United Nations A/AC.105/1086

General Assembly

Distr.: General
23 December 2014

Original: English

Committee on the Peaceful Uses of Outer Space

Report on the United Nations/Mexico Symposium on Basic Space Technology: Making Space Technology Accessible and Affordable

(Ensenada, Baja California, Mexico, 20-23 October 2014)

I. Introduction

1. The United Nations/Mexico Symposium on Basic Space Technology on the theme “Making space technology accessible and affordable” was the third in a series of international symposiums on basic space technology development to be held in the regions that correspond to the Economic Commissions for Africa, Asia and the Pacific, Latin America and the Caribbean, and Western Asia. The symposiums are part of the Basic Space Technology Initiative, which is carried out as part of the United Nations Programme on Space Applications and is aimed at supporting capacity-building in basic space technology and promoting the use of space technology and its applications for the peaceful uses of outer space and in support of sustainable development (see www.unoosa.org/oosa/en/SAP/bsti/index.html).

2. The Symposium was organized by the Office for Outer Space Affairs of the Secretariat and hosted by the Center for Scientific Research and Higher Education at Ensenada, Baja California, Mexico, and the Mexican Space Agency, on behalf of the Government of Mexico, and was held at the Center’s campus in Ensenada.

3. The present report contains a description of the background, objectives and programme of the Symposium, summaries of the presentations made during its technical sessions and panel discussions, and the recommendations and observations made by the participants. The report is prepared pursuant to General Assembly resolution 68/75. It should be read in conjunction with the reports on the three United Nations/Austria/European Space Agency symposiums on small-satellite programmes held between 2009 and 2011 (see A/AC.105/966, A/AC.105/983 and A/AC.105/1005), the report on the United Nations/Japan Nanosatellite Symposium (A/AC.105/1032) and the report on the United

Nations/United Arab Emirates Symposium on Basic Space Technology (A/AC.105/1052).

A. Background and objectives

4. The United Nations Programme on Space Applications was launched as a result of discussions at the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE), held in Vienna in 1968. The Programme is implemented by the Office for Outer Space Affairs and provides support to capacity-building in space technology and its applications to all States Members of the United Nations, independent of their level of economic development. The initial focus of the Programme was on the applications of space technology in, for example, satellite communications, Earth observation and positioning and navigation services.

5. Advances in technology, as well as the adoption of philosophies of technology development that accept a higher, but still reasonable, level of mission risk, have resulted in increasingly capable small-satellite missions that can be developed with an infrastructure and at a cost that make them feasible and affordable for organizations such as academic institutions and research centres that have a limited budget for space activities. The many benefits that can be derived from such activities have led to an increased interest in establishing basic capacities in space technology development, including in developing countries and in countries that had previously only been users of space applications.

6. In response to that interest, the Basic Space Technology Initiative was added as a new cornerstone to the United Nations Programme on Space Applications in 2009, pursuant to its mandate to stimulate the growth of indigenous nuclei and an autonomous technological base, to the extent possible, in space technology in developing countries, with the cooperation of other United Nations entities and/or Member States, as set out in General Assembly resolution 37/90.

7. The Initiative focuses on the development of affordable, small-satellite platforms with a mass below 150 kg and on the associated technical, managerial, regulatory and legal issues. It supports capacity-building in basic space technology and its applications for the peaceful uses of outer space in support of sustainable development and, in particular, their contribution to achieving internationally agreed development goals, including those set forth in the United Nations Millennium Declaration (General Assembly resolution 55/2), as well as those set out in the Plan of Implementation of the World Summit on Sustainable Development,[1] the Johannesburg Declaration on Sustainable Development[2] and the outcome document of the United Nations Conference on Sustainable Development, entitled "The future we want".[3]

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[1] *Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August-4 September 2002* (United Nations publication, Sales No. E.03.II.A.1 and corrigendum), chap. I, resolution 2, annex.

[2] Ibid., chap. I, resolution 1, annex.

[3] General Assembly resolution 66/288, annex.

8. The Basic Space Technology Initiative began with the holding, in 2009, 2010 and 2011, of three United Nations/Austria/European Space Agency symposiums on small-satellite programmes. The first symposium addressed general issues related to capacity-building in space technology development and small-satellite development activities. For the second symposium, the theme "Payloads for small-satellite programmes" was chosen. The third symposium focused on the theme "Implementing small-satellite programmes: technical, managerial, regulatory and legal issues". The theme of the United Nations/Japan Nanosatellite Symposium held in 2012 was "Paradigm shift: changing architecture, technologies and players" and the theme of the United Nations/United Arab Emirates Symposium on Basic Space Technology held in 2013 was "Small-satellite missions for developing space nations". The objectives of the Symposium that is the subject of the present report were:

(a) To review the status of capacity-building in basic space technology, including lessons learned from past and ongoing small-satellite (below 150 kg) development activities, with a focus on regional and international collaboration opportunities, in particular for countries in Latin America and the Caribbean;

(b) To examine issues relevant to the implementation of small-satellite programmes, such as organizational capacity-building, development and testing infrastructure, and launch opportunities;

(c) To review state-of-the-art small-satellite programmes in the field of Earth observation and disaster management;

(d) To examine regulatory issues relating to space technology development programmes, such as frequency allocation and space debris mitigation measures for the long-term sustainability of outer space activities, and to import and export controls;

(e) To examine legal issues and responsibilities related to space technology development programmes, such as those emanating from the relevant provisions in international space law;

(f) To continue the development of an education curriculum for space engineering;

(g) To review the existing space applications for early warning systems and discuss future collaborative projects in the field;

(h) To discuss the way forward for the Basic Space Technology Initiative.

B. Attendance

9. Participants in the Symposium were selected on the basis of their academic qualifications and their professional working experience in space technology development or their involvement in the planning and implementation of the small-satellite programmes of relevant governmental organizations, international or national agencies, non-governmental organizations, research or academic institutions or private sector companies.

10. The invitations to participate in the Symposium were disseminated through the offices of the United Nations Development Programme and permanent missions to the United Nations and through various publications and mailing lists related to space technology development. Applications from qualified female applicants were particularly encouraged.

11. The Symposium was attended by 159 space professionals involved in nanosatellite and small-satellite missions from governmental institutions, universities and other academic entities and the private sector from the following 30 countries: Argentina, Austria, Bolivia (Plurinational State of), Brazil, Canada, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, Germany, Guatemala, India, Israel, Japan, Malaysia, Mexico, Nicaragua, Poland, Republic of Korea, Russian Federation, Saudi Arabia, South Africa, Spain, Turkey, United Kingdom of Great Britain and Northern Ireland, United States of America, Uruguay and Venezuela (Bolivarian Republic of).

12. Representatives of the Office for Outer Space Affairs and the International Telecommunication Union (ITU) were also among those participating in the Symposium.

13. The Symposium was co-sponsored by the Ministry of Transport and Communications of Mexico, the State of Baja California, the Universidad Autónoma de Baja California, Axon' Cable, Honeywell, and UK Trade and Investment, a department of the Government of the United Kingdom. Funds allocated by the United Nations and the co-sponsors were used to defray the costs of air travel, accommodation and airport transportation for 31 participants. To demonstrate their qualifications, all participants applying for full or partial sponsorship were required to submit an abstract in accordance with the requirements of the Symposium's call for papers. The sponsors also provided funds for the organization and facilities of the Symposium and for the local transportation of all participants.

C. Programme

14. The programme of the Symposium was developed by the Office for Outer Space Affairs, the Mexican Space Agency and Center for Scientific Research and Higher Education, in cooperation with the programme committee of the Symposium. The programme committee included representatives of national space agencies, international organizations and academic institutions. An honorary committee and a local organizing committee also contributed to the successful organization of the Symposium.

15. The programme consisted of an opening session, keynote addresses, eight technical sessions, two panel discussions, a poster session and discussions on observations and recommendations, followed by closing remarks by the co-organizers.

16. During the poster session, a total of 20 posters, covering a broad range of technical topics related to the development of small satellites, were presented.

17. The chairs and rapporteurs assigned to each of the technical sessions and panel discussions provided their comments and notes as input for the preparation of the present report. The full programme, background information and copies of the

presentations given have been made available on the website of the Office for Outer Space Affairs (www.unoosa.org/oosa/en/SAP/bsti/mexico2014.html).

II. Summary of Symposium programme

A. Opening session and keynote addresses

18. At the opening session, welcoming remarks were made by the Director of Decentralized Entities of the Ministry of Transport and Communications, the General Director of the Center for Scientific Research and Higher Education, the Mayor of Ensenada, the Comptroller General of the government of Baja California, the Vice-Rector of the Universidad Autónoma de Baja California, and the representative of the Office for Outer Space Affairs.

19. In the first keynote address, the representative of the University of Surrey and its commercial arm, Surrey Satellite Technology Ltd., a key player in launching the small-satellite revolution, reviewed the history of small-satellite activities and discussed how small satellites were changing the economics of space, making space technology accessible and affordable and thereby allowing an increasing number of countries to join in and contribute to the exploration and peaceful uses of outer space.

20. In the second keynote address, the General Director of the Mexican Space Agency provided a Latin American perspective on the Symposium theme, "Making space technology accessible and affordable". He reviewed the history of space activities in Mexico, which had begun in the 1970s, presented the ongoing and planned activities under the Mexican space programme and gave his view on the outlook for space cooperation in Latin America. In Mexico, the space infrastructure framework was an integral part of the national development and infrastructure plan. The present focus was on two national projects: (a) deploying a satellite early warning system for natural disaster prevention, mitigation and management; and (b) establishing and strengthening human and technical capacities, in particular for telecommunication and science satellite platforms. A key event for Mexico would be the organization of the sixty-seventh International Astronautical Congress, which was to be held in Guadalajara, Mexico, in 2016.

21. The keynote addresses were followed by a presentation by the representative of the Office for Outer Space Affairs on the goals of the Basic Space Technology Initiative and on the objectives of and practical arrangements for the Symposium.

B. Technical sessions

22. Technical sessions were held on the following topics: (a) space technology development activities in Latin America and the Caribbean; (b) capacity-building in basic space technology development; (c) small satellites for Earth observation and disaster management; (d) small-satellite projects for engineering education; (e) education curriculum on space engineering; (f) regulatory and legal issues; (g) use of space technologies for early warning systems; and (h) international experiences. The presentations made during the sessions were selected on the basis of a review of all the abstracts submitted in response to the Symposium's call for

papers. Highlights of and major discussion points raised during the sessions are summarized below.

1. Space technology development activities in Latin America and the Caribbean

23. During the session on space technology development activities in Latin America and the Caribbean, the status of space technology development activities in various countries of Latin America and the Caribbean was highlighted. The focus was on the different approaches towards capacity-building taken in Argentina, Bolivia (Plurinational State of), Colombia, Costa Rica and Mexico.

24. In the first presentation, the representative of the Space Agency of the Plurinational State of Bolivia spoke about the country's Tupac Katari-1 (TKSAT-1) telecommunications satellite and its applications for national social development. The Agency, in cooperation with Chinese partners, was working on the development of a national remote sensing satellite programme.

25. Libertad-1 had been launched in April 2007 and was the first satellite of Colombia. Libertad-2, a 4-kg nanosatellite with an optical camera for Earth observation, was under development at the Universidad Sergio Arboleda in Colombia. The Libertad-2 programme was coordinated together with the Colombian Space Commission and was aimed at promoting aerospace capacity-building.

26. The Center for Scientific Research and Higher Education had been involved in various space technology and application activities since 1976. Its present focus was on tele-epidemiology applications by satellite and on the development of SATEX-2, a 50-100-kg experimental microsatellite project that involved Mexican academic institutions, universities and research centres and that was aimed at building Mexican human resource capacity in the field of space technology development. The Center was also participating in the development of two nanosatellites for the Mexican Space Agency, a three-unit Cubesat with a video sensor in the visible spectrum, and a 1-unit Cubesat to test a stabilization and attitude control subsystem designed by the Center.

27. The representative of the Central American Association for Aeronautics and Space, a non-profit organization working to promote and develop Central American talent in the aerospace field, presented considerations for identifying opportunities for developing the aerospace sector in Central American countries. The Association was leading the DSpace satellite project, on the transmission of carbon dioxide concentration data from remote locations in Costa Rica.

28. The session concluded with a presentation by the representative of the Argentine Association for Space Technology, who offered an overview of the space history of Argentina and the country's ongoing satellite and launcher development activities. He also proposed the promulgation of a new standard for a small satellite platform offering a larger payload volume and accommodating more powerful payloads compared with the existing Cubesat quasi-standard.

2. Capacity-building in basic space technology development

29. The session on capacity-building in basic space technology development covered the latest developments in space technology development capacity-building and examples were presented of training programmes and human resources

development initiatives, as well as experiences with cooperation and partnership programmes for technology and knowledge transfer.

30. The representative of Honeywell made a presentation on the company's experience with building aeronautical engineering and technology capabilities in Mexico. Mexico was at the forefront of commercial aviation research and experience in the aeronautics field could be used to build space technology development capability. It was important to reach consensus on what should be achieved and to put into place a long-term plan and a strategy with a road map and to fully engage the community, including the relevant government entities and the academic sector.

31. The Satellite Engineering Academy of the Space Commercial Services Holdings Group of South Africa was one of several capacity-building initiatives offered on a commercial basis to meet the need for small-satellite training. The Academy built on the company's extensive experience with small-satellite development and took into account recent advances in satellite engineering and the impact on human capital development. Participants in the Academy could gain hands-on experience by developing a 20-kg-class satellite with a hyperspectral optical payload.

32. The representative of Johns Hopkins University presented a study on complex international science technology and innovation partnerships, with a focus on collaborative satellite projects and international university partnerships. Over 15 countries had implemented such partnerships with regard to satellites, which often involved multiple stakeholders and objectives, complex organizational relationships and significant financial investment over a long period. The study looked at how best to design complex international science technology and innovation partnerships to meet established goals and how to assess their performance.

33. Berlin Space Technologies of Germany studied different business models for small-satellite development capacity-building and technology transfer. It analysed the success of those initiatives by defining success criteria based on a three-level model. The analysis showed that many capacity-building efforts had failed to achieve their objectives and that it was important to create a win-win situation between the client and the training entity. On the basis of that finding, Berlin Space Technologies was offering complete training packages to build sustainable small-satellite programmes and was cooperating with the National University of Singapore in implementing the Kent Ridge 1 mission, a 80-kg-class satellite with three optical payloads.

34. The representative of Wakayama University of Japan presented the first images obtained with the UNIFORM-1 Satellite, a low-cost satellite with a low-cost ground-station infrastructure. On the basis of that satellite's success, the development of a small-satellite constellation, with international cooperation, was proposed under the UNIFORM project. A constellation of satellites would considerably increase the revisit frequency and thus enhance the operational value of the satellites and their applications. Several countries had already concluded cooperation agreements to participate in the programme and discussions with additional potential cooperation partners were ongoing.

35. The Brazilian National Institute for Space Research was supporting space technology development capacity-building. The results and lessons learned from developing, launching and operating the NanosatC-Br1 were presented. Based on the Cubesat platform, the project was aimed at providing a very low-cost space mission to Brazilian researchers. While the 1-unit platform and ground station had been purchased through an international bid, the satellite's payloads, including a fault-tolerant field-programmable gate array, had been developed domestically. Based on that experience, the Institute was in the process of developing the 2-unit NanosatC-Br2 and the 8-unit CONASAT, a data-collection mission.

3. Small satellites for Earth observation and disaster management

36. Over the previous few years, affordable small-satellite platforms had been developed that were capable of delivering medium- to high-resolution imagery for a wide range of geospatial applications. Those platforms could provide useful information in support of disaster risk reduction.

37. The Disaster Monitoring Constellation, an international collaboration involving several countries and private entities and developed under the leadership of Surrey Satellite Technology Ltd., had been a major contributor of space-based information provided in response to activations of the Charter on Cooperation to Achieve the Coordinated Use of Space Facilities in the Event of Natural or Technological Disasters (also called the International Charter on Space and Major Disasters). The satellites were also used for a wide range of other applications, such as crop and forest monitoring and geoscience applications. The third, improved generation of Disaster Monitoring Constellation satellites would be launched in 2015. A complementary, low-cost S-band synthetic aperture radar satellite constellation was under development.

38. The presentation by the representative of NewSpace Systems South Africa focused on what was the right size for an operational satellite. It covered technical, cost and reliability issues in small operational satellite missions and provided useful metrics relevant for the sizing of satellite missions. The representative concluded by recommending that the overall cost of the service should be considered instead of taking into account only the cost of developing the satellite.

39. A representative of the Universidad Nacional Autónoma de México reported on the development and preliminary validation of a Cubesat-compatible nanosatellite bus. The SATEDU Educative Satellite Project had begun in 2008 and was aimed at building human capacity in space technology development. A secondary objective was the creation of a multipurpose Cubesat platform to support satellite activities in Mexico and applications in fields such as remote sensing, climate change research and environmental monitoring.

40. The project manager for the remote sensing satellite project of the Bolivarian Republic of Venezuela (VRSS-2) discussed the country's experience with remote sensing data management, focusing on factors relevant to developing countries. VRSS-2, building on the experience with the VRSS-1 System (Satélite Miranda) that had been launched in 2012, would be assembled and tested by the Bolivarian Agency for Space Activities and was expected to be launched in 2017. The data management system, which was under development, would support the country's

e-government initiatives, allowing access to the data by the public, clients and Government through a dedicated website designed by engineers from the Agency.

41. Synthetic Aperture Radar was a weather- and daylight-independent sensor solution for Earth observation applications. Application areas encompassed all the dynamic processes of the Earth's sphere. The German Aerospace Centre had a long history of experience with Synthetic Aperture Radar missions, including TerraSAR-X, TanDEM-X, Sentinel-1 and the TanDEM-L mission, which was under development. Synthetic Aperture Radar was a promising technology for disaster management applications and could also be realized, with relaxed requirements, using smaller satellite platforms.

42. The final presentation of the session covered the impact of small-satellite missions on technology development in developing countries. The presenter, who also represented the Mexican Talent Network, Germany Chapter, recommended that countries in Latin America and the Caribbean should seek detailed collaboration agreements based on strategic partnerships, the desire to seek long-term solutions and the need to develop a regional road map on space technology based on a shared programme to which countries in the region could contribute.

4. Small-satellite projects for engineering education

43. Participants in the session on small-satellite projects for engineering education reviewed small-satellite projects that provided hands-on experience and opportunities for students to participate in actual space missions.

44. The first presentation comprised an overview of the space technology education and student projects at the Warsaw University of Technology. A student space association had been established in 1996 and had been involved in nearly 50 space missions. The association was focusing on the PW-Sat2 satellite project, which would also test a de-orbit solar sail as a possible way of mitigating space debris.

45. The representative of the Herzliya Science Center and the Israel Space Agency gave a presentation on the Duchifat project (Duchifat being the name of the national bird), the first Israeli nanosatellite designed, developed and operated by high-school students, which had been launched in June 2014. The group was involved in assembling a two-unit Cubesat that would contribute to the QB50 constellation mission. It was the only QB50 team involving high-school students, showing that small-satellite development activities were possible at the high-school level.

46. The University of Tokyo had a long history of successful small-satellite projects for engineering education and beyond. More than 500 students from 26 universities had been involved in those activities since 1999 and had been given the opportunity to be involved in the full cycle of a space project, from defining the general mission concept to the launch and operation of the satellite. The University of Tokyo was developing the next generation of advanced 50-kg-class Hodoyoshi satellites. The project organizers welcomed international cooperation and the transfer of knowledge to developing countries.

47. University Space Engineering Consortium-Global was a non-profit organization comprising members from universities and academic institutions from around the world. It had been established with the goal of involving, by the end

of 2020, university students from more than 100 countries in space technology capacity-building activities. The organization was organizing the CanSat Leader Training Program and the Mission Idea Contest, which were open to international participants.

48. The role of small satellites in workforce development was discussed by one of the developers of the Cubesat quasi-standard. The Cubesat activities at the California Polytechnic State University had resulted in the creation of a start-up company called Tyvak, which offered advanced nanosatellite system services. It was just one of many examples demonstrating that commercialization was an important part of the Cubesat value chain. Small-satellite projects were an ideal hands-on education tool for use in the training of a skilled workforce that would be employable in a wide range of industries.

49. The final presentation, by a representative of the Universidad Nacional Autónoma de México, covered experiences with using a stratospheric balloon platform for testing space systems as a cost-effective alternative to actual in-orbit testing. The advantages of using such a platform were the ability to recover the payload after flight and avoiding the creation of mission-related space debris.

5. Education curriculum on space engineering

50. The development of an education curriculum on space engineering was part of the workplan of the Basic Space Technology Initiative. In the session on the curriculum, international education experts were invited to contribute to the curriculum's development. It was expected that the space engineering curriculum would be finalized in 2016.

51. The session began with a presentation on the status of the education curriculum on space engineering. Education curricula are developed for use in the regional centres for space science and technology education, affiliated to the United Nations, as well as in all other academic institutions with an interest in space technology development.

52. Representatives of the Universidad del Valle in Guatemala, the Kyushu Institute of Technology and the University of Tokyo in Japan, the University of Florida in the United States, the Brazilian National Institute for Space Research and the Space Generation Advisory Council reported on their activities related to space engineering education and made recommendations for the space engineering education curriculum.

53. The current draft version of the curriculum was presented and opened for input and ideas from the Symposium participants. A working group was established that further refined the scope of the curriculum and made recommendations for hands-on and project-type activities.

6. Regulatory and legal issues

54. The session on regulatory and legal issues covered the regulatory and legal issues of small-satellite programmes. The representative of the Office for Outer Space Affairs discussed the registration procedures for satellites with the United Nations, the liabilities of launching States, space debris mitigation guidelines and

the status of the discussions on the long-term sustainability of outer space activities in the Committee on the Peaceful Uses of Outer Space.

55. Representatives of the Sergio Arboleda University in Colombia and the University of Vienna made presentations on the responsibilities of States with regard to the authorization and supervision of the space activities of its nationals and on the role of national space legislation.

56. The representative of ITU conducted a workshop on frequency registration for small-satellite missions. The workshop materials are available for download from the Symposium website.

7. Use of space technologies for early warning systems

57. Space technology and its applications could make significant contributions as integral components of early warning systems. The session on the use of space technologies for early warning systems comprised presentations on relevant ongoing and planned small-satellite missions.

58. The development of the HUMSAT constellation, led by the University of Vigo in Spain, was an activity endorsed by the Basic Space Technology Initiative. The presentation covered the Brazilian contribution to HUMSAT, which provided global low-data-rate transmission services for data gathered by ground-based sensor networks. The data could be delivered to users' smartphones and the use of the constellation for various store-and-forward-based applications was being explored.

59. The presentation by the representative of the Ames Research Center of the National Aeronautics and Space Administration (NASA) of the United States covered the optimization of distributed small-satellite networks and their role in establishing an Earth-orbit infrastructure. In a distributed network, the payload capabilities, normally resident on a single spacecraft, would be separated over multiple heterogeneous satellite modules that could share a common wireless data network.

60. The Condor UNAM-MAI project was a collaborative satellite mission between the Russian Federation and Mexico that was aimed at promoting academic exchange and science and technology demonstrations. The satellite payload would monitor the Earth's atmosphere for the study of ionospheric precursors of earthquakes.

61. The societal requirements for early warning systems were being studied at the Mexican space agency. There were currently no indigenous remote sensing satellites operated by Mexico and the country therefore relied on international cooperation to obtain satellite imagery relevant to its national interests. Under its national space infrastructure plan, Mexico was considering the development of a small-satellite constellation to address its space-based data needs.

62. The Space Flight Laboratory of the Institute for Aerospace Studies at the University of Toronto of Canada had carried out several successful small-satellite programmes. It had also launched several vessel-monitoring satellites, such as AIS SAT-1 and AIS SAT-2, which were utilized by Norway for maritime monitoring along its coastline. AIS SAT-3, carrying an advanced AIS receiver, was under development.

63. The final presentation, by the representative of the Mexican Talent Network, United Kingdom Chapter, covered design drivers, challenges and requirement trade-off considerations for the development of high-resolution Earth observation payloads.

8. International experiences

64. The final technical session was on international experiences and covered capacity-building in space technology development in Chile, China, Colombia, Egypt, Malaysia and Turkey.

65. The representative of Astronautic Technology (M) Sdn Bhd of Malaysia presented the TiGA-U three-unit Cubesat standard satellite bus. The status of small-satellite projects within the Turkish University Space Engineering Consortium (UNISEC) was discussed by the representative of Istanbul Technical University. The representative of the National Authority for Remote Sensing and Space Science presented recent developments in the Egyptian space programme and the representative of Beihang University in Beijing discussed the university's small-satellite programmes in support of basic space technology capacity-building.

66. The Dandelion Cubesat-based mobile exploration platform had been developed at the Universidad Austral of Chile. The rover design could transverse rugged terrain and had caught the attention of NASA and a number of other potential partners. Lastly, the presentation by the representative of the Universidad Distrital Francisco Jose de Caldas in Colombia covered the use of small satellites for training and for developing telemedicine applications in Colombia.

C. Panel discussions

67. Panel discussions were organized on the following topics: (a) prospects, plans and visions for regional cooperation in space technology development among countries in Latin America and the Caribbean; and (b) best practices to develop capacity-building in basic space technology.

1. Prospects, plans and visions for regional cooperation in space technology development among countries in Latin America and the Caribbean

68. In their discussions, the panellists from Costa Rica, Ecuador, Mexico and Venezuela (Bolivarian Republic of) discussed the status of space technology development in Latin America and the Caribbean. They reflected on the prospects, plans and visions for regional cooperation, the opportunities and potential challenges.

69. The panellists concluded that the different countries in the region had different levels of capacities, capabilities and experiences with regard to space technology development. Technology cooperation worked best among partners with similar levels of development and with common interests, such as in specific applications. It was recommended that existing cooperation frameworks, for example, the Space Conference of the Americas and the Latin American Alliance of Space Agencies, should be adopted and strengthened. It was noted that the development of a

nanosatellite constellation could offer opportunities for closer cooperation among countries in the region.

2. Best practices to develop capacity-building in basic space technology

70. The panellists from Colombia, Japan, Mexico, South Africa and the United States had considerable experience with capacity-building in basic space technology development. They discussed how small-satellite missions could lead to or complement and enhance larger, more complex satellite missions and if and how small-satellite projects could contribute to creating business opportunities for the private sector.

71. The panellists agreed that small satellites could complement larger, more expensive satellite missions by providing complementary services or by reducing mission cost and the consequences of mission failure.

72. They noted that small-satellite projects could create business opportunities, including in developing countries, as proven by the Libertad-1 satellite mission of Colombia, which had resulted in the establishment of Sequoia Space, the first company in Latin America offering complete space missions for sale. Small satellites in the sub-150-kg-class were moving into the commercial application phase, as demonstrated by commercial companies such as Planetlabs and Skybox, and were increasingly attracting venture capital. Profit could be made in the upstream applications: future business opportunities could be found through identifying application niches and services or through becoming a supplier of unique mission hardware.

73. A further positive aspect of small-satellite development activities was in human resources training. Experience in Japan had shown that trained students could quickly move to jobs in the large satellite industry and that their skills were also easily transferable to other industry sectors.

74. A university satellite project faced the same legal and regulatory framework as any other satellite mission and it was therefore necessary, as part of such projects, to be aware of the applicable rules and to adhere to them. All panellists agreed on the importance of a supportive Government and of a legal framework that encouraged non-governmental space activities.

75. A challenge for the development of small satellites, in particular for their commercial applications, was the need to increase their performance and reduce their mission failure rates to make them competitive with larger satellite missions. A potential obstacle to commercial utilization was the limited bandwidth available in the frequency bands traditionally used for small-satellite missions. However, panellists pointed out that technological solutions to that problem were being developed and that alternatives such as relaying data through geostationary orbit satellites were already being implemented.

76. With their shorter development cycles, small-satellite missions were not only useful for capacity-building but would also be key components for future space development and utilization. Indeed, the panellists concluded that the future would be a spacefaring world and not a world of a few spacefaring nations.

III. Observations and recommendations

77. With regard to capacity-building and international cooperation in space technology development, the participants in the United Nations/Mexico Symposium on Basic Space Technology:

(a) Noted the importance of capacity-building in space technology, in particular the development of small-satellite missions, which could result in a wide range of benefits, such as opportunities to train, educate and give transferable skills to engineers and project managers, the acquisition of technical capabilities with potential relevance to other industrial sectors, the establishment of commercial businesses, opportunities for international space cooperation, the development and enhancement of a country's space capacity and the benefits accruing from the operational use of small satellites;

(b) Noted the speed with which developments were taking place in the field of small-satellite activities, the increase in the launch rate and in the capabilities of small satellites and the growing number of operational small-satellite missions;

(c) Noted the significance of regional and international cooperation for capacity-building in space technology development worldwide and of the existing and proposed frameworks for space cooperation in Latin America and the Caribbean in particular, for example, the Space Conference of the Americas, the Latin American Alliance of Space Agencies and its Bogota Declaration, the Central American Association for Aeronautics and Space and the Regional Centre for Space Science and Technology Education for Latin America and the Caribbean.

78. With regard to legal and regulatory issues, the participants in the Symposium:

(a) Noted that all space activities, including those involving small satellites, should be conducted in full compliance with national and international space law and with relevant General Assembly resolutions, such as resolution 62/101, entitled "Recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects" and resolution 68/74, entitled "Recommendations on national legislation relevant to the peaceful exploration and use of outer space", as well as with the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space;[4]

(b) Noted the discussions in the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee, under the agenda item on the long-term sustainability of outer space activities, and their relevance for space missions, including those with small satellites, and also noted that entities involved in small-satellite activities should commit to fully implementing the voluntary guidelines for the long-term sustainability of outer space activities, when those guidelines were published;

(c) Considered the usefulness of developing guidelines for operators of satellites, in particular for constellations and swarms consisting of dozens or even hundreds of space objects with short operational lifetimes, with regard to the

[4] *Official Records of the General Assembly, Sixty-second Session, Supplement No. 20* (A/62/20), paras. 117 and 118 and annex.

optimal orbital regimes that could be used to be compliant with existing and emerging practices for space debris mitigation and safe on-orbit operation;

(d) Discussed measures to enhance the detectability of small satellites by ground-based radar or optical facilities to ensure safe on-orbit operation, such as design modifications to increase the radar cross section or the optical visibility of the satellites;

(e) Noted that educational activities related to space technology development could also make use of suborbital flight opportunities or balloons or could be implemented using a Cansat-type platform, which would not only simplify the legal aspects, project logistics and complexity, and cost and risk management involved in such activities, but would also ensure that there was no harmful impact on the long-term sustainability of outer space activities;

(f) Noted that small satellites were space objects in the legal sense and therefore subject to the same legal and regulatory obligations as all other space objects, and should not be singled out or be subject to specific rules and regulations;

(g) Recommended that every space project should plan to include legal management in addition to technical and administrative management.

79. With regard to frequency allocation and coordination, the participants in the Symposium:

(a) Noted that Member States and small-satellite operators were urged to follow the ITU Radio Regulations related to the use of frequency bands and notifications of small-satellite systems;

(b) Noted that the radio amateur band was not for commercial use;

(c) Recalled that Member States and academia were invited to actively participate in the ITU Radiocommunication Sector Working Party 7B studies related to small satellites (question ITU-R 254/7, on nano- and picosatellite characteristics and current practice), in order to participate in the exchange of views and decision-making process within ITU, to be finalized at the World Radiocommunication Conference 2018 (see www.itu.int/en/ITU-R/study-groups/rsg7/rwp7b);

(d) Noted that Member States were invited to actively participate in the World Radiocommunication Conference 2015, to be held in Geneva from 2 to 27 November 2015, which would cover various satellite service general items;

(e) Noted that, in its resolution 757, entitled "Regulatory aspects for nano- and picosatellites", the World Radiocommunication Conference 2012 had resolved to invite the World Radiocommunication Conference 2018 to consider whether modifications to the regulatory procedures for notifying satellite networks were needed to facilitate the deployment and operation of nano- and picosatellites, and to take the appropriate actions;

(f) Noted that Member States, academia and satellite operators were invited to actively participate at the ITU Symposium and Workshop on Small-Satellite Regulation and Communication Systems to be held in Prague from 2 to 4 March 2015 (see www.itu.int/en/ITU-R/space/workshops/2015-prague-small-sat);

(g) Noted that, at its fifty-third session, held in 2014, the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space had requested the Secretariat to develop, in consultation with ITU, an information handout on issues related to registration, authorization, debris mitigation and frequency management with respect to small and very small satellites, for the benefit of space actors intending to operate such satellites, and that the handout would be presented to the Legal Subcommittee at its fifty-fourth session.

80. Reviewing the activities of the Basic Space Technology Initiative, participants at the United Nations/Mexico Symposium:

(a) Endorsed the continuation of activities under the work programme of the Basic Space Technology Initiative, as contained in paragraphs 59 and 60 of document A/AC.105/1005;

(b) Noted the continuing work on the education curriculum on space engineering and recommended that the curriculum should include lectures on various aspects of the development, launch, operation and practical uses of small satellites, including best practices for space debris mitigation measures and for the long-term sustainability of outer space activities;

(c) Welcomed the offer by South Africa to host the United Nations/South Africa Symposium on Basic Space Technology in 2015.

81. Lastly, the participants recommended that the delegation of Mexico, in cooperation with the Office for Outer Space Affairs, should make a technical presentation to the Scientific and Technical Subcommittee at its session in 2015, to bring to the attention of the Committee the increasing role of small-satellite activities in the exploration and peaceful uses of outer space, including for outreach, education and capacity-building and for commercial and non-commercial operational applications.

IV. Conclusions

82. The next Symposium on Basic Space Technology will focus on capacity-building in space technology development for Africa. For the period 2016-2018, representatives of institutions of the following countries have expressed an interest in hosting a future regional workshop on basic space technology development: Brazil, China, Egypt and Turkey.