Paper ID: 102520
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23rd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 23rd IAA SYMPOSIUM ON SPACE DEBRIS (IP)

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DESIGNING CRITERIA FOR A NET-POSITIVE SPACE DEBRIS CLEAN-UP MISSION.

Abstract

Does humanity understand the space debris problem? Millions of pounds are being spent to remove the estimated 170 million pieces of debris in orbit. Over 50 companies worldwide are working on the problem, but their proposed missions are missing a precise measure of success. Each proposed active debris removal (ADR) mission creates some amount of space debris, environmental pollution, and risk of failure that will produce even more debris. The amount of orbital debris removed from orbit must offset this output and potential output for the mission to be environmentally beneficial. However, quantifying this environmental output is difficult due to the number of factors to be considered and is largely ignored by ADR companies. This report reviews proposed mission designs for ADR, investigates environmental impact data from previous space missions, and uses this data to create an impact model. This model projects the environmental impact of theoretical missions; from this, an "Impact Factor" is defined. Then data from current ADR plans is used to rank and characterise types of space debris to define an "Effect Factor", which integrates factors such as impact probability, mass, and location to quantitatively identify how beneficial a debris's removal will be. If a mission removes multiple pieces of debris, the Effect Factors are summed, which is the mission's Total Effect Factor. For an ADR mission to break even with its environmental output, its Impact Factor must equal its Effect Factor. This is the new net zero. The mission's Effect Factor must be greater than its Impact Factor for any environmental benefit. In 2012, the Committee on the Peaceful Uses of Outer Space stated that 9.1 objects annually must be removed from LEO to stabilise the exo environment within 200 years. However, this number does not account for the sizable increase in space debris since 2012 nor specify the volume, mass or material of the 9.1 pieces of debris. Since this report was published, there has been no update on the ADR goal. Currently, ESA and the UK are considering "Tentacles", "Multiple arms", "Net capturing", and "Harpoon" as viable methods of debris collection mechanisms. All of these methods have advantages and drawbacks and are examined further in this report. Therefore, the purpose of this report is to conclude the amount of debris that an ADR mission must remove to create a net-positive effect on the environment.