



General Assembly

Distr.: General
2 December 2020

Original: English/Spanish

**Committee on the Peaceful
Uses of Outer Space
Scientific and Technical Subcommittee
Fifty-eighth session
Vienna, 1–12 February 2021
Item 7 of the provisional agenda*
Space debris**

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

Addendum

Contents

	<i>Page</i>
II. Replies received from Member States	2
Colombia	2
Mexico	2
III. Replies received from international organizations	4
European Union	4
International Atomic Energy Agency	8

* A/AC.105/C.1/L.387.



II. Replies received from Member States

Colombia

[Original: Spanish]
[13 November 2020]

In Colombia, in order to promote space debris mitigation and remediation measures, the State carries out space activities, including launches of suborbital vehicles and registration with the United Nations of objects launched into outer space, thus promoting compliance with the necessary measures, such as the removal of such objects from Earth orbit at the end of their useful life through controlled re-entry or transfer to a disposal orbit.

In the case of the country's first Earth observation satellite, FAC-SAT 1, the Colombian Air Force is contributing to space debris mitigation measures by enabling the satellite's re-entry into the atmosphere at the end of its useful life. This will ensure the sustainability of outer space activities for future generations.

It would be useful for States to establish domestic regulations governing space debris mitigation and remediation measures and to conduct research with a view to developing technologies that mitigate risks, such as collisions of space debris or the atmospheric re-entry of space debris resulting in harm to humans or to the environment. Such initiatives would also enable States to learn about the space activities being carried out, in the interests of transparency and fulfilment of the commitments made through the various treaties on outer space.

In addition, in order to ensure that space debris levels are kept under control at all times, it is necessary for States to encourage, at the domestic level, the registration with the United Nations of objects launched into outer space and the recording of the end of the useful life of those objects, as well as the recording of the state of objects before control is lost.

It was on the basis of the foregoing considerations that Colombia issued Decree No. 1065 of 10 June 2014, promulgating the Convention on Registration of Objects Launched into Outer Space, and subsequently approved Decree No. 2258 of 6 December 2018, establishing rules and procedures for the registration of objects launched into outer space, which entered into force on 6 December 2018, in compliance with the international regulatory provisions established by the United Nations and the Registration Convention.

Mexico

[Original: Spanish]
[10 November 2020]

National research on space debris

Mexico has been involved in the work on the Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space, one of the main issues under consideration being that of space debris. The complexity of the issue is such that it will take time and the commitment of the international community to ensure that the guidelines are implemented to the greatest extent possible and that viable solutions can be found for supporting the establishment of national and international practices and frameworks for the safe conduct of activities in outer space.

Although Mexico has not yet adopted a national regulatory framework for space debris mitigation, its policy to date, at least with regard to geostationary satellites, and in line with space debris remediation practice, has been to provide its satellites

with sufficient fuel so that they can be automatically removed from orbit at the end of their service life.

With regard to research on space debris, public universities in Mexico, such as the National Autonomous University of Mexico, through the Faculty of Engineering and its High Technology Centre on the campus of Juriquilla, Querétaro, are developing mathematical models for the identification and timely measurement of items of debris. Furthermore, the National Autonomous University of Mexico is working to install a vacuum chamber and an electromagnetic radiation chamber for testing satellites and their capacity to cancel out such interference, thus reducing the likelihood that they will malfunction during space operations and become space debris. The University is also working to develop electrical power propulsion units in order to ensure that, once satellites reach the end of their service life, they leave their orbit, re-enter the Earth's atmosphere and disintegrate, thus avoiding the generation of additional space debris.

In addition, the Autonomous University of Sinaloa has taken on the task of monitoring space debris in order to ensure the safety of space infrastructure. That activity forms part of the international efforts led by the International Scientific Optical Network, which has been monitoring space debris since 2012 and has discovered dozens of new objects every year, including fragments and lost satellites that orbit beyond the geostationary orbit. The astronomical observatory jointly operated by the Autonomous University of Sinaloa and the International Scientific Optical Network records up to 864 images and detects between 30 and 70 space objects per night.

The Centre for Research on Physical and Mathematical Sciences of the Autonomous University of Nuevo León, which is part of the international system for monitoring space debris, comprising a network of 25 observatories in more than 15 countries under the coordination of the Keldysh Institute of the Russian Academy of Sciences, has also joined those efforts. The observatory conducts space debris monitoring with the aim of identifying debris that could cause damage to operational satellites and, as a result, disrupt services such as mobile telephone signals or flights, or cause Global Positioning System (GPS) errors.

Further, the National Polytechnic Institute, through the Ticomán School of Mechanical and Electrical Engineering (ESIME), founded the ESIME Ticomán Aerospace Association, one of the activities of which is to carry out research on subjects such as space debris. Those bodies frequently publish articles on the topic, disseminating information within the Institute and among the general public.

Another organization, operating since 2011, is the Space Science and Technology Network, a group of researchers interested in space science and technology in Mexico who seek to raise funds to conduct multidisciplinary seminars, workshops and projects involving coordination among national and international actors from academia, government institutions, businesses and civil society with the aim of promoting the development of space science and technology in Mexico.

It should be noted that all of the above-mentioned activities are carried out in compliance with international regulations governing debris remediation, such as International Telecommunication Union recommendation ITU-R S.1003, on the basis of which the Federal Institute of Telecommunications and the Mexican Space Agency (AEM) jointly established an ad hoc group on satellite-generated debris. The group's objectives are to provide the Institute with inputs relating to technical and regulatory issues regarding debris generated at the end of the service life of non-geostationary and geostationary satellite systems and by collisions with those systems.

It is also important to note the participation of Mexico, together with Canada, Czechia and Germany, in the creation of the compendium of space debris mitigation standards. The purpose of the compendium is to provide member States with information on the current instruments and measures that have been implemented by

States (including Mexico) and international organizations and to assist those wishing to enact or implement similar standards in relation to this important issue.

Lastly, and given the importance of the matter, AEM has applied for observer status with the Inter-Agency Space Debris Coordination Committee. As one of the requirements is the submission of a formal request, AEM is preparing a report on the research and work being carried out at the aforementioned scientific and academic institutions and universities in Mexico.

Safety of space objects with nuclear power sources on board and problems relating to their collision with space debris

Although this issue is not directly applicable to Mexico, the country is aware that deep space missions require nuclear energy and that such sources involve the as yet unresolved question of space debris. It is a problem for which there is no simple solution. A solution has not yet been found to the space debris generated from 4 October 1957 to the present. Although there is a database of objects that are orbiting the Earth but stopped operating many years ago, the orbit with the greatest number of such objects being low Earth orbit, the problems of how to remove those objects and who is responsible for doing so remain to be solved.

As advances are made in space technology, it may be possible to establish mechanisms enabling objects launched into outer space to return to Earth and disintegrate as they pass through the atmosphere.

The long-term sustainability of space activities is essential. It is vital to establish binding measures or technologies so that satellite operators and all entities that launch objects (rockets) into outer space are obliged by their respective Governments to return those objects to Earth.

Another question linked indirectly to this issue is whether the collision of a space object with a nuclear power source on board with another human-made object or item of space debris would fall within the scope of the Convention on International Liability for Damage Caused by Space Objects if it were possible to identify the owner of that debris.

III. Replies received from international organizations

European Union

[Original: English]
[2 December 2020]

Since 2016, the European Union, through the Space Surveillance and Tracking Consortium, has provided 24/7 services on collision avoidance, re-entry and fragmentation to European users. These services contribute to ensuring safe space operations and sustainability in outer space. Today, 148 spacecraft – civil, military and commercial – of the European Union and its member States benefit from this service, which reduces the risk of collision in all orbit regimes. The European Union also aims to develop space surveillance and tracking capabilities in order to achieve a higher level of strategic autonomy in Europe and, in turn, to contribute to global burden-sharing.

The European Union is about to adopt its Space Programme Regulation to boost its space capabilities, notably in the field of space situational awareness.

Several research projects were developed under the Horizon 2020 research framework programme (2014–2020) and cover issues such as:

(a) A thruster-based pack that can be “bolted” onto a satellite to provide de-orbiting capability (D3);

- (b) A holistic approach to spacecraft design to meet de-orbit and disposal needs (ReDSHIFT);
- (c) Self-removal passive technology for de-orbiting a large spacecraft (TeSeR);
- (d) Orbit manoeuvring through natural orbit perturbation with applications in space debris evolution and mitigation (COMPASS);
- (e) A de-orbit kit based on drag produced by electrodynamic tether technology (E.T.PACK).

More information on the Horizon 2020 projects can be found at <https://cordis.europa.eu/en>.

In the previous FP7 research framework programme, several space debris projects were funded, among them RemoveDebris, which actually performed the first European on-orbit demonstration of debris removal technologies, including net capture and harpoon. The upcoming European Union Research and Innovation Framework Programme Horizon Europe intends to support robust European Union capacity to monitor and forecast the state of the space environment, for example, space weather, including radiation hazards, space debris and near-Earth objects. The first work programme, for the period 2021–2022, is, however, still under discussion with States members of the European Union.

Project abstracts

COMPASS – 679086: Control for Orbit Manoeuvring through Perturbations for Application to Space Systems

Space benefits humankind through the services it provides to Earth. Future space activities progress thanks to space transfer and are safeguarded by space situational awareness. Natural orbit perturbations are responsible for the trajectory divergence from the nominal two-body problem, increasing the requirements for orbit control; whereas, in space situational awareness, they influence the orbit evolution of space debris that could cause hazards to operational spacecraft and near-Earth objects that may intersect the Earth. However, this project proposes leveraging the dynamics of natural orbit perturbations to significantly reduce mission cost, which is currently extremely high, and creating new opportunities for space exploration and exploitation.

The COMPASS project will bridge the disciplines of orbital dynamics, dynamical systems theory, optimization and space mission design by developing novel techniques for orbit manoeuvring by “surfing” through orbit perturbations. The use of semi-analytical techniques and tools of dynamical systems theory will lay the foundation for a new understanding of the dynamics of orbit perturbations. We will develop an optimizer that progressively explores the phase space and, through spacecraft parameters and propulsion manoeuvres, governs the effect of perturbations to reach the desired orbit. It is the ambition of COMPASS to radically change the current space mission design philosophy: from counteracting disturbances to exploiting natural and artificial perturbations.

COMPASS will benefit from the extensive international network of the principal investigator, including the European Space Agency (ESA), the National Aeronautics and Space Administration (NASA) of the United States of America, the Japan Aerospace Exploration Agency (JAXA), the National Centre for Space Studies (CNES) of France and the United Kingdom of Great Britain and Northern Ireland Space Agency. Indeed, the proposed idea of optimal navigation through orbit perturbations will address various major engineering challenges in space situational awareness for application to space debris evolution and mitigation, missions to asteroids for their detection, exploration and deflection, and, in space transfers, for perturbation-enhanced trajectory design.

D3-711193: Smart propulsive device for controlled satellite decommissioning and re-entry

Space is nowadays fundamental for our life. Most of the services we use every day are based on space assets: weather forecasting, navigation, Earth observation, security, disaster prevention and management, and telecommunications. For decades, spacefaring nations and private organizations have underestimated the fact that orbital space is a limited resource. As a consequence, out of the about 6,000 satellites launched since the beginning of the space age, only 1,300 are operational: the remaining wander uncontrolled in the space around Earth and risk colliding with each other or against operational satellites. In addition to this, many dead satellites re-enter the atmosphere in an uncontrolled manner and their larger components survive the high heat of the re-entry and may cause damage to assets and persons on the ground.

For these and other reasons, space operators have started to develop methods to safely remove their satellites, pushed by international regulations issued by space agencies, international organizations (e.g., the United Nations and the Inter-Agency Space Debris Coordination Committee) and national Governments. The D3 project is aimed at responding to the increasing need to guarantee safe and clean access to space for both satellite operators and manufacturers, and in general for all the stakeholders involved. This approach has already received positive feedback and endorsement from important space players such as ESA, NASA and the Italian Space Agency, as well as both satellite operators and manufacturers.

Since its establishment in 2011, D-Orbit has developed a decommissioning device (called D3) for satellites and launcher stages. It is capable of removing them in a safe and controlled way at the end of mission or if a major failure occurs. This technology has been pushed up to a current technology readiness level of six. D-Orbit intended to validate the D-Orbit's decommissioning concept in space in 2016 in the D-SAT mission and to collect data, inputs and lessons learned for updating, optimizing and fine-tuning the design, the engineering and the production of the D-Orbit's D3.

E.T.PACK – 828902: Electrodynamic Tether Technology for Passive Consumable-less Deorbit Kit

The Low Work-function Tether (LWT) is a long conductive tape coated with a material that enhances thermionic and photoelectric electron emissions. It enables spacecraft to de-orbit and/or reboost without the need for consumables. It interacts passively with its environment (ambient plasma, magnetic field and solar radiation) to exchange momentum with the planet's magnetosphere. E.T.PACK is aimed at developing a proof of concept for LWTs by breaking through and combining the current frontier of knowledge in three fields: plasma physics, low work-function material science, and space tethers. These will be integrated into a de-orbit kit and a flight simulator for mission analysis. The kit is aimed at reaching technology readiness level four and will have two modes of operation: a fully passive LWT and a conventional electrodynamic tether equipped with an active hollow-cathode (backup mode). A new coating process for the electride, C12A7 ($[Ca_{24}Al_{28}O_{64}]^{4+}(4e^-)$), will be developed and used to manufacture an LWT demonstrator. The C12A7 and its extraordinary properties will also be applied to the hollow cathode of the kit, which will include a novel deployment mechanism specifically designed for LWT applications. The complex current exchange of LWTs with the ambient plasma under space-charge conditions will be studied theoretically and used to develop accurate simulators. The theory-experiment comparisons will lead to a solid framework for LWT operation and constraints, including thermal, mechanical, optical, electrical, atomic oxygen and ultraviolet resistance, and survivability. Hitherto impossible mission scenarios will be explored, thus opening up new horizons in space science and technology. These interdisciplinary activities, at the cutting edge of their fields and highly interdependent, make E.T.PACK a high-risk project. This is fully compensated by its potential impact: Europe being the first with access to a reversible in-space propulsion technology free of consumables.

ReDSHIFT – 687500: Revolutionary Design of Spacecraft through Holistic Integration of Future Technologies

ReDSHIFT will address barriers to compliance by spacecraft manufacturers and operators, now and in the future, with requirements and technologies for the de-orbiting and disposal of space objects. This will be achieved through a holistic approach that considers, from the outset, opposing and challenging constraints for the safety of the human population when these objects re-enter the atmosphere, designed for demise, and for their survivability in the harsh space environment while in orbit. Ensuring robustness into the future, ReDSHIFT will take advantage of disruptive opportunities offered by 3D printing to develop highly innovative, low-cost spacecraft solutions, exploiting synergies with electric propulsion, atmospheric and solar radiation pressure drag and astro-dynamical highways to meet de-orbit and disposal needs and also design for demise. Inherent to these solutions will be structures to enhance spacecraft protection by fracture along intended break-up planes and re-entry demise characteristics. These structures will be subjected to functional tests as well as specific hypervelocity impact tests and material demise wind tunnel tests to demonstrate the capabilities of the 3D-printed structures. At the same time, novel and complex technical, economic and legal issues of adapting the technologies to different vehicles and implementing them widely across low Earth orbit will be tackled through the development of a hierarchical, web-based tool aimed at a variety of space actors. This will provide a complete debris mitigation analysis of a mission, using existing debris evolution models and lessons learned from theoretical and experimental work. It will output safe, scalable and cost-effective satellite and mission designs in response to operational constraints. Through its activities, ReDSHIFT will recommend new space debris mitigation guidelines, taking into account novel spacecraft designs, materials and manufacturing and mission solutions.

TeSeR – 687295: Technology for Self-Removal of Spacecraft

Orbital space is becoming increasingly crowded and a few collision events could jeopardize activities in important orbits and cause significant damage to the infrastructure in space. As a preventive measure to be included in future spacecraft, TeSeR proposes a universal post-mission disposal module to be carried into orbit by any spacecraft to ensure its proper disposal after ending its service lifetime, be it planned or unscheduled, due to spacecraft failure. This module shall be independent of the spacecraft. The principal aims of TeSeR are to:

- (a) Develop a removal module beginning with the exploration of concepts, with a functional design that is aimed at manufacturing and testing an on-ground prototype module that demonstrates the main functions;
- (b) Perform a thorough qualitative and quantitative mission analysis of existing removal concepts;
- (c) Develop a ground-breaking new semi-controlled removal concept based on a passive removal concept that ensures the de-orbit of a large spacecraft (>1 t) into the Pacific Ocean without a propulsion system but with an accuracy of a fraction of one orbit;
- (d) Advance and manufacture removal subsystems prototypes for controlled, semi-controlled and uncontrolled disposal, based on existing technology with a focus on scalability and standardized implementation of the removal module via a common interface;
- (e) Analyse the feasibility and potential advantages of multi-purpose concepts of the module and its removal subsystems (e.g., shielding by deployable structures);
- (f) Perform a market study and define a business case for TeSeR;
- (g) Use TeSeR as leverage to propose changes in legal aspects and advanced state-of-the-art licensing standards for spacecraft, including the improvement of international debris mitigation guidelines and standards.

EUSTM – 101004319: Space Traffic Management for Twenty-first Century Space Operations

Space activities have increased impressively in the last decades. New actors and concepts are raising new challenges to ensure the security, safety, sustainability and stability of space operations. Initiatives at the national and international levels are aimed at tackling this issue through the promotion of prevention, understanding of the situation, active collision avoidance operations and active debris removal.

To ensure autonomy and leadership in the field while reducing dependence on United States of America space situational awareness data, the European Union has started work on an independent space situational awareness/space surveillance and tracking capability.

EUSTM is an end-to-end activity towards the definition of a future space traffic management capability:

- (a) Counting on the main experts in all applicable domains within the team;
- (b) Consulting the main stakeholders worldwide in relevant domains;
- (c) Defining the needs in terms of organization and responsibilities, technology, policy, laws, guidelines, best practices and standards;
- (d) Elaborating detailed specifications, a preliminary design, a reference road map and a rough order of magnitude cost analysis;
- (e) Developing an innovative collaborative platform for exchange of information inside the team and with external stakeholders;
- (f) Creating a community of interest on space traffic management that will be active beyond the duration of the project;
- (g) Organizing workshops and a dedicated European space traffic management conference anchored to a space event.

EUSTM is coordinated by GMV, the main European industrial player in the space situational awareness/space surveillance and tracking domain, supported by the following European stakeholders:

- (a) Industrial players and research institutes from all across Europe;
- (b) Experts in space situational awareness/space surveillance and tracking-related technologies;
- (c) Current and future (NewSpace) users (European Telecommunications Satellite Organization and many others);
- (d) Experts in the policy (European Space Policy Institute), governance and security (European Union Satellite Centre) and legal domains (Institute of Space and Telecommunications Law), professionals in impact assessment and cost-benefit analysis (PwC) and key actors in the air traffic management domain (ENAIRE).

EUSTM is supported by more than 20 additional stakeholders, including operators, industry, emerging NewSpace players and institutions, and the Secure World Foundation.

International Atomic Energy Agency

[Original: English]
[2 December 2020]

The International Atomic Energy Agency (IAEA) provides support to the Working Group on the Use of Nuclear Power Sources in Outer Space of the Scientific and Technical Subcommittee in order to facilitate the implementation of the Safety Framework for Nuclear Power Source Applications in Outer Space, jointly developed by IAEA and the Working Group.

In case of a collision with a spacecraft with a nuclear power source on board, which could potentially result in the re-entry of such sources into the Earth's atmosphere, IAEA has an active programme in the area of preparedness for and response to nuclear and radiological emergencies.

IAEA maintains the International Emergency Preparedness and Response framework, which facilitates the development and maintenance of capabilities and arrangements for preparedness and response to nuclear and radiological emergencies and is based on international legal instruments.

Through the Inter-Agency Committee on Radiological and Nuclear Emergencies, IAEA and the Office for Outer Space Affairs, together with other organizations, maintain the Joint Radiation Emergency Management Plan of the International Organizations (JPLAN), which provides a mechanism for coordination and clarifies the roles and capabilities of the participating international organizations. JPLAN describes a common understanding of how each organization acts during a response and in making preparedness arrangements for a nuclear or radiological emergency.
