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NATIONAL RESEARCH ON SPACE DEBRIS

SAFETY OF NUCLEAR-POWERED SATELLITES

PROBLEMS OF COLLISIONS OF NUCLEAR-POWERED SOURCES WITH SPACE DEBRIS

Note by the Secretariat

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INTRODUCTION

1. In its resolution 50/27, paragraph 37, of 6 December 1995, the General Assembly considered it essential that Member States pay more attention to the problem of collisions of space objects, including nuclear power sources, with space debris, and other aspects of space debris, and 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. In the same paragraph of that resolution, the Assembly 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.

2. The General Assembly, in paragraph 21 of the same resolution, invited Member States to report to the Secretary-General on a regular basis with regard to national and international research concerning the safety of nuclear-powered satellites.

3. In a note verbale dated 19 July 1996, the Secretary-General invited all Member States to communicate to the Secretariat, by 30 September 1996, the information requested above so that the Secretariat could prepare a report containing that information for submission to the Subcommittee at its thirty-fourth session.

4. The present document was prepared by the Secretariat on the basis of information received from Member States as of 6 December 1996. Information received subsequent to that date will be included in addenda to the present document.

REPLIES RECEIVED FROM MEMBER STATES *

Brunei Darussalam

[Original: English]

Brunei Darussalam reports that at present it is not conducting any research relating to space debris and that it does not have satellites that operate with nuclear energy. Consequently, studies are not being conducted on possible collisions of nuclear-power sources with space debris.

Bulgaria

[Original: English]

Bulgaria reports that at present it neither supports nor participates in space programmes involving satellites with nuclear power sources on board and does not take part in the development or launch into space of transportation systems causing the release of space debris. Consequently, Bulgaria does not possess information on either the safety of satellites with on-board nuclear reactors or on collisions of such satellites with space debris.

Studies on the issue of space pollution have been envisaged for 1997 within the framework of the National Aerospace Programme of the Republic of Bulgaria until the year 2000.

Canada

[Original: English]

With regard to the issue of collision with space debris and practices adopted to minimize the creation of space debris the following steps have been taken.

In order to minimize the creation of space debris, the RADARSAT program undertook two specific preventative measures.

- The first consisted of establishing a system level requirement that any solid debris resulting from the operation of a restraint/release mechanism be contained. That is, all contractors were required to design a system such that no debris would be released by the spacecraft during deployments.

- The second preventative measure consisted of protecting the RADARSAT spacecraft from the existing space debris environment. This measure was undertaken in order to ensure, to the best extent possible, that the RADARSAT spacecraft does not prematurely become space debris as a result of a space debris impact. This activity consisted of defining the space debris environment to be encountered by RADARSAT using NASA's EnviroNET database. Individual spacecraft components were then examined to determine their vulnerability to this predicted environment. This vulnerability assessment included using hypervelocity impact equations as well as actually subjecting spacecraft hardware to hypervelocity impact tests at the NASA Johnson Space Center.

*The replies are reproduced in the form in which they were received.

Where required, shielding was added to the spacecraft in order to bring the survivability of the spacecraft to an acceptable level. The shielding included adding Nextel (a 3-M ceramic fibre cloth) to thermal blankets, adding bumpers in front of exposed hydrazine lines and wire bundles, and thickening some component boxes in order to protect their enclosed circuits.

Hungary

[Original: English]

Hungary reports that at present it is not conducting any research relating to space debris and that it does not have satellites that operate with nuclear energy. Consequently, studies are not being conducted on possible collisions of nuclear-power sources with space debris.

Japan

[Original: English]

A. Introduction

The Japanese Government Space Activities Commission (SAC) expressed Japan's policy on space debris in the report on Japan's Space Long Term Vision which was published in July, 1994.[1]

"Japan will aim to develop such systems that will leave as little space debris as possible. With regard to existing space debris, we will cooperate with other countries in considering ways of reducing it."

Based on this report, SAC revised the Fundamental Policy of Japan's Space Activities on January 24, 1996.[2] It contains the first Japanese national policy statement on the preservation of the space environment.

Systematic or organized activities have been performed since 1990 when the Japan Society for Aeronautical and Space Sciences (JSASS) founded the Space Debris Study Group.[3] The Study Group consisting of over 30 members from space related organizations and industries, issued an interim report in January 1992 and final report in March 1993. Some of the recommendations presented in the report have been taken up by the two newly formed JSASS Study Groups.

Japan (NAL, NASDA, ISAS, and other space related organizations) have also been a member of the Inter-Agency Space Debris Coordination Committee (IADC) since 1992 and maintains a level of debris awareness through information exchanges and discussions at the IADC, IAF, COSPAR, ISCOPS and other international and domestic conferences.

This report is a brief overview of recent research progress and space debris reduction practices in Japan.

B. Recent research progress

1. SFU post-flight analysis

The JSASS study group, National Aerospace Laboratory (NAL) and other organizations are jointly performing the post-flight analysis of the Space Flyer Unit (SFU). SFU is an unmanned, re-usable, sun pointing, 3-axis stabilized satellite, and constitutes the first of its kind built by Japan. It is octagonal in shape, measures 4.46 m in diameter and 3 m in height, and weighs about 4 tons. It was launched by the H-II third flight on March 18, 1995 and was retrieved by Shuttle STS-72 on January 13, 1996. It occupied a circular orbit at an altitude of 500 km and inclination 28.5 degrees. Impact surveys are making good progress - a total of 337 impact features with diameters 200-1,000 µm have so far been found, mainly on Kapton MLI and Teflon surfaces.[4, 5]

2. Hypervelocity impact test

The National Space Development Agency of Japan (NASDA) - which is responsible for implementing practical applications resulting from space developments in Japan - has been conducting a series of impact tests, using a two-stage hydrogen light-gas gun, for the design of the JEM Stuffed Whipple bumper and carbon fibre reinforced plastic tube for the arm of the JEM Remote Manipulator System.[6]

NAL has been carrying out shaped-charge tests in collaboration with MHI and Chugoku Chemicals. The changes used are 7.0 cm in diameter and 14.7 cm in length; the liner angle in 30 degrees, the thickness of aluminum liner is 2.1 mm. The copper inhibitor, which has a hole diameter of 15 mm, was selected through intensive parametric studies of both the inhibitor method and reactive plate method. Using this inhibitor, a single cylindrical jet without a trailing jet was obtained. The mass of the tip jet is about 1.9 g, and the velocity obtained is about 10.6 km/s.[7] NAL and MHI are planning to refine the inhibited shaped charged for the purpose of the JEM impact tests.

C. Space debris reduction practices

NASDA has implemented the draining of residual propellants (LOX, LH_2, N_2H_4) and residual helium gas of the H-I/H-II second stage. The release of mechanical devices at satellite separation and solar paddle deployment has been avoided except in some particular missions such as the separation of spent apogee motors for the geostationary meteorological satellite. In order to prevent the unintended destruction of H-II second stages in space, the command destruct system is disabled immediately after injection into orbit and its pyrotechnics are thermally insulated to preclude spontaneous initiation.[8]

Although the measures adopted by NASDA programs seem to be relatively inexpensive, they have been proven to be very effective. For example, the orbital life of the ETS-VI H-II second stage (1994-056B) was reduced to about 7 months as a result of deorbiting.[9] (It re-entered on March 31, 1995.)

Measures to limit space debris generation must be developed and implemented on a multilateral basis by the spacefaring nations. The JSASS committee on space debris prevention design standards published the final report[10] for NASDA standards and design criteria in March 1996. Based on this report, NASDA established the NASDA-STD-18 "Space Debris Mitigation Standard" on March 28, 1996.[11] A comparison of the guidelines and assessment procedures developed in the NASA Safety Standard 1740.14 and the NASDA Standard 18 was discussed at the 20th International Symposium on Space Technology and Science, held in Gifu, Japan, May 19-20, 1996,[12] and details of the standard will be presented at the 47th International Astronautical Congress in Beijing, October 7-11, 1996.[13]

With the aim of sharply reducing transportation costs and serving to protect the space environment, Japan will proceed with advanced R&D activities focusing on new fully-reusable transportation vehicles based on a novel design concept by upgrading the results of development of an advanced H-II launch vehicle and HOPE technologies.[1]

In conclusion, space environment conservation with respect to space debris is necessary to ensure long-lasting and expanding human space activities. We need to take action now, while the space debris problem is still manageable and the costs of dealing with it are fairly low.

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Portugal

[Original: English]

Portugal reports that at present it does not have space objects that operate with nuclear energy. Consequently, studies are not being conducted on possible collisions of nuclear-power sources with space debris.

Republic of Korea

[Original: English]

The Republic of Korea reports that at present it has two KITSAT satellites and two KOREASAT satellites in orbit. In view of the five-year operational life of the first satellite launched, KITSAT I in 1992, there will be no space debris produced by a satellite of the Republic of Korea until 1997. With respect to national research on space debris, the Republic of Korea reports that it has initiated some preliminary research activities such as monitoring of space debris.

Sweden

[Original: English]

Sweden reports that it does not conduct any national research of its own on space debris, but supports the activities undertaken within United Nations, ESA and other fora. Technical design studies are being carried out by industry (Saab Ericsson Space) on payload separation systems in order to mitigate the creation of new debris.

United Kingdom of Great Britain and Northern Ireland

[Original: English]

In 1996 the British National Space Centre continued its discussions with the national space agencies of France (CNES), Germany (DARA), and Italy (ASI) and the European Space Agency on harmonization of debris activities. This grouping has generated a report summarizing the expertise and facilities resident in Europe that are capable of addressing space debris issues.

The fourth United Kingdom Orbital Debris/Co-ordination Group Meeting was held at Matra Marconi Space in Bristol, England, on Tuesday, 14 May 1996. This brought together academia, industry and Government, including the British National Space Centre, the British Geological Survey, Fluid Gravity Engineering, Cranfield College of Aeronautics, Advanced Systems Architectures, Century Dynamics, Matra Marconi Space, Royal Greenwich Observatory, Queen Mary and Westfield College, SIRA, Vega, the University of Kent and the Defence Research Agency. Amongst the topics discussed and presentations given were optical and radar detection of debris in orbit, prediction of solar activity and atmospheric response, design of optical systems to detect debris, prediction of the long-term evolution of the orbital debris population, unmodelled sources of debris, the inferred microparticulate population encountered in orbit as derived from examination of retrieved space-exposed surfaces, and hydrocode modelling. A special seminar on the challenges of using hydrocodes to model hypervelocity impacts by meteoroids and debris was also held. The meeting was well attended and permitted discussion and coordination of national programmes with international activities such as the Inter-Agency Debris Committee and the United Nations Committee for the Peaceful Uses of Outer Space. The next meeting will be held during 1997 at the Royal Greenwich Observatory in Herstmonceux, England.

A delegation from the United Kingdom attended the 13th Inter-Agency Debris Coordination Group (IADC) held from 28 February until 1 March 1996 in Darmstadt, Germany. This was in recognition of the growing hazard of space debris and the need for an international solution to a global problem. While the United Kingdom has been involved with the activities of the IADC from its inception, via its membership of ESA, this was the first meeting attended by the United Kingdom as independent members. The IADC membership includes the European Space Agency (ESA), the National Aeronautics and Space Administration

(NASA), the Russian Space Agency (RKA), the China National Space Administration (CNSA), Japan, the Indian Space Research Organization (ISRO) and the French Space Agency (CNES).

Significant interest in the return of debris objects such as the China 40 (FSW-1) reentry capsule led to the United Kingdom participating in a Workshop on the Reentry of Space Debris Objects organized by the European Space Agency and held at the European Space Operations Centre in Darmstadt on 17 September 1996.

A number of technical papers have been produced by United Kingdom research groups during 1996. The reference section of this report lists some of the published papers.

A. Retrieved surface analysis and impact morphology

The University of Kent continues its work on retrieved surface analysis and hypervelocity impact modelling. Numerous papers have been published on new work presenting the results of brittle material response to hypervelocity impact[1,2,3] and new population data from in-flight experiments.[4,5] Important work was also carried out on phenomena associated with hypervelocity impacts which were likely to cause damage to satellites such as impact plasma production.[6] Significant work on population modelling is also carried out.[7]

B. Ground-based detection

The Electro-optics division of SIRA is involved in the design and construction of CCD camera electronics and control and data acquisition software for an optical space debris camera to be installed in Tenerife in 1997. This work is funded by the European Space Agency. The British Geological Survey carries out research into the modelling of atmospheric effects[8] on the trajectories on satellite and debris objects. The Royal Greenwich Observatory remains involved in the detection of debris objects in orbit using ground-based optical systems.[9,10]

C. Impact simulation

Century Dynamics continue to develop the Autodyne Hydrodynamic software to model a variety of impact scenarios and simulations. These range from general ballistic limit investigations[11] through to specific impacts on thin[12] and thick plates.[13] The Department of Aerospace at the Cranfield College of Aeronautics has also been involved in modelling hypervelocity impacts in space[14] using the DYNA3D code[15] and assessing the resulting damage.[16]

D. Risk assessment, population modelling

The Defence Research Agency continues its work on population modelling[17] and risk analysis[18] with particular emphasis on the impact of novel constellation architectures[19] on the space environment.[20] In addition to defining the risk to satellites, protective measures are considered.[21] The University of Southampton has added to its work on risk analysis following the break-up of an object in orbit. Using a novel development of the probabilistic continuum dynamics method[22] a number of different fragmentation scenarios[23] have been considered.[24] The University of London, Queen Mary and Westfield College continues to research future debris population growth modelling,[25] and the estimation of un-modelled sources such a microparticulate ejecta.

These studies demonstrate that the United Kingdom continues to be actively involved in, and in many cases has a unique capability in, a broad range of debris-related activities.

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