AWARENESS-RAISING AND CAPACITY-BUILDING RELATED TO THE IMPLEMENTATION OF THE GUIDELINES FOR THE LONG-TERM SUSTAINABLITY OF OUTER SPACE ACTIVITIES (LTS GUIDELINES)

Event 4 – Section D, Scientific and Technical Research and Development

26 June 2023

Summary Report

About the Project

The Awareness-raising and Capacity-building Related to the Implementation of the LTS Guidelines Project is delivered in the context of the 2019 adoption of the Guidelines for the Long-term Sustainability Outer Space Activities (LTS Guidelines) by the Committee on the Peaceful Uses of Outer Space (COPUOS).

Building upon the success of the multi-stakeholder event series organized in 2021, and the stakeholder study report published in 2022, the third phase of the project once again convenes key players through a new virtual event series. Each event is linked with one section of the LTS Guidelines (A-D), engaging diverse experts in the space field in targeted discussions.

Event #4 – Scientific and Technical Research and Development

To access the recording of the event, please click here.

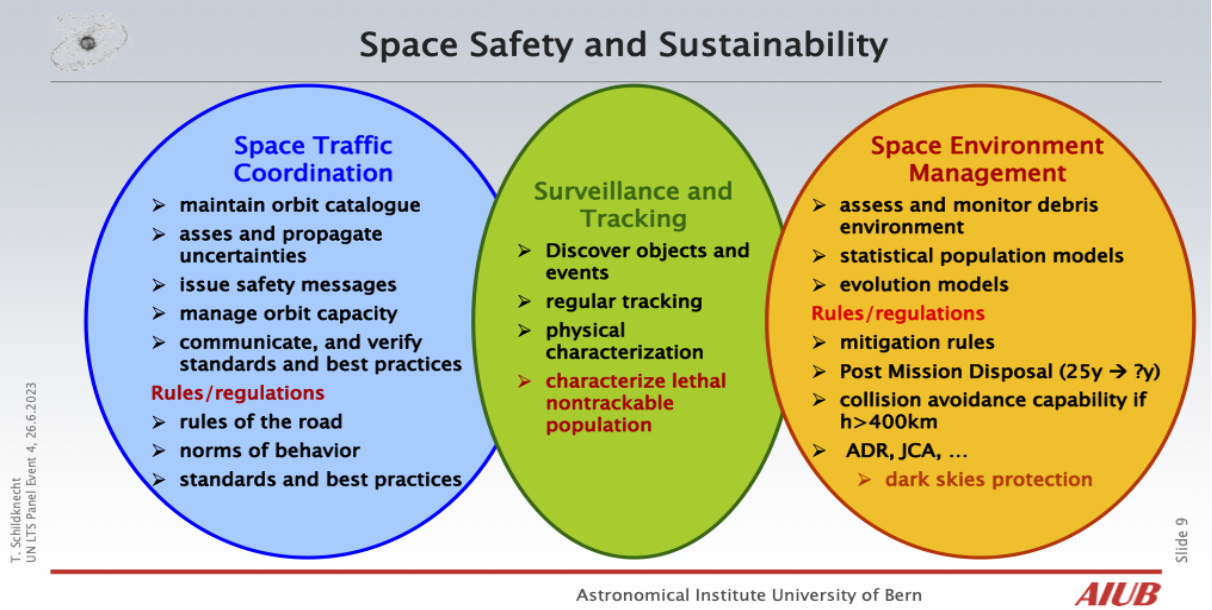
Panelists:

- Moderator: **Thomas Schildknecht,** Vice-Director, Astronomical Institute – Bern University
- **Aquib Moin,** Senior Affiliated Scientist & Associate Professor – National Space Science and Technology Centre, United Arab Emirates University
- **Jer Chyi Liou**, Chief Scientist for Orbital Debris – NASA
- **Maria-Paz Zorzano**, Planetary Physicist, Senior Research Scientist at the Center for Astrobiology – National Institute of Aerospace Technology, Spain.
- **Mila Francisco Ferrada**, Counsellor and Alternate Representative of Chile to the United Nations Office in Vienna
- **A K Anil Kumar**, Associate Director – Telemetry Tracking and Command Network (ISTRAC) of the Indian Space Research Organization (ISRO)

Summary

The moderator, **Thomas Schildknecht,** started his intervention by introducing some of the challenges to the long-term sustainability of outer space activities. He, for instance, addressed the growing number of non-functional space objects – from the size of a mm to 10 cm –found on the Earth's trajectories, underlining how space debris poses a great challenge for the scientific and technical community both in terms of its prevention and remediation. Another challenge Mr. Schildknecht emphasized was the increasing number of satellites launched into constellations and placed in the orbital space environment. He further indicated how regular tracking of space debris, characterization of the non-trackable space object

population, efficient coordination of growing space traffic, and the introduction of re-mediation techniques (such as active debris removal) may all be needed to keep the orbital space environment safe and sustainable, and for which scientific and technical research and development (R&D) are necessary.



Excerpt from Mr. Schildknecht's presentation

Mr. Schildknecht also emphasized the issue of dark and quiet skies, stating that light pollution and radio noise caused by satellite constellations may deprive people from enjoying the pristine night sky, and may cut astronomers from accessing knowledge about the universe. In addition, the need to protect the Moon and other celestial bodies was also mentioned by Mr. Schildknecht.

After his first remarks, the moderator gave the floor to each speaker to make observations on the subject.

The first speaker of the event, **Jer Chyi Liou,** emphasized the rapidly growing number of orbital debris objects placed in the near-Earth space environment. The NASA scientist shared that the largest (10 cm and more) space objects are tracked by the Space Surveillance Network of the United States Space Force. Due to the high impact speed in space, however, even sub-millimeter non-trackable debris objects pose a realistic threat to human spaceflight and robotic missions. Thus, orbital debris mitigation has been included in every National Space Policy of the United States since 1988. Additionally, Mr. Liou highlighted that NASA is a founding member of the Inter-Agency Space Debris Coordination Committee (IADC) and has contributed to the development of the IADC Guidelines. NASA's key efforts in scientific and technical R&D on space debris include monitoring the ever-changing orbital debris environment with radar, optical and in-situ measurements, and developing orbital debris modeling tools for mission support and orbital environment management [**LTS Guideline D.2**]. Furthermore, NASA continues to share orbital debris research results with the international community in multiple fora.

The second speaker, **Mila Francisco Ferrada** concentrated her remarks on the protection of the dark and quiet skies. Ms. Francisco highlighted that the increasing proliferation of satellites, especially those launched in large constellations, may lead to unsustainable use of the orbital space environment. Furthermore, the constant increase of satellites in low-Earth orbit severely compromises ground-based astronomical observations – both optical and radio – with multiple negative impacts on science, space knowledge, industry, tourism and other relevant areas. Moreover, Ms. Francisco argued that the issue of dark and quiet skies is especially critical for Chile, as the country is one of the most important destinations for astronomy due to its beneficial conditions for astronomical research. These include, for instance, providing an average of 330 cloudless and clear nights, a counting for over 40% of the world's astronomical observation, and being home for some of the largest and most advanced telescopes in the world.

Ms. Francisco continued her presentation by underlining Guideline D1 paragraph 1 and Guideline D1paragraph 3 of Section D of the LTS Guidelines in connection to dark and quiet skies. Accordingly, **paragraph 1 of Guideline D.1** calls the attention to promoting and supporting research and development of sustainable space technologies, while **paragraph 3 of Guideline D.1** advocates for development of technologies that minimize the environmental impact of manufacturing and launching space assets. Ms. Francisco emphasized that the two above paragraphs under Guideline D.1 are especially relevant to the topic of dark and quiet skies since they are trying to achieve the protection of the skies while still receiving the benefits from satellite activities. Chile sees that raising awareness on the issue is of primary importance, [**Guideline C.4**] and that the research community has a pivotal role in communicating about the issue in a comprehensible manner. Consequently, Ms. Francisco highlighted the role of the astronomy community in gathering evidence about the negative effects of large constellations in astronomy, and also their crucial role urging the international community about the need to take mitigating steps in response to the growing issue in various fora. Chile has also developed national norms and regulations, for example in the establishment and enforcement of quiet and dark surroundings of the observatories, or about the diminishment of light pollution in order to tackle the problem. However, Ms. Francisco underlined the international characteristic of the issue and the need to have a deeper understanding of the impact of large constellations in the relevant global forum, namely at COPUOS. Ms. Francisco also suggested that not only States, in various development stages, and observer organizations should be included in the constructive dialogues, but also scientists and satellite operators in order to bring all different interests together and to identify effective solutions to the growing global challenges [**Guideline C.1**].

Next, **Maria-Paz Zorzano** introduced the notion of planetary protection in her introductory remarks. She linked this to her work searching for life on Mars and other celestial bodies, and the protection of biospheres. Referencing **paragraph 1 of Guideline D.1** Ms. Zorzano argued that the development of sustainable space technologies is necessary in planetary protection, and such innovations may include the development of new sustainable design methods for in-situ resource utilization

(access to water, extraction of oxygen and minerals on the Moon and other celestial bodies), etc. Ms. Zorzano connected **paragraph 4 of Guideline D.1** to planetary protection by highlighting recommendations relevant to safety measures to protect the Earth and the space environment from harmful contamination. Accordingly, Ms. Zorzano explained that while humanity explores the universe and the origin of life, it is essential to keep the space environment pristine and non-contaminated (without bioburdens) from terrestrial life. It is likewise imperative to prevent harmful impact of returned missions (backwards contamination). Ms. Zorzano also clarified that the Committee on Space Research (COSPAR) Panel on Planetary Protection defines its recommendations based on scientific knowledge and latest state of the art research relevant to planetary protection.

Excerpt from Ms. Zorzano's presentation

Some sterilization methods and relevant standards were discussed by Ms. Zorzano. The scientist concluded her introduction by stressing the significance of global partnerships and awareness of the applicable measures to guarantee that the biospheres of various celestial bodies are kept separated and harmful contamination is prevented.

In his presentation, the fourth speaker, **Aquib Moin** introduced his research on measuring and observing space debris. Mr. Moin and his international partners have been building a space domain awareness infrastructure and eco-system to detect, track, monitor all space objects, including active satellites, and non-active space debris as a response to the growing utilization of the orbital space environment. The infrastructure comprises several ground-based networks of sensors and stations, connected to a central processing facility. In this infrastructure, orbital determination propagation (or the mapping of the trajectories) takes place through a cloud-based data management and aggregation unit, with the initiative to intelligently share the outcome of the measurements and observations with the space community, which Mr. Moin believes, is a crucial element of a sufficient mechanism.

In relation to **Section D** of the LTS Guidelines, Mr. Moin argued that R&D efforts were key and may consequently lead to concrete solutions. For example, the

identification of space objects is needed in order to later set up a space traffic coordination system with proper warning and mitigation mechanisms. Mr. Moin highlighted that besides tracking, the establishment of a sufficient catalogue is also necessary, along with the set-up of a mechanism to distribute the data through blockchains. This can lead to the establishment of an AI-based, autonomous system. Such initiatives, however, Mr. Moin indicated, require international, multi-stakeholder and even interdisciplinary cooperation (involving various areas in science and technology and research and development), and worldwide data sharing.

The last speaker, **A K Anil Kumar** presented India's efforts relevant to the long-term sustainability of outer space activities, including safeguarding the country's space assets and the prevention of space debris proliferation. India's research activities in areas such as risk mitigation through collision avoidance, launch collision analysis and re-entry analysis, impact predictions, space objects' orbital determination, object categorization and cataloguing, and post mission disposal of spacecrafts were emphasized by Mr. Anil Kumar. He also stressed how India's activities are carried out in line with the IADC and the Space Debris Mitigation Guidelines of COPUOS.

In relation to **Guideline D.1,** according to Mr. Anil Kumar, ISRO has initiated the development of more environmentally friendly technologies, including the use of green propellants for their launch vehicles and satellite propulsion system. On that note, materials such as AND (ammonium dinitramide) and HAN (hydroxylammonium nitrate) based on monopropellants, and hydrogen peroxide and kerosine based bi-propellants are being actively studied and have been ground-tested at subscale engine level in India. On **Guideline D.2**, Mr. Anil Kumar reported that India sees international cooperation and data-sharing of paramount importance to carry out space activities in a sustainable manner. Furthermore, topics on passivation of launch vehicle upper stages at end of mission; monitoring atmospheric re-entry of upper stages; operational collision avoidance; post-mission disposal of GEO satellites were touched upon by Mr. Anil Kumar in considering new measures to manage the space debris population in the long term. In fact, Mr. Anil Kumar emphasized several ongoing R&D initiatives of ISRO, such as activities relevant to deorbiting LEO satellites to reduce post-mission orbital lifetime, or controlled re-entry of satellites.

During the discussion portion of the event, **Ms. Zorzano** commented on the potential biological contamination of the Moon due to ongoing initiatives to have human presence on the celestial body again. Even though we know that the Moon contains water, necessary for microbial communities, it is frozen and is situated in the polar region of the celestial body. For that reason, Ms. Zorzano explained, COSPAR's Policy on Planetary Protection has proposed to delimitate mostly the polar regions with the instruction that missions to the lunar poles and the rich icy deposits need to record their full organic inventory, while most missions to the Moon's surface still only need to report volatiles released by their propulsion systems. Although areas that are not relevant to biological contamination are outside the scope of COSPAR, Ms. Zorzano highlighted, it is common sense to list where the spacecrafts are landing or crashing on the lunar surface and to make sure

that we don't accumulate debris unintentionally, or we find or develop the procedures to collect the debris on the Moon.

In terms of orbital debris and public funding, **Mr. Liou** highlighted that enhanced investment in research should be targeted to the design and development of quality of satellite components. This would be especially important for subsystems that have well-documented history of explosions, such as the propulsion system and batteries, to avoid such explosions in the future. Another investment area, Mr. Liou suggested, was low-cost and high reliability post-mission disposal technologies, to avoid the long-term presence of non-functioning satellites in the orbital space environment. **Mr. Moin** elaborated that smart resource management is crucial to have sufficient R&D activities for space sustainability practices. A good approach, according to Mr. Moin, to enable cost-effective and financially feasible efforts to monitor and assess space debris is to establish more sensor stations worldwide, which allows for higher level collaboration – international as well as between the private and public sector – and resource sharing. **Mr. Anil Kumar** argued that States can best support sustainable space research through active engagement in international and multi-stakeholder cooperation and data-sharing among spacecraft operators. Additionally, Mr. Anil Kumar highlighted that observational facilities need to be established to track space objects, so it is possible to avoid future collisions and fragmentation events. Furthermore, States need to acknowledge the important potential of non-governmental entities, including the private sector, in supporting research and development activities for the long-term sustainability of outer space activities. Hence, States should make sure that private space entities have sufficient access to research facilities, according to Mr. Anil Kumar.

In terms of further research in the domain of dark and quiet skies, **Ms. Francisco** called attention to the need to concentrate not only on the impact of satellites on astronomy but on other accumulative and long-term effects of orbital space objects, including light pollution affecting living beings, skyglow, interference with radio frequency, etc. Addressing certain strategies that may be effective against the detrimental implications of satellites are therefore key according to Ms. Francisco, including solutions in the technical, political and diplomatic realms.

Conclusion

In their short concluding remarks, the panelists stressed the pivotal role of international cooperation and public-private partnership in space research and development for the long-term sustainability of outer space activities. Information-sharing was also highlighted by the speakers, stating that besides collecting important data, researchers should also pay attention to properly documenting such data and to support making such data open to the public as much as feasible.

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