United Nations A/AC.105/C.1/L.343

General Assembly

Distr.: Limited
10 December 2014

Original: English

Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
Fifty-second session
Vienna, 2-13 February 2015
Item 13 of the provisional agenda*
Long-term sustainability of outer space activities

Draft report of the Working Group on the Long-term Sustainability of Outer Space Activities

Working paper by the Chair of the Working Group

I. Establishment of the Working Group, its terms of reference and its methods of work

1. At its forty-seventh session in 2010, the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space established the Working Group on the Long-term Sustainability of Outer Space Activities. Peter Martinez (South Africa) was elected Chair of the Working Group (A/AC.105/958, paras. 181-182).

2. At its fifty-third session in 2010, the Committee on the Peaceful Uses of Outer Space welcomed the establishment of the Working Group and noted with appreciation the Chair's proposal for its terms of reference and methods of work (A/AC.105/L.277).

3. At its forty-eighth session in 2011, the Subcommittee considered the draft for the terms of reference and methods of work for the Working Group and agreed that a revised version of the document would be presented to States members of the Committee at the fifty-fourth session of the Committee (A/AC.105/987, annex IV).

4. At its fifty-fourth session, in 2011, the Committee adopted the terms of reference and methods of work of the Working Group (A/66/20, annex II). Objectives and outputs of the Working Group included identifying areas of concern

* A/AC.105/C.1/L.341.

for the long-term sustainability of outer space activities, and examining and proposing measures, in the form of a series of voluntary guidelines, that could enhance the safe and sustainable use of outer space for peaceful purposes and for the benefit of all countries (A/66/20, annex II, paras. 11-12). It was agreed that the Working Group would meet annually during the sessions of the Scientific and Technical Subcommittee, and would also use opportunities to work intersessionally (A/66/20, annex II, para. 21).

5. As provided for in its terms of reference and methods of work, the Working Group established expert groups to expedite the work of the Working Group as a whole (A/66/20, annex II, para. 22). The expert groups centred around four thematic areas:

(a) Sustainable space utilization supporting sustainable development on Earth (expert group A);

(b) Space debris, space operations and tools to support collaborative space situational awareness (expert group B);

(c) Space weather (expert group C);

(d) Regulatory regimes and guidance for actors in the space arena (expert group D).

6. Expert group A was co-chaired by Enrique Pacheco Cabrera (Mexico) and Filipe Duarte Santos (Portugal), and included approximately 40 experts; expert group B was co-chaired by Claudio Portelli (Italy) and Richard Buenneke (United States of America), and included approximately 70 experts; expert group C was co-chaired by Ian Mann (Canada) and Takahiro Obara (Japan), and included approximately 40 experts; and expert group D was co-chaired by Anthony Wicht (Australia), who was succeeded by Michael Nelson (Australia), and Sergio Marchisio (Italy), and included approximately 50 experts. Each expert group developed a workplan, including objectives, outputs and methods of work (A/AC.105/C.1/L.324, A/AC.105/C.1/L.325, A/AC.105/C.1/L.326 and A/AC.105/C.1/L.327), and also submitted a working report upon the completion of its work. The working reports of expert groups A through D are contained in documents A/AC.105/C.1/2014/CRP.13, A/AC.105/2014/CRP.14, A/AC.105/C.1/2014/CRP.15 and A/AC.105/C.1/2014/CRP.16, respectively. The working reports contained, inter alia, proposed guidelines on the thematic areas covered by each of the expert groups, and topics for future consideration by the Committee or its Subcommittees.

7. A dedicated web page on the long-term sustainability of outer space activities was developed prior to the forty-ninth session of the Scientific and Technical Subcommittee in 2012. The web page, a part of the website of the Office for Outer Space Affairs, has restricted access and facilitates the sharing of information among the members of the Working Group and its expert groups. This dedicated web page is also accessible to all the national points of contact in the Working Group. As of December 2014, 36 States members of the Committee and five intergovernmental organizations had designated points of contact for the Working Group.

II. Findings of the expert groups

8. In line with their specific topics, expert groups A through D compiled information and provided analysis on current practices, procedures and cross-cutting issues associated with the long-term sustainability of outer space activities. The expert groups also identified a number of gaps in existing approaches. The main findings of the expert groups are summarized below, and provide the context from which the candidate guidelines have been developed.

A. Space and sustainable development

1. Space activities and sustainable development on Earth

9. Space technologies can play a special role in economic development, social development and environmental protection, the three pillars of sustainable development. They offer valuable tools for supporting sustainable development, the benefits of which are to be leveraged for all humankind. At the same time the possible harmful impacts of space activities themselves on the Earth's space environment also need to be addressed to safeguard the long-term sustainability of outer space activities.

10. Space-based applications such as Earth observation, global navigation satellite systems, and telecommunications provide objective data and information, which may improve our understanding of trends, assist with the evaluation of needs, and contribute to better-informed decision-making. In a world experiencing severe and frequent disasters, space technologies can gather information for systems and models that can predict disasters and trigger early warnings. Space technologies can also provide critical support to disaster relief and recovery activities.

11. As the exploration and use of outer space is to be carried out for the benefit and in the interest of all countries, it is crucial that international cooperation should address equitable access to outer space for purposes of human development. International cooperation may take many forms, including the sharing of data, capacity-building activities in technical and legal fields, and support for countries wishing to establish their own national capacities for outer space activities.

12. Space activities themselves should have minimal negative impact on the Earth or on the space environment. The promotion and development of technologies that minimize the environmental impact of launching space assets and maximize the use of renewable resources and the reusability or repurposing of existing space assets can support these efforts.

13. Institutional and public awareness of space activities, space applications, and the benefits they bring to sustainable development should be promoted, and in doing so special attention should be paid to the needs of young people and future generations. Information-sharing and education offer the best opportunities for raising the profile of sustainable space utilization in support of sustainable development on Earth.

2. Spectrum protection

14. Radio frequency communications play a key role in space activities. Radio waves not only convey commands to satellites, but also allow satellites to transmit data back to Earth and to provide services that are critical to the normal functioning of the modern information society. Radio-frequency interference can interrupt or impede the performance of satellites and result in the loss of data or disruption of services.

15. In addition, a number of space-based systems for Earth observation rely on certain regions of the electromagnetic spectrum and are susceptible to interference from artificial sources of electromagnetic radiation.

16. As the radio-frequency spectrum is a finite resource which crosses national boundaries, international coordination and cooperation is needed to ensure that this resource is used in a rational and equitable manner, in accordance with the Radio Regulations and Recommendations of the International Telecommunication Union.

17. Even with existing international mechanisms for cooperation, further work is needed to ensure that countries or groups of countries have equitable access to radio frequencies, to ensure that space activities are conducted in such a way as to prevent harmful interference with the space activities of other States and intergovernmental organizations, and to improve measures for prompt resolution when cases of harmful radio frequency interference do occur.

B. The Earth's orbital environment

1. Space debris mitigation

18. The current space debris environment is deteriorating due to an increasing number of orbital objects, despite worldwide efforts to reduce that increase through the implementation of internationally agreed debris mitigation standards and guidelines. Orbital space debris arises from various sources: non-operational satellites, upper stages of launch vehicles, carriers for multiple payloads, debris intentionally released during spacecraft separation from a launch vehicle or during mission operations, solid rocket motor effluents, and paint flakes released by thermal stress or small particle impacts. Debris can also be created by collisions or by the explosion of spacecraft or the upper stages of launchers. Since 2007, some major collision events (both accidental and intentional) have significantly increased the proportion of collision-induced debris in the overall debris population.

19. Objects larger than about 10 cm in diameter in low-Earth orbits (LEO) and larger than about 1 metre in the geostationary orbit (GEO) can be detected and tracked with ground-based sensors. Those size ranges are governed by the sensitivity of radar sensors as the primary surveillance and tracking devices for LEO and optical telescopes as the preferred sensors for altitudes above LEO and up to GEO. Altogether, some 19,000 objects are currently being tracked. The number of objects that are too small to detect from the ground but pose a significant risk to space missions is far larger. Even tiny debris or meteoroids smaller than 1 mm can pose a risk to exposed electric harnesses or other vulnerable components, possibly resulting in the loss of functions or even in a break-up.

20. For debris hazard analyses one must distinguish two major risk categories: (a) risk of deterioration or termination of a space mission, mainly owing to the impact of a subcentimetre debris object; and (b) risk of a catastrophic break-up due to the collision of a large, intact object with an object large enough to be catalogued (debris or intact). Events of the first category are more frequent, due to the larger abundance of small debris particles, but they normally affect only one space mission. Events of the second category are predicted to occur in certain LEO subregions every 5 to 10 years (mostly among non-operational objects), with a lasting effect on the debris environment, and potentially affecting many space missions.

21. Operational space objects comprise just five per cent of the overall catalogued population. The remainder of catalogued space objects have the potential to cause catastrophic collisions, yielding large-sized fragments that could lead to further catastrophic collisions. In some orbital regions this may cause an unstable, runaway situation often denoted as the Kessler syndrome, where the increase in the amount of debris from collisions exceeds the reduction due to orbital decay.

22. In 2007, the General Assembly, in its resolution 62/217, endorsed the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space. The Guidelines represent the first international consensus to reduce space debris and are an important step in providing all spacefaring nations with guidance on how to mitigate the problem of space debris. These qualitative guidelines are based on the technical content and the basic definitions of the Space Debris Mitigation Guidelines of the Inter-Agency Space Debris Coordination Committee (IADC). In applying the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, it is recommended to refer to the latest version of the IADC Guidelines for the detail of the recommended practices and the latest recommendations.

23. A number of States are also using the IADC Space Debris Mitigation Guidelines, the European Code of Conduct for Space Debris Mitigation, and standard 24113:2011 (Space systems: space debris mitigation requirements) of the International Organization for Standardization (ISO) as a reference in their regulatory frameworks for national space activities. In this regard, some States have taken measures to incorporate internationally recognized guidelines and standards related to space debris in their national legislation. In addition, some States have strengthened their national mechanisms governing space debris mitigation through the nomination of governmental supervisory authorities, the involvement of academia and industry and the development of new legislative norms, instructions, standards and frameworks.

24. At a technical level, States that have implemented national mechanisms for space debris mitigation use a range of approaches and concrete actions to mitigate space debris, including the improvement of the design of launch vehicles and spacecraft, end-of-life operations (including passivation and placing satellites into disposal orbits), and the development of specific software and models for space debris mitigation.

2. Space debris monitoring

25. Given the large number of potentially dangerous space debris objects, the complex evolution of both individual objects and their population as a whole, and the vast volume of near-Earth space over which the objects are scattered, regular monitoring of the situation in near-Earth space is extremely challenging and requires significant financial, technical and human resources.

26. No State in the world is currently able to provide a complete and constantly updated picture of the situation in orbit on its own. Thus, there is an objective need to combine capabilities in this area. The tools and technologies for optical observations of objects in near-Earth space are no longer financially costly and are available to all interested States, which makes it quite feasible to ensure the widest possible participation in studying man-made debris in near-Earth space.

27. Space debris monitoring data cannot be correctly interpreted and used without understanding the methodology behind them. This fact must be taken into account during the planning, sharing and collaborative use of data. Therefore, a key aspect of international cooperation in the investigation of the man-made space debris environment in near-Earth space (besides the exchange of data) is the development and harmonization of common approaches to evaluating the quality of the data, interpreting them and assessing their potential use for specific tasks.

28. Currently only a few States carry out regular observation of space debris in near-Earth space. The development of common, mutually agreed approaches to verifying the information received from other parties and fusing data from different sources in a qualified way has been and remains a relevant issue. This fact inevitably limits practical capabilities and efficiency of collaboration. Furthermore there is no international mechanism for exchanging verified information that, using the same methodological approach, might be used by different countries which do not carry out observations themselves, but have qualified scientific personnel, including specialists in physics, mathematics and materials engineering.

29. Another aspect of the problem that is equally important in the study of the space debris environment in near-Earth space is the lack of standard approaches to representing measurement data, which are primary in nature, and derived products on space debris, which include orbital information (centre-of-mass motion parameters), estimations of mass, size, attitude motion parameters relative to the centre of mass, and reflection characteristics. Despite the large amount of work carried out by different States at the national and international levels, there are no scientifically well-motivated and practically well-supported common formats that define the structure and content of various types of information, models for obtaining and processing information, or methods of interpretation and practical use of information. All of those issues have yet to be completely agreed upon.

3. Accuracy of orbital data

30. The accuracy of orbital data depends on a variety of factors, such as the quantity and accuracy of the measurements used, the distribution of measurements over the orbit determination arc, the geographical distribution of tracking sensors, and the suitability of the orbit determination and propagation techniques. Orbital data on functional and non-functional space objects may come from different sources.

31. For functional objects, orbital data are usually obtained by traditional means, such as processing of ground control station trajectory measurements derived from telemetry. An increasing number of functional space objects use on-board navigation techniques, but the required accuracy of the orbital data is mainly dictated by mission or operational requirements, and these do not necessarily meet the spaceflight safety requirements. Therefore, even for functional space objects it is also required to establish common approaches to achieving and maintaining the required accuracy of the orbital data. For space objects with no functioning on-board equipment, the only direct sources of orbital information are entities processing measurements acquired by radar and active, as well as passive, optical instruments. Radars constitute the primary source of information for large objects in LEO, while passive electro-optical sensors provide the majority of data for objects in high-altitude orbits.

32. The current geographical distribution and capabilities of these sensors are limited and in many cases do not permit the timely derivation of orbits of suitable quality for conjunction analysis and subsequent decisions on collision avoidance manoeuvres. The problem becomes even more pronounced for the increasing number of small-sized intact space objects such as CubeSats.

33. One currently unsolved problem for objects performing nearly continuous intentional changes of their trajectory, for example by means of electric propulsion engines, is the determination and prediction of the trajectory parameters and the estimation of their accuracy (position and velocity uncertainties). Another problem exists for non-functional space objects for which no accurate dynamical model of the orbital motion can be established due to unknown accelerations caused by outgassing, varying effective cross-section, uncertain surface reflection properties and other factors.

4. Conjunction assessment

34. Approximately 1,000 functional spacecraft in orbit today are joined by tens of thousands of pieces of space debris. The orbital collision of the functional Iridium 33 and non-functional Cosmos 2251 in February 2009 proved that a catastrophic satellite collision is a realistic possibility.

35. Conjunction assessment can be divided into two categories: pre-launch screening and orbital conjunction assessment.

(a) Pre-launch screening and launch phase

36. Guideline 3 of the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space encourages operators to avoid collisions during the system’s launch phase. In implementing this guideline, launch vehicle operators are expected to plan launch windows to avoid potential conjunctions with orbital objects. Some launch vehicle operators adjust launch times by screening for collisions with the International Space Station; a few of them also screen for collisions with functioning spacecraft. Some conjunction assessment organizations offer pre-launch collision avoidance screening services to assist launch vehicle operators in performing screenings and adjusting launch times. However, there are several gaps in this process.

37. For example, there are no common standards to represent planned orbital insertion phase trajectories (i.e., before injection of all payloads into final orbits) and associated uncertainties for use in conjunction assessment analysis as described above. There is also no common practice for performing conjunction assessment analysis during the actual orbital insertion phase (until initial orbital insertion of all payloads). Even with the capability to perform conjunction assessment, the ability to adjust launch trajectories is limited by launch vehicle design and technology, and cannot be addressed by a guideline. Precise orbital insertion is often limited by fundamental technical constraints. Further technical research and development would be required to address this gap.

(b) Orbital phases

38. Today, an increasing number of spacecraft operators are attaching greater importance to avoiding collisions. To attain this goal, some operators perform conjunction assessments. Other operators, who may not have sufficient flight dynamics expertise, access to precise orbital data, appropriate software tools, or around-the-clock operational teams, work with appropriate organizations capable of performing conjunction assessments to screen the orbital parameters of functioning spacecraft against other space objects to identify potential conjunctions. Some operators interact directly with other operators to perform conjunction assessments and collision avoidance manoeuvres for spacecraft for which they are responsible.

C. The space weather environment

1. Space weather

39. Space weather is the collection of changes in Earth's natural environment and space-based and terrestrial infrastructure caused by solar events that alter the solar system space environment. These solar events include flares, the sudden eruptions of energetic photons and charged particles from the Sun's surface; coronal mass ejections, in which the Sun typically sheds billions of tons of mass of its atmosphere as magnetized plasma; and the solar wind, the continuous outflow of charged particles that race through the solar system at around 400 to 800 km/sec or more. On Earth, these charged particles and high-energy photons have an impact on the dynamics of the near-Earth space environment, specifically the magnetosphere, ionosphere, and even the neutral atmosphere, and affect the operation of terrestrial and space infrastructure.

40. These space weather phenomena lead to increased radiation hazards for astronauts, charging of spacecraft surfaces and internal charging of spacecraft components, degradation of spacecraft solar arrays and materials, anomalous behaviour of electronic components, failure of computer memory units, blinding of optical systems, degradation or loss of spacecraft tracking information, anomalous drag and loss of altitude (sometimes leading also to enhanced erosion or degradation of spacecraft surface materials or coatings by atomic oxygen).

41. Space weather also causes changes in the ionosphere that disrupt high-frequency communications and alter the signals of global navigation satellite systems (GNSS). Commercial flights over the poles must re-route, at considerable expense, to protect crews from radiation exposure and to assure communications

capability. Solar coronal mass ejections can disrupt the Earth's magnetic field, leading to electrical blackouts, potentially on a continental scale. Since global banking and finance rely on timing signals from GNSS, loss of this service due to a solar storm would lead to disruptions of this economic sector with unforeseeable secondary impacts. Space weather can also adversely affect some terrestrial infrastructure, including high-voltage electrical transmission systems and pipelines.

42. Additionally, swelling of the atmosphere as a result of space weather can change satellite orbits, thereby degrading space situational awareness information. This occurs in two ways. Firstly, the space debris population and its evolution are tied to the altitude-dependent density of the atmosphere, which is dependent upon solar effects. Secondly, the ability to predict conjunctions and hence enable collision avoidance also depends on accurate knowledge of atmospheric density.

2. Models and tools for space weather prediction

43. Significant improvements in the mitigation of space weather effects can be obtained from a synergistic approach to the monitoring of space weather in the heliosphere that includes the modelling of space weather dynamics, the generation of space weather forecasts, studies of the impacts of space weather on technological systems, and the development and implementation of technical standards for the design and manufacture of vulnerable terrestrial and space-based infrastructure, including satellites.

44. A variety of Earth-based and space-based sensors are used to gather information about the conditions on the Sun, the interplanetary space environment, the Earth's magnetosphere, radiation belts and the ionosphere. These observations must be integrated to provide comprehensive situational awareness of space weather. These data are also used for space weather modelling and forecasting.

45. A variety of models have been developed to address different phenomena that contribute to space weather. These include models for sunspots, solar flares, solar coronal mass ejections, the solar corona, and the solar wind. There are also models for the interaction of these solar phenomena with the interplanetary space environment and with the Earth's magnetosphere, the Van Allen radiation belts and the Earth's ionosphere and atmosphere.

46. The risks posed by space weather phenomena to space systems may be mitigated from an engineering and operations perspective through implementing certain design approaches, technical standards and operational practices that reduce or avoid the adverse effects of space weather on operational space systems.

47. The long-term improvement of space weather services requires coordinated, committed partners from around the world. International cooperation is necessary to create a shared satellite-based system for critical observations, to maintain reliable access to regional data, to advance service capabilities, and to ensure the global consistency of the end products that are delivered to users of space weather information and data services.

3. Current gaps in space weather forecasting and modelling

48. There is an urgent need to adopt a coordinated approach to the collection, collation, and access to key data, metadata, design guidelines, space weather models

and forecasts, and the reporting of the occurrences of space weather effects and related information, such as records of operational satellite anomalies. This should be achieved, wherever possible, through the use of common data formats and data repositories that will both collate data from international sources and make those data available to entities with interests in space activities in all States. The following gaps have been identified:

(a) A need for improved coordination to support and promote the collection, archiving, sharing, intercalibration and dissemination of critical space weather data;

(b) A need for more advanced space weather models and forecast tools in support of user requirements;

(c) A need for the coordinated sharing and dissemination of space weather model outputs and forecasts.

49. The experience gained by established spacefaring States in mitigating the potentially harmful effects of space weather through spacecraft design methods and operational techniques could be very useful for new participants in space activities. In particular it would be helpful to support and promote the collection, sharing, dissemination and access to information relating to established practices for mitigating the effects of space weather on terrestrial and space-based systems and related risk assessments. Education, training and capacity-building are also important for developing and sustaining a global space weather monitoring and forecasting capability, and a global capability to mitigate the harmful effects of space weather on space systems.

D. Regulatory regimes

1. Registration information

50. The Convention on Registration of Objects Launched into Outer Space, adopted by the General Assembly in its resolution 3235 (XXIX) of 12 November 1974 and entered into force on 15 September 1976, is one of the five international treaties governing outer space developed under the auspices of the United Nations. As of December 2014, there were 62 States parties to the Registration Convention and four signatory States. There were also three international intergovernmental organizations that have declared their acceptance of the rights and obligations under the Convention. States not parties to the Convention can use General Assembly resolution 1721 B (XVI) of 1961 as the basis for voluntary registration submissions.

51. Under the Registration Convention, every space object launched into Earth orbit or beyond shall be entered in a registry maintained by its launching State. The Convention defines "launching State" to mean (a) a State that launches or procures the launching of a space object; or (b) a State from whose territory or facility a space object is launched.

52. General Assembly resolution 62/101 recommends enhancing the practice of States and international intergovernmental organizations in registering space objects and also recommends, with regard to the harmonization of practices, that consideration should be given to the furnishing of additional appropriate information to the Secretary-General of the United Nations on the geostationary

orbit location, any change of status of a space object in orbit, such as change of status in operations (inter alia, when a space object is no longer functional), the approximate date of decay or re-entry, the date and physical conditions of moving a space object to a disposal orbit, the date of change in supervision, the identification of the new owner or operator, any change of orbital position and any change of function of the space object.

53. The lack of comprehensive information on objects launched into orbit results in a patchy and incomplete picture of what is in orbit and where. This affects space situational awareness, and ultimately safety too, if a potentially hazardous situation arises and inadequate information is available to identify a space object and/or its operators, or it is unclear under whose control or jurisdiction the object falls. The importance of the link between supervision and registration is therefore underlined. Providing appropriate and accurate information about space objects, as recommended by Assembly resolution 62/101, requires a close link between the operator of the space object and the supervising State. It is desirable that the State of registry should also be the State initially responsible for the supervision of space operations of a given space object.

2. Regulatory practices

54. International cooperation in the peaceful uses of outer space is one of the key means of enhancing the long-term sustainability of outer space activities. In particular, international cooperation provides a basis for developing countries and countries with incipient space programmes to benefit from the experience of countries with more advanced space capabilities. International cooperation should be conducted in accordance with international law, national legislation and applicable multilateral commitments.

55. The development of national regulatory frameworks provides an opportunity to promote behaviours that enhance the long-term sustainability of outer space activities. In this regard, it is important to encourage advisory input from participants in space activities likely to be affected by any regulatory developments. In addition to providing advice, non-governmental entities also play a role in increasing awareness of issues relating to the long-term sustainability of outer space activities.

56. Regulation of space activities may involve multiple regulatory bodies dealing with different issues pertaining to, inter alia, launch safety, on-orbit operations, radio frequency usage, remote sensing activities, end-of-life disposal and controlled items. For this reason it is important to ensure that appropriate communication and consultation mechanisms are in place within and among the competent bodies that oversee or conduct space activities. Communication within and among relevant regulatory bodies can promote regulations that are consistent, predictable and transparent so as to ensure that regulatory outcomes are as intended.

57. Regulations should address risks to people and property and should provide clear guidance to participants in space activities under the jurisdiction and/or control of a particular State.

58. Existing international standards and recommended practices can complement regulation. These include standards published by ISO, the Consultative Committee

for Space Data Systems, and national standardization bodies and recommended practices published by IADC and the Committee on Space Research (COSPAR).

59. Dissemination of information and appropriately targeted outreach and education can assist all participants in space activities in gaining a better appreciation and understanding of the nature of their obligations, in particular relating to implementation, which can lead to improved compliance with the existing regulatory framework and the practices currently being employed to enhance the long-term sustainability of outer space activities. This is particularly valuable where the regulatory framework has been changed or updated, resulting in new obligations for participants in space activities.

E. Information-sharing

1. Contact information for entities responsible for controlling spacecraft or performing conjunction assessment

60. When an orbital close approach is predicted after conjunction assessment or a trajectory adjustment is performed for orbital collision avoidance, timely notifications are important. It is also important to have timely coordination between relevant entities responsible for spacecraft operations and conjunction assessment.

61. Contact information facilitates coordination between relevant entities to make appropriate trajectory adjustment decisions. This contact information can also allow States with space monitoring capabilities to provide close approach notifications to potentially affected spacecraft operations entities, allowing them to make timely decisions on trajectory adjustments for collision avoidance. Moreover, entities with information on debris-producing events can also use contact information to share this information with other entities responsible for launch operations, spacecraft operations or conjunction assessment.

62. Although the national regulations of some States require private-sector satellite operators to provide contact information to entities that control spacecraft, there is no commonly agreed practice for States to compile and share this contact information with other States for the purpose of timely coordination for collision avoidance. Current registration procedures for space objects also do not provide for exchanges of contact information for entities responsible for conjunction assessment. When contact information for entities responsible for spacecraft operations is provided, it may not mention the supervising State and may not be updated in a timely fashion.

2. Prior notice of launches and controlled re-entries

63. During launches of space objects or controlled de-orbiting of space objects it is possible to provide prior notice for areas where surviving fragments of launch vehicle stages or spacecraft might fall. The projected ground impact area and time of fall can be estimated during the planning of the launch or while planning the controlled re-entry of a space object.

64. The value of furnishing such information in the context of the long-term sustainability of outer space activities is twofold:

(a) Prior notice of controlled re-entries of large spacecraft is a safety issue. Timely notices enable the reduction of risks of possible injuries or damage to assets on the Earth's surface and in its airspace;

(b) Such notices are one of the measures to enhance transparency and trust between States, demonstrate responsible behaviour and enable appropriate awareness of such events.

65. The practice of providing special notices in aviation and maritime navigation is well developed and in current use. These notices contain, inter alia, information on danger zones in air and maritime areas that for a certain period of time can constitute a danger for aircraft and ships.

66. Only a few States currently have the technical capability to monitor the uncontrolled re-entry of objects into the Earth's atmosphere, and no State has the technical capability to predict the location and time of an uncontrolled re-entry with sufficient accuracy to issue actionable warnings. This issue will require further study and outreach before a guideline for cooperation can be worked out.

3. Standards for sharing orbital information

67. Receiving, accumulating, sharing and distributing orbital information is necessary for ensuring the safety of orbital operations and for the determination and analysis of physical characteristics of space debris objects.

68. Strictly speaking, orbital information not accompanied by an assessment of its precision or calculated with simplified motion models should not be used when a decision about a potential collision avoidance manoeuvre is being made. Simplified motion models introduce a significant margin of error into the assessment of the predicted centre of mass position of the approaching object.

69. The existing, internationally recognized orbital information standards offer a considerable degree of flexibility for the description of both the data and the models for obtaining them. However, the formal use of information provided in line with those standards does not necessarily result in a correct conclusion, because the models used to process the basic measurement data, including models for accuracy estimation, may differ from one another.

70. Another important issue concerns the procedures for sharing and using orbital information. There are two fundamental models for collecting and distributing the information: centralized data archiving and distributed information storage. Either option allows for information-sharing upon request and by electronic mail.

III. Guidelines for the long-term sustainability of outer space activities

71. The expert groups have considered inputs received from States members of the Committee, international intergovernmental organizations and non-governmental entities to identify areas of concern for the long-term sustainability of outer space activities. The expert groups have also considered current practices, operating

procedures, technical standards and policies associated with the safe conduct of space activities. On the basis of all the information collected, the expert groups have proposed measures in the form of candidate guidelines that could enhance the safe and sustainable use of outer space, for the benefit of all countries. The expert groups also identified a number of topics for further consideration by the Committee.

72. Expert group A (sustainable space utilization supporting sustainable development on Earth) has proposed seven candidate guidelines and identified four topics for future consideration in its working report (A/AC.105/C.1/2014/CRP.13). Expert group B (space debris, space operations and tools to support collaborative space situational awareness) has proposed eight candidate guidelines and identified three topics for future consideration in its working report (A/AC.105/2014/CRP.14). Expert group C (space weather) has proposed five candidate guidelines and identified two topics for future consideration in its working report (A/AC.105/C.1/2014/CRP.15). Expert group D (regulatory regimes and guidance for actors in the space arena) has proposed eleven candidate guidelines and identified five topics for future consideration in its working report (A/AC.105/C.1/2014/CRP.16). These thirty-one candidate guidelines proposed by the four expert groups, and two additional guidelines proposed by the Chair of the Working Group, have all been collected by the Chair in a single document for consideration by the Working Group (A/AC.105/C.1/L.339).

73. On the basis of the four working reports compiled by the expert groups and the input from States members of the Committee, the Chair of the Working Group has produced a set of consolidated draft guidelines for the long-term sustainability of outer space activities (A/AC.105/C.1/L.340). A detailed procedural summary of the work of the Working Group leading up to this document is contained in Annex I of the present report.

IV. Topics recommended by the expert groups for future consideration by the Committee

74. The expert groups have identified a number of issues relevant to the long-term sustainability of outer space affairs that are still open or for which the current state of knowledge is inadequate to propose candidate guidelines. The expert groups have therefore recommended these issues as topics for future consideration by the Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee and Legal Subcommittee. These topics are presented in the following subparagraphs:

(a) The Committee on the Peaceful Uses of Outer Space should consider the issue of the exploitation of natural resources in outer space in the context of sustainable development;

(b) The Committee should consider the compilation of a compendium of measures, practices, standards and other elements conducive to the safe conduct of space activities, including the sustainable exploitation of natural resources in outer space. Such a compendium could be made freely available and promoted by all participants in space activities, including States and international intergovernmental organizations;

(c) The Committee should work towards the development of initiatives for space benefits and for equitable, efficient and rational access to space to support sustainable development on Earth;

(d) The Committee should consider the development of new standards for the avoidance of harmful contamination of outer space to promote the long-term sustainability of outer space, including celestial bodies;

(e) The Committee should consider the scientific, technical and legal questions arising from active removal of space debris. For instance, regulatory issues still to be addressed include the identification of the launching State and the responsible State in relation to a space object, the question of whether it is necessary to get the consent of the State or States involved, and the question of who bears the costs and risks of such an activity. The Committee should consider whether active space debris removal could be undertaken or authorized by a single State, or if an international framework for active space debris removal under international consensus would be more suitable;

(f) The Committee should consider ways and means to develop a basis for the coordination of ground- and space-based research and operational infrastructure to ensure the long-term continuity of critical space weather observations;

(g) The Committee should consider ways and means to improve the coordination of space weather information, including observations, analyses and forecasts, to support decision-making and risk mitigation related to the operation of satellites, spacecraft, and suborbital vehicles, including rockets and vehicles used in human spaceflight;

(h) The Committee should work towards developing definitions of terms related to a number of key issues affecting the long-term sustainability of outer space activities. Regulation is generally most effective when there is a clear understanding of the scope of the regulation. In addition, the increasing connection between ground infrastructure and space infrastructure indicates that the definition of space activities may become important to States in the future, within their national regulatory frameworks;

(i) The Committee should work towards developing regulations relating to the ownership of space objects. While under existing international law, all objects in space are under the jurisdiction of a State, regardless of their funding source, functionality or integrity, space objects increasingly have multiple owners. Hosted payloads are increasingly common, increasing the number of ownership interests in a single satellite. A single launch can now deliver the payloads of many different entities into orbit (for example, launching a number of CubeSats), which could potentially blur the lines of responsibility and ownership;

(j) The Committee should work towards enhancing the practice of States and international intergovernmental organizations in registering space objects, as recommended by the General Assembly in its resolution 62/101 of 17 December 2007. A variety of practices currently exist with regard to the quality and timeliness of information being provided, and this undermines the utility of global information-sharing;

(k) The Committee should work towards improving consistency in the practice of States concerning licensing, registration fees and insurance requirements. Inconsistencies in current practices concerning licensing, registration fees and insurance requirements may encourage "regulation shopping", which may not encourage efficient practices and procedures in relation to the long-term sustainability of outer space activities;

(l) The Committee should work to implement a process to evaluate the impact, and review the progress of, the implementation of the guidelines on the long-term sustainability of outer space activities, and to update the guidelines, if deemed necessary.

Annex I

Procedural summary of the work of the Working Group and its expert groups

1. At its forty-ninth session in 2006, the Committee on the Peaceful Uses of Outer Space was presented with a working paper entitled "Future role and activities of the Committee on the Peaceful Uses of Outer Space" (A/AC.105/L.265), prepared by the Secretariat. This working paper was prepared in response to a request by the Committee at its forty-eighth session in 2005, when discussions on the future role and direction of the Committee were spurred by an informal paper on planning for future roles and activities of the Committee, prepared by the Chair of the Committee for the period 2004-2005, Adigun Ade Abiodun (Nigeria), and by a special presentation made by Karl Doetsch (Canada), Chair of the Scientific and Technical Subcommittee for the period 2001-2003 (A/60/20, paras. 316 and 317).

2. The Committee agreed to continue considering the issue at its fiftieth session, and further agreed that the Chair of the Committee for the period 2006-2007, Gerard Brachet (France), would conduct intersessional, open-ended informal consultations with a view to presenting a list of elements that could be taken into consideration in its future work (A/61/20, para. 297).

3. In 2007, a working paper by the Chair of the Committee (A/AC.105/L.268, in particular paras. 26-29) was presented at the fiftieth session of the Committee, identifying the long-term sustainability of outer space activities among the issues facing the future peaceful uses of outer space. It suggested that a working group could be set up within the Scientific and Technical Subcommittee to develop recommendations to deal with the new realities of space operations and to suggest a way forward.

4. In 2008, the Scientific and Technical Subcommittee and the Committee discussed the idea of introducing the long-term sustainability of outer space activities as an agenda item of the Scientific and Technical Subcommittee and what such an agenda item could encompass. Subsequently, in 2009, at the forty-sixth session of the Scientific and Technical Subcommittee, a proposal was put forward by France to include the long-term sustainability of outer space activities as a new agenda item of the Scientific and Technical Subcommittee under a multi-year workplan (A/AC.105/C.1/2009/CRP.14). The Working Group of the Whole agreed to submit the proposal for a decision by the Committee (A/AC.105/933, para. 170 and annex I, paras. 20-22).

5. At its fifty-second session in 2009, the Committee agreed that the Scientific and Technical Subcommittee should include, starting from its forty-seventh session in 2010, a new agenda item entitled "Long-term sustainability of outer space activities" (A/64/20, paras. 160-162). Consequently, in 2010, the Scientific and Technical Subcommittee established the Working Group on the Long-term Sustainability of Outer Space Activities, and elected the Chair of the Working Group (A/AC.105/958, paras. 181 and 182).

6. At its fifty-third session in 2010, the Committee welcomed the establishment of the Working Group and agreed to invite States members of the Committee and

permanent observers of the Committee to present information on their activities pertaining to the long-term sustainability of outer space activities, and to nominate points of contact to facilitate further intersessional progress (A/65/20, paras. 152, 157 and 158).

7. The Working Group held four meetings during the forty-eighth session of the Scientific and Technical Subcommittee in 2011, and agreed on the establishment of expert groups during the intersessional period.

8. At its fifty-fourth session in 2011, the Committee adopted the terms of reference and methods of work of the Working Group (A/66/20, annex II). The Committee also noted that, as expert group chairs, co-chairs and experts had already been nominated, the expert groups could commence their work (A/66/20, para. 152). The Committee further extended the invitation to States members of the Committee and intergovernmental organizations with permanent observer status with the Committee to nominate points of contact for the Working Group and suitable experts to participate in the expert groups (A/66/20, para. 153).

9. The Working Group held three meetings at the forty-ninth session of the Subcommittee in 2012. The Working Group noted that expert groups B, C and D had held informal meetings on the margins of the sixty-second International Astronautical Congress in October 2011. The Working Group also held a workshop where the intersessional activities of the expert groups were considered, and where the Working Group agreed on procedural guidance for the expert groups (A/AC.105/1001, annex IV).

10. At its fifty-fifth session in 2012, the Committee had before it working papers presenting the workplans of the four expert groups (A/AC.105/C.1/L.324, A/AC.105/C.1/L.325, A/AC.105/C.1/L.326 and A/AC.105/C.1/L.327). The documents were made available for comments by States members of the Committee and permanent observers to the Committee. All four expert groups held meetings on the margins of the session, and also agreed to hold informal meetings during the International Astronautical Congress in October 2012.

11. At the fiftieth session of the Subcommittee in 2013, the Working Group held five meetings, and had before it the above-mentioned workplans of the expert groups that had already been made available at the fifty-fifth session of the Committee. The Working Group also had before it, inter alia, a conference room paper containing a progress report by the Chair of the Working Group (A/AC.105/C.1/2013/CRP.10).

12. Also at the fiftieth session of the Subcommittee, and in accordance with the terms of reference and methods of work of the Working Group (A/66/20, annex II), the Chair of the Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities presented the activities of that group to the Working Group. Additionally, a workshop was organized where representatives of national non-governmental organizations and private-sector entities provided information on their experiences and practices in the conduct of sustainable space activities.

13. During its fifty-sixth session in 2013, the Committee permitted the Working Group to hold two meetings in plenary to enable the Working Group to benefit from interpretation services. The Working Group had before it document A/AC.105/1041,

containing a compilation of the draft guidelines proposed by the expert groups. All four expert groups met on the margins of the session, and a joint meeting of the expert groups was also held. It was agreed that a revised version of A/AC.105/1041 would be made available in all official languages of the United Nations. It was also noted that expert groups A, B and D had decided to meet informally on the margins of the sixty-fourth International Astronautical Congress in September 2013.

14. At its fifty-first session, in 2014, the Subcommittee had before it a working paper by the Chair containing a proposal for a draft report and a preliminary set of draft guidelines of the Working Group (A/AC.105/C.1/L.339). The working reports of expert groups A, C and D were also made available in conference room papers (A/AC.105/C.1/2014/CRP.13, A/AC.105/C.1/2014/CRP.15 and A/AC.105/C.1/2014/CRP.16).

15. The Working Group held five meetings during the session of the Subcommittee, and had before it, among other documents, two working papers related to the long-term sustainability of outer space activities submitted by the Russian Federation (A/AC.105/C.1/L.337 and L.338), and conference room paper A/AC.105/C.1/2014/CRP.17, also submitted by the Russian Federation. The conference room paper contained three new proposed guidelines, including a proposal to establish a unified Centre for Information on Near-Earth Space Monitoring under the auspices of the United Nations.

16. The Chair of the Working Group held informal consultations throughout the session, during which proposals for the consolidation of the draft guidelines were discussed. The United States presented one such proposal in conference room paper A/AC.105/C.1/2014/CRP.14. As a result of the informal consultations, the Chair presented a non-paper containing a proposal for the consolidation and grouping of the guidelines. On the basis of this non-paper, the Working Group agreed that the Chair would prepare a further proposal for the consolidation of the draft guidelines, for consideration at the fifty-seventh session of the Committee (A/AC.105/1065, annex III, para. 12).

17. The Working Group also agreed that the Chair of the Working Group would present a proposal for arranging consultations among interested delegations on questions relating to the use of terminology in the guidelines in the six official languages of the United Nations. Additionally, the Working Group recalled that, in accordance with the agreement of the Committee at its fifty-sixth session, the Chair of the Working Group would inform the Legal Subcommittee at its fifty-third session of the progress achieved by the Working Group.

18. At its fifty-seventh session in 2014, the Committee allowed the Working Group time to meet in plenary so as to benefit from interpretation services. During the session, the Working Group held five meetings and a number of informal consultations. The Working Group had before it the report of the Group of Governmental Experts on Transparency and Confidence-building Measures in Outer Space Activities (A/68/189); a working paper submitted by the Russian Federation (A/AC.105/L.290); a working paper by the Chair containing a proposal for a draft report and a preliminary set of draft guidelines of the Working Group (A/AC.105/C.1/L.339); a proposal by the Chair for the consolidation of the draft guidelines (A/AC.105/2014/CRP.5); and suggested amendments to the draft guidelines, put forward by Pakistan (A/AC.105/2014/CRP.12), the Bolivarian

Republic of Venezuela (A/AC.105/2014/CRP.16) and the Netherlands (A/AC.105/2014/CRP.22).

19. The Working Group discussed the report of the Group of Governmental Experts (A/68/189) during one meeting with a view to identifying interlinkages in the recommendations by the Group of Governmental Experts and the work under way in the Working Group.

20. The Working Group also agreed to establish a translation and terminology reference group. The translation and terminology reference group comprised the co-chairs of the four expert groups, and one first-language speaker of each of the United Nations languages. The translation and terminology reference group will coordinate via electronic means intersessionally, and meet on the margins of the sessions of the Scientific and Technical Subcommittee and the Committee.

21. Expert group B continued informal consultations on its report on the margins of the Committee's fifty-seventh session, and presented its working report to the Working Group in document A/AC.105/2014/CRP.14.

22. As the workplan of the Working Group that was agreed to at the fifty-fourth session of the Committee in 2011 came to an end at the fifty-seventh session of the Committee, the Committee discussed an extension of the workplan and a time frame for the completion of the Working Group's work. A detailed timeline is contained in paragraph 199 of the report of the Committee (A/69/20), stating that the guidelines should be finalized, approved by the Committee, and sent to the General Assembly for adoption, in 2016.

23. Taking into consideration comments and proposals received prior to, during and following the fifty-seventh session of the Committee, the Chair of the Working Group compiled an updated set of draft guidelines (A/AC.105/C.1/L.340). These updated draft guidelines were circulated prior to, and will be considered during, the fifty-second session of the Subcommittee in 2015.