United Nations A/AC.105/C.1/111/Add.1

General Assembly

Distr.: General
24 November 2016

Original: English

Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
Fifty-fourth session
Vienna, 30 January-10 February 2017
Item 7 of the provisional agenda*
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

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* A/AC.105/C.1/L.355.

V.16-10037 (E) 011216 021216

II. Reply received from Member States

Germany

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[24 November 2016]

Overview

Research activities on issues related to space debris are conducted in Germany in all relevant fields, including space debris environment modelling, observation of space debris, technology development for observations, studies of the effects of hypervelocity impact on spacecraft, and protection of space systems from impact of micrometeoroids and space debris. German experts actively participate in relevant international forums in the field of space debris research and space safety, inter alia, the Inter-Agency Space Debris Coordination Committee (IADC), and in international standardization activities in the field of space debris mitigation. German industry and academia are also involved in technology developments to serve the long-term sustainable use of outer space and protection of the Earth.

For space projects of the Space Administration of the German Aerospace Center (DLR), space debris mitigation requirements are a mandatory part of the product assurance and safety requirements for DLR space projects. Those requirements ensure the implementation of internationally recognized mitigation measures, including those identified in the Space Debris Mitigation Guidelines of IADC and the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space. The general objectives are to limit the creation of new space debris and thus to mitigate the risk to current and future space missions and the risk to human life. The measures to be adopted in order to achieve these objectives include the conduct of a formal space debris mitigation assessment; specific design measures to prevent the release of mission-related objects, fragmentations, malfunctioning, and on-orbit collisions, as well as measures pertaining to passivation, end-of-life disposal and re-entry safety.

In order to establish a national space surveillance competence, capabilities for generating and utilizing sensor data are needed, e.g., to establish a space object catalogue or to perform orbit determination. Such an object catalogue is the backbone of space situational awareness operations. The development of this end-to-end capability requires a coordinated programme of work, covering many different aspects. Such a programme is running at the DLR Space Administration and began with the development and commissioning of the German Experimental Space Surveillance and Tracking Radar (GESTRA) in 2015. GESTRA, which is being developed by the Fraunhofer Institute for High Frequency Physics and Radar Techniques, is an experimental system to determine orbital information in low Earth orbit; testing is expected to start at the end of 2017. Novel concepts for space surveillance with radar are also being studied at the same institute.

Using a newly developed software tool at the Institute for Space Systems (IRS) at the Technical University of Braunschweig sensor measurements are being simulated. Based on the simulated data, key functionalities including object correlation, orbit determination and creation of an object database are implemented. Complementary methods for orbit determination and propagation are being investigated so as to ensure the availability of fast and accurate methods available within the process chain of a simulated space surveillance system. An optical telescope will be installed to observe space debris and support research activities.

At the same institute, analyses of the long-term evolution of the space debris environment are being conducted using long-term propagations of that environment.

Such analyses are an important tool for assessing the effectiveness of space debris mitigation measures and are being used in studies by IADC. The studies take into account recently observed changes in the launch rate and mission types, i.e., the increasing number of small satellites and potential megaconstellations in low Earth orbit.

Efforts are under way to develop a network of optical stations at DLR in close cooperation with the Astronomical Institute of the University of Bern, Switzerland. It is intended for the monitoring of the geostationary regions and related orbits to support research on collision avoidance and other scientific topics. Telescopes will be operated remotely and data will encompass objects larger than approximately 50 cm in geostationary orbit. The first station will be set up at the Sutherland Observatory in South Africa in March 2017. In successful test campaigns, objects fainter than magnitude 18 were detected and their positions measured. The precision of the derived orbits was better than 200 m in all three dimensions, and clustered satellites were resolved unambiguously.

In a joint effort between the Simulation and Software Technology facility and the Space Operations and Astronaut Training facility, both at DLR, a software system for space surveillance is being developed. Central to the project is the Backbone Catalogue of Relational Debris Information, an orbital database for objects in Earth orbit. The main research topics are object correlation using observations from different sensors, orbit determination and orbit propagation, including state vector and state uncertainty. The orbital database will be used primarily to predict close approaches for purposes of collision avoidance, but it can be expanded to include other uses. Research topics include comparison of the accuracy of different orbit propagators. The optical telescope network being developed between DLR and the Astronomical Institute will provide the first observational data to be processed by the system.

An optical space debris observation station is operated by the DLR Institute of Technical Physics for research and development. The station is equipped with a 17-inch Dall-Kirkham telescope and various high-end camera systems. Its time-of-flight laser system is operational and has successfully measured the distance to objects in low Earth orbit. In combination with passive optical tracking, this system can realize three-dimensional tracking of orbital objects during station passage to an accuracy of a few metres. In addition, optical stare and chase procedures were demonstrated successfully, allowing for the tracking of uncatalogued objects. A mobile laser-optical ground station for laser tracking of space debris is currently in development.

Materials on the exterior of spacecraft are exposed to the harsh environment of space, which causes degradation. The main threats are charged particle radiation, ultraviolet radiation, atomic oxygen in low Earth orbit, extreme temperatures, thermal cycling and the impact of micrometeoroids and debris. The relative impact of the individual threats depends on the type of mission to be performed, the mission duration, the solar cycles, solar events and the orbit in which the spacecraft will be placed. Sources of degradation particles are the paints applied on upper stages and multilayer insulation foils used on almost every spacecraft to maintain the operation temperature. The degradation process and the inherent release and generation of particles smaller than 1 millimetre are simulated on the basis of empirical modelling parameters.

Active removal of space debris is an additional area of research at institutes in Germany. Research activities cover technologies including sensors, capture mechanisms, and guidance, navigation and control.

New numerical methods to simulate hypervelocity impacts on spacecraft and the subsequent material failure and fragmentation processes are being investigated at the

Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut. Impacts on small, simulated material probes are compared with results from tests performed with the hypervelocity impact facilities of the institute.

Several German companies and research organizations are involved in European Space Agency studies addressing the topic of space debris re-entry. The objectives of the Characterization of Demisable Materials (CHARDEM) project are to increase knowledge on material behaviour and demise processes during re-entry and reduce the uncertainties of the simulation tools currently used for re-entry risk assessment. The high-enthalpy-flow wind tunnels of DLR in Cologne, in particular, are used for this purpose. The Rapid Assessment of Design Impact on Debris Generation (RADID) activity is aimed at the development of a new generation re-entry analysis tool with the capability of being used concurrently in various engineering facilities with automatic design optimization features. "Design-for-Demise" (D4D) studies are focused on innovative engineering solutions for spacecraft components in order to achieve as much demise as possible during re-entry, consequently reducing the on-ground risk.

The new In-Orbit Tumbling Analysis (ιOTA) tool will provide a long-term, six-degrees-of-freedom propagator, supporting future active debris removal missions with reliable predictions of the tumbling rates of the target object.