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RECYCLING SPACE JUNK: RESOURCE HARVESTING AS A SOLUTION FOR ORBITAL DEBRIS

Abstract

Although there are currently several proposed methods for mitigation of orbital debris problems, drawbacks exist. Proposals for the pure removal of orbital debris via deorbiting proliferate. However, such methods result in the complete loss of all the resources invested in the spacecraft that originated the debris objects, and also require additional resources to implement. Methods to rehabilitate debris objects, such as on-orbit servicing, also exist, but tend to be extremely expensive, due to the large amount of resources which must be invested in the servicing spacecraft.

To address the growing problem of orbital debris, this study investigates a new approach, which recasts the orbital debris problem as an opportunity, such that solutions may be sought to repurpose rather than remove the large amounts of material already on orbit. Orbital debris then becomes a resource to be harvested instead of a nuisance to be removed. This approach offers the potential for offsetting or recovering the investment needed to initiate orbital debris removal via material reuse. The orbital debris removal architectures resulting from this approach may also represent precursors to important directions for space technology in the future, including asteroid mining, orbital manufacturing, and long-duration orbital stays. There are also scientific and historical benefits: orbital debris bodies could be studied, before being recycled, to glean information about spacecraft performance or the space environment that may be useful for developing future spacecraft, and historic spacecraft may be recovered for archival purposes.

This study looks at both the on-orbit debris resources made available by this approach and the technology needed to implement this approach. A resource survey is presented that quantifies the types and amount of resources available on orbit, such as metals, propellants, functioning systems and their associated orbits and even potentially recoverable momentum. A systematic survey of orbital debris removal methods (both currently in development and proposed for future development) as well as technologies for complementary missions (such as asteroid harvesting) with the potential for repurposing for orbital debris harvesting is also presented. This information, which defines the solution space for the orbital debris harvesting problem, is used to develop and present promising architecture concepts that have the potential to offer significant benefits by accessing high-value orbital debris resources.