Spacecraft to Remove Orbital Debris

Concept to allow autonomous capture of debris in LEO

Innovators at NASA Johnson Space Center have designed an Active Debris Removal Vehicle (ADRV) that can remove large orbital debris from low-Earth orbit (LEO). The ADRV will approach a debris object, assess its characteristics and motion, determine an initial capture trajectory, match its rotation rates, execute a capture maneuver, and control and deorbit the object. This concept can help mitigate catastrophic collisions with debris involving astronauts, their spacecraft, and other valuable space assets. The ADRV incorporates several NASA inventions including a novel spacecraft control system, debris object characterization system, and capture and release system. These NASA ADRV technologies may also be applied to satellite servicing and orbital adjustments.

The Active Debris Removal Vehicle (ADRV) is at technology readiness level (TRL) 6 (which means the system/sub-system model or prototype has been demonstrated in an operational environment) and the related issued patent is now available to license. Please note that NASA does not manufacture products itself for commercial sale.

**BENEFITS**

- Protects space and ground assets from debris exposure risk
- Small form factor enables reduced launch costs
- Eight ADRVs can be launched on a single payload allowing multiple missions
- Bi-propellant hypergolic propulsion system can achieve high mass fractions for efficient maneuver and removal operations
- The capture and release system (CARS) snare design can adaptively capture a variety of uncooperative targets not designed for capture
- Developed to be a low-cost alternative to other proposed orbital debris removal systems
THE TECHNOLOGY

An approach to mitigating the creation of additional orbital debris is to remove the sources of future medium debris by actively removing large spent objects from congested orbits. NASA has introduced the ADRV, an efficient and effective solution to remove large debris from LEO such as spent rocket bodies and non-functional satellites. The concept yields a single use, low-cost, lightweight, high mass fraction vehicle that enables the specific removal of large orbital debris (1000 - 4000 kg mass, 200 - 2000 km altitude, and 20 – 98-degree inclination). The ADRV performs rendezvous, approach, and capture of non-cooperative tumbling debris objects, maneuvering of the mated vehicle, and controlled, targeted reposition or deorbit of the mated vehicle. Due to its small form factor, up to eight ADRVs can be launched in a single payload, enabling high impact orbital debris removal missions within the same inclination group.

Three key technologies were developed to enable the ADRV: - 1) The spacecraft control system (SCS) is a guidance, navigation, and control system that provides vehicle control during all phases of a mission; - (2) The debris object characterization system (DOCS) characterizes movement and capture of non-cooperative targets; and - (3) The capture and release system (CARS) allows the vehicle to capture and mate with orbital debris targets. These technologies can improve the current state-of-the-art capabilities of automated rendezvous and docking technology significantly for debris objects with tumbling rates up to 25 degrees per second. This approach leverages decades of spaceflight experience while automating key mission areas to reduce cost and improve the likelihood of success.

APPLICATIONS

The technology has several potential applications:

- Orbital debris removal
- Satellite orbiting adjustments, servicing, deorbiting

PUBLICATIONS

Patent No: 9,187,189; 9555905

Due to its small form factor, eight ADRVs can be clustered in a single launch vehicle payload. Each vehicle can be assigned to a unique debris target.