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Committee on the Peaceful Uses of Outer Space

Report on the United Nations/International Astronautical Federation Workshop on Space Technology for Socioeconomic Benefits: "Space sustainability as a game changer for development"

(Milan, Italy, 11–13 October 2024)

I. Introduction

1. The Office for Outer Space Affairs of the Secretariat and the International Astronautical Federation (IAF) jointly organized the thirty-first edition of the Workshop on Space Technology for Socioeconomic Benefits, in cooperation with the Government of Italy. The Workshop was hosted in Milan, Italy, by the Italian Space Agency (ASI) from 11 to 13 October 2024.

2. The Workshop was held immediately prior to the seventy-fifth International Astronautical Congress, which was hosted at the Milano Convention Centre by the Italian Association of Aeronautics and Astronautics. The Office for Outer Space Affairs, IAF and ASI had jointly selected the theme "Space sustainability as a game changer for development", which was aligned with the theme of the International Astronautical Congress, namely, "Responsible space for sustainability".

3. Space applications remain a game changer in many sectors of the economy and have revolutionized the way in which services essential for socioeconomic development are provided in many areas, from agriculture to transport and telecommunications. However, for those benefits to remain available, space activities themselves need to become sustainable. The Workshop included two and a half days of presentations and discussions about various meanings of the concept of sustainability for the space sector, how to align space activities with environmental concerns on Earth, how to ensure that activities in space would remain feasible for all in the long term and how space-based tools were essential enablers for sustainability initiatives on Earth.

4. The Workshop provided a platform for discussions between representatives of spacefaring nations and entities from other countries that wished to adopt policies and technical solutions already in use, so that the benefits offered by space activities would remain available to all in the long term.

5. The present report provides a description of the objectives of the Workshop, details on the participation and a summary of the discussions.

II. Background and objectives

6. The Office for Outer Space Affairs disseminates knowledge with respect to the added value of space applications in addressing societal issues, notably through events of the United Nations Programme on Space Applications held at the request of Member States and organized jointly. The Programme on Space Applications has been organizing events since 1971, and the United Nations/IAF Workshop held in 2024 was the thirty-first in the series. The workshops in this series have been aimed at raising awareness of opportunities to use space science, technologies and applications in support of sustainable economic, social and environmental development.

7. In 2024, the Workshop was devoted to sustainability and had the following objectives:

(a) To raise awareness of the various initiatives to measure and predict the impact of space activities (spacecraft manufacturing, launch and re-entry) on the Earth environment;

(b) To showcase changes in space engineering practices to reduce the carbon footprint of the space sector overall, utilizing technical innovations for greener technologies, the financing of innovations and regulatory incentives for their adoption;

(c) To provide capacity-building activities on space sustainability, especially from the perspective of new spacefaring countries and non-spacefaring countries that wish to adopt best practices and preserve the sustainability of the space environment;

(d) To share challenges and success stories in relation to deorbiting spacecraft responsibly, such as technical deorbiting methods and tools, and to discuss the most effective methods;

(e) To showcase success stories of technical coordination for space activities that have been impacting each other, such as astronomical observations and satellite operations, and for various activities on the Moon and Mars;

(f) To share information on innovative space-based applications and services that contribute to environmental sustainability on Earth.

8. In order to facilitate networking among participants, time was allocated on the first and second days of the Workshop to help those seeking training or specific skill sets for their teams to find potential partners. This structured interaction on specific themes had been tested successfully at the previous edition of the Workshop and had received enthusiastic reviews from participants. Increased interactions among Workshop participants were aimed at initiating long-lasting and interdisciplinary collaborations.

III. Attendance

9. The Workshop was held exclusively in person. A total of 210 individuals registered for the event; among them, 50 per cent were men, 48 per cent were women and 2 per cent preferred not to indicate their gender. In total, 59 per cent of those registered came from developing countries or economies in transition. Registration at the door was also provided, up to the maximum capacity of the available space, and 37 additional persons were able to join the event, at least in part, at the last minute, compensating to some degree for the 55 absentees among those registered. In total, 192 individuals attended the Workshop in person, which was the highest number of participants recorded for the event series.

10. In total, 28 women and 35 men spoke at the event; 34 speakers came from developing countries and accounted for 64 per cent of the 53 speakers who had been selected for the technical programme. Those speakers had been selected through a review of 355 abstracts received, with due attention to ensuring a wide geographical

representation and to enabling newcomers to the space sector to make their voices heard. About two thirds of the speakers selected for the technical programme had never attended the Workshop before.

11. Attendees constituted a diverse mix of representatives from Governments, space agencies, research institutes, academia, non-governmental organizations and the private sector. Some participants worked in government or belonged to the diplomatic community, namely, representatives of the African Union Commission, the Office of the President of Djibouti, the Ministry of Transportation of Iraq and the Ministry of Information, Communication and Information Technology of the United Republic of Tanzania. Representatives of the following space agencies attended the event: Bolivarian Agency for Space Activities, Brazilian Space Agency, Colombian Space Agency, Egyptian Space Agency, Ethiopian Space Science and Technology Institute, European Space Agency, European Union Agency for the Space Programme, Geo-Informatics and Space Technology Development Agency (GISTDA) of Thailand, German Aerospace Centre (DLR), Indian Space Research Organization, Israel Space Forum, Japan Aerospace Exploration Agency (JAXA), Kenya Space Agency, Korea AeroSpace Administration, Maldives Space Research Organisation, Mexican Space Agency, National Aeronautics and Space Administration (NASA) and Office of Space Commerce of the United States of America, National Earth Observations and Space Secretariat of South Africa, National Space Programme Management Office of Angola, National Research and Innovation Agency of Indonesia, National Space Research and Development Agency of Nigeria, National Space Science Agency of Bahrain, Paraguay Space Agency, Polish Space Agency, Saudi Space Agency, South African National Space Agency, Space Agency of Azerbaijan (Azercosmos), Turkish Space Agency, United Kingdom Space Agency, Viet Nam National Space Centre and Zimbabwe National Geospatial and Space Agency. The International Astronomical Union and the Committee on Space Research were also represented.

12. The following 75 countries were represented at the Workshop: Algeria, Angola, Argentina, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belgium, Benin, Bolivia (Plurinational State of), Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Djibouti, Dominican Republic, Ecuador, Egypt, Eritrea, Ethiopia, France, Germany, Greece, Guatemala, Honduras, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Lesotho, Malaysia, Maldives, Mexico, Morocco, Netherlands (Kingdom of the), Nigeria, Pakistan, Paraguay, Philippines, Poland, Portugal, Republic of Korea, Romania, Rwanda, Saudi Arabia, Slovakia, Slovenia, South Africa, South Sudan, Spain, Sri Lanka, Thailand, Tunisia, Türkiye, Uganda, Ukraine, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, United States, Uruguay, Venezuela (Bolivarian Republic of), Viet Nam and Zimbabwe.

13. The Office for Outer Space Affairs and IAF provided support for 33 individuals from the following 26 countries to attend the Workshop: Argentina, Azerbaijan, Bangladesh, Benin, Chile, Colombia, Côte d'Ivoire, Egypt, Ethiopia, Honduras, India, Indonesia, Jordan, Kazakhstan, Kenya, Lesotho, Nigeria, South Africa, South Sudan, Thailand, Türkiye, Ukraine, United Republic of Tanzania, Venezuela (Bolivarian Republic of), Viet Nam and Zimbabwe. In total, 31 of those individuals received a return flight to Milan, 25 received accommodation in Milan for the duration of the Workshop and 25 received free access to the International Astronautical Congress held the following week.

IV. Programme

14. The programme addressed the concept of sustainability from three angles: (a) how the space sector can reduce its emissions to be more closely aligned with environmental concerns on Earth; (b) how to ensure that activities in space remain feasible for all stakeholders in the long term, despite the exponential increase in the number of objects in Earth orbit; and (c) how space applications are essential enablers for sustainability initiatives on Earth.

15. The programme included four formats: keynote speeches, sessions, panel discussions and three-minute “pitch presentations”. Most of the co-organizers and sponsors provided a keynote speech. In the sessions, each presenter was given 10 minutes to address the audience, followed by 2 minutes for questions and answers. Panel discussions were structured in three parts: an initial introduction by each panellist in a presentation lasting 5 minutes, followed by a structured discussion of 30 minutes between panellists and the moderator, then 15 minutes for questions and answers with the audience. In order to maximize the number of speakers, pitch presentations were included as a new format in between sessions and panels.

16. A short biography for each speaker and all presentations were made available on the website of the Office for Outer Space Affairs[1] in advance of the Workshop. Access to that information enabled the coordination of content among speakers for panel discussions and facilitated networking between speakers and members of the audience throughout the event.

17. In total, the event lasted for 20 hours. In addition to presentations and panel discussions, it included a total of two and a half hours of interactive networking organized by topic of interest, catered lunches and a complimentary evening reception for all participants.

18. The co-organizers held an opening ceremony and a closing ceremony, at which high-level officials represented each organization. The Director of the Office for Outer Space Affairs highlighted the need to make the space economy more environmentally friendly on Earth and in orbit as one of the pressing challenges currently facing the space sector. The subject of space sustainability had received the highest level of attention during the recent Summit of the Future, after which 193 States had adopted the Pact for the Future, which included an action to reinforce the role of the Committee on the Peaceful Uses of Outer Space, as new frameworks were required for space traffic management, space debris and space resources, and the private sector and civil society needed to engage with intergovernmental processes.

19. In his welcome address, the President of IAF recalled that the main theme of the International Astronautical Congress in 2024 was “Responsible space for sustainability”. The Congress would bring together more than 10,000 attendees in Milan and would be the largest gathering of space professionals in history, at a time of significant growth in space activities. He stressed that the core agenda of IAF was focused on sustainability, including sustainable investment, in order to foster expansion of the space sector. The Permanent Representative of Italy to the United Nations in Vienna welcomed all participants to Milan and explained how Italian space diplomacy built on the will to foster international cooperation, dialogue and progress. Space was not an unlimited resource, and Italy, as a key player in the space economy, was keen to advocate for shared responsibility. Space had to be preserved as a stable and peaceful domain for future generations, in order to ensure that space exploration would remain open to all, equitably and without discrimination.

20. The co-organizers gave presentations on the context and background of the Workshop. The representative of the Office for Outer Space Affairs explained why the topics of the Workshop were chosen and elaborated on the programme and administrative matters. The Executive Director of IAF noted that space applications were game changers in many sectors of the economy, from agriculture to transport and telecommunications. For such benefits to remain available, space activities needed to remain sustainable. The Workshop would provide a platform to foster discussions on global and regional collaboration, and the International Astronautical Congress would provide the opportunity to engage with a wide range of professionals, from ministers and parliamentarians to students, engineers, young professionals and heads of agencies.

21. The President of ASI highlighted challenges, notably how the proliferation of space debris increased the complexity of space operations and how large

[1] www.unoosa.org/oosa/en/ourwork/psa/schedule/2024/un-iaf-workshop.html.

constellations currently under deployment would challenge the long-term stability and sustainability of space activities. In addition, the increasing number of objects in orbit was reducing possibilities to study the universe and celestial bodies. The President of the Italian Association of Aeronautics and Astronautics described the evolution of the Italian aerospace sector since 1920, when the Association had been founded. Political action would be required for space activities to become accessible to all, and sustainability would not become a reality spontaneously, but would require dedicated work.

22. The Chair of the IAF Committee for Liaison with International Organizations and Developing Nations (CLIODN) explained the Committee's purpose. She noted that various international organizations worked in different fields of space activities, from creating rules to ensuring sustainability for future generations and supporting emerging countries to enable them to join space activities in a sustainable manner. The Vice-Chair of the IAF Committee on Connecting Emerging Space ecoSystems (ACCESS) explained the Committee's purpose as a place where newcomers went to discuss how to become part of the space industry. He encouraged those starting space activities to present their work at the Committee's booth in the exhibition hall during the International Astronautical Congress.

23. The five speakers of the first session highlighted the need to assess the impact of space activities on the Earth environment. As the activities of the space sector had been increasing sharply, the building, launching and deorbiting of spacecraft had been contributing to the depletion of scarce resources and to polluting the Earth's atmosphere, land and oceans. The falling of space debris to Earth was no longer a rare event, and research had started to assess which chemicals were released into the atmosphere when space debris burned on re-entry. Measurements of metal aerosols in the atmosphere had shown that the influx of aluminium had significantly increased, with anthropogenic influx exceeding, since 2021, 80 per cent of the amount contributed by meteoroids each year. In 2023, the mass of aluminium oxide injected into the mesosphere from anthropogenic objects had reached 48 tons, more than double the amount reached in 2016, and future scenarios predicted a tenfold increase. Further impact on the environment was caused by the amount of material accumulating around Point Nemo in the South Pacific, 2,700 km from the nearest shore, where many large spacecraft were deliberately directed when deorbiting the Earth. Point Nemo had been designated as the safest location for the controlled re-entry of spacecraft and their components in 1970; nevertheless, owing to oceanic currents, that pollution had been dispersing and had an impact on marine ecosystems and the Antarctic.

24. Data were essential to climate research; however, in addition to physical pollution from space activities, the storage and processing of very large amounts of satellite data had an impact on the environment in terms of electronic waste and energy consumption, leading to a "space sustainability paradox" whereby the technologies designed to support sustainability, such as satellite data, contributed to environmental degradation. The speaker from the United Kingdom explained that, in total, the digital footprint of humanity amounted to 3 per cent of global greenhouse emissions and, if the Internet were a country, it would be the fourth largest polluter. In addition, some space activities had started to impede others, such as research in astronomy being constrained by satellites crossing the field of view of telescopes. Interference, which was now well assessed by direct measurements, could be reduced if satellites were made in such a way that they were less reflective of light, if their positions were accurately predicted and if radio emissions avoided radio telescopes. Satellite operators and manufacturers were becoming aware of the issue, but mitigation measures presented technological and operational difficulties, besides being costly. The speaker from the International Astronomical Union stressed that, in addition to improvements of a technical nature, policy initiatives were necessary to render the space sector more sustainable.

25. Two short project pitches were presented. The representative of the Space Industry Association of Australia gave an overview of sustainability initiatives in the

country, and the speaker from the Kenya Space Agency explained how the Agency was planning to build a local launch facility. Launching spacecraft from the equatorial spaceport in Kenya would be less costly and more sustainable than the alternatives, as the Agency planned to compensate for the carbon emissions generated by launch activities.

26. The members of the first panel discussed ways to reduce the environmental impact of space activities. The panel included representatives of space agencies and private industry from countries in different regions of the world (Azerbaijan, France, Italy, Malaysia and South Africa), each of which was at a different stage in developing capabilities. While the other countries were involved in building spacecraft, Malaysia had an initiative focused on the development of a new spaceport, the first in the country. The speakers provided their own perspectives on the different motivations for their focus on improving sustainability and on the outcomes; arguments ranged from customer requests to concerns about compliance with local environmental laws, requests from financial partners, national commitments to reduce the carbon footprint of the economy, a cultural change among staff, and the belief that assessing sustainability was an opportunity to reduce waste and internal costs and would therefore render the company more efficient against competitors.

27. A debate ensued about how to bridge the gap between research and the operational deployment of technology, and about the factors that influenced that transition. A representative of a space manufacturing company explained how that company had recently achieved a quantified reduction of its carbon footprint by 19 per cent; the trigger for that achievement had emanated from creating a dedicated sustainability team within the company. Some space agencies, such as the French Space Agency, and financial institutions, such as the International Monetary Fund, were starting to ask the projects that they funded to implement specific sustainability measures. Taking the example of designing reaction wheels, one speaker pointed out that the adaptation of production processes in his company was facilitated by digital technologies that had shortened technology development cycles, especially for small companies that were newcomers to the space sector. In discussions on how to balance profitability and sustainability, and on how the public perception of space activities was likely to evolve, the speakers concluded that actions to ensure the sustainability of the space environment and to reduce pollution within the sector could no longer be considered optional.

28. Three speakers gave project pitch presentations in which they explained how they had raised awareness of space sustainability. The speaker from the United Republic of Tanzania had attended, for the first time, the previous edition of the United Nations/IAF Workshop in Baku in 2023; the event had provided valuable lessons from other participants and had provided impetus for the Ministry of Information, Communication and Information Technology to take further steps towards establishing partnerships and collaborations for space activities. In Zimbabwe, the Ambassador-at-large of the Milo Space Science Institute of Arizona State University had been preparing activities on space law and hands-on training. In Ukraine, the representative of the V.M. Koretsky Institute of State and Law of the National Academy of Sciences had developed a so-called “serious game” to teach policymakers about concrete issues in space law and policy in an entertaining yet educational manner.

29. The second panel discussion was focused on legal best practices for space sustainability. Speakers shared examples of policy frameworks that promoted the sustainable use of space. They discussed how legal practices would need to evolve and whether that evolution could be inspired by practices in other areas of law, in particular human rights law. Speakers from Nigeria, South Africa, the United Kingdom and Zimbabwe each presented an overview of the existing legal frameworks on space sustainability in their respective country or region, and of the plans for future legal instruments. The development of laws that stipulated the modalities of private sector participation was a priority. New instruments were needed for space debris, space traffic management and space situational awareness. When designing and

adopting measures, since regulations needed to pass the national legislature, legislators needed to acquire sufficient education on the topic, and some countries lacked specialists to promote space sustainability. Challenges remained in ensuring actual compliance with the measures adopted.

30. As human activities extended to outer space and human rights obligations were closely linked to the Sustainable Development Goals, the speaker from the Manfred Lachs Centre for Space Law at the University of Warsaw discussed how human rights norms and principles should be extended to space. No business enterprise, including in space, should infringe upon human rights. The concept of corporate social responsibility had formed the basis for a variety of instruments and it was essential to observe the three pillars of the United Nations Guiding Principles on Business and Human Rights: States had a duty to protect human rights, private companies had the responsibility to respect human rights, and affected persons should have access to effective remedies. The speakers debated how balancing sustainability with economic challenges remained a challenge. In addition, the speakers agreed that national regulators had a central role to play in ensuring the sustainability of space activities, in the sense that they had the duty to ensure that all operators that they oversaw complied with the legal framework and adopted practices.

31. A networking activity was organized at the end of the first day, in which speakers and attendees could meet those working on the same topic to discuss their respective needs and the activities that they could undertake jointly.

32. The second day started with a keynote speech by the IAF Vice-President for Relations with International Organizations about the space debris crisis. Since the astronomer Donald Kessler had modelled the process of a cascading increase in space debris through collision in 1978, the direct threat posed by debris to space activities had materialized. There had been notable examples of large clouds of debris created after a single collision. For instance, the clouds of debris resulting from the Fengyun-1C anti-satellite test in 2007 and from the collision between the Kosmos 2251 and Iridium 33 satellites in 2009, had drifted very far from those spacecrafts' initial orbits within just a few months, and those dangerous zones continued to expand. The risks of damage or casualties on the ground caused by spacecraft re-entry into the atmosphere also kept increasing, both because of the increase in the number of objects re-entering and because of certain technical innovations; for example, carbon composite materials maintained their structural integrity at very high temperatures instead of vaporizing into metal particles in the upper atmosphere. As such, atmospheric friction during re-entry was less effective and resulted in large objects crashing on Earth, such as a Vega upper module composite fuel tank recovered in India. Today, the development of remediation measures for active debris removal remained a challenge; technologies under development had not yet reached the stage of maturity required to be effective at the large scale needed. Accurate observations of the growing debris population demanded an ever-increasing number of measurements, but such mitigation measures remained the only way to control the growth in space debris.

33. The second session provided deeper insights into the topics of space situational awareness, trajectory models and collision avoidance between spacecraft. Four speakers gave presentations, including on the activities of the National Oceanic and Atmospheric Administration (NOAA) of the United States and those of DLR, and on initiatives of private companies. The democratization of the space sector and the operation of satellites by large numbers of small private companies meant that some operators were unable to know with accuracy where their satellites were, and they needed better sources that indicated precise locations for space situational awareness. The number of satellites was increasing without the infrastructure required to support that growth through the sharing of data between satellite operators. To alleviate the issue, the speaker from NOAA proposed that States might need to consider introducing a licence to operate a satellite, rather than licences only for the use of the spectrum. A market for space situational awareness services could emerge where satellite operators themselves would not need to build and maintain infrastructure for

tracking, but could outsource that task to others. NOAA also considered that the Committee on the Peaceful Uses of Outer Space would play a fundamental role in ensuring information-sharing.

34. The representatives of private companies described the products that they were developing. Manoeuvring a satellite to avoid a collision disrupted operations, and staff in the operations room needed to assess the validity of the warnings, then take a decision on whether to move a satellite or not. With existing surveillance systems and more than 130 million pieces of debris currently in low Earth orbit, 99.9 per cent of collision alerts were false positives that required screening. As the risk of collision increased, a market existed for providing traceable and actionable information to support decision-making, on the basis of sophisticated prediction models, on-demand tracking and better risk estimates. The two key factors causing orbital decay in low Earth orbit were space weather and atmospheric drag. DLR was modelling atmospheric drag forces on objects in low Earth orbit as a function of solar activity for the purpose of debris removal mission planning. Geomagnetic storms could lead to orbital decay amounting to several hundred metres per day, as could be seen with great accuracy on catalogued objects of interest. During the most recent geomagnetic storm, on 10 May 2024, operators had had to manoeuvre more than 5,000 spacecraft to maintain a margin of safety. To improve the situation, spacecraft would need the ability to monitor their own environment, and the further development of active debris removal technologies was essential.

35. The third panel discussion was focused on innovations among emerging technologies that could become game changers for the sustainability of space missions, such as additive manufacturing, including the printing of biological material; rendezvous operations; solar sails; and robotics. Technologies allowing repair, refuelling or recycling were opening up new possibilities for space missions, both in orbit and on the surface of other planets. Solar sails could be used for passive deorbiting, for extending the lifespan of spacecraft or for in-orbit manufacturing and in-orbit assembly. Sails were very versatile; however, for collision avoidance, structures equipped with solar sails required early warnings, with plenty of lead time, as they could be manoeuvred only very slowly. Docking plates would facilitate the catching and moving of objects in space, and robotic tools to grab objects could dock into and actively deorbit non-equipped spacecraft. A proof of concept for docking plates had already been demonstrated in space. For long-term space missions, the development of specific additive manufacturing processes using biological material that could grow locally was needed; once developed, the technology would also find markets elsewhere, such as in isolated areas on Earth.

36. The panellists discussed the slow pace at which technology development progressed until it reached the stage when a demonstration could occur – it would take more than 10 years to establish any new technology. Fully recycling spacecraft or recycling all waste on space stations would take much longer, probably another 10 or 20 years, as full recycling did not yet take place on Earth. A first step would see a reduction of the waste, rather than recycling, and some material would then be repurposed. Academia had a role to play in proposing new ideas for capture tools or life extension, while industry would focus on implementing the most mature technologies in real situations, provided that a market existed for the service. As the development of active debris removal was driven by policy, it was likely that the use of technologies to extend a spacecraft’s lifespan, thereby providing financial gain to the owner, would happen faster than the use of technologies for deorbiting. To date, without a business case, active debris removal missions had only been technical demonstrations on a national scale. Similarly, if space agencies were to jointly define standard technical interfaces for docking, that would facilitate the adoption of refuelling or deorbiting technology, because worldwide harmonization and standardization involved costs that manufacturers were not willing to cover. In the discussion with the audience, representatives of manufacturers repeatedly stressed that customer requests were the essential impetus for the industry’s adaptation.

37. In Lesotho, Impact School pioneered initiatives for comprehensive space-related education and advocated for the inclusion of space technology in the Lesotho National Research and Education Network. Capacity-building activities were progressing well: in the Kibo Robot Programming Challenge, organized by JAXA in 2024 with support from the Office for Outer Space Affairs, the school had been ranked eleventh out of 54 countries.

38. The third session involved the presentation of outcomes of capacity-building initiatives to increase awareness of why space sustainability was essential, both for activities in space and for sustainable development on Earth. The speakers presented best practices and lessons learned in working with developing countries. Grassroots initiatives had often been able to generate growing interest in space science among local young people. So-called "space enablers" were individuals and organizations that promoted, organized and built space ecosystems. They were often the first to mobilize through grassroots initiatives before private companies invested in space activities that led to increases in revenue and export opportunities. A return on investment of three to five times was not uncommon in the space applications sector, while the building of spacecraft or launchers was riskier economically. Historically, most small satellite programmes had started as bilateral collaborations between countries; having partners enabled the implementation of a visionary concept despite a lack of local expertise. Initially, such collaborations had involved one of the first spacefaring nations; nowadays, many countries were open for gradual collaboration, moving from training to co-development and technology licensing. For a national space programme to become sustainable in the long term, industry, academia and government all needed to play their part, and realistic goals, budgets and schedules needed to be set. Citing as an example a collaboration with GISTDA, a speaker from the United Kingdom explained how an industry with a local supply chain had been developed in Thailand.

39. The most successful capacity-building programmes were those that addressed direct needs. Maldives had implemented workshops on space sustainability and capacity-building events with various partners. The country was keen to develop space activities and innovative research using the local marine ecosystem, for instance by studying how the adaptability of coral could be leveraged to build space habitats. New Zealand had initiated a local space ecosystem, using competition prizes and showcasing solutions to local problems, such as quantifying methane emissions and assessing the health of lakes. In Japan, since the completion in 2012 of the small satellite deployer of the International Space Station Japanese Experiment Module (Kibo), JAXA had supported several developing countries in releasing satellites from the facility. The KiboCUBE programme, which was carried out in collaboration with the Office for Outer Space Affairs and enabled developing countries to launch their first satellites, was asking for compliance with both the Space Debris Mitigation Guidelines and the Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space. Reflecting upon challenges, and without downplaying the difficulties in raising funding, the speakers indicated a need to advocate more widely; mentalities changed once people came to understand why space was useful. In space projects, unrealistic expectations were the main challenge, and acquiring competence took time; those aiming for grandiose achievements often underestimated the time and resources required for the desired result to be achieved.

40. The speakers who gave pitch presentations after the third session were from countries that were developing CubeSats with missions that would contribute either to the sustainability of space activities in their own country or to sustainability on Earth. For example, the CubeSat of Indonesia was using subsystems developed almost entirely domestically, while the spacecraft from Bahrain would monitor carbon dioxide in the atmosphere, and a mission developed in Japan would test a multispectral imaging payload that could later be used for Moon exploration. The respective projects had reached various stages of maturity, and several speakers represented beneficiaries of the Access to Space for All initiative of the Office for

Outer Space Affairs. Those speakers either participated in the KiboCUBE programme with JAXA or were students in Japan as a result of the Office's joint initiative with the Kyushu Institute of Technology.

41. One pitch presentation session was dedicated to the exploration of the Moon. The speakers from Egypt, Jordan and Venezuela (Bolivarian Republic of) were all working on the development of technology for lunar programmes. The speaker from the Al-Balqa' Applied University in Jordan was seeking collaboration partners, the Egyptian Space Agency was building a high-resolution hyperspectral camera, and the Bolivarian Agency for Space Activities was developing methods for collecting, processing and utilizing lunar regolith for lunar infrastructure. The latter two were both contributors to the International Lunar Research Station project of the China National Space Administration.

42. In a keynote speech, the President of ASI explained how Earth observation was a powerful tool to track progress in achieving the Sustainable Development Goals. He elaborated on how Italy had several collaborations in place to facilitate access to Earth observation data for scientists, contributed to international and inter-agency initiatives, such as the recovery observatory of the Committee on Earth Observation Satellites and the Polar Space Task Group, and promoted capacity-building. Using concrete examples of urbanization and water resource management, he explained how it was possible to measure the vertical rate at which the ground was sinking owing to the over-exploitation of underground water resources, which also damaged houses as a consequence. ASI was widening access to the data from the Constellation of Small Satellites for Mediterranean Basin Observation (COSMO-SkyMed) mission by using an open call model for scientific projects on climate change, in which 5 per cent of the data were reserved for interested parties from developing countries.

43. As on the first day, time was reserved for networking at the end of the second day, in the same format. Participants were invited to visit multiple tables in order to discuss more topics. To enable further networking among participants, a reception was organized by IAF later in the evening.

44. The last day started with an overview of European Space Agency activities to reduce debris. The speaker made reference to action 56 of the Pact for the Future. At the same time, European Space Agency member States had encouraged the Agency to implement a "zero debris" approach for its missions, in order to encourage partners and other actors to pursue similar paths. A community of proactive actors in Europe and beyond, who were committed to space safety and sustainability, had written the Zero Debris Charter jointly, defining principles and targets for long-term space sustainability. The Charter had been endorsed by Governments, intergovernmental organizations, industry and academia, and had 87 signatories to date.

45. In the last session, speakers from South Sudan, Thailand and Viet Nam gave presentations on initiatives in their respective countries, where space applications had proved to be an essential tool to solve some daily challenges for local users. In Thailand, the GISTDA Dragonfly initiative was providing a monitoring system for six economic crops nationwide and provided data updates every five days, so that farmers could plan adequate fertilizer and water use and predict yields. End users accessed the information from a smartphone and could record data on production results and expenses using a personal digital notebook. Additional services were being prepared, such as carbon credit schemes, pest and disease alerts and crop insurance. In Viet Nam, since the Government was encouraging the development and deployment of solar power systems, relevant sites for producing solar energy were being selected using satellite imagery. The Viet Nam Academy of Science and Technology was combining maps of solar radiation obtained from satellite data with geographical maps of land use, local topography and natural hazards in order to identify economically efficient locations for solar power. The data were shared with the centre that operated the nationwide power grid to predict how much demand could be met based on daily solar radiation forecasts.

46. In South Sudan, the government regulator for telecommunications also had a mandate to promote connectivity. To encourage the deployment of telecommunications infrastructure, the Government funded the installation of telecommunications towers locally and the local operator funded the equipment installed on the towers. Given that the deployment of terrestrial networks was difficult in South Sudan, satellite communications technology was widely used to connect remote towers to the operators' core networks. Gaining the ability to make phone calls was such an important development for local communities that one village celebrated the commissioning of its local tower, and the location had become a landmark for the community.

47. Two speakers presenting pitches discussed effective initiatives for sustainability implemented in developing countries. In Colombia, innovations enabled by satellite-based data were shaping industries in regions where economic and social barriers often impeded access to global trade. From the perspective of Honduras, the Morazán Project had been launched in response to the devastation caused by floods. The satellite was developed in collaboration with Costa Rica and Guatemala to provide a monitoring and early warning system to enhance the response to climate-related events.

48. The last panel reflected on activities that had been successful in incentivizing the development and use of space applications in developing countries. The speakers from the European Union Agency for the Space Programme, the Massachusetts Institute of Technology and the African Union Commission gave an overview of several initiatives that contributed to a green transformation, socioeconomic benefits and sustainable development in developing countries. In several cases, such as in the monitoring of ship traffic, illegal fishing and methane emission sources, obtaining data had provided enough evidence to prompt decision makers to take regulatory action. Noting that no two successful projects had been alike, the panellists discussed factors that could support sustainable implementations. To transform data into actionable information, the private sector had often provided the link between what had been generated by space programmes and use cases at the local level. Transposing best practices elsewhere, or scaling up those successes, required funds and treatment as a political priority; when funds were lacking, stakeholders needed to become better at demonstrating benefits and at advocating for the multiplier effect of investing in space activities. Presentations and conferences were useful, but tangible outcomes were more likely to attract funding, for example by quantifying how concrete projects had improved local outcomes.

49. The panellists provided concrete examples of recommendations they would make to newcomers and to non-spacefaring countries. They reiterated that the local ownership of project activities was necessary, and they discussed the example of a NASA project in Angola in which data-processing activities had been handed over to trained local experts, who themselves determined which data services they could sell locally in order to become financially sustainable. A key to success was to define a niche and to improve communication on how to present the services. Partnership was often an underrated element; for example, the African Union had launched very helpful partnerships with governmental agencies to address the issues that they faced. Participants in such partnerships helped each other in different ways, both to unlock funding and to build advocacy groups locally, thereby also circumventing language barriers.

V. Outcomes of the networking activity

50. Following the enthusiastic feedback from participants the previous year, when the networking activity had first been tested, three time slots, lasting a total of two and a half hours, were allocated for networking among participants. The activity was organized in two separate rooms with a total of 17 tables dedicated to specific topics, so that people with similar interests could find and meet each other. A moderator at each table ensured some level of continuity between the three rounds of discussions.

The Office for Outer Space Affairs had briefed the moderators in advance of the event, as well as those replacing absent colleagues at the last minute, and had stressed the need to be inclusive in such a multicultural context, which also featured people of a wide range of ages and levels of expertise. Moderators were asked to elicit concrete proposals from participants and to be proactive in suggesting contact persons among the participants in the various discussions.

51. The participants could choose from 17 topics, with the level of interest in each topic determined through a questionnaire sent to all participants before the event. Those topics were: (a) how to define “sustainability”; (b) the impact of space activities on the environment; (c) Earth observation to monitor the Earth environment; (d) Earth observation for agriculture; (e) greener manufacturing practices; (f) greener technology to reduce debris; (g) space situational awareness; (h) technology for in-orbit activities; (i) sustainable lunar exploration; (j) collaboration for space exploration; (k) manufacturing and recycling in space; (l) space law and regulation; (m) policies using space applications; (n) capacity-building with CubeSats; (o) capacity-building; (p) awareness, communication and publicity; and (q) the game on space policy presented during the Workshop.

52. The two most popular topics (Earth observation to monitor the Earth environment, and sustainable lunar exploration) were allocated two tables each. At one of the tables, the so-called “serious game” on space policy, which had been presented earlier in the Workshop, could be played in person with its creator. On the first day of the Workshop, most participants remained for the full hour at the table that they had initially picked, while on the second day, most participants rotated to another table after forty-five minutes of discussion. Overall, most participants of the Workshop took part in three rounds of discussion at different tables.

53. The volunteer moderators at each table organized the discussion differently according to the number of participants at the table in each round. The goal was to share knowledge and seek support from peers. Some tables brought together a small number of dedicated experts who had extensive in-depth discussions for the entire allocated time, while other tables had numerous participants who first introduced their respective areas of work and discussed commonalities, then held bilateral discussions. In some cases, participants could be matched with potential partners or with potential employers. For some topics, participants developed recommendations for further partnership opportunities and organized ways to remain in contact through social media.

54. The debriefing on Sunday morning confirmed that participants had strongly benefited from the discussions, and all were positive about the experience. Some suggested that the time slots should be set earlier in the day so that participants suffering from jet lag would be better able to contribute. Some participants would have appreciated the Office for Outer Space Affairs implementing a structured approach to maintaining discussions on each topic beyond the Workshop, or providing a repository through which to submit summaries of what had been discussed, which could be valuable to others. Others felt that the modalities for maintaining discussions among the newly established networks should be left to the participants. In view of the very active engagement of participants during the entire duration of the allocated time slots, the organizers considered that the initiative should continue in future editions of the Workshop.

VI. Conclusions and lessons learned

55. Before concluding the Workshop, the Office for Outer Space Affairs sought feedback from participants to understand what they had achieved during the presentations and networking activities. Participants felt that the Workshop had provided a platform for wide-ranging discussions about how to develop the capabilities of the space sector in a sustainable way. In addition to innovative technologies, approaches to reducing the contribution of the space industry itself to

the climate crisis had been a new topic for many attendees. Rather than in-depth discussions, the programme had provided a broad overview of different efforts and initiatives that covered a wide range of sustainability activities. The Workshop had aimed to inspire participants and to increase awareness of the technical means available to improve the long-term sustainability of outer space activities.

56. In his concluding remarks, the representative of the Italian Association of Aeronautics and Astronautics, the Co-Chair of the International Programme Committee of the International Astronautical Congress in 2024, considered the synergies between the Workshop and the programme of the Congress. He highlighted that global collaboration remained essential to foster the development of space technology and its applications. Whenever technology was mature enough to be used, there were practical answers that could address, in a sustainable manner, many of the challenges discussed.

57. The IAF Vice-President for Developing Countries and Emerging Communities invited participants to take advantage of the opportunities offered by the International Astronautical Congress and to take an active role in the IAF committees, in which the topics addressed during the Workshop could be further discussed. She stressed the relevance of the Committee on Connecting Emerging Space ecoSystems (ACCESS) to facilitate knowledge transfer between well-established space agencies and newcomers from developing countries.

58. The Director of the Office for Outer Space Affairs expressed appreciation for the speakers' contributions and for the participants' engagement during the Workshop. She commended the efforts of those in the space industry who were starting to drive a change towards sustainability. Although deorbiting to prevent space debris was paramount, chemicals were being added into the atmosphere and the space sector needed to increase its efforts to reduce its impact and better understand the implications of its activities. She emphasized the importance of capacity-building activities in the strategy of the Office, especially for newcomers to the space sector, and expressed hope that the participants had found the partners that they had been hoping to meet at the Workshop. She concluded the Workshop by providing an overview of the respective roles of those involved in preparing the event.

59. The Workshop participants were encouraged to provide written feedback using a dedicated online form. Feedback was received from 75 persons, who represented 39 per cent of the participants, and was overwhelmingly positive: the average rating came to 4.58 out of 5. The average rating given by the 47 newcomers to the workshop series was 4.87. Words of appreciation were received both from speakers and from attendees, including newcomers and those who had attended previous editions of the event. Respondents were especially positive about the networking activities, which had enabled many participants to discuss ways to address their own challenges concretely, and stated that they had appreciated the opportunity to build relationships that would be beneficial to their work beyond the Workshop.