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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

Addendum

I. Introduction

1. The present document has been prepared by the Secretariat on the basis of information received from two Member States, Japan and Mexico. The information provided by Japan, which includes pictures and figures related to space debris, will be made available as a conference room paper at the fifty-second session of the Scientific and Technical Subcommittee.

* A/AC.105/C.1/L.341.

II. Replies received from Member States

Japan

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[13 November 2014]

1. Overview

In Japan, activities relating to space debris are mainly conducted by the Japan Aerospace Exploration Agency (JAXA).

The details of the JAXA strategic plan for space debris were set out in the document "National research on space debris, safety of space objects with nuclear power sources on board and problems relating to their collision with space debris" dated 16 November 2012 (A/AC.105/C.1/107).

In the section below, major advances are presented in the following space debris-related activities conducted by JAXA during 2014:

(a) Research on conjunction assessment and collision avoidance manoeuvres in relation to JAXA satellites and debris;

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

(c) In situ microdebris measurement system;

(d) Protection from the impact of microdebris;

(e) Development of a propellant tank that easily disintegrates during re-entry;

(f) Contribution to the activities of the International Organization for Standardization (ISO).

2. Status

2.1. Research on conjunction assessment and collision avoidance manoeuvres in relation to JAXA satellites and debris

JAXA receives conjunction notifications from the Joint Space Operations Center. For example, in September 2014, the number of notifications received was 27, which exceeded a specified conjunction threshold value. Between 2009 and 2014 (September) JAXA executed nine collision avoidance manoeuvres for LEO spacecraft.

In parallel, JAXA determines the orbit of space objects by using radar and telescope observation data from the Kamisaibara spaceguard centres of the Japan Space Forum, predicts close approaches using the latest orbit ephemerides of JAXA satellites, and calculates probability of collision data using its in-house methods.

Also, JAXA evaluates the criteria for conjunction assessment and collision avoidance manoeuvres based on its experience. In its evaluations, the trends in parameters for conjunction conditions and prediction errors due to perturbations (e.g. uncertainty in air drag) are analysed.

2.2. *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 LEO objects is conducted by radar, but JAXA has been trying to use optical systems instead to reduce the cost for both construction and operation. Arrays of optical sensors are used to cover large regions of the sky. Survey observations using an 18-cm telescope and a charge-coupled device (CCD) camera showed that objects 30 cm or more in diameter were detectable at an altitude of 1,000 km and that 15 per cent of those were uncatalogued. For GEO observation, a field-programmable gate array that can analyse 32 frames with a resolution of up to 4,096x4,096 pixels (commonly referred as 4Kx4K) in 40 seconds confirmed that objects 14 cm in diameter were detectable by analysing CCD images taken with a one-metre telescope at the Bisei spaceguard centre. Compared to the current size limit for detecting objects in GEO, reported to be 1 metre, this result can be said to show that the technique is effective for detecting small fragments caused by the break-ups in the GEO region.

2.3. *In situ microdebris measurement system*

For microdebris (less than 1 mm in diameter), which cannot be detected from the ground, JAXA is developing an on-board detector for in situ measurement. Its sensor is the first to apply a sensing principle based on conductive (resistive) lines.

If such sensors were installed on a large number of spacecraft, the data acquired could help to improve the debris environment model. An improved flight model will be launched with the H-II Transfer Vehicle Kounotori-5 (HTV-5) in 2015. The environmental and impact verification tests have been completed.

Currently little is known about tiny debris and micrometeoroids in outer space, although having such information is essential for impact risk assessment, for spacecraft survivability analysis, and for designing cost-effective protection for spacecraft. It would be very welcome if the world's space agencies launched such devices, installed them on their spacecraft, shared the data collected, and thus contributed to the improvement of the existing debris and meteoroid models.

2.4. *Protection from the impact of microdebris*

The amount of LEO microdebris (less than 1 mm in diameter) has increased. The impact of microdebris can inflict critical damage on satellites because its impact velocity is, on average, 10 km/s.

To assess the effects of debris impact on satellites, JAXA is conducting hypervelocity impact tests and numerical simulations for structure panels and bumper shield materials. Internal damage to structure panels has also been investigated with the help of numerical simulations.

The results of that research are reflected in the "Space debris protection design manual" (JAXA manual JERG-2-144-HB). The original version of the manual was published in 2009, and it was revised in 2014.

JAXA has developed a debris impact risk assessment tool named Turandot. Turandot analyses debris impact risks using a three-dimensional model of a given spacecraft. Turandot has been updated to apply the latest debris environment model of the European Space Agency, MASTER-2009.

2.5. Development of a propellant tank that easily disintegrates during re-entry

Propellant tanks are usually made of titanium alloys, which are superior because of their light weight and good chemical compatibility with the propellants used. However, their melting point is so high that they would not disintegrate during re-entry and pose the risk of casualties on the ground.

JAXA has conducted research to develop an aluminium-lined tank overwrapped with carbon composites, which will have a lower melting point. As a feasibility study JAXA has conducted fundamental tests, including a test to determine the compatibility of aluminium as a lining material with hydrazine propellant, and an arc heating test. JAXA is now conducting trial production of a scale model named Trial 1. Before the carbon fibre-reinforced plastic was wrapped around the tank, fundamental tests were conducted to determine the filament winding parameters using a proxy that represented the cylindrical part of the aluminium liner. The next step is trial production of the full-scale tank and a qualification test. Once it has passed the qualification test, the tank will cost less and have a shorter manufacturing lead time than previous titanium tanks.

2.6. Contribution to the activities of the International Organization for Standardization

The ISO technical committee on aircraft and space vehicles, subcommittee on space systems and operations (ISO/TC20/SC14), has developed many debris-related standards. They consist of top-level standard ISO-24113:2011 (Space systems: space debris mitigation requirements) and several lower-level standards that detail the methods, procedures and techniques to be followed to meet the top-level standard. Japan has proposed to develop a more comprehensive technical report to support the engineers in charge of designing spacecraft systems, subsystems and components, and spacecraft operators. Its draft title is “Space debris design and operational manual for spacecraft” (reference number TR-18146). It will suggest the timely application of mitigation measures at every phase of development and recommend best practices for major subsystems and components.

Mexico

[Original: Spanish]
[28 October 2014]

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 for the use of nuclear power sources in outer space and is a peaceful State guided by such international instruments 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.

Without prejudice to the foregoing, 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 (the Outer Space Treaty) of 1967, in which the first paragraph of article IV establishes 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, the fact of the matter is that there are no sanctions in the case of a disaster caused by a space object carrying a nuclear load, other than what we might understand by "reparation in respect of the damage", in the words of the Convention on International Liability for Damage Caused by Space Objects. This issue is key to "transparency and confidence-building measures in outer space activities".[1]

Mexico collaborates with the Working Group on the Long-Term Sustainability of Outer Space Activities within the four expert groups: expert group A: sustainable space utilization supporting sustainable development on Earth; expert group B: space debris, space operations and tools to support collaborative space situational awareness; expert group C: space weather; and expert group D: regulatory regimes and guidance for actors in the space arena.

Mexico participated in the initiative of Canada, Czech Republic and Germany to create a compendium of space debris mitigation standards, submitted at the fifty-third session of the Legal Subcommittee of the Committee on the Peaceful Uses of Outer Space, which is the first document with direct information from the Member States (including Mexico) on regulatory measures for the mitigation and removal of space debris.

[1] With some exceptions, the treaties do not establish any sanctions; the space treaties are not among those exceptions.