

Active Debris Removal - An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space

A Presentation By
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INTRODUCTION – PURPOSE

To introduce and briefly present the Report of the International Interdisciplinary Congress on Space Debris Remediation and On-Orbit Satellite Servicing, that was

- organised in November 2011 by the IAASS in cooperation with
 - my home institution, the Institute of Air and Space Law, McGill University, Canada, &
 - the Institute of Air and Space Law of Cologne University, Germany;
 - co-sponsored by the Canadian Space Agency & the UN OOSA; and
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- The Congress was attended by over 50 invited experts who participated in their personal capacities and who:
 - are experienced in various fields,
 - came from several countries, universities, agencies & international organizations, &
 - thoroughly analysed the problem and openly discussed various solutions (following the *Chatham House Rules*)

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The Report of the Congress seeks to:

1. assess the current space debris situation and to determine what can be achieved by active space debris remediation (ADR) and on-orbit servicing of satellites (OOS);
2. examine various technical concepts and means, legal and economic aspects, operational and organizational requirements for space debris remediation and on-orbit servicing of satellites; and
3. suggest policy and regulatory steps (mechanisms) that may be considered by States and other stakeholders to facilitate the removal of space debris and the servicing of satellites on orbit.

The main goal of the Report is to contribute to the international discourse on these issues. This is not a technical report. As such, many of the data, ideas, concepts and means described in this Report have not been referenced, tested and/or validated.

1. THE PROBLEM :

SPACE DEBRIS SITUATION & NEED FOR ADR & OOS

- More objects are being launched into higher orbits (and thus are staying longer in space), and many more countries are also launching objects.
- Currently, global rate of launches into LEO averages 36 launches per annum. Assuming that each launch injects 2 objects into LEO; i.e., 1 payload and 1 rocket body – at least 72 new objects are being injected into LEO each year. Taking the natural decay rate of 5 objects per year into consideration, it is estimated that at the current launch rate, 67 new objects remain in orbit in LEO each year.
- Even if no new space objects are launched, taking into account the number of objects already in orbit, the space environment (at least in the most used Earth orbits) might not be sustainable on a business as usual basis, if no mitigation or/and remediation efforts are undertaken.

- The IADC and UNCOPUOS have adopted a series of guidelines that lay down specific recommended measures to be implemented by all space actors so as to mitigate or reduce the possibility of creating space debris. These mitigation guidelines focus on the mitigation (or reduction) of the rate at which *new* pieces of space debris are generated.
- However, in view of the massive amount of debris already in existence in Earth orbit, growing consensus among experts suggests that an active process for the removal of *existing* debris from space and for on-orbit servicing of satellites is required, in addition to the mitigation efforts.
- It appears that we are at the threshold of a new epoch in which environmental preservation of outer space has taken on a new meaning and sense of urgency not only for purposes of protecting valuable space assets in the short-term, but also to ensure the continued sustainability of space activities in the long-term.

2. ISSUES & SOLUTIONS : EMERGING TECHNICAL MEANS FOR ADR & OOS

- Various technical concepts, means and capabilities have been developed (are currently being developed or considered) to support active debris removal and on-orbit satellite servicing activities.
- For untracked objects smaller than 10cm in diameter in LEO, such concepts include the use of thin film or other methods. They are ground-based or space based lasers to remove or reduce the momentum of small objects thereby lowering their orbit in order to facilitate their decay by re-entry into the Earth's atmosphere.
- However, removal of small untracked objects in LEO may not be cost effective or practical. Instead, it may be a better idea to remove potential sources of small debris by implementing debris mitigation techniques like end of mission disposal and by removing large debris objects that are susceptible to collision and fragmentation.

- Small objects might not trigger catastrophic collisions. The focus should therefore be on removal of larger objects capable of causing catastrophic collisions and massive fragmentations in space.
- There are different removal strategies: i.e., removal by mass, by area, by altitude or inclination, or a combination of all three. Furthermore it should be considered that the uncontrolled re-entry of objects of large mass constitutes a safety risk for the public on Earth. Therefore, the technique selected for removal of large debris must also take into account the need to minimize the public safety risk on Earth. .

The following are some of the essential prerequisites for the conduct of active debris removal and on-orbit satellite servicing:

- A "cost effective" technique;
- A proper legal and policy framework to protect the parties involved;
- Available and willing target for removal or customer for servicing;
- Someone to pay;
- Capability to locate, approach, connect deorbit/servicing device, control orientation and to move the target object to desired destination; and
- Safety of the public on ground, at sea and traveling by air.

- The removal of large objects faces numerous challenges. These include the fact that there might be the need to rendezvous with, and control, the target debris object which may be tumbling and may possess unknown mass properties. Another challenge lies in the fact that there may not be a convenient place to grab the object or attach a deorbit device to it. Finally, the removal effort itself may result in the creation of more debris.
- With roughly 2600 dead satellites and spent stages already spread all over LEO (approximately 2000 tons in total), statistical estimates suggest that the next catastrophic collision is likely to yield as many fragments as the Iridium-Cosmos collision and Fengyun 1C breakup combined, and that collisions of such magnitude might occur every 12 years on average.

- To significantly reduce the frequency of catastrophic collisions and the future growth of the number of fragments in LEO, debris removal on a small scale will not be sufficient, but will have to be carried out on a wholesale basis. And, in order to be commercially viable, it is envisaged that active debris removal should cost much less than typical launch costs.
- Although the technology for active debris removal and on-orbit satellite servicing may be ready, the relevant operational procedures are lagging behind.
- In connection with on-orbit satellite servicing, the technology for autonomous servicing of prepared clients has been demonstrated.
- Moreover, the implementation of active debris removal and on-orbit satellite servicing raises a number of difficult economic, strategic, institutional, legal and regulatory challenges that must be addressed at the very outset.

Cost-effectiveness of active debris removal and on-orbit satellite servicing?

- In the short term (i.e., 20-30 years), active debris removal will have minimal apparent benefit to operating satellites. The primary benefit of ADR will be realized only in the long term as it will reduce the possibility of uncontrolled debris growth and future limitations on space operations. ADR must therefore be performed in conjunction with adherence to debris mitigation guidelines for maximum long term benefit. Presently, funding is needed to cover the development and testing of removal techniques. In the future, long term funding will be required for a removal service.
- On the other hand, on-orbit satellite servicing offers short-term benefits by way of mission life extension through refuelling and assurance that the operator can meet post-mission disposal requirements. Life extension directly affects income for commercial systems and extends capabilities for government satellites. Thus, there may be a business case for implementing on-orbit satellite servicing.

Who should pay for the developed needed technology for ADR and OOS?

- The development of new and reliable technology for active debris removal and on-orbit satellite servicing is considerably expensive. One of the solutions that have been proposed is the initiation of competition under a Global Economic Fund for Space Debris Removal, partially borrowing from the X-prize model.
- All launch and space systems operators should contribute equitably – government and private – in proportion to their current share of the global launch and operations activities.
- The Fund can be expected to stimulate a diversity of international entities to compete in developing the needed technology; and the Fund could be shut down when the mission is accomplished.

Who should undertake ADR and OOS servicing?

- As a general rule, the State or entity (i.e., principal space system procurers, developers and operators) responsible for creating space debris should bear primary responsibility for its proper removal.
- However, under current circumstances, cleaning up the useful Earth orbits is a technologically challenging and costly activity. On the other hand, satellites constitute significant global "social infrastructure" that provide immense benefits to the world at large. Thus, it is only fair and equitable that all who are involved in space development – either directly by way of utilization or indirectly by way of deriving benefits therefrom - cooperate internationally in an effort to find appropriate mechanisms for the conduct of active debris removal and on-orbit satellite servicing.

Issues related to definition of space debris, jurisdiction & control and liability

- The technical definition of space debris endorsed by the IADC and UNCOPUOS focuses on the functionality. Thus, if a space object is functional, it is not space debris and *vice versa*. However, this technical definition is not sufficient for purposes of active debris removal because space objects that are non-functional may still have legal value or implications.
- The State that holds jurisdiction and control over a space object is the State on whose registry an object launched into outer space is carried. If a State, or a State-licensed actor, wishes to remove or service a space object, it can only legally do so if it has legal jurisdiction and control over that space object *or prior* permission from the State of registry.
- The international community needs to think about what mechanisms will facilitate the seeking and granting of permission and establish rules respecting both the jurisdiction and control issue and consent.

- In removing a satellite, there might be the need to cross orbits on the way up or down. This might increase the risk for the entity conducting the removal operation in terms of liability.
- The term "space object" connotes legal liability for a certain class of States associated with the object (i.e.. Launching States). Thus, if space debris is a constituent category of space objects, then certain liability implications will arise for the launching States, if damage is caused during the active removal of debris from space.
- There is a serious need to establish a standard and legally acceptable definition of what constitutes space debris in order to permit the conduct of active debris removal and on-orbit satellite servicing activities. Perhaps the best solution to the definitional problem of space debris would be to have a treaty that addresses the issue.

National policies and regulations facilitating ADR and OOS activities:

- National policies, laws and regulations can facilitate the conduct of active debris removal and on-orbit satellite servicing activities. For example, Canada's *Remote Sensing Space Systems Act* contains provisions regarding systems disposal. A licensee and, in the case of a licence that has terminated, the former licensee, is required to ensure that his satellite system is disposed of in accordance with the system disposal plan approved by the Minister.
- Each State can unilaterally implement, as part of its licensing process, a similar provision that enables it to order remediation as a possible solution to the growing space debris problem.

National export control regulations:

- In furtherance of national security and economic interests, several countries have established domestic legal and regulatory regimes that impose onerous restrictions on the transfer of jurisdiction and control over their space objects to parties in foreign countries. The US regime of ITARs best exemplifies such legal and regulatory restrictions.
- Performing active debris removal and on-orbit servicing of a US satellite, or a satellite of another country that has US components or technology on board, falls within the definition of "export" under the US ITARs. If a US company wanted to contract with a foreign country for removal, this would be considered a defense service regulated under the ITARs. It is also likely that satellite refuelling will raise ITAR issues. For the foreseeable future, it is reasonable to assume that ITARs will continue to be a major hindrance to the conduct of active debris removal and on-orbit satellite servicing operations.

Strategic (military) issues:

- By their very nature as well as their dual use attributes, ADR and OOS technologies come with very significant strategic and military implications. They can be used for Anti-Satellite Tests (ASAT). What matters the most in this connection is the capability of the technology, not the intent behind it. All of these capabilities are important from a strategic and military perspective.
- Therefore, Transparency and Confidence Building Measures (TCBMs) will have a significant role in reducing mistrust and misperceptions in the conduct of ADR and OOS operations. As such, initial ADR missions should focus on non-controversial debris. For attributed debris, the State that created the debris would be responsible for removing it either by way of its own ADR operations or by expressly authorizing others to remove it. This approach would minimize military, diplomatic, and political concerns.

3. IMPLEMENTATION: ORGANIZATIONAL & OPERATIONAL ASPECTS OF ADR & OOS

- It is believed that public-private partnerships, with activities monitored and coordinated at both the national and international levels, will be conducive to implement and carry out ADR and OOS operations. Accordingly, it is proposed that an operational and regulatory framework that would facilitate these should encompass the following three elements:

(1) Establishment of an **inter-governmental organization** (IGO) based on the early INTELSAT model to foster the development of the technology(ies) for active debris removal and on-orbit satellite servicing, and subsequently to perform removal and servicing operations on a commercial basis. The international agreement establishing such an organisation should have (a) a clear definition of space debris, and (b) a provision under which the participating States authorise the removal or servicing of those pieces of space debris and/or non-functional satellites for which they are the States of registration. Such agreement can also serve as a TCBM mechanism.

(2) Subscription of governments to procure on a commercial basis the removal of **space debris created by their own national space activities**. Each country could impose a national “space garbage” collection tax on final users of space-based commercial services available in the country.

(3) Amendment of national licensing rules to include an **assured removal clause** that would apply to satellite and relevant launcher upper stage(s). Under the clause, the operator should be required to take out an insurance policy to cover the costs of removal or disposal in the event that a failure or malfunction prevents performance of the planned disposal.

CONCLUSIONS AND FINAL REMARKS:

- The problem of space debris is of growing concern for space safety and the long-term sustainability of outer space activities. Estimates suggest that, even if no new space objects are launched, the amount of space debris will continue to grow.
- The implementation of debris mitigation measures might have a significant impact in curtailing the rate of creation of *new* debris during the conduct of space activities. However, taking into consideration that there is a massive amount of space debris already in orbit, it is clear that the time has come for active debris removal and on-orbit satellites servicing. This is necessary in order to meet the long-term need to protect the space environment as well as a short-term need to protect operating space assets from damage or destruction by debris.
- In addition to the development of technical means and operational procedures for ADR and OOS, other relevant legal, regulatory, financial, safety, organisational and strategic challenges must also be addressed for effective conduct of active debris removal and on-orbit satellite servicing.

!!! THANK YOU FOR YOUR ATTENTION !!!