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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*

Addendum

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* The present document was prepared on the basis of a reply from a Member State received on 16 February 2009.

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II. Replies received from Member States

Canada

[Original: English]

1. International activities

1. In May 2008, Canada hosted the Ninth International Conference on Protection of Materials and Structures from the Space Environment. A keynote address covering the status of research and development on space debris mitigation measures was given by a representative of the Canadian Space Agency (CSA).

2. Canada contributed to the Thirty-seventh Scientific Assembly of the Committee on Space Research, held in Montreal, Canada, from 13 to 20 July 2008, with a scientific and technical presentation entitled "Canadian activities in space debris mitigation technologies", which was delivered to an international panel of experts on space debris.

2. Activities of the Canadian Space Agency

3. The Canadian Space Agency undertook an initiative to coordinate scientific and technical activities in addressing space debris research and development across Canada.

4. In that context, a working group on orbital debris was formed to achieve the following objectives:

(a) To increase the scientific and technical knowledge and awareness on orbital debris in the space community;

(b) To identify and encourage targeted research and development in orbital debris and mitigation measures;

(c) To identify and encourage the development of orbital debris detection and collision avoidance techniques and technologies;

(d) To promote scientific and technical collaboration across Canada and with international partners;

(e) To identify scientific and technical opportunities in relation to future potential missions that can directly benefit from the results of targeted research and development and novel operational techniques, and develop and coordinate technical solutions in Canada and with international partners;

(f) To establish and maintain technical relations with international partners in order to foster a sustainable space environment.

3. Canadian space debris mitigation research and development activities

5. Research activities in Canada focussed mainly on the development of novel hypervelocity ground test capabilities to allow investigation into the physics of hypervelocity impacts and technologies to protect space assets from space debris and to limit the generation of space debris in the future. Such activities included the

development of debris shield material designs, self-healing material processes to mitigate debris generation and spacecraft demise technologies.

6. In 2008, national research activities in Canada were supported in the following areas: hypervelocity impact facilities; debris mitigation and self-healing materials; and spacecraft demise technologies.

Hypervelocity impact facilities

7. There are many challenges in having facilities capable of accelerating projectiles of the size/mass range of greatest concern to velocities of 10+ km/s for meaningful impact studies. The main facilities used to evaluate hypervelocity impact on spacecraft are light gas guns. Such guns are limited to velocities of 7 km/s with projectiles of 1 cm and are barely able to access the regimes of impactor size and velocity range of interest for orbital debris and micrometeoroids.

8. There is an urgent need for a hypervelocity launcher facility that can achieve the velocities and deal with the particle mass range needed to represent the threat.

9. Canada has focused on the development of a novel implosion-driven hypervelocity launcher facility. The results to date are based on a first stage device that has managed to deal with a projectile of 0.8 g travelling at 6 km/s. The target for a second stage implosion development is to deal with a projectile of 10 g achieving a velocity of 10 km/s.

Debris mitigation and self-healing material

10. Self-healing materials offer a potentially revolutionary solution in various fields, including structural composites (matrix cracking, interfacial de-bonding, ply de-lamination), microelectronics and adhesives (microcracking).

11. In the harsh space environment, the repair and/or replacement of space assets is a delicate and expensive undertaking. In that context, self-healing material has the potential to offer a suitable technology for the mitigation of space debris damage on-board spacecraft. Such technology would mean that a crack caused by a micrometeoroid or piece of debris could start healing itself. Canada has investigated three main issues:

(a) Storage of the healing agent inside microcapsules with a diameter of <100 µm;

(b) Transport of the healing agent to the damaged site;

(c) Initiation at the crack tip and crack fill process by capillary action, triggering of the healing action, chemical reactions and polymerization between the healing agent (monomer) and matrix-embedded catalyst particles.

12. CSA has supported Canadian industry and universities in the development and testing of a self-healing concept demonstrator consisting of an epoxy used in space for internal structures (resin and curing agent), with a monomer healing agent prepared, as small microcapsules within thin shells of poly (urea-formaldehyde), and the catalyst distributed within the epoxy structure. The concept has allowed the demonstration of autonomous self-healing processes in simulated space conditions, the aim of which is to mitigate the propagation of debris.

Spacecraft demise technologies

13. CSA has started exploring spacecraft demise technologies involving the intentional disintegration of objects during re-entry to ensure that no debris reaches Earth.

14. Any active "demisability devices" must still function on a "dead" spacecraft, meaning that usual separation technologies such as explosive bolts and linear cutting charges cannot be used. Explosive components also represent significant safety risks.

15. CSA is supporting Canadian industry and universities to explore novel concepts to address this need based on incorporating inherently safe, reactive compositions (pyrotechnics) that activate passively upon re-entry.

16. In its simplest implementation, linear elements of a non-explosive pyrotechnic charge are attached to a propellent tank. Upon re-entry, these charges ignite, cutting the tank. More sophisticated designs would actually incorporate reactive structural components into the design of tanks, contributing to their strength.

4. Study on orbital debris in low-Earth orbit

17. A study has been carried out by Defence Research and Development Canada entitled "Deorbiting of microsatellites in low-Earth orbit (LEO)". A technical memorandum released in June 2008 outlined the problem of orbital debris in LEO and presented an overview of various technologies that could be used to deorbit micro- and nanosatellites from LEO. The study contained recommendations on the deorbiting requirements of micro- and nanosatellites to ensure the Canadian microspace programme would not be compromised in the future.

5. Current operational practices

18. CSA has prepared post-mission plans for disposing of its remote sensing satellite RADARSAT-1 and its scientific satellite SciSat. The plan for RADARSAT-1 is guided by two of the Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space,[1] namely: guideline 5, for removing the energy stored in satellite propellent tanks, wheels and batteries, and guideline 6, for using the remaining fuel to lower the orbit in addition to orienting the satellite in such a way as to maximize drag in order to reduce the orbit life of the satellite as much as possible.

19. Since SciSat has no propellent subsystem and has the shape of cube, its post-mission disposal plan is guided by guideline 5 only with regard to the removal of energy stored in its wheels and batteries.

6. Canadian space industry practices

20. The Canadian space industry, especially space operators and manufacturers, is adopting space debris measures on a voluntary basis and is following up technical advances to mitigate debris generation. In the case of space operators like Telesat, space debris mitigation measures are monitored throughout the procurement

[1] *Official Records of the General Assembly, Sixty-second Session, Supplement No. 20* (A/62/20), annex.

process, including final delivery in orbit. Operating practices include monitoring activities to prevent collisions with objects and post-mission disposal of satellites using the Space Debris Mitigation Guidelines of the Inter-Agency Space Debris Coordination Committee.

7. Policies and regulations of the Government of Canada

21. Canada has a number of requirements integrated into its policies and regulations. Within the framework of the Remote Sensing Space Systems Act, a number of requirements address the disposal of remote sensing satellites. Applicants have to provide information on all of the following:

(a) The method of disposal proposed for each satellite and the reliability of that method;

(b) The estimated duration of the satellite disposal operation;

(c) The probability that human life will be lost and how that probability was calculated;

(d) The amount of debris expected to reach the surface of the Earth, the size of the impact area expressed in square metres and how such data were calculated;

(e) The geographical boundaries of the likely debris re-entry impact area, the level of confidence that those boundaries are correct and how the boundaries and the confidence level were calculated;

(f) The kind and quantity of hazardous material and dangerous goods contained in each satellite at the end of its mission life, the quantity expected to reach the surface of the Earth on re-entry and how that quantity was calculated;

(g) The orbital elements and epochs of the proposed disposal orbits for each satellite;

(h) An assessment of the space debris expected to be released from each satellite during normal operations by explosions, intentional break-ups and in-orbit collisions, and the measures proposed to mitigate the production of space debris.

22. For newly licensed geosynchronous satellites, the Government of Canada requires that Canadian satellite operators minimize potential space debris at the end of satellite missions. Applicants for a radio frequency licence are asked to comply with the International Telecommunication Union (ITU) Radio Regulations, the Radiocommunication Act and the Radiocommunication Regulations of Canada, and Canada’s spectrum utilization policies pertaining to the licensed radio frequency bands.

23. At the end of its life, each satellite shall be removed from the geostationary satellite orbit region in a manner consistent with the ITU recommendation on the environmental protection of the geostationary satellite orbit. Pursuant to that recommendation, as little debris as possible should be released into the geostationary orbit during the placement of a satellite in orbit and a geostationary satellite at the end of its life should be transferred, before complete exhaustion of its propellant, to a super synchronous graveyard orbit. The recommended minimum reorbiting altitude is 300 km.