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Item 5 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-first 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.105/1307, para. 82). Accordingly, a communication dated 18 September 2024 was sent to Member States and international organizations having permanent observer status, inviting them to provide their reports by 31 October 2024 so that the information contained in them could be made available to the Subcommittee at its sixty-second session.

2. The present document has been prepared by the Secretariat on the basis of information received from three Member States, namely, Bahrain, Japan and Myanmar. Further information provided by Japan, including figures related to space debris, will be made available as a conference room paper at the sixty-second session of the Subcommittee.

* A/AC.105/C.1/L.418.

II. Replies received from Member States

Bahrain

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[27 October 2024]

Space debris poses a critical risk to space missions, threatening the safety of spacecraft and astronauts. The National Space Science Agency (NSSA) is actively engaged in research and development to devise innovative solutions aimed at mitigating this risk and ensuring the sustainability of space exploration. One example of these solutions is the development of an onboard artificial intelligence-based space debris detection and localization system. The challenge is that space debris smaller than 2 millimetres cannot be detected from the ground. This research is therefore focused on an artificial intelligence-based on-board space debris detection and size classification system with the capacity to calculate Keplerian elements in the low Earth orbit. The proposed system will analyse images for object detection using deep learning. If debris is detected, a flag will be raised and the image can be downloaded along with the results of the analysis, such as the object's width, height and location, as well as the time of detection. The output of the proposed system can be utilized by employing ground processing to calculate all orbital parameters of the space debris and to predict its motion and associated risk. The proposed system showed promising results, contributing to the global effort to track space debris and collision avoidance.

Another example of the Agency's efforts to devise innovative solutions for space debris mitigation is the detection and classification of space debris using radar detection data for an optimized low-complexity and low-cost system. 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 model's architecture was based on 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, involving clustering instead of classification. The model can be integrated into numerous payload sensors and other radar gadgets that will aid in space debris monitoring, collision avoidance and decision-making, and contribute to the long-term sustainability of outer space activities.

The Agency continues to have various initiatives and projects dedicated to the sustainability of space and the reduction of space debris for the benefit of future generations.

Japan

[Original: English]
[31 October 2024]

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 2024, 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: 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 and is aimed at executing active debris removal missions in partnership with private companies. In the first phase of the programme, key technologies such as non-cooperative rendezvous and proximity operation, and the inspection of the H-IIA second stage, were demonstrated in 2024. ADRAS-J, developed by Astroscale Japan Inc. with support from the Government of Japan, successfully approached the target debris to a distance of about 50 m, and also achieved fixed-point observations at that distance. 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 as a partner company through an open competition.

Japan published the “Guidelines on a license to operate a spacecraft performing on-orbit servicing” in November 2021, prescribing requirements to ensure the safe, secure and transparent performance of on-orbit servicing. The Guidelines require the operator of on-orbit servicing, including active debris removal, to obtain consent from the entity having authority over the client object and to provide information regarding the operation and management plan so that the Government of Japan may make an in-advance announcement of on-orbit servicing, thereby ensuring transparency. The above-mentioned first phase of the CRD2 programme has been carried out in compliance with the Guidelines, and the mission information has been available on the Government’s website since February 2024.

Debris avoidance manoeuvres and research on space situational awareness technology

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

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.

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, 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. 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.

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.

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 positive 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.

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 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. 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 working as expected in orbit. In order to enable the reflector to be installed on many spacecraft (satellites, upper stages of rockets, etc.), JAXA is currently transferring technology related to manufacturing to several companies. 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.

Myanmar

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[31 October 2024]

A representative of Myanmar attended the UNISPACE+50 high-level segment held on 20 and 21 June 2018. Myanmar was congratulated and noted for participating in the historic anniversary of the first United Nations Conference on the Exploration and Peaceful Uses of Outer Space, supported by the Office for Outer Space Affairs. Myanmar will remain a member of the international space community with the aim of strengthening the uses of space in achieving the Sustainable Development Goals.

As a developing country, the Government of the Republic of the Union of Myanmar has already formulated the Myanmar satellite systems MyanmarSat-1 and MyanmarSat-2, which are aimed at fulfilling the space aspirations of launching the Myanmar national satellite and gaining control over strategic national telecommunications and broadcasting services. While operating its satellite system, Myanmar will emphasize space science, technology, law and policy for the benefit of the regional and multiregional community and also contribute to the achievement of global initiatives such as the 2030 Agenda for Sustainable Development.

Since the Myanmar national satellite project MyanmarSat-3 is at the planning stage, the country has not faced the issues of space debris, nuclear power sources and related problems. Although Myanmar has not yet considered the research on those issues, it will focus on cooperation with the international community and organizations to develop and implement space debris mitigation, in view of the importance of building a secure and peaceful space environment while its own satellite system is in progress.