

Mission Sustainable: Ensuring Earth-Space Human Activities are Sustainable by Default

Surrey Space Centre, University of Surrey, 21 May 2025



Aims and methods

The Mission Sustainable: Ensuring Earth-Space Human Activities are Sustainable by Default workshop was designed as an interdisciplinary forum to reflect on the interconnected themes and issues across disciplines which need to be addressed if human space activity is to be sustainable.

Current approaches to sustainable space law and governance are fragmented along disciplinary lines as well as within silos. For example within law and policy environmental dimensions of sustainability are commonly researched by environmental lawyers while intellectual property aspects are covered by intellectual property lawyers. This fragmentation is also evident across fields such as science and space engineering, finance, security, and international relations. The result is a patchwork of research that lacks the multidimensional coherence needed to understand the complex interconnections and interdependencies underpinning human space activity—and why it remains unsustainable.

The workshop was designed to foster interdisciplinary collaboration and support a holistic systems-thinking approach to problem identification and solving. This workshop brought together experts in space science and engineering, law and policy, finance and economics, international relations, and cyber security. The workshop format included two keynote speakers, four panels and two breakout sessions where space sustainability related scenarios were reviewed and discussed by between six to eight people from a range of disciplines. For the panels speakers were given three minutes to give a 'lightening pitch' of their topic and raise questions on space sustainability from their own specialism within their discipline. Following on from the 'lightening pitches' the conversation was opened up amongst panellists as well as other workshop participants. The format was chosen to ensure the

workshop was dynamic, engaging and stimulating for all throughout the day. We were privileged to host the workshop at Surrey Space Centre, and so were able to offer participants a tour of the labs at lunchtime. The tour led by Emeritus Professor Craig Underwood was a highlight which was commented on in the feedback by a number of participants.

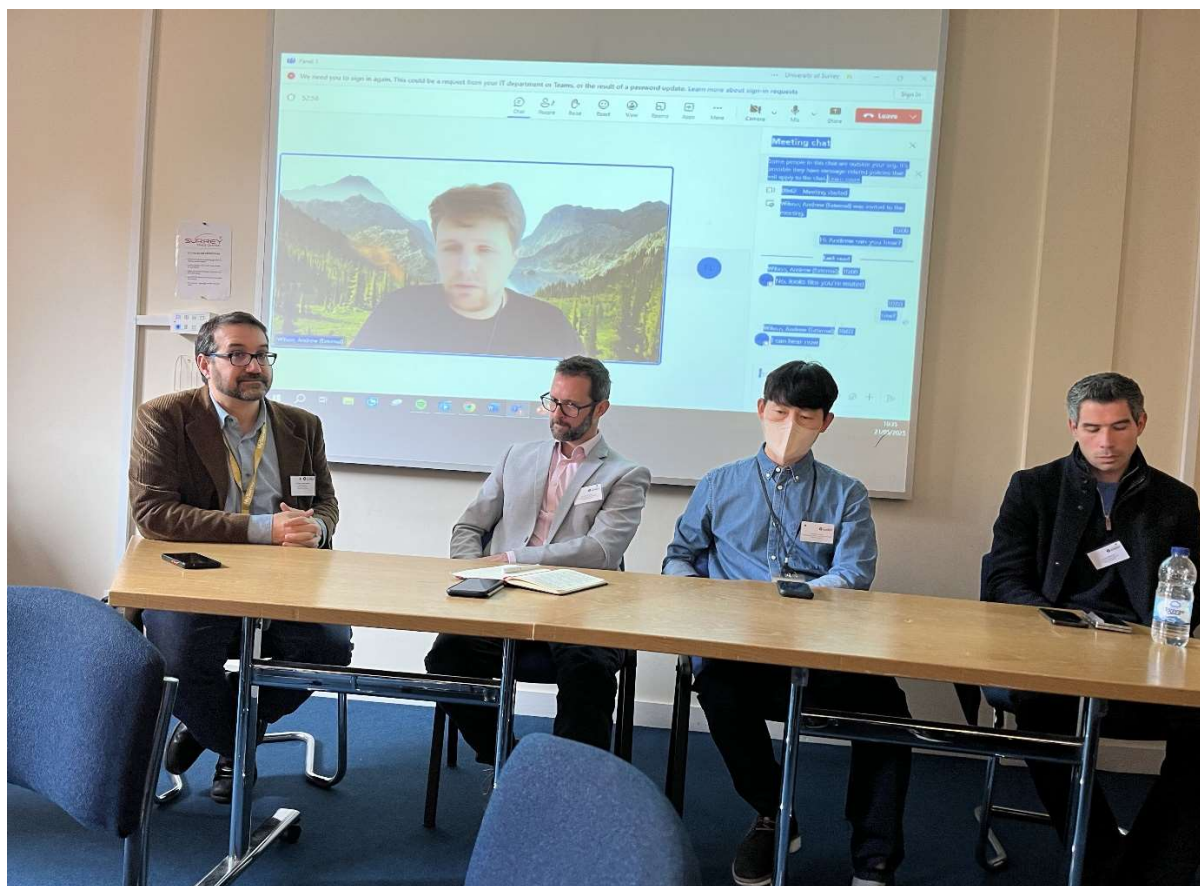
Themes and topics

Following a welcome address by Professor Adam Amara (Chief Scientist, UK Space Agency and Professor of Cosmology, University of Surrey), Dr Colin Baldwin (Executive Director, UK Space) delivered the opening keynote. Dr Baldwin outlined the urgent need to pursue Earth–space sustainability, articulating a vision for how a sustainable space economy could be achieved in the UK. He also discussed the differentiated roles and responsibilities that various stakeholders—across government, industry, academia and civil society—must assume in advancing this agenda.

Dr Baldwin kindly incorporated content from a keynote originally prepared by Joanne Wheeler (Earth Space Sustainability Initiative, ESSI), who was unfortunately unable to attend. Her presentation included a comprehensive overview of the ESSI *Memorandum of Principles for Space Sustainability*, launched on 27 June 2023.

After lunch, the workshop featured a specially recorded video message from Ms. Aarti Holla-Maini, Director of the United Nations Office for Outer Space Affairs (UNOOSA). In her message, the Director emphasized the increasing importance of multilateral diplomacy through UN agencies and other international forums to coordinate the growing number of actors involved in Earth–space activities—particularly non-state entities. She further highlighted the ongoing efforts to embed the *UNOOSA Guidelines for the Long-term Sustainability of Outer Space Activities* (2021) into everyday practices across the global space sector.

The workshop then proceeded with its first panel, ***Space Science, Technology and Sustainability***. The panel brought together a broad spectrum of expertise to explore how science and technology can drive environmentally responsible space operations. Chaired by Professor Adam Amara (Chief Scientist, UK Space Agency / University of Surrey), the panel featured Gary Cannon (Satellite Applications Catapult), Dr Sungwoo Lim (University of Surrey), Dr Adam Mitchell (European Space Agency), and Dr Andrew Wilson (Glasgow Caledonian University) [online]. The discussion centred on reducing the environmental impact of space activities, improving orbital traffic management, and applying sustainability principles to future lunar operations. Dr Wilson highlighted the growing need to transition from single-use systems to circular designs through life cycle assessment (LCA) methodologies, which can help quantify environmental impact from early design stages. Dr Lim discussed technological pathways for designing reusable and serviceable technologies to use in lunar activities including mining, while Dr Mitchell emphasized the importance of investing in atmospheric research to understand the cumulative effects of re-entries and propulsion systems. Gary Cannon focused on the need for practical tools that enable commercial users to adopt sustainable practices without compromising competitiveness.



Panel 1: Prof. Adam Amara, Gary Cannon, Dr. Sungwoo Lim, Dr. Adam Mitchell and Dr. Andrew Wilson [online].

The second panel, Legal Dimensions of a Sustainable Space, chaired by Feja Lesniewska (Surrey Law School), brought together Dr Efen Diaz Diaz (Secretary General, Spanish Association of Aeronautical and Space Law), Dr Berna Akcali Gur (Centre for Commercial Law Studies, Queen Mary University of London), Dr Michael Picard (Edinburgh Law School, University of Edinburgh), and Dr Phil Merchant (Marks & Clerk LLP) to explore the urgent need for cohesive and adaptable legal frameworks in response to the growing complexity of space activity. Dr Diaz Diaz highlighted the regulatory fragmentation across Europe and the lack of a unified EU-wide space law, stressing the need to harmonise national competencies, particularly around space traffic management and critical infrastructure. Dr Akcali Gur focused on the emerging challenge of cyber-sovereignty, warning that states' unilateral actions—especially around mega-constellations—could undermine orbital sustainability and global governance. She advocated for a balanced approach that bridges soft and hard law instruments. Dr Picard presented a circular economy model based on satellite reuse, repair, and recycling, identifying legal hurdles such as salvage rights, ownership transfer, and jurisdictional conflicts. Dr Merchant addressed the dual role of intellectual property rights, noting that while they incentivise innovation, they can also inhibit interoperability and recycling due to unclear legal provisions for space-based technologies.



Panel 2: Dr Feja Lesniewska, Dr. Efrén Díaz Díaz, Dr. Berna Akcali Gur, Dr. Michael Pickard and Phil Merchant.

The third panel, **Sustainable Space Finance – Innovation, Investment, and Insurance**, was chaired by Professor Emma Edhem (University of Durham; Chairman, OpenUK Space Advisory Board) and brought together experts from academia, industry, and finance to explore how the financial architecture of the space sector can evolve to meet sustainability challenges. Dr Chris Hobbs (Enterprise Expert in Residence, SETsquared Surrey, University of Surrey) emphasized the need for targeted early-stage funding and structured entrepreneurial support to help scalable, sustainable innovations reach market readiness. Professor Matt Angling (Head of Research and Innovation, Digital Intelligence Space Business Unit, BAE Systems) called for stronger alignment between R&D, government policy, and commercial investment strategies to mitigate technological and financial risk. Chris Newlands (CEO and Founder, Space Aye) highlighted the crucial role of startups and SMEs in pioneering sustainable space technologies, while Neil Stevens (Head of Space, Price Forbes) addressed the evolving role of the insurance sector, noting the need to develop new underwriting models that reflect the growing risks of orbital congestion and debris.

The final panel, **Space Sustainability – Diplomacy and Security**, chaired by Dr Joshua Andresen (Associate Professor of National Security and Foreign Relations Law, Surrey Law School), explored the urgent need for more inclusive and adaptive governance frameworks to manage the accelerating commercialization, orbital congestion, and strategic competition in outer space. Dr Fabio Tronchetti (Associate Professor, School of Law, University of Northumbria) addressed the growing paralysis in international diplomacy, particularly within the UN system, and argued for coalitions of like-minded states to take the lead in setting norms and advancing space technologies. Dr Nikita Sze Wai Chiu (Associate Professor in Space Innovation and Technology Governance, University of Durham) advocated for a shift toward a circular satellite economy, drawing on Cold War-era treaties to support

the development of enforceable mechanisms for satellite servicing, reuse, and repair. Ian Christensen (Senior Director, Private Sector Programs, Secure World Foundation) highlighted the dominant role of private operators—who now control over 75% of active satellites—and stressed the need for regulatory frameworks that are inclusive, enforceable, and responsive to the sector’s diverse actors.

Workshop break out group activities

During both the morning and afternoon sessions, workshop participants took part in a scenario-based breakout activity. The objective was to bring together individuals with diverse expertise—spanning science, engineering, law, finance, insurance, cybersecurity, and international relations—at each table to encourage interdisciplinary engagement. Two carefully constructed scenarios were presented, each designed to elicit responses that required input from multiple disciplines, ensuring relevance for all participants.

Information about the scenarios was withheld until the start of each session to encourage real-time, spontaneous responses. Participants were given ten minutes to review the scenario individually and reflect on their initial reactions. This was followed by group discussions at each table, where ideas were exchanged, refined, and summarised. Each group then shared their collective insights with the wider workshop audience, facilitating a broader exchange of perspectives and solutions.

The first scenario, **The Mega constellation Moratorium**, involved a private African consortium's plan to launch 24,000 new satellites into Low Earth Orbit (LEO), prompting urgent debate on whether to support a proposed two-year global moratorium on mega constellation launches, and what frameworks are needed to make such systems sustainable by default.

The key takeaways from the session were that groups views varied over the utility of the moratorium, there was strong consensus on the urgent need for a mix of technical, legal, and governance interventions to make mega constellations sustainable. Recurring proposals included mandatory space traffic management (STM) impact assessments, propulsion requirements for all satellites, transparent data-sharing mechanisms, adaptive licensing linked to sustainability benchmarks, and public-private collaboration on global monitoring infrastructure. These discussions aligned closely with current international initiatives such as the ESA Zero Debris Charter, the Net Zero Space Initiative, and ISO standards development, reinforcing the need for agile, inclusive, and enforceable space governance frameworks in an increasingly crowded orbital environment.

For the second scenario, **Moon Dust, Gold Rush, and the Missing Environmental Assessments**, across all five groups, there was strong consensus that LunaXtract, as currently proposed, exposes serious gaps in international governance, risk management, and environmental oversight for lunar activities. Participants broadly supported the integration of formal lunar Environmental Impact Assessments, cyber-resilience certifications, and transparent consultation processes into any future commercial lunar operations. There was also shared concern that the absence of binding legal norms could escalate geopolitical tensions and trigger resource-based competition on the Moon.

Key recommendations included: (1) establishing an internationally recognized Lunar Environmental Review Mechanism; (2) developing a cyber and operational risk certification process for autonomous lunar systems; (3) integrating lunar activities into evolving space ESG frameworks; and (4) advancing multilateral negotiations toward a binding governance regime for lunar resource extraction. These align with ongoing efforts such as the ESSI Declaration, UNOOSA’s work on lunar governance dialogues, and recent UK proposals for space sustainability metrics. Overall, the exercise reinforced the need for anticipatory, cross-disciplinary regulation to ensure that lunar resource activities contribute to shared human benefit, not short-term gain or geopolitical fragmentation.

Workshop Findings and Recommendations:

The workshop findings can be summarised as follows including recommendations necessary to foster a transition towards Sustainable-by-Default Earth–Space Governance.

- **Adopt Global Environmental Integration in Mission Design:** Interdisciplinary collaboration across science, engineering, and law is essential to embed environmental assessment tools—such as Life Cycle Assessments (LCAs)—early in space mission planning. This ensures sustainability is a design principle, not a retroactive fix.
- **Standardise Orbital Tracking and Debris Mitigation Mechanisms:** Scientists and legal experts called for internationally agreed orbital tracking standards, supported by transparent, interoperable data-sharing protocols to reduce collision risks and support debris management across borders and jurisdictions.
- **Advance Modular and Circular Space Technologies:** Engineers, commercial innovators, and policymakers agreed that standardising modular, serviceable systems is key to enabling satellite reuse and astrosalvage, facilitating the shift toward a circular space economy.
- **Promote EU-Wide and Multilateral Legal Frameworks:** Legal scholars at the workshop advocated for finalising an EU-wide space law and developing multilateral agreements that address STM, in-orbit servicing, and salvage rights to reduce legal fragmentation and regulatory uncertainty.
- **Incorporate Intellectual Property into Sustainability Governance:** It was widely agreed that there is a need to reform IP frameworks to support innovation while ensuring interoperability and access. Open-source licensing and flexible patent regimes were seen as critical enablers for repair and reuse.
- **Build Financial Mechanisms for Sustainable Practice:** Finance and insurance experts proposed dedicated investment funds and performance-based insurance models that reward responsible operations, reduce risk, and help scale sustainable innovation.
- **Embed Sustainability in Investment and Risk Frameworks:** Participants stressed the importance of embedding ESG-style sustainability metrics into investment decisions and enhancing transparency in reporting standards to attract long-term capital.
- **Integrate Cybersecurity into Space Sustainability Agendas:** Cybersecurity specialists and engineers underscored the critical role of resilient, validated autonomous systems and called for coordinated global norms, workforce development, and public–private cyber governance tools.
- **Adopt a Polycentric Governance Model:** International relations experts and lawyers advocated for a flexible, multi-level governance architecture that spans international treaties, regional bodies, national regulation, and industry-led initiatives to enhance agility and inclusivity.
- **Ensure Legal Accountability and Discourage Arbitrage:** there is a need for robust due diligence frameworks and global reputational standards to deter regulatory arbitrage and ensure shared legal and environmental responsibility across spacefaring nations and private operators.

The workshops interdisciplinary insights highlight that no single domain holds the solution to sustainable space governance. The workshop’s integrated approach—bringing together scientists, engineers, legal scholars, financiers, cybersecurity professionals, and policy experts—demonstrated the power of collaboration to develop governance structures where sustainability is embedded by default. This model provides a replicable pathway toward a resilient and inclusive earth–space governance system capable of responding to rapid commercial expansion, technological innovation, and geopolitical complexity.

Post-Workshop Developments and Future Outputs

Following the workshop, Space South Central featured a summary in its regional newsletter, commending the event's groundbreaking interdisciplinary focus on sustainability at the intersection of Earth and space. The piece highlighted the workshop's unique ability to bring together experts from science, engineering, law, policy, cybersecurity, and finance to address complex governance challenges across Earth-space systems.

A comprehensive workshop report, peer-reviewed by participants, will be finalised and published in autumn 2025. The report will be hosted on the websites of sponsoring institutions and disseminated via academic networks and professional social media channels. It will present key findings and actionable recommendations to embed sustainability as a default principle in Earth-space activities, with an emphasis on cross-sector and transdisciplinary collaboration.

The lead organiser, Dr Feja Lesniewska, will be at the UK Space Conference (Manchester, 16–17 July 2025), joining colleagues from the Surrey Space Centre at the official launch of the Institute for Space, University of Surrey. A workshop summary brief, highlighting key takeaways and recommendations, will be made available at the conference and online.

Several collaborative initiatives have already emerged from the workshop. Plans are underway to submit joint applications to the British Academy Interdisciplinary Awards, with projects focused on space traffic management and cyber sovereignty, in partnership with panellists Dr Berna Akcali (Queen Mary University of London) and Dr Joanna Kulesza (University of Lodz). Additionally, exploratory discussions are taking place on a proposed comparative research project examining the sustainability of spaceport infrastructure in Scotland and Norway, led by Dr Michael Picard (University of Edinburgh).

International and institutional collaborations are also developing. The organiser has received an expression of interest from a Taiwanese institution to support curriculum development for a new space law programme, and meetings are scheduled in August 2025 with two Adelaide-based companies working on advanced space systems to explore Earth-space sustainability research partnerships. Furthermore, the organiser has been invited to contribute to the BSI Space Sustainability Standards consultation and will participate in discussions with Iona Bratu, Director of the Centre for Space Sustainability and Security at Vrije Universiteit Amsterdam, to explore aligned research agendas.

A follow-up meeting with the organising committee will be held in September 2025 to reflect on the outcomes, consolidate key insights, and plan for future interdisciplinary collaborations. This will ensure ongoing knowledge exchange and maximise the policy, academic, and industry impact of the workshop.

Publications and Research Outputs

As a direct result of the workshop, several academic publications are in development:

A journal article titled "Earth–Space Sustainability by Default: An Interdisciplinary Framework", drawing from workshop discussions, is being prepared for submission to a special issue of *Earth System Governance* (submission deadline: 1 September 2025).

A research paper, "Space Assets: The New Frontier for Critical Infrastructure Regulation?", presented at the Security in the Digital Age Conference (Erasmus Centre for Law and Digitalisation, June 2025), is being revised for submission to the open-access journal Technology and Regulation.

Another draft research paper, "Shifting Regolith: Taxonomies of Sustainability for Lunar Mining – A Critical Techno-Legal Perspective", will be presented at a conference hosted by the University of Northumbria (8–9 July 2025), with publication details to follow.

Workshop feedback

The workshop was widely praised in feedback by participants both in the IAS online survey and via e-mail to the organisers. These included:

Feedback via e-mail

- 'I found it incredibly interesting and it was one of the most engaging and well organised events like this I've attended.'
- 'this really felt like the beginning of a conversation and I am looking forward to the next steps. Congratulations again to you and the team for such an excellent (and excellently organised) event.'
- 'Thank you ever so much for a really lovely day- it went so fast. Normally these things can drag on, but it felt like it was over too quick (well done). It would be wonderful to stay in touch and if there are any opportunities for us to work together even better!.'
- 'It was a very good day, far exceeding my expectations. I would gladly participate in a future, follow-up event.'

Feedback via IAS survey

- 'Congratulations for the preparation and organisation, for the enthusiasm, for the interesting scenarios and logistics, also for the meeting, the meals and your friendliness.'
- 'It was very well organised, with the right level of attendees to make it effective, relevant and useful for all attendees. The guided tour was a nice break and I heard many saying it was their first interactions with space related hardware and tracking systems. All good!'
- 'One-day workshops are the way forward. Well done. The tour of the space centre after lunch was an excellent initiative and one of the highlights. The two case studies were interactive and gave us the chance to network and understand each other's perspectives. All a very successful event. Please do this again!'
- 'A very well-planned and well-executed workshop on a critical subject. The contents of the workshop deserve a much wider audience.'
- 'This was possibly the best organised academic/industry crossover event I have attended. It was well thought through, well organised and productive. The cross-disciplinary nature of the discussions was invaluable. Really impressive.'
- 'It was a truly stimulating day with enthusiastic participants - and well organised and facilitated. It's often a challenge to take a day out of the office, knowing emails and work are piling up - I'm so glad I did.'

Acknowledgements

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Like all workshops a great deal of time and effort is spent by a number of people to make the event possible. I wish to say a huge thank you to the following: Mirela Dumic and Louise Jones (IAS) for guiding me through the process of delivering a workshop drawing on their extensive experience, Dan Smith, (Space South Central), for helping identify and contact people for the panel, Dr Lucía F. de la Bella, (Surrey Space Centre), for constant support, making links with the Surrey space community and helping with organising the logistics for the day, Theo Donnelly, (School of Social Science) for taking on extra administrative work and finally Dr Matthew Peacock (Governing Plastics Network, Surrey Law School) who went beyond the call of duty to ensure all aspects of the workshop were delivered. We are also grateful for all presenters for taking the time to make this such a wonderful and inspiring event.