Active Debris Removal and On-Orbit Satellite Servicing Scenario Workshop

November 5, 2012
Carnegie Endowment for International Peace
1779 Mass. Ave NW

0900 **Welcome and Overview**
Victoria Samson, Secure World Foundation (SWF)

0915 **Scenario 1:** A long duration, highly maneuverable LEO debris removal system

1000 **Scenario 2:** A ground-based laser debris avoidance system for LEO
1045 **Coffee Break**
1100 **Scenario 3:** A life extension service for GEO communications satellites
1230 **Working Lunch**
Scenario 4: A service to create new satellites from recycled space debris

1330 **Wrap-Up Discussion**
Victoria Samson, SWF
1400 **Close**

Workshop Goal

The goal of this exercise is to identify critical policy and regulatory issues that need to be addressed to ensure the safe, sustainable, and secure development and operation of active debris removal (ADR) and on-orbit servicing (OOS) capabilities. Specific areas of interest are:

- Spectrum allocation, management, and coordination
- Technology transfer and licensing
- Compliance with international and national laws
- Communication and coordination with other space actors
- Transparency and confidence-building measures

Methodology

Over the course of this workshop, we will be using a series of simple scenarios to help focus the discussion. The scenarios are all based on actual concepts in development or being evaluated, but are not intended to exactly mirror the specifics of these concepts. In some cases, they may be composites of more than one concept, and in others certain details may have been changed or left out. In all cases, each scenario is designed to highlight particular aspects of ADR or OOS. Details may have been left out or altered in order to stimulate discussion.

Each scenario contains background information about a particular ADR or OOS mission, the entities involved (which may or may not be fictional), and a description of the activities they will be performing in orbit.

Ground Rules

1. This discussion is under Chatham House rule. Participants are free to use the content of the discussions but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed
2. This discussion is at the unclassified level.
3. Unless otherwise stated, each participant is providing input based on their own personal expertise, experience, and opinions and is not representing the organization they currently work for.
4. SWF will be compiling a summary report from the workshop that will be used for our internal planning and study and also published on our website.

Scenario 1 - A long duration, highly maneuverable LEO debris removal system

The American Acme Debris Removal company has developed an operational debris removal spacecraft code-named Wall-E. It consists of a 5-km long tether that uses electrodynamic fields interacting with the Earth's magnetic field to maneuver without using fuel, as long as it has electrical power. This allows the spacecraft to slowly maneuver in all orbital dimensions, including inclination changes.

The Inter-Agency Debris Removal Committee (IADC) was tasked to identify large, high-threat debris objects in LEO that should be removed. The top 5 are as follows:

SATNO	Common Name	Apogee (km)	Perigee (km)	Inclination (deg)	RCS (m^2)	Launching State
7274	Meteor 1-17	879	852	81.23	5	CIS
18821	SL-14 Rocket Body	958	934	82.54	4.8	CIS
12586	SL-3 Rocket Body	570	543	97.41	7.3	CIS
27386	Envisat	767	766	98.46	19.8	FRA
37718	Haiyang 2A	967	966	99.36	5.2	PRC

Acme Debris Removal has received funding and approval from Russia, France, and China to remove their respective objects on the list over a one-year period. After being launched into a 700 km x 700 km parking orbit, the Wall-E spacecraft will proceed to rendezvous with the first debris object on the list and capture it using a net system. Wall-E will then maneuver over a period of several days down to an orbit below that of the International Space Station and release the debris object. The debris object will re-enter the atmosphere via natural decay in a matter of months. Meanwhile, the Wall-E spacecraft will maneuver back up to grab the next item on the list and repeat the process.

Wall-E will be under full operational command and control at all times. Ground operators will provide it with the orbital elements of its next debris target. Wall-E will conduct the rendezvous process autonomously, with planned safety holds at set distances from the target. During rendezvous operations, it will be using optical cameras and LIDAR to detect and track its target.

Scenario 2 - A ground-based laser debris avoidance system for LEO

The Australian Clean Space company has developed a ground-based laser system that can change the orbit of small debris objects in LEO. Clean Space uses a distributed network of 100 small optical telescopes around the world to track all debris objects down to 1 cm in size. Clean Space uses a 5 kW laser located in Australia to fires multiple pulses at a single, small debris object in one pass, changing its perigee via photon pressure. Over successive orbits these changes are enough to alter the object’s orbit by several hundred meters.

Using this technique, Clean Space offers a paid collision avoidance service for satellite operators. Clean Space uses its tracking network to detect and predict collisions between debris objects and satellites. For a fee, satellite operators can subscribe to an alert service to be notified of potential collisions between one of their active satellites and a piece of debris. For an additional fee, Clean Space will use its laser to change the orbit of the debris object, thus preventing the collision without the operator needing to expend fuel. Clean Space also offers this service to owners of large, dead satellites that have been left in orbit, and for a fee will use its laser to prevent small debris objects from hitting the large satellites left in orbit.

In the near future, Clean Space plans to add a more powerful laser that is capable of removing small pieces of debris from orbit entirely through ablation.

Scenario 3 - A life extension service for GEO communications satellites

The American Satellite Life Extension company operates a service that can extend the life of satellites in the GEO region. The company has three small backpack satellites orbiting just below the active GEO belt. When contracted by a satellite operator. one of these backpack satellites will drift along the belt to the host satellite's location and maneuver to rendezvous. It will attach itself to the host satellite and takeover maneuvering and stationkeeping duties for the length of the contract up to five years.

The backpack satellites are also available to help a satellite reach its desired active orbit after being stranded in another orbit as the result of a launch system malfunction.

While attached, the backpack satellite will be controlled by Satellite Life Extension's ground control facility in Virginia.

Scenario 4 - A commercial company creating new satellites from recycled space debris

The U.S.-based Satellite Recycling Company (SRC) manufactures new communications satellites out of recycled parts from defunct satellites. Using technology originally developed by DARPA, SRC operates a robotic vehicle in and near the active GEO belt to gather parts from hosted payload slots on active GEO satellites and use them to converts pieces of dead satellites in the GEO graveyard into fully-functioning satellites. SRC works to match customer requirements for the new communications satellites with apertures available on satellites in the graveyard, including the ability to negotiate transfer of ownership of the aperture from the original owner.

After an aperture is converted to a fully functioning satellite, SRC conducts a checkout of all major systems before handing it over to the customer. In many cases, customers are using these newly created satellites as part of a cluster operating in a GEO slot.