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MITIGATING THE SPACE DEBRIS CRISIS – INNOVATIONS IN ORBITAL CLEANUP

Abstract

We are currently orbited by more than 160 million man-made pieces of space debris, forming a cage of steel, aluminum, and paint chips traveling at 23 times faster than the speed of sound. If space debris continues to pile up, we could create a Kessler effect, a continuously colliding debris field that no satellite could survive and no spaceship could escape, trapping us on Earth. This paper explores four emerging technologies aimed at actively removing space debris and preventing catastrophic collisions in Earth's orbit.

This study examines four approaches to removing space debris: Claw Capture, Magnetic Capture, Net and Harpoon System, and Laser Broom. ClearSpace, a Swiss-based startup, has developed a four-armed claw to retrieve defunct satellites and guide them into Earth's atmosphere for safe disposal. Japanese company Astroscale proposes a magnetic docking system that allows satellites to be repaired or pushed into atmospheric reentry. Remove Debris, a project led by Surrey Satellite Technology Limited, utilizes a net-casting mechanism and a harpoon to capture and secure space debris. Electro Orbit Systems (EOS) is developing high-energy ground-based lasers to deflect or slow debris, causing it to burn up in the atmosphere.

The claw capture method targets large objects but requires precise velocity matching. Magnetic docking is ideal for pre-equipped satellites but less effective for existing debris. The net and harpoon system efficiently capture objects of various sizes but risks fragmentation. Laser brooms provide a rapid-response solution for smaller debris but face technical challenges such as atmospheric distortion.

If effective action isn't taken to reduce the amount of space junk in our orbit, we risk creating a cage of metal swirling around our planet, inhospitable to satellites and untraversable by spacecraft. A multi-faceted approach, integrating these technologies, is crucial for ensuring sustainable space operations. As our utilization of space ramps up, it's critical to explore in a way that is sustainable, lest the debris build up and we turn Earth into an inescapable space prison.