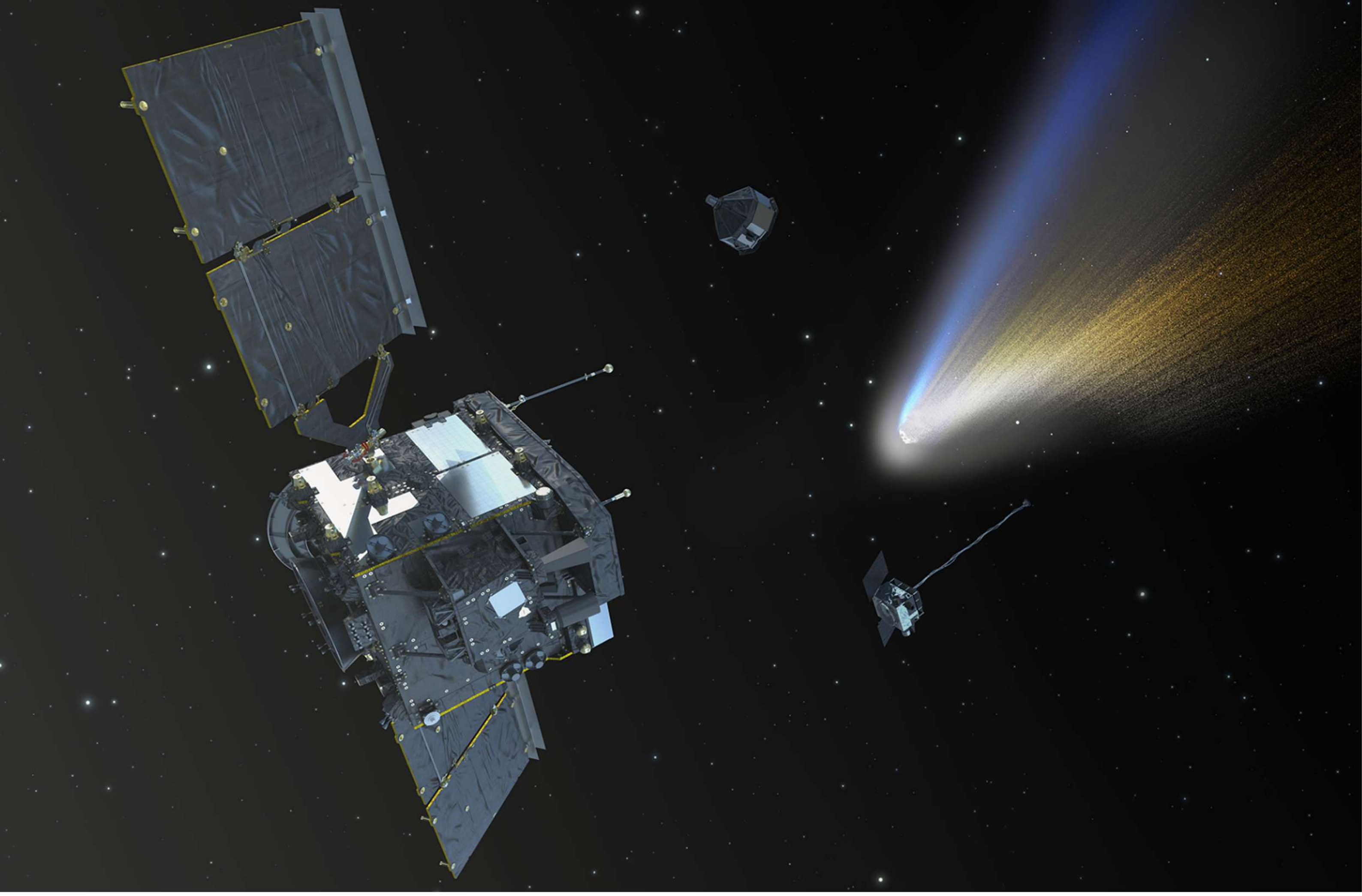


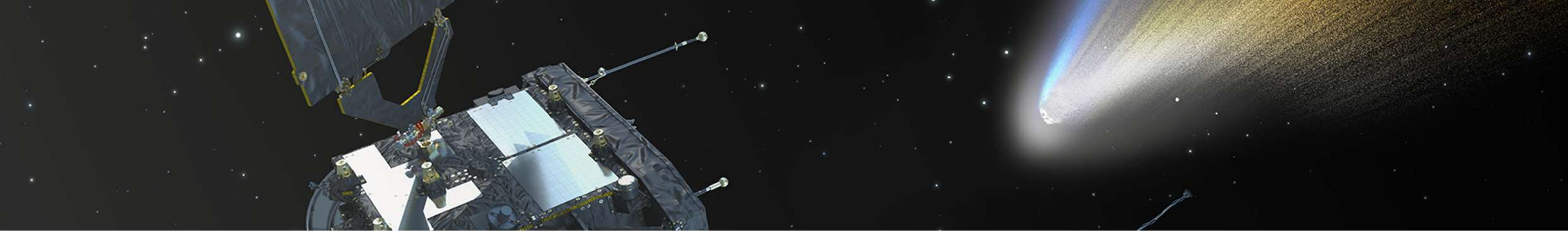
Comet Interceptor Monitoring & Evaluation Support

Interim Process & Impact Evaluation

Report for the UK SPACE AGENCY

know.space

May 2025



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to understand clearly and with certainty

know.space[1] is a specialist space economics and strategy consultancy, based in London and Edinburgh. We are motivated by a single mission: to be the source of **authoritative economic knowledge for the space sector**.

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Acknowledgements

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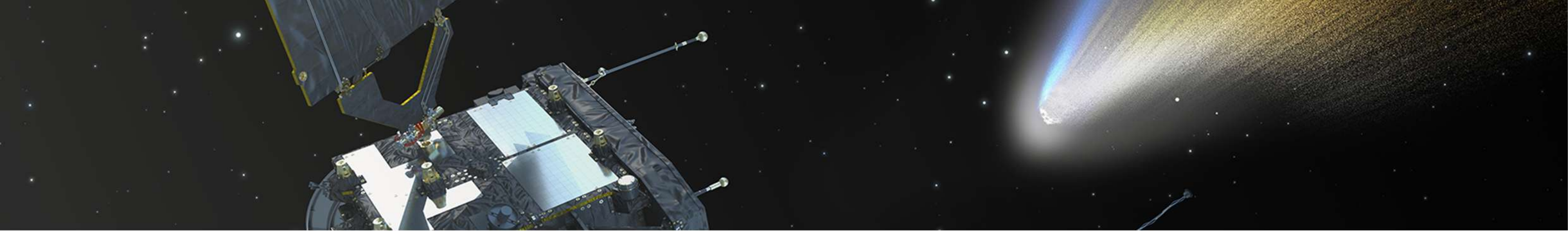
[1] **know.**consulting ltd. (CRN: 12152408; VAT: 333424820), trading as **know.**space



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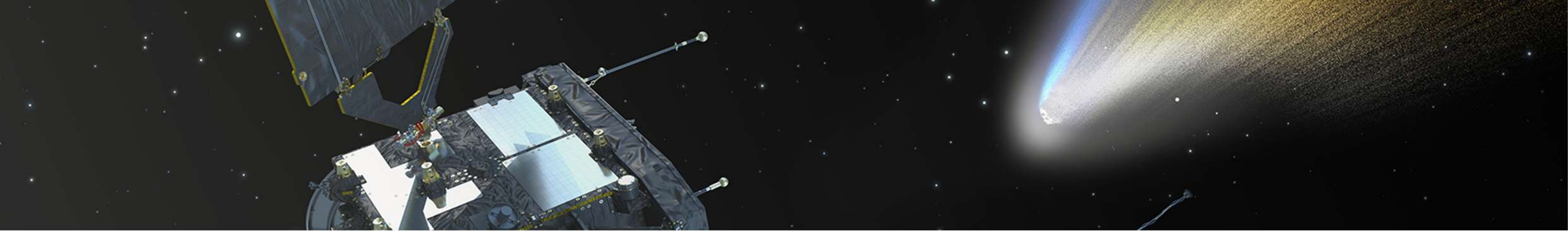


Executive Summary

Introduction

Comet Interceptor is ESA's first **F-Class (fast, flexible, and low-cost) mission**, set to launch in **2029** in collaboration with JAXA. It aims to be the **first mission to intercept a pristine comet**. It is the only comet mission in development following ESA's Rosetta mission, which ended in 2016. The UK is playing a leading role in the mission, with **£16m of national funding** from the UK Space Agency planned, complementing mandatory ESA contributions. This national funding is the focus of our study.

UK scientific influence was secured through key roles for the **University of Edinburgh** and **University College London**, as well as leadership over two instruments: **MIRMIS (Oxford University)** and the **Fluxgate Magnetometer (Imperial College London)**. UK Space Agency funding aims to align with three strategic objectives:

1. **Increased scientific knowledge and UK research competitiveness**, including positioning the UK as the partner of choice for future space science missions.
2. **More international collaborations and partnerships**, bolstering the UK's international reputation and enhancing the reach of the UK space sector
3. **Inspired and upskilled space talent pipeline** to expand the UK's academic base and address the technical skill gaps outlined in the R&D People and Culture Strategy.

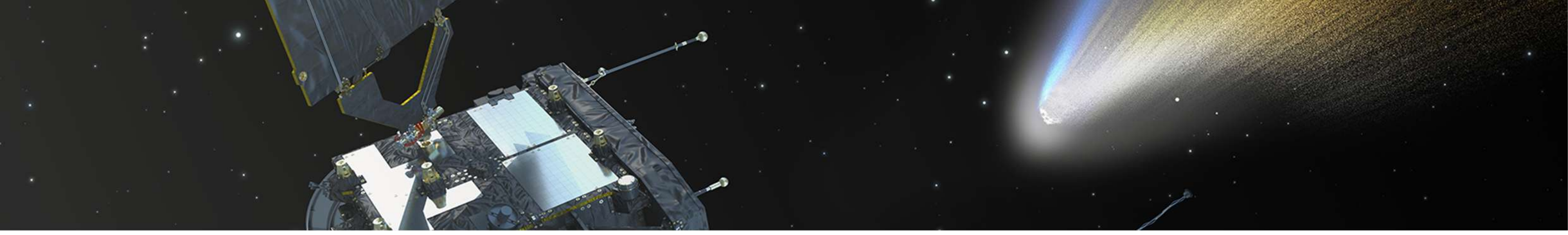
Although not a core funding objective, we also assess innovation spillovers to other sectors to evaluate alignment with broader UK Space Agency objectives outlined in the business case. Monitoring and Evaluation (M&E) has been embedded into UK Space Agency's governance of national funding for Comet Interceptor. **know.**space were commissioned to assess progress over the last 2+ years, providing early evidence on impact and effectiveness of the UK's national investment.

Key findings

This evaluation of UK Space Agency's investment into Comet Interceptor highlights **early progress** across scientific, technical, and reputational objectives. While it is too early to assess full routes to impact, funding – and the leadership roles it has secured – is leading to greater UK returns from the mission. Without UK Space Agency funding, ESA may have selected an alternative F-Class concept, or the UK's role in Comet Interceptor would have been limited. While still early stage, emerging outcomes and benefits strongly reflect the **additionality** of UK Space Agency's investment.

Funding has led to a **steady increase in the quantity and quality of UK science outputs**, as scientific literature is beginning to emerge around the mission – with 72% of Comet Interceptor-related publications coming post-funding. This is a limited sample currently (UK authors have produced 67 out of 164 relevant publications), as sizeable scientific impacts are expected to emerge post launch, underpinned by new discoveries made with mission data. Stakeholders reported in interviews that funding has **enabled UK researchers to shape the mission**, notably through Interdisciplinary Scientist roles, which provide leadership and influence. In turn, these roles help to maximise the science return, and set foundations for strategic benefits such as increased international collaboration, reputational or leadership enhancements.

It is often difficult to untangle the specific impact of UK Space Agency national contributions for Comet Interceptor, as they are closely integrated with complementary activities not funded by UK Space Agency. As a result, outcomes can reflect the combined effect of multiple inputs, making it challenging to attribute them solely to UK Space Agency support. Outreach activities and presentations at high-profile conferences are examples of such activities. While not funded directly



by UK Space Agency, **they would not be possible in the same way if the funding had not been committed**, as UK researchers may not have held key mission roles, and may not have been invited to present mission progress.

While the mission has helped develop skills across funded organisations, retention risks are ever-present given the long-term nature of the mission. Stakeholders felt **retention risks are exacerbated by limited resourcing and uncertainty over future funding**. In some cases, there are **single point of failure risks** if/as people move on without knowledge transfer. They have already manifested to some extent, with UCL's limited involvement following the departure of a key senior team member, who had previously co-developed the mission concept and held an Interdisciplinary Scientist (IDS) role.

The commercial benefits story is still early stage, and like other complementary activities, **difficult to prioritise with current resourcing constraints**. £150k of export/revenue opportunities linked to the MIRMIS instrument has been secured, which could translate to repeat business and future UK mission roles. However, it is too early to draw conclusions on commercial impacts.

The high-level findings of our process evaluation are that, despite challenges with funding certainty, resourcing, and third-party dependencies, **project team relationships with UK Space Agency, ESA, and the consortium are strong**. With sufficient contingencies in place, the mission, and UK contributions within it, were regarded as **broadly on track to meet future milestones**.

Overarching performance against the evaluation questions (as set out in the M&E framework) is broadly positive, with our **RAG ratings against all impact and process questions all either 'amber' or 'green'**. Often, amber ratings reflect that not enough time has elapsed to come to a definitive view. Green ratings represent good initial progress, caveated by this often reflecting being on course for good future outcomes, rather than sizeable socio-economic returns today.

Interim Process Evaluation

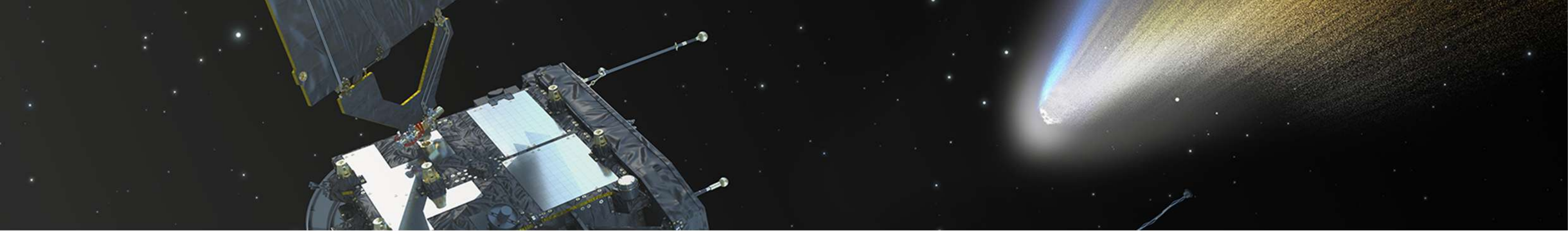
Management & oversight

Working relationships in the UK and wider consortium were considered strong, with stakeholders appreciative of UK Space Agency's role in supporting UK mission roles. Aside from a period where staff changes led to no point of contact, engagement with UK Space Agency was seen as effective. Project Management Board (PMB) meetings were seen as useful for finding solutions to challenges, and were frequent enough. The UK team also valued ESA's oversight, guidance, and adaptability.

The **Interdisciplinary Scientist roles** on the mission were deemed to be an **effective way of formalising UK influence** over the mission, although they have not been without complexities and challenges. Early confusion with ESA over roles and responsibilities were cited as slowing progress. Decision-making within the group could be enhanced with more structured leadership. However, IDS roles were regarded as crucial in improving synergies between instrument leads and scientists.

Mission delivery

UK-funded activities are **broadly on track, with instrument delivery meeting core milestones, and preparatory science activities slowly ramping up**. While the team has experienced challenges and slight delays, the UK contributions remain on course, with no significant causes for concern. Stakeholders unanimously highlighted the unpredictability of the government's **short-term spending review cycles, which complicate the long-term planning** essential for delivery. While this challenge extends beyond UK Space Agency's control, it could impact staff retention, increase administrative overheads, and risk delivery of UK contributions - potentially affecting the UK's reputation if commitments are not met in a 'worst case' scenario. Currently, a 6-month bridging period is in place, although this is regarded as a short-term solution with continued administrative burden, and does not address broader impacts of funding challenges on retention of key staff.



The Covid pandemic, inflation, depreciation of the pound, and the UK's withdrawal from the European Union, were cited as wider factors which introduced delivery complexities, delays on components, and cost increases. However, **the impacts of these factors were seen as navigable, with contingencies in place**. Arguably the largest external delivery risk for Comet Interceptor is the rideshare mission, Ariel, which is currently experiencing schedule slips. Comet Interceptor has been designed to be launch-date agnostic, **limiting the potential impact of delays**. However, these **could have cost and scientific return implications for the UK**, as this would require extending funding of key personnel, and research activity could shift to other areas.

Administration & resourcing

The mission continues to benefit from strong expertise of UK-based individuals supported by UK Space Agency funding. However, constraints on resourcing were raised as creating key **'single point of failure' risks within funded organisations, which could create skills and expertise gaps as staff move on.** Some stakeholders felt the current allocation is too limited in time and budget to explore spillover commercial opportunities or to publish research. Others appreciated how UK Space Agency funding helped hire a project support officer, whose role is to aid in project management tasks.

Misalignment of reporting requirements between ESA and UK Space Agency have been cited as a source of **excessive administrative overheads, although others have highlighted progress in this area** as the mission has unfolded. All stakeholders felt reporting mechanisms were disproportionate for the new F-Class mission structure at the outset, but appreciated efforts to harmonise processes between the two agencies. Further streamlining of reporting was suggested, and consistency in templates between months was highlighted as a potential mitigating factor for these overheads.

Monitoring and Evaluation activities were unanimously appreciated by the project team in **collating emerging impact narratives between organisations**. Stakeholders also stressed the importance of the study in gathering evidence to inform future funding decisions, and highlighted the requirement for these activities in the business case for the investment.

Process evaluation recommendations

Regularly review the balance between the ambition of objectives and realities of allocated resources. *[know.space and stakeholder recommendation]*

Consider providing more dedicated funding to support wider commercialisation and outreach activities. [know.space and stakeholder recommendation].

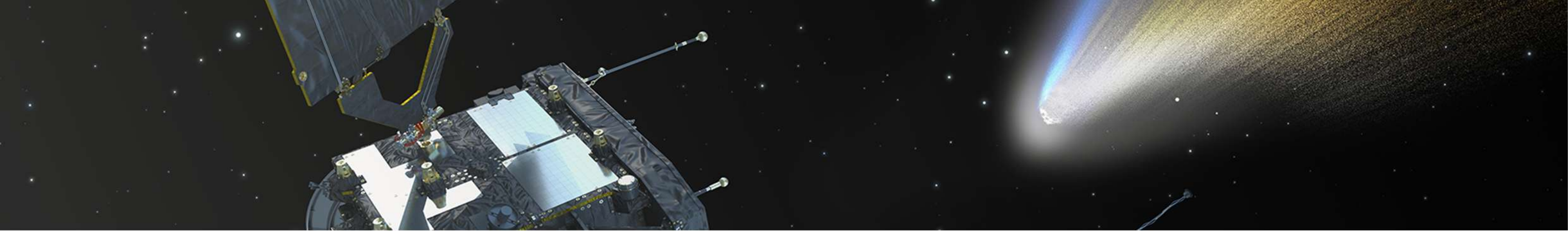
Ensure succession plans are in place to deal with internal staff changes at UK Space Agency. *[know.space and stakeholder recommendation].*

Consider providing additional / dedicated administrative support to a wider range of project team members. *[Stakeholder recommendation]*

Consider how best to ensure continuity of expertise and knowledge. *[know.space recommendation].*

Streamline reporting requirements, especially with regards to small/bridging grants on Researchfish. *[know.space and stakeholder recommendation].*

Continue monitoring and evaluation efforts, recognising that if impact evidence is not collected, it may be lost. *[know.space and stakeholder recommendation].*



Interim Impact evaluation

Science

Most scientific benefits from the mission will emerge in the longer term, as researchers analyse cometary gas, dust, and plasma data from the fly-by of the target comet, after launch in 2029+. **Early scientific trends should be seen as precursors to larger future impacts**. However, preparatory science is ongoing, and publications outlining Comet Interceptor's scientific objectives, instrument developments, and new analysis of Rosetta data have emerged over our study. Prof. Snodgrass, who holds the Interdisciplinary Scientist (IDS) role, is able to **influence the scientific direction of the mission through this role**, which steer science working groups.

- A total of **164 Comet Interceptor related publications** have been produced to date, with 72% of these coming after UK Space Agency funding. New scientific discoveries are limited currently, as these will centre around comet fly-by data, following mission launch. Publications at this stage of the mission are more focused on profile-raising and instrument developments.
- **UK-based authors were featured in 39% of these publications**, demonstrating early leadership over publications, although these are initial shifts in a long-term picture. For context, the UK produces approximately 7.5% of all space-related publications[2].

18 UK-based organisations have produced a Comet Interceptor-related publication, showing wider impacts of UK Space Agency funding. The University Edinburgh is the leading contributor, followed by UCL, Oxford, and Imperial, highlighting the leading role the funded project team is playing in producing publications. Stakeholders highlighted that **limited resourcing means instrument development has been prioritised** in some cases. Modest research output from Universities of Northumbria, Kent, and Birkbeck (among others) demonstrate UK wider interest in the mission.

While it is too early to assess citation activity due to time lags and a small sample, two mission papers show high impact based on Relative Citation Ratio (RCR), which compares citation performance to other publications in the same field and year.

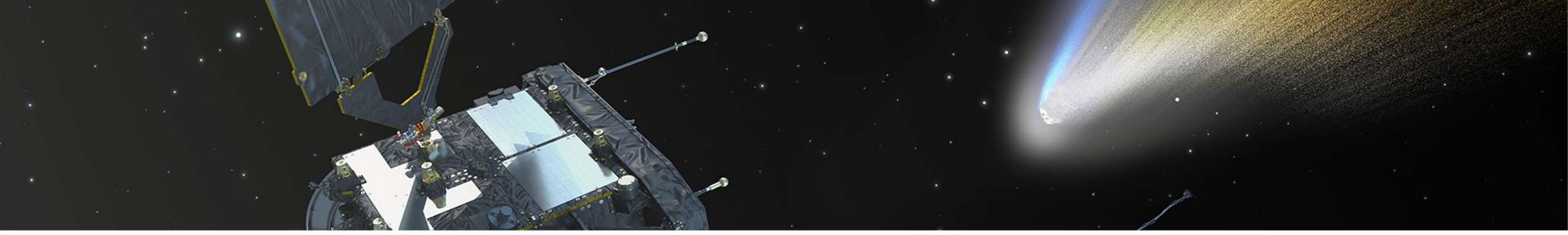
- There has been a total of **271 citations** on UK-authored Comet Interceptor-related publications, with **70%** of these published in the baseline period (i.e. pre national funding).
- There is growing citation activity in the analysis period, with **a broader spread of papers cited more than the average** cometary science publication as measured by RCR.

In the longer term, Comet Interceptor is expected to lead to increased research activity in the field of cometary science, although publications only comprise ~4% of this wider field to date. It is the **only cometary science mission internationally currently in development**, meaning this data is likely to be leveraged extensively by the UK and wider research community. This data is expected to fill the gap in available data left by the Rosetta mission, which ended in 2016.

- Despite co-authoring between 12-16% of cometary science publications, UK researchers are featured in **25% of the top cited cometary science papers** in the analysis period.
- UK researchers have demonstrated disproportionately high citation impact relative to papers produced; a trend set to continue as Comet Interceptor research ramps up.

Comet interceptor publications have had some wider online reach, **including references in 5 Wikipedia pages and 7 news articles**, including Phys.org, MSN, and Universe Today. Wider attention is expected to follow launch and operations of Comet Interceptor over the longer-term.

[2] OECD, 2019. *The Space Economy in Figures. How Space Contributes to the Global Economy*. (Available at: https://www.oecd.org/content/dam/oecd/en/publications/reports/2019/07/the-space-economy-in-figures_518092bf/c5996201-en.pdf)



Competitiveness & reputation

Comet Interceptor is an inherently internationally collaborative mission, featuring 90 organisations from 7 countries. Oxford and Imperial are in close collaboration with teams from Austria (Academy of Sciences), Poland (CBK), Finland (VTT, University of Helsinki), and the USA (NASA Goddard), to develop the MIRMIS and FGM instruments, as well as the Dust, Fields, Plasma (DFP) instrument group. Co-authorship of publications demonstrates ongoing collaboration with Italy and France.

- **94% of UK-authored Comet Interceptor research publications are internationally collaborative in the analysis period**, rising from 64% in the baseline period.
- UK researchers have collaborated with researchers from **26 countries, up from 7 in the baseline**. They produced **the 2nd most Comet Interceptor papers worldwide**, behind Italy (who have 14 researchers across the science working team, compared to 8 in the UK).

UK influence is expected through Prof. Snodgrass' IDS role, which has been cited as essential in shaping the mission to maximise future scientific return. **The reputation of the UK in the view of ESA and the wider consortium is regarded to be positive**, although we are still at an early stage. Benefits associated with the reputation and leadership of UK organisations are linked to successful delivery of mission roles, and **we are assessing initial trends in a longer-term picture**. Future mission developments and risks highlighted by the project team could affect the UK's ability to deliver. Stakeholders noted **retention risks associated with fixed-term contracts ending**, which could lead to reputational damage if UK contributions are delayed or cannot be delivered.

Skills & inspiration

At this early stage, **we see early progress against UK Space Agency objectives of inspiring, attracting, and retaining talent to upskill the UK workforce, alongside potential barriers** to some of these longer-term benefits. We are primarily assessing activities and outcomes at this stage, identified through interviews with the project team, who have provided examples of early upskilling impacts. The UK team has conducted outreach for a range of audiences, which have **potential to raise the profile of the Comet Interceptor mission, as well as attract and inspire broader skills development** in STEM subjects in the UK over the long term.

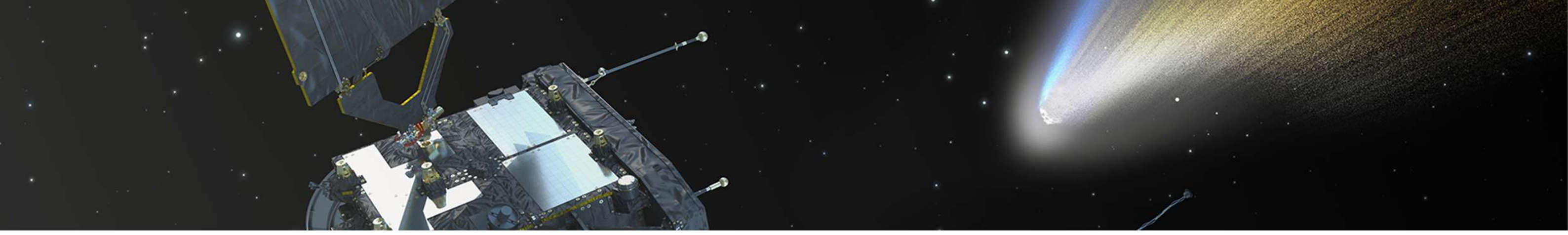
- Project team members have **delivered presentations in 45 conferences, and various outreach and engagement events** since 2021, spanning 13 countries across 4 continents.
- Around **two-thirds of these are for a professional audience**, but others are targeted at families and school pupils. The routes to impact here will play out over longer timescales.

Direct project team upskilling is evident, across both technical and project management aspects of the mission. These skills could lead to longer-term benefits of addressing skills gaps and enhancing UK competitiveness for future missions, although salaries and short-term contracts have been cited as key barriers to realising these longer-term benefits. Comet Interceptor has provided early-career scientists and engineers space mission experience, although team sizes are limited compared with M or L-Class ESA missions. There are ~10 people in the UK Comet Interceptor project team, compared to 50 in the UK project team on the M-Class rideshare, Ariel.

- **Technical skills development** has included computing, modelling techniques, systems engineering, and soldering – key skills which can be taken with early-career researchers into future projects and missions, and that are in-demand in the wider space sector.
- **Project management skills development** has included a team-wide adaptation to new ESA processes, as well as risk, schedule and budget management over the mission for early-career workers – developing core skills required for future Principal Investigator roles.

Innovation

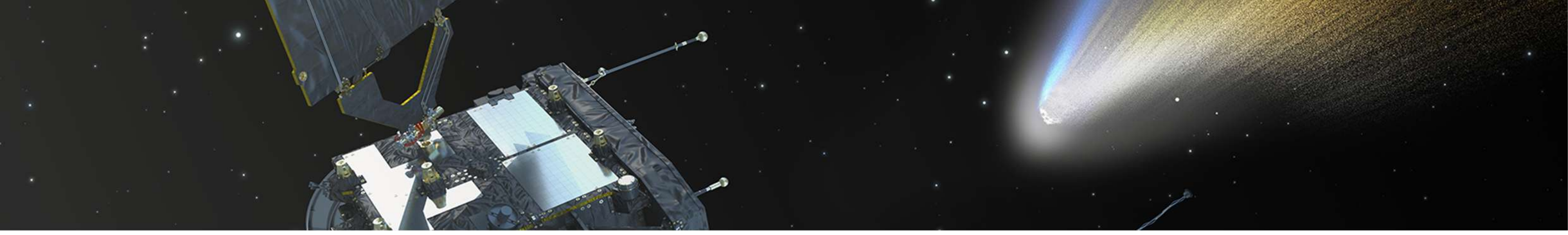
Given the F-Class nature of the mission, focused on instrumentation with high existing technology readiness levels, scope for radical innovation is limited (to minimise development timelines and cost). However, there have been early commercial benefits linked to instrument development. The



University of Oxford has sold **£150k** worth of filters derived from the design of the MIRMIS instrument to a **US company**, paving the way for potential further revenue and export benefits.

Comet Interceptor is **strengthening the case for UK involvement in other missions**, by demonstrating delivery heritage, although **limited resourcing could pose a barrier**. Comet Interceptor roles are the current priority for teams, though potential NASA mission roles are being explored (at an early stage). UK roles are also **creating procurement opportunities for the UK supply chain** beyond project teams, which could help organisations support/create employment.

The link to the MIRMIS instrument for commercial benefits indicates high additionality to UK Space Agency funding, although this instrument builds upon previous heritage developed for Lunar Trailblazer. Prospective innovation impacts will need more time to elapse before they can be assessed.



1 Introduction

1.1 The Comet Interceptor mission

Comet Interceptor is ESA's first F-Class mission, which aim to deliver fast, flexible low-cost missions. The mission was formally adopted by ESA in 2022, in collaboration with the Japanese space agency JAXA, and is scheduled for launch alongside the ESA Ariel mission in 2029.

The mission aims to **be the first to visit a pristine comet** (i.e. a comet which has never been altered by close encounters with the sun), which could be reaching the inner solar system for the first time. To achieve this, the mission will conduct a high-speed flyby to study the surface composition, shape, morphology and structure of the target object, as well as its interaction with the solar wind, to create a 3D map of the comet's nucleus, coma and tail. By analysing the comet's composition, structure, and activity, the mission could provide new insights into the origins of the solar system, including the materials that formed planets.

Comet Interceptor will become **the first space science mission to launch without a pre-selected target**. After launching in 2029, the spacecraft will be transported to Lagrange Point 2 (L2), a stable region in space 1 million miles away from Earth. From there, the spacecraft can conserve fuel and wait until a suitable target is discovered, and then approach the comet with two sub-probes – the JAXA-provided B1, and ESA-provided B2, which will travel at different trajectories through the coma. This multi-probe approach is also a new capability to cometary science.

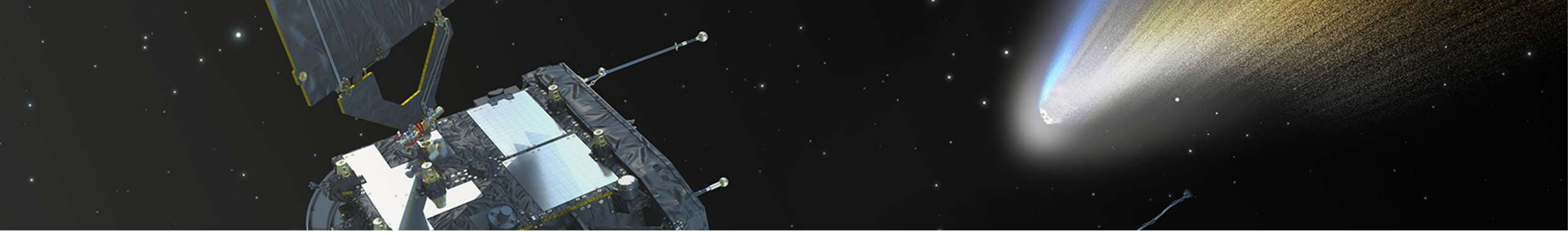
Alongside mandatory contributions to ESA, **UK Space Agency plans to spend an additional £16m of national funding to the Comet Interceptor mission**, in order to secure scientific and technical leadership over the mission. It is this national contribution which is the focus of our monitoring and evaluation activities.

Prof. Colin Snodgrass, from the University of Edinburgh, and Prof. Geraint Jones, from UCL, were both instrumental in developing the mission concept, demonstrating key academic leadership from the UK. Prof. Snodgrass now occupies a science leadership role as 1 of 3 Interdisciplinary Scientists (IDS), while Prof. Geraint Jones also previously held an IDS role, but has since moved on to work for ESA on the BepiColumbo mission to Mercury. The UK also has leadership over two instruments being developed for the mission: the MIRMIS (Modular InfraRed Molecules and Ices Sensor), which is led by Oxford University, and the FGM (Fluxgate Magnetometer) instrument, which is being led by Imperial College London.

1.2 Background to this study

Commitment to the Comet Interceptor mission through the UK Space Agency National Space Science Programme aims to deliver benefits and impacts aligned with the UK Space Agency's three strategic objectives for the mission, namely to:

1. **Increased scientific knowledge and UK research competitiveness**, including positioning the UK as the partner of choice for future space science missions.
2. **More international collaborations and partnerships**, bolstering the UK's international reputation and enhancing the reach of the UK space sector
3. **Inspired and upskilled space talent pipeline** to expand the UK's academic base and address the technical skill gaps outlined in the R&D People and Culture Strategy.



While not an explicit objective of the mission, we also assess progress in stimulate **innovation** in space technology, through knowledge and technological spill overs to other fields or research and industry, to assess alignment with broader UK Space Agency objectives also referenced in the business case.

M&E has been embedded into UK Space Agency's governance of Comet Interceptor national funding, to monitor benefits realisation on an ongoing basis as the mission unfolds. **know.**space was commissioned by UK Space Agency to conduct these activities for 2+ years of the mission following selection, to provide a greater understanding of progress, the effectiveness of the funding, and the impacts it is producing.

This study is also designed to feed into and support UK Space Agency's wider M&E efforts and benefits management, which help the agency assess progress, maintain accountability, and adjust programme strategies through evidence-based decision-making. This helps to ensure optimal use of public funds to benefit stakeholders across academia, industry, and public sectors, and contributing to the strategic national objectives set out in the National Space Strategy.

While Comet Interceptor is designed to be fast and flexible, space science missions are still long-term endeavours, and most of the benefits and impacts associated with UK science return and leadership are only expected to be realised after the mission is operational and returning data. However, through a regular cadence of data capture, we have provided UK Space Agency with early evidence to assess whether investment objectives are on course to be met. Collection of indicator information over time is also vital for informing the longer-term impact story, as trends evolve.

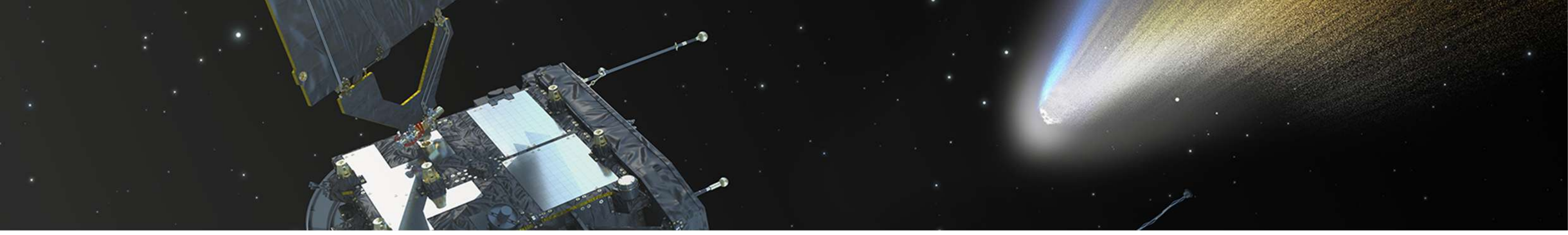
This report presents an interim process and impact evaluation, assessing the benefit realisation narrative to date associated with UK Space Agency's national funding for Comet Interceptor. The process evaluation examines key delivery factors, including identifying successes and areas for improvement, to provide UK Space Agency with timely recommendations as the mission advances, while the impact evaluation explores the benefits realized to date.

Where possible, we have sought to isolate the impacts of UK Space Agency's national funding, though some outcomes are inevitably linked to broader mission funding and external factors. Our impact evaluation employs **baseline** and **analysis** periods to compare key metrics before and after UK Space Agency's national funding was announced. Throughout, we assess the attribution of impacts – the causal link between funding and observed outcomes – and explore the counterfactual scenario, considering what might have occurred without this investment across different impact themes.

1.3 Methodological approach

To track emerging impacts and delivery factors, we conducted 6-monthly benefits management reporting to UK Space Agency, which followed a broad 4 stage process: data collection, data analysis, synthesis and conclusions. This report includes a final iteration and summary of the 6-monthly reporting process, preceded by September 2024, March 2024, and September 2023 editions.

Across the study, we have employed a **mixed-methods approach**, utilising stakeholder consultations and desk-based research (including online materials, project reporting documentation, PMB minutes and slides, and UK Space Agency Researchfish data). Bibliometric and altmetric analysis were used as two other key data collection methods, which are expanded upon in the Annex. Bibliometric analysis was conducted leveraging the NASA ADS database, supplemented by UK Space Agency Researchfish data.



One key methodological limitation in our study is the **attribution** of benefits to UK Space Agency investment. The UK national investment into Comet Interceptor is intertwined with other key inputs, such as contributions from the universities themselves, or core ESA mission funding. Overall, these issues are common to many research and innovation evaluations, as outcomes often occur in a complex interconnected series of interventions and activities. Throughout our report, we communicate the role which funding has played in securing early benefits at this interim stage. Another key challenge is **measurability**. Outcomes, especially potentially sizeable spillover benefits (as new knowledge and techniques are applied elsewhere) are especially hard to capture and quantify. While interviews with key stakeholders provided useful qualitative insights, this study may miss long-term or indirect benefits of UK Space Agency funding for Comet Interceptor.

Our interim process evaluation uses interviews and desk-based research to assess the extent to which UK Space Agency funding for Comet Interceptor has been delivered in an effective manner. Data collection efforts were driven by five core evaluation questions, for which early progress against has been summarised in section 2.4. The evaluation also employed a **real-time evaluation (RTE)** approach to capture insights on mission delivery and to develop appropriate feedback and recommendations for subsequent phases of Comet Interceptor, as well as other UK Space Agency-funded missions.[3]

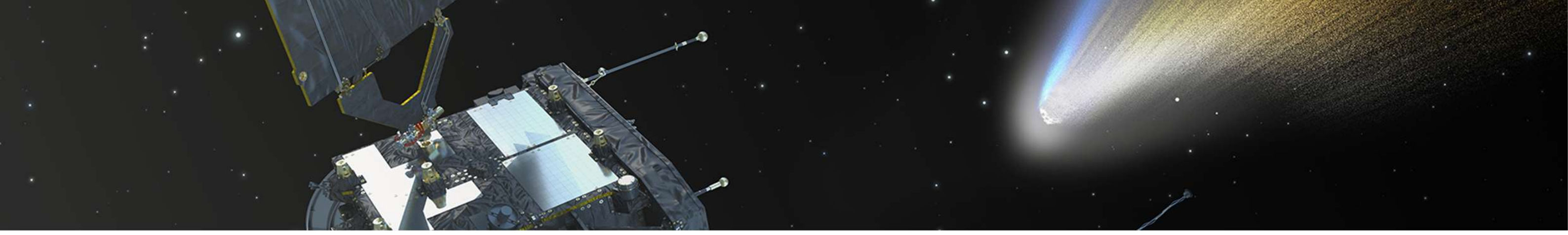
Our interim impact evaluation leveraged the abovementioned data collection methods to collect **indicator information at regular intervals**, which build upon UK Space Agency's existing work in the Comet Interceptor Benefits Map (within the UK Space Agency business case for Comet Interceptor). Each indicator has been attributed a **baseline measure** (i.e. initial conditions before UK Space Agency investment), and were consistently measured over the duration of our study. In practice, the baseline is as much about providing context for future impacts rather than a mechanistic process of 'observed impact minus baseline impact = net impact'. The baseline is developed to provide a general picture of what was going on in the research field prior to the UK's announcement, for context when interpreting future impacts. This consideration for the baseline also applies to all impact 'themes', especially when interpreting scientific / bibliometric impact.

In turn, evolution of these trends informed progress against the evaluation questions developed at the beginning of the study. These evaluation questions were developed to assess progress against UK Space Agency's investment objectives, and broadly follow the four impact themes of this study (progress against these evaluation questions is summarised in section 3.5. We have used **a theory-based evaluation approach**, assessing outcomes from UK Space Agency investment through **contribution analysis**. This methodological approach explores attribution through assessing the contribution an intervention is making to observed results and verifies the intervention's Theory of Change (ToC)[4] and logic model, paying attention to other factors that may influence the outcomes, providing evidence about its contribution. The UK Space Agency-developed ToC can be found in annex (section 4.5).

To produce a streamlined narrative and understanding of the changes seen from the baseline to the current period, we have synthesised findings from across the 6-monthly reporting process, alongside any additional qualitative insights gathered through stakeholder engagement or desk-based research. We provide any broader concluding views across the progress of Comet Interceptor activities, identifying the general shifts in trends over this initial analysis period.

[3] RTE seeks to address three core questions: (i) *are we doing things right?* (ii) *are we doing the right things?* and (iii) *how do we decide what is the right approach?*

[4] A ToC is a visual or written description which outlines the anticipated causal pathways to impact from an intervention, progressing from inputs and activities, to outputs, short and medium-term outcomes, and ultimately, impacts.



2 Interim Process Evaluation

The process evaluation addresses the delivery effectiveness of the UK (nationally funded) elements of the Comet Interceptor mission to date, identifies factors which have both aided and hindered progress, and discusses the success of working relationships and management approaches. **The evaluation is intended for internal UK Space Agency use, and feedback from stakeholders was provided on the basis of anonymity (where practicable)**. The evaluation also, where appropriate, identifies lessons and forms recommendations for future mission delivery.[5] These are focused on UK and UK Space Agency involvement, and in areas where UK activities can make an impact, recognising the divisions of responsibility between UK Space Agency and ESA in mission delivery. In line with HMG *Magenta Book* principles, the process evaluation aims to answer the question:

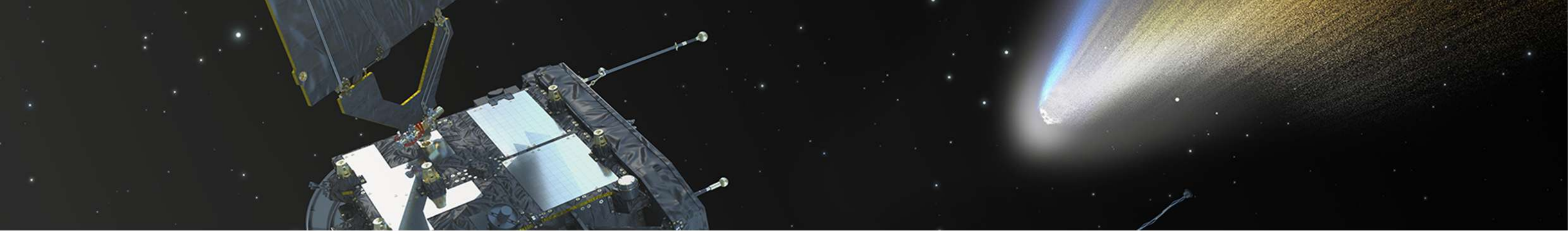
"What can be learned from how UK contributions to Comet Interceptor have been delivered?"

Whilst quantitative data can be useful, it can fail to capture the complexities and nuances of implementation or real-world challenges and successes. Therefore, this process evaluation relies largely on **qualitative insights**, emphasising the experiences and opinions of those involved rather than relying on quantitative indicators.

Summary of key findings

- **UK-funded activities are broadly on track, with instrument delivery meeting core milestones, and preparatory science activities slowly ramping up.** While the team has experienced slight delays, predominantly from non-UK partners, as well as uncertainties around funding, the UK contributions to the mission remain on course with no significant causes for concern.
- **There was widespread appreciation for the role UK Space Agency have played in supporting UK contributions to the mission.** The level of contact between organisations was deemed mostly appropriate and effective, except in instances where staff changes at the Agency left project teams without clear points of contact in the interim.
- **The Interdisciplinary Scientist roles on the mission were deemed to be an effective way of formalising UK influence over the mission, although they have not been without complexities and challenges.** Early confusion over roles and responsibilities (caused by ESA) were cited as slowing progress on the mission. The current arrangement is a relatively 'flat hierarchy' between IDS roles, and could be enhanced with more structured leadership and engagement. However, the roles were regarded as crucial for maximising the scientific return of the mission, and improving synergies between instrument leads and scientists.

[5] Recommendations are accompanied by an indication of which stakeholder group(s) have made, contributed to, or endorsed that particular recommendation. Where recommendations are based on the expertise of **know.**space – drawing on our experience of programme and mission process evaluation - this too is indicated.

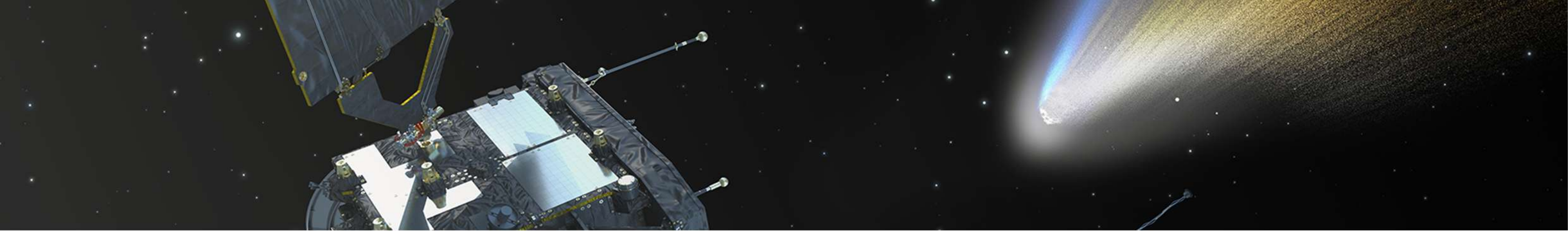


- **Stakeholders raised concerns about the unpredictability of the UK government's short-term spending review cycles, which complicate the long-term planning essential for Comet Interceptor.** While this challenge extends beyond UK Space Agency's control, it could impact staff retention, increase administrative overheads, and risk delivery of UK contributions - potentially affecting the UK's reputation if commitments are not met in a 'worst case' scenario.
- **Constraints on resourcing were also raised as creating key 'single point of failure' risks within funded organisations, which could create skills and expertise gaps as staff move on.** Some stakeholders felt the current allocation is too limited in time and budget to explore wider opportunities, such as spillover commercial opportunities, or the generation of additional publications. Others appreciated UK Space Agency funding as crucial in hiring project support officers to deal with some project management responsibilities.
- **Misalignment of reporting requirements between ESA and UK Space Agency have been cited as a source of excessive administrative overheads, although others have highlighted progress in this area as the mission has unfolded.** All stakeholders felt reporting mechanisms were disproportionate for the new F-Class mission structure at the outset, but appreciated efforts to harmonise processes between the two agencies. Further streamlining was suggested, and consistency in reporting templates between months was highlighted as a potential mitigating factor for these overheads.
- **Monitoring and Evaluation activities were unanimously appreciated by the project team in collating emerging impact narratives between organisations.** Stakeholders also stressed the importance of the study in gathering evidence to inform future funding decisions, and highlighted the requirement for these activities in the business case for the investment.
- **Wider international factors such as the Covid pandemic, inflation, and the UK's withdrawal from the European Union were cited as introducing delivery challenges.** These factors were regarded as broadly navigable – and outside of UK Space Agency's control - with sufficient contingencies in place. However, delays on the Ariel mission could create unavoidable cost increases and potentially influence the scientific return from the mission.

The recommendations which follow are a combination of suggestions from stakeholders, and **know.**space's own expertise of evaluating similar programmes. Throughout, we have tried to make it clear where **know.**space endorse a recommendation. Where we do not explicitly endorse a recommendation, it may be because we lack the information to confidently do so.

Recommendations

- **Regularly review the balance between the ambition of objectives and realities of allocated resources.** Many of the risks regarding the manifestation of future impacts, such as 'single point of failure' risks and lack of support for activities beyond direct project activities, stem from stretched resources. UK Space Agency should regularly review the balance between objectives from the national funding and the available resources to ensure that the mission, including both its scientific and technical ambitions, can be delivered within the available resource envelope. *[know.space and stakeholder recommendation].*
- **Consider providing more dedicated funding to support wider commercialisation and outreach activities.** The project team is understandably focusing their limited resourcing on direct mission roles. However, many have innovative potential applications of their expertise that they wish to develop further, related to knowledge transfer, commercialisation and broader spillovers (e.g. Oxford University with its commercial EO design and route to market). From other evaluations, we have identified how spillovers can



be a sizeable proportion of total benefits. Supporting dedicated time (resource) to pursue these could therefore build a stronger long-term impact narrative for Comet Interceptor in the future. *[know.space and stakeholder recommendation].*

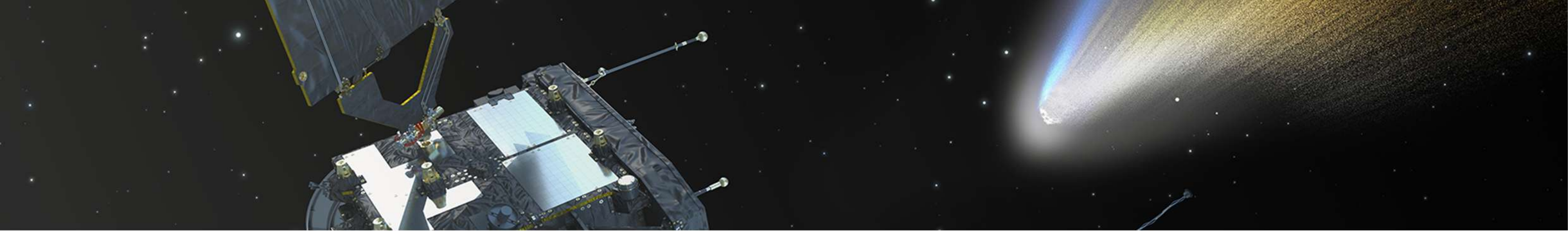
- **Ensure succession plans are in place to deal with internal staff changes at UK Space Agency.** While earlier concerns regarding missing points of contact have now been resolved, future planning can be crucial in ensuring project teams receive guidance and support irrespective of staff changes. *[know.space and stakeholder recommendation].*
- **Consider providing additional / dedicated administrative support to a wider range of project team members.** UK Space Agency should, where possible, seek to allocate additional resources to support with reporting requirements and broader administrative burdens. *[Stakeholder recommendation]*
- **Consider how best to ensure continuity of expertise and knowledge.** UK consortium members, in collaboration with UK Space Agency, should develop clear approaches to preserving and sharing both institutional and technical knowledge over the duration of the Comet Interceptor mission. This is especially important for building the capabilities of early-career scientists and engineers, and for safeguarding against setbacks caused by the departure of key staff. One key team member has already departed the UK team, and the impacts of this regarding UCL's role and scientific leadership on the mission should be monitored. *[know.space recommendation].*
- **Streamline reporting requirements.** While it is important that M&E activities continue in coming years, the Researchfish reporting framework is currently seen as sub-optimal. Project team members noted that grant reporting requirements should be streamlined where possible, to avoid multiple, small grants having to be reported against. More broadly, if M&E support is externally commissioned, UK Space Agency should consider the risk of Researchfish duplicating effort, with (suboptimal) reporting on the platform necessitating new primary research to fill gaps, leading to limited additional value. Reporting mechanisms should also be streamlined in line with ESA's, where feasible, to reduce administrative burden *[know.space and stakeholder recommendation].*
- **Continue monitoring and evaluation efforts, recognising that if impact evidence is not collected, it may be lost.** We – and the project team - recommend that M&E efforts continue throughout the remainder of the Comet Interceptor mission. If data and evidence are not collected, there is a strong risk of evidence gaps that will not be able to be addressed later on. Stakeholders highlighted the value of M&E in identifying areas requiring additional support, showcasing impact, and informing broader decision-making. The process has not only enabled UK Space Agency to track progress effectively but also provided a rare formal opportunity for project teams to reflect on their contributions. *[know.space and stakeholder recommendation].*

2.1 Management and oversight

In general, stakeholders believe that relationships within the Comet Interceptor consortium are functioning effectively, with the necessary structures in place to support the UK's contributions to the broader mission. Although there were early challenges related to UK leadership roles and interactions with ESA, ongoing adjustments among all parties seem to have led to a situation where current management practices are now operating smoothly. Many of the initial challenges experienced in delivering UK contributions to the wider mission fell outside of UK Space Agency's direct control.

2.1.1 UK Space Agency and Project Management Board (PMB)

There was consensus among stakeholders that **the relationship between the project team and UK Space Agency was positive.** Over the two-year evaluation period, the team consistently



conveyed that it was easy to work alongside UK Space Agency, and while there was frustrations around funding uncertainty, they recognised the constraints under which the UK Space Agency project management team are working, which affect the Agency more broadly. There was widespread appreciation for the role that UK Space Agency staff have played in supporting delivery of the mission.

> *"The team at UK Space Agency have done an amazing job."*
>
> *"It must be exhausting for colleagues at UK Space Agency having to deal with factors outside of their control, although there are valid reasons for raising them."*

The involvement of UK Space Agency in the mission – primarily through an oversight and management capacity, was viewed by stakeholders as largely appropriate and proportionate for a mission of this size and scale, with frequency of meetings regarded as the right level. Quarterly review meetings with the UK Space Agency were cited as useful routes for input on UK contributions to the mission.

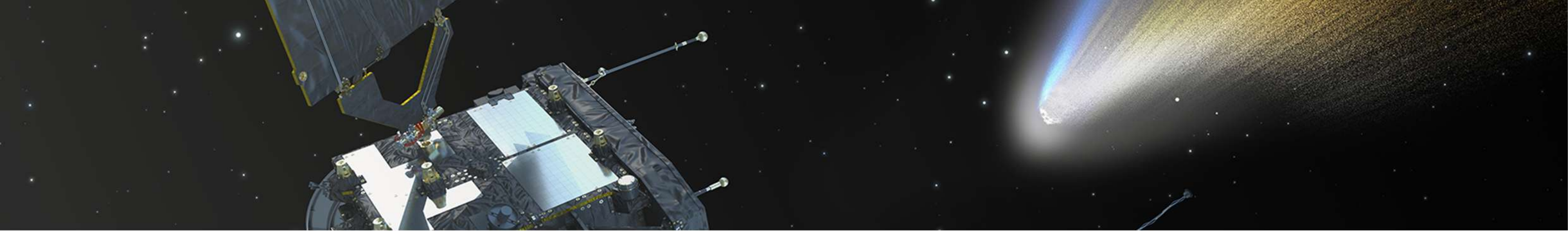
Stakeholders did highlight at some points of the study, that there were periods **without a clear point of contact on the UK Space Agency side**, especially in-between staff changes at the Agency. While this was unavoidable to some extent, stakeholders expressed this had made communication challenging. While these were noted, the Agency's responsiveness and commitment to engagement were appreciated once these staff changes were settled.

Broad oversight from the PMB was seen by stakeholders as valuable tool for "solution orientation", with the meetings providing a forum for discussing cost schedules, risk management, and wider updates. Records of outstanding actions provided a useful mechanism for aligning on responsibilities across the UK project team and UK Space Agency, with the frequency of engagement also regarded as suitable. Stakeholders generally felt while updates were necessary, they would not wish for more frequent PMB meetings, as this could impede mission delivery.

2.1.2 IDS roles

Throughout our study, the Interdisciplinary Scientist Roles (IDS) on Comet Interceptor emerged as a key position for driving mission-level decisions around science by providing personnel with the authority to oversee and steer the science working team and groups within it. While the mission concept was initially formulated by Prof. Jones and Prof. Snodgrass, there was some uncertainty over whether this would translate to formal leadership roles for both on the mission once it was selected. The UK Space Agency national contribution was vital in strengthening the case for UK IDS roles, and it would **not have been possible to obtain these roles without this funding**.

While out of the control of UK Space Agency, this initial uncertainty impeded progress in UK scientific leadership over the mission in the early stages. However, since the mission was at that time still years away from launch, there were no lasting implications once roles had been re-established. With the appointment of Prof. Snodgrass (and formally Prof. Jones) in these roles, UK researchers have outlined the research priorities for the science working groups and **formalised their leadership over the mission** over the course of our study. Within these roles, UK researchers also obtain 'a seat at the table' regarding decisions made at the instrument level, which in turn has implications for their performance and the scientific data which can be captured as a result. These positions have been cited as essential for keeping the mission on track regarding scientific objectives over the longer term, and hence the UK contributions to these roles are providing UK leadership over the core scientific objectives of the mission.



"The IDS roles keep everything on track. Without them, it would be easy for ESA to oversee something the delivery of something which can be built, rather than something which supports the science we need to do."

The IDS roles have been a central route to UK influence. However, stakeholders have raised practical delivery challenges which, while not obstructing progress to date, could present potential roadblocks in the future. For instance, the 'flat' nature of the IDS appointments – i.e. the fact that no single role holds overall authority in decision-making, has the potential to slow progress and **makes it harder to drive forward key actions, as responsibility is diffused**.

"It is not about being dictatorial, but the flat nature of the group could benefit from enhanced leadership in decision-making."

To a large extent, these barriers have not materialized, as the most important scientific decisions on the mission will begin closer to launch, when the target selection process can begin. Given the implications of these decisions for the scientific return of the mission, stakeholders have highlighted aspects of the IDS roles that may benefit from further consideration. For instance, UK researchers have observed that the two other IDS appointments have had varying levels of engagement with the decision-making process, and bring expertise from broader scientific backgrounds rather than cometary science specifically. While this was cited as a potential challenge, it demonstrates UK leadership is currently driving forward mission-level discussions. It will be important to track how discussions unfold in the future, **particularly as the mission moves toward target selection and key scientific trade-offs**.

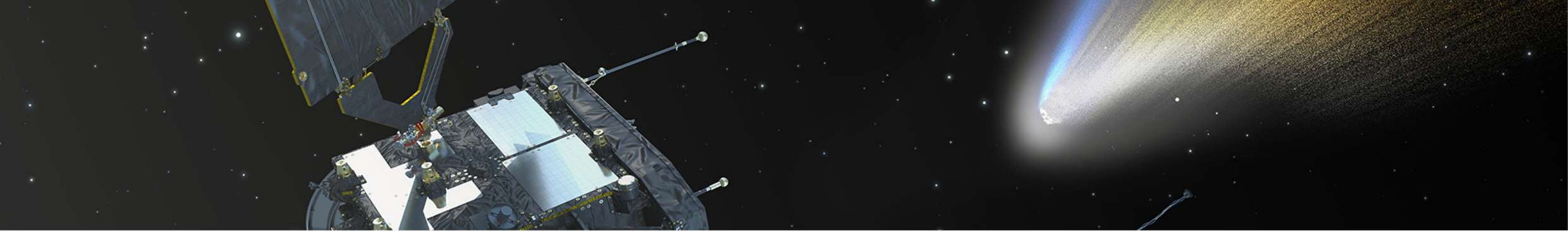
UK Space Agency has limited direct influence over these appointments, but a proactive approach in shaping formal governance structures for these processes could help maximize the mission's scientific return. Strengthening communication channels, clarifying decision-making responsibilities, and ensuring that scientific expertise is fully leveraged will support the UK's contributions and the overall success of the mission. While Prof. Jones' departure from the mission has led to Prof. Snodgrass assuming his prior responsibilities, with limited reduced impact on overall UK influence over the mission, the UK now has one IDS role instead of 2. The appointment of his replacement is still yet to be determined, but is unlikely to be UK-based.

2.1.3 ESA

By nature of its size and structure, engagement with ESA can be complex. Stakeholders generally felt that there was an adjustment period for all parties associated with moving to a new approach to missions – as Comet Interceptor represents the first F-Class mission of its kind. However, throughout the study, stakeholders highlighted continuous learning processes on both sides which have contributed to a **strong working relationship** on the mission. Furthermore, most stakeholders noted that they would be willing to participate in future F-Class missions, and hence did not see this learning curve as a future issue for ongoing collaboration.

"It is difficult for an organisation the size of ESA to be doing these smaller and cheaper missions, while adhering to normal ESA processes."

"ESA seem to be learning well, and responding to what works and what doesn't. It has been an extremely useful process."



Processes, especially associated with instrument development for the mission, were generally regarded as burdensome relative to the size of the mission, especially at mission inception. Moreover, uncertainty over Prof. Jones' and Snodgrass' roles introduced significant delivery slips to the mission at an early stage. However, **stakeholders generally reflected positively on ESA's adaptability** as the mission has unfolded, citing their pragmatism as a positive for the mission overall.

> *"Comet Interceptor was being treated as an M-Class mission in terms of paperwork, and we don't have the associated budget for that. "*
>
> *"Over time, ESA processes have become closer to working with industry for a mission."*

Despite initial challenges faced by the UK project team, stakeholders were unanimously of the view that **ESA provide a crucial route to UK leadership** over space science missions, and stressed that the importance of the oversight and coordination that ESA provide should not be understated. Stakeholders also appreciated the frank and constructive nature of ESA feedback, citing the science operations workshops as a process which was working particularly well to support instrument operations plans.

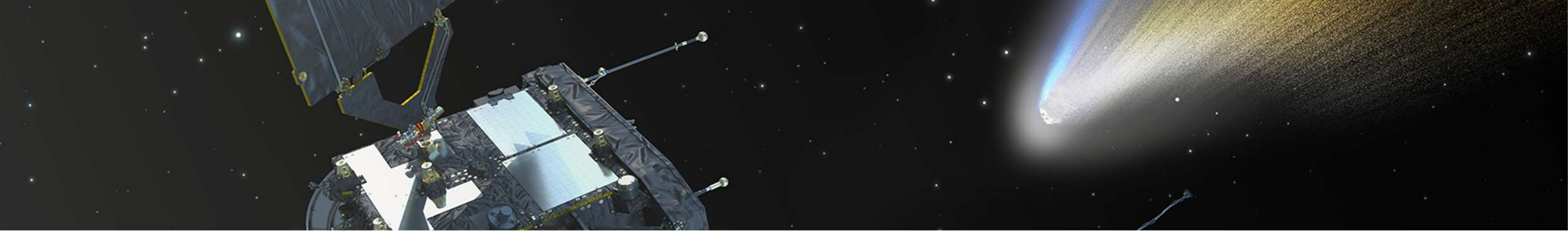
> *"Working with ESA is the key way we secure genuine leadership roles over missions. We could supply small components to NASA missions, but that would not give us a say in how the mission is run. "*

2.2 Mission delivery

The focus of this evaluation is the UK's national investment into Comet Interceptor, rather than the broader mission. However, the two are **inevitably interconnected**, especially when assessing progress against strategic objectives such as scientific leadership, which relies on delivery of space capabilities and missions. While we are still at a very early stage of the mission, UK roles on the wider mission are regarded as key to its overall success. The high levels of international collaboration seen between UK roles and the wider consortium was regarded as a **key strength by stakeholders.**

Comet Interceptor is progressing through major milestones, and while some international partners have experienced slight delays, progress has generally unfolded as expected and there are minimal schedule risks identified to date. As captured in UK Space Agency reporting, **mission-level progress appears strong, with no significant issues reported across any of the science management or instrument development activities taking place in the UK**.

In common with many evaluations of UK research and innovation investments, we heard how **UK-specific funding issues associated with spending review uncertainties** have impacted planning, staff retention, and contractor spend. These impacts are real, and commonly highlighted, however we recognise that they are largely beyond the control of UK Space Agency to address. The same is true for wider international and geopolitical factors – which can have implications for broader mission delivery.



2.2.1 Mission progress and schedule status

Currently, mission instruments are in the assembly, integration and testing phases, and **developments relating to mission hardware continue at pace**. The last of the actions from ESA's Critical Design Review (CDR) are being implemented through the continued testing of the FGM and MIRMIS instruments. The electronic flight models (Imperial) were delivered on time in June 2024, and underwent integration successfully in August. The mission is largely meeting originally agreed timelines, and is currently at ESA phases C/D, where detailed definitions alongside qualification and production are underway. Overall, **the project was regarded as on track to meet the launch date expectations**.

There have been some challenges highlighted by the project team – including a ~3 month delay on contributions from Finland, due to an electronics rework for the MIRMIS instrument, and incomplete software for down sampling and compressing of FGM data by a third party, placing some international partners on the 'critical path' for the mission. However, while these factors are outside of the UK's control to some extent, project team members are supporting these partners in some cases. Stakeholders were also optimistic that the schedule is stabilising, and felt that **ongoing meetings between key actors were productive in navigating challenges as they emerge**.

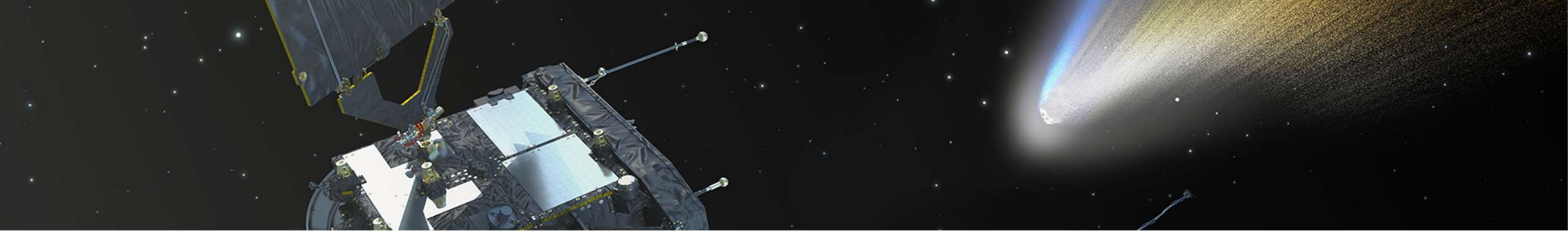
> *"We listen to each other in operational plan meetings, and manage to iterate to find compromises which satisfy everybody. That has been very constructive from my point of view."*

Stakeholders also generally felt that **sufficient contingencies had been built into the schedule to account for any dependencies on third parties**. This is partly due to the nature of the mission's design, which allows for the flight-ready spacecraft to be stored whilst awaiting delivery of its rideshare – the Ariel mission.

> *"Part of the reason we were selected is that Comet Interceptor is agnostic to launch date."*

Indeed, the timelines for Comet Interceptor's launch are highly contingent on the Ariel mission rideshare. While largely out of the control of the UK project team, there are challenges on the Ariel mission which may lead to impacts on future launch dates. Any delays to Ariel will result in a delay in Comet Interceptor's launch as well, which will have implications for when the more significant post-launch benefits of either mission will materialise.

However, while out of the control of the Comet Interceptor project team and UK Space Agency, delays on the Ariel mission **could have real impacts for the UK and its wider scientific community**. There is a cost associated with keeping the project team 'ready to go', even if significant developments are not required for the mission. Moreover, as the cometary science community awaits data from a new mission, researchers may be forced to pursue other research avenues within space science. In turn, this could lead to a less active scientific community when Comet Interceptor eventually comes online. These are wider factors beyond the control of UK Space Agency, the project team, or the wider consortium, yet still pose real delivery risks which could prevent maximum scientific return for the UK Space Agency's investment. Future developments on the Ariel mission will be critical to stabilise the schedule and mitigate these potential risks.



2.2.2 Funding

One of the recurring concerns raised by stakeholders is the unpredictability generated by the UK government’s spending review cycles, which are short-term in nature, but have implications for the long-term planning required to successfully deliver a space mission. The so-called “cliff-edge” effect – where decisions are subject to changes based on broader government priorities – creates **significant risks for project continuity and delivery**. As UK contributions to the mission are required over long timescales, stable financial backing over several years is required. The current March 2025 spending review has forced the project team to operate under considerable financial uncertainty, making it difficult to plan activities and spending with confidence. Stakeholders cited this as especially challenging for the organisations developing hardware for the mission, as it has impacted during the where period qualification and production activities are underway.

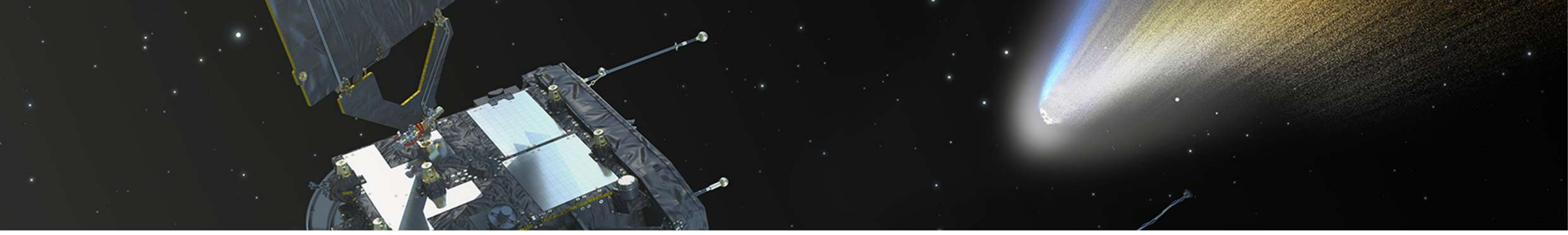
While stakeholders understood the constraints under which UK Space Agency operates, they emphasized the direct impact of this uncertainty on staff retention. Consultees highlighted concerns about job security, noting that key scientists and engineers have understandably sought more stable opportunities elsewhere. Additionally, they pointed out that within the wider Comet Interceptor consortium, **this challenge appears unique to the UK**, posing a risk that talent may relocate from the UK as a result.

> *“It would be nice if the budget was clearer in the future, but we understand that UK Space Agency are constrained here.”*
>
> *“These are known issues to the agency, but we need to point them out to government. There may be implications for the width of UK Space Agency’s programmes, but this might be needed to alleviate the system-level problems we are facing.”*

Given the relatively limited number of staff working across the UK project team, some stakeholders have raised concerns that retention challenges could create risks to delivery of the mission overall, and could hence **lead to reputational damage for the UK in the view of ESA and the wider consortium.** Although these risks have not materialised to date, there remains an ever-present possibility that this uncertainty could lead to risks being escalated to ESA.

> *“This is creating a risk of no delivery, causing a lot of stress and extra work for the team.”*
>
> *“We have not had clear directions from UK Space Agency, but we still need to pay people. There is a risk that engineers will be made redundant and frankly they are the ones who will deliver the instrument.”*

While **fiscal constraints will inevitably limit what is possible**, we heard suggestions and requests for longer-term funding commitments from UKRI and UK Space Agency, the establishment of contingency reserves to cover funding gaps, and the promotion of industry partnerships to complement public investment where appropriate. While the **six-month bridging period from March 2025 was welcomed by stakeholders**, to ensure continued funding ahead of the next spending review, it was generally regarded as a **short-term solution that does not fully address the broader funding challenges**. It also raises concerns about the additional administrative burden and ongoing uncertainty associated with such measures, although solutions to these may lie beyond UK Space Agency's control.



2.2.3 Wider international context

The Comet Interceptor consortium brings together expertise from a number of partner nations and organisations, and hence faces broader geopolitical challenges. While these factors are not directly linked to the UK investment in the mission specifically, they can affect the context within which the UK consortium members (and the mission overall) operates.

Stakeholders cited **the Covid pandemic, as well as inflation, as cost drivers in the early stages of the mission**, which affected suppliers of raw materials and components. The impacts of these factors were cited by the project team as longer lead times, which compressed delivery schedules around major milestones. Several stakeholders also observed that it was challenging for the mission to contain these cost increases within the initially-allocated budgets. There were concerns in the initial phases of the mission that both the overall level of funding for the mission, as well as the level of budget contingency built into the costs, were too low. While these factors have introduced complexities, they have not led to significant risks to the overall delivery of the mission.

> *"One key lesson we have learned is that it is difficult to do these sorts of missions coming out of a global pandemic!"*

Stakeholders also pointed to factors such as **depreciation of the pound relative to other currencies, and the UK's exit from the European Union** as factors which have made it challenging to hire staff from Europe. Consultees stated that they had experienced a reduction in job applications for UK roles from European scientists and engineers relative to previous missions, meaning attraction of talent to the UK from overseas was relatively limited. These factors were also regarded as particularly key for more experienced staff, meaning the UK project team has had to recruit more junior staff and train them up in some cases. While this can have other benefits for the space talent pipeline in the UK, it is indicative of broader factors which may pose a barrier to longer-term ambitions of attracting senior talent to the UK space sector.

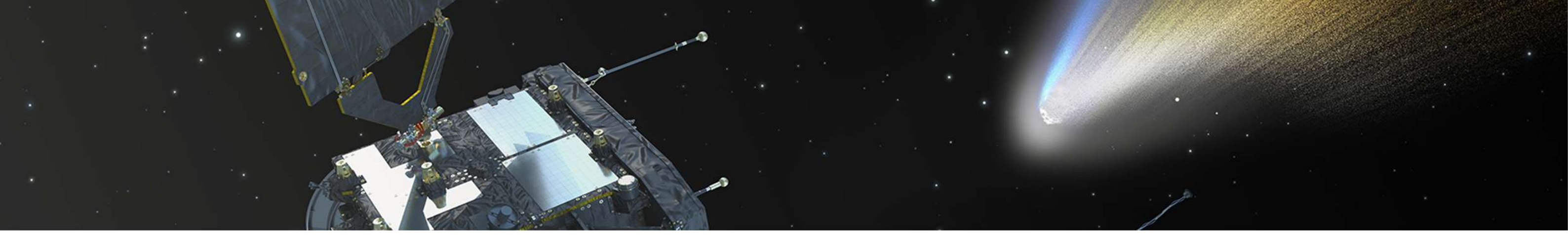
2.3 Administration and resourcing

The administration and resourcing of Comet Interceptor reflects a complex landscape bridging both national and pan-consortium requirements which cannot be entirely separated. Nevertheless, the mission continues to benefit from strong institutional expertise of UK-based individuals and organisations supported by UK Space Agency funding.

A key concern raised by team members is the constraints on available resourcing, **which is too limited in time and budget to explore wider opportunities**, such as spillover commercial opportunities, or the generation of additional publications. Administrative overheads, such as reporting mechanisms, can place additional burdens on the project team which were not always factored into the budget. There are also risks pertaining to institutional knowledge retention, as over the course of a long-term mission such as Comet Interceptor, the likelihood of staff turnover due to new roles and retirement can be high, and this can create skills gaps within organisations when these staff move on. Given the limited number of people working on the mission, upskilling of early-career researchers and engineers should continue to be a core focus of the UK consortium, supported by UK Space Agency.

2.3.1 Staff resourcing

Staff within the consortium were considered to be motivated individuals with **strong technical and scientific expertise**, and the introduction of early-career researchers and engineers is supporting



the development of capabilities which can be leveraged throughout the Comet Interceptor mission, as well as for future projects and missions.

Overall, we have begun to see emerging opportunities for potential spillover impacts, including commercial exploitation as well as outreach and engagement activities. For example, there is still strong market potential around the miniaturised infrared imaging instrumentation from Oxford University within the domain of EO, as set out in the Comet Interceptor business case.

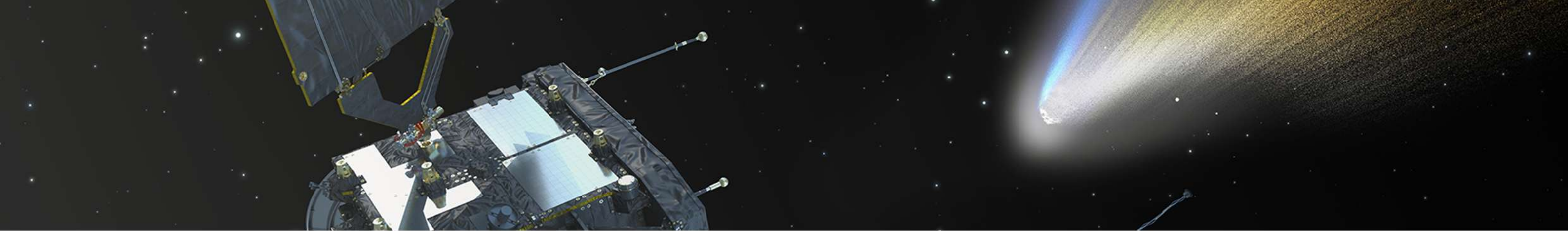
However, given the resourcing constraints that the team is feeling, **there is limited scope to drive these opportunities forward**. For instance, some organisations in the UK project team have a combined FTE of 1 dedicated to the mission, which stakeholders have suggested is particularly low, and leaves 'no slack for errors'. In the future, this may lead to opportunities for wider impacts being turned down by members of the project team. At times throughout our study, stakeholders have expressed how they have been instructed by UK Space Agency to reduce their FTE dedicated to the mission further, which raised concerns with some that there is 'nothing left to cut' without severely impeding delivery. In these cases, stakeholders mentioned that UK Space Agency had recognised the limited resourcing allocated to the mission.

Some stakeholders felt that **the combination of limited resourcing and high administrative overheads** was a particular challenge for delivery, while others appreciated UK Space Agency's financial support in alleviating some of these burdens. In the latter instance, UK Space Agency funding had been used to hire a project support officer for Prof. Snodgrass (as per initial plans for the mission), mitigating administrative overheads for senior team members, especially at a time when Prof. Jones' departure has led to Prof. Snodgrass assuming a greater level of responsibility in some aspects of mission-level decision making.

> *"This is particularly stressful as we enter our delivery year. I can't work on the instrument as I am spending so much time on admin."*
>
> *"The administrative burden has been difficult, but my project support officer has been great in alleviating some of that."*

While stakeholders appreciated UK Space Agency efforts to navigate the spending review 'cliff-edge' discussed above, stakeholders felt that short-term fixes to these issues were also **a source of rising administrative overheads, which was occupying additional time and effort and detracting from delivery.** Stakeholders welcomed the idea of costed extensions, which were seen as a more efficient process in terms of administrative burdens. There were also growing concerns around whether this process would continue after the next 6-month bridging grant, as the frequency of proposals was seen as too high for a long-term mission – especially for what is supposedly a lighter, faster F-Class design. Stakeholders **appreciated the previous system of 3 year grants with intermediate reviews**, which was seen as broadly appropriate for managing accountability and transparency, without detracting from delivery. This is something that they hope to see done again in the future –with an even longer time period than 3 years if possible.

> *"The effort required to extend each grant is an overhead."*
>
> *"The fact we need to do proposals for no-cost extensions and go through delivery review boards for authorisation of underspend carryovers is a significant challenge. We need to seriously consider whether that level of effort for small grants is required when millions have already been spent."*



Of course, **this challenge is not entirely unique to the Comet Interceptor mission or UK Space Agency funding**. Stakeholders recognised that this was a problem commonly seen across academia, where the balance between time taken to secure grants and conducting research was a common source of tension. However, given the mission is operating on long timescales, the administrative burden relating to grant funding was regarded as particularly misaligned to the strategic objectives of the mission.

2.3.2 Institutional expertise and reputation

UK organizations supported by UK Space Agency in delivering the Comet Interceptor mission bring valuable expertise to the consortium, with key team members recognized as essential in advancing the mission. We also found instances of early-career researchers and scientists obtaining access to space science missions for the first time, upskilling themselves and helping maintain knowledge within the organisations.

However, one recurring concern from interviews was the **risk of 'single points of failure'** within the team, and the risk of institutional knowledge loss - a factor which is particularly key when evaluating missions which span several years, and could shape a research field in the coming decades.

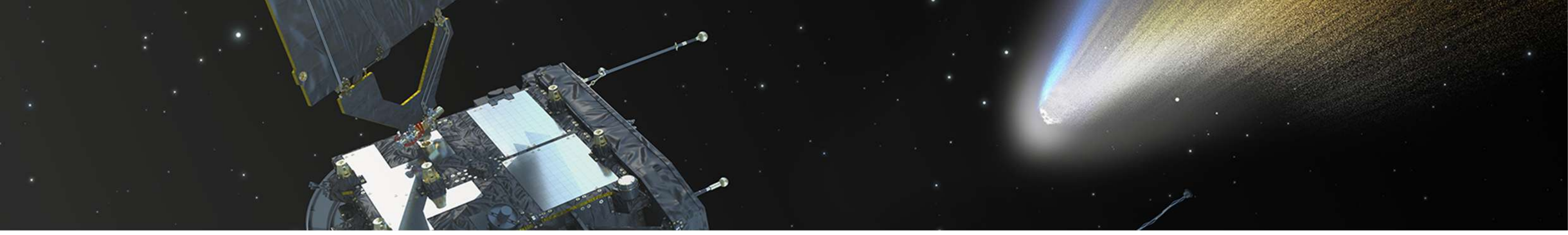
The UK contribution to the mission **currently relies on a handful of core staff**, creating a risk that if a team member suddenly became unavailable (e.g. moving to a new role, illness, personal reasons), then it would have significant implications for project delivery, and the impacts of the mission to the UK. For instance, with Prof. Jones' departure from the mission to occupy a new role at ESA, there is limited, if any, involvement from UCL on the Comet Interceptor mission currently. While other factors would play a role in the competitive application for the IDS vacancy (e.g. geo-return policies at ESA, or the expertise of other key consortium members), this development has occurred without a potential successor to his role on the mission from the UK. According to stakeholders, this trend of relying on individual expertise is not uncommon throughout academia; however, **it does introduce the risk that organisational knowledge is not retained due to staff changes**.

Of course, **the impacts of staff turnover can be mitigated** with enough warning, provided the foundations are in place for effective knowledge transfer to others within the project team. Moreover, a new role does not inherently mean negative outcomes – Prof. Jones' new role is an effective transfer, rather than loss, of UK leadership. However, it may cause losses to the UK's leadership and reputation in the future if contingencies are not put in place. Therefore, UK Space Agency and partner organisations should consider establishing a long-term strategy to transfer institutional and technical knowledge, by upskilling the younger generations throughout the lifecycle of the Comet Interceptor mission.

2.3.3 Reporting to UK Space Agency and ESA

Stakeholders recognised the rationale and necessity behind reporting requirements, with a general acceptance that oversight and transparency are necessary. Moreover, reporting was broadly seen as useful for tracking progress against milestones. Stakeholders had mixed views on the level of administrative burden, with some saying it was broadly 'light touch', while others felt the overheads were 'excessive', and some highlighted that these activities had not been sufficiently factored into initial overhead costs for the team. Stakeholders were unanimous in the view **that the process could be streamlined further to enhance efficiency**.

For example, throughout our evaluation period, a number of stakeholders highlighted the misalignment of reporting requirements between UK Space Agency and ESA, which imposed an ongoing administrative burden. This was in reference to *what* information needed to be reported,



how the information was presented, and the *timing* at which the reporting was expected. Some of these challenges are out of the control of UK Space Agency, and touch on broader concerns around misaligned expectations for reporting requirements in new F-Class missions.

UK Space Agency have also been proactive in responding to the demands of the project team for more synchronised reporting between the two Agencies, **harmonising some aspects of the reporting process** to mitigate administrative burdens. Stakeholders did mention that over time, reporting to UK Space Agency has been streamlined to an appropriate level over time (e.g. by becoming less frequent), but warned that any requests for additions to the reporting template had created additional burdens. Moreover, there was some confusion to changes in the reporting template, where project teams had collated impact information on publications and outreach, only to find they were no longer being requested. While these were minor concerns, stakeholders stressed the need for consistency between reporting cycles.

A further concern raised regarding reporting was the use of Researchfish. While consultees generally recognized the platform's benefits and the need for consistency in reporting grant impacts, they pointed out that for those managing numerous small follow-on or bridging grants within the same programme, this required attributing impacts to each individual grant. This approach **diluted the overall impact narrative and created an unnecessary burden for grant recipients.** As a result, some recipients tended to provide only the minimum required responses on the platform, rather than offering more detailed insights into emerging impact stories.

UK Space Agency should reconsider collaborating with Researchfish to simplify some of the reporting requirements. Additionally, UK Space Agency could assess the overall effectiveness and efficiency of Researchfish in capturing impact data and consider whether alternative methods should be explored if the platform does not provide sufficient value. We understand that this is a broader issue than just for Comet Interceptor, since Researchfish is leveraged across multiple UK Space Agency programmes. However, we have heard similar feedback within other evaluations.

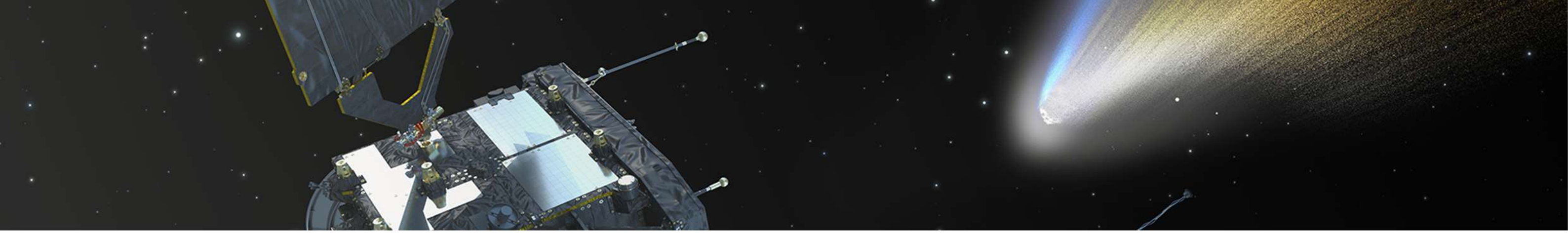
2.3.4 Monitoring and Evaluation (M&E)

M&E activities have played a central role in providing UK Space Agency with an ingoing, structured understanding of benefits realisation across the mission. By tracking progress against defined metrics, the process has enabled UK Space Agency to proactively identify areas that may require additional support, as well as areas where processes and approaches are working well.

Stakeholders reported that they found engaging with the M&E team valuable, not only as a means of highlighting success stories and demonstrating broader impact, but also as a mechanism for feeding insights back to UK Space Agency. Consultees expressed a desire to have greater exposure to the outputs of M&E activities, having contributed insights and inputs. It was noted that for some, **the M&E process represented one of the few formal opportunities they had to reflect on their contributions to the mission.**

> *"It is crucial in putting the whole story together and understanding the benefits from across the team."*
>
> *"Benefits realisation analysis should be happening as it is part of the business case."*

In contexts where the impact of research is inherently difficult to quantify – such as reputation and influence, direct conversations with the project team proved essential for capturing intangible benefits. These discussions ultimately provided clearer and more nuanced view of the mission's



progress, and of the broader impacts which are attributable to UK Space Agency funding. This aims to be particularly useful in developing evidence-based approaches to communicating the impacts of Comet Interceptor to senior stakeholder groups, in an easily digestible format.

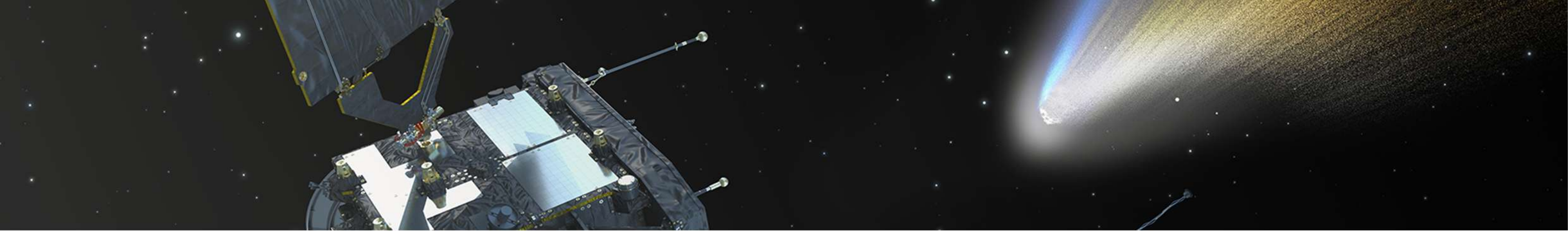
Overall, the implementation of monitoring and evaluation for Comet Interceptor and Ariel has been unique to the way the UK collects evidence on the role of UK investment into space missions. For our evaluation, we have been able to collect data in a consistent and timely manner across the last two years, which helps to identify timeseries trends and measure emerging benefits as they materialise. This avoids the pitfalls associated with ex post evaluations, where missing data often lessen the impact narrative, which is an issue we as evaluators have witnessed on other missions (e.g. within our Gaia Interim Impact Evaluation). Therefore, we recommend that **UK Space Agency continues M&E efforts throughout the lifecycle of Comet Interceptor**, to collate an in-depth narrative across all impact themes regarding the value it brings for the UK's investment.

2.4 Performance against process evaluation questions

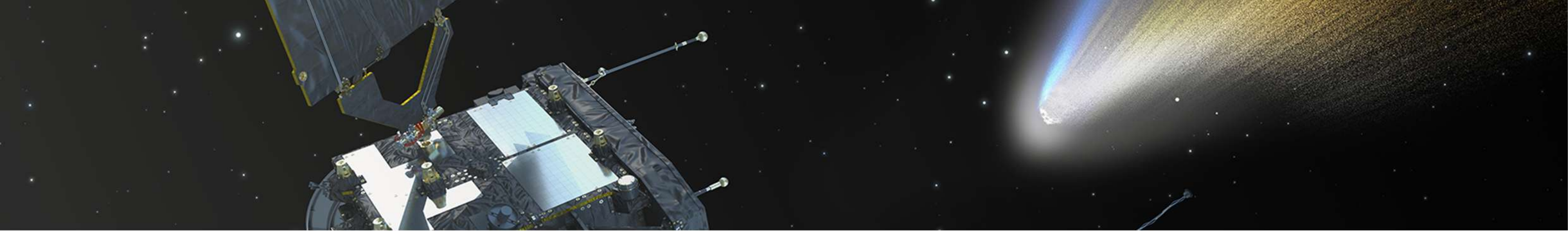
Below, we provide a high-level overview of the performance of the mission's processes against the evaluation questions set out in the original M&E framework report. Not all evaluation questions are fully addressed – this is to be expected, since there is still a long timeline of future delivery factors on the mission, and hence it is too early to capture these in our evaluation to date. We utilise a Red-Amber-Green (RAG) assessment process[6] to provide a high-level summary of progress against each impact evaluation question.

Evaluation Question	RAG rating	Performance
Are UK-funded Comet Interceptor activities being delivered as expected?	**G**	UK-funded activities are broadly on track, with instrument delivery meeting core milestones, and preparatory science activities slowly ramping up. While the team has experienced slight delays, predominantly from non-UK partners, as well as uncertainties around funding, the UK contributions to the mission remain on course with no significant causes for concern. The project team have raised potential concerns around the scope to pursue activities beyond 'core responsibilities' due to time and resource pressures. Examples of activities include pursuit of commercialisation activities, generation of new publications, and attendance at outreach and engagement events. While these are not mission-critical, they underpin several routes to UK impacts which could be seen in years to come, and hence impact the level of return on the UK's investment. This will be important to track in future.
Has the wider international context influenced delivery of UK roles?	**G**	The project team have cited some external factors which have introduced delivery challenges, including the Covid pandemic, inflation, and the UK's withdrawal from the European Union, which have led to longer lead times for components, increased costs, and hiring difficulties. However, these factors have not significantly impeded progress to date, and have been viewed as broadly navigable. UK project team members have also highlighted dependencies on third-parties from other countries as a potential risk. However, despite some delays, these contributions are broadly stabilising, and sufficient contingencies are regarded as being in place to meet mission delivery requirements. This may have come at the cost of increased resources being dedicated to UK oversight over

[6] Our Red-Amber Green assessment process includes 5 success categories against the relevant impact evaluation question at the interim stage of our evaluation: **Fully Addressed**, **Mostly Addressed**, **Partially Addressed**, **Minimally Addressed**, **Not Addressed**



Evaluation Question	RAG rating	Performance
		international contributions to the mission, although this has led to emerging evidence of UK leadership and closer international collaboration. The key wider delivery factor which could impact the schedule and science return of the Comet Interceptor mission is delays to the rideshare mission, Ariel. While UK contributions to the mission may mitigate these challenges in the coming years, there is currently delays and rising costs across the consortium, and independent reviews required to stabilise the schedule. In turn, this could translate to cost and schedule implications for the UK contributions to Comet Interceptor, as FTE has to be 'retained' in the lead up to, and throughout, the mission. Delays would also increase the gap between cometary science missions which the wider research community requires to advance new analytical techniques and discoveries in the field.
What delivery factors have helped or hindered progress against outputs and objectives?	A	Several factors on the mission have shaped progress, including improved communication between the consortium and ESA, UK-led scientific coordination and leadership, and a collaborative mindset of UK researchers and the wider consortium. Beyond external factors (e.g. the Ariel mission schedule and political and economic factors), low funding levels and limited resourcing, coupled with uncertainty over future funding and a perceived burdensome level of administrative overheads are the key sources of risk for the project team. These factors are highlighted as risks for staff retention and knowledge transfer, as well as barriers to some of the wider impacts which are beginning to emerge as a result of the UK's contributions to the mission.
What project-wide working practices and interfaces have worked well, and / or could be improved upon in the future?	A	The level of communication between UK Space Agency and the UK project team is broadly considered to be appropriate and effective for the mission, aside from some instances where there were not clear points of contact on the UK Space Agency side. While challenges were experienced in the early stages of the mission, ESA's responsiveness, expertise, and adaptability were also cited as key enablers to successful delivery. The mission is broadly considered to have been a learning process for many stakeholders, where initial adaptations were required to align expectations over the processes required for F-Class missions. Further detail on areas for improvement are discussed below.
Are any delivery changes needed, and how would / could they be implemented?	A	Much of the delivery mechanisms and working practices within the Comet Interceptor project team are working well, although there is scope to improve proactive, rather than reactive risk management. While risks have been manageable thus far, longer-term coordination and planning was cited as a key gap in the UK's approach to the mission to date, including setting out actionable mitigation measures for risks that may threaten the critical pathway for the UK team. Administrative burdens, especially around reporting elements, were another a key area of concern. Simpler solutions include ensuring alignment of reporting between UK Space Agency and ESA wherever possible, and limiting changes to the reporting format so that people do not need to constantly duplicate effort or learn new ways of doing things. Many of the constraints on the delivery team were focused around 'time' and 'money', including on administrative elements but also for wider spillover activities. These may be challenging for UK Space Agency to address, or indeed be outside of its remit.



3 Interim Impact Evaluation

Our impact evaluation and benefits management activities throughout this study have collected, analysed and synthesised a combination of primary and secondary data and evidence. We draw upon indicator insights, qualitative contextual information, and quantitative non-indicator information to report early outcomes and impacts against the corporate objectives outlined in UK Space Agency's theory of change, with findings grouped **across four broad categories:**

Science	UK Competitiveness & Reputation
Skills & Inspiration	Innovation

Throughout our impact evaluation, we have presented time-series data with a two-year baseline window (2019-2020), which cover the first two years following ESA selection, but is prior to UK Space Agency national funding and ESA mission adoption[7]. This is followed by four year analysis period (2021-2024). The baseline period provides an early snapshot of activity against which future stages of mission development can be compared against, although other factors, such as the £1.8m contribution from UK Space Agency to the mission study phase, and trends in other comet missions (such as Rosetta), are also likely to influence findings.

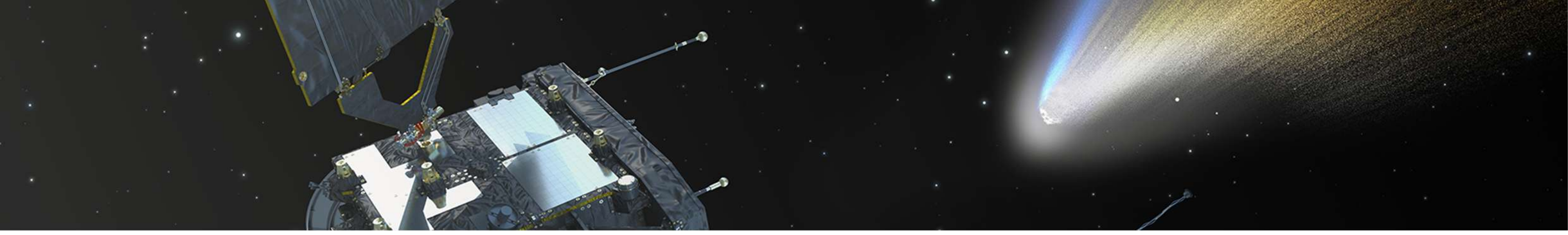
3.1 Science

The UK's national investment into the Comet Interceptor mission is intended to build **enhanced UK research competitiveness** in mission-related science, such as strengthening UK contributions to the wider field of cometary science. The mission will **include the first spacecraft to encounter a dynamically new or long-period comet**, which could potentially offer a glimpse into the chemistry of the early solar system. The mission also aims to support comparative science between previously studied short-period comets (such as 67P/Churyumov-Gerasimenko, which was the focus of the Rosetta mission) and pristine long-period comets.

Science at this stage of the mission is largely dominated by preparation for the mission's target selection, which utilises a new approach to space exploration, by launching without a pre-defined target and trajectory, as mentioned above in section 1.1. This is an innovative approach which could enable **future rapid-response missions to unpredictable targets**, and preliminary work in the Target Identification Working Group (led by Prof. Snodgrass of the University of Edinburgh) is underway to develop a target selection process.

The majority of the scientific benefits and impacts are, however, expected to be realised in the longer term, when the scientific community analyses the data produced on cometary gas, dust and

[7] *While this baseline window provides useful context to compare recent trends, limited sample sizes for some metrics mean the sample sizes for some baseline data are not statistically significant.*

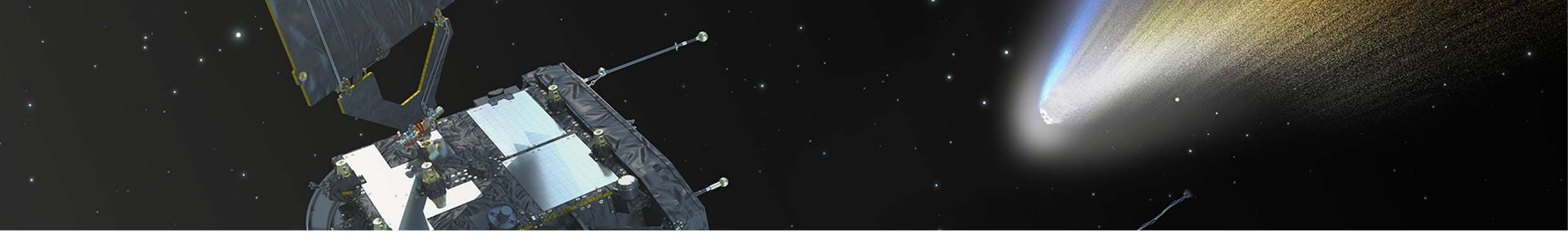


plasma measurements of the target comet. Naturally, this science can only be done when data is released to the scientific community which will occur post-launch, and is expected in 2029 at the earliest. It is therefore crucial to view **early scientific trends as a precursor to more sizeable long-term benefits** which could accrue over longer time horizons. At this stage of the mission, we are primarily assessing outcomes, as it is too early in the mission to see significant scientific impacts.

> *"The fact we secured two UK interdisciplinary science roles was strong evidence of UK leadership. In practice, even with one UK interdisciplinary scientist, the mission has always been regarded as UK-led."*
> *"It feels as though there has been a bit of a dip in science underpinned by Rosetta as the low-hanging fruit has now been picked, but Comet Interceptor is starting to inform the research areas we are working towards, such as a greater focus on comet outgassing, for example."*

Summary of key findings

- **The wider mission is currently on track to achieve the impact evaluation questions developed in this study; however, this is an evolving narrative which could change significantly in the coming years.** Scientific progress on the mission is regarded as 'on track' by the UK project team (with future activities essential to realise these objectives), early scientific leadership has been secured through IDS and working group chair roles, and the quantity and quality of Comet Interceptor-related outputs is growing.
- **At this preliminary stage, we assess current progress against the UK scientific objectives for the mission as early steps in the right direction.** However, future instrument development, target selection and scientific exploitation will be essential in realising the potentially sizeable long-term impacts from the mission, especially as it is still several years from launch.
- **Comet Interceptor publications cover mission descriptions, instrument developments, and preparatory science using Rosetta data.** These publications are raising the mission's profile. However, the bulk of potential major scientific discoveries are expected to follow in future research and publications leveraging mission data.
- **There is a limited but growing pool of Comet Interceptor-related publications, featuring strong UK involvement.** A total of 164 Comet Interceptor related publications have been produced to date, with 72% of these coming in the analysis period. UK-based authors were featured in 39% of publications (down slightly from 48% in the baseline), demonstrating early leadership over publications (with some year-on-year fluctuation), although these are initial shifts in a long-term picture.
- **While organisations from the funded project team are the key contributors to Comet Interceptor research, UK Space Agency funding is driving early contributions from across the UK.** A total of 18 UK organisations have produced a Comet Interceptor-related publication, up from 7 in the baseline. Edinburgh are the leading contributors, followed by UCL, Oxford, and Imperial. Publications from the Universities of Northumbria, Kent, and Birkbeck (among others) demonstrate wider interest in the mission.
- **Cometary science is experiencing a downwards trend in research output between major missions.** This aligns with stakeholder perceptions that the 'low hanging fruit' of Rosetta data has been analysed, and Comet Interceptor is yet to influence the wider field significantly. As the only comet mission in development, UK researchers are well positioned for enhanced future leadership over the field – they already demonstrated



disproportionately high citation impact relative to the number being produced. Despite co-authoring between 12-16% of publications, UK researchers are featured in around 25% of the top cited cometary science papers in the analysis period.

- **Citations take time to materialise, and are weighted towards older publications, but have been growing over our study.** Currently, 70% of citations on UK authored Comet Interceptor publications are in the baseline period, but citations in the analysis period are growing, with more publications cited above the average within cometary science. For instance, the top 5 publications in the analysis period were cited 2.7 times more than average in their respective years, compared to 2.2 in the baseline. The two Comet Interceptor mission papers are the highest profile publications, with the older publication cited 8 times more than the average cometary science publication that year, while the more recent publication is currently at almost 7 times the average.
- **Publications are not the only measure of activity on the mission, and are not a current priority for all in the project team.** Instrument assembly, integration and testing have been cited as key mission priorities, which may detract from publication activity at this stage of the mission. Moreover, stakeholders have stated they have been instructed to reduce FTE dedicated to Comet Interceptor while spending review uncertainties persist, meaning core roles and responsibilities are being prioritised.
- **We assess UK-authored scientific outputs relating to Comet Interceptor as highly attributable to UK Space Agency investment, although less so for the wider field of cometary science at this stage.** However, as the only comet mission in development, there is a chance that cometary science trends would have unfolded differently in absence of UK Space Agency investment (especially if another F-Class mission was selected).

3.1.1 Publications, research output, and UK involvement

Comet Interceptor is principally a science mission, and bibliometric analysis is an essential component for tracing a core pathway to impact. However, following the trajectory of other space science missions, the majority of Comet Interceptor publications are expected to arise once the mission is fully operational and returning data for the scientific community to analyse. Moreover, it is these later publications that are likely to be more essential for generating new scientific knowledge related to the outputs from the mission.

While Comet Interceptor is distinct in scientific objectives and size, we provide an indication of publication trends associated with the Gaia mission from our *2023 Gaia Interim Impact Evaluation*. These trends broadly indicate the trajectory of publications expected for Comet Interceptor, even if trends are different in absolute number, and are not grouped around iterative data releases. Considering we are not yet even at mission launch for Comet Interceptor, this context reinforces the fact that we are assessing initial trends in a much longer-term picture.

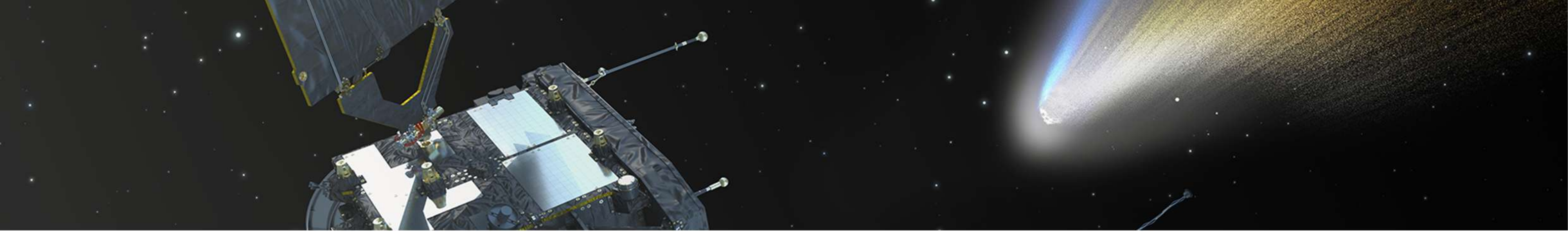
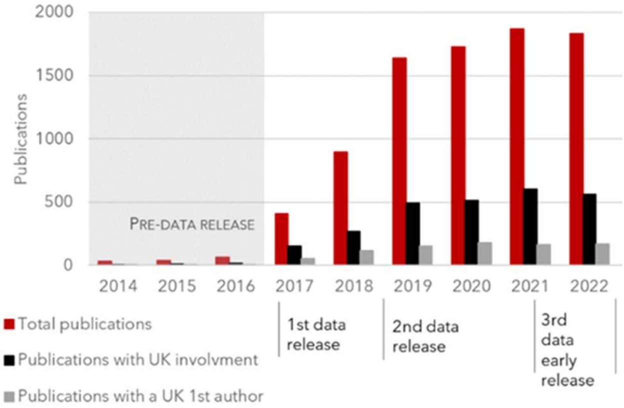


***Figure 1** Publication trends in the Gaia mission*



Source: know.space analysis of NASA ADS data

At this initial stage, caution should be taken in the interpretation of year-on-year trends, as small sample sizes can lead to large swings in the data. At this stage of the mission, there has been limited scientific impact in terms of new discoveries. Of course this is to be expected, as new discoveries underpinned by the Comet Interceptor mission are expected when the mission is returning data from the fly-by of the target comet, which will follow launch in 2029+. To date, Comet Interceptor publications fall into two general categories:

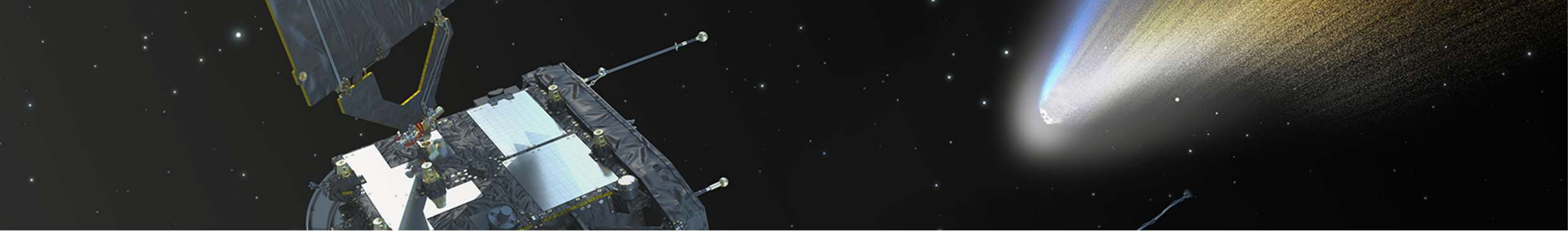
- **Profile and visibility-raising publications –** outlining Comet Interceptor's scientific objectives and aim to increase awareness of the upcoming mission (including conference papers).
- **Preparatory science and engineering papers –** including development of the Large Synoptic Survey Telescope simulator, instrument developments, and leveraging Rosetta data in new ways to investigate complex dynamics between comets and the space environment.

In the longer term, contributions from the project team are expected to rise, due to the profile and timing of scientific impacts associated with the mission, but also due to greater resources being dedicated towards the scientific exploitation of Comet Interceptor data, rather than the building and testing of instrumentation. It is these publications which are expected to benefit the wider scientific community, as new discoveries are made. Understandably, for many of the UK leadership roles on the mission, the priority has been instrument development, testing and assembly, rather than the generation of new publications.

Comet Interceptor scientific publications

The average number of Comet Interceptor related publications released per year has **roughly doubled between the baseline and analysis periods of our study**, from 14.5 to 33.8. While year-on-year variations are expected, this demonstrates a relatively consistent level of research output over the previous four years, which has grown significantly from the years between mission selection in 2019 and adoption in 2022.

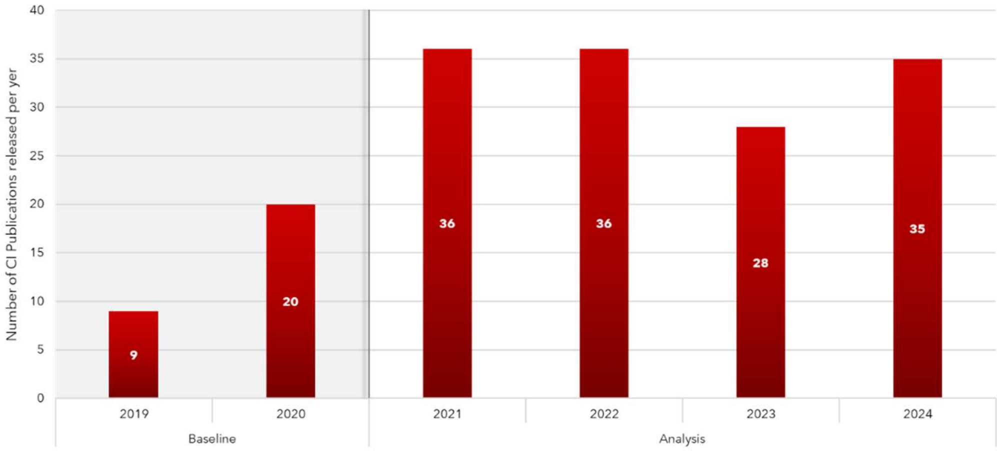
Overall, there **a total of 164 Comet Interceptor publications** have been produced, indicating a relatively small pool of literature which directly references the mission, although it has grown fivefold during the analysis period. This is to be expected at this stage of the mission, as Comet Interceptor is the first ESA F-Class mission, which does not have a legacy of publications which predate selection, as is often the case for M-Class or L-Class missions, as it was developed quickly to meet the emerging call. Moreover, the mission is still currently in the build phase, and has been purposefully designed without a specific destination comet. Therefore, it is understandable that



publications are not necessarily the priority for many within the project team at this current point in time.

In the coming years, we would expect to see a spike in publication activity around and following launch (as demonstrated with the Gaia mission in *Figure 1*), as Comet Interceptor receives wider attention in the academic community, scientific objectives are refined, and target identification activities are finalised. Following this, we would expect the greatest publication activity to be clustered around the release of mission data to the consortium and wider scientific community. Therefore, these initial trends should be interpreted as early needle shifts within a much longer-term picture, where small year-on-year fluctuation are to be expected (such as between 2022 and 2023), due to ongoing instrument development activities and review milestones.

Figure 2 *Number of Comet Interceptor publications released per year*



UK authorship in Comet Interceptor publications

Looking at Comet Interceptor publications which feature UK author involvement, we see a general increase in the number produced each year since 2019, with a large spike in publication activity in 2021, due to a cluster of design activity being published by UK project team members prior to formal mission adoption by ESA's science Programme Committee in 2022. Overall, 40% of Comet Interceptor publications feature UK author involvement, demonstrating strong contributions from UK researchers, although we are dealing with small sample sizes at this stage of the mission, which can lead to jumpiness in the data year-on-year.

For context, 48% of publications in the baseline period featured UK involvement, in comparison to 39% in the analysis period, although the robustness of this comparison is limited by the fact that there are only 29 total publications in the baseline period. The baseline period had key UK academics leading the design of the mission, including early mission description papers. As progress on the mission has unfolded, publications have diversified to an extent, featuring contributions from instrument development leads, working group members, and wider researchers who are interested in the mission, and are increasingly engaging with it.

As illustrated in *Figure 3*, there is some year-on-year fluctuation in the number of publications per year in the analysis period, which is to be expected with relatively small sample sizes of publications over a long-term space mission. Drivers of these fluctuations vary, including aligning with key mission papers being published, specific events being held (i.e. conference abstracts), or specific milestones of the mission being reached. The cluster of UK-authored publication activity in 2021, for example, centred around the publication of research which included trajectory design for the mission, sensor design for the Fluxgate Magnetometer (FGM), and a spike in conference abstracts which outline the mission's objectives.

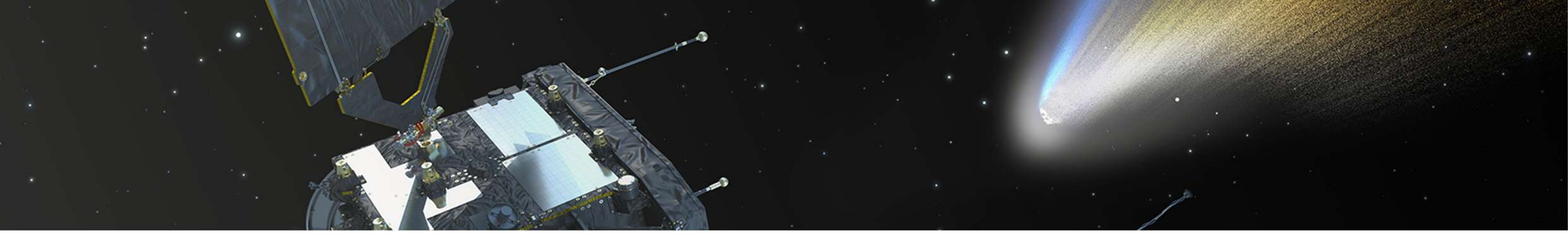
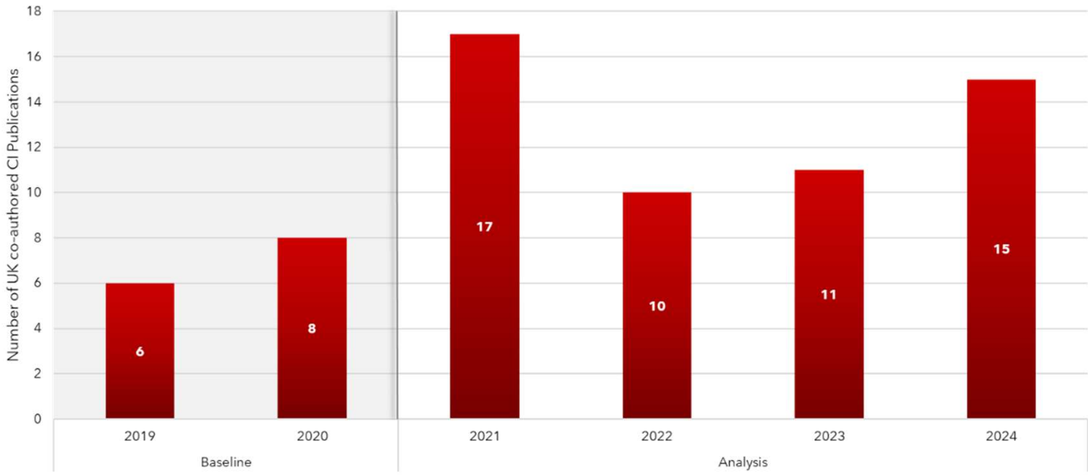


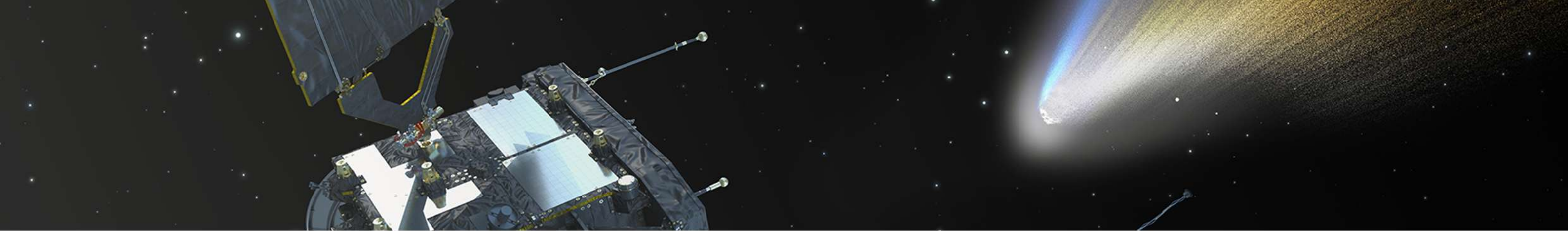
Figure 3 *Number of Comet Interceptor publications featuring UK authors released per year*



In the UK, contributions to Comet Interceptor have largely, although not exclusively, come from organisations in the project team. In total, **18 different UK-based organisations have produced a Comet Interceptor related publication**. While the number of non-project team publications is relatively limited, it does demonstrate wider interest from the UK research community in the mission, as well as highlight where potential future spillover benefits could emerge across the UK. As illustrated in *Figure 4*, the UK project team has been the key source of new publications in the analysis period, alongside contributions from Northumbria University (who have a researcher in the Far Environment Working Group), as well as the University of Kent and Birkbeck. Additional organisations that have produced relevant publications but have missed out on the list in the analysis period include Airbus Defence and Space, the University of Glasgow, Telespazio, the University of Hertfordshire, University of Leicester, and STFC. The number of organisations in the analysis period has grown from an initial 7 organisations in the baseline period, indicating growing awareness and interest in the Comet Interceptor mission from the wider community, however the total numbers of publications per institution are still relatively limited in many cases.

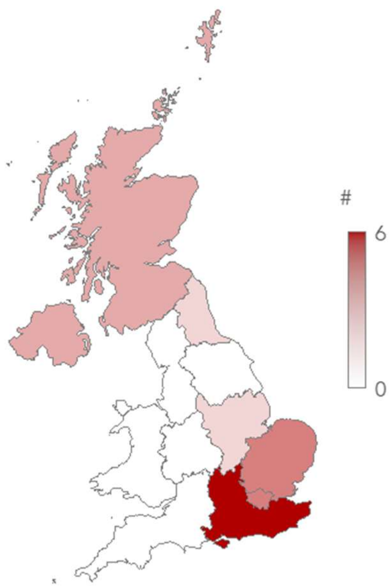
Figure 4 *Top 10 UK organisations producing Comet Interceptor related publications*

	Baseline		Analysis	
	Organisation	**#**	**Organisation**	**#**
1	UCL	**11**	University of Edinburgh	**19**
2	University of Edinburgh	**7**	UCL	**18**
3	Birkbeck	**4**	University of Oxford	**10**
4	University of Oxford	**2**	Imperial College London	**10**
5	RAL Space	**2**	Northumbria University	**6**
6	Queen's University Belfast	**1**	University of Kent	**5**
7	The University of Cardiff	**1**	Birkbeck	**4**
8	Open University	**1**	Open University	**3**
9	-	**-**	Cranfield University	**3**
10	-	**-**	Armagh Observatory	**3**



While the UK Space Agency-funded project team is relatively concentrated in the South East of England (aside from the University of Edinburgh), this distribution of organisations highlights initial contributions from organisations across the UK, and it will be useful to track how this involvement grows in the lead up to, and following, mission launch.

Figure 5 *Distribution of UK organisations producing Comet Interceptor related publications since 2019*

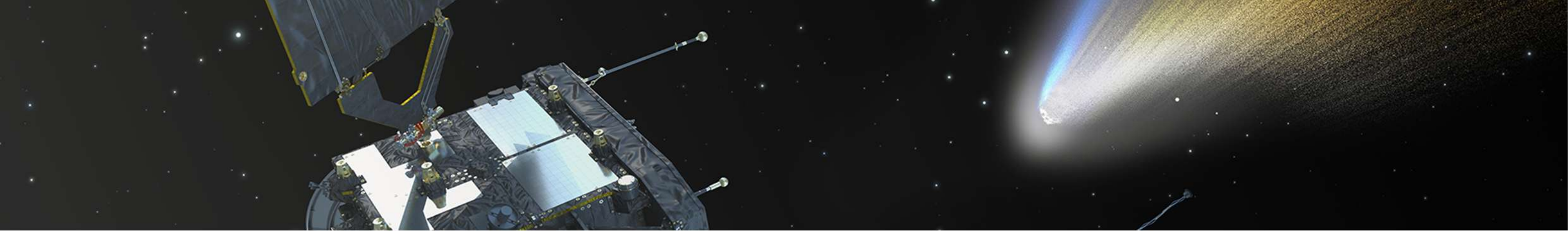


While this distribution of organisations shows initial progress in widening UK organisational involvement in the mission, the University of Edinburgh and UCL are still the two key UK institutions producing Comet Interceptor relevant publications, relative to contributions from other countries. Given Prof. Jones' recent withdrawal from his IDS role on the Comet Interceptor mission to work on the ESA BepiColumbo mission, we would expect UCL's relative position to drop in the coming years, although it is too early to identify the impact of this, given the time lag associated with publications. As one of the two key UK organisations seen in these tables (as measured by number of publications), the UK is likely to see less influence attributed to UCL in the future.

In terms of the top performing research institutions measured by the number of publications, the Italian National Institute for Astrophysics is the key contributor for Comet Interceptor papers within the analysis period, which is to be expected, given INAF researcher presence in the Target Identification Working Group, Near Environment Working Group and Far Environment Working Group.[8] Following this is ESA themselves, and the University of Edinburgh, **driven largely by Prof. Snodgrass' key IDS role and as co-creator of the mission concept**. Other notable contributions include the Swedish Institute of Space Physics (IRF), who are providing the Solar wind Cometary Ions and Energetic Neutral Atoms (SCIENA) instrument for the mission, and the Laboratory of Physics and Chemistry of the Environment (LPC2E) – which is based in France and is leading the Cometary Plasma Light Instrument.

While these trends provide some indication around mission involvement at this stage, they should be interpreted with caution, especially given the small sample size of publications. Stakeholders in the project team have stressed that they are largely occupied with assembly, integration and testing milestones for instrumentation at this stage of the mission, meaning essential contributions to the mission can mask trends witnessed in narrow interpretations of bibliometric analysis. For

[8] ESA, 2022, *Call for Membership of Comet Interceptor Working Groups*, available at: https://www.cosmos.esa.int/web/comet-interceptor-wgs-2022



example, JAXA is a key contributor to the mission, yet does not feature as a key organisation below in *Figure 6*. However, this may also be due in part to our keyword search process being in English.

There are other factors influencing the level of research output from UK organisations at this stage of the mission. Members of the project teams have highlighted that **UK Space Agency had instructed team members to reduce their FTE dedicated to the mission by around 30% until the next spending review, meaning limited available time has been leveraged to meet delivery milestones**, rather than produce publications such as instrument description documents.

Figure 6 *Top 10 institutions as measured by number of Comet Interceptor related publications*

	Baseline		Analysis	
	Organisation	**#**	**Organisation**	**#**
1	UCL, UK	**11**	INAF, Italy	**39**
2	INAF, Italy	**9**	ESA	**24**
3	University of Edinburgh, UK	**7**	University of Edinburgh, UK	**19**
4	Parthenope University of Naples, Italy	**5**	IRF, Sweden	**19**
5	DLR, Germany	**4**	LPC2E, France	**19**
6	University of Helsinki, Finland	**4**	UCL, UK	**18**
7	Birkbeck, UK	**4**	CNRS, France	**17**
8	VTT Tech Research Centre, Finland	**4**	Parthenope University of Naples, Italy	**17**
9	CNR-IFN Padova, Italy	**3**	IAA-CSIC, Spain	**15**
10	ASI, Italy	**3**	LESIA, France	**15**

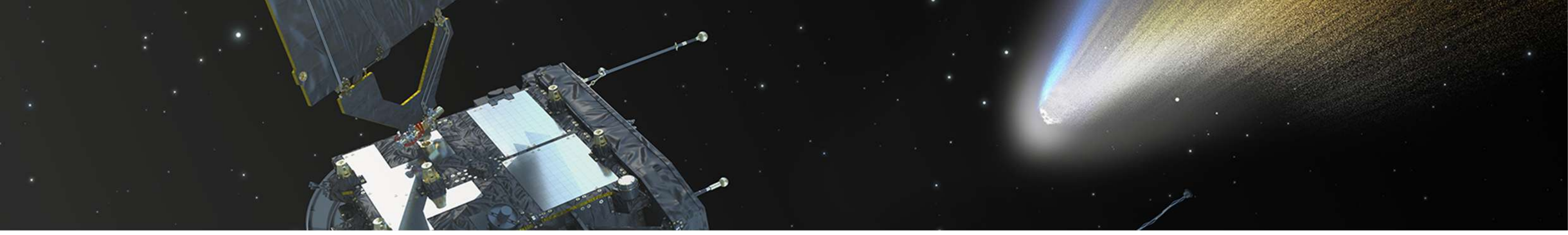
Trends in cometary science

In the longer term, Comet Interceptor is expected to lead to increased research activity in the field of cometary science. It is **the only cometary science mission internationally currently in development**, meaning this data is likely to be leveraged extensively by the wider research community. For context, trends in this wider field provide useful context, but are not attributable to UK Space Agency funding. Rather, they demonstrates **activity within the wider scientific community for which the mission will be of particular interest**. In the longer term, tracking these trends will enable UK Space Agency to monitor the influence of the Comet Interceptor mission within the scientific community over time.

Much of the supporting science for Comet Interceptor in this wider field currently leverages Rosetta data, although publication trends in the wider field are also subject to other factors. For context, Comet Interceptor publications currently comprise approximately 3% of this wider field, while around 7% make direct reference to Rosetta, or Rosetta's target comet (*67P / Churyumov-Gerasimenko*). Ground based observations have also contributed to the generation of publications, and not all publications are likely to have referenced mission data directly.

However, in the view of stakeholders, these trends are expected to shift in the coming years. Several have stated that the wider field of cometary science is in a period of transition, where analysis of Rosetta data is becoming less fruitful, and attention is beginning to turn towards the potential of Comet Interceptor:

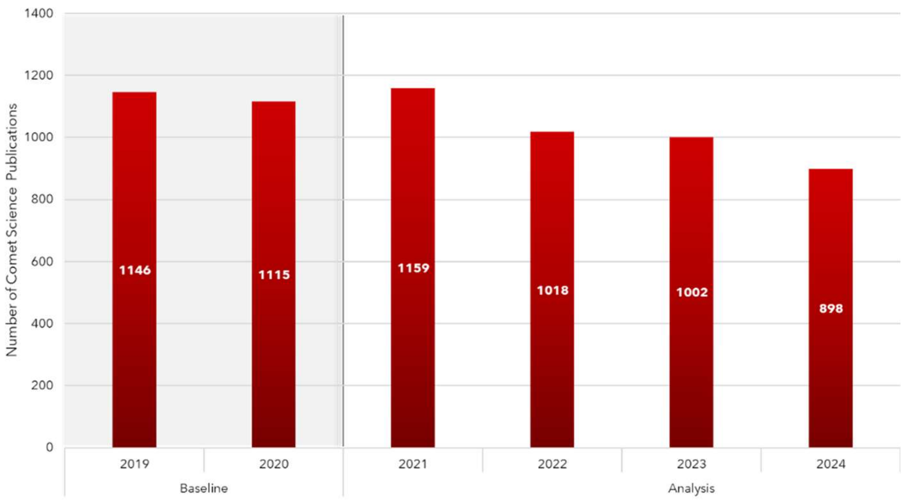
> *"There is lots that can be done with Rosetta data, but in terms of analysis of the data, we are reaching the point where there is less low hanging fruit from a scientific perspective."*



> *"We are at a stage with Rosetta where increasing depth in modelling is required, which takes longer. With comet interceptor, the science hasn't really kicked off yet, so there is a bit of a dip in what is available to the community at the moment."*
>
> *"I have seen more research related to Comet Interceptor planning. Things like identifying the right flyby speeds, and how we could predict where plasma boundaries would be. So the science has begun to ramp up over the past couple of years, but I think this is only going to get better as the mission gets closer.*

As illustrated below in *Figure* 7, the number of cometary science related publications which have been produced globally per year has begun to drop off since 2021, broadly reflecting the views of the project team, as it has been 8 years since the Rosetta mission ended, and there has been no mission since then which has produced new scientific data for the community to analyse.

Figure 7 *Number of cometary science publications released per year*



Within these global trends, UK involvement in cometary science publications has remained relatively constant since 2019. Given the gradual reduction in research output globally, this has led to a slight increase in the relative share of publications being produced within the UK scientific community, with some year-on-year fluctuation. For instance, levels of cometary science research output was similar in 2021 and 2024, yet UK publications accounted for 12% in 2021, and 16% in 2024.

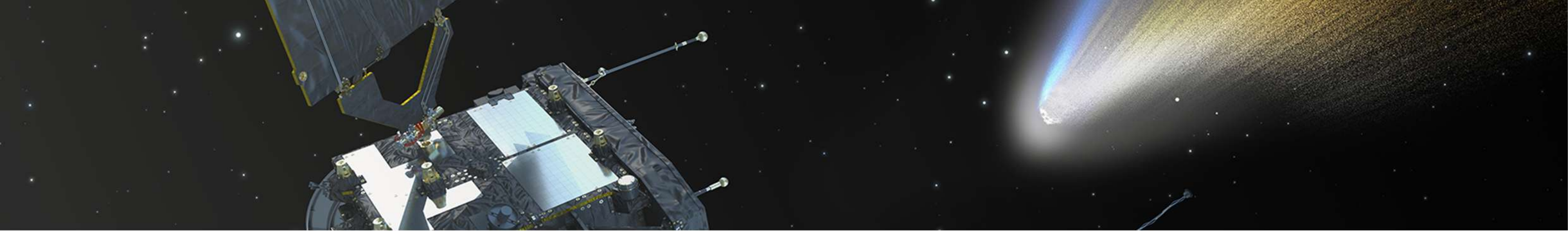
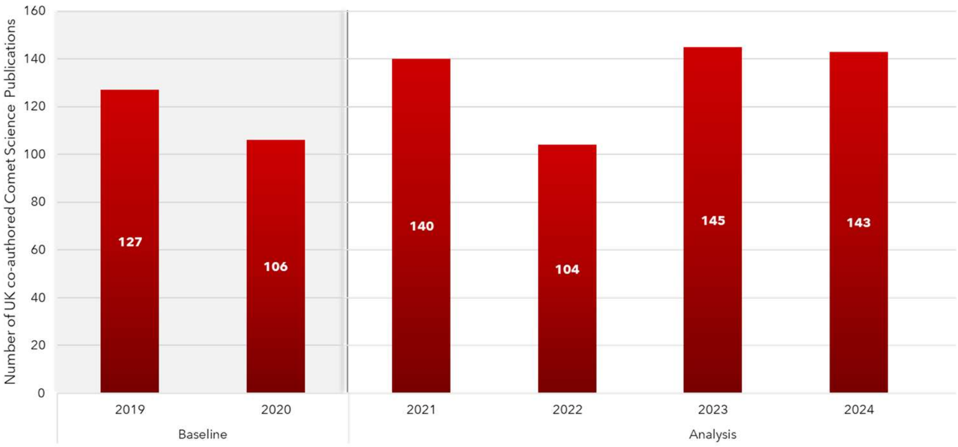


Figure 8 *Number of UK co-authored cometary science publications produced per year*



While activity in cometary science has remained steady over the timeframe of our study, **the proportion of Comet Interceptor publications co-authored by UK authors remains significantly higher than in the wider field of cometary science – at 40%, compared to 14%**. While sample sizes of publications are limited, this illustrates the UK scientific community is beginning to showcase early signs of scientific leadership within the mission.

3.1.2 Citations and evidence of research impact

Monitoring publication numbers over time offers valuable insight into scientific outputs related to the mission and the broader field. Citations add another layer of analysis, by indicating the influence and impact of these publications.

At present, we are dealing with a small but growing sample size of publications. We have seen an uptick in citation activity across the baseline and analysis periods across the timeframe of our study, most notably in 2024. While the absolute number of citations in the baseline period is higher, this trend is expected at this stage of the mission. For instance, it is also important to consider the time lag associated with citations, which require other researchers to read the publication, carry out their own research, write the citing publication, progress through peer review, get accepted by a journal, and then be published.

While caution must be taken in drawing comparisons between missions given differences in size, budget, and objective, citation trends in the ESA Solar Orbiter[9] mission provide useful context for the trajectory of citations in the run-up to mission launch. The mission launched in 2020, with routine science operations beginning in 2021. As *Figure 9* illustrates, there is a considerable uptick in citation activity when the mission is operational – rising from 600 citations in 2019 to over 3,000 by 2023. While numbers are likely to vary, this trend highlights the growing scientific impact of the mission as more data and results become available to the research community.

[9] *The ESA Solar Orbiter mission is taking the closest ever images of the Sun, including the polar regions, measuring the composition of the solar wind, and investigating areas of origin.*

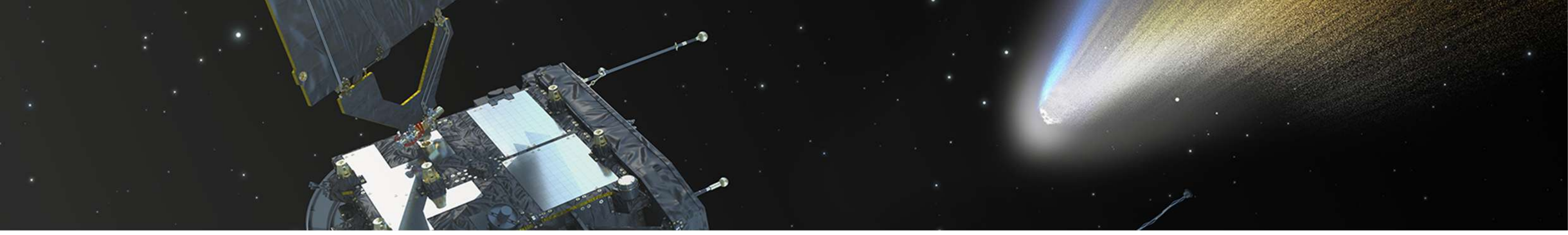
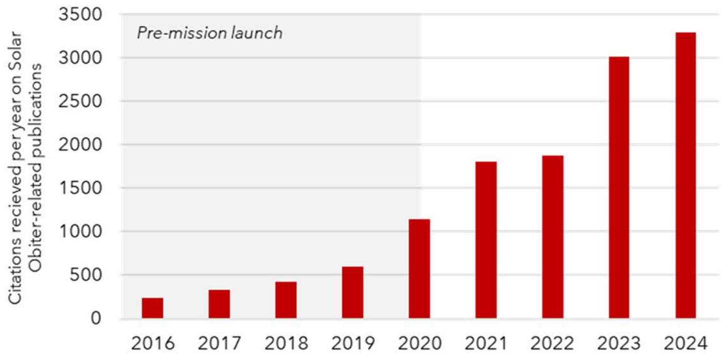


Figure 9 *Citations per year on Solar Orbiter-related publications*



Source: know.space analysis of Dimensions.ai data

UK authored Comet Interceptor publication citation performance

To date, we have identified **271 citations on UK authored Comet Interceptor related publications**, with 70% of citations accruing on publications released in the baseline period. Currently, there are 188 citations on publications in the baseline, relative to 83 in the analysis period. Citations take time to accumulate, and this is therefore not a like-for-like comparison at this stage, as we would not expect publications released in the last 2 years to amass a significant number of citations. Indeed, a 2-year minimum timeframe for analysing citation impact is commonplace in many bibliometric studies[10]. Given the limited sample size of citations to date, these overall trends can still be influenced significantly by citations on single publications.

In the coming years, we would expect to see further increases in citations for publications which have been released to date, and time lag effects for these publications to become less pronounced over time. Given these limitations, it is too early to comprehensively assess citation performance of publications within the analysis period.

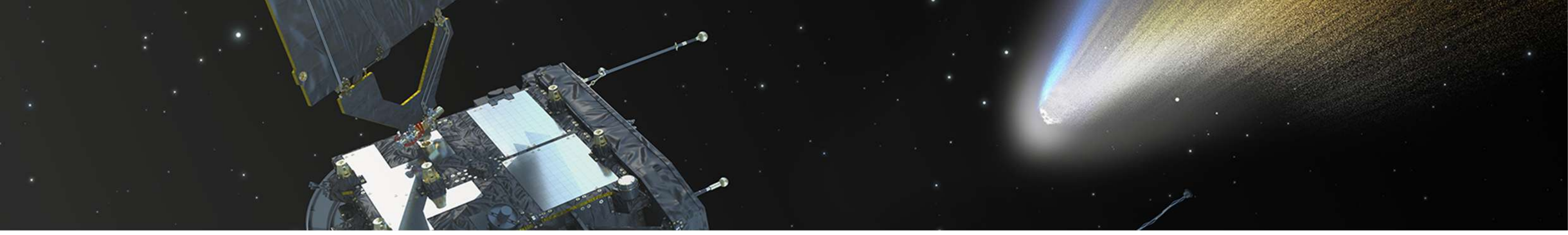
In order to control for the biases inherent in measuring citations year-on-year, and to account for different citation trends across fields of research, we provide Field Citation Ratio (FCR) metrics below. The FCR is calculated by:

$$\text{Field Citation Ratio} = \frac{\text{\# of citations}}{\text{Average \# of citations in the same field of research and year}}$$

As illustrated below, citation trends across both periods are highly influenced by a small number of top cited publications across both periods, which almost all feature contributions from Prof. Jones or Prof. Snodgrass, or both. While the baseline and analysis periods offer useful comparison, authorship trends also highlight the role which early UK Space Agency support (and perhaps, the expectation of future support) may have played in the generation of publications by the UK project team in the early years of the mission.

Below, we provide additional context on these publications (in terms of FCR and overall citation count). An FCR of 1 indicates that a publication has received the same number of citations as the

[10] Dimensions, 2022. *What is the FCR? How is it calculated?* Available at: https://dimensions.freshdesk.com/support/solutions/articles/23000018848-what-is-the-fcr-how-is-it-calculated



average paper in its field of research, while an FCR of 2 demonstrates the paper has received double the average.

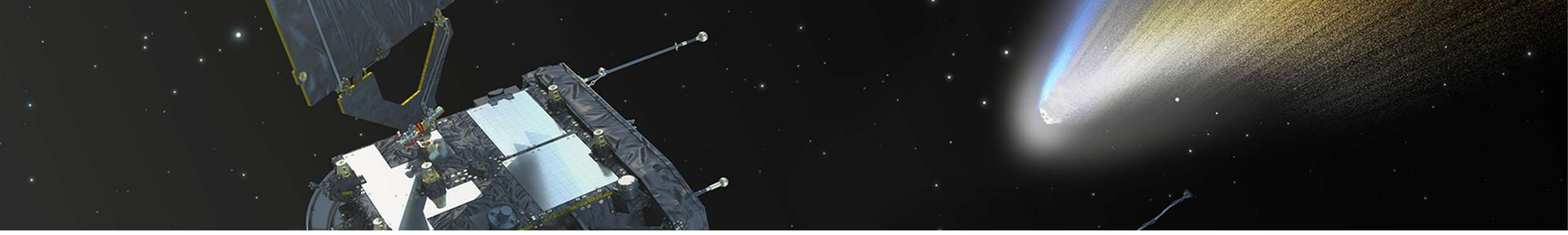
Below, we present the top 5 publications in the baseline and analysis periods by FCR and total citation count:

Figure 10 *The top 5 UK publications in the baseline and analysis periods by FCR and total citation count*

	Baseline			
	Author/Date	Publication Title	Citations	FCR
1	C. Snodgrass, G. Jones. 2019	The European Space Agency's Comet Interceptor Lies in Wait	**143**	**8.2**
2	M. Schwamb, et al. 2020 (inc. C. Snodgrass)	Potential Backup Targets for Comet Interceptor	**21**	**1.7**
3	C. Snodgrass, G. Jones. 2019	Comet Interceptor: A proposed ESA Mission to a Dynamically New Comet	**9**	**0.5**
4	C. Pernechele, et al. 2020 (inc. G. Jones)	Comet Interceptor's EnVisS camera Sky Mapping Function	**5**	**0.4**
5	G Brydon, G. Jones. 2019	Comet Interceptor's EnVisS Camera: Multispectral and Polarimetric Full-sky Imager for a Comet Flyby	**4**	**0.4**

	Analysis			
	Author/Date	Publication Title	Citations	FCR
1	G. Jones, C. Snodgrass, et al. 2024	The Comet Interceptor Mission	**23**	**6.8**
2	J.P. Sanchez, et al. 2021 (inc. C. Snodgrass)	ESA F-Class Comet Interceptor: Trajectory design to intercept a yet-to-be-discovered comet	**24**	**2.7**
3	C. Goetz, et al. 2021	Warm protons at comet 67P/Churyumov-Gerasimenko - implications for the infant bow shock	**14**	**1.6**
4	M Fulle, et al. 2022 (inc. C. Snodgrass)	Comets beyond 4 au: How pristine are Oort nuclei?	**12**	**1.5**
5	R. Marschall, et al. 2022 (inc. G. Jones)	Determining the dust environment of an unknown comet for a spacecraft flyby: The case of ESA's Comet Interceptor mission	**7**	**0.9**

Within the baseline period, the top 5 UK-authored Comet Interceptor publications received a total of 182 citations, representing 97% of the citations in that period. The highest cited publication is the previous mission paper, co-authored by Prof. Jones and Prof. Snodgrass, and was commonly used as the default citation for publications which referenced the Comet Interceptor mission generally. The majority of citations in the baseline period are driven by this publication alone, and it has been **cited over 8 times more than the average cometary science publication in that year.** This could suggest wider interest in the mission concept by the wider community when undertaking wider cometary science research on data from other sources, such as ground-based observations or Rosetta data.



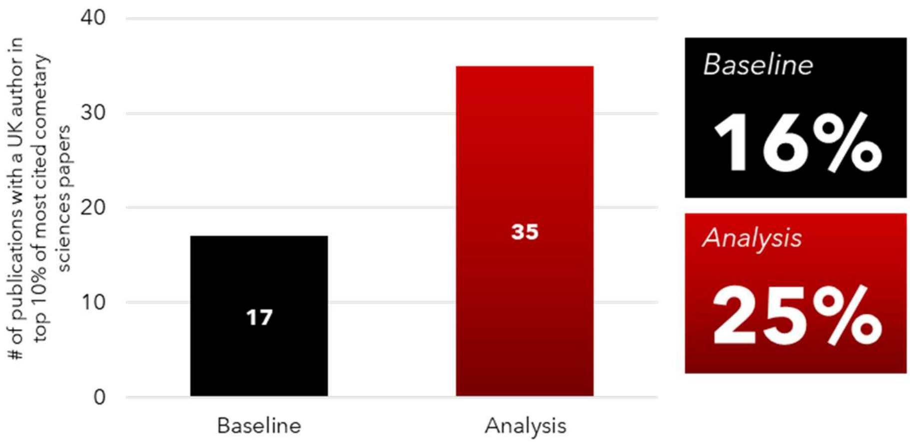
In the analysis period, the top 5 cited publications represent 96% of total citations in the period. The highest two cited publications are mission description papers, which provide summaries of the scientific objectives of the mission. The 2024 mission paper is particularly notable, as it has accumulated 23 citations in a year, **being cited almost 7 times more than the average cometary science paper in 2024**.

While overall citation counts are higher in the baseline, driven largely by the highest cited paper (which has also had more time to accumulate citations), **the analysis period has had a broader spread of papers which have been cited more than average**, as measured by FCR. Once adjusted for time lag effects, the **top 5 publications in the analysis period were cited 2.7 times more than average in their respective years, compared to 2.2 in the baseline**. While it is too early to read into these trends significantly, this could indicate a growing body of publications with high citation potential, especially given the tendency for citations to exhibit a 'snowballing' effect – where citations raise the profile of a publication, and hence lead to additional citations. These citations could be indicative of rising interest and engagement with UK-authored Comet Interceptor related research, although it is too early to assess these trends fully.

Wider Citation Trends

In the wider field of cometary science, UK researchers have demonstrated **disproportionately high citation impact relative to the number being produced**. Despite co-authoring between 12-16% of cometary science publications, UK researchers are featured in around 25% of the top cited cometary science papers in the analysis period. UK involvement in the wider field includes contributions from UK project teams, alongside notable involvement from the University of Cambridge, the Open University and University of Leeds.

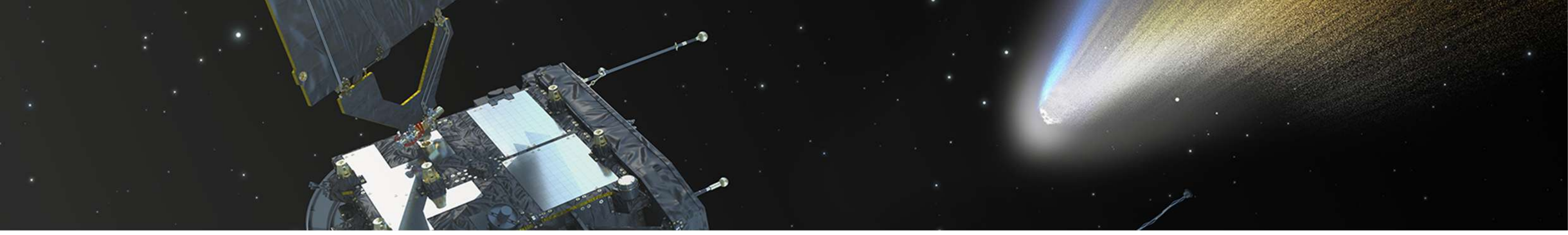
Figure 11 *Number and percentage of publications with a UK author in the top 10% of most cited cometary science publications*



Additional evidence of scientific impact

To complement analysis of publication numbers and citations, Altmetrics are a tool that can help identify activity around publications beyond direct citations, as articles are often shared, mentioned, and discussed in many different forums and contexts. Altmetrics can be used as a way to measure the level of online activity surrounding a particular piece of research output, but it is not a measure of the quality of the research or researcher.

The Altmetric Attention Score is part of the Digital Science portfolio, and is automatically calculated through the weighted count of all attention a research output has received, based on three main factors:



- **Volume:** score rises as more people mention the article. The weight only counts one mention from each person per source.

- **Source:** each 'category' of mention contributes a different weight to the final score, e.g. newspaper article is weighted more strongly than a blog post.

- **Authors:** considers how often the author of each 'mention' discusses scholarly articles, whether there is bias towards a particular journal / publisher, and the audience they leverage.

We have assessed the altmetric attention of all cited Comet Interceptor publications across both the baseline and analysis periods of this study. UK-authored comet interceptor publications have had some wider online reach, including being referenced in a total of **5 Wikipedia pages and 7 news articles**, including *Phys.org, Inverse, MSN*, and *Universe Today*. Despite some online presence for the top cited publication in the baseline, the highest altmetric scores have come in the analysis period, with the highest altmetric score being 61. For context, this places the publication in the top 10% of publications released in the same journal at a similar time, although it does not feature contributions from the UK project team, and hence is not attributable. The publication was produced by three US-based academics, who outlined interstellar objects which could be accessible for in-situ mission designs, such as Comet Interceptor. It is expected that wider coverage of Comet Interceptor related research will increase around launch and the subsequent comet fly-by.

3.1.3 Counterfactual

UK efforts, particularly from Prof. Jones and Prof. Snodgrass, were influential in shaping the scientific objectives of the Comet Interceptor mission up to adoption, with early support provided by UK Space Agency in the mission study phase. Remove this, and there would be no mission. This also complicates simple analysis of baseline vs analysis period scenarios – as these trends could reflect early UK Space Agency support, or could be influenced by the expectation of future funding if the mission was selected by ESA. In a scenario where this work was undertaken, but UK Space Agency's national contribution had not materialised, **it is likely that Comet Interceptor would not have been selected,** and another ESA F-Class candidate would have taken its place. If the mission were still to go ahead absent of national funding, this would have led to a significant reduction in scientific leadership, with these roles potentially reallocated to countries such as Germany or Austria.

As the only cometary science mission under development, **it is clear that absent of UK Space Agency national funding for Comet Interceptor, the benefits to the UK cometary science community would have been significantly reduced**, and the emerging scientific impacts listed above would not have materialised if another mission candidate was selected. There were five alternative F-Class candidates, which all had distinct scientific objectives to Comet Interceptor. The first reserve mission for Comet Interceptor is Debye, which was a planned thermal electron telescope that would have measured how electrons are heated in astrophysical plasmas.[11]

Other candidates included *Asteroid In-situ Interior Investigation* 3ways (AI^3), which aimed to monitor the asteroid Apophis, and *Near-Earth Space Trekker* (NEST), which was envisioned to rendezvous with the same asteroid.[12] The *Stellar and ISM Research via In-orbit E(UV) Spectroscopy mission* (Sirius) was a proposed low-cost extreme ultraviolet observatory, which would have

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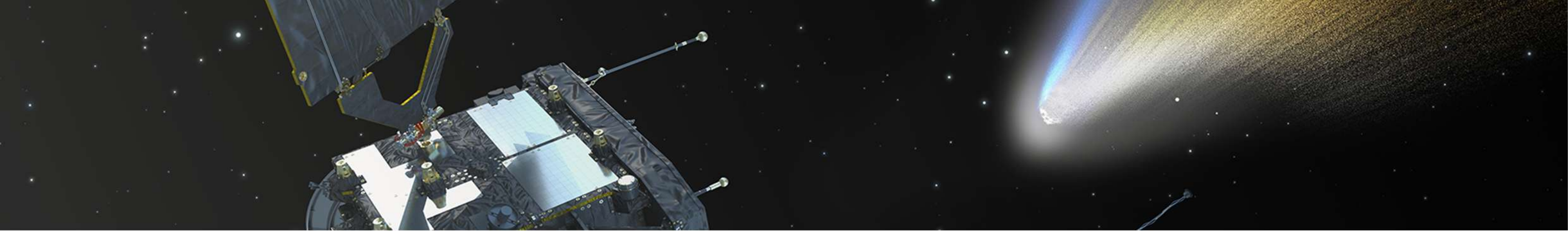
[11] UCL News, 2019. *Comet Interceptor: ESA selects new mission to an ancient world*. Available at: https://www.ucl.ac.uk/news/2019/jun/comet-interceptor-esa-selects-new-mission-ancient-world

[12] OA-ROMA, n.d. *NEST Science Goals*. Available at: https://www.oa-roma.inaf.it/nest/nest-science-goals/



observed young stars and the evolution of white dwarves.[13] The All-sky Astrogam would have studied high-energy astronomical events.[14]

While any of these missions would have produced scientific outcomes, they would not necessarily have featured key UK leadership roles. Moreover, they would not have produced impacts within the cometary science domain.

3.1.4 Conclusions

At this interim stage, we have examined how outcomes and impacts to date have supported progress against UK Space Agency's strategic objectives for the Comet Interceptor mission. We assess the preliminary evidence as **early steps in the right direction, with no cause for concern**. However, as would be expected at this stage of the mission, we are primarily assessing activities and short-term outcomes, and sizeable scientific impacts are not yet evident. Future developments, especially regarding target selection, the comet flyby, and the subsequent scientific exploitation of mission data by the project team and wider research community, will be essential in realising longer-term, more sizeable scientific benefits. Below, we assess performance against the relevant evaluation questions posed at the beginning of our study, including:

Is the programme on track to achieve its scientific aims, as defined by the UK-led science team?

At this stage of the mission, there is a limited but growing body of Comet Interceptor-related research, encompassing publications which outline Comet Interceptor's scientific objectives, as well as papers presenting instrument developments. Preparatory science is being undertaken on Rosetta data to investigate methods for investigate complex dynamics between comets and the space environment, which could offer interesting comparisons against the pristine comet which will be studied with Comet Interceptor. While these publications are undeniably important, **the most valuable scientific impacts are expected to be linked to the potential new discoveries enabled by the spacecraft itself in the coming years**.

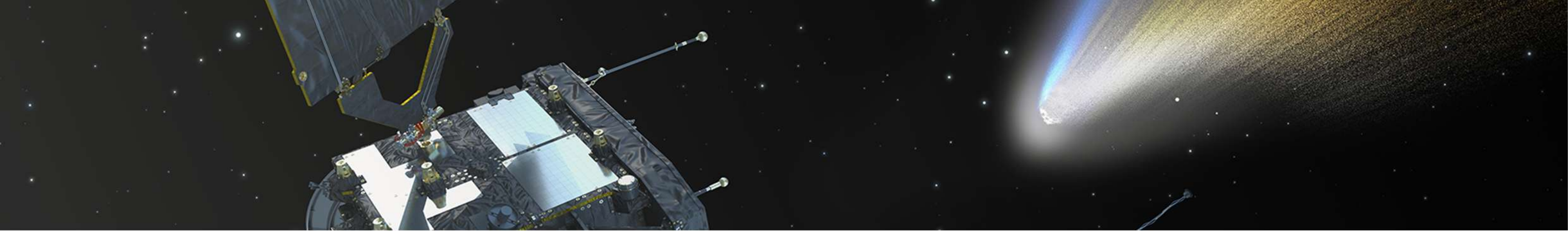
Stakeholders in the project team generally felt that initial restructuring by ESA and confusion over UK roles on the mission had led to early barriers to progress, but progress among the science working groups was getting back on track. However, stakeholders also mentioned how it was too early in the mission to determine whether the mission is on track to achieve its longer-term scientific aims, as while recent progress has been promising, future developments regarding instrument performance and target selection will largely determine progress against the mission's objectives. Moreover, wider factors, such as the risk of delays on the Ariel mission, could affect the schedule for the mission, and hence the amount of preparatory science time available to the consortium.

What difference has the UK's national investment into Comet Interceptor made to securing UK scientific and technical leadership within comet research and space science?

The Comet Interceptor mission has been UK-led from inception, with Prof. Snodgrass and Prof. Jones the leading drivers of the mission concept. **UK Space Agency's national investment into the mission was vital in ensuring Comet Interceptor was selected, and in carving out leadership roles within it**. This places the mission under UK scientific and technical leadership,

[13] University of Leicester, 2024. *New space missions to explore suns' influence on habitable worlds.* Available at: https://le.ac.uk/news/2024/august/sirius-elfen

[14] De Angelis, A., et al. 2019. *Proposal for the ESA F Mission Programme*. Available at: https://www.lip.pt/~rcsilva/AllSkyASTROGAMSubmitted25202018.pdf

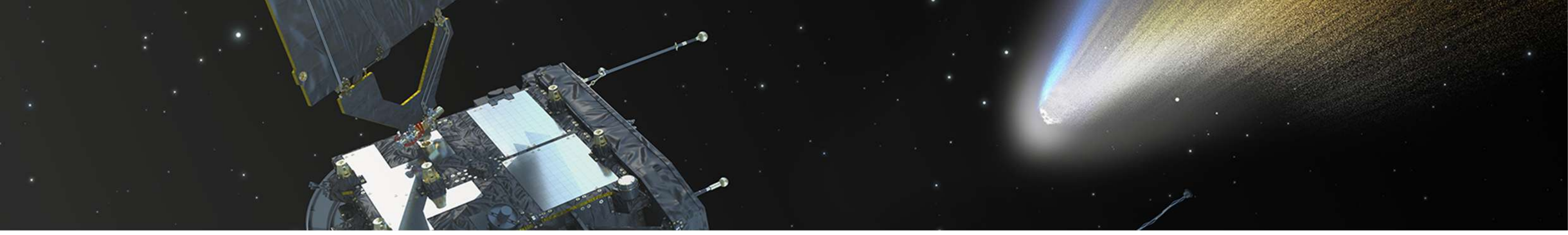


which has supported the steady growth of UK authored Comet Interceptor related publications year-on-year throughout our study.

To date, we have seen relatively limited numbers of citations (which could be interpreted as a measure of the reach of the mission), however this is likely a result of the combination of small sample sizes and time lag effects. The highly cited mission papers from the baseline and analysis periods indicate strong wider interest in the mission. While it is too early to assess trends fully, there is a broader spread of publications in the analysis period which are cited more than the average in the field, which could be interpreted as early indications of increasing engagement with Comet Interceptor related research.

In the wider field of cometary science, there is evidence that UK researchers feature disproportionately in the top cited publications (relative to their overall involvement). However, trends in cometary science are still influenced heavily by data from other missions, such as Rosetta, and are hence not directly attributable to UK Space Agency's national contribution. Over the longer term, we would expect to see Comet Interceptor publications occupying a larger relative share of publications, as the only comet mission currently in development worldwide. **UK researchers are therefore well positioned to further enhance scientific and technical leadership over the field of cometary science**. It is too early to assess impacts on UK leadership over the wider space science research community, which first relies on successful delivery of the Comet Interceptor mission. Moreover, with no new comet missions upcoming aside from Comet Interceptor, it is challenging to forecast the scientific and technical opportunities associated with the mission.

A key route to **scientific leadership** over the mission is discussed in more detail below in section 3.2.2, as the Interdisciplinary Scientist (IDS) roles and working group chair roles secured by Prof. Snodgrass, and formerly Prof. Jones are central mechanisms for influencing the direction of mission science, and ensuring instrument development unfolds to maximise the future science return. In the longer term, these roles could also be crucial in influencing the target selection process -a key scientific decision on the mission which could be influenced by the priorities of UK researchers. As discussed in more detail in section 3.4, the mission has also enabled the University of Oxford to continue to develop instrument flight heritage, leveraging technologies for the MIRMIS instrument which were initially developed for other NASA missions. In turn, this technical leadership could carve out future roles on other space science missions, and could lay the foundations for **technical leadership** in years to come.



3.2 UK Competitiveness & Reputation

Another core strategic objective of the Comet Interceptor mission is to **build global leadership and reputation of the UK space science community**, by collaborating internationally with partners within the consortium. The UK's investment into the mission aims to **enhance UK competitiveness in future space science missions** over the longer term.

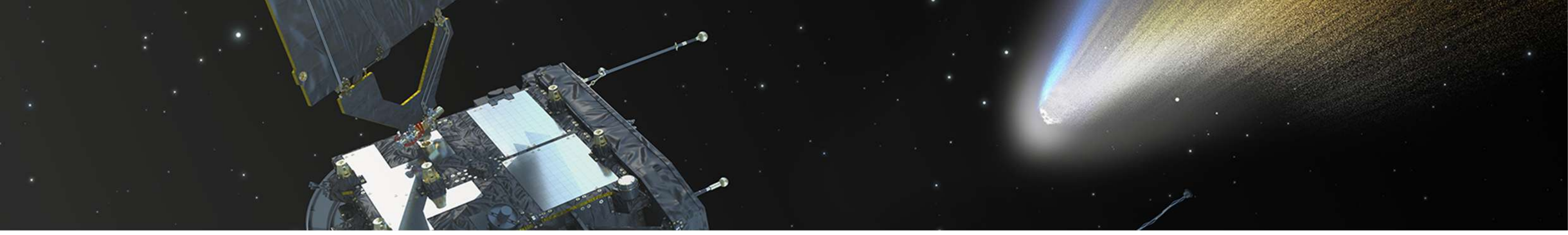
As mentioned previously, Prof. Snodgrass (and formerly Prof. Jones) are able to influence the scientific direction of the mission through the IDS role, which enables them to steer developments in the wider consortium, including decisions on hardware developments. Prof. Snodgrass also leads the Target Identification working group, overseeing preparatory science for the first stages of the mission. Moreover, the key UK roles in instrument development have allowed Imperial College London and Oxford University to collaborate internationally to deliver their roles and responsibilities (including working with organisations in Austria, Poland, Finland and the USA), while also showcasing UK competitiveness and technical expertise.

However, benefits associated with the reputation and leadership of UK organisations are inherently linked to successful longer term delivery of responsibilities on the mission, and we are assessing initial outputs and trends within this much longer-term picture. These trends could evolve quickly as a result of future mission developments.

> *Through the key Interdisciplinary Science role, we can steer the science activities within the consortium through regular meetings and executive sessions. At this stage of the mission, relatively few key changes have been required.*

Summary of key findings

- **Comet Interceptor is an inherently collaborative mission, and the UK has enhanced the quantity and quality of international collaboration over the course of our evaluation period.** The consortium features approximately 90 organisations from 7 countries, and UK organisations are collaborating internationally to support instrument delivery, and in leading preparatory science activities. This indicates early progress in expanding the reach of the space sector, although this is a longer-term impact narrative.
- **As measured by co-authorship of publications, UK authors are becoming increasingly internationally collaborative, producing research within the consortium and beyond.** 94% of UK-authored publications are internationally collaborative in the analysis period, up from 64% in the baseline. Italy, France, the USA, Sweden and Finland are the top collaborating countries since 2021. The UK has collaborated with 28 countries in the analysis period, up from 7 in the baseline.
- **The UK is one of the leading countries producing Comet Interceptor publications, demonstrating early signs of international competitiveness.** Italy has produced the most Comet Interceptor related publications, followed by the UK and France, broadly reflecting involvement across science working groups.
- **There are early positive signs for UK reputation and leadership on the mission, but it is too early to assess wider reputational benefits.** Stakeholders felt the UK is perceived to be a reliable partner internationally, and was considered as having scientific leadership – especially through securing 2 IDS roles. However, reputation is again contingent on successful delivery. Comet Interceptor was regarded by stakeholders as a key route for further developing heritage, which could subsequently



strengthen the case for future mission involvement. There is also a concern that since Prof. Jones' departure to work on another mission, this influence may be diminished. Early progress against this evaluation question is regarded as positive, but it is too soon to comprehensively assess routes to more sizeable impacts at this stage.

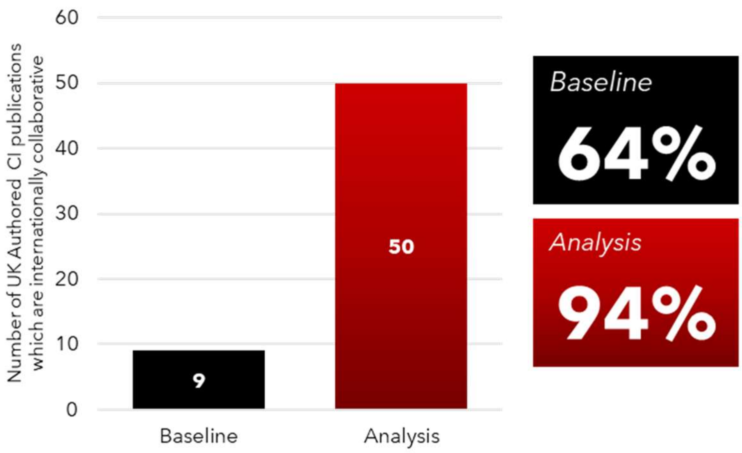
- **Despite early benefits, stakeholders were wary of reputational risk associated with long-term funding uncertainty.** They noted potential retention challenges associated with fixed-term contracts ending, which could create significant skill gaps in UK funded organisations due to 'single point of failure' risks. These risks could impact the involvement of UK organisations significantly, such as with UCL and Prof. Jones.
- **In a scenario without UK Space Agency investment, it is unlikely that we would see the same level of international collaboration and UK influence over the mission.** Early outcomes and benefits are inherently linked to UK leadership roles which were secured as a result of UK Space Agency support.

3.2.1 International collaboration

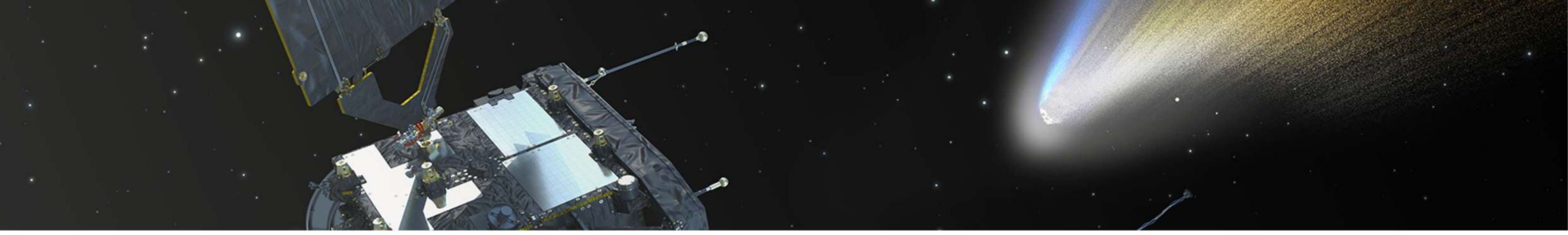
Comet Interceptor is **inherently internationally collaborative**, as an international space science mission which features contributions from approximately 90 institutes, from 6 ESA member states, as well as JAXA in Japan. As a science mission, one core measure of international collaboration is through co-authorship of scientific publications, which provides a quantitative measure of the key international networks of collaboration, and how they have evolved over time. International collaboration within space science missions could lead to other strategic benefits over the longer term, such as enhanced profile and visibility of UK research performing organisations, closer ties with allied nations, and soft power benefits associated with becoming a sought-after partner in space activities.

As measured by co-authorship of publications, we have seen rising levels of international collaboration between UK and international researchers in both absolute and relative terms between the baseline and analysis periods. As illustrated in *Figure* 12, 64% of publications before UK Space Agency investment into the mission were internationally collaborative, whereas this has now risen to virtually all publications featuring some level of international collaboration.

Figure 12 *Number and percentage of UK authored publications which are internationally collaborative*



In the analysis period, **UK authors have collaborated with researchers from a total of 26 countries**, up from 7 in the baseline. These trends are largely driven by collaborations within the Comet Interceptor consortium, but also includes collaborations beyond it. For instance, collaboration with the USA includes developments on the MIRMIS instrument from NASA Goddard,



as well as complementary science and engineering publications by researchers in the USA who are otherwise uninvolved in the mission (e.g. investigating relevant coma compositions), indicating early wider interest. In the baseline, **the key collaborating countries were USA, Spain, and Finland**, followed by Italy and Germany, and Estonia. In the Analysis period, **Italy was the most common collaborator**, followed by France, the USA, Sweden, and Finland. Japan and Spain have also collaborated with UK researchers in the analysis period, but have narrowly missed out on this list. These trends indicate ongoing collaboration in publications relating to instrument development, e.g. between the University of Oxford, VTT Technical Research Centre of Finland and University of Helsinki on the MIRMIS instrument, as well as preparatory science collaboration between the University of Edinburgh (and historically, UCL), with Italian institutions such as the University of Padova.

Figure 13 *top 5 collaborating countries with the UK by number of co-authored publications*

	Baseline		Analysis	
	Country	**#**	**Country**	**#**
1	USA	**4**	Italy	**24**
2	Spain	**4**	France	**21**
3	Finland	**4**	USA	**12**
4	Italy	**3**	Sweden	**11**
5	Germany	**3**	Finland	**11**

Publications can also be used as a proxy for levels of research output, providing a broad indication of levels of relative contribution to the Comet Interceptor mission. Of course, publication trends are likely to fluctuate year-on-year, and as previously mentioned, publications are to date less of a priority to many on the UK project team, such as those who are focused on developing and testing instrumentation. In total, **the UK has produced the 2nd most Comet Interceptor related publications globally**, as UK authors are featured in around a third of all publications. Italy have published the largest share currently, although the UK is marginally behind by just 4 publications. This is likely due to the fact there are 13 Italian scientists within the Science Working team, relative to the 5 (previously 6) UK roles on the mission, despite these being largely leadership positions. While these trends offer useful initial context, the bulk of new scientific discoveries will occur following analysis of the data produced by Comet Interceptor's flyby of a (still to be determined) comet. The UK's prominent position is likely a reflection of UK leadership roles over the mission. However, it will be important to measure how these trends evolve as scientific exploitation of Comet Interceptor mission data unfolds in the years (and even decades) following launch.

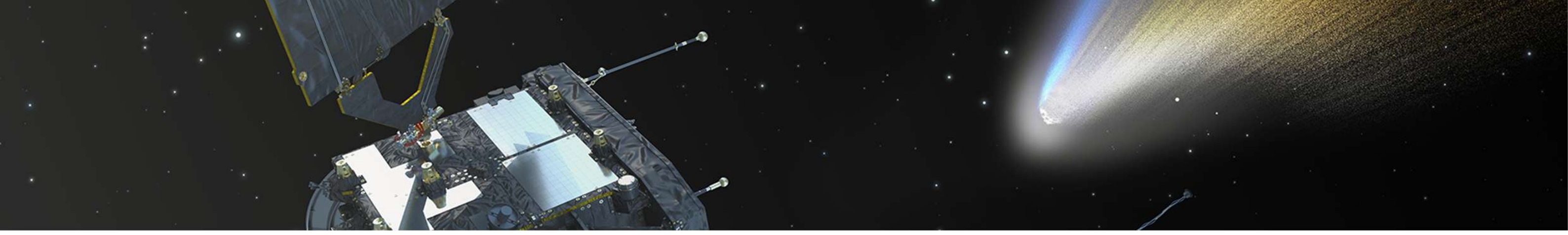
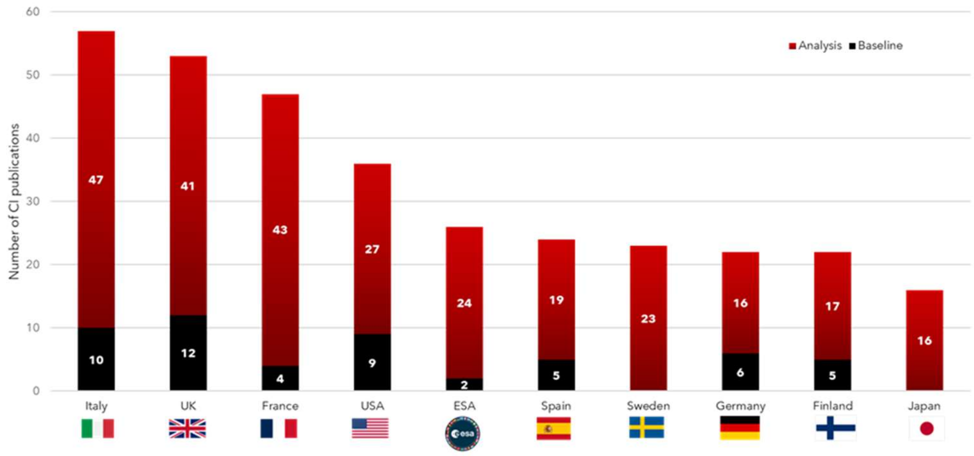


__Figure 14__ Number of Comet Interceptor publications produced per country



In 2025, researchers from **29 different counties** have produced at least 1 Comet Interceptor related publication, compared to 18 countries in 2023, indicating a **growing global interest over the course of our study**. This interest is in-part due to the diversification of research activity related to the mission, as a wider range of organisations (and their collaborators) publish instrument and science working group updates, while other researchers have published findings relating to the LSST search locations and characterisation techniques for potential targets. UK researchers have collaborated with researchers from 90% of these countries, suggesting that UK contributions are playing a significant role in raising the global profile of the mission through co-authorship of research.

As can be seen in *Figure 15*, Europe is, as expected, playing a key role in the generation of Comet Interceptor publications, although there are also contributions from other strategic partners such as the USA and Japan, as well as Chile, New Zealand, China, India, South Korea, Morrocco, and the United Arab Emirates. While this spread indicates potential for broader reputational benefits to the UK beyond the Comet Interceptor consortium, given wider engagement with the mission, publications from these countries are generally limited in number at this stage. Therefore, these trends should be interpreted as initial foundations for more sizeable potential partnerships and impacts when the mission has reached a more mature stage. These partnerships could lead enhanced engagement with (and scrutiny of) mission science, leading to better quality research outputs, potentially enhancing the UK's reputation and leadership over the field, and positioning the UK for future mission roles in similar fields of space science (e.g. future comet or small bodies missions).

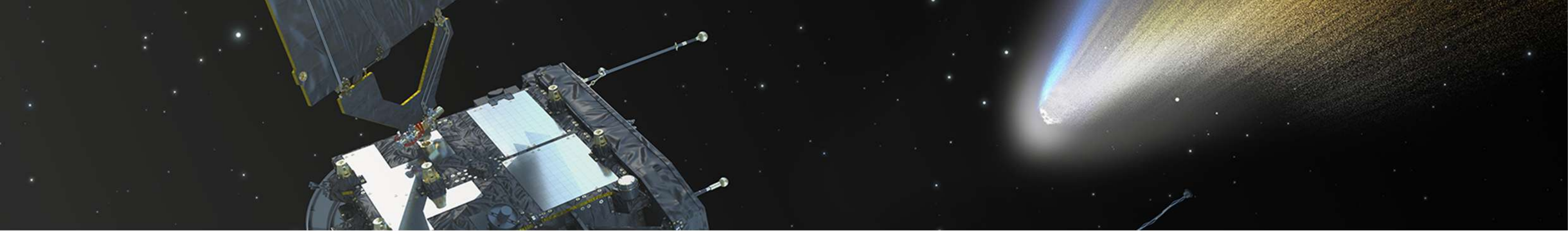
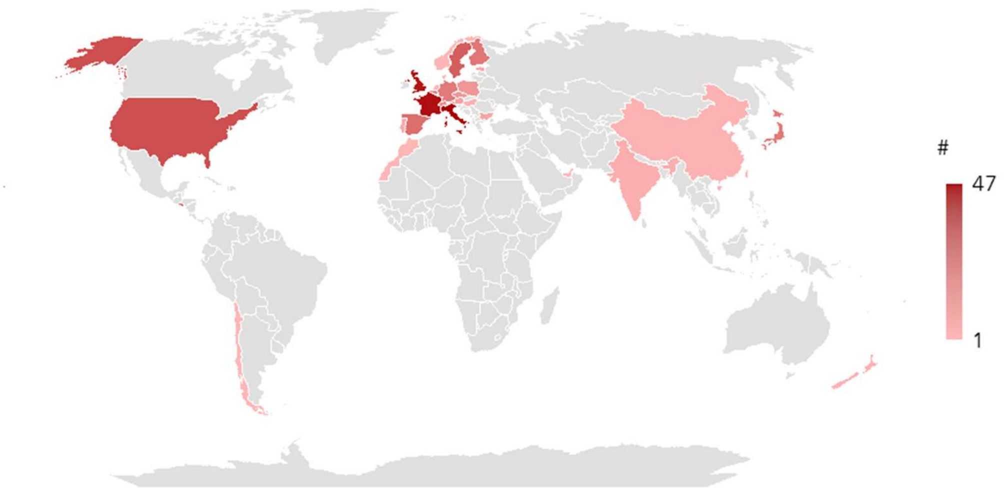


Figure 15 Distribution of Comet Interceptor Publications since 2021



Source: know.space analysis of NASA ADS affiliation data

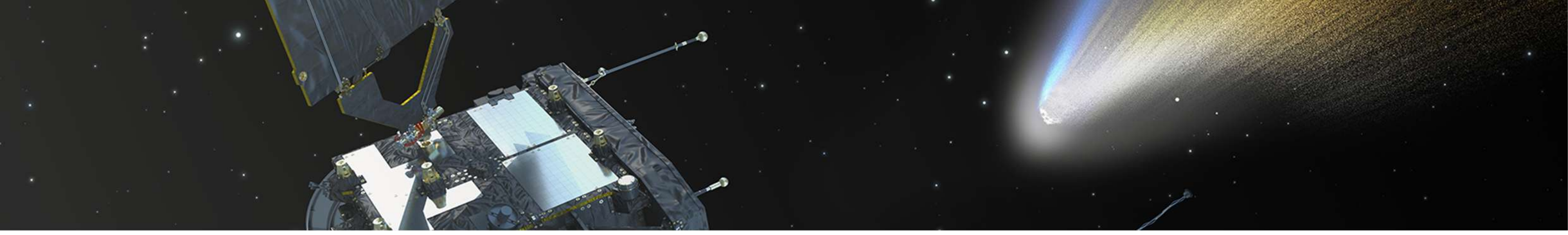
3.2.2 The UK's reputation and influence

As aforementioned, UK leadership roles have been central in initiating the mission, while the IDS role held by Prof. Snodgrass enables the UK to shape the direction of mission science across an international consortium of approximately 90 institutes from 7 countries. However, at this interim stage, there has been little perceived need to divert from the plans and objectives initially laid out in the Red Book for the mission. While this is likely a reflection that the mission is already shaped to UK strengths and interests, stakeholders also cited the importance of scientific involvement over instrument development decisions, ensuring that trade-offs do not significantly influence the science return in the future. We expect to see greater evidence of UK scientific leadership over the mission closer to launch, when decisions on target selection will be made.

The other factor influencing the direction of future mission science is the performance of instrumentation, such as the MIRMIS and Fluxgate Magnetometer (FGM) hardware being developed at Oxford University and Imperial College London. The former instrument will influence future research and analysis of the target comet's nucleus and coma, while the latter will be essential for understanding interaction between the comet's coma and solar wind. Both instruments will therefore be vital for shaping the underpinning data upon which future scientific impacts are based, and hence are strongly shaped by UK technical expertise, and could therefore provide additional evidence of UK competitiveness and leadership.

Reputational benefits are inevitably intertwined with sustained international collaboration and UK influence over the Comet Interceptor mission. Evidence of reputation and influence can arise at both individual and organisational levels, extending to broader aspects such as perceptions of the UK's space science strength, the reputation of UK Space Agency and broader government, and the UK's capabilities compared to international counterparts.

Over the longer-term, UK leadership over the Comet Interceptor mission may enhance the UK's reputation and influence with ESA and beyond, and could be used as a marker for UK space science and instrumentation roles on other missions. We heard from several stakeholders that **delivery heritage from previous successful missions is a key factor in carving out opportunities for future mission involvement**, as they act as a demonstration of UK capabilities and expertise. It is too early to assess the impact of UK Space Agency funding for Comet Interceptor in this regard, as reputational improvements are contingent on successful mission delivery, and future opportunities will take time to unfold. However, fulfilment of mission roles



successfully today **could underpin longer term benefits to the UK space science research community** in the future. Mission roles are often interlinked, and building heritage over time can support future mission roles – for instance, Oxford's MIRMIS instrument is derived from the Lunar Thermal Mapper payload for the Lunar Trailblazer mission, could support additional missions in the future.

At this stage of the mission, we generally find evidence of activities, outputs and outcomes of UK Space Agency funding for the Comet Interceptor mission, rather than the longer term impacts that the funding could support. This is to be expected at this stage of the mission. However, future monitoring will be essential in tracking whether these benefits are realised, as reputation is likely to evolve over the course of a long-term mission. As the only comet mission currently in development worldwide, these benefits could potentially be sizeable in the international cometary science community, and position UK researchers for potential follow-on mission leadership roles.

While there is potential for future reputational benefits, the project team has also identified **potential risks to the UK's reputation** within the consortium and wider research community. Stakeholders stressed the challenge of teams having to deliver hardware to ESA without certainty that their funding will continue beyond March 2025, which is not the case for other participating nations. These risks have been mitigated to some extent through a 6-month bridging grant, which should allow progress to continue in the short term.

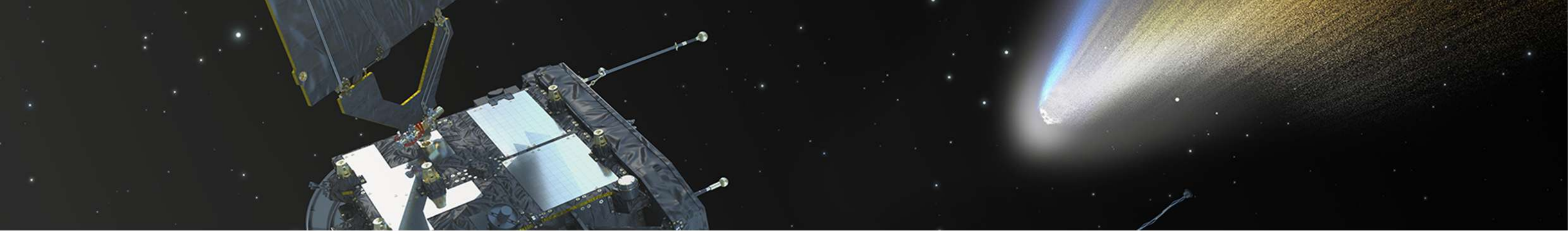
> *"It does not help our reputation when these conversations are ongoing, but there is a level of understanding that each country operates their budgets differently. We are still viewed as a reliable partner in terms of getting things out in time."*

This is part of a larger challenge regarding UK government / UK Space Agency funding cycles, and their misalignment with mission activities, and as such one that gets referenced in many evaluations. However, in the case of Comet Interceptor, UK project team resources are relatively limited, both in terms of Full Time Equivalent (FTE) and headcount, meaning the potential implications of losing key personnel due to unavailability of funding are a concern, as they create **'single point of failure' risks**. Administrative overheads associated with grants were also highlighted as a risk compounded by low FTE dedicated to the mission. This was stressed as a potential barrier to future UK influence and leadership, if lack of funding leads to organisations in different countries (or ESA) having to take on a larger role to fill capability gaps left by UK organisations. Moreover, lack of resourcing can lock project teams into doing the 'bare minimum' to fulfil mission roles, meaning they are unable to explore wider opportunities and potential spillover impacts. While these risks are present, they have not materialised to date.

3.2.3 Counterfactual

In a scenario without UK Space Agency investment, **it is unlikely that we would see the same level of international collaboration and UK influence** over the mission, as these outcomes and benefits are inherently linked to UK leadership roles which were secured as a result of UK Space Agency support. In a scenario where the Comet Interceptor mission was taken forward without UK contributions, the majority of the benefits associated with international collaboration and influence would have been relocated beyond the UK – for example, the IDS roles used to shape the direction of mission science and instrument development may have been assumed by researchers based in other countries.

In a scenario where the mission was not selected, international collaboration between UK authors in scientific publications would likely still occur, albeit not necessarily in cometary science, and perhaps not at the same frequency. Given the top collaborating countries are strongly linked to the



roles on the Comet Interceptor mission, we assess there to be **high additionality between UK leadership roles and co-authorship trends in mission-relevant science, and the international collaborations that are evident within them**.

In absence of leadership roles secured by the UK's investment, there is also a risk that talented researchers and scientists in the UK could relocate internationally to secure opportunities, in turn reducing UK influence and reputation. Additionally, given the UK's key role in developing the Comet Interceptor mission concept, there could have been a reputational hit to the UK if it had withdrawn support for the mission.

3.2.4 Conclusions

There have been limited competitiveness, reputation, and influence-related impacts to date, as to be expected at this early stage of the mission. To the extent that emerging benefits have materialised, these impacts are highly additional to UK Space Agency national investment in the mission.

The Comet Interceptor mission is inherently international, and has been led by UK researchers since inception. UK Space Agency's national contribution has helped to secure both scientific and technical leadership roles over the mission, **contributing to early signs of influence, with limited impact so far**. Generally, progress has unfolded as envisaged in line with the original scientific objectives, with limited requirements for Prof. Snodgrass to shape the mission in a different direction – although he is well placed to do so if/when this is required. Early signs of UK reputation are beginning to unfold as the mission progresses, though **future improvements are contingent on successful delivery of mission responsibilities**. It will therefore be important to monitor how reputation evolves over the duration of the mission. Below, we assess preliminary performance against the evaluation questions of this study, to assess progress against UK Space Agency's strategic objectives at this interim stage of the mission.

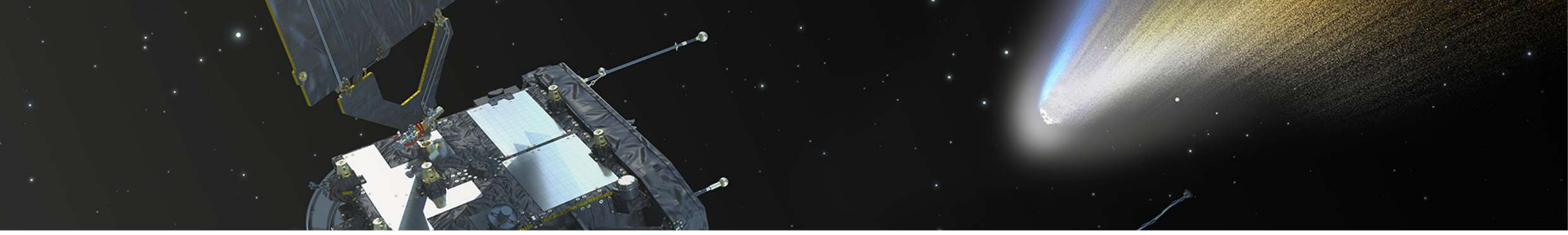
To what extent has the UK Space Agency investment in Comet Interceptor led to a greater quantity or quality of international collaborations and partnerships?

Comet Interceptor is a highly internationally-collaborative mission, as demonstrated by author affiliations, but also by the number of countries represented across the working groups and instrument leads. Within this international consortium, the UK continues to maintain strong influence. UK academics are releasing publications and maintaining key roles, helping to enhance the global visibility of the mission. UK universities are also key in ongoing instrument assembly, integration and testing activities, where they have collaborated internationally with organisations in countries such as Finland and Poland.

As measured by publications, the UK remains a significant country in producing Comet Interceptor research, alongside France and Italy. Only Italy have (just) produced more publications than the UK, which is likely due to the strong presence of Italian researchers across the Comet Interceptor working groups. The UK continues to collaborate with a wide range of countries, most closely within the consortium, but also with other key space players such as the US.

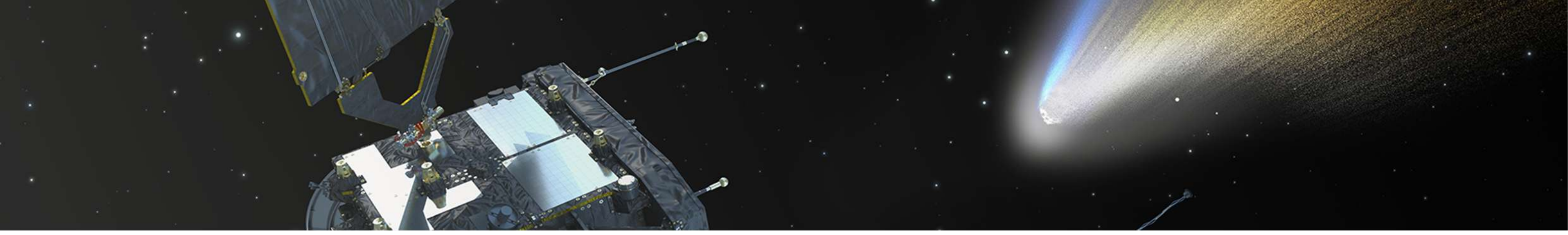
To what extent has UK Space Agency's investment led to enhanced reputation and influence of UK space and research institutions?

Promising early progress has been made in enhancing the UK's reputation and influence on the mission, through ongoing instrument development and qualification activities. Although as discussed, this could change quickly depending on future delivery. While stakeholders have reflected positively on the UK's reputation to date, uncertainty over long-term funding has been cited as a key risk, as provision of hardware to ESA could be affected by the loss of key members of



staff due to unavailability of funding, which have created ‘single point of failure’ risks across project teams with relatively low FTE dedicated to the mission.

Another risk to UK influence identified in previous reporting was Prof. Jones’ withdrawal from the mission to pursue a role at ESA as a project scientist on the ESA BepiColumbo mission. However, there is limited evidence to suggest that losing a second IDS slot has reduced UK influence over the mission, given Dr Colin Snodgrass has maintained his key roles and consolidated some of the mission activities that were once shared. Overall, there is promising early progress in enhancing the reputation of the UK project team, although there is still a long way to go, and broader reputational benefits are likely to unfold on longer timescales if progress unfolds as envisaged, and key risks do not materialise.



3.3 Skills and Inspiration

A long-term goal of UK national investment into Comet Interceptor mission is to inspire and upskill the UK's space talent pipeline. UK Space Agency aims to leverage the profile of Comet Interceptor, alongside the Ariel rideshare mission, to attract and retain talent in the UK space sector, strengthening human capital and capabilities in the space sector.

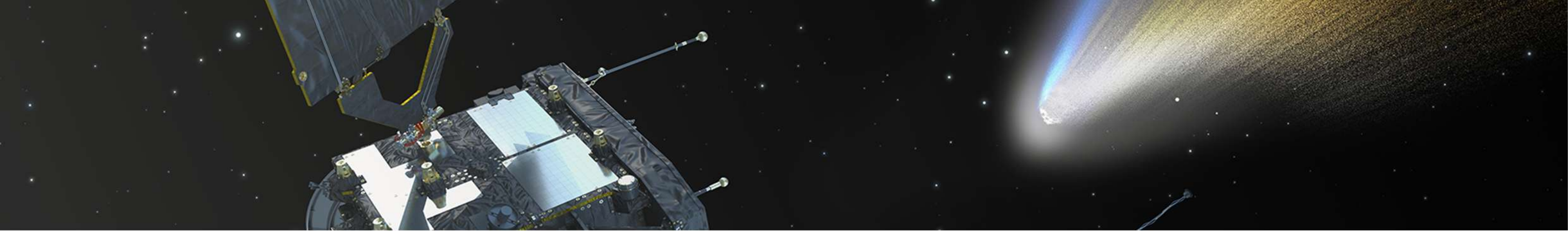
> *"Presenting at conferences has been key in getting awareness of the mission out there for the wider community."*
>
> *"These roles are giving people access to the inner workings of a space science mission for the first time, giving them experience interacting with ESA and international partners, and the project management side of things."*

Summary of key findings

- **At this early stage of the mission, we see early progress against UK Space Agency objectives of inspiring, attracting, and retaining talent to upskill the UK workforce, alongside potential barriers to some longer-term benefits.** We are primarily assessing activities and short-term outcomes at this stage. However, there are emerging signs of early upskilling impacts, and it will be important to track how these evolve in the future. Future progress against this evaluation question will depend largely on whether these risks materialise, or are mitigated through effective knowledge transfer.
- **The UK project team has conducted outreach and engagement for a broad range of audiences, which each have a purpose.** They have delivered 45 events since 2021, spanning 13 countries across 4 continents. Around two-thirds of these are for a professional audience, but others are targeted at families and school pupils. These could attract and inspire broader skills development in the UK over the long term.
- **Direct project team upskilling is evident, across both technical and project management aspects of the mission.** These skills could have longer-term benefits of addressing skills gaps and enhancing UK competitiveness for future missions, although salaries and short-term contracts have been cited as key barriers to realising these longer-term benefits.
- **Additionality to UK national funding is context-dependent with these emerging impacts.** There is an indirect link to UK Space Agency funding for the emerging impacts of outreach activities, which are not always directly supported by UK Space Agency, but benefit from UK leadership roles over the mission. Upskilling of the project team is directly attributable to UK Space Agency support.

3.3.1 Conferences, outreach and public engagement activities

UK project team members have participated in and hosted various events and keynote speeches, to generate wider interest in the Comet Interceptor mission across a range of audiences. We may be underrepresenting the number and breadth of engagement activities undertaken by the project team, as these are **best estimates from information available to us** through interviews, project team reporting documentation, online sources, and Researchfish (see annex for more detail on evidence sources). For example, it is unlikely that our figures capture all university open days undertaken throughout the study where Comet Interceptor may have been mentioned.



Across the project team, we have identified at least **45 public engagement activities** undertaken by the project team since 2021[15], including at least 4 events in the last 6 months.

At least **45 public engagement** activities undertaken by the Comet Interceptor project team since 2021

Includes workshops and conferences in **13 countries**

Engagement includes a **range of audiences**, including academia, industry, students and families

Approximately **two thirds of these engagement activities have been to a professional audience** (academic and/or industry staff), where the UK project team has travelled internationally to space science conferences and workshops to raise the profile of the mission. While the majority of conferences have been in the UK, **in-person keynote speeches have also been delivered in four continents** – Europe, North America, Asia, and Africa. Examples of notable technical conferences attended by the UK project team over the course of our study include:

EGU General Assembly, Vienna (2024)

The General Assembly of the European Geosciences Union attracted 21,000 registered attendees, of which 18,400 were in person (including researchers and scientists from 116 countries), covering Earth, Planetary and Space Sciences. There was significant UK representation, as the Edinburgh, Imperial, UCL, and Oxford all attended and presented Comet Interceptor updates alongside the University of Northumbria (who are in the consortium).

IAU General Assembly, South Africa (2024)

The International Astronomical Union General Assembly was held in Cape Town, attracting over 2000 in-person participants from 109 countries. Prof. Snodgrass presented an overview of the Comet Interceptor mission within the planetary science session, to an audience of hundreds of people in-person and online.

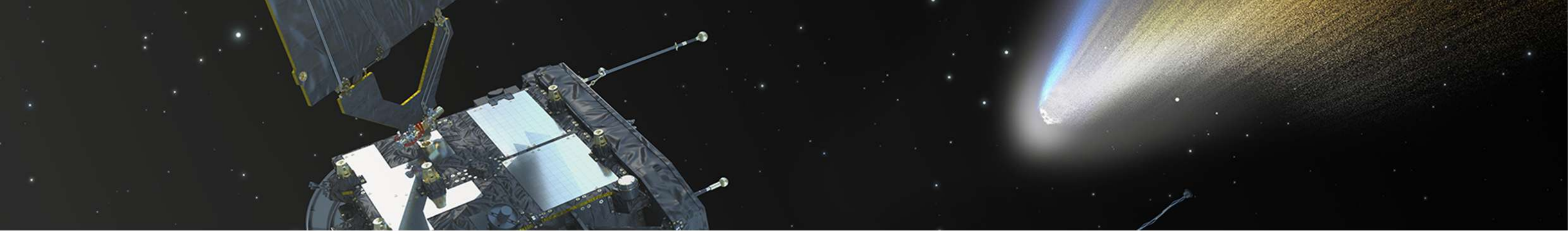
COSPAR Scientific Assembly, Korea (2024)

The COSPAR Scientific Assembly in Korea attracted approximately 3000 participants from across the world, and was attended by Oxford project team members. The Comet Interceptor mission was also presented in day sessions by researchers from Italy, Poland and ESA.

These are not solely attributable to the UK Space Agency's investment, as the national contribution does not explicitly fund outreach events. However, the scientific and technical leadership roles on the mission have allowed the UK project team to disseminate updates on their mission progress to the wider space science research community. Recommendations on how to support benefits realisation around outreach and engagement activities are provided in section 2.3.

For professional audiences in industry and academia, these engagements generally **highlight the mission's scientific and technological progress and objectives**, fostering potential collaboration networks within the space science community, and showcasing UK capabilities internationally. This could strengthen the UK's position in securing future space science mission roles. Meanwhile, outreach efforts aimed at the general public, including young students and families, aim to **inspire**

[15] We note the project team undertook activities earlier than 2021; however, we have not counted before the analysis period.



curiosity about space exploration and encourage the next generation of scientists and engineers, which could have long-term benefits in building a stronger pipeline of STEM skills in the UK.

> *"It has been great to demystify science to pupils at school, and show them potential role models. It reminds you of the interest and enthusiasm that space brings to people."*
>
> *"As a young woman working in space science, it is really important to be present as a human being, and potentially inspire others. One young girl was surprised that a woman in a dress could also be a scientist."*

Examples of key outreach activities undertaken by the UK project team include:

Imperial Great Exhibition Road Festival, London (2022, 2023, 2024)

The Great Exhibition Road Festival is a free annual event in South Kensington run by Imperial College London, the Natural History Museum, the Science Museum, the V&A and the Royal Albert Hall, which is regularly attended by around 50,000 visitors. While visitors such as secondary school students and families attend for many reasons, the project team have created interactive games and stands (such as 'catch a comet' and 'encounter with a comet') for visitors to learn more about comets and cometary auroras.

Imperial Lates, London (2022, 2023)

The project team from Imperial College also run a targeted after work event for local people and families. Comet Interceptor stands have been part of space-themed events, which are hosted for audiences of hundreds of members of the general public.

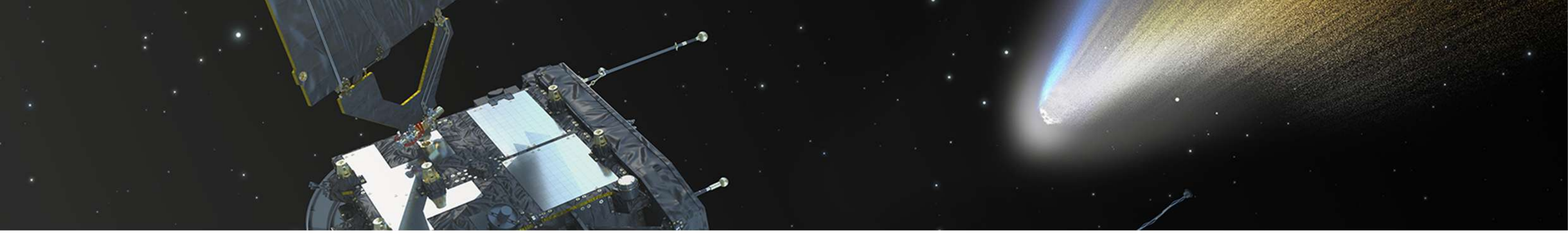
UK Astronomical Societies: Flamsteed, Lewes, Newbury, Farnham, South Cheshire (2022, 2023, 2024)

Project team members have also attended various Astronomical Societies across the country, giving invited talks to smaller, more targeted audiences of amateur astronomers across the country, raising awareness of the mission and its objectives to the informed general public.

These outreach and engagement events have reached a wide range of audiences, potentially reaching **approximately 230,000 people**[16]. For context, this does not represent the true number of people spoken to, or the number of people 'in the room', but rather the number of participants and attendees at the events in which there was representation from the UK project team.

However, the *nature* of engagement activities is at least as important as their *number*. For instance, smaller but more targeted outreach activities (e.g. visits to secondary schools to give talks) risk being lost in the noise of this indicator, amidst participation at larger events. Both types of engagement activity offer value in terms of potentially inspiring and raising awareness of the Comet Interceptor mission, and audience size alone should not be interpreted as potential impact.

[16] *Audience sizes are derived from desk-based research of online event materials, supplemented by project team estimates where available. In cases where participant/attendee information was not available, we provide conservative estimates.*



3.3.2 Skills development and career progression

Technical skills development in the project team

UK roles on Comet Interceptor have also provided a pathway to develop high value-added technical skills which are essential to support mission delivery. These skills are often, although not exclusively, developed by early career researchers, as the high existing heritage of instrumentation required for F-Class missions have limited scope for developing new technologies, meaning more senior staff are primarily leveraging 'tried and tested' techniques. However, for early-career researchers, Comet Interceptor has provided individuals with **the opportunity to work on a space mission for the first time**.

These roles provide a key route to upskilling, supporting a future pipeline of space scientists and engineers to **develop skills which can be taken forward to other space missions throughout their careers**. For instance, computing and 3D modelling techniques, systems engineering, FPGA firmware code development, and soldering are key skills which stakeholders have credited UK Space Agency investment into Comet Interceptor as developing. These roles have supported early career individuals to spin-in to the space sector, primarily by progressing through academia, but also hiring staff from space companies, as well as less directly-related fields.

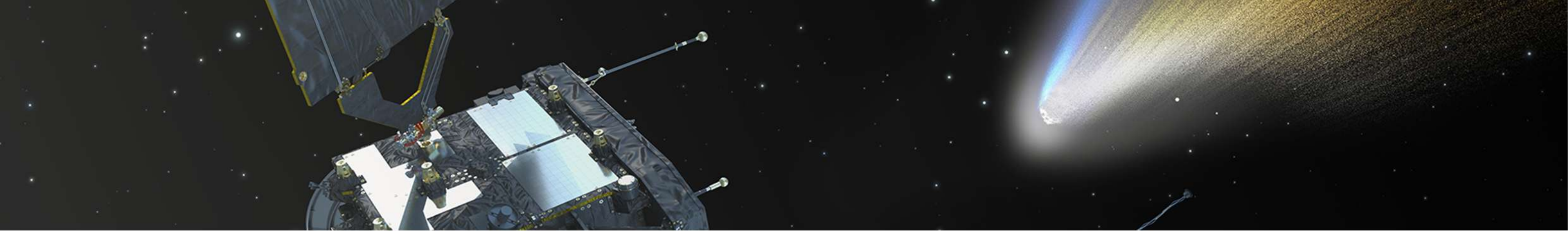
> *"I have learned computing and modelling techniques through preparatory work for Comet Interceptor, which are very transferrable to other aspects of space science."*
>
> *"We hired someone who was previously in admin as a temporary personal assistant, and she is now doing small component work, supporting assembly of the instrument."*

Project management and coordination skills development

As Comet Interceptor is the first ESA F-Class mission, there have been **team-wide learning opportunities from a project management perspective** since the inception of the mission. UK project teams have had to manage the interface with ESA management as well as interactions with wider consortium partners, as well as risk, schedule and budget management over the mission. These skills have been developed across all UK organisations, including for those in senior management roles as well as early career researchers.

> *"It has given me a key understanding of the work required to plan and initiate a mission, and I have a better understanding of how current research gaps can feed into future missions."*

For instance, Prof. Snodgrass has leveraged UK Space Agency funding to hire a postdoctoral research assistant to support delivery of the mission. While in the coming years her role will include work on the Large Synoptic Survey Telescope (LSST) to identify suitable targets, her current responsibilities are to support Prof. Snodgrass in managing progress across the consortium. She is helping to organise working group meetings, support with grant management, and may support outreach and engagement initiatives at the University of Edinburgh, all while gaining crucial exposure to ESA processes. Alongside development of technical expertise, these hands-on project management stills could position early career researchers with **the relevant experience for future Principal Investigator roles** on other space science missions.



UK leadership roles have also developed skills in knowledge transfer and collaborative project management, as UK instrument leads have worked closely with overseas teams that have varying levels of space mission experience. They have **provided guidance and practical expertise to newer contributors**, helping them to navigate mission-critical processes in instrument design and development, and ensuring contributions align with the stringent engineering and scientific mission requirements. This proactive approach to mentoring and collaboration reinforces the UK's position as a leader in international scientific partnerships and lays the groundwork for future large-scale missions with a broader network of contributors.

> *"Our partners are learning a lot from us. Moving from CubeSats to bigger space missions has been tricky for them, and we are helping them to stay on track."*

Attraction, retention, and career progression

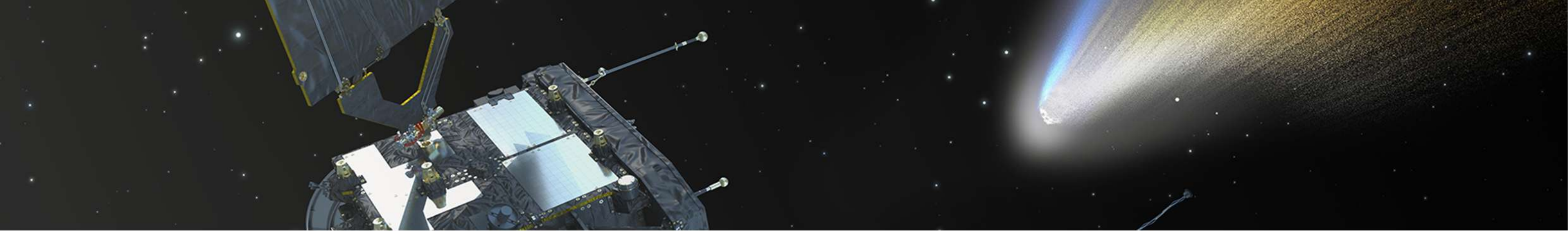
There **are approximately 10 individuals currently working across the UK Comet Interceptor project team**, including permanent staff, postdoctoral researchers, PhD students, and engineers. Across the funded organisations, UK-based teams feature balanced levels of experience, with evidence of a pipeline of new staff members coming through, which will be essential for supporting future scientific exploitation on the mission following the flyby. Stakeholders have cited the Comet Interceptor mission as a factor in **attracting talent into the UK space science ecosystem,** for the organisations involved in the mission.

> *"Comet interceptor is definitely a draw in terms of recruitment."*

Over the longer term, this could support the pipeline of researchers working on the mission for years to come. We heard how exposure to real-world mission challenges provide highly specialised technical expertise and heritage which is otherwise difficult to obtain, equipping the next generation to drive future space science or commercial opportunities. Investing in early-career talent **not only strengthens the workforce but also enhances national and international competitiveness, with potential for spillovers to other sectors of the UK economy**.

However, the UK project team have also raised risks which are working in the opposite direction, and pose as barriers to the realisation of these longer term benefits. The project team generally felt their organisations could not offer competitive salaries relative to the private sector, and some apprentices have transitioned into industry roles for this reason. Moreover, given uncertainty over future funding, some stakeholders have mentioned recruitment challenges associated with short-term fixed contracts, and at least two members of staff have relocated to the US. While staff are motivated by a range of incentives, and knowledge spillover between academia and industry can have additional benefits for the UK space sector, retention challenges **could introduce potential for disruption to long-term mission progress, and could lead to skills gaps in project teams**.

> *"The benefits of working on Comet Interceptor are limited by uncompetitive salaries relative to industry."*
>
> *"We have brought on someone with UK Space Agency funding. However, this funding will technically only last 9 months. Our expectation is that UK Space Agency will fund the role for 2 years, and she can stay*



for longer, but the university will be underwriting these costs in the meantime."

3.3.3 Counterfactual

Without UK Space Agency support for the mission, **project team outreach and engagement activities are unlikely to have materialised to the same extent**, especially where the UK project team has been invited to give keynote speeches relating to the mission. The project team may have continued to conduct outreach and engagement activities, although they would have evolved with a scope and direction different from the Comet Interceptor mission focus, and may have been limited by reduced financial and technical resources. Many public engagement activities were not directly funded by UK Space Agency, so while they are attributable to an extent, **this is an indirect link to the UK Space Agency national contribution**.

It is likely that skills would have evolved in different directions without UK Space Agency support for the mission. However, UK Space Agency support has exposed UK project teams to new challenges and opportunities inherent with delivering a complex international space science mission – as well as learning the requirements of a new 'F-Class' type of mission. **Enhancements in project management and coordination skills are unlikely to have materialised to the same extent absent from UK leadership roles over the mission**, which were secured due to the UK Space Agency's national contribution to the mission. While technical skills could have been developed in absence of funding, it is uncertain whether alternative opportunities would have been comparable in scope.

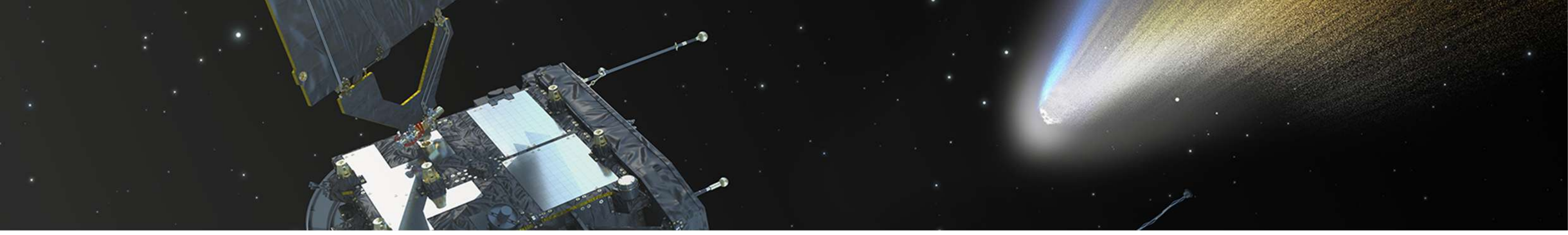
3.3.4 Conclusions

At this early stage of the mission, we see **early progress against longer-term UK Space Agency objectives of inspiring, attracting, and retaining talent to upskill the UK workforce, alongside potential barriers** to some of these longer-term benefits. As with other routes to impact, we are primarily assessing activities and short-term outcomes at this stage. Nevertheless, there are emerging signs of early upskilling impacts, and it will be important to track how these evolve in the future, and to understand the extent to which potential barriers materialise. Below, we assess performance against the evaluation questions of this study, which were developed to track progress against UK Space Agency's benefits realisation objectives.

Beyond the project team, there is also evidence of wider conference, outreach and engagement activities, which have the potential to raise the profile of the mission, and could sow the seeds for broader skills development in the UK, although it is too early to see tangible evidence of this. Outreach events have the potential to inspire the next generation towards pursuing STEM subjects and careers within the space sector and could address broader skill gaps in high value-added roles in the UK economy.

To what extent has the UK Space Agency investment in Comet Interceptor helped develop the future talent pipeline through inspiration effects?

The UK project team have undertaken a breadth of outreach events, including presentations to a technical audience, as well as initiatives for school pupils, families and the general public. The breadth of engagement activities is notable, and **could underpin future benefits for the space talent pipeline, although it is ultimately too early to see these routes to impact emerging yet**. These events are not directly funded by UK Space Agency, although they are indirectly linked to the extent that UK leadership roles on the mission have been promoted. Additionality to UK Space Agency investment specifically is context dependent, though **key mission roles may have had a**



'stamp of approval' effect, whereby project team members have delivered talks which may not have happened in absence of their roles on the mission (e.g. keynote speeches).

The number of outreach events is still relatively low (less than 50). The UK project team have flagged that it is challenging to carry out these types of events when their FTE resourcing on the mission is so low – they do not have capacity to carry out non-critical activities. However, the mission is also several years from launch, where we would expect to see more 'awareness-raising' work be carried out.

To what extent has the UK Space Agency investment in Comet Interceptor helped attract talent to, and retain talent in, the UK workforce (e.g. national, from overseas)?

The Comet Interceptor mission has supported approximately 10 people, with varying levels of FTE time spent on the mission. **It has been cited as a draw for recruitment and retention of talent** in the UK space talent pipeline, at least for those organisations involved in the mission. However, to note that this is a small group of people within the wider sector, and hence will not have a large impact in the shorter-term. Over a longer period – especially post-launch, once scientific research is underway – we would hope to see further links between Comet Interceptor and recruitment of talent within this field of research. Thanks to UK leadership on the mission, the would be to have the UK positioned as 'the place to be' for cometary science, but we do not see strong evidence of this happening yet.

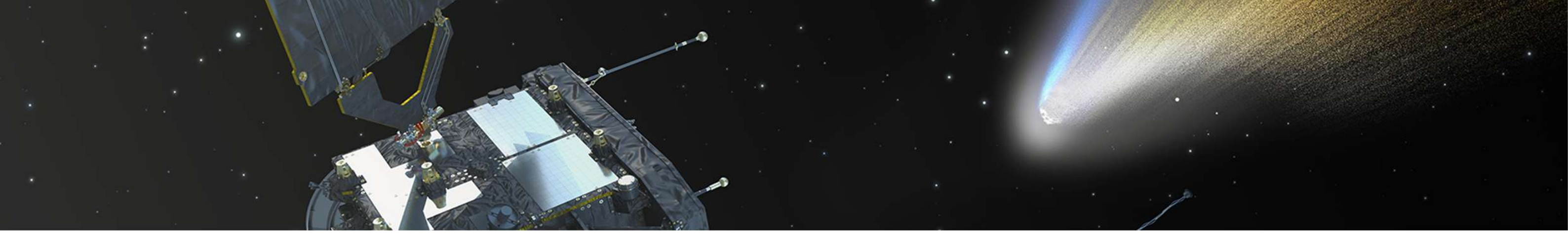
Furthermore, uncertainty over future funding (especially regarding those on fixed-term contracts) and uncompetitive salaries relative to industry have been cited as **challenges working in the opposite direction**. There has been evidence of project team members pursuing other opportunities, most notably Prof. Jones and Oxford's project manager, but also other more junior apprentices and engineers. While turnover should be expected on long-term space science missions, this could be interpreted as early signs of barriers which could prevent the long-term attraction and retention of talent in the UK – although individuals are motivated by a range of incentives.

Have individuals directly involved in Comet Interceptor (e.g. MSc, PhD, post-docs, mission delivery team) seen tangible skills improvements as a result of the mission?

Across the project team, **there is good evidence of direct technical and project management upskilling**, with the mission providing a key route to entry into space missions for several early-career scientists and engineers. While skills may have developed in a different direction absent of UK Space Agency funding, we assess these direct upskilling opportunities as highly attributable to the UK's national contribution to Comet Interceptor.

Roles on the mission have enabled the project team to develop technical skills in computing, modelling, systems engineering, and software engineering. These are tangible near-term impacts which could have longer-term benefits, as the **skills developed today can be taken throughout the future careers of those working on the mission**. While the size of the project team is relatively modest, skills are being developed in priority areas of the broader UK space sector, such as systems engineering and digital and data skills – which could have some benefit in addressing skills gaps in areas for which space companies have struggled to recruit.[17] The team are also developing crucial project management and coordination skills, in order to deliver roles and responsibilities on the mission. This has involved interactions with ESA management and the wider consortium, as well as enhanced knowledge in budget and schedule management, which are all skills required for **future Principal Investigator roles on other space science missions**.

[17] Space Skills Alliance, know.space, 2023. *Space Sector Skills Survey 2023*. Available at: https://assets.publishing.service.gov.uk/media/650078401886eb0013977223/Space_Sector_Skills_Survey_2023_final2.pdf



3.4 Innovation

The objectives of UK Space Agency investment into the Comet Interceptor mission are primarily science, collaboration, competitiveness, and skills-based. However, in tracking the breadth of innovative activities emerging from the UK investment into Comet Interceptor, our study has monitored any initial progress against wider UK Space Agency objectives, such as catalysing investment and **supporting the growth of the UK space sector**.

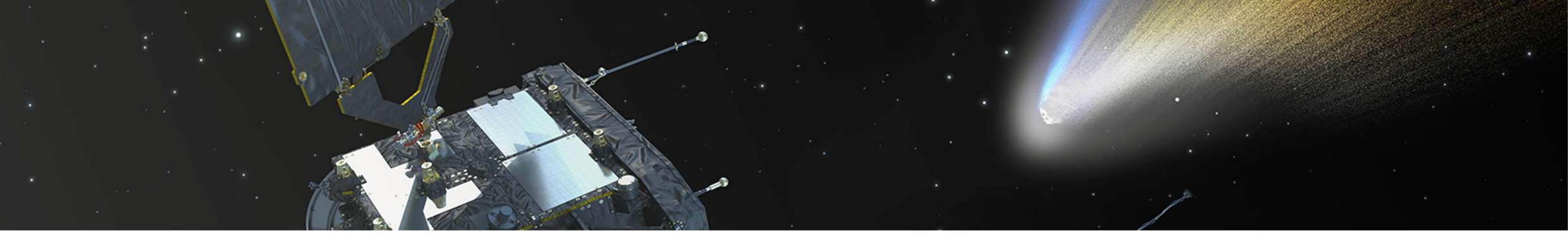
Given potential commercial benefits from space science missions, such as spin-out companies, technology spillovers, product commercialisation, investment and revenues, **these benefits are only expected to materialise on long time horizons**. The scope for radical technological maturation and innovation has also been limited by the F-Class nature of Comet Interceptor, which relies on instrumentation with high existing technology readiness levels (TRL). As mentioned by stakeholders, building on strong in-house heritage was the premise for the 'fast' timeline of the mission.

Summary of key findings

- **As expected, there have been relatively limited commercial benefits associated with Comet Interceptor.** Given the F-Class nature of the mission, the scope for radical innovation is limited. Nevertheless, there have been promising commercial opportunities underpinned by instrument development on the mission, highlighting modest progress against the evaluation question of 'stimulating innovation and commercial opportunities', with the potential for future impacts.
- **The University of Oxford sold £150k worth of filters derived from the design of the MIRMIS instrument to a US company.** These filters could pave the way for further revenue and export benefits in the future. Oxford were able to secure this opportunity as it required minimal additional resourcing – as they were approached for a direct adaptation of the technology from the MIRMIS instrument.
- **There are also early mission opportunities unfolding, where Comet Interceptor is strengthening the case for UK involvement.** Mission opportunities with NASA and US actors are closely linked to prior delivery heritage, although these are preliminary discussions at this stage.
- **Limited resourcing could pose a barrier to future commercial exploitation opportunities.** Mission roles are the current priority for teams, though opportunities for EO applications are being explored – which are currently at an early stage.
- **UK roles on Comet Interceptor are creating procurement opportunities in the UK supply chain for the MIRMIS instrument.** Contracts have been awarded to 11 organisations across the UK to deliver MIRMIS, which could help them expand and support/create employment, although we have limited evidence of this at this stage.
- **Additionality is strong for realised commercial opportunities**. The direct link to the MIRMIS instrument for commercial benefits indicates a close connection to UK Space Agency funding; however, it is also building off previous mission heritage of similar designs. It is too soon to assess how UK Space Agency investment in Comet Interceptor has led to opportunities in other future missions, although some early-stage discussions are underway.

3.4.1 Unfolding commercial opportunities

While any sizeable commercial benefits arising from UK involvement in the Comet Interceptor are only likely to materialise in the longer term, there have been recent developments which indicate a



positive initial trajectory for future commercial benefits attributable to the UK's roles on Comet Interceptor. For instance, the project team at the University of Oxford have sold filters to a US company in FY 2024/25, to be leveraged for an upcoming Mars mission. The technology is a direct adaptation from the systems being developed for the MIRMIS instrument on Comet Interceptor, limiting the resourcing necessary to meet the requirements of the company when they approached Oxford for the technology.

£150k in exports from sales of technologies developed for Comet Interceptor

Potentially laying the foundations for **repeat business** and **follow-on missions**

This opportunity could lead to repeat business for the University of Oxford, as demand for these systems may rise through the implementation of NASA's Mars Exploration Future Plan and NASA's Moon to Mars Strategy and Objectives[18], although these are contingent on future funding decisions. Over the longer term, networks developed through Comet Interceptor and these US-based connections **could lead to future mission roles**, as the project team is currently in discussions around involvement on a upcoming NASA mission, alongside potential future ESA missions such as Lightship[19] and other F-Class and M-Class missions, which are regarded as directly linked to technology development for the MIRMIS instrument, alongside previous activities, such as developing the Lunar Thermal Mapper instrument for the NASA Lunar Trailblazer mission[20]. This highlights the potential for tangible commercial benefits associated with sustained international collaboration in space science missions.

> *"All of these opportunities are flowing out of MIRMIS technology development."*
>
> *"We have a contract with an American organisation which could come to something if they win the bid, and we are involved in bids to look at future missions."*

These developments illustrate **promising early commercial impacts** from UK involvement on the Comet Interceptor mission, with the potential for further benefits outlined in the future. However, we are reporting on short-term trends in a wider picture, and at present impacts are limited in size.

The project team have also highlighted potential barriers to future commercial exploitation of space technologies developed through the Comet Interceptor mission, such as limited resource availability. For instance, the same technologies could be repurposed for Earth Observation purposes, representing further revenue and mission potential. However, to fully capitalise on these opportunities (e.g. through establishing a spin-out company), key project team members would likely have to take secondment from their roles on the Comet Interceptor mission, and given the limited staff on the mission, this was deemed unlikely to be possible at this stage. Other challenges cited were university bureaucracy, and higher than anticipated administrative overheads associated with Comet Interceptor. We discuss measures which UK Space Agency should consider to further

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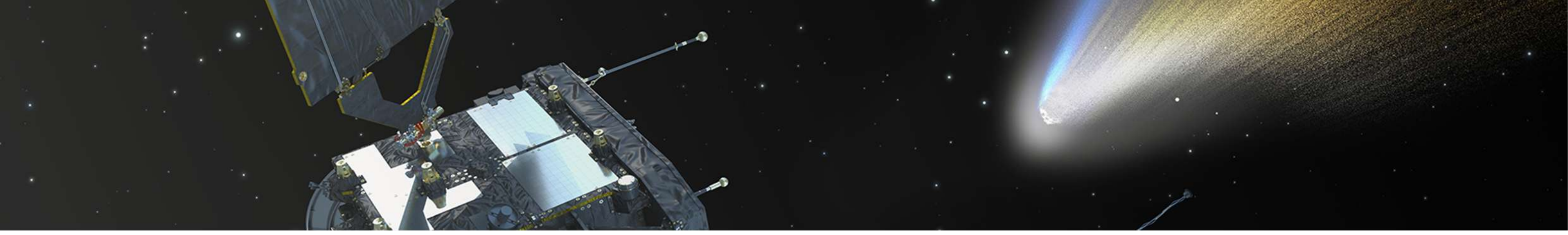
[18] NASA. 2024. *Expanding the Horizons of Mars Science – A Plan for a Sustainable Science Program at Mars*. Available at: https://assets.science.nasa.gov/content/dam/science/psd/solar-system/mars/campaigns/mars-future-plan/20241204_Mars_Future_Plan_Final_Print.pdf

[19] LightShip is an ESA initiative comprising of four parallel studies to define small, low-cost Mars satellite platforms, which will be used to begin investigating full exploration mission concepts in 2026

[20] NASA's Lunar Trailblazer launched in February 2025, and will orbit the Lunar surface in order to detect and map water on the surface.



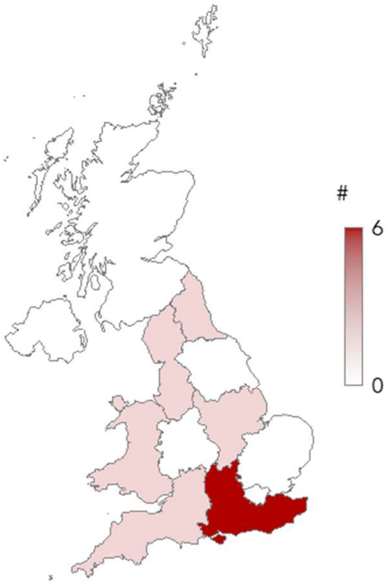
support future benefits realisation relating to commercial impacts in more detail in the process evaluation.

3.4.2 Wider benefits to the UK supply chain

Comet Interceptor funding has also provided additional contract opportunities for UK organisations, who form the wider supply chain for instrumentation being developed for the mission. The Oxford-developed MIRMIS instrument featured contributions from Durham University's Centre for Advanced Instrumentation, the University of Cardiff, RAL Space, and specialist engineers and manufacturers based across the UK, including AC Precision, Micro Systems, Photofabrication, WLR Precision, Ramp, Arcona, and Machtech. Oxford are leveraging a supply chain initially established for the NASA's Lunar Trailblazer mission.

KISPE Ltd were also procured to support with thermal analysis and finite modelling, and this contract has enabled the organisation to spin-in to civil space applications of their services, helping to strengthen the UK space science base and potentially benefitting the broader sector in the long term.

Figure 16 *Regional distribution of the MIRMIS supply chain*

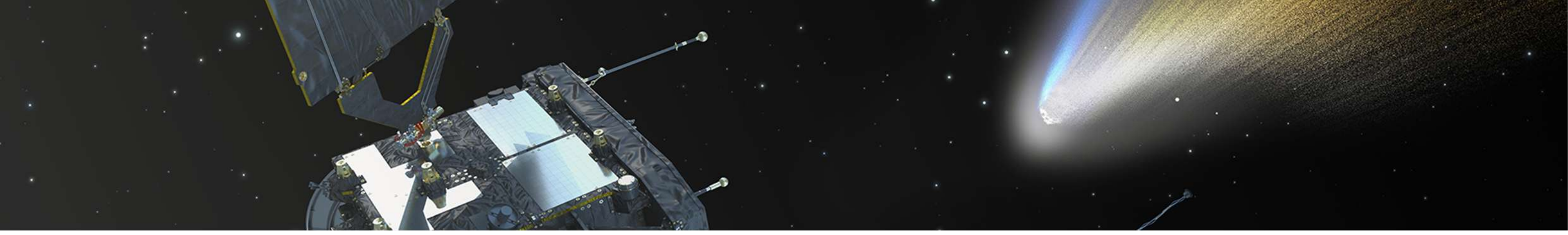


While the value of these procurements are not known, these contracts provide revenue streams to the UK's space supply chain, which could allow suppliers to expand operations, invest in new capabilities, and support and grow their workforce.

3.4.3 Counterfactual

UK Space Agency funding for Comet Interceptor has contributed to some initial modest commercial benefits, with the potential for additional impacts in the future. The exports secured to date are directly linked to technology being developed through UK instrumentation roles, meaning **while these revenues are small, they are highly attributable to UK Space Agency support**.

With respect to future mission roles, we heard from stakeholders that selection for space missions is highly interconnected, with prior delivery heritage a key factor in securing these roles. While roles on Comet Interceptor are likely to strengthen the potential for future involvement, other



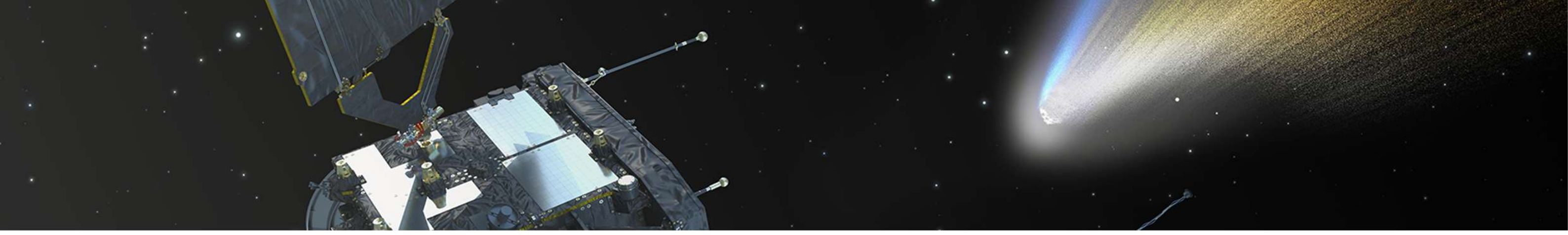
missions, such as the Lunar Trailblazer (or others) are also likely to factor. Additionality is highly context-dependent - although as these are still preliminary discussions, it is **too early to assess the role of UK investment in Comet Interceptor** in this regard.

3.4.4 Conclusions

To what extent has Comet Interceptor stimulated innovation and commercial opportunities?

As anticipated, benefits regarding commercial exploitation of Comet Interceptor have been limited so far, although **preliminary impacts are emerging** which could contribute positively to UK Space Agency's wider objectives of growing the UK space economy. Due to the F-Class nature of the mission, which relies on high maturity instrumentation, technology development under Comet Interceptor has been limited in scope for new intellectual property, such as of proofs-of-concepts, patents, and digital assets.

However, the mission has underpinned small export benefits for the UK, and **could pave the way for more sizeable revenue and export benefits in the future** – predominantly related to the MIRMIS instrument being developed at the University of Oxford. Preliminary discussions are also ongoing for participation in future missions, and it will be important to track how these benefits unfold over time. Future commercial exploitation may be restricted by commitment to mission roles and responsibilities, as project teams have limited scope to pursue spillover applications of technologies. However, opportunities are being identified and could be subsequently exploited in the future. These benefits could also spillover to the wider UK supply chain through procurements.

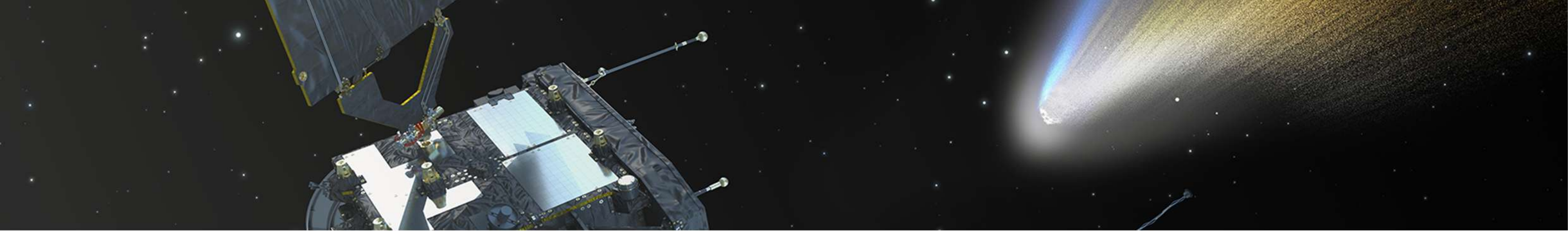


3.5 Performance against impact evaluation questions

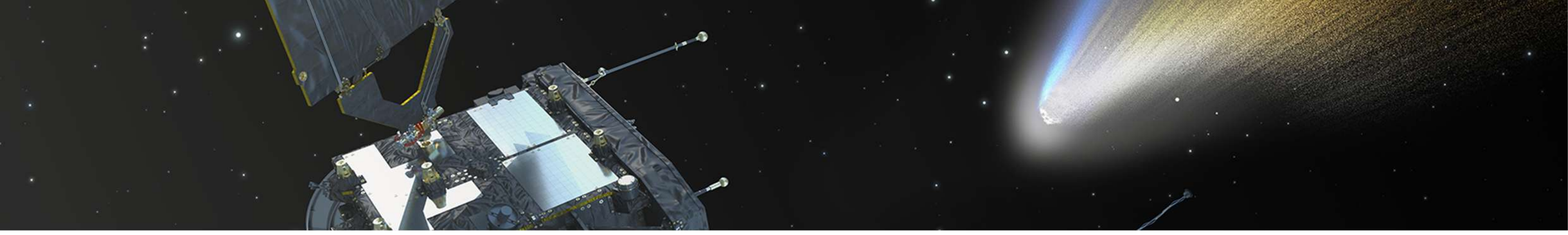
Below, we provide a high-level overview of the impact of the UK Space Agency national investment into Comet Interceptor against the evaluation questions set out in the original M&E Framework. Not all evaluation questions are fully addressed – this is to be expected, since some of the benefits will only emerge in the longer-term, and hence it is too early to capture these in our evaluation to date. We utilise a Red-Amber-Green (RAG) assessment process[21] to provide a high-level summary of performance against each impact evaluation question.

Evaluation Question	RAG rating	Performance
Is the programme on track to achieve its scientific aims, as defined by the UK-led science team?	G	The Comet Interceptor mission appears to be on track to achieve its scientific aims, as expected by this point of the mission – noting it is still several years away from launch. Prof. Snodgrass' IDS role means that he has been able to participate in discussions on instrument design that may otherwise affect the quality of scientific output, and to date there has not been any major concerns raised. However, this is an evolving narrative, as future instrument development and target selection will influence performance and potential scientific return significantly. Steady growth in Comet Interceptor-related research activity, as well as the updated UK-led mission paper indicate preparatory science is going well, and the mission has been progressing through milestones on track, indicating strong initial progress.
What difference has the UK's national investment into Comet Interceptor made to securing UK scientific and technical leadership of comet research, and space science by nominal end of mission?	G	The UK's investment into Comet Interceptor has secured key UK leadership roles within the consortium, which in turn have underpinned UK influence of the mission across scientific and technical elements. The mission has been shaped by UK leadership since its inception, being co-developed by Prof. Jones and Prof. Snodgrass. This has been further enhanced from a science perspective by Prof. Snodgrass maintaining a key IDS role and Chair of the Target Identification Working Group, as well as from a technical perspective by the UK leading on the FGM-B2 and MIRMIS. As measured by publications, the mission has not had a significant influence on the wider field of cometary science to date. This should be expected, as the bulk of the scientific return will immediately follow the comet flyby post-launch – although we would expect to see uptick in publication activity prior to that, especially regarding the selection process and increased attention around launch. While it is too early to assess broader UK leadership over cometary science, Comet Interceptor is the only comet mission currently in development. As publications from the Rosetta mission continue to decline, UK leadership roles on the mission have positioned the UK to be at the forefront of new scientific discoveries in the wider field. However, this is likely to be a longer-term benefit, and there is still a long way to go on the mission before this is realised.
What difference has the UK's national investment into Comet Interceptor made so far in enhancing the reach and reputation of the UK's space sector?	A	There are early signs that UK leadership roles are enhancing the reach and reputation of the organisations involved in the mission, driven largely by international collaboration both within the consortium and beyond. Furthermore, the fact that the mission is both designed and led by respected UK academics has helped lay the groundwork for the UK to position itself as being central to the hub of future cometary science research. We see other UK organisations already starting to publish more research pertaining to Comet Interceptor (comparatively from baseline to

[21] Our Red-Amber Green assessment process includes 5 success categories against the relevant impact evaluation question at the interim stage of our evaluation: **Fully Addressed**, **Mostly Addressed**, **Partially Addressed**, **Minimally Addressed**, **Not Addressed**



Evaluation Question	RAG rating	Performance
		analysis period), whilst stakeholders emphasised that Comet Interceptor was always perceived as a 'UK'-led mission in the wider space sector. However, UK reputation is inherently linked to successful delivery the mission, and it is therefore premature to comprehensively assess improvements in the UK's reputation, since it is an evolving narrative several years away from launch. Furthermore, it is too soon to analyse how the mission has enhanced the reach and reputation of the UK's space sector overall, since this is a longer-term impact narrative.
What difference has Comet Interceptor made so far to inspiring, attracting, and retaining talent to upskill the UK workforce?	A	As illustrated through attendance of conferences, as well as wider outreach and engagement events, the project team are sowing the seeds for wider inspiration impacts, which could lead to longer term benefits for the wider UK space sector. At this stage, we are primarily evaluating activities and short-term outcomes, and it will be important to track the longer-term impacts of these activities in drawing talent to the UK space science research community. There have been tangible benefits regarding the upskilling of project team members, especially early-career researchers, who are obtaining experience on space missions for the first time. The technical and managerial skills enhanced to date could strengthen the UK's competitiveness in future space missions, as well as have positive knowledge spillover impacts to the wider UK economy. Attraction and retention of staff has been mixed, with the mission cited as a key draw, but salaries and uncertain future funding working as incentives in the opposite direction.
What difference has Comet Interceptor made so far in stimulating innovation and commercial opportunities?	A	As expected, innovation and commercial benefits for an F-Class mission are limited by the requirements of the mission, although we have seen preliminary impacts which could underpin more sizeable ones in future. Future commercial exploitation of Comet Interceptor instrumentation is the key route to commercial benefits highlighted to date, and future opportunities (including potential missions) will have to be balanced against resourcing concerns.
How differently have the various stakeholders been impacted by Comet Interceptor?	A	While outreach and engagement activities have had some impact on the general public, engagement with the mission is anticipated to grow around and following mission launch, where more notable breakthroughs are expected, and media coverage could increase. This is a trend seen in other space missions, where wider attention is only seen in the longer-term.
To what extent would observed outcomes have happened in the absence of the UK Space Agency investment?	G	While additionality is context-dependent, many impacts across the four themes are unlikely to have materialised at all, or at least to the same extent without the UK's national contribution to the Comet Interceptor mission. UK leadership roles are a key route to many of the emerging impacts identified in the study, and would not have been maintained without money on the table from the UK national contribution.
What are the key lessons learned from the [impact] evaluation?	A	While this evaluation has highlighted important outputs and outcomes (and some initial impacts), there is a long-term payoff with many more sizeable impacts. It is these sizeable impacts which will contribute the most to fulfilment of UK Space Agency's strategic objectives. There is also lessons for ensuring future evaluations employ a long-term, holistic view of impact. For instance, purely measuring scientific impact of a space science mission risks omitting key strategic, upskilling and commercial benefits which are beginning to unfold on the mission at this early stage. Moreover, these impacts must be tracked fully over the long-term to ensure the full UK return on investment is captured.



4 Annex: Data Collection

4.1 Stakeholder consultations

4.1.1 Interviews

We held semi-structured interviews with members of the project team, building upon the conversations held previously. These interviews enabled us to gather updates on the mission, inform our indicators, and obtain important contextual information regarding their respective roles on the mission. Below is an overview of the **4 interviews** with key representatives we held to inform this report.

Organisation	Role
University of Edinburgh	Interdisciplinary Scientist, Chair of Target Identification Working Group
Imperial College London	Fluxgate Magnetometer (FGM) Lead Scientist
Oxford University	Modular InfraRed Molecules and Ices Sensor (MIRMIS) Lead Scientist
Imperial College London	PhD student

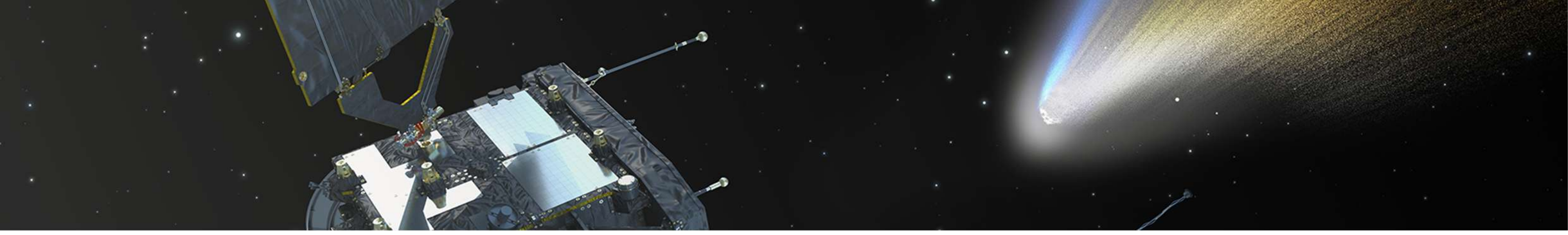
Throughout this report, we also draw upon previous interview insights collated throughout our study. **We have conducted a total of 18 interviews**, including recurring meetings with the above mentioned project team, alongside additional insights from:

Organisation	Role
UCL	Former Interdisciplinary Scientist and Chair of Far Environment Working Group
UK Space Agency	Head of Space Science

4.2 Desk-based research

We conducted additional **desk-based research** to collect data for each iteration of the 6-monthly updates, as well as this interim evaluation. We used two editions of Researchfish data, which was cross-referenced with other data collection, and incorporated into our findings where relevant. While not a comprehensive source of data, Researchfish has been used to highlight activities such as outreach, as well as some of the recruitment challenges that they are experiencing.

Additionally, we had initially included two questions relating to outreach and publications in the monthly reporting documentation (which has reduced in frequency since then, at around every two months). We have cross-referenced this information with insights provided through interviews to prevent double counting of impacts. Other desk-based research was conducted on PMB minutes and slides, as well as online materials and publications relating to the mission, and the UK's contributions within it.



4.3 Bibliometrics

Bibliometrics are a useful proxy measure for the scientific impact that a given mission or activity is having, and have been used to monitor Comet Interceptor publications, which have risen incrementally in number since selection in 2019. We also analyse the wider field of cometary science, which has a longer standing, active research community.

To do this, we have replicated the same keyword search, data extraction and analysis processes that were used to identify baseline figures for the indicators, ensuring consistency in measurement over time. Publications were identified and extracted from the NASA Astrophysics Data System (ADS) database, and supplemented by project team contributions, through Researchfish and reporting documentation.

For comet science, the following search string was used (including a filter for the relevant years):

abs:("comet" OR "cometary") OR ("Rosetta") OR ("Comet Interceptor") Collection: astronomy

For comet interceptor, the following simple search string was used to extract relevant publications:

abs:"comet interceptor"

Additional analysis undertaken to track UK authorship, collaborations and undertake additional altmetric analysis, which is expanded upon below.

4.4 Altmetrics

Altmetrics are a tool that can help identify activity around publications which could demonstrate research impact beyond citations, as articles are often shared, mentioned and discussed in many different forums and contexts. It is not a method to replace traditional citation / citation-based metrics, but acts as a complementary approach to show interest in research that cannot be measured in a citation count.

The Altmetric Attention Score is part of the Digital Science portfolio, and is automatically calculated through the weighted count of all attention a research output has received, based on three main factors:

- **Volume:** score rises as more people mention the article. The weight only counts one mention from each person per source.
- **Source:** each 'category' of mention contributes a different weight to the final score, e.g. newspaper article is weighted more strongly than a blog post, which is stronger than a tweet.
- **Authors:** considers how often the author of each 'mention' discusses scholarly articles, whether there's a bias towards a particular journal / publisher, and the audience they leverage.[22]

It is best used as a way to quickly measure the level of online activity surrounding a particular piece of research output; it is not a measure of the quality of the research or researcher.

In order to capture altmetrics data for our research, we extracted the DOIs of the top 10 cited publications in the relevant period and scope, and ran them through the altmetric.com

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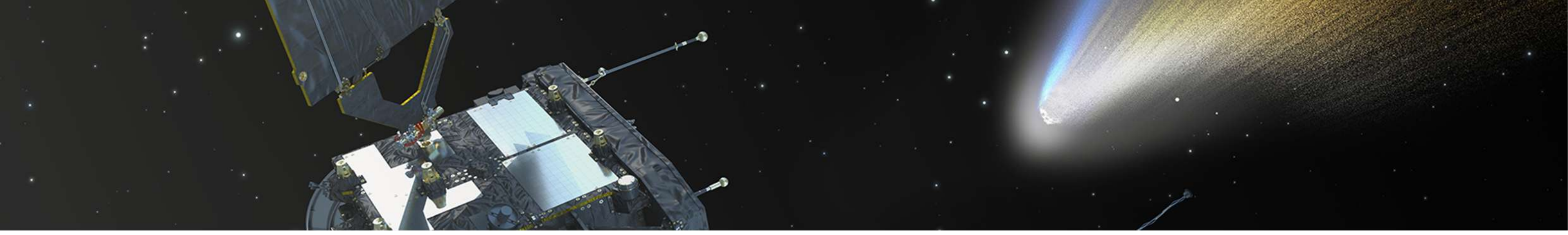
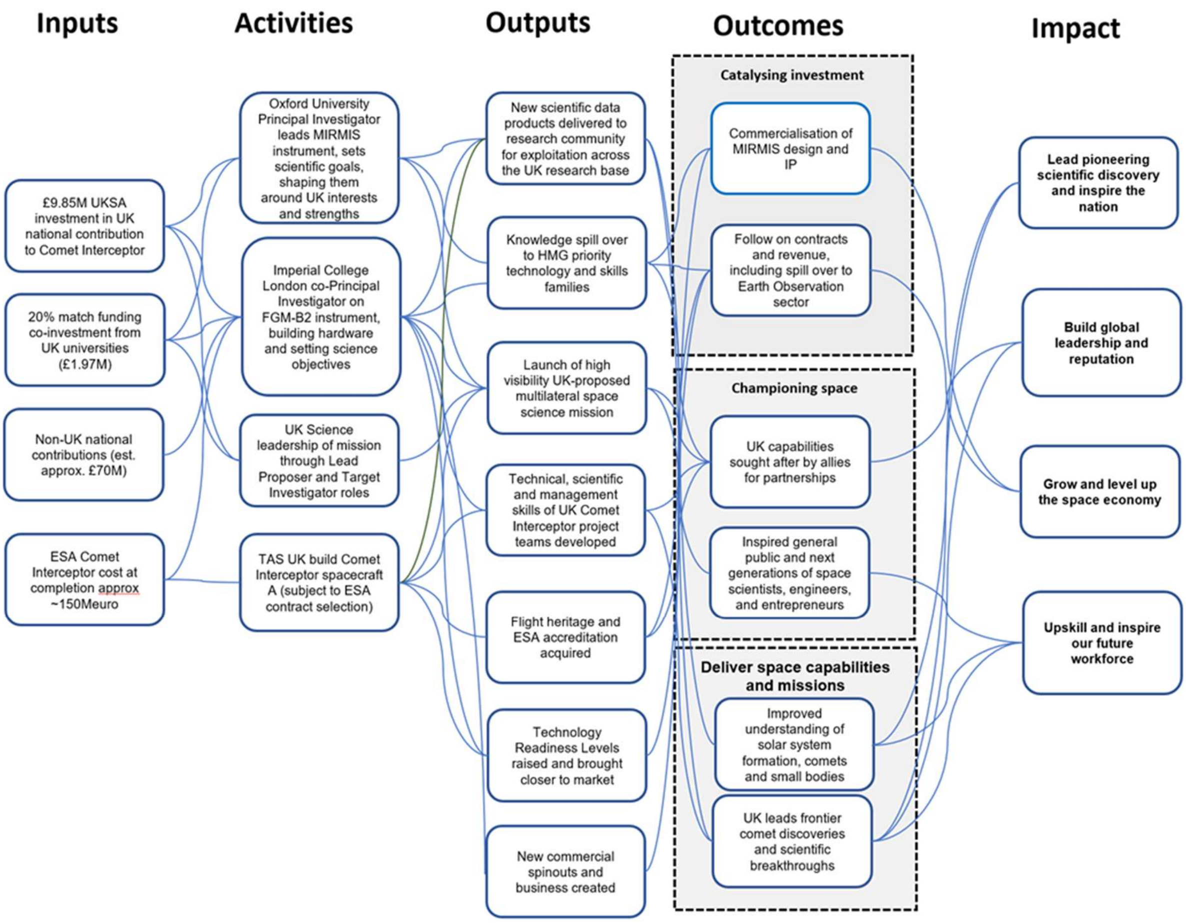
[22] Altmetric Ltd., 2023. *The donut and altmetric attention score*. Available at: https://www.altmetric.com/about-us/our-data/donut-and-altmetric-attention-score/



bookmarklet. This provided us with an altmetric attention score, the number of Mendeley readers, and the rank of the publications within the same journal published in the same three-month period. The bookmarklet also provides us with additional information on the number of news articles, Wikipedia articles, blog posts, and social media posts in which the article is mentioned.

4.5 Theory of Change

Below, we provide the UK Space Agency developed Theory of Change (ToC) which outlines the causal pathway of events from inputs to impacts aligned with the goals and pillars of the HM Government National Space Strategy. We have constructed our evaluation questions and impact categories to broadly follow this logic model, presenting indicator information which provided initial trends which indicate early progress against these longer-term objectives.



...now you **know.**