Science and Technology Facilities Council

RAL Space

RAL Space Highlights Report

2025

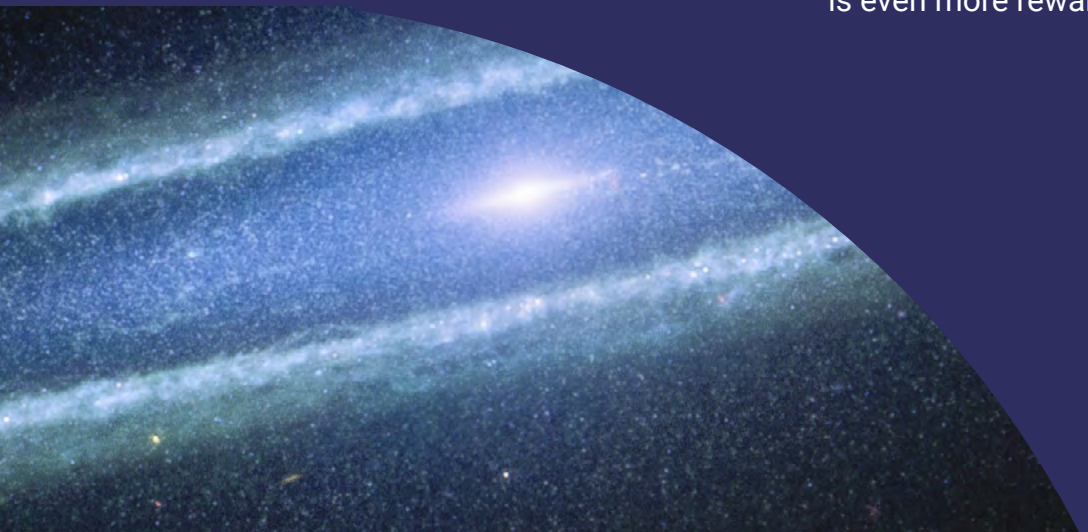
Welcome

As the UK's National Space Laboratory, we are here to tackle the big science challenges and the big societal challenges – delivering the Government's priorities in space. We're here to pioneer technologies and provide the end-to-end capabilities that enable the UK space sector to deliver growth and improve lives. But we're also here to inspire the nation - to make us feel proud of what the UK can achieve.

Rocket launches offer a moment to do just that. And in 2025, RAL Space were proud to be involved with not just one, but eight spacecraft on board five launchers. PUNCH, MicroCarb, MetOp-SG A, MTG-S1, and SpeQtre have all made it into orbit.

This represents decades of expertise, dozens of colleagues waiting with bated breath, and celebrations with partners across the world.

However, launch is just one moment in the life of a space mission. As our Principal Investigator for SpeQtre, the UK's first quantum mission of its kind, says about his launch – that's when the fun begins. It's a huge milestone for us when our bespoke technologies work perfectly and we start receiving data. But seeing the real-world impact as we tackle those big challenges is even more rewarding and inspiring.



The Sombrero Galaxy captured by the Webb Telescope's Mid Infrared Instrument (MIRI). Credit: NASA, ESA, CSA, STScI

This year we:

- Improved resilience for critical infrastructure from space weather through the translation of scientific research and technology development to operational capabilities
- Future proofed transactions in our day to day lives through the development and testing of new and improved communications links
- Enhanced the ability to respond to air pollution events thanks to better monitoring data
- Supported the quest to uncovering mysteries about our place in the Universe by leading international consortia
- Sparked the imaginations and developed the skills of people who are often left feeling that science isn't for them through targeted outreach projects

All of which you can read about in these pages, thanks to the dedication and ingenuity of our community of experts here at RAL Space. We are powering the discoveries that improve our future.

Dr Sarah Beardsley,
RAL Space Director


R100
RAL Space

RAL Space is the UK's national space laboratory, working in partnership with government, industry, and academia to advance our understanding of space and our environment — for the benefit of all.

Based at the Rutherford Appleton Laboratory and Chilbolton Observatory, our 350+ experts work across the lifecycle of space missions:

- Leading early-stage concept studies and innovative scientific research
- Designing and building bespoke instrumentation
- Providing world-class testing and ground-based facilities
- Processing and analysing data

We contribute to groundbreaking projects across Earth observation, space weather, planetary science, and astronomy, working with UK and international partners including ESA, NASA, and the UK Space Agency. As part of the Science and Technology Facilities Council (STFC) and the wider UK Research and Innovation (UKRI), RAL Space plays a central role in shaping the UK's space capabilities.

2025: A landmark year for Earth observation

2025 has been an exciting year for Earth observation, with multiple missions launching that will transform how we monitor our planet's climate, weather systems and atmospheric composition.

RAL Space has played an important role in several EO satellites launched this year – MicroCarb, MetOp Second Generation, and Meteosat Third Generation.

MetOp-SG A1 encapsulated within the rocket's fairing in preparation for launch. Credit: ESA-CNES-ARIANESPACE


arianespace

MicroCarb: Pinpointing Urban Carbon Emissions

Developed jointly by the UK and French space agencies, MicroCarb is Europe's first dedicated carbon dioxide monitoring satellite and the latest addition to the international greenhouse gas virtual constellation – a global network of satellites working in unison to monitor Earth's atmospheric composition.

Orbiting 650km above Earth, MicroCarb uses city-scanning technology to map CO_2 emissions across urban areas at unprecedented 2km x 2km resolution. This precision is crucial for understanding emissions from cities, which are responsible for over 70% of global CO_2 output.

This capability is supported by the satellite's Pointing and Calibration System (PCS), developed at RAL Space. This critical component steers the satellite's view to scan specific locations, whilst maintaining the precision calibration essential for accurate measurements throughout the mission's lifetime.

Following the PCS delivery to Airbus in France in 2020, RAL Space welcomed the entire satellite back to Oxfordshire in December 2022 for its final assembly, integration and test phase.

Working alongside Thales Alenia Space (UK) which led the campaign, RAL Space teams put the satellite through rigorous vibration, shock, and thermal vacuum tests to ensure it could withstand the harsh conditions of launch and space. RAL Space also manufactured multi-layer insulation blankets that protect it from the extreme temperatures faced in orbit.

The first images from Sentinel-4 highlight concentrations of atmospheric nitrogen dioxide, sulphur dioxide and ozone. Credit: European Union, Copernicus Sentinel-4 imagery

MetOp-SG and MTG: Transforming Atmospheric Monitoring

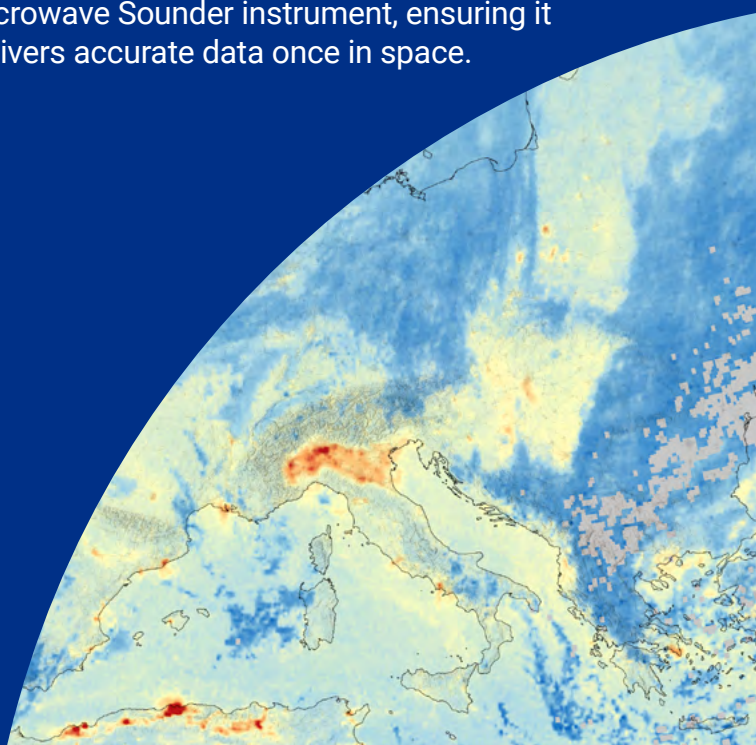
Accurate weather forecasting, climate monitoring and air quality management depend on continuous, high-quality atmospheric data. However, gaps in coverage and measurement capabilities have limited our ability to track rapidly changing atmospheric conditions.

The 2025 launches of Meteosat Third Generation Sounder (MTG-S1, carrying Copernicus Sentinel-4) and MetOp Second Generation (MetOp-SG A1, carrying Copernicus Sentinel-5) represent a leap in Europe's Earth observation capabilities. MTG-S1 is the first geostationary satellite for atmospheric trace gas monitoring over Europe, whilst MetOp-SG A1 is the first of a series of six polar-orbiting satellites that will deliver comprehensive meteorological data for over 20 years.

RAL Space has supported Airbus Defence and Space through thermal vacuum test campaigns for both Sentinel-4 and Sentinel-5, and developed multiple operational data processors for ESA, EUMETSAT and Copernicus.

Beyond Sentinel-5, RAL Space's contribution to the MetOp-SG programme extends to advanced technology and calibration services. These satellites will have increased observational capability with improved sensitivity, thanks in part to state-of-the-art technology developed at RAL Space. 32 advanced millimetre-wave receivers flying across all six satellites will deliver improved atmospheric temperature and humidity data to meteorologists, resulting in more accurate weather forecasts, and better prediction and tracking of extreme weather phenomena.

RAL Space teams also developed the ground calibration system and supported Airbus Defence and Space's test campaign for the Microwave Sounder instrument, ensuring it delivers accurate data once in space.



Over 30 years of CEDA

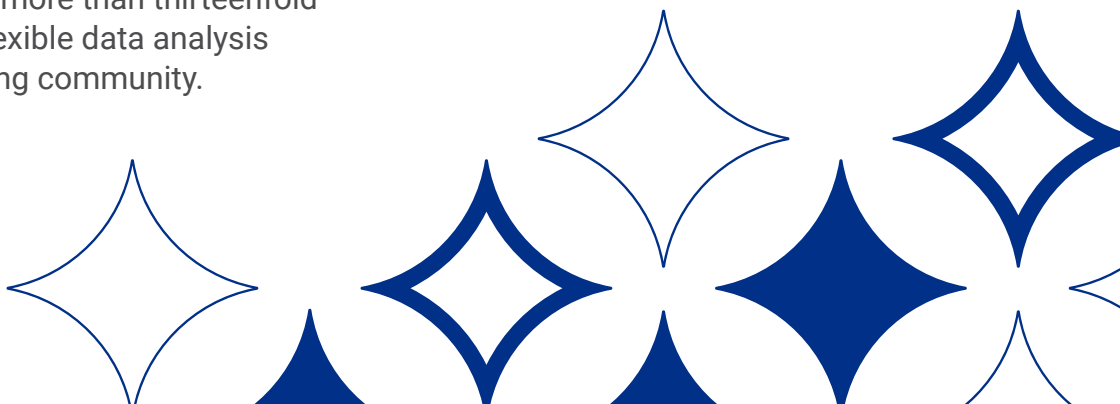
For over 30 years, expert teams have designed, improved and maintained the vast data and compute services of the Centre for Environmental Data Analysis.

From supporting a single project 30 years ago to leading data management for projects in international and world-leading settings today, CEDA is increasingly supporting researchers beyond core atmospheric, Earth observation, and solar and space physics communities. CEDA now enable fields including engineering, economics, and health.

Earth observation data now comprises approximately 80% of CEDA's long-term archive – having come a long way from being stored in a box under a desk. The JASMIN data-intensive supercomputer, which provides the infrastructure upon which CEDA archives and services are delivered, has expanded its capacity more than thirteenfold since 2012, offering flexible data analysis capabilities to a growing community.

Service is at the centre of CEDA's work and the 40,000 users who have joined in the last 5 years benefit from FAIR data principles (Findable, Accessible, Interoperable and Reusable), user-centricity, co-location of compute and data, and training.

Based within RAL Space, CEDA's diverse portfolio works with a diverse range of partners including UKRI's Natural Environment Research Council, UK Met Office, Department for Environment, Food and Rural Affairs, Department for Science, Innovation and Technology, European Commission, UK Space Agency, European Space Agency, and UKRI Digital Research Infrastructure.



Users & Projects

300+ active projects supported

40,000+ new user registrations (for the long term data archive) in the last five years

2,000+ researchers actively using JASMIN services for data analysis and collaborative research

Data & Infrastructure

26+ petabytes in the CEDA Archive

60+ petabytes of JASMIN disk and solid state storage

90 petabytes of tape storage

JASMIN at the Centre for Environmental Data Analysis. Credit: NCAS

SWIMMR: Building UK resilience against space weather

Imagine waking up to find GPS isn't working, flights are grounded, and power grids are struggling. These aren't cyber-attacks or science fiction – they're potential consequences of severe space weather. In 1989, a solar storm caused blackouts across Quebec, leaving millions without power. Today, as our systems grow ever more interconnected, a similar event could trigger even greater disruption.

Initiated in 2019, the Space Weather Instrumentation, Measurement, Modelling, and Risk (SWIMMR) programme brought together UK experts from academia, government and industry to address this challenge and better understand, predict and mitigate space weather impacts. This £20 million UKRI-funded effort enabled 11 projects addressing everything from satellite radiation exposure to aviation safety and ground-based infrastructure risks.

As the UK's national space laboratory with decades of solar science heritage, RAL Space was ideally placed to coordinate the programme alongside the Natural Environment Research Council and working closely with the Met Office. SWIMMR projects have flown radiation monitors into space, on board aircraft and installed ground-based sensors including the UK's first neutron monitors since the 1970s.

Models developed through the programme are now becoming operational at the Met Office Space Weather Operations Centre (MOSWOC). The support to take models and data from research into forecasting operations has significantly enhanced the UK's capability for monitoring and predicting space weather, positioning the UK as a global leader in this critical area.

SWIMMR helps to protect the UK's substantial investment in space infrastructure whilst opening doors for closer international collaboration. Its models, data and monitoring capabilities will continue safeguarding satellites, aviation, power grids and communications systems for years to come, and will pave the way for future programmes to enhance our understanding and ability to mitigate the risks of space weather.

“SWIMMR has significantly strengthened the UK’s ability to monitor and forecast space weather. It’s been a powerful example of research-to-operations, translating models and data into forecasting tools through MOSWOC, and has shown how strategic science goals can be delivered through strong partnerships and effective funding. It sets an important precedent for future programmes.”

Professor Ian McCrea, SWIMMR programme lead at RAL Space

A radiation monitor developed by the University of Surrey takes flight on a weather balloon as part of the SWIMMR programme. Credit: Ben Clewer, University of Surrey

“SWIMMR projects are bringing significant improvements to Met Office capability for monitoring and forecasting space weather events, helping cement the UK's position as a global leader in this area.

"SWIMMR is a great example of how UK scientific experts and Met Office working together can provide new modelling and monitoring capabilities to bring tangible improvements to capabilities and the vital services they underpin.”

Met Office Head of Space Weather Mark Gibbs

Over 40

partnerships and collaborations created or strengthened by the programme

40 jobs

created or supported, including software engineers, physicists, geophysicists and postdoctoral researchers

40

new airborne or space-borne sensors contribute to MOSWOC

Quantum technology for space weather

Solar storms create temporary disturbances in the Earth's magnetic field and can be large enough to affect ground-based technology such as power grids, Global Navigation Satellite System receivers and railway signals.

Until now, it has not been possible to study regional variations, or 'pulses,' using the three existing UK geomagnetic observatories. However, a new generation of quantum sensors has been deployed across the UK – including one at RAL Space's Chilbolton Observatory.

These instruments will fill gaps in national coverage, allow monitoring of small-scale, local variations, and developing an understanding of how extreme solar storms affect the Earth's magnetic field.

The sensors were developed and optimised by the University of Strathclyde and RAL Space with funding from UK Research and Innovation and the UK Space Agency.

Thanks to the teams' expertise, these sensors can detect changes in the magnetic field 100 times smaller compared to standard sensors, at a faster rate and with improved accuracy.

They will generate high-resolution data to support the British Geological Survey (BGS) in monitoring and understanding the impact of extreme magnetic storms.

Project members at the installation of the new quantum magnetometer sensor at RAL Space's Chilbolton Observatory, Hampshire. Credit: BGS / UKRI.

“We are incredibly excited to be able to study the magnetic field around the UK in greater detail than ever before. The installation of the five new quantum magnetometers will help to fill in the gaps between the existing observatories and will improve our vision of the changes taking place during extreme magnetic storms.

These new measurements will greatly enhance our understanding of how extreme magnetic storms impact different parts of the country. This means that society in general will have access to the advice and information needed to understand where we are vulnerable to magnetic storms and to make informed decisions on how to mitigate against them.”

Dr Ciarán Beggan, geophysicist at BGS

PUNCH mission releases first data

Exploring and understanding the evolution of space weather events such as coronal mass ejections is vital for scientists to make accurate predictions about space weather events, which can be disruptive to technology in orbit and on Earth.

NASA's PUNCH (Polarimeter to Unify the Corona and Heliosphere) mission captures global, 3D observations of the inner solar system to learn how the mass and energy of the near-Sun atmosphere evolve into the solar wind, a stream of charged particles escaping from the Sun in all directions. All four PUNCH spacecraft launched in March 2025 and are already delivering valuable insights.

As well as contributing to the mission's scientific goals, RAL Space teams have designed, developed, and manufactured the systems for the mission's four visible-light cameras, which are already capturing a unique perspective of the evolving solar wind, delivering valuable data to scientists worldwide.

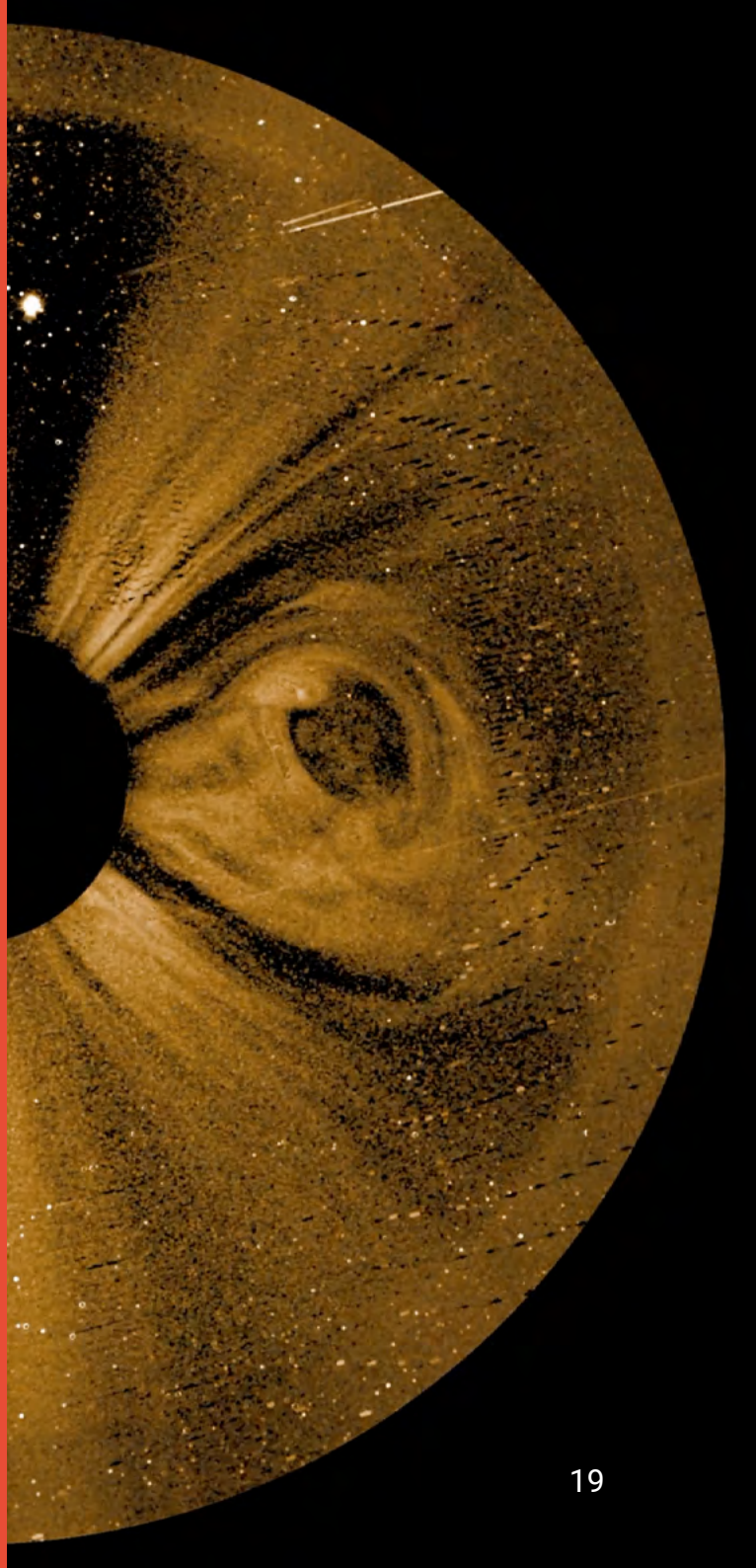
Scientists from RAL Space have also drawn on their experience from an earlier NASA solar mission, STEREO, to lead PUNCH's in-flight calibration, working closely with mission leads at the Southwest Research Institute (SwRI). The aim is that the PUNCH satellites will work together as a single, seamless "virtual instrument", making precise calibration essential to ensure the highest quality data throughout the mission.

"Seeing the successful launch and first images was a proud moment for the entire PUNCH team. It's incredibly rewarding to know that our long-standing expertise in imaging systems is providing new insights into our Sun's outer atmosphere."

Dr Nick Waltham, Technology Research and Innovation Lead at RAL Space

“It's incredibly exciting to see PUNCH in orbit. The camera systems we've developed are providing an innovative view of the solar wind, helping scientists understand how space weather forms and evolves. This research is vital for protecting technology and infrastructure on Earth.”

Dr Jackie Davies, Heliospheric Physics Programme Lead at RAL Space and UK Science Lead for PUNCH



This huge coronal mass ejection, captured by PUNCH on 3 June 2025, grew to nearly 100 times the Sun’s size as it travelled across the solar system. Credit: Courtesy of SwRI

Ariel: Europe's upcoming exoplanet explorer

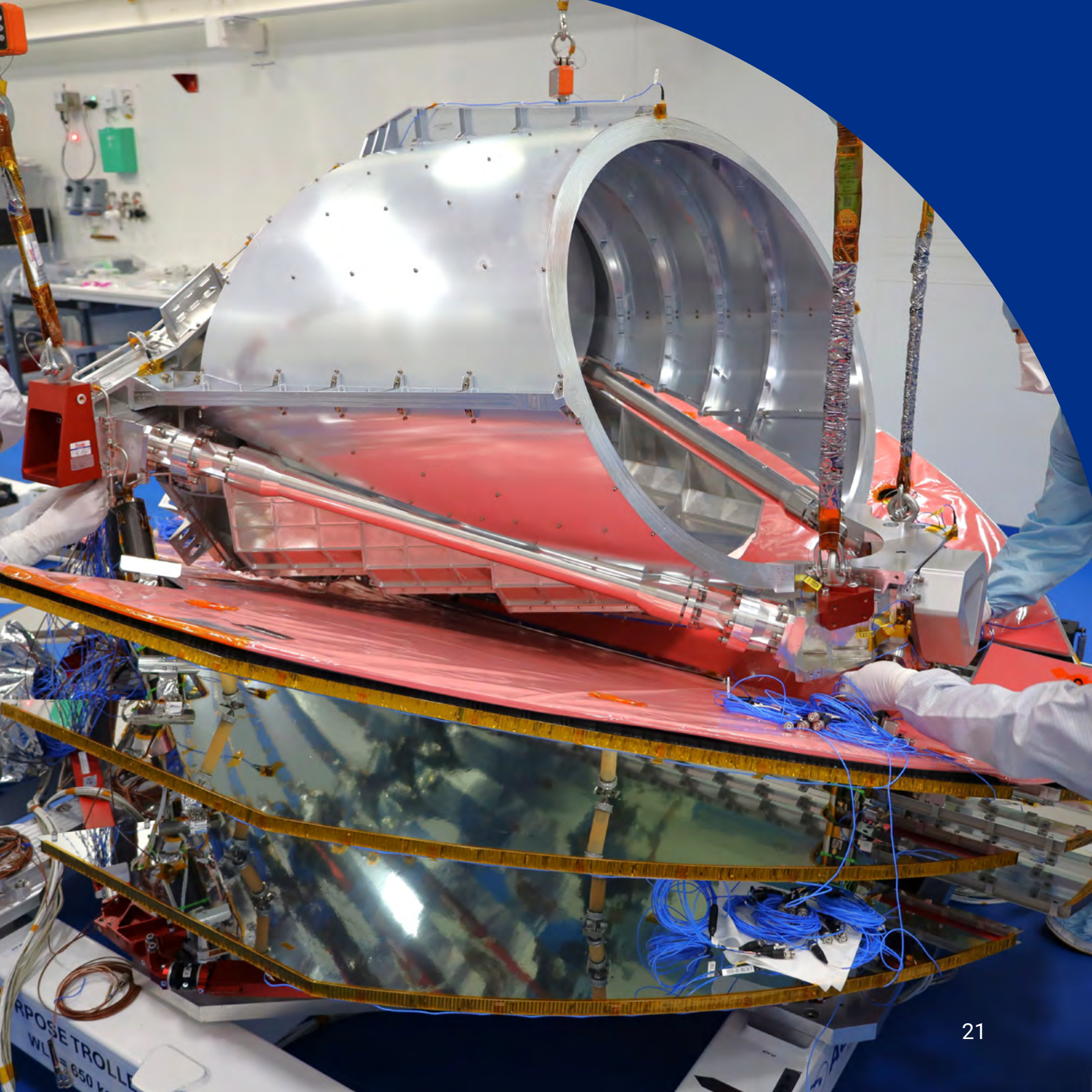
The European Space Agency's Ariel mission will explore the atmospheres of 1000 exoplanets, from distant rocky worlds to vast gas giants outside our solar system.

Through this unprecedented survey, Ariel will reveal how planets form and evolve and help us understand the link between a planet's characteristics and those of its parent star. The spacecraft's journey will take it 1.5 million kilometres beyond Earth to the Sun-Earth Lagrange point 2 – a stable position in space ideal for observing the cosmos.

RAL Space is leading a consortium of over 50 institutes across 16 countries to build Ariel's science payload, which includes the instruments that will capture light from distant planetary atmospheres and decode their chemical compositions. Meanwhile, King's College London is leading the mission science, ensuring the data gathered answers fundamental questions about these mysterious worlds.

Construction and environmental testing of the payload's structural model is well underway at RAL Space. These tests represent a crucial step towards the development of the flight model, proving the structural design can survive the journey and operate flawlessly once Ariel reaches its destination in space.

Assembly of the Ariel payload's structural model underway at RAL Space. Credit: STFC RAL Space



2 instruments

16 countries

50 institutes

1000 exoplanets

A groundbreaking new view of the Sun's poles

Thanks to its newly tilted orbit around the Sun, ESA's Solar Orbiter is providing unprecedented views of the Sun's polar regions that will transform our understanding of its magnetic field, the solar cycle and the mechanisms behind space weather.

These high-latitude observations are key to understanding the Sun's magnetic field and why it flips roughly every 11 years, coinciding with peaks in solar activity. Current models and predictions of the 11-year solar cycle cannot precisely forecast when and how powerfully the Sun will reach its most active state.

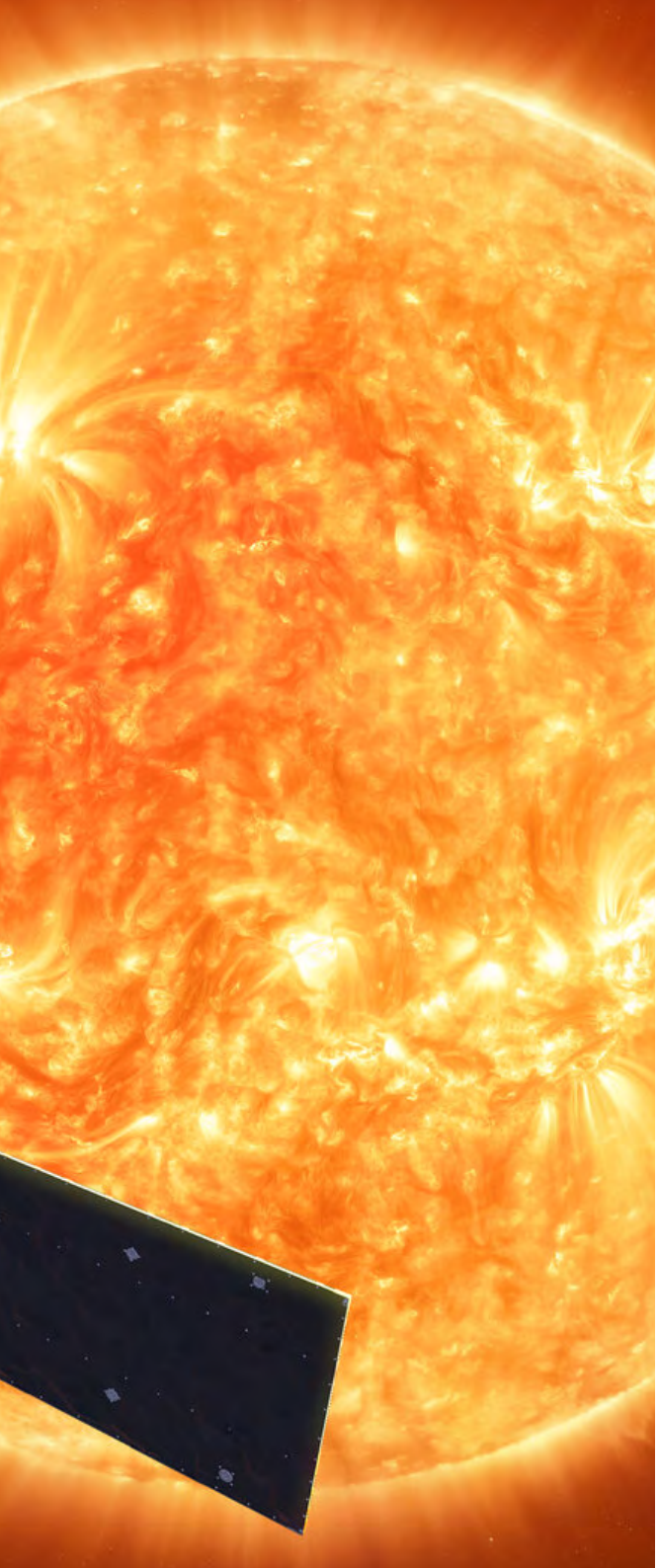
This breakthrough comes five years after the mission's launch in February 2022, and RAL Space teams continue to contribute to the operations of one of Solar Orbiter's onboard instruments: SPICE.

SPICE – Spectral Imaging of the Coronal Environment – was developed by an international consortium led by RAL Space. It measures the light in extreme ultraviolent wavelengths sent out by specific chemical elements at known temperatures to reveal what happens in different layers above the Sun's surface.

The SPICE team has also managed to use precise tracking of spectral lines to measure how fast clumps of solar material are moving.

Following a close Venus flyby in February 2025, Solar Orbiter began its new phase of operations with an orbital inclination of 17°. Future Venus gravity assists in 2026, 2028 and 2029 will increase this inclination to 24°, 30°, and eventually 33°, enabling even better views of the poles.

Supported by the UK Space Agency, the SPICE team at RAL Space remains dedicated to ensuring the continued success of science operations through the anticipated end of the mission in 2030. More than 800 scientific papers have been published so far, with a wealth of insights still to come.



“The RAL Space team conceived and defined the SPICE observations of the polar regions, ensuring they are perfectly planned and executed. Data from the first observations have already been received, and more such studies will follow during the next perihelia. The results so far show only a small sample of the capabilities that SPICE can offer in studying the polar regions, and we look forward to future discoveries.”

Dr Andrzej Fludra, SPICE Co-PI and Solar Physics Programme Lead at RAL Space

ESA's Solar Orbiter mission is the most complex scientific laboratory ever to have been sent to the Sun. Credit: ESA

Test and calibration services

In 2025, we marked the National Satellite Test Facility's first full year of operations – a milestone year that has seen teams working intensively to commission complex equipment and begin delivering critical test services to the UK space industry.

Following the first electromagnetic compatibility tests last year, test teams have achieved further milestones in 2025 with the completion of inaugural acoustic tests and mass properties testing. These capabilities are essential to verify that spacecraft can withstand the violent conditions of launch and perform reliably once in space.

RAL Space's smaller facilities have been equally busy supporting the UK and wider space industry. This includes the Small Satellite Calibration Facility, operated jointly with the National Physical Laboratory, which is providing crucial calibration services to start-ups and SMEs developing instruments for small satellites. By ensuring instrumentation is precisely calibrated before launch, the facility is helping guarantee the accuracy and reliability of data these missions will collect in orbit.

From large-scale spacecraft to compact CubeSats, thorough pre-launch testing and calibration underpin every successful space mission. Operating at all scales and to internationally recognised standards, RAL Space test facilities give industry customers the confidence that their missions will perform as intended in orbit and deliver trustworthy data back to Earth.

The National Satellite Test Facility's dynamics suite. Credit: STFC RAL Space

Thermal Vacuum

43 test campaigns completed

Dynamics

75 test campaigns including

16 pyroshock tests

3 acoustic tests

1 mass properties test

Test service

4.8/5 star rating from 118 facility users

Unlocking opportunities through higher frequency communications

At a time when streaming services and digital communications are driving unprecedented data needs, traditional communications bands are reaching their limit.

In a milestone that will help pave the way for much faster data transfer rates, the European Space Agency (ESA), Telesat and RAL Space have successfully established a Q-band link with a satellite in Low Earth Orbit (LEO).

Using a specially developed Q-band receiver mounted onto Chilbolton Observatory's 25-metre antenna, the team established a stable link with a Telesat LEO 3 satellite passing overhead in a significant leap forward in satellite communication technologies.

Unlocking higher frequency bands will help connect communities, support emergency response systems, and enable new possibilities for digital communications throughout the economy and society.

The project was performed under a Memorandum of Understanding signed in early 2024 between Telesat and ESA, and funded as an ARTES Advanced Technology activity, supported by the UK Space Agency.

“We are proud to see our collaboration with Telesat – and now RAL Space – continue to grow, unlocking new opportunities through higher frequency communications. It highlights how our Member States are driving innovation to meet both market needs and societal challenges. Congratulations once again to the entire team!”

Antonio Franchi, ESA’s Head of Space for 5G/6G and Sustainable Connectivity programme line

The 25m antenna at Chilbolton Observatory. Credit: NCAS

Making space science accessible to all

RAL Space has partnered with Oxford University's History of Science Museum and Iffley Academy – a specialist school for young people with complex Special Educational Needs and Disabilities (SEND) – to co-create accessible science learning resources for museums, outreach events, and families at home.

Through hands-on sessions exploring light and optics, students directly shaped the design and contents of activity backpacks, an "Explore at home" booklet, and a "Science and Magic" outreach show. Their input was invaluable: they chose backpacks over shoulder bags for comfort, requested larger fonts and shorter text sections, and simplified vocabulary on instruction cards. RAL Space scientists also ran careers Q&As and hosted a laboratory visit, connecting space science to real-world applications.

The resources have reached over 742 people to date, and the backpacks are available for anyone to borrow and follow a trail in the museum.

For the 11 advisory students, almost all of them achieved key outcomes. They explored science concepts, felt inspired to learn more, understood how science relates to their world, developed questioning skills, and felt valued for their contributions.

The legacy of the collaboration has fundamentally influenced how both RAL Space and the History of Science Museum approach inclusive resource development – championing space as accessible for all whilst building lasting relationships that continue to create opportunities for SEND children to engage with science.

During 2025, the team presented this project in the Frontiers In Education journal and at the Association of Science and Technology Centers conference in San Fancisco, ensuring its findings and impact were shared with the wider outreach community.

Read the full article in Frontiers:

https://tinyurl.com/22knhnrr

"This project has done more than teach our students about science. It has proven that the more science capital a child has, the more likely they are to aspire to explore science of the world around them. This project has awakened a sense of curiosity... and has given them a tremendous sense of purpose and confidence, knowing that they have made a valuable contribution as mini consultants."

Teacher at Iffley Academy

62 events that reached over 33,000 school students and members of the public

34% of our audiences were from backgrounds underrepresented in STEM

77% of students are more likely to consider pursuing STEM

SpeQtre: A new approach to space technology

Space and quantum represent two vastly different frontiers – one reaching beyond our planet, the other delving into the tiniest concepts imaginable. Both sectors demand pioneering science and engineering at the very limits of what's possible, and although combining them might sound like science fiction, this fusion might soon be essential to our digital security.

Quantum computing promises exciting breakthroughs in many fields, but it also poses a threat to current cybersecurity. Today's encryption methods will eventually become vulnerable to hacking by these advanced computers. But quantum technology also offers a possible solution. Encryption keys formed using quantum randomness are theoretically unhackable by any computational means.

Deploying this technology in space amplifies the difficulty of an already complex feat. However, it is crucial for enabling communication over long distances, creating powerful impacts on everyday lives and the economy.

The UK and Singapore are collaborating on SpeQtre – an in-orbit demonstration satellite that takes a radically different approach from conventional space missions. Rather than following the lengthy, risk-averse processes typical of many space projects, the SpeQtre team has embraced experimentation and speed.

The project combines off-the-shelf components with cutting-edge technology through an experimental development process that accepts calculated risk. This approach has enabled the satellite to progress from concept to being ready for launch more quickly and at lower cost than comparable missions, whilst still meeting technical standards.

RAL Space has led the UK's contribution, overseeing the space components and developing the optical instrument that beams quantum signals back to Earth, whilst Singaporean quantum communications company SpeQtral has provided the quantum hardware.

Crucially, SpeQtre aims to demonstrate this technology from a cubesat roughly the size of a microwave oven – a notably more difficult

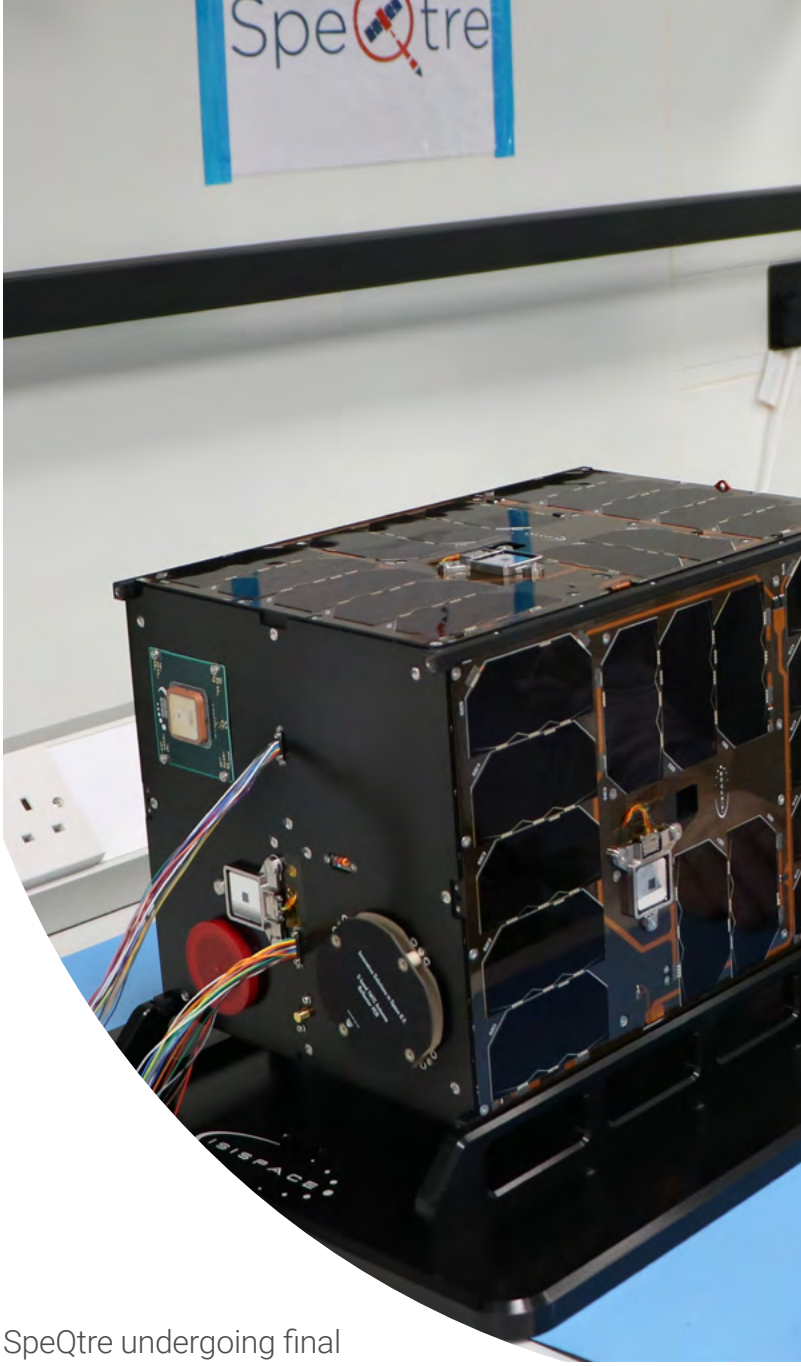
technical challenge than using larger satellites. By proving that quantum communications can work from such a compact platform, the project could make future systems more accessible and affordable.

The satellite launched in November 2025 and is already informing future projects. Following commissioning, quantum experiments will begin, exchanging quantum information between RAL Space's ground station at Chilbolton Observatory and a corresponding facility at the National University of Singapore.

"The approach we're taking to this mission is very exciting. We're doing things quickly, cheaply and ultimately more creatively than what the space industry is generally used to.

"This kind of technology is hard enough as it is, but by doing things differently, we're paving the way for future missions."

Andy Vick, Disruptive Technology Lead at RAL Space and UK Principal Investigator for SpeQtre



SpeQtre undergoing final preparations before being shipped from RAL Space. Credit: STFC RAL Space

Early Careers

8
people currently on the graduate programme in RAL Space

12
graduates completed their training in 2025

1
industrial placement student working at RAL Space

4
apprentices working at RAL Space

Science and Technology Facilities Council

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