

POSITION PAPER

A GRAND CHALLENGE FOR ACTIVE REMOVAL OF SPACE DEBRIS

1. Focus: Protection of the near-Earth space environment requires removal of large debris objects that could be the source of great numbers of small fragments if involved in collisions. The evolution of the debris environment is an international issue and concern. At present, there is little incentive to encourage resolution of legal and policy impediments and development of the technologies required to remove these objects.

2. Statement of Position: The IAASS should actively encourage and support, via its conferences and publications, the development of an International Grand Challenge for Active Debris Removal (ADR). The Grand Challenge, organized and funded by space agencies, would provide monetary rewards for resolving impediments and for demonstrated successes related to active debris removal.

3. Substantiation

a) Background:

The population of objects orbiting Earth in the Low Earth Orbit (LEO) regime, defined as altitudes up to 2000 km above the Earth's surface, continues to grow. Current research is showing that a major contributor to the long-term growth of debris, and particularly small debris less than 10 cm in size, will be collisions involving large, dead satellites and launch stages¹. Since there is currently no practical way to remove small debris from orbits, recommendations are to remove at least five large, dead objects per year as a critical part of a long-term strategy to stabilize the debris environment. Based on these results, the U.S. National Space Policy directs that the United States will “[p]ursue research and development of technologies and techniques ... to mitigate and remove on-orbit debris...”.

There are two key requirements for moving forward on active removal of space debris. The first is incentive for moving forward given the expense of developing and testing related technologies. The second is developing a legal and regulatory framework for ADR given current international agreements relating to ownership of debris objects and the associated responsibility and liability of owners (especially of their respective States). As the U.S. Congressional Research Service (CRS) notes², the non-technical (especially and policy and legal) challenges related to debris removal must be addressed prior to an actual attempt to remove a significant object. Quoting the CRS report:

The most prominent legal issue associated with debris removal relates to the ownership of objects in space. Article VIII of the 1967 Outer Space Treaty declares that space objects continue to belong to the country or countries that launched them. The launching state retains “jurisdiction and control” for a space object while it is

in outer space, on a celestial body, and upon its return to Earth. The launching state never loses authority over the object, and no other nation has the legal authority to remove or otherwise interfere with it without authorization from the state of registry. This is true even if the space object is nonfunctioning or fragmented. “There is no right of salvage analogous to the right found in maritime law, which means that even though a satellite or some other space object may not be functioning, it does not imply that it has been abandoned by the nation that launched it.”³ In addition, “international space law deems fragments and components from space objects as individual space objects in and of themselves, which would require identification to determine the owner and either individual or blanket consent to remove it from orbit.”⁴ Absent some form of consent or international agreement, the United States would be limited to retrieving and removing objects only from its own registry.

The CRS also identifies liability as a significant concern:

Under the current space law treaty regime, damage caused by spacecraft is covered by the 1972 Convention on International Liability for Damage Caused by Space Objects (Liability Convention). Article II of the Liability Convention states that the launching state is absolutely liable for damage caused by its space object on the surface of the Earth or to aircraft flight. When space objects cause damage in outer space, however, a fault standard is applied.⁵ If one spacecraft collides with another in space there is only liability if negligence can be proved. This could lead to extremely complicated fault assessments if damage or fragmentation occurred during removal operations, particularly operations involving multiple governments.

Models show that for the LEO environment, we need to clear the way for an active debris removal program that would begin within the next 20 to 30 years. Given that collisions are rare at present, there may not be the incentive to develop solutions for these types of issues in the near term, much less to invest in developing and testing the necessary technologies. The question is: What can be done to move forward with ADR?

b) Context:

An approach that has had success in spurring creativity in new areas is to establish a prize. The XPrize, NASA’s Centennial Challenge, and DARPA’s Grand Challenge are examples where offering a prize can spur developments toward accomplishing a hard-to-achieve goal. As the XPrize Foundation says “We believe that you get what you incentivize. And that without a target, you will miss it every time...We believe that challenges must be audacious, but achievable, tied to objective, measurable goals. And understandable by all.” In fact, an XPrize for debris removal has been proposed but not yet approved. The winning team for that prize would “remove a minimum of five specified pieces of cataloged space debris larger than 50 centimeters from Low Earth Orbit or Geostationary Earth Orbit altitudes. The winning team must deposit the debris in an accepted safe location in a

predicted fashion within a limited amount of time.” The prize amount has not been specified.

The prize proposed by the XPrize Foundation would specify the pieces of debris to be removed, and this would be a critical component of any challenge of this type. But as noted, removal is only part of the challenge: removal must be executed in a way that doesn't create more debris and doesn't add to the collision hazard for other objects once the removal process has been initiated. And to make ADR palatable as a long-term business goal, the legal, regulatory, responsibility, liability, strategic and policy impediments need to be addressed as part of the development of the challenge.⁶

c) Approach:

Building on the prize or challenge concept, a prize for Active Debris Removal is suggested as a way to move forward. The prize would confirm government's interest in ADR as a long-term component of a strategy to minimize the growth of space debris. The prize could be structured to encourage both technical and non-technical developments that support ADR. And in committing to the prize concept, governments could initialize formal internal and external discussions that would make a limited number of currently existing debris objects available as targets for removal.

The overall prize might be structured as follows:

- **Identify a sponsor.** It is likely that in addition to taking a leadership role in identifying objects for removal, the costs associated with removal of significant objects might be substantial and a government agency might necessarily be the sponsor for the prize and provide some incremental funding support as competitors develop their concepts and meet specified milestones. A government agency sponsor might also “own” three target debris objects, a fact that could facilitate the types of agreements and releases required. A challenge inviting worldwide participation would be preferred, but might not be possible initially.
- **Identify three debris objects that would serve as targets for early removal efforts.** Each of the three targets would bring more complexity to the removal process—a **launch stage** would have a nozzle that could be used as an attachment point; a **“simple” spacecraft** would not have a convenient attachment point, but would be free of appendages that would potentially break off in a retrieval attempt; and a **“complex” satellite** might have extended solar panels and other appendages that would make close approach and grappling difficult.
- **Define the goal for the challenge.** The overall goal would be to safely remove each of the three debris objects described above without creating additional hazard for existing objects or creating more debris in the process. Priority would be given to removal concepts that would use technologies that are adaptable for all three retrievals.
- **Define the prize(s).** Given the technical and non-technical difficulties, the prize might be to provide financial rewards for both technical and non-technical

achievements; e.g., for meeting critical technical milestones, or signing formal agreements, as well as for successful removal of a target object.

The sponsor of the prize would also lead efforts to open a path for removal of the three objects. Specifically, the sponsor would:

- **Negotiate agreements with object owners (especially their respective States).** Agreements would be negotiated with the owners of the three objects authorizing their use as targets. Each object's owner would provide details on the object's physical properties, and the size of the prize might be increased based on the increasing difficulty and complexity of the object. Points could be given for the technique that could be applied to the most object types.
- **Develop the legal and regulatory framework enabling removal of debris objects.** The sponsor would identify and resolve legal, regulatory, strategic and policy impediments for removal of each of the three objects noted above, moving toward a more general solution to non-technical issues affecting ADR.

4. IAASS Position

Whereas:

- Preservation of the space environment is an international issue;
- The safety of space operations will be reduced by projected increases in the population of debris objects;
- Large debris objects currently in orbit are potential sources of large numbers of new debris objects if involved in a collision;
- The legal and policy framework supporting debris removal must be developed;
- The development and demonstration of creative solutions for removal of large debris objects must be encouraged;
- Grand challenges and prizes have proven to provide incentives for development of new capabilities; and
- An international prize or grand challenge for safe removal of large debris objects would provide a path for developing both the physical hardware and mission designs, as well as development of the necessary policy and other issues.

Now, therefore, the International Association for the Advancement of Space Safety supports and will promote the development of an International Grand Challenge for active debris removal.

References:

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1. Liou, J.-C., N.L. Johnson, N.M. Hill, "Controlling the growth of future LEO debris populations with active debris removal," *Acta Astronautica*, vol. 66, no. 5-6 (March-April 2010), pp. 648-653.

2. Hildreth, S.A. and A. Arnold, "Threats to U.S. National Security Interests in Space: Orbital Debris Mitigation and Removal," Congressional Research service, January 8, 2014.
3. Listner, M., "Legal issues surrounding space debris remediation," The Space Review, August 6, 2012, <http://www.thespacereview.com/article/2130/1>.
4. Ibid.
5. Liability Convention, Article III.
6. Active Debris Removal - An Essential Mechanism for Ensuring the Safety and Sustainability of Outer Space, UN COPUOS Document, A/AC.105/C.1/2012/CRP.16, 12 January 2012.