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SPACE DEBRIS: DISCUSSIONS IN THE UNITED NATIONS IN 1996

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Abstract

This year the Scientific and Technical Subcommittee discussed the measurements of space debris with a view to provide the understanding of data and of the effects of this environment on space systems. In the Legal Subcommittee, while conducting consultations on new items for the agenda, some delegations proposed to review existing norms of international law applicable to space debris with the aim to clarify the issues involved and help to improve the interpretation and application of existing norms. The Legal Subcommittee, however, has not reached consensus in this matter. The Committee on the Peaceful Uses of Outer Space expressed its agreement with the reports of both Subcommittees and its satisfaction with the report prepared by the Secretariat on steps taken by space agencies for reducing the growth of the damage potential of space debris. The paper concludes with a brief review of possible perspectives and of an issue which might elude a satisfactory solution.

A. Scientific and Technical Subcommittee

Election of the Chairman

The thirty-third session of the Scientific and Technical Subcommittee was held in Vienna from 11 to 23 February 1996. After the resignation of Professor Carver last year, the Subcommittee elected as its new Chairman, Professor Dietrich Rex of the Federal Republic of Germany. In his professional life, Professor Rex is heading the Institute for Spaceflight Technology and Nuclear Reactor Technology at the Technical University of Braunschweig, Germany. He serves as Chairman of the European Space Agency Space Debris Advisory Group and is a member of the US National Research Council's Committee on Space Debris. He and his colleagues are authors of many highly important scientific papers on space debris. At a time when Space Debris is a priority item, the Subcommittee has a chairman who is an eminent

expert in the field. A fast progress of the Subcommittee in that field can be anticipated.

Views of Delegations

About twenty delegations participated in the discussion on Space Debris. Only a few contributions can be mentioned here:

The Russian Federation proposed to establish an international centre for providing information and advance warning on explosions in space, on fragmentation of space objects and on possible collisions of space objects with space debris. Also an exchange of data on space debris was advocated with a view to make the catalogues of space debris more reliable, consistent, and complete.

Indonesia considered important to adopt an explanation of the term "space debris". The view was expressed that designating an object as "space debris" should not depend on the identification of the owner. The following wording was proposed:

"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 reasonable expectation of their being able to assume or resume their intended functions or any other functions for which they are or can be authorized".

Some delegations stressed the importance of reorbiting geostationary satellites into disposal orbits after the termination of their useful lifetimes. India proposed to reorbit to more than 300 km while Japan recommended a higher altitude of at least 500 km beyond the geostationary orbit. The latter is a somewhat higher and safer altitude than that proposed in the IAA Position Paper on Orbital Debris (300 km) but requires more fuel. It should be noted in this context that space debris in the geostationary orbit were discussed under the item on Space Debris and not under the item on the Geostationary Orbit.

The US reported in detail about results obtained with the Haystack Debris Radar which is so powerful that it can detect a pea (0.65 cm) at 650 km distance. Because of the increased accuracy, some of the debris can be assigned to individual breakup events, and previously unrecognized debris sources can be discovered. NASA completed the development of the Liquid Metal Mirror Telescope for observing orbital debris. It will be possible to observe objects of 2.5 cm at 900 km altitude and of 10 cm in the geostationary orbit. In February 1995, the second mission of the Orbital Debris Radar Calibration Spheres was launched. Three spheres and three dipoles of different sizes were deployed from the Shuttle. They were observed by ground based radars and optical telescopes . The observations were used for calibrating their scales and consequently improving their interpreting capabilities.

The Czech delegation stressed the importance of preventive measures but pointed out that a large number of inactive objects is already in orbit. Their highest density occurs at about 800 to 1500 km where the average lifetime is very long, of several hundred years at least. During that time secondary collisions will multiply the number of debris. Methods for removing those objects from orbit have been already studied but further research is needed. The scientific community should be encouraged to study these methods with an emphasis on efficiency and cost effectiveness.

Some delegation supported the view that the Legal Subcommittee should be informed of the

discussions in the Scientific and Technical Subcommittee and that a set of international rules should be adopted in order to reduce the risk posed by orbital debris and to support a rational use of outer space. That view was, however, not shared by all delegations. Some considered it premature at present and insisted on a thorough discussion of all important technical aspects of the problem by the Scientific and Technical Subcommittee before deciding on any possible further steps.

Technical Presentations

Several technical presentations[2] supplemented the information provided by delegations.

Prof. Dr. Walter Flury, speaking for the European Space Agency, gave an overview of measurements of space debris and effects of the environment on space systems. He treated in detail ground-based measurements, in particular those made by radar and by optical telescopes, space-based measurements by radar, by optical means by infrared sensors and particle detectors, and those derived from spacecraft returned from space. He concluded with an analysis of possible damage to space systems. He found that impacts by debris of 1 cm size can seriously damage a spacecraft, while larger debris can destroy it.

Dr. Dieter Mehrholz of the Research Institute for High Frequency Physics in Germany, reported on research activities of the Research Establishment for Applied Science, in particular on the Tracking and Imaging Radar system. It uses a 34 m antenna for tracking objects down to 5 cm at 2500 km distance and to 1 m objects in the geosynchronous orbit. The imaging data can be used for checking the functionality of the spacecraft and for identification purposes.

Dr. S. Banerjee and A.S. Ganeshan of the ISRO Satellite Center in Bangalore, India, reported on a Hybrid Model to find Spatial Distribution of Debris from a Breakup. The paper lays down the background for the development of a new analytical method for studying small debris which are not listed in catalogues and have to be studied statistically.

Dr. Andrew Potter of the Johnson Space Center, NASA, presented a Summary of the United States Space Debris Measurements Programme. The programme uses radars for low earth orbits, optical telescopes for deep space, and surfaces returned from space for identifying man-made particles in impact pits. Many results have been already arrived at: There are over 100.000 debris in LEO down to 1 cm size. An unsuspected source of debris was discovered near 900 km altitude, possibly from Rorsat nuclear reactors. A study of surfaces returned from space yields evidence for swarms of microdebris and some microdebris in highly elliptical orbits. Damage on Shuttle windows shows that the microdebris population is underestimated and that it is growing. An additional capability for studies of debris at geosynchronous altitudes is needed. Very little is known about debris population in Molniya and geotransfer orbits, although one geotransfer breakup has been accidentally detected.

Dr. Fernand Alby of the Centre Spatial de Toulouse, CNES, France, spoke on Modelization of Space Debris and Comparison of Observations. Impact craters on exposed surfaces are being searched for and impacting particles identified. The observed flux of particles in space is compared with theoretical models. At the same time, detectors of debris are studied with a view to mount them on satellites to obtain informa-

[2] A/AC.105/638, of 7 May 1996.

tion on the debris population, in particular in the geostationary orbit.

Dr. Richard Crowther of the Defence Research Agency, United Kingdom, reported on The Unique Hazards Associated With Satellite Constellations. A constellation is a collection of satellites performing a common function, such as global positioning, earth observation, personal communications by means of hand-held phones, etc. Several constellations are planned for launch in the near future, requiring tens or hundreds of satellites with lifetimes of 5-8 years. Each system would require frequent launchings of new satellites and frequent deorbiting of satellites approaching the end of their useful lifetimes. Unless the system has a built-in mechanism for restricting the number of debris, the collision risk would increase substantially. The paper gives estimates of collision probabilities. New constellations will add a new dimension of com-plexity in managing the space debris en-vironment but operational practices can reduce the hazard.

Mr. George Levin, NASA Headquarters gave a summary of the United States National Research Council Report on Space Debris 1995[3]. The Report presents the most recent and detailed information. It puts its authority behind previously recommended measures, in general confirming the conclusions of the IAA Position Paper on Orbital Debris. It makes several recommendations for improving knowledge of the debris environment, for improving spacecraft protection against the impact of debris, and for reducing the future debris hazard. In the last area, it advocates:

- Reduction of debris on a multilateral basis in order not to penalize those engaging in mitigation measures,
- Prevention of explosions,
- Minimizing of mission-related debris,
- Minimizing unintentional release of surface materials, such as paint,
- Avoiding intentional breakups, in particular those producing debris with long lifetimes,
- Reorbiting of spacecraft and rocket bodies in Low Earth Orbit after their functional lifetime and achieving an international consensus on the magnitude of such maneuvers, and,
- Until a verifiably superior strategy is produced, reorbiting spacecraft and rocket bodies in the geostationary orbits at least km beyond that orbit.

Other Documents

Several documents on space debris, some of them in connection with nuclear power sources, were before the Subcommittee:

National Research on Space Debris, Safety of Nuclear-Powered Satellites, Problems on Collisions of Nuclear-Powered Sources with Space Debris[4]. Contains replies from Canada, Chile, Germany, Japan and the United Kingdom.

Interpretation and Development of the Safety Principles for Nuclear Power Sources in Space, working paper by the United Kingdom[5].

Collisions between nuclear power sources and space debris[6], working paper by the Russian

[3]Orbital Debris: A Technical Assessment, National Research Council, National Academy Press, Washington, D.C., 1995, ISBN 0-309-05125-8, 224 p.

[4]A/AC.105/619 of 21 Nov 1995 and Add.1 of 1 Feb 1996.

[5].A/AC.105/C.1/L.203 of 9 Feb 1996.

[6]A/AC.105/C.1/L.204 of 13 Feb 1996.

Federation.

Brief Review of the Work Done by Russian Scientists on the Problem of the Technogenic Pollution of Near Space[7], working paper by the Russian Federation.

Space Agencies

The implementation of concrete steps for reducing the amount of space debris in future missions is in the hands of those space agencies which provide the launching of spacecraft. They can influence the design , launching and operation of satellites. These may be the reasons why many delegations expressed their appreciation of the document[8] on Steps Taken by Space Agencies for Reducing the Growth or Damage Potential of Space Debris. It reports on preventive measures adopted by space agencies on a voluntary basis, without awaiting the out-come of the discussions in the United Nations.

A few specific examples follow:

- Venting of hypergolic upper stages and discharging of batteries in order to prevent explosions in orbit,
- Measures for avoiding the generation of new debris, such as ballistic re-entry trajectories, trapping of explosive bolts, using of recoverable satellites,
- Measures for decreasing orbital lifetime of inactive spacecraft,
- Re-orbiting of geostationary satellites into disposal orbits, and
- Shielding of vital parts of satellites.

This is regarded as an important event because space agencies have shown that they are approaching the problem of space debris with a high degree of responsibility and that they have not only the power but also the will to preserve outer space in a state fit for future space activities. Several delegations therefore supported the proposal that space agencies should be brought into a closer contact with the Subcommittee. The Subcommittee decided to invite a representative of the Inter-Agency Space Debris Coordination Committee to give a presentation at the next session of the Subcommittee.

Technical Report

The most important part of the work of the Subcommittee consisted in preparing a structured Technical Report[9] in agreement with last year's decision to follow a multi-year Work Plan. Accordingly, the Technical Report deals briefly with previous history and explains why it has to be structured. It contains also an explanation of the term "space debris". As recently as last year, a proposal to explain what is the common understanding of the term failed to find the agreement of the Subcommittee. This year, the Report (see footnote 5, para 95) states:

"It is understood that space debris are inactive man-made objects, such as spent upper stages, spent satellites, fragments or parts generated during launch or mission operations, or fragments from explosions and other breakups".

No size limits of space debris have been expressly stated. Evidently, the upper limit is the largest man-made spacecraft, if and when it

[7] A/AC.105/C.1/L.205 of 13 Feb 1996

[8] A/AC.105/620 , of 21 November 1995.

[9] A/AC.105/637, of 4 March 1996, para 94-138.

becomes inactive. The lower limit in size can be inferred from the text of the Report. It deals with impacts of submillimeter-size particles and with craters and holes extending from several millimeters down to micrometers. Thus the smallest debris are the size of dust particles.

This year , only the part dealing with Measurements of space debris was detailed, while Modelling and Mitigation will be filled in the next two years.

B. The Legal Subcommittee

The Legal Subcommittee has held its thirty-fifth session from 18-28 March. It did not have space debris on its agenda but it discussed topics for new items to be put on the agenda in the future. Two of these topics deal with space debris:

Review of Existing Norms of International Law Applicable to Space Debris. The item was proposed by the delegation of the Czech Republic in an unofficial background note[10]. The purpose of the item is to examine the problem of space debris from the perspective of existing international law which could be applicable to space debris. The following questions could be discussed:

- Does the definition of "space object" as contained in instruments of space law cover space debris?
- Do provisions of the 1967 Outer Space Treaty concerning the avoidance of harmful contamination of outer space and adverse changes in the environment of the Earth apply to the problem of space debris?
- Should the protection of ownership of space objects, and of their component parts, also be extended to space debris?
- Should liability for damage caused to a space object and/or its crew by space debris depend on the proof of fault as in the case of a collision of two space objects?

The consideration of these and other questions would serve to clarify the issues involved and improve the interpretation and application of existing norms. It would not amount to the drafting of new provisions. The item could be limited to 2-3 meetings at two sessions of the Subcommittee. It would help the main Committee to decide possible further steps after it examines the Technical Report prepared by the Scientific and Technical Subcommittee which could be finished in 1998.

Legal Aspects of Space Debris. The item was proposed every year since 1993 but there never was a consensus on the matter because some delegations were of the opinion that the Technical Report by the Scientific and Technical Subcommittee has to be completed before any legal considerations can be initiated.

C. The Main Committee

The Committee on the Peaceful Uses of Outer Space has held its thirty-ninth sessions from 3 to 14 June. It discussed space debris in the agenda item "Report of the Scientific and Technical Subcommittee" and in the item "Report of the Legal Subcommittee" when new items for the inclusion in the agenda of the Legal Subcommittee were under consideration.

In brief, the Committee agreed with the Scientific and Technical Subcommittee that international cooperation was needed to de-

[10] A/AC.105/639, of 11 April 1996, Annex E.

velop appropriate and affordable strategies to minimize the impact of space debris; that there was need for further research; that national research should continue and its results made available to all interested parties; and that the Inter-Agency Orbital Debris Coordination Committee (IADC) should be invited to give a presentation to the Subcommittee at its next session. The Committee expressed its satisfaction with all documents on space debris which were before the Subcommittee and with the first part of the Technical Report.

As regards possible new items for the agenda of the Legal Subcommittee, the Committee noted the opinion of some delegations that a new item entitled "Review of existing norms of international law applicable to space debris" should be put on the agenda of the Subcommittee in 1997. Other delegations considered that proposal premature.

The Committee agreed that proposals for new agenda items should have a multi-year work plan which should address, i.a., the objectives of the work to be undertaken, any reports to be provided by the Secretariat or Member States, and the possible end product.

For the sake of completeness, let us mention that the Committee entrusted the Chairman to undertake intersessional informal consultations among the members of the Committee with the aim of reaching consensus, i.a., on agenda structures. These consultations could lead to important decision of the Committee at its session in 1997, including new agenda items for the Legal Subcommittee.

D. Perspectives

It can be anticipated that the Technical Report will be completed in 1998 and that it will be examined by the COPUOS and a decision will be made about further steps to be taken on space debris. At the same time, Space Agencies, in particular members of the IADC, can be expected to coordinate and extend their measures for restricting the generation of debris and for mitigating their harmful impact. They already realize that such practices have to be adopted by all because there is no significant effect if they are adopted only by one operator. An optimistic point of view is justified as regards a significant restriction of generation of space debris in the future.

The situation is different with regard to space debris which are already in orbit and which have no maneuvering capability. It is true that a few objects have been retrieved by the Space Shuttle but these were exceptions. In general, the cost of retrieving a worthless piece of debris by a manned spacecraft is prohibitive. Deorbiting by means of a tether is theoretically possible but no successful experiments have been conducted and the cost involved will probably be very high. Drag augmentation by large balloons[11] or sweeping small debris by large spread films have the inherent difficulty of a potential encounter with an operating spacecraft.

Ground-based methods for removing debris have been proposed, such as directing a powerful laser beam on a piece of debris and evaporating it or at least changing its trajectory and reducing its lifetime. Since such a laser could be looked upon as an antisatellite weapon and an unauthorized removal of debris could be considered to constitute a breach of the Outer Space Treaty, an application of this or a similar method would require international discussions and agreements.

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[11] J. Loftus Jr., Space Debris Mitigation, Int. Astronaut.Congress, Oslo 1995, paper IAA.95-IAA.6.5.01.

Briefly, no adequate and affordable methods for removing passive debris from orbit exist at present. On the other hand, orbiting debris may become very dangerous. According to several recent investigators[12],[13],[14] debris will start colliding among themselves, producing large numbers of fragments. As a consequence, the collision probability for active satellites will increase considerably. At present, there are about 2000 tons of debris below the altitude of 2000 km presenting a combined cross-section of 10.000 square meters. With this amount of mass, which is a critical factor, the safety of future operations in space seems to be in jeopardy and research on a wide basis seems to be indispensable.

An appeal should be directed to the scientific community, specifically to international scientific organizations, such as the IAF, IAA, COSPAR, or, in fact, to the IADC, to try to find new , or substantially improve the existing, ways for removing large as well as small passive objects from outer space. The new inventions, if and when they are made, will, of course, have to be assessed from the point of view of cost and effectiveness as well as from the legal point of view.

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[12]D.J. Kessler: Collisional cascading: The limits of population growth in Low Earth Orbit. COSPAR, The Hague, Netherlands, paper MB 2.2.2(1990).

[13]D. Rex and P. Eichler: The possible long term overcrowding of LEO and the necessity and effectiveness of debris mitigation measures. Proc. of the First European Conference on Space Debris, Darmstadt, Germany, 5-7 April 1993, 607-615.

[14]P. Eichler and R. Reynolds: Mid- and long-term debris environment projections using the EVOLVE and CHAIN models. Int. Astronaut. Congress, Oslo, Norway 1995, paper IAA-95-IAA.6.4.07.