United Nations A/AC.105/C.1/103

General Assembly

Distr.: General
5 December 2011

Original: English

Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
Forty-ninth session
Vienna, 6-17 February 2012
Item 14 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 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 following member States: Australia, Belgium, Japan and the United Kingdom of Great Britain and Northern Ireland; from the following international intergovernmental organization having permanent observer status with the Committee: Asia-Pacific Space Cooperation Organization; and from the

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* A/AC.105/C.1/L.310.

following international non-governmental organizations having permanent observer status with the Committee: Committee on Space Research, International Astronautical Federation, Secure World Foundation and Space Generation Advisory Council.

II. Replies received from member States

Australia

[Original: English]
[10 November 2011]

The Australian Government is a party to all the major United Nations space-related treaties, including the 1967 Treaty on Principles Governing the Activities of States on the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, and supports international cooperation through those treaties and other international agreements.

The Australian Government has developed a policy framework entitled "Principles for a national space industry policy", which identifies a framework around space sustainability. One of the key policy principles is "Contributing to a stable space environment"; Australia will continue to support rules-based international access to the space environment and the promotion of peaceful, safe and responsible activities in space.

The Australian Government also encourages the sustainability of space by supporting projects that contribute to a safe and sustainable outer space environment. This supports Australia's policy objective of ensuring access to space-based capabilities. This is also addressed under the second principle, "Ensure access to space capability". Through this policy principle Australia hopes to ensure resilient access to those space systems on which we rely now and those important for our future national security, economy, environment and social well-being.

The Australian Government also has a regulation in place that governs space-launch activities by Australian nationals. The Australia Space Licensing and Safety Office implements the regulatory and safety regime for space activities in Australia and by Australians overseas. The Office has responsibility for enforcing the provisions of the Space Activities Act (1998) and the Space Activities Regulations (2001).

The importance of space situational awareness is also recognized by the Australian Government, and Australia is working in partnership with the United States on this issue.

The Australian Government's Australian Space Research Programme has funded a project entitled "Automated Laser Tracking of Space Debris". The project is aimed at effectively resolving orbit prediction uncertainty by demonstrating significantly higher accuracy of satellite orbits through the use of a fully automatic remotely operated laser-based tracking station. The project outcomes contribute important research and development within the space surveillance industry.

More detail on the "Principles for a national space industry policy", the Space Licensing and Safety Office regulation and safety regime and the Australian Space Research Program can be found on the website www.space.gov.au.

Belgium

[Original: English]
[7 September 2011]

Belgium considers the topic of the long-term sustainability of space activities one of the most important topics addressed by the Committee on the Peaceful Uses of Outer Space. It is a challenge not only for its member States to demonstrate the effectiveness of the Committee and its subordinate bodies, but also for the space community to formulate solutions to ensure the sustainable and sound use of outer space for all nations.

In an early phase, Belgium supports a technical approach to the main concerns and issues identified as the bases of the work of the Working Group and its expert groups. Those expert groups should be given the possibility of assessing draft documents prepared by experts at the request of the chair of each expert group. It is the view of Belgium that the work already performed and the document already published by the Brachet group, to the extent that it can be endorsed by the members of the expert groups, could serve that purpose. Belgium also proposes that the work of each expert group focus on three dimensions:

(a) Identification and review of current national and international measures, mechanisms or actions undertaken with regard to the topic to be handled;

(b) Assessment of the positive and negative results, achievements or shortcomings of those existing measures, mechanisms or actions;

(c) Formulation and suggestions regarding possible extensions, corrections, improvements or complements to be brought to those existing measures, mechanisms or actions.

Belgium therefore suggests that the chair of each expert group set up as soon as possible a drafting committee, composed of three or four experts, which would prepare a non-paper to be circulated among the members of the expert group, by e-mail, calling for a first round of comments, remarks, proposals, ideas or suggestions, to be provided to the Chair before a fixed date. At the end of this first round, a meeting of the expert group could be organized to discuss the results and the way forward.

Japan

[Original: English]
[11 November 2011]

Experiences and practices related to the long-term sustainability of outer space activities and space weather in Japan

I. Long-term sustainability of outer space activities

A. Background of orbital environment

Major efforts to limit the generation of space debris have been made in most countries. However, from the perspective of long-term sustainability, we should take into account the following points:

(a) The debris environment is deteriorating in spite of the establishment of the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space and other international and national standards;

(b) The risk of collision cannot be ignored in densely populated orbital regions;

(c) The major source of debris generation in the near future will be a collision among existing objects.

Thus, preventing damage from collisions with orbital objects in the following ways should be emphasized, in addition to limiting the generation of debris:

(a) Preventing collisions with large debris (including debris clouds just after fragmentation);

(b) Preventing collisions with manned space systems at the launching phase;

(c) Preventing damage from collisions with tiny debris.

B. Experiences and practices in Japan

Japan, mainly through the Japan Aerospace Exploration Agency (JAXA), is executing measures to limit the generation of debris and also addressing protection from collision. To develop comprehensive measures with regard to debris, it is useful to follow the contingency planning method, which consists of "preventive measures", "detection of threats", "immediate action" and "permanent measures".

1. Practice, procedure and technical rules associated with expert group B topics

(a) Space debris

Measures to reduce the creation and proliferation of space debris include:

(a) Application by JAXA of a space debris mitigation standard that is almost equivalent to the space debris mitigation requirements of International Organization for Standardization standard 24113 (ISO 24113);

(b) Good compliance with the standard for "mission-related objects", "prevention of break-ups" and "removal from the geosynchronous Earth orbit (GEO) protected region". Some areas are identified as needing improvement.

With regard to re-entry notifications and hazardous substances on board, JAXA requires operators to refrain from using materials that will survive re-entry because of their high melting point or high specific heat. This should be encouraged throughout the world.

With regard to technical developments and possibilities regarding space debris removal, Japan conducts research on technologies to remove objects mainly by using the electrodynamic tether system.

(b) *Space operations*

Conjunction assessment is conducted using available information in the world, and avoidance manoeuvres will be planned, if necessary.

JAXA provides pre-launch notifications in accordance with the Hague Code of Conduct, and it analyses the probability of collision with manned systems and controls the launch window. Collision avoidance for manned systems at launch is expected to be encouraged among the world's launch service providers.

(c) *Tools to support collaborative space situational awareness*

With regard to registries of operators and contact information, to assess risk and plan avoidance manoeuvres, the status and point of contact of approaching spacecraft are expected to be made available on the United Nations website in timely fashion.

With regard to the collection, sharing and dissemination of data on functional and non-functional space objects:

(a) JAXA provides the United Nations with information on when the space object was registered and when it was no longer functional or in Earth orbit, in accordance with the Convention on Registration of Objects Launched into Outer Space and the recommendations on enhancing the practice of States and international intergovernmental organizations in registering space objects;

(b) JAXA publishes satellite launch information and in-orbit operation status as needed;

(c) JAXA intends that information regarding functional and non-functional space objects is shared through the usage and improvement of the website of the Office for Outer Space Affairs.

With regard to the storage and exchange of operational information:

(a) Information on orbital characteristics can be obtained from catalogued United States data, on which Japan basically depends;

(b) If an operating satellite causes a break-up, the operator should so inform the appropriate organization. The relevant authority is expected to notify the world of the event.

(d) *Other*

For rendezvous and proximity operations, JAXA operates the H-II Transfer Vehicle based on internationally agreed rendezvous, proximity operations and the de-orbit operations procedure. The detection, notification and avoidance procedures for the close approach of space debris are also specified in the flight rules and the operations interface procedure.

The impact of tiny objects is risky for spacecraft. The United Nations is expected to encourage academic institutes to study population models for tiny debris and cost-effective protection design.

Quality and reliability are major factors involved in the debris issue. The sharing of mature technologies with newcomers and students is encouraged, through ISO and other international standards.

2. Relationship to current work in the Committee on the Peaceful Uses of Outer Space and other bodies

The population models for tiny debris and the cost-effective protection design can be encouraged in the work of the Inter-Agency Space Debris Coordination Committee (IADC).

The standards to ensure quality and reliability can be promoted by ISO.

3. Relationship of input submission to other expert groups

The suggestion regarding “quality and reliability” is to be discussed with expert group D.

II. Space weather

(a) Space-based observation

JAXA is now conducting space environment measurement by using five satellites: low-Earth orbit (LEO), 2; GEO, 1; Quasi-Zenith Satellite orbit, 1; and International Space Station (ISS)/Japan Experiment Module. Data have been provided in real time or quasi-real time, depending on the situation, via the JAXA website.

The National Institute of Information and Communications Technology (NICT) is also gathering solar wind data by using the NICT ground station. Solar wind data have been provided via the NICT website in real time.

(b) Ground-based observation

Ground-based observation has been performed by NICT and the Space Environment Research Center (SERC), Kyushu University.

NICT conducts solar observations by optical telescope and radio telescope. The data have been provided via the NICT website in real time.

SERC has deployed magnetometer systems to over 50 places all over the world. The data have been provided via the SERC website in real time or quasi-real time.

(c) Space weather modelling

There are several space weather models in Japan, most of which are being developed in universities. JAXA too has been developing a space radiation model based on the observation data collected by JAXA satellites. It is an empirical/average model, depending on solar activity. In 2011, JAXA published a paper that demonstrated a new dynamic model.

(d) *Space weather forecast tool*

NICT has been developing a real-time geospace simulator, whose input is real-time solar wind information. In 2011, NICT succeeded in calculating the space plasma environment in the vicinity of satellites. The NICT geospace simulation data is open to the public via the NICT website.

(e) *Standard for satellite manufacturing*

There are space weather effects on satellite charging and the single event, etc. JAXA has been revising the document on the standard for satellite manufacturing.

United Kingdom of Great Britain and Northern Ireland

[Original: English]
[4 November 2011]

1. Introduction

Many countries have reflected their obligations under the outer space treaties through the enactment of national legislation. The United Kingdom of Great Britain and Northern Ireland brought into force its Outer Space Act in 1986. When the outer space treaties were developed, there was no understanding of space debris. However, the treaties and national regulations are flexible enough to address the issue in an effective manner, relying upon best practice and codes and principles to encourage the adoption of space debris mitigation measures.

A number of standards and guidelines for minimizing debris production and protecting spacecraft now exist at both the national and the international level. The importance of such mitigation measures is recognized by space-faring nations. This is a key step in managing the future evolution of the orbital environment in a fair and equitable manner, as there is a cost associated with many mitigation practices.

To ensure that their application will not penalize operational competitiveness, such mitigation measures must be recognized and applied by all users of space in a coordinated manner. To be effective, mitigation practices will need to become an intrinsic and consistent element of in-orbit operations rather than a piecemeal, ad hoc practice. If these practices can be embodied within national legislation, then operators will be obliged to consider space debris mitigation during all phases of a mission, from initial definition and feasibility studies to final disposal. The United Kingdom’s Outer Space Act is the basis for licensing the activities of United Kingdom nationals in space, and technical assessments have recently been adapted to include consideration of space debris mitigation practices when deciding whether to issue a licence to an applicant.

2. Outer Space Act

The Outer Space Act 1986 is the legal basis for the regulation of activities in outer space (including the launch and operation of space objects) carried out by persons connected with the United Kingdom. The Act confers licensing and other powers on the Secretary of State acting through the UK Space Agency. The Act ensures compliance with United Kingdom obligations under the international conventions covering the use of outer space to which it is a signatory. Those conventions are:

(a) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty);

(b) Agreement on the rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement);

(c) Convention on International Liability for Damage Caused by Space Objects (Liability Convention);

(d) Convention on Registration of Objects Launched into Outer Space (Registration Convention).

Under the legislation of the Outer Space Act, the Secretary of State shall not grant a licence unless he is satisfied that the activities authorized by the licence will not jeopardize public health or the safety of persons or property, will be consistent with the international obligations of the United Kingdom and will not impair the national security of the United Kingdom. Further, the Secretary of State requires the licensee to conduct operations in such a way as to prevent the contamination of outer space or adverse changes in the environment of the Earth, and to avoid interference with activities of others in the peaceful exploration and use of outer space.

The Secretary of State requires the licensee to insure himself against liability incurred in respect of damage or loss suffered by third parties, in the United Kingdom or elsewhere, as a result of the activities authorized by the licence. Further the licensee shall indemnify Her Majesty's Government in the United Kingdom against any claims brought against the Government in respect of damage or loss arising out of activities carried out by the licensee to which the Act applies.

The Outer Space Act provides the necessary regulatory oversight to: consider public health and safety and the safety of property; to evaluate the environmental impact of proposed activities; to assess the implications for national security and foreign policy interests; and to determine financial responsibilities and international obligations.

3. Licensing process and technical evaluation

Safety evaluation is aimed at determining whether an applicant can safely conduct the launch of the proposed launch vehicle(s) and any payload. Because the licensee is responsible for public safety, it is important that the applicant demonstrate an understanding of the hazards involved and discuss how the operations will be performed safely. There are a number of technical analyses, some quantitative and some qualitative, that the applicant must perform in order to demonstrate that the commercial launch operations will pose no unacceptable threat to the public. The quantitative analyses tend to focus on the reliability and functions of critical safety systems and the hazards associated with the hardware, and the risk those hazards pose to public property and individuals near the launch site and along the flight path and to satellites and other in-orbit spacecraft. The qualitative analyses focus on the organizational attributes of the applicant, such as launch safety policies and procedures, communications, qualifications of key individuals and critical internal and external interfaces.

The launch of a payload into orbit and the hazards associated with such an operation can be categorized according to the general mission phases of:

- Pre-launch
- Launch
- Orbit acquisition
- Re-entry

In the technical submissions for a licence under the Outer Space Act 1986, an applicant must provide an assessment of the risk to public safety and property, covering each phase of the mission relevant to the proposed operations and licensed activity. The assessment should include:

(a) Discussion of possible vehicle and payload failures that could affect safety (including the safety of other active spacecraft);

(b) Estimation of the likelihood of their occurrence, supported by vehicle reliability data, both theoretical and historical;

(c) Consideration of the effects of such failures.

As appropriate, the assessment should address:

(a) Launch range risks;

(b) Risk to down-range areas owing to the impact of discarded mission hardware;

(c) Overflight risks;

(d) Orbital risks, including the risk of collision and/or debris generation, owing to intermediate and final orbits of vehicle upper stages and payloads;

(e) Re-entry risks of vehicle upper stages and payloads.

The risk assessment is then used as a basis for the review conducted by assessors to determine whether the applicant's proposed activities are compliant with the requirements of the Outer Space Act. The qualitative and quantitative criteria used for the evaluation are based on standards and practices employed by a variety of formal bodies. In each case, the assessor seeks to understand the approach proposed by the licence applicant, to judge the quality of the process, to check the degree of consistency within the project, to consider the effectiveness of the proposed technology or process and to establish its conformance with industry or Agency norms and with the requirements of the Outer Space Act. In the document hierarchy, level 0 documents are those which outline the United Kingdom's international obligations, level 1 documents are those which present the specific requirements placed on the applicant, level 2 documents are those generated by the applicant to demonstrate compliance (or otherwise), level 3 documents are those generated by the assessors in their evaluation of the application, and level 4 documents are the licences themselves.

4. Space debris mitigation and interpretation under the Outer Space Act

In developing the technical evaluation framework to reflect space debris mitigation issues, the particular issues of physical interference and contamination referred to in the Outer Space Act are employed. Although the problem of space debris was not recognized when the Outer Space Act was enacted in 1986, the Act is flexible enough to allow interpretation to cover this aspect in the technical evaluation. Thus, "physical interference" is used to address probability of collision with other objects in orbit and "contamination" to address safe disposal at end of life. As regards the actual measures that are used to evaluate a licence application, use is made of the growing number of guidelines, codes and standards that are being developed to deal with space debris mitigation. The Mitigation Guidelines of IADC and the Committee on the Peaceful Uses of Outer Space and the European code of conduct provide qualitative and quantitative measures that are used to assess the compliance of licence applicants' proposed activities and measures with recognized best practice within the community. The most common licence that the UK Space Agency processes is a payload licence. In the case of a payload licence, the safety assessors check the satellite platform's specification (e.g. attitude control system, orbit, power storage mechanism, launcher interface and separation mechanism) and the safety processes (plans and procedures) to assess their effectiveness at space debris mitigation. Examples are given below:

Attitude control system. Initial determination of nature of system and whether fit for purpose. Is the technology cold gas thrusters, reaction/momentum wheels, is there a potential for stored energy at end of life? If so, consider the likelihood of fragmentation occurring and if so, recommend passivation measures at end of life.

Orbit. Basic understanding of the orbital elements of the proposed trajectory. Consider natural lifetime, stability of orbit under the influence of natural perturbations, degree of crowding at a particular altitude, any unique aspects of orbit configuration.

Power storage mechanism. General review of technology and suitability. Is it physical (flywheel) or electric, are fuel cells standard technology, are there any unique/exotic elements (e.g. radioisotope thermal generator), is the system scaled for platform power requirements and charge cycles (account for eclipse characteristics), is there a potential overcharge problem at end of life, passivation consideration?

Launcher interface and separation mechanism. Understand the nature of the coupling and ejection process. Is the interface dictated by the launcher or payload, is the launch environment very demanding, is the launch environment well understood/specified and payload qualified, how many objects are introduced into orbit in addition to upper stage and payload, does separation process minimize debris production?

Safety processes and procedures. Determine existence and consideration of safety issues. Where relevant to the launch phase, consider the safety implications of the payload for the launcher; are there unique risks associated with the payload, if it is a multiple payload launch, does payload deployment pose a risk to others? With regard to contamination of the environment, the impact on both the debris and radiation environment is assessed (for example, frequency interference).

Impact on the debris environment. Safety assessors consider the likelihood of collision of payload with other operational payloads and the general debris environment. This is determined by orbital configuration, orbital lifetime, physical size and spatial density of objects at proposed altitude.

De-orbit and re-orbit plans. Regarding the operator's ability to comply with safety requirements, the applicant is asked about his de-orbit/re-orbit plans, whether plans exist to remove the satellite from the operational orbit should an irrecoverable failure occur, whether such capability is available, etc. Safety assessors need to understand if plans exist and if so, are they effective? Has the issue been considered, at what altitude is operational orbit, is disposal necessary, is re-orbit to higher altitude or de-orbit to lower altitude planned, are disposal orbits effective, do they comply with existing standards/guidelines (e.g. use of IADC re-orbiting formula for GEO satellites, 25-year maximum disposal orbit lifetime below 2,000 km), what is feasible with platform technology, the extent of autonomy on-board to conduct de-orbit/re-orbit without ground intervention, what criteria are used to determine end of life? Are operational procedures agreed or will they be put in place prior to regular operations?

5. Summary

The United Kingdom has implemented space debris mitigation measures in its evaluation of licence applications under the Outer Space Act 1986 to ensure compliance with the established outer space treaties and conventions and the emerging set of guidelines, codes and standards. The United Kingdom recognizes that regulation is an important element of ensuring the sustainability of operations in outer space.

III. Replies received from international intergovernmental organizations having permanent observer status with the Committee

Asia-Pacific Space Cooperation Organization

[Original: English]
[24 October 2011]

Sustainable space utilization supporting sustainable development on Earth

A data-sharing service platform and its applications pilot project were a top-priority project whose feasibility study was completed last year, and it is now in the implementation stage. China, being a member State of the Asia-Pacific Space Cooperation Organization (APSCO), has already committed to contribute remote-sensing data for the service. The first part of the project is expected to be completed by the end of May 2012, and the applications pilot projects are expected to be undertaken by member States subsequently.

The APSCO Applied High-Resolution Satellite Project was the second project on the priority list. Its feasibility and system-definition study was completed last year, in which experts from all member States of APSCO, as well as Ukraine, took part. The study envisages having a constellation of two satellites, but the second will be developed after launching the first so as to use the experience gained from the first. The first satellite will have a panchromatic imager with two-metre resolution and a multispectral imager with eight-metre resolution, besides other auxiliary and experimental payloads. The manufacturer will be determined through competitive international bidding. The prime and backup control stations will be located in the member States of APSCO. The project was approved in the last week of January 2011. After the necessary preparations are made, the project is expected to kick off early next year.

Space debris, space operations and tools to support collaborative space situational awareness

The Asia-Pacific ground-based optical space observation system is another prioritized project whose feasibility study was completed last year, and it was approved in the last week of January 2011. The project will facilitate space object detecting, tracking and identification, orbit determination and cataloguing, collision early warning, re-entering space object prediction, technical consultation and training. The first phase of the project is under implementation and is expected to be completed by the end of May 2012, after which regular operation will start. Phase two of the project will commence subsequently.

Space weather

The projects on electromagnetic satellite payload for earthquake prediction and research on determining precursor ionospheric signatures of earthquakes by ground-based ionospheric sounding have recently been approved by the APSCO Council for conducting feasibility studies. APSCO is currently going through a phase of assessing the requirements of the member States of APSCO. A symposium on that theme, conducted in Beijing in September 2011, was also a step towards the consolidation of requirements of member States and the completion of feasibility studies. After a preliminary requirement assessment, detailed proposals will be invited from APSCO member States and discussed in an expert group meeting planned for the second half of 2011. Discrete technical proposals on the electromagnetic satellite payload for earthquake prediction and research on determining precursor ionospheric signatures of earthquakes by ground-based ionospheric sounding will be consolidated with the cost-benefit analysis and implementation plan and will be presented to the APSCO Council by mid-2012 for approval. The research and implementation of these projects will focus on ionospheric signatures, thermal infrared activities, long-wave radiation, atmospheric changes, etc., and will contribute to modelling space weather.

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

Committee on Space Research

[Original: English]
[3 November 2011]

Scientific Commission on Space Studies of the Earth's Surface, Meteorology and Climate

The Committee on Space Research (COSPAR) Scientific Commission on Space Studies of the Earth's Surface, Meteorology and Climate promotes and enhances effective international coordination, discussion and cooperation in various areas of the study of the Earth system where space observations can make unique and useful contributions. Earth observation is essential to monitor the current state and evolution of our planet's environment. Space satellites provide a large amount of data that can be (a) assimilated into various models for better forecasts in meteorology and oceanography or (b) analysed for monitoring the state of and changes in climate and ecosystems. Additional phenomena such as health, energy, agriculture and biodiversity, energy and disasters have also increased the use of Earth observation data during recent decades.

The Scientific Commission's activities relevant to long-term sustainability are achieved through COSPAR membership in the Group on Earth Observations, which is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS) for providing decision-support tools to a wide variety of users. A dedicated Group on Earth Observations task group has been created within COSPAR to promote, among other things, education and outreach regarding sustained, high-accuracy, well-calibrated, regional observing systems in developing countries for contributions to global data sets.

Various scientists involved in the Scientific Commission are also contributing to international bodies such as the Global Terrestrial Observing System, the Global Climate Observing System and the Integrated Global Ocean Services System to assist in writing scientific or policy reports aimed at promoting long-term sustainability activities for the study of our planet. The Scientific Commission has recently participated in educational activities through several capacity-building workshops around the world whose objectives are to promote the long-term sustainability of Earth observation data analysis in various domains.

Panel on Satellite Dynamics

Part of the activities of the Panel on Satellite Dynamics concerns the orbital motion and precise orbit determination of Earth-orbiting artificial satellites. Precise knowledge of the orbital motion of near-Earth orbiting objects is not only crucial regarding the safety of activities in space (e.g. collision avoidance and evolution of space debris and decommissioned satellites), but is also indispensable for the use and exploitation of almost all near-Earth-orbiting satellites, including navigation, telecommunication and almost all scientific Earth-observing satellites. For monitoring the Earth's environment and climate, it is often required to reconstruct the orbital motion of satellites with decimetre- or even centimetre-level precision.

The Panel on Satellite Dynamics brings together scientists and users who continuously work on implementing and improving methods and software systems for orbit determination. In addition, the Panel addresses the impact of such work in the fields of positioning and Earth monitoring (sea-level change, ice-mass balance, natural hazards, etc.).

Panel on Technical Problems Related to Scientific Ballooning

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

(a) NASA/Columbia Scientific Balloon Facility (United States of America): after 10 years of development, the Ultra-Long Duration Balloon project, a balloon system operating at any latitude and in any season for stratospheric flights lasting up to several weeks, is progressing and is now in the beginning of the qualification phase;

(b) JAXA (Japan): implementation of a new balloon launch site in Japan (Taiki Aerospace Research Field) with first flights operated in mid-2008;

(c) Swedish Space Corporation (Sweden): construction of a second building for integration of a scientific gondola on its rocket and balloon base in northern Sweden (Kiruna); availability for operations is scheduled for 2013;

(d) Centre national d'études spatiales (CNES) (France): in 2013 qualification of Nosyca, a new, complete system for operating stratospheric balloons, with a planned duration of use of 15 years.

Panel on Potentially Environmentally Detrimental Activities in Space

Space debris is one of the seven topics to be addressed by the new 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 organized 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.

In 2010 the theme of the Potentially Environmentally Detrimental Activities in Space sessions was "Space debris — a global challenge". One half-day session was devoted to space debris mitigation and remediation, the principal space debris issues facing the long-term sustainability of activities in outer space. At the 39th Scientific Assembly of COSPAR, in 2012, the theme of the Panel's sessions will be "Space debris — steps towards environmental control". COSPAR continues to be a leader in promoting a better understanding of the nature and risks of the space debris environment and in encouraging space-faring 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. This naturally leads to a detailed study of the space environment and of its effects on space vehicles and astronauts. One major current challenge is to contribute to recently initiated programmes such as the European Space Agency's space situational awareness programme.

In the next two to three years several space missions dedicated to the study of radiation belts will be launched (RBSB, United States of America; ERG, Japan; and Resonance, Russian Federation). Those missions will generate much activity in the next 10 to 15 years, during which time data will accumulate and be analysed. Of course, the Panel on Radiation Belt Environment Modelling will be a central forum for scientists to communicate about new findings and to collaborate.

Panel on Space Weather

The Panel on Space Weather welcomes the inclusion of space weather within the remit of a working group, and the Panel officers look forward to the group's initial report with interest. The Vice-Chair of the Panel on Space Weather has been elected Chair of the associated Space Weather expert group.

The Panel's recent activities have been aimed at illustrating the wide range of ongoing international activities in the area of space weather and at encouraging collaboration between groups involved. Recent events have clearly highlighted the wealth of data currently available and the rapidly evolving field of research. Further investigation is welcome in order to identify mechanisms to optimize the sharing of scientific and technical information of common interest with a view to ensuring the safety of space assets.

Recent Panel events have also focused on the sustainability of key data sets underpinning services. In addition to the study of short-term variability in the space environment, the study of longer-term properties through use of long-term and historical data archives has been highlighted as a key aspect of understanding space weather phenomena. The recent solar minimum period gave a good example of this case, with scientists looking at measurements dating back many solar cycles in order to better understand current phenomena.

The Panel on Space Weather also emphasizes the importance of bringing together the scientific and engineering communities to better understand the problems experienced by modern systems and encourage greater awareness of space weather among the operators and owners of affected systems. For example, issues such as timeliness and data formats, which, although not primary goals in the context of scientific understanding of space weather phenomena, are critical for providing actionable information to end-users.

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 planetary satellites within the solar system, and (b) preventing the contamination of Earth by materials returned from outer space that may be carrying 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 of the United Nations, 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.

Panel on Exploration

The mandate of the COSPAR Panel on Exploration, founded in Montreal in 2008, is to provide independent science input to support a global space exploration programme while working to safeguard the scientific assets of our solar system. Apart from alliances of established space nations, the engagement of newly emerging and developing countries at an early stage and in a meaningful way will be a pillar to support a sustainable global space exploration program. The first Panel on Exploration report, entitled: “Towards a global space exploration programme: a stepping-stone approach” (June 2010; an updated version will appear in *Advances in Space Research* in 2011), proposes activities that support the transition towards larger space architectures.

The stepping stones include Earth-based analog research programmes preparing for planetary exploration, an International Space Station (ISS) exploitation programme enabling exploration science, and an international CubeSat programme in support of exploration, as well as more complex endeavours, such as human outposts. Several of these preparatory activities should involve a wide range of actors in the global space community. By joining such preparatory activities, developing and emerging space nations that are constrained by limited budgets and expertise face a low entry-barrier to gaining experience in the conduct of future space exploration. Building up basic space technology capacity with a wider range of countries, ensuring that new actors in space act responsibly, and increasing public awareness and engagement provide a broader interest in space exploration and programme sustainability.

In summary, the Panel on Exploration is developing a bottom-up approach to strengthen a long-term global space exploration programme by highlighting opportunities to integrate many countries and stakeholders into that endeavour. COSPAR unites institutions from 46 countries and works with numerous associated bodies, and can thus provide and engage a worldwide scientific network for cooperation. On behalf of COSPAR, and in support of this approach, the Panel holds workshops, issues official reports and helps engage developing countries in worldwide space exploration efforts.

Panel on Capacity-Building

The 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 contributes directly to this aspect of outer-space sustainability.

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

This Panel on Capacity-Building programme is now 10 years old, and in that time about 15 capacity-building workshops have been organized. The 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 such 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 to 35 students (the term "student" 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 being discussed. The students spend the rest of the time working on a project using real data and software of one of those space missions, under the supervision of the lecturers.

In 10 years about 500 students have been trained through these workshops, on topics such as 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 is provided by several international organizations (ESA, NASA, International Astronomical Union (IAU), Office for Outer Space Affairs, etc.) and the host country.

International Astronautical Federation

[Original: English]
[7 November 2011]

International Astronautical Federation and the issue of long-term sustainability of outer space activities

A series of incidents, such as the collision between two spacecraft — Cosmos 2251 and Iridium 33 — in February 2009, has illustrated the danger of the ever-increasing orbital debris population, particularly in low Earth orbits, the crowding of selected orbit families and various radio interference concerns between active spacecraft in the geostationary orbit. Faced with this situation, the International Astronautical Federation (IAF) has taken an interest in the issue of long-term sustainability of outer space activities. As the only international federation of actors in outer space bringing together governmental institutions, private commercial companies and academia, its duty is to facilitate exchanges of views and dialogue between these actors on ways and means to maintain outer space as a safe and secure environment.

IAF is active in many areas of direct relevance to the long-term sustainability of outer space activities, particularly through its Committee on Space Security, set up in late 2008. That Committee, chaired by Kazuto Suzuki of Hokkaido University, Japan, addressed this topic during the 60th International Astronautical Congress, held in Daejeon, Republic of Korea, in October 2009; the 61st Congress, held in Prague, in October 2010; and the 62nd Congress, held in Cape Town, South Africa, from 3 to 7 October 2011. The Committee consists of more than 20 experts on political, economic, legal and technical matters, including Peter Martinez, Chair of the Working Group on the Long-term Sustainability of Outer Space activities of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space.

The International Astronautical Congress is organized every year by IAF in association with the International Academy of Astronautics and the International Institute of Space Law. The Congress brings together more than 2,500 experts from the scientific, technical, legal and cultural areas of outer space and provides an excellent opportunity to review the progress made in ensuring the safety of space activities and mitigating space debris and to discuss technical and legal issues of active orbital debris removal.

The 62nd Congress brought together 2,900 participants. As had previous Congresses, it included a symposium dedicated to space debris, coordinated by Nicholas Johnson of NASA and Christophe Bonnal of CNES, with many high-quality contributions, including some on active debris removal. One session of the symposium focused on mitigation and standards and another on space debris removal issues.

The topic “Towards space debris remediation” was selected for the 26th International Academy of Astronautics/International Institute of Space Law Scientific/Legal Round Table, chaired by Kai-Uwe Schrogl of ESA and Wendell Mendel of NASA. Presentations were given on the status of space objects that should be removed, the potential costs of the removal and the changes required in the legal and regulatory framework. There was a shared view that, with the recent cases of re-entry of larger space objects (most recently the Upper Atmospheric Research Satellite and Roentgen Satellite), threats in outer space and on the ground were not only increasing but were also becoming more visible to the public. Measures therefore had to be taken to avoid the further production of space debris through collisions with larger inactive space objects, as well as to avoid endangering people on the surface of the Earth and to avoid a negative image among the public. Besides the technical steps, the legal framework would have to be shaped in such a way that space debris could be classified and dealt with without treating them as "space objects", as is the case under current international space law. A critical issue was that debris removal missions were still far too costly to be taken into consideration, even if the potential damage produced by a single item of space debris, such as an inactive large spacecraft, could be offset.

Of particular interest to delegations to the Committee on the Peaceful Uses of Outer Space, the issue of long-term sustainability of outer space activities was the topic of a specific session of the symposium on space policy, law and economics, on 5 October. That session was jointly organized by the IAF Committee on Space Security and Commission V of the International Academy of Astronautics. Peter Martinez, Chair of the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee, chaired the session, which included a number of contributions. Mr. Martinez then moderated a panel discussion, with the participation of Ciro Arévalo, Chair of the Committee on the Peaceful Uses of Outer Space in 2008-2009, Gerard Brachet, Chair of the Committee in 2006-2007, and Karl Doetsch, Chair of the Scientific and Technical Subcommittee in the period 2004-2006.

The 63rd International Astronautical Congress will be held in Naples, Italy, from 1 to 5 October 2012. It will again include a symposium dedicated to space debris. More information on the programme of the 63rd Congress is available at www.iac2012.org. Following its meeting in Cape Town, the IAF Committee on Space Security plans a joint session with the space debris symposium at the 63rd Congress, dedicated to political, economic and institutional aspects of space debris mitigation and removal. The IAF Committee on Space Security has also discussed preliminary ideas for sessions dedicated to the long-term sustainability of outer space activities at the 64th Congress, in Beijing in October 2013.

IAF and its partner organizations, the International Academy of Astronautics and the International Institute of Space Law, are actively involved in promoting a safe and secure space environment for use by all nations and by future generations.

Secure World Foundation

[Original: English]
[5 November 2011]

The long-term sustainability of space activities is the primary focus of the Secure World Foundation (SWF). Throughout 2011, the Foundation has worked with a variety of partners to stimulate thinking and action on the set of issues that space sustainability raises. SWF staff are also participating as experts in the

United States contribution to the expert groups in support of the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee. The following paragraphs list the major activities SWF has undertaken in support of this important goal.

Brussels Space Policy Round Table: 2011 Space Security Index launch in Europe, November 2011

SWF and the Mission of Canada to the European Union partnered to organize the 2011 Space Security Index launch in Europe as the part of the SWF Brussels Space Policy Round Table series of short panel discussions focusing on significant global space events with a particular emphasis on Europe.

Transparency and confidence-building measures in outer space activities

SWF and the United Nations Institute for Disarmament Research organized an event titled: "TCBMs in outer space activities: looking back and moving forward", which was held at United Nations Headquarters in New York City in October 2011. The event featured speakers from a range of disciplines discussing the current state of, past work on and possible future of transparency and confidence-building measures in space, with special attention paid to the upcoming meeting of the group of governmental experts on the subject.

Beijing Space Sustainability Conference, October 2011

The Space Sustainability Conference, held at Beihang University in Beijing, discussed 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 Conference was co-organized by SWF, International Space University and Beihang University.

Ensuring the long-term sustainability of outer space activities

The long-term sustainability of space activities is a matter of common concern for all current and future space actors. The increasing number of countries and private operators operating space systems and the growing amounts of space debris raise important questions about continuing to operate spacecraft in Earth orbit over the long term. Frequency management to prevent interferences and the influence of space weather are other critical issues. A session held during the International Astronautical Congress in Cape Town, South Africa, in October 2011, was intended to support the activities of the Working Group on the Long-term Sustainability of Outer Space Activities; it explored the policies, guidelines and application of the legal provisions of the outer space treaties that will be needed to assure long-term sustainability. SWF staff co-chaired the session and contributed two conference papers, on ensuring the long-term sustainability of space activities and on developing a potential strategy and policies for space sustainability based on sustainable management of common resources.

Analysing the development paths of emerging space nations

While the advent of emerging space nations certainly creates opportunities, it also raises new concerns. Balancing the new sets of opportunities and risks requires an understanding of the rationale and development paths of all space actors, including emerging ones. An analysis of six emerging space nations (Brazil, India, Malaysia, Nigeria, South Africa and Venezuela (Bolivarian Republic of)) reveals opportunities and challenges to space sustainability. The analysis, entitled *Analysing the Development Paths of Emerging Space Nations*, done by three recent graduates of the George Washington University master's programme, examines those nations' space policy development and interest (or lack thereof) in international cooperation, assessing how best the United States and the international community can reach out to them in the advancement of space sustainability. The authors also examine the European Union's draft code of conduct for outer space activities to assess how those emerging actors view it. Finally, the authors discuss the role that the United States has played to date and suggest ways in which it might enhance its efforts.

Improving Our Vision V, Chateau de Betzdorf, Luxembourg, June 2011

Organized in cooperation with the Eisenhower Center for Space and Defense Studies, the Studies and Expansion Society, and Intelsat, this fifth in the series of space situational awareness workshops examined ways in which shared space situational awareness data could be applied to enhance the safety, stability and security of operations in space. Discussions included an expanded look at issues beyond in-orbit operations, to include a comprehensive consideration of space systems' life cycle from launch to final disposal, discussion of United States and European policies for sharing space situational awareness data, and potential mechanisms to apply the uses of those data to improving the shared use of the space domain.

2011 Space Security Index release in Washington, D.C., June 2011

Held in partnership with the Canadian Embassy, the Space Security Index launch event focused on an overview of the 2011 Space Security Index, which examines major space security and sustainability events of the preceding year, and a discussion of various issues that may affect space security and sustainability over the coming year. The goal of the Space Security Index is to improve transparency with respect to space activities and provide a common, comprehensive knowledge base to support the development of national and international policies that contribute to space security and sustainability.

Space policies and laws in Asia

Given the rapid increase in space activities in Asia and the increasing importance of space in the lives of Asian citizens, many States in the region are building or refining their national space policies and laws. This is a crucial time for the region, as it builds its legal and policy frameworks that are needed to support the long-term sustainability and use of space for Asia and the international community in general. The workshop, on space policies and laws in Asia, held in Beijing in May 2011 in partnership with the China Academy of Sciences Institute for Policy and Management, brought together regional and international experts to examine the history, current state of affairs and future of Asian space policy. It also explored space cooperation at the national and regional levels in support of space sustainability.

Space verification: building common understanding

The workshop on the theme "Space verification: building common understanding" was aimed at identifying and exploring key topics that need to be agreed upon in order to lay the foundation for future verification norms for outer space that would increase international security and stability. The workshop, held at the Brussels office of SWF in March 2011, explored exactly what space verification should encompass and what factors need to be taken into account when assessing how to implement verification methods.

Space Generation Advisory Council

[Original: English]
[4 November 2011]

The next generation of space leaders believes that the sustainability of space activities is crucial to future space endeavours. To this end, the Space Generation Advisory Council's Space Safety and Sustainability Working Group supports the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee and participated in its session at the 62nd International Astronautical Congress, in Cape Town, South Africa. The Space Safety and Sustainability Working Group provides a forum for enthusiastic students and young professionals to participate in global deliberations on the safety and sustainability of space activities. Comprising members from established and emerging space countries and an advisory team of professionals in the field, the group identifies and exchanges ideas concerning critical issues threatening the sustainability of space activities.

The Group co-hosted the International Association for the Advancement of Space Safety (IAASS) paper competition, and the three winners were sponsored to present their research output, related to space safety and sustainability, at the 5th IAASS conference, in Versailles, France. Furthermore, the Group organized a workshop session at the 10th Space Generation Congress, during which delegates brainstormed on the subject "Technical and policy challenges of space debris mitigation and removal", resulting in the following recommendations:

(a) To improve space situational awareness coverage and the quality of space data, and foster collaboration between established and emerging space nations to host additional SSA infrastructure;

(b) To foster the fair and responsible use of space, the issue of mistrust among space actors should be dealt with by encouraging interaction and exchange of information and thus transparency;

(c) To promote international data-sharing, establish a neutral data centre to manage sensitive or proprietary space situational awareness data voluntarily contributed by participating space actors;

(d) The effectiveness of the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space can be increased by encouraging their adoption in national space policies and by giving incentives to space actors that comply with the guidelines.

The Group is currently compiling a literature review series in its thematic areas (space debris, space situational awareness, space weather and its effects on spacecraft, and space safety) to aid outreach efforts by providing comprehensive reference documents for people who are new to the field and expects that this will motivate them to take up careers related to the sustainability of space activities. The Group is running a number of technical projects on topics ranging from debris detection and removal to space situational awareness systems, all powered by the system toolkit of Analytical Graphics Inc. In addition, the Group is researching policy-oriented projects inspired by challenges facing the sustainability of space activities.