29 January 2024

English only

**Committee on the Peaceful Uses of Outer Space**
**Scientific and Technical Subcommittee**
**Sixty first session**
Vienna, 29 January–9 February 2024
Item 6 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

The present document has been prepared by the Secretariat on the basis of information provided by Japan on 20 October 2023, by Jordan on 22 November 2023, by India on 7 December 2023 and by the International Peace Alliance on 8 January 2024, and contains figures and pictures related to space debris, not included in A/AC.105/C.1/125 and A/AC.105/C.1/125/Add.1. The document is issued without formal editing.

* A/AC.105/C.1/L.412.

# Replies received from Member States

## India

[Original: English]

### Overview

India always places high importance on the implementation of space debris mitigation guidelines in its space programmes. India's national space policy 2023 addresses the space debris mitigation requirements for all Indian space missions to ensure the safety and sustainability of outer space activities.

The Indian Space Research Organization (ISRO), the national space agency, pursues research activities in the areas related to space situational awareness and space traffic management, which includes modelling of space debris environment, atmospheric re-entry analysis, fragmentation analysis and compliance with the international guidelines on space debris mitigation and long-term sustainability of outer space. Under the framework of the ISRO System for Safe and Sustainable Space Operations Management (IS4OM), concerted efforts and centralized management of all related activities are being carried out.

A network of space objects tracking radar and optical telescopes is being set up for dedicated tracking and monitoring of low Earth orbit and geostationary orbit space objects, including space debris as part of the Network for space object Tracking and Analysis (NETRA) project. In light of the ever-increasing space object population, continual initiatives are undertaken to improve the accuracy of the existing close approach analysis methodologies for spacecraft and launch vehicles.

India follows space debris mitigation guidelines of the United Nations and the Inter-Agency Space Debris Coordination Committee (IADC) to the maximum extent practicable while striving for better compliance. The measures undertaken to curtail the growth of space debris include pre-launch collision avoidance to determine safe lift-off for launch vehicles, space object proximity analyses for operational spacecraft, execution of collision avoidance manoeuvres as and when needed, passivation of rocket stages, post mission disposal of satellites and launch vehicle upper stages. In the year 2023, GSAT-12 was reorbited to a super synchronous orbit and passivated before its decommissioning, in perfect compliance with the post-mission disposal guidelines for geostationary orbit objects recommended by the United Nations and IADC. An immensely challenging experiment for de-orbiting Meghatropiques-1 and ensuring its controlled atmospheric re-entry over an uninhabited zone in the Pacific Ocean was carried out successfully. All orbital rocket stages launched by India were passivated after the end of mission. The upper stage of PSLV-C56 was de-orbited to 300 km altitude to limit its post-mission orbital lifetime to less than a month. Specific initiatives are undertaken for awareness-raising and hand-holding of new entrants in the space arena regarding the implementation of measures for space debris mitigation.

India also actively contributes to various activities and studies related to space debris as a member of IADC, International Academy of Astronautics' Space Debris Working Group, the International Astronautical Federation's Space Traffic Management Technical Committee, International Organization for Standardization Working Group 7, and the United Nations Committee on the Peaceful Uses of Outer Space's Working Group on the Long-term Sustainability of Outer Space Activities.

ISRO's Chandrayan-3 mission's Propulsion Module houses two Radioisotope Heater Units (RHUs) for technology demonstration in the lunar orbit. The RHUs were designed with adequate insulation and claddings to protect the fuel assembly against aerothermal heat loads during any accidental re-entry of the RHU and subsequent ground impact. The cladding layer prevents any accidental release of radioactive fuel into the environment. An outermost aeroshell layer of high-strength material is used to encapsulate the insulator and the inner assembly with the cladding to protect against any thermal shock in case of any launch vehicle explosion. All necessary safety procedures as per the international standards were addressed through appropriate standard operating procedures which were strictly adhered to during the transportation, storage and handling, and integration with the spacecraft at the launch site.

## Japan

[Original: English]

**Overview**

The present report outlines the debris-related activities mainly conducted by the Japan Aerospace Exploration Agency (JAXA), in response to the request received from the Secretariat. As at October 2023, 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) Development of a composite propellant tank;

(f) 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 major themes (figure 1): non-cooperative rendezvous, capture technology for non-cooperative targets and de-orbiting technology for the removal of massive intact space debris. In an effort to provide 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.

Furthermore, JAXA has taken the lead in the Commercial Removal of Debris Demonstration (CRD2) programme. This programme consists of two phases (figure 2) and is aimed at executing active debris removal missions in partnership with private companies. In the first phase of the programme, the demonstration of key technologies such as non-cooperative rendezvous and proximity operation, and the inspection of the H-IIA second stage are planned for Japanese fiscal year 2023. In the second phase, the demonstration of active debris removal of the H-IIA second stage is planned after Japanese fiscal year 2026. Astroscale Japan Inc. was selected through an open competition in February 2020 as a partner company for the first phase.

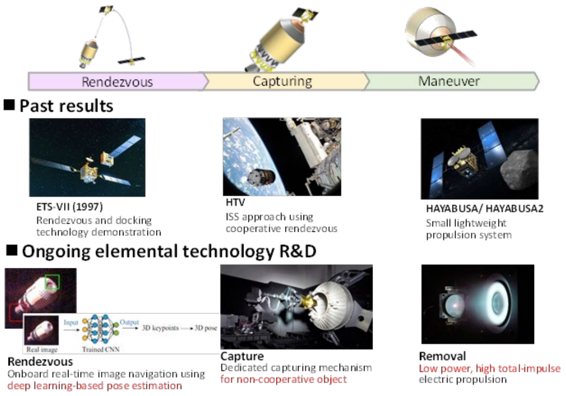


Figure 1
**Active Debris Removal research activities**

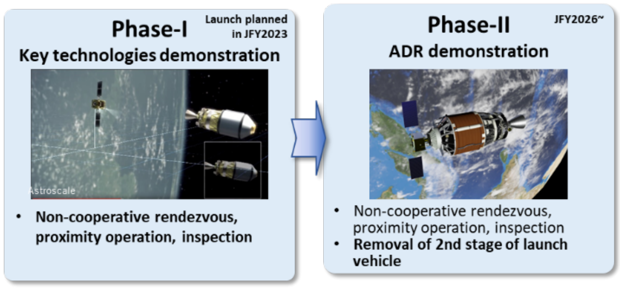


Figure 2
**Demonstration of the removal of large-sized debris in two phases**

## Status of debris avoidance manoeuvres and research on core technology for Space Situational Awareness (SSA)

JAXA regularly receives conjunction notifications from the Combined Space Operations Center (CSpOC). In 2022, JAXA executed two 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 (SSA)*

The Ministry of Defence and JAXA developed a space situational awareness system, which has been fully operational since April 2023. The system encompasses 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;

(b) Telescopes: JAXA has refurbished its 1-m-class and 50-cm-class telescopes to increase their capability to observe space debris in high orbit, 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. Since March 2021, JAXA has made the tool available, at no cost, to all satellite operators via its website.

The tool is expected to simplify the process for debris avoidance manoeuvres and reduce the associated workload. JAXA remains committed to providing ongoing support for this initiative.

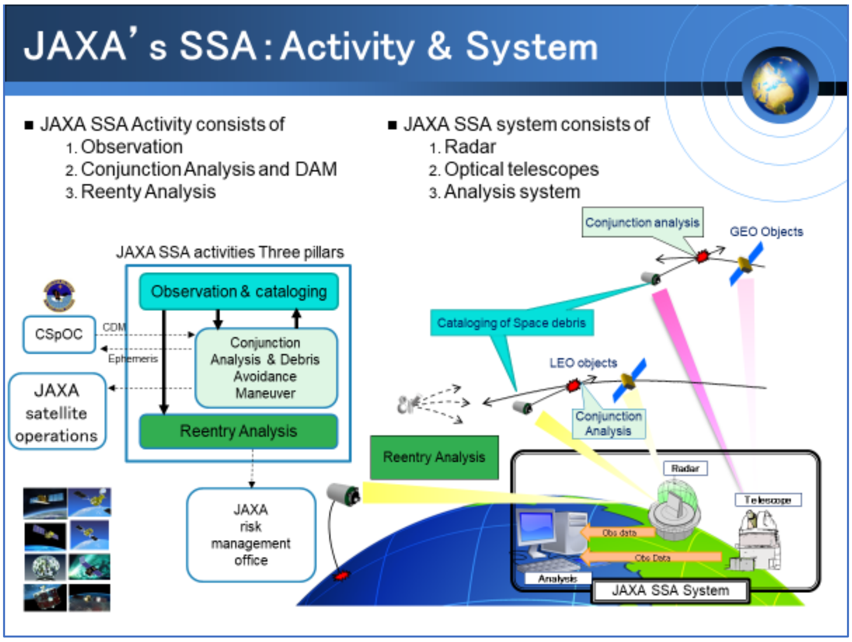


Figure 3
**Activity for SSA in JAXA**

**Research on technology to observe objects in low Earth and geostationary (geosynchronous) orbits and determine their orbits**

Generally, the observation of objects in low Earth orbit is conducted mainly by radar system, but JAXA has been working to develop an optical 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 (figure 4). Analysing the data from the CMOS sensor with graphics processing unit-based image-processing technologies can help detect objects in low Earth orbit that measure 10 cm or less. To increase capabilities for observing objects in low Earth orbit and geostationary orbit, two remote observation sites have been established in Australia. These additional observation sites, along with the Mount Nyukasa Observatory in Japan, will make it possible to carry out precise orbital determinations and altitude estimation of objects in low Earth orbit using the data from the sites in Australia.

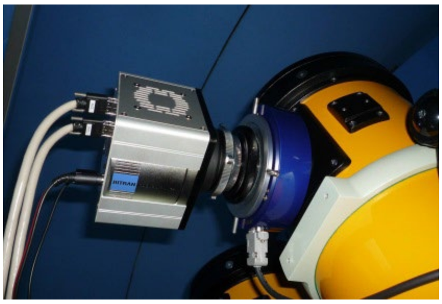

Figure 4
**The CMOS sensor manufactured by Bitran which can detect 10 cm LEO objects analysing the data with FPGA-based image-processing technologies**

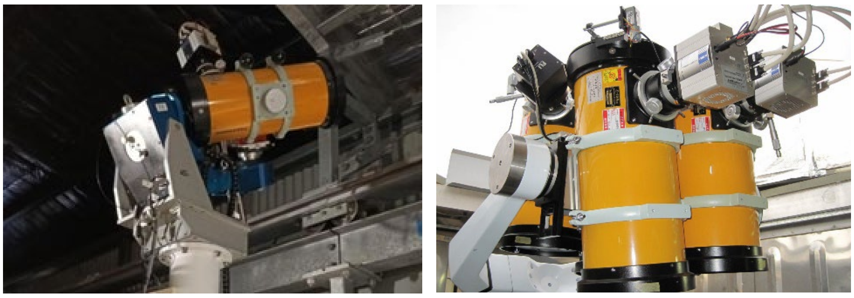

Figure 5
**The remote observation sites in Australia. The left figure shows the telescope install at the Zadko Observatory (western side of Australia). The right one is four 18 cm telescopes install at the Siding Spring Observatory (eastern side of Australia)**

### In-situ microdebris measurement system

The space debris monitor is an in situ microdebris sensor focusing on micro- to milli-sized debris in orbit. The most recent flight experiment was conducted by the H-II Transfer Vehicle Kounotori-5 (HTV-5). Information based on actual measurements of these small debris objects is essential to properly understand the vast amount of small 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 does not need any special calibration before flight, and the potential to collaborate easily with other sensors. The space debris monitor consists of two main components: the debris detection area and the 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 the impacted debris is measured by detecting 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 presents the first opportunity to integrate a space debris monitor with other sensors, such as the NASA debris sensor, and will involve measurement of not only the size of the debris, but also its velocity, material and various other relevant aspects.

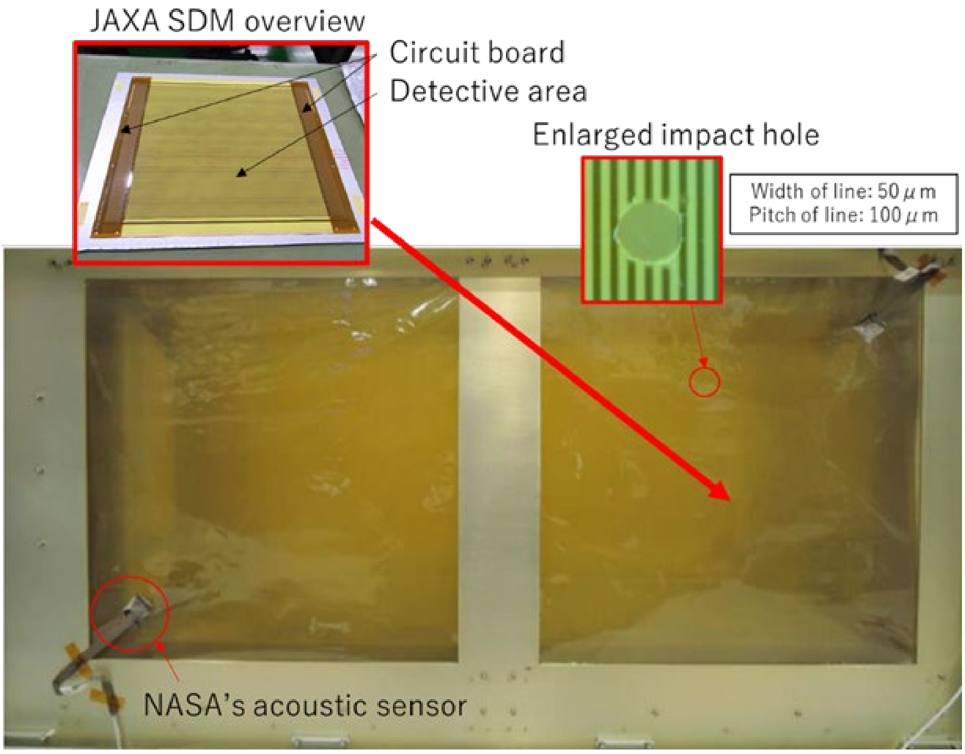


Figure 6
**JAXA SDM mounted on the test frame for HVIT**

### Development of a composite propellant tank

A propellant tank is usually made of titanium alloy, which is superior because of its light weight and good chemical compatibility with propellants. However, its melting point is so high that such a propellant tank would not demise during re-entry and would pose a risk to people on the ground.

For several years, JAXA has been working to develop an aluminium-lined, carbon composite overwrapped tank with a lower melting temperature. To gauge its feasibility, JAXA conducted fundamental tests, including a liner material aluminium compatibility test with a hydrazine propellant and an arc heating test.

Following the manufacture and testing of a shorter engineering model EM-1 tank, JAXA manufactured a full-sized EM-2 tank. The shape of the EM-2 tank is identical to that of the nominal tank, which includes a propellant management device. Using the EM-2 tank, a proof pressure test, a vibration test (for wet and dry conditions), an external leak test, a pressure cycle test and a burst pressure test were conducted, and all showed good results. Subsequently, the critical design review was completed.

Notably, the composite propellant tank offers a shorter delivery time and lower cost compared with a titanium propellant tank. Experimental and analytical evaluation of its demisability during atmospheric re-entry is ongoing.

Figure 7
**EM-2 tank**

Figure 8
**Evaluation tests by arc heating wind tunnel**

**Space debris observation using Satellite Laser Ranging and development of a general-purpose SLR reflector**

JAXA has been focusing on satellite laser ranging as the third space debris observation method after radar and telescope observation. 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, which can be used universally in low Earth orbit. JAXA is promoting its application internationally to improve the trackability of on-orbit objects, thereby making a meaningful contribution to the sustainable utilization of outer space.

Figure 9
**JAXA SLR Tsukuba station and SLR Reflector (Mt.FUJI)**

## Jordan

[Original: English]

**Efforts made to mitigate space debris**

The Regional Centre for teaching Space Science and Technology for West Asia, the Royal Geographical Centre, has made efforts in the field of space debris such as:

(a) Capacity-building and highlighting the importance of space debris mitigating through may lectures, seminars and conferences, as well as television seminars and scientific programmes;

(b) Using computer simulations to track space debris in cooperation with various astronomical centres;

(c) Using virtual reality methods to raise awareness in the field of space debris mitigation;

(d) Following up on scientific research presented by international universities and space and aviation agencies to mitigate space debris;

(e) Working on the establishment of a space debris laboratory.

# Replies received from Observer Organizations

## International Peace Alliance (Space)

[Original: English]

At the space debris closed-door meeting held in Beijing on 18 November 2023 as a part of the International 2023 conference, key figures in space governance, including co-chairs from the International Peace Alliance (Space), experts, and representatives from various international space organizations, convened to discuss urgent and critical issues in space governance. The primary focus was on addressing the increasing threats posed by space debris, the rapid development of low-orbit giant constellations, and the need for effective regulation of emerging space activities. The discussion highlighted the potential role of and possible need for an international centre and/or program (the “International Research and Cooperation Center for Space Environment and Space Governance”) to advance the goal of improving governance related to space environments including, but not limited to space debris. Hainan, China, was discussed as a promising location for such an activity to be based.