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Committee on the Peaceful Uses of Outer Space

Report on the United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development

(Graz, Austria, 8-11 September 2009)

I. Introduction

1. Since 1994, the Office for Outer Space Affairs of the Secretariat, the Government of Austria and the European Space Agency (ESA) have jointly organized symposiums on space science and technology and their applications. The symposiums, held in Graz, Austria, have addressed a broad range of themes, including the economic and social benefits of space activities for developing countries, space industry cooperation with the developing world and enhancing the participation of youth in space activities. Information on the symposiums is available on the website of the Office for Outer Space Affairs (http://www.unoosa.org/oosa/SAP/graz/index.html).

2. Since 2003, the symposiums have been dedicated to promoting the benefits of using space science and technology and their applications to carry out the Plan of Implementation of the World Summit on Sustainable Development.[1] The initial series of three consecutive symposiums, held during the period 2003-2005, focused on water resources and sustainable water management (A/AC.105/844).

3. The second series of three symposiums, held during the period 2006-2008, focused on atmosphere-related issues. The first symposium of that series, held in September 2006, addressed the benefits of using space tools for monitoring air pollution and energy use for sustainable development (A/AC.105/877). Building on that event, the symposium held in September 2007 pursuant to General Assembly resolution 61/111 dealt with space tools and solutions for monitoring the atmosphere

[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.

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in support of sustainable development, focusing on issues such as air quality, climate change and weather, ozone depletion and ultraviolet monitoring (A/AC.105/904). The United Nations/Austria/European Space Agency Symposium on Space Tools and Solutions for Monitoring the Atmosphere and Land Cover,[2] which was the third and concluding symposium of the series on atmosphere-related issues, was held in September 2008. It promoted the use of demonstrated capabilities of space technologies and their applications to support the actions called for in the Plan of Implementation of the World Summit on Sustainable Development (A/AC.105/924).

4. The Office for Outer Space Affairs, the Government of Austria and the European Space Agency are jointly organizing the third series of three consecutive symposiums, to be held during 2009-2011, to promote the use of space technology and its applications in support of activities to carry out the Plan of Implementation of the World Summit on Sustainable Development. This series of symposiums aims to enhance access to space applications tools for sustainable development by building indigenous institutional capabilities in basic space technology and small satellite technology.

5. The United Nations/Austria/European Space Agency Symposium on Small Satellite Programmes for Sustainable Development was held in Graz, Austria, from 8 to 11 September 2009. The Symposium was hosted and co-sponsored by the Federal Ministry for European and International Affairs of Austria, the Federal Ministry for Transport, Innovation and Technology of Austria, the State of Styria, the City of Graz and ESA. The International Academy of Astronautics and the Austrian Academy of Sciences supported the Symposium.

A. Background and objectives

6. At the World Summit on Sustainable Development, held in Johannesburg, South Africa, from 26 August to 4 September 2002, Heads of State and Government reaffirmed their strong commitment to the full implementation of Agenda 21,[3] which had been adopted at the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, from 3 to 14 June 1992. They also committed themselves to achieving the internationally agreed development goals, including those contained in the United Nations Millennium Declaration (General Assembly resolution 55/2). The Summit adopted the Johannesburg Declaration on Sustainable Development[4] and the Plan of Implementation of the World Summit on Sustainable Development.

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[2] The documents and presentations of the 2008 symposium are available on the website of the Office (http://www.unoosa.org/oosa/SAP/act2008/graz/index.html), which also serves as a portal by providing links to useful reference and tutorial materials, including links to atmosphere-related data and websites.

[3] *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992, vol. I, Resolutions Adopted by the Conference* (United Nations publication, Sales No. E.93.I.8 and corrigendum), resolution 1, annex II.

[4] *Report of the World Summit on Sustainable Development*, chap. I, resolution 1, annex.

7. In its resolution 54/68, the General Assembly endorsed the resolution entitled "The Space Millennium: Vienna Declaration on Space and Human Development",[5] which had been adopted by the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in Vienna from 19 to 30 July 1999. States participating in UNISPACE III adopted the Vienna Declaration as the nucleus of a strategy to address future global challenges using space applications. In particular, in the Vienna Declaration, States noted the benefits and applications of space technologies in addressing the challenges to sustainable development, as well as the effectiveness of space instruments for dealing with the challenges posed by the pollution of the environment and the depletion of natural resources.

8. Space science and technology and their applications can provide important information in support of policy- and decision-making for sustainable development. In some cases, space-based solutions are essential or afford the only or most cost-efficient means of collecting specific data. For example, the gathering and assessment of global environmental information can often be accomplished only by means of space-based sensors.

9. The series of symposiums organized by the Office for Outer Space Affairs during 2009-2011 consider how existing space technology-based tools, infrastructures, services and solutions could contribute to and strengthen the capacities of developing countries and countries with economies in transition to address challenges to sustainable development.

10. The following trends indicate a growing interest in space technology:

(a) An increasing number of countries are setting up space programmes or strengthening their space activities, including developing countries;

(b) An increasing number of countries are developing or acquiring satellites, thus driving demand for indigenous capacity in space technology;

(c) The move towards commercial off-the-shelf components for small satellites and miniaturized consumer technology means that small satellites can be developed with relatively modest infrastructures and at an affordable price.

11. Developing an indigenous capacity in basic space technology can help a country to shift from being a passive user or recipient of space services to becoming a more active player and preferred cooperation partner for space activities.

12. The goal of the three symposiums is to enhance access to space applications for sustainable development by capacity-building in basic space technology to support some of the actions called for in the Plan of Implementation of the World Summit on Sustainable Development. The primary objectives of the symposiums are to review the utility of small satellites and to harness accumulated experience in small satellite development for the purpose of conceptualizing national small satellite development programmes. At the first symposium, participants mainly considered the issues related to small satellite mission planning and implementation, taking part in practical exercises in mission design. At the second symposium, to be

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[5] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1.

held in 2010, participants will consider scientific and engineering issues and receive training in payload, instrument and sensor design. At the third symposium, to be held in 2011, the focus will be on operational and regulatory issues.

13. The 2009 Symposium had the following specific objectives:

(a) To promote ongoing relevant national, regional and global initiatives related to the demonstrated capabilities of small satellite technology as a means of providing specific solutions to development issues;

(b) To promote international cooperation in basic space technology development between and among countries at all levels of development, with a particular focus on supporting developing countries through capacity-building activities in small satellite technology development;

(c) To assist countries wishing to develop and use small satellite technology and to benefit from the spin-offs of the development of such technology to have appropriate access to the relevant information and means (e.g. information exchange, databases, cooperation opportunities with the private sector);

(d) To contribute to the development of indigenous capabilities in small satellite technology in the participants' institutions and to contribute to building up a critical mass of professionals.

14. Participants were expected to gain the following from the Symposium:

(a) An understanding of the World Summit on Sustainable Development framework, the context of sustainable development, the role of small satellite technology in that context and the capabilities of the relevant space technology-based tools, solutions and information resources, as well as strategies for including such tools in the relevant decision-making processes;

(b) Knowledge of small satellite technology-based tools, solutions and resources for sustainable development and knowledge of ways to utilize existing partnerships or establish new functional partnerships to promote the use of small satellites;

(c) An understanding of national, regional and international strategies, programmes and projects to promote the use of small satellite technology for sustainable development;

(d) The knowledge and skill to implement national plans for small satellite programmes.

B. Programme

15. The programme of the Symposium was developed jointly by the Office for Outer Space Affairs and the programme committee of the Symposium, which included representatives of a number of national space agencies, international organizations and academic institutions. The input received from both the honorary committee and the programme committee, as well as the direct participation of members of those committees in the Symposium, ensured that the aims of the Symposium were achieved.

16. At the opening session, representatives of the Space Science Center of Morehead State University and ESA delivered keynote speeches. Representatives of the Office for Outer Space Affairs reviewed the highlights, objectives and expected outcome and follow-up activities of the Symposium. An introductory lecture entitled "Small satellites — a driver for capacity-building" was delivered by a representative of the German Aerospace Center (DLR) and the International Academy of Astronautics.

17. The programme of the Symposium focused primarily on small satellite mission design. Presentations included case studies of successful applications of small satellite technology that provide cost-effective solutions and essential information for planning and implementing programmes or projects related to sustainable development.

18. The Symposium consisted of sessions on the following themes: utility of small satellites for capacity-building; establishing a small satellite programme: policy, planning and implementation; launch opportunities for small satellites and regulatory issues; and a hands-on activity on mission design. A technical visit to the ground station and satellite facilities in Graz was organized during the second day.

19. At the symposium, 41 presentations were delivered by speakers invited from both developing and developed countries, and a discussion session was held at the end of each presentation session. Eight papers were presented at the poster sessions.

20. The detailed programme of the Symposium and related information are available from the website of the Office for Outer Space Affairs (www.unoosa.org).

21. On the fourth day of the symposium, three working groups were formed to develop small satellite mission plans and proposals in the following areas of application selected by the participants: (a) climate change monitoring and education; (b) disaster management; and (c) humanitarian missions. The suggested framework for the working group meetings included discussions on a mission statement and operational concept, timeline, budget estimations, identification of possible partners and collaborators, education and training required and access to technical facilities.

C. Attendance

22. A total of 60 decision makers, programme managers and professionals from governmental institutions, environment agencies, universities, academic entities and the private sector from the following countries attended the Symposium: Angola, Austria, Bangladesh, Brazil, Burkina Faso, Cambodia, Cameroon, China, Ecuador, Finland, France, Germany, Ghana, India, Indonesia, Japan, Kenya, Malaysia, Mexico, Netherlands, Nigeria, Pakistan, Russian Federation, South Africa, Spain, Sudan, Switzerland, Turkey, Uganda, United Arab Emirates, United States of America and Venezuela (Bolivarian Republic of).

23. Representatives of the following United Nations entities and international, intergovernmental and non-governmental organizations were among the participants: Office for Outer Space Affairs, Secretariat of the United Nations Framework Convention on Climate Change, International Telecommunication

Union (ITU), ESA, International Institute for Applied Systems Analysis and International Academy of Astronautics.

24. Funds allocated by the United Nations and the co-sponsors were used to defray the cost of the air travel, daily subsistence allowance and accommodation of 20 participants. The co-sponsors also provided funds for local organization, facilities and the transportation of participants.

II. Summary of thematic presentations

A. Utility of small satellites for capacity-building

25. The first technical session considered the ways in which small satellite projects could contribute to capacity-building programmes in developing countries. Papers presented during that session emphasized that the low cost and short time needed to develop and produce small satellites, coupled with advances in electronic miniaturization and associated performance capabilities, made small satellite missions extremely attractive for governmental and private entities, as well as for educational institutions in developing countries. Currently, space programmes were considered an integral part of national innovation and development systems of political, economic, humanitarian and educational value. Those programmes also helped to build up technical infrastructure in developing countries and to stimulate local industry. Presenters demonstrated that, in addition to contributing to technological development, small satellite programmes had numerous scientific merits and could have significant educational, outreach and public awareness-raising impact.

26. It was recognized that continuing education programmes were extremely important for ensuring the continuity and sustainability of small satellite programmes in developing countries. The participants were shown examples of activities carried out by the ESA Education Office in the area of small satellite technology that aim to motivate students to work in space engineering, technology and science and to provide university students with practical experience in real space projects. The participants were informed about recent small satellite missions (such as the second Young Engineers' Satellite launched in 2007) and learned about ongoing projects (such as CubeSats on the Vega maiden flight, scheduled for launch in 2010, the European Student Earth Orbiter, scheduled for launch in 2012, and the European Student Moon Orbiter, scheduled for launch in 2013). An overview of the Global Educational Network for Satellite Operations was also presented. That project, which had been endorsed by the International Space Education Board, aimed at linking and sharing university and amateur ground stations globally to provide near-global coverage for all participating educational small satellite missions.

27. Presenters at the session also showed that small satellite projects were promoting international cooperation within regions or worldwide by means of bilateral or multilateral programmes. Small satellite projects could result in fruitful cooperation between countries in the planning, implementation and operation of scientific and application satellite missions, as well as in the effective utilization of the data acquired and in sharing developmental and operational costs. In that

context, the Satellite Technology for the Asia-Pacific Region (STAR) programme led by the Japan Aerospace Exploration Agency was presented to participants as a good example of regional cooperation. Seven countries were currently taking part in the programme, which was aimed at building capacity in space technology and at increasing the number of Earth observation satellites to satisfy the needs of the Asia-Pacific region. The mission definition and system requirements for the Micro-STAR project were under discussion, as was a system study for the Earth Observation-STAR mission, another regional small satellite programme.

28. A number of case studies and reports on ongoing and planned small satellite missions and projects in Africa, Asia and South America, as well as on data needs in the context of climate change studies, were presented at the session.

B. Establishing a small satellite programme: policy, planning and implementation

29. The second technical session considered issues related to planning and implementing national small satellite programmes. It was recognized that there was a rapidly growing demand for access (including reliable online access) to fundamental geospatial information that could meet the needs of decision makers and local communities. Presenters at the session demonstrated that small satellites were able to provide valuable and timely information with a high spatial, spectral and temporal resolution. The development of supporting information infrastructures, such as the Mesoamerican Regional Visualization and Monitoring System (SERVIR), an ongoing project facilitated by the Regional Centre for Mapping of Resources for Development in Kenya, was vital for the efficient utilization of data derived from small satellites. It was explained that SERVIR was a system that integrated satellite and other geospatial data for improved scientific knowledge and decision-making, and that it addressed the nine societal benefit areas identified in the group on Earth Observations 10-Year Implementation Plan: disasters, ecosystems, biodiversity, weather, water, climate, health, agriculture and energy. The Hermes project carried out by the Ecuadorian Civilian Space Agency offers international academic and educational communities online access to real-time data from spacecraft passing over the Hermes-A coverage area (mostly in the southern hemisphere), as well as providing the CubeSat community with tracking and command capabilities over the Internet.

30. Presenters at the session also demonstrated that constellations of small satellites had proved to be economically feasible and to serve both local and global needs efficiently, as demonstrated by the Disaster Monitoring Constellation (DMC), which had been designed as a proof-of-concept constellation capable of multispectral imaging of any part of the world, every day. It was unique in that each satellite was independently owned and controlled by a separate State, but all satellites had been equally spaced around a sun-synchronous orbit to provide daily imaging capability. DMC satellites provided a unique resource that made it possible to observe Earth from anywhere in the world, greatly improving the value of the data.

31. Presenters at the session emphasized the need for greater awareness among the public and decision makers of the potential benefits of space technology

applications. It was recognized that every country or group of countries should consider the attainment of a minimum level of space capability, as that could be invaluable in enhancing socio-economic development, as well as the health and quality of life of the population. In that respect, a dedicated national organization or agency should play an important role in the definition, planning and implementation of small satellite programmes. Examples of such programmes in Brazil (the NanoSatC-BR project), Malaysia (the RazakSAT mission), Mexico (the Satedu project), South Africa (the Sumbandila mission) and Turkey (the BiLSAT and Rasat projects) were presented.

C. Launch opportunities for small satellites and regulatory issues

32. Representatives of national and international organizations and the private sector informed participants about the latest developments in launch opportunities for small satellites and regulatory issues.

33. The representative of ITU explained that the remit of his organization involved protecting satellites (including CubeSats and small satellites) from harmful telecommunication interference. He provided an overview of the history, key priorities and mission of ITU, and the legal framework within which it operated. Developers of small satellites must follow the radio regulations. A list of the actions required of all satellite developers and information on when those actions should be taken to comply with ITU regulations were also provided to the participants.

34. Representatives of the private sector provided an overview of launch opportunities available on the commercial market. They presented their launch vehicles and the status of development of their new carriers. Finally, they explained that in addition to a good quality and reliable service, they were able to offer low-cost launch opportunities based on very simple and robust designs or with the capacity for cluster launches. They also provided information about their typical mission management flow, the main specifications and the configurations of their launchers, the launch sites, the operation flow and the facilities.

35. The representative of the Bureau of Telecommunication and Post of the Netherlands Antilles presented its activity involving the Spectrum Five satellite, which is a direct broadcasting satellite for television, shared the Bureau’s experience and presented the procedures for satellite orbit slot filling with the ITU Bureau.

36. Finally, the representative of the Indian Space Research Organisation provided an overview of the Indian launch vehicle programme, the launchers of the organization and the typical compartments available for the accommodation of small satellites.

D. Hands-on activity on mission design

37. Detailed lectures were delivered on mission design focusing on considerations in designing spacecraft as compared to terrestrial devices; satellite orbits; the space environment; power systems and communications design; on-board command; and telemetry links.

38. Hands-on training in the use of the Satellite Tool Kit, a commercially available software package, was provided. Additionally, the Ecuadorian Civilian Space Agency demonstrated the Hermes system, a space flight control station capable of connecting Internet users to orbiting spacecraft. The station could be used by students and scientists anywhere in the world to access satellites and spacecraft online using only a computer and an Internet connection. The Ecuadorian Civilian Space Agency organized training in operating the system.

III. Conclusion

39. The final day of the Symposium was dedicated to the three working group meetings. The first group focused on small satellite missions dedicated to climate change monitoring and education, the second group focused on the use of small satellites for disaster management and the third group focused on humanitarian missions. Each group was asked to develop a mission proposal, including a mission statement and an operational concept.

40. Participants recommended that the Office for Outer Space Affairs use the proposals as input for the next in the series of symposiums, on small satellite programmes for sustainable development.

41. The feedback received from participants, including participating co-sponsors, was overwhelmingly positive and some co-sponsors indicated their willingness to continue supporting the 2010 symposium. Discussions and preparations for the theme and content of that symposium were already under way. Several participants committed to using the knowledge gained from the Symposium to introduce changes and improvements to ongoing activities in their home institutions.

A. Working group on small satellite missions for climate change monitoring and education

42. The working group on small satellite missions for climate change monitoring and education focused on gathering relevant climate data using space technology and taking maximum advantage of national personnel and facilities and of student participation.

43. The objectives of the proposed mission included gathering useful climate and weather data on the ground, sharing that information with potential stakeholders, encouraging the involvement of academic institutions and students at universities and in secondary education and building capacity in space technology.

44. The data collected could be used in such areas as climate change studies, agriculture, public health, disaster management and education. User groups could include local universities, local communities, local schools, aid organizations and the global academic community.

45. The system concept suggested by the working group included one micro-satellite on a sun-synchronous orbit, a ground station with a data and application centre, and a network of low-cost weather stations operated by schools and local communities. The satellite payload could include ultraviolet, infrared and visible spectrum sensors, as well as a low-volume data storage system.

Satellite-derived data would primarily be used for the calibration of ground equipment. A downlink of 500 kB in S-band was estimated as sufficient for the purpose of that mission, even if storage and forward capabilities would be added to the spacecraft.

46. The target region for the project discussed was Africa; initially it could include Cameroon and its neighbours. Local university students could participate in data processing and utilization as well as in distributing data from weather stations and giving feedback on the results to schools that operated weather stations.

47. The concerns and requirements identified by the working group included potential difficulties in procuring low-cost weather stations, coordination with regional and local organizations, integration of existing assets (e.g. ground stations and data application centres), development of satellite payload and securing an appropriate budget for the project.

B. Working group on the use of small satellites for disaster management

48. The working group on the use of small satellites for disaster management discussed a project aimed at establishing a constellation of small satellites for providing information for the detection and mitigation of natural disasters, and prediction, if feasible.

49. The mission statement of the working group related to planning a disaster management constellation of satellites to help countries in the event of flooding, droughts, cyclones and earthquakes.

50. A constellation of 32 small satellites on a sun-synchronous orbit with a high revisiting rate (one day or shorter) was proposed. The group suggested a 4-band imaging payload with a 20-m ground resolution and an 80-km swath, with a required data rate of 43 Mbps. The proposed ground segment included a mission control centre, a ground station and a data processing and product generation centre.

51. Multiple launch agencies and multiple launchers were proposed to develop such a constellation. The project timeline was estimated to be 24 months (before launch) and the proposed budget was about US$ 350 million, including space and ground segments, facilities and labour.

52. The working group noted that the implementation of the mission would contribute to capacity-building through education and training in spacecraft design, spacecraft testing, data processing and data utilization for the participating institutions and organizations.

53. The working group identified the following requirements for the mission: (a) electrical and mechanical laboratory facilities; (b) a clean room; (c) hot and cold thermo-vacuum and vibration facilities; and (d) various design tools.

C. Working group on the use of small satellites for humanitarian missions

54. The working group on the use of satellites for humanitarian missions worked on the design of a constellation of nanosatellites for enabling communication in areas lacking infrastructure.

55. The mission of the working group was to design a system composed of a constellation of nanosatellites, with an associated ground segment and a user segment to provide telecommunication services in support of humanitarian applications and to monitor parameters related to climate change.

56. The working group suggested the following potential areas of application for their mission: (a) public health (transmission of medical data); (b) monitoring and early warning of natural disasters through the use of ground sensor networks; (c) climate change monitoring; (d) environmental pollution monitoring (in rivers, lakes, seas) in areas that are difficult to access; and (e) control of infrastructure (e.g. water pipes).

57. The working group also defined the key technologies for the spacecraft, ground segment and user segment as well as the estimated time schedule and budget. It was suggested that a CubeSat standard should be used for the mission as it can provide the required spacecraft reliability and lifetime. The ground segment should be based on the stations in the Global Educational Network for Satellite Operations, with the initial node at the University of Vigo, in Spain. Other spacecraft standards (e.g. the Russian TNS technological nanosatellite platform) could also be taken into consideration by the project teams.

58. The project timeline estimated by the group was two years and the budget proposals covered the procurement of low-cost hardware for ground stations (less than €20,000) and satellite payloads (around €30,000 for a proto-flight model). The group also considered a free launch opportunity on Vega's maiden flight, and was open to the possibility of negotiating inexpensive opportunities with private launching companies.

59. The working group recommended that, for education and training purposes:

(a) Mission design, development, implementation, verification and operations should mainly be performed by universities and students in connection with MSc and PhD thesis work;

(b) Cooperation, support and technology transfer between universities should be promoted;

(c) E-training and e-working opportunities should be exploited;

(d) The mission should build on the experience of the ESA Education Office and it should provide access to ESA expertise through that Office;

(e) The formation of teams with different levels of experience should be promoted.

60. The working group also recommended that universities share facilities, testing and simulation tools (e.g. clean rooms, anechoic chambers, vacuum and thermal chambers, shakers, commercial off-the-shelf hardware and software tools etc.).