications Catapult
☒	Asteria

SUMMARY

Strong academic research is one of the pillars of industrial progress, especially in the sectors of the future, such as Space technologies. Scholars based in Scottish universities are top specialists in the fields relevant to the space sector. They participate in numerous international programmes contributing to organising and maintaining space missions and analysing data obtained through them. Despite the long-term nature of space exploration, the government should support research and development-driven innovation now to secure capturing a fraction of the newly emerging markets of on-demand launches, Earth observation, satcomms, the lunar economy, etc. This document presents information on existent scientific strengths relevant to the space sector in Scotland.

The government's view set out in the Science and Technology Framework (https://www.gov.uk/government/publications/uk-science-and-technology-framework) identifies five critical technologies of the future: Artificial Intelligence (AI), Engineering biology, Future telecommunications, Semiconductors, Quantum technologies. These technologies are key drivers of the development of the UK space economy, as well. In its turn, space research and space applications can be an inspiration for breakthroughs in science. Also, the Space sector provides a global scale for innovations in these critical technologies increasing their positive impact. There are 10 priority areas stated in the National Space Strategy (www.gov.uk/government/publications/national-space-strategy-in-action). This report reflects the alignment between these areas and identified scientific expertise in Scotland's academia.

1: Capture the European market in commercial small satellite launch

The industry of commercial small satellites is complex, consisting of launch, upstream and downstream components. The work undertaken in Scottish universities, such as the University of Strathclyde, was in the foundation of the first commercial CubeSats. The researchers continue delivering innovation in this sector supporting existing collaborations with the space business companies and working on improving the properties of satellites and

their manufacturing pipeline with the support of institutions, such as NMIS. Universities with a large number of scholars working on space technologies, such as the University of Glasgow, maintain big centres to stimulate long-term future thinking for developing new methods in satellite network communication, satellite equipment and satellite data analysis. Growing its existing strengths, the University of Edinburgh aims to position Edinburgh as the space data capital of Europe.

In addition to the currently possible commercial usage, small satellites can be platforms for testing emerging technologies in quantum computing, applied photonics and innovative telecommunication.

2: Fight climate change with space technology

Multiple Scottish universities have research groups working on improving and more efficient usage of Earth observation technologies. This research area has direct application to the assessment of the anthropogenic impacts, monitoring and tackling climate change. It is also important to understand the ecological, economic and societal impacts of developing space economy infrastructure. This information can be used in numerous commercial and public services: monitoring farming, fishing and construction infrastructure, as well as bridge and road damage, preventing and mitigating the impacts of natural disasters. It is important to continue the programmes, such as the Centre for Satellite Data in Environmental Science, to train high-class environmental scientists. It is important for the innovation hubs, such as the Data Lab, to continue connecting satellite data analysis and high-tech companies to develop new profitable services.

3: Unleash innovation across the space sector

There are emerging technologies, which require a focus of the academic community to become applicable in the space sector. Some examples, where there is strong expertise of Scottish scientists are photonics and quantum technologies. Robotics and AI technologies play a significant role in developing autonomous systems, assistive technologies and operation systems in space. It is a positive practice, that Scottish universities cooperate in such initiatives as the National Robotarium.

A prospective area of space innovations is bio-based techniques for mining, in-situ resource generation and recycling in space, which should enable space explorations for humanity and make our operation more sustainable in space and on Earth. Considering the number and international recognition of research groups, Engineering Biology is one of the areas of research strength in Scotland.

4: Expand our horizons with space science and exploration

There is a large number of Scottish scientists working on astrophysics research, on studying geological aspects of extraterrestrial objects and Earth. A lot of scholars are involved in projects such as the LISA mission, Rosalind Franklin Mars Rover. Missions like this can not only answer fundamental scientific questions, but also be a test-bed for prospective technologies in robotics motion and control, extraterrestrial mining and in-situ resource usage. Supporting this research would make Scotland a valuable stakeholder in global projects such as the Artemis lunar programme. These projects set a foundation for far-future space exploration.

5: Develop our world-class space clusters

The Scottish Space Academic Forum (SSAF) is an initiative aimed at ensuring collaborative ties between university researchers and industry. Big space research centres, such as Space Glasgow, the Bayes Centre, the Aerospace Centre of Excellence, etc., are already actively working with space-oriented businesses. In the past, there was an example of the Space Technology Centre at the University of Dundee, which gave rise to a constellation of world-impactful spin-offs. It is important to ensure the sustainability of research at the academic centres and significant support to long-term projects.

It will be beneficial to spread information about the world-leading space research ecosystem present in Scotland to attract more talented experts and collaborators/customers. It is also crucial to inform about positive examples of profitable space companies emerging in Scotland.

6: Lead the global effort to make space more sustainable

There is demand for developing technologies to manage and measure space debris, improve our ability to repair satellites and improve the sustainability of the space supply chains. Numerous research groups in Scottish universities work on the topics of debris removal,

satellite orbital modifications and optimising production processes. The work of these groups should be supported and used in various demonstrative missions to set standards in these key areas of the space economy.

Space economy infrastructure exists not only in outer space, but on the Earth as well. There are numerous research groups of ecologists and environmentalists in Scotland. Their studies are not directly related to the space industry applications, but their expertise is important to evaluate risks and mitigate any negative consequences of developing space capabilities in Scotland, for example, at space ports.

7: Improve public services with space technology

Earth observation, as mentioned above, can provide tremendous benefits to support construction works, farming, energy sector. There are Scottish scientists, who work on developing models that allow to translate satellite data into impactful information for business and the public. International collaboration, for example, to achieve UN SDG or to mitigate the consequences of natural disasters, could position the UK and Scotland as a global leader in this humanitarian sphere.

8: Deliver the UK Defence Space Portfolio (www.gov.uk/government/publications/defence-space-strategy-operationalising-the-space-domain)

A lot of technologies developed by Scottish scientists in space research can have dual applications in the civilian and defence sectors. Defence Space portfolios priorities are a) Secure Satellite Communication, b) Space Domain Awareness which works in conjunction with the civil Space Surveillance and Tracking programme, c) Intelligence, Surveillance and Reconnaissance which comprises usage of Earth observation techniques, d) Space Command and Control which is focused on data analysis and training professional in it, e) Space Control to develop adequate resilience of space infrastructure, f) Position, Navigation and Timing which focused on precise navigation and timely delivering, g) Launch.

9: Upskill and inspire our future space workforce

Due to its frontier science, Scottish universities attract the best talents to work on various topics including the space sector-related ones. Scottish universities offer a competitive career ladder for early-career researchers in space topics to pursue. In addition, several universities

participate in public engagement events, that promote STEM education and in particular Space research among school students. These activities can be inspiring for both academics and students. International collaborations and addressing global challenges are beneficial for established researchers to learn new techniques and approaches.

10: Use space to modernise and transform our transport system

I have not found many laboratories that link together the transport system and space research in Scotland. The space sector is closely connected to launch and aircraft transport. Thus, it is possible, that work in the transport area is done by businesses and charities at the Scottish Space clusters. There are also clear applications of satellite communication in the control and navigation of drones and optimisation of railway and car transport. UKSA and ESA can provide funding in these areas.

EDINBURGH NAPIER UNIVERSITY

Edinburgh Napier University does not have any study programmes specifically related to the space sector.

There is a Centre for Artificial Intelligence & Robotics (CAIR) – human-robot interaction, the design of robots to operate in unknown environments (such as space exploration). They mention collaboration with the National Robotarium and partners at NASA Jet Propulsion Laboratory on their website. However, it might be possible that the person, who has previously worked in the NASA JPL has left Napier University and became a Senior Strategic Partnerships Manager in Edinburgh Innovations.

Also, there is a Centre for Cybersecurity, IoT & Cyberphysical Systems.

Several scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Prof Robert Briers – ecologist, who uses Geographical Information Systems and remote sensing techniques to research conservation and carbon flows;

Prof Sally Smith – the Director of the Centre for Computing Education Research at Edinburgh Napier University. Her research interests are mobile and pervasive computing. She has previously worked in the telecommunications and aerospace industries in the UK and Europe;

Dr Naser Ojaroudi Parchin – an electrical engineer interested in antennas currently focused on microwave power transfer. In the past, he was a research fellow in SATNEX V project, funded by ESA.

Connections:

The National Robotarium.

GLASGOW CALEDONIAN UNIVERSITY

The Glasgow Caledonian University has no study programme directly related to the space sector, but space applications are a part of BEng (Hons) Electrical and Electronic Engineering, Meng Electrical and Electronic Engineering.

In 2023, there was founded a space forum group “Research into the Space Economy”, which aims to inform practitioners, academics, etc. about the current developments in space business and the Space Economy and to offer insights about the future. The representative of the forum is Prof D Edgar

Several scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Dr Godwin Enemali – electronics engineer. His work is focused on laser-based sensing and instrumentation systems for environmental monitoring, industrial process tomography, green transportation, engine diagnostics and fuel research;

Dr Andrew Wilson – specialist in space sustainability with a focus on life cycle assessment, carbon accounting and energy systems of engineering projects;

Dr Firdous Ul Nazir – electrical engineer working on power system operation and optimisation, renewable energy integration;

Dr Keith J Baker – a policy specialist with an interest in energy and the built environment. He leads the partnership of the Built Environment Asset Management (BEAM) Centre at the Glasgow Caledonian University with the Aerospace Centre for Excellence at the University of Strathclyde;

Dr Muhammad Usman – electronic engineer. He works in the field of 5G, radio frequency sensing and communication, cyber security;

Dr Sajid Nazir – Computing specialist. His current research interests include deep learning, embedded systems, blockchain and cloud computing. He worked on developing solar-powered remote monitoring systems supporting satellite and cellular communications. He has also worked in the industry as a Systems Engineer at Firstco Ltd., London;

Dr Caroline Gallagher – Environmental Impact Assessment and Geographical Information Systems (GIS). Her applied research informs policy and practice in urban greenspace planning;

Prof Bonnie Steves – astrophysicist, who studies celestial mechanics, solar system dynamics, and chaotic systems applied to planetary stellar systems;

Dr Roberto Ramirez-Iniguez –Building Integrated Photovoltaic (BIPV) Systems, optical front-ends for wireless infrared and visible light communications, optical antennas and optical collimators for illumination;

Dr Juanma Parrilla-Gutierrez – engineer, who studies the Origin of Life using Artificial Intelligence, Computer Vision and 3D-printing in building autonomous robots.

Connections:

Research into the Space Economy;

Built Environment Asset Management (BEAM) Centre;

ESA.

HERIOT WATT UNIVERSITY

The Heriot Watt University has several programmes directly related to the space sector: BEng (Hons) Aerospace Engineering and MEng Aerospace Engineering, MSc Imaging, Vision and High-Performance Computing.

There are Institutes of Photonics and Quantum Sciences, of Mechanical, Process and Energy Engineering, of Sensors, Signals, and Systems.

Several scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Prof Robert Thomson – photonics and its applications in astronomy, laser manufacturing, fundamental physics and medicine. Co-founder of the laser-manufacturing spin out, Optoscribe;

Prof Yvan Petillot – Robotics and Computer Vision. He works on robotics solutions to service the offshore renewable sector, but similar technologies of robots could be used in space;

Prof Duncan Hand – specialist in Applied Optics and Photonics, who works on the applications of high-power lasers for manufacturing, sensing and medical applications;

Prof Brian Gerardot – Quantum Photonics. His research may play a crucial role in the development of future hardware for the communications, metrology, etc;

Prof Gerald Buller, Prof Ajoy Kar – Photonics and Optics. They work on quantum cryptography and single-photon technologies for enhanced imaging approaches;

Prof George Goussetis – Wireless Communications, Antenna Components for Space; His interests include satellite communications and developing technologies to enhance spaceborne antennas;

Prof Ross Donaldson – quantum optical technologies for satellite communications: receivers for satellite, high-bandwidth and addressing background noise in free space;

Prof Mehul Malik – quantum photonics. His research is focused on fundamental aspects of quantum mechanics and practical aspects such as quantum communication;

Dr Dimitrios Anagnostou – antennas, microwaves and applied electromagnetics;

Prof Mathini Sellathurai – Signal Processing in a range of applications including Radar, Lidar, Sonar and RF networks, Network Coding, Cognitive Radio, MIMO signal processing, satellite communications and underwater communications. She has a significant industrial research experience;

Dr Natalia Herrera Valencia – Photonics and Quantum Communication;

Dr Feng Zhu – Quantum Information and Quantum Optics. He is working on super-resolution of quantum imaging;

Prof Abderrahim Halimi –statistical signal and image processing, with applications to remote sensing (hyperspectral imaging, satellite altimetry).

Connections:

UK Astronomy Technology Centre (UKATC);

The National Robotarium – a world-leading centre for Robotics and Artificial Intelligence. Its research groups are Robotics and Autonomous Systems, Human-Robot Interaction, Precision Laser Applications;

UK Space Agency.

UNIVERSITY OF ABERDEEN

University has the Department of Planetary Sciences (www.abdn.ac.uk/geosciences/departments/planetary-sciences/about-us-1448.php). Their main research topics: Mars Research (REMS/Curiosity, HABIT/Exomars Surface Platform, ACS/Trace Gas Orbiter, ISEM/ExoMars rover, …), Climate Change studies, Geomorphological studies, 3D mapping system and geological studies, Remote Sensing and Radiative Transfer of planetary atmospheres (Far-infrared- Outgoing-Radiation Understanding and Monitoring (FORUM) of the ESA Earth Explorer Mission 9), Hardware development for planetary exploration. In addition, the department has expertise in astrobiology, especially investigating biomarkers, and collaborates with Biological Sciences in studying the impact of microorganisms on climate.

The Team of the Department of Planetary Sciences are

Prof Javier Martín-Torres – a theoretical physicist with expertise in radiative transfer, remote sensing, atmospheric studies, Mars Research and Astrobiology. The Principal Investigator of the HABIT/ExoMars 2020 instrument, and co-I of NASA´s Curiosity rover, Exomars rover and the ESA´s Trace Gas Orbiter;

Dr Thasshwin Mathanlal – engineer focused on instrument development for space and planetary exploration. He works currently on the HABIT project.

Dr Miracle Israel Nazarious – development of hardware and software for Earth and planetary research and exploration: instrument prototyping, laboratory and field site campaigns: Sub-liquid and Atmospheric Measurement (SAM), Metabolt, Methanox, HABIT project.

Juan Antonio Ramirez Luque – an experienced specialist in data analysis and software development for space instruments (HABIT) and drone mapping.

Dr Anshuman Bhardwaj – a specialist in remote sensing, trained in glacio-hydrological and planetary sciences. He has experience in high-resolution terrain modelling, using drones for environmental and Mars research;

Dr Shaktiman Singh – field-based terrestrial glacio-hydrological research using satellite data. He has been involved in planning and carrying out Martian land-surface research;

Dr Lydia Sam – environmental research of planetary surfaces using drones, airborne and satellite remote sensing and GIS, terrain modelling and interpretation, including Martian landforms;

The Department of Planetary Sciences runs a programme: MSc Planetary Sciences

Several other scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Dr Iraklis Giannakis – geophysicist, who uses machine learning and signal processing for non-destructive testing and geophysical investigation. It was applied to analyse lunar radar data and see what lies beneath the lunar surface;

Dr Alexander Brasier – geochemist and astrobiologist, who studies the identification of ancient microbial fossils in addition to palaeoenvironmental reconstructions;

Prof Malcolm Hole – volcanologist, who is also interested in lunar research;

Prof. John Parnell – geologist involved in Mars research including life search and field campaigns support;

Dr Yingfang Zhou – advanced imaging techniques to study the minerals and mechanical properties of asteroid rocks;

Dr Maria Manoli – international space law with emphasis on sociopolitical aspects, including territoriality in outer space, and regulation of private companies operating in space;

Dr Amir Siddiq – multiscale modelling of materials and structures for a range of temperatures (cryogenic to high) and for a broad range of loading conditions including space crash/impact, and explosion-related damage simulations;

Dr Alfonso Martínez-Felipe – monitoring emissions and energy flow via visualisation tools and satellite technology. This research has implications for climate action;

Dr Maria Elena Giannaccini – expert in the fields of bioinspiration, mechatronics, soft robotics, robot sensing and safety in human-robot interaction;

Dr Raffaello Secchi – investigation of the impact of new video streaming technologies on satellite networking. He participates in the research supported by ESA: "Future Web Technologies and Protocols over Broadband GEO Satellite Networks";

Prof Vladimir Nikora, Dr Stuart Cameron and Dr Mark Stuart – the study of the turbulence flows related to the characterization of planet surfaces and their formation mechanisms;

Dr Fabio Verdicchio – researcher of signal processing and information theory, distributed communication systems and peer-to-peer networks, including satellite-based systems;

Prof Godred Fairhurst – researcher of Internet Engineering and Satellite Internet, especially IP transmission over DVB. Participant of the Satellite Network of Excellence;

Dr Marcus Campbell Bannerman – the development of engineering simulation software, which allows studying particle dynamics, such as cement. These simulations could also be applied to space rocks;

Dr William Harcourt – remote sensing & Earth observation, data science, artificial intelligence, Arctic science;

Dr David Green – environmental applications of geospatial technologies including: GIS, remote sensing, cartography, WebGIS and UAVs/drones to coastal & marine spatial planning, precision agriculture & viticulture.

Connections:

UK Space Agency;

ESA;

UNOOSA (The United Nations Office for Outer Space Affairs)

HABIT((HabitAbility, Brine Irradiation and Temperature)) (ExoMars Mission): HABIT will characterize the habitability of the ExoMars landing site Oxia Planum, in terms of Ultra-Violet (UV) radiation, air and ground temperature (T), as well as liquid water availability and in-situ atmospheric water extraction usage. This project involves international collaborations such as with ESA. HABIT will be the first demonstrator of a water-capturing system on the surface of Mars, and the first European In-Situ Resource Utilization on the surface of another planet. To be launched in 2028. (www.abdn.ac.uk/geosciences/departments/planetary-sciences/news/14262/);

Far-infrared-Outgoing-Radiation Understanding and Monitoring (FORUM) will measure from space the far-infrared part of the electromagnetic spectrum emitted from Earth. This has very important implications related to problems such as Climate Change. To be launched in 2026. (www.abdn.ac.uk/geosciences/departments/planetary-sciences/news/14263/);

Space North East: an outreach initiative to help teach students in schools more about space and planetary sciences.

UNIVERSITY OF DUNDEE

The University of Dundee is listed as a research organisation by the Science and Technology Facilities Council and UK Space Agency (www.ukspacefacilities.stfc.ac.uk/Pages/University-of-Dundee.aspx). There were several successful space projects developed at the Space Technology Centre at the University of Dundee: image processing chips for vision-based navigation for planetary landers, a software tool to simulate planetary landing, surface roving and in-orbit rendezvous operations (PANGU, currently used by ESA), data-handling network for on-board spacecraft (SpaceFibre). The latter two are currently supported by the spinout STAR-Dundee (www.dundee.ac.uk/stories/space-research).

I have not found open information about the Space Technology Centre at the University of Dundee. I have sent an e-mail enquiry to them to find out, whether it is possible to find out whether it still operates and what are the current projects there, but received no response. It is possible, that this Centre is not funded anymore, therefore Scotland's Space Strategy does not mention the University of Dundee as an important Research and Development centre.

Several scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Prof Mark Cutler – Earth Observation methods to extract information relating to terrestrial and freshwater ecosystems;

Dr Thomas Jones – the development of new manufacturing processes by implementing devices such as Laser, 3-D printing, inkjet and traditional metal casting;

Prof Gunnar Hornig – the magnetohydrodynamics, behaviour of electrically conducting fluids such as plasmas in the atmospheres of stars;

Dr Agis Athanassoulis and Dr Irene Kyza – numerical algorithms for the Schrodinger- Poisson system with applications in cosmology;

Dr Scott Gregory – analysis of the stellar magnetism data and multi-wavelength observations of young stars study stars and planetary systems development;

Dr Soko Matsumura – theoretical astrophysics, with a focus on the formation, evolution, and dynamics of planetary systems, especially the circumstellar disks and the debris disks;

Dr Karen Meyer – simulation and observations of the Sun's magnetic field;

Dr Aurora Sicilia Aguilar – theoretical astrophysics, with a focus on star formation and protoplanetary disks

Dr David Pontin – investigation of the dynamics of magnetic fields: from the corona to the solar wind;

Connections:

UK Space Agency;

STAR-Dundee (www.star-dundee.com/);

Dundee Satellite Station Ltd (www.dundeesat.co.uk/#0), which is the former University of Dundee Satellite Receiving Station.

UNIVERSITY OF EDINBURGH

The University of Edinburgh has several study programmes related to the Space sector: BSc and MPhys Astrophysics, BSc and MPhys Physics with Meteorology, BSc and MEarthPhys Geophysics and Meteorology. There are also numerous programmes teaching Physics and Astronomy as a part of the course.

The Bayes Centre (www.ed.ac.uk/bayes/access-expertise/space-satellites) brings together the University of Edinburgh's expertise in Space and Satellites and facilitates collaborations with the space industry, creating real-world impact. It works closely with the Edinburgh International Data Facility which hosts large volumes of satellite and other geospatial data to enable new research and large-scale analysis in areas such as environmental sustainability, agricultural technologies and geo-spatial planning.

There is **the Space Innovation Hub**, whose ambitious mission sounds like "establish the city of Edinburgh as the Space Data Capital of Europe by 2030". They host large volumes of satellite and other geospatial data, support the strategic expansion of Space and Satellite-related research across the University, create partnerships with companies, NGOs and governments, create an ecosystem for start-ups and spin-outs, and enhance sector-specific training.

Team (www.ed.ac.uk/bayes/access-to-expertise/specialist-areas/space-satellites/space-hub/space-and-satellites-team): Kristina Tamane – Space Sector Lead, Prof Iain Woodhouse – Space Research Theme Lead;

Academic colleagues working in Space: (list taken from the website above. Scholars, who do not have mentioning of space-related research in their profile are marked with asterisks)

Prof Tughrul Arslan – engineer addressing the challenges associated with current and future electronic system design. Algorithmic research and software and hardware platform developments addressing areas such as navigation and telecommunication. He works on fault tolerance, adaptive digital systems;

Prof Robert Bingham – investigating world's ice sheets and glaciers dynamics;

Prof Charles Cockell – astrobiology and microbiology. His research focus lies in the study of life in extreme environments, understanding the diversity, processes and biosignatures of life in extremes, the potential habitability of extraterrestrial environments and bio-mining;

*Dr Rachael Craufurd Smith – specialist in media law, the regulation of culture and European Union law;

Prof Colin Cunningham – precision engineering for astronomy, especially optical telescopes;

*Prof Andrew Curits – imaging and inverse theory, machine learning, seismology, mathematical and quantitative geology;

*Prof Godfrey Fitton – developing X-ray analytical techniques in petrology and geochemistry of basic volcanic rocks;

Prof Raja Ganeshram – marine biogeochemistry and oceanography with a focus on polar sea ice environments;

Dr Yanyan Gao – particle physicist working on topics including Dark Matter in space;

Prof Noel Gourmelen – investigation of the response of the Cryosphere to a changing climate. Using Earth observation techniques for measuring ice caps, glaciers;

*Prof Margaret Graham – carbon and biogeochemical cycles in sustaining life;

Dr Steven Hancock – developing methods to measure vegetation structure with remote sensing instruments and using these data to better understand climate, weather and ecological processes. Global Spaceborne LIDAR.

*Dr Lara Kalnins – geologist, whose expertise includes analysis of magmatism and paleogeology on Mars;

Dr Stuart King – mathematician, who studies fluid dynamics and applications of machine learning algorithms, particularly to image-like data. For example, he works on improving synthetic aperture radar satellite imagery;

*Prof Finn Lindgren – mathematician, working on spatio-temporal stochastic models, environmetrics, computational methods and software;

*Prof James Loxley – specialist in Renaissance and early modern literature. He used geolocation and visualisation technologies to map historic literary scape;

*Prof Ian Main – geologist studying fluid-rock interactions and earthquakes: predictability, dynamics, triggering.

Dr Fraser MacDonald – specialist in historical geography, geopolitics, visual culture, histories of social and scientific knowledge, the Cold War and the history of astronautics;

Prof Edward Mitchard – developing methods for mapping natural carbon stocks globally using satellite data. He is the Chief Scientist of Space Intelligence Ltd;

Prof Simon Mudd – specialist in arid region hydrology, geomorphology and landscape changes due to tectonic, climatic and bio factors, who uses satellite data;

*Dr Mark Naylor – statistical seismology and forecasting of earthquakes and other hazards

seismic monitoring of bedload transport in mountain rivers;

*Prof Bryne Tendelo Ngwenya – aqueous environmental and microbial geochemistry of metals, coupled fluid flow and rock deformation;

Dr Caroline Nichol – remote sensing of photosynthetic light use efficiency, including using space-borne LiDAR;

*Tom Ogilvie – Senior Consultant at Edinburgh Innovations;

Prof Paul Palmer – Atmospheric composition modelling. He is developing novel mathematical models for satellite data on CO2 and methane in Earth's atmosphere, is developing a 3D Mars Global Circulation Model with a focus on atmospheric chemistry, is studying the atmosphere of exoplanets;

*Caroline Parkinson – strategy lead for the engagement with the Creative Industries at the Edinburgh Futures Institute;

Dr Genevieve Patenaude – carbon management, forest loss risks, forest finance, Kyoto Protocol and Post-Kyoto international negotiations, Ecosystem services. She was involved in the development of a mission concept for a Spaceborne Multispectral Lidar (NERC NCEO).

Dr Symon Podilchak – engineer in antenna and radar systems, professional software design, including in small satellites and military applications;

Dr Hugh Pumphrey – geophysicist and meteorologist, who uses microwave limb sounding and develops techniques for the UARS (Upper Atmosphere Research Satellite) and the EOS AURA satellite;

*Prof Murray Roberts – a marine biologist who studies the biology and ecology of deep-sea or cold-water corals. He is a coordinator of iAtlantic project: integrated assessment of Atlantic marine ecosystems in space and time;

*Dr David Rush – Fire Safety Engineering, focusing on the structural performance in fire of both conventional and innovative structural materials and systems;

*Dr Nayha Sethi – bioethics and in particular, the interface between medicine, ethics and the law. She worked on the design of autonomous medical systems;

*Ksenia Siedlecka – Financial Services & Fintech Engagement Manager, Edinburgh Futures Institute;

*Prof Chris Seed – informatician, who studies the Network Society, Digital Art and Technology, and The Internet of Things;

*Prof Dan van der Horst – specialist in the sustainable use of natural resources, energy and ecosystem services. He also worked on the policy-related aspects of renewable energy projects;

Tom Wade – Chief Pilot and Facility Manager, Airborne Research and Innovation;

Dr Gary Watmough – specialist in developing approaches for geographical targeting of scarce resources across the planet. He uses multi-source data, such as satellite imagery to map and monitor aspects of human livelihoods. The majority of his projects have been co-designed with UN agencies;

*Prof Wyn Williams – Rock magnetism and Palaeomagnetism;

*Dr Marisa Wilson – human geography with the focus on uneven effects of plantation agriculture on environments and cultures.

The key Partners of the University of Edinburgh in Space Research are

SPRINT network (www.sprint.ac.uk/capabilities) – UK-wide of expertise and skills in space-related activities;

EDINA (edina.ac.uk/) – a world-class centre for data and digital expertise;

The Higgs Centre for Innovation (www.roe.ac.uk/higgscentre/) – an incubator for commercialising research in the space sector;

Ecometrica – a platform providing access to Earth Observation, geospatial intelligence and satellite mapping applications;

The National Robotarium – a world-leading centre for Robotics and Artificial Intelligence;

The Milo Space Science Institute (miloinstitute.org/) – a collaboration with Arizona State University and Lockheed Martin;

The Space Enterprise Lab by the Satellite Applications Catapult.

UK Astronomy Technology Centre – a national centre for the development of scientific instrumentation and facilities for ground- and space-based astronomy;

UK Centre for Astrobiology – a research centre studying life in extreme environments, and habitability on Earth and beyond;

Centre for Satellite Data in Environmental Science – the centre for doctoral training was launched in 2019 and aims to train 50-70 specialists in advanced data science and Earth Observation techniques. Funded by UK Space Agency and UKRI, it is a collaboration of the Universities of Edinburgh, Leeds, the National Oceanography Centre and the British Antarctic Survey.

Also, the University of Edinburgh is home to the Centre for Engineering Biology. One of its focus areas is Bio-Based Manufacturing in Space. It explores using microorganisms and other biological systems to secure the production of materials and resources needed to sustain life in space.

Several other scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Dr Matjaz Vidmar – researcher in innovation, entrepreneurship and future design, especially in the space industry, artificial intelligence and data-driven economy. He co-founded two new research networks, the Scottish Social Dimensions of Outer Space network and the international Social Studies of Outer Space network;

Prof Louise Horsfall – synthetic biology to improve the sustainability of biological processes and products. One of the themes is using microbes to accumulate rare metals from contaminated soils;

Dr Stephen Wallace – industrial biology using a combination of synthetic biology and chemistry to create novel metabolic pathways, which can be used in greener recycling;

Dr Alistair McCormick – biologist, who studies the optimisation of photosynthesis to engineer synthetic systems for the production of high-value biofuels and biochemicals;

Dr Rosa Santomartino – sustainable space exploration using microorganisms, space bioproduction, biomining;

Dr Samuel Patrick – astrophysicist interested in the formation of the universe using mathematical simulation models, high-performance computing;

Dr Pieter Blue – mathematician, who studies the geometry of black holes;

Dr Karen Donaldson – modular robots for enabling operations in extreme environments;

Dr Joan Simon Soler – mathematician studying particle physics and black holes;

Dr Adam Stevens – astrobiologist with a focus on the habitability of Mars;

Prof Simon Lewis – geologist, who uses Airborne SAR and LIDAR measurements to characterise biomass structure and water resources;

Dr Fergus Cullen, Dr Adam Carnall, Dr Derek McLeod – astrophysicists studying the evolution of galaxies using a combination of imaging and spectroscopic surveys and cosmological simulations;

Prof Ian Underwood – engineer in the field of in the field of liquid crystal microdisplays. He is a co-founder of MicroEmissive Displays (MED). He was involved in developing a water activity sensor system for planetary exploration;

Dr James Lucietti – a mathematical physicist working on black holes, general relativity and gravitational theories inspired by string theory and holography;

Prof Wasiu Popoola – electrical engineer in optical communications;

Dr Michael Davidson – Survey Astronomy Software Developer. For example, he worked on Gaia mission data;

Stelios Voutsinas – software engineer in Royal Observatory, who worked with Gaia mission data;

Dr Dominique Laniel – a physicist working on chemical interactions within organic substances under high pressure and on using Nitrogen for novel rocket propellant;

Prof Ram Ramamoorthy – a computer scientist with specialization in robotics and machine learning, focusing on learning, adaptation and control mechanisms to enable autonomous robots to cope with the unknown, and effective work in human-AI teams;

Dr Chris Evans – astrophysicist with an interest in stellar evolution. He works with VLT-FLAMES Tarantula survey and the European Extremely Large Telescope;

Prof Majid Safari – engineer studying the modelling, design, and analysis of optical communication systems. MIMO and techniques for energy-efficient and high-speed atmospheric optical links suitable for terrestrial (e.g., mobile backhaul) or satellite applications;

Prof Austin Tate – specialist in Artificial Intelligence. His work has been applied to search and rescue and emergency response tasks, space technology applications;

Prof David Laurenson – engineer working on mobile radio channel modelling, biomedical imaging, multihop routing and cognitive radio. He contributed to the paper discussing the use of LEO satellite constellation for active network management in power distribution networks;

Dr Simon Malpas – specialist in aesthetics, Romanticism, continental philosophy, literary theory, postmodernism, and the literature, culture and politics of the Restoration period. He co-authored “Creative Visions and Critical Reflections on Scotland's Space Futures”. He leads Social Dimensions of Outer Space Research Network;

Prof Conchur O'Bradaigh – specialist in fibre-reinforced composite materials with interests in manufacturing, testing and modelling of composite materials for renewable energy applications, cryogenic properties and space applications;

Dr David Garcia Cava – engineer with interests in structural vibrations. One of his lab projects is the dynamic characterisation of 3D printed components for space applications;

Dr Agata Rozek – astrophysicist working on modelling of near-Earth asteroid environment with ground-based optical and radar observations;

Dr Ross Collins – survey astronomy software developer;

Dr Encarni Medina-Lopez – civil and environmental engineering, remote sensing to study water, energy and environmental problems;

Dr Liang Feng – methane and carbon observations using satellite data;

Dr Alessandro Novellino – geoscientist, analysing natural hazards and landslides using remote sensing, Synthetic Aperture Radar;

Dr Murray Collins – specialist in environmental economics and forest carbon ecosystem, who uses satellite data;

Dr Mark Lunt – understanding of greenhouse gas emissions, using data from satellites and ground-based platforms;

Dr Douglas Finch – geoscientist, who worked on the detection of atmospheric NO2 plumes from satellite data;

Dr Chris Old – engineer, working measurement and characterisation for Offshore Renewable Energy development using satellite data observations;

Dr David Milodowski – landscape dynamics and forest structure impact analysis using satellite observations, for example, Light Detection and Ranging (LiDAR) surveys;

Prof Simon Tett –quantitative analysis of models and observations of climate change in order to constrain the future using satellite records;

Prof Peter Nienow – glacier hydrology and ice dynamics, ice-ocean interactions using satellite investigations;

Prof Wenxuan Hou – specialist in corporate finance, financial development, law and finance. He used satellite data to study drivers of low-carbon economy;

Prof Brian McKinstry – Health Service research particularly in remote information exchange between clinicians and patients. He is interested in telemonitoring chronic diseases including using geolocation;

Prof Dylan Clements – clinical and laboratory projects investigating osteoarthritis in dogs and cats. Part of his research is quantifying the mobility of animals using GPS;

Dr Andrew Gray – glacial Biogeochemistry. He used satellite data to characterise algae in the Antarctic.

UNIVERSITY OF GLASGOW

The University of Glasgow runs many study programmes in the field of modern science and technology. Among them, there are directly space sector-related: Physics & Astronomy PhD/EngD/MPhil/MSc, Astrophysics MSc, Geospatial data science PhD, Autonomous systems and connectivity PhD/MPhil/MSc.

Space Glasgow (www.gla.ac.uk/research/az/spaceglasgow/) is an umbrella group for space activities at the University. The research themes of the group are

Solar and heliospheric physics, Space weather monitoring and solar-flare forecasting – to mitigate risk in sensitive technological systems, on the ground, but also aircraft and spacecraft. The research involves spatial-temporal modelling of sensor data, optimal sensor positioning, sampling and data selection in 3D sensor networks, including satellites. Scholars: Prof Lyndsay Fletcher, Prof Marian Scott, Dr Matteo Ceriotti, Dr Eduard Kontar;

Water and life in the solar system – to develop models for the early evolution of Earth and Mars and exoplanets, to understand the availability of water and hydrogen on the moon, asteroids and Mars, and how it could be used to support human exploration of the Solar System. Scholars: Prof Martin Lee;

Extraterrestrial hydrology – to identify suitable extraterrestrial habitats. Scholars: Prof Darren Mark, Prof Finlay Stuart

The Sun as astrophysical accelerator – to understand fundamental plasma and high energy processes throughout the universe: from black holes to fusion laboratories on Earth. Scholars: Dr Iain Hannah;

Ultrasonic drill tools for planetary exploration – to obtain access to these underground areas of extraterrestrial planets such as Mars to search for water and other resources. Scholars: Dr Patrick Harkness;

Autonomous guidance of planetary rovers – to provide rovers with the capability to make decisions about path planning in situ, improving their reliable operation distance and ultimately increasing the data gathering about extraterrestrial objects. Scholars: Dr Douglas Thomson, Dr Euan McGookin, Prof Darren Mark;

Numerical models of stellar and planetary dynamos – to characterise the geomagnetic field and its implications on our plant, to investigate influences of solar magnetism, to use these processes as a navigational aid; Scholars: Dr David MacTaggart, Dr Radostin Simitev;

UK Fireball network – to build a network of all sky cameras across the UK to detect falling meteorites, recover and study them. Scholars: Dr Luke Daly;

Orbital dynamics, control and formation flight – to investigate methods to control the motion of bodies in space. This research should lead to reducing space technology costs. Scholars: Dr Matteo Ceriotti, Prof Colin Mcinnes;

Solar Sailing – to study the orbital dynamics and the control of solar sails, ultimately to allow cheaper and longer space missions. Scholars: Dr Matteo Ceriotti, Dr Patrick Harkness, Prof Colin Mcinnes;

Orbital debris – to improve the precision of the prediction of the orbit of debris to achieve safer space missions. Scholars: Dr Matteo Ceriotti, Dr Gianmarco Radice;

Asteroid deflection and exploitation – to improve the detecting of Near Earth Objects and to investigate mitigation and threat removal possibilities. Scholars: Dr Ian Watson, Prof Colin Mcinnes;

Technologies of the future developed at the University of Glasgow:

CubeSat-based ionospheric sounders – to develop an antenna system for measurements of the ionospheric channel that are crucial for the space-based radars of the future. Also, this mission will train expertise in building complex antennae and beacons in small satellite carriers. Scholars: Dr Patrick Harkness;

High-precision laser interferometry – to probe gravitational effects. The group is involved in the LISA mission, a joint effort of ESA and NASA to measure gravitational waves in space. There might be future applications in the area of high-power lasers, in manufacturing, in defence and communications. Scholars: Dr David Robertson, Prof Henry Ward, Dr Alasdair Taylor, Mr Michael Perreur-Lloyd;

3D printing of chemical nanofactories – to develop a chemical platform to use raw materials on Mars and Moon for fuel/water/basic chemical transformations. Scholars: Prof Lee Cronin;

Aerobrakes for space debris mitigation – to remove old spacecrafts securely. Scholars: Dr Patrick Harkness;

Landing on other worlds – to tackle challenges of extraterrestrial landing such as extreme conditions during atmospheric entry and abrasive dust. Scholars: Prof Konstantinos Kontis, Dr Hossein Zare-Behtash, Dr Andrea Cammarano;

ANDING ON OTHER WORLDS

Diamond electronics for space-based operation and exploration – to research solid-state-based electronics solutions to address the requirements of electronic component operation within the harsh environmental conditions of space. Scholars: Prof David Moran;

Cognitive binocular vision of space robotics – to develop reliable cognitive vision systems to allow robots to undertake complex missions. Scholars: Dr Paul Siebert;

Emerging Space technologies, Micro-to-Macro – to investigate new concepts for space technologies, satellite platforms and mission design from micro-to-macro length scales. The

group envisage a direct printing of structures in space, adaptable space platforms and a new class of space system, which uses clouds of networked sensor nodes. Scholars: Prof Colin McInnes, Dr Kevin Worrall, Dr Matteo Ceriotti;

Autophage nanolaunchers – to develop launchers for individual nanosatellites. Scholars: Prof Patrick Harkness, Dr Kevin Worrall, Prof Konstantinos Kontis;

Electric propulsion for small satellites – to develop microfabrication of electrospray sources for satellite propulsion. Scholars: Dr Enric Grustan-Gutiérrez;

Connections:

ESA.

NASA.

The University of Glasgow is involved in public initiatives to popularise Space research such as ISSET (International Space School Educational Trust), REXUS-BEXUS, Space internship network.

James Watt Nanofabrication Centre (JNWC): the source of many micro- and nano-fabricated components in use throughout the UK quantum technology programme. The University of Glasgow is working on the construction of the Clyde Waterfront Innovation Campus, which will be the expansion of the university's facilities in Medicine and Engineering, including the JWNC.

The University of Glasgow has notable expertise in Materials Research, Quantum and Nano Technologies, Robotics and Autonomous Systems.

There is a Centre for Quantum Technology translating quantum technologies into real-world applications.

Partners: Dnipro National University, Orbital Access Ltd (Prestwick), Royal Academy of Engineering, Alba Orbital Ltd, Craft Prospect Ltd, The Royal Society, EU Horizon 2020 Framework Programme, Clyde Space Ltd, OHB SE, Astronika, British Antarctic Survey.

UNIVERSITY OF ST ANDREWS

The University of St Andrews has several study programmes related to the Space sector: Environmental Earth Sciences BSc, Earth Sciences MGeol, Astrophysics BSc and Astrophysics MPhys.

Below is a list of scholars identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics. Some of them are combined in clusters according to their research institutes and groups:

Dr Mark Claire – a planetary scientist focused on the study of the early Earth, especially biogeochemical cycles of oxygen, carbon, hydrogen, and iron. He was part NASA funded research of Mars geochemistry and atmosphere;

Dr Aubrey Zerkle – isotope geochemist and geobiologist with research interests in the early Earth and extraterrestrial environments: isotope biosignatures for microbial activity, examining biogeochemical cycling in extreme environments such as Martian systems;

Dr Peter Woitke – a specialist in the field of star and planet formation. The PI of a SPACE project DIANA (DIsc ANAlysis) to learn about the physical and chemical properties of the planet formation;

Dr Paolo Pagano – investigation of magnetohydrodynamics, especially in the solar corona;

Dr John Elliott – specialist in developing capabilities for signal content analytics, decipherment of unknown phenomena and message construction, which is important for security systems, but also for extra-terrestrial life search. He is a Chair of the UK SETI Research Network and a Coordinator for the SETI Post Detection Hub;

Dr Katy Louise Chubb – characterising the atmospheres of exoplanets, with a focus on theoretical molecular spectroscopy.

Prof R Alan Cairns – theoretical physicist studying plasma physics relevant to nuclear fusion and magnetohydrodynamics in astrophysics;

Dr Friedrich Ernst Wilhelm König – quantum optics and quantum information, in particular, quantum optics in curved spacetime;

Astronomy Group (astronomy.wp.st-andrews.ac.uk/):

Exoplanets, star formation, galaxies and their evolution, cosmology and theories of gravity.

Prof Ian Bonnell – numerical simulations to probe the gravitationally driven gas dynamics in which star formation occurs;

Dr Ian Czekala – planet formation, radio interferometry, high resolution spectroscopy, hierarchical Bayesian inference and machine learning;

Dr Juan Venancio Hernandez Santisteban – the multi-wavelength study of accreting compact objects;

Prof Moira Mary Jardine – primarily a theorist collaborating with international observing teams, such as MagIcS and Bcool, to study the magnetic activity of a range of stars, their effect on the exoplanets detection and astrobiology of exoplanets.

Dr Rita Tojeiro – astrophysicist researching spectra of galaxies to understand the content, geometry and expansion history of the Universe;

Dr Anne-Marie Weijmans – investigation of the structure and evolution of galaxies using integral-field spectroscopy. Participant of MaNGA (Mapping Nearby Galaxies at APO) survey;

Prof Vivienne Wild – observational data and large simulations to study both the spectral and morphological evolution of galaxies following a starburst phase;

Dr Kenny Wood – research of the star formation and the interstellar medium. He works closely with observers in modelling data from observatories: the VLA, Hubble and Spitzer;

Dr Hongsheng Zhao – research of the dark matter with modelling and gravitational lensing;

Solar And Magnetospheric Theory Group (solar-mcs.wp.st-andrews.ac.uk/):

Applied mathematicians who study the Sun and the Earth's magnetosphere using mathematical modelling techniques. They use observational data from satellites and from ground based observatories. Industrial relevance: space weather forecasts;

Prof Thomas Neukirch – magnetohydrodynamics (MHD) equilibria, reconnection, particle acceleration, rotating magnetospheres;

Prof Ineke De Moortel – phase mixing, MHD waves, coronal oscillations, observations with NASA's Transition Region And Coronal Explorer (TRACE) spacecraft;

Dr Tom Elsden – magnetospheres, low frequency waves;

Prof Alan Hood – MHD instabilities, magnetostatic equilibria, tearing modes, prominences;

Prof Duncan Mackay – prominence theory, flux transport simulations, coronal heating;

Prof Clare Parnell – magnetic reconnection, coronal heating, magnetic carpet, solar and heliospheric observations;

Dr Alex Russell – magnetic reconnection, MHD waves, magnetic topology, solar flares, space weather;

Dr Andy Wright – magnetic helicity, alfvén waves, magnetosphere, resonant absorption, particle acceleration;

Dr Vasileios Archontis – investigation of magnetic fields and coronal mass ejection;

Prof Peter Cargill – studying coronal heating, plasma physics, magnetospheric physics;

Dr Klaus Galsgaard – 3D numerical computations, magnetic reconnection, flux emergence;

Dr Tom Howson – investigation of energy dissipation and wave propagation in the solar corona;

Dr Jim Lang – a specialist in spectroscopy, atomic physics, SOHO, STEREO observatory

Prof Eric Priest – researcher of, the solar wind, the Earth's Magnetosphere and the magnetic field interactions, especially in the solar atmosphere.

Prof Bernard Roberts – developing coronal seismology, a new field about the solar coronal magnetic field;

St Andrews Centre for Exoplanet Science (exoplanets.wp.st-andrews.ac.uk/)

Using a combination of geochemistry, field geology, spacecraft data, and numerical modelling the scholars study how the evolution of life has changed our planet with aims to uncover general principles that could affect the evolution and detectability of planets elsewhere in the Galaxy. They also work with philosophers and social scientists at the University of St Andrews to explore topics of ethics, responsible communication and public dialogue around exoplanet science.

Dr Adam Bower – international law and governance, space security, disarmament and arms control.

Prof Andrew Cameron – investigation of stellar magnetic fields and the discovery and characterisation of exoplanets. He leads the data analysis group for the Science Team for the ESA S-class CHaracterising ExOPlanets Satellite (CHEOPS; launch expected 2019);

Dr Claire Cousins – planetary scientist (geothermal systems, volcanism, biosignatures), who works on the technologies related to robotic space missions She is a part of the Panoramc Camera instrument team for the ESA ExoMars Rover;

Dr Martin Dominik – exoplanet search by microlensing, robotic telescopes;

Dr Emily Finer – literature scientist with a focus on topics in the intersections between global science fiction, exoplanet science, and space policy.

Prof Andy Gardner – investigation of Darwinian adaptation to social evolution, cosmological natural selection, anthropic bias;

Prof Keith Horne – specialist in the interpretation of astrophysical observations, developing novel data analysis and astro-tomography methods for exoplanet search. He worked on developing concepts and proposals for two space missions - NASA/Kronos and ESA/Eddington, neither of which was selected for flight;

Dr Sami Mikhail – geochemistry, petrology, atmosphere-formation with a focus on the influence of the accretion, differentiation, and plate-tectonic cycling;

Dr Paul Savage – geochemist who studies the formation and evolution of rocky planets;

Dr Aleks Scholz – an observational astronomer working on problems in star and planet formation. He works with space-/telescopes like the ESO/VLT, Subaru, Spitzer, Kepler, James Webb, Gaia and facilities ALMA and SMA;

Dr Eva Stüeken – geologist and geochemist interested in the early evolution of life and habitability of other planets.

Also, there is a Photonics Group (photonics.wp.st-andrews.ac.uk/) and a Condensed Matter Physics Group (www.st-andrews.ac.uk/physics-astronomy/research/research-areas/condensed-matter/), The Centre for Designer Quantum Materials (www.quantummatter.co.uk/), The Organic Semiconductor Centre (www.st-andrews.ac.uk/~osc/home.shtml) .

Several scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Dr Manuel Fernando Benitez Paez – geoinformatician using GIScience and data science tools to develop new methods for spatiotemporal problems, focusing on data fusion methods and urban analytics;

Prof Mike Fedak – ecology, physiology and life history of marine mammals using satellite and mobile data systems;

Dr Tun Jan Young – geophysicist and radioglaciologist, interested in the dynamics of glaciers and ice sheets and their response to climate change. He uses geospatial data.

Connections:

NASA, ESA;

University's Access Teams runs a Space School for pupils from schools across Fife;

There is the James Gregory Telescope. Almost all components of the telescopes have been manufactured in Scotland. The optical telescope has now been in operation for more than fifty years. (observatory.wp.st-andrews.ac.uk/jgt/);

The School of Physics and Astronomy communicates with the following companies: Photonics Scotland, M Squared Lasers Ltd, Sodi-Tech EDM Ltd (Sodick Technology Hub), KP Technology Ltd, Thomas Keating Ltd, PhotoSynergy Ltd, Razorbill Instruments Ltd, Ambicare Health Ltd.

UNIVERSITY OF STIRLING

The University of Stirling has 1 space sector-related course: MSc Environmental Remote Sensing and Geospatial Sciences.

Several scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Dr Evangelos Spyrakos – Earth observation studies with a focus on water ecosystems. He was funded by the ESA and Scottish government to use satellite data to monitor rives and carbon fluxes in the Arctic;

Dr Armando Marino – monitoring the environmental conditions that are predictors of outbursts of malaria epidemics, monitoring ocean pollution. His research was funded by the UK Space Agency and ESA;

Dr Thiago Silva – earth observation, creating software and hardware for ecological sensing. He collaborated with NASA and the Japanese Aerospace Exploration Agency on the topics of biogeochemical models of tropical aquatic systems;

Dr Verity Flower – researcher in remote sensing and natural hazards. She works with NASA , ESA, JAXA satellites to investigate patterns of activity in natural hazards, volcanic eruptions;

Dr Peter Morland – environmental scientist, who studies forestry using satellite data;

Mr Matthew Blake – tech specialist in Earth observation monitoring inland and coastal waters;

Dr Mortimer Werther – optical water colour remote sensing, oceanography, computer science;

Dr Dalin Jiang – using remote sensing for assessing water quality;

Dr Peter Hunter – ecosystem assessment and monitoring, environmental management, regulation and evidence-based policy-formation by development, validation and application of methodologies for processing, analysing and visualising data from drones, aircraft and satellites;

Dr Cristian Jose Perez – monitoring of surface water extent (flood/drought) from SAR imagery, extracting information from satellite imagery supported by statistical and machine learning algorithms;

Prof Andrew Tyler – Scotland Hydro Nation Chair. He leads the NERC consortium Global Observatory of Lake Responses to Environmental Change and forges the collaborative relationships across the Scottish water sector to deliver solutions for sustainable water management in Scotland, including going beyond net zero, using Earth Observation methods;

Prof Alistair Jump – a global change ecologist with a strong focus on understanding and predicting the impacts of climate change on plant populations. Used satellite data in his research.

Connections:

UK Space Agency;

ESA;

NASA.

UNIVERSITY OF STRATHCLYDE

At the University of Strathclyde, there is 1 study programme directly related to the Space Sector: MSc Satellite Data for Sustainable Development. There are also other programmes, which may contribute to the Space economy of the future: MEng Electronic & Digital Systems, MSc Photonics, MSc Quantum Technologies, etc.

The University of Strathclyde has a Space cluster, which is a single entry point to space-related activity. They claim to have expertise in Small satellite technology & engineering, Space safety & sustainability, Space mechatronics, robotics & autonomy and Earth observation & data analysis.

The university takes part in many space-related activities, for example, Virgin Orbit's Inaugural Spaceflight from Spaceport Cornwall in Newquay. It leads international collaborations such as quantum technology networks.

I have identified several centres at the University of Strathclyde, which work on projects related to the Space sector:

Aerospace Centre of Excellence

(www.strath.ac.uk/engineering/mechanicalaerospaceengineering/aerospacecentreofexcellence/research/) : Research in Computational Intelligence, Research in Computational & Theoretical Aerodynamics, GNC & Autonomy, Flight & Spaceflight Mechanics and Space Systems.

Projects: UTOPIAE European Research Training Network – European research and training network looking at cutting-edge methods bridging optimisation and uncertainty quantification applied to aerospace systems;

GOCE Re-Entry Prediction Uncertainty Analysis – theoretical and computational methods helping to predict the orbit evolution of the object in space expected to impact on the ground due to loss of altitude due to orbit perturbations;

Future UK Small Payload Launcher – to develop short and long-term technical roadmaps for building national capabilities for reusable launch systems for small payloads, and to perform technical feasibility studies on different partially re-usable launch systems concepts;

Physics-based Modelling and Simulation of Spaceplanes Nonequilibrium Aerodynamics – formulating innovative computational approaches that use an explicit description of the dynamics of the air molecules to perform accurate studies of strongly accelerating, decelerating and distorting flows around vehicles moving at supersonic and hypersonic speeds and at high altitudes;

Debris Evolution Uncertainty Quantification – to model the dynamics of objects, drag sails and fragments during de-orbiting and re-entry. To analyse the dynamics of debris in LEO subject to ionospheric effects. To quantify the uncertainties related to those processes.

Advanced Space Concepts Lab

Prof Massimiliano Vasile – Computer Intelligence specialist and Aerospace engineer. He has worked on non-deterministic planning for robots, fault-tolerant navigation systems for spacecraft and nonlinear uncertainty quantification in space flight mechanics, with particular application to space debris and asteroid manipulation;

Dr Christie Maddock – an expert in mathematical modelling and system design optimisation for trans atmospheric flight vehicles, including spaceplane-based launch systems;

Dr Jinglang Feng – orbital dynamics and uncertainty analysis around small solar system bodies. She works in the field of space debris removal and asteroid deflection;

Prof Matthew Cartmell – modelling of nonlinear dynamical systems, application of the principles of nonlinear dynamics to problems in structural vibration, energy harvesting, flexible rotors, and momentum exchange space tethers. He is involved in new experimental work for making fundamental measurements of gravitation;

Future Air-Space Transportation Technologies Laboratory

Dr Edmondo Minisci – engineer working in model-based analysis and design optimisation of complex mechanical/aerospace systems/devices;

Prof Marcello Lappa – fluid motion and stability behaviour, computational fluid dynamics, organic and inorganic materials sciences, particle dynamics and microgravity science. He has conducted scientific experiments in materials science on board the International Space Station;

Dr Marco Fossati – multiphysics computational aerodynamics. His expertise is in the field of high-speed and non-equilibrium flows, modal-based Modeling for aerodynamics, mesh optimization and generation;

Dr Mohammed Afsar –multiphysics computational aerodynamics, aircraft and rotorcraft aerodynamics, high-speed and non-equilibrium flows, modal-based Modeling for fluid dynamics and aeroicing, mesh optimisation and generation;

Dr Christie Maddock;

The Intelligent Computational Engineering Laboratory

Dr Edmondo Minisci

Dr Annalisa Riccardi – computational scientist working on optimisation, blockchain applications in aerospace, socio-economic applications of EO data, AI for industrial decision support;

Dr Christie Maddock;

Prof Massimiliano Vasile;

Dr Jie Yuan – the development of tools to optimise nonlinear aerospace systems in conditions of uncertainty, stability stress and contact friction;

Centre for Space Science and Applications

(www.strath.ac.uk/science/physics/research/centreforspacescienceandapplications/)

Projects: Satellite test of the Equivalence Principle – testing a fundamental principle in Physics (the equivalence of gravitational and inertial mass) in an ultra-quiet environment of space;

The Gravity Group (www.strath.ac.uk/science/physics/research/gravity/);

Ocean colour remote sensing – observation of the blooms of, plumes of sediments from rivers and areas of coastal erosion and simulating and validating physical-ecosystem models. Developing radiative transfer simulations that predict water leaving reflectance signals. Processing remote sensing data from NASA and ESA in order to assess algorithm performance;

The Marine Optics and Remote Sensing Group (pols.phys.strath.ac.uk/research/marine/)

Silicon hydride-based chemical rocket and scramjet propulsion – developing more efficient silicon-based fuel;

Strathclyde Intense Laser Interaction Studies Group (silis.phys.strath.ac.uk/index.htm);

Space radiation reproduction and radiation hardness testing at SCAPA – using high-power lasers to irradiate a target to mimic certain types of radiation in space. This helps to facilitate testing procedures and to improve radiation durability for the space technology;

Strathclyde Intense Laser Interaction Studies Group (silis.phys.strath.ac.uk/index.htm);

Space-based quantum experiments

Computational Nonlinear & Quantum Optics Group – developing quantum experiments that can be launched on nanosatellite platforms, CubeSats,

(cnqo.phys.strath.ac.uk/research/quantum-information/space-based-quantum-experiments/)

Dr Daniel Oi – quantum theory, quantum engineering, the theory of quantum computation, and quantum space science and technologies;

Dr Thomas Brougham, Dr Roberto Gonzalez Pousa – quantum communication for satellites;

Centre for Signal & Image Processing

(www.strath.ac.uk/research/subjects/electronicelectricalengineering/instituteforsensorssignalscommunications/centreforsignalimageprocessing/): Research in Sensor Signal Processing and Security, Broadband Multi-Sensor Processing, Video and Hyperspectral Imaging, Applied Space Technology, Neuromorphic Sensor Signal Processing

Projects: Growth of the Scottish small-satellite sector with global impact (Impact case study: https://www.strath.ac.uk/media/1newwebsite/ref/ref2021/impactcasestudies/engineering/Growth_of_the_Scottish_small-satellite_sector.pdf)

Prof Malcolm Macdonald – Director of the Applied Space Technology Laboratory (democratisation, exploration, and exploitation of space). He is a Visiting Professor at the Centre for Space Research at the University College Dublin and vice-chair of the Space Technology Advisory Committee of the UK Space Agency. He was the Founding Director of the Scottish Centre of Excellence in Satellite Applications, SoXSA, and a Non-Executive Board Member of UK Space Agency;

Dr Ruaridh Clark – developing design tools for the next generation of satellite constellations with AAC Clyde Space, mapping tidal channels. He participated in horizon-scanning for the UK Space Agency and carried out rocket experiments for ESA's REXUS programme;

Concurrent and Collaborative Design Studio (no direct public link about it found) – developing assessments and virtual prototyping of new space missions and concepts. It uses a large toolbox collection as the Strathclyde Mechanical and Aerospace Engineering Toolbox to perform design optimisation in complex systems. This design approach is currently used at ESA and at Harwell;

xSPANCION Pioneer Partnership Project to develop an innovative satellite constellation service;

Dr Carmine Clemente – radiofrequency sensor signal processing for defence and civilian applications: Automatic Target Recognition, Electronic Surveillance, Earth Observation, emerging radar techniques;

Strathclyde Space Mechatronic Systems Technology Laboratory (no direct public link about it found) – system design, modelling, simulation and prototyping for use on high-reliability microcontroller systems in robotic space hardware and mechanical fabrication tools for prototype and proof-of-concept development.

Several other scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Dr Susan Spesyvtseva – expert in photonics and optical trapping. She works closely with industry and the public sector to facilitate collaboration and knowledge transfer of the department's applied research with key academic strengths in photonics, quantum technologies, space, plasma, etc;

Dr Johannes Herrnsdorf – semiconductor-based photonics, digital illumination, micro-LED in communications and imaging;

Dr Paul Griffin – experimental methods precision measurements in atomic physics based on quantum technologies;

Prof Harald Haas –Strathclyde's LiFi Research and Development Centre. Enhancing the communications infrastructure by switching to optical wireless communications instead of infrared;

Dr Christos Ilioudis –MIMO (Multiple-input multiple-output) Radar systems design and signal processing;

Prof John Soraghan – neural networks for multimedia signal processing, signal processing, radar signal analysis, parallel processing architectures and algorithms;

Prof Martin Dawson – Director of Research at the University of Strathclyde's Institute of Photonics. He has been involved in the formation and technical development of spin-out businesses, such as mLED and Neuro-VLC;

Mr Shahroz Khan – artificial intelligence (AI) assisted design system. He is working on the GRAPES (learninG, pRocessing, And oPtimising shapES) Project, developing intelligent computational design tools for the maritime and mechanical industry;

Prof Xiu Yan – mechatronic system design methodology with applications in autonomous space robotics and modular spacecraft assembly;

Dr Gianluca Filippi – network model for the design process of space systems;

Dr Jonathan McKendry – LED-based Visible Light Communications;

Mr Gwenole Henry, Mr Youhua Li – developing a mechatronic platform for Space Robotics;

Dr Robert Atkinson – industrial application of machine learning, cybersecurity, and the Internet of Things. He worked on the framework for Sentinel-1,2 analysis;

Dr Sebastian Diaz Riofrio, Dr Julie Graham, Dr Cheyenne Powell – radar technologies for satellite manoeuvre, space debris detection, satellite scheduling;

Dr Bryn Jones, Dr Peter Nagy – geometric sensitivity study for the aerodynamics;

Dr Maria Anna Laino – assembly and disassembly dynamics of modular solar power satellite;

Dr Christos Tachtatzis – Artificial Intelligence in Advanced Manufacturing and Cybersecurity. He participated in projects for asset tracking within aerospace manufacturing and using radar for coastal mapping;

Dr Scott Brady – mechatronics for space-based robotics applications;

Prof Michael Strain – high-sensitivity inter-satellite optical communications using chip-scale LED and single photon detector hardware;

Dr Duncan McArthur – viable satellite free space optical quantum communication;

Dr Olga Ganilova – application of smart materials in Aerospace Engineering;

Dr David McMillan – engineering and model analysis for energy security. He participated in the Satellite Climate Observation for Offshore Renewable Energy Cost Reduction project;

Ms Astrid Werkmeister – satellite data for condition monitoring, archaeological assessment, disaster management;

Prof Stephen Marshall – image analysis of data from Compact Multi-Spectral sensor from nanosatellites;

Dr Seonaid Rapach – earth observation data for sustainable finance;

Dr Edward John Hart – using satellite data for the offshore renewable energy sector;

Dr Robert Cowlishaw – decentralised data processing in Earth observation;

Dr Lewis Walker – mitigation of debris using space-based lasers;

Prof Federico Coffele, Kinan Ghanem – data usage of BGAN satellite communications for remote outstations;

Dr James Bowden – enhancing sustainable finance with satellite data and advanced analytics

Dr Joshua Gribben – Matryoshka Orbital Networks, satellite pickup and delivery scheduling;

Dr Iosto Fodde – satellite orbiting around asteroids;

MSc Mohammed Eshaq – flight software, electrical power, communication system design for CubeSat;

Dr Waqquas Bukhsh – optimisation, networks, algorithm design for electricity networks. He worked on developing new technologies for satellite communication antennas;

Connections:

(www.strath.ac.uk/science/physics/internationalnationalpartnerships/)

UK Space Agency;

The Space Enterprise Lab by the Satellite Applications Catapult;

ESA;

National Manufacturing Institute Scotland (NMIS);

Virgin Orbit;

Fraunhofer Centre for Applied Photonics;

Lockheed Martin;

There is an outreach programme engaging school pupils in Space research – Scottish Space School.

UNIVERSITY OF HIGHLANDS AND ISLANDS

University of the Highlands and Islands
Oilthigh na Gàidhealtachd agus nan Eilean

University of the Highlands and Islands has no specifically space sector-related course, but there are programmes with closely related topics, such as Aircraft Engineering BEng.

Several scholars were identified to be directly involved in manufacturing, data analysis for the space sector, analysis of the data acquired through space technologies or theoretical studies of space-related topics:

Prof Andrew Rae – aircraft and vehicle aerodynamics, aircraft design;

Dr Qusai Al-Hamdan – gas turbine engines design, modelling, simulation. He participated in testing rocket engines, for example of the HAWK missile rocket engine;

Dr Christopher MacLeod – investigator of spacecraft propulsion and artificial intelligence;

Dr Philip Anderson – using robotic aircrafts and remote sensing technologies in atmospheric analysis and studying sea-ice dynamics in the Arctic. He is a member of the British Antarctic Survey;

Dr Eddy (Eddie) Graham – meteorology, climate change, astronomy (site selection, site testing). He participates in NASA Global Precipitation Measurement Mission, Skyteam: Astronomical Site Characterisation and Site Testing, KOTI / SASKA: Kenyan Optical Telescope Initiative;

Dr Lonneke Goddijn-Murphy – marine optics and physics. Projects involve remote sensing of various aspects of the sea surface such as marine plastic pollution, air-sea gas exchange and wave energy;

Dr Kristin Burmeister – investigating the variability of temperature, salinity and biogeochemical components in ocean circulation and climate using different kinds of observational data, including satellite;

Dr Matthew Davey – algal ecologist, who is interested in space applications of algae biotechnology;

Dr David Constable – a planetary scientist with a background in physics and radio frequency engineering. Current research: auroral acceleration at Jupiter;

Dr Alison Cook – mapping and research on Antarctica, focusing on glaciology and ice/ocean interactions, using remote sensing techniques.

There are environmental scientists in UHI, who do not work on space-related projects, but who could contribute to understand the ecological, economic and societal impacts of such building developments as the Space Hub Sutherland.

Connections:

UKSA and ESA, for example The Connecting Health Care (CHC) Project to deliver satellite connectivity to care homes and GP practices;

The Space Hub Sutherland.

SPACE SECTOR SUPPORTING INSTITUTIONS

Fraunhofer Centre for Applied Photonics

(www.cap.fraunhofer.co.uk/)

A world-leading centre in the field of applied laser research and development. A wide range of space missions rely on critical optical technologies. Fraunhofer CAP has experience in a wide range of applications applicable to space, including single-frequency lasers for quantum technology (atom trapping, interferometry and clocks), lidar systems for Earth observation or navigation, remote laser spectroscopy systems for Earth observation, quantum-key-distribution systems and secure communication.

Space-related projects:

REMOTE (RuggEd Mirco-ECDL technology for cOld aTom applications in spacE) –quantum technologies research to reduce the size and cost of the critical industrial components in order to place the UK at the vanguard of QT development and commercialisation;

Next Generation Satellite QKD – developing the capability to manufacture the next generation of space Quantum Key Distribution payloads. A similar project is "3QN: Towards A New UK Industry for Novel Quantum Receivers in Nascent Satellite QKD Global Markets";

QUEST - Quantum Entangled Source – developing optical components for space applications satellite quantum communication.

Fraunhofer CAP has a key partnership with Fraunhofer IAF, the Institute for Solid-state Physics (Freiburg, Germany).

National Manufacturing Institute for Scotland

(www.nmis.scot/)

Collaborating with industry, academia and the public sector, NMIS aims to increase productivity, support the development of a modern workforce, strengthen supply chains and boost the transition to net-zero in Scotland.

There are the following centres: University of Strathclyde's Advanced Forming Research Centre, Lightweight Manufacturing Centre, Digital Factory, Digital Process Manufacturing Centre and Manufacturing Skills Academy.

The Institute is involved in the xSPANCION Pioneer project that will inform the design and operation of complex satellite networks and constellations of spacecraft;

Also, there is expertise in the field of orbital assembly and manufacturing. Also, the Institute collaborates with industries and agencies in the aerospace field. For example, they have engineered new spacecraft and satellite propellant aluminium tanks for ESA and Airbus.

CENSIS

(censis.org.uk/)

CENSIS is Scotland's not-for-profit Innovation Centre established to support private businesses and public sector organisations to accelerate the pace of innovation by exploiting sensing, imaging and Internet of Things (IoT) technologies.

This centre could become a link between business to expand applications of remote sensing, Earth observation and satellite-based communication.

The Data Lab

(thedatalab.com/)

The Data Lab is Scotland’s innovation centre helping companies, organisations and individuals benefit from the commercial opportunities that exist within data and AI field.

One of the projects Data Lab contributed to is Trade in Space: Monitoring supply chains with satellite data. The Data Lab funded research experts at the University of Edinburgh to create a report on modelling satellite and climate data with an aim to demonstrate the value of predicting coffee yield.

Royal Observatory Edinburgh

The Royal Observatory Edinburgh comprises the UK Astronomy Technology Centre of the STFC, the Institute for Astronomy of the University of Edinburgh, the Higgs Centre for Innovation and the ROE Visitor Centre.

UK ATC (www.ukatc.stfc.ac.uk/Pages/home.aspx) is a centre for excellence in the development of scientific instrumentation for ground and space-based astronomical observatories. Current projects include software for the SKAO, the world's largest radio telescope based in South Africa and Australia, instrumentation for both the Very Large Telescope and the Extremely Large Telescope in Chile. In the recent path, they contributed to constructing MIRI, one of four scientific instruments on the James Webb Space Telescope.

The ROE Visitor Centre (visit.roe.ac.uk/) organises public events to popularise space science.

The Higgs Centre for Innovation (www.higgscentre.org/) is a business-focused facility in collaboration with the University of Edinburgh, that supports startups and enterprises working in the space and data-intensive sectors and encourages collaboration between researchers, engineers and postgraduate students.

The Institute for Astronomy of the UoE (ifa.roe.ac.uk/) – one of the parts of the School of Physics and Astronomy at the UoE.

Its Research Areas are:

Active Galactic Nuclei (Dr James Aird, Prof Philip Best, Prof Andy Lawrence) – studying cores of distant galaxies with supermassive black holes using deep and wide radio surveys, studying relativistic jets, particle acceleration and quasars;

Cosmology (Dr Florian Beutler, Dr Yanchuan Cai, Prof Romeel Dave, Prof James S Dunlop, Prof Catherine Heymans, Prof Sadegh Khochfar, Prof Avery Meiksin, Prof John A Peacock, Dr Alkistis Pourtsidou, Dr Britton Smith, Prof Andy N Taylor, Dr Joe Zuntz) – investigating the contents, laws and history of the Universe on its largest scales. There is a particular specialism in the field of weak gravitational lensing, numerical simulations of the evolution of the Universe, the distribution of Dark Matter and galaxies.

Exoplanets (Dr Beth Biller, Dr Trent Dupuy, Prof Ken Rice) – direct imaging detection and characterization of extrasolar planets, their atmospheres and planet formation;

Galaxy Formation & Evolution (Dr James Aird, Prof Philip Best, Prof Romeel Dave, Prof James Dunlop, Prof Annette Ferguson, Prof Sadegh Khochfar, Prof Bob Mann, Prof Ross McLure, Dr Britton Smith) – studying the physical processes responsible for the formation and evolution of galaxies using large-scale multi-wavelength and spectroscopic surveys of the Universe;

Milky Way & Local Group (Dr Nick Cross, Prof Annette Ferguson, Dr Nigel Hambly, Dr Sergey Koposov, Prof Jorge Peñarrubia, Dr Nick Rowell, Dr Anna Lisa Varri) – searching for signatures of hierarchical assembly in galaxy peripheries, mapping the distribution of dark matter in galaxies, studying the internal stellar dynamics, measuring the star formation history of the Milky Way exploiting data from Gaia, the Hubble Space Telescope and various wide-field surveys conducted with large telescopes and running simulations on supercomputers;

Simulations (Prof Romeel Dave, Prof Sadegh Khochfar, Prof Avery Meiksin, Prof Jorge Peñarrubia, Prof Ken Rice, Dr Britton Smith, Dr Eric Tittley, Dr Anna Lisa Varri) – simulations of astrophysical systems, from the formation of planetary systems in the Galaxy to the evolution of cosmic structures and the large-scale structure of the Universe;

Solar System (Dr Cyrielle Opitom, Dr Colin Snodgrass) – tracing the conditions and processes at the formation of our Solar System to better understand how planets form. using a wide range of telescopes to observe and explore minor bodies using robotic spacecraft. Group members are involved with the ESA Rosetta comet mission, the NASA Dart and ESA Hera steroid deflection experiments, and a Chinese asteroid and main belt comet mission.

Wide-Field Astronomy Unit (www.roe.ac.uk/ifa/wfau/) (Prof Andy Lawrence, Prof Bob Mann) – survey astronomy projects, such as the GAIA Data Flow System to characterise radiation damage effects on the detectors;

The IfA also hosts or manages a number of resources for astronomers in different fields (ifa.roe.ac.uk/data-sets-resources).

The Satellite Applications Catapult

(sa.catapult.org.uk/)

It is one of nine Catapults established to transform the UK's capability for innovation in specific areas and to help drive future economic growth. It helps organisations make use of, and benefit from satellite technologies and bring together multi-disciplinary teams to generate ideas and solutions in an open innovation environment. The Catapult's missions are to drive a thriving, equitable and sustainable in-space economy, helping to solve grand challenges on Earth by 2030, to bring the benefits of advanced, resilient, satellite services to a new generation of autonomous services, to see safe, secure and performant connectivity available everywhere and affordable by every person by 2030, to use space capabilities to enable safe and just outcomes for climate displaced people and their communities by 2030. Their missions are strongly aligned with the UK Government Space Strategy themes.

They have created the Space Enterprise Labs (SELs), a UK-wide network of local places for space innovation that are free-to-use and digitally inclusive. They include free access to resources and expertise to facilitate connecting and collaborating, prototyping and development, manufacturing, testing and validation. 2 out of 14 are located in Glasgow (hosted by the University of Strathclyde) and Edinburgh (hosted by the University of Edinburgh).

Asteria

(www.asteria-space.com/)

Asteria is a group from Edinburgh and the world to engage the students in the space industry, equip, and inspire the next generation of engineers, scientists, and artists, and set a precedence for student space engineering in the UK. Asteria is supported by Chancellor's Fellow for Space and Satellite Analysis at the University of Edinburgh, members of the European Space Agency and private sponsors.

There are three departments: Engineering – building small satellites, high-altitude balloons for remote-sensing with multiple applications, Research – exploring methods to achieve sustainable space exploration. Creative – promoting the just governance of outer Space.