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Political, Legal, Institutional and Economic Aspects of Space Debris Mitigation and Removal - STM Security (8-E9.1)

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THE ENHANCED ECONOMICS, INCENTIVES, AND MULTINATIONAL COOPERATION ENABLED BY REFUELING ARCHITECTURES CENTERED AROUND DEBRIS CLUSTERS FOR SUSTAINABLE ACTIVE DEBRIS REMOVAL

Abstract

As Low Earth Orbit (LEO) sees ever increasing congestion, there has never been a more important time to find sustainable solutions to debris mitigation and removal. This debris congestion has far-reaching multinational effects and consequences that numerous bodies such as IADC, UNCOPUOS, and agencies worldwide have been working to mitigate. Although multiple active debris removal (ADR) missions have been proposed, they are often demonstrations that remove only a small portion of the overall debris mass and collision risk in orbit yet still require tremendous financial resources. The high mass and volume objects that pose the highest collision risk typically require highly-capable, large, expensive ADR vehicles with significant quantities of fuel to remove a single object, let alone multiple objects before fully depleting, which severely limits the number of missions each vehicle can perform before another is required.

These fuel limits and capital replacements serve as major economic and feasibility challenges for comprehensive debris removal, which results in much of the funding and development of debris removal falling to a few single or multinational governmental parties. As debris is generated by and affects all space-faring nations, reducing these costs can better incentivize shared financial burden across them. The authors believe that a refueling architecture for ADR vehicles centered around each debris cluster is the key enabler to making this not only possible, but also economically sustainable.

In previous studies by Orbit Fab, to be presented at the Space Debris Modeling Remediation Workshop, the highest risk objects, as defined by Dr. Darren McKnight, fall into 3 major delta-V clusters, where all objects are within a few hundred meters per seconds of each other:

- 99.0+/-1.0deg inclination, 780-920km altitude, totaling 100 tonnes across 50 objects

- 82.0+/-1.0deg inclination, 840-950km altitude, totaling 300 tonnes across 210 objects
- 72.5+/-1.5deg inclination, 750-1500km altitude, totaling 400 tonnes across 185 objects

Together, the 445 objects within these clusters make up over 50% of the debris mass in orbit. This makes a strong case for developing refueling architectures to maximize accessibility with minimum fuel expenditure and effectively unlimited fuel availability for vehicles to perform multiple missions dramatically reducing debris removal costs at economies of scale, which this paper will explore. A high-level legal framework required to achieve this debris removal at this scale will also be examined to understand the associated cost breakdowns and incentives for different parties globally to contribute to a safer, more sustainable space.