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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

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I. Introduction

1. In paragraph 25 of its resolution 59/116 of 10 December 2004, 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-first session, the Scientific and Technical Subcommittee invited Member States and regional space agencies to continue to provide reports on national research on space debris, safety of space objects with nuclear power sources on board and problems relating to their collision with space debris (A/AC.105/823, para. 87). In a note verbale dated 5 August 2004, the Secretary-General invited Governments to submit any information on the matter by 29 October 2004 so that that information could be submitted to the Scientific and Technical Subcommittee at its forty-second session.

3. The present document has been prepared by the Secretariat on the basis of information received from Member States.

II. Replies received from Member States

Finland

[Original: English]

Finland has several ongoing space debris research activities and applications:

(a) The debris in-orbit evaluator (DEBIE), space debris sensors and data-processing units were launched on board the Project for On-board Autonomy (PROBA) satellite in October 2001;

(b) DEBIE will later fly on the International Space Station in a more operational role;

(c) A low-Earth orbit (LEO) space debris survey was carried out using European incoherent scatter (EISCAT) radars (demonstrated capability: 1-centimetre and larger objects) in Lapland;

(d) The University of Turku carried out a geostationary orbit space debris survey using the European Space Agency's telescope in the Canary Islands, Spain.

Guinea

[Original: French]

The Government of Guinea reported that a programme of research on debris and space objects had not yet been drawn up. However, intensified surveillance was taking place to detect the possible fall of space debris on to the national territory.

United Kingdom of Great Britain and Northern Ireland

[Original: English]

1. Introduction

1. The British National Space Centre (BNSC) continues to maintain an active role in addressing the space debris problem. In particular, BNSC encourages coordination at the national, European and international levels to achieve consensus on the most effective debris mitigation solutions.

2. Key to this is the membership of BNSC on the Inter-Agency Space Debris Coordination Committee (IADC), the main international forum for reaching agreement on a variety of space debris issues. BNSC contributes to IADC in a number of ways: exchanging information on space debris research activities with other member space agencies, facilitating opportunities for cooperation in space debris research, reviewing the progress of ongoing cooperative activities and identifying debris mitigation options. In April 2004 the United Kingdom of Great Britain and Northern Ireland participated in the twenty-second meeting of IADC, which was hosted by the Italian Space Agency (ASI) in Abano Terme, Italy. Participants at the meeting discussed the IADC Space Debris Mitigation Guidelines and reviewed comments received from member States of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space.

3. Within Europe, the European Space Agency (ESA) coordinates research capabilities through a Network of Centres on space debris. This was initiated in 1999 as a pilot phase before entering a qualification phase in 2002. BNSC is a member of the group together with ESA and three national agencies—the Centre national d'études spatiales of France, the German Space Agency (DLR) and ASI. The Network of Centres is currently working towards the development of an integrated European work plan and strategy for space debris.

4. At the national level, BNSC maintained its support of the United Kingdom Space Debris Coordination Group, which meets annually to provide a forum for the coordination of all debris research and policy activities in the United Kingdom. Observatory Sciences will host the next meeting, with attendees expected from many of the leading research groups in industry and academia of the United Kingdom. The meeting will discuss recent international developments, in particular with respect to debris mitigation guidelines and standards, and provide an opportunity to report on the latest research in the United Kingdom.

5. The United Kingdom has particularly strong debris research capabilities, which BNSC has regularly called upon for impartial technical support and advice.

During the past year, organizations in the United Kingdom have conducted a wide range of activities, some of which are summarized below.

2. Observation and measurement of the debris population

In-situ detectors and measurement of retrieved surfaces

6. Debris and micro-meteoroid impact data from the Debris In-orbit Evaluator (DEBIE) detectors, which were launched aboard the polar-orbiting Project for On-board Autonomy (PROBA) satellite in late 2001, were analysed in a continuing effort by the Open University and Unispace Kent. The results will eventually be used to update particulate models of the space environment. Furthermore, the Open University and Unispace Kent are developing new debris detector techniques as part of the ESA initiative.

7. Staff from the Natural History Museum in London were involved in two substantial space debris research programmes during the period 2003-2004: a collaborative survey funded by ESA of damage to the solar cell arrays of the Hubble Space Telescope; and the design and testing of particle residue collectors for monitoring the debris environment of the International Space Station. Both programmes involved substantial international collaboration with other research groups from France, Germany, Italy and the Netherlands and were reported at Network of Centres meetings and in the scientific programme of the Committee on Space Research (COSPAR). Together with staff from Unispace Kent and the National Office for Aerospace Studies and Research (ONERA) in Toulouse, France, the Hubble Space Telescope survey involved microanalysis of impact residues returned in 2002 from the low-Earth orbit (LEO) by the shuttle orbiter Columbia. Preliminary results showed a similar flux regime to that determined from the solar cell survey from 1993 retrieval, with a decline in the number of smaller space debris impacts from solid rocket motor firings. The residue collector research has seen successful light-gas gun shots of micro-meteoroid and space debris analogue particles onto purpose-built multi-layer polymer blankets and into silica aerogel and continued evaluation of electron-, proton- and ion-beam, laser and infra-red microanalysis techniques in laboratories throughout the United Kingdom and the United States of America.

3. Debris environment modelling

8. Debris researchers from the United Kingdom remain active in modelling the debris environment, its long-term evolution and the potential risks it causes to possible future space systems.

(a) Support to the IADC Environment and Database Working Group

9. Representatives from QinetiQ and the University of Southampton have supported BNSC in the IADC Environment and Database Working Group. Studies performed by the Group have focused on electrodynamic tethers in space, comparisons of engineering models and comparisons of results from geostationary Earth orbit (GEO) environment models. Additionally, in the light of recent advances in a number of debris environment models, a new study to predict the LEO environment has recently been initiated.

(b) Modelling the debris environment

10. A European team is currently upgrading the Meteoroid and Space Debris Terrestrial Environment Reference Model (MASTER) of ESA, under ESA contract. As part of that work, QinetiQ has started development of a new version of the Debris Environment Long-Term Analysis (DELTA) model.

11. In support of IADC studies, the University of Southampton has further developed and validated the Debris Analysis and Monitoring Architecture for the Geosynchronous Environment (DAMAGE) software model. Developmental work has included the addition of a new, fast-collision risk-prediction algorithm (dubbed CUBE2) for long-term environment modelling and the addition of a suite of tools, named TRINITY, for modelling the near-Earth object (NEO) threat to Earth. Validation work has used the results of the IADC orbital propagator comparison and GEO historical evolution tasks to verify DAMAGE predictions.

(c) Fast debris cloud propagator

12. At the University of Southampton, a postgraduate (PhD) programme to devise a novel space debris cloud orbital propagator for the GEO region was concluded during the period under review. The method proposed the propagation of a set of statistical parameters that define the initial break-up of a spacecraft, rather than the debris fragments themselves. The method was tested to determine its effectiveness at predicting the long-term debris impact threat to orbiting systems compared with standard methods. It was found to be both accurate and computationally efficient.

(d) Modelling the interaction of space tethers with the debris environment

13. Another PhD programme at the University of Southampton, to examine the threat posed by debris to space tether systems, was also concluded during the period. A software tool—the Tether Risk Assessment Program (TRAP)—was developed, which combined sophisticated risk algorithms with a user-friendly graphical user interface. Significant emphasis was placed on visualization in the graphical user interface. The program employs techniques to model the debris field that allow the debris density to vary along the length of the tether. A journal paper is being prepared.

(e) Debris hazard study of synthetic aperture radar interferometry formations

14. Missions involving formations of spacecraft to perform interferometric synthetic aperture radar (SAR) observations have recently been proposed. These typically comprise a master transmitting SAR satellite—Envisat, for example—with an accompanying formation of smaller passive receiver spacecraft. A study has been performed at the University of Southampton to assess the impact hazard to the system in the event of loss of control or break-up of one of the small components of the formation. The results were reported in a paper to the International Astronautics Congress held in Vancouver, Canada, in October 2004.

4. Spacecraft debris protection and risk assessment

15. The assessment of risk to and protection of spacecraft from hypervelocity debris impacts is another research area in which the United Kingdom has been active.

(a) Support to the IADC Protection Working Group

16. On behalf of BNSC a representative from QinetiQ has participated in and chaired the IADC Protection Working Group. The chairmanship of the Group was a two-year position that ended at the twenty-second IADC meeting, in April 2004. A major task of the Group has been the development of a protection manual containing technical information relating to spacecraft debris risk assessment and protection. The resulting document will be published shortly on the IADC website.

(b) Satellite survivability modelling and protection optimization

17. The University of Southampton has secured ESA funding for a one-year feasibility study into a technique for debris protection, which was recently developed as part of a PhD programme. The method uses a genetic algorithm to optimize the internal layout of a spacecraft to maximize its survivability in the space debris environment. The study will use a software model called SHIELD to assess the viability of the technique on a real spacecraft configuration—MetOp in this case.

18. QinetiQ has been involved in an ongoing ESA contract, led by the Ernst Mach Institute in Germany, to characterize the response of typical spacecraft equipment to debris and meteoroid impacts. An extensive impact test programme is about to commence and the resulting damage equations are about to be incorporated into the SHIELD software model. With the new equations, SHIELD will be able to provide a more accurate assessment of the survivability of typical unmanned spacecraft.

(c) Numerical simulation of hypervelocity impacts

19. Century Dynamics continues to develop, sell and support the AUTODYN software to the worldwide space community, including agencies, industry and academia. AUTODYN is one of the leading codes for simulating hypervelocity impacts from physical principles and has been used to investigate shielding solutions for the International Space Station.

(d) Hypervelocity impact testing

20. The University of Kent two-stage light-gas gun has continued to be used for impact studies in the hypervelocity regime. A Master of Science (MSc) thesis has been prepared by a student, examining oblique incidence penetration of the outer layer of bumper shields. Visitors (from Japan, the United Kingdom and Europe) have also continued to use the gun. Presentations have included a talk at the thirty-fifth COSPAR Scientific Assembly, held in Paris from 18 to 25 July 2004. Work will continue in 2004-2005 to study bumper shield performance and the use of aerogel to capture materials in LEO.

5. Debris mitigation

(a) Support to the IADC Mitigation Working Group

21. In the IADC Mitigation Working Group, BNSC has been supported by representatives from QinetiQ and the Rutherford Appleton Laboratory. The Group is currently working towards a refinement of the recommendation on re-orbiting GEO objects at the end of their useful life. The focus of the work is to provide guidance

on the disposal orbit eccentricity, which studies have shown should be limited to prevent natural orbit evolution returning the object to the protected GEO region.

(b) Debris mitigation standards

22. Through its membership in the Orbital Debris Coordination Group of the International Organization for Standardization, BNSC is actively leading the development of debris mitigation standards suitable for implementation by the space industry. The definition of a standards framework for spacecraft end-of-life manoeuvres is the current focus of effort. Contributions from United Kingdom experts are provided at the national level through the British Standards Institute.

(c) Debris Risk Assessment and Mitigation Analysis (DRAMA) tool

23. For ESA, QinetiQ is currently leading a European team in the final stages of the development of the ESA Debris Risk Assessment and Mitigation Analysis (DRAMA) software tool. The aim of the tool is to enable satellite programmes in Europe to assess their compliance with the recommendations in the European Code of Conduct for Space Debris Mitigation. DRAMA is composed of five individual software applications collected under a common graphical user interface. The individual applications have been designed and developed to address different aspects of debris mitigation. They make it possible to assess collision avoidance manoeuvres, collision flux and damage statistics, disposal manoeuvres at end-of-life and re-entry survival and re-entry risk analysis.

(d) United Kingdom satellite-licensing process

24. BNSC is responsible for issuing licenses to confirm that United Kingdom satellites are launched and operated in accordance with the obligations of the United Kingdom under the Outer Space Act of 1986. To assist BNSC in the licensing assessment process, QinetiQ uses a specially developed software tool, the Satellite Collision Assessment for the United Kingdom Licensing Process (SCALP), to evaluate satellite collision risks and liabilities. This analysis forms part of the overall assessment that allows BNSC to make an informed judgement on whether to grant a licence.

6. Space debris mitigation standard

25. The United Kingdom has been actively involved in work to identify and draft engineering standards related to the mitigation of space debris. Inputs have been provided through the European Cooperation for Space Standardization and the International Organization for Standardization, where the United Kingdom chairs a working group charged with coordinating all work on space debris mitigation standards throughout the Organization. In drafting the standards, care has been taken to align them, as far as possible, with the IADC guidelines for space debris mitigation.

7. Near Earth objects

26. The Rutherford Appleton Laboratory supports BNSC in helping to deliver the recommendations of the United Kingdom Task Force on Near Earth Objects through its leading of the Organisation for Economic Cooperation and Development

Working Group on the Risk of Near Earth Objects. The Working Group studies the risk posed to individual nations by a range of sub-global impactors considering the airburst, ground impact and ocean impact hazard. The focus of the work is to address the NEO risk issue in a similar manner to more familiar natural hazards (e.g. geological and meteorological), in particular in relation to the societal risks, in order to enable a commensurate policy response to be developed. This work is to be reported to and inform the deliberations of the Action Team on Near-Earth Objects of the Committee on the Peaceful Uses of Outer Space.