The Latest Policy Trends of Satellite Data Utilisation in the UK

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Summary

This report discusses the latest policy trends of Satellite data utilisation in the UK. A review of some of the available literature and interviews with key persons provide insights into the background and activities of the satellite data utilisation in the UK.

Key findings include:

- The UK's space policy is implemented by organisations under the Department for Business, Energy and Industrial Strategy (BEIS) and strongly promoted as one of the areas of industrial promotion by science and technology.
- The UK government is currently promoting the UK space industry to achieve the ambitious goal to increase the UK's share in the global space industry market to 10% by 2030.
- The UK government is focusing on building an entire "ecosystem" to create new businesses using satellite data. The following four elements make up this ecosystem.
  (1) Satellite data platform
  (2) Space cluster
  (3) Regional centres (Centres of Excellence)
  (4) ESA Ambassador Network
- The current ecosystem in the UK is functioning to a certain extent, but adding the fifth element to it will build a stronger ecosystem in the UK.
  (5) Mobility of young researchers

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1 Introduction

Recently, the high spatial resolution of many Remote Sensing satellites has progressed and the functions of small satellites made by the private sector, which are inferior to large satellites made by the public sector but are easy to launch, have been greatly improved resulting in large amounts of satellite data available at low cost. In addition, recent advances in Digital Technologies such as IoT (Internet of Things), Big Data and AI (Artificial Intelligence) have been remarkable all over the world. By gathering various data, accumulating it as Big Data and analysing this data by using AI, it is possible to grasp the current situation of phenomena, predict the future more accurately, create new values and solve many problems in a lot of fields such as the natural environment, society and the economy. These Two major trends are joined together and many countries around the world are making efforts to create new space utilisation services by using Digital Technologies in the field of utilisation of satellite data. In particular, many countries are aggressively promoting efforts to Open and Free satellite data in order to improve accessibility to satellite data for general public and private.

The UK has an ambitious goal to increase its share in the global space industry market to 10% by 2030, and the UK government is promoting commercial space activities to achieve the goal. In particular, the creation of business by using satellite data plays a very important role in promoting the space industry in the UK. The UK government is currently working with the ESA (European Space Agency) and EU programmes to offer a data platform to encourage the UK's industry to use satellite data and to promote industry-academia-government collaboration. On the other hand, the UK government is also making efforts to utilise satellite data for environmental research and public use, mainly for academia and government agencies.

The purpose of this study is to understand current government organisation and recent policy trends of satellite data utilisation in the UK, and to find out what ecosystem is effective for utilising satellite data by reviewing activities for satellite data utilisation in the UK and Europe.

2 Findings

2.1 Current government organisation in the UK

The most important role in promoting science, technology and innovation in UK is the Department for Business, Energy and Industrial Strategy (BEIS). The BEIS was created by the May administration, which was launched in July 2016 in place of the Cameron administration, through a merger between the Department for Business, Innovation and Skills (BIS) and the Department of Energy and Climate Change (DECC). The BEIS currently affiliates approximately 50 government organisations, including the UK Space Agency (UKSA), the UK Research and Innovation (UKRI), and the Met Office, and is leading UK's Space Policies. Figure 1 shows main government departments promoting science, technology and innovation in the UK, and in particular organisations and programmes responsible for Space policies.

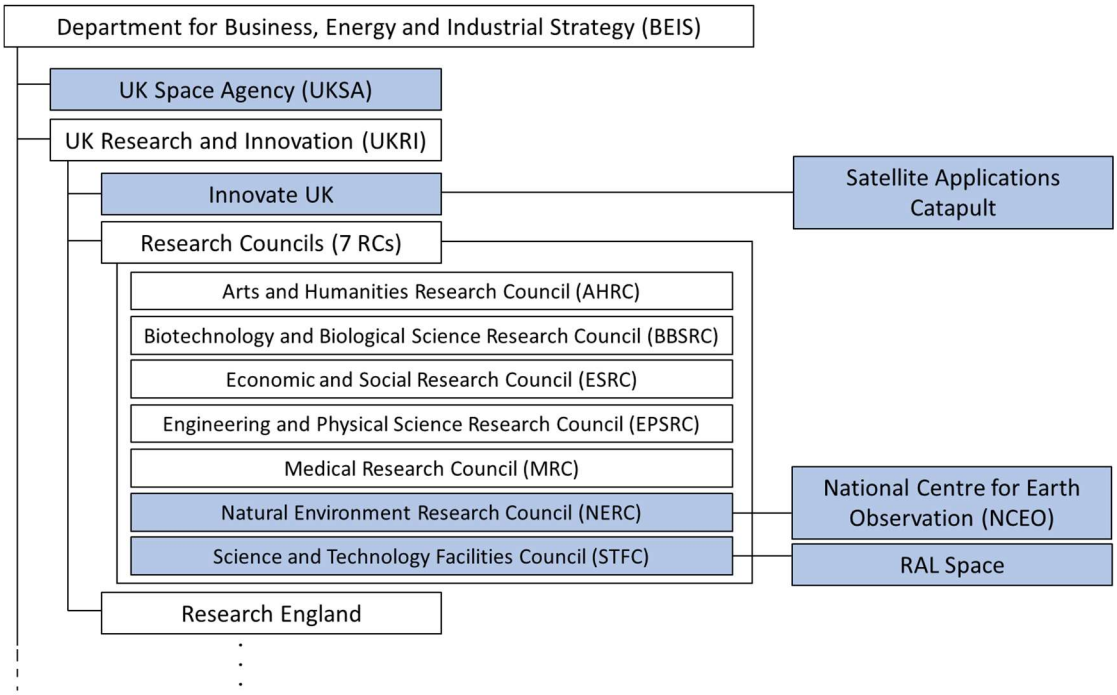

Fig. 1 Government organisations promoting science, technology and innovation

The UK Space Agency was established in April 2010 to replace the British National Space Centre (BNSC) and is in charge of planning, designing and coordinating government policies concerning space exploitation in the UK. It provides funding for projects such as Earth Observation and space exploration and represents the UK in all negotiations on space matters with the ESA and other space agencies.

The UK Research and Innovation (UKRI) is the largest funding agency in the UK and was established in April 2018 through a merger between the Innovate UK, which supports industry innovation activities, the Research Councils (RCs), which provides research grants set up in seven fields, and the Research England, which mainly supports research at universities in the England. The Innovate UK, the Research Councils (7 RCs) and the Research England have discretionary authority in implementation of research programmes and projects and are free of interference from the UKRI and the BEIS.

The Innovate UK mainly supports collaborations between industry, academia and the government in the UK and innovation activities in companies. In recent years, in particular, the Innovate UK has not only subsidised R&D expenses but also set up Catapult centres to accelerate collaborations between industry, academia and the government through matching funds with industry. The Satellite Applications Catapult, established by the Innovate UK as a catapult centre in the space field, is an under-one-roof centre in satellite applications.

The Research Councils (RCs) consist of seven councils by fields. The Arts and Humanities Research Council (AHRC), the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC) only provide research funding. On the other hand, the Biotechnology and Biological Sciences Research Council (BBSRC), the Medical Research Council (MRC) and the Natural Environment Research Council (NERC) have their own institutes to conduct research in addition to research funding. In particular, the NERC has the National Centre for Earth Observation (NCEO), which conducts research on climate change using Earth observation data. The Science and Technology Facilities Council (STFC) not only provides research funding, but also manages and operates research facilities in the UK. The RAL Space, established in the Rutherford Appleton Laboratory (RAL) by the STFC, has research facilities for testing space-related equipment such as satellites and robots.

2.2 Recent Space and Earth Observation policies in the UK

2.2.1 Recent Space policies

1) A UK Space Innovation and Growth Strategy 2010 to 2030 (Feb. 2010)

The growth strategy was developed by Space Innovation and Growth Team (Space IGT), which was established by a joint initiative between industry, academia and the government in the UK. It was authorised under the Labour government as a strategy for the next 20 years to grow the UK Space industry and set the following numerical targets mainly by industry.

- Establish the UK as one of the World's leading Space nations and grow the UK's share of the global market from around 6% to 10% by 2030.
- Create at least 100,000 new high-skilled, high-value jobs in the UK by the proposed expansion plans.
- Promote applications and services using Space data and grow the UK Space industry from £6 billion in 2007 to £40 billion by 2030.

2) Space Innovation and Growth Strategy 2014-2030 Space Growth Action Plan (Nov. 2013)

The action plan was re-developed by Space IGT under the Conservative government after the change of government from the Labour part to the Conservative party. It largely followed 'A UK Space Innovation and Growth Strategy 2010 to 2030' and added the following numerical targets as interim goals for 2020.

- Grow the UK's share of the global market from 6.5% in 2007 to 10% by 2030.
  - Capture 8% of the world's space economy by 2020.
- Grow the UK Space industry from £6.6 billion in 2007 to £40 billion by 2030.
  - Grow the UK Space industry to £19 billion turnover by 2020.

Furthermore, this action plan recommended five concrete items to achieve the above numerical targets.

- Recommendation 1: Develop the high-value priority markets identified to deliver £30 billion per annum of new space applications by promoting the benefits of Space to business and Government and engaging service providers.
- Recommendation 2: Make the UK the best place to grow existing and new space business and attract inward investment by providing a regulatory environment that promotes enterprise and investment in the UK.

- Recommendation 3: Increase the UK's returns from Europe by continuing to grow the UK's contributions to European Space Agency (ESA) programmes and securing greater influence in large European-funded programmes.
- Recommendation 4: Support the growth of UK Space exports from £2 billion to £25 billion per annum by 2030 by launching a National Space Growth Programme and defining an international policy that will improve collaboration with nations across the world, enhance the UK's competitive edge in export markets and enable targeted and market-led investments in leading edge technology.
- Recommendation 5: Stimulate a vibrant reginal space SME sector by improving the supply of finance, business support, information, skills and industry support.

3) Government Response to the UK Space Innovation and Growth Strategy 2014-2030 Space Growth Action Plan (Apr. 2014)

The government response was a formal statement of the UK Government's position on 'Space Innovation and Growth Strategy 2014-2030 Space Growth Action Plan' proposed by Space IGT, and was developed by the UK Space Agency. In the government response, the UK Government announced that they fully supported all five recommendations in the action plan and that the UK Space Agency would lead actions to achieve the goal of growing the UK's share of the global market to 10% by 2030. Moreover, it was emphasized that the growth created from developing downstream applications and from maximizing export opportunities would be the substantial part of the future growth story.

4) National Space Policy (Dec. 2015)

The National Space Policy was the first comprehensive space policy formulated by the UK Government based on 'Government Response to the UK Space Innovation and Growth Strategy 2014-2030 Space Growth Action Plan'. In the document, the UK Government reported that the UK Space industry had grown from £6.5 billion in 2007 to £11.8 billion in 2014, and set four commitments.
Government:

- Recognises that space is of strategic importance to the UK because of the value that space programmes deliver back to public services, national security, science and innovation and the economy.
- Commits to preserving and promoting the safety and security of the unique space operating environment, free from interference.
- Supports the growth of a robust and competitive commercial space sector, underpinned by excellent academic research.

- Commits to cooperating internationally to create the legal frameworks for the responsible use of space and to collaborating with other nations to deliver maximum benefit from UK investment in space.

5) The Space Industry Act 2018 (Mar. 2018)

The Space Industry Act 2018 was enacted to establish a regulatory framework for the expansion of space commercial activities and the UK's Spaceport. In the UK, the Outer Space Act 1986 had stipulated launch and operation of space objects and activities in outer space prior to the enactment of the Space Industry Act 2018. However, companies had had significant disadvantages in developing and operating satellite systems in the UK because they had been required a lot of time and money to get a license for the satellite system. In addition, there had been concerns that Brexit could have a long-term negative impact on the UK Space industry. For these reasons, the UK government developed the Space Industry Act 2018 to provide incentives for the space industry around the world to challenge on-orbit servicing in the UK. For example, accidents in outer space can be covered by government compensation.

2.2.2 Recent Earth Observation policies

1) Strategy for Earth Observation from Space 2013-16 (Oct. 2013)

The strategy was developed by the UK Space Agency to drive the shared the UK vision for Earth Observation (EO) from space with international leadership in development and use of EO-derived information and technology. In the strategy, the UK Space Agency set out the UK's basic stance on Earth Observation:

- The UK will strengthen our world-leading position in EO science and technology working with partners in academia, government and industry, and provide leadership on major international space programmes.
- EO data is critical for the UK to create new products and services for a wide range of market sectors to achieve economic growth.
- EO is also expected to underpin much of public sector policy-making and services, and provide the monitoring capability to support many of our environmental management obligations at local, national and international levels.

Moreover, the UK Space Agency identified four key strategic priorities for its activities in Earth Observation.

- Leverage from our membership of European programmes to secure maximum returns in scientific excellence, programme efficiencies, and economic growth for all UK stakeholders in academia, government and industry.
- Build on UK leadership in processing, analysis, quality assurance and control, modelling and visualisation of space data for environmental research and climate applications.
- Become global leaders in Synthetic Aperture Radar (SAR) technologies and exploitation especially for civil resilience, natural hazard management and maritime security.
- Increase UK leadership in developing small, low-cost missions.

2) The EO Technology Strategy (Nov. 2017)

The technology strategy was prepared for the UK Space Agency by the Centre for Earth Observation Instrumentation (CEOI), which had been established to implement and manage the UK EO technology development by the UK Space Agency. The aim of this strategy is that over the next decade innovative new technologies developed by the UK EO space sector make substantial contributions to economic growth, new jobs and societal benefit, with the UK entities competitive in global EO commercial, institutional and science markets, and the strategy is expected to support the UK Space Agency in future investment decisions in EO technology and help to ensure that the UK receives best return from the national and bilateral programmes, and from the investment in the ESA and other European EO programmes.

The four key objectives of the EO Technology Strategy are:

- Economic Impact: Develop EO technologies which lead to increased exports and economic growth
- Innovation: Keep the UK at the forefront of EO technology development by supporting new and innovative ideas that offer tangible benefit to future missions
- Capability: Strengthen capability where the UK already leads, has the potential to build a lead or to overtake existing capability elsewhere
- Return on ESA Invesment: Maximise the benefit to be derived from the UK funding to ESA and other institutional bodies.

2.3 Activities for satellite data utilisation in the UK and Europe

2.3.1 UK Space Agency (UKSA)

The UK Space Agency (UKSA) is the policy lead for satellite Earth Observation, responsible for strategic decisions on the UK civil space programme, and works closely with the UK community to continually develop the UK's world leading capability.

1) Space for Smarter Government Programme (SSGP)

   The Space for Smarter Government Programme (SSGP) is a national strategic programme established in 2014 to help the UK public sector embrace space to realise efficiencies. It is led, managed and funded by the UK Space Agency but is delivered in close collaboration with the Satellite Applications Catapult to drive the uptake and use of space products, data and services across government departments.
   SSGP aims to:
   - Increase awareness of satellite technologies and space enabled solutions to create a sustainable informed intelligent customer base in the public sector.
   - Accelerate public-sector uptake of space-enabled services and applications to make government policy development and operational delivery more effective.
   - Support wider UK growth targets to increase the space sector market share and create additional jobs by 2030.

   Recent SSGP projects making use of EO data have:
   - Investigated the feasibility of using satellite imagery and Machine Learning to identify barriers to widespread roll out of Electric Vehicle charging infrastructure via automated identification and measurement of the features of public and on-street locations.
   - Demonstrated a cost and time effective procedure utilising satellite-derived data to aid in the management of interventions to structures forming UK Critical National Infrastructure.
   - Quantified maritime traffic to give a more realistic representation of vessel movements in congested maritime environments in order to improve safety and secure cost savings.

2) Centre for EO Instrumentation (CEOI)

   The Centre for EO Instrumentation (CEOI) is funded by the UK Space Agency to advance the development of innovative instrumentation for Earth Observation and to

maintain the UK position as a world-leader in EO satellite technology. The CEOI was established in 2007 with the aim to develop key capabilities in EO instrumentation through the teaming of scientists and industrialists. It is a partnership led by Airbus DS together with the University of Leicester, the STFC Rutherford Appleton Laboratory and the QinetiQ.

The CEOI is focusing on development of technologies for the ESA and for export to maximise the return from the UK investment and is running competitions for grants to develop new ideas in EO technology and oversee the selected projects, so as to position UK teams to win leading roles in future space programmes.

3) Space4Climate

Space4Climate is a public-private-academic partnership working collaboratively to ensure a seamless supply chain for climate data from space. The UK Space Agency chairs the partnership. Space4Climate supports the UK's world-leading climate community to deliver, sustain and make use of climate information from space, enabling it to be integrated "as standard" in a variety of climate services for global economic and societal benefit.

Space4Climate aims to:

- Expand market uptake domestically and internationally, raising the profile of UK expertise, products and services, identifying climate services user requirements and facilitating and brokering new market growth opportunities.
- Sustain and grow the network, expanding UK community by developing and maintaining lists of UK providers, and building community capacity by providing training and alerts to funding sources.
- Support delivery of a seamless supply chain, by identifying new requirements and barriers to provision and sustainability, and working together to address these.

2.3.2 Innovate UK

The Catapult Programme, one of the programmes managed by the Innovate UK, has recently received attention in the UK. The programme aims to establish a technology and innovation hub that will enable the UK to lead the world in several specific technology areas, and it also aims to promote the UK economic growth by creating innovations and putting research results to practical use together with companies, engineers and scientists under one roof.

The programme currently has nine Catapult Centres, which are hubs that produce world-class technologies that enable industry to solve technical problems, and also platforms that attract long-term investments to enable companies to provide new products and services by using the knowledge of academia such as universities. The features of the Catapult Programme are that the main players who put research results to practical use are the industries and that Research & Development through industry-led initiatives is required. The areas of the nine Catapult Centres are as follows.

- Cell and Gene Therapy
- Compound Semiconductor Applications
- Connected Places
- Digital
- Energy Systems
- High Value Manufacturing
- Medicines Discovery
- Offshore Renewable Energy
- Satellite Applications

The Satellite Applications Catapult was established in May 2013 on Harwell Campus, an area south of Oxford. The Catapult aims to help grow the UK space industry under the mission of ‘to innovate for a better world, empowered by satellites’ and contribute to the UK's goal of capturing 10% of the global space market by 2030.

Fig. 2 The Satellite Applications Catapult building on Harwell Campus

The backgrounds of the establishment of the Satellite Applications Catapult are as follows.

- There was debate over the need for the UK to have an institution that could bridge the industry, such as the Fraunhofer in Germany, because the UK did not make sufficient efforts to convert research results into business while the UK maintained a high level of science.
- In the 2010s, the UK space industry proposed Space Policies together with the government and the UK Space Agency was established.

The former is the background that the UK government decided to build the Catapult Centres, and the latter is the background that 'Satellite Applications' was selected as one of the Catapult Centres.

The vision of the Satellite Applications Catapult is to create valued partnerships and to deliver game-changing results by embracing a pioneering, agile, collaborative and entrepreneurial spirit, and the Catapult aims to be a focal point where SMEs, large industry and end-users interested in satellite applications can work together with researchers to challenge barriers, explore and develop new ideas, and bring these to commercial reality. The Catapult's achievements to date include building technology platforms, providing state-of-the-art facilities to support a diverse range of projects, and developing strong relationships with many organisations from different market sectors. The Catapult has made contract with over 1,800 organisations, engaged with over 240 SMEs and worked with over 30 universities.

1) Personnel Organisation

The Satellite Applications Catapult has approximately 140 staff with Ph.D or MBA, 50% of whom are in charge of technology and the other 50% are in charge of business, and doesn't have any academic staff.
The Catapult uses its own network to attract academic researchers and engage them in specific projects, but students and postdocs are rarely attracted. In addition, the Catapult is not an educational institution such as a university, so it cannot grant students a degree.

2) Centre Operation and Resource Allocation

The annual budget of the Satellite Applications Catapult is around £10 million and is dedicated to operating the Centre and research projects.
The funding portfolio is modeled on the Fraunhofer in Germany, with 1/3 a core-grant, 1/3 a competitive research fund, and 1/3 a contract research with industry. The initial portfolio of the Catapult in 2013 was 100% core-grant, but in five years the ideal portfolio of 1/3 each was achieved. The Catapult mimics the Fraunhofer's portfolio because

matching funds are an effective bridge to industry. For example, if a private company wants to get £100,000 from the Catapult, the company must prepare the same amount of £100,000 on its own. The governing board of 6 people, including the Innovate UK, determines which companies the Catapult should invest in.
Each Catapult Centre is evaluated annually by the Department for Business, Energy and Industrial Strategy (BEIS) in terms of how much funding has been obtained from private companies.

3) Business Support

The Satellite Applications Catapult provides a variety of support for private companies to create business. Key offerings by the Catapult include:

- Networking opportunities with key partners from both the upstream and downstream space sectors, government organisations, trade associations, clusters, legal and finance markets, and academia
- Dedicated support team, including both technology and business staff
- Strong links to the UK's business angel networks, venture capital community and other funding agents
- Knowledge and know-how needed to get a company off the ground and help grow it into a thriving, profitable business

For example, the Catapult helps private companies process raw satellite data and build simulation models.

Furthermore, the Catapult first selects a specific private company to invest in, and picks up and gathers the knowledge and technologies that the company wants to consolidate to create business, while the Fraunhofer in Germany pushes the knowledge that has already been accumulated at universities strongly into commercialization through joint research.

4) Facilities

The Satellite Applications Catapult offers Climate, Environment and Monitoring from Space (CEMS) facility as a platform for satellite data utilisation. The CEMS provides access to extensive data, along with a range of applications and tools that can help users analyse data more effectively in a virtualised environment. The data, which is supplied by institutions and organisations based in the UK and abroad, can be searched, manipulated and processed efficiently and cost effectively by the CEMS' high performance computing facilities. Users have access to fully configurable virtual machines within their own

privately managed virtual data centres, and the CEMS cloud facility can be used for hosting applications, public facing web portals and development environments.
In addition, the Satellite Applications Catapult also offers the Sentinel Data Access Service (SeDAS) as an online data hub offering open access to Earth Observation (EO) data from the Copernicus Sentinel-1 and 2 satellites, along with additional datasets from other EO satellites. The SeDAS provides immediate access to a live feed of the Sentinel data on the CEMS service, and these two platforms are connected on the cloud. These platforms are basically available for free while users have to pay for additional options. Moreover, the Copernicus, an Earth Observation programme by the EU, also offers free and open platforms for satellite data utilisation, but the UK government has built CEMS and SeDAS as its own data platform for accelerating the development of new satellite applications in the UK.

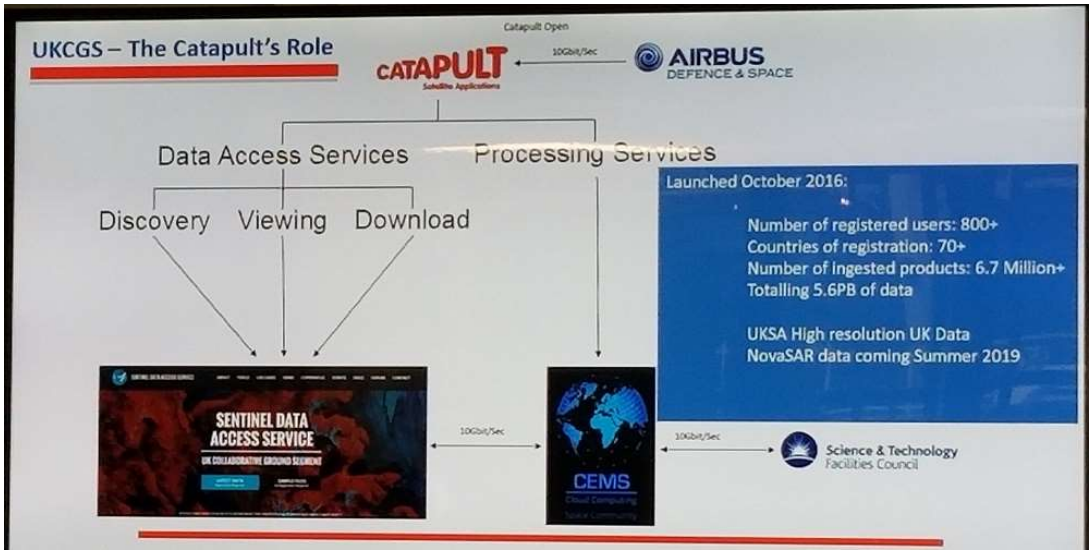

Fig. 3 The Satellite data platform provided by the SA Catapult

In addition to the data platform, the Catapult also has the following cutting-edge facilities:

- Operations Centre that can be used for operational services through its satellite ground control capabilities and tests for the management and exploitation of Earth Observation data
- SatComms Lab that can be used by satellite operators and SMEs to develop and test upstream and downstream satellite-based technologies
- Videowall Room for visualising satellite applications data at extremely high resolutions
- Demo Centre for SMEs, industry, researchers and academics to use at any time to demonstrate their capabilities, meet and network
- Conference facilities that can be used to host all types of events, including meetings, seminars, workshops and exhibitions for up to 180 people

5) Centres of Excellence (CoEs)

In October 2013, the Satellite Applications Catapult held a UK wide competition to grow the space ecosystem through Regional Centres of Excellence in Satellite Applications and made an initial investment in three Centres. These Centres were founded in the East Midlands, Scotland and the North-East of England in April 2014. In April 2016, the Catapult and the UK Space Agency together invested in a further two Centres of Excellence, and extended the regional footprint of the Scottish Centre of Excellence into the Highlands and Islands of Scotland.
The Regional Centres of Excellence programme aims to support industry and the science base across the UK, and the five Centres of Excellence are operated in each region as hubs for promoting industry-academia-government collaboration, including local SMEs and universities, physically under one roof.

Fig. 4 The Centres of Excellence supported by the SA Catapult

The five Centres of Excellence are as follows:

(1) East Midlands Centre of Excellence
- A collaborative partnership between the University of Leicester, the National Centre for Earth Observation (NCEO) and the British Geological Survey and hosted by the University of Leicester
- Urban monitoring, agri-tech solutions and decarbonizing future energy

(2) North East Centre of Excellence
- Hosted at Business Durham, the economic development arm of Durham County Council
- Maritime and logistics

(3) Scottish Centre of Excellence
- Hosted at the University of Strathclyde
- Aquaculture, forest vegetation mapping, etc.

(4) South Coast Centre of Excellence
- Hosted at the University of Portsmouth
- Offshore wind power, shipping, autonomous systems, etc.

(5) South West Centre of Excellence
- Hosted at the University of Exeter
- Agritech & food Supply, eHealth & eWellbeing, marine & maritime and mining

Moreover, details of the South Coast Centre of Excellence are as follows.

- South Coast Centre of Excellence (SCCoE)
  The SCCoE has completed its first phase from April 2016 to March 2019, and is now in the second phase from April 2019 to March 2021. It has successfully forged partnerships with 10 organisations including industry, academia and government in the first phase, and has already forged additional partnerships with 12 organisations in the second phase. This indicates that the SCCoE has been recognised as a regional centre for promoting innovation.

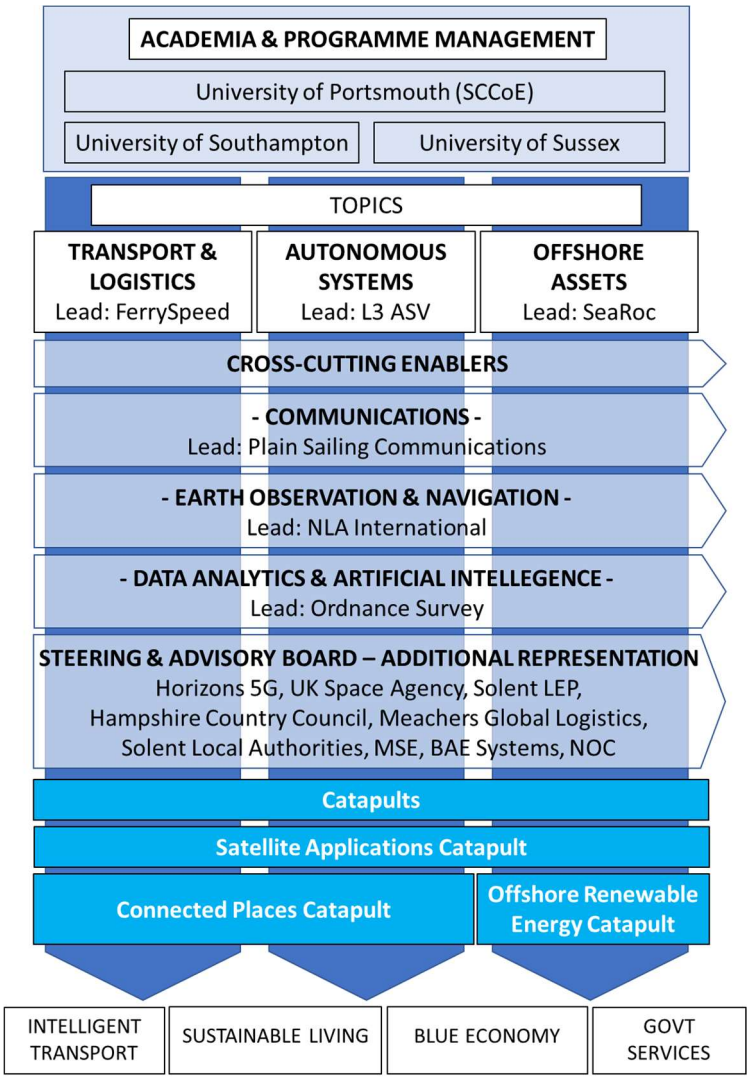

Fig. 5 Organisational structure of the SCCoE

The SCCoE has three topics, Transport & Logistics, Autonomous systems, and Offshore assets, and aims to bring together various knowledge and technologies of partnership organisations by leading private companies.
It is noteworthy that the SCCoE has an ESA Business Applications Regional Ambassador (further details will be described later), and is working with ESA to create businesses using satellite data.

2.3.3 Natural Environment Research Council (NERC)

The Natural Environment Research Council (NERC) currently has a total of six institutes. One of these institutes is the National Centre for Earth Observation (NCEO), which is headquartered in the University of Leicester, located in central England, with the aim of harnessing the potential of Earth Observation for environmental research. When the NCEO was founded in 2008, it was headquartered in the University of Reading, which had a small centre for Earth Observation researchers at that time. In 2014, John Remedios, a professor at the University of Leicester, became the director of the NCEO, and the headquarters also moved to the University of Leicester. The NCEO has a vision to 'be a globally outstanding UK scientific institution dedicated to leading EO research and its applications, encouraging, collaborating with, and building the EO community to serve science and society', and not only conducts its own environmental research, but also supports the EO community in the UK, including industry, by offering data infrastructure and new EO technologies.

The backgrounds of the establishment of the NCEO are as follows.

- The small centre at the University of Reading was not bad for an academic research programme, but was disadvantageous for doing long-term research. It needed to be strengthened into a large centre.
- The funder, the NERC, wanted to set up an institute that would be more tailored to the needs of the UK government than a particular area of research based on the ideas of researchers. In other words, the UK government felt the need to create an institute for the UK to take responsibility for ESA's Earth Observation mission.

1) Personnel Organisation

The NCEO brings together over 100 scientists distributed across leading UK universities and research organisations such as the University of Leicester, the University of Reading, the University of Edinburgh, the King's College London, the Imperial College London, and the STFC Rutherford Appleton Laboratory. The NCEO is organised in divisions according to three broad scientific activities – Data Assimilation, EO Data and Model Evaluation, and EO Instruments and Facilities – each with a divisional director and associated key capabilities and infrastructure (the platforms). The platforms serve as vehicles for interactions within the NCEO and with the wider NERC science community.

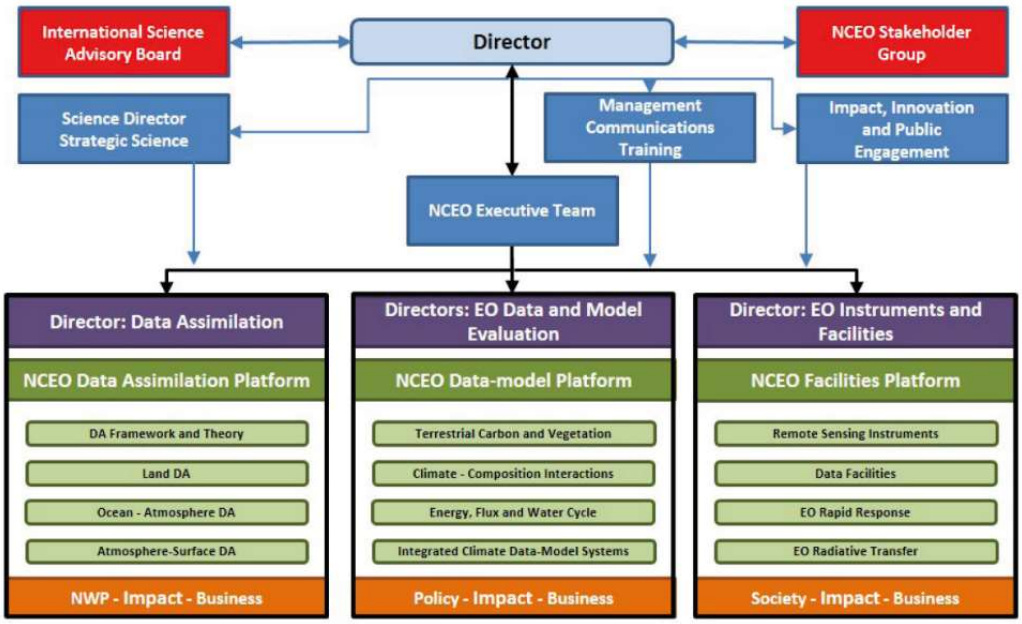

Fig. 6 Organisational structure of the NCEO

2) Balancing Academic Research and Business Support

The NCEO's mission is to balance environmental science research and business support, and the NCEO aims to support governments and private companies with various ideas. Therefore, the NCEO's scientists support the industry while conducting their own research. The NCEO doesn't have staff dedicated to business support, because the scientists provide business support by participating in specific projects that are collaborated by industry, government and academia.
The NCEO scientists are evaluated for both academic achievements and contribution to industry. The number of papers is mainly used to evaluate academic achievements, and the Research Excellence Framework (REF) is used to evaluate contributions to industry. The REF is a research evaluation system by which the UK government determines the allocation of budget to national universities, and the impact of research on society is one of the evaluation indicators. All national universities must submit to the UK government Impact Case Study, a document that describes the research that has impacted society and the major impacts. This evaluation system is effective because most NCEO researchers belong to national universities.

3) Facilities

The NCEO provides scientific oversight, governance and coordination of a series of NERC-funded facilities, data centres and computing infrastructures. These facilities are

available for the entire NERC and wider UK science communities to access via grant awards or direct access proposals.

Details of the facilities offered by the NCEO are as follows.

(1) NERC Field Spectroscopy Facility (FSF)

The NERC Field Spectroscopy Facility (FSF), hosted by the University of Edinburgh, offers expertise and equipment for high-performance optical remote sensing, both in the field and in the laboratory. For example, ground-based spectral measurements are used to study environmental phenomena such as the photosynthetic activity of vegetation, the albedo of snow and ice, the gases and particulates contained in polluted plumes, and the detailed spectral reflectance and emittance properties of vegetation, rocks, soil and water under various observing conditions. These measurements are used to develop and evaluate EO algorithms and data products coming from remote sensing by satellites, aircraft and unmanned aerial vehicles (UAVs).

(2) NERC Earth Observation Data Acquisition and Analysis Service (NEODAAS)

The NERC Earth Observation Data Acquisition and Analysis Service (NEODASS) is a 24-hour / 7-day per week satellite data processing and analysis facility hosted by the Plymouth Marine Laboratory (PML). It provides Near Real-Time (NRT) information where required, for anywhere in the world and derived within minutes of satellite data arrival, forwarding targeted information to those in need. The facility supports the NERC scientists to better identify, understand and monitor rapid changes in the global environment and advise governments, the public and other stakeholders on the nature and impact of the phenomena.

(3) Centre for Environmental Data Analysis (CEDA) and JASMIN

The NCEO offers access to data, alongside massive storage, processing and analysis capabilities, through the Centre for Environmental Data Analysis (CEDA), hosted on the high-performance computing infrastructure called JASMIN at the RAL Space on Harwell Campus. These infrastructures support a range of activities which aid the analysis requirements of the UK and European climate and environment science communities.

The CEDA data centre holds and provides online access to new datasets created by the NCEO and other NERC supported scientists, and maintains copies of large

datasets produced by other agencies, such as ESA, EMUSAT, NASA and NOAA. The CEDA Earth Observation data collection on JASMIN is the largest archive in the UK, with older data including remote sensing data from 1980s, and the CEDA is the UK academic data hub for ESA's Sentinel missions, with responsibility for storing Sentinel data and providing access to the UK science community. The CEDA allows free access to academia in the UK, but asks them to answer questions, such as who will access to the CEDA, and who will fund the project. The information on the answers will be open to the entire UK science community.
On the other hand, the CEDA does not support private companies in processing raw satellite data and developing simulation models.

Fig. 7 JASMIN installed at the RAL Space

2.3.4 Science and Technology Facilities Council (STFC)

The RAL Space was established in the Rutherford Appleton Laboratory (RAL) on Harwell Campus, the same location as the Satellite Applications Catapult, and is managed and operated by STFC for testing space-related equipment such as satellites and robots. The RAL Space has launched over 200 instruments into space and undertakes world-leading space research and technology development, provides space test and ground-based facilities, designs and builds instruments, analyses and processes data and operates ground-station facilities. Uniquely positioned between industry and academia, its skilled staff and cutting-edge facilities strengthen the UK space community and inspire the next generation of scientists and engineers. The RAL Space has indispensable facilities for steadily sending satellites into space and promoting the operation of the satellites in order to promote satellite data utilisation.

- National Satellite Test Facility
  The RAL Space was awarded £99 million in 2017 for the National Satellite Test Facility as part of the UK Government's Industrial Strategy. From summer 2022 UK companies will have access to a comprehensive set of satellite test capabilities, suitable for satellites up to 7 tonnes, in one location.

Fig. 8 RAL Space R100 building on Harwell Campus

2.3.5 European Space Agency (ESA)

The ESA is currently composed of 22 members, including the UK, and has a wide range of projects, such as space transportation like the Ariane series, space exploration to the Moon and Mars, space science, Earth Observation and satellite communication. Among them, the ESA Business Applications and the European Centre for Space Applications and Telecommunications (ECSAT) are related to the promotion of satellite data utilisation.

1) ESA Business Applications

The ESA Business Applications programme offers private companies (mainly SMEs) funding to develop, implement and pilot innovate, viable and sustainable services for the benefit of society. Business Applications activities require the integration of at least one space asset into a service proposition to be eligible, and these services add value by integrating space assets, such as Telecommunications, Earth Observation, Navigation, and Human Spaceflight technologies, with existing terrestrial assets and legacy system to provide new, commercially driven solutions. The innovative services supported by this programme are required to start from market demand rather than technology push, and be focused on business development rather than technology development. Furthermore, the objectives of this programme is to foster utilisation of existing space capabilities, to avoid research and new technology developments, to work in close partnership with users and customers, and to develop integrated and sustainable services.

The ESA Business Applications programme offers the following supports:

- Zero-Equity Funding (€60k-€2M+)
  ESA funds without holding any stake in the startups it supports. This fund is a matching fund, which requires private companies to take out their own funds (50% for Demonstration Project and Feasibility study, and 25% for Kickstart).
- Tailored Project Management Support
- Access to ESA's Network and Partners
- Use of the ESA Brand for Credibility

In addition, the ESA Business Applications programme has the Ambassador Network, which is the largest Innovation support network in the world. The ESA ambassadors act as 'honest broker' between ESA, industry and the user community, and each ESA ambassador, which has its own assigned area, works as a collaborator for private companies interested in the ESA Business Applications. The ESA ambassadors identify

new domains which might benefit from integration of space assets, and stimulate the submission of ideas and proposals to the ESA Business Applications.
Currently, the UK has 6 ESA ambassadors, one of whom is a Network Coordinator, while nine countries of the ESA members have a total of 14 ambassadors (UK 6, Italy 1, Austria 1, Switzerland 1, Germany 1, Norway 1, Finland 1, Belgium 1, and Portugal 1).

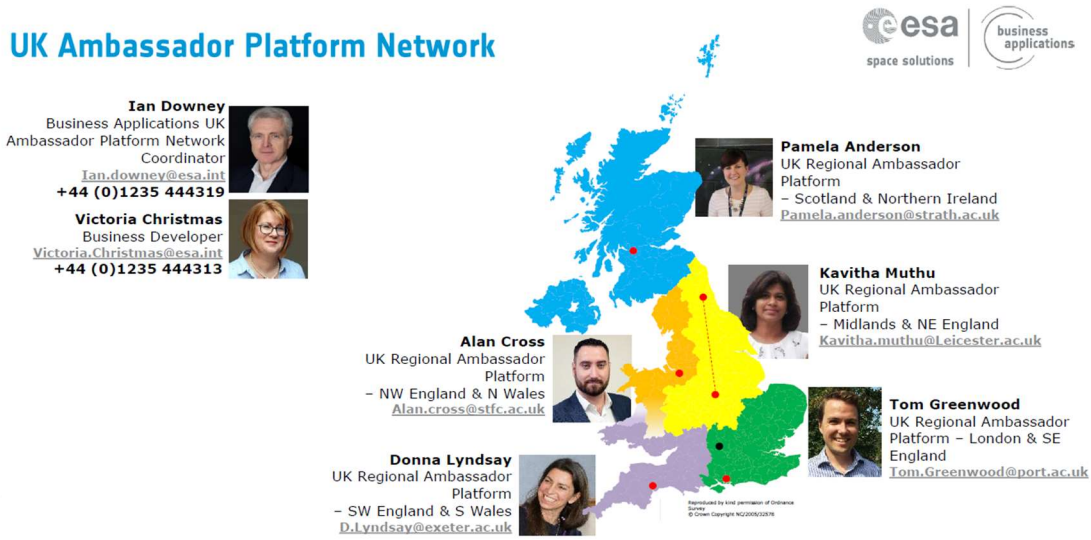

Fig. 9 ESA Ambassador Network in the UK

In the UK, there are five regional ambassadors and one coordinator for the UK Ambassador Platform Network. Mr. Tom Greenwood, one of the regional ambassadors, is hosted by the University of Portsmouth through the Satellite Applications Catapult South Coast Centre of Excellence. This means that the ESA Business Applications and the Catapult programme, an industry-academia-government collaboration programme by the UK government, are working closely together to create businesses using satellite data.

2) The European Centre for Space Applications and Telecommunications (ECSAT)

The European Centre for Space Applications and Telecommunications (ECSAT) is the only ESA centre in the UK that opened in 2013 on Harwell campus, where the Satellite Applications Catapult was also built. The ECSAT is the headquarters of ESA's Directorate of Telecommunications and Integrated Applications, and aims to boost innovation to keep European and Canadian industry at the leading edge of the highly competitive global market for satellite communications and applications.

Fig. 10 ECSAT building on Harwell Campus

The backgrounds of the establishment of the ECSAT are as follows.

- The UK government invited an ESA centre in the UK to allow the UK to reach new customers in the space business. The government was particularly interested in creating satellite communications services in the downstream industry, which could benefit from new customers and create jobs in the UK.
- The UK originally had strengths in the satellite field, because it had the Surrey Satellite Technology Ltd and the Clyde Space, which manufactured and operated small satellites.

(1) Personnel Organisation

The ECSAT has over 100 staff from 22 countries that are members of the ESA. About one-third of them are from the UK and the other two-thirds are countries outside the UK, and about 60% of them are permanent ESA employees and the rest are contract employees with fixed-term employment for several years.

Most of the staff have business and marketing experience, and the ECSAT employs little academic staff. This is because the ECSAT's mission is to support business creation using existing technologies, and the ECSAT employs staff who have business experience in private companies rather than academic or engineering experience. For example, the Downstream Business Applications Department, the largest department in the ECSAT, has no academic or technical team.

On the other hand, the ECSAT has an academic collaboration with the University of Oxford, which is near Harwell Campus, and assigns students and postdocs to research groups in the ECSAT to participate in collaborative research with private companies and write their theses or papers. In addition, the private companies are recruiting young people who have completed a Master's programme to hire them as trainees for the development in the ECSAT.

(2) Centre Operation and Resource Allocation

The budget of the ECSAT is funded by the governments of ESA member countries, and the UK is the largest contributor with 40% of the budget. These funds are used for centre operations, such as staffing, but most of the contributions from the UK government are allocated to the development of satellite data services. This means that the ECSAT aims to not only fulfill the ESA's mission but also contribute to the implementation of the UK industrial policies. The ECSAT plays a role in fostering downstream business in the UK by fully utilising its project management and marketing functions.

(3) Cooperation with other organisations

The ECSAT is working with the ESA Business Incubation Centre United Kingdom (ESA BIC UK), which helps young space-related companies to meet new challenges, enabling them to leverage the funding, support, skills and facilities they need to transform technology into successful, vibrant businesses. The ESA BIC network is now the largest single incubation network in Europe, with 20 ESA BICs across 17 European countries which have supported more than 700 new companies. Harwell was chosen as the first ESA BIC UK location on account of the wide range of technical expertise and facilities available through the ECSAT, the Satellite Applications Catapult, the RAL Space and other organisations within the Harwell Space Cluster.
Furthermore, the ESA Ambassador Network plays a key role in getting startups to contact the ECSAT. The ambassadors frequently appear at many conferences and events throughout Europe, and give presentations to companies and entrepreneurs about the ECSAT funding and support programmes. Their activities connect many startups and investors.

2.3.6 EU Space programmes

The European Union (EU) has many space programmes, such as Earth Observation, GNSS, Space Situational Awareness (SSA) and Governmental Satellite Communications (GovSatcom). Among them, Copernicus, an Earth Observation programme, and Galileo, a GNSS programme, are related to the promotion of satellite data utilisation.

1) Copernicus

Copernicus is an Earth Observation programme aimed at global environmental monitoring and security, supervised by the DG GROW, the European Commission's Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, and it is a tool for economic development and a driver for the digital economy. DG GROW outsources the actual satellite development and operation to ESA. The vast amount of satellite data acquired is open and free, from the public to the public sector, policy makers, scientists and industry.
Copernicus started full-service operations in 2014, taking over its predecessor, the Global Monitoring for Environment and Security (GMES), and currently consists of the following three observation data.

(1) Sentinel Missions
Sentinel Missions consist of Sentinel-1 to 6, and will launch about 20 satellites by 2030 since the launch of Sentinel-1A in 2014.

Name	Profile & Status	Resolution	Revisit period	Observed objects
SENTINEL-1	➢ C-band Synthetic Aperture Radar (SAR) ➢ 2 Sats in Orbit	4-40m	6 days at equator	Land surface, Marine environment (All-weather, Day-and-night)
SENTINEL-2	➢ Multispectral Optical Sensor ➢ 2 Sats in Orbit	10-60m	5 days	Land cover, vegetation and forest, marine environment
SENTINEL-3	➢ Altimeters & Radiometers ➢ 2 Sats in Orbit	300-1,200m	< 2 days	Sea- surface, forest, land-use, climate
SENTINEL-4	➢ Passive Imaging Spectrometer ➢ 1st Launch in 2022	8km	60 min	Chemical composition of the atmosphere
SENTINEL-5p	➢ To reduce data gaps between Envisat and SENTINEL-5 ➢ 1 Sat in Orbit	7-68km	1 day	Chemical composition of the atmosphere
SENTINEL-5	➢ Passive Grating Imaging Spectrometer ➢ 1st Launch in 2021	7.5-50km	1 day	Chemical composition of the atmosphere
SENTINEL-6	➢ Radar Altimeter ➢ 1st Launch in 2020	TBD	10 days	Sea-surface height (Globally)

(2) Contributing Missions
- Public satellite data from ESA and European countries
- Private commercial satellite data

(3) In-situ Data
- Observation data of ground sensors, ships and aircraft by the European Environment Agency (EEA) and European countries

The data products created by integrating the above three observation data are divided into six fields: Atmosphere Monitoring, Marine Environment, Land Monitoring, Climate Change, Emergency Management, and Security, and are provided open and free through their respective data platforms. In addition to these six platforms, the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), which actually operate the Sentinel satellite and existing satellites, are also providing four independent data platforms, so Copernicus currently has a total of ten data platforms. However, the availability of ten data platforms means that access to data is complicated and that users need to download huge amounts of data to their own computers. In June 2018, DIAS (Data Access & Information Service), a new platform that provides one-stop access to all Copernicus data, was launched to eliminate the disadvantage of inconvenience for users. DIAS allows users to access data in the cloud and use the data processing and analysis tools and software needed to develop applications with the data. Currently, five private company consortiums have been selected and commissioned by the European Commission as DIAS operators, and each consortium operates its own DIAS.

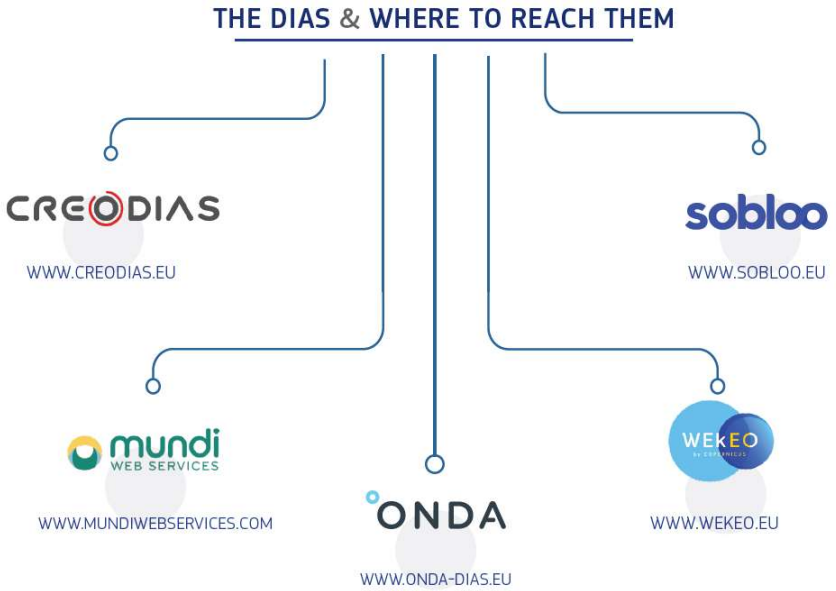

Fig. 11 Copernicus DIAS

2) Galileo

Galileo is a European global navigation satellite programme developed by the European Commission and operated by the European GNSS Agency (GSA). Galileo plans to operate a total of 30 satellites at altitudes of about 23,000 km in the future, and 26 satellites have already been launched. While GPS by the United States and GLONASS by Russia are already operating as their own GNSS, Galileo aims to build an independent GNSS as Europe without relying solely on GPS or GLONASS. Furthermore, Galileo is the world's first civilian system and was developed with the goal of promoting GNSS downstream industries while GPS and GNSS were launched for military use.
The initial service started in December 2016, and currently operates the following four services.

(1) Open Service (OS)
Galileo open and free of charge service set up for positioning and timing services.

(2) High Accuracy Service (HAS)
A service complementing the OS by providing an additional navigation signal and added-value services in a different frequency band. The HAS signal can be encrypted in order to control the access to the Galileo HAS services.

(3) Public Regulated Service (PRS)
Service restricted to government-authorised users, for sensitive applications that require a high level of service continuity.

(4) Search and Rescue Service (SAR)
Europe’s contribution to COSPAS-SARSAT, an international satellite-based search and rescue distress alert detection system.

Open Service (OS) and Search and Rescue Service (SAR) are already available free, and in the future High Accuracy Service (HAS) will also be free.

Along with BREXIT, the UK government announced its withdrawal from Galileo in December 2018 and has decided to invest in the development of its own GNSS. The UK Space Agency has already launched a funding project for SMEs with ideas or technologies for investigating and developing concepts for satellite system receivers. The UK left the EU at the end of January 2020 with a transition period until the end of December 2020. The European Union Law continues to apply to the UK during the transition period, and the UK government is going to negotiate a new trade agreement with EU by the end of the period. How the EU wants the UK to participate in Galileo will become a significant issue.

3 Conclusion and Recommendation

The UK's space policy is implemented by organisations under the Department for Business, Energy and Industrial Strategy (BEIS) and strongly promoted as one of the areas of industrial promotion by science and technology. The UK government has developed a series of Space policies and Earth Observation policies since 2010, and is currently promoting the UK space industry to achieve the ambitious goal to increase the UK's share in the global space industry market to 10% by 2030. The UK government aims to create and expand business in the downstream industry, which is expected to grow significantly in the future, especially by utilising satellite data. Both the Satellite Applications Catapult and the ECSAT for creating new businesses were established on Harwell Campus in 2013, and the National Centre for Earth Observation (NCEO), which has been conducting Earth Observation research, has responded to the recent trend of promoting the space industry, for example, evaluating researchers at the NCEO for their contributions to the industry as well as their academic achievements.

The characteristics of satellite data utilisation in the UK are as follows.

1) Ecosystem in the UK

   The UK government is focusing on building an entire "ecosystem" to create new businesses using satellite data. The following four elements make up this ecosystem.

   (1) Satellite data platform

   As a satellite data platform to promote the utilisation of satellite data, the Satellite Applications Catapult provides the CEMS and SeDAS system for industry and the NCEO provides the CEDA and JASMIN system for academia. In addition, the Copernicus DIAS provided by the EU programme is available to anyone. These three platforms are easy-to-use platforms that allow all users to access, process and analyse satellite data in the cloud. However, these platforms are operated independently of each other, and it is difficult to process data and move data between platforms. Therefore, it is necessary to use different data platforms depending on the purpose of use. For example, the Copernicus DIAS is good at accessing real-time satellite data obtained by the ESA and European countries, the CEMS and SeDAS system is suitable for application development with support for processing satellite data and creating algorithms by the Satellite Applications Catapult, and the CEDA and JASMIN system is suitable for academic research using the vast amount of satellite and terrestrial data acquired by space agencies and research institutes around the world.

(2) Space cluster

The Satellite Applications Catapult, the RAL Space (with CEDA and JASMIN computing infrastructure), the ECSAT, and the ESA BIC UK are all established on Harwell campus, all of which are important institutions that make up the Harwell Space Cluster. There are no universities on Harwell campus, but the adjacency of these institutions provides a seamless connection from academic research to business and strengthens the link between the UK government and the ESA.

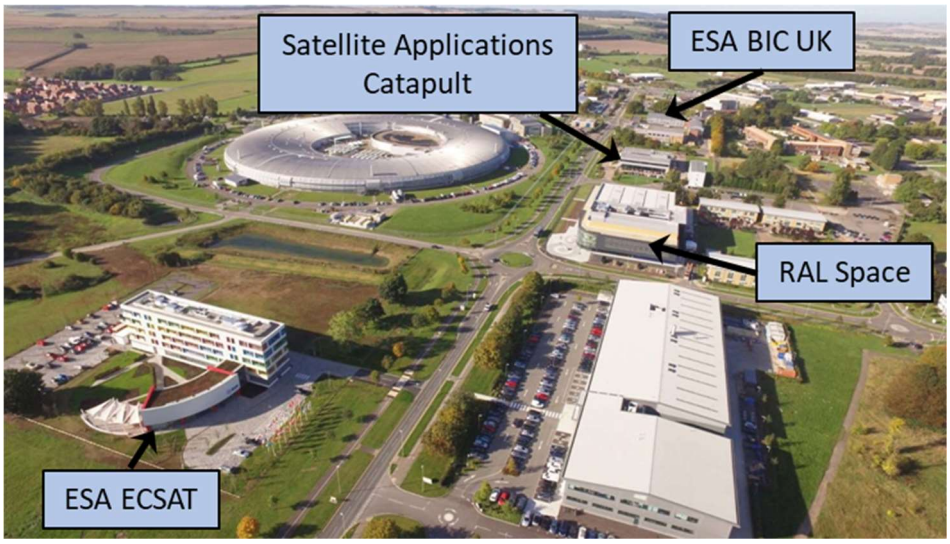

Fig. 12 Harwell Campus

(3) Regional centres (Centres of Excellence)

In addition to the Harwell Space Cluster, five Centres of Excellence across the UK are run by the Satellite Applications Catapult to grow the overall UK space industry. These centres promote industry-academia-government collaboration, including local SMEs and universities, physically under one roof in each region, and support the development of new satellite application businesses that solve local problems.

(4) ESA Ambassador Network

The UK has a network of six ESA ambassadors who act as intermediaries between the ESA, industry and the user community, while eight other countries outside the UK with ESA ambassadors each have only one ambassador. The ESA Ambassador Network plays a key role in getting SMEs such as startups to contact the Satellite Applications Catapult, the ECSAT, ESA BIC UK, venture capitals and academia, and so on. They identify new domains which might benefit from integration of space assets, and stimulate the submission of ideas and proposals to the funding and support programmes by the Satellite Applications Catapult, the ECSAT and ESA BIC UK.

Moreover, some ESA regional ambassadors are working at the Centres of Excellence funded by the Satellite Applications Catapult. This means that the ESA Business Applications and the Catapult programme, an industry-academia-government collaboration programme by the UK government, are working closely together on the same goal of creating a business utilising satellite data.

2) Recommendations for the ecosystem in the UK

The current ecosystem in the UK is functioning to a certain extent, but the fifth element needed for more effective business creation is '(5) Mobility of young researchers'. The ECSAT assigns students and postdocs of the University of Oxford to research groups in the ECSAT to participate in collaborative research with private companies, and private companies recruit young people who have completed a Master's programme to hire them as trainees for the development in the ECSAT. On the other hand, the Satellite Applications Catapult does not actively involve such students and postdocs.

The Satellite Applications Catapult focuses on increasing contract researches with industry through matching funds, modeled on the portfolio of the Fraunhofer in Germany. However, another characteristic that the Satellite Applications Catapult should acquire from the Fraunhofer is high mobility of young researchers. The Fraunhofer builds a research institute next to a university, and has a university professor serve as a director of the institute or a department head, which enables graduate students and postdocs to participate in collaborative research with private companies at the Fraunhofer institute with their professor and to write their theses or papers while gaining a business sense. Many of them start working in industry after spending about seven years as a Master's student, Doctoral student and postdoc at the institute. This flow of young researchers from the institute to the private companies transfers knowledge and technology from a university to industry and stimulates the development of new businesses.

Adding this element to the current UK's ecosystem will build a stronger ecosystem in the UK.

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