United Nations A/AC.105/1301

General Assembly

Distr.: General
12 December 2023

Original: English

Committee on the Peaceful Uses of Outer Space

Report on the United Nations/International Astronautical Federation Workshop on Space Technology for Socioeconomic Benefits: "Challenges and capacity-building opportunities for emerging space nations"

(Baku, 29 September–1 October 2023)

I. Introduction

1. The Office for Outer Space Affairs of the Secretariat and the International Astronautical Federation (IAF) jointly organized the thirtieth edition of the Workshop on Space Technology for Socioeconomic Benefits, which was hosted by the Space Agency of Azerbaijan (Azercosmos) in Baku from 29 September to 1 October 2023.

2. The Workshop was held immediately prior to the International Astronautical Congress. The Office for Outer Space Affairs, IAF and Azercosmos jointly selected the theme "Challenges and capacity-building opportunities for emerging space nations", which was aligned with the International Astronautical Congress theme "Global challenges and opportunities: give space a chance".

3. The Workshop included two and a half days of presentations and discussions on capacity-building. The event brought together representatives of spacefaring nations and entities from other countries keen to develop capabilities in the wide variety of topics that space activities encompass. Presentations and discussions focused on the use of space technologies and applications for sustainable economic, social and environmental development. Speakers analysed how countries had reached their current level of achievement, clarifying what needs had not yet been met and what educational and economic policy measures had been successful in various cases. Those conducting capacity-building activities, either from Governments, space agencies, research institutes, academia, non-governmental organizations or the private sector, were encouraged to network and establish partnerships with those interested in training a workforce and developing a space sector ecosystem in their country.

4. The present report describes the objectives of the Workshop, provides details of the participants and summarizes the discussions.

II. Background and objectives

5. The Office for Outer Space Affairs disseminates knowledge with respect to the added value of space applications in addressing societal issues, notably through

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events of the 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 of 2023 was the thirtieth 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.

6. In 2023, the Workshop addressed challenges and capacity-building opportunities for emerging space nations and had the following objectives:

(a) Raise awareness of the capacity-building efforts made in various countries and regions of the world, in particular efforts made through regional or international cooperation;

(b) Share challenges and success stories relating to capacity-building efforts, and discuss what methods are the most effective and what synergies could be harnessed between initiatives of different stakeholders;

(c) Bring together stakeholders from various Governments, space agencies, academia and industries to promote partnerships.

7. In order to facilitate networking among participants, an interactive activity called “building partnerships” was organized on the second day to help providers and recipients of capacity-building find each other. The face-to-face interaction was a new element of the Workshop. Ten specific themes had been defined by the participants through a questionnaire circulated in advance and open until the day of the event.

III. Attendance

8. The Workshop was held exclusively in person, in Baku. A total of 222 individuals, 52 per cent of whom were men and 80 per cent of whom came from developing countries or economies in transition, were invited to participate in the Workshop.

9. Among the participants, 26 women and 28 men were invited to speak. A total of 72 per cent of the speakers came from developing countries and 72 per cent had never attended the Workshop before. The speakers had been selected with a view to ensuring wide geographical representation and to enabling newcomers to the space sector to make their voices heard.

10. The Workshop was attended by members of the diplomatic community, namely, representatives of the African Union Commission and of the Ministry of Higher Education, Technology and Innovation of Namibia, as well as representatives of the following space agencies: Azercosmos, Bolivarian Agency for Space Activities, Bolivian Space Agency, Brazilian Space Agency, Egyptian Space Agency, Ethiopian Space Science and Technology Institute, European Union Agency for the Space Programme, Gabonese Agency for Space Studies and Observation, Geo-Informatics and Space Technology Development Agency (GISTDA) of Thailand, Indian Space Research Organization (ISRO), Iranian Space Agency, Japan Aerospace Exploration Agency (JAXA), Kenya Space Agency, Korea Aerospace Research Institute, Maldives Space Research Organisation, Mexican Space Agency, National Aeronautics and Space Administration (NASA) of the United States of America, National Research and Innovation Agency of Indonesia, National Space Research and Development Agency of Nigeria, National Space Science Agency of Bahrain, Pakistan Space and Upper Atmosphere Research Commission, Paraguay Space Agency, Peruvian Space Agency, Philippine Space Agency, Polish Space Agency, Romanian Space Agency, Royal Centre for Remote Sensing of Morocco, Slovak Space Office, South African National Space Agency (SANSA), Space Research and Technology Agency of Uzbekistan, Turkish Space Agency, United Kingdom Space Agency, Viet Nam National Space Centre and Zimbabwe National Geospatial and Space Agency.

11. Representatives from the following 78 countries were invited to participate in the Workshop: Australia, Austria, Azerbaijan, Bahrain, Belgium, Bhutan, Bolivia (Plurinational State of), Botswana, Brazil, Bulgaria, Burkina Faso, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Côte d'Ivoire, Ecuador, Egypt, Equatorial Guinea, Eritrea, Ethiopia, France, Gabon, Georgia, Germany, Ghana, Guatemala, India, Indonesia, Iran (Islamic Republic of), Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lesotho, Libya, Malaysia, Maldives, Mexico, Morocco, Namibia, Nepal, Netherlands (Kingdom of the), Nigeria, Pakistan, Paraguay, Peru, Philippines, Poland, Portugal, Republic of Korea, Romania, Russian Federation, Saudi Arabia, Senegal, Serbia, Seychelles, Singapore, Slovakia, South Africa, Sri Lanka, Togo, Thailand, Tunisia, Türkiye, Uganda, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, United States, Uzbekistan, Venezuela (Bolivarian Republic of), Viet Nam and Zimbabwe.

12. The Office and IAF provided financial support to 30 individuals from the following 27 countries: Bhutan, Bolivia (Plurinational State of), Brazil, Colombia, Côte d'Ivoire, Ecuador, Ghana, India, Iran (Islamic Republic of), Jordan, Kazakhstan, Kenya, Lesotho, Maldives, Mexico, Nepal, Nigeria, Pakistan, Peru, Philippines, Sri Lanka, Thailand, Tunisia, Türkiye, United Republic of Tanzania, Venezuela (Bolivarian Republic of) and Zimbabwe. They were offered a return flight, accommodation in Baku for the duration of the Workshop and, in addition, 25 persons received free access to the International Astronautical Congress that was held the following week.

IV. Programme

13. The programme was structured in the following three sequential parts, each consisting of sessions with a series of presentations, and panel discussions: (a) needs of new spacefaring nations or of non-spacefaring nations; (b) education activities carried out on various topics required to create a space sector workforce and (c) lessons learned.

14. In order to maximise the number of speakers, each presenter in a session was given 12 minutes to address the audience, followed by several minutes for questions and answers. Panel discussions were structured in three parts: an initial introduction of each panellist with a presentation lasting five minutes, followed by a structured discussion between the panellist and the moderator, and a few minutes for questions and answers with the audience.

15. A short biography for each speaker, as well as all presentations, were made available on the website of the Office for Outer Space Affairs in advance of the Workshop. Access to that information facilitated coordination of the content among speakers and networking between speakers and members of the audience throughout the event. The presentations and biographies remain available on the website.[1]

16. In total, the event lasted for 22 hours. To facilitate networking among participants, an additional interactive activity called "building partnerships" was held at the end of the second day. The activity brought together providers of capacity-building with those interested in building capacity in relation to 10 specific themes selected by the participants.

17. The co-organizers held an opening ceremony and a closing ceremony with high-level officials representing each organization. The Director of the Office for Outer Space Affairs, who had very recently joined the Office, emphasized the importance of capacity-building in space technology and applications, to support countries in achieving the Sustainable Development Goals. She gave concrete examples of the successful capacity-building activities of the Office and encouraged participants to take advantage of those opportunities and to build effective partnerships during the Workshop. In his welcome address, the President of the International Astronautical

[1] www.unoosa.org/oosa/en/ourwork/psa/schedule/2023/un-iaf-workshop.html.

Federation recalled that the main theme of the International Astronautical Congress 2023 was “Global challenges and opportunities: give space a chance”. He explained how that theme and the theme of the United Nations/IAF Workshop were linked in supporting the diverse international space community in establishing strong collaboration for growth. He also explained that the core agenda of IAF was focused on sustainability, investment to foster expansion of the space sector and security. The Chairman of Azercosmos, the Space Agency of Azerbaijan, welcomed all participants to Azerbaijan and gave an overview of the history and space-related activities of the country. He concluded by thanking the co-organizers for the coordination of the event.

18. The co-organizers gave a presentation on the background of the Workshop. The representative of the Office for Outer Space Affairs explained how the Access to Space for All initiative enabled newcomers to become spacefaring nations and informed participants about training courses recently offered as part of the wide range of capacity-building activities provided by the Office. The Executive Director of IAF explained the importance of the Workshop in supporting emerging space nations. He highlighted the various IAF activities that had been implemented to meet that need. The Project Manager at Azercosmos of the International Astronautical Congress 2023 welcomed participants to Azerbaijan and outlined the objectives of and efforts made by Azercosmos to host the event. The Chair of the IAF Committee for Liaison with International Organizations and Developing Nations (CLIODN) explained the Committee’s work, presenting its new terms of reference and workplan. The Committee had been working with the Office to support the Workshop, and the Chair of the Committee stressed that CLIODN was keen to take a bigger role in future events. The Vice-Chair of the IAF Committee on Connecting Emerging Space ecoSystems (ACCESS) explained the Committee’s work and how it had rebranded and expanded its activities by setting up regional groups to discuss, partner with and support the work of the different actors in emerging regions.

19. The first panel discussion addressed the need of new spacefaring nations and non-spacefaring nations to develop and obtain knowledge and skills related to space. It brought together four speakers from African countries and a representative of the Food and Agriculture Organization (FAO). Zimbabwe was using geospatial science to improve sustainability in agriculture and water management and to map renewable energy resources. In addition, it was collaborating on using satellite applications with the space agencies of Japan, the Russian Federation and South Africa. In Ghana, “CanSats” (satellites the size of a beverage can) had been developed in some schools to increase the level of interest in science and technical topics. In the United Republic of Tanzania, basic training programmes for young people on the space sector had recently been launched; the Government had appointed a technical team to develop a programme to jump-start space activities. In Côte d’Ivoire, space applications were perceived as tools to address challenges in agriculture and food security, water-related issues and climate-related disasters, but there was no space programme yet; the country aimed to build its first satellite and was planning to start providing education in aerospace engineering. FAO was using satellite data extensively for information retrieval, working with providers of satellite imagery and the national organizations that used that imagery to defeat hunger and improve nutrition and food security. Many of the African countries that were considering starting a space programme had land-based economies that needed Earth observation data to support their agriculture.

20. Several speakers highlighted that Earth observation data from satellites were often freely available, and collaborating with others to get access to space technology was also often feasible at no cost. Young professionals and students who wanted to acquire specific skills might not have access to appropriate infrastructure in their own country and needed opportunities to learn abroad first. Several exchange programmes both for students and professionals were available to educate them abroad in the time it took for local entities to either purchase or build their own infrastructure. Space technologies required a large set of skills, not purely scientific disciplines, and some of those skills were transferable from other areas. The key to persons acquiring knowledge and bringing it back to their own country was to identify persons who were

willing to acquire those skills and who would not underestimate the challenge of studying abroad and in a foreign language. It was essential to assess those volunteers' motivation and ability to learn before they undertook suitable training.

21. Discussing what motivated developing countries to become spacefaring nations, the speakers noted that both the United Republic of Tanzania and Zimbabwe were looking for opportunities to save money, and were keen to obtain results fast and would therefore be eager to collaborate with other countries if they could fast-track their knowledge acquisition process. For instance, partnering with countries that owned data processing and archiving centres for Earth observation data would be directly beneficial. Regional collaboration could provide cost-effective regional solutions targeting common issues such as supporting agriculture. In other countries, such as Ghana, entrepreneurs felt that they still needed to explain what value space applications could bring in terms of socioeconomic benefits in concrete terms. In that context, collaboration with others could provide information at the technical level, but also advice on how to successfully address politicians. A debate ensued about whether building or buying a spacecraft, or merely accessing the data a spacecraft produced, was the most appropriate first step into space activities. Some speakers were of the view that buying and launching a satellite and then trying to learn from that experience was not the most sustainable way to proceed, especially when such a project relied on support from others. In contrast, others believed that, while the ultimate goal was to build skills locally, that was a slow process during which acquiring a spacecraft would enable entrepreneurs that were developing space applications to start providing them immediately.

22. The second panel discussed the need of new spacefaring nations and non-spacefaring nations to develop an industry and space ecosystem. It brought together five representatives from different regions of the world (Australia, Brazil, Maldives, Nigeria and Peru), each at a different stage of developing capabilities. The speakers were from the public sector, academia and private companies and provided their own perspective on what had enabled a space economy to start and grow. Although one country had only recently started to use space applications provided by third parties, others had already established an industry that was able to develop technology and offer commercial services. The panellists discussed the extent to which international collaboration had been instrumental in the acquisition of skills and the development of a local workforce. One speaker, explaining her experience of partnering with entities in India, stressed that while Australia had not been as advanced, contrary to her expectations, all persons contacted had been willing to help. She recommended contacting potential partners in well-developed ecosystems and taking advantage of government initiatives to initiate bilateral discussions, such as trade delegations and consulate networks. Panellists agreed that partnerships were more productive when needs had been clearly identified beforehand, with measurable goals and concrete objectives. Some of the speakers had benefited from partnering with private entities, while others had experienced difficulties in clarifying data ownership within joint projects.

23. The role of government policy varied between countries; while in Brazil it was perceived as mostly necessary for enabling a secure regulatory environment for industry to act, in Australia the Government had been driving development, introducing space-related topics to the education system and providing incentives for industry-led initiatives. In many African countries, Governments played a prevalent role in supporting the growth of the space sector. Defining a space policy was considered a good first step for Governments of non-spacefaring countries to initiate activities, especially when policies using space-based applications were linked to socioeconomic development. One such example was the development in Maldives of early warning systems that use Earth observation data and satellite communication to build resilience to the climate crisis. Capacity-building relating to space applications and space-based infrastructure had been carried out in parallel to local economic development.

24. The panellists discussed what incentives had successfully led to the creation of a sustainable space economy locally. In some countries, the private sector still needed to evolve from having a risk-averse mindset, with industry waiting for government procurement for public projects. In contrast, in countries with a thriving space ecosystem, industry had been influencing government consultations, actively advocating for more activities. There was no point in creating an industry if there were no customer; even where start-ups and small companies had been created following government incentives, such as in Australia and Peru, sustainable demand from local customers was required to sustain the sector economically. In addition, the role of civil society was essential in building professional networks and a community of practice. Besides raising the level of interest in space-related activities by showing why space mattered for economic development, civil society could also initiate capacity-building by bringing together entities with mutually beneficial interests.

25. In the session on education in space engineering, a range of initiatives for university students to acquire technical skills were presented. Azerbaijan had been involved in satellite development for many years. Education in aerospace engineering was available, with advanced courses on the design, production and technical operation of rockets and spacecraft. Undergraduate students also had access to specific courses and competitions to design small satellites. The Mexican Space Agency had been testing a dual education model whereby students enrolled in robotics engineering or computer science took part in three successive Agency projects. Directly involving students provided mixed results; students needed fundamental knowledge first and Agency staff members were not trained to be teachers, but working at the Agency equipped them well for a job in the future and provided them with access to infrastructure, such as robots, that would otherwise not be available at university. In Jordan, training had initially been carried out using NASA kits for space education, before the speaker's team decided to develop their own kit and build a CubeSat. Webinars, such as those offered by the Office for Outer Space Affairs, provided theoretical knowledge and partially substituted on-site mentoring, but students needed to be able to see the physical model to learn effectively. The CubeSat had been built using open-source resources and low-cost, low-power technology. A ground station had also been developed for that purpose, since there were previously none available in the country; the team was currently looking for a launch opportunity.

26. The University Space Engineering Consortium-Global (UNISEC-Global), an international non-profit, non-governmental organization, had been developing training and capacity-building initiatives in space science and technology since 2013, on the basis of the principle of leaving no one behind. Some of the activities, such as the contest to design an innovative, affordable and technically achievable satellite mission, did not require access to specific technical resources, only brainpower and an Internet connection. UNISEC-Global had taught trainers from 54 countries how to develop a CanSat since 2011 and had carried out 10 training events on CubeSats for 53 countries since 2015. UNISEC-Global was organized with local chapters that promoted and supported practical space projects at the university level; they had met regularly during annual global events since 2013. Kazakhstan had a long history of carrying out technical aerospace activities and was currently operating three types of satellites produced with the Russian Federation or with France, as well as a ground control centre in Astana and communication infrastructure. Several universities provided education in space engineering and technology or in Earth remote sensing, up to the Master's and PhD levels. In order to provide spacecraft design experience to teachers and opportunities for students to do practical work, despite its limited financial means, the Eurasian National University was partnering with two local companies active in the space sector.

27. In the Bolivarian Republic of Venezuela, the Bolivarian Agency for Space Activities needed scientists, engineers and technicians, as well as contract specialists and administrative staff, and was designing a space education programme. The programme was focused on space robotics and artificial intelligence, with the following three pillars: self-development, artificial intelligence-powered teaching and mentoring,

and collaborative working. Skillsets were transferable from aerospace engineering courses that already existed, with topics such as entrepreneurship added to enable university students to develop their own business model. The Iranian Space Agency had been carrying out project-oriented training with Earth observation microsatellites for university students since 2016. Competitions had been organized, for instance with the mission to test inter-satellite links and formation flying, as well as an aircraft surveillance payload. A total of 21 teams had submitted an initial proposal, 10 had progressed to a preliminary design, 5 had done the detailed design and 3 had built the engineering model. As no launcher was available, the satellites were not launched but the learning opportunity had been fruitful and the Agency was proposing a similar international competition to the Asia-Pacific Space Cooperation Organization.

28. The final panel discussion of the first day brought together awardees and partners of the Access to Space for All initiative. The Office for Outer Space Affairs provided an overview of the activities carried out so far. All opportunities were accessed following a competitive process and three opportunities were currently open for applications (DropTES, HyperGES and KiboCUBE). The four speakers provided feedback on their own experience of participating in the initiative and in collaborating with the Office.

29. The representative of the German Center of Applied Space Technology and Microgravity (ZARM) explained how experiments were dropped within a capsule in the Center's 110-metre-high tower, and how experiments could be launched with a catapult in the same tower; each option provided 4.7 seconds or 9.3 seconds of microgravity, respectively. ZARM had been collaborating with the Office since 2014, selecting teams on a competitive basis, and was currently waiting to receive proposals from a ninth round of applications. The Kyushu Institute of Technology (Kyutech) was keen to democratize space technology by offering opportunities to develop and use nanosatellites and microsatellites, such as CubeSats. Those satellites, with their low price and short development time, were a suitable entry-level activity for newcomers to the space sector. Since 2013, Kyutech and the Office had been providing scholarships to attend their international space engineering course. In addition, Japan was offering the possibility to launch CubeSats from the International Space Station, notably under the KiboCUBE programme.

30. Winners of past opportunities from Bolivia (Plurinational State of) and Kenya discussed their respective experiences and explained how taking part in the Access to Space for All initiative had helped them acquire skills. The Kenya Space Agency had availed itself of several opportunities, notably to access equipment (hardware and software) and space-related infrastructure. Thanks to the initiative, the Agency had built a local workforce with competencies in space engineering, space science and space law. Since 2015, Bolivian Catholic University had been selected twice to carry out microgravity experiments (DropTES), and it was about to undertake experiments in augmented gravity (HyperGES). Besides providing direct benefits to the students involved and attracting more students to technical fields, the teachers and tutors also benefited from mentoring and networking opportunities provided by the initiative and by the Office. The Office had witnessed how the Access to Space for All initiative had successfully enabled several countries to become spacefaring nations within a few years and was interested in widening the range of opportunities that could be offered.

31. The IAF Vice-President for Relations with International Organizations opened the second day of the Workshop by explaining what education and mentoring opportunities were being made available by the Federation. IAF was focusing on sustainability, with specific initiatives for academia and students, as well as workforce development to address inequalities in terms of geography, generation and gender, with a mentorship programme. He invited attendees to take advantage of those offers.

32. The session on university-level education in developing and using space applications brought together four speakers from developing countries, who explained what courses were available. The Inter-Islamic Network on Space Sciences and Technology (ISNET) promoted cooperation on space activities and offered workshops

and online courses. A knowledge repository was available, with information on those courses, as well as presentations and lectures for course participants. Several workshops on space applications organized at various locations had been followed by technical projects on specific applications, to encourage tangible outcomes locally. In Nepal, the Centre for Space Science and Geomatics Studies had established a laboratory for training students on satellite navigation and was collaborating with organizations in Australia, Canada and Japan. It was also involved in the Office's Space for Water activities, with a project on crop loss owing to monsoon floods.

33. India had a large range of academic courses on space applications, with training centres distributed throughout the country, including the regional centre affiliated with the United Nations, the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP). Free online geoportals provided access to software, data and resources, as well as software for the visualization of Earth observation data products. A "Space on Wheels" bus was providing training and education on space technology and applications to the general public throughout India. In Peru, no university had a specific training programme on space yet, but some relevant research laboratories existed, such as the image processing laboratory of the University of Science and Humanities. The laboratory was conducting research projects on aerospace systems, including by designing and using clinostats for simulated microgravity research on biological samples. Students at the laboratory mostly came from related disciplines such as systems engineering and electronic engineering.

34. In response to questions from the audience, the speakers recommended taking advantage of opportunities to connect with other organizations, such as by applying for observer status with ISNET or joining the UNispace Nanosatellite Assembly and Training by ISRO (UNNATI) programmes. Discussing brain drain, all speakers acknowledged that they faced similar challenges in retaining talented students owing to the limited range of space-related job opportunities; graduates either moved to other professional fields entirely, or moved abroad to work in the space sector. The speakers wished that there was greater awareness at the government level, with specific programmes to encourage scientists to return and financial support to create start-up companies locally, especially for space applications, such as those that India had implemented.

35. The session on university-level education in space policy and law started with a presentation on the International Institute of Space Law (IISL). Created in 1960, IISL was the main global platform of space lawyers and now had members from 50 countries in all regions of the world. IISL offered global education and activities for young generations, notably, the Manfred Lachs Space Law Moot Court Competition, presided over by three judges of the International Court of Justice. A prestigious event held annually during the International Astronautical Congress, the Moot Court Competition had been an incentive for thousands of law students to get acquainted with space law and to network with their peers. The University of Colombia had created the Latin American and Caribbean Space Network (RELACA) of academics and researchers in space law and policy. Network members provided training courses and published books on space law and policy, with national points of contact in 10 countries and annual international meetings held since 2017. Since 2020, the Network had been the organizer of the Latin American round of the Moot Court Competition.

36. Until recently, Brazil had no space law courses; the speaker from the Brazilian Space Agency explained how he had launched a new post-graduate course in the country after having graduated abroad. Working with the well-recognized Catholic University of Santos, he had involved researchers in space law and policy in developing the curriculum for that pedagogical project, but had also included content from other space-related fields such as international affairs and technical topics. The course was primarily taught in Portuguese and aimed to attract more international students, in particular those from the Community of Portuguese-speaking Countries. A new offer in Spanish and English would also attract students from Latin American countries where similar courses were not available. In Nigeria, the African Space

Leadership Institute had recently been founded, following the launch of a space programme by the African Union. Persons from the region rarely participated in international policy and law meetings because of limited funds and a gap in knowledge in the region; more training opportunities were required. The Institute was offering training courses and resources on space law, and organized events such as the United States-Africa Space Partnership round table convened last year. The speaker from the African Space Leadership Institute noted that courses needed to address not only the governance of outer space, but also the governance of space institutions.

37. An overview was given of the state of development of space law in the South Caucasus region, comparing the situation in Armenia, Azerbaijan and Georgia. While both Armenia and Azerbaijan had a specific law on space activities and a national space agency, Georgia had no space agency and the few space-related activities there were carried out by a non-governmental organization. None of the main universities in the three countries had a specific course on space law and policy. Two universities in Georgia, the Business and Technology University and the New Vision University, were collaborating on a summer course that would include the topics of space law and policy, in addition to topics such as applications of artificial intelligence and blockchain technology in space. In the ensuing discussion, the speakers noted the rising demand for space law and policy courses around the world and welcomed opportunities such as the Office's Space Law for New Space Actors project.[2] They also stressed the importance of social media for networking and meeting experts in the discipline.

38. The session on lessons learned in building education opportunities brought together speakers from developing countries in Africa and Asia, which all faced similar challenges to other developing countries: limited resources, a lack of infrastructure and dependence on other countries for components or for the manufacture of spacecraft, with related import and export issues. They also faced intense competition when bidding for opportunities in the space sector at the international level. Speakers recommended starting small, seeking international collaboration and public support with a long-term commitment and diversifying funding sources. The Egyptian Space Agency was seeking to evaluate the effectiveness of the various space education programmes for school pupils and university students that it had provided since 2016. One university programme had been designed so that graduation projects produced technical parts or systems directly related to projects of the Space Agency. Integrating space science and technology education into school curricula was providing better results than teaching the topics separately. Similarly, teaching students about space technology as part of engineering courses at university led to a remarkable increase in the use of satellite laboratories once professors understood how to integrate the topic of satellites into the topics they were already teaching. Training camps led to a substantial surge in business creation and better quality proposals for acceptance in business incubators.

39. The speakers from Nepal and Thailand explained how they had developed training on how to build satellites. The first Nepalese satellite had been built in Japan and members of that team, once back in Nepal, had trained the next generation of engineers. Non-technical difficulties were more of an obstacle than technical issues in Nepal. CubeSats of increasing size had been built as part of high school projects. Obtaining support from other countries, notably through mentoring, had been instrumental in that success. In Thailand, the Thailand Earth Observation System (THEOS) had been conceived as a technology transfer initiative with the United Kingdom of Great Britain and Northern Ireland to develop a satellite industry locally. GISTDA had a licence to rebuild the spacecraft acquired from the United Kingdom under the technology transfer agreement and was now providing training within Thailand. In Nepal, obtaining media coverage and appealing to private companies regarding their corporate social responsibility had been a successful approach to securing funding for training programmes. In Thailand, the creation of courses in a

[2] www.unoosa.org/oosa/en/ourwork/spacelaw/capacitybuilding/advisory-services/index.html.

hybrid format had reduced the cost and made it possible to start a three-step process with 200 trainees; basic training was provided online, followed by advanced courses, then hands-on training for several months in three small groups of 10 participants each.

40. The last two speakers discussed how to embed space activities within society and attract a wide range of talents, as the space sector ecosystem needed more than aerospace engineers. Some countries were of the view that building satellites should be the first project to start an ecosystem. The alternative was to first build an ecosystem based on existing expertise and established industrial sectors, focus on downstream applications, encourage private sector involvement and reframe what "space" stakeholders meant. In order to justify and motivate investment, Governments needed to understand and clarify the genuine and immediate issues that space could address. The speakers provided examples such as food supply in Rwanda, bushfires in Australia and connectivity in the Philippines. Role models and storytelling were a powerful way to attract a workforce and to increase its diversity, while mentoring was the most impactful outreach method for nurturing new talent.

41. The session was followed by a panel discussion on lessons learned in building a space ecosystem. The six speakers considered the advantages of developing services based on space applications versus developing manufacturing capacity, depending on the local context. The representative of the Italian Space Agency stressed the importance of first establishing a solid education system relevant to space activities that could be nurtured by many other disciplines and by international collaboration, before transferring knowledge and competencies from academia to industry. Bhutan had been using satellite data before the space sector had been developed domestically, mostly for hydropower and for mapping water resources. As the cost of acquiring those satellite data increased, it made economic sense for the country to start generating data on its own. In Slovakia, where research and development in electronics and computer science was already being carried out, the electronics and computer science industries had been a good entry point into the space sector, notably because return on investment in those industries happened faster than with other types of technologies. The representative of the African Union noted that both the upstream and downstream parts of the space value chain needed to grow concurrently. Each country was already a user of space applications. Acquiring the capabilities to develop satellites and infrastructure for the space sector depended on other types of skills.

42. The speakers discussed factors that could incentivize the development of space activities, the respective impact of public and private entities and the role of young people. In Lesotho, where basic computing skills did not always exist, the first step had been to create awareness and spark interest among young people. In Bhutan, development had been driven by government policies and frameworks involving public entities rather than by promoting a private sector. In contrast, some African countries encouraged development within the private sector. In Slovakia, private companies and academia had been working in space activities without first having a comprehensive framework. Industry had then started building the space ecosystem. An explicit political will to commence space activities was perceived as essential by several speakers. Such government messages promoted long-term commitment and encouraged investment. Space activities must be perceived as a tool to improve socioeconomic circumstances and policies must be developed in a way that kept future generations and future growth of the space sector in mind.

43. The speakers provided concrete examples of recommendations they would make to newcomers and to non-spacefaring countries. A starting point was to assess what motivated the development of new capabilities and how the existing ecosystem in various established economic sectors could contribute. Without downplaying resistance to change and challenges, the speakers stressed that many international cooperation programmes existed and could be used, as could support from intergovernmental organizations that were active in the space sector. Helping academia to prepare an appropriate curriculum and to generate ideas through activities such as competitions or hackathons were instrumental. At the personal level, those

interested in initiating space-related activities where there were none should focus on good communication and networking and not expect immediate success. Finding like-minded individuals and mentors was rendered even easier by social media and online networking platforms; in some cases, government schemes incentivized expatriates to return and become entrepreneurs in their home country.

44. An interactive activity called “building partnerships” was organized at the end of the day, in which speakers and attendees were invited to discuss their needs and what capacity-building activities they could offer to others in relation to 10 topics ranging from space law to technical training. To enable further networking among participants, a reception was offered by IAF later that evening.

45. The last session of the Workshop, on the third day, presented education initiatives at the level below universities. They included training within secondary schools, after-school activities and initiatives involving the general public. The NASA Astrobee robots on board the International Space Station were used to encourage middle-school pupils to learn to code, with a graphical interface and a simulation environment to practice. The code could be tested on robots in a mock-up of the Space Station at the NASA Ames Research Centre before being tested on the real robots on the Space Station. Last year, a competition involved 178 middle schools, with teams of 6 to 10 pupils each and a NASA astronaut moderating the final competition round using the robots on the International Space Station. NASA organized similar programming challenges with various partners, such as the United Arab Emirates and the Navajo Nation. The competition was similar to the JAXA Kibo Robot Programming Challenge. In Ecuador, the Sideralis Foundation space summer camp was aimed at educating participants about space, as well as about the Earth ecosystem, robotics, coding and mental health. In order to develop career skills, the curriculum was designed in the form of modules based on modern education methods and the Scout Movement’s principles. In addition to making adaptations to the curriculum for Guatemala, discussions were under way to customize the content and translate it into Arabic and Romanian, adapting it to the unique context and cultural nuances of the countries in which the courses were to be provided.

46. The two following speakers informed participants about activities in Sri Lanka and Nigeria. The speaker from Sri Lanka, who was currently studying space technology in Japan, explained that school curricula covered the basics about planets and stars but not technology or space applications. Some astronomical societies brought together amateurs, and social media was used to share knowledge about space activities, especially following the launch by Sri Lanka of its first CubeSat in 2019. However, without a space sector in the country, there were no jobs and no university courses on space systems. She was keen to volunteer and presented her plans to raise interest in schools. In Nigeria, the National Space Research and Development Agency had started a programme in 2022 to train African girls and women in space robotics. Its mission was to educate a new generation of girls, equipping them with critical skills that could be directly transferred to other areas, such as solving environmental challenges. In view of the age pyramid in Africa, the programme targeted children. A network of eight countries were involved in hands-on training, with practical courses on space applications. It aimed to include each African country that did not yet have a space agency. One point of entry for newcomers was to partner with local robotics clubs that existed all across Africa. However, space robotics was considered a very advanced topic, and unfortunately, in Africa some children believed it was not suitable for them. More outreach was needed to overcome self-imposed limits, notably, train the trainers programmes for female teachers.

47. The last two speakers reflected on what activities had been successful in engaging young people. For the Space Foundation, which offered a wide range of capacity-building activities relating to space technologies, networking events were key. The Foundation’s activities were open to anyone wishing to share, especially students, teachers and librarians. It was of the view that partnerships among like-minded individuals in the industry were essential for developing a space ecosystem, and it partnered with the Space Generation Advisory Council to organize mentoring.

In the Philippines, the Philippine Space Agency had developed expertise by operating the country's first two satellites and had been developing space applications. The Agency was now targeting its outreach efforts towards young people. "Datacamp" workshops and monthly webinars with engineers and scientists had been held on a regular basis, with high-school students processing geospatial data sets using open-source technology, to build a community of interested persons. Schools were starting to integrate the programme into their lessons. Besides the challenge of a lack of Internet connectivity in rural areas – a problem also faced by other countries – the Philippine Space Agency needed a larger workforce so that staff members could carry out outreach tasks in addition to their usual work.

V. Outcomes of the "building partnerships" activity

48. At the end of the second day, the Office conducted a well-received partnership-building event to connect capacity-building providers and beneficiaries. The participants elected to participate in discussions on the following 10 topics, chosen from a questionnaire sent previously to all participants: (a) workforce development and science, technology, engineering and mathematics; (b) CubeSats; (c) Earth observation; (d) space entrepreneurship; (e) outreach and communication; (f) space systems engineering; (g) satellite communications; (h) space policy; (i) ground infrastructure and testing; and (j) space law and regulation. During the one-hour event, participants rotated once among the topic tables, thereby participating in at least two rounds of discussions.

49. Volunteer topic leaders organized the discussions differently according to the number of participants or the topic. For each topic, participants were separated into capacity-building providers and beneficiaries, and then matched with potential partners. For some topics, the volunteer leaders facilitated discussions focusing on case studies, creating recommendations for further partnership opportunities or sharing lessons learned. The Earth observation group created a social media account to continue sharing knowledge and seek support from peers.

50. The main comment after the event was that it was too short; most participants would have liked a longer, more in-depth partnership session. All participants appreciated the interactive nature. Some suggested that such an event should be held earlier in the Workshop schedule so that participants could continue to interact over the two and a half days. Others felt the quality of the discussions reflected the connections that participants had already made during the Workshop's lunches and coffee breaks. As an appetite exists for more partnership engagement, this event may be featured in future editions of the Workshop.

VI. Conclusions and lessons learned

51. The Office for Outer Space Affairs and the co-organizers concluded the Workshop by seeking feedback from participants and discussing what they had achieved.

52. In his concluding remarks on behalf of IAF, the Vice-President for Relations with International Organizations expressed appreciation for the speakers' contributions and for participants' engagement during the Workshop. He emphasized the importance of the ongoing cooperation between his organization and the Office for Outer Space Affairs for the last 30 years. He invited participants to take advantage of the opportunities offered by the International Astronautical Congress and to take an active role in the IAF committees.

53. The Chair of Azercosmos noted with satisfaction that the audience and the speakers included a wide range of nationalities. He welcomed the information exchange on how developing countries and emerging space nations had been building

capabilities locally and encouraged the attendees to actively continue the discussions after the Workshop.

54. The Director of the Office welcomed the participants' active engagement during the Workshop, notably during the interactive event on building partnerships. She had particularly appreciated the high level of enthusiasm and intense discussions during the breaks. She was convinced that the discussions would be the starting point for collaboration and partnerships and expressed the hope that future editions of the Workshop could be made financially accessible to even more participants from developing countries. She concluded the Workshop by providing an overview of the respective roles of those involved in preparing the event.

55. The Workshop participants were encouraged to provide written feedback using a dedicated online form. The feedback received was overwhelmingly positive; participants rated the event 4.75 out of a maximum rating of 5. Words of appreciation were received both from speakers and attendees. They had particularly valued the "building partnerships" activity, which had provided many participants with a variety of solutions that could be applied to the unique challenges of individual countries, and they had appreciated the opportunity to build relationships that would be beneficial to their work beyond the Workshop.

56. Although remote attendance had not been possible, many participants wished that it had been. Providing an online broadcast of the physical event would decouple attendance from any financial limitations and provide access to the panel discussions, as the various perspectives expressed would not be accessible otherwise. The Office and IAF would consider the cost implications and investigate whether an online platform could be provided at future editions of the Workshop.