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Agenda item 7
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: reply of Canada

The present document has been prepared by the Secretariat on the basis of information received from Canada. The report of Canada will be reproduced in document A/AC.105/931/Add.2 after the conclusion of the session of the Subcommittee, with proper references to images contained in the original submission of Canada.

Canada

1. International Activities

In May 2008, Canada hosted the International Conference on Protection of Materials and Structures from the Space Environment (ICPMSE) with a keynote address by the Canadian Space Agency, which covered the status of research and development on space debris mitigation measures.

Canada further contributed to the 37th Committee on Space Research (COSPAR) Scientific Assembly with a scientific and technical contribution on *Canadian activities in space debris mitigation technologies*, delivered to the international panel on space debris, held during July 2008, in Montreal, Canada.

2. Activities at Canadian Space Agency Level

The Canadian Space Agency (CSA) undertook an initiative to coordinate the Scientific & Technical (S&T) activities in addressing space debris research and development (R&D) across Canada.

In this context, an Orbital Debris Working Group (ODWG) has been formed to address the following objectives:

- To increase the S&T knowledge and awareness of Orbital Debris in the space community;
- To identify and encourage targeted R&D in orbital debris & mitigation measures;
- To identify and encourage development of orbital debris detection and collision avoidance techniques & technologies;
- To promote S&T collaboration across Canada and with our international partners;
- To identify S&T opportunities in relation to future potential missions which can directly benefit from the results of targeted R&D and novel operational techniques, and develop & coordinate technical solution in Canada and with international partners; and
- To establish and maintain technical liaison with our international partners in order to foster a sustainable space environment.

3. Canadian Space Debris Mitigation Research & Development Activities

Research activities in Canada focussed mainly on development of novel hypervelocity ground test capability to allow investigation of physics of hypervelocity impacts and technologies to protect space assets from space debris, and to limit future generation of space debris. These included debris shield material designs, self-healing material processes to mitigate debris generation and spacecraft demise technologies.

In 2008, national research activities in Canada were supported in the following areas:

A. Hypervelocity Impact Facility

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 the light gas guns. These guns are limited to velocities of 7 km/s with projectile sizes of 1 cm and are barely able to access the regimes of impactor size and velocity range of interest for orbital debris and micrometeoroids.

There is an urgent need for a hypervelocity launcher facility that can realize the velocities and particle mass range that represent the threat.

Canada has focused on development of novel Implosion-Driven Hypervelocity Launcher facility. The results to date are based on a first stage device which has achieved 0.8 g projectile at 6 km/s. The target for a second stage implosion development with a 10 g mass and velocity of 10 km/s remains the development objective.

B. Debris mitigation & Self Healing Materials

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

In the harsh space environment the repair and/or replacement of space assets is a delicate and expensive undertaking. In this context self-healing material has the potential to offer a suitable technology for the mitigation of space debris damage on-board spacecraft. With this technology a micrometeoroid or debris crack could initiate a self healing process within the material. In this context Canada has investigated three main issues:

- storage of the healing agent inside <100 μm diameter microcapsules;
- transport of the healing agent to the damaged site; and
- 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.

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 & 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. This concept has allowed demonstration of autonomous self-healing in simulated space conditions to mitigate propagation of debris.

C. Spacecraft Demise Technologies

CSA has initiated preliminary exploration of spacecraft demise technology to assure intentional disintegration during re-entry to ensure that no debris reaches earth.

Any active *demisability* devices must still function on a “dead” spacecraft, meaning that usual separation technologies such as explosive bolts, linear shaped cutting charges, cannot be used. Explosive components also represent significant safety issues.

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.

In its simplest implementation, linear elements of a non explosive pyrotechnic charge are attached to propellant tank. Upon re-entry, these charges ignited, 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 (LEO)

A study has been carried out by Defense and Research and Development Canada (DRDC) agency on *Deorbiting of micro satellites in Low Earth Orbit (LEO)*. The Technical Memorandum (TM) was released on June 2008, which outlined the problem of orbital debris in Low Earth Orbit (LEO), presented an overview of various technologies that could be used to deorbit micro- and nanosatellites from this orbit. The study proposed recommendations on the deorbiting requirements of micro- and nanosatellites to ensure Canadian microspace program is not compromised in the future.

5. Current Operational Practices

CSA has prepared post-mission disposal plans to dispose of its remote sensing satellite RADARSAT-1 and scientific satellite SCISAT. The plan for RADARSAT-1 is guided by COPUOS guideline 5 for removing the energy stored in the satellite propellant 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 that drag is maximized aiming to reduce its orbit life to the lowest possible.

Since SCISAT has no propellant subsystem and has the shape of cube, its post-mission disposal plan is guided by COPUOS guideline 5 only for removing the stored energy in the wheels and the batteries.

6. Canadian Space Industry Practices

The Canadian space industry, especially space operators and manufacturers are adopting space debris measures on a voluntary basis, and are following up technical advances to mitigate debris generation. For space operators like Telesat, space debris mitigation measures are monitored during all the procurement process, up to final delivery in orbit. Operating practices include monitoring activities to prevent collisions with objects and post mission disposal of satellites using the Inter-Agency Space Debris (IADC) guidelines.

7. Government of Canada Policy and Regulations

Canada has a number of requirements integrated in its policies and regulations. Within the *Canadian Remote Sensing Space System Act*, a number of requirements address the disposal of remote sensing satellite. Applicants have to provide the following information:

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

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

(c) the probability of loss of human life and how it 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 they were calculated;

(e) the geographic boundaries of the likely debris re-entry impact area, the confidence level of the determination of the boundaries and how the boundaries and confidence level were calculated;

(f) the identity 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 the quantities were calculated;

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

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

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

The satellite, at the end of its life, shall be removed from the geostationary satellite orbit region in a manner consistent with Recommendation ITU-R S.1003 *Environmental Protection of the Geostationary Satellite Orbit*. This recommends, for instance, "that as little debris as possible should be released into the geostationary orbit during the placement of a satellite in orbit", and that "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 given as 300 km.