United Nations A/AC.105/C.1/111

General Assembly

Distr.: General
2 November 2016
English
Original: English/Spanish

Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
Fifty-fourth session
Vienna, 30 January-10 February 2017
Item 7 of the provisional agenda*
Space debris

National research on space debris, safety of space objects with nuclear power sources on board and problems relating to their collision with space debris

Note by the Secretariat

I. Introduction

1. In its resolution 71/90, the General Assembly, deeply concerned about the fragility of the space environment and the challenges to the long-term sustainability of outer space activities, in particular the impact of space debris, which was an issue of concern to all nations, considered it essential that States pay more attention to the problem of collisions of space objects, especially those with nuclear power sources, with space debris, and other aspects of space debris. It called for the continuation of national research on that question, for the development of improved technology for the monitoring of space debris and for the compilation and dissemination of data on space debris. The Assembly also considered that, to the extent possible, information thereon should be provided to the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, and agreed that international cooperation was needed to expand appropriate and affordable strategies to minimize the impact of space debris on future space missions.

2. At its fifty-third session, the Subcommittee agreed that Member States and international organizations with permanent observer status with the Committee should continue to be invited to provide reports on research on space debris, the safety of space objects with nuclear power sources on board, problems relating to the collision of such space objects with space debris and ways in which debris mitigation guidelines were being implemented (A/AC.105/1109, para. 113). Accordingly, a communication dated 29 July 2016 was sent to Member States and international organizations with permanent observer status inviting them to provide the reports by

* A/AC.105/C.1/L.355.

V.16-09404 (E) 151216 161216

17 October 2016, so that the information could be made available to the Subcommittee at its fifty-fourth session.

3. The present document has been prepared by the Secretariat on the basis of information received from four Member States, namely Japan, Mexico, Portugal and Spain, and from the International Association for the Advancement of Space Safety (IAASS) and the Space Generation Advisory Council (SGAC). Further information provided by Japan and SGAC, which includes pictures and figures related to space debris, will also be made available as a conference room paper at the fifty-fourth session of the Subcommittee.

II. Replies received from Member States

Japan

[Original: English]
[28 October 2016]

Overview

The present report outlines the principal research on space debris conducted by the Japan Aerospace Exploration Agency (JAXA).

Major areas of research introduced in the next section are as follows:

(a) Conjunction assessment results and core technology for space situational awareness;

(b) Research on technology for observing objects in low-Earth orbit and geosynchronous Earth orbit and for determining the orbit of such objects;

(c) In situ microdebris measurement system;

(d) Protection from the impact of microdebris;

(e) Easy-to-demise propellant tank during re-entry;

(f) Active debris removal.

Conjunction assessment results and core technology for space situational awareness

Conjunction assessment results

JAXA receives conjunction notifications from the Joint Space Operations Center. In August 2016, the number of notifications received was 110, which exceeded the specific conjunction threshold value. From 2009 to August 2016, JAXA executed 19 collision avoidance manoeuvres for low-Earth-orbit spacecraft.

Core technology for space situational awareness

JAXA determines the orbit of space objects by using observation data acquired from a radar in the Kamisaibara Spaceguard Center and telescopes in the Bisei Spaceguard Center, predicts close approaches using the latest orbit ephemerides of JAXA satellites and calculates the probability of collision using unique methods. JAXA also evaluates the criteria for conjunction assessment and collision avoidance manoeuvres based on its experience. In those evaluations, the trends in each conjunction condition and prediction errors due to perturbations (e.g. uncertainty in air drag) are analysed.

As a research topic, JAXA has studied re-entry analysis by changing the number of observational passes from the ground radar facilities. JAXA found that when the observation arc was longer than about 24 hours, the errors in re-entry prediction were small.

Research on technology for observing objects in low-Earth orbit and geosynchronous Earth orbit and for determining the orbits of such objects

Generally, the observation of low-Earth orbit objects is conducted mainly by a radar system, but JAXA attempts to apply an optical system to reduce the cost of system construction and operation of those operations. Arrays of optical sensors are used to cover a large area of the sky. Objects of 15 cm or larger are detectable at an altitude of 1,000 km using a set of systems consisting of an 18-cm telescope and a complementary metal-oxide semiconductor (CMOS) sensor, and 36 per cent of those objects are uncatalogued, according to survey observations. Additionally, JAXA succeeded in detecting a polar orbiting passive atmospheric calibration sphere in the orbit, which was an aluminium sphere of 10-cm diameter. A CMOS sensor with low noise has also been developed. The sensor is able to observe objects five times wider and detect objects one order of magnitude fainter than the previous one. For geosynchronous Earth orbit observation, a new observation method uses the data of two nights for the initial orbital determination. The method reduces observation time by one third, which allows the observation of 1.5 times more objects.

In situ microdebris measurement system

JAXA has developed an on-board detector for the in situ measurement system of submillimetre-class microdebris, which cannot be detected from the ground. The sensor in this in situ measurement system, named space debris monitor (SDM), is the first to apply a sensing principle based on conductive (resistive) lines to detect debris.

If such sensors were installed on a large number of spacecraft, the acquired data could help to improve the debris environment model. The first SDM was launched with the Japanese cargo ship H-II Transfer Vehicle (HTV) on 19 August 2015. That was the world’s first microdebris measurement demonstration experiment on the International Space Station using a conductive (resistive) strip lines concept for detection. JAXA is currently analysing the acquired data.

Microdebris measurement systems are essential for risk assessment of the survivability of spacecraft against debris and for the design of cost-effective protection of spacecraft. However, limited measurement systems are available. JAXA has provided two SDMs to the commercial satellite IDEA OSG 1, developed by a start-up company named ASTROSCALE. Space agencies are encouraged to launch their spacecraft with SDM, share their data and contribute to the improvement of debris and meteoroid models.

Protection from the impact of microdebris

The amount of submillimetre-class microdebris is increasing in low-Earth orbit. The impact of microdebris can inflict critical damage on satellites because its impact velocity is, on average, 10 km per second.

To assess debris impact on a satellite, JAXA is conducting hypervelocity impact tests and numerical simulations for materials used for spacecraft components and bumper shields. JAXA has also started investigating the electrical failure of power harnesses caused by debris impact.

The results of that research are reflected in the “Space debris protection design manual” (JERG-2-144-HB), which was published in 2009 and revised in 2014.

Furthermore, JAXA has developed a debris impact risk assessment tool named TURANDOT. TURANDOT analyses debris impact risks against a three-dimensional model of a spacecraft. That tool is updated to apply the National Aeronautics and Space Administration's (NASA) latest debris environment model (ORDEM 3.0).

Easy-to-demise propellant tank during re-entry

A propellant tank is usually made of titanium alloy. Although the light weight and good chemical compatibility of titanium alloy with propellant are suitable characteristics for propellant tank material, its high melting point prevents a propellant tank from demising during re-entry, posing a risk of casualties on the ground.

JAXA conducted research to develop an aluminium-lined tank, overwrapped with carbon composites, with a lower melting temperature. As a feasibility study, JAXA conducted fundamental tests, including a liner material aluminium compatibility test with hydrazine propellant and an arc heating test. JAXA tried manufacturing the first engineering model (EM) tank, which was smaller in size compared with a nominal tank. Using the first EM tank, a proof pressure test, an external leak test, a pressure cycle test and a burst pressure test were conducted, and all of them showed positive results. Vibration tests were conducted on the propellant management device (PMD) to confirm its tolerance to the launch environment. Following the test of the first EM tank and PMD model, the second EM tank is now in the process of being manufactured. The shape of the second EM tank is the same as the nominal tank, which includes a PMD. The second EM tank will undergo proof pressure tests, external leak tests, pressure cycle tests, vibration tests (under wet and dry conditions) and burst pressure tests. After the second EM tank, prototype model manufacturing and testing are planned. In the future, it is expected that costs and manufacturing lead time will be less than that of previous titanium tanks.

Active debris removal

JAXA runs a research programme that is aimed at the realization of a low-cost active debris removal mission. The programme consists of an active debris removal scenario study, research and development of key technology, and research and development of on-orbit service technology for robotic servicing in the near future.

There are three themes for research and development of active debris removal key technology: non-cooperative rendezvous, capture technology for non-cooperative targets and de-orbiting technology to remove massive targets. An electrodynamic tether (EDT) system is promising as the active debris removal device, which allows for the de-orbiting of debris without any propellant and can be easily attached to the non-cooperative debris object. A demonstration flight of the EDT system named KITE is planned for fiscal year 2016. An illustration of the KITE mission is given in the conference room paper to be made available at the fifty-fourth session of the Subcommittee. An experimental EDT module will be installed on the HTV. It will be activated just before re-entry of the HTV to Earth, and its function as a de-orbit device will be demonstrated.

Mexico

[Original: Spanish]
[14 October 2016]

In the present report, the Mexican Space Agency (AEM), which has always been committed to undertaking study and research with a view to strengthening activities relating to innovative space technologies, presents the progress of its research on space debris, the safety of space objects with nuclear power sources on board and problems relating to the collision of such objects with space debris.

With regard to the safety of space objects with nuclear power sources on board, Mexico participates actively in the work of the Scientific and Technical Subcommittee and the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space. Mexico adheres to the relevant principles concerning the use of nuclear power sources in outer space and is a State that promotes peace and is guided by international instruments such as the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Treaty of Tlatelolco). In addition, Mexico is party to the Convention on Nuclear Safety, which approaches the issue of safety as a preventive and systematic endeavour and reflects the importance that the international community attaches to ensuring that the use of nuclear energy is safe, well regulated and environmentally sound.

Mexico considers it important to formalize and make progress in the analysis of the proposals to develop a universal and comprehensive convention that makes the principles relating to outer space binding and that supplements the provisions of the existing United Nations treaties on outer space. Mexico is party to the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies of 1967, in the first paragraph of article IV of which it is established that “States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.” Although there are binding and non-binding regulations, there are no sanctions in the case of a disaster caused by a space object carrying a nuclear load, other than what might be understood by “reparation in respect of the damage” under the Convention on International Liability for Damage Caused by Space Objects.

Mexico collaborates with the Working Group on the Long-Term Sustainability of Outer Space Activities within the four expert groups: expert group A, on sustainable space utilization supporting sustainable development on Earth; expert group B, on space debris, space operations and tools to support collaborative space situational awareness; expert group C, on space weather; and expert group D, on regulatory regimes and guidance for actors in the space arena. Mexico participated in the initiative of Canada, the Czech Republic and Germany to create a compendium of space debris mitigation standards, which was submitted to the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space at its fifty-third session.

Space activities in Mexico started in 1985, with the launch of the geostationary satellites Morelos I and Morelos II. There are currently six satellites in operation. In accordance with practice regarding the elimination of space debris, Mexican policy on the orbit of geostationary satellites has consisted in retaining enough fuel to ensure that, at the end of its lifespan, a satellite will automatically de-orbit. That is the procedure used by Satmex. All the procedures referred to above take into account the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space and the relevant regulations issued by various countries with influential space programmes.

In accordance with the Outer Space Treaty, Mexico has maintained its position in favour of the non-militarization of outer space and the peaceful uses of outer space.

Portugal

[Original: English]
[28 October 2016]

Space debris activities in Portugal

The main space debris-related activities in Portugal are briefly described below.

Space debris from spacecraft degradation products

This activity is carried out under a European Space Agency contract by the Faculty of Sciences of the University of Lisbon (FCUL) as the prime contractor and Onera (France) and the Technical University of Braunschweig (Germany) as subcontractors.

The activity is aimed at assessing the amount and characteristics of space debris objects resulting from the exposure of spacecraft exteriors to their operational environment in space. Emphasis is on multilayer insulation and paint flakes, which are both surface degradation products. Understanding, characterizing and quantifying the debris generation processes is crucial for modelling the space environment.

Here, experimental degradation studies are performed under realistic or accelerated space environment conditions.

Portuguese space surveillance and tracking system

This is an activity carried out by a consortium of national industry actors with the participation of academic partners. It is being developed in collaboration with the Ministry of Defence and the Ministry of Science.

The consortium is composed of Software Services and Development Company (EDISOFT) (leader), Deimos Engenharia (DEIMOS), GMV, Electronics Research and Development Company (EID), the Institute of Telecommunications, the Faculty of Sciences at the University of Porto and the Faculty of Sciences at the University of Lisbon.

Currently, it is in the proposal phase. Several meetings of all stakeholders (companies and ministries) have already taken place.

The aims are diverse and can be summarized as follows: exploring the potential deployment of a Portuguese space surveillance and tracking system and submitting a Portuguese application to the space surveillance and tracking (SST) system support programme of the European Union.

This system would allow the collection of information on objects orbiting the Earth, including space debris, and on foreign satellite passes and activities, thus being a geostrategic asset valued by other nations. Having direct and autonomous access to such information through its SST system would enable Portugal to leverage its political weight.

The footprint of the Portuguese infrastructures that can be adapted for the SST system includes Azores and Madeira. The installation and maintenance of those infrastructures will boost the local economy, thereby creating jobs and economic growth.

Spain

[Original: Spanish]
[18 October 2016]

Over the past decade, Spain has built up extensive experience in the area of space debris. Spanish research and industrial bodies have developed a large number of systems and tools to identify and predict the orbit of space objects. Furthermore, the Government has established a national space surveillance system and has joined international projects to improve space surveillance and reduce on-orbit collision risks.

Those activities have been accompanied by significant research and development. Astronomical telescopes have been adapted in order to detect objects in Earth orbit. The first observation campaigns have yielded very positive results, enabling many objects to be detected and providing a considerably better understanding of the on-orbit collision risks posed by space debris. At the same time, new systems are being developed specifically to detect and monitor space objects. Those systems will significantly enhance the ability to monitor Earth orbits and, on the basis of the information collected, study their behaviour and reduce the risk of collisions.

Spain has also joined the European Union space surveillance and tracking (SST) support framework, a programme that is aimed not only at providing SST services but also at conducting research to improve the state of the art of such technology. That research was scheduled to begin in 2016 and will continue until at least 2020. It will enable significant progress to be made in understanding the situation with regard to space debris in Earth orbit. Furthermore, those activities will enable on-orbit collision risks to be reduced.

Within the European Space Agency, Spain has played a key role in the space situational awareness programme, which includes space surveillance. Spain has been the largest contributor to the programme and has led many of its activities, thereby making a substantial contribution to improving understanding of the complex problem of space debris.

It should be noted that although none of those activities are specifically linked to objects with nuclear power sources, the resulting general reduction in collision risks will be of benefit to that field in particular. Therefore, those activities will have a positive effect on reducing the likelihood of a collision with an object with a nuclear power source.

III. Replies received from international organizations

International Association for the Advancement of Space Safety

[Original: English]
[23 October 2016]

Introduction

IAASS is a non-profit organization dedicated to furthering international cooperation and scientific advancement in the field of space systems safety. In 2004, IAASS became a member of the International Astronautical Federation and in 2010, it was granted observer status at the Committee on the Peaceful Uses of Outer Space. IAASS is the first and only organization worldwide offering a wide range of specialized events for continuing education and training in space safety. IAASS organizes workshops, seminars, conferences and hands-on courses. IAASS conferences are held every 18 months and are a unique opportunity to assess space safety and the space environment.

During the 8th IAASS conference, held from 18 to 20 May 2016 in Melbourne, Florida, United States of America, a dedicated panel session was organized to analyse the impact of newcomers to space activity on the space environment. Thirty experts from several countries around the world participated in the discussions, addressing questions regarding the impact of CubeSats, chipsats and small-satellite constellations on the space environment. The theme was chosen because of the emergence in recent years of new space projects conducted outside the traditional framework of space agencies, major satellite operators and traditional industry. That is the case with regard to CubeSat projects led by newcomers (new spacefaring countries, new manufacturers and new operators). It is also the case with megaconstellation projects that involve hundreds of satellites in low-Earth orbit that will be operated by new, powerful consortiums.

Impact of newcomers, CubeSats, chipsats and small-satellite constellations on space debris risk

The arrival of newcomers, CubeSats and megaconstellations raises three important issues:

(a) They will have a major impact on the orbital population in low-Earth orbit. Such a dramatic evolution will increase the collision risk and consequently require new efforts in the field of space surveillance;

(b) Many of the nanosatellites have no manoeuvre capacity and poor reliability and launch as a secondary passenger on an orbit optimized for the main payload;

(c) New actors are appearing (countries, manufacturers and operators) who continue to field unreliable, first-generation systems. A legal framework for space operations does not exist in most of the new spacefaring countries, and some new operators may have a limited knowledge of United Nations guidelines.

The first concern relates to the evolution of the population of objects in orbit around the Earth. New projects involve a large number of satellites. In 2015, for example, more than 120 CubeSats were launched and, in the case of megaconstellations, hundreds of satellites could be injected into low-Earth orbit. The upper stages of launchers necessary to put them in space must also be taken into account. Additional satellites also have to be launched regularly to replace satellites that have failed or reached end of life in order to ensure continuity of service. That situation could represent a problem if the small satellite orbit is above 650 km. During the first workshop, discussions focused on developments in low-Earth orbit population: how many satellites would there be in 10 years? How many CubeSats were expected to be launched in 2020? Should the commercial use of CubeSats be considered?

The increase in the number of objects may cause an increased risk of collision for other users of space if the satellites have no manoeuvre capability. Guideline 3 of the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space indicates that “if available orbital data indicate a potential collision, adjustment of the launch time or an on-orbit avoidance manoeuvre should be considered”. Unfortunately, most CubeSats and some microsatellites have no propulsion or a very limited capacity when they have an electric propulsion system, and some of them might be unable to perform avoidance manoeuvres. Should it be accepted that half of the population in orbit does not comply with the regulations?

Although the collision probabilities and consequences are lower because of the size of the objects, the mathematical models used to simulate those events must be adapted to take such specificities into account. Further studies appear necessary.

Finally, the tracking and identifying of CubeSats by space surveillance systems is difficult. There is a risk of confusing satellites in neighbouring orbits, which would represent an additional legal difficulty in case of damage on the ground or in space. Similarly, the Convention on Registration of Objects Launched into Outer Space should be applied consistently by all launching States, without exceptions for any kind of space objects.

The second concern deals with the technical characteristics of small satellites. For instance, to comply with the "25-year rule", satellites have to perform end-of-life manoeuvres if they are deployed above 650 km. Given the reliability of up-to-date space systems, compliance is achieved less than six times out of ten in low-Earth orbit. The reliability of small satellites could therefore be another important factor leading to a limited implementation of the guidelines: their design is simplified as much as possible in order to achieve the lowest possible cost. That can lead to a reduction in the number of functionalities and overall reliability of the satellite, with the risk of having defunct satellites that have lost their ability to be controlled abandoned in space. That potential drop in reliability can have an impact on the long-term stability of the population in low-Earth orbit. The mathematical models simulating the long-term evolution of the population take into account assumptions such as the annual number of satellites launched and the success rate of disposal operations. Under a "business-as-usual" scenario, experts fear an exponential increase in the number of items in outer space. On the one hand, the number of objects put in orbit should increase sharply: for example, OneWeb plans to launch 900 satellites at an altitude of 1,200 km. On the other hand, the rate of compliance with end-of-life operations could decline owing to reduced reliability of small satellites.

Finally, the third concern is compliance with the international recommendations or regulations relating to space debris, namely the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, the Space Debris Mitigation Guidelines of IADC, the space debris mitigation requirements of the International Standardization Organization and the national laws of several countries. A case in point is the so-called "25-year rule", which limits the duration in low-Earth orbit after mission to 25 years. In practice, many small satellites have no manoeuvrability allowing them to change orbit at the end of their operational life. Without manoeuvre capability, they should be required to be injected only into low-altitude orbits providing natural re-entry within 25 years. Unfortunately, small satellites do not usually choose their orbit, since they are launched as secondary passengers; the orbit is determined by the larger, more expensive satellites of the main payload. Their rideshare should drop them off at a maximum altitude of about 650 km and not higher.

The question that then arises is how to implement international recommendations. Because of their low cost, small satellites (CubeSats, chipsats) become accessible to new operators: student projects at universities, for example. Those new operators may not be aware of the existence of guidelines agreed at the international level. In addition, not all countries have a legal system to enforce those guidelines. How is it possible to ensure that new countries will monitor the activities of their operators as requested by the various treaties? One option might be to ask launch operators to perform this check, the advantage being that launch operators are well known, limited in number and under State control. Nevertheless, this option would require agreement by all operators to avoid distortion of competition. Another option would be the creation of a new international organization similar to the

International Civil Aviation Organization to impose rules for the benefit of all commercial operators.

In summary, the development of low-cost small satellites such as CubeSats leads to the emergence of new projects and new operators. Several important consequences were analysed during the panel organized by IAASS in May 2016:

(a) Short-term increase of collision risk for active satellites and of the workload of space surveillance systems;

(b) Inability of some small satellites to perform collision avoidance and end-of-life manoeuvres, as a result of their simplified design;

(c) Poor awareness of space debris guidelines by newcomers and lack of national regulatory framework for new spacefaring countries;

(d) Possible long-term exponential increase of object population in low-Earth orbit.

Space Generation Advisory Council

[Original: English]
[17 October 2016]

Introduction

The space debris issue is now at the forefront of discussions on the sustainability of outer space. Given the increased number of small satellites, it is unclear if current policies are enough to mitigate the risk of space debris. With increased interest in long-duration missions, the number of spacecraft launched with a nuclear power source on board is also increasing. The collision between nuclear-powered spacecraft and space debris could lead to nuclear contamination of the Earth or the space environment, with dire consequences. That possibility calls for the implementation of new policies to maintain the safety of those spacecraft and to raise awareness of the threats to the sustainable use of outer space.

Space debris problem

Ever since the first satellite was launched, in 1957, Earth's orbits have become more and more crowded. Many nations and commercial enterprises have launched their own spacecraft into orbit around Earth, and many are still there. Among all floating objects in space, an estimated 6 per cent are still operational, while almost 60 per cent of space objects are fragments produced by explosions and collisions. More than 20,000 pieces of space debris the size of a tennis ball or larger orbit the Earth with a velocity of nearly 17,500 miles per hour. Those uncontrolled fragments and other debris (such as discarded rocket bodies and retired satellites) can collide with each other and generate more debris, in a cycle popularly known as "Kessler syndrome". Kessler syndrome in turn results in the exponential growth of orbital debris as time progresses, with an ever-increasing risk for operational bodies in orbit. In addition to their number, pieces of debris have enough energy to break the rigid wall of satellites, and to destroy satellites. Moreover, the number of collisions recorded by the International Space Station and the number of times the Space Station has had to manoeuvre to avoid debris demonstrate the true impact of such objects on space operations.

Currently, the debris field in low-Earth orbit is unstable. Simulations have shown that even without any future launches, the debris field will grow slowly. With launches continuing at current rates and no mitigation measures, the quantity of debris in orbit is likely to grow exponentially. Fragments generated from the anti-satellite test conducted by China in 2007 and the collision between Iridium 33 and Cosmos-2251 in 2009 were major factors in the jump in the number of pieces of space debris. Research has concluded that 60 per cent of tracked fragments have been generated by explosions and collisions in space, mostly related to activities of the United States and Soviet Union in low-Earth orbit. Every year, an average of 120 to 150 satellites are launched, resulting in an additional 300 to 500 fragments per year in outer space. The rise in the number of small satellites being launched into orbit and plans for constellations of small satellites by several commercial entities clearly show that those numbers will grow even further.

The probability of collision varies with altitude. The major risk of collision is in the orbital altitudes of 500 to 1,200 km and 1,400 to 1,600 km. Those orbit ranges are mostly used for scientific experiments or Earth observation.

IADC developed a set of guidelines, including the "25-year rule", now being followed by many stakeholders. In addition, some States have developed their own space debris mitigation standards based on those guidelines. Recent studies are inconclusive as to whether the "25-year rule" might be a suitable solution, highlighting the need for the revision of those guidelines based on recent developments in the sector.

Concrete actions taken by States who have adopted the IADC guidelines include:

(a) The improvement of the design of launch vehicles and spacecraft;

(b) The de-orbiting of satellites;

(c) The development of specific software and models for space debris mitigation.

Many methods have been proposed for cleaning space debris, and the space sector is taking initiatives to tackle this problem. On-orbit servicing, active debris removal and passive de-orbiting capabilities are all being studied to maintain a more stable space debris environment.

Nuclear power sources in space

Initial advancements in nuclear power technology led to engineers trying to integrate that new technology into different sectors, from planes to marine vehicles, and space was no exception. Both the United States and the Soviet Union attempted to launch nuclear reactors into space: the United States launched SNAP-10A, while the Soviet Union ran the RORSAT programme. Several disasters resulted, including:

(a) Launch failure and the reactor falling into the Pacific Ocean north of Japan (25 April 1973);

(b) Kosmos-954 experiencing re-entry over Canada owing to a boost failure, irradiating 124,000 square km of the North-Western Territories.

The RORSAT programme was designed to eject its nuclear cores into orbit, some of which are still there, decaying. The mishaps of those programmes led to a halt of nuclear activities in Earth orbit.

Traditional fission reactors are no longer used for space missions. Instead, radioisotope thermoelectric generators (RTGs) are now used for exploration class missions, such as the Curiosity rover. Those systems rely on the heat generated by the decay of a radioactive sample for energy generation and are much simpler in design and safer than traditional reactors. Nonetheless, they do pose a risk of contamination if the fuel container leaks.

The main concern in the use of RTGs in spacecraft is contamination owing to a launch failure or failure during operations in Earth orbit. Risk assessment for previous missions has shown that the risk for such mishaps varies by phases of the mission, with the risk being as high as 1 in 10 for the Cassini-Huygens. Previous mission failures leading to contamination — such as the 1964 United States Transit-5BN-3 launch failure, and the 1969 Russian Lunokhod launch failure — have led to intact re-entry requirements for RTGs, which reduces the likelihood of contamination. That has reduced the impact of failures that came after those missions, including the Russian Mars 96 and the Apollo 13 lunar lander re-entry — with no contamination being recorded in those cases. Despite those efforts, all spacecraft, including those with RTGs, are prone to collisions. If an RTG fuel container is damaged owing to a collision, contamination is unavoidable.

Today, States are considering the implementation of the Safety Framework for Nuclear Power Source Applications in Outer Space. The Safety Framework would facilitate the conduct of missions involving nuclear power sources on a bilateral or multilateral basis by States. While the creation of the IADC guidelines seems to be a good first step, execution measures need to be implemented in order to fully benefit from those guidelines. For example, a mission launch authorization procedure needs to be put in place.

Need for a global vision

The peaceful use of outer space, in particular space orbits, is extremely important in providing communication services for the global population in the twenty-first century. It is also integral in contributing to governance mechanisms to address a wide array of global problems, for example, monitoring climate change and providing early warnings for natural disasters through the use of satellite images, supporting local development by connecting communities to the Internet and providing the infrastructure necessary for development in the information technology industry. As such, space debris mitigation is paramount in ensuring social progress and global development. Nevertheless, the existing governance landscape regarding outer space remains comparatively underdeveloped.

While major international actors, including international organizations, States and non-governmental organizations, are devising concrete steps for the realization of the Sustainable Development Goals, the lack of an explicit reference to space sustainability leaves space sustainability initiatives outside of the framework of the Sustainable Development Goals. Relevant stakeholders may consider the following steps to assert the importance of space sustainability and, subsequently, the relevance and potential of space debris mitigation:

(a) Discuss orbits as finite resources and a global resource;

(b) Assert the relevance and importance of debris mitigation, especially concerning space objects with nuclear power sources, in contributing to longer-term sustainable development through improved operations of space assets.

Conclusion

Today, the most challenging issue facing space operations is collision avoidance. The space debris problem definitely requires common action by all stakeholders if it is to be rectified. In that regard, the IADC guidelines are a starting point. Further action to address the increasing space debris population seems to be the only solution in the long run to tackle this issue. Owing to the high risk of collisions in low-Earth orbit, the use of nuclear power sources should be limited to exploration class interplanetary missions. Safety guidelines put forth by the Committee on the Peaceful Uses of Outer

Space and the International Atomic Energy Agency should be taken into account in such cases, along with planetary protection guidelines to make sure missions are undertaken safely and ethically.

The SGAC Space Safety and Sustainability project group recommends the following:

(a) Moving towards the implementation of the Safety Framework for Nuclear Power Source Applications in Outer Space by the designation of an international body for launch authorizations for nuclear-powered spacecraft;

(b) Implementing the Space Debris Mitigation Guidelines;

(c) Monitoring the above guidelines and reporting regularly on the implementation thereof by the Committee on the Peaceful Uses of Outer Space;

(d) Revising the guidelines every five years, to keep pace with technological advancements;

(e) Recognizing the orbits and outer space as a global commons, and integrating space sustainability into the global development agenda, in particular in relation to achieving the Sustainable Development Goals.

About the Space Generation Advisory Council in support of the United Nations Programme on Space Applications

SGAC works at the international, national and local levels to connect university students and young professionals in the space sector in order to think creatively about international space policy issues and to inject the new generation’s point of view into international space policy. Having been created as a result of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), its work with the United Nations, particularly the Committee on the Peaceful Uses of Outer Space, is of central importance to the mission of SGAC. SGAC works to give regular input to the work of the Committee and its delegates and acts as a conduit for the opinions of its members and the outcomes of its projects. SGAC takes part in the work of a variety of United Nations action teams and working groups pertaining to space issues, and participates in the United Nations Programme on Space Applications. No other space organization for young adults has a permanent observer status with the Committee and is as active or as engaged in the work of the United Nations as SGAC — a fact of which the Council feels very proud. In addition to having permanent observer status within the Committee since 2001, SGAC has held consultative status within the Economic and Social Council since 2003.

About the Space Generation Advisory Council Space Safety and Sustainability project group

The SGAC Space Safety and Sustainability project group was created with the aim of encouraging active participation by students and young professionals in space safety and sustainability-related debates and activities. Through this project group, SGAC has created an international space forum to showcase the perspectives of the next generation of space leaders on the safety and long-term sustainability of outer space activities. The project group runs several projects during the year, focusing on the topics of space situational awareness, space weather and space debris.