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Committee on the Peaceful Uses of Outer Space
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Item 13 of the provisional agenda*
Long-term sustainability of outer space activities

Information on experiences and practices related to the long-term sustainability of outer space activities

Note by the Secretariat

I. Introduction

1. In accordance with the terms of reference and methods of work of the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee, adopted by the Committee on the Peaceful Uses of Outer Space at its fifty-fourth session, in 2011 (A/66/20, annex II), member States of the Committee, international intergovernmental organizations having observer status with the Committee, international non-governmental organizations having observer status with the Committee, United Nations entities and intergovernmental bodies, and other international organizations and bodies, subject to the provisions of paragraphs 16 and 17 of the terms of reference and methods of work, were invited by the Secretariat to provide information on their experiences and practices that might relate to the long-term sustainability of outer space activities and on their experiences and practices in the conduct of sustainable space activities, as well as on how they envisage work under the topic.

2. The present document has been prepared by the Secretariat on the basis of information received from the Committee on Space Research and Secure World Foundation, international non-governmental organizations having permanent observer status with the Committee; and from the Office for Disarmament Affairs of the Secretariat. The European Organisation for the Exploitation of

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Meteorological Satellites has informed the Secretariat that their contribution, contained in document A/AC.105/C.1/103/Add.1, is still valid.

II. Replies received from international non-governmental organizations having permanent observer status with the Committee

Committee on Space Research

[Original: English]
[26 October 2012]

Scientific Commission on Space Studies of the Upper Atmospheres of the Earth and Planets including Reference Atmospheres

The Committee on Space Research (COSPAR) Scientific Commission on Space Studies of the Upper Atmospheres of the Earth and Planets including Reference Atmospheres studies terrestrial upper atmospheres and also creates reference atmospheres, which can contribute to the long-term sustainability of outer space activities. The research area includes satellite/rocket and ground-based observations of the mesosphere, thermosphere, ionosphere and a part of the magnetosphere, modelling of the atmosphere from the ground to the upper atmosphere, and updating of reference atmospheres. Many of the satellites, especially low Earth orbit satellites, are in the researched atmospheres. Recent studies by COSPAR have shown that the couplings between different atmospheric regions are much more significant than previously thought. Electromagnetic teleconnection along geomagnetic fields is important, but so is coupling by various waves in the plasma and neutral atmospheres from the ground to the top of the atmosphere as well as between the hemispheres. COSPAR efforts to understand these different regions as a "whole atmosphere" and to describe it through sophisticated models is very useful in planning or operating sustainable outer space activities.

Scientific Commission on Space Plasmas in the Solar System, including Planetary Magnetospheres

The COSPAR Scientific Commission on Space Plasmas in the Solar System, including Planetary Magnetospheres studies the large- and small-scale environment of the interplanetary medium and its connection with energetic particle transport. Theoretical considerations and real-time observations are used to protect spacecraft systems and other relevant technologies (such as the Global Positioning System (GPS)) from damage and, hence, to predict space weather. The knowledge of transport and acceleration of energetic particles helps to understand the risk of air flights over the poles, their influence on ozone depletion and other atmospheric molecules, and to interpret the results of Earth-bound large-area telescopes, such as IceCube, Milagro, Pierre Auger and others. A good understanding of energetic particle fluxes is required for manned space missions in order to protect the astronauts.

The long-term variability of the cosmic ray flux is used to reconstruct the long-term variability of the Sun and its influence on climate, which in turn requires the knowledge of all relevant processes in interplanetary space.

Finally, the heliospheric and Earth magnetospheric models are used in comparative studies of other astrospheres and exoplanetary magnetospheres.

Scientific Commission on Research in Astrophysics from Space

Astronomy and solar and heliospheric physics

The use of space techniques plays a key role in the advance of astrophysics by providing access to the entire electromagnetic spectrum from the radio to gamma rays, complemented by planned ground-based large observatories. The increasing size and complexity of large space-based observatory missions places a growing emphasis on international collaboration. This is particularly marked by the increasing range of joint missions involving the large space agencies of Europe (European Space Agency (ESA)), Japan (Japan Aerospace Exploration Agency (JAXA)), the Russian Federation (Russian Federal Space Agency) and the United States of America (the National Aeronautics and Space Administration (NASA)), while an important contribution from the Chinese and Indian space agencies is becoming a fact.

It is important that the world's space agencies coordinate their mission plans for both large- and smaller-scale enterprises. The coordination of existing and future data sets from space-based and ground-based observatories is an evident mode of powerful and relatively inexpensive collaboration to address problems that can be tackled only through the application of large multi-wavelength data sets. At a time of worldwide restricted financial capabilities, the lack of a common strategy at the international level could become a major stumbling block. Inter-agency coordination will be the obvious way to limit large single agency investment in observatory class satellites (Hubble, the James Webb Space Telescope etc.) to ensure a sustainable scientific space programme in the next two decades.

An updated overview of worldwide space programmes in astronomy and astrophysics has been produced by the COSPAR Working Group on the Future of Space Astronomy (Ubertini and others, *Advances in Space Research*, vol. 50, issue 1 (2012), pp. 1-55).

Conclusions

Astronomy from space is a model for international scientific cooperation. Most missions have some international hardware collaboration, and virtually all feature extensive data-sharing. International astronomical databases now include ground-based as well as space-based archival data in standard formats, so that astronomers anywhere in the world can access all results after brief proprietorial periods. Hence, astronomers can perform extensive multi-wavelength investigations of large data samples from their desktops; this minimizes investment and travelling and makes possible important scientific investigations aided by a sustained contribution from the scientific communities of developing countries and those with new and mid-sized space programmes.

With respect to space sustainability, an important role is played by the effect of the Sun-Earth interaction, an essential part of space astrophysics investigations. This interaction drives space weather-related events and their effect on human activities for different societies and for different economic sectors. Space weather is now formally recognized as an area of relevance to World Meteorological Organization activities.

Finally, an important and growing concern in terms of the sustainability of space activities is advance planning for de-orbiting of large space observatories at the end of their lives.

Panel on Technical Problems related to Scientific Ballooning

The current worldwide development of stratospheric balloon systems clearly demonstrates the long-term sustainability of this kind of vehicle for near-space science. For example, among the major balloon operators, the following may be mentioned:

(a) NASA/Columbia Scientific Balloon Facility (United States). The Facility has operated eight flights from its balloon facilities (Palestine, Texas and Fort Sumner, New Mexico) and from Kiruna, Sweden, and three long-duration flights from the United States McMurdo Station (Antarctica) are being planned during the next winter;

(b) JAXA (Japan): despite the use of the new Taiki site, with its two annual campaigns, the search for a foreign site is in progress to increase the number of flight opportunities and flight durations;

(c) Centre national d'études spatiales (CNES) (France): the qualification of the new telemetry, tracking and control system (NOSYCA) developed for zero-pressure stratospheric balloons has begun. The operation of this new complete system is planned for the next 15 years, and its use will be extended to the other types of balloon (e.g. superpressure and infrared Montgolfier balloons);

(d) Canadian Space Agency (CSA) (Canada): the establishment of a new balloon facility in Timmins, Ontario, in cooperation with CNES. The qualification flights of the NOSYCA system will take place from this new balloon facility in early 2013.

Panel on Potentially Environmentally Detrimental Activities in Space

Space debris is one of the seven topics to be addressed by the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee. COSPAR was one of the first international bodies to hold regular discussions concerning the nature of the space debris environment and the hazards it presents to operational space systems. The first technical session on space debris was held during the 25th Scientific Assembly of COSPAR, in Graz, Austria, in 1984. For many years, the Panel on Potentially Environmentally Detrimental Activities in Space has held multiple space debris sessions at each biannual COSPAR Assembly.

At the 39th Scientific Assembly of COSPAR in 2012, the theme of the sessions of the Panel on Potentially Environmentally Detrimental Activities in Space was "Space debris — steps toward environmental control". One half-day session was

devoted to space debris mitigation and remediation, which are the principal space debris issues with respect to the long-term sustainability of activities in outer space. In 2014, the theme of the Panel's sessions will be "Space debris — responding to a dynamic environment".

COSPAR continues to be a leader in promoting a better understanding of the nature, risks and evolution of the space debris environment and in encouraging spacefaring nations and organizations to act responsively in space for the benefit of all through each mission phase, including deployment, operations and disposal.

Panel on Radiation Belt Environment Modelling

The effects of the space radiation environment on spacecraft systems and instruments are significant design considerations for space missions. In order to meet these challenges and have reliable, cost-effective designs, the radiation environment must be understood and accurately modelled. The nature of the environment varies greatly between low Earth orbits, higher Earth orbits and interplanetary space. There are both short-term and long-term variations with the phase of the solar cycle. This naturally leads to a detailed study of the space environment and of the effects that it induces on space vehicles and astronauts. One major challenge is to address new issues that arise for spacecraft that must be designed to operate for 10 or more years in Earth orbit. Such long missions often exceed the duration of the data sets used to characterize the space environment for satellite design.

In the next few years several space missions dedicated to the study of radiation belts will be launched (e.g., the Radiation Belt Storm Probes (United States), launched 2012; Energization and Radiation in Geospace (Japan); and Resonance and Lomonosov (Russian Federation). These missions will generate much activity in the next 10-15 years, during which data will accumulate and be analysed. Of course, the Panel on Radiation Belt Environment Modeling will be a central place for scientists to communicate about new findings and to collaborate.

Panel on Space Weather

Precise knowledge of the space environment and its variability are important factors in guaranteeing the sustainability of activities in space. Spacecraft are designed according to an expected environment and lifetime, taking into account the long-term properties of that environment. In addition, space weather services provide the opportunity to mitigate the impact of individual space weather events on affected space- and ground-based infrastructure through the use of real-time data and modelling. Consequently, both reliable statistics and real-time observations of key parameters are important factors.

Events of the Panel on Space Weather held during the 39th COSPAR Scientific Assembly in Mysore, India, in 2012 highlighted a number of activities relevant to sustainability and included a briefing on the plans of expert group C, on space weather, of the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee.

Operational and pre-operational space weather services rely heavily on reliable data streams from spacecraft and ground-based observatories, as well as data services providing processed data products. Many of the primary data sources that

underpin current services are primarily scientific observatories, leading to high-quality data but often with a number of availability and continuity uncertainties, which a developer will find problematic. In addition, scientific missions usually have a finite lifetime and no replacement strategy enabling long-term monitoring. An example is the dependence of many services on the near-real-time solar wind measurements from the L1 vantage point. The main source of these data is currently the NASA/Advanced Composition Explorer spacecraft, which has been in operation since 1997.

The Panel on Space Weather noted the recent work done by the Inter-programme Coordination Team on Space Weather task group to identify and document a comprehensive set of key data requirements underpinning services. The requirements and accompanying guidelines provide a reference for current and future measurement systems. In addition, given the stringent requirements for the timeliness of data availability established for space weather services, it was noted that dedicated actions to improve existing space weather data availability and its real-time collection, storage and dissemination could substantially benefit current service provision.

Panel on Planetary Protection

The Panel on Planetary Protection works on behalf of COSPAR to provide an international consensus policy on the prevention of biological interchange in the conduct of solar system exploration, specifically, (a) avoiding contamination of planets other than the Earth by terrestrial organisms, including through planetary satellites within the solar system; and (b) preventing the contamination of Earth by materials returned from outer space that may be carrying potential extraterrestrial organisms.

The Panel works for the COSPAR Bureau and Council to develop, maintain and promulgate planetary protection knowledge, policy, and plans to prevent the harmful effects of such contamination, and through symposiums, workshops and topical meetings at COSPAR assemblies to provide an international forum for the exchange of information in this area. Through COSPAR, the Panel is expected to inform the international community — e.g. the Committee on the Peaceful Uses of Outer Space as well as various other bilateral and multilateral organizations — of policy consensus in this area. At the second session of its 34th meeting, on 20 October 2002, in Houston, United States of America, the COSPAR Council adopted a revised and consolidated planetary protection policy, which was most recently updated in March 2011.

Through the prevention of biological interchange during space exploration, the COSPAR policy is intended to safeguard the future conduct of scientific investigations of possible extraterrestrial life forms, precursors and remnants, and to protect the Earth for a sustainable future of space exploration. The Panel has formed a close partnership with the COSPAR Panel on Exploration in pursuing the overlapping components of their common goals. Given their complementary roles, the Panel on Exploration and the Panel on Planetary Protection have worked together to elaborate a pathway for future expansion of environmental protection, as well as the use, of outer space.

Panel on Exploration

With increased interest in developing new infrastructure, transport systems and space probes to explore the Earth-Moon-Mars space both robotically and with humans, we are entering a new era of space exploration. Numerous national space agencies are now defining road maps and exploration architectures to plan for space activities in the decades ahead. Given the many obstacles that can be faced at any point in this process, at this time it is vital to create a long-term, sustainable space exploration programme to inform and guide the diverse plans made by individual agencies.

Such a programme will involve international cooperation at an early stage, both the alliances of established space nations and increased engagement of new emerging and developing countries. Such cooperation, if done in a meaningful way, will be a pillar to support a sustainable global space exploration programme.

While the programme must integrate the perspectives and ideas of diverse stakeholders, it will be important that the same programme be based on the most up-to-date scientific and environmental understanding about space and planetary bodies. The COSPAR Panel on Exploration was created in 2008 at the COSPAR Assembly in Montreal to provide independent science input to support a global space exploration programme, while working to safeguard scientific assets of the solar system in the conduct of the programme. Since that time, the Panel on Exploration has compiled a report published in the peer-reviewed literature, entitled "Toward a global space exploration program: a stepping stone approach" (*Advances in Space Research*, vol. 49, issue 1 (2012), pp. 2-48). In that report, the Panel on Exploration proposed a stepping stone approach to activities that support the transition period towards larger space architectures. These stepping stones include an Earth-based analogue research programme preparing for planetary exploration, an International Space Station utilization programme enabling complementary exploration science, an international CubeSat programme in support of exploration, as well as more complex endeavours such as the conceptualization and planning of future human outposts. These preparatory activities offer the opportunity to involve a wide range of actors in the global space community.

The Panel on Exploration has elaborated a bottom-up approach that can be used to strengthen a long-term global space exploration programme. The Panel on Exploration approach offers numerous opportunities to integrate many countries and stakeholders in preparation for the crafting and execution of any global space exploration programme. Because COSPAR unites institutions from 46 countries and works with numerous associated bodies, it can thus provide and engage a worldwide scientific network for cooperative activities in support of exploration through both approaches. To that end, the Panel on Exploration is already involved in efforts to contribute to sustainable space activities, holding several workshops annually and issuing official reports of their results, and helping to engage developing countries in worldwide space exploration efforts. In this way, the COSPAR Panel on Exploration can make important scientific and international contributions that will be crucial to planning and executing sustainable space exploration activities in the coming decades.

See www.gwu.edu/~spi/pex.cfm for additional information about the activities of the Panel on Exploration and the report on space exploration.

Panel on Capacity-building

Sustainability of outer space necessarily requires the availability of trained scientists and technicians who can plan and carry out activities that make use of outer space in an efficient and effective way. COSPAR directly contributes to this aspect of outer-space sustainability.

The COSPAR Panel on Capacity-building carries out a programme of capacity-building workshops aimed at increasing the community of scientists that make use of data collected from space missions.

The Panel on Capacity-building programme is now 11 years old, and in this period 17 capacity-building workshops have been organized. These workshops take place in developing countries, addressing the interest of communities that normally do not have experience with the use of space data. The workshops help to overcome the initial barrier faced by scientists in those countries when they want to access that information.

The venues and topics of the workshops are selected on the basis of a few general criteria, including a regional dimension and publicly and freely available space data and analysis software. The workshops have a duration of two weeks and usually centre on data from one or two space missions that are in operation at the time of the workshop. Typically, a workshop consists of 30-35 students (the term "student" in this context includes PhD students, postdoctoral fellows and young staff members) and about 10 lecturers. The lecturers are scientists directly related to the missions (usually NASA, ESA or JAXA scientific space missions). Half of the time of the workshop is devoted to formal lectures on the science topics that can be addressed by the missions discussed in the workshop. The students spend the rest of the workshop working on a project using real data and software of one these space missions under the supervision of the lecturers.

In 11 years, about 550 students have been trained through these workshops, on topics ranging from remote sensing, Sun-Earth interactions, planetary science and astrophysics. Workshops have been held in South America (Argentina, Brazil and Uruguay), Asia (China, India and Malaysia), Africa (Egypt, Morocco and South Africa) and Eastern Europe (Romania). COSPAR contributes about one third of the costs of a workshop; the other two thirds are provided by several international organizations (ESA, NASA, the International Astronomical Union, Office for Outer Space Affairs etc.) and the host country.

Secure World Foundation

[Original: English]
[22 October 2012]

The Secure World Foundation (SWF) has a keen interest in the long-term sustainability of the space environment and considers it to be an important topic. In 2012, the Foundation continued to conduct and sponsor research on space sustainability topics. In April, SWF hosted an all-day, by-invitation-only workshop entitled "Defining sustainable use of space". It was the second workshop in the SWF Frameworks and Strategy for Space Sustainability (FSSS) programme. The FSSS programme examines existing theoretical frameworks for sustainable

governance and how these might contribute to the ongoing debate about space sustainability, with the ultimate goal of producing practical guidance for policymakers. The first FSSS workshop, held in September 2011, brought together a small group of experts to explore the applicability of Nobel Laureate Elinor Ostrom's principles for sustainable governance of the commons to the space environment, issues with terminology, and the sufficiency of current space governance mechanisms. Major conclusions from the initial workshop informed the design of the second workshop entitled "Defining sustainable use of space", which successfully convened a small sample of prominent, international thinkers representative of the various stakeholders in space to discuss what space sustainability means to them and what they would like to see emerge from current international initiatives. The same experts also participated the following day in a panel discussion entitled "International Perspectives on Space Sustainability from Africa, Asia and Latin America".

For the third year in a row, the Secure World Foundation partnered with Beihang University and the International Space University to hold a conference in Beijing, on 8-9 November 2012, to discuss issues related to the long-term sustainability of outer space activities, including orbital debris mitigation and removal, national implementation of debris mitigation guidelines and regulations, tools to enhance space situational awareness data-sharing and space weather. The 2012 conference also featured two sessions of student papers from around the world in technical and law and policy topics to help foster dialogue and new thinking on space sustainability issues.

On-orbit satellite servicing and active debris removal are part of an emerging category of future on-orbit activities that are critical for taking the next leap in our use of Earth orbit. The ability to repair or refuel satellites, construct new satellites in orbit and even remove orbital debris can help drive innovative uses of space and create new possibilities. These activities also raise a host of diplomatic, legal, safety, operational and policy challenges that need to be tackled for this future to be possible.

Therefore, in 2012, the Foundation continued to conduct and sponsor research on addressing some of the legal and policy concerns related to actively removing space debris from orbit and cooperative governance mechanisms for using space in a sustainable manner. Technical advisor Brian Weeden published a report examining key technical shortcomings of the current space situational awareness systems used to help satellite operators avoid collisions in orbit and conduct space activities in a safe and responsible manner.[1] The report recommended that space situational awareness capabilities used for public safety measures, such as maintaining a catalogue of space objects and providing a collision avoidance service, be developed in a more open manner involving all stakeholders.

In order to foster dialogue on these topics, SWF is holding two international conferences to bring in the perspectives and viewpoints from all stakeholders on issues of on-orbit servicing and active debris removal and extend the conversation to an international audience. The first conference was held in Brussels on 30 October 2012, in partnership with the French Institute of International

[1] Available from http://swfound.org/news/all-news/new-swf-report-on-improving-space-situational-awareness.

Relations (IFRI), and the second conference is planned to take place in Singapore on 20 February 2013.

In June, SWF announced the release of the executive summary of *Space Security Index 2012*, the ninth annual report on developments that have an impact on the security and long-term sustainability of outer space. The *Space Security Index* provides a comprehensive summary of civil, commercial and military space activities in 2011, identifies important trends and analyses their impact on space security.

Also in 2012, SWF published three new fact sheets summarizing current space sustainability initiatives. The first was on the draft international code of conduct for space activities, which is a non-legally binding, voluntary international instrument aimed at building norms of responsible behaviour in space activities. The second was on the Working Group on the Long-term Sustainability of Outer Space Activities, an initiative of the Scientific and Technical Subcommittee tasked with producing a consensus report outlining voluntary best practice guidelines for all space actors to ensure the long-term sustainable use of outer space. Finally, the third was on the group of governmental experts on transparency and confidence-building measures in outer space activities, which is a small group of international space experts from a variety of countries convened to examine and report on methods for improving cooperation and reducing the risks of misunderstanding and miscommunication in space activities.

In March, SWF brought together officials from Australia, Japan, the Russian Federation, the United States and the European Union to review the current status of the international code of conduct. The Brussels-based event focused on the international code of conduct for outer space activities, proposed by the European Union. It examined its current status, challenges and the way forward from the point of view of several States.

III. Replies received from United Nations entities and other intergovernmental bodies

Office for Disarmament Affairs of the Secretariat

[Original: English]
[1 October 2012]

The Conference on Disarmament began formal deliberations on the issue of prevention of an arms race in outer space in 1985 with the establishment of the Ad Hoc Committee on the Prevention of an Arms Race in Outer Space. This resulted from the initiative put forward in General Assembly resolutions 36/97 C and 36/99. In those resolutions, the General Assembly requested the Conference on Disarmament to consider the question of negotiating effective and verifiable agreements prohibiting anti-satellite weapons (resolution 36/97 C), and to embark on negotiations with a view to achieving agreement on a treaty banning the deployment of any type of arms in outer space (resolution 36/99).

Although the deliberations in the Ad Hoc Committee demonstrated by the middle of the 1990s the fundamentally different perceptions of security risks to

outer space activities, as well as the divergent views on the priorities and methods to address them, the Conference on Disarmament has remained seized of the matter. In accordance with its mandate, the Conference on Disarmament has centred its attention on the following issues:

(a) Ban on the placement of weapons in outer space;

(b) Prohibition of the use of satellites themselves as weapons;

(c) Prohibition of testing and use of weapons on satellites so as to destroy or damage them;

(d) Development of transparency and confidence-building measures in outer space activities.

Working papers submitted by Canada, China and the Russian Federation, including the draft treaty on the prevention of the placement of weapons in outer space and of the threat or use of force against outer space objects (CD/1839 of 2008) by China and the Russian Federation, have served as a basis for discussion on the above-mentioned issues.

In 2012, Member States addressed the issue of the prevention of an arms race in outer space at two plenary meetings in the framework of the thematic discussions that were held in the Conference on Disarmament. They took into consideration the work at the first session of the group of governmental experts on transparency and confidence-building measures established pursuant to General Assembly resolution 65/68 and the European Union draft international code of conduct for outer space activities. The expectation was expressed that the recommendations of the group of governmental experts, jointly with the European Union draft international code of conduct would constitute a set of measures and rules that would help to mitigate risks related to space debris. Many delegations spoke out in favour of expanding cooperation between United Nations institutions and agencies in order to make progress in providing more secure and safer conditions for outer space activities.

At the same time, as the number of nations aspiring to gain access to outer space is growing and the orbits are getting more and more populated with space objects of different kinds, the question has arisen whether the current international legal framework on outer space, including the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies of 1967 is still adequate to address all space security challenges. In that regard, the view was expressed that as long as the Conference on Disarmament remains in deadlock, efforts on non-discriminatory and universally accepted transparency and confidence-building measures could be stepped up. At the same time, such efforts cannot be considered a substitute for negotiations on a legally binding instrument but rather a step-by-step process towards achieving legally binding measures complemented by and mutually reinforced through transparency and confidence-building measures.