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Item 6 of the provisional agenda*
Space debris

Research on space debris, the 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. At its sixty-second session, the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space agreed that Member States and international organizations having 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 the ways in which debris mitigation guidelines were being implemented (A/AC.105/1338, para. 55). Accordingly, a communication dated 4 September 2025 was sent to Member States and international organizations having permanent observer status, inviting them to provide their reports by 24 October 2025 so that the information contained in them could be made available to the Subcommittee at its sixty-third session.

2. The present document has been prepared by the Secretariat on the basis of information received from four Member States, namely, Bahrain, Brazil, Japan and Slovakia, and from two international organizations, namely, the International Atomic Energy Agency and the United Nations Environment Programme. Further information provided by Japan, including figures related to space debris, will be made available as a conference room paper at the sixty-third session of the Subcommittee.

* A/AC.105/C.1/L.426.

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II. Replies received from Member States

Bahrain

[Original: English]
[21 October 2025]

Space debris poses a critical risk to space missions, spacecraft and crewed operations. The Bahrain Space Agency (BSA) is actively engaged in research and development to devise innovative solutions aimed at mitigating this risk and ensuring the sustainability of space exploration.

Three research papers were published by BSA scientists and engineers on space debris, details of which are provided below.

One example of these solutions is the development of an on-board artificial intelligence-based space debris detection and localization system. Routine ground tracking focuses on larger objects (approximately equal to or greater than 10 cm in low Earth orbit), while millimetre- and centimetre-sized debris is not routinely catalogued – although some radars can detect millimetre-class particles for statistical estimates. On-board sensing can partly close this gap. Therefore, the research paper proposes an artificial intelligence-based on-board space debris detection and size classification system with the capacity to calculate Keplerian elements in low Earth orbit. The proposed system will analyse images for object detection using deep learning. If debris is detected, a flag is raised, and the image can be downloaded along with the results of the analysis, such as the object's width, height, time and location. The output of the proposed system can be utilized by ground processing to calculate all orbital parameters of the space debris and predict its motion and associated risk. The proposed system has shown promising results with respect to contributing to global efforts to track space debris and collision avoidance.

This work develops a deep neural network approach to detect and classify targets from radar returns, with a pipeline for target lists, labelling, classification and filtering. An artificial intelligence, deep learning model was developed using a deep neural network for target detection and the classification of real-time space debris. Since the developed model followed an architecture consisting of target listing, classification, data labelling and filtering, the system was shown to distinguish and classify objects adequately. Subsequently, an analysis of the deep learning model was conducted using the approach of clustering instead of classification. The developed model can be integrated into numerous payload sensors and other radar equipment that will aid in space debris monitoring, collision avoidance and decision-making for the long-term sustainability of outer space activities.

The ongoing efforts of BSA to ensure the sustainability of outer space operations include the development of a national space traffic coordination framework, which is a first-of-its-kind initiative in the region. The framework, designed using stakeholder engagement, gap analysis and policy development, aims to align Bahrain's space activities with international standards while promoting safety, security and long-term sustainability in orbital operations. It integrates key components such as data-sharing, regulations, technical capacity-building and international collaboration, with a strong emphasis on space situational awareness for improved monitoring and tracking of space objects. The framework's scalable architecture enables its expansion for future global coordination efforts, thus offering valuable lessons and recommendations for emerging spacefaring nations seeking to establish their own space traffic coordination frameworks.

BSA continues to pursue initiatives that improve space sustainability and reduce debris risks for future generations, in step with the global assessments that show a rapid growth in the debris environment.

Brazil

[Original: English]
[30 October 2025]

Brazil, aligned with international guidelines on outer space sustainability, has been intensifying its efforts to monitor and mitigate outer space debris, and has been promoting research and initiatives aimed at preserving outer space for future use. The following actions related to outer space debris conducted in the period 2024–2025 are highlighted:

(a) The Brazilian Aerospace Industry Catalogue has begun identifying national companies engaged in space situational awareness and space debris mitigation solutions. Notable examples include Safe on Orbit, a start-up specialized in space situational awareness and orbital security, and Saipher ATC, a national company with 30 years of experience that has expanded its air traffic control operations to the space segment;

(b) The Brazilian Space Agency (AEB), in partnership with the National Institute for Space Research (INPE), supports the monitoring of orbital objects, focusing on operational and inactive satellites that may pose a collision risk;

(c) AEB maintains the practice of registering national space objects launched into outer space, in compliance with articles II and III of the Convention on Registration of Objects Launched into Outer Space;

(d) AEB funds the participation of the Brazilian delegation in the International Organization for Standardization (ISO), which develops technical standards for space activities, including space debris mitigation.

In this context, it is worth mentioning Brazil's recent Law No. 14.946/2024, which regulates outer space activities in the country. The law establishes guidelines and standards for managing and mitigating space debris to protect the outer space environment and ensure the safety of outer space operations.

Accordingly, all satellite projects currently under development in Brazil strictly follow international standards and best practices for space debris mitigation, including end-of-life planning, execution of controlled deorbit manoeuvres, and safe re-entry operations, in accordance with section IV of the new law.

Additionally, Law No. 14.946/2024 assigns clear responsibilities to both public and private space operators for the management of debris generated by their activities. In cases of non-compliance with the established norms, the law provides for sanctions that include fines, the suspension of licenses and other administrative penalties.

AEB is also working to establish standards for mitigating outer space debris, as outlined in the 2025–2026 Regulatory Agenda. Item 4 of the Agenda addresses the definition of a set of guidelines and norms aimed at minimizing the generation of debris in Earth orbit, with the purpose of protecting the space environment for future use and reducing risks associated with collisions, satellite damage and threats to terrestrial safety.

Such initiatives are in line with the Guidelines for the Long-term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space, in particular guidelines A.1 (Adopt, revise and amend, as necessary, national regulatory frameworks for outer space activities); A.2 (Consider a number of elements when developing, revising or amending, as necessary, national regulatory frameworks for outer space activities); A.3 (Supervise national space activities); A.5 (Enhance the practice of registering space objects); and C.4 (Raise awareness of space activities).

Colombia

[Original: Spanish]
[23 October 2025]

Space debris

Colombia considers that cooperation between countries with established space capabilities and countries that are new to the space sector must be stepped up in order to enable access to information on lessons learned from research, the transfer of knowledge and the sharing of data, information and analytical methods in relation to space situational awareness, so that the problem of space debris can be tackled more effectively. This will ensure the sustainability of outer space for future generations, as well as the safety of space assets.

In 2023, Colombia adopted Act 2302 on the regulation of space activities within the country, article 3 of which ("Protection of the environment") establishes that those space activities permitted in Colombia must be such as to ensure that any adverse effects of those activities on the environment are minimized, both on Earth and in outer space, and that outer space continues to be used sustainably, specifically through the reduction of space debris generation in such a way that neither harmful pollution nor detrimental impacts on the environment are caused.

Furthermore, the Colombian Aerospace Force, through the Space Operations Centre, is part of a space surveillance network that provides data in support of space situational awareness, which is necessary to prevent collisions and thus reduce the quantity of space debris generated in outer space.

Use of nuclear power sources in outer space

Colombia recognizes the crucial role played by nuclear power sources in outer space, especially in exploratory missions to regions of deep space, such as Mars, where solar energy sources are not viable owing to distance and extreme conditions.

These technologies make it possible for scientific instruments and communication systems to continue functioning in hostile environments, thus ensuring the success of missions that are critical to the advancement of human knowledge.

Colombia supports the development of international frameworks that regulate the safe and responsible use of those technologies, prioritizing strict safety standards that minimize environmental and operational risks. It also promotes the exploration of sustainable and safe energy alternatives, such as systems for generating hybrid energy, which complement the use of nuclear sources in space.

Japan

[Original: English]
[20 October 2025]

Overview

The present report outlines Japan's ongoing debris-related activities and highlights several missions conducted by the Japan Aerospace Exploration Agency (JAXA), in response to the request received from the Secretariat. As at October 2025, the following debris-related research and development activities are being undertaken:

(a) Active debris removal;

(b) Debris avoidance manoeuvres and research on space situational awareness technology;

(c) Research on technology to observe objects in low Earth orbit and geostationary orbit and determine their orbits;

(d) In situ microdebris measurement system;

(e) Space debris observation using satellite laser ranging, and the development of a general-purpose satellite laser ranging reflector.

Status

Active debris removal

JAXA has established a research programme with the aim of realizing low-cost active debris removal missions. The research and development of key technologies for active debris removal has three main areas: non-cooperative rendezvous, capture technology for non-cooperative targets and de-orbiting technology for the removal of massive intact pieces of space debris. In an effort to further develop these essential key technologies, JAXA is collaborating with Japanese private companies to enable the conduct of low-cost active debris removal missions on a commercial basis.

JAXA has also taken the lead in the Commercial Removal of Debris Demonstration (CRD2) programme. This programme consists of two phases and is aimed at executing active debris removal missions in partnership with private companies. In 2024, during the first phase of the programme, JAXA successfully demonstrated key aspects of active debris removal technologies such as non-cooperative rendezvous and proximity operation, and the inspection of the H-IIA second stage. ADRAS-J, developed by Astroscale Japan Inc. with support from the Government of Japan, successfully approached the target debris within approximately 15 metres and captured debris imagery. In the second phase, the demonstration of active debris removal of the H-IIA second stage is planned after the Japanese fiscal year 2027. Astroscale Japan Inc., a partner company of JAXA, was selected as a partner company through an open competition.

In November 2021, the Cabinet Office of Japan published the “Guidelines on a license to operate a spacecraft performing on-orbit servicing”, which sets out requirements to ensure the safe, secure and transparent conduct of on-orbit servicing activities. The Guidelines require the operator of on-orbit servicing missions, including active debris removal, to obtain consent from the entity that owns and operates the client object and to provide detailed information on the operation and management plan to the Government of Japan. The Government then announces the on-orbit servicing activity to ensure transparency. The first phase of the CRD2 programme was carried out in compliance with the Guidelines, and the information on the mission was published on the Government’s website in February 2024.

Furthermore, in February 2025, the Cabinet Office of Japan formulated the “Guidelines for collision avoidance with satellites and others”, which outlined operational principles to reduce the risk of collisions associated with space activities. The Guidelines emphasize the importance of conducting pre-mission risk assessments, sharing orbital information and implementing effective collision-avoidance measures. They are also applicable to active debris removal and other on-orbit servicing missions.

Additionally, at the sixty-eighth session of the Committee on the Peaceful Uses of Outer Space, the Minister of State for Space Policy of the Cabinet Office announced that Japan would convene a domestic study group in 2025 to clarify standard coordination matters among stakeholders, including government entities and private companies, when conducting future international on-orbit servicing missions such as active debris removal. This initiative will be carried out with collaboration between the public and private sectors, with inputs from international experts.

Debris avoidance manoeuvres and research on space situational awareness technology

JAXA regularly receives conjunction notifications from the Combined Space Operations Center (CSpOC). During the Japanese 2024 fiscal year, JAXA executed eight debris avoidance manoeuvres for its spacecraft in low Earth orbit. As an active satellite operator, JAXA acknowledges the escalating risks of conjunction caused by space debris, in the ever-deteriorating space environment.

Core technology for space situational awareness

The Ministry of Defence and JAXA jointly developed a space situational awareness system that became fully operational after March 2023. The system consists of the following components:

(a) Radar: JAXA has engineered a new low Earth orbit radar, capable of detecting 10-cm-class objects at an altitude of 650 km. The Ministry of Defence has also begun operating a space situational awareness radar system that continuously monitors satellites in geostationary Earth orbit and their surroundings;

(b) Telescopes: JAXA has refurbished its 1-m-class and 50-cm-class telescopes to enhance their ability to observe space debris in high orbits, including the geostationary orbit;

(c) Analysis system: JAXA has introduced a new system to analyse observation data obtained from radar and telescope facilities. This system is instrumental in conducting risk assessments and formulating collision avoidance plans in cases where space debris is approaching JAXA satellites.

JAXA has also developed a tool to support planning for debris avoidance manoeuvres upon receiving conjunction data messages from CSpOC. The tool is designed to simplify the debris avoidance manoeuvres process and reduce its associated operational workload. JAXA has made the tool available, at no cost, to all satellite operators via its website since 2021 and remains committed to providing ongoing support for this initiative.

Research on technology to observe objects in low Earth orbit and geostationary orbit and determine their orbits

Generally, the observation of objects in low Earth orbit is conducted mainly by radar system. However, JAXA has been developing an optical observation system to reduce the cost of both construction and operation. As a result, a large complementary metal-oxide semiconductor (CMOS) sensor for low Earth orbit observation has been developed. By analysing the data collected from the CMOS sensor using graphics processing unit-based image-processing technologies, JAXA can detect objects in low Earth orbit that measure 10 cm or less.

To increase capabilities for observing objects in both low Earth orbit and geostationary orbit, two remote observation sites have been established in Australia. Those additional observation sites, together with the Mount Nyukasa Observatory in Japan, will make it possible to carry out more precise orbital determinations and altitude estimation of objects in low Earth orbit using the data from the sites in Australia.

In situ microdebris measurement system

The space debris monitor is an in situ microdebris sensor designed to detect debris ranging from micrometre- to millimetre-sized particles in orbit. The most recent flight experiment was conducted by the H-II Transfer Vehicle Kounotori-5 (HTV-5). Data derived from the actual measurements of such small debris objects is essential to properly understand the vast number of minute debris orbiting near the Earth, especially since such debris is becoming a dominant risk factor in orbit.

The unique properties of the space debris monitor are its simple detection system, which requires no special calibration prior to flight, and its potential to collaborate easily with other sensors. The space debris monitor consists of two main components: a debris detection area and circuit areas. The debris detection area is made of very thin polyimide film equipped with thousands of 50-µm-wide conductive grid lines that can detect the diameter of collided debris ranging from 100 µm to millimetres. The size of an impacting debris object is determined by counting the number of grid lines severed when the debris impacts and penetrates the film.

JAXA is currently collaborating with the Orbital Debris Program Office of the National Aeronautics and Space Administration (NASA) of the United States of America to develop a new space debris monitor. This initiative marks the first opportunity to integrate a space debris monitor with other sensors, such as the NASA debris sensor, enabling measurement not only of the size of the debris but also of velocity, material composition and various other relevant parameters.

Space debris observation using satellite laser ranging, and the development of a general-purpose satellite laser ranging reflector

JAXA has been focusing on satellite laser ranging as the third method for space debris observation, after radar and telescope systems. As such, the Tsukuba satellite laser ranging station began operating in June 2023.

In recent years, it has become increasingly important to improve the visibility of orbiting objects. To meet this need, JAXA has developed an affordable and compact satellite laser ranging reflector named "Mt.FUJI", designed for universal use in low Earth orbit. The reflector was installed on the small satellite (CE-SAT-IE) and launched by the H3 Launch Vehicle Test Flight No. 2 in February 2024. In August of the same year, it was confirmed that the reflector was operating as expected in orbit.

In order to enable the installation of the reflector on a wide range of spacecraft, including satellites and upper stages of rockets, JAXA is currently transferring manufacturing technology to several companies. The Agency is also promoting the reflector's international application to improve the global trackability of on-orbit objects, thereby making a meaningful contribution to the sustainable utilization of outer space.

Slovakia

[Original: English]
[28 October 2025]

Slovak optical sensor observations of targets that are potential candidates for active debris removal missions and to monitor pre-re-entry conditions

The Division of Astronomy and Astrophysics which is part of the Faculty of Mathematics, Physics and Informatics (FMPI) of Comenius University in Bratislava observes, on a regular basis, with its 0.7-m Newton telescope (AGO70), objects in low Earth orbit that are potential candidates for the active debris removal missions. AGO70 acquired astrometric observations of the European Space Agency's Cluster satellite Rumba (COSPAR identification number 2000-045A) one week before its re-entry, which occurred on 22 October 2025. Observations supported the re-entry location prediction calculated by the European Space Agency's team.

Application of Slovak all-sky meteor network for monitoring re-entry events

The Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava is using observations from its own network of the All-Sky Meteor Orbit System (AMOS) to model re-entry events. AMOS is routinely used for automatic detection of meteors, the determination of their orbit and spectrum extraction. FMPI developed and is now operating worldwide 24 AMOS cameras in total (including spectral ones), seven of which are situated in the Slovak Republic, three in the Canary

Islands (Spain), four in Chile, four in the Hawaiian islands (United States of America), six in Australia and four in South Africa. AMOS network detects the re-entry events, which allows FMPI to perform modelling of the trajectories of created fragments in the atmosphere and analyse the spectral properties of the fragments. New re-entry events were captured over the course of 2025 by AMOS cameras. In January 2025, a small satellite was captured during its re-entry by two AMOS cameras installed on Hawaiian islands. In July 2025, all-sky and spectral AMOS cameras installed in Chile captured the re-entry of an upper stage, detecting spectra of the fragments. The analysis of the acquired data is ongoing with a focus on improving our knowledge of re-entry physics and improve predictions of fragment survivability and the assessment of on-ground population risk.

Space debris characterization through photometry and spectroscopy, and light pollution estimation

The Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava performs several studies dedicated to the classification and characterization of space debris objects to better understand the origins space debris and the mechanisms of their creation and the effects of space debris on the night sky and light pollution. AGO70 is used to acquire light curves and phase functions of space debris. These data are used to identify the object's reflectance properties and size and shape. By using different spectral-type photometric filters and the spectrograph installed on the AGO70 telescope, FMPI is investigating surface reflectance properties of space objects as a function of wavelength, which is directly related to the material properties. At the end of 2024, FMPI was awarded a contract by the European Space Agency for the characterization of space debris utilizing the available infrastructure in Slovakia. The activity is reaching its final stages and is performed in collaboration with Slovak industry and with a partner in Italy.

Airborne observation campaign to observe decommissioned European Space Agency Cluster satellite Salsa organized by Slovak industry and academia

In 2024, Slovak industry was a coordinator in the international airborne observation campaign to observe the demise of the European Space Agency Cluster satellite Salsa over the Pacific Ocean during daylight. The airborne ROSIE-Salsa observation mission, which had the objective of improving knowledge about the processes of re-entry physics in order to increase safety on the ground, was a joint effort of industrial and academic partners from Slovakia, Germany and Australia. The campaign was successful, and more than a dozen instruments on board the aircraft observed the re-entry event. The data collected by the mission has been preliminarily analysed and published in peer reviewed and conference papers.

III. Replies received from international organizations

International Atomic Energy Agency

[Original: English]
[17 October 2025]

The International Atomic Energy Agency (IAEA) continues to support the work of 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. Furthermore, IAEA is ready to support future activities of the Working Group on consideration and safety implications of potential future uses of nuclear power sources in outer space, particularly those involving nuclear reactors.

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 for and response to nuclear and radiological emergencies and is based on the international legal instruments. In this context, the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), for which IAEA provides the secretariat and the United Nations Office for Outer Space Affairs is a member, plays an important role. IACRNE maintains 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 the common understanding of how each organization acts during a response and in making preparedness arrangements for a nuclear or radiological emergency.

IAEA is organizing a joint meeting with the United Nations Office for Outer Space Affairs and the Working Group to be held in June 2026. The joint meeting will cover a wide range of areas, including the history of space fission systems, space missions enabled by radioisotope power sources, space missions enabled by nuclear reactor technologies, and the safety aspects of nuclear power source applications in space.

United Nations Environment Programme

[Original: English]
[10 October 2025]

The United Nations Environment Programme (UNEP) has not undertaken research into the safety of nuclear power sources or on collision issues. However, in collaboration with the United Nations Office for Outer Space Affairs, UNEP co-hosted an expert workshop on the environmental impacts of space activities. The outcomes of this workshop, summarised in an issue note, will be published in the coming weeks. While this paper addresses the issue of space debris and outlines actions to mitigate its environmental impact, it does not specifically consider the question of nuclear power sources on broad space objects. In this regard, UNEP recommends the establishment of a dedicated scientific group to examine these specific matters and to provide comprehensive and up-to-date advice on the current state of knowledge.