Part of the conference series
Transforming our future

The UK's space sector

3 June 2025

Conference report

THE ROYAL SOCIETY

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Contents

Introduction

On 3 June 2025, the Royal Society hosted a hybrid conference on the UK's space sector.

This event was delivered as part of the Royal Society's *Transforming our future* conference series. Meetings in this series bring together experts from industry, academia, funding bodies, the wider scientific community and government to explore and address key scientific and technical challenges of the coming decade. These conferences are organised with the support of the Royal Society's Science, Industry and Translation Committee.

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A summary of key discussion points along with abstracts of the talks and overviews of the panel sessions are presented in this report.

This document is not a verbatim record, but a summary of the discussions that took place during the event and the key points raised. Comments and recommendations reflect the views and opinions of the speakers and not necessarily those of the Royal Society.

Image: Professor Michele Dougherty FRS, conference organiser, Professor of space physics at Imperial College London, President-elect of the Institute of Physics, and Executive Chair of the STFC.

"An overarching 10 year vision and a more specific, updated 5 year plan would make all the difference in providing visibility on what the UK can do in the future."

Professor Michele Dougherty FRS, conference organiser, Professor of space physics at Imperial College London, President-elect of the Institute of Physics, and Executive Chair of the STFC.

Executive summary

The UK's space sector conference was held on 3 June 2025. It brought together stakeholders from industry, academia and government to discuss the history, current state and potential future of the UK's space community.

A keynote presentation from Professor David Parker, University of Southampton, set the scene for the day by providing an overview of the UK's approach to space within a global context. His talk was followed by two sessions of short presentations, which explored the potential applications of space technology and innovations in space sustainability, respectively. Baroness Catherine Ashton then provided a short mid-point review of the House of Lords inquiry into the UK's engagement with space.

In the afternoon, Sir Martin Sweeting OBE FREng FRS launched the Royal Society's *Space: 2075* report. He outlined the key discussion points and recommendations from the report, which examines how space science and technology may develop over the next fifty years. This keynote was followed by two panel discussions focused on collaboration: the first panel discussed the need for, and barriers to, international collaboration, while the second panel shared their thoughts on how stakeholders within the UK space community could work together more effectively.

> "The partnership between the public and private sectors remains essential, especially where capabilities enabling critical national infrastructures and security are at stake."
>
> Professor David Parker, conference organiser, Visiting Professorial Fellow in Space Systems and Policy at University of Southampton, former Director at ESA, former Chief Executive of UKSA.

Key themes that arose across the various sessions of the meeting include:

- **The space community is a broad church:**
  - Several speakers noted that the UK space community encompasses a huge breadth of activity and a wide range of scientific and technological specialisation.
  - This is exemplified by the diversity of perspectives feeding into the House of Lords inquiry on the UK's engagement with space.
  - Some consider space as an 'environment', rather than as a distinct sector or industry. Like other environments (eg the ocean), various scientific and technological approaches can be used to examine and explore space.
  - There is currently no single entity providing leadership for the future of the UK's space community. Several organisations support different aspects of space science and innovation (eg the UK Space Agency, different research councils within UKRI and the Ministry of Defense). While there are some examples of collaboration across these bodies, the landscape is still somewhat fragmented and can be difficult for academics and companies to navigate.

- **Collaboration is key:**
  - Related to the above points, many speakers noted a need for greater collaboration across the UK's space sector. The final panel discussion of the day explored this topic in detail. Speakers highlighted a need for a cohesive vision for the space community, ideally linked to long-term (ie ten-year) funding cycles. This would need to balance the community's desire for stability against the government's need for flexibility.
  - The space community was encouraged to seek out and make use of existing support. For example, the Met Office provides space weather monitoring and forecasting, which can help improve the resilience of the UK's space assets. There has also been relatively low uptake of certain ESA funding and facilities access opportunities.
  - Historically, the UK has had strong links with many international partners (eg Japan, the US, and particularly the European Space Agency). Maintaining and developing these connections will continue to be important for the delivery of ambitious, exploratory projects and to ensure access to wider markets for UK space companies.
- **Innovation is flourishing, but more support is needed:**
  - While supporting international collaboration is critical, the UK space community also benefits from its national freedom of action. This means the UK is relatively free to determine its own priorities in terms of developing space capabilities.
  - Speakers noted that there are now over 1,800 companies operating in the space sector, employing ~50,000 people and contributing over £18 billion to the UK economy. Space science and technology is increasingly part of everyone's daily life, with applications (or potential applications) identified in most industries.
  - The space clusters were highlighted for their fantastic work in accelerating space-based innovation. These clusters, distributed across the UK, improve access to funding and facilitate networking between companies and academics interested in space science and technology.
  - Sustainability is a driving issue for many space start-ups. Many companies are developing space technologies to improve sustainability on earth (eg using satellites to reduce agricultural inputs), while others are focused on improving the sustainability of the space sector (eg by removing space debris).
  - As in many sectors, supporting space start-ups in scaling up continues to be a challenge. There are many contributing factors, including a perceived low appetite for risk amongst UK investors and the need for UK companies to secure a domestic customer before they are able to access larger international markets.
  - There was some discussion of consolidation and vertical integration. As many space-focused companies operate on tight profit margins, companies could move towards bringing more of their value-chain in-house. This type of strategy is already employed by some companies (eg Starlink, Kuiper Systems).

Recordings of the presentations are available on YouTube **youtube.com/playlist?list=PLg7f-TkW11iVnOnw-tHETSHEI8sQY_Ij9**

OPENING KEYNOTE

The $1.8 trillion question: the global space sector and the challenges facing the UK

Professor David Parker, University of Southampton
To watch the keynote, visit **youtube.com/@royalsociety**

Professor David Parker, University of Southampton, provided an overview of some of the challenges facing the UK space community and discussed what the UK could learn from other space powers.

We are living in one of the most dynamic, fascinating and uncertain eras in the history of the space sector. Paradoxically, this is not due to an abundance of brand-new ideas. Rather, ambitions that have been discussed for a long time are finally being realised – thanks in part to the development of a range of enabling technologies (eg quantum science, artificial intelligence, low-cost launch capabilities, etc).

In-orbit servicing, assembly and manufacturing (ISAM) is a good example. In the 1980s, British Aerospace plc (now BAE Systems) was developing a project to produce a large, multi-use, uncrewed station to carry out different Earth observation activities. The plan was to ensure a long lifespan for the station by developing a means to refuel and service it via the NASA Space Shuttle. However, the project was later scaled back. The resulting satellite (Envisat) was launched in 2002 and has been inactive since 2012. Today, there is renewed interest in ISAM, driven by a convergence of advances in robotics with lower cost launches and a growing concern about potential damage to the ozone layer from de-orbiting huge numbers of dead satellites. The hope is that serviceable space platforms will finally reduce the number of 'throwaway' satellites. Other examples of 'old ideas' finally being realised include small launch capabilities and space-based solar power.

Image: Professor David Parker, conference organiser, Visiting Professorial Fellow in Space Systems and Policy at University of Southampton, former Director at ESA, former Chief Executive of UKSA.

'Checking the rear-view mirror can remind us how far we've come. It also shows us how long it can take for new ideas to finally become reality.'

Professor David Parker, University of Southampton, conference organiser.

Economic implications

The growing demand for satellite manufacturing and launch capabilities does not seem to be translating into huge economic growth for space companies. Advances in space science and engineering have yielded technologies that are more powerful and useful, and in many cases cheaper. However, the pace of change and the investment needed to stay competitive can make for slim profits. Many space companies are focused on surviving the next six months rather than the next 50 years. However, if a company isn't exploiting AI or thinking about sustainability, they are increasingly unlikely to see long-term success.

In a 2024 report, the World Economic Forum (WEF) predicted that the global space economy would reach $1.8 trillion USD by 2035[1]. So-called 'backbone applications' including satellites, launchers and services such as broadcast TV and global positioning systems currently make up about half of the economic value of the sector. Crucially, space technologies will increasingly underpin a huge number of wider markets (eg weather forecasting, security and defence).

The diversity and energy in the UK's space sector is palpable. The key question is, how should the UK, or indeed any country, respond to the vision laid out in the Royal Society's *Space:2075*[2] report?

International context

Globally, there are a range of approaches to developing the space sector. Examples include:

- France operates on a centralised model where the Centre National d'Etudes Spatiales (CNES) is overseen by the Ministry of Armed Forces, the Ministry of Economy and Finance, and the Ministry of Higher Education, Research and Innovation. Thus, by design, CNES serves science, commerce and defence.
- Japan has a clearly articulated Space Strategy that explicitly links high level policies with programmes and projects to deliver those policies. Overall leadership rests with the Japanese Government's Cabinet Office, and not individual departments. This guarantees alignment between Japan's civil, military and security space activities. This top-down approach has advantages and disadvantages; however, the clarity of its aims may be one reason why Japan is such a respected and reliable international partner.
- During the first Trump administration, Scott Pace was the Executive Secretary of the National Space Council. Under the authority of Vice President Pence, he developed US space policy via short punchy directives. Each one had the same preamble giving the whole federal government its space marching orders. Seen in retrospect, this was a kind of rolling agenda successfully advancing US civil, military, and commercial space leadership.
- The European Space Agency (ESA) is celebrating its 50th birthday this year. Over the past 50 years, its convention has proved to be a remarkably flexible tool allowing it to support pan-European but also individual member state objectives.

Looking ahead

The public dialogues that fed into the *Space: 2075* report revealed a broadly cautious outlook on the future of space. There's an important warning carried here: the historically positive public perception of space innovation and exploration could shift in a negative direction – it is our collective duty to continue to explain the value of space while also working harder to make our sector more sustainable.

1. World Economic Forum. 2024. Space: The $1.8 Trillion Opportunity for Global Economic Growth. See https://www3.weforum.org/docs/WEF_Space_2024.pdf (accessed 27 June 2025).
2. The Royal Society. 2025. *Space:2075*. See https://royalsociety.org/-/media/policy/projects/space2075/space-2075-report.pdf (accessed 27 June 2025).

SESSION ONE

Space applications

Chair: Louis Barson, Institute of Physics
To watch session one, visit **youtube.com/@royalsociety**

TALK ONE

The value of space applications to a range of sectors: overview

Stuart Martin, Imperial College London, highlighted the progress that has been made in space applications since 2010 and considers what we can see over the next 15 years.

In 2010, the groundbreaking *A UK Space Innovation and Growth Strategy*[3] report was published. This marked the first time that UK government, industry and academia got together to produce a comprehensive vision for the UK's space sector. It was bold in its outlook. It discussed how great value lay in the applications and services that space technology was increasingly enabling on Earth. It described the emerging "NewSpace" economy, and how this would require new sources of capital and new ways of getting technology into space. The report included the first call for UK launch capability. It described the potential for new constellations of satellites and how these would transform industries. The report also detailed the need for a UK Space Agency to coordinate activities across government and lead the national effort to benefit from the potential of the space sector.

Image: Stuart Martin, Imperial College London.

Current space applications

Low Earth orbit constellations of small satellites are now ubiquitous, delivering important services while competing with and augmenting terrestrial communications. According to *The Size and Health of the UK Space Industry 2023* report[4], approximately 18% of the UK economy is now underpinned by space technology. This number is only predicted to grow.

3. Space IGS. 2010. A UK Space Innovation and Growth Strategy. See https://spaceskills.org/public/docs/Space%20Innovation%20and%20Growth%20Strategy%202010.pdf (accessed 7 July 2025).
4. UK Government. 2023. The size and health of the UK space industry 2023. See https://www.gov.uk/government/publications/the-size-and-health-of-the-uk-space-industry-2023 (accessed 7 July 2025).

Some of the early adopters of satellite technology include:

- The agriculture industry, where John Deere (an agricultural machinery company) began using satellite navigation to guide tractors and large machinery in the early 1990s. Observing any agricultural operation now, satellites are used not only to guide tractors but also to monitor humidity levels in the field and target the use of additives and inputs onto the field. Space has become ingrained within the industry.
- The maritime sector, which took advantage of space navigation largely to avoid collisions at sea. Today, satellite technology is also used to monitor cargo in real time, track emission levels and to detect illegal activities such as sanction evasion. All activity in the sea is monitored and tracked by space technologies.
- The transport and logistics industry, where companies such as Uber and Bolt rely entirely on satellite navigation for their businesses to operate. These services have only become feasible due to the low cost and widespread availability of satellite technology which developed in such way over the last 15 years.

> "In 2010, the reality is we weren't ready to take full advantage of the opportunities available. We are in a much better place now. We have a more entrepreneurial culture, and we have better access to start-up funds and private capital."
>
> Stuart Martin, Imperial College London.

Looking forward

There are 3 key trends that are opening up a new set of opportunities for the future:

- Large-scale space infrastructure: with advancements in launch vehicles such as SpaceX's Starship, launch costs have been dramatically reduced, enabling the transport of much larger payloads into orbit. This also opens doors to constructing large-scale structures in space that were previously unthinkable.
- Exploiting the unique space environment: microgravity offers advantages for certain biological and manufacturing processes, such as sedimentation and thermal convection for purer crystal growth. This is driving interest in space-based production of materials such as semiconductors.
- Commercial solutions to environmental challenges on Earth: UK-based firms such as BioOrbit, Space Forge and Space Solar are pioneering efforts to relocate polluting industries off the planet. An example is harvesting solar energy in orbit to beam it back to Earth.

To support the industrialisation of the space environment, and to protect our planet, a new generation of space logistics companies, such as Orbit Fab (specialising in in-space refuelling) and Astroscale (responsible for space debris removal), are necessary. The next 15 years hold huge potential, and with growing entrepreneurship and better access to capital, the UK is well positioned to become a space industry leader.

TALK TWO

Fundamental physics in space driving technology for onward applications

Professor Sheila Rowan CBE FRS, University of Glasgow, details how space was used for the Gravity Probe B mission to test predictions in general relativity and how the technology developed was used later for the detection of gravitation waves.

Gravity Probe B

Gravity Probe B (GP-B) was a mission designed to use precision gyroscopes to test two predictions made by general relativity, namely the frame-dragging effect and the geodetic effect. The GP-B star tracking telescope assembly was built from low expansion fused silica and required to withstand physical challenges such as launch stresses and temperature cycling, while enabling precision measurements of changes in the direction of spin of gyroscopes to be made.

Silicate bonding

Challenges persisted in bonding silica to silica as required in the construction of the star tracking telescope, leading Dr Jason Gwo to develop silicate ('hydroxy-catalysis') bonding as part of the GP-B mission. This technique enabled precision placing and alignment of fused silica components while proving capable of withstanding thermal cycling, launch stresses and the vacuum environment. With this solution, GP-B successfully launched in 2004 and went on to confirm predictions of the frame-dragging effect and the geodetic effect.

Image: Professor Sheila Rowan CBE FRS, University of Glasgow..

Case studies: Adapting technology to detect gravitational waves

General relativity predicts that in a system of rapidly changing configurations of mass, such as two dense stars or black holes orbiting one another, gravitational waves will be emitted. These gravitational waves change the effective distance between markers in inertial space. To measure this change, laser interferometry is used: the markers are mirrors widely separated and at the ends of perpendicular arms and changes to the interference pattern created from lasers bouncing off them are monitored to search for the effects of the traversal of a gravitational wave. However, this poses a significant precision measurement challenge as predictions suggest that mirrors in such a system would move less than a thousandth of the diameter of a proton.

- **LIGO**

  Ground-based gravitational wave observatories under construction in the late 1990s used fused silica mirrors highly isolated from external disturbances, suspended as pendulums using metal wires and kept in a vacuum environment. However, the mirrors and their suspension material still had undesirable levels of thermal noise within the frequency range where gravitational waves were expected to be detected.

  In the UK, studies of novel all-fused silica suspensions were conducted aimed at achieving significantly reduced thermal noise and the University of Glasgow demonstrated the ability to make fused silica fibres for suspension with extremely low mechanical dissipation and thus low thermal noise. To join these to the fused silica mirrors, the silicate bonding technique developed previously for the GP-B mission was transferred by Stanford University to researchers at Glasgow. Its use was demonstrated in practice in the UK-German GEO600 gravitational wave detector and eventually adapted for use in scaled-up suspension systems by the Advanced LIGO UK consortium and the US LIGO lab. This technology proved critical in constructing quasi-monolithic mirror suspensions of ultra-low thermal noise. The improved low frequency sensitivity helped enable the first detection of gravitational waves in 2015.

- **LISA and LISA Pathfinder**
  The concept of a space-based gravitational wave observatory has been developed over several decades, as the sensitivity of ground-based observatories at low frequencies is limited by local gravitational effects. The LISA (Laser Interferometer Space Antenna) mission is a planned space-based observatory comprised of three spacecrafts, with two freely floating cubes inside each one, in an equilateral triangle formation with armlengths of about 2.5 million kilometres. Laser interferometry will be used to measure the relative motion of the freely floating cubes and to monitor changes in the armlengths to search for the effects induced by gravitational waves.

  LISA Pathfinder acted as a technology demonstrator, testing the method to measure the relative positions of the freely floating cubes on a much smaller scale before a full-scale launch of the LISA mission. It featured a highly stable reference optical system made up of mirrors joined via the silicate bonding technique to produce a stable quasi-monolithic optical bench. When LISA Pathfinder launched in 2015, it surpassed mission requirements. LISA was adopted by the European Space Agency in 2024 with a planned launch date in the mid-2030s.

Space has a critical role in advancing fundamental physics and has led to the development of technologies such as the silicate bonding technique which has both been key to the testing of general relativity predictions and has wider applications, for example in making high-powered lasers and compound optics. However, timescales for space missions are long, requiring decades of continued development and innovation where international collaborations and partnerships are crucial.

> "We go to space because there are things we could not do on Earth. Space is a very special environment."
>
> Professor Sheila Rowan CBE FRS, University of Glasgow.

TALK THREE

Satellite Communications: Which lessons from the last 25 years are relevant for the next?

Andrew Stanniland, Satellite Industry Executive, highlighted the key advances, opportunities and risks experienced by the satellite communications community in the past 25 years, and discussed how we might apply the lessons learned over the next 25 years.

Image: Andrew Stanniland, Satellite Industry Executive.

The satellite communications industry, driven by technical advancements and evolving geopolitical priorities, is undergoing a significant transformation. It is critical for the UK to remain competitive in a rapidly evolving market dominated by global giants, while continuing to leverage domestic strengths and shape sustainable, long-term strategies.

The outlook for satellite communications – is it exciting or boring?

The sector has expanded significantly over the last few decades, with an increase in approximately 11,000 satellites in just 15 years. Satellite to ground data transmission rates have scaled rapidly from hundreds of kilobits to hundreds of megabits, and this will likely reach gigabits as a matter of course very soon. There has been a notable and welcome shift in focus from satellites to ground-based infrastructure where aspects such as affordable user terminals are now being prioritised. In contrast to the previous decade, which was led by civil space, defense satellite communications are once again leading innovation.

However, despite the vast improvements in technology, the fundamental physics of the system in which a communications satellite operates has not changed. Building a satellite or constellation still requires substantial financial investment and a long development timeline, implying the underlying economic model has not fundamentally shifted even if the market is growing. Consolidation also looks like a cause for excitement but is actually a symptom of a recurring pattern where many of those in the industry develop innovative solutions but then are often merged into larger entities.

> "Most of the upcoming change in satellite communications is actually evolution, not revolution."
>
> Andrew Stanniland, Satellite Industry Executive.

The UK's position in global satellite communications

While the UK has strong capabilities, there is substantial potential to capitalise on these capabilities with more effectiveness. With a strong record of successes, including the Government's Skynet programme, its involvement in ARTES (ESA's Advanced Research in Telecommunications Systems) and ECSAT (ESA's European Centre for Space Applications and Telecommunications) in Harwell, the UK has a major strength in supporting challenging Satcom programmes as well as R&D. The UK is also notably home to the headquarters of Inmarsat, a major satellite operator and Eutelsat Oneweb, one of the newest constellation operators.

Despite this strong foundation, the UK faces challenges in retaining the valuable assets it has built and further risks missing out on major projects such as the next wave of European satellite communications development IRIS2 (Infrastructure for Resilience, Interconnectivity and Security by Satellite). This inconsistency in supporting R&D, but not sustaining long-term strategic involvement, may reduce the UK's attractiveness as a global satellite communications leader. It is critical to assess how the UK can engage with and benefit from major international players while reinforcing its domestic strengths – ultimately maintaining influence in a rapidly evolving, competitive sector.

The future of satellite communications

Despite the recent hype shaping the satellite communications industry, particularly involving emerging trends such as AI, cloud and in-orbit manufacturing, the real trajectory of the industry remains uncertain. The line between sustainable innovation and speculative excitement is becoming increasingly blurred. The satellite communications business is expected to double its commercial value by the end of 2030, however many manufacturers still struggle to achieve profitability, indicating the need for developing new, resilient business models.

At the same time, defense satellite communications are set to play a central role amid ongoing geopolitical tensions, where flexible and hybrid networks will be relied upon. The rapid adoption of major commercial providers continues to raise critical questions regarding trust and control in national defense infrastructures. The UK must evaluate whether such platforms are trends, strategic assets or disrupters. The method in which these decisions, regarding national capability, technology maintenance and partnerships, are taken forward will shape the UK's satellite communications leadership in the coming decades.

SESSION TWO

Innovation in the space sector: emerging technologies

Chair: Dr Chris Hobbs, Enterprise expert in residence at SETsquared Surrey and former Head of Business Strategy at the Satellite Applications Catapult.
To watch session two, visit **youtube.com/@royalsociety**

TALK ONE

Knowing the space environment

Mark Gibbs, Met Office, described the importance of space weather and how phenomena occurring within the environment can impact various other sectors, including space.

Environmental conditions in near-Earth space pose a major concern for many different sectors within industry as there is an increasing reliance by society on critical activities conducted in orbit.

The Met Office is responsible for assessing space weather risk within the UK's National Risk Register. Industries reliant on space-based infrastructure are highly vulnerable to changes in space weather, however, the engagement between the Met Office and the space sector is relatively limited. It is vital that those within the industry develop an understanding of the available services that can assist in mitigating potential issues that arise from the space environment.

What is space weather?

Space weather describes the conditions in regions of near-Earth space that are influenced primarily by solar activity, such as the emission of matter and electromagnetic radiation from the sun.

Key space weather phenomena include:
- Solar flares, which describe the eruption of electromagnetic radiation from the sun. These flares can cause disruptions such as blackouts in high-frequency and over-the-horizon radio communications.
- Solar radiation storms, which are caused by eruptions on the sun that accelerate energetic particles into space. These can lead to disruptions to satellite systems, communications interferences and navigation errors. These high-energy particles travel at nearly relativistic speeds, giving minimal capability for forecasting and warning.
- Geomagnetic storms, which refer to the disturbance in Earth's magnetosphere due to solar activity. Produced by Coronal Mass Ejections (CME), these are the slowest moving of all space weather phenomena.

The thermosphere and ionosphere

The thermosphere can undergo large, rapid density changes as a result of space weather activity such as major geomagnetic storms. It can also experience more frequent and smaller changes from events such as solar flares. Recent data from the NSpOC (National Space Operations Centre) suggests that the number of collision risks to UK-licensed satellites correlates directly with months of high space weather activity.

There is also a focus on mitigating ionospheric impacts on critical systems such as GNSS accuracy, SATCOM reliability and over-the-horizon and high-frequency communications. Understanding the state of the ionosphere is vital in assuring resilient operations within environments affected by space weather.

The AENeAS (Advanced Ensemble Networked Assimilation System) modelling platform, delivered in partnership with the University of Birmingham, is in its early stages of implementation at the Met Office. AENeAS is looking at probabilistic forecasting and nowcasting as part of a coupled system for both the thermosphere and ionosphere. There is a particular emphasis on thermospheric density and the impact it has on orbit analysis and conjunction analysis. Due to increasing civil and military space situational awareness, atmospheric density forecasting data is now being delivered to the NSpOC for orbit analysis modelling purposes.

ESA Vigil mission

The Met Office Space Weather Operations Centre is involved in the ESA Vigil mission to Sun-Earth Lagrange point 5. This is due to launch in 2031, subject to continued funding, and will replace the NASA STEREO capability. This mission will provide a side-on view of CMEs directed towards Earth. Identifying whether the CME poses danger in the form of a narrow fast CME or a slow wide CME is critical in determining the likely impact. The mission will also improve solar activity detection and forecasting.

However, a more collaborative effort is needed to fully realise the maximum potential of the space sector, where the contribution of *in-situ* data from operational assets and hosted payloads for space weather monitoring is actively encouraged. This partnership is essential to maintain the safeguarding of assets and operational resilience in orbit.

> "Because at the end of the day, while we're a forecasting agency, we're interested in making capability more robust to space weather, whether that be through space weather forecasts or implementing engineering resilience measures"
>
> Mark Gibbs, Met Office.

TALK TWO

Made in space, for Earth

Joshua Western, Space Forge, highlighted the benefits of harnessing the space environment to produce new types of semiconductors for use on Earth.

As systems in critical sectors (such as aerospace, energy and telecommunications) demand higher power, greater efficiency, and more compact packaging, the dependence on semiconductors continues to grow at a phenomenal pace. Whilst silicon is currently the dominant material for semiconductors, its performance has been pushed to its physical limits. Further advances in semiconductor capabilities are likely to depend on compound semiconductor materials such as silicon carbide (SiC) and gallium nitride (GaN), which are now gaining traction.

Overcoming Earth's limitations

The production of compound semiconductors on Earth has proven to be a significant challenge particularly due to constraints of Earth – chiefly gravity and a dense ambient atmosphere.

In contrast to Earth's environment, space contains a near-perfect vacuum as well as microgravity conditions, enabling more ideal and controlled crystal growth. These features make it a compelling setting for various high-precision industrial processes. It is possible to produce compound semiconductors that are many orders of magnitude higher in purity when compared to their terrestrial counterparts.

Purity, in terms of crystals, specifically refers to the absence of chemical impurities and dislocation density (a measure of defects present in a crystalline structure). Nitrogen is a common impurity in crystals – even within the best Earth-based vacuums, nitrogen contamination remains an issue. However, above 500km altitude, nitrogen levels are dramatically reduced. The considerable reduction in background contamination during crystal growth can lead to higher quality crystals and improved semiconductor performance when compared to Earth-based production.

> "It's important to highlight that the entire world depends on compound semiconductors, in a way that in the 20th century we depended on oil and in the 19th century, we depended on coal."
>
> Joshua Western, Space Forge.

Outcomes of compound semiconductors produced in space

A key benefit of these semiconductors is their thermal conductivity. Greater heat control can either result in an increasingly powerful performance, or significantly lower associated energy use. Space-produced semiconductors will be particularly important as the use of energy-intensive AI approaches continues to grow.

Space Forge expects to offset the CO_2 produced through launch and company procedures via the vast amount of energy saved from advanced, high-performance materials manufactured in space alongside a circular use of resources through a reusable satellite system. The CO_2 output has been closely monitored since the company's inception.

The ForgeStar

The UK company Space Forge has developed the ForgeStar, a micro-orbiting factory designed to work with 14 operational launch vehicles, including 80% of the launch vehicles in development within the UK. ForgeStar-1 was launched in June 2025 and is the UK's first in-space manufacturing satellite. The ForgeStar has been designed with sustainability as a guiding principle. Depending on the complexity of the crystals in production, the ForgeStar can stay in orbit from 2 weeks to 6 months, after which the re-entry system known as Pridwen is deployed. The Pridwen, shaped as an inverted umbrella, acts as a radiative heat shield allowing for the material to safely float down through the atmosphere instead of burning up. The broad aim is to develop returnable and reusable satellite platforms to protect Earth's atmosphere and keep space clean for future generations.

TALK THREE

Clearing the path for the future

Sharon Parker-Lines, Astroscale, discussed the cutting-edge technology utilised in inspecting and ultimately removing large debris from orbit for a more sustainable space environment.

Image: Sharon Parker-Lines, Astroscale.

In the last 60 years of space exploration, there has been a surge in activity particularly due to the recent commercialisation of space, further leading to a proliferation of satellites and space missions. Many of these missions have had a focus on single-use technologies where equipment was not designed to be reused or deorbited, resulting in thousands of non-operational objects being left in orbit. This is a growing hazard for current and future missions, further impacting everyday life on Earth.

The threat of space debris

Space debris refers to non-functional, man-made objects in orbit around Earth - these may range in size from flecks of paint to upper stage rocket bodies. Despite the vastness of space, small fragments of debris continue to pose a significant threat to many satellite systems and spacecraft, particularly due to their incredibly high speeds. There is a heavy reliance by society and the economy on services provided by space systems, such as internet infrastructure, GNSS, and disaster monitoring. These services are consistently prone to disruption caused by space debris collisions.

The low Earth orbit belt (LEO) and Geostationary Earth Orbit belt (GEO) are becoming increasingly congested with space stations, large telecommunication constellations, earth observation satellites and more. There are currently over 2690 non-functional satellites in orbit.

Most pieces of debris at low altitudes tend to re-enter in a 5-year time period, however other objects at higher altitudes may stay in orbit permanently or can be sent into a graveyard orbit, an area in which decommissioned satellites are moved to minimise the risk of collision with active spacecrafts. This is mainly due to the high costs associated with returning objects that are stationed far out of LEO. The growing number of defunct satellites combined with uncontrolled, unmonitored debris is a serious risk to future missions. Managing and mitigating this threat is now a critical priority within the sector.

Inspect, service and remove

It is essential to ensure that both the remediation and mitigation of space debris are being tackled. The UK company Astroscale Ltd. provides three core service lines to support this goal:

- **Inspect**
  - This allows for a close-up inspection of non-functioning satellites, such that operators can understand whether the satellite is repairable or should be removed.
  - Astroscale Japan's ADRAS-J mission has demonstrated the ability to safely approach, inspect and characterise a 3-ton upper-stage rocket body, ahead of a second phase to remove it.
- **Service**
  - Although payloads on satellites in GEO remain useful, they are costly to build and launch. By servicing these objects in orbit and avoiding the launch of new replacements, the process becomes cost-effective in returning on investment on existing assets.
  - LEXI is currently under development at Astroscale US. It is designed to dock with GEO satellites and supply fuel, ultimately extending the operational lives of otherwise healthy payloads.
- **Remove**
  - This covers active debris removal, where objects such as satellites, which have not been designed for removal are manoeuvred to a lower orbit through the use of robotic arms with a highly sensitive end-effector.
  - End-of-life services target satellites that are pre-designed for later removal. Astroscale's ELSA-d mission demonstrated how magnetic technology can be used to release and recapture satellites equipped with magnetic docking plates.

Ultimately, by 2075, a circular space economy is envisioned where satellites are routinely serviced, refueled and recycled at orbital stations – similar to how vehicles are maintained on Earth. This will be a transformative step toward a safer and more sustainable future in space.

> "Rather than just clearing up our heritage, it's time we start talking about a multi-use, circular economy in space."
>
> Sharon Parker-Lines, Astroscale.

TALK FOUR

Innovation in the space sector – enabling innovation through novel insurance and regulatory approaches and sustainable practices

Professor Joanne Wheeler, Alden Legal – Earth and Space Sustainability Initiative, described how the incentivisation of novel insurance models, innovative regulatory approaches and the use of sustainable practices can enable valuable emerging technologies and stimulate growth.

Regulation and insurance have a critical role in enabling innovation and encouraging sustainable practices within the space sector. Space operators are legally required to ensure that all launch and in-orbit activities are licensed, and benefit from third-party liability (TPL) insurance cover. This protects the operator from financial responsibility in case of damage to people or property due to the operation of their spacecraft.

The standard cost of TPL coverage (approximately €60m per object) has a disproportionate effect on the small satellite community, who pay an excessive premium for low-risk/low-value missions. This particularly affects the UK, known to be the home for world-leading small satellite manufacturers. To confront this concern, a new insurance model is necessary.

Mutual Insurance Model

The Mutual Insurance Model is a not-for-profit insurance fund owned and run by small satellite operators. All premia will be held and accumulated within the mutual fund, delivering financial benefits directly to members within the industry.

This model, independent of third-party insurers, provides transparency, cost efficiency and flexibility through the ability to align decisions with the best interest of the small satellite industry. It is also a well-established and proven model accepted by the government; mutual insurance models have been used in various other contexts such as fire, military and local authority services alongside energy, nuclear and maritime fields. This model will result in lower, proportionate insurance costs, permitting the UK to be more competitive in the global space industry and further encouraging international collaboration. Several other countries have also expressed an interest in implementing such a model.

Space industry sustainability standards

Due to the fast-paced commercialisation of low Earth orbit (LEO), satellites in this region have been predicted to be uninsurable within the next 1.5 to 2 years. Space insurers are pulling back coverage as a consequence of the increasing risk of collisions in a congested LEO and difficulty in quantifying risks due to the diverse characteristics of satellites launched. One of the most efficient methods in tackling this issue is through the introduction of space industry sustainability standards. Encouraging industry and insurance led standards that provide clear benchmarks for the quality of equipment used and accredit products and services will lead to a better understanding of the reliability of satellites and the insurance risk, motivating space insurers to provide cover. These standards are critical in enabling continued innovation and commercial growth in the space sector.

Regulations and approaches to space sustainability

Space regulation is evolving into a strategic tool used to attract foreign direct investment and boost national revenues. The outcome-based regulatory approach used by the UK is recognised as a strength that the UK could globally lead on, given that it leverages its strong heritage in finance, insurance and tax. Space and Earth are a part of a single ecosystem where the environmental law on Earth also applies to space. Not all countries have the tools to assess the environmental risks of space activity, which makes it all the more important for the UK to establish leadership and clear standards, which are an asset for regulatory diplomacy. It is critical to recognise that space is not merely an inanimate matter to be exploited, but a shared environment, like Earth, that must be protected to enable innovation for current and future generations.

TALK FIVE

The intersection between the space and non-space industries and opportunity for mutual benefit

Katharine Jarman, Rolls-Royce, explained how the nuclear industry plays a pivotal role in supporting the UK's space capabilities.

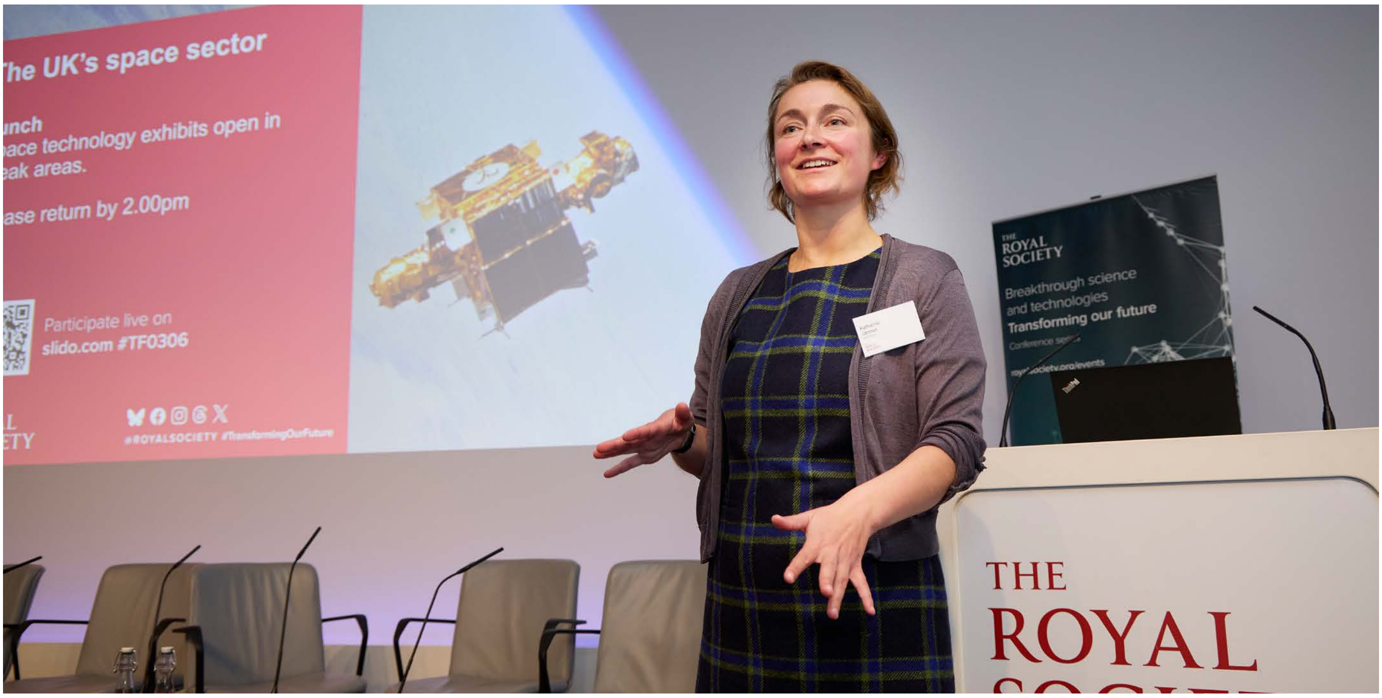


Image: Katharine Jarman, Rolls-Royce.

In space, nuclear fission can provide a long-term, sustainable and reliable power source as it is extremely energy dense. The fuel produced from a small pellet of nuclear fuel is equivalent to approximately 17,000m^3 of gas. This dense energy source can be utlilised in bases, satellites and various missions, for example, by increasing manoeuvrability in cislunar space or assisting in a faster journey to Mars through a more efficient propulsion system. There is also great opportunity in Radioisotope Power Systems (RPS), which use nuclear materials that naturally decay over time. This decay continuously generates heat for years without needing any moving parts or maintenance, which can then be transferred into a small yet steady supply of electricity. There is particular interest from the UK in using americium-241 as a fuel for RPS, as the UK has a stockpile of reprocessed civil nuclear fuel where americium-241 occurs as a natural byproduct.

The UK's nuclear industry

The UK has a long-standing nuclear heritage, dating back to the 1960s. Approximately 15% of the UK's electricity is generated through nuclear power. However, due to the retirement of many advanced gas reactors that currently provide this base load, the percentage is predicted to drop. The previously stated UK government aim of increasing nuclear-generated power to 25% by 2050 is looking to be increasingly difficult to achieve. It is vital to treat this time as a pivotal point in the UK's nuclear industry, where retiring reactors are replaced and capacity is expanded through the use of new technologies.

> "We're living through a nuclear renaissance — it's the only solution to some of the global challenges we face, from climate change to space exploration."
>
> Katharine Jarman, Rolls-Royce.

Micro-reactors for space

Rolls-Royce, through the UK Space Agency's International Bilateral Fund and National Space Innovation programme, is now looking to apply its nuclear expertise from developing submarine nuclear reactors and small modular reactors, to produce small-scale nuclear power systems for space. By defining the universal technical requirements for a single, versatile, space reactor, product development for various missions will considerably increase in efficiency.

To showcase the benefits of micro-reactors more effectively, various technology demonstrations have been developed by Rolls-Royce. This includes showcasing the first closed Brayton cycle within the UK. Unlike jet engines, which pull in and then expel gas, the closed Brayton cycle continuously reuses the same air to generate power which may be used at space-relevant scales. Rolls-Royce has also constructed an interactive physical demonstrator which showcases impressive visual aspects such as the flow of fluids around a reactor. These demonstrations support both technical progress and wider understanding of nuclear energy. It is vital to engage with students and the general public to help build the future workforce needed for both space and Earth energy solutions as there still exists major barriers to broader use of nuclear power, such as the policy and regulation in the transport and handling of these materials.

Nuclear power is energy-dense, low-carbon and does not rely on environmental conditions in the same way as solar or wind-based power. This means that it is able to be used at any location, whether in space or remote areas on Earth. Innovation, collaboration and public engagement will be crucial in unlocking its full potential across both domains.

TALK SIX

An inquiry mid-point overview: House of Lords special inquiry into the UK's engagement with space

Baroness Catherine Ashton, Chair of the House of Lords Inquiry into UK Space Engagement, provided an update on the emerging areas of interest from the inquiry.

A House of Lords special inquiry into the UK's engagement with space is ongoing and set to conclude at the end of November 2025. The UK Engagement with Space Committee is made up of 12 members of the House of Lords with a breadth of knowledge in engineering, law, creative industries, higher education, science and venture capital. The Committee was appointed to consider UK policies relating to space, and both the opportunities and challenges related to the UK's engagement with space. So far, there have been 14 sessions, 32 witnesses and 90 submissions. The Committee will hear evidence from witnesses associated with the recently published Strategic Defence Review[5] shortly. In addition to areas covered in that report, the emerging areas of focus from the inquiry have been economic issues, international partnerships and regulation.

Skills is a big issue and there are many different types of skills needed in this industry. In education, getting children excited and engaged in space is important, as well as featuring the many different possibilities of work beyond just becoming a rocket scientist. Questions have also been raised on how we make sure that there are enough people working in software and data, as these have emerged as areas where there are shortages. As part of this, it is important to think about how we can bring in people from overseas with appropriate visas, particularly given the changing political scene. Finally, we are interested in how we can use STEM and STEAM education pathways as ways to engage people in the whole plethora of what can be done in this industry.

"We have a huge job to do simply to get people to understand what is going on and the implications of what could happen"

Baroness Catherine Ashton, Chair of the House of Lords Inquiry into UK Space Engagement.

The role of government is important and some of the witnesses feel that there is too much of a 'scattergun' approach from the government rather than a focussed and strategic approach to what the UK can do and where it should be best positioned. At times, these approaches are in contradiction because of the need to allow for innovation in this area. There is also a question mark on how far there should be a focussed approach from government given we largely have the knowledge on areas we already know about. Another question for the role of government is in the challenge of growing Small and Medium-sized Enterprises (SMEs) to bigger companies without them being taken over or moved away.

In terms of partnerships, questions have been raised on how far we should continue to grow and strengthen our partnership with the European Space Agency (ESA). As we are now fourth in investment in the ESA, do we want to climb higher in investment or are we at the right level? How far do other partnerships with other countries become more significant? Many in the industry are divided on their opinion on these questions.

There is also the big challenge of funding and making sure that we can bring in the private sector and venture capital that is necessary, whilst recognizing the long-term and insecure nature of this industry as well as our own unique selling propositions. For example, how far should the UK be involved in launch? One, two or three sites? Do we go with Cornwall, Sutherland or Flaxford? If we are going to start to manufacture in space and repair and re-use satellites, does this affect our launch sites? Do we continue down small satellites robotics and how far do we build up the industries that go alongside our legal, financial and insurance work?

Findings from the inquiry will be summarised alongside recommendations to the UK government in a report later this year.

5. UK Government. 2025. The Strategic Defence Review 2025 – Making Britain Safer: secure at home, strong abroad. See https://www.gov.uk/government/publications/the-strategic-defence-review-2025-making-britain-safer-secure-at-home-strong-abroad (accessed 4 July 2025).

KEYNOTE

Space in 2075: implications for government and society

Sir Martin Sweeting OBE FREng FRS, University of Surrey Space Centre and Surrey Satellite Technology Ltd
To watch the keynote, visit **youtube.com/@royalsociety**

Sir Martin Sweeting OBE FREng FRS, University of Surrey Space Centre and Surrey Satellite Technology Ltd, gave an overview of the Society's *Space: 2075* policy report.

Image: Sir Martin Sweeting OBE FREng FRS, University of Surrey Space Centre and Surrey Satellite Technology Ltd.

Sir Martin co-chaired the Space: 2075[6] project alongside Professor Charles Cockell and Professor Suzie Imber. The purpose of the report is to stimulate early discussion on the potential implications of the development of space activities that might be expected by 2075. It does not attempt to predict the future, nor advocate for a particular outcome. Instead, the objective was to indicate the direction of travel to prompt decision makers to consider what the future might hold to allow our society to be better prepared for the unexpected – and make wiser choices.

Human activity in space has accelerated dramatically over the last five years, largely driven by the private sector. More satellites have been launched since 2020 than in all previous years of the space age combined. It is a challenge for policymakers to be able to respond to something that is changing so dynamically and there are risks associated with customs and policies becoming established by dominant, fast-moving, commercial players.

A vision of the future?

New launch systems, such as SpaceX's Starship rocket, could make it considerably more economical to send large payloads to orbit, enabling for example, construction of large structures in orbit, scale-up of manufacturing, and data centres powered by solar energy.

6. The Royal Society. 2025. Space: 2075. See https://royalsociety.org/-/media/policy/projects/space2075/space-2075-report.pdf (accessed 8 July 2025).

Space offers unique opportunities for technological innovation, science, and commercial business – as well as security and resilience. Building on the examples of the ISS and Antarctica today, the Moon may host permanent outposts for commercial and scientific activity and will likely be prepared by autonomous robots prior to human presence. Lunar missions could help to prepare for the much more technically challenging missions to Mars, where the timescales and distances will also raise ethical questions relating to humans working and living in space over extended duration separated from Earth.

Geopolitical tensions have already stimulated some nations to prepare for conflict in space and it is critical that we avoid misunderstandings that may lead to unnecessary confrontation in orbit or on the Moon. International engagement and collaboration on space, wherever possible and however politically challenging, is essential to promote mutual understanding, visibility and trust.

Conclusions

Space is at an inflection point, the UK is in danger of missing out. Space-enabled communications, remote sensing, positioning, navigation and timing are all components of the UK critical national infrastructure, underpinning our society and supporting 18% of UK GDP. Space has implications across all government departments.

Recommendations

1. Examine approaches taken by other international space powers that benefit from a single point of leadership in government, to consider how the UK might be better organised to deliver a coherent approach for space, resilient capability, and take full advantage of emerging opportunities.
2. Protect and maximise the use of space assets and data to mitigate risks to the UK's Critical National Infrastructure, recognising UK reliance on space assets for obligations on the economy, security and climate change.
3. Make a commitment to a long-term science vision by implementing a minimum of 10-year priorities and funding horizons for space science to end the damaging cycle of short-termism and stop-start investment. This should include regular review cycles to ensure funding keeps pace with inflation.
4. Initiate and maintain a 10-year rolling programme of regular in-orbit/in-space technology and service demonstration missions using small satellites to respond to emerging technologies, economic opportunities, and supporting national strategic and defence goals.
5. Reduce the risk of the UK space industry being left behind by incentivising the finance sector to stimulate scale-up of space SMEs through access to capital markets at an order of magnitude greater than today to position the UK as a global supplier, innovative service provider, a leader in satellite insurance and space reinsurance services.
6. Seek to broaden and grow international partnerships (including existing and new programmes in Europe) to access a wider range of space opportunities, achieve best value for money through collaborative approach, and send clear signals to attract foreign direct R&D investment.
7. Recognising that the space environment is at risk; show leadership in driving policy and regulation in sustainable space technologies to provide long-term confidence to encourage investment. Influence international agreements focussing on orbital congestion, debris management, fair resource sharing, and responsible planetary resource extraction with respect for sites of scientific importance.

For more information on the *Space: 2075* project, visit: **royalsociety.org/space2075**

PANEL DISCUSSION

International outlook: collaborate, coexist or compete in a changing global order

Chair: Professor David Parker, University of Southampton
Watch the panel discussion at: **youtube.com/@royalsociety**

Professor David Parker, University of Southampton, chaired a discussion on the strategic value of engaging with international partners within the global space sector.

International collaboration has a vital role to play in shaping the future of space science, technology and exploration while also maintaining global security and stability. From the European Space Agency's Gaia mission to the James Webb Space Telescope, there are many demonstrations of the value of jointly working with our global partners.

Looking ahead, the challenges and opportunities lie in making space a truly global endeavour where collaboration, coexistence and competition benefit and propel humanity forward. To further explore this topic, Professor David Parker (University of Southampton) chaired a discussion with a panel of experts, including:

- Professor Gillian Wright CBE FRSE, STFC, UK Astronomy Technology Centre; and
- Dr Tomas Hrozensky, European Space Policy Institute.

Why has international collaboration been so important in space?

- International collaboration in space is necessary for security. The threat landscape has changed so much that it will be detrimental to only rely on individual national capabilities.
- Alongside the advantages of sharing cost, building and maintaining technologies, platforms and facilities for widespread use support intellectual partnerships and diversity of thought. It is a fundamental part of science to share and collaborate to accomplish something larger than what an individual may be capable of on their own.

Image: Dr Tomas Hrozensky, Professor Gillian Wright CBE FRSE and Professor David Parker.

- The European Organisation for the Exploitation of Meteorological Satellites is an example of a European success story regarding international collaboration. It has 30 member states and a funding model led by meteorological and environmental offices, instead of space agencies. The precision globally maintained in meteorology would not be possible without this sort of international coordination.

What is the view from Europe looking back and forward at the UK?

- With major shifts in US space policy, Europe is facing systemic and tectonic changes, including a growing reconvergence of the defence and space industries. Globally, around 50% of public space budgets are defence-related, whereas, in Europe this figure remains closer to 15%[7]. The key challenge for Europe is to harness the momentum of national initiatives and to channel them into collective, collaborative action.
- With the UK's renewed participation in Horizon Europe, connections are strengthening amongst many European and international scientists. Global focus is becoming increasingly diversified with growing attention in Europe and more engagement from the Global South. This is an essential tool for fostering collaboration between academia, industry and public institutions across the continent.

What more can we do to build an inclusive and ambitious future for global space?

- While the United States allocates approximately 0.262% of its GDP to space-related endeavours, Europe currently invests only around 0.06%. This disparity raises important questions about whether Europe's financial commitment aligns with its ambition of being regarded globally as a leading space power.
- There is also a challenge in building a truly diverse workforce in the industry, not only in terms of protected characteristics but also focussing on socio-economic and cultural diversity. Talent is required, regardless of where it originates from, and collaboration should take place with this aspect in mind.
- The UK has many international programmes and partnerships to open doors and create opportunities for those who want to get engaged with space but lack the access to enter the sector. However, questions remain about whether the scale of these opportunities are large enough to reach their full potential of impact.

> "We need to ramp up our ambition to be able to be competitive, collectively as Europe, with the other players on the stage."
>
> Tomas Hrozensky, European Space Policy Institute

7. European Space Agency. 2024. Report on the space economy 2024. See https://space-economy.esa.int/documents/b61btvmeaf6Tz2osXPu712bL0dwO3uqdOrFAwNTQ.pdf (accessed 4 July 2025).

PANEL DISCUSSION

Getting the best return for the UK: how to facilitate a more joined up space sector

Chair: Professor David Southwood CBE, Imperial College London
Watch the panel discussion at: **youtube.com/@royalsociety**

Professor David Southwood CBE, Imperial College London, chaired a discussion on how best to nurture collaboration and innovation in the UK's space community.

To some, the term 'space sector' is a misnomer. The UK's space community is not a defined industry with a specific methodology. Rather, it is a heterogenous and geographically dispersed collection of industries and sectors that use space-based technologies and science for a variety of purposes. There is no singular leadership body.

Recently, the space community has been considering whether there is a need for a more cohesive national approach. To further explore this topic, Professor David Southwood CBE chaired a discussion with a varied panel of experts, including:

- Dr Paul Bate, UK Space Agency;
- James Cemmell, Open Cosmos;
- Professor Michele Dougherty CBE FRS, Science and Technology Facilities Council;
- Professor Kate Robson Brown, University College Dublin; and
- Elizabeth Seward, Space and Defense Strategic Advisor.

Image: James Cemmell, Open Cosmos; Elizabeth Seward, Space and Defense Strategic Advisor; Professor Michele Dougherty CBE FRS, Science and Technology Facilities Council; Professor Kate Robson Brown, University College Dublin; Dr Paul Bate, UK Space Agency; and Professor David Southwood CBE, Imperial College London.

A synopsis of the wide-ranging conversation is provided below.

Does the UK need a more unified space sector?

- Not everyone thinks so. Many other national and supranational space agencies employ a 'top-down' approach that considerably restricts the scope of space activities. In contrast, organisations within the UK have a relatively high level of freedom to choose which capabilities to develop and what research programmes to pursue – this is an approach that promotes innovation.
- In certain areas, the UK's space sector is already successfully joined up. Examples include:
  - The National Space Operation Centre. This organisation is responsible for developing and operating the UK's space surveillance and protection capabilities. It is led by the UK Space Agency together with UK Space Command, in partnership with the Met Office.
  - The Space Academic Network. This is a self-organised interdisciplinary community that provides a voice for academics working across five fields (earth observation, space engineering and technology, space science and exploration, data and analysis, and space and society).
  - The space clusters. These regional hubs bring together industry and academia to support training, catalyse investment and foster innovation.
- When looking at whether other joined up initiatives are needed, it is important to consider what outcomes matter (eg enhanced economic growth, increased national security).
- The funding landscape can be difficult to navigate. Numerous bodies within the UK fund different, yet overlapping, areas of space-based R&D (eg EPSRC funds engineering research; STFC funds fundamental space science; the UK Space Agency funds instrumentation and commercialisation of space technologies, etc). Academics often find it challenging to identify which opportunities are relevant. Some projects may require funding from different agencies for different aspects of the work, demanding complex coordination. This could perhaps be improved via increased collaboration amongst funding agencies on joint initiatives, regular discussions about research gaps and which agency is best placed to support research in a given area, and a cross-organisational vision for space science.
- Developing a holistic, ten-year vision for the UK's space community could provide guidance on the strategic allocation of limited resources and offer a sense of long-term stability to the community. In crafting this vision, the UK should reflect on what kind of 'space power' it intends to become.

What does it mean to be a space power?

- Space-based research and development contributes to both military and economic power. It is now a core part of the state's apparatus, and as such it is a component of almost every national strategy.
- There are various ways of classifying space powers, often based on an assessment of capabilities and autonomy. In past decades, the UK was generally considered a global space leader due to its advanced industrial landscape, world-leading work in instrumentation and Skynet (the Ministry of Defence's military satellite communications programme).
- The UK's current status as a global leader in space technology is less certain. Space-based assets are increasingly being consolidated, particularly in the telecommunications industry, and many companies founded in the UK are now foreign-owned.

What is needed to foster space-based innovation?

- The UK has a strong record in supporting innovation. There are many successful UK-founded start-ups (eg Open Cosmos and Space Forge, both of which feature in the agenda for this meeting). International companies, such as AstroScale, have also established branches in the UK due to its 'fertile ground' for growing innovation.
- There seems to have been a general decline in the amount of spin-outs from universities in the last five years. This corresponds with the growing financial crisis in the Higher Education sector. If students and academics are not incentivised to explore innovative ideas, the space sector will risk the likelihood of becoming stagnant in the coming years.
- As in many sectors, space-focused start-ups in the UK often struggle to scale. While there is a considerable amount of public sector funding and support available for early-stage companies, many still find it extremely difficult to access private investment when trying to advance towards market readiness (eg when trying to raise Series A funding). Compared to their American counterparts, UK investors seem to be relatively risk-averse and often look to government to take on or share the risk involved with investing in start-ups.

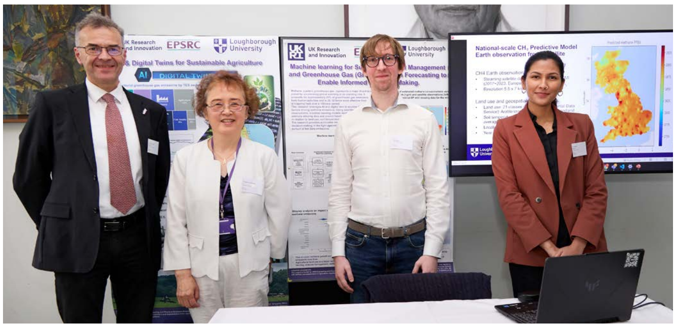
- To scale-up, companies need customers. To access foreign markets, companies typically first need domestic customers. A government contract is an excellent way to tick this box. UK government contracts are often difficult for smaller companies to secure, as the government procurement processes typically have low tolerance for risk. However, providing guaranteed government contracts to start-ups would not be an effective means of encouraging innovation. Companies looking for a government contract need to provide a product that is better (and ideally cheaper) than current government solutions.
- An assessment of UK SMEs that are showing high growth and some ability to attract capital (so-called 'gazelles') could inform a broader innovation strategy for the space community. Highlighting and supporting these companies could give more confidence to investors that a market for space-based technologies exists in the UK.

"If the UK's space sector isn't joined up, it is perhaps a reflection of the broader UK – heterogeneity is our brand identity. It isn't necessarily a bad thing, and what is clearly a good thing is to talk about this fragmentation as a sector."

Professor David Southwood CBE, Imperial College London.

Space science and technology exhibitions

During the meeting, several research groups exhibited posters and physical models of novel space technologies. By sharing their early-stage ideas and products, they were able to elicit feedback from the broad space community about the commercial potential of their work.



Imperial College London
The Imperial exhibit demonstrated the highly miniaturised MAGnetometer from Imperial College (MAGIC) instrument. Whilst space-based magnetic field measurements are fundamental for space science, many applications require very low resource sensors. MAGIC is a flight-proven science-grade magnetometer that uses 10x less resource than traditional designs and is an example of space technology that may have applications for sensing other environments on Earth.

University of Birmingham
Optical clocks have the potential to replace current microwave clocks due to their improved uncertainty and stability. The Alkaline group at the University of Birmingham aim to build transportable clocks to realise applications such as GNSS improvement, gravitational redshift measurements, ultra-light dark matter detection, quantum-enabled radar, and fundamental physics research.

University of Leicester
A self-learning digital twin for sustainable land management was demonstrated live by a team from the National Centre for Earth Observation at the University of Leicester. Earth Observation images, the JULES-CROP land surface model and weather data are combined with land use decisions by farmers to estimate the carbon dioxide emissions from their fields on drained peatland. The technology is intended to accelerate the land use transition to net zero.

Loughborough University
Loughborough University demonstrated how AI, digital twins, and satellite data can be integrated to analyse greenhouse gas emissions, identify major contributors, and explore correlations with land use, climate, and other influencing factors. Their research offers actionable insights to support data-driven decision-making in the fight against global warming and the pursuit of Net Zero emissions.

University of Edinburgh

The University of Edinburgh highlighted technologies in satellite data fusion and remote sensing, focusing on innovative vegetation models for wildfire management, enhancing observation, planning, and operations. They presented soft robotics for space and Earth exploration, combining bioinspired engineering, microfluidics, and sensors. The University also introduced the Edinburgh Space Hub that brings together industry and academics across entire end-to-end space sector.

Durham University

Durham University exhibited emerging technologies for space optics, such as freeform optical surfaces and additively manufactured (3D-printed) metallic mirrors for optical payloads. These technologies will enable future Earth observation and communication systems to be more compact, lighter, and more resilient to the harsh conditions of space. The University also highlighted its new Space Research Centre, which aims to tackle some of the most pressing questions about the future of space through a multidisciplinary approach involving the Departments of Physics, Computer Science, the Business School, the Law School, and the School of Government and International Affairs.

University of Surrey

The University of Surrey exhibited two new instruments for measuring space weather: included was the new High Energy Proton Instrument (HEPI) which measures charged particles travelling close to the speed of light and the SAIRA monitor which measures radiation increases on aircraft which can be caused by solar storms.

Acknowledgements

The Royal Society is grateful to the organising committee for their guidance in shaping the agenda and for leading delivery of the conference.

Organisers
Professor Michele Dougherty FRS, Professor of space physics at Imperial College London, President-elect of the Institute of Physics, and Executive Chair of the Science and Technology Facilities Council (STFC)
Dr Chris Hobbs, former Head of Business Strategy at the Satellite Applications Catapult, Enterprise expert in residence at SETsquared Surrey
Iain Hughes, Head of the National Space Innovation Programme, UK Space Agency
Professor David Parker, visiting Professorial Fellow in Space Systems and Policy at University of Southampton, former Director at ESA, former Chief Executive of UKSA

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The Society's strategic priorities emphasise its commitment to the highest quality science, to curiosity-driven research, and to the development and use of science for the benefit of society. These priorities are:

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- Corporate and governance

For further information
The Royal Society
6 – 9 Carlton House Terrace
London SW1Y 5AG

T +44 20 7451 2500
W royalsociety.org

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