SPACE GENERATION
ADVISORY COUNCIL

Towards An Intergenerational Pact for Space Sustainability

SGAC Official Policy Position

January 28th, 2024

SPACE GENERATION
ADVISORY COUNCIL

In support of the United Nations Programme on Space Applications
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On behalf of the whole space youth, this Report presents the official policy position of the Space Generation Advisory Council (SGAC) on the sustainability of space activities. This document has been developed by a dedicated team of 12 SGAC members - the IPASS Team - established in April 2023 within SGAC's Advocacy and Policy Platform (SGAPP), and has been approved by SGAC's Executive Committee in January 2024.

ACKNOWLEDGEMENTS

The IPASS Team would like to thank the remarkable individuals we interviewed for the precious time and invaluable expertise they offered in support of our work:[1] **Kyle Acierno** (OffWorld), **Márcia Alvarenga dos Santos** (National Institute for Space Research), **Jacques Arnould** (Centre National D'Etudes Spatiales), **PJ Blount** (Cardiff University), **Romain Buchs** (ClearSpace), **Steven Freeland** (Western Sydney University), **Michelle Hanlon** (For All Moonkind & University of Mississippi), **Christopher Johnson** (Secure World Foundation), **Tanja Masson-Zwann** (International Institute of Air & Space Law, Leiden University), **Lee-Anne McKinnell** (South African National Space Agency), **Charles-Aimé Nzeussi Mbouendeu** (SES), **Antonino Salmeri** (Lunar Policy Platform), **Ruvimbo Samanga** (MILO Space Science Institute), **Jenni Tapio** (European Space Agency), **Valentin Valhondo** (ClearSpace), **Amélie Werbrouck** (SES), **Petra Wijnja** (Royal Netherlands Air Force), **Andrew Williams** (European Southern Observatory).

Furthermore, the Team extends its sincere gratitude to all **SGAC members** who actively participated in the IPASS survey and provided valuable feedback, and in particular to the **SGAC leadership** for their championship, contributions, and guidance.

[1] *The views expressed in the interviews are solely those of the interviewees and do not reflect the official position of their affiliated organisations.*

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The IPASS Report has been developed by a dedicated group of 12 SGAC members listed below. The IPASS Team was established in April 2023 within SGAC's Advocacy and Policy Platform (SGAPP), and its final Report was approved by SGAC's Executive Committee in January 2024.

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The SGAPP Coordinators, Gina Petrovici and Giuliana Rotola, directed the SGAPP policy division producing this present report and supported its development. The SGAC Chairs, Hamza Hameed and Antonino Salmeri, personally contributed to the recommendations outlined in the IPASS Report and wholeheartedly support its innovative proposal for an intergenerational, global and multi-stakeholder pact for space sustainability.

LIST OF ABBREVIATIONS

ADR : Active Debris Removal

ALAN : Artificial Light at Night

APPG : All-Party Parliamentary Group

CNES : National Centre for Space Studies (French: *Centre national d'études spatiales*)

COPUOS : Committee on the Peaceful Uses of Outer Space

COSPAR : Committee on Space Research

CPS : Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference

DLR : German Aerospace centre (German: Deutsches Zentrum für Luft- und Raumfahrt)

ECOB : Environmental Consequences of Orbital Breakups

EIA : Environmental Impact Assessments

ERM : Enterprise Risk Management

ESA : European Space Agency

ESO : European Southern Observatory

ESSI : Earth Space Sustainability Initiative

FCC : Federal Communications Commission

GNSS : Global Navigation Satellite Systems

GSOA : Global Satellite Operators Association

IADC : Inter-Agency Space Debris Coordination Committee

IAU : International Astronomical Union

IIASL : International Institute of Air and Space Law

IISL : International Institute of Space Law

IoT : Internet of Things

ISO : International organisation for standardisation

ITU : International Telecommunication Union

JAXA : Japan Aerospace Exploration Agency

LEO : Low Earth Orbit

LTS : Long Term Sustainability
MRO : Mission Related Objects
NASA : National Aeronautics and Space Administration
NGSO : Non-Geostationary Satellite Orbit
OPCC : Office for the Protection of the Sky Quality in Northern Chile
SDMG : Space Debris Mitigation Guidelines
SDA : Space Data Association
SDG : Sustainable Development Goals
SGAC : Space Generation Advisory Council
SGAPP : Space Generation Advocacy and Policy Platform
SKAO : SKA Observatory
SSR : Space Sustainability Rating
SSA : Space Situational Awareness
STM : Space Traffic Management
STSC : Scientific and Technical Subcommittee
SWF : Secure World Foundation
UNGA : United Nations General Assembly
UNOOSA : United Nations Office for Outer Space Affairs
UNESCO : United Nations Educational, Scientific and Cultural organisation
UNCOPUOS : United Nations Committee on the Peaceful Uses of Outer Space
WRC : World Radiocommunication Conference

1. INTRODUCTION

Over the last 60+ years, space activities have undergone a remarkable evolution, transitioning from the early days of pioneering exploration, to a situation characterised by their unprecedented development. What began as a race amongst nations during the mid-20th century, has now matured into a dynamic landscape with a multitude of space actors, encompassing both public and private entities. However, with the intensification of space endeavours comes a set of formidable challenges, some radically new and others already existing but becoming increasingly complex, as recently noted by the UN Secretary-General in his Policy Brief on Outer Space for the 2024 UN Summit of the Future.[2]

The past decade has witnessed a surge in private missions to space, propelled by cost decreases and increased launch options. Private companies have taken the lead, engaging in missions encompassing communications, resource activities, space tourism, and scientific endeavours. This surge, coupled with the deployment of large satellite constellations, points towards a significant escalation in space traffic in the coming decade, which is not without raising serious concerns regarding the long-term sustainability of space activities.

As custodians of the cosmos, it is our role and duty to address these issues with the seriousness they require. Contrary to popular belief, outer space is not the playground of the few; it is the realm of everyone.

Despite the profound impact of these activities, the broader public often perceives space matters as distant and unrelated to our daily lives. It is imperative, however, to recognise the role that space is bound to play in the sustainable development of humanity at large. Today, approximately 40 percent of the targets underpinning the UN Sustainable Development Goals leverage Earth observation and global navigation

[2] Our Common Agenda Policy Brief 7, For All Humanity–the Future of Outer Space Governance, UNGAOR, 77th Sess., Un Doc. A/77/CRP.1/Add.6 (2023), available online.

satellite systems.[3] Space plays a pivotal role in providing essential data and imagery for monitoring Earth's climate, anticipating natural disasters, and supporting disaster management. It significantly contributes to understanding agriculture, connecting the world, and enabling education and health assistance in remote areas. The outcomes of space activities are not reserved for a select few but have the potential to benefit all humankind. The long-term sustainability of space activities stands at a critical juncture, requiring thoughtful consideration of how to navigate and address associated risks and implications for both present and future generations.

The Space Generation Advisory Council (SGAC) is the largest network of students and young professionals in the space sector. With over 28,000 members across 165+ countries, SGAC is globally recognised as the premier organisation representing the united voice of the space youth. The organisation was conceived at UNISPACE III in 1999, whereby States resolved, as part of the Vienna Declaration, "to create a council to support the United Nations Committee on the Peaceful Uses of Outer Space, through raising awareness and exchange of fresh ideas by youth. Its vision is to employ the creativity and vigour of youth in advancing humanity through the peaceful uses of outer space". It has since obtained a Permanent Observer status at the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) and regularly takes part in the annual meeting, as well as its Legal and Scientific and Technical Subcommittees. As a result, SGAC is in a unique position to act as a bridge between the next generation of space leaders and the established space community at large.

Since 2021, the organisation has released every year, a report through its specialised Space Generation Advocacy & Policy Platform (SGAPP), outlining SGAC's policy position on key topics relevant to the younger generation, such as Lunar governance[4] and climate action[5]. The overarching objective is to present a unified voice within the global

[3] Idem, p. 11.
[4] Dr. Antonino Salmeri *et al.*, *Effective and Adaptive Governance for a Lunar Ecosystem*, available online (2021).
[5] Sahba El-Shawa *et al.*, *Saving Our Future on Earth Through Our Presence in Space*, available online (2022).

space community by developing, advocating, and implementing cohesive space policy positions on behalf of the youth, as well as coordinating, consolidating, and disseminating space policy activities conducted within SGAC.

In 2023, recognizing the critical importance of space sustainability for our shared future in space, SGAC mandated a team to produce a report supporting the elaboration of a sustainability "pact" between generations; one that will foster synergy between space stakeholders and raise awareness on the necessity to achieve space sustainability. This "Intergenerational Pact for Space Sustainability" (IPASS) aims to articulate the organisation's vision for a safe and sustainable space environment, fostering unity within the global space community. It identifies key topics that should be addressed by policymakers when discussing the long-term sustainability of space activities and considers different avenues to achieve the Pact's desired outcomes.

Over a year, the IPASS Team met with stakeholders across national space agencies, private industry, non-governmental organisations, and academia to better understand how space sustainability is perceived by different segments of the space sector. One of our early observations was the absence of a universally accepted definition for the concept of "space sustainability". Nonetheless, through these discussions, the IPASS Team was able to identify several commonly agreed-upon elements of the concept, such as sustainability requiring the adoption of a long-term approach when designing space missions and the necessity to consider their impact on future generations' ability to carry out their own space activities. We also noted that implementing sustainability may call for different actions depending on the nature of the space activity undertaken. For instance, avoiding collisions in low-Earth orbit (LEO) and promoting the rational management of *in situ* resources found on celestial bodies both support the goal of space sustainability, yet they require distinct solutions in practice. Consequently, achieving space sustainability calls for a holistic approach to avoid the pitfalls of siloed thinking while, at the same time, it must allow for enough flexibility that specific actions may be used to answer specific problems. For this reason, the IPASS Team decided to adopt an issue-oriented approach, guided by the need to ensure that future generations may benefit from outer space to the same extent as we do today.

For the purpose of the report, several issues were considered by the IPASS Team, from space debris to space traffic management to cybersecurity to activities beyond Earth orbit; the rationale being that we must address not only current challenges but also anticipate issues in the near future. After careful deliberation, we chose to focus on four core problems: 1) space debris, 2) mega-constellations, 3) dark and quiet skies, and 4) activities beyond Earth orbit, with special emphasis on space resource activities. While this list is not exhaustive—and acknowledging that other challenges are pertinent to space sustainability—it is noteworthy that the scope of long-term sustainability is as large as space activities are varied. As such, it is not possible to address all issues, existing and foreseen, in a single document without diluting the meaningful impact of the report. The selection of these four core issues was informed by ongoing discussions at UNCOPUOS and insights gained from interviews with various stakeholders in the space sector.

2. STATUS QUO

This section provides a comprehensive overview of the key topics that we consider imperative for prioritising discussions on space sustainability. The selection of these topics stems from careful deliberation, incorporating extensive research and the outcome of interviews with 18 stakeholders. Additionally, the section considers the current legal landscape addressing space sustainability. For a more detailed exploration of existing legal instruments, encompassing both binding and non-binding instruments, as well as initiatives contributing to the resolution of challenges in space sustainability, readers are directed to Annex I.

2.1. Space debris

Space debris represents a pressing and multifaceted challenge for activities in outer space. These debris are non-functional human-made objects, ranging from defunct satellites and spent rocket stages to tiny fragments, whirling around Earth at high velocities. Their presence poses several significant problems and threats to both space operations and the long-term sustainability of outer space.

One of the most immediate problems posed by space debris is the increased risk of collisions. These objects travel at tremendous speeds, often exceeding 17,500 miles per hour.[6] Even small fragments can inflict severe damage when they collide with operational spacecraft, such as damaging or destroying communication, navigation, and Earth observation satellites. A notable collision incident is a collision, in 2009, between the active commercial Iridium-33 satellite and the defunct Russian satellite Cosmos-2251, which resulted in generating thousands of fragments.[7] Beyond material damage, such collisions generate great financial loss. They damage expensive functional objects and affect industries, governments, and individuals who rely on

[6] Mark Garcia, *Space Debris and Human Spacecraft*, available online (2021)
[7] Brian Weeden, *2009 Iridium-Cosmos Collision Fact Sheet*, available online (2019).

satellite services.[8] According to Adilov et al.,[9] in 2020, the economic annual losses from satellite collisions with orbital debris were estimated at $86-103 million.

Space debris also puts space stations, like the ISS, in constant jeopardy. The integrity of these habitats, which host astronauts for extended durations, must be maintained to ensure their safety. Even small debris impacts can puncture the station's shielding and threaten the lives of the crew members. In March 2023, the ISS had to maneuver twice in a week to avoid colliding with such debris.[10]

Beyond the increased risk of collision, space debris is a form of environmental pollution in space. With time, certain orbits become more congested with debris and thus become less usable for future space missions. These cluttered regions limit the available space for satellite deployment and scientific exploration, hindering the expansion of human activities in outer space. Hence, the accumulation of debris threatens the safety and viability of future space endeavours, including space exploration, scientific research, and commercial ventures.

2.2. Mega-constellations

Among the various challenges to ensure space sustainability, the proliferation of mega-constellations represents a pivotal issue that demands careful consideration. Mega-constellations refer to vast networks of small satellites orbiting Earth, typically in LEO, intending to provide global internet connectivity, Earth observation, or other communication services. Prominent examples include SpaceX's Starlink, OneWeb, and Amazon's Project Kuiper.[11] While mega-constellations promise numerous advantages for humanity, their rapid expansion poses significant challenges and necessitates a robust framework of policies and regulations to ensure space sustainability.

[8] Nodir Adilov et al., An estimate of expected economic losses from satellite collisions with orbital debris, 10 Journal of Space Safety Engineering 66 (2023).
[9] *ibid*.
[10] Brett Tingley, *International Space Station fires thrusters to dodge space junk*, Space.com, available online (2023).
[11] *How You Can See Spacex Starlink Satellites In The Sky This Week*, The Independent, available online (2020); Information on OneWeb is available online; Information on Project Kuiper is available online.

The adoption of large constellations of satellites working in synergy presents undeniable advantages over individual satellite deployments. Confronted by the complexities of traditional operational methods, stakeholders have been compelled to seek innovative solutions, optimising satellite interoperability.[12] These constellations offer continuous coverage, facilitating seamless data flow and real-time Earth monitoring. Furthermore, the economies of scale in satellite production have dramatically reduced costs.[13]

Nevertheless, the ascent of mega-constellations, coupled with the absence of comprehensive regulations, casts a shadow on space sustainability.[14] Their sheer numbers, particularly in LEO, amplify collision risks and contribute to an alarming accumulation of space debris, imperilling both ongoing space activities and operational satellites.[15] The finite radio frequency spectrum faces heightened competition as mega-constellations vie for bandwidth, potentially resulting in interference that disrupts existing and future satellite systems.[16] Moreover, the reflective surfaces and radio emissions of mega-constellations encroach upon astronomical observations and scientific research, impacting our exploration of the universe.[17]

Yet, their rapid proliferation has brought to light a complex issue – the industry's accelerated pace is outstripping the development of essential regulations, hindering collaboration among all stakeholders. Mega-constellations are one of the challenges that have been developed ahead of a legal framework, and *a fortiori*, sustainability considerations.

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[12] Jingrui Zhang et al., *LEO Mega Constellations: Review of Development, Impact, Surveillance, and Governance*, Space: Science & Technology, available online (2022).
[13] Antonio Harrison Sánchez, Tiago Soares & Andrew Wolahan, *Reliability aspects of mega-constellation satellites and their impact on the space debris environment*, in 2017 Annual Reliability and Maintainability Symposium (RAMS) 1 (2017).
[14] Jonathan O'Callaghan, *Satellite Constellations Could Harm the Environment, New Watchdog Report Says*, Scientific American, available online; Benjamin Bastida Virgili & Holger Krag, *Mega-constellations Issues*, 41 PEDAS 1 (2016).
[15] Bastida Virgili and Krag, *supra* note 11.
[16] Bastida Virgili and Krag, *supra* note 11.
[17] Bastida Virgili and Krag, *supra* note 11.

2.3. Dark and quiet skies

Another consequence of the proliferation of mega-constellations is the potential impediments they pose to astronomical observations.[18] Indeed, satellites produce light and noise pollution which can affect the data obtained by scientists. The former occurs when sunlight reflects off the surfaces of satellites whereas the latter originates from radio frequency interference.[19] Hence the call of the international scientific community for "dark and quiet skies".[20]

In particular, light pollution from passing satellites creates bright streaks that leave trails in astronomical images, obscuring or degrading the quality of data.[21] This is especially problematic for activities involving telescopes that capture long-exposure images.[22] In a similar manner, satellites' radio frequency emissions can disrupt or contaminate signals from celestial objects, thus impeding radio astronomy.[23] One such problem can be observed with some satellites in LEO. When communicating with Earth, these satellites use radio signals in frequency bands that overlap with frequencies used for radio astronomy observations. As a result, when these satellites pass over the radio astronomy observatories, their transmissions interfere with the observatory's ability to receive weak cosmic signals.

In response to these concerns, initiatives have emerged, urging satellite operators to reduce reflectivity or adjust satellite orbits to minimise their terrestrial impact.[24] Indeed, the impact of satellites on radio astronomy can vary depending on the specific frequency bands used by both satellites and radio astronomers, as well as the design and operation of the observatory and the satellite systems. Satellite operators and

[18] B. M. Shustov, *Satellite Mega-Constellations and the Dark and Quiet Sky Problem*, 66 Astronomy Reports 725 (2022).
[19] International Astronomical Union, *Dark and Quiet Skies, An IAU Global Outreach Project*, available online.
[20] *Ibid.*
[21] Antonia M. Varela Perez, *The increasing effects of light pollution on professional and amateur astronomy*, 380 Science 1136 (2023).
[22] *Ibid.*
[23] Radio Frequency Interference, National Radio Astronomy Observatory, available online.
[24] Aparna Venkatesan et al., *The impact of satellite constellations on space as an ancestral global commons*, 4 Nature Astronomy 1043 (2020).

space agencies are also working on minimising the impact of satellite mega-constellations on the night sky by playing on different factors, such as the altitude of the satellites, their reflective surfaces, and the time of night.[25] Moreover, it can further be noted that the topic of “dark and quiet skies” has been discussed within the confines of the UNCOPUOS for several years. In 2017, the Committee consented to the organisation, by UNOOSA jointly with the International Astronomical Union (IAU), of a conference on the general topic of light pollution.[26] More recently, the Committee highlighted “the importance of implementing measures to mitigate factors that could hinder scientific discoveries” and took note of “various national and international efforts to balance the provision of satellite services with astronomical observation activities”.[27]

2.4. Challenges beyond Earth's orbit

The IPASS report stands out for its forward-looking perspective. Much of the discourse on space sustainability primarily centres around activities in Earth’s vicinity, such as addressing dark and quiet skies, space debris, and mega-constellations. However, the past decade has witnessed a growing interest in expanding private space ventures beyond Earth’s orbit, with the Moon emerging as a favoured destination. Consequently, our studies on space sustainability must extend their focus beyond Earth’s immediate vicinity as well.

A crucial distinction between the issues highlighted in the preceding sections lies in their existing impact on space sustainability. Space debris and mega constellations have already left their mark on Earth’s orbits and astronomy, showcasing tangible negative consequences. Conversely, activities beyond Earth orbit—such as space resources utilisation on the Moon—have yet to manifest such adverse effects. This could be attributed to a case of “out of sight, out of mind” thinking and a fragmented

[25] *Ibid.*
[26] Summary of discussions on dark and quiet skies for science and society, Note by the Secretariat, UN Doc. A/AC.105/1257 (2021).
[27] Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 78th Sess., Supp. No. 20, at 164-165, UN Doc A/78/20 (2023).

approach that treats space activities in isolation, rather than recognizing them as part of a shared ecosystem—i.e., the space ecosystem. These activities should therefore adhere to common sustainability principles, including long-term planning and impact assessment.

Rather than deferring consideration for private lunar activities, the IPASS team actively advocates for their consideration today. This presents a unique opportunity for proactive action rather than reactive responses. Currently, the situation on the Moon is less problematic compared to Earth's vicinity. Lunar orbits remain relatively free from space debris, and space traffic management is not a significant concern. However, adopting a laissez-faire attitude, as previously seen with Earth's orbital activities, could potentially lead to similar challenges in the future. Here, we have an opportunity to apply the valuable lessons learned from over six decades of space exploration and utilisation.

But in the absence of tangible consequences, what risks should be mitigated? The nature of the planned activities already offers valuable insights. For instance, it is possible to draw a parallel between the consequences of mining natural resources on Earth and on the lunar surface. We can anticipate that lunar mining will raise issues regarding the preservation of the pristine lunar environment: chemicals will be released into the ground, the geology of the Moon will be affected, and lunar dust will be displaced.

Space resource utilisation also raises the issue of managing the celestial bodies' finite and non-renewable resources. History has shown that such cases necessitate prudent management, and a sustainability approach obliges us to consider the interests of both present and future generations. It involves evaluating the costs and benefits of resource exploitation, and determining how much can be ethically extracted over a given timeframe to maximise long-term benefits.

Lastly, while the orbits of celestial bodies beyond Earth are currently less crowded, it is not unreasonable to anticipate that increased activity on the lunar surface will lead to a rise in ground and orbital debris. To date, there are no plans to recycle rovers and landers sent to the Moon. Additionally, heightened traffic will likely ensue as more satellites are required to manage space objects on the lunar surface. This underscores the need for a proactive and holistic approach to space sustainability in these uncharted territories.

2.5. Law and Policy Framework

The existing international legal framework for space activities comprises five binding treaties: the 1967 Outer Space Treaty, the 1968 Return and Rescue Agreement, the 1972 Liability Convention, the 1976 Registration Convention, and the 1979 Moon Agreement.[28] Although these treaties do not explicitly mandate sustainable practices in outer space, they encompass principles aligned with the concept, such as the "equitable use"[29] of outer space and the "province of all mankind"[30]. Notably, the Moon Agreement underscores the need to consider the interests of present and future generations.[31] To an extent, the Outer Space Treaty and the Moon Agreement directly address concerns about preserving the outer space environment, requiring states to adopt measures to avoid harmful contamination. Despite the absence of explicit references to "sustainability", these UN Space Treaties advocate for States' responsibility, supervision of private entities, and a long-term approach to space activities, providing a legally binding foundation to promote the long-term sustainability of space activities among space-faring nations.

Following the adoption of the last UN Space Treaty in 1979, the international community progressively moved towards new methods of regulating space activities–and *a fortiori*

[28] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, *entered into force* October 10, 1967, 610 UNTS 205 (Outer Space Treaty); Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space, *entered into force* Dec. 3, 1968, 672 UNTS 119; Convention on International Liability for Damage Caused by Space Objects, *entered into force* October 9, 1973, 961 UNTS 187; Convention on Registration of Objects Launched into Outer Space, *entered into force* September 15, 1976, 1023 UNTS 15; and Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, *entered into force* July 11, 1984, 1363 UNTS 3 (Moon Agreement).
[29] Moon Agreement, Art. 7.
[30] Outer Space Treaty, Art. I, and Moon Agreement, Art. 4 (1).
[31] Moon Agreement, Art. 4.

sustainable practices–at the international level, namely guidelines, principles, and standards. These non-legally binding instruments tend to answer specific issues arising from the development of space activities, such as the IADC and UNCOPUOS space debris mitigation guidelines or COSPAR's planetary protection policy to preserve scientific research on celestial bodies.[32] However, it is noteworthy that in 2019, UNCOPUOS adopted 19 *Guidelines for the Long-term Sustainability of Outer Space Activities* (LTS Guidelines)[33] to provide a comprehensive framework ensuring the safe and sustainable use of outer space; thus recognizing space sustainability as an issue of its own.

Moreover, alongside international initiatives, several States have incorporated measures promoting space sustainability into their national regulations governing space activities. For instance, countries such as France require space operators to comply with end-of-life measures to mitigate space debris generation.[34] A noteworthy development also occurred on October 2nd, 2023, when the US Commission's Enforcement Bureau took historic action, imposing sanctions on the American television provider DISH for non-compliance with the orbital debris mitigation plan for its EchoStar-7 satellite. The provider incurred a $150,000 fine and committed to a compliance plan. It can also be noted that some States, like Finland and Belgium, adopted national space legislations that explicitly refer to space sustainability.[35] Moreover, as underscored by a 2021 report from SGAC,[36] numerous States are working on implementing the LTS Guidelines. It can

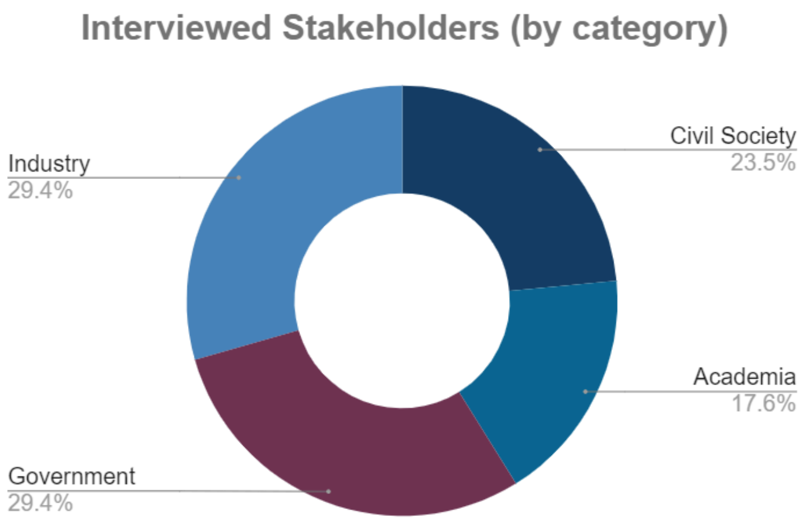
[32] IADC, Space Debris Mitigation Guidelines, IADC Steering Group and Working Group 4, IADC-02-01 Rev. 3 (2021); UNCOPUOS, Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 62nd Sess., Supp. No. 20, at 117-118 and Annex, UN Doc. A/62/20 (2007); COSPAR, *COSPAR Policy on Planetary Protection*, 211 Space Research Today 12 (2021).
[33] Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 74th Sess., Supp. No. 20, at 163 and Annex II, UN doc. A/74/20 (2019).
[34] LOI n° 2008-518 du 3 juin 2008 relative aux opérations spatiales, Art. 5 (FR).
[35] Decree of the Ministry of Economic Affairs and Employment on Space Activities, 74/2018, (FI); Law of 17 September 2005 on The Activities of Launching, Flight Operation or Guidance of Space Objects, consolidated text as revised by the Law of 1 December 2013 (B.O.J. of 15 January 2014) and Royal Decree implementing certain provisions of the Law of 17 September 2005 on the activities of launching, flight operations and guidance of space objects, C–2022/31435, 2022 (BE).
[36] See e.g. Chan Yuk Chi et al., *SGAC Report on the LTS Guidelines National Implementation*, *in* Technical Presentations Made at the UNCOPUOS LSC (2021) available online.

also be noted that some space agencies, like ESA, NASA, and JAXA, condition their cooperation—financial or otherwise—to comply with space debris mitigation measures and planetary protection policies.

In conclusion, the legal framework supporting the long-term sustainability of space activities is based on a multi-level governance approach, incorporating both binding and non-binding instruments at the international and national levels.

3. INTERVIEW OUTCOME

The present section outlines the outcome of a series of interviews conducted by the IPASS Team between May and October 2023 with 18 stakeholders representing the various segments and interests of the international space community. The discussion centred on the meaning of space sustainability and explored the efficiency of current mechanisms, as well as possible avenues for the future.



From the outset, it is worth noting that all interviewees underscored the urgency to take prompt action to ensure the long-term sustainability of space activities. It was noted that the predominant focus on space sustainability is characterised by concerted efforts, from various organisations working together to address different challenges, such as space debris mitigation, the extension of satellite lifespan, and the development of technologies for in-orbit servicing. This collective effort stems from the acknowledgment that space activities not only benefit humanity on Earth but also impact the broader space environment, which could impede future ventures in outer space, including that of future generations.

According to interviewees, the concept of space sustainability refers to the necessity of preserving the space environment for future generations and ensuring fair access to space; there is evident divergence concerning the precise definition of the concept and its practical implementation. One explanation for this divergence of opinions is the multifaceted nature of space sustainability. Indeed, sustainability issues are not limited to one space activity but, on the contrary, it affects all activities to an extent. As a result, achieving space sustainability calls for a holistic approach while at the same there is a need for specific solutions for specific issues: the problem of space debris does not call for the same solutions as dark and quiet skies. Interviewees also highlighted the fact that space sustainability is not limited to Earth applications, the concept also calls for the consideration of the outer space environment. Additionally, several interviewees emphasise the increasing significance of ethics in space sustainability, underscoring a shared responsibility to steward resources and the space environment beyond regulatory considerations.

The series of interviews also highlighted several shortcomings pertaining to how we approach sustainability issues today. According to most interviewees, the primary impediment to achieving space sustainability is politics. Although governments are not intentionally hindering the progress of sustainable technologies, their priorities often lean towards safeguarding their national strategic interests. In particular, the intricate interplay of geopolitics introduces a significant challenge, intertwining national interests, security concerns, and economic competition. In comparison, several stakeholders consider technological limits as a minor issue compared to the complexities presented by politics and regulation. Ongoing developments in promising technologies offer potential solutions, with identified technological obstacles being addressable through additional resources such as funding and time.

The second major obstacle centres around regulatory issues, encompassing a lack of enforcement mechanisms and a fragmented regulatory landscape. In many instances, existing regulations lack effective enforcement mechanisms, allowing organisations to circumvent compliance and undermining the intended efficacy of regulatory measures. Moreover, the diversity in regulations across different countries and regions creates a fragmented and inconsistent regulatory environment. This lack of harmonisation introduces confusion and uncertainty, making it arduous for organisations to implement consistent and effective sustainability practices.

It is noteworthy that stakeholders in the commercial sector emphasised the importance of taking the economic dimension into account when referring to the concept of sustainability. Indeed, at its essence, the concept advocates for a harmonious balance between environmental, economic, and social considerations. Thus, while preserving outer space is crucial, it should not be pursued to an extent that it jeopardises space industries' operational viability.

Moreover, interviewees acknowledge and commend ongoing initiatives aimed at promoting space sustainability, notwithstanding their deficiencies. While the current solutions may have their limitations, they signify a positive step forward, emphasising action rather than mere discourse. For instance, effective information sharing in the space sector remains a critical but unoptimized aspect of space sustainability. Indeed, the absence of a centralised registry for space objects or activities results in a lack of transparency and data sharing. Nevertheless, various actors are actively collaborating to champion sustainability. Through partnerships, these entities stay informed on best practices, foster a shared understanding of the international regime, and align on implementation strategies.

Another challenge identified by interviewees is the absence of a universally agreed-upon set of metrics for measuring space sustainability. The lack of standardised metrics hinders the ability to compare the effectiveness of initiatives and track progress over time, leading to ongoing debates on the best metrics for different risks and impacts. While Life Cycle Assessment (LCA) gains popularity in the space industry for its sustainability metrics, challenges in its comprehensive implementation remain. For this reason, engaging in dialogue with industry becomes essential, as it increasingly takes a proactive role in setting best practices and incorporating long-term considerations into short-term activities.

Concerning the way forward, it is possible to identify common trends between all segments of the space sector. All stakeholders interviewed agreed that space sustainability cannot be achieved through a solution that fails to foster international collaboration. It is the only way to obtain a unified approach. This approach should be transdisciplinary and involve all segments of the space community. Altogether, interviewees favour a comprehensive approach that reflects a commitment to addressing immediate challenges while laying the groundwork for sustained and responsible space exploration. In particular, they recommend that,

- In **the short term**, our efforts focus on identifying priority areas for action and establishing common ground among diverse actors, thus transcending geopolitical interests through collaborative efforts.
- In t**he medium to long term**, the focus shifts towards harmonising regulatory frameworks globally, developing clear guidelines and legal principles, and continuously evaluating and adapting regulations to address emerging challenges. All interviewees highlighted the need for an inclusive and interdisciplinary approach, ensuring that diverse stakeholders, including developing countries and industry experts, contribute to the discussion. Another mid-to-long-term goal is the dissemination of information as well as raising awareness about space sustainability.
- In **the long term**, strategies aim to enhance government interventions, embedding sustainability across the entire value chain. Regarding more practical issues, solutions should be developed to effectively manage space debris and eliminate threats to satellite operations.

Finally, although no consensus could be identified regarding the identification of a forum to carry out future actions, there is a prevailing belief that the UNCOPUOS serves as the most suitable forum. Despite its value in providing a forum for States to exchange views, facilitate dialogue, and address concerns, there is also a recognised limitation in its effectiveness for achieving consensus and implementing concrete measures. Alternative forums, including the International Telecommunication Union, the United Nations, and the World Economic Forum, have also been suggested. Regardless of the chosen forum, a multi-stakeholder approach is deemed indispensable. This approach would allow for the inclusion of diverse perspectives, fostering collaboration and innovation. Furthermore, having regard to the pivotal role of collaboration, future discussions and actions must foster partnership between industry and government. It will help develop regulations that frame private activities without impeding their operationality. Several interviewees further advocated for a combined bottom-up and top-down approach, where the industry sets best practices and standards, adopted, and enforced by governments. The importance of government involvement was underscored as a means to maintain global consistency and adherence to principles in the dynamic landscape of space sustainability.

4. SURVEY RESULTS

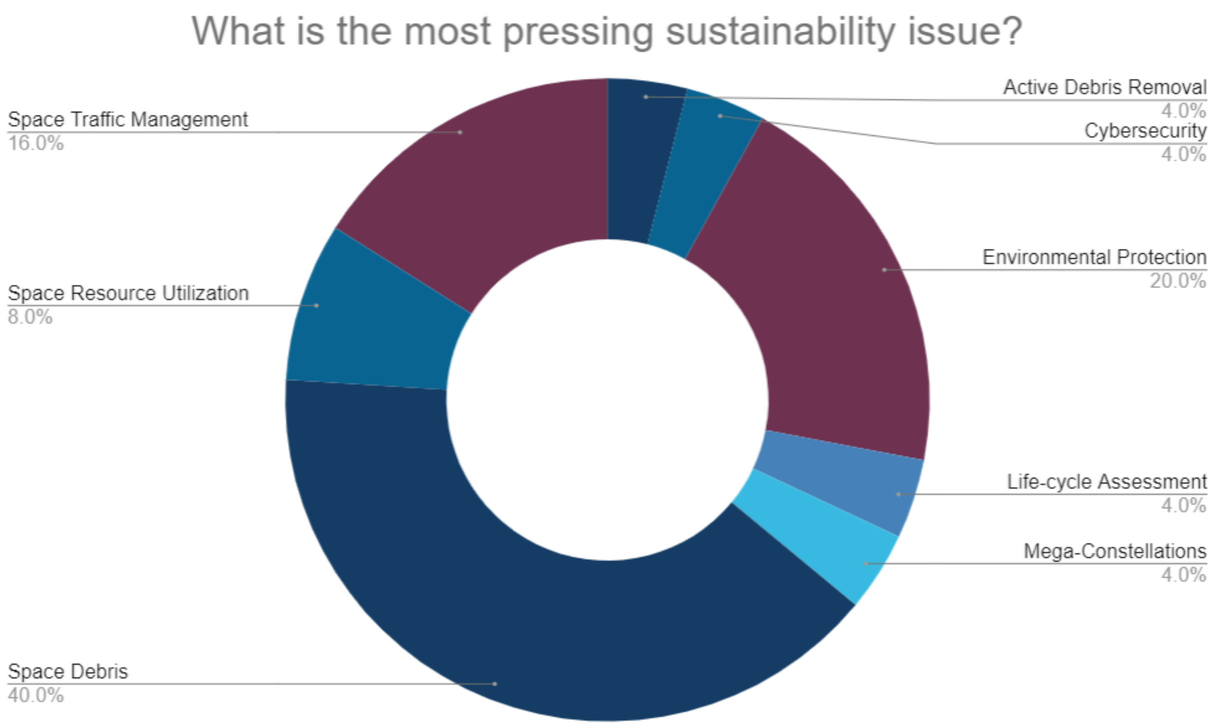
Our Team created a survey that was distributed to SGAC members, in our attempt to understand what are the most pressing issues for space generation around the issue of space sustainability.[37] The dissemination took place in two phases: initially, the questions were sent to members of the Executive Committee (EC), as the Team wished to get a more high-level overview of the stance of our organisation. Executive Committee members oversee several different initiatives within SGAC and they have a more holistic understanding of the SGAC initiatives with regards to space sustainability. Once these responses have been collected, the survey was opened to the public.

For the publicly available survey, the IPASS team made a change in the second (out of the two) questions. To facilitate a more comprehensive analysis, we decided to ask the public what should be a key position that our community needs to implement as soon as possible. It was based on the solutions that EC respondents mentioned in the second question of their survey, which was more qualitative. However, as analysed further down in this section, there are numerous similarities, regarding the most important aspects of space sustainability, that we need to take action for as soon as possible.

In conducting a thorough analysis of the responses to the question on the most pressing issue the IPASS Team needs to tackle, it becomes evident that the concerns of individuals aged 18-35 with some knowledge of the space sector are both varied and deeply insightful. The frequency of responses highlights certain areas as particularly pressing. For example, Space Debris, specifically its mitigation, emerged as the most cited concern, mentioned in almost half of our responses (43%). This was closely followed by Environmental Protection in Outer Space, which garnered 21% of the mentions, underscoring a significant awareness among our demographic about the risks and ecological impacts of space activities. Other issues such as Mega Constellations and Space Traffic Management were each mentioned in 17% of the received responses, reflecting an understanding of the newer challenges in space

[37] The list of survey questions can be found in Annex II.

activities as space becomes more accessible. Space Resource Utilisation, though mentioned less frequently (8.5%), suggests emerging ethical and legal considerations in the exploitation of celestial resources. It is believed that the technological advancements in this area, which are significantly smaller when compared to other space activities, led our respondents not to consider it as an immediate threat to space sustainability. Last but not least, issues like Active Debris Removal, Cybersecurity, and Life-cycle Assessment, although only gathering around 4% of the responses each, are still recognised as critical components of a sustainable space environment.

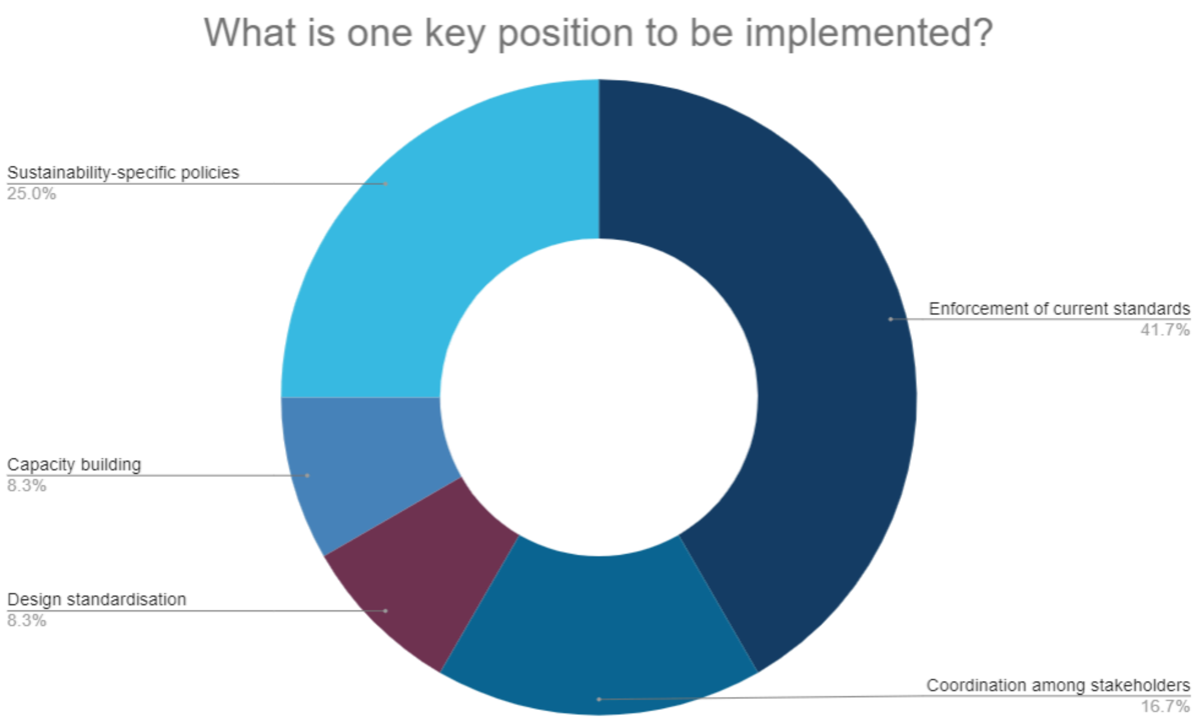


The implications of these concerns are profound. The prominence of Space Debris Mitigation in the survey indicates a preference for proactive strategies in reducing and removing space debris, which is seen as a primary concern for maintaining sustainable space activities. This emphasis on mitigation suggests that respondents favour a proactive approach, valuing preventive measures over-reactive solutions. The concern for Environmental Protection in Outer Space reflects a recognition of the need to extend

Earth-bound environmental protection concepts to space activities, highlighting a strong environmental consciousness among the respondents. It shows consideration for the preservation of the outer space environment, likely including worries about contamination and the long-term ecological impacts of space operations.

Mega-constellations, a relatively new phenomenon due to the only recent rise of satellite constellations for global internet coverage, also featured prominently. The mention of this issue implies that respondents are aware that the management and regulation of these constellations are high priorities to prevent potential issues like frequency interference and increased risk of collisions. Equally, the concern over Space Traffic Management points to the importance of monitoring and managing the orbits of satellites to prevent collisions and maintain a sustainable environment in heavily trafficked areas of space. The mention of Space Resource Utilisation suggests a focus on the ethical, legal, and environmental implications of extracting resources from celestial bodies, reflecting the respondents' awareness of the growing interest in this area.

Despite being mentioned less, the issues of Active Debris Removal, Cybersecurity, and Life-cycle Assessment are no less important. Active debris removal is a subset of debris mitigation, cybersecurity is crucial for protecting space assets from digital threats, and life-cycle assessment reflects a holistic view of space sustainability, considering the impact of space projects from inception to deorbiting. The respondents appear to support policies that anticipate and prevent problems rather than addressing problems after they occur. This preference for proactive measures over reactive ones is a notable trend in the responses.



The variety of issues mentioned, which require coordinated international efforts, implies a respondent inclination towards the need for global regulation and management of space activities. The respondents are not just generally aware but also informed about the specific technical aspects and the complexity of space operations. This diverse range of concerns suggests that respondents view space sustainability as a multifaceted issue that spans technical, environmental, and security concerns.

In summary, the survey responses paint a picture of a well-informed, environmentally conscious, and forward-thinking group. They show a nuanced understanding of the issues, recognizing the need for a comprehensive and proactive approach to ensure the long-term viability of space activities. The respondents' perspectives underscore the need for comprehensive, proactive, and globally coordinated policies to ensure the sustainability of space activities, considering the immediate and long-term challenges. They highlight the interconnected nature of these issues and the necessity of an integrated policy approach that considers the lifecycle of space objects, from design and launch to operation and decommissioning, ensuring each phase adheres to sustainability principles. The data underscores the need for policies focused on reducing and actively removing space debris, regulations safeguarding the space environment, management of mega-constellations, enhanced systems for space traffic management, responsible frameworks for resource extraction in space, and the integration of cybersecurity, life-cycle assessment, and active debris removal into comprehensive space sustainability policies.

Analysing the responses from the Executive Committee Members to the question about key measures for inclusion in the IPASS Report reveals a diverse range of concerns and suggestions. One respondent emphasises the need for continuity and long-term commitment in space exploration programs. This concern highlights the issue of political disinterest leading to short life cycles of space programs, which can limit opportunities for future generations of space enthusiasts. This points to a broader need for sustainability in space exploration, requiring long-term planning and consistent support.

Another response succinctly suggests “Economical Measures” though it lacks specificity. This could imply a call for financial strategies or incentives to support sustainable practices in space activities. Following this, a respondent recommends a private sector pledge with peer-reviewed reports of sustainability measures, drawing inspiration from initiatives like the Paris Peace Forum's Net Zero Space Initiative. This suggests a desire for transparency and accountability in corporate contributions to space sustainability.

The importance of education, especially in aerospace engineering curriculums, is highlighted by another respondent. They advocate for a focus not just on mitigation but also on realistic prevention of space-related issues, indicating an interest in integrating sustainability principles into early educational frameworks. In contrast, another response points to the need for regulations governing space mining activities, particularly with future exploration of the Moon and Mars in mind. This reflects concerns about the ethical, legal, and environmental implications of extraterrestrial resource extraction.

The issue of space debris is a recurring theme in several responses. One respondent articulates a comprehensive approach to space debris management, emphasising the need to reduce, reuse, and recycle, akin to waste management practices on Earth. This suggests prioritising debris mitigation and considering innovative solutions like in-orbit servicing (IOS) and active debris removal (ADR). Another response echoes this concern, advocating for mandatory end-of-life plans for satellites to ensure responsible disposal and minimise space debris, which they see as essential for the long-term sustainability of space activities.

Cybersecurity is also mentioned as a key concern, with a focus on ensuring the robustness and efficiency of space infrastructure. The respondent warns that without adequate cybersecurity measures, information and communication technology (ICT) systems in space could become obsolete or vulnerable, increasing the risk of malfunctions or collisions. This highlights the growing importance of digital security in the context of space sustainability.

A suggestion to promote the adoption of national legislation on end-of-life disposal of space objects further stresses the need for regulatory frameworks. It suggests a move towards more standardised and globally recognised practices for managing space assets. Additionally, ensuring equitable and sustainable space resource use between countries is proposed, indicating a concern for fairness and international cooperation in the allocation of space resources. This is coupled with a call for space debris disposal measures, drawing a parallel to the carbon bonds approach in the Kyoto protocol. Such a comparison suggests using economic incentives and a liability regime to encourage sustainable behaviour in space.

In conclusion, the responses to the question about key measures for the Pact reveal a spectrum of concerns and recommendations. These range from the need for long-term commitment in space programs, economic measures, educational initiatives, regulations for space mining, comprehensive space debris management, mandatory end-of-life plans for satellites, robust cybersecurity, to the adoption of national and international legislation. The overarching theme is the pursuit of sustainable and responsible practices in space activities, emphasising a multi-dimensional approach that addresses technical, environmental, legal, and ethical aspects. The diversity of these responses underscores the complexity of space sustainability and the need for a holistic, integrated approach in formulating the Pact.

5. TOWARDS AN INTERNATIONAL PACT FOR SPACE SUSTAINABILITY

This section outlines our proposal for the development of a new "pact" between generations, to achieve a safe and sustainable space environment that fosters a united global space community. Consistently with the analysis conducted throughout this Report, our proposal for an "Intergenerational Pact for Space Sustainability" (IPASS) is structured into three sections: SGAC's vision (5.1.) the prioritisation of key topics (5.2.), and the exploration of avenues to promote the sustainability of space activities (5.3.).

5.1. SGAC's vision

The vision of SGAC is to build a safe and sustainable space environment for a unified global space community. We believe that this vision can be realised if IPASS would accomplish the following five key objectives:

1) Achieve a globally recognised and well-managed space environment, not only in Earth orbit but also beyond, safeguarding both current and future space operations as well as the benefits of space for Earth, including for climate action, disaster management, astronomy and global connectivity;
2) Encourage the implementation of the Guidelines for Long-Term Sustainability of Outer Space activities (LTS Guidelines), and consider them as initial building blocks for an international STM framework;
3) Facilitate the implementation of the UN "Space2030" Agenda and the use of space applications and technologies for the achievement of the Sustainable Development Goals;
4) Establish a collaborative and more inclusive global space community that upholds principles of sustainability, equity, and shared responsibility, and;
5) Nurture a future generation that is knowledgeable, engaged, and capable of advancing sustainable space exploration and stewardship.

5.2. Priority topics

As it has been established in the Report, achieving space sustainability calls for a holistic approach. However, as is customary in any project, a starting point is essential. At the minimum, the IPASS should address the following five priority areas:

i. Multilateral governance of space issues, inclusivity and youth participation in space

1) Increase active participation in a globally inclusive space governance framework that ensures safe and sustainable space activities, also through increased multi-stakeholder participation, e.g. in the work of COPUOS as the central multilateral forum for the further development of space law and policy by expanding institutional mechanisms for participation by civil society and allowing commercial actors to acquire observer status.

2) Adopt dedicated institutional measures to ensure the meaningful participation of representatives from recognised youth organisations in the work of international fora, within and beyond the UN system.

ii. International collaboration and cooperation in the exploration and use of space

1) Develop dedicated tools and practices for enhanced information sharing, among others to implement Article XI of the Outer Space Treaty, such as for example a global platform enhancing transparency and cooperative problem-solving.

2) Promote capacity building in space law and policy to ensure that emerging nations can actively participate in the development of key rules for the sustainable use of space and its resources.

iii. Space Traffic Management, including Dark & Quiet Skies

1) Regularly exchange and use lessons learnt about national, regional and international tools and practices on the way towards adopting and enforcing

shared standards and best practices for space traffic management to ensure safe and sustainable orbital pathways.

2) Develop and implement measures to reduce light pollution and radio frequency interference, in collaboration with the International Telecommunication Union (ITU).

iv. Space Debris

1) Develop norms, fix milestones, and support technologies for the incremental removal of all space debris, taking into due consideration related scientific, strategic and legal aspects.

2) Take steps towards ensuring that all space activities, particularly those carried out by commercial entities, are conducted keeping in mind the space environment, with a view towards the long-term sustainability of our orbital resources.

3) Ensure swift implementation of the 2019 Guidelines on the Long-Term Sustainability of Outer Space Activities, promoting a circular approach based on reusability and interoperability.

v. Sustainability beyond Earth Orbit

1) Ensure the long-term sustainability of activities beyond Earth Orbit, e.g. lunar activities, by proactively and regularly evaluating their impact on the outer space environment, including the need for appropriate mitigation measures.

2) Commit to always limit in time and size all territorial-based uses of the Moon and other celestial bodies, and develop an evolving list of sites and resources internationally recognised as scarce.

3) Pledge to extract and use space resources with due regard to the corresponding interests of all others, with special consideration to the needs of developing

countries and future generations. Special diligence is required, since all exploration activities influence the natural surroundings of celestial bodies and thus may deprive science of the opportunity to investigate their original conditions.

5.3. Potential Avenues to achieve the Pact's objectives

We are convinced that there is not a singular path to realise the aforementioned goals. Currently, the international community employs a combined approach of both national and international instruments, both binding and non-binding, to address critical space sustainability challenges. Our approach aims to be equally adaptable. Thus, the Pact contemplates three primary avenues to achieve its objectives.

i. Creating Binding Agreements

1) Develop and sign effective international agreements that are legally binding, ensuring commitment and compliance from all stakeholders, particularly to ensure peaceful, sustainable, and safe space activities for the benefit of all.

ii. Promoting Technological Advancements

1) Encourage investment in and adoption of innovative technologies for improved space operations, environmental protection, and disaster risk reduction, bridging the digital divide and economic growth.

2) Coordinate a digital governance framework to guide global, regional, and national approaches around shared principles, priorities, and objectives to ensure that technological advancements contribute to more sustainable space activities as well as the use of space technology and data for the benefit of the SDGs (see: Space2030 Agenda).

3) Organise a multi-stakeholder dialogue and cooperation for this purpose, such as the proposed annual Digital Cooperation Forum.

iii. Global Educational and Advocacy Programs

1) Support and participate in educational initiatives and advocacy campaigns aimed at raising awareness and fostering a culture of sustainability in space.

2) Expand and strengthen diverse and inclusive youth participation in national, international, and UN-led decision-making processes through dedicated avenues for including the viewpoint of the youth, a standing UN Youth Town Hall, as well as through intergenerational dialogues.

6. CONCLUSION

This Report condenses the results of almost a year of intense work specifically focused on the long-term sustainability of space activities. Throughout this period, we engaged with 18 stakeholders globally to investigate the essence of space sustainability and explore the necessary actions to achieve it. Each meeting revealed the remarkable contributions of these stakeholders, enriching the global discourse on space sustainability with their diverse expertise.

Our analysis extensively considered existing legal frameworks, providing a robust foundation for our understanding and recommendations. We also reflected on the impact of various initiatives addressing both general and specific challenges posed by space activities to achieve their long-term sustainability.

In conducting this research, we pursued three primary objectives: first, to formulate concrete recommendations on how SGAC should approach, address, and advocate for space sustainability; second, to gain a nuanced understanding of the space sector's position on this issue, encompassing perspectives from academia, private industry, civil societies, space agencies, governments and military; and third, to capture and represent the viewpoints of the youth, advocating their perspectives on a broader scale. We are committed to ensuring that these recommendations not only resonate within SGAC but also influence the broader discourse on space sustainability. It is our conviction that these efforts will contribute significantly to shaping a more sustainable future in space exploration and utilisation.

We firmly believe that while there is no singular path toward space sustainability, there is one community. Space sustainability can only be achieved by fostering synergy among stakeholders and acting collectively, guided by a shared vision. This vision, adaptable at various levels—international or national, binding or non-binding, general or specific—allows us to work together towards a common goal. After all, space is not the problem of a few but the responsibility of all.

ANNEX I. OVERVIEW OF INSTRUMENTS AND INITIATIVES PROMOTING SPACE SUSTAINABILITY

This annex provides an overview of legal instruments and initiatives promoting space sustainability in general and within specific context.

1. Global space sustainability instruments

1.1. UN Space Treaties

To date, there are five international binding treaties governing space activities: the 1967 Outer Space Treaty,[38] the 1968 Return and Rescue Agreement,[39] the 1972 Liability Convention,[40] the 1976 Registration Convention,[41] and the 1979 Moon Agreement.[42] Although none of these instruments provide States with an obligation to operate in outer space in a sustainable manner—or even directly refer to the concept of sustainability, they contain principles that emulate the concept.

Scholars have noted that several established principles of space law embrace the idea of sustainability.[43] This is the case, for instance, of the principles of "province of all mankind",[44] "equitable use",[45] "benefit of all countries",[46] "common heritage of mankind",[47] "non-appropriation"[48] and "due regard"[49]. Moreover, it must be underlined

[38] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, *entered into force* October 10, 1967, 610 UNTS 205.
[39] Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space, *entered into force* Dec. 3, 1968, 672 UNTS 119.
[40] Convention on International Liability for Damage Caused by Space Objects, *entered into force* October 9, 1973, 961 UNTS 187.
[41] Convention on Registration of Objects Launched into Outer Space, *entered into force* September 15, 1976, 1023 UNTS 15.
[42] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, *entered into force* July 11, 1984, 1363 UNTS 3.
[43] Vishakha Gupta, 'Critique of the International Law on Protection of the Outer Space Environment' (2016) 14 ASTROPOLITICS 20, 32; Lotta Viikari, The Environmental Element in Space Law Assessing the Present and Charting the Future (Martinus Nijhoff Publishers 2008) 145.
[44] Outer Space Treaty, art. I, and Moon Agreement, art. 4§1.
[45] Moon Agreement, art. 7.
[46] Outer Space Treaty, art. I, and Moon Agreement, art. 4§1.
[47] Moon Agreement, art. 11§1.
[48] Outer Space Treaty, art. II, and Moon Agreement, art. 11§2.
[49] Outer Space Treaty, art. IX, and Moon Agreement, art. 4§1.

that the Moon Agreement expressly refers, in its Preamble and Article 4, to the necessity of accounting for the interests of "present and future generations". This expression is not without echoing a key component of sustainability, namely our ability to think in the long term and to consider the impact of our activities today on future generations.

Furthermore, the Outer Space Treaty and the Moon Agreement directly address concerns regarding the preservation of the outer space environment. In their respective Article IX and Article 7, the two treaties require States to adopt measures to avoid causing harmful contamination to the extraterrestrial environment. Although these provisions leave the particulars of implementing such measures in the hands of States,[50] the intention to preserve the environment of celestial bodies can be ascertained. It can further be argued that such concerns further extend to the orbital environment of Earth,[51] and *a fortiori* the problem raised by space debris.

Overall, the UN Space Treaties promote principles that are crucial to the achievement of space sustainability. They advocate for the responsibility of States regarding the impact of their activities on *inter alia* the outer space environment, requiring them to supervise private entities' space operations and support a long-term approach. Consequently, despite the absence of reference to sustainability in these instruments, it can be said that the five UN Space Treaties remain relevant to the matter. They offer a legally binding basis to foster sustainability practices among space-faring nations.

1.2. UNCOPUOS' LTS Guidelines[52]

In 2019, UNCOPUOS formally adopted its *Guidelines for the Long-term Sustainability of Outer Space Activities* (LTS Guidelines). This non-legally binding instrument aims to establish a comprehensive framework ensuring the safe and sustainable use of outer

[50] For a critical analysis of the environmental regimes of the Outer Space Treaty and the Moon Agreement, see Gabrielle Leterre, *Space Mining and Environmental Protection: Recycling International Agreements into New Legal Practices*, 62 *in* IISL Proceedings 83 (2020).
[51] *Id.*
[52] Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 74th Sess., Supp. No. 20, at 163 and Annex II, UN doc. A/74/20 (2019).

space.[53] The need for such guidelines arose from the acknowledgment that the increasing number of space actors posed a threat to the long-term safety of space activities, and that "a safe environment for space activities is no longer a given if one takes a long-term view".[54]

The LTS Guidelines's primary recipients are States and international intergovernmental organisations, though they are also of relevance for non-governmental actors,[55] such as private entities. The instrument aims to assist policymakers in managing risks associated with space activities and offer guidance in developing and implementing sustainable policies and practices, emphasising cooperation and coordination for the long-term sustainability of space operations.

Furthermore, despite the Guidelines being voluntary and thus lacking legal binding under international law,[56] they are impactful. Indeed, the absence of binding character should not be mistaken for a lack of efficiency; States can always decide to implement their content into their national order and to enforce it.[57] To date, the LTS Guidelines remain the most comprehensive and current international guidance on the long-term sustainability of space activities.

In substance, the LTS Guidelines are divided into four sections–sections A to D–with each guideline providing detailed guidance regarding their implementation. Accordingly, Section A addresses the long-term sustainability of space activities from the perspective of policy and regulatory frameworks for space activities. It recommends that States establish and continually update robust national regulatory frameworks for

[53] Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 74th Sess., Supp. No. 20, at 163 and Annex II, UN doc. A/74/20 (2019).
[54] Future Role and Activities of the Committee on the Peaceful Uses of Outer Space, U.N. Doc. A/AC.105/L.268, § 26 (2007).
[55] LTS Guidelines, U.N. Doc. A/AC.105/C.1/L.366/Rev.1, preamble, ¶ 11 (2018).
[56] LTS Guidelines, preamble, §15.
[57] For instance, some Member States, like the United Kingdom, regularly report to UNCOPUOS on their advancement and approach to implementing the LTS Guidelines. United Kingdom Update on its Reporting Approach for the Voluntary Implementation of the Guidelines for the Long-Term Sustainability of Outer Space Activities, UNCOPUOS STC, 59th Sess., UN Doc. A/AC.105/C.1/2022/CRP.22 (2022). Also see e.g. Chan Yuk Chi et al., *SGAC Report on the LTS Guidelines National Implementation*, *in* Technical Presentations Made at the UNCOPUOS LSC (2021) available online.

outer space activities. These frameworks should prioritise considerations of safety, environmental impact, international cooperation, and equitable access. States are further encouraged to collaborate to guarantee fair utilisation of orbital regions, radio frequency spectrum, and space resources. Additionally, it is advised that States register their space objects with the United Nations to contribute to transparency and international coordination.

Section B considers the safety of space operations. It promotes enhanced information sharing among States and international intergovernmental organisations regarding space objects and orbital events. This involves improving the accuracy of orbital data for space objects, as well as collecting and sharing information on space debris monitoring and conducting conjunction assessments. Furthermore, Section B encourages the sharing of operational space weather data and forecasts, the development of space weather models and tools, the safe design and operation of space objects, responsible de-orbiting at the end of their useful life, and the secure use of laser beams.

Section C underlines the importance of international cooperation, capacity building, and awareness. It highlights the pivotal role of international cooperation in guaranteeing the enduring sustainability of space activities. It calls for collaboration among States, international intergovernmental organisations, and non-governmental entities to exchange knowledge and expertise. Additionally, the emphasis is on supporting developing countries through capacity-building initiatives and fostering public awareness about the significance of space sustainability.

Lastly, Section D focuses on the future by encouraging further scientific and technical research and development. It underscores the significance of cultivating and applying sustainable practices across all facets of space exploration and utilisation. This involves the development of technologies that minimise environmental impact, safeguarding both Earth and the space environment from detrimental contamination.

Furthermore, the section advocates for the exploration and implementation of innovative measures to sustainably manage the space debris population, incorporating approaches like active debris removal and space traffic management. However, this must be done while taking into consideration the associated costs for emerging spacefaring nations.

Ultimately, the LTS Guidelines apply to all space activities, whether planned or ongoing, and cover every phase of a space mission, including launch, operation, and end-of-life disposal.[58] Overall, the instrument provides flexibility tailored to specific national circumstances. This adaptability ensures their relevance and achievability over time, reflecting the dynamic nature of the evolving space sector. However, it comes at a cost, since their large scope leaves the door open to different interpretations, which could lead to inconsistent implementation practices across States. For instance, there is no consensus on what constitutes a "congestion assessment".[59]

Nevertheless, it is worth noting that the LTS Guidelines is an instrument bound to evolve and the guidelines are regularly reviewed and updated.[60] In 2021, UNCOPUOS established the "LTS Working Group 2.0" with a mandate to consider new guidelines for the long-term sustainability of outer space activities, recognizing the need for dynamic updates to address evolving space activities. Over a 5-year period, the group aims to support the implementation of existing guidelines, study challenges posed by emerging space uses, and enhance capacity-building efforts. Expected to conclude in 2026, the LTS Working Group 2.0 will present a draft final report, contributing significantly to the ongoing promotion of the sustainable use of outer space for future generations by ensuring the LTS Guidelines remain current and effective.

[58] *Ibid.*
[59] National Aeronautics and Space Administration, *Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook* (NASA/SP-2020-5011318, 2020)
[60] LTS Guidelines, U.N. Doc. A/AC.105/C.1/L.366/Rev.1, preamble, ¶ 24 (2018).

1.3. 2023 EU Council conclusions on "Fair and sustainable use of space"[61]

The European Union's 2023 Council Conclusions on "Fair and Sustainable Use of Space" underscores the importance of recognizing space as a global commons, accessible to all States without discrimination, and emphasises the right to a free, fair, and peaceful use of space for the benefit of all, ensuring sustainability for future generations. Acknowledging the indispensable role of space technology, data, and services in European daily life, the document expresses concern over specific satellite orbits, particularly LEO, becoming congested and hazardous due to increasing space objects, posing risks to safe orbital traffic and space activities.

The Council calls for the implementation of mitigation measures to minimise future space debris and promote research on debris remediation, emphasising safety, security, and sustainability as essential factors for a fair and sustainable use of space. It encourages the exploration of requirements for safe space activities, urges collaboration with satellite service providers, and invites the EU Commission to explore incentive measures for sustainable space use. The document further addresses concerns about light pollution, electromagnetic interference, space weather hazards, and the rational use of frequency resources. Additionally, it calls for continued implementation of voluntary guidelines for the long-term sustainability of outer space activities and encourages a concerted European approach in line with international cooperation. The Council emphasises the need for global implementation of guidelines promoting the safe and sustainable use of space while recognizing the importance of multilateral efforts to preserve safety, security, and sustainability in space.

1.4. Space Sustainability Ratings (SSR)

Launched in 2016 by the World Economic Forum, the Space Sustainability Rating (SSR) is a pioneering initiative developed in collaboration with ESA, MIT, BryceTech, and the University of Texas in Austin, USA. Originally managed by the World Economic Forum,

[61] EU Council, Council conclusions on "Fair and sustainable use of space", Doc. 9675/23 (2023).

the SSR is now independently overseen by the École Polytechnique Fédérale de Lausanne (EPFL Space centre) in Switzerland.

The SSR employs a tiered scoring system to quantify and measure the sustainability decisions made by satellite operators. Its rating system evaluates operators on various criteria, such as data sharing, orbit selection, collision avoidance measures, and de-orbit plans, with bonus marks awarded for additional elements like grappling fixtures. It relies *inter alia* on its mission index module, derived from ESA's debris index, to assess the potentially harmful physical interference caused by planned missions. The SSR strives to promote voluntary actions among satellite operators, fostering sustainability by reducing the risks associated with space debris and collisions. Ultimately, the initiative seeks to shape the behaviour of all spaceflight actors, especially commercial entities, driving the widespread adoption of sustainable practices across the space industry.

1.5. Secure World Foundation

The Secure World Foundation (SWF) functions as a private operating foundation dedicated to advancing cooperative solutions for space sustainability and the peaceful utilisation of outer space. Serving as a research body, convener, and facilitator, the organisation addresses key space security and related topics, exploring their impact on governance and international development. SWF actively contributes to space sustainability by addressing space debris issues. The organisation disseminates knowledge through reports, articles, and books, which comprehensively covers various aspects of space sustainability, including orbital debris, space weather, and improved space situational awareness. Since 2020, SWF has been organising the annual Summit for Space Sustainability, a high-level, multi-day event focused on developing solutions for space sustainability. The organisation has established itself as a prominent advocate for this intricate topic, fostering multi-stakeholder dialogue to address the challenges of space sustainability.

2. Mitigation of space debris

Space debris stands as a formidable challenge, casting a shadow over the panorama of space activities. Emerging from the remnants of human-made objects launched and operated in outer space, these non-functional artefacts contribute significantly to the congestion of Earth's orbit; a recent evaluation from ESA estimates that there are about 128 million orbital debris smaller than 1cm, 900.000 between 1 cm and 10cm, and 34.000 larger than 10cm.[62] This congestion, in turn, amplifies the peril of collisions in outer space, posing substantial risks to the safety, security, and sustainability of space operations.

First and foremost is the immediate risk of collision with operational satellites and spacecraft, where even diminutive debris pieces can unleash catastrophic damage due to their high velocities. Second, the threat extends to crewed missions and space stations, like the ISS, and often requires intricate evasive manoeuvres to steer clear of potential collisions. Third, the ominous Kessler Syndrome, a worst-case scenario of cascading collisions, emerges as a significant long-term threat where the self-perpetuating chain reaction would potentially render entire orbital regions unusable, posing dire consequences for future space exploration, commercial activities, and national security.

For this reason, addressing the mitigation of space debris has remained a prominent interest of the space community for over forty years. This focus has manifested in the implementation of national legislation, the formulation of non-binding guidelines and standards, and the development of several initiatives throughout the space sector. The following section provides an overview of existing instruments, mechanisms, and initiatives launched to coordinate international efforts towards an outer space environment devoid of space debris.

[62] ESA, Towards A CLean Space: ESA's Zero Debris Approach (2023), available online.

2.1. IADC's Space Debris Mitigation Guidelines[63]

The Inter-Agency Space Debris Coordination Committee (IADC) emerged from discussions among the United States, ESA, Japan, and the Soviet Union in the late 1980s to address the escalating issue of space debris. The IADC's primary objective is to foster cooperation and information exchange on space debris research and mitigation among various space agencies. It concentrates on producing mitigation guidelines applicable throughout a space object's lifecycle. Established by space agencies rather than governments, the IADC guidelines are voluntary, thus lacking binding force. Crafted by technical experts, these guidelines offer precise directives for operators and space program managers based on consensus among IADC members, reflecting current best practices.

The guidelines encompass measures for limiting debris release, minimising break-ups during operational phases, reducing the probability of accidental collisions, preventing intentional destruction, and managing long-term space object presence in LEO post-mission. Recommendations encourage operators to design projects aiming not to release debris, minimise debris generation, and avoid congesting areas like LEO. To address on-orbit break-ups, the IADC suggests passivation measures for stored energy, requires a demonstration of a low probability of operational-phase break-ups and discourages intentional destruction. The guidelines also propose post-mission disposal measures such as re-orbiting to a "graveyard orbit" or de-orbiting with a preference for Earth's atmosphere re-entry. Additionally, collision avoidance procedures, involving probability assessments, conjunction assessments, and coordinated launch windows, are encouraged.

While the IADC guidelines lack legal binding force, they serve as a standard for responsible space operators and have influenced the development of national space

[63] IADC, Space Debris Mitigation Guidelines, IADC Steering Group and Working Group 4, IADC-02-01 Rev. 3 (2021).

legislations and international instruments, including the UNCOPUOS Space Debris Mitigation Guidelines adopted in 2007.

2.2. UNCOPUOS' Space Debris Mitigation Guidelines[64]

In 1994, the UNCOPUOS initiated discussions on space debris, officially adding it as a recurrent agenda item.[65] Over the following five years, the Subcommittee on Technical and Scientific Matters (STC) accumulated knowledge on space debris, resulting in the 1999 publication of a Technical Report on Space Debris.[66] The report advocated for prudent steps in debris mitigation due to existing technological limitations. The Subcommittee, aiming to propose space debris mitigation guidelines, adopted a multi-year plan and invited the Inter-Agency Space Debris Coordination Committee (IADC) in 2003 to present its mitigation guidelines. The UNCOPUOS STC used these guidelines as a basis and formed a dedicated Working Group to draft its own guidelines, a process concluded in 2005.[67] The UNCOPUOS' Space Debris Mitigation Guidelines were adopted in 2007, receiving endorsement from both the UNCOPUOS and the UN General Assembly.[68]

Content-wise, the UNCOPUOS guidelines encompass various key aspects. These include recommendations for spacecraft and launch vehicles to incorporate options like controlled reentry or moving to designated "graveyard orbits" post-mission. Launch and deployment procedures are highlighted, emphasising the importance of optimal coordination during spacecraft launches to minimise debris production. Prolonging the operational lifespan of spacecraft is encouraged to reduce the number of objects launched into outer space. Space Traffic Management (STM) and collision avoidance measures are deemed crucial for protecting space infrastructure, emphasising

[64] UNCOPUOS, Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 62nd Sess., Supp. No. 20, at 117-118 and Annex, UN Doc. A/62/20 (2007).
[65] Report of the Scientific and Technical Subcommittee on the Work of its Thirty-first Session, UNCOPUOS, §§ 63-74, UN Doc. A/AC.105/571 (1994).
[66] Technical Report on Space Debris, UNCOPUOS STC, UN Doc. A/AC.105/720 (1999).
[67] Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 60 Sess., Supp. No. 20, §126, UN Doc. A/60/20 (2005).
[68] GA Res. 62/217, UNGA, 62 Sess., §27, UN Doc. A/RES/62/217.

transparency and international information sharing for Space Situational Awareness (SSA). The UNCOPUOS Space Debris Mitigation Guidelines advocate for education and outreach initiatives to raise awareness about debris challenges and promote responsible behaviour in space. Additionally, they endorse technologies for active debris removal (ADR) when full mitigation measures are not feasible. International cooperation, involving both state and non-state entities, is strongly encouraged to ensure the long-term sustainability of space activities. There is however a notable difference with the IADC Space Debris Mitigation as the UNCOPUOS guidelines do not specify a time-limit for deorbiting, unlike the IADC's 25-year rule.

2.3. ISO Standard 24113:2023 on space debris mitigation requirements

In 2023, the International organisation for standardisation (ISO) issued the standard ISO 24113:2023,[69] which sets out the principal regulations for mitigating space debris for all unmanned space systems. As an international non-governmental organisation composed of national standardisation bodies, standards adopted by ISO reflect international consensus on best practices, and in the present case, on the necessity to manage space activities and minimise collisions and casualties. ISO's purpose is *inter alia* to adapt international guidelines–such as the ones promoted by the UNCOPUOS–into engineering practice. In this sense, the international NGO offers technical definitions that aim at facilitating the systematisation of industry best practices and, ultimately, at institutionalising the sustainable operation of space assets.

ISO experience in this area has been proven in several domains, including the space sector. Indeed, space industries have been known to use ISO standards to enhance the quality and reliability of their operations. For instance, in 2006, SpaceX claimed full compliance to ISO standards 9001 on International Quality Management; a standard that evaluates the design, manufacture, and testing of launch vehicles.[70] In a similar manner, Airbus ERM used ISO standard 31000 on Risk Management to ensure its

[69] ISO, Standard ISO 24113:2023 Space systems — Space debris mitigation requirements, available online,
[70] SpaceX Achieves International Quality Standard, Space Daily (2006), available online.

compliance with the Dutch Corporate Governance Code,[71] and both EIS Electronics and Beyond Gravity's practices are aligned with ISO standard 14001 on Environmental Management.[72]

2.4. Paris Peace Forum's Net Zero Space Initiative[73]

The Net Zero Space initiative, launched during the 2021 Paris Peace Forum, addresses the escalating issue of orbital debris, posing threats to the safety and sustainability of space operations. Comprising 64 stakeholders from industry, governmental institutions, research associations, and space agencies across 24 countries, it emphasises the exponential growth of space activities, providing new opportunities for human development but concurrently raising concerns about the rising amount of orbital debris. In its Declaration, the initiative stresses the need to protect Earth's orbital environment as a shared resource for all humanity, in line with the Outer Space Treaty. It advocates for the central consideration of sustainability in both public and private space activities, aiming to ensure equitable access to outer space.

Additionally, the non-binding document calls for international and multi-stakeholder cooperation, involving the private sector, civil society, academia, and public authorities, to achieve the shared goal of safe space operations and the long-term sustainability of outer space activities. The Net Zero Space initiative urges urgent action, commencing in 2021, to contain and reduce ongoing pollution by preventing further hazardous space debris generation and remediating existing threats. It invites global stakeholders to support the initiative, emphasising the commitment to concrete actions contributing to the Net Zero Space goal.

[71] Airbus, Enterprise Risk Management, available online.
[72] Spacetech Expo Europe, E.I.S. Electronics GmbH, available online; Thales Alenia was last qualified with this certification in 2014 but has not since been renewed, Thales, Thales Alenia Space's Quality, Health, Safety and Environment Certifications renewed (2014), available online.
[73] The Net Zero Space Declaration (2021), available online.

To monitor progress and maintain momentum, the declaration recommends annual reporting on the initiative's status and encourages subsequent steps toward realising the Net Zero Space goal, highlighting the importance of collaborative efforts to achieve sustainable use of outer space by 2030.

2.5. ESA's Zero Debris Charter[74]

The Zero Debris Charter, released by the ESA during the Space Summit 2023 in Seville, is a non-legally binding initiative aimed at promoting space safety and sustainability. It is the result of a collaborative effort involving over 30 space actors, including entities such as Airbus Defence and Space, OHB, and Thales Alenia Space. The Charter aims to achieve Zero Debris within the next decade and includes guiding principles that emphasise the intentional avoidance of space debris release, the mitigation of adverse effects, and continuous efforts to enhance knowledge regarding space debris populations. Alongside these principles, the Charter outlines specific targets for 2030, encompassing the limitation of debris generation probability, timely clearance of orbital regions, minimization of casualty risks, promotion of information sharing, and improvement of data access for collision avoidance.

Participating entities commit to progressively contributing to these targets, demonstrating a shared responsibility for the sustainable future of space activities. The operational aspects of the Charter include regular exchanges on contributions, encouraging new entities to join, maintaining a public list of partners, promoting Charter awareness, inviting collaboration beyond 2030, and fostering the development of relevant technologies and performance indicators. This Charter stands as a testament to collective determination, guiding the space community towards sustainable practices and ambitious targets, ensuring the long-term benefit of humankind.

[74] European Space Agency, The Zero Debris Charter (2023), available online.

2.6. ClearSpace-1: ESA's active debris removal mission

At the Space19+ Ministerial Council in Seville, ESA made a landmark decision to contract a commercial provider for the safe removal of an inactive ESA-owned object from LEO: the Vespa (Vega Secondary Payload Adapter) upper stage, a derelict object left in orbit after an ESA Vega launcher's second flight in 2013.[75] This strategic move is part of the Active Debris Removal/In-Orbit Servicing (ADRIOS) project, which pursues two key objectives: the removal of human-made objects from space and the development of competencies in in-orbit servicing to extend infrastructure lifetimes. In pursuance of this goal, ESA purchased ADRIOS as a service from the Swiss startup ClearSpace SA, emphasising the collaboration to demonstrate debris removal technologies and pave the way for a sustainable commercial sector in space.

The ClearSpace-1 mission stands as a groundbreaking initiative to actively remove a significant piece of space debris from orbit, marking the first-ever mission of its kind. Scheduled for launch in 2026, ClearSpace-1 sets itself apart by employing highly precise, complex, and close proximity operations to capture and safely deorbit a large derelict object for controlled atmospheric reentry. The Vespa, with a mass of 100 kg, serves as an ideal initial target due to its size and relatively simple structure.

Equipped with a quartet of robotic arms, the ClearSpace-1 spacecraft, often referred to as the "chaser", will perform a rendezvous and capture operation in orbit under ESA supervision. Following this, the chaser and Vespa combination will be intentionally deorbited, ensuring a controlled burn-up in the Earth"s atmosphere. Despite facing challenges, such as the Vespa adapter being hit by another debris in August 2022, the mission remains on track.

ClearSpace-1 represents a pivotal step in addressing the escalating issue of space debris and underscores ESA's commitment to actively contribute to space cleanup while

[75] See e.g. ESA, L'ESA achète à une start-up la première mission au monde d'enlèvement d'un débris, available online.

establishing a foundation for a sustainable commercial sector focused on in-orbit servicing. The mission is a testament to the agency's dedication to ensuring the long-term sustainability of outer space activities.

2.7. GSOA's Code of Conduct on Space Sustainability

The Global Satellite Operators Association (GSOA) is a leading CEO-driven association uniting the satellite industry globally. Functioning as a collaborative platform, it offers a unified voice for various companies within the satellite ecosystem. On November 13, 2023, the GSOA released its "Code of Conduct on Space Sustainability".[76] The Code's primary purpose is to identify and endorse industry practices promoting space sustainability, acknowledging space's substantial benefits to humanity and the planet. It emphasises timely actions to preserve these benefits amidst the increasing utilisation of orbits for valuable services.

The document addresses key areas, including mitigating the risk of in-orbit collisions through spacecraft design, trackability assurance, and coordinated safety-of-flight operations. It recommends practices for spacecraft design and operations to minimise risks, adhering to international rules. The importance of monitoring operational spacecraft, tracking orbital debris, and promoting situational awareness through information sharing is highlighted. Additionally, the Code emphasises practices to minimise non-trackable debris, ensuring proper post-mission disposal, and underscores the importance of spacecraft design and operation to preserve human life in space. Furthermore, it stresses the need to limit satellite reflectivity and its impact on ground-based optical astronomy. Overall, the GSOA Code of Conduct serves as a comprehensive framework, guiding space operators to contribute to the long-term sustainability of space resources and activities.

[76] Global Satellite Operators Association, *GSOA Code of Conduct on Space Sustainability* (2023), GSOA. Available online.

3. Challenges raised by mega-constellations

Mega-constellations, characterised by vast networks of interconnected satellites orbiting the Earth, pose a multitude of challenges that extend beyond their intended benefits. One significant issue is the detrimental impact on dark and quiet skies, a concern particularly relevant to the field of astronomy. These constellations, designed for global communication and internet coverage, involve numerous bright and reflective satellites that can interfere with astronomical observations. The luminosity from these satellites can create light pollution, affecting the ability of ground-based telescopes to capture clear images of celestial bodies. The radiofrequency interference generated by mega-constellations also hampers radio astronomy, impeding the observation of faint cosmic signals.

In addition to their impact on astronomy, mega-constellations contribute to the growing problem of space congestion and space debris. The sheer number of satellites deployed as part of these constellations raises the risk of collisions and adds to the already cluttered low Earth orbit. This congestion not only poses operational challenges for satellite operators but also heightens the potential for space debris generation, as collisions or accidental breakups could result in fragments that further populate Earth's orbital environment. Addressing these challenges requires careful consideration of regulatory frameworks, international cooperation, and technological innovations to ensure the responsible and sustainable deployment of mega-constellations. International institutions such as the International Telecommunication Union (ITU) and the UNCOPUOS are actively engaging in discussions to formulate such regulatory frameworks.

3.1. UNCOPUOS' discussion on mega-constellations

In recent years, the proliferation of mega-constellations has caught the attention of the UNCOPUOS, leading to a recognition of their substantial political and regulatory implications. The focal point of concern, particularly in relation to the 1974 Registration

Convention, revolves around several States lacking adequate national legislation to ensure compliance with Article VI of the Outer Space Treaty (i.e., their obligation to authorise and supervise space activities, and their international responsibility). This deficiency becomes particularly pronounced when non-governmental entities express interest in launching and operating mega-constellations.

Recognizing the significance of this matter, as well as the impact of mega-constellations on astronomy, the UNCOPUOS has directed its STSC to thoroughly examine during its session in 2024, the scope, timeline, and designation of an agenda item focused on "dark and quiet skies and large constellations" under the agenda item entitled "Future role and method of work of the Committee".[77] The ultimate goal is to present this proposal for inclusion in the Subcommittee's agenda during its sixty-seventh session.

However, while there is unanimous agreement on the importance of sustaining this agenda item, debates have emerged regarding the optimal extent of expertise within the proposed Expert Group. The postponement of discussions until the Subcommittee's meeting in February 2024 leaves the potential impact of adding this item to the agenda uncertain, pending further deliberation and decision-making.

3.2. ITU regulatory framework for mega-constellations

The International Telecommunication Union (ITU) oversees the allocation of radio frequency spectrums and orbital slots to prevent interference among existing satellites and *a fortiori* mega-constellations.[78] To that end, the institution convenes every three to four years a World Radiocommunication Conference (WRC) to address international spectrum use.[79]

[77] Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 78th Sess., Un Doc. A/78/20, Supp. No 20 (2023), para. 176.
[78] See D. Jha, N.P. MANTI, A. Carlo et al., "Safeguarding the final frontier: Analysing the legal and technical challenges to mega-constellations", *Journal of Space Safety Engineering* 9, 2022, p. 638.
[79] ITU, World Radiocommunication Conferences (WRC) (2023) available online.

During its 38th World Radiocommunication Conference in 2019 (WRC-19),[80] the ITU adopted an agreement that established a novel regulatory approach for the implementation of Non-Geostationary Satellite Orbit (NGSO),[81] particularly for bands and services encompassing mega-constellations in LEO.[82] In this novel regulatory framework, satellite operators will need to deploy 10 percent of their constellations within the initial two-year period following the conclusion of the ongoing deployment phase. Subsequently, this requirement will escalate to 50 percent over the subsequent five years. Finally, operators will be mandated to accomplish the full constellation placement within a span of seven years.[83]

The WRC-19 has played a pivotal role in establishing a robust foundation to facilitate various innovative technologies poised to revolutionise the digital economy, including artificial intelligence, cloud services, big data, and the Internet of Things. This aligns with the objectives of the UN Sustainable Development Goal No. 9, specifically focusing on expanding digital connectivity and working towards achieving widespread and affordable Internet access in developing countries by 2030. The reevaluation of the current regulatory framework for NGSO systems, particularly mega-constellations, has contributed significantly to advancing this goal. Mega-constellations, comprised of interconnected satellites, seek to enhance the quality and capacity of satellite services while reducing costs. This, in turn, empowers satellite operators to introduce market-driven solutions that effectively improve global connectivity access.[84]

[80] The latest WRC meeting at the time of the drafting of this report.
[81] The ITU defines NGSO satellites as moving "across the sky during their orbit around the earth, in medium Earth-orbit 8,000 – 20,000 km above the earth and in low-Earth orbit at elevations between 400 and 2000 km". ITU World Radiocommunication Conference adopts new regulatory procedures for non-geostationary satellites (2019) available online.
[82] *Id.*
[83] *ITU World Radiocommunication Conference adopts new regulatory procedures for non-geostationary satellites* (2019) *ITU*. Available at: https://www.itu.int/en/mediacentre/Pages/2019-PR23.aspx (Accessed: 17 November 2023).
[84] Mario Maniewicz, WRC-19: Enabling global radiocommunications for a better tomorrow, ITU News (2019), available online.

4. Advocacy for dark & quiet skies

The preservation of dark and quiet skies holds paramount importance in the context of space sustainability. Dark skies, free from excessive light pollution, are essential for astronomical observations and scientific research, enabling astronomers to study celestial objects with clarity and precision. Light pollution from mega-constellations can impede these observations, hindering our understanding of the universe. Additionally, maintaining quiet skies is crucial for radio astronomy, allowing for the detection of faint signals from distant celestial sources.

Furthermore, the focus on dark and quiet skies aligns with broader sustainability goals in space activities. As the number of satellites and mega-constellations continues to grow, the potential for radiofrequency interference and space congestion poses significant challenges. Effective regulation to ensure dark and quiet skies not only supports scientific endeavours but also contributes to sustainable practices in space. By addressing these concerns, space sustainability efforts can harmonize technological advancements with environmental preservation, fostering a responsible and balanced approach to the exploration and utilisation of outer space.

4.1. The inclusion of the Dark and Quiet Skies Item on the UNCOPUOS's agenda

In 2022, the UNCOPUOS sanctioned the inclusion of a dedicated agenda item titled “General exchange of views on dark and quiet skies for science and society” for discussion at the STSC's sixtieth session in 2023.[85] Seizing this opportunity, a comprehensive proposal garnered support from various nations and organisations, including Chile, Spain, Slovakia, Bulgaria, the Dominican Republic, Peru, South Africa, the European Southern Observatory (ESO), the International Astronomical Union (IAU), and the Square Kilometre Array Observatory (SKAO).[86] This proposal underscores the importance of establishing an Expert Group, accountable to the STSC, to methodically

[85] Report of the Committee on the Peaceful Uses of Outer Space, UNGAOR, 65th Sess., UN Doc. A/77/20 (2022), para. 190.
[86] Conference Room Paper on the Protection of Dark and Quiet Skies for science and society, STSC, 60th Sess., UN Doc. A/AC.105/C.1/2023/CRP.18/Rev.1 (2023).

assess the impact of satellites on astronomy, gather insights from global stakeholders, and devise recommendations to effectively address and mitigate these effects.

The deliberations regarding the proposal took place during the STSC's sixtieth under the dedicated item 17. While there was a consensus to maintain the item on the agenda for the next session, the scope of the proposed expert group remained a subject of intense debate.[87] Divergent opinions emerged on the timeline and mandate of the proposed expert group. While some suggested its initiation at the sixty-first session of the Subcommittee, others argued against a short-term mandate, emphasising the importance of involving a wide range of stakeholders to address the identified issues effectively. Discussions acknowledged that the topic had also been covered in the context of the long-term sustainability of outer space activities, and there were varying opinions on the appropriateness of establishing a new expert group given the time required to agree on its terms of reference.

4.2. The work of the International Astronomical Union

The Dark and Quiet Skies Global Outreach Project,[88] initiated by the International Astronomical Union (IAU), aims to raise awareness about the imperative to preserve both dark and quiet skies. Dark sky protection addresses the mitigation of light pollution caused by artificial light at night through regional and national policies, legal measures, and public awareness initiatives. Additionally, the project extends its focus to safeguarding the night sky from optical and infrared impacts resulting from the increasing number of satellites in Low Earth Orbit. On the other hand, quiet sky protection within the project pertains to addressing the radio interference posed by satellite constellations. The primary concern related to satellites is managed by the IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference, a key partner in the initiative. The project seeks to educate individuals on the significance of dark and quiet skies, emphasising their role in human culture,

[87] Report of the Scientific and Technical Subcommittee on its sixtieth session, held in Vienna from 6 to 17 February 2023, STSC, 66th Sess., UN Doc. A/AC.105/1279 (2023), sect. XVII.
[88] IAU, Global Outreach Project on Dark and Quiet Skies to Take Place in May 2023 (2023) available online.

heritage, and health. Furthermore, it underscores their impact on ecosystems and their crucial role in facilitating astronomy research.

Furthermore, the IAU has established a Working Group on Dark and Quiet Sky Protection, a continuation and transformation of the Working Group on the International Year of Light 2015.[89] It aims to make tangible progress in halting the encroachment of artificial sky glow and radio-frequency interference on major astronomical research facilities, and to raise public awareness to prevent losses caused by light pollution, emphasising the fundamental right to starlight. The Working Group collaborates with national and international authorities to establish legal policies and guidelines for protecting areas suitable for observational research and potential astronomical world heritage sites. To achieve its objectives, the Working Group coordinates with various commissions and associated working groups, covering technical aspects such as spectral output, propagation, artificial sky glow, and regulatory issues. It also addresses site protection efforts, sustainable development within a quality lighting framework, and works towards gaining UNESCO status for astronomical areas with cultural significance through the Windows on the Universe/High Mountain Observatories proposal.

4.3. European Southern Observatory

One of the main stakeholders currently involved in the campaign vindicating the protection of skies' darkness and quietness is the European Southern Observatory (ESO), an intergovernmental organisation dedicated to science and technology in astronomy.[90] ESO's mission centres on designing, constructing, and operating advanced ground-based observatories, coupled with a commitment to nurturing international collaboration in the field of astronomy. The organisation envisions advancing humanity's comprehension of the universe by collaboratively working with and supporting the astronomy community, delivering world-leading facilities.

[89] IAU, Executive Committee WG Dark and Quiet Sky Protection, available online.
[90] ESO, ESO at a glance, available online.

Moreover, ESO actively addresses the threats posed by satellite constellations to ground-based astronomical observatories. As part of the Dark and Quiet Skies Working Group, led by the IAU, ESO scientists and policy experts contributed to reports in 2020 and 2021, highlighting the importance of protecting dark and quiet skies. In collaboration with the IAU and other partners, ESO also petitioned the UNCOPUOS for enhanced safeguards. The 2022 paper submitted to UNCOPUOS marked the first formal agenda item on dark and quiet skies at the United Nations.

Additionally, as a permanent observer at UNCOPUOS, the organisation actively engages in various organisations supporting dark and quiet skies protection, holding lifetime membership in the International Dark-Sky Association and participating in regional initiatives like the European Dark Skies Conference. It is also a Contributing Member of the IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference, coordinating global efforts to mitigate the negative impact of satellite constellations on astronomy and public enjoyment of the night sky. In conclusion, ESO emerges as a leading advocate for preserving the darkness and tranquillity of our skies.

4.4. The UK's "Ten Dark Sky Policies for the Government"

The All-Party Parliamentary Group for Dark Skies, established in January 2020, is a unique initiative within the UK Parliament with a dedicated focus on reducing light pollution. The group emphasises the preservation of the night sky in the UK and advocates for dark sky-friendly lighting and planning policies.

To that end, the Parliamentary Group has developed a comprehensive plan–the "Ten Dark Sky Policies for the Government"[91]–resulting from extensive consultations with over 170 stakeholders, including academics, legal professionals, astronomers, government representatives, and lighting experts. The policy plan addresses the escalating issue of light pollution in the UK, proposing innovative solutions across three main themes: challenging the existing legal framework, overhauling rules for outdoor lighting installations, and introducing educational and incentivizing initiatives at all

[91] APPG, Ten Dark Sky Policies for the Government, available online.

government levels. It recommends specific actions, including updating the legal framework by strengthening the National Planning Policy Framework, expanding the scope of planning permissions, and reinforcing statutory nuisance provisions. The proposal also advocates for supercharging standards for lighting, with suggestions such as creating a statutory Commission for Dark Skies, setting standards for brightness and colour temperature, and establishing 'best practice' use for lighting.

4.5. Chile's new standard to safeguard its dark skies

Chile, the host country for all three ESO observatories and a crucial partner, has recently introduced a pioneering standard to safeguard its globally acclaimed dark skies. Developed in collaboration with ESO and other professional observatories, and with guidance from the Office for the Protection of the Sky Quality in Northern Chile (OPCC) and the Cielos de Chile Foundation, the new standard was established by the Chilean Ministry of the Environment. It focuses on controlling emissions from outdoor lighting and signs. The standard's primary objectives are to combat light pollution, preserve the exceptional quality of Chile's night skies, promote public health, and safeguard biodiversity.

The standard extends existing regulations enforced in the regions of Antofagasta, Atacama, and Coquimbo, where ESO's observatories are situated. Key measures include the adjustment of public lighting to prioritise amber-toned light and restrict blue light. Additionally, advertising and sports lighting will be subject to schedule controls to minimise disturbances for nearby residents. The regulation reinforces preventive measures for products or projects that deviate from these guidelines.

This significant step aligns with Chile's recent decree, issued by the Ministry of Science, Technology, Knowledge, and Innovation, delineating specially protected areas for astronomy in Antofagasta, Atacama, and Coquimbo. In collaboration with ESO and other observatories, Chile underscores its strong commitment to astronomy and recognises its pivotal role as a driver of societal development.

5. Beyond Earth Orbit: COSPAR's planetary protection policy

In recent years, the landscape of space exploration has undergone a transformative shift with the increasing privatisation and development of activities beyond Earth's orbit. This evolution includes, for instance, ventures into space resource exploitation, highlighting the essential need for standardised guidelines to mitigate the environmental impact of human activities on celestial bodies. The establishment and adherence to these standards are essential to ensuring the long-term sustainability of these new space activities.

When addressing these challenges, a crucial mechanism arises through the development of international policies by the Committee on Space Research (COSPAR). As a non-governmental organisation, COSPAR not only endeavours to foster scientific space research but also assumes a critical role in formulating scientific and technical standards aimed at preventing planetary contamination. In particular, through its planetary protection policy, COSPAR establishes a framework to mitigate the risk of contamination during space exploration and related activities. The policy is designed to safeguard celestial bodies from potential harm resulting from human endeavours, emphasising the importance of maintaining the pristine conditions of extraterrestrial environments. In doing so, COSPAR contributes significantly to the preservation of the scientific integrity of celestial bodies and the potential for future exploration.

In a nutshell, the organisation's planetary protection policy is divided into five distinct categories, determined by the combination of the target celestial body and mission type, as well as the level of concern regarding planetary contamination. The policy outlines planetary protection standards and reporting duties for space missions, with these requirements escalating as one progresses through the categories:[92]

- Category I applies to any mission to a target body that is not of direct interest in understanding the process of chemical evolution or the origin of life; it applies to

[92] COSPAR, *COSPAR Policy on Planetary Protection*, 211 Space Research Today 12 (2021).

"undifferentiated, metamorphosed asteroids". As such, there is no requirement for Category I missions.

- Category II includes all types of missions to target bodies that are of significant interest but where the potential for contamination compromising future research is remote. It applies inter alia to missions to Venus, the Moon, Jupiter, Saturn, Uranus, and Neptune as well as Callisto and comets. For these missions, space operators are required to submit "simple documentation" regarding their planetary protection plan, pre- and post-launch reports, a post-encounter report, and an end-of-mission report.

  Since 2021, Category II includes two new subcategories, IIa and IIb, specifically designed for activities on the lunar surface. In particular, the two subcategories draw a distinction between surface activities in the Moon's Permanently Shadowed Regions (PSRs) and at the lunar poles, as opposed to activities in other lunar areas. In addition to Category II documentation, COSPAR requires space operators to report an organic inventory, with the extent contingent upon whether the mission occurs within a protected area.

- Category III concerns flyby and orbiter missions to target bodies that present a significant interest regarding the process of chemical evolution or the origin of life, as well as an increased chance of contamination that would compromise future investigations. It applies inter alia to missions to Mars, Europa, and Enceladus. Category III requirements include Category II documentation and the implementation of procedures, including trajectory biassing, the use of cleanrooms, and possibly bioburden reduction.

- Category IV refers to missions involving direct contact with the target body, such as lander and probe missions. Category IV requirements include Category III documentation, and the implementation of additional procedures, such as the partial sterilisation of contacting hardware. It applies inter alia to lander missions to Mars, Europa, and Enceladus.

- Category V comprises all Earth-return missions and addresses issues of backward contamination. The policy distinguishes between unrestricted Earth return and restricted Earth return. Unrestricted Earth return concerns returning samples from celestial bodies with no indication of indigenous life forms, like the Moon; planetary protection requirements only apply to the outbound phase and correspond to that phase. All other Category V missions are defined as "restricted Earth return". For these missions, COSPAR requires, for instance, the containment of any sample and the sterilisation of all returned hardware that directly contacts the target body.

COSPAR's planetary protection policy, though implemented voluntarily, has garnered notable adoption by various space-faring nations and agencies. Since its establishment in 1958, these standards have continuously evolved and are now widely embraced by both public and private entities involved in space exploration. Notably, several space agencies, like NASA and ESA, link their support for planned missions with compliance to COSPAR's or equivalent planetary protection standards.

Hence, the non-binding nature of the instrument does not lessen the significance of COSPAR's planetary standards, as they wield tangible influence in practical applications. Moreover, COSPAR remains committed to ensuring the relevance of its policies by regularly revising them to align with current scientific knowledge. The recent update to the planetary protection policy in June 2021 underscores its status as a firmly established and dynamic framework capable of adapting to the changing dynamics of space activities. In this manner, COSPAR's planetary protection policy functions as a vital and adaptable framework for the responsible and sustainable exploration and utilisation of celestial bodies.

ANNEX II. SURVEY QUESTIONS

1. What is your role in SGAC?
2. In your opinion, what is the most pressing issue that the Intergenerational Pact for Space Sustainability should address?
    - Mega-constellation
    - Space debris
    - Space Traffic Management
    - Environmental protection in outer space
    - Cybersecurity
    - Dark & quiet skies
    - Space resources utilisation (space mining)
    - In-orbit servicing
    - Space situational awareness
    - Active Debris Removal
    - Life Cycle Assessment
    - Space debris mitigation measures
    - Other
3. What is one key measure you think should be implemented by the space community as a whole? (max. 350 characters)

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