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Space Debris Removal Concepts (6)

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ACTIVE SPACE DEBRIS REMOVAL USING CONCENTRATED SUNLIGHT

Abstract

Most active space debris removal projects currently underway involve sending up a robotic spacecraft that can capture or attach to target debris and then de-orbiting the debris along with the capturing spacecraft. There are apparent problems with this approach in that it is extremely expensive, slow and inefficient. A wide range of alternative de-orbiting mechanisms, such as tether deployed nets, foams, terminal tether, and use of laser or ion beam, have been proposed to assist with the removal of debris from orbit. These approaches would be far more effective and thus cost less than the one-by-one active de-orbit missions. Nevertheless, reliable, accurate, controllable and effective technology to assist debris removal has still to be accomplished.

This paper presents a novel active space debris removal approach using concentrated sunlight. A mirror system on an active removal satellite is proposed to focus sunlight on target debris. The sunlight pressure would then gradually de-orbit the debris in a controllable way. The size of the major mirror and the mass of the debris determine the speed of de-orbiting when all collected sunlight casts to the debris. In this way, the area of the debris receiving sunlight is extended equivalently and the sunlight pressure is enlarged accordingly. In addition, the direction of the concentrated sunlight could be designed and adjusted to de-orbit the debris no matter the direction of the sun.

For debris on low earth orbit of about 900km altitude, the orbit altitude could be reduced by approximately 350km within 1 year when the equivalent area to mass ratio achieves $1m^2$/kg. This altitude reduce rate is sufficiently rapid compared to the 25 year de-orbit rule for LEO objects. The equivalent area to mass ratio provide requirement for the size of the major mirror. For small debris within 1kg, 1 m^2 sunlight collection area is required to achieve fast active removal. Debris within 100kg needs $100m^2$ collection area in the same way.

In summary, a novel active space debris removal approach using concentrated sunlight is proposed. It could provide relatively rapid orbit removal service for debris of all kinds of orbit. The active removal satellite does not need to capture or attach to the debris. Therefore, it could serve multi debris in the lifetime. Sunlight is safe and clean without danger of damaging as high-powered laser or ion beams. The concentrated sunlight could also proved power to satellites nearby.