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Summary Report on BEREC External Workshop on environmental footprint of satellite constellations

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Executive Summary

As part of its annual work program, on 25 September 2025, BEREC organised an external workshop to understand the environmental footprint of satellite constellations, complementing its previous work on satellite communications. This workshop brought together representatives from key stakeholders: regulators, space and satellite experts, international bodies and industry players to explore the environmental aspects of the satellite systems and build an overview of existing initiatives and stakeholder perspectives on these aspects.

The workshop included a discussion on existing studies on life cycle environmental impact assessment of satellite constellations. Various challenges associated with these assessments were highlighted, relating to limited data availability and uncertainties in environmental impact mechanisms. The discussion also covered issues like space debris and light pollution, particularly its effect on ground-based astronomical observations, weather monitoring activities and nocturnal wildlife. The concept of planetary boundaries was addressed, referring to the ecological and physical limits within which both Earth and orbital environments must remain. The environmental impact of constructing and maintaining ground infrastructure (e.g. satellite dish installations and data centres) was also discussed. Advancements in sustainable satellite design were also presented.

The workshop included a presentation from the European Commission (EC) delivered by Ms Vera Pinto, Policy Coordinator at the Directorate General for Defence Industry and Space (DG DEFIS), a presentation by Dr Marie Le Pellec from the European Space Agency (ESA), presentation by Dr Ulpia-Elena Botezatu from the UN COPUOS[1] Scientific and Technical Subcommittee (STSC), a presentation by Mr Alexandre Vallet from the International Telecommunication Union (ITU), a presentation by Dr Laurence Monnoyer-Smith from the French National Centre for Space Studies (CNES), presentations by the leading academic researchers: Dr Andrew Ross Wilson, Lecturer at Glasgow Caledonian University and Prof Massimiliano Vasile, Professor at University of Strathclyde, and presentations by the stakeholders: Mr Jordi Casanova (Amazon, Kuiper Project), Mr James Matthews (Eutelsat), Mr Julien Doche (Aéro Décarbo), Ms Natalia Vicente (GSOA) and Mr Mario Neri (Telesat). The workshop concluded with a panel discussion moderated by Ms Bianca Sofian (Cullen International).

The following summary report provides an overview of the workshop's presentations and main contents. The definitive version of the workshop discussions is set out on BEREC's YouTube channel recording[2] and interested parties are encouraged to view it, observing that this report serves only as a guide to what was an informative and lively discussion about this important topic.

[1]United Nations Committee on the Peaceful Uses of Outer Space
[2]https://youtu.be/UqEv_82N2iM?si=3mz4TgzmKVqxqOEd

1. Welcome by the Incoming BEREC Chair 2026

The Incoming BEREC Chair 2026, Mr Marko Mišmaš, Director of the Agency for Communication Networks and Services of the Republic of Slovenia (AKOS) opened the workshop, welcomed the participants, and briefly presented the importance of the topic for BEREC.

Mr Mišmaš noted that over the last years, the growth of satellite constellations has been remarkable. These systems are reshaping global connectivity, digital inclusion, universal service, etc. and are bringing new opportunities to people in locations that were once unreachable. On the other hand, constellations also show the limits of our planet. Issues of space debris, atmospheric changes and the effects of ground infrastructure remind us that this technology has to remain within the planetary boundaries.

This workshop is part of BEREC's broader sustainability strategy and, as the European Commission is preparing to revise the European Electronic Communications Code, sustainability should stand next to connectivity as one of its important priorities. BEREC stays committed to its strategic goal of sustainability by building upon its previous work on sustainability indicators and environmental footprint of ICTs, and BEREC's efforts will continue to be aligned with the European Green Deal and the UN 2030 Agenda.

BEREC enables collaboration between the European regulators to promote data-driven regulation, evidence-based and informed decision-making. In this regard, a clear legal mandate for collecting environmental data is needed for the NRAs. Mr Mišmaš called for an open dialogue and cooperation between stakeholders to discuss sustainable satellite design solutions, improve data availability and coordinated regulatory approaches to ensure innovations and connectivity are being developed in harmony with the planet.

2. Introduction by the Co-Chairs of the BEREC Sustainability working group

Ms Mary Sarantopoulou (EETT) and Mr Tom Nico (Arcep), Co-Chairs of the Sustainability working group (SUS WG), presented some information relating to the environmental footprint of satellite constellations, and provided an overview of BEREC's work on environmental sustainability so far.

Ms Sarantopoulou noted that BEREC has integrated environmental sustainability into its 2021–2025 strategy and annual Work Programmes to support the EU Green Deal and the UN 2030 Agenda and its associated Sustainable Development Goals. In 2023, BEREC published a report on *Sustainability Indicators for Electronic Communications Networks and Services*[3]

[3] https://www.berec.europa.eu/system/files/2023-10/BoR%20%2823%29%20166%20Final%20Report%20on%20sustainability%20indicators%20for%20ECN%20ECS.pdf

and contributed to the ongoing work of the EC's DG Connect and the Joint Research Centre (JRC), which will result in establishing an EU Code of Conduct for the sustainability of telecommunications networks by 2025. In 2024, BEREC focused on end-users with the report on *ICT Sustainability for End-Users* and a dedicated communication campaign. In 2025, BEREC organized an external workshop and published a summary report on *Ecodesign of Digital Services for Greener Networks and ICTs*[4][5], as well as the *Infrastructure Sharing as a Lever for ECN/ECS Environmental Sustainability*[6] report.

In addition, over the last few years BEREC has organised several workshops on satellite connectivity and published reports which analysed different aspects of satellites communications: universal service[7], secure and reliable connectivity from LEO satellite fleets[8], usage of satellite technologies in mobile communications[9] and direct-to-mobile-device satellite connectivity[10].

In light of the rapid expansion of satellite constellations, a dedicated workshop on their environmental footprint was included in BEREC's 2025 Work Programme. While such constellations bring new opportunities for connectivity, especially where the traditional networks are unavailable, they also pose challenges for environmental sustainability. Ms Sarantopoulou noted that the environmental footprint of satellites spans across their entire lifecycle (manufacturing, launch, operation, deorbiting), and is multidimensional due to its impacts on:

- Earth (ground infrastructure, material and land use, energy demand)
- Atmosphere (rocket launches emissions, atmospheric pollution caused by re-entry of satellites and debris), and
- Space (space debris and orbital sustainability, light pollution, pressure on orbital resources)

Moreover, light pollution from satellites affects ground-based astronomy, weather monitoring activities and nocturnal ecosystems.

Mr Tom Nico noted that society's increased demand for greater connectivity and faster connections comes at the cost of an increased number of satellites being launched into orbit

[4]https://www.berec.europa.eu/en/events/external-workshop-on-the-ecodesign-of-digital-services-for-greener-networks-and-icts

[5]https://www.berec.europa.eu/system/files/2025-10/BoR%20%2825%29%20130_BEREC%20Summary%20Report%20on%20external%20workshop%20on%20digital%20services%E2%80%99%20ecodesign%20for%20greener%20networks%20and%20ICTs.pdf

[6] https://www.berec.europa.eu/en/all-documents/berec/reports/berec-report-on-infrastructure-sharing-as-a-lever-for-ecnecs-environmental-sustainability

[7]https://www.berec.europa.eu/en/document-categories/berec/reports/report-on-satellite-connectivity-for-universal-service

[8]https://www.berec.europa.eu/en/document-categories/berec/reports/summary-report-berec-workshop-on-secure-and-reliable-connectivity-from-leo-satellite-fleets-13-april-2023

[9] https://www.berec.europa.eu/en/all-documents/berec/reports/summary-report-berec-external-workshop-about-the-usage-of-satellite-technologies-in-mobile-communications

[10] In an internal workshop over three sessions during 2025 .

and contributing to the rapid development of large constellations, especially at non-geostationary orbits. According to the UN, the number of satellites in orbits could increase from around 9,000 to 100,000 by 2030. This significant growth raises concerns about the environmental impacts both on Earth and in space.

From the launch phase to the end-of-life management of satellites, many questions are being raised by different stakeholders: What are the greenhouse gas emissions caused by satellites? What is the risk of uncontrolled collisions in orbits and debris falling to Earth? What is the pollution of the upper atmosphere? What disruption do satellites cause to astronomical observations?

Mr Nico emphasised that the workshop would focus on a number of existing projects and studies, discuss challenges, showcase innovation in sustainable satellite design and good practices, and promote dialogue among regulators, industry, academia, and international bodies.

Finally, Mr Nico noted that BEREC acknowledges that the environmental footprint of satellite constellations is a shared challenge which requires collective efforts and actions from multiple stakeholders to be adequately addressed.

3. Presentation from the European Commission, Environmental sustainability of EU space activities, Ms Vera Pinto, Policy Coordinator at the Directorate General for Defence Industry and Space, DG DEFIS

Mr Nico welcomed Ms Vera Pinto, Policy Coordinator at the Directorate General for Defence Industry and Space, DG DEFIS.

Ms Pinto highlighted the rapid growth of satellite constellations. With currently around 13,000 satellites already in orbit, licenses for 15,000 additional satellites have recently been requested in the US. This could soon bring the total number of satellites to nearly 30,000, raising many concerns including concerns regarding different space debris mitigation technologies. Discussions have recently begun on exploring sustainable alternatives to de-commissioning satellites.

Ms Pinto added that the EU is monitoring these developments. Ms Pinto explained that EU's approach to address some of these concerns includes the Space Traffic Management (STM) which is broadly defined as the means and rules to access, conduct activities in, and return infrastructure from outer space safely, sustainably and securely.

While STM traditionally includes elements such as:

- Space Situational Awareness (SSA), including Space Surveillance and Tracking (SST) [11]
- Orbital debris mitigation and remediation
- Space orbits and radio spectrum management, and
- Re-entry phase of spacecraft (controlled and uncontrolled).

Ms Pinto added that, within the current STM approach, the EU is starting to include elements that extend beyond the traditional scope of traffic management, relating to environmental and space sustainability. This includes the entire life cycle of space operations, from design and launch phase, in-orbit operations of spacecraft to end-of-life and de-orbit operations.

Ms Pinto noted that for the first time, the Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS^2) Regulation[12], includes a dedicated article linked to environmental and space sustainability. Under this article, the EU has a legal obligation to measure, mitigate and offset the greenhouse gas emissions arising from IRIS^2 operations. In line with the EU Green Deal and the EU Climate Law, which aim to make Europe climate neutral by 2050, these sustainability principles must also apply to the EU space infrastructure.

She emphasised that Life Cycle Assessment (LCA) is not new to the space sector, and that Europe is at the forefront of this field, thanks to the European Space Agency's (ESA) 12 years of work, in developing methodologies aligned with international standards. Although applying LCA to EU space programs can raise environmental standards and promote good practices, a common LCA standard covering the entire life cycle is still lacking.

To address this, Ms Pinto stressed the need for harmonised LCA practices, access to robust and comparable data and advanced impact assessment models. The EC's Product Environmental Footprint (PEF) Category Rules (PEFCR), in the frame of the Green Deal, provide standardised methods to objectively measure impacts and assess whether the reduction measures are realistic.

She explained that the proposed EU Space Act is built on three pillars: safety, resilience and sustainability. Safety, because space is rapidly becoming congested; resilience, because it is contested and sustainability because both Earth and space are polluted. One of its goals is to develop a common methodology for calculating the environmental impacts, as regulators currently lack clarity on whether setting a 20% emissions reduction target for satellite constellations is realistic, given the wide scope of interpretation of the measurements.

To prepare this technical proposal, the EC together with stakeholders launched PEFCR4Space initiative, bringing together large and small companies, start-ups, research

[11] EU SST - EU Space Surveillance and Tracking

[12] IRIS² is part of the EU's broader Secure Connectivity Programme, intended to provide secure, resilient satellite communication for Europe while supporting sustainability goals under the European Green Deal and Climate Law; IRIS² | Secure Connectivity - Defence Industry and Space

centres, universities and NGOs to identify methods for calculating environmental impacts and adapting them to the space specificities. A common measurement framework will ensure transparency, comparability and efficient data reuse, reducing the need to collect data repetitively.

The Technical Secretariat of the PEFCR4Space initiative, representing at least 56% of the European space market share (only considering launch, manufacturing and operations), decides by consensus on the calculation rules. Supporting working groups address more detailed issues, while external space experts also contribute to the process. DG DEFIS and ESA, both part of the Technical Secretariat, are working together to reach a common approach on ESA LCA activities by the end of 2027. This will allow data collected for LCA in the frame of ESA contract, to be reused both in the frame of the PEFCR4Space and the European Space Act, in order to avoid duplication.

The EC launched the PEFCR4Space a year ago, established initial calculation guidelines, and began developing a benchmark for LCA calculations. Key milestones include a call for participation in supporting studies (open until September 2025) and a public consultation on the draft PEFCR (15 October– 30 November 2025), with the final version expected by the end of 2027.

Ms Pinto concluded that a common approach to data collection and measurement will enable better decision-making, allowing policymakers to set effective sustainability rules. Joint efforts will also help identify supply chain bottlenecks, reduce costs, and ensure that future generations can continue to access and explore space.

4. European Space Agency: Sustainability strategy and sustainable space missions, Dr Marie Le Pellec, Space Sustainability Coordinator, European Space Agency

Ms Sarantopoulou welcomed Dr Marie Le Pellec, Space Sustainability Coordinator at ESA.

Dr Le Pellec presented an overview of ESA's initiatives on space sustainability. ESA is committed to the peaceful exploration and use of space for the benefit of people, society and our planet, acting responsibly across three different, but very interconnected environments: The Earth orbit, the Moon and deep space. ESA provides data to support climate change mitigation, the circular economy and technology transfer from space to Earth. It promotes responsible use of resources, contamination prevention, waste management, reduction of space debris, as well as reduction of environmental impacts on Earth, including climate change, ozone depletion and biodiversity loss.

The ESA Green Agenda is based on two pillars, the first focuses on maximising sustainability benefits, so that ESA and European space programmes contribute to the objectives of the Paris Agreement and the European Green Deal; the second aims at minimising environmental impacts by reducing ESA's own emissions.

In its 2019 baseline assessment, ESA identified that most of its impact comes from Scope 3 (supply chain and external activities) which is the most challenging to reduce due to limited control. However, by 2030 ESA is committed to reduce its operational activities emissions by 46% and activities executed by its suppliers by 28%.

Dr Le Pellec noted that for a decade ESA has been developing LCA methods specific to space missions. LCA hotspot analysis has helped identify the main drivers of global warming, mineral resource depletion, and other environmental impacts throughout the mission phases.

ESA is exploring greener solutions through long-term planning, taking into account energy-intensive satellite testing and the use of rare materials in manufacturing. It maintains a robust LCA database and has issued supplier guidelines to harmonise communication and comparability. ESA's technology roadmap identifies key environmental impacts and solutions to guide investments, while ecodesign approach focuses on simplified early-stage assessments using templates and generic databases.

Taking into account the burden of conducting numerous LCAs, ESA has streamlined its ecodesign process to focus on the main environmental hotspots, where interventions have the greatest impact. Addressing sustainability early in the design phase is more cost-efficient than making changes later. ESA's ecodesign policy ensures systematic implementation across all programmes and activities, requiring each project to perform a simplified early-phase LCA to identify significant hotspots and potential ecodesign alternatives.

Dr Le Pellec stressed that ecodesign can have exponential effects: optimising a platform that is reused many times has a greater impact than one-off projects, supporting platform standardisation. Testing can also be optimised: using common design and shared components reduces both the number of testing and energy consumption.

She acknowledged existing gaps, but noted that ESA is addressing them through four pillars: supporting knowledge sharing, participating in field data collection, developing ground testing and improving modelling.

ESA and the global community also support a Zero Debris approach[13], but the long-term goal is circular space economy. In the future, satellites could be reused instead of burned or discarded to the ocean. One example is the RISE[14] mission, planned for 2028, that will demonstrate that it can safely rendezvous and dock to a geostationary client satellite, extending the life of geostationary satellites that need support with attitude and orbit control, but are otherwise in working order.

Dr Le Pellec stressed that in the context of this mission, ESA's role is to demonstrate the technology and make it ready for commercial partners to turn into viable business models. She underlined that while sustainability is essential, it must also make economic sense to ensure long-term adoption.

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[13] ESA - ESA's Zero Debris approach
[14] ESA - RISE mission to extend life of geostationary satellites

Dr Le Pellec concluded that while satellite constellations present major environmental sustainability challenges, they also offer opportunities. Standardisation enhances the impact of ecodesign and in-space servicing while also offering potential for cost reduction through energy savings, and fostering innovation. For ESA, this represents a chance to strengthen competitiveness in the global space economy. Finally, she underscored the importance of adapting early to regulatory changes, as proactive adaptation is less costly and more effective.

5. Sustainability in Space: Exploring the balance between expanding satellite technology and preserving the environment for future generation, Dr Ulpia-Elena Botezatu, Chair of the Scientific and Technical Subcommittee (STSC), UN COPUOS

Ms Sarantopoulou welcomed Dr Ulpia-Elena Botezatu, Chair of the Scientific and Technical Subcommittee (STSC) of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS).

Dr Botezatu noted that outer space activities are expanding faster than ever before, with large satellite constellations transforming global connectivity and supporting critical sectors such as agriculture, banking, transportation, disaster management and climate science. While these developments bring major benefits, they also raise critical questions about safety, sustainability, and equitable access to space as a shared global domain.

Dr Botezatu recalled that the Outer Space Treaty of 1967 (the “1967 Treaty”) established key principles still guiding space activities today. The 1967 Treaty reaffirmed that space must be used for the benefit and in the interest of all countries, that activities should avoid harmful contamination of the outer space and Earth, and that states remain internationally responsible for both governmental and private actions. These fundamental obligations, she emphasised, form the basis of today’s global discussions on sustainability and responsible behaviour in orbit.

Today, over 90 countries operate satellites, compared to just 14 at the beginning of the century, a sign of rapid democratisation of space. The emergence of mega constellations composed of hundreds or thousands of satellites, brings exciting opportunities to expand services like global internet coverage, as well as create new economic opportunities. However, this surge in space activity also poses technical, legal, environmental and geopolitical challenges, particularly space debris and orbital crowding. The Earth’s orbital environment, especially the lower orbits, is finite and vulnerable. Decades of space activities have left tens of thousands of objects in the orbit, now circling the planet. They might be small or inactive, but they travel at very high speed and a collision with even a tiny fragment can disable an active spacecraft.

To address this, the UN COPUOS adopted Space Debris Mitigation Guidelines (2007) and, later, the Guidelines for the Long-term Sustainability of Outer Space Activities (2019)[15] – a landmark set of 21 best practices developed with input from over 90 member states. The LTS guidelines address a wide range of measures, from technical and regulatory frameworks to safety operations, international cooperation, and scientific research. Together, they form the cornerstone of current space sustainability efforts and reflect a decade of multilateral negotiation and scientific collaboration.

Dr Botezatu emphasized that the next challenge is not creating new guidelines but implementing and sharing them effectively. UN COPUOS now focuses on practical implementation and sharing experiences at an international level to strengthen compliance and capacity-building, including for developing countries. The United Nations Office for Outer Space Affairs (UNOOSA) plays an essential role in supporting this process through training, data sharing, and promoting transparency among space actors.

She also highlighted emerging concerns, such as the impact of satellite constellations on astronomy and the night sky. With the proliferation of satellites, their reflections and radio emissions increasingly interfere with ground-based astronomical observations. UN COPUOS has therefore taken up the issue of “Dark and Quiet Skies for Science and Society”, in cooperation with the International Astronomical Union and UNOOSA, to find balanced solutions.

UN COPUOS and partners such as the International Astronomical Union are developing measures to limit satellite brightness, protect radio astronomy bands, and ensure the coexistence of space operations and astronomy**.** Another focus is the terrestrial environmental footprint of space activities, from satellite manufacturing and launches to ground operations and data centres. These activities all emit greenhouse gases and pollutants, highlighting the need for a life-cycle perspective that links space sustainability with Earth sustainability.

Dr Botezatu stressed that no single nation can manage these challenges alone. Global cooperation through UN COPUOS, under the guidance and endorsement of the UN General Assembly (UNGA), remains essential to develop harmonized standards, shared norms, and responsible behaviour in orbit. Its scientific, technical, and legal subcommittees continue to shape frameworks that balance innovation, security, and environmental stewardship.

She concluded by reminding participants that space, like Earth, is a common heritage that must be protected for future generations, quoting:

“We do not inherit the Earth from our ancestors, we borrow it from our children. The same applies to outer space.” In closing, Dr Botezatu reaffirmed her confidence that through cooperation, shared responsibility and innovation, the international community can achieve a truly sustainable space economy, one that thrives for generations to come.

[15] https://spacesustainability.unoosa.org/content/The_Guidelines

6. International Telecommunication Union's Initiatives on Space Sustainability, Mr Alexandre Vallet, Chief of the Space Services Department, Radiocommunication Bureau of the International Telecommunication Union (ITU)

Mr Nico welcomed Mr Alexandre Vallet, Chief of the Space Services Department at Radiocommunication Bureau of the International Telecommunication Union (ITU).

Mr Vallet explained that satellite constellations can have two main types of environmental footprint: on Earth and in space. While national or regional initiatives are advancing (as seen in ESA and UN examples), international work on assessing these impacts is still at an early stage.

Mr Vallet highlighted that the ground segment of the satellite constellation systems is simply telecommunication systems which consist mainly of electronic devices. Therefore, regarding environmental impacts on Earth, many issues, such as e-waste from user terminals, fall under existing telecommunication sustainability standards developed by the ITU, making the development of new standards unnecessary. However, assessing the environmental effects of manufacturing and launch activities still requires more international coordination. Apart from e-waste, which occurs at the end of the life cycle, there is still a lot to do in assessing manufacturing impacts.

The other environmental footprint is in space itself and this is generally referred to as space sustainability. Mr Vallet referenced a graph from the US Government Accountability Office (GAO) report, illustrating that the Federal Communications Commission's (FCC) long-standing exemption of the space industry from environmental review under the National Environmental Policy Act (NEPA) – a policy set in the 1990s, when satellite activity was far less intensive – may need reassessment, given the sector's rapid evolution.

The environmental footprint of space activities relates to orbital sustainability, closely linked with safety and security, which cannot be addressed in isolation. Mr Vallet noted that fragmented national responsibilities often hinder coherent action; effective international cooperation requires consistent national positions across different forums and agencies. Mr Vallet presented the ITU initiatives on space sustainability. To strengthen coordination, the ITU organised the second Space Sustainability Forum in October 2025 (Geneva). The forum focused on three action lines:

- Data sharing to improve communication and collision avoidance among satellites, especially for smaller operators.
- Awareness and capacity building – training telecommunications regulators who often handle satellite licensing in countries without dedicated space agencies, helping them apply best practices even in the absence of national space laws.

- Technical standardization – encouraging industry to develop and share technological solutions through the ITU's standardization bodies.

Mr Vallet also highlighted the ITU's role in addressing **"**dark and quiet skies**"** – light and radio pollution affecting astronomy. The "dark skies" concern relates to sunlight reflected by satellites that can disrupt optical telescopes, while the "quiet skies" issue focuses on protecting radio astronomy from interference caused by satellite transmissions. The World Radiocommunication Conference (WRC-27) will consider measures to protect major observatories such as ALMA in Chile's Atacama Desert and MeerKAT in South Africa, two of the world's largest and most sensitive radio astronomy sites. One proposal under discussion is the creation of international radio-frequency protection zones that extend beyond the ground-based observatories into space, ensuring satellites avoid emitting signals when passing overhead.

However, defining appropriate emission thresholds to guarantee effective protection remains technically complex. Moreover, the growing number of non-geostationary satellite constellations means that interference can now come from multiple directions across the sky, making it far more difficult for astronomers to find interference-free observation windows. These developments underscore the urgency of strengthening coordination between the space and astronomy communities within the ITU framework.

In addition, Mr Vallet elaborated on a specific concern for radio astronomy related to spectrum use. While certain frequency bands are formally allocated to radio astronomy, astronomers often study signals across the entire spectrum, not just within their protected bands. In the past, this was manageable because geostationary satellites occupied a fixed region of the sky, allowing observations to be scheduled in interference-free zones. However, the proliferation of large non-geostationary constellations – comprising thousands of satellites in constant motion – means that radio emissions now traverse nearly every part of the sky. As a result, astronomers can no longer simply avoid interference by waiting for a quiet patch, and persistent background noise threatens to limit the sensitivity of even the most advanced observatories. Addressing this challenge will require new coordination mechanisms and possibly revised protection criteria within the ITU's technical framework.

Finally, Mr Vallet drew attention to the growing number of lunar mission filings – 55 so far from nine countries, including ten from private companies. He urged regulators to include environmental protection of the Moon, particularly the radio-quiet far side – the hemisphere permanently facing away from Earth, naturally shielded from radio emissions – in licensing considerations, warning that once polluted, such environments may be impossible to restore. Mr Vallet stressed the need to preserve the Moon's radio-quiet far side, protected under international treaty. He urged regulators to reflect these safeguards in national laws, warning that even minor interference could cause irreversible harm to this unique scientific zone.

7. Presentation from academics: Advancing Space Sustainability: Initiatives from academia and industry, Dr Andrew Ross Wilson, Lecturer in Environmental Management, Department of Civil Engineering and Environmental Management, Glasgow Caledonian University

Mr Nico welcomed Dr Andrew Ross Wilson, Lecturer in Environmental Management at Glasgow Caledonian University (GCU).

Dr Wilson opened by noting that the growing interest in space sustainability is timely, as the space sector undergoes a profound transformation. We are seeing more and more launches, objects placed into space and a transition from state-run space programs to greater involvement of private sector actors. This great involvement from private sector actors has resulted in both positive and negative results: on the one hand, economic activities have been expanded and key societal challenges have been addressed, particularly through the provision of space data. On the other hand, there has been the generation of greater space debris, increasing orbital congestion, light pollution and a larger environmental footprint of the space sector.

Dr Wilson described this tension as the “space sustainability paradox”: the more humanity depends on space to support sustainable development, the greater the risk that the space sector becomes unsustainable, both in orbit and on Earth.

Dr Wilson also referred to the “Doughnut Economics" framework of planetary boundaries, a model that represents a safe and just space for humanity between two concentric rings: a social foundation and an ecological ceiling, balancing human and social needs without exceeding Earth’s ecological limits. Policies designed to promote space sustainability must therefore also be sustainable in themselves, ensuring that interventions do not shift the burden from one domain to another.

Dr Wilson presented his work at GCU and Metasat UK, a research and consultancy start-up founded in 2020 that focuses on space life cycle assessment (LCA), ecodesign, and carbon accounting. Metasat UK manages the Strathclyde Space Systems Database (SSSD), the world’s first and only space-specific life cycle sustainability assessment (LCSA) database. The SSSD combines environmental, economic, and social datasets to evaluate and reduce the sustainability footprint of space missions and integrate sustainability metrics into mission design. It is currently used by stakeholders across 11 countries and three continents. Originally developed in 2016 at the University of Strathclyde and publicly released in 2019 the SSSD continues to evolve under Metasat UK.[16]

[16] Access requires a legal contract that defines the terms and conditions.

Dr Wilson shared insights from studies indicating that, if unchanged, the space sector's contribution to global environmental impacts could reach 5%, with about 2% contribution to planetary boundaries. Research on space tourism further revealed particularly high environmental impacts, underscoring the need to integrate environmental assessment alongside technical and economic analysis.

At GCU, a major ongoing project is a UK space sector carbon footprint study, aimed at providing recommendations on viable decarbonisation pathways in line with UK net-zero targets. The report will be published in December 2025.

GCU also contributes to the PEFCR for the space sector, collaborating with partners including VITO, Pre-Sustainability, EcoMatters, Eco-Innovation, and Nova Space. GCU's role involves supporting studies to test and validate the effectiveness of PEFCR methodologies across different space products.

Dr Wilson announced plans for a new tool that will combine a simplified LCA with cost analysis helping organizations understand the financial implications of sustainable design decisions early in the mission concept stage — addressing common concerns about the perceived cost of ecodesign implementation.

Beyond research, GCU plays an active role in informing policymakers by fostering collaboration. GCU co-leads Space Scotland's Environmental Task Force, which developed the world's first national Space Sustainability Roadmap. GCU also participates in the Cross-Party Group on Space in the Scottish Parliament, promoting the role of space as a force for good in addressing global challenges, particularly climate change.

Further collaborations include the UK Space Energy Initiative Working Group, exploring space-based solar power – a concept requiring early attention to environmental design given the large scale of such systems. GCU is also engaged in the European Space Agency's Technical Task Force on LCA and Ecodesign, contributing to European-level dialogue on sustainability practices. Dr Wilson emphasised that space sustainability is a cross-cutting discipline that must consider both "sustainability from space" (how space supports sustainability on Earth) and "sustainability for space" (how we sustain the orbital environment itself).

He concluded by calling for stronger collaboration between academia and industry, noting that progress depends on shared efforts rather than competition. The partnership between GCU, Metasat UK, and the University of Strathclyde demonstrates how this synergy can accelerate innovation and sustainable outcomes.

8. Presentation from academics: Space Sustainability a Complex Systems Perspective, Prof Massimiliano Vasile, Professor of Space Systems Engineering, Director of the Aerospace Centre of Excellence, University of Strathclyde

Ms Sarantopoulou welcomed Prof Massimiliano Vasile, Professor of Space Systems Engineering, Director of the Aerospace Centre of Excellence, University of Strathclyde.

Prof Vasile and Dr Wilson published a paper[17] on the "space systemic paradox" which aims to define what space sustainability is from a technological perspective. Prof. Vasile explained that space sustainability rests on three broad pillars that must be considered together: sustainability from space, which focuses on using space as a platform to directly or indirectly address global challenges; sustainability in space, which treats space as a natural resource to be responsibly preserved, explored, and utilised; and sustainability for space, which emphasises protecting Earth's environment from the impacts of space activities. These three pillars are deeply interconnected, meaning that a change in one area will inevitably affect the others.

Launching more satellites will lead to more traffic in space and potentially more damage to the space environment, but also more pollution on Earth due to the use of raw materials.

The University of Strathclyde is addressing these challenges through its contribution to the Scottish Space Sustainability Roadmap[18] and related implementation activities. The University is also supporting the UK delegation to the Inter-Agency Space Debris Coordination Committee (IADC)[19], by providing analysis and insights on how to address sustainability comprehensively including both the long-term management of orbital debris and the environmental impacts of space activities on Earth.

Several collaborative projects with the ESA have been funded, such as the SOLERO project[20] which examines the impact of very large infrastructures in space, including potential space-based solar power satellites that could beam renewable energy to Earth to help reduce terrestrial emissions.

The paper focuses more at the long-term sustainability of the space activities focusing on how current practices may affect the ability to operate in orbit in the future. Together with Dr Wilson, Prof Vasile is exploring ecodesign approaches to make satellites less polluting and more resource-efficient.

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[17] https://www.sciencedirect.com/science/article/pii/S0959652623030275

[18] https://spacescotland.org/wp-content/uploads/2023/11/Space-Sustainability-A-Roadmap-for-Scotland-Compressed-Version.pdf

[19] Inter-Agency Space Debris Coordination Committee (IADC)

[20] https://activities.esa.int/index.php/4000144200

In this project, a complex system approach to space sustainability is applied. Rather than studying single satellites or orbits in isolation, the research models the orbital environment as an interconnected network, where different regions of space and satellite populations influence one another. For instance, one constellation can affect the operations or safety of an Earth observation satellite. The goal is to understand how environmental impacts propagate through this network and how policy interventions could mitigate systemic risks. To support this, a model called NESSY[21] (NEtwork Model for Space SustainabilitY), has been developed. NESSY helps quantify how regions of space interact, how each actor influences the others, and how regulatory or operational measures could prevent cascading failures in the orbital environment. Prospective models related to the launch traffic have also been developed, to assess the current trend and how it is evolving in the near future. Other possible futures are considered, for example, scenarios in which, mega constellations are launched alongside the possible implementation of different policy measures. These include: the disposing of satellites within a certain period of time; allowing half of them to remain in orbit or ensuring that no satellites remain once their operational lifetime is over. Such measures would improve the situation by reducing end-of-life objects, but they would not completely solve the problem due to the persistent population of fragments already in orbit.

The team also investigates how disturbances in one orbital region can affect others, a phenomenon quantified using network connectivity metrics. Prof Vasile and Dr Wilson found that the more interconnected the orbital environment becomes, the more fragile it is, a finding with implications for both orbital safety and lifecycle sustainability assessments.

The life cycle sustainability assessment was integrated into a diagram in which the loop was closed between assessing the life cycle of the entire system and considering the impacts during space operations. A special database developed at the University of Strathclyde was used along with the tool dedicated to assess the life cycle.

Reducing the environmental impact on Earth is reducing environmental impact in space: it is important to balance the two aspects. Consequently, in order to be able to study this, a web tool was developed together with MIT and Colombia, a Canadian company, with which it is possible to analyse the interplay between the environmental impact on Earth and the environmental impact in space, trying to find a reasonable balance between the two.

[21] https://www.researchgate.net/publication/393007618_A_Holistic_Approach_to_Space_Sustainability_Closing_the_Loop_Between_Global_Space_Health_Indicators_and_Life_Cycle_Assessment

9. Decarbonization Roadmap of the French Space Sector, Dr Laurence Monnoyer-Smith, Director of Sustainable Development at the National Centre for Space Studies (CNES)

Mr Nico welcomed Dr Laurence Monnoyer-Smith, Director of Sustainable Development at the National Centre for Space Studies (CNES).

Dr Monnoyer-Smith presented the French decarbonisation roadmap for the national space sector, a major cooperative initiative mandated by the French Ministry of Economy and coordinated by CNES.

The objective of this roadmap is to bring together the entire space ecosystem, from upstream to downstream industries – to collectively assess, plan, and implement measures that reduce the sector's carbon footprint in line with national and European climate objectives.

The project was developed within the framework of COSPACE, an industrial forum that convenes companies, government representatives, and the French Ministry of Economy on a regular basis to discuss the development and international promotion of the French space ecosystem. Within COSPACE, a dedicated sustainability working group, led by Thales Alenia Space and the French Ministry of Economy, was tasked with developing the roadmap. Work began in January 2024 and extended over eighteen months, involving multiple in-person meetings and thematic workshops aimed at defining the baseline emissions, setting targets, and identifying both concrete mitigation levers and supporting actions.

A crucial first step was to establish a reference year, marked as T-zero (2023), and establish a first evaluation of the carbon footprint of the French space sector. This process was technically complex and required significant data sharing between companies, made possible through the signing of non-disclosure agreements and a strong spirit of voluntary cooperation. Using a life cycle assessment approach, covering activities from research and development to end-of-life, CNES assessed emissions across four main segments of the space industry: launches, the space segment, the ground segment, and user activities.

The total footprint of these four main segments was estimated at around 1.8 million tons of CO_2 equivalent. Each segment accounts for roughly one-third of total emissions. However, Dr Monnoyer-Smith emphasized that this figure represents a lower-bound estimate, as emissions occurring in the upper atmosphere are not yet fully accounted for, though they may be significant.

The roadmap aligns with the French National Low-Carbon Strategy (SNBC) and the EU Green Deal, aiming for a reduction of –49% by 2040 and –83% by 2050 compared to 2015 industrial levels. Translating these national targets to the space sector means reducing current emissions from 1.8 Mt CO_2e to about 1.1 Mt by 2040, and further to 0.3 Mt by 2050 – a massive 83% cut requiring innovation across all components of the space value chain.

The working group identified a series of priority levers to drive decarbonisation. These include reducing energy consumption and transitioning to renewables, improving transport efficiency, using more sustainable materials, and developing cleaner propellants. Circular economy principles, particularly through “pooling” or the shared use of industrial infrastructure and standardisation across companies, emerged as a particularly promising approach. The group also focused on data optimisation, aiming to minimise the energy and emissions associated with data generation, storage, and processing. A further lever – addressing emissions in the upper atmosphere – remains under study, as more research is needed to quantify its impact.

Not all the levers have the same impacts. In addition, the roadmap identifies facilitating further actions such as education and awareness campaigns, public investment, regulatory and policy support, and European level coordination and lobbying. These cross-cutting measures are essential to create the conditions under which the identified levers can be effectively implemented by both industry and government actors. Building on these elements, several scenarios were developed to explore different combinations of growth assumptions and mitigation pathways. Based on the projections, the French space sector is expected to grow at an average annual rate of approximately 2.2% over the coming decades. In the most comprehensive mitigation scenario, where all levers are fully activated, the sector’s carbon footprint could fall to about 1.1 million tons by 2040, coming close to the 48% reduction target. However, even under the most optimistic assumptions, the 2050 target of an 83% reduction remains out of reach, with an estimated shortfall of over 600,000 tons of CO_2.

In conclusion, Dr Monnoyer-Smith underlined that the decarbonisation roadmap is above all a collective, pragmatic effort built on trust, transparency, and shared responsibility. While many data points remain estimates, the process itself has created a common foundation for action across the French space ecosystem. The roadmap demonstrates that meaningful progress is possible only through sustained cooperation between industry, government, and research, guided by clear data and measurable goals. She stressed that achieving deep decarbonisation will require persistence, innovation, and continuous dialogue, but the collaborative framework now in place ensures that the sector moves forward together. As she noted, the real success of this initiative will be measured not by the roadmap itself, but by the lasting change it enables across the space community.

10. Roundtable discussion: “Reducing the environmental footprint of satellite constellations: views from stakeholders”

Moderator Ms Bianca Sofian (Cullen International) noted that the discussion is very timely and builds on the momentum that the environmental footprint of satellite constellations is gaining within the EU policy.

Ms Sofian reiterated the fact that there is more awareness of the rapid expansion of space activities and the sustainability concerns which come with it. When it comes to space

sustainability, the most common issues that come up in our discussions remain space debris, satellites collisions, environmental impact of satellite manufacturers and rocket launches.

Ms Sofian opened the roundtable discussion and invited panellists to take the floor and share their views on strategies, best practices and possible challenges in ensuring that satellite constellations positively contribute to environmental sustainability.

Ms Sofian welcomed the panellists: Mr Jordi Casanova (Amazon, Kuiper Project), Mr James Matthews (Eutelsat), Mr Julien Doche (Aéro Décarbo), Ms Natalia Vicente (GSOA) and Mr Mario Neri (Telesat).

Mr Jordi Casanova, Head of EU Public Policy, Telecoms and Space at Amazon Kuiper Project

Project Kuiper is Amazon's LEO satellite broadband network project, first announced in 2019. The company is planning to launch more than 3,000 satellites into low Earth orbits. Its mission is to provide affordable and high-speed broadband to citizens around the world who currently lack access to reliable internet.

To launch the constellation, Amazon is partnering with the EU space industry. In 2022, Amazon Kuiper project represented two thirds of the order for ArianeGroup, and through this partnership it contributed to the EU strategic autonomy and the access to space, according to Mr Casanova. Amazon also partnered with Beyond Gravity, a Swiss-Swedish company that will manufacture satellite dispensers.

A recent Oxford Economics study commissioned by Amazon estimated the positive impact of those partnerships with the EU economy close to 3 billion euros in GDP contribution, more than 3,000 jobs and more than 700 million euros in taxes.

Amazon has announced an investment of 10 billion dollars in project Kuiper, with roughly one quarter directed to the EU space industry through these partnerships.

The services offered by Amazon will include customer terminals providing broadband access from space to a wide range of users: residential customers, small businesses, public institutions in areas with no fibre coverage as well as locations where only non-terrestrial services are viable such as airplanes, ships and trains.

Amazon will also provide services for emergency use, ensuring that connectivity remains available to citizens and emergency service providers during natural disasters when terrestrial networks are disrupted. Finally, Amazon plans to offer a satellite backhaul service for mobile network operators. To assess the potential connectivity benefits in Europe, Amazon commissioned a study covering seven countries in the EU[22]. This study found that the cost of extending fibre to households increases exponentially as networks reach the most remote areas. Despite Europe’s dense population, around 20% of EU households still lack fibre

[22] https://www.aboutamazon.eu/news/innovation/closing-the-digital-divide-in-the-eu

coverage. The study concluded that LEO satellite technology could offer a highly efficient and cost-effective alternative for serving remote regions, with cost curves significantly more favourable than those of fibre deployment.

Mr James Matthews, Director of Corporate Social Responsibility at Eutelsat

Eutelsat is a commercial satellite operator with over 45 years of experience, originally set up in 1977, as an intergovernmental organization (IGO). In 2023, Eutelsat integrated the OneWeb LEO constellation and became the world's first combined LEO-GEO operator and the largest fleet in Europe. Eutelsat currently operates 34 GEO satellites and a fully launched LEO constellation of 654 satellites. It provides connectivity and broadcast services all around the world.

Eutelsat defines itself as a responsible operator. Sustainability is at the core of their values. The company has always upheld high technical and operational standards, proactively taking steps to further advance both Earth and space sustainability. Eutelsat divides its sustainability work into two main areas: Earth-based environmental impact, primarily assessed through carbon footprint calculations, and space sustainability, focused on safe and responsible operations in orbit. As a European operator, Eutelsat is subject to the upcoming EU Space Act. According to the company, its main concerns relate to the potential administrative burden from increased regulation which could contribute to a competitive disadvantage for European versus non-European operators, offer limited business initiatives and pose risks linked to excessive data disclosure.

Mr Matthews stressed that carbon emission factors and environmental impacts remain highly uncertain. He noted that Eutelsat's participation in the PEFCR initiative and various decarbonisation roadmaps aims to improve data accuracy and informed decision-making.

Another key priority for Eutelsat is the responsible use of space. The company operates under some of the most stringent legal frameworks in the world – including the 2008 French Space Operations Act for its GEO fleet and two pieces of UK legislation governing its LEO operations.

Eutelsat also participates in collaborative sustainability initiatives such as the RISE[23] (ESA's in-orbit servicing mission) and ELSA-M[24], a demonstration mission by Astroscale that will remove a Eutelsat OneWeb satellite from orbit.

Finally, Mr Matthews reaffirmed Eutelsat's support for the proposed EU Space Act as a necessary step towards a more harmonised and higher sustainability standards to ensure the long-term viability of space activities. However, he also stressed that the next focus should be on enhancing environmental and carbon impact assessments rather than expanding regulatory requirements.

[23] https://www.esa.int/Space_Safety/ESA_to_build_first_in-orbit_servicing_mission_with_D-Orbit
[24] https://www.esa.int/Applications/Connectivity_and_Secure_Communications/Sustainable_connectivity_in_space

Mr Julien Doche, Secretary of Aéro Décarbo

Aéro Décarbo is an NGO specialised in the decarbonisation of the aerospace sector. It conducts literature reviews, facilitates dialogue among stakeholders and identifies levers to support decarbonisation of the space industry in alignment with the EU Space Act and existing roadmaps.

Mr Doche noted that space activities are unique as they affect all layers of the atmosphere, yet the sector's CO_2 impacts remain insufficiently understood. Key concerns include effects on the ozone layer, the release of alumina particles during launches, and the environmental consequences of satellite re-entry. The space sector is growing rapidly, even though major uncertainties persist – not about whether these effects exist, but about the scale of their impacts. Therefore, more systematic measurements are needed to assess the environmental footprint of both satellite operations and launch events.

Mr Doche also highlighted the importance of questioning why we want to have these constellations. Some consist of only a few satellites, while others number several hundred or even thousands, providing very different types of services. For example, in Europe, where the demand for telecommunication connectivity is relatively high and well served, reliance on satellite broadband is lower compared to the US, where many regions have less access to telecommunication infrastructure and therefore a greater need for satellite services.

Depending on their intended use, such as connecting remote populations, constellations require different designs and strategies. The total number and mass of satellites, as well as their launch and maintenance requirements, have a direct influence on the sector's overall environmental footprint. Consequently, sustainable deployment strategies must take both the scale and purpose of satellite constellations into account.

Ms Natalia Vicente, Vice President of Public Affairs at the Global Satellite Operators Association (GSOA)

Ms Vicente introduced the Global Satellite Operators Association (GSOA) which provides a platform for collaboration among companies involved in the global satellite ecosystem and serves as unified voice for the industry. GSOA focuses on highlighting the positive innovation emerging in the sector.

She noted that in 2023, GSOA established a Code of Conduct with its members. The objective was to identify and endorse industry-led space sustainability practices that enable the world to maximise access to and benefits from space resources.

GSOA recognises that space provides significant benefits to people and our planet and that preserving those benefits amid growing orbital use requires proactive and coordinated action.

GSOA identified four main topics that were relevant:

- Mitigating the risk of in-orbit collisions by implementing measures to minimise the likelihood of spacecraft collision.

- Minimising the creation of non-trackable debris by integrating preventive measures throughout the spacecraft lifecycle from design and launch to orbit operation and deorbiting, including state-of-the-art satellite design techniques and risk assessments to avoid accidental destruction.
- Preserving human life in space by ensuring that spacecraft do not endanger other supporting structures and human life.
- Limiting satellite reflectivity to minimise the negative impact on ground based optical astronomy while allowing observation of optical wavelengths and ensuring the delivery of satellite services.

Ms Vicente reaffirmed that for GSOA, the dialogue and collaboration among stakeholders are essential. She emphasised that duplication of work should be avoided and more coordination is needed to avoid hindering the significant potential of the satellite industry.

Mr Mario Neri, Director of Spectrum Strategy, Innovation and Space Sustainability at Telesat

Telesat is a Canada-based satellite operator founded in 1969, offering services in Europe that will be subject to the EU Space Act. Since 2016, it has been developing *Telesat Light Speed,* a LEO constellation intended to provide global broadband connectivity solely for governments and enterprises, and not consumers.

Mr Neri pointed out that this point is directly related to sustainability. He explained that not all LEO constellations have the same mission, aim, or technical characteristics, and therefore their environmental and operational impacts can differ significantly. Recognising these differences is important when assessing the overall sustainability of satellite systems. In addition, the constellation uses Ka-band spectrum only and Optical Inter-Satellite Links, which are related to a sustainable use of resources, as fewer ground segments are required.

Telesat aims to start offering connectivity services with only 156 satellites, planned for launch in December 2026. The company is deploying a relatively small number of satellites for two reasons. First, they orbit high, around 1,300 kilometres of altitude, which allows each satellite to cover a wider area and second, each satellite is relatively large, weighing about 800 kilograms, which enables greater capacity per unit.

Mr Neri underlined that satellite operators are responsible and need access to space, orbital and spectrum resources in an environmentally sustainable way in order to thrive. It is in the interest of operators to use the space resources sustainably.

In his second message, Mr Neri pointed out that the highest risk is not caused by constellations, but from an aggregation of hundreds of individual payloads that have less sophisticated collision avoidance.

Having a constellation operated by a single technical body (the operator) can enhance safety. Because the operator manages the entire system, it has a strong incentive to prevent collisions

between its own satellites, which could disrupt network services and generate debris. Such debris would contaminate the same orbital shell — the specific altitude band where the constellation operates — making it more hazardous for the operator's other satellites and for future missions. Moreover, a single operator can choose to apply safety practices that go beyond the current minimum regulatory standards.

Mr Neri also mentioned the need for harmonised rules. Most of the lower constellations are providing a service globally. If the industry is regulated differently depending on geography, the operators and the manufacturers are left with the choice of the design standard to use. These rules not only need to be harmonised but also science-based and regulation should not be enforced before technical studies have been carried out and peer-reviewed.

Finally, according to Mr Neri, in the definition process of the Implementing Acts of the EU Space Act, regulators and decision makers should leverage the technical and operational experience of the operators and involve them in the process to learn from their experience in operating satellites.

11. Q&A session

The workshop ended with a Q&A session moderated by Ms Sofian (Cullen International). The Q&A session highlighted a consensus among panellists on the critical need for robust research to better understand the less obvious environmental impacts of satellite constellations.

On a question regarding the specific regulatory actions that should be taken, several panellists shared their perspectives on possible approaches and next steps. Mr Doche argued that regulation must proceed without delay, asserting that policymakers cannot afford to wait 15–20 years for absolute scientific completeness, especially given the increase in space activities and the emergence of early "frightening numbers". Prof Vasile agreed that decisions require numerical support but noted that a lack of coordinated efforts and common metrics currently prevents clear scientific consensus on what constitutes sustainable activity.

A question was raised about the strategies used to reduce carbon intensity and Scope 3 emissions (indirect emissions including the emissions related to supply chain and external activities), and whether these efforts are seen as significant constraints or potential sources of economic benefit for operators and their customers.

Mr Matthews from Eutelsat stated that sustainability and economic benefits often align. He underlined that for Scope 3 emissions, Eutelsat does not have an absolute reduction target, even though Scope 3 represents the largest share of its carbon footprint, mainly from satellites and launches. As Eutelsat will continue launching satellites to maintain its constellation, the company will target carbon intensity reduction by over 50% by 2030, by extending satellite lifespans and maximising the performance of new assets. Regarding Scopes 1 and 2, which are direct emissions, he noted that switching to green energy and generating own solar power are key measures. He added that Eutelsat's modelling showed that the main environmental impact of user terminals comes from their lifetime energy use, not manufacturing, or transport.

Therefore, Eutelsat has begun designing solar-compatible terminals and engaging suppliers to integrate this feature into future products.

Another question concerned whether economic comparisons between satellites and servers have been extended to include carbon or sustainability indicators. Mr Casanova noted that existing studies that compare the carbon footprint of LEO satellite networks and fibre are not precise, since they do not calculate the end-to-end emissions for satellite systems including launches, manufacturing and customer terminals but only compare this to the use phase of fibre. This method omits the significant carbon impact associated with building the vast terrestrial infrastructure required for fibre, such as digging trenches, laying cables and constructing exchanges which satellite operators largely avoid. Mr Casanova further pointed out that while fibre is efficient in high-density areas, it becomes highly inefficient in remote and rural areas, where deployment of infrastructure has a high carbon footprint. He concluded that existing studies do not yet offer a robust answer and called for more detailed comparative analysis. He reaffirmed Amazon's commitment to net zero by 2040, with Kuiper being part of that goal, and welcomed the EC's effort to develop a common, robust environmental methodology.

Mr Matthews highlighted the primary challenge: the lack of granular and accurate data to calculate the environmental footprint. He noted that without this data, environmental impact is not currently a consideration when selecting, for example, a launch operator, though work like the PEFCR is expected to improve environmental transparency. Mr Matthews also stressed the unique nature of the space industry, pointing to its extremely long lead times and periods from the beginning of the conception of the technologies to the end of the operational phase (e.g. a satellite conceived 25 years ago may still be operating today), which makes the adoption of new, greener technologies challenging.

Ms Pinto stated that due to a variety of studies with different results, the industry lacks clarity regarding the methodologies and the assumptions used in the assessments. She noted that the current level of ambition in the environmental part of the EU Space Act is intentionally low, as it merely asks operators to use the same assumptions and calculation methods to first gather reliable information before regulators set any thresholds.

Ms Vicente underscored the importance of working with the industry because experts within the companies, with decades of experience, hold the knowledge required to determine the correct sustainability indicators and avoid using misleading data.

Mr Neri added that the environmental impact is largely dependent on the supply chain, which is often outside the operators' control. He emphasized that the limited number of suppliers for crucial services, such as launching, gives operators a very thin margin on how to improve things.

Mr Doche echoed this and suggested on that point that like in the case of some other industries relying on smaller companies to build their final product, such as aviation, large companies could use mechanisms like questionnaires to pressure smaller supply chain companies to measure and improve their environmental performance, making it a criterion for future work.

Mr Doche also asked operators about their roadmaps for quantifying and reducing the impact on the ozone layer.

Later in the discussion, the industry's stance on the EU Space Act was largely positive. Mr Matthews confirmed support for the environmental aspects, seeing the PEFCR work as positive for standardizing calculations. Mr Casanova mentioned that a core concern is the proposed categorization of operators with different safety obligations, arguing that "the rules of the road are the same for everyone". Mr Neri highlighted that the standardization and harmonization provided by the Act are a key positive, potentially influencing non-European actors, but cautioned against "reinventing the wheel" by ignoring existing standards.

In response to Ms Sofian's question on how the EU Space Act impacts environmental responsibilities, industry members confirmed general support for the Act's principles, while highlighting specific concerns about its execution.

Mr Matthews confirmed strong support for the environmental aspects of the Act, noting that the industry is actively engaged in the PEFCR working group to create standardised rules for calculating the environmental footprint. He stressed that the Act is necessary to create a level-playing field globally and domestically, protecting business and advancing standards, without necessarily causing a competitive disadvantage since European operators are already subject to strict existing regulations. Mr Neri agreed that the Act's strength lies in its opportunity to standardise and harmonise rules, which also reduces administrative burdens by providing a single compliance certificate.

However, several concerns were voiced. Mr Casanova expressed concerns about the proposed draft categorisation of operators into different groups with varying safety rules. He, along with Mr Neri, strongly objected to the Act's reliance on future implementing acts and its tendency not to rely on existing, mature international standards from bodies like ISO (International Organization for Standardization) and IADC, which they argued will create a lot of uncertainty. Mr Julian Doche suggested that while the Act is a great start, it cannot stop at mere measurement; it must eventually define thresholds and introduce incentives to actively reduce the environmental footprint of the space industry. Countering a popular narrative, Mr Mario Neri disputed the claim that the Act is necessary because "space is becoming full of junk," arguing that the increasing risk is not linked to the number of new satellites in constellations but rather to old, large objects with non-manoeuvrable capabilities, and debris from past government tests. Ms Pinto acknowledged the issue of old debris but added that exempting non-manoeuvrable new objects, such as certain CubeSats, from the strictest safety requirements should not be in the Act. She confirmed that the EC is open to consultation as the text has not been finalised yet.

In response to a question about coordination between DG DEFIS and DG Connect on the EU Space Act, Ms Pinto explained that the two directorates general (DGs) work together under very specific rules on how they interact. Ms Pinto confirmed that for the EU Space Act proposal, this process involved extensive discussions, even outside the formal consultation procedure.

It was suggested by a participant from the aerospace industry that implementation of the EU Space Act should be incremental rather than applied in full immediately, to limit costs and safeguard industry competitiveness and profitability. Mr Neri strongly agreed, stating that a gradual approach would minimise costs, particularly if it started with rules already standardised globally. He emphasised that the primary cost driver is regulatory divergence, not adherence to accepted international norms. Mr Neri stressed the necessity of a delay between the publication of technical implementing acts and their entry into force to provide the industry with adequate time to adapt manufacturing and operational procedures.

Finally, Mr Vallet then shifted the focus to the related topic of exemptions, arguing against exempting universities and small satellite companies from the rules. He asserted that many space companies lack regulatory expertise, and that incorporating regulatory aspects into university projects is essential for training a skilled future workforce. He considers this an advantage for the space industry, ensuring that future engineers are familiar with the regulatory realities of the sector.

Conclusions and acknowledgements

BEREC thanks the distinguished speakers and participants at this workshop on environmental footprint of satellite constellations. As part of its commitment, BEREC will continue to build its expertise to help understand drivers and identify solutions to lower the environmental footprint of electronic communications, including those used in satellite constellations. BEREC continues to pursue its work to support the green transition of digital players and ICT and enable them to reach international and European environmental targets.