

The Development and Implementation of International UN Guidelines For The Long-Term Sustainability of Outer Space Activities

Peter Martinez

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The Secure World Foundation strives to be a trusted and objective source of leadership and information on space security, sustainability, and the use of space for the benefit of Earth. We use a global and pragmatic lens to study and evaluate proposed solutions to improve the governance of outer space. While recognizing the complexities of the international political environment, SWF works to encourage and build relationships with all willing stakeholders in space activities, including government, commercial, military, civil society, and academic actors. Central to this approach is increasing knowledge about the space environment and the need to maintain its stability, promoting international cooperation and dialogue, and helping all space actors realize the benefits that space technologies and capabilities can provide.

About Dr. Peter Martinez

Peter Martinez is the Executive Director of the Secure World Foundation. He has extensive experience in multilateral space diplomacy, space policy formulation, and space regulation, as well as capacity building in space science, technology, and workforce development. Before joining the Secure World Foundation, he chaired the UN COPUOS Working Group on the Long-Term Sustainability of Outer Space Activities and the South African Council for Space Affairs.

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The development and implementation of international UN guidelines for the long-term sustainability of outer space activities

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Abstract

In recent years the world has witnessed a rapid increase in the number space actors and new satellites being launched into space. Coupled with the steady increase of orbital debris from the space activities of previous decades, this has given rise to concerns about the long-term sustainability of space activities. This paper describes the international process to develop the UN Guidelines for the Long-Term Sustainability of Outer Space Activities (usually referred to in abbreviated form as “the LTS Guidelines”). We present the general content of the guidelines and the first steps by the international community to implement these guidelines. To frame this discussion in the context of the present Special Issue focusing on space environment management and space sustainability, we present some suggestions on how COSPAR could support the implementation of the LTS Guidelines and further multilateral work on space sustainability.

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1. Introduction

The editorial decision to dedicate a Special Issue of *Advances in Space Research* to the topic of space environment management and space sustainability is both timely and an acknowledgement of the salience that this topic has gained within the broader space community during the past few years. In the non-space community, and particularly among political leaders and diplomats, the notion that outer space is a shared domain that must be managed and used sustainably, just like any other shared domain on Earth, has only really taken hold in the last 10 years or so.

Just as the scientific community started sounding the alarm about climate change for decades before the world’s political leaders took note, the same thing has happened with warnings about the impact of space activities on the

Earth’s orbital environment. Space experts have been warning since the 1970s of the dangers of unchecked debris proliferation and orbital congestion (e.g., [Kessler and Cour-Palais, 1978](#)), but the issue only began to surface in the international diplomatic fora in the 2000s, and even then, it took several years of hard work to raise the salience of the issue among diplomats to make it a point on the multilateral agenda of space diplomacy.

The preeminent international diplomatic forum for discussions of such questions is the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS). This is a standing committee of the United Nations that was established in 1959 and it is the leading international forum for the progressive development and codification of space law and norms of behavior in outer space. Since its establishment, UN COPUOS has negotiated five legally binding international treaties on space activities and many other principles, resolutions and guidelines that do not have the binding weight of treaties, but which many States implement as responsible practices.

¹ Chair, UN COPUOS Working Group on the Long-Term Sustainability of Outer Space Activities, 2010-2018.

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Recognizing the immense potential of space technology for socioeconomic development, the United Nations organized three global Conferences on the Exploration and Peaceful Uses of Outer Space - the so-called UNISPACE conferences - to promote cooperation among States and international organizations in the peaceful uses of outer space. UNISPACE I, held in 1968, focused on raising awareness of the vast potential of space benefits for all humankind. UNISPACE II, held in 1982, focused on strengthening the United Nations' commitment to promoting international cooperation to enable developing countries to benefit from the peaceful uses of space technology. UNISPACE III, held in 1999, built on the theme of using space to support human development, security, and welfare. In the *Vienna Declaration on Space and Human Development* (United Nations, 1999), which presented the outcomes of UNISPACE III, there was one paragraph devoted to action to be taken for preserving the space environment.

During the years following UNISPACE III, elements of what we now consider to be part of the broader topic of space sustainability (such as space debris, exchange of information on space objects, development of space law and regulatory capacity) were included in the agenda of UN COPUOS, but they were treated in isolation and not in the wider context of what we now broadly refer to as space sustainability.

The first efforts to raise attention to this issue in UN COPUOS began in the mid-2000s as part of reflections on the accomplishments of this UN Committee during its first 50 years and looking ahead to the next 50 years. Indeed, the term "space sustainability" was not in common use in the mid 2000s and it only emerged in the general lexicon of the space community sometime later. At that time, the development of the commercial sector was starting to accelerate, but most delegations to UN COPUOS did not foresee the advent of extremely large constellations of satellites that we have witnessed in the past few years.

The late 2000s witnessed an acceleration in the number and diversity of space actors. This was fueled by a lowering of the technological and financial barriers to space activity through the advent of cubesat technology and the ready availability of commercial off-the-shelf components. This lowering of financial barriers not only allowed more non-State entities to become space actors, but it also brought space within the realm of activities funded by venture capital, which led to an accelerating cycle of investment and private sector development in the space sector that has continued to this day, unabated by the COVID-19 pandemic (Space Capital, 2022).

The main driver for space sustainability discussions in UN COPUOS was the growing proliferation of space debris

and fears that debris-producing events such as the 2009 Cosmos-Iridium collision might become more common in the future as more countries became active participants in space activities.² The idea to put the topic of space sustainability on the agenda of COPUOS was first raised during the French presidency of COPUOS by the Chair, Gérard Brachet, and the French delegation did much to socialize the topic among COPUOS member States in the years that followed. It took several years of dedicated efforts on the part of the French delegation and several other like-minded delegations to socialize the issue of space sustainability in the United Nations to the point where it was accepted as a global problem that needed collective action by all countries. A more in-depth description of the early socialization phase of the LTS discussions has been presented by Brachet (2012).

The initial efforts to get this issue on the agenda of COPUOS met with limited success. There were several reasons for this, which partly had to do with the way the issue was framed.

Some countries did not see space debris as their problem to worry about, and therefore did not see it as an issue for discussion in the multilateral format. Other countries viewed the environmental concerns as a convenient pretext for the advanced space nations to preserve their leading positions by raising the barriers to entry to the "Space Club" at just the time when the technology was becoming widely accessible and affordable to developing nations with space aspirations.

As the person who was at the heart of an eight-year-long process in the United Nations, leading international negotiations on a set of international guidelines for the long-term sustainability of outer space activities (generally referred to as 'the LTS Guidelines'), I witnessed the change in perceptions and attitudes to the importance of this issue. That there is now a much better understanding of the serious nature of this issue is evidenced by the inclusion of space governance as one of the pillars of the recently published report of the UN Secretary General titled *Our Common Agenda* (United Nations, 2021) that addresses some of the key challenges facing the world today.

I started this Introduction with an analogy to climate change, and I want to close by referring to that analogy again. Just as we expect that every responsible citizen on Earth should be aware of the global climate crisis and to make deliberate choices in their daily lives to support collective climate action, so too should every member of the space community be aware of our impact on the space environment and the actions that we can take individually and collectively to preserve this fragile and limited natural resource for the benefit of all nations and for future generations.

In this regard, the widest cross section of the space community should be aware of the space sustainability guidelines that have been adopted by the United Nations at the highest level to preserve the outer space environment. Let me be clear - these guidelines are *minimum standards* for

² At the same time, there were also growing concerns that some countries might develop and carry out tests of antisatellite weapons, generating yet more debris. However, this issue was tied to disarmament discussions, which fall outside the scope of UN COPUOS.

the responsible conduct of space activities, but if all countries and all space actors implement them, that will not only help to address the challenges of space sustainability, but also change the way we go about thinking about, planning, authorizing and conducting space activities, during all phases of a mission cycle.

This paper is structured as follows. [Section 2](#) describes the process of the development of the UN guidelines for space sustainability. [Section 3](#) presents an overview of the guidelines. [Section 4](#) discusses some implementation questions and early implementation experiences, and [Section 5](#) presents some concluding remarks. Throughout, I will make references to the role of COSPAR during the development of these guidelines and their implementation going forward.

2. The UN COPUOS process to develop the UN guidelines for space sustainability

Following several years of effort to socialize this issue in the UN, in 2010 UN COPUOS established the Working Group on the Long-term Sustainability of Outer Space Activities ('LTS Working Group'). The Working Group was tasked to produce a report on the long-term sustainability of outer space activities and a consolidated set of voluntary best-practice guidelines that could be applied by States, international organizations, national non-governmental organizations and private sector entities to enhance the long-term sustainability of outer space activities for all space actors and throughout all the phases of a mission life cycle. These guidelines were to be based on established practices, operating procedures, technical standards and policies.

The Working Group took as its legal framework the existing United Nations treaties and principles governing the activities of States in the exploration and use of outer space; it was specifically mandated *not* to consider the development of new legally binding instruments. The guidelines were to be consistent with existing international legal frameworks for outer space activities and were to be voluntary and not be legally binding.

2.1. Consideration of topics

The Working Group began its work by identifying a set of topics that delegations agreed to be of relevance to the overall considerations of space sustainability. These topics ranged from issues such as space debris, space situational awareness and space weather, to broader operational and regulatory issues. The topics thus identified were then clustered to allow for more efficient consideration of related matters and four expert groups were established to consider these related sets of topics in parallel. These expert groups were populated with experts nominated by their national governments. The experts (several of whom were COSPAR Associates) served in a personal capacity and did not necessarily represent their governments' positions

on the matters under discussion. The expert groups were tasked to write a report on their topics of consideration and to propose candidate draft guidelines for consideration by the Working Group. The Working Group was to consider the inputs from the expert groups and take any necessary decisions. In this way, a clear separation was established between the expert groups as technical deliberative fora and the Working Group as a diplomatic negotiating forum within COPUOS.

The four expert groups and the scope of their deliberations were as follows:

Expert Group A: Sustainable space utilization supporting sustainable development on Earth

Co-chaired by Filipe Duarte Santos (Portugal) and Enrique Pacheco Cabrera (Mexico).

This expert group addressed the societal benefits of space activities and their contribution to sustainable development on Earth. This expert group also considered the role of international cooperation in ensuring that outer space continues to be used for peaceful purposes for the benefit of all nations. This expert group proposed seven candidate guidelines and four topics for further consideration by the Working Group. ([United Nations, 2014a](#)).

Expert Group B: Space debris, space operations and tools to support collaborative space situational awareness

Co-chaired by Richard Buenneke (United States of America) and Claudio Portelli (Italy).

This expert group considered many of the issues that are foundational to ensuring safe, predictable, and sustainable conditions for space operations. This included an analysis of risks from space debris and measures to reduce the creation and proliferation of space debris, and measures to strengthen cooperative space situational awareness, such as developing common standards and practices for information exchange. This expert group proposed eight candidate guidelines and three topics for further consideration by the Working Group. ([United Nations, 2014b](#)).

Expert Group C: Space weather

Co-chaired by Takahiro Obara (Japan) and Ian Mann (Canada).

This expert group focused on measures to reduce the risks of disruption of operational space systems from space weather phenomena through enhanced sharing of key data related to space weather conditions in real or near-real time, as well as sharing of models and forecasts. This expert group proposed five candidate guidelines and two topics for further consideration by the Working Group. ([United Nations, 2014c](#)).

Expert Group D: Regulatory regimes and guidance for actors

Co-chaired by Anthony Wicht (Australia) and Sergio Marchisio (Italy).

This expert group considered the role of international and national legal instruments and regulatory practices to promote the long-term sustainability of outer space activities. This included guidance on the development of national regulatory frameworks for the authorization and ongoing supervision of space activities. This expert group proposed eleven candidate guidelines and five topics for further consideration by the Working Group. (United Nations, 2014d).

In formulating their recommendations for candidate guidelines, the expert groups were tasked to identify issues for which sufficient international expert consensus could be found to recommend guidelines based on established best practices. Where the experts identified issues pertinent to the long-term sustainability of outer space activities, but for which they could not recommend consensus guidelines based on operational experience, those issues were referred to the Working Group for its attention and possible future consideration.³ The four expert groups concluded their work in 2014 and submitted their reports to the Working Group, containing a total of 31 proposed draft guidelines and a list of fourteen topics for future consideration. (United Nations, 2014a, 2014b, 2014c, 2014d).

2.2. Coordination with other entities and processes

The Working Group coordinated with a number of other entities and processes, both inside and outside the UN system, to enrich its deliberations. At the inter-governmental level, the Working Group liaised with the UN Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities, the Conference on Disarmament, the Commission on Sustainable Development, the International Civil Aviation Organization (ICAO), the International Telecommunication Union (ITU) and the World Meteorological Organization (WMO), as well as relevant intergovernmental organizations, such as the European Space Agency (ESA), the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), the Asia-Pacific Space Cooperation Organization (APSCO) and the Group on Earth Observations (GEO).

At the non-governmental level, the Working Group solicited and obtained inputs from a number of international organizations and bodies, such as the Committee on Space Research (COSPAR), the Consultative Committee for Space Data Systems (CCSDS), the Inter-Agency Space Debris Coordination Committee (IADC), the International Space Environment Service (ISES), the International

Organization for Standardization (ISO), the International Academy of Astronautics (IAA), and the International Astronautical Federation (IAF). Several other academic and civil society organizations also provided inputs into the work of the Working Group and its expert groups.

2.3. Negotiation of the LTS guidelines

Following the conclusion of expert group deliberations, the Working Group began developing the draft guidelines based on the recommendations contained in the reports of the four expert groups. Several member States also proposed draft guidelines for consideration by the Working Group. Not surprisingly, there was some overlap in all the candidate guidelines that needed to be harmonized. By the start of 2016, through a process of consolidation and streamlining, the Working Group had narrowed its focus to 29 draft guidelines, which were at various stages of maturity in terms of the negotiation process.

At this point, readers who are not familiar with the workings of multilateral fora may be wondering why it takes so long to make progress on pressing issues. There are several points worth emphasizing here.

Firstly, in multilateral diplomacy, processes often move at the pace of the slowest participants. It is very important to socialize an issue thoroughly before beginning negotiations and to understand that some countries need more time than others to get up to speed on an issue to form a considered national position. Experience has shown that attempts to short-cut this diplomatic gestational stage by opening discussions with highly developed documents runs the risk of raising questions about motives and losing the participation and support of some delegations from the outset. (Martinez, 2021).

Secondly, readers not familiar with how negotiations are conducted in UN COPUOS may find it instructive to know that COPUOS reaches decisions only by absolute (meaning 100%) consensus of *all* its member States. *This means that any draft text put before member States for adoption must be acceptable to all COPUOS members, in all six official languages of the UN, all which are equally authentic, as there is no "ruling" version of the text.* Unlike the way decisions are taken in other UN bodies, like the General Assembly, there is no voting. This means that States continue to discuss an issue until either they reach agreement on a formulation that is acceptable to all, or they agree to remove the contentious issue from the text.

Thirdly, as an issue gains international prominence, more countries become diplomatically invested in it because they have a stake in the outcome of the negotiations and want to ensure that their interests are protected. This was evident in how the nature of the LTS negotiations and their political prominence in COPUOS evolved during the negotiation process from 2016 to 2019. At the beginning of the LTS work in 2010, the membership of COPUOS stood at 70 States. By the end of the process in 2018, the membership of COPUOS had grown to 92 States

³ This is the reason why there are no guidelines on close-proximity operations in orbit, or very large satellite constellations. At the time these issues were discussed, there were no established practices that could be recommended as guidelines.

and many more States were actively engaged in the LTS discussions. Given the consensus decision-making rule in COPUOS, progress in the discussion of the guidelines was slow and uneven, but by June 2016 COPUOS reached agreement on the first 12 guidelines (Martinez, 2018). Perhaps it should come as no surprise that these first guidelines to be agreed were based on the inputs of the technical experts. The remaining guidelines were more political in nature and the negotiations were correspondingly more complex. In February 2018, agreement was reached on a further 9 guidelines and the text of a politically significant context-setting preamble that included the following definition of space sustainability:

*The long-term sustainability of outer space activities is defined as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations.*⁴

In June 2019, COPUOS adopted the preamble and 21 guidelines for the long-term sustainability of outer space activities and encouraged all States and international inter-governmental organizations to voluntarily take measures to ensure that the guidelines were implemented to the greatest extent feasible and practicable. Fig. 1 shows the adoption copy of the LTS Guidelines, signed by many of the delegates who negotiated these guidelines over a period of eight years.

3. The guidelines

The twenty-one LTS Guidelines (United Nations, 2019a) comprise a collection of internationally recognized measures for ensuring the long-term sustainability of outer space activities and for enhancing the safety of space operations. They address the policy, regulatory, operational, safety, scientific, technical, international cooperation and capacity-building aspects of space activities. The guidelines are intended to support States in the development of their national space capabilities in a manner that avoids causing harm to the outer space environment and the safety of space operations while allowing for flexibility to accommodate specific national circumstances. The guidelines are relevant to both governmental and non-governmental entities, to all space activities, and to all phases of a space

⁴ Readers familiar with the “Brundtland report” titled *Our Common Future* by the World Commission on Environment and Development (1987) will notice a parallel between the definition of sustainable development on Earth given in that report as ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’ and the UN COPUOS definition of space sustainability quoted above.

mission, including launch, operation and end-of-life disposal.

The existing United Nations treaties and principles on outer space provide the fundamental international legal framework for these guidelines. The guidelines themselves are voluntary and not legally binding under international law. However, *non-binding* does not mean *non-legal* in the sense that States may choose to incorporate elements of the guidelines in their national legislation, thus giving them a legal character within the relevant jurisdiction. An example of this is the way that several States incorporate international best-practice guidance for debris mitigation in their national regulatory regimes for licensing and supervising the space activities of entities under their jurisdiction and/or control.

The number of pages available for this article does not permit us to reproduce the text of the LTS Guidelines in extenso here, so we will simply discuss their structure and salient features. Each of the 21 LTS Guidelines takes the form of a short action-oriented title text that summarizes the main intent of a given guideline, followed by several paragraphs of more detailed recommendatory text to support the implementation of the guideline. Table 1 contains the titles of the guidelines. The full text of the guidelines is available in UN document A/74/20, Annex II.⁵ (United Nations, 2019a).

The guidelines are grouped into four categories: (A) Policy and regulatory; (B) Safety of space operations; (C) International cooperation and capacity-building; and (D) Scientific and technical aspects. Below, we summarize the main contents of each of these sections:

- Category A, *Policy and regulatory framework for space activities*

This group of guidelines addresses national regulatory frameworks for space activities and the elements that States should consider when establishing or revising such regulatory frameworks. The guidelines emphasize the importance of States establishing and maintaining the necessary competencies to carry out their treaty obligations to authorize and supervise their national space activities. The guidelines encourage entities carrying out space activities be mindful of the importance of space sustainability and that this should be reflected in the governance, organizational, technical and operational aspects of their space activities. This includes due regard for issues such as rational and equitable use of orbit and spectrum resources and the implementation of post-mission disposal to avoid the long-term presence of non-functional spacecraft in protected orbi-

⁵ In addition to the 21 agreed guidelines, there were another seven draft guidelines that were discussed by the Working Group, but for which it did not reach consensus before the expiry of its mandate (United Nations, 2019b). The progress made in discussions of those draft guidelines will inform the future discussions of space sustainability in COPUOS referred to in Section 5 of this paper.

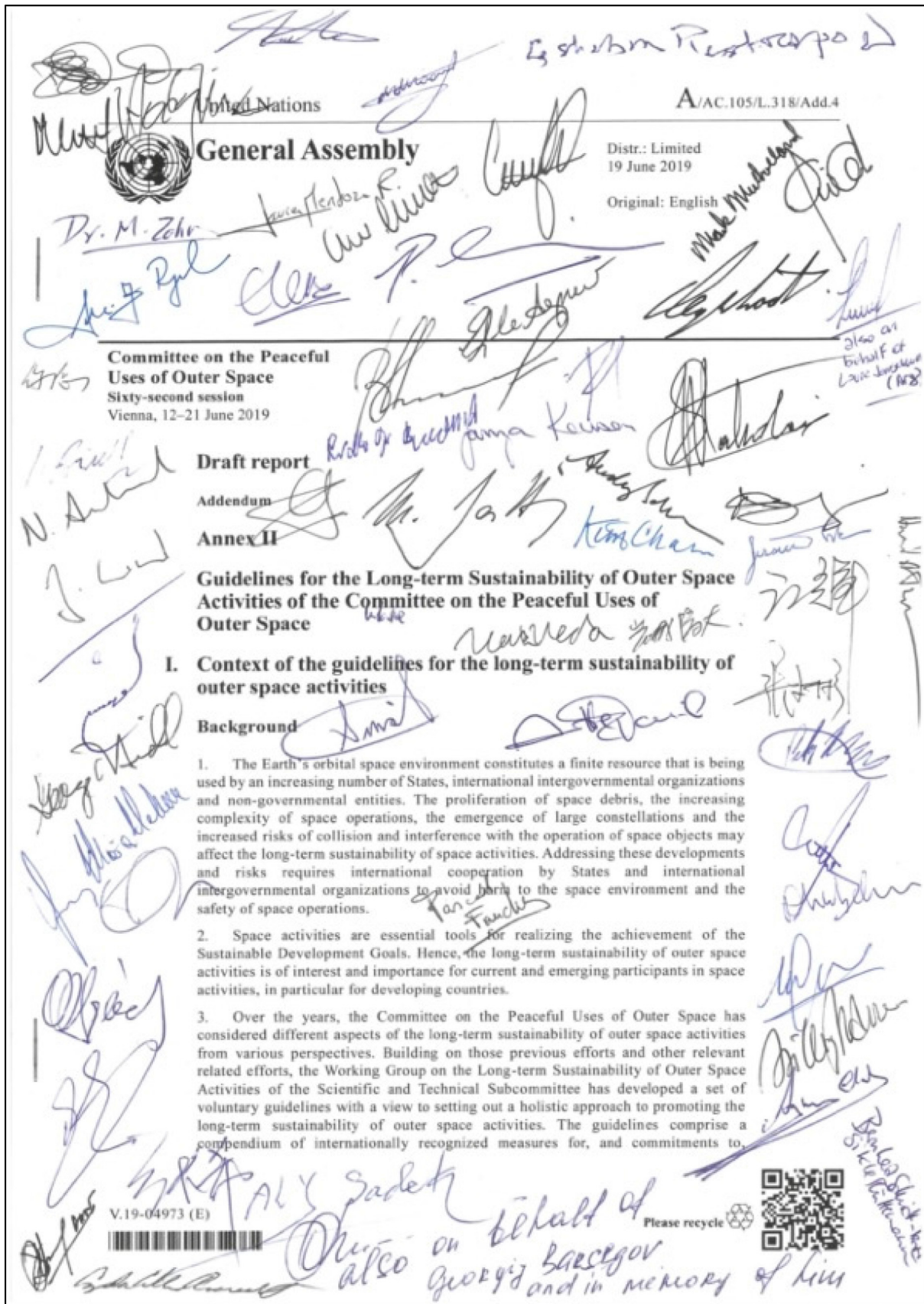


Fig. 1. Adoption copy of the LTS Guidelines, signed by many of the negotiators of these guidelines following their adoption by UN COPUOS on the 20th of June 2019. (Photo: P. Martinez).

Table 1

UN COPUOS Guidelines for the Long-Term Sustainability of Outer Space Activities. The full text of the guidelines appears in Annex II of UN document A/74/20. (United Nations, 2019a).

<i>A. Policy and regulatory framework for space activities</i>	
Guideline A.1	Adopt, revise and amend, as necessary, national regulatory frameworks for outer space activities
Guideline A.2	Consider a number of elements when developing, revising or amending, as necessary, national regulatory frameworks for outer space activities
Guideline A.3	Supervise national space activities
Guideline A.4	Ensure the equitable, rational and efficient use of the radio frequency spectrum and the various orbital regions used by satellites
Guideline A.5	Enhance the practice of registering space objects
<i>B. Safety of space operations</i>	
Guideline B.1	Provide updated contact information and share information on space objects and orbital events
Guideline B.2	Improve accuracy of orbital data on space objects and enhance the practice and utility of sharing orbital information on space objects
Guideline B.3	Promote the collection, sharing and dissemination of space debris monitoring information
Guideline B.4	Perform conjunction assessment during all orbital phases of controlled flight
Guideline B.5	Develop practical approaches for pre-launch conjunction assessment
Guideline B.6	Share operational space weather data and forecasts
Guideline B.7	Develop space weather models and tools and collect established practices on the mitigation of space weather effects
Guideline B.8	Design and operation of space objects regardless of their physical and operational characteristics
Guideline B.9	Take measures to address risks associated with the uncontrolled re-entry of space objects
Guideline B.10	Observe measures of precaution when using sources of laser beams passing through outer space
<i>C. International cooperation, capacity-building and awareness</i>	
Guideline C.1	Promote and facilitate international cooperation in support of the long-term sustainability of outer space activities
Guideline C.2	Share experience related to the long-term sustainability of outer space activities and develop new procedures, as appropriate, for information exchange
Guideline C.3	Promote and support capacity-building
Guideline C.4	Raise awareness of space activities
<i>D. Scientific and technical research and development</i>	
Guideline D.1	Promote and support research into and the development of ways to support sustainable exploration and use of outer space
Guideline D.2	Investigate and consider new measures to manage the space debris population in the long term

tal regions. The guidelines in this category emphasize the importance of establishing and maintaining robust national registration practices for space objects as one of the means of supporting the safety of space operations. States are encouraged to collect and provide information on any change of status in operations of their national space objects (e.g., release of sub-satellites, or when a space object is no longer functional, following changes in the orbital position, or changes in jurisdiction resulting from transfers of ownership).

- **Category B, *Safety of space operations***

This category contains most of the guidelines and addresses issues affecting the safety of space operations. A golden thread running through all these guidelines is the timely sharing of information on space objects and events. This includes exchanging up-to-date contact information for the operators of space objects and the establishment of mechanisms to enable timely coordination to reduce the risk of collisions and to facilitate effective responses to orbital events that might increase the risks to spaceflight safety in orbit or the risks from uncontrolled re-entries of space objects to people, property or the environment on the ground. These guidelines address the practical issues relating to the exchange of relevant information on space objects and events in near-Earth space and the importance of harmonized and standardized record-keeping on space objects and events. The guidelines recognize that space-

flight safety depends strongly upon the accuracy of orbital and other relevant data on both functional space objects and orbital debris, and encourage States to investigate and promote methods to improve the accuracy of such data. The guidelines also address the importance of conducting pre-launch conjunction assessments as well as conjunction assessments during all phases of controlled orbital flight. The guidelines also address measures to enhance the trackability of satellites, regardless of their size or operational status, and the importance of measures to limit the long-term presence of space objects in protected regions of near-Earth space after the end of their mission. A couple of guidelines in this category address measures to enhance the resilience of space systems against disruption due to space weather effects and recommend the sharing of operational space weather data, models, and forecasts. There is also a guideline that recommends measures to address risks associated with the uncontrolled re-entry of space objects and another that recommends following measures of precaution when using laser beams in space.

- **Category C, *International cooperation, capacity-building and awareness***

This category contains several guidelines that address how international cooperation, information sharing, and capacity-building can be used to support emerging space nations to develop their space capabilities in a

manner that supports the long-term sustainability of outer space activities.

- **Category D, *Scientific and technical research and development***

This category contains guidelines that address the importance of carrying out research on the evolution of space debris and how to manage the space debris population in the long term, as well as developing new technologies and operational measures to promote the sustainable exploration and use of outer space.

In adopting these guidelines COPUOS envisaged that it would periodically review and possibly revise or add to these guidelines to ensure that they continue to provide effective guidance to States on how to promote the long-term sustainability of outer space activities.

4. Implementation

States and international intergovernmental organizations are encouraged to implement the LTS Guidelines to the greatest extent feasible and practicable, in accordance with their respective needs, conditions and capabilities, and with their existing obligations under applicable international law.

The first step toward guideline implementation by States is for national governments to promote awareness of the guidelines in their domestic space community and to express their commitment to the implementation of the guidelines through national regulatory frameworks and processes for the authorization and ongoing supervision of space activities under their jurisdiction and/or control.

There are a number of challenges that States will confront when implementing these guidelines. The first is that the scope of the guidelines is very broad, as they address policy, regulatory, operational, scientific and technical aspects of space activities. The exact form of implementation is not prescribed, leaving it up to each country to determine its own modalities for implementation. This is intentional, to allow for the very different levels of space activities in different countries and the different ways in which space activities are organized, conducted and governed in different States.

This inherent flexibility to allow for implementation in different national contexts can also lead to uncertainty or inconsistency in implementation. For this reason, it is important to “unpack” what guideline implementation means in different contexts. It has been suggested that some sort of guidebook for implementation that captures a variety of implementation practices would be a helpful reference for States. In this regard, COSPAR could play a valuable role in discussions on the practical implications of guideline implementation in different contexts.

International cooperation is required to implement the guidelines comprehensively and to monitor their impact and effectiveness. However, UN COPUOS recognizes that not all space actors have equal capability or capacity to

implement these guidelines. Therefore, the guidelines place strong emphasis on international cooperation, information sharing and capacity-building. States and international intergovernmental organizations with extensive experience in conducting space activities are encouraged to support developing countries to strengthen their national capacities to implement the guidelines. Working with its network of partners in the international space community, COSPAR could act as a convener of capacity-building events. As an Observer in UN COPUOS, COSPAR could also contribute to expert analyses of the impact of the increasing congestion in the Earth’s orbital environment and participate in broader discussions on the management of orbital capacity and space traffic.

Effective guideline implementation will require greater coordination and cooperation among regulators in different States. This is to avoid regulatory gaps and fragmented or inconsistent regulation that leads to “regulation shopping” and chain-of-custody issues where space activities are conducted across multiple jurisdictions. These are not hypothetical concerns. Two well-documented examples of such chain-of-custody issues that raise concerns for space sustainability have already occurred. The first was the unauthorized launch of multiple unlicensed and untrackable small satellites by Swarm Technologies Inc in January 2018 in defiance of a ruling by the Federal Communications Commission, for which the company was subsequently fined \$900,000. (Shepardson, 2018) Another example was the undocumented (and, more importantly, unauthorized) introduction of microscopic tardigrades onto the Beresheet lunar mission, which subsequently crashed on the lunar surface in April 2019. (Johnson, et al., 2019).

Developing countries and emerging space nations may face general LTS Guideline implementation challenges in the sense that they may not have sufficient capacity in government or sufficient experience in the regulation of space activities to support effective guideline implementation. There may also be a general lack of awareness among policy makers of space sustainability issues in general and the LTS Guidelines in particular. COSPAR is well placed to address these challenges by working through its national adhering bodies in different countries to promote awareness and implementation of the LTS Guidelines at a national level.

At the international level, States could share their guideline implementation experiences to socialize the wider implementation of the guidelines in the international space community. Some delegations to UN COPUOS have already started to report their guideline implementation actions and experiences during the sessions of the Committee. These actions include the development or revision of relevant domestic legislation, enhanced practices for the registration of space objects, the implementation of new national space policy directives, and enhancing national capabilities in space situational awareness and debris monitoring.

Although the guidelines are contained in a UN document that is directed at States, they will only achieve the desired effect if they are implemented by *all* space actors, not just governmental space actors. This is especially important since private sector space actors now greatly outnumber the governmental actors, and this situation will only become more and more pronounced with each passing year.

Several private sector actors are already taking steps to demonstrate and promote responsible behaviours in outer space through the manner in which they plan and conduct their own space operations. Industry associations, such as the Space Data Association and the Space Safety Coalition, are also playing a role to promote implementation of the LTS Guidelines and responsible behaviours by their members. Other industry-led initiatives, such as the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), are developing technical and operational standards for commercial on-orbit servicing, rendezvous and proximity operations. The development of such standards could pave the way for UN COPUOS to discuss and adopt best-practice international guidelines on these topics in the future.

5. Conclusion

In this paper we have described how the steady rise in the number of space actors and active satellites and space debris has given rise to concerns about the long-term sustainability of space activities. We have described the deliberations on this topic in the United Nations system and the resulting set of UN guidelines for space sustainability, which States are now beginning to implement in their national regulatory frameworks for space activities. We will end this paper with a few reflections on the ways that the multilateral system can continue to enhance global efforts to ensure space sustainability, and some possible roles for COSPAR to support these efforts.

Firstly, with regard to the already adopted LTS Guidelines, we have made several references in Section 4 on ways that COSPAR might be able to support capacity building for wider implementation of these guidelines. Secondly, COSPAR could also respond to those guidelines that call for more research on specific topics. One category of the guidelines points to the need to promote and support research into and the development of ways to enhance the sustainable exploration and use of outer space. This includes investigation of measures to manage the space debris population in the long term. COSPAR could bring to bear the considerable international expertise contained within its relevant Panels and Commissions to address aspects of these issues. Experience has shown that a bottom-up, technically based approach that builds on the collective expertise of space scientists and engineers is a good foundation for the development of internationally accepted norms, best practices and standards for managing the space environment.

The space sustainability discussions in COPUOS did not end with the adoption of the 21 guidelines in 2019. Indeed, part of the adoption decision was agreement among member States to establish a new LTS 2.0 process with a five-year mandate. This new Working Group is getting under way and envisages that it will incorporate inputs from international organizations. As a permanent Observer member of COPUOS, COSPAR would be well placed to contribute to the work of this new LTS 2.0 Working Group in COPUOS. This includes work on the implementation of the 21 already agreed guidelines, as well as discussions of possible new guidelines for the future. Examples of topics for discussion could include close-proximity operations or questions of orbital carrying capacity raised by the deployment of extremely large satellite constellations.

The UN Secretary General's report titled *Our Common Agenda* (United Nations, 2021), calls for a stronger, more networked and inclusive multilateral system, anchored within the United Nations to address global challenges relating to the management of the various global commons, and specifically lists the governance of outer space activities as an area requiring urgent attention and strengthening through multi-stakeholder dialogues. The report calls for the development of a global regime to coordinate space traffic and the elaboration of new instruments to prevent the weaponization of outer space. The report proposes that States convene a multi-stakeholder dialogue on outer space as part of a Summit of the Future that would bring together governments and other leading space actors to seek a high-level political agreement on the cooperative governance of outer space activities in support of the peaceful, secure and sustainable uses of outer space. It is expected that preparatory discussions for this Summit will be convened under the aegis of UN COPUOS and as an Observer member of this UN Committee, COSPAR would be well placed to participate in such preparatory deliberations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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