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Committee on the Peaceful Uses of Outer Space

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

Contents

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I. Introduction

1. In its resolution 64/86, the General Assembly considered that it was essential that Member States pay more attention to the problem of collisions of space objects, including those with nuclear power sources, with space debris, and other aspects of space debris, called for the continuation of national research on that question, for the development of improved technology for the monitoring of space debris and for the compilation and dissemination of data on space debris, also considered that, to the extent possible, information thereon should be provided to the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, and agreed that international cooperation was needed to expand appropriate and affordable strategies to minimize the impact of space debris on future space missions.

2. At its forty-sixth session, the Scientific and Technical Subcommittee agreed that research on space debris should continue and that Member Sates should make available to all interested parties the results of that research, including information on practices that had proved effective in minimizing the creation of space debris (A/AC.105/933, para. 74). In a note verbale dated 31 August 2009, the Secretary-General invited Governments to submit information on the matter by 30 October 2009, so that that information could be submitted to the Subcommittee at its forty-seventh session.

3. The present document has been prepared by the Secretariat on the basis of information received from Germany, Italy, Japan, Myanmar, Poland and Thailand.

II. Replies received from Member States

Germany

[Original: English]

[5 November 2009]

In 2009 Germany actively participated in the work of the Inter-Agency Space Debris Coordination Committee (IADC), the European Network of Competences on Space Debris, the European Cooperation for Space Standardization Space Debris Working Group and the International Organization for Standardization Orbital Debris Coordination Working Group.

Space debris mitigation requirements are part of the “Product Assurance and Safety Requirements for DLR Space Projects” of the German Aerospace Center (DLR). The latest version of this document was issued in 2009 and is now applicable to all national space projects supported by DLR.

German research activities related to space debris issues cover various aspects, such as space debris environment modelling, observation technologies (for instance, the development of in situ detectors to be flown on spacecraft and studies of the effects of hypervelocity impact on spacecraft), as well as technologies to protect space systems from space debris and to limit future generation of space debris.

Financing is ensured either via the German national space budget directly or via the European Space Agency (ESA).

Below is a summary of nationally funded research activities carried out in Germany in 2009.

Improvement of hypervelocity impact test capabilities

The Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut (EMI), in Freiburg, is well known for its expertise in performing hypervelocity impact experiments. Currently there are two projects ongoing to improve the test facilities at the Institute. The objectives are to be able to simulate, in experiments, hypervelocity impacts at velocities of about 10 km/s without changing the physical properties of the projectile and to reduce the loads of the light-gas gun (LGG) in order to reduce experiment costs. For that purpose, an existing light-gas gun, the so-called "Baby LGG", is being upgraded to be able to accelerate millimetre-sized particles to velocities of 10 km/s in a reproducible manner. In the first half of the year, a new high-pressure section was installed and tested.

Furthermore, a new accelerator concept based on the light-gas gun technique, the so-called "Twin Gun", is being developed at EMI to accelerate particles to high velocities. During the reporting period, the basic design of the new accelerator was completed.

Both new accelerators will help to improve the understanding of the physics of impacts in the upper hypervelocity regime.

Technical University of Braunschweig: analyses of the position of Germany with regard to space debris mitigation measures in relation to economic and sustainability aspects

The objective of these analyses is to support the national position with regard to the economic and sustainability aspects of space debris mitigation measures in the context of scientific and technical discussions, and to support the position of the German delegation in ESA and international committees such as IADC and the Scientific and Technical Subcommittee. The analyses are being carried out by the Institute of Aerospace Systems of the Technical University of Braunschweig. A comprehensive description of these analyses is given in the previous national report on space debris research activities (see A/AC.105/931).

The relevant analyses resulting in the current position

The IADC Space Debris Mitigation Guidelines define two orbital regions as "protected regions". These are the low-Earth orbit (LEO) environment below an altitude of 2,000 km and the geostationary (GEO) ring. To date, four known catastrophic collisions between catalogued objects have occurred, these events being followed by the recent Iridium 33 and Cosmos-2251 event in the spring of 2009. All of these have taken place in the LEO region. Recent simulations have shown that the single largest driver today for future collisions are major explosion events from spent rocket bodies and satellites in LEO. The gross majority of active satellites in the GEO ring have an orbital inclination near 0 degrees and occupy well-defined slots around the Earth's equator. These satellites must perform frequent manoeuvres so that they do not violate their slot boundaries. Any passive object in this region may however drift through these slots and collide with any of the estimated 381 controlled satellites,[1] creating more potential collision partners. Mitigation measures should therefore make the following two goals their first priority:

(a) Inhibit all explosions pertaining to the LEO region;

(b) Remove all major debris objects from the GEO region.

The economic cost and benefit of plausible mitigation scenarios are currently being studied based on the "Space Debris End-to-End Service" project from 2004 and insight from recent simulations.

Investigation on proposals to space debris removal

The meaning of space debris removal is recognized, but the feasibility and effectiveness of the, in principle, technically demanding and financially effortful methods still have not been proved.

Methods for the dedicated elimination of greater objects are aimed at the prevention of fragmentations in orbits that are much used. The larger space debris objects to be removed will be deorbited down into the atmosphere or stored in a graveyard orbit by different measures. For changing the orbits of such objects, concepts such as robotic systems with conventional propulsion systems or deployment of large structures to interact with the Earth's atmosphere ("drag augmentation"), with the geomagnetic field ("electrodynamic tethers", "magnetic sails") or with the radiation pressure of the solar wind ("solar sails") are proposed.

While the elimination of larger objects is having an influence on the long-term reduction of space debris-producing events, the elimination of smaller objects has an effect on the short-term reduction of already available fragments.

The most common suggestions for the elimination of smaller objects are aimed at either direct distraction or thermal decomposition by means of ground-, air- or space-based laser systems or by collection with capture devices. With regard to the last category, an idea at DLR has led to the issue of patent DE 10 2008 005 600.6. This patent is based on the design of an extensive capture device attached to a satellite platform. The satellite platform has the capability of flying orbital manoeuvres (low eccentric orbits) to collect space debris objects in the flight direction as well as from the rear. Initial investigations have demonstrated that effective orbits for space debris removal can be found.

In situ detector MDD3

Within the framework of the On-Orbit Verification programme of DLR, the in situ detector MDD3, developed and built by EMI, will be flown on a Russian Spektr-R satellite. This detector is part of an experiment to directly detect the hypervelocity impacts of micrometeoroids and space debris by means of several independent sensors; this experiment will thus contribute to the enhancement of knowledge about these populations of microparticles in Earth orbit. During the

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[1] See: R. Choc and R. Jehn, *Classification of Geosynchronous Objects*, Issue 11 (Darmstadt, Germany, European Space Agency, European Space Operations Centre, February 2009).

reporting period, the flight model was finalized and tested, and is scheduled to be flown at the end of 2009.

Italy

[Original: English]

[24 November 2009]

Italy is involved in space debris initiatives at the national level and supports international activities to mitigate and prevent damage caused by space debris.

The spacecraft operators of the Italian Constellation of Small Satellites for Mediterranean Basin Observation (COSMO) SkyMed satellite constellation performed some collision avoidance manoeuvres during 2009, including following the Iridium 33 accident.

At the fifty-second session of the Committee, held in Vienna from 3 to 12 June 2009, the delegation of Italy made a proposal, jointly with the delegation of Germany, regarding the establishment of an international platform of data and information on objects in outer space, under the auspices of the United Nations (see A/AC.105/2009/CRP.19). This database — containing data supplied on an entirely voluntary basis and freely accessible to Member States — would favour the promotion of safe and sustainable development of the peaceful uses of outer space and is in line with the ongoing issue of "long-term sustainability of outer space activities" proposed by the delegation of France.

Japan

[Original: English]

[5 November 2009]

1. Overview

The research relating to space debris in Japan, mainly conducted in the Japan Aerospace Exploration Agency (JAXA) and at Kyushu University, has concentrated on the following topics. The main objective of the research and development strategy of JAXA is to find a solution or countermeasures to the debris issue according to the following categories:

- Category A. Mission assurance: to provide benefits from space activities shall have the highest priority (tactics: observation and modelling; risk assessment and management; protection design, monitoring of debris and collision avoidance etc.)
- Category B. Preservation of the environment and safety assurance on the ground: to ensure sustainable development of space activities and ground safety from objects falling from orbit (tactics: debris mitigation management; estimation of future debris population; safety control for re-entry objects; monitoring of re-entry objects etc.)

- Category C. Improvement of the orbital environment: to prevent chain reactions of debris generation from collisions among orbital objects, and remove disposed objects from densely populated orbital regions (tactics: removal of existing large objects through international cooperation)

The present report introduces some topics of the various research and development items defined by the above strategy.

2. Research on observational technologies for space debris in geostationary orbit

The innovative technology research centre of JAXA is developing observation technology for objects in geostationary orbit (GEO) in order to deal with the space debris problem. The centre has run a space debris observation facility at Mount Nyukasa, Nagano, since 2006. The facility contains two telescopes and two large charge-coupled device (CCD) cameras.

The main objective of the facility is to establish technologies for detecting uncatalogued GEO debris and determining their orbits. The stacking method, using multiple CCD images to detect very faint objects that are undetectable on a single CCD image, has been developed since 2000. The only weak point of the stacking method is the time required to analyse the data when detecting an unseen object whose movement is not known, because a range of likely paths must be assumed and checked. Although space debris whose movements can be estimated in some way is an easy target to detect, finding uncatalogued space debris is time-consuming work and not really practical. In order to reduce the analysis time of the stacking method, a field-programmable gate array (FPGA) system is being developed. The most time-consuming part of the stacking method is calculating median values of each pixel from the sub-images. As FPGA is a kind of electrical circuit, it shows its power in simple calculations. A more sophisticated and simplified algorithm is required for FPGA. It was discovered that binarizing the sub-images with a proper threshold and then calculating the sum of the binarized sub-image could derive almost the same outcome as the original algorithm of the stacking method. Figure 1[2] represents the difference between the original algorithm and the new algorithm. Calculating the sum is much simpler than calculating the median, and it is very suitable for FPGA. Moreover, binarization itself reduces the amount of data to one sixteenth, which greatly helps to reduce the analysis time. For executing this algorithm, an FPGA system was developed. Figure 2[2] shows the FPGA board (H101-PCIXM, manufactured by Nallatech). The FPGA board was shown to be able to reduce the analysis time to about one thousandth. This is significant progress. The FPGA board will be installed in the facility and used for actual observation in the near future.

3. New type of sensor for in situ space debris measurement

The importance of measuring large debris particles (larger than 100 μm) has increased, especially from engineering viewpoints (e.g. space system design and operations). However, it is difficult to measure the impact flux of these large

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[2] The original report submitted by Japan, containing images referred to in the text and the annex, can be found on the website of the Office for Outer Space Affairs of the Secretariat (www.unoosa.org/oosa/natact/sdnps/2009/index.html).

particles because of their low spatial density. Sensor systems to monitor these sizes must have a large detection area, while the constraints of a space environment deployment require that these systems be low in mass, be low in power, be robust and have low telemetry requirements. The in situ measurement data are useful for:

(a) Verifications of meteoroid and debris environment models;

(b) Verifications of meteoroid and debris environment evolution models;

(c) Real-time detection of unexpected events, such as explosions on an orbit (e.g. anti-satellite test).

JAXA has been developing a simple in situ sensor to detect dust particles ranging in size from 100 micrometres to several millimetres. Multitudes of thin, conductive strips are formed with fine pitch on a thin film of non-conductive material. A dust particle impact is detected when one or more strips are severed by the impact hole. The sensor is simple to produce and use and requires almost no calibration as it is essentially a digital system. The authors have developed prototypes of the sensors and have performed hypervelocity impact experiments. As a result, prototype models have been manufactured successfully and the projectile diameter (debris diameter) is able to be estimated from the number of broken strips.

4. Collision risk monitoring

JAXA has monitored close approaches of other space objects to the Advanced Land Observing Satellite (ALOS), a large-size Earth observation satellite, since 2008. Orbital information on space objects is received from the United States Space Surveillance Network and provided in the two-line element format. The automated collision risk assessment is performed daily, with seven-day predictions, and the result is sent via e-mail. When the conjunctions that meet established criteria are detected, JAXA considers radar observation, if observable, in order to receive more accurate orbital information on risk objects. When collision risks are still determined to be high by the precise conjunction assessment, ALOS conducts a collision avoidance manoeuvre.

JAXA developed the conjunction assessment tool in 2007. In order to conduct the assessments efficiently, a sequence of processes, as described above, are all performed by this tool. The tool has a three-dimensional visualization function and helps intuitive understanding of how two objects approach each other.

ALOS has experienced one collision avoidance manoeuvre so far. JAXA will continue collision risk monitoring in the future.

5. Active debris removal system

JAXA is studying an active space debris removal system. Conceptually, this consists of a small spacecraft (a microsatellite capable of piggyback launch with other payloads) that transfers large debris objects occupying useful orbits to a disposal orbit. Electro-dynamic tether (EDT) technology is being investigated as a high-efficiency orbital transfer system for this concept. An EDT package could be used to lower the orbit of the debris removal system without the need for propellant. (See annex.)[2]

Myanmar

[Original: English]

[9 November 2009]

1. Introduction

Space debris are all man-made objects, including their fragments and parts, whether their owners can be identified or not, in Earth orbit or re-entering the dense layers of the atmosphere, that are non-functional with no expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized.

As the effect of the space debris environment on the operation of space systems becomes more important, to minimize the potential for space debris in future missions, international cooperation is needed to evolve appropriate and affordable strategies.

Any country with its own satellite for peaceful uses of outer space should conduct research related to space debris, including debris measurement techniques, mathematical modelling of the debris environment, space debris risk assessments and space debris mitigation measures.

2. Current situation in Myanmar

Although the application of space technology has been widely used in Myanmar for over a decade, the development of space technology is still in its early stages and the infrastructure for space technology has not yet been fully established. Space education and training courses related to space technology have already been held and some research in space technology has been started in recent years.

According to the Chairman of the State Peace and Development Council, some contribution through research and development in space technology under the Ministry of Science and Technology can be expected, although Myanmar is not at present a space-faring country. In the private sector, the astronomical research group has made space observations by telescope.

Myanmar, which intends to extend the development of space technology, plans to conduct research related to space debris, with international cooperation, and to make a valuable contribution to the technical reports and data of IADC and the Office for Outer Space Affairs of the Secretariat.

3. Aspects of research related to space debris

When the space research groups under the Ministry of Science and Technology prepare the conceptual study on space debris, the following aspects will need to be studied:

(a) Measurements of space debris, including ground-based measurements and space-based measurements; effect of the space debris environment on the operation of space systems;

(b) Modelling of the space debris environment and risk assessment;

(c) Space debris mitigation measures, including the reduction of space debris increase over time, protection strategies and effectiveness of debris mitigation measures.

In the ground-based measurements, there are two categories: radar measurements and optical measurements. Space-based measurements consist of retrieved surfaces and impact detectors and space-based debris measurements, followed by a study of the effect of large debris objects on the operation of space systems and the effects of small debris objects on space systems.

Modelling of the space debris environment includes short-term models and long-term models. When space debris risk assessments are considered, it is necessary to study the collision risk assessments for objects in LEO and geostationary orbit and risk assessments for re-entering space debris.

With regard to the reduction of space debris increase over time, it is necessary to study the avoidance of debris generated under normal operations, the prevention of on-orbit break-ups and the deorbiting and reorbiting of space objects. As part of the protection strategies, shielding and collision avoidance should be considered in the design of spacecraft. Scenarios of mitigation measures and the cost or other impact of mitigation measures are necessary considerations in the effectiveness of debris mitigation measures.

4. Conclusion

As Myanmar is still at an early stage in space technology, it is necessary to receive data on space debris from the Scientific and Technical Subcommittee, JAXA and the Database and Information System Characterising Objects in Space of ESA and research related to space debris through international cooperation. If such assistance for the measurement of the space debris environment is received, the subsequent progress in research related to space debris will be submitted to the Committee and the Office for Outer Space Affairs.

Poland

[Original: English]

[25 November 2009]

A nanosatellite project was conducted at the Warsaw University of Technology to demonstrate the technology of deorbitation of satellites after their operational phase in order to decrease the amount of space debris in low-Earth orbits. The demonstration was originally planned for November 2009 but was postponed until the fall of 2010 owing to delays in the development of the Vega launcher. Activities in this field were carried out by Adam Mickiewicz University in Poznań in cooperation with the Space Research Centre of the Polish Academy of Sciences .

Thailand

[Original: English]

[24 November 2009]

Cooperation among experienced space agencies should be encouraged in order to enhance the exchange and distribution of related data and technologies in the space community. This information should be taken into account for satellite development in the future.