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Evaluation of the Centre for Earth Observation Instrumentation (CEOI)

Final Report

Theodora Ogden, Billy Bryan, Chris Carter-Gordon, James Besse, Mélusine Lebret, Oliver Swainston, Marissa Martin, Alyssa Frayling, Eloise Trimingham, Greg Sadlier, and Deepika Ravishankar

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Preface

The UK Space Agency (UKSA) commissioned RAND Europe, **know**.space, Luca Budello and Aravind Ravichandran to deliver an evaluation of the Centre for Earth Observation Instrumentation (CEOI) programme from May 2023 to March 2025. The evaluation provided an assessment of the effectiveness of CEOI's delivery (process), the extent to which it has achieved its objectives (perceived impact) and whether it represents value for money (economic).

Phase 1 of this study began with a deliverable scoping out this initial study phase, with a second deliverable presenting the monitoring and evaluation (M&E) literature review around space research and development (R&D), the initial baselining of the Earth Observation R&D sector when the CEOI programme launched in 2007, and the programme's process and stakeholder mapping. This study's third deliverable (the inception report) included all products presented in the second deliverable, with additional chapters developing the proposed approach to the evaluation.[1]

Phase 2 of this study commenced in June 2023 and ran until March 2025. It included interviews and surveys with CEOI programme project leads, partners, and wider cross-government stakeholders to understand the CEOI programme's processes and impacts better. The team also compiled a series of international case studies to provide insights into Earth Observation (EO) sectors in other countries, created and updated a baseline of the UK's EO sector, and conducted several policy roundtables. The interim findings from this stage were reported in mid-2024.[2]

This report constitutes the fifth and final deliverable, summarising the findings under phase 2 of this study.

For more information on this study, please contact the Project Lead, Billy Bryan (bbryan@randeurope.org).

[1] Khelifi et al. (2024).
[2] Ogden et al. (2024).

Summary

Earth Observation (EO) science is fundamental to humanity's understanding of our planet, its climate and natural processes. Launched in 2007, the Earth Observation Instrumentation Programme (EOIP) aims to enhance the UK's capabilities in low-Technology Readiness Level (TRL) Earth Observation (EO) instrumentation, focusing on TRLs 3 or 4.[3] The programme also aims to fortify the position of UK-led teams in international contracts and export opportunities, particularly in European Space Agency (ESA) EO missions. The Centre for Earth Observation Instrumentation (CEOI), established with EOIP, has been crucial in its delivery. Initially funded by the Natural Environment Research Council (NERC), EOIP advances UK technical capabilities in EO instrumentation. The EOIP was later expanded into the EO Technology Programme (EOTP) with an additional £15m up to March 2025 to develop innovative EO instrumentation to maintain the UK's position at the forefront of EO capability and expertise.

This final report presents the findings of the CEOI programme evaluation commissioned to RAND Europe and know.space. It includes an overview of the UK EO sector, evaluation of perceived CEOI impacts, the economic evaluation of the programme, and evaluation of CEOI processes, exploring potential alternative delivery models. This report presents findings assessing the perceived impacts, execution, and value for money of the CEOI, aiming to understand how the programme has enhanced EO capabilities in the UK.

The findings of this report reveal the following on the UK EO sector today, contextualising CEOI results:

- UKSA has increased its spending on both national programmes and ESA contributions in overall terms. In 2022, the UK increased EO and climate programmes investment by 45 per cent to counteract the impacts of the temporary withdrawal from EU components of the Copernicus programme.
- In 2021, EO satellite services supported industries, contributing £109bn of the UK's GDP (4.8 per cent), demonstrating how EO can help underpin economic activity.
- By the financial year 2021/22, the EO sector, including meteorology, contributed £784m to the overall £18.9bn income of the UK space industry, marking a significant increase from previous years.
- The UK has more than doubled its investment in the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and remains actively engaged in international EO organisations such as the Committee on Earth Observation Satellites (CEOS), the European Association of Remote Sensing Companies (EARSC), the European Space Sciences Committee (EASRC), and the Group on Earth Observations.

[3] TRL measures a technology's maturity from concept (TRL 1) to full operation (TRL 9), guiding investment and decision-making.

Key insights:

- The UK is a significant player in global EO technology development and CEOI plays an important role within the ecosystem.
- The CEOI programme funds innovative projects which lead to enhanced technological progression and promising mission concepts.

Interim programme impacts:

- The CEOI programme has been important in advancing TRLs of UK-developed EO emerging capabilities by an average of 2.2 points, with many participants attributing significant project progress to the support provided by CEOI.
- Approximately 46.2 per cent of survey respondents reported enhancements in their skills through participation in CEOI events, while 73.1 per cent gained valuable technical insights from technology showcases facilitated by the programme.
- Some 69.2 per cent of respondents indicated that CEOI funding has increased their ability to commercialise their research, and 96.2 per cent reported gaining reputational benefits because of their involvement with CEOI. Overall, participants widely acknowledged that their involvement with CEOI has maintained or enhanced their technical skills in the development of innovative EO instruments.
- CEOI-supported technologies have featured on four successful satellite launches between 2015 and 2023, with seven additional launches currently in progress, five projects selected for further study, and eleven more planned for future launches.
- Most respondents stated that CEOI has strengthened their capacity to partake in international missions, while two thirds acknowledged that the programme has enhanced their export capabilities.
- In addition to directly enabling increased TRLs, CEOI is appreciated by project stakeholders for fostering collaboration and establishing pioneering partnerships, particularly between universities and private sector entities. Survey data indicates that industry collaborations frequently involve a broad network of additional stakeholders.
- The strategic focus of CEOI on supporting primarily early-stage EO research and development (R&D) has been identified as a key factor in maintaining the UK's capabilities in EO.

Key insights:

- CEOI fills an important gap in funding low-TRL UK EO projects and supporting their development to higher levels.
- Coordination among government, academia, and industry strengthens the UK EO and space sector, with CEOI's expertise and networks serving as an enabler of such collaboration.
- The progression pipeline from CEOI-funded projects to ESA funding or involvement in international missions is evident, contributing to the UK's international standing.

Economic evaluation:

- The true value for money (the benefits relative to the costs) from CEOI projects will be realised in the long term, potentially years or even decades after initial funding, due to the extended timelines

required for early-stage technology development to be incorporated into EO missions. Nonetheless, there are some indications of potential for substantial future benefits, notably through several large investment events.

- With the caveat that this economic evaluation of the CEOI programme only focuses on projects ranging approximately from 2018 to 2025 (i.e. Calls 11-16), mainly due to data limitations in earlier years, current estimates suggest that the real discounted Present Value (PV) of UK benefits from CEOI Calls 11-16 is at least £30.2m to date. This is primarily driven by three large ESA contracts. Including expectations, this PV benefit rises to at least £57.6m.
- The evaluation acknowledges that many significant benefits of CEOI, such as scientific progress, enhanced collaboration and spillover benefits to adjacent sectors, are non-monetisable, suggesting that quantitative estimates may underestimate the full impact of the programme.

Key insights:

- Increasing funding for CEOI could deliver further value to UK EO. Project participants advocate for expanding the CEOI programme, though there are potential challenges and trade-offs to consider.
- Future monitoring will be essential to fully capture the programme's value for money. Regular ongoing monitoring, concurrent with project delivery, will be key to capturing benefits as they arise in future.

Process evaluation:

- Applicants highly value the support provided by CEOI for early-stage technology development, a core feature of the programme that fills a critical gap in funding for low-TRL innovations in the space sector, considering the high risk and low profitability of early-stage technologies.
- Interviewed project participants found the application process to be clear, rigorous, and characterised by quick turnaround times. The transparency of funding call needs and objectives, along with CEOI's responsiveness, was appreciated.
- Generally, participants expressed satisfaction with CEOI's project management and reporting structures, which include a light process approach and regular updates to keep projects on track. Though there have been some reports of management delays, particularly during COVID, these have been overcome, according to interviewed project leads.
- CEOI's programme design, which incorporates flexible funding tied to milestones and responsive communication, is highly valued by participants. Though some academic project participants found the payment milestones and reporting timelines challenging, for the most part, these aligned well with the needs and expectations of project leads.
- The CEOI funding and delivery model provides unique benefits to applicants and grant holders. It provides technical advice from bid stage to the very end of the project, improving project designs and supporting ongoing R&D. This may not be the case with a traditional, centrally managed UKSA programme where there is less capacity to provide such embedded industry expertise. The trade-off between outsourcing costs and project quality currently leans positively towards quality, though work is needed to ensure CEOI has enough administrative and M&E support to ensure its benefits can be properly captured and shared.

Key insights:

- The current CEOI model has advantages due to the level of stakeholder buy-in, programme transparency and support for international funding down the line.
- There is value in exploring alternative delivery models, such as an expanded CEOI model, a more centralised model, or a fully centralised model delivered directly by UKSA. However, altering the delivery of the programme is likely to have trade-offs, which require further study.

Table of contents

Figures

Tables

Boxes

Abbreviations

AI	Artificial Intelligence
ARIA	Advanced Research and Invention Agency
BIS	Business, Innovation and Skills
BNSC	British National Space Centre
CDT	Centre for Doctoral Training
CEOI	Centre for Earth Observation Instrumentation
CEOS	Committee on Earth Observation Satellites
CHIME	Copernicus Hyperspectral Imaging Mission
CIMR	Copernicus Imaging Microwave Radiometer
COTS	Commercial Off the Shelf
CRISTAL	Copernicus Polar Ice and Snow Topography Altimeter
CSC	Copernicus Space Component
DASA	Defence and Security Accelerator
DBT	Department for Business and Trade
DESNZ	Department for Energy Security and Net zero
DG	Directorates General
DIUS	Department for Innovation Universities and Skills
DOSTAG	Data Operations Scientific and Technological Advisory Group
DS	Defence and Space
DSIT	Department for Science, Innovation and Technology
DSTL	Defence Science and Technology Laboratory
EASRC	European Association of Remote Sensing Companies
ECMWF	European Centre for Medium-Range Weather Forecasts
EO	Earth Observation

EOIP	Earth Observation Instrumentation Programme
EOITP	Earth Observation Technology Programme
EPS	Earth, Planets and Space
EPSRC	Engineering & Physical Sciences Research Council
ESA	European Space Agency
ESSEO	European Scientists on Spectrum for Earth Observation
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FORUM	Far-Infrared Outgoing Radiation Understanding and Monitoring
FWCI	Field- Weighted Citation Impact
FTE	Full Time Equivalent
FY	Financial Year
GDP	Gross Domestic Product
GEMINI-UK	Greenhouse Gas Emissions Monitoring Network to Inform Net Zero Initiatives for the UK
GMES	Global Monitoring for Environment Security
GSR	Government Social Research
GVA	Gross Added Value
IASI-NG	Infrared Atmospheric Sounding Interferometer New Generation
IBF	International Bilateral Fund
LOCUS	Linking Observations of Climate, the Upper Atmosphere and Space Weather
IP	Intellectual Property
LSTM	Land Surface Temperature Monitoring
MET OP SG	Meteorological Operational Satellite- Second Generation
MOD	Ministry of Defence
MOSWOC	Met Office Space Weather Operations Centre
MWIR	Mid-Wave Infrared Thermal Imagers
NASA	National Aeronautics and Space Administration
NERC	Natural Environment Research Council
NPL	National Physical Laboratory
NSIP	Nationally Significant Infrastructure Projects

NPSV	Net Present Social Value
NSS	National Space Strategy
ONS	Office for National Statistics
PV	Present Value
RAL	Rutherford Appleton Laboratory
ROSE-L	Radar Observing System for Europe in L- Band
SAR	Subject Access Request
SENSE	Satellite Data in Environment Science
SPIN	Satellite Applications Catapult's Space Placements in Industry
SSTL	Surrey Space Technologies Ltd
STEM	Science, Technology, Engineering, and Mathematics
STFC	Science and Technology Facilities Council
SWOT	Surface Water and Ocean Topography
TRL	Technology Readiness Level
TRUTHS	Traceable Radiometry Underpinning Terrestrial- and Helio-Studies
UAV	Unmanned Arial Vehicle
UK	United Kingdom
UKRI	United Kingdom Research and Innovation
UKSA	UK Space Agency
UVNS	Ultraviolet Visible Near Infrared Short-wave Infrared Spectrometer
WECD	Warwick Economics & Developments

1. Introduction

1.1. The CEOI programme

The Earth Observation Instrumentation Programme (EOIP) was launched in 2007 to maintain and grow UK capability in instrumentation for low-Technology Readiness Level (TRL) Earth Observation (EO), up to TRLs 3 or 4).[4] The EOIP aims to strengthen the position of UK-led teams bidding for export opportunities and international contracts, particularly in these ESA EO missions. The Centre for Earth Observation Instrumentation (CEOI) has overseen the EOIP since its inception in 2007. The Natural Environment Research Council (NERC) initiated the EOIP to help develop UK technical capability in innovative EO instrumentation and offer a strategic funding source to this end. The CEOI consortium that has delivered the programme is led by Airbus Defence and Space (DS) in partnership with QinetiQ, the University of Leicester, STFC/Rutherford Appleton Laboratory and, more recently, know.space. The consortium aims to develop innovative technologies to observe Earth from space by teaming UK scientists with industrialists. Founded in 2010, the UK Space Agency (UKSA) took over EOIP funding responsibility from NERC.

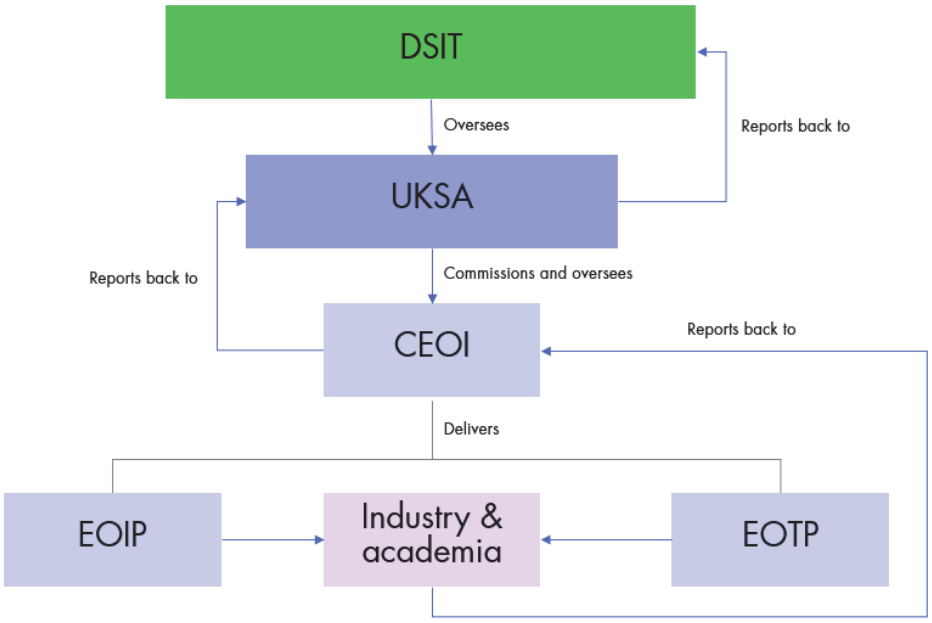
To date, there have been two primary elements to the EOIP:

- **The Technology Programme**: 74 projects funded via 16 themed/open R&D grant funding calls, with a wide range of technologies funded.
- **The Added Value Programme:** Knowledge exchange and networking events to establish and strengthen networks between academia and industry, with advice to upskill and guide companies bidding for ESA projects and strategic/technical advice for UKSA, the DSIT and the wider government.

Announced in November 2022, the Earth Observation Technology Programme (EOTP)[5] was designed to develop innovative EO satellite instrumentation to maintain the UK's position at the forefront of EO capability and expertise. By co-funding innovation with industry and academia, the programme aims to help mature technologies to a level where they can form satellite mission payloads or be part of viable commercial applications. Figure 1 outlines a simple view of the CEOI's governance structure.

[4] 'Low-TRL' technologies are those in the early stage of development, i.e. concepts or models that may not yet have been tested or prototyped.
[5] HMG (2022).

Figure 1: CEOI governance structure



Source: RAND Europe analysis of UKSA documentation on CEOI.

EOTP enabled the EOIP's scale-up and delivery by expanding the existing CEOI contract. The EOTP aims to enable the development of select technologies further than previously possible, potentially including airborne and/or in-orbit demonstration to prove capability and additional support to lower-level TRL projects. The EOTP also expands on the EOIP's objectives, focusing more on closer-to-market technologies and ESA's and other international space agencies' adoption rate of EOTP/EOIP-supported projects and recognising the need to mitigate the economic impact of the period of non-association with Copernicus, the European Union (EU) EO programme, to which the UK rejoined as an associate country in 2024.[6]

In 2017, the CEOI prepared the UK EO technology strategy[7] for UKSA, setting out the UKSA vision for EO over the next decade so that the UK could be a world leader in new EO technologies. The strategy was updated in 2019 and set out the four key objectives underpinning EOIP/EOTP-funded activities:

- **Economic Impact:** Develop EO technologies that increase exports and economic growth.
- **Innovation:** Keep the UK at the forefront of EO technology development by supporting new and innovative ideas that offer tangible benefits to future missions.
- **Capability:** Strengthen capabilities in which the UK already leads, has the potential to lead or could overtake existing capability elsewhere
- **Return on UK Government Investment:** Maximise the benefits derived from UK funding to ESA and other institutional bodies.

[6] HMG (2023).
[7] UKSA (2017).

This report refers here on to the CEOI programme as a combination of the EOIP, the EOTP and the CEOI delivery consortium.

1.2. Study objectives

This evaluation aimed to assess the CEOI's impact, delivery and value for money and to understand how both programmes have/are contributing to improving the UK's EO capabilities. The overall objective was to deliver an impact, process and economic evaluation across CEOI to optimise the programme's ongoing delivery.

Guided by His Majesty's Government's (HMG) Magenta, Green & Aqua Books' best practices and Government Social Research (GSR) ethics guidelines, the monitoring and evaluation (M&E) activity funded through this project aims to help UKSA understand how effective funding from CEOI has been by establishing what tangible difference it has made and for whom (direct beneficiaries, associated or non-participating organisations and broader society). It also gathered lessons learned to support future programmes' design and implementation and the CEOI's next steps.

It should be noted that the methodology used for the impact evaluation is not sufficiently robust to be termed a proper impact evaluation in line with HMG guidance. An *impact evaluation*, and assessment of concrete impacts assumes the deployment of quasi-experimental methods and the identification of a proper counterfactual or control group, which are not used here due to data availability constraints and the lack of a well-defined control. Instead, this work employs a theory-based approach, and the impacts identified are instead *perceived* or *interim impacts.* For ease of reading, we still refer to impacts throughout the report, but this caveat should be considered by the UKSA and by readers.

The evaluation was supported by extensive primary and secondary research, underpinned by a Theory of Change (ToC) and process map. A previous evaluation of CEOI was conducted in 2022, covering the period from the CEOI's inception until 2021. Rather than duplicating that effort, this evaluation extended and tested those findings by revisiting the impact of CEOI projects to date. Our approach to assessing the impact of the programme was primarily centred around contribution analysis (CA) to test the claims set out in the ToC and evaluation framework. By employing CA, we aimed to develop a framework for understanding how CEOI contributed to observed outcomes in the ToC. To build a strong basis for the evaluation, we implemented an impact indicator framework which detailed what metrics would be used to answer the evaluation questions. From this, indicators and evaluation questions were synthesised to underpin specific interview questions, data analysis and bibliometric analysis. Results have been reported broadly against the original contribution claims, detailing the level of attribution to the CEOI intervention.

M&E and benefits management ensure optimal spending of public funds to benefit a wide range of UK stakeholders (e.g. industry, academia and the general public) and contribute to achieving national and regional strategic objectives, especially those set out in the National Space Strategy (NSS). UKSA's North Star metric uses the total investment level and contract revenue brought into the UK space sector to assess the sector's overall value. Doing so effectively requires data collection from the outset to support and evidence UKSA's evaluations in the coming decade and provide transparency in how the UK benefits from this investment and lessons for the future.

1.3. Methodology

This study phase involved multiple data collection and synthesis methods, detailed in the section below.

Table 1: Methodologies used across each evaluation stream

Method Category	Methods used
Process Evaluation	Surveys
	Interviews
	Policy Round Tables
Economic Evaluation	Secondary Data Analysis
	Monitoring Forms
Data Science	Bibliometrics

Source: Internal document repository.

1.3.1. Process Evaluation

The process evaluation of CEOI focuses on using contribution analysis (CA) - based on theories of change (ToC) analysis, as part of a theory-based approach – exploring programme hypotheses and alternative hypotheses through creating a contribution story derived from key stakeholders and participatory methods like surveys, interviews, and policy roundtables. Stakeholder surveys, policy roundtables and CEOI participant interviews were utilised for impact analysis with an interview with CEOI centred around process evaluation itself. The addition of contribution stories through qualitative data gathering enables theory implementation during design and provides strong evaluation outcomes based on actual stakeholders. An overview of the methods used to contribute to the process evaluation are below:

- **Survey:** between November 2023 and February 2024, we circulated an online survey through SmartSurvey to project leads and partners from all projects funded by the CEOI since its inception. The questionnaire covered process and impact questions, asking respondents to indicate the level of support they received from CEOI for their projects, and identify their TRL progression rate, along with core questions around their experience with CEOI processes (See Annex B for survey questions). Of 68 project leads, 26 responded (38.2 per cent response rate). This low response rate is attributable to the sector's relatively high turnover, the project teams' demanding workloads and 'survey fatigue', since stakeholders had already engaged in surveys for previous and concurrent evaluations. We focused more on our interview range and document review to cover gaps.
- **Interviews:** Interviews were the primary data-collection method for capturing the rich qualitative data needed to answer the evaluation questions (EQs). Interviews were semi-structured, using clearly defined topic guides that reflected survey topics. We conducted a total of 26 online interviews via Teams across four stakeholder types: the wider programme team (e.g. CEOI and UKSA EO policy leads, n=5), project leads (n=10), other beneficiaries (e.g. project partners, n=3) and wider policy stakeholders (e.g. DSTL and ESA, n=7). We conducted the analysis in MAXQDA and grouped the results thematically against the indicator frameworks.
- **Policy Roundtables:** The study team also held two policy roundtables with practitioners within the UK EO sector, as well as government stakeholders working on EO policy, R&D and strategy. Organisations and departments attending the EO sector roundtables included UKSA, DSIT,

DEFRA, The Met Office, National Physical Laboratory, STFC RAL Space, Surrey Satellite Technology Ltd. ESA and UKRI. The two roundtables were held on 23rd October 2024 and 6th November 2024 via Teams. The sessions discussed the UK's strengths and gaps in the EO market, key past trends in the UK's domestic and international EO policy and programmes, opportunities for EO investment, future needs and strategies, job creation, and exploration of the ideal delivery model for EO sector funding. The discussion from the roundtables helped validate findings and add qualitative strength to the evaluation.

1.3.2. Economic Evaluation

Our economic evaluation brought together qualitative and quantitative evidence to evaluate the extent to which CEOI has offered value for money. We collated data on costs and benefits, using cost data provided by the CEOI and data on benefits from monitoring forms, the survey and to a lesser extent, interviews. We made adjustments for additionality, attribution, deadweight, displacement and leakage, as well as appropriately discounting and deflating figures.

- **Secondary data analysis:** We analysed secondary data using various sources, reporting descriptive information about the projects and application numbers via CEOI's programme data and feeding this into a portfolio analysis to help contextualise results data. The CEOI-provided documentation included project reports, quarterly reports and selection panel results. However, the documentation received was unevenly spread across the funding calls, averaging only 59 per cent of projects with available reports. Table 2 below shows the documentation received across each funding round.

Table 2: CEOI documentation received

	Rounds 1–6	Round 7	Round 8	Round 9	Round 10	Round 11	Round 12
Number of projects	18	16	6	6	18	7	12
Number of projects with reports available	9	15	4	5	11	2	3
Share of projects with reports available	50 per cent	94 per cent	67 per cent	83 per cent	61 per cent	29 per cent	25 per cent

Source: Internal document repository.

- **Monitoring forms:** The research team designed monitoring forms in consultation with UKSA and CEOI to capture economic data among project participants. The forms collected information on the projects, including the value of CEOI funding, match funding, starting and end TRLs. The forms were designed to be issued periodically to project stakeholders to enable CEOI to gather economic data on a rolling basis to fulfil North Star Metric reporting requirements.

1.3.3. Data Science

Data science methods were employed as a quantitative mechanism for this analysis of impact report for CEOI. A bibliometrics methodology was adopted – opted for over alternatives like altmetrics due to data scarcity and temporal constraints on the research team - due to data scarcity and thus open-source data can

be used to obtain information on key impact parameters like publication counts, FWCI, publications by year, and publications in the top 1% of their respective fields. [8] Our specific method below is outlined:

- **Bibliometrics:** The study team conducted bibliometric analysis to understand the UK's contribution to international research on EO technologies. Due to challenges in attributing research outputs specifically to the CEOI programme, the focus was on the UK's overall position in EO research. OpenAlex was selected as the database for its completeness.[9] The process of filtering UK-related EO publications was iterative, focusing on papers from 2006 to 2023 and using specific search terms to identify relevant research. The research team manually reviewed results from different search term combinations, adjusting them to maximise the inclusion of relevant papers. The search conducted on 19 November 2024 yielded 37,140 journal articles. From this dataset, additional datasets were created for the UK, France, Germany, Canada, Japan, Australia, South Korea, Norway, and Finland to compare their presence in EO research. This approach benchmarks the UK's performance against these countries. Publications from several UK institutions were also selected to explore their performance against scientometric indicators. Box 1 shows the search terms used in OpenAlex for this study.

Box 1: Search terms used in OpenAlex

Terms: "earth observation" AND ("satellite" OR "ir radiometry" OR "optical imaging" OR "ir spectroscopy" OR "lidar" OR "optical spectroscopy" OR "passive microwave" OR "radiation detection" OR "gnss-r" OR "spatial resolution" OR "radar altimetry" OR "radar scatterometry")

Full OpenAlex query

1.4. Caveats and limitations

There were several challenges in conducting this evaluation which we identify here and should be kept in mind while considering the results:

- **Reporting gaps:** This research's secondary data analysis was limited by the availability of project reporting. Funding values for early calls (before the seventh call) are stored in secure commercial servers and have not been migrated to the new system since the transformation of CEOI leadership under UKSA. As such, the figures for these projects are aggregated.
- **Low survey response:** The initial survey only achieved a 38.2 per cent response rate. The research team was required to pivot from a second survey to interviews which gathered more qualitative data. Interviews had a good response rate and enabled participants to tell the story of their project and the impact of CEOI.

[8] Altmetrics is a form of more inclusive bibliometrics that relies on scraping data from social media, patent submissions, non-scholarly forums, mainstream media, policy documents, and social networks. However, it is incredibly time intensive and requires advanced data scraping methods to meaningfully replace normalised bibliometrics.

[9] For analyses of OpenAlex's completeness relative to other bibliographic databases, see Culbert, Jack, Anne Hobert, Najko Jahn, Nick Haupka, Marion Schmidt, Paul Donner, and Philipp Mayr. "Reference coverage analysis of openalex compared to web of science and Scopus." arXiv preprint arXiv:2401.16359 (2024).; Alperin, Juan Pablo, Jason Portenoy, Kyle Demes, Vincent Larivière, and Stefanie Haustein. "An analysis of the suitability of OpenAlex for bibliometric analyses." arXiv preprint arXiv:2404.17663 (2024).

- **Low monitoring form response**: Less than a third of the total grantee population returned the monitoring forms, limiting the insights that could be drawn from across the portfolio, particularly in terms of the economic evaluation. This is despite the mandatory requirement since 2022 for projects to report data on the North Star Metrics, questions of which were present within the monitoring form.
- **Retrospective recall:** Reaching stakeholders has been challenging for some projects awarded over 15 years ago, which also potentially impacted the response rate. Project leads were interviewed and surveyed as part of the CEOI evaluations. However, this report relies heavily on documentary and secondary data sources to reduce the questioning needed in surveys and interviews.
- **Measuring impact:** There are considerable challenges to measuring impact linked to the nature of the funded innovation. Across many programmes, scientific impact is expected but has yet to materialise. Intellectual property (IP) tested products and publications may not yet have been generated in some cases.
- **Self-reported TRL:** There are some limitations to this and previous approaches to evaluating the CEOI in allowing project leads to self-evaluate TRL increases across their projects. Without a detailed definition of TRLs, stakeholders may assess their projects' TRLs differently, limiting reporting accuracy and cross-comparability. Organisations may also feel compelled to report TRL increases to justify their CEOI funding. Future evaluations may benefit from employing a third party (e.g. a peer review panel) to compile and assess this data.
- **Various outputs:** Outputs may vary depending on the project and lead type (e.g. commercial, academic or government). Some projects – particularly those with an academic lead – prioritise publication over generating IP, while others prioritise product commercialisation without releasing findings into the public domain.
- **Evaluation timelines:** The study team encountered challenges in gauging outputs at this evaluation stage, especially for those yet to materialise. While some completed projects have already achieved their intended outputs or outcomes, others may be slower to materialise due to longer causal pathways between the project's output and its national-scale impact. Other projects are ongoing, with further awards pending. Therefore, their expected outputs are unlikely to manifest until later in the evaluation.
- **M&E was not in the original scope of CEOI**: Including M&E post-award has led to inconsistent responses and a lack of a baseline per project. This is made more difficult by the time constraints CEOI staff are under. M&E reporting expectations in the GFA should be expanded to include clear guidelines on data collection, storage and transfer to evaluators.

2. The UK EO sector today

2.1. Summary

EO remains a strategic priority for the UK, identified as a 'high growth area' in the National Space Strategy (NSS, 2021) and reinforced in the National Space Strategy in Action (2023). UKSA has increased national and ESA spending, investing more in EO to mitigate impacts from the short-term exit from EU elements of Copernicus. The UK has re-engaged with the EU arm of Copernicus to ensure participation in key space initiatives and strengthen its position in European EO activities. UKSA primarily delivers through ESA and contributes to several international EO missions. However, the UK EO sector faces challenges such as skills shortages, and requires targeted strategies and long-term funding to enhance growth and innovation.

Box 2: Quick figures on the UK EO sector, past and present

- In 2021/22, the EO sector, including meteorology, contributed £784m to the UK space industry's £18.9bn income.
- In 2021, EO satellite services supported industries that contribute £109bn to UK GDP (4.8 per cent).
- The UK has more than doubled its investment into EUMETSAT and continues to participate in international EO organisations such as CEOS, EASRC, ESSEO and the Group on Earth Observations.

2.2. Context

The UK EO sector has grown since 2007, through strategic investments, technological advancements, and increased international collaboration. Previously the British National Space Centre (BNSC) coordinated and funded UK space activities, but in 2011, UKSA was created as the government's main delivery agency for UK civil space programmes, including oversight of the CEOI programme.[10] The Department for Science, Innovation and Technology (DSIT) sits above UKSA, setting civil space policy.[11]

Since 2007, government funding for the space sector has seen an increase, reflecting a growing commitment to enhancing UK space capabilities. National spending has risen from £21m in 2010/11[12] to £102m in 2023/24.[13] Over the same period, the UK's total contributions to ESA have more than doubled,

[10] UKSA (2012a).
[11] NAO (2024).
[12] UKSA (2012a). Value in current price.
[13] UKSA (2024a). Value in current price.

climbing from £217m[14] to £482m.[15] In 2021/22, EO satellite services supported industries that contribute £109bn to UK GDP (4.8 per cent), demonstrating how EO can help underpin economic activities.[16] It also highlights the expanding role of EO in decision-making, risk assessment, and sustainability efforts, reinforcing its strategic importance to the UK economy.

Since 2007, EO has been a strategic priority for UKSA and the UK's space ambitions, with policies aimed at maintaining global leadership in EO capabilities. The *2010 Space Innovation and Growth Strategy*[17] identified EO as a major growth area, leading to the *Strategy for Earth Observation from Space 2013-16.*[18] This strategy focused on enhancing international EO leadership through collaboration among academia, government, and industry, improving EO technology and data accessibility. It aimed to maximise returns from UK membership in European programmes, including ESA and EU space subscriptions. In 2019, the *UK EO Technology Strategy*[19] was published to guide investment in upstream technologies for future EO missions, emphasising returns from international programmes like ESA and Copernicus. It prioritised developing technologies relevant to future EO missions to strengthen the UK's position in national, European, and global initiatives.

The NSS,[20] the UK's first Space Strategy published in 2021, identified EO as a key sector for capability development. The *2023 National Space Strategy in Action*[21] outlined steps to maintain leadership in EO technology, including creating a national EO strategy, enhancing government EO data use, and integrating civil and defence activities. Priorities include advancements in EO technology, especially small satellites, and developing a robust EO data ecosystem. The UK aims to become a global hub for high-quality EO data and leverage EO for climate, weather, and environmental challenges. International collaboration, particularly with ESA, EUMETSAT, the EU, and Five Eyes, is essential to fulfilling these objectives.

Since 2007, the EO sector has also faced significant challenges. The UK's exit from the EU introduced uncertainty regarding the UK's access to the Copernicus programme, the EO component of the EU's space programme, with the UK's membership temporarily paused from 2021 to 2024. As a result, UK institutions were unable to participate in Copernicus projects or receive funding, and projects progressed without UK involvement. Meanwhile, funding fluctuations and a demand for specialised skills have also impacted the growth of the sector.

2.3. Funding and spending

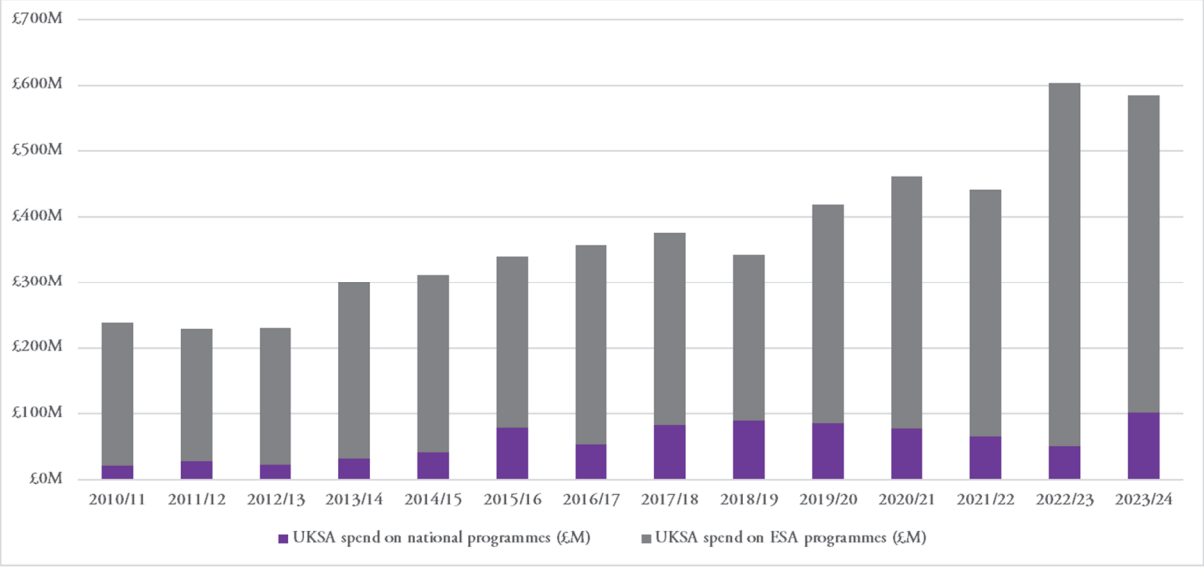
Since its inception in 2011, UKSA's budget allocation has consistently grown, with most spending channelled through ESA. National expenditure increased from £21m in 2010/11 to £102m in 2023/24, while ESA contributions rose from £217m to £482m over the same period.[22] The CEOI is a key EO-specific funding programme, complemented by broader funding opportunities like UKSA's International Bilateral Fund (IBF) and the National Space Innovation Programme (NSIP), which support EO projects and foster

[14] UKSA (2012a). Value in current price.
[15] UKSA (2024a). Value in current price.
[16] UKSA (2024b).
[17] Space IGS (2010).
[18] UKSA (2013).
[19] CEOI (2019).
[20] UKSA, et. al (2021).
[21] DSIT & MoD (2023).
[22] UKSA (2012a); UKSA (2024a). Values are in current prices.

innovation. Besides UKSA, other public bodies like UK Research and Innovation (UKRI), and its subordinate Science and Technology Facilities Council (STFC), and the Natural Environment Research Council (NERC) play crucial roles in EO funding and collaboration, [23] in addition to the Met Office. The Defence Science and Technology Laboratory (Dstl) also contributes significantly to UK space research, focusing on space technology for defence and security.[24]

The figure below highlights the trend in general UKSA space expenditure over time, to demonstrate its increasing national importance as a sector. A breakdown at EO level is difficult to identify, not least due to lack of data and how EO activities can sit within non-EO-specific programmes.

Figure 2: UKSA expenditure on national and ESA programmes[25]



Source: UKSA Annual Report and Accounts 2011/12 – 2023/24 (see References for full list).

While detailed EO-specific data is limited, increased national space expenditure and ESA contributions suggest a rise in EO-related spending. Recently, the UK government committed to supporting the EO sector to meet NSS goals and address funding challenges from the temporary Copernicus suspension. In 2022, a £187.6m investment was announced, repurposing funds initially for Copernicus. This included £65m to develop UK EO capabilities, fostering innovation and strengthening the domestic EO ecosystem, and £122.6m for ESA EO programmes, securing international collaboration.[26] This strategic redistribution of funds highlights the UK's commitment to maintaining leadership in EO despite geopolitical uncertainties. In 2023, a further £47m investment was announced, building on the 2022 deal, with £41.7m through ESA and £1.1m via STFC and NERC, underscoring the UK's EO leadership commitment.[27]

The table below showcases UKSA's increased spending on national programmes, from 2022/23 onwards. The fall in EO spend from 2022/23 to 2023/24 reflects lower ring-fenced funding in relation to the Earth

[23] UKRI (n.d.a).
[24] DSIT & MoD (2023a).
[25] These values are in current prices.
[26] BEIS, et al (2022).
[27] DSIT, et. al (2022).

Observation investment package – which was announced to support the UK EO sector during the temporary pause in Copernicus membership. The EO investment package value was £123.1m in 2022/23 and just £46.3m in 2023/24. Of the ring-fenced EO budget, UKSA spent £4.7m on funding CEOI and £41.6m on ESA programmes in 2023/24. The EO investment package spend for 2024/25 has further reduced given the UK has fully rejoined Copernicus.[28] EO remains the third largest programmatic expenditure in 2024/25, underscoring its strategic importance and sustained investment focus within UKSA's overall budget.

Table 3: Spend trends from 2022/23 to 2024/25

UKSA Priorities	2022/23 Actuals (£m)	2023/24 Actuals (£m)	2024/25 Allocation (£m)
Earth Observation	213.8	152.0	90
Discovery	217.4	247.3	233
Sustainability	44.4	48.0	41
Levelling Up	N/A	15.0	54
Innovation	145.1	167.8	151
Low Earth Orbit	N/A	N/A	N/A
Inspiration	N/A	N/A	N/A
Launch[29]	22	8	13

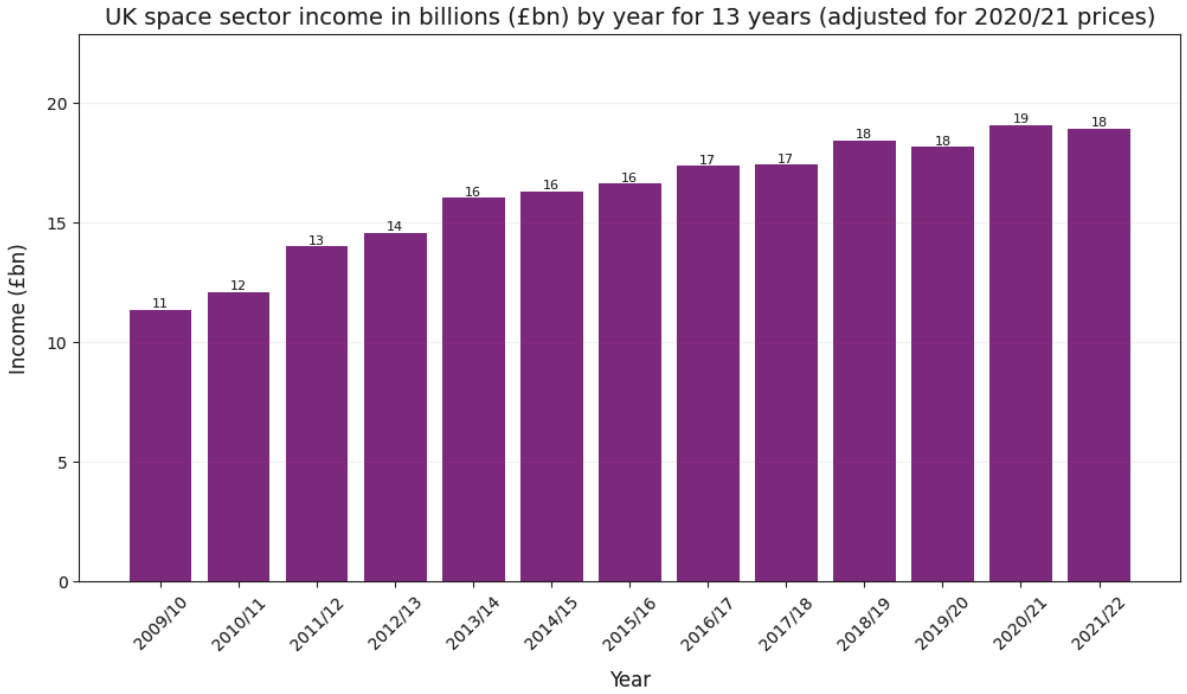
Source: UKSA Annual Report and Accounts (2024a).

2.4. Capabilities

In 2009/10, UK space-related income was estimated to be around £11.3bn. By 2021/22, total industry income had increased to £18.9bn, including £733m from the EO sector and £51m from meteorology. Medium-term sector growth has been strong, with income increasing by 2.7% between 2018/19 and 2021/22.[30]

[28] UKSA (2024a).
[29] UKSA (2023a).
[30] UKSA (2024b). Values in current prices.

Figure 3: Trends in UK space industry income (adjusted to 2020/21 prices)



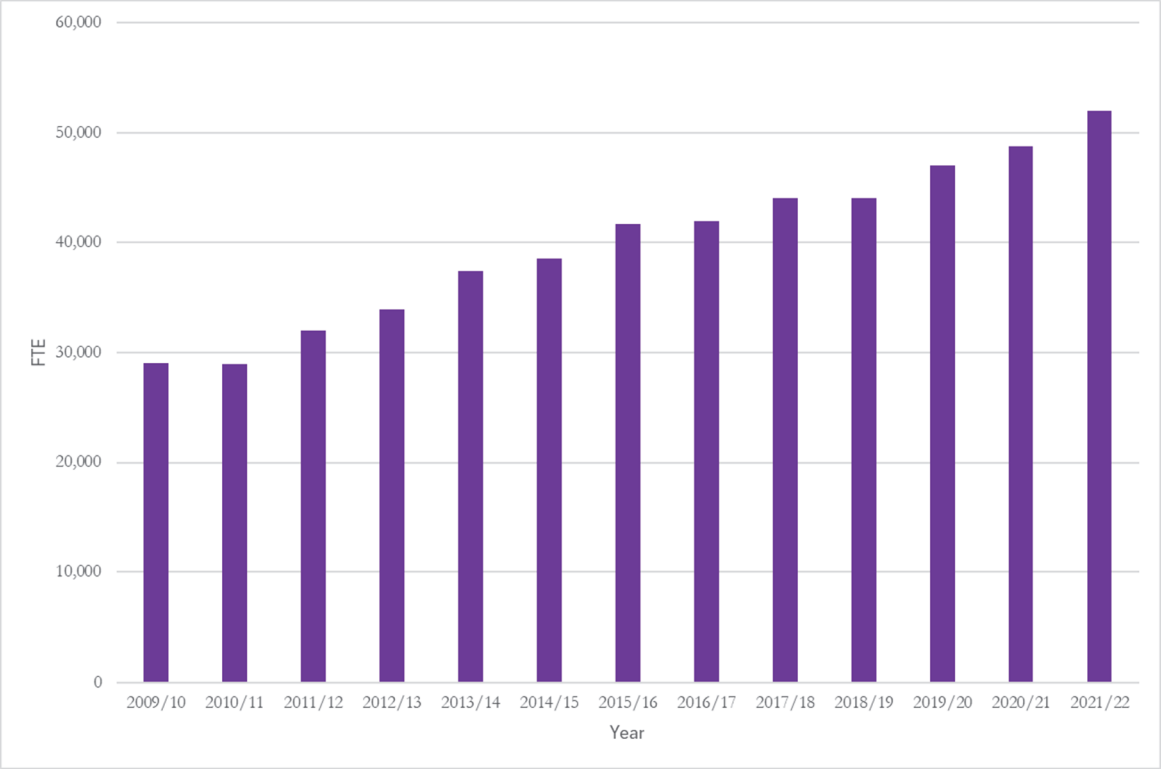
Source: UKSA Size and Health of the UK Space Industry (2023).

There has been a gradual increase in total employment in the UK space industry with 52,028 Full Time Equivalent (FTE) in 2021/22, compared to 28,995 FTEs in 2009/10. This includes 10,586 employees within the space manufacturing segment and 4,914 employees within the space operations segment in 2021/22. Growth in employment in 2021/22 was approximately 5%.[31] In 2020/21, there were 432 UK space organisations with some EO activities, and we estimate that 2,820 FTE jobs existed in EO.[32]

[31] UKSA (2024b).

[32] know.space estimates using proprietary know.space databases.

Figure 4: Trends in employment in the UK space industry



Source: UKSA UK Space Industry: Size and Health Report reports (2023).

2.4.1. Skills and Training

The UK space sector is characterised by a highly skilled workforce, though data on EO skills specifically is more limited. Most space industry employees have a university education, with 80 per cent holding at least a bachelor's degree.[33] The average qualification level in the space industry exceeds that of any sector reported in the Office for National Statistics (ONS) Census data. Still, the sector faces significant barriers in aligning workforce capabilities with demand, with skills shortages remaining a key challenge. The Space Sector Skills Survey showed that 52 per cent of organisations reported skills gaps in their workforce in 2023, highlighting the persistent nature of this challenge for the UK space industry.[34] Whilst these challenges are not specific to CEOI-funded organisations, or even just the EO sector, CEOI funded projects must operate within this broader context. In general, EO-funded organisations may face challenges whilst looking to expand or recruit, due to these skills shortages.

Since 2007, several initiatives have aimed to build a skilled workforce and support the sector's growth. The Satellite Applications Catapult's Space Placements in Industry (SPIN) programme, in collaboration with UKSA, has facilitated nearly 450 work placements in the space sector over the past decade, with 75 per cent of alumni entering space or tech fields.[35] The Satellite Data in Environmental Science (SENSE) Centre for Doctoral Training (CDT), launched in 2020 by the Universities of Edinburgh and Leeds and funded by NERC and UKSA, is training 69 PhD students to tackle environmental challenges using satellite

[33] UKSA (2024b).
[34] UKSA (2021b); UKSA (2023b).
[35] UKRI (n.d.b).

data and EO methods.[36] Additionally, the Engineering & Physical Sciences Research Council (EPSRC) CDT for Geospatial Systems, in partnership with Newcastle University, the University of Nottingham, and UKRI, trains doctoral students to enhance the UK's economic benefits from open geospatial data.

2.5. National EO activities

Since 2007, the UK has funded national EO activities, including UK-led missions and grant schemes like the CEOI, enhancing core capabilities and fostering sector growth. These efforts have advanced satellite technology and improved data acquisition for environmental monitoring. Notable missions include the NovaSAR satellite, funded with £21m by UKSA in 2011, designed for flood, forest, and disaster monitoring.[37] Another key mission was UKube-1, the UK's first national CubeSat, built by AAC Clyde Space, launched in July 2014, successfully demonstrating technology deployment and data collection.[38]

Major UK industrial stakeholders have also played critical roles in supporting and delivering EO missions, reinforcing the private sector's capacity for innovation. For example, Carbonite-1 (2015 - 2018) was a technology demonstration mission developed by SSTL, designed to showcase low-cost, high-performance video imaging applications. The mission achieved its objective by demonstrating that the concept of a commercial-off-the-shelf (COTS) imaging payload is viable.[39] #

Since its establishment, the National Centre for Earth Observation (NCEO) has enabled the advancement of several UK EO capabilities. The NCEO was established in 2014 as part of the Natural Environment Research Council (NERC) dedicated to long-term study and exploitation of EO data to generate new knowledge about the physical, chemical and biological systems of Earth.[40] NCEO scientists are playing key roles in recently launched and upcoming satellite missions, such as ESA's BIOMASS (launched April 2025), EarthCARE (launched May 2024), FORUM and TRUTHS missions and the joint UKSA/CNES MicroCarb (launched July 2025), contributing to mission design, sensor development, system and data analysis, modelling, algorithm creation, and validation.[41]

2.6. International collaborations and partnerships

Since 2007, the UK has continued its membership of international organisations including ESA, EUMETSAT, Copernicus (albeit with a temporary pause), the Group on Earth Observations, and CEOS (the Committee on Earth Observation Satellites) – of which the UK assumed Chair of in October 2024 for a 12-month period. The UK maintains strong involvement in EO activities at a European level through industry and policy engagement. Several UK companies are active members of the European Association of Remote Sensing Companies (EARSC), contributing to advancements in remote sensing and geo-information services.[42] The UK also has representation at the European Scientists on Spectrum for Earth Observation (ESSEO), a group of senior scientists shaping the European science community's views on frequency

[36] SENSE - Centre for Satellite Data in Environmental Science (n.d.a).
[37] UKSA (2012b).
[38] UKSA (2015a).
[39] eoPortal (2018).
[40] NCEO (n.d.d).
[41] NCEO (n.d.a).
[42] EASRC (n.d.a).

regulatory matters in Earth science, meteorology, and climate,[43] ensuring continued influence in continental initiatives. This participation highlights the UK's strategic commitment to staying at the forefront of EO at an international level.

2.6.1. ESA

As in 2007, most UK EO activities are channelled through the country's subscription to ESA programmes. UKSA invests in ESA because its technical expertise, knowledge, and test facilities offer opportunities to strengthen national capabilities and expand the UK space sector.[44] Between 2010/11 and 2023/24, UKSA increased its expenditure on ESA subscriptions from £217m to £482m.[45]

We estimated UKSA's subscription to ESA's EO portfolio rose from approximately £41.014m in 2013 to £46.9m in 2016.[46] During this time, the country's EO subscription remained steady at around 16 per cent of UKSA's overall contribution to ESA programmes. In 2013, in addition to the EO subscription, other key EO-related activities include GMES (Global Monitoring for Environment and Security – the precursor to Copernicus), with an estimated contribution of £7.6m, and MetOP-SG with an estimated contribution of £20.1m. GMES included initiatives focused on management of the environment, understanding and mitigating the effects of climate change and ensuring civil security.[47] Furthermore, the MetOp-SG satellites serve as the second-generation meteorological satellites for EUMETSAT, providing detailed global observations for weather and climate.[48]

Over the period between 2017/18 and 2023/24, the UK has consistently spent around 20-24.5 per cent of its overall subscription on EO activities. We estimated that UKSA's subscription to ESA's EO portfolio rose from £64.4m in 2017/18 to £111.4m in 2023/24.[49] Investments into ESA, including the Earth Observation Envelope Programme (EOEP), have given the UK the opportunity to contribute to, and in some cases play a leading role, on large scale missions. One high-profile mission is the UK-led Traceable Radiometry Underpinning Terrestrial- and Helio-Studies (TRUTHS) missions – the country's first ESA EarthWatch mission, due to launch in 2030.[50] It seeks to establish a space-based observatory for climate and calibration, enhancing the accuracy of climate measurements and supporting strategies for achieving net zero and assessing their impact. Airbus UK is leading the mission's implementation phase under an ESA contract, following the successful completion of the feasibility and predevelopment phase in 2022. The National Physical Laboratory (NPL) and Teledyne e2v Space Imaging and other UK organisation are contributing key technologies, calibration support, and scientific expertise to optimise the mission's data accuracy and overall performance.[51] CEOI directly contributed to this success, funding early TRL raising of the TRUTHS radiometer and calibration system.[52]

[43] ESA (n.d.a).
[44] NAO (2024a).
[45] See all UKSA resources for data in the References (values in current prices).
[46] know.space analysis. UKSA (2014a, 2015, 2016a) - calendar years used to reflect UKSA annual reports reporting (values in current prices).
[47] ESA (2012).
[48] EUMETSAT (n.d.a).
[49] See all UKSA resources for data in the References (values in current prices).
[50] UKSA (2020).
[51] UKSA (2021d).
[52] CEOI (n.d.a).

2.6.2. The EU and Copernicus

Beyond ESA, the UK has had significant involvement in high-profile European missions over the past decade, notably Copernicus. The UK was actively involved in the Copernicus (previously GMES) programme from its inception.[53] However, the UK's exit from the EU created uncertainty about whether UK organisations could bid for Copernicus contracts, given that it is an EU-funded programme. Whilst the UK continued to be associated with the ESA arm, the Copernicus Space Component (CSC-4), there was ambiguity as to whether UK organisations would be able to bid for Copernicus contracts tendered through ECMWF[54] and Mercator Ocean.[55] The UK was also limited to using lower resolution open-source Copernicus data, meaning these satellites were mainly useful for climate monitoring rather than sensitive security missions.[56]

In 2022, during this period of uncertainty about the UK's future in the Copernicus programme, the UK government announced a £187.6m investment package to support EO activities, followed by a further £47m in FY23/24.[57] In 2023, three years after exiting the EU, the UK secured a revised agreement to rejoin Copernicus. While we do not know the specifics for Copernicus only, the European Commission estimates that the UK will contribute almost £2.18bn (€2.6bn) per year on average for its participation to both Horizon Europe and the Copernicus component of the Space programme.[58] This milestone reinstated UK organisations' eligibility to compete for Copernicus contracts. Additionally, the deal restored full access to the programme's resources and high-impact projects, reinforcing the UK's role in European EO initiatives.[59]

2.6.3. EUMETSAT

The UK also enhances its EO capabilities through continued investment in EUMETSAT, having been a Member State since its establishment in 1986. EUMETSAT operates satellites for meteorological data crucial to weather forecasting and climate monitoring. The Met Office represents UK interests in EUMETSAT, supporting research and operational needs.[60] We estimate that UK contributions to EUMETSAT, including mandatory programmes like Meteosat and the EUMETSAT Polar System, totalled £59.3m in 2023, compared to £23.4m in 2007. Since 2007, the UK has consistently been among the top contributors to EUMETSAT, averaging as the second or third largest contributor.[61]

In partnership with CNES, UKSA delivered the Infrared Atmospheric Sounding Interferometer New Generation (IASI-NG) instrument in 2019, successfully launched in August 2025 as part of the MetOp-SG-A series weather satellites, crucial for weather prediction, atmospheric studies, and climate research.[62]

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[53] Centre for Strategy & Evaluation Services (2013).
[54] The European Centre for Medium-Range Weather Forecasts (ECMWF) is both a research institute and an operational service that produces global numerical weather predictions and maintains one of the largest meteorological data archives. It operates a world-class supercomputer for forecasting, provides advanced training, and supports the WMO's programmes. As a key player in the EU's Copernicus programme, ECMWF delivers quality-assured climate and atmospheric data while also developing digital twins of the Earth through the Destination Earth initiative.
[55] DSIT & BEIS (2020); Mercator Ocean International is a non-profit organisation transitioning into an intergovernmental entity, providing ocean science-based services for conservation and sustainable use, backed by ten major operational oceanography institutions.
[56] UK in a Changing Europe (2023).
[57] UK Parliament (2023).
[58] European Commission (2023).
[59] UK in a Changing Europe (2023a).
[60] Met Office (n.d.a).
[61] know.space estimates of UK contributions to EUMETSAT, using historical exchange rates (in current prices). See all EUMETSAT resources in References.
[62] CNES (2025).

The EUMETSAT Polar System (EPS) MetOp mission series provides global meteorological and environmental data. In 2024, Airbus Defence and Space UK delivered the Ultraviolet Visible Near-infrared Short-wave infrared Spectrometer (UVNS) instrument for MetOp-SG-A, enhancing monitoring of air quality, ozone changes, and wildfire emissions.[63]

2.6.4. Bilateral collaboration

Following a bilateral agreement signed in 2014, UKSA and CNES have collaborated on three significant weather and climate missions – IASI-NG (see above), MicroCarb and SWOT (Surface water and ocean topography). MicroCarb, launched in July 2025, is a joint UKSA and CNES climate mission supported by a £13.9m UKSA investment. The UK is involved with the assembly, integration and testing of the satellite, as well as design and build of key parts, data collection, algorithm development and scientific mission preparation.[64] It will be the first European satellite designed to measure greenhouse gas fluxes on Earth by measuring how much carbon is being absorbed by oceans and forests, the main sinks on the planet.[65]

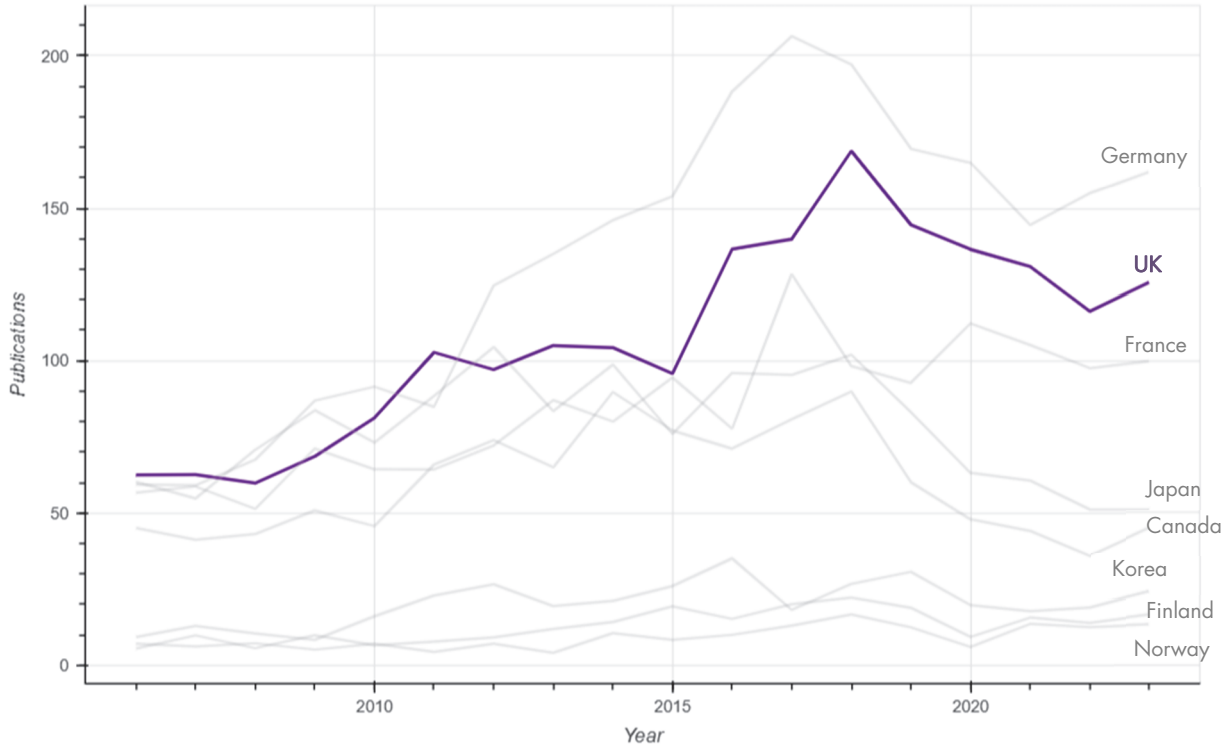
The UK also contributed to the NASA-led SWOT mission, launched in December 2022, to make the first global survey of the world's surface waters and oceans. UKSA provided £12.2m in funding for Honeywell UK[66] to develop and build a duplexer for the mission, a vital component to route radar signals around the satellite at a power of 1,500W – a level never seen in this kind of device.[67]

2.7. The UK's scientific output - publications

The UK is a leader among comparator countries in the production of papers in the EO domain, with a steady increase each year (Error! Reference source not found.) only exceeded by Germany. The UK is also a leader in the influence of its EO papers (Figure 6**), as measured by Field-Weighted Citation Impact (FWCI).** These results show that the UK is an influential player in EO science, and has exceeded the rates of publication of many of the comparator countries since CEOI began.

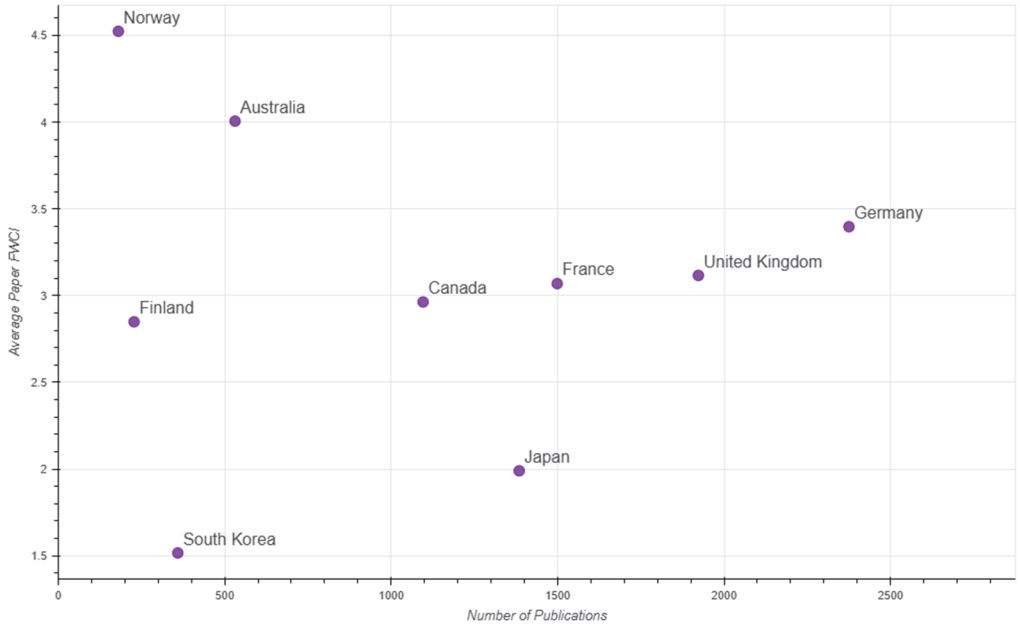
[63] Airbus (2024).
[64] UKSA (2024c).
[65] Space4Climate (2024).
[66] UKSA (2022a).
[67] UKSA (2019b).

Figure 5: Comparison of EO-related publications per comparator country.



Source: OpenAlex. Publications were plotted by year for each of the comparator countries. Fractional counting was used, where each country was assigned a fractional score for each publication corresponding to its share of the authorships.

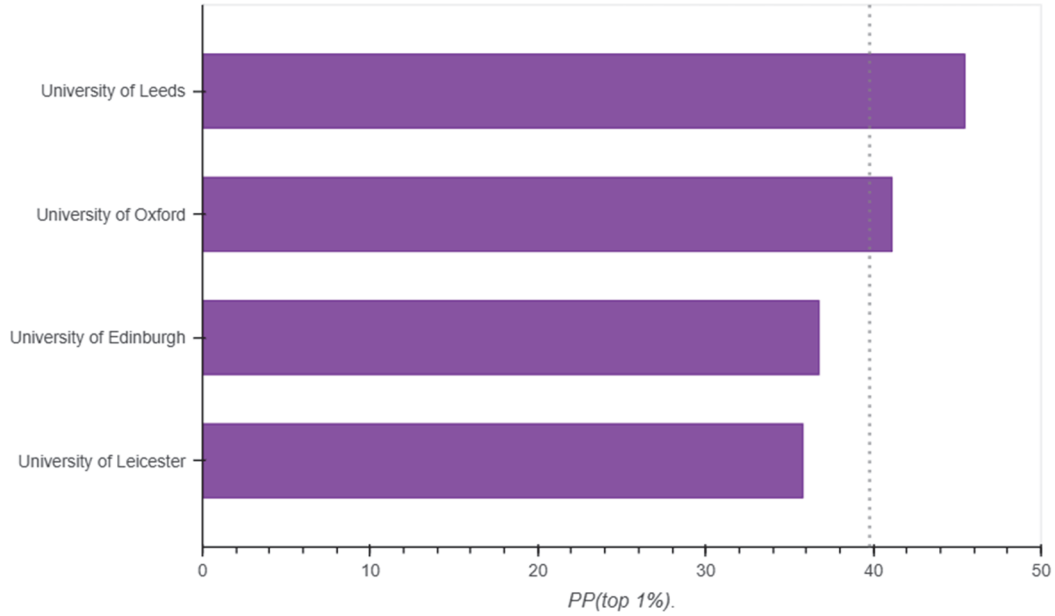
Figure 6: Comparison of EO-related publications' FWCI per comparator country



Source: OpenAlex. FWCI as implemented in OpenAlex groups publications by year of publication and sub-field (e.g., 2020, Geophysics), then for each publication divides the received citations by the expected citations (average citations for all publications) within its group. The outcome is a single number for each publication, where 0 indicates that it has received exactly as many citations as should be expected, values above 0 indicate above average citations, and values below 0 indicate below average citations. Average FWCI was taken for each comparator countries, with the publication counts used for each country obtained using fractional counting.

When we compare the universities with the highest rates who also received CEOI funding (University of Edinburgh, the University of Leicester, the University of Leeds, and the University of Oxford), we find that their production and influence of EO publications also increased over the same time period. We also found that those universities were producing EO papers that perform largely in line with expectations compared with other publications in the same field and in the same year, belong to the top 1 per cent most frequently cited (**Error! Reference source not found.**). This can be attributed in part to funding provided to these universities by the CEOI, but also to the UK's wider support of EO R&D.

Figure 7: Comparison of universities receiving CEOI funding, highly cited papers in EO



Source: PP(top 1 per cent) is defined as "The number and the proportion of a university's publications that, compared with other publications in the same field and in the same year, belong to the top 1 per cent most frequently cited."[68] This was done by using OpenAlex's implementation of citation normalised percentile and calculating the percent of each institution's publications in the dataset labelled as in the top 1 per cent of most frequently cited works.

2.8. Challenges faced in EO sector

Many of the challenges faced by the UK EO sector today are similar to those it faced in 2007 at the launch of CEOI. While some are specific to the EO sector, some are more broadly applicable to the space sector and should be considered accordingly. Some of these challenges include:

[68] CWTS (2024).

- **Skills shortages:** Across the UK space industry, a significant skills shortage continues to persist (see Section 2.4.1 Skills and Training). As the demand for EO services and data analytics has grown across industries like agriculture, defence, and climate science, the sector has struggled to recruit skilled professionals to meet these needs. Whilst significant efforts are already being made to address the skills gap, such as the Space Placements in Industry (SPIN) programme and the various Centre for Doctoral Training initiatives, further targeted educational programmes and apprenticeships, focusing on both university courses and vocational training, should help to alleviate skills shortages. Increased investment in STEM (Science, Technology, Engineering, and Mathematics) education, enhanced cross-sector collaboration and stronger industry-academic partnerships may also help to ensure future generations are equipped with the necessary technical skills.
- **Need for a targeted strategy**: In the wake of the NSS, there is a recognised need within the UK EO sector for a more detailed strategy on EO (and other core capabilities), specifically around strengthening the vision on data acquisition, access and use. It is challenging to make the case for early-stage technology development when there is a lack of clear understanding of the potential end-use case for said technology. While there is general support for EO, funding is often spread thinly across multiple initiatives without clear strategic direction. This limits the sector's ability to develop innovative solutions, fully mature and commercialise technologies, and scale up operations, hindering the UK's ability to fully capitalise on EO opportunities.
- **Spending uncertainty:** UK EO activities have been subject to frequent uncertainty due to changes in government funding allocations, particularly arising from the Comprehensive Spending Review cycle. These reviews, which determine public sector spending, have often resulted in fluctuating support for EO initiatives. There is a recognition within the UK EO sector that providing short-term funding for many different projects and programmes without guaranteed long-term support could potentially put the country at a disadvantage compared to other nations.

3. Interim programme impacts

3.1. Summary

The CEOI programme is widely seen as fostering collaboration and enabling both emerging and established organisations to grow in the EO sector. It plays a key role in facilitating access to additional funding and ESA missions, while enhancing participants' skills. Those interviewed believed that CEOI strengthens the capacity of UK-led initiatives to compete, export, and helps to elevate the UK's international reputation in EO. The information provided in this chapter is an updated summary of the chapter on CEOI project outcomes published in the interim evaluation report.[69]

Box 3: Quick figures on CEOI interim impact assessment

- Projects funded by CEOI have seen TRLs increase by 2.2 points on average, with many grant recipients crediting it for project progress.
- 46.2 per cent of respondents reported improved skills through CEOI events.
- 73.1 per cent of project participants gained technical insights from CEOI showcases.
- 69.2 per cent reported increased commercialisation ability due to CEOI funding; 96.2 per cent gained reputational benefits.
- CEOI-backed technologies have featured on four launches (2015-2023), with seven more underway, five selected for study, and eleven planned for future launches.
- 88.5 per cent of respondents affirmed CEOI's role in bolstering capacity for international missions; 65.4 per cent acknowledged enhanced export capacity.
- Foreign investment in CEOI projects surpassed UK investment, with strong ESA support. From FY21/22 to 24/25, projects received £23.4 million in foreign public investment - 4.5 times more than the original total CEOI grant funding over that period.
- Job creation links are unclear, but some anticipate substantial annual revenue from CEOI-funded projects, with one estimate at an additional £10-20m in extra revenue per year.

[69] The interim report is accessible here: https://www.gov.uk/government/publications/evaluation-of-the-centre-for-earth-observation-instrumentation-ceoi/summary-evaluation-of-the-centre-for-earth-observation-instrumentation-ceoi-interim-report

3.2. Technology development

Across the projects reviewed, there is an increase in TRL levels attributed to the CEOI programme's funding and support. Survey and monitoring form responses indicate an average increase of 2.2 TRL points from the starting point of projects to the present. The programme and its funding were found to have a particularly substantial impact on technologies in the early stages of development. This is especially critical for academic stakeholders, as such projects might otherwise lack the opportunity to advance rapidly. According to the survey responses, the average starting point of projects is TRL 2.5. As anticipated, the projects reviewed exhibit considerable variation in TRLs, with some technologies reaching levels as high as 9, while others remain at TRL 3. This variation is largely influenced by the size and complexity of each project.

Many respondents indicate that without CEOI funding, their project would have stagnated or not existed.[70] One project lead noted their technology stalled after an unsuccessful bid in the 15th call, yet found renewed momentum with CEOI's accepted 16th call.[71] Another interviewee suggested alternate funding might have led to slower development compared to CEOI's shorter turnaround grants.[72] It was also noted that project work might not have been undertaken otherwise, creating a gap in the field and highlighting the significant role of the CEOI in advancing EO technology development in the UK.[73]

CEOI's contributions to TRL progression includes sharing knowledge within its extensive network. One project partner suggested that involvement in the CEOI programme indirectly enabled the team to study a larger satellite than they currently fly, providing a case study of the internal design, which progressed their own technology.[74] These kinds of second order effects are common in the portfolio and a product of the CEOI team's longstanding role and dual roles in their own organisations, tapping into their networks to the benefits of project teams.

CEOI's focus on low TRL projects enhances UK competitiveness internationally. Despite limited funding, CEOI enables basic and advanced research at lower TRLs, where support is most needed due to an existent funding gap for otherwise high-risk and low-profitability early-stage technologies.[75] As international funding often demands higher TRLs, CEOI's role at early stages is crucial. The progression of major projects from CEOI to ESA funding highlights CEOI's foundational role.[76]

CEOI's funding of low TRL projects signals key EO technology areas to the government and facilitates the development of technologies in line with those signals. Some government stakeholders perceive the programme as highlighting emerging technologies.[77] However, a UK Defence stakeholder noted limited

[70] INT_6B
[71] INT_7B
[72] INT_9B
[73] INT_10B
[74] Int_13B
[75] INT_6A
[76] Int_7A
[77] Int_3A

tracking of CEOI outputs within their body.[78] Nonetheless, UK Defence's recent call for SAR system innovations up to TRL 4-5[79] aligns with CEOI-supported work, suggesting potential for follow-on funding.

3.3. Collaborations and partnerships

CEOI is recognised for collaboration and partnerships, particularly between universities and the private sector. Survey data reveals that industry collaborations often involve a broad network of additional entities. Project leads commend CEOI's role in uniting academia, industry, and government, emphasising the significance of a cohesive space community. Some participants noted unexpected advancements from idea exchanges within this diverse network.[80] The absence of CEOI support might have hindered the formation of these partnerships, potentially excluding participants from future competitions.[81]

The CEOI programme also fortifies existing partnerships, with respondents most likely to enhance ties with universities and industry, and to a lesser extent, public sector stakeholders. Project leads confirmed that CEOI support bolstered pre-existing relationships. The programme's integration of industry and academia is particularly valued, with CEOI support aiding in de-risking critical technologies and facilitating industry-academia collaborations that might be challenging without financial backing, e.g. with one company gaining access to university facilities through a collaboration on a CEOI project.[82]

CEOI's role in bringing together diverse stakeholders ensures that students gain practical experience within the broader space ecosystem. Leveraging university facilities is seen as a key enabler for innovation and cooperation, with CEOI's funding strengthening industry-university partnerships.[83] Although these partnerships may not always endure, enhancing industry's understanding of university capabilities is deemed crucial for future projects.[84]

CEOI-facilitated events enhance inter-community connections and sector knowledge-sharing. Workshops that aggregate CEOI-supported projects contribute to sector growth through shared knowledge, even if they do not directly result in new contracts.[85]

3.4. Skills, jobs and knowledge

Many participants report CEOI's impact on skills and employment due to its funding and initiatives. Participants widely acknowledged that CEOI involvement maintained or enhanced their technical skills in developing innovative EO instruments. Some 69.2 per cent of survey respondents saw strongly increased ability to commercialise research, while 96.2 per cent of respondents reported reputational benefits.[86]

The CEOI is instrumental in helping projects secure additional funding, with 88.5 per cent of survey participants finding CEOI support effective for international mission competition. One example highlighted

[78] Int_5A
[79] DASA & DSTL (2023).
[80] Int_10B
[81] INT_1B; INT_5B
[82] Int_9B
[83] Int_12B
[84] Int_10B
[85] Int_9B
[86] Int_4B ; Int_9B

a case where a CEOI project carried out by SSTL resulted in an instrument that would go on to be flown on CYGNSS, a NASA constellation.[87] Overall, between 2015 and 2023, CEOI-backed technologies have featured on four launches, with seven more underway, five selected for further study, and eleven slated for future launches. For instance, the TRUTHS mission, aiming to provide highly accurate climate data was backed by the CEOI during the proposal stage and was chosen from 35 proposals.[88] Several interview participants acknowledged the CEOI support for bidding on ESA projects, in particular.[89] One project lead commented they were able to secure further funding from NERC, building on a CEOI-supported project, going on to win an ESA bid, expanding the project further.[90]

Over 46.2 per cent of respondents credited CEOI events and workshops with skill improvement. Survey data showed full attendance at CEOI annual conferences, with many participants finding them valuable for skill and knowledge development. Additionally, 73.1 per cent attended technology showcases.

The CEOI programme enables knowledge sharing, with 38.5 per cent of respondents noting increased exchange between academic and industrial EO communities. While measuring knowledge acquisition is inherently complex, interviews revealed a growing knowledge base among participants, facilitated by project collaboration and broader CEOI network engagement. This growth has deepened technical understanding and expanded awareness of advancements in the EO sector. For example, one project lead noted that CEOI involvement enhanced their understanding of novel defence technologies, opening new opportunities in the defence sector.[91]

3.5. International impact

Policy roundtable participants agreed that the UK has a strong heritage in the EO sector, with experience across academia and industry in highly specialised instrumentation.[92] Legacy datasets generated from sensors constructed with UK expertise still have the potential for new applications, highlighting the durability of UKSA's historical EO investments, including CEOI.[93]

CEOI's strategy to support predominantly early-stage EO R&D was identified as key in the maintenance of the UK's EO capabilities, but had led to few clear prime examples of a new UK-led mission that has derived from that funding. The exception to this is TRUTHS, whereby the CEOI's calibration and coordination expertise was instrumental in it becoming a UK-led ESA mission, providing the technical expertise and rigour necessary to progress in the ESA landscape.[94] A related threat is the impact from the UK's withdrawal from the European Union having an impact on the UK's ability to collaborate with EU and ESA entities. Emphasis was placed on needing to both maintain and rebuild relationships to take

[87] Surrey Satellite Technology Ltd (2016).
[88] WECD (2022).
[89] Int_6B; INT_8B
[90] Int_8B
[91] Int_4B
[92] Findings from Roundtable 1: the state of UK EO, with wider stakeholders / CEOI adjacent stakeholders
[93] Findings from Roundtable 1: the state of UK EO, with wider stakeholders / CEOI adjacent stakeholders
[94] Findings from Roundtable 2: CEOI adjacent

advantage of internationally collaborative EO programmes into which projects supported by CEOI can expand their R&D.[95]

A potential example of the issues caused by the UK's brief period outside of Copernicus is from 2020, following ESA's announcement of contractors developing the next generation of Sentinel spacecraft. All six missions' primary contracts have been handed to continental bids, despite UK efforts to win them, with around a 30 per cent reduction in UK-based sub-contracted work from expectations.[96] The Copernicus Expansion is targeting a slate of six missions, including the Copernicus Hyperspectral Imaging Mission (CHIME), the Copernicus Polar Ice and Snow Topography Altimeter (CRISTAL) and the Copernicus Anthropgenic Carbon Dioxide Monitoring (CO2M) mission, none of which the UK holds a primary contract for.[97]

The CEOI programme is key in enhancing UK companies' competitiveness for international funding, with 88.5 per cent of respondents affirming its role in bolstering their capacity to lead or partake in international missions. Half of the respondents acknowledged a substantial increase in their competitiveness due to CEOI funding. The programme fulfils a need in the UK space sector by fostering industry-academic collaboration, enhancing the UK's standing against European entities in ESA. Notably, CEOI's support has been instrumental for those actors in securing ESA bids and gaining visibility amongst member states and Data Operations Scientific and Technical Advisory Group (DOSTAG).[98] This was evidenced by a project lead who leveraged CEOI support to obtain NERC funding, subsequently winning an ESA bid.[99]

Several projects with an export focus have lauded CEOI's early-stage support in technology development and EO service provision. Approximately 65.4 per cent of survey respondents acknowledged that the CEOI programme enhanced their capacity to export products and services. Nearly one-third emphasised that CEOI significantly enabled exports. A project lead noted that up to 98 per cent of their services are now exported from the UK, facilitated by CEOI's initial funding.[100] However, another respondent mentioned that while their project did not benefit from the UK network facilitated through CEOI due to export-centric markets, they gained from the data acquired and exported to international clients.[101]

Certain participants perceived CEOI's impact as constrained by insufficient funding and broader governmental support in international markets. One project lead refrained from bidding on another CEOI round due to limited UK market opportunities, opting for alternative funding to access international markets.[102] Though beyond CEOI's remit, UKSA might consider post-project support to help projects access larger international funding pools, alongside UK programmes like the National Space Innovation Programme and the Unlocking Space for Business programme.

Stakeholders acknowledged CEOI's role in bolstering the UK's international reputation. Despite lower UK public EO R&D investment compared to Germany and France, the UK's scientific contributions are significant, with CEOI as a key driver.[103] The survey revealed that 57.7 per cent of respondents felt CEOI-

[95] Findings from Roundtable 2: CEOI adjacent
[96] Amos (2020).
[97] Amos (2020).
[98] Int_10B ; Int_6B ; Int_8B
[99] Int_8B
[100] Int_4B
[101] Int_1B
[102] Int_4B
[103] Int_3A; Int_6A; Int_7A; INT_1A

funded projects promoted UK EO capabilities. The programme's coordination is valued, enhancing the UK's credibility as a space entity. One stakeholder suggested that without CEOI, the UK would be a 'platform' rather than a 'satellite and sensor' nation, diminishing its international leadership. A CEOI-funded project achieved success with NASA, illustrating CEOI's "soft influence" in spurring international innovation.[104] However, a partner noted that international awareness is limited by the focus on mission launches over initial R&D, affecting CEOI's international reputation, though its primary aim is enabling post-project successes.[105]

3.6. North Star Metric outcomes

This evaluation encountered notable reporting gaps regarding the North Star Metric data collection among projects participants. The North Star Metric is designed to evaluate the investment and revenue stimulated by UKSA within the UK space sector, serving as the principal measure of Agency success. The key elements of the North Star Metric include match funding, private investment, internal investment and revenue. Despite a requirement for projects to report on the North Star Metric in grant funding agreements since 2022, the research team encountered reporting gaps that require attention from UKSA and CEOI to improve ongoing monitoring activities.

Since round 6, CEOI has allocated over £31.8m to projects, while partners have contributed £10.6m.[106] In addition to match funding, several of the projects reviewed allocated internal investment to progress the technologies. In general, this internal funding was highest among private companies than universities, some of whom were only able to allocate limited resources, and only where necessary – for example – to enable a demonstration. The amounts of internal funding varied from a few tens of thousands for small projects, to £3m of funding by a company over two years to progress their CEOI-funded Flagship project.

Based on available data, foreign public investment across reviewed projects exceeded UK public investment, indicating strong international interest, as well as TRL progression among CEOI-funded projects. For 2021/22 reviewed projects secured £2m from foreign public funding, compared to £0.8m from UK public funding, with this gap increasing year on year (2022/23: £2.8m foreign public vs £0.1m UK public; 2023/24: £6.7m foreign public vs £1m UK public; 2024/25: £11.9m foreign public vs £3.4m UK public). Most of the international public funding came from ESA, reflecting the progression of CEOI-funded projects to eventually supporting international missions.

Most of the recent CEOI projects we surveyed are in the pre-revenues stage, with technologies still under development. As such, there are few examples of realised revenues to date, but some organisations were buoyant in their future revenue expectations. Notably, one organisation anticipates selling 1-2 satellites or payloads annually from year 2 to 5, generating £10-20m in revenue per year, which is a significant portion of total annual revenue of £65m. However, the wider benefits of their technology are difficult to quantify, as customers may gain more financially from the services enabled by the technology than from the contract value, and the CEOI-funded product is just one component of a complex spacecraft system.

[104] Int_2A
[105] Int_6B ; Int_13B
[106] There are missing match funding figures for 9 out of 118 projects recorded from the 6th call onwards.

Most project teams noted jobs were protected by CEOI funding, although few project participants were able to link CEOI funding directly to job creation. While in a few cases recruitment increased around the same time as the start of the project, in only a minority of cases was this directly attributed to CEOI funding, and not linked to organisational growth more broadly – though this may hint to a more indirect impact of CEOI funding on the ability of funding recipients to plan for the future and to achieve growth, including through involvement in major missions.

4. Economic evaluation

4.1. Summary

This economic evaluation optimises the use of limited data on CEOI's economic outcomes, focusing on 39 projects with cost and benefit data. We assess CEOI Calls 11-16 (2018-2025) and smaller calls due to earlier data gaps. Despite these limitations, **the real discounted (Present Value (PV), 2024/25) and attribution-adjusted UK benefit of CEOI (Calls 11-16) is estimated at £30.2m,** driven by three large ESA contracts worth over £20m combined.

Box 4: Quick figures on CEOI economic evaluation

- The real discounted and attribution-adjusted UK benefit of the CEOI (Calls 11-16) is at least £30.2m to date, excluding expectations.
- FDI stands at £28.9m in UK benefit (73 per cent of total benefits)
- Internal investment contributes £4.1m (14 per cent) to total UK benefits and UK private external investment a further £3.1m (9 per cent). Economic value associated with GVA, job creation and publications is low, likely a reflection of the early stage of this evaluation.
- The total nominal economic cost of CEOI Calls 11-16, and smaller projects over this period, (approximately 2018-2025) will be £20.8m, of which £14.9m comes from grant funding and £5.8m comes from matched funding.

4.2. Introduction

Whilst the rest of this report has covered the CEOI since its inception, this economic evaluation focuses on Calls 11 to 16 of the CEOI, covering approximately 2018-2025, due to earlier data limitations.[107] Since economic data (e.g. investment, revenues, job creation etc.) has not been routinely captured for funded projects, there is a trade-off between recent projects with complete data and older projects with developed impacts. We focus on newer projects (Calls 11-16) but include a case study of earlier CEOI funding to the University of Leeds, funded over a decade ago, to illustrate the long timelines for substantial impact.

Our economic analysis focuses on benefits to funded organisations, but future benefits are expected to extend to wider society, particularly in understanding climate change. Any quantitative estimates likely underestimate the ultimate benefit of CEOI funding, especially at this early stage. This challenge is common

[107] In our analysis we cover CEOI Calls 11-16, as well as any smaller ad hoc calls over the same period. These include EE11 and EE12 (Earth Explorer) Mission Proposal Development Support projects, TRL Raising and Facility Enhancement Fast Tracks, Special Projects, Strategic Projects and 2024 Small Projects. In total, we cover 76 CEOI projects.

to public R&D funding, not just CEOI or space R&D funding. Some significant benefits of CEOI funding, such as knowledge, scientific progress, and facilitated collaborations, are challenging to monetise. Thus, our quantitative estimates should be seen as a lower bound on the economic benefit to date.

4.3. Approach to economic evaluation

Our economic evaluation aims to holistically capture benefits from funding, acknowledging that the benefits realisation journey is ongoing and data on impacts, particularly monetisable outcomes, is sometimes incomplete. Given this, our central economic evaluation is limited to the 39 projects for which we have data on both costs and benefits. For more details, see the Evaluation Plan.[108]

At a high level, we compare the costs of delivering each programme to the benefits delivered so far. Costs include grant funding (the public cost) and matched funding contributions (the private cost). The benefits we quantify are leveraged external investment,[109] internal investment, Gross Value Added (GVA) and the value of job creation. Evidence on these impacts comes from two surveys to funded organisations, supplemented by targeted interviews and desk-based research.

Cost data was provided by the CEOI at a project level, setting out the grant funding allocated to each project, the associated matched funding contribution, and project start and end dates. We assumed that costs were spread evenly across project durations, to estimate total costs by financial year.

Organisations were asked for the amount and sources of external investment received to date, as well as expectations for external investment over the next five years (forecasts not included in our central analysis). We also asked for estimates of internal investment to date.

We estimate GVA using a space industry specific revenue to GVA ratio of 2.6.[110] We leverage revenue estimates provided by funded organisations, including realised revenues and expected revenues over the next five years (forecasts not included in our central analysis).

The value of job creation is estimated using a wage premia approach[111] which assumes that in the absence of CEOI funding, those in roles created through funding would instead be working in similar roles outside the sector, earning different salaries.[112] A wage premia approach supposes that the economic value of job creation lies in creating new, better paid roles, rather than new jobs per se. Job creation data was sourced

[108] The evaluation plan is available here: https://www.gov.uk/government/publications/evaluation-of-the-centre-for-earth-observation-instrumentation-ceoi/summary-evaluation-of-the-centre-for-earth-observation-instrumentation-ceoi

[109] Throughout our analysis we treat external and internal investment as benefits to society, reflecting the positive role of investment in creating a pipeline for future economic benefit and the central role of investment in UKSA's North Star Metric. However, we note that DSIT appraisal advice focusses on quantifying the benefits which stem from investment, which are likely to accrue over the longer term. UK external and internal investment are therefore counted as a cost by DSIT, reflecting the opportunity cost of investment. Foreign investment is not included in the cost-benefit calculation. This methodology will capture the long-term benefit of investment but for the CEOI, it is too early to meaningfully calculate net present social value (NPSV) using this approach. We include private external investment and foreign public external investment (including ESA funding) in our totals.

[110] These are sourced from the Size & Health of the UK Space Industry 2022 underlying economic model.

[111] See know.space (2023). *Estimation of wage premia associated with UK Space Agency funding*.

[112] Using contextual information, job creation is divided into sub-categories of role type and seniority. The wage premia associated with each job type is then taken from know.space (2023). *Estimation of wage premia associated with UK Space Agency funding*. Estimates of wage premia are adjusted to current prices. For a fuller description of the methodology employed, see ibid.

directly from funded organisations and wage premia estimates come from a recent study of wage premia in the space sector.[113]

We also estimate the economic value of research publications, using an EO-specific estimate of the benefit of such publications,[114] adjusted for year of publication (£19k per paper). The methodology underpinning this estimate assumes that the social benefit of such publications will be at least as much as the private cost of writing (and publishing) an article. This is a conservative methodology and generates a lower bound estimate on the value of publications. Data on publications comes directly from project teams.

Our economic evaluation covers 76 CEOI projects from Call 11 to the most recent Call 16. This aligns with the 2017/18 to 2024/25 period. In our central analysis, we consider benefits over this period, but we also provide alternative numbers if expectations are considered over the 2025/26 to 2029/30 period. Project teams were asked to provide expectations of external investment and income over the next five years. These provide an indication of the expected medium-term benefits from CEOI funding, but nonetheless still provide only a partial picture of potential future benefits, given gaps in reporting and the limited time horizon. These estimates are also subject to strong uncertainty.

4.3.1. Caveats to economic evaluation

Below, we set out the key caveats specific to our economic evaluation:

- **Data gaps:** Our findings are based on 34 survey responses, interviews, and an earlier survey with 26 responses, covering 39 of the 76 projects in scope (51 per cent). Since data gaps only affect the benefits side, our central analysis estimates value for money from projects with available impact data, avoiding artificially low returns by excluding projects without benefit evidence. This might overestimate benefits due to selection bias, as successful projects may be more likely to respond to our survey. To address this, we provide alternative estimates including all projects, assuming zero benefits from non-respondents, which likely underestimate CEOI's value for money.[115] We also provide estimates if we assume these non-respondents generated half the total benefits of respondent organisations.
- **Non-monetisable benefits:** Some significant benefits of CEOI funding, such as knowledge, scientific progress, and facilitated collaborations, are challenging to monetise. Thus, our quantitative estimates should be seen as a lower bound on the economic benefit to date.
- **Long timelines to impact**: This evaluation covers only Calls 11 to 16 of the CEOI, approximately 2018-2025, due to earlier data limitations. Since we expect many of the key benefits to be realised with a substantial lag, our estimates will underestimate the eventual expected benefits arising from funded projects.

[113] See know.space (2023). Estimation of wage premia associated with UK Space Agency funding.

[114] Morretta et al. (2022) estimate that the average value of researcher and publisher activity in 2018 was between €4.5k and €22k. We take the average of these two values, convert the average to GBP then adjust for inflation to give £19k per publication.

[115] We have not extrapolated the impacts for projects on which we have impact data to all funded projects. This is because there is likely to be selection bias in respondents, i.e. those whose projects have achieved the most favourable impacts are more likely to respond to our requests.

- **Attribution of benefits**: This is a key challenge to any economic evaluation, with impacts stemming from multiple inputs in complex ways. For example, CEOI projects often received funding from other sources, but additionally, many of the projects funded through Call 11 onwards received earlier funding through CEOI, which is outside the scope of our present analysis. This makes attribution particularly complex, with the most recent studies building on possibly years of prior research. Broadly, our approach has been to ask project teams directly for benefits which are linked to their CEOI projects, for example, "*How much revenue has your organisation generated which can be attributed to CEOI?*". We have also applied an attribution share (see below).

4.3.2. Key assumptions

Our analysis has necessarily relied on a number of assumptions:

- **Discounting:** Future benefits are discounted using the standard 3.5 per cent discount rate recommended by the Green Book. We present all totals in discounted Present Value (PV) terms (2024/25).
- **Inflation-adjustment:** All costs and benefits are adjusted to constant prices (2024/25).
- **Optimism bias adjustment:** A 50 per cent optimism bias adjustment[116] is made to forecasted estimates, aiming to address the demonstrated systematic tendency for individuals to over-estimate future benefits.
- **Attribution shares:** Where impacts are clearly the result of multiple inputs, an attribution share has been assumed on a case-by-case basis. Below, we discuss the extent to which benefits are attributable, leveraging insights from our assessment of programme impacts.
- **Leakage:** Non-UK benefits have also been removed to account for leakage, i.e. the extent to which benefits accrued outside of the UK, such as non-UK jobs and external investment into non-UK arms of funded organisations.[117]
- **Additionality:** We apply a 90 per cent additionality assumption to all benefits to account for deadweight, i.e. a small proportion of economic activity generated would likely have gone ahead without CEOI funding.

4.4. The economic benefits of CEOI

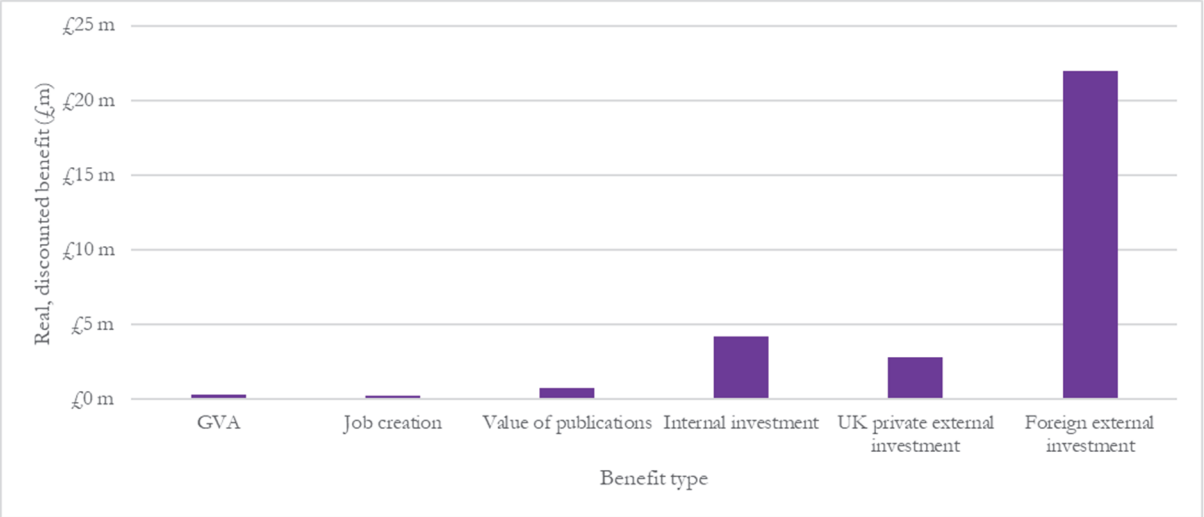
We estimate that the real discounted and attribution-adjusted UK benefit of the CEOI (Calls 11-16) is at least £30.2m to date, excluding expectations. This total is driven by foreign external investment, i.e. foreign investment into the UK, which accounts for £28.9m in UK benefit (73 per cent of total benefits). ESA contracts are the most common source of foreign investment. Notable investment events driving this trend include two ESA contracts to Craft Prospect, worth £6.1m and £7m respectively, and a £7m ESA

[116] 50 per cent is necessarily a somewhat arbitrary number without concrete evidence on the extent to which optimism bias is prevalent. We chose 50 per cent to reflect HM Treasury (2013): *Supplementary Green Book Guidance: Optimism Bias*.
[117] Due to limited information provided in survey responses, we were not always able to verify that economic activity occurred in the UK.

contract to RAL Space.[118] This finding is in line with the objective of the most recent CEOI Business Case to *'Prepare the UK EO community to win global market opportunities, including those resulting from CMin22'*.[119] Still, overall benefits are driven by a few large events, and are therefore sensitive to their inclusion.

Beyond foreign external investment, internal investment contributes £4.1m (14 per cent) to total UK benefits and UK private external investment a further £3.1m (9 per cent). The economic value associated with GVA, job creation and publications is currently low relative to investment impacts, with these benefits totalling just £1.3m. We view this as a reflection of the relatively early stage of projects. Most projects are still at the pre-revenue stage or are generating modest early revenues, which means GVA to date is low. At this stage, most of the employment benefits of CEOI are concentrated in existing jobs supported through CEOI funding, rather than wholly new positions being created. This is also a reflection of the early stage of impact generation- as projects progress towards commercialisation, we would expect greater job creation associated with more economic activity within funded organisations. Lastly, the low value of publications to date is both a reflection of the relatively low number of publications made for these recent projects, linked to long timelines for publication, and our conservative approach to modelling the economic value of these publications.

Figure 8: Real discounted benefit, *excluding* expectations, 2017/18 to 2024/25



Source: Interviews and surveys of CEOI project leads. know.space analysis.

Most reported benefits have accrued in the last two years, with a significant jump in 2021/2022. This is in part a reflection of long timelines to impact, but also largely demonstrates the bias in our sample towards more recent projects, who were more likely to respond to our survey. Of the 39 projects for which we have some impact data, 20 finished in 2024/25. For every other year of project completion, we have 2-4 data points.

[118] We note that due to limited detail provided in survey responses we were unable to independently verify these contracts. We have assumed 100 per cent attribution, as survey questions were framed to capture only those benefits attributable to CEOI.
[119] ESA (2022).

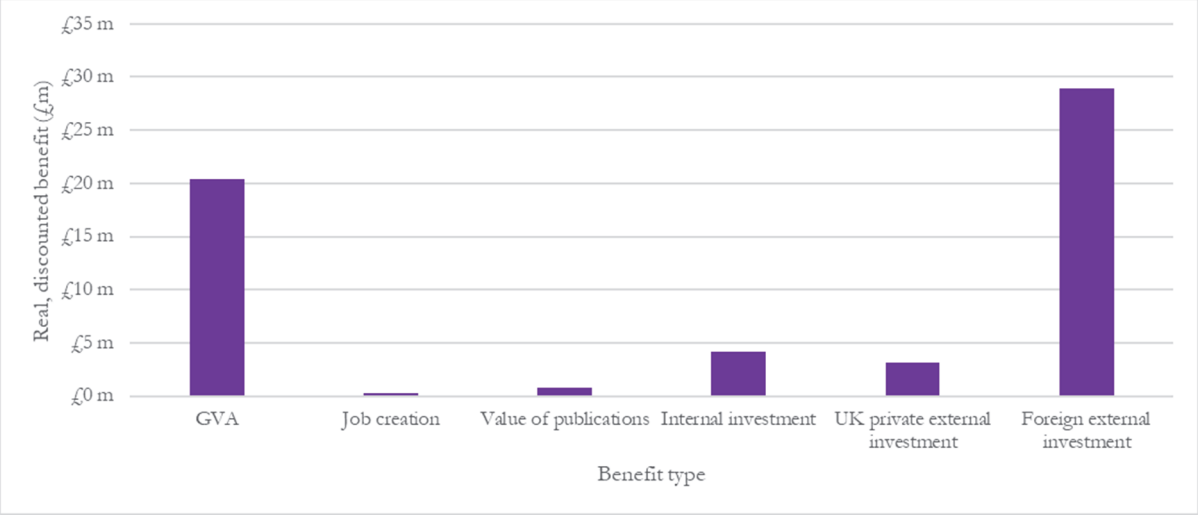
Table 4: Real discounted benefit by year, *excluding* expectations, from 2017 to 2025

	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
Total real discounted UK benefit	£0.1m	£0.1m	£0.1m	£0.1m	£2.2m	£3.9m	£10m	£13.9m

Source: Interviews and surveys of CEOI project leads. know.space analysis.

Given we are assessing impact at an early stage, the largest benefits are expected to accrue in future. Many project teams are targeting upcoming EO missions, often ESA-led, and pointed to substantial future ESA funding they could potentially capture. Reflecting this, we also estimate monetisable benefit over the 2025/26 to 2029/30 period, including expectations in our totals.[120] These forward-looking estimates, provided by funded organisations, should be treated as indicative only, given potential for optimism bias and gaps in our data. Notwithstanding these caveats, if we include expectations then the real discounted and attribution-adjusted UK benefit of the CEOI (Calls 11-16) is at least £57.6m.

Figure 9: Real discounted benefit, *including* expectations



Source: Interviews and surveys of CEOI project leads. know.space analysis.

Foreign external investment is still the largest component of total benefit when we include expectations, accounting for 50 per cent of all benefits, but expected revenues are also sizeable, with expected GVA accounting for £20.4m in expected benefit (35 per cent). Revenue, and therefore GVA, forecasts are driven by a small subset of projects' expectations of future revenue. SSTL forecast buoyant revenues of between £10-20m per annum over the next 5 years, as they expect to sell 1-2 satellites or payloads per year. If we exclude just these SSTL revenues, total benefit falls to £46.6m. Space Flow also project notable revenues of £30m from their Glamis project across consortium members. Whilst it is normal for the largest impacts of R&D funding to be concentrated in just a few projects, we note that this increases the risk that if one or two projects do not deliver their expected benefits, the overall benefits from the programme could be far lower than expected. We note that many organisations chose not to provide forecasts of any future revenue or investment.

[120] Project teams were asked to estimate future investment and revenues as part of our recent survey. A 50 per cent optimism bias has been applied to these estimates- see Key assumptions.

Overall, our evidence suggests that the near-term benefits of CEOI funding are concentrated in external investment, with internal investment also being significant. Over the medium term, we expect GVA to form a more substantial component of overall benefit as technologies developed through CEOI are commercialised, generating revenues. Further into the future, we might expect spillover benefits to form a significant proportion of overall benefits as consumers and society more broadly benefit from technologies developed, for example, through improved climate monitoring. Our case study (see below) provides an example timeline of benefits realisation for a CEOI-funded project.

4.4.1. Attribution of benefits

All results presented have been adjusted for attribution. The appropriate level of attribution is considered for individual benefits, and our totals are also subject to a 90 per cent additionality assumption[121] to account for deadweight, since our survey results suggested that a small minority of projects may have gone ahead similarly without CEOI funding. Our assumptions about the extent to which benefits are attributable to CEOI are crucial to determining total monetisable benefits. In particular, given the extent to which a few large foreign external investment events, notably ESA contracts, drive overall benefits, results are sensitive to our assumptions about the extent to which these external investments are attributable to CEOI. For example, if we apply a further 50% attribution adjustment to the three large ESA investments generated by Craft Prospect and RAL Space, total real discounted realised benefit falls from £30.2m to £23.6m.

Evidence from funded organisations suggests that crowding out associated with CEOI is low. Crowding out refers to the phenomenon where increased government spending leads to a reduction in private investment. In our earlier survey, 88 per cent of respondents reported that they did not consider any other funding programme when applying to CEOI and those who did look elsewhere only considered public funding sources. One project lead noted, "*CEOI seems unique in funding projects at the tricky TRL levels of 2-4*". Another team noted '*We are a university… relying on sources such as UKSA and CEOI for this type of development*". Given the low TRL nature of supported technologies, private investors were unlikely to fund technology development without prior de-risking from government.[122]

Displacement (i.e. the extent to which economic activity generated by CEOI displaces other activity in the economy) was also considered. For revenues, external and internal investment, we assume zero displacement, as the UK is presumed to be capturing a share of emerging global markets which brings new economic activity to the UK. For job creation, our DSIT-recommended wage premia methodology implicitly assumes 100 per cent displacement, i.e. everyone in a job created as a result of CEOI funding would otherwise be working in a similar job outside the space sector. We believe this is a reasonable assumption, given the economy was operating near full employment over much of the period of analysis.

Our approach was also designed to account for leakage (outflows of funds from the UK). Project teams were deliberately asked for UK-specific benefits (e.g. 'Were any UK-based jobs were created as a result of

[121] This means that we include 90 per cent of total reported benefits.

[122] This finding has been demonstrated elsewhere in the space industry. See European Space Policy Institute (2024). *Space Venture Europe 2023: Investment in the European and Global Space Sector.* Available at: https://www.espi.or.at/reports/space-venture-europe-2023-investment-in-the-european-and-global-space-sector/

CEOI funding?') and we researched individual investment events to ensure funds were going into UK-based companies.

Lastly, we believe that the deadweight associated with the CEOI is likely to be low, with most projects not going ahead at the planned scale in the absence of funding. 54 per cent of projects teams reported that they could not have undertaken their project at all without CEOI funding and 35 per cent could not have undertaken their projects at the same scale. Just 12 per cent of project teams believed they could carry out their projects at the same scale without CEOI funding. To reflect the small minority of projects which could have gone ahead without CEOI funding, we apply a 90 per cent additionality adjustment to our totals.

4.4.2. Non-monetisable benefits

The evidence suggests that the non-monetisable benefits from CEOI are large and should be central to any evaluation of the extent to which the CEOI is delivering value for money. As detailed in the impact assessment, there are key benefits of the CEOI which we cannot monetise. Notably, the programme has facilitated an average TRL progression of 2.2 points, bolstered the UK's international standing in EO, and facilitated valuable collaboration across industry and academia. Moreover, we expect the most significant benefits of funding to be realised once technologies are commercialised or otherwise operationalised, facilitating benefits to end users and wider society. Notably, with a number of projects developing technologies which are intended to improve climate monitoring, a key societal benefit could lie in marginal improvements in the global response to climate change through an improved understanding of how our planet is changing. Improved EO solutions can also be expected to generate efficiency savings in wide-ranging downstream markets, for example, agriculture, mining and maritime activities. For these reasons, it is crucial that we consider the value for money offered by CEOI holistically, looking beyond monetised estimates of benefit.

4.5. The economic cost of CEOI

Overall, we estimate (for the purposes of economic modelling, using simplifying assumptions, rather than an accurate breakdown of spending[123]) that the total nominal economic cost of CEOI Calls 11-16, and smaller projects over this period, (approximately 2018-2025) will be £20.8m, of which £14.9m comes from grant funding and £5.8m comes from matched funding.

In our central value for money analysis, we focus on the subset of these projects for which we have some impact data. We estimate that the total nominal economic cost of the 39 projects for which we have some impact data will be £10.9m, of which £7.9m comes from grant funding and £3.0m from matched funding. In real discounted terms, the cost of these projects is £12.2m, of which £8.9m is grant funding[124].

The full economic cost of these CEOI projects will not be limited to total project costs. As the technologies developed through CEOI are further developed, this will be associated with additional private costs.

[123] As noted above, in the absence of data on CEOI funding and matched funding contributions by financial year, we assume costs are spread evenly over the duration of funded projects.

[124] These are the cost totals we use in our central analysis.

4.6. Value for money

It is too soon to comment on the eventual total economic impact of these projects. Nonetheless, there are positive indicators of future benefits. Notably, further investment catalysed by CEOI is creating a pipeline for future benefits creation, concentrated in a few projects. Additionally, sizable benefits could not be quantified**.** Our estimates should be treated as lower bounds on potential benefits given potential for large as yet unforeseen future benefits and the importance of non-monetisable benefits in driving overall impact. Future evaluation will be key to tracking these evolving benefits and providing stronger conclusions on overall value for money.

4.6.1. Comparison to anticipated returns

Our ability to meaningfully compare our results with anticipated returns is limited by differences in methodology and a few large economic impacts dominating results. The 2022 CEOI Business Case set out an anticipated return on investment (RoI) of £3 for every £1 invested over the 2016-2021 period, leveraging the results of a previous CEOI evaluation (unpublished). We do not estimate RoI. The most notable differences in approach are that the previous evaluation considered leveraged UK public funding as a benefit (we do not), we consider a broader range of benefits (internal investment, jobs, revenue and publications) and we also adjust for additionality and inflation.

A £14m ESA investment (RAL Space's ESA Scout mission) and a £15m private investment into Satellite Vu drive the previous evaluation's results, demonstrating that, like our findings, their estimates are very sensitive to a few large investment events. The previous evaluation did not adjust these impacts for additionality or attribution. For illustrative purposes, if we remove these two investments, the RoI falls from 3 to 1. Whilst we cannot meaningfully compare the RoI estimated previously with our own results due to differences in approach, it is clear that large impacts, particularly investment events, concentrated in a few projects drive the overall value for money associated with the programme. This is to be expected for an R&D programme, especially a low TRL programme, where we cannot expect all projects to succeed.

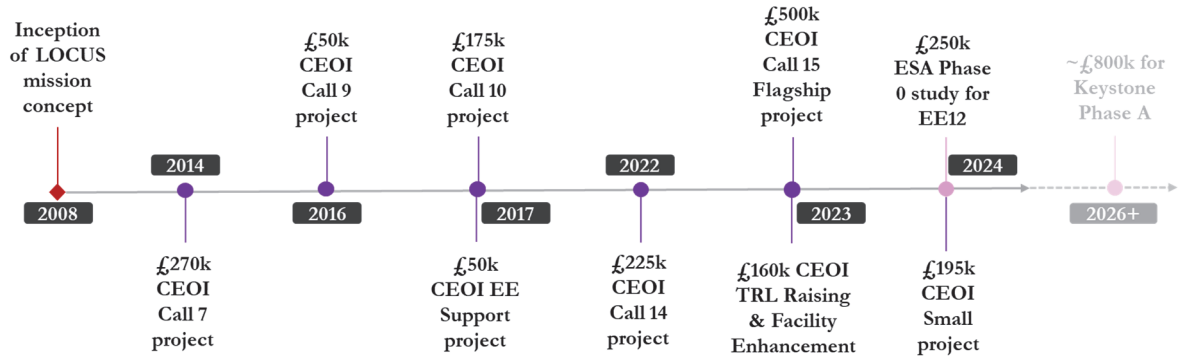
4.7. Case study: the University of Leeds

Throughout our economic evaluation, we have focused on the most recent CEOI projects from Call 11 onwards, noting the limitation that these projects are relatively early into their benefits realisation journeys. We have also focused on monetisable benefits. The following case study of funding received by the University of Leeds for terahertz (THz) quantum-cascade laser development demonstrates the potentially significant benefits which can arise from funding over longer timelines than those covered in our main economic analysis.

The University of Leeds and their partners at RAL Space have led eight CEOI projects, with a combined value of £2.0m. Over a decade later, the project team are on the cusp of potentially winning a large ESA contract for their Keystone mission. The idea for a LOCUS (Linking Observations of Climate, the Upper-Atmosphere and Space-Weather) ESA mission was first conceived in 2008 to fill a gap in capabilities in observing gases in the THz frequency range. CEOI was chosen as a route to develop the technology to a point where the team could bring it to ESA as a potential mission, with the first CEOI technology funding received in 2014. CEOI funding has enabled the University of Leeds and their partners to build their

capabilities in THz receivers over more than a decade. Today, the THz lab at Leeds supports 20-25 researchers, with at least six to seven employees or postgraduate researchers working on a project originating from CEOI funding at any one time.

Figure 10: Funding timeline for the University of Leeds' LOCUS concept



Note: funding amounts for Keystone Phase A and the next ESA EE12 mission are uncertain at the time of writing.

With CEOI support, LOCUS developed into a new mission concept, Keystone, to be delivered by a consortium including the University of Leeds, RAL Space, TK Instruments and University of Bern. ESA is funding a £250k Phase 0 study for Earth Explorer 12 (EE12) to develop a calibration system for THz receivers.[125] While the present ESA contract is small, Keystone is one of four potential candidates for ESA's EE12 mission. If selected in 2026, the contract for EE12 could be worth approximately £800k to the consortium, but the largest potential benefits are expected to affect wider society through improved climate monitoring. If selected, Keystone would provide the first direct observations of atomic oxygen in the altitude range of 50–150 km, allowing scientists to better understand the processes driving variability in the mesosphere-lower-thermosphere region of the atmosphere. This could inform models of the thermosphere, enhancing the accuracy of climate change monitoring, in turn facilitating better policymaking and supporting efforts to combat the climate crisis. This technology could also facilitate earlier detection of space weather events, through enhanced ability to detect certain atmospheric gases; early detection of these events can negate the worst impacts of space weather. These impacts are challenging to monetise, particularly at this early stage, but nonetheless should be considered key benefits of CEOI funding.

Lastly, this technology has potential commercial applications in communications, as THz waves can be used in quantum key distribution, facilitating secure communications. This application has been demonstrated in the lab, but is at least five years away from commercialisation. Nonetheless, it could ultimately offer a further revenue stream from this technology, as well as better communication for end users.

[125] This case study leverages insights from an interview with the University of Leeds.

CEOI funding is leading to potentially very substantial economic and societal benefit, more than a decade after funding was first received. Whilst it is expected that monetisable benefits to the consortium will be substantial, the largest benefits are likely to be social impacts which are intrinsically difficult to monetise. Value for money analysis provides a vital tool for assessing the extent to which funding has been effective but cannot capture the full benefit of funding.

Case study: The University of Leeds

- >£2m in CEOI investment to date (incl. matched funding contributions) across eight projects led by the University of Leeds and RAL Space.
- Development of leading UK capabilities in observing gases in THz frequency range, including six to seven highly skilled roles supported at any one time.
- £250k ESA Phase 0 study for Earth Explorer 12 (EE12) won, with the potential for a ~£800k contract if chosen for EE12.
- Substantial societal benefit expected if chosen for EE12: improved climate monitoring, earlier detection of space weather events and more secure communications.

The true value of CEOI projects will be realised over the long term, potentially years or decades after initial funding. Projects often require years of research before technologies can be incorporated into missions, followed by more years before benefits to end users are seen. As with any R&D programme, not all CEOI-developed technologies will be successfully used, so benefits are expected to be concentrated in a few projects that were highly successful in developing and operationalising their technologies. At this relatively early stage, impacts are concentrated in projects that have leveraged CEOI work for further investment and contracts, particularly ESA missions. With long timelines, only early signs of future potential can be measured now. Ongoing monitoring is essential to capture emerging benefits for a comprehensive future assessment of value for money.

5. Process evaluation

5.1. Summary

The headline conclusion from the process evaluation is that CEOI's model and processes are working broadly well for grant holders. Consultees praised the technical expertise and support CEOI was able to give at each stage of their applications and projects, citing it as the key added value of the CEOI model. The current third-party consortium model is considered optimal for CEOI going forward for retaining those benefits. However, the one-year funding cycles limit projects' and CEOI's abilities to achieve technical and scientific outcomes, and to support even more high-quality applications ensuring more uniform and comprehensive data collection will also help to evidence CEOI's success for future spending reviews.

Box 5: Process evaluation - key points

- The CEOI third-party consortium is designed to promote impartiality, prevent conflicts of interest and IP disputes.
- Outsourcing remains the preferred model for UKSA and CEOI. UKSA would not be able to internally replicate CEOI's expertise, experience, or heritage in EO to provide the same benefits to grant holders without significant investments in technical expertise.
- CEOI's current FY funding constraints limit their potential impact.
- Adopting a multi-year funding model could improve CEOI and project outcomes.
- There is scope for improvement in current M&E practices and guidelines to ensure the required data is being recorded, maintained and transferred to evaluators.

5.2. The CEOI model

Before assessing the processes of CEOI model, the research team first conducted interviews with CEOI and UKSA to understand how the model worked, why it was chosen and its general characteristics. We present this briefly first before discussing the results of the wider process evaluation.

Generally, competitive public funding for R&D projects is funded, overseen, and administered by a government department or body, such as UKRI councils or agencies like UKSA. Typically, this is done to ensure sufficient oversight of the spend, transparency and fairness in the selection processes. Non-governmental institutions and consortia may be contracted to distribute, manage, or monitor such funding in cases where there is no capacity and/or capability to do so within government. CEOI fits into this latter model. A summary of how the model works and why it was selected is shown below:

- **The funding and delivery model used by UKSA for delivering CEOI programmes is via a third-party consortium.** This gives the UKSA funding oversight but takes advantage of EO expertise as well as academic and industrial partners to distribute competitive grant funding within the sector, while also presenting risks such as insufficient oversight or engagement with grantees by UKSA.
- **The CEOI programme is constructed to ensure neutrality**. CEOI uses organisational security system agreements and operating practices to avoid potential conflicts of interest and inadvertent IP sharing. The main roles within CEOI are its director, co-directors, directors of technology and of science, as well as technology project support and operations (contracts and projects). CEOI, particularly in the most recent renewal contract, includes a wide group of advisors adding capabilities around developing business cases and links to ESA.
- **The CEOI model provides impartial support to grant holders**. A key benefit of CEOI's delivery model is that its experts can advise applicants at the bidding stage, helping to improve R&D concepts and eventual outcomes. The consortia's technological expertise and successful working relationship with ESA were also cited as benefits that a grant distribution programme alone could not achieve to the same scale.[Error! Bookmark not defined.]
- **CEOI's model has had a positive effect since its inception in 2007.** The model delivers a level of transparency that a research council, UKSA or other government agency would not have been able to achieve.[126] Despite no explicit rationale for UKSA's (originally NERC and the Department for Trade and Industry) initial choice to fund CEOI in this way, the most recent evaluation gave an assessment of the value of outsourcing CEOI, concluding that CEOI offered a credible mechanism and platform for EO stakeholders to develop their technologies.

5.3. CEOI Processes

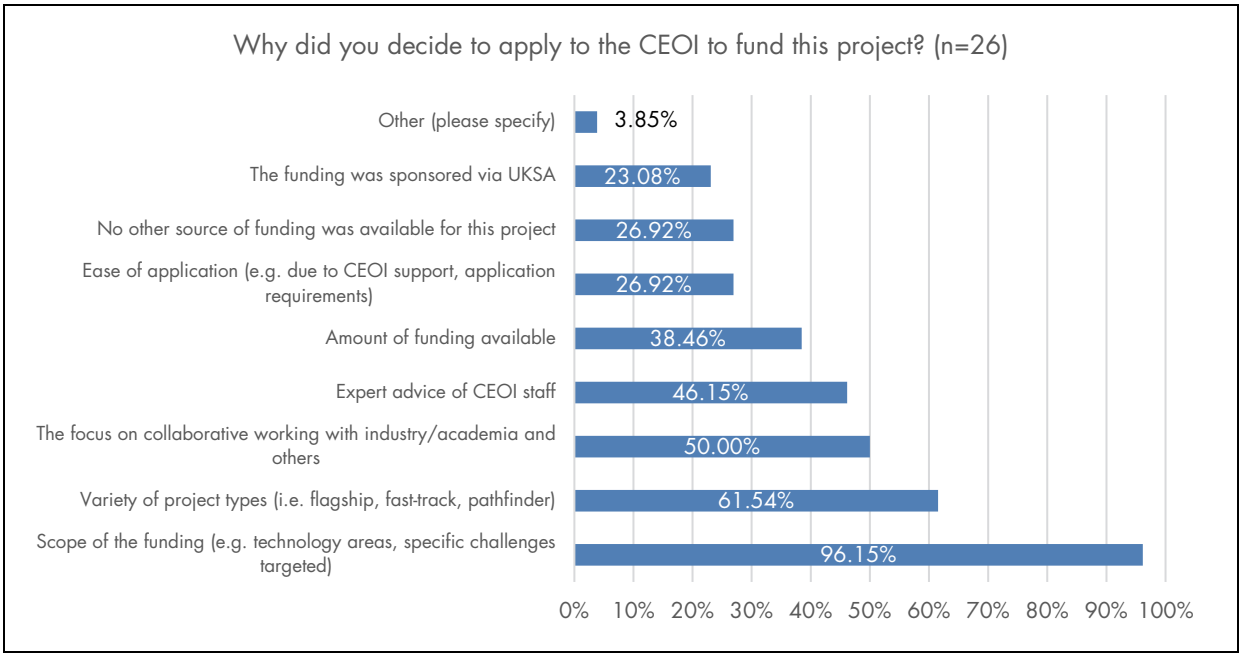
The results presented below are a summary of those reported in the interim report.

5.3.1. Application processes

Applicants cited several reasons for seeking CEOI funding, with the scope of funding being the primary factor, as 96.2 per cent applied due to the targeted technology areas or challenges.[127] The variety of project types—'Flagship,' 'Fast Track,' and 'Pathfinder'—was the second-most influential factor, with 61.5 per cent of respondents highlighting this factor in their decision to apply. Collaborative opportunities with industry and academia motivated 50 per cent of applicants, and 46.2 per cent by the expert advice from CEOI staff.

[126] UKSA (2016)
[127] INT_8B

Figure 11: Rationale for applying to CEOI programme funding



Source: RAND Europe. Project lead survey analysis.

Applicants value CEOI's support for early-stage technology development, a key feature of the programme. Low-TRL grant funding in the space sector involves significant risks, with returns potentially realised over long timescales. CEOI fills a gap by investing in critical low-TRL innovations, deemed 'essential' by stakeholders, where other funding sources may hesitate due to high risk and low profitability at early-stage investments. This approach is favourably viewed by stakeholders, who also appreciate its opportunities for individuals with non-traditional backgrounds in the EO community.[128]

Project participants found the application process clear, rigorous, and with quick turnaround times. The clarity of funding call needs and objectives, along with CEOI's responsiveness, was appreciated.[129] The transparency of the process, constructive feedback, and the independent expert review panel were seen as strengths.[130] The cadence and notification of funding calls were valued as they enabled prospective applicants to plan ahead,[131] though short tender cycles posed challenges for some. Extending the turnaround time to three months and enhancing application requirement transparency were suggested to address these issues.[132]

5.3.2. Project management and delivery

Most project participants value CEOI's project management and reporting structures, which include a light process approach and regular updates to keep projects on track. Clear guidelines for monthly reports and update meetings balance reporting with technology development.[133] While similar to industrial project management, which some prefer, this approach may pressure academic settings unused to frequent

[128] INT_7B; INT_3B
[129] INT_6B; INT_9B
[130] INT_6B; INT_7B
[131] INT_12B; INT_7B
[132] INT_4B
[133] INT_7B; INT_9B

reviews.[134] Participants appreciate CEOI's flexible funding tied to milestones, and responsive communication.[135]

Project participants value the knowledge, expertise, and credibility of the CEOI team, which enhances their projects through consistent engagement. Early engagement by CEOI is helpful for project success, aligning participants with key technological areas and ensuring timely and responsive support.[136] Technical CEOI officers with engineering backgrounds provide valuable feedback, strengthening project quality.[137] The roadmap for future technologies and investments is also appreciated.[138] However, one stakeholder noted potential challenges in scaling CEOI to larger projects, including the need for adequate funding at higher TRLs and specialised support for organisations with limited space technology knowledge, which should be addressed if CEOI expands.[139]

In isolated cases, project participants reported delays, though these were mostly overcome, with minimal longer-term impacts on project delivery. One lead mentioned staff changes at CEOI causing project start delays,[140] while another noted lengthy startup timelines due to funding constraints from their company.[141] Legal challenges were also mentioned, though CEOI was cooperative after initial delays.[142] A few interviewees suggested improving email responsiveness and project closure, which could be addressed with additional resources, given CEOI's budget constraints and the inability to carry funds over between financial years.[143]

The COVID-19 pandemic caused disruptions, but CEOI overcame these challenges. UK-wide lockdowns in 2020-2021 notably affected research projects, hindering experimental work and in-person collaboration. It was suggested that six-week review intervals might have been unnecessary during this time.[144] COVID-related delays in physical testing contributed to project completion delays.[145]

Overall, project delivery was smooth, with most projects delivered on time and within budget. One lead faced challenges with quick spending due to CEOI's March 2025 contract end-date, affecting smaller academic projects.[146] Another had to change project goals after underestimating custom optics costs but appreciated CEOI's accommodating nature and understanding of technological innovation needs.[147]

Part of this process evaluation involved conceptualising different delivery models for CEOI that may be considered for future funding rounds. These are outlined below.

[134] INT_2B; INT_3B
[135] INT_7B
[136] INT_4B
[137] INT_9B; INT_7B
[138] INT_9B; INT_7B
[139] INT_10B
[140] INT_10B
[141] INT_12B
[142] INT_10B
[143] INT_12B; INT_9B
[144] INT_3B
[145] INT_9B
[146] INT_7B
[147] INT_3B

5.4. Alternative delivery models

We consider the CEOI delivery model on a spectrum from an expanded version of the current model, all the way to a centralised in-house model run by UKSA, including pros and cons.

Table 5: Comparison of CEOI governance and delivery models

Governance / delivery model	Pros	Cons
Current model: external to UKSA, built from a consortium of EO companies and academics. Designs, delivers, and administrates the funding.	Independent from UKSA, but retains oversight and accounting, led by sector experts plugged into the needs of UK and global EO.	Less control of design and delivery for UKSA, CEOI does not benefit from UKSA's capacity in M&E of projects leading to workload issues. Full-time program managers do not discharge grants.
Enhanced / expanded model: enhanced resources to buy out more time of the current CEOI leads and administrator.	Capacity issues for rapid grant distribution addressed, including M&E.	Cost implications.
More centralised model: pulling back the administration of CEOI funding to UKSA but retaining CEOI to help choose projects.	M&E and grant distribution may be better handled by UKSA due to their heritage, including in M&E.	Less ability to take advantage of the technical knowledge and relationships built by CEOI. UKSA is less tuned into the EO community than the consortium.
Fully centralised model: funding completely under UKSA. Design and delivery, no external involvement beyond peer review and consultations.	Operational oversight is more direct (e.g. for M&E and grant distribution). The costs would be lower overall.	The benefits cited by previous evaluations of the outsourced model would be lost unless UKSA builds up the capability to match them.

We presented these options in our consultations with CEOI, UKSA and wider stakeholders. The responses are summarised below:

- **UKSA would not be able to match CEOI's EO expertise in-house:** Although UKSA employs staff experienced in EO science and engineering, there is not the capacity in-house to devote the same amount of specialised support that CEOI currently provide to applicants and grant holders.
- **Internal financial deadlines create limits on project progression:** The UKSA's current budgetary restraints do not currently allow funds to be carried across financial years. This poses risks to project teams, with limited flexibility around delays towards the end of the financial year.
- **The lack of a long-term budget leads to a more difficult bidding process for applicants:** The short turnaround (3-months) by which CEOI can give notice of upcoming calls is a challenge for

applicants. This is particularly difficult for business who need time to put together an internal business case before they can start bid writing.[148]

- **The frequent recent restriction to one-year funding cycles reduces CEOI's agility:** Much of CEOI staff time is devoted to administration, which is made worse when additional calls per year are fitted into the schedule due to wider UKSA underspends.[149] This reduces CEOI's capacity to strategically plan, identify potential disruptive technologies or to be proactive about upcoming trends in EO.[150]
- **Adopting a longer-term plan with a consistent call-cycle can reduce bottlenecks:** Pivoting to a longer funding period of two to three years could reduce bottlenecks by increasing the time in the FY cycle that CEOI can support R&D projects and offer a greater level of project coverage and competitiveness.[151] Furthermore, 2-3 calls during the 5-year cycle could be planned with regular intervals to support industry, academic, and organisational planning.[152]

5.5. Future opportunities and challenges

The subject of future trends in the wider EO sector and CEOI's role in it was discussed as part of the policy roundtables and interviews with UKSA and CEOI. This sub-section presents these results, triangulating and substantiating the findings with other sources to provide suggested paths forward.

The UK's current contribution to EO focuses heavily on improving interconnectedness and breadth.[153] CEOI's consortium approach is a testament to that strategy, though it is an uncommon one for UKSA which has brought up some issues in how best to govern and financially manage this model. A future opportunity for development of a centre of data exploitation built in a format similar to CEOI (e.g. based on ESA Φ-lab[154]) could be beneficial for ensuring the UK remains at the forefront of not just instrumentation, but EO data exploitation as well.

Programmes like CEOI and other UKSA and ESA programmes have enabled technologies to reach mid-TRL, but more work is needed to continue that development upstream and downstream. In practice the UK has leveraged capabilities across the EO value chain from conception to instrumentation to manufacturing to data processing and exploitation, excluding launch presently. Current expertise outside of CEOI and UK subsidiaries like Airbus UK, are still heavily focused on data exploitation through organisations like the Met Office, ESA Climate Office, and Lloyds insurance. Our consultees recommended that UKSA could invest more in higher-risk, potentially disruptive technologies, acknowledging that leadership in a sector is often derived through first-mover advantage. A national drive to invest in prospective or low-TRL technologies that the UK wants to lead in was suggested, including investing long-term in facilities and infrastructure. Part of this can and should be done via the CEOI mechanism.

In a 2023 market analysis of UK-based EO companies, there were major strengths in the quantity of EO companies operating in the product and analysis markets (~90 per cent of all UK-EO companies as of

[148] CEOI_UKSA_Group_Interview (2025)
[149] CEOI_UKSA_Group_Interview (2025)
[150] CEOI_UKSA_Group_Interview (2025)
[151] CEOI_UKSA_Group_Interview (2025)
[152] CEOI_UKSA_Group_Interview (2025)
[153] Findings from Roundtable 2: CEOI adjacent
[154] ESA Φ-lab (2025).

2023), highlighting UK heritage in that area.[155] Conversely, many of these are SMEs or spinouts from academia (with < 10 staff), which could be seen as oversaturating the market at the SME level. This may contribute towards a bottleneck, with an overly competitive micro and small firm EO ecosystem, which reduces accessibility to UKSA/ESA funding and increases the chances of failing to spinout. Such a bottleneck could prevent advancements in the market and horizontal integration of capabilities across the EO value chain.

The UK's current goals to commercialise the EO sector further was highlighted with key challenges from overemphasis on open data to public-focused EO programmes, fragmentation in the market, and raw data uncertainty. These were supported by views that low-TRL development should continue to be supported without undermining higher level mission-based or higher-TRL operationalisation. Roundtable discussions followed by the comments from CEOI both advised that a new EO strategy ought to be adopted by the UKSA, to foster a more EO specific approach to innovating and growing the UK space ecosystem.

[155] Red Kite (2023).

6. Conclusions

The CEOI programme is an important feature of the overall UK EO landscape, funding innovative projects which lead to enhanced technological progression and promising mission concepts. The programme is well liked by grant recipients, with many calling for CEOI's budget to be expanded and for its funding to span over more than one financial year. The programme is largely well run, though delivery partners have struggled to administer the funding within one financial year when additional calls are added, leading to difficulties in collecting monitoring data.

6.1. Conclusions

The following conclusions summarise findings from the preceding chapters, organised by CEOI's 2019 objectives:

- **Economic Impact:** Develop EO technologies that increase exports and economic growth.
- **Return on UK Government Investment:** Maximise the benefits derived from UK funding to ESA and other institutional bodies.

- **It is too soon to determine whether CEOI will deliver good value for taxpayers' money, though there are early signs of potential for substantial future benefits**. Our economic evaluation is subject to notable data gaps, so we chose to focus on 39 recent projects (Calls 11-16) for which we have some data on economic impacts. This may introduce selection bias into our results since projects who chose not to respond to our surveys may have realised more minimal benefits.
- **The real discounted (Present Value (PV), 2024/25) and attribution-adjusted UK benefit of the CEOI (Calls 11-16) is at least £30.2m to date.** This total is driven by large three ESA contracts - results hinge on the success of a small subset of projects. If we include expectations, the PV benefit of the CEOI (Calls 11-16) rises to at least £57.6m. Furthermore, many benefits of the CEOI are intrinsically very challenging to monetise, so any quantified estimates will underestimate the full benefit of the programme.

- **Innovation:** Keep the UK at the forefront of EO technology development by supporting new and innovative ideas that offer tangible benefits to future missions.

- **CEOI fills an important gap in funding low-TRL UK EO projects and supporting their development to higher levels.** With an average project TRL progression rate of 2.2 points, CEOI is delivering value in supporting project teams to progress their EO technologies. Due to their focus on low-

TRL projects, CEOI is also enabling wider access to the EO market among smaller organisations, diversifying the UK EO sector and promoting innovation.

- **Coordination among government, academia, and industry strengthens the UK EO and space sector, with CEOI serving as an enabler of such collaboration.** The funding model of the programme, as well as the events and networks CEOI facilitates are recognised to encourage collaboration and the cross-pollination of ideas.

> ➢ **Capability:** Strengthen capabilities in which the UK already leads, has the potential to lead or could overtake existing capability elsewhere.

- **The UK is a key player in global EO technology development and CEOI plays an important role within the ecosystem.** The progression pipeline from CEOI-funded projects to ESA funding or involvement in international missions is evident, contributing to the UK's international standing. UK contribution to international EO scholarship and academic publications is also significant, and in part facilitated by programmes such as CEOI.
- **The current CEOI model has advantages due to the level of stakeholder buy-in, programme transparency and support for international funding down the line.** CEOI's match-funding model and collaborative approach delivers on ensuring ownership among stakeholders, while the team's technological expertise and successful working relationship with ESA is key to promoting access to future funding and involvement in international missions.
- **However, there are drawbacks of the current CEOI model, which merits the exploration of alternative delivery models.** This report presents three examples of alternative delivery models. While an enhanced/expanded CEOI model could enhance the offer of CEOI, this comes with cost implications. A more centralised model could improve grant distribution, but would miss out on the knowledge and networks of CEOI. A fully centralised model would enhance operational oversight, but would struggle to generate the same benefits as CEOI.

6.2. Recommendations

The following recommendations are intended to help improve CEOI's delivery, outcomes for projects and overall value that the programme brings to UK EO and the taxpayer:

- **CEOI's funding support of low-TRL EO technology is highly important for UK EO – and support at these development stages should be maintained.** Adapting the model of CEOI or expanding the programme to support higher TRL projects should not neglect this earlier development stage. However, there are also arguments for CEOI to focus on supporting disruptive technologies and longer-term projects to prevent innovation bottlenecks in the UK EO ecosystem.
- **The CEOI model can build on its strength in connecting partners, sharing knowledge and enabling collaboration.** The expertise and networks of the CEOI team are significant advantages of the current programme model, bolstering the UK's ability to bring together space industry, academia and government. The benefits and disadvantages of alternative delivery models need to be weighed carefully against the current CEOI model and its strengths in facilitating collaboration.

- **Sustaining or increasing funding for CEOI is likely to deliver further value to UK EO.** Project participants throughout this evaluation overwhelmingly argued for expansion of the CEOI programme, though such upscaling is likely to come with challenges and trade-offs. The recent increase in CEOI funding brought an increase in projects and innovation in the EO sector but also significant administrative burden coupled with only annual budgets. Extending budget horizons to two years would allow CEOI to deliver more value to UKSA by enhancing the quality of project bids and M&E reporting.
- **Beyond additional funding, CEOI can benefit from strategic guidance from UKSA and the broader UK government.** Roundtable participants suggested creating a UK department for EO, akin to those in the US and New Zealand, to enhance strategy and capability building. A new UK EO strategy was recommended to improve connections between UKSA, developers, and end-users, boosting competitiveness in EO missions. This includes a more risk-taking funding approach to foster innovation.[156]
- **Clear prioritisation of EO market areas is needed for CEOI to support the UK's leading data analysis capabilities and fill other niches.** For example, roundtable participants suggested focusing on UK sensor manufacturing and extending remote sensing from space-based to aerial and UAV technologies, aligning with UAV-Satellite synergies. [157]
- **Our evaluation, particularly the economic evaluation, has been hindered by incomplete data on impacts from project teams.** Capturing this data retrospectively once projects have finished is challenging, given project teams have little incentive to reply to surveys and requests for information. Regular ongoing monitoring, concurrent with project delivery, will be key to capturing benefits as they arise in future. Regular quarterly monitoring should be implemented to capture North Star Metric impacts from project teams, in line with mandatory UKSA reporting requirements. Additionally, capturing expected North Star Metric impacts at application stage, in line with other UKSA programmes, could provide a useful source of forecast data, against which realised impacts can be compared.

[156] ESA (2020).
[157] Alvarez-Vanhard et al. (2021).

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Annex A. Interview overview

A.1. Interviewed organisations

CEOI
UKSA
QinetiQ
University of Leicester
CEOI
Airbus
UKSA
DSTL
NCEO
Met Office
Defra EOCoE
ESA/ ESTEC
University Cambridge
University of Strathclyde
Teledyne e2v
Queen's University Belfast
University of Nottingham
University of Edinburgh
STFC RAL Space
Craft Prospect
Cranfield University
Open Cosmos
Terahertz
University of Leeds
Leonardo MW Ltd

A.2. Interview protocol example

CEOI interview protocol - Direct beneficiaries of grants

Interviewee name	
Role and Organisation	
Interviewer	
Interview date/time	
Involved in which funding call(s)?	

A.2.1. Ahead of the interview

The interviewee has been selected as they were a project lead in the CEOI. Project leads are being interviewed for a comprehensive and robust account of processes and impacts. Prior to each interview, familiarise yourself with the background documentation available (quarterly reports, summary reports, final phase reports etc).

A.2.2. Interview

Instructions for interviewer:

Begin by introducing yourself and providing some background to the interview. Please confirm the participant's consent to participate in the evaluation and recording.

A.2.3. Background to the research to be shared with the interviewee

Thank you for agreeing to take part in this interview. As you may know, UKSA has commissioned a consortium led by RAND Europe, to conduct an independent evaluation of the CEOI programme. The comments you share in this interview will provide valuable insight to feed into the evaluation of this programme.

This interview should last from around 45 minutes to an hour.

Your participation in this interview is voluntary and you can change your mind at any time. The information that you provide will be treated in confidence by the evaluation team.

We would like to use your inputs and request your permission for the following:

1. To use the feedback you provide, together with any additional information you choose to disclose ("Information") for the evaluation study.
2. We will provide **an anonymised version of this and** any analysis we carry out as part of the evaluation study with UKSA, for its own internal purposes only. However, due to the number of projects in each sub-programme, complete anonymity may not be possible.
3. UKSA expect to publish **aggregate, unattributed results** of the evaluation which includes analysis of information from these interviews.

We would like to audio record the discussion for analysis purposes, which will be used to help us accurately collect findings for the research. The recordings will be securely stored and retained by us and destroyed by the end of the evaluation. **Are you happy for us to proceed?**

A.2.4. Introduction

Instructions for interviewer:

This section includes brief introductory questions to understand which sections of the interview guide are most relevant to the interviewee.

This section shouldn't take more than a couple minutes.

1. Could you please give an overview of your role and involvement in the CEOI programme?

Prompts:

i. *Which project(s) were you involved in as a project lead?*
ii. *Which funding call(s) were you a part of?*
iii. *Were you involved in any additional projects as partners?*

2. ***(if applicable)*** *Are you able to speak to the other projects you were involved in?*
3. ***(If applicable)*** Why did your organisation/ team decide to engage in more than one project under the CEOI?
4. ***Did your organisation make any additional applications to the CEOI at any other stage that were unsuccessful?***

Instructions for interviewer: If the interviewee made an unsuccessful application in addition to their successful application, questions __ - __ are relevant to ask.

5. **(If applicable)** Thinking specifically about the application that was not funded in the CEOI, did your organisation pursue this project by other means? **(If not, move on to question 5)**

If so, probe for:

i. How did you fund this project? (Private/ public/ own funds/ international?) Were there any co-investment opportunities?
ii. Who did you partner with?
iii. To what extent did the direction of travel of the project change? How and why did this happen?
iv. What have been the projects key achievements to date?
v. What have been the main differences between the project funded under CEOI and this one?

6. **(If applicable)** Why didn't your organisation choose to pursue this project?

Probe for:

i. Were there any funding issues?
ii. How would the direction of the project have had to change? Was this possible?
iii. What could have been the key achievements to date?
iv. What were the key parts of CEOI that this project was dependent on?

A.2.5. Application and assessment processes

Instructions for interviewer:

This section aims to understand the applicant's views around the application process.

Note that interviewees may not be able to recall certain information, as some applications were made 10+ years ago.

7.
a. Can you please describe your application process to the CEOI funding call?
b. How clear was your understanding of the needs and objectives of the funding call? And how did these align with your own?
c. Were you provided with enough time and information to form your consortium and prepare your submission?
d. **(If applicable)** Were there any differences in the application process for the other projects you were involved in for different CEOI funding calls?

8. Can you please describe your experience in the application assessment process.

Prompts:

i. How transparent was the application assessment process?
ii. Were you provided with appropriate feedback?
iii. **(If applicable)** Were there any differences between funding calls for the projects you were involved in?

9. Are there any ways in which the application or assessment processes could have been improved or streamlined?

A.2.6. Other CEOI processes and design

Instructions for interviewer:

This section aims to understand the stakeholder's view around the processes, management and design of the CEOI. We will use this information to refine the process maps and may follow up with interviewees for review.

10. What elements of the CEOI's design and processes worked particularly well in your view? (ask the interviewee to specify which funding call they are referring to, or whether they are referring to the CEOI as a whole)

Prompts:

i. How satisfied was your organisation with the programme?
ii. Were there any process barriers to delivering projects on time and within budget?

b. What processes present best practice opportunities for future programmes or iterations for CEOI funding calls?

c. To what extent do you think the CEOI holds potential for scaling up? What would this involve, and is there a sufficient market demand for it?

11. Which parts of the CEOI's design and processes do you think worked or didn't work well for EO companies?
    i. Do EO companies need additional support to compete more effectively on an international stage for missions?

12.

a. What are the current funding mechanisms/ methods used in CEOI's delivery? To what extent do you think these mechanisms are appropriate? (i.e. match funding or grant funding).

b. Were other funding mechanisms considered as part of the CEOI's delivery plan?

Probe for:

i. *Why were alternate choices not chosen?*
ii. *Do any of these present opportunities worthy of merit?*

13. Were efforts taken to ensure that EDI factors were considered in the design and delivery of the project(s) you were involved in?

Were there any challenges in implementing EDI factors?

A.2.7. CEOI impacts

Instructions for interviewer:

This section aims to understand the stakeholder's views around the impacts resulting from the CEOI.

14. From your perspective, what have been the main impacts that have occurred as a result of the project(s) you were involved in?
    i. Did the project(s) contribute to the development of new UK EO instrumentation and technologies? (e.g., TRL, CRL and SRL progression data)
    ii. Did the project(s) achieve commercialisation as a result of involvement with the CEOI?

(Related to CEOI added value programme)

15. To what extent has the CEOI:

    i. Helped your organisation to leverage new contracts and investment opportunities?
    ii. Enabled you to generate new knowledge exchange opportunities?
    iii. Enabled you to create new capabilities within the project(s)?

16. How has good value for money been demonstrated in the project(s)?

Prompts (areas of VfM that we are considering - no need to ask about all of them):

i. *New publications and citations*
ii. *New strategic partnerships*
iii. *Additional funding leverage by strategic partners*
iv. *Additional competitive research funding*
v. *New and improved products/ services, processes or practices*
vi. *New patents, licenses and IP*

vii. *New and active organisations/ businesses supported (spin-offs, start-ups, SMEs and other commercial businesses)*
Number of new jobs created and retained.

17. We are also interested in understanding your perspectives on the programmes influence on the wider EO technology sector as a whole. To what extent do you think the CEOI has contributed to the growth of the EO sector?

Probe for:

i. *New and strengthened relationships*
ii. *New knowledge*
iii. *Training examples*
iv. *New and active organisations (spin-offs, start-ups, SMEs and other commercial businesses)*
v. *Private and public sector funding*
vi. *Productivity increase*
vii. *International reputation*

18. Counterfactual question: What might have been expected to happen without CEOI investment?

Prompts:

i. *Technological development differences*
ii. *Formations of partnerships*
iii. *Co-investment opportunities*
iv. *Other impacts*

19. Did the CEOI enable your project to collaborate with international fora?

Prompts:

i. *Access to international knowledge, people, skills and facilities*
ii. *International EO reputation in terms of establishing new international collaborations and accessing/ leveraging international funding.*

20. To what extent do you think the CEOI has affected the UK's credibility and reputation among the international EO community?

A.2.8. Closing

Instructions for interview

This section aims to wrap up and give the opportunity to the interviewee to add anything they might have missed when answering a previous question or

regarding a topic we haven't asked about. Please thank the interviewee for their time and participation.

This section should be relatively short (around 5 minutes). If the interviewee has many comments to share at the end, please feel free to give them more time if available or invite them to share further comments in writing.

21. If you were designing the CEOI from scratch, what aspects would you remove? What aspects would you add?

22. Is there anything you would like to discuss that hasn't been touched upon already?

Thank you for taking the time to answer these questions. We might follow up with some project-specific output questions if that's alright? If you have any further questions or comments, please feel free to email me or the project manager Theodora Ogden.

Annex B. Survey overview

B.1. Surveyed organisations

Organisations surveyed
TAS UK Ltd
National Oceanography Centre
STFC RAL Space
Leonardo MW Ltd
Surrey Space Centre, Univ of Surrey
University Cambridge
University of Strathclyde
University of Leeds
University of Glasgow
University of Oxford
Cranfield University
University of Cardiff
University of Edinburgh
University College London
University of Leicester
Durham University
University of Reading
Queen's University Belfast
National Physical Laboratory
MSSL
TAS UK Ltd
Airbus DS
Earth-i Limited
Craft Prospect

B.2. Survey questions

Survey topic	Survey questions
Background	
Welcome to the survey that we, RAND Europe, are conducting as part of an evaluation of the CEOI (Centre for Earth Observation Instrumentation), commissioned by the UK Space Agency (UKSA). The evaluation is led by RAND Europe, with partners, know.space, as well as earth observation (EO) experts, Aravind Ravichandran & Luca Budello. It will run until March 2025 and will culminate in a public final report (with commercially sensitive information redacted).	
The aim of the evaluation is to explore how well the programme has been delivered and to what extent it has achieved its objectives, from its inception to the present day. The CEOI comprises of two programmes, the EO Instrumentation Programme (EOIP), launched in 2007, and the EO Technology Programme (EOTP), announced in November 2022. This survey is aimed at all project leads funded by the CEOI under EOIP and/or EOTP from all funding calls.	
Other research methods will include interviews, case studies, policy roundtables and analysis of project reporting. To avoid duplication and respondent burden, this survey only asks questions that cannot be obtained by those other means and by existing data sources.	
This survey	
The first part of this survey asks briefly about the most notable achievements of your work, before moving on to the capabilities developed in the context of the funding you received. The remainder of the survey asks about the commercialisation of the technology developed, international missions, your participation in events, and the new partnerships and knowledge exchange that may have happened. Finally, the survey asks about your perception of the processes carried out in the context of the EOIP/EOTP, and the future of the programme.	
This survey is made up of closed and open free-text questions, and should take 10-15 minutes to complete.	
Confidentiality and data	
None of the questions in the survey are mandatory and you are able to withdraw at any time. You are free to request the withdrawal and deletion of your submission and data at any point in time during the course of the study.	
By completing this survey, you agree to the terms of the privacy policies outlined by RAND Europe and UKSA, which are linked below, and the data you provide for use in this project only.	

<table>
<tr><td colspan="2">All data and information provided will be considered as confidential, it will only be used by RAND Europe for the purposes of conducting the evaluation, and we will not share with anybody (including UKSA) any raw response data that is directly attributable to you. Any wider publication of results from the survey will only be in a synthesis and anonymised form in our reporting. Please see RAND Europe's and UKSA's privacy policy for more information.

If you have any questions please feel free to contact Theodora Ogden, the RAND Europe study manager (togden@randeurope.org), or Joe Hicks at UKSA (joe.Hicks@ukspaceagency.gov.uk).</td></tr>
<tr><td>Understand the profile of the respondent</td><td>1. Before securing your EOIP/EOTP award, had you previously:
a. Secured any other grant funding (UKSA or not) for EO R&D as a lead partner
b. Participated in EO R&D via other means (e.g. private contracts, partner on projects led by others)</td></tr>
<tr><td>Tech / achievements</td><td>One way of measuring technological development is by using the Technology Readiness Level (TRL) scale, which describes the different stages of development a solution might go through.

We are interested in where the solution(s) were at the beginning of your project, when the project finished, and now. For example, a new sensor might have only been proven in theory (TRL 3), by the end of the project it was tested in an operational environment (TRL 7), and now it has actually been sold to customers (TRL 9).
2. What was the TRL of the main innovation you developed as part of the project (e.g. product, technology, process, service) before receiving EOIP/EOTP funding, by the end of the project and now?

<table>
<tr><th>TRL levels</th><th>When you were awarded the EOIP/EOTP funding</th><th>By the end of the project</th><th>Present day</th></tr>
<tr><td>TRL 1- Research: Basic principles observed. Scientific observations made and reported. Examples could include paper-based studies of a technology's basic properties.</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
</table>

	TRL 2- Research: Technology concept formulated. Envisioned applications are speculative at this stage. Examples are often limited to analytical studies.			
	TRL 3- Research: Experimental proof of concept. Effective research and development initiated. Examples include studies and laboratory measurements to validate analytical predictions.			
	TRL 4- Development: Technology validated in lab. Technology validated through designed investigation. Examples might include analysis of the technology parameter operating range. The results provide evidence that envisioned application performance requirements might be attainable.			

	TRL 5- Development: Technology validated in relevant environment. Reliability of technology significantly increases. Examples could involve validation of a semi-integrated system/model of technological and supporting elements in a simulated environment.			
	TRL 6- Development: Technology demonstrated in relevant environment. Prototype system verified. Examples might include a prototype system/model being produced and demonstrated in a simulated environment.			
	TRL 7- Deployment: System prototype demonstration in operational environment. A major step increase in technological maturity. Examples could include a prototype model/system being verified in an operational environment.			

	TRL 8- Deployment: System complete and qualified. System/model produced and qualified. An example might include the knowledge generated from TRL 7 being used to manufacture an actual system/model, which is subsequently qualified in an operational environment. In most cases, this TRL represents the end of development.			
	TRL 9- Deployment: Actual system proven in operational environment. System/model proven and ready for full commercial deployment. An example includes the actual system/model being successfully deployed for multiple missions by end users.			

3. To what extent have the technology or solutions developed in your project reached its intended user base? Select all that apply
    a. Launched as part of a mission
    b. Sold to customers
    c. Being applied by practitioners

d. Being used / further developed by other researchers
e. Other (please specify):

4. Have the technological solutions created by your project led to any of the following benefits for end-users? *Select all that apply (Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A)*
    a. Supported the development of low-mass cost-effective EO instrumentation for institutional and commercial markets
    b. Increased knowledge exchange between the academic and industrial EO community
    c. Promoted CEOI capabilities, technologies and achievements of the UK EO research and industrial sector
    d. Leveraged external follow-on funding
    e. Improved understanding within the UK EO community of opportunities presented by CEOI, UKSA and mainly ESA, the EU/Copernicus

Have the technological solutions created by your project led to benefits in the following areas? *Select all that apply (Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A)*

a. Environment and Net Zero targets
b. National security
c. Engagement with students / early-stage career profiles for employment in space/STEM

+ free text box to capture rationale/qualitative information

How has your technology helped advance UK EO capabilities?

Category	Type	**Supported** existing capabilities	**Advanced** existing capabilities	**Enhanced** new capability
Data	Data processing			
	Data modelling			

	Passive imagery	Panchromatic			
		Multi-spectral			
		Pan-sharpened			
		Hyper-spectral			
		Microwave radiometry			
	Active imagery	SAR			
		Lidar			
		Radar altimetry			
		Radar scatterometry			
		GNSS-R			
	Parameters	Spatial resolution			
		Revisit time			

Commercialisation	5. Can you provide an estimate of the value of EO-related contract(s) won and investment, which you would attribute to your involvement in EOIP/EOTP, if applicable? *a.* Public funding (e.g. public service contracts, further R&D grants) (*free text box*) *b.* Private funding (including venture capital) *(free text box)* *c.* Of the above, what amount was from non-UK based sources? *(free text box)* 6. To what extent has the EOIP/EOTP funding allowed you to capture more of your domestic and international markets for your products/services between the point of your award and the present day, if applicable? d. Domestic (per cent gain in market share attributed to the funding): e. International (per cent gain in market share attributed to the funding): *7.* Have you applied for and/or been granted patents specifically for technology developed as part of your EOIP/EOTP funding? *f.* Patents applied for *(drop down menu to choose a number between 1 and 10)* g. Patents granted *(drop down menu to choose a number between 1 and10)* h. *Extra box* : If a patent was granted, what was the patent number? 8. How much total revenue have you generated through IP licensing across patents? free text

	9. Have any spin-outs been created from the work conducted as part of the EOIP/EOTP funding? a. No *b.* Yes (please specify how many, company names and approximate number of employees)
Jobs / capabilities and skills	10. Has the EOIP funding enabled the development of new skills and capabilities at your organisation <u>from the point of your award to the present day</u> such as: (*Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A)* i. Your ability to lead/participate in bids for international missions (e.g. ESA, bilateral) j. Your ability and capacity to export your technologies k. Maintain and improve the technical knowledge and skill of your workforce / yourself in developing innovative EO instrumentation l. Ability to access international expertise and facilities m. Increased ability to commercialise research outputs (e.g. IP, patenting, products) n. Increased ability to capture commercial contracts o. Reputational benefits 11. As a result of the EOIP/EOTP funding you received: p. How many EO jobs were created? (free text box) q. How many EO jobs were retained? (free text box) r. How many PhDs were supported? (free text box) s. How many apprentices were supported? (free text box) t. How many exchanges were supported (e.g. sabbatical of employees within the industry) (free text box)? (free text box) 12. To what extent did your organisation experience commercial benefits as a result of the EOIP/EOTP funding you received? u. Overall company growth

	v. Increased wages w. Increased revenue from sales/licencing (actual and expected) x. Increased productivity/efficiency 13. Did you occur any additional costs (over and above those covered by EOIP/EOTP and your committed match funding)? a. No b. Yes (please specify a specific £ figure if possible and/or staff time):
International missions	14. How many submitted ESA EO-related mission bids have you been involved in (either as lead or partner) that **included technology you developed as part of your EOIP/EOTP grant**? y. Number of ESA EO-related mission applications *(drop down list 1-10)* z. Number of successes *(drop down list 1-10)* aa. Value secured in GBP, only in relation to your contribution not the total contract value *(free text box)* 15. Have you been involved in any other international EO-related mission bids (either as lead or partner) that **included technology you developed as part of your EOIP/EOTP grant**? If applicable, can you provide any details concerning the number of bids submitted, successful bids and value? *(free text box)* 16. To what extent was the technical support you received as part of the EOIP/EOTP adequate to help you compete for international missions? *(Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A)*
Events 1/2	17. Did your organisation take part in one or more of the following activities organised by the CEOI (select all that apply): *(if any selected, see if possible to activate the "events" section later without jumping straight to it)* a. Challenge workshop b. Technology strategy workshop

	c. Training workshop d. Other workshops (please specify) e. CEOI Earth Observation Conferences (CEOI annual conferences or National EO Conference) f. Technology and projects showcase events g. CEOI support for developing concepts for ESA Earth Explorer Rounds h. CEOI supported PhD studentships (as a sponsor, supervisor or as a student) i. CEOI training and development programme j. Industry consultation workshop k. SME event
Events 2/2	18. Did your participation in events/workshops organised by the CEOI lead to: (*Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A*) a. Increased knowledge and skills b. Networking c. New collaborations d. New commercial outcomes e. New investments 19. To what extent have the public event(s) organised by the CEOI allowed you to showcase your achievements? (*Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A*)
Partnerships / knowledge exchange / networks	20. As a result of the EOIP/EOTP funding, did you form any new partnerships (i.e. partners with which you had not had a formal project collaboration with before) or collaborated with any of the following stakeholders between the point of your award and the present day? If applicable, how many new partnerships or collaborations? (*tick box + drop down menu 1-10 next to each*) a. Academic/University b. Private sector (e.g. industry) c. Third sector (Charity/Non-Profit/NGO) d. Public sector (e.g. policymakers, local government)

21. To what extent have existing partnerships (i.e. partners who you previously had formal project collaborations with) been strengthened as a result of your EOIP/EOTP funding? (*Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A*)

22. To what extent has EOIP/EOTP funding allowed you to widen your pool of partnerships on a geographic level between the point of your award and the present day? E.g. it may have allowed you to work with particular companies/academics in a certain country, which was not possible without the funding.

    Please select all that apply.

	To a large extent	To a moderate extent	To some extent	To no extent	Don't know/ N/A
Local / regional level					
UK level					
International level					

Counterfactual

23. Did you consider any other funding programme when applying for EOIP/EOTP funding? (Y/N)
    a. (if yes) What was the name of the alternative funding programme and the funder?
24. To what extent would the benefits of the programme for your project would have come about via other means if you **had not** received EOIP/EOTP funding?)

	All benefits would have been achieved	Most benefits would have been achieved	Some benefits would have been achieved	None of the benefits would have been achieved	Don't know/ N/A
TRL increases					

New Intellectual Property developments						
Demonstration opportunities						
Technology commercialisation						
Development of existing and new partnerships						
New jobs created / existing ones retained						
New knowledge and skills developed						
Training and development delivered						

25. Could you have undertaken your project without EOIP/EOTP funding?
    a. Yes, at a larger scale
    b. Yes, at the same scale
    c. Yes, at a smaller scale
    d. No
    e. Not sure / N/a

<table>
<tr>
<td>Processes / how well the programme responds to the needs of the sector</td>
<td>
26. To what extent was the funding you secured sufficient for addressing your original objectives? (Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A)

27. From your experience, how satisfied were you with the following processes within the EOIP/EOTP? (Likert scale 1-5: to a large extent, To a moderate extent, To some extent, Not at all, Don't know / N/A)
a. Frequency of funding calls e.g. number per year
b. Overall number of funding calls
c. Format used to announce opportunities
d. Strategic direction document provided to applicants
e. Bidding process (including intention to bid notification as well as submission of the bid itself)
f. The eligibility and selection criteria for the programmes
g. Mode of assessments for the bids
h. Time from application to award
i. Contractual conditions of the award
j. Post-award support
k. Programme monitoring (including monthly progress reports, quarterly reports, mid-project reviews and final project report)

28. Do you have any suggestions of how processes within the programme could be implemented differently in the future? (timeliness, transparency, support…) (free text box)
29. To what extent did your project take into consideration issues of equality, diversity and inclusion:
<table>
<tr><th></th><th>To a large extent</th><th>To a moderate extent</th><th>To some extent</th><th>To no extent</th><th>Don't know/ N/A</th></tr>
<tr><td>Within the project (e.g. equitable access to training, team gender/ethnicity balance)</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td>
</tr>
</table>

	As part of the intended impact of the R&D (e.g. making EO data/resources available to underserved indigenous communities)					
Closing / Future of the programme	30. If there was one thing you would change about the EOIP/EOTP programmes to improve them in the future, what would it be and why?					