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LONG-TERM SUSTAINABILITY OF SPACE OPERATIONS: A LASER-BASED DEBRIS REMOVAL SYSTEM

Abstract

The paper suggests a novel system-based architecture for removing space debris utilizing laser technology. The architecture addresses both large and small debris objects and is designed to operate from a polar location, making it more effective for debris objects in sun-synchronous orbit (SSO). A trade study was conducted to determine the best target orbit for the satellite, with SSO being chosen due to its high debris concentration. The paper analyzes the power requirements for the satellite and selects a fiber-based laser architecture due to its compactness and efficiency. The International Coherent Amplification Network's (ICAN) laser was found to be sufficient for de-orbiting small debris objects (1-10 cm) via laser ablation. Based on ICAN laser specifications, the paper estimates the power requirements for the satellite. The paper also estimates the entire mission lifetime cost, revealing high initial development costs but lower operational costs compared to other debris removal methods. The cost per object removed is calculated for both ground-based and space-based Laser Orbital Debris Removal (LODR) systems. The research discusses the reasons for such a mission, including the need to prevent spacecraft loss to debris collisions and optimize crowded satellite orbits. The proposed architecture provides a commercially viable option for discovering and implementing effective debris removal technologies. In conclusion, this paper suggests a new system-based architecture for space debris removal utilizing laser technology. It addresses the debris objects in SSO and analyzes the power requirements of the satellite. The paper also estimates the entire mission lifetime cost and highlights the reasons for such a mission. The proposed architecture provides a commercially viable option for implementing effective debris removal technologies, which is critical for the long-term sustainability of space operations.

Keywords: Space debris removal, Laser technology, System-based architecture, Sun-synchronous orbit, Debris ablation