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CUBESAT-BASED LASER ABLATION DEBRIS REMOVAL CONCEPT

**Abstract**

Large debris objects in Low Earth Orbit (LEO) pose a significant threat to the safety of current and future space missions, necessitating their immediate removal. Small satellites, such as CubeSats, offer a platform for low-cost debris removal missions that could expedite the realization of effective debris mitigation strategies. In particular, ablative laser propulsion (ALP) stands out as one of the most promising concepts for debris removal, given its efficiency and technology readiness level. This paper presents a low-power Laser Ablation Debris Removal (LADR) system onboard a CubeSat. The resulting thrust force decelerates debris objects and reduces their orbital lifetime. The satellite employs a 64W laser that shoots 6.4 millijoule energy pulses with a repetition rate of 10kHz and a pulse duration of 10 ns. The presented design shortens the propagation distance to 10cm, eliminating the need to track debris. Furthermore, the small propagation distance ensures that the laser energy density on the target is sufficient to initiate and optimize ablation while being achieved with low power. Our concept also eliminates the need to detumble debris before deorbiting, significantly reducing the mission time. The feasibility of the concept is tested in simulated scenarios where the representative debris objects, selected based on their priority for removal, vary in mass and initial orbital altitudes. The calculation of performance parameters considers all of the main constituent materials commonly found in space debris. For all case studies, the system can reduce the orbital lifetimes of debris objects to below 25 years, as recommended by the Inter-Agency Space Debris Coordination Committee (IADC). Extrapolating to longer periods of operation, the laser can be expected to reduce the population of large debris objects in LEO significantly. In conclusion, this research highlights laser ablation propulsion and CubeSats as enablers of efficient, low-cost, and low-power debris removal missions.