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HYPER-VELOCITY IMPACT BASED ORBITAL DEBRIS REMOVAL SYSTEM USING ACTIVE MULTI-LAYERED SHEILDING

Abstract

The detrimental impact of space debris measuring between 1-10 cm on operational satellites is well-documented, as it can cause severe damage to critical components such as solar panels, antennas, and structural elements, thereby compromising the entire mission. Hyper-velocity impact studies have revealed that debris in this size range vaporizes into a plasmatic dust cloud upon impact. This finding has led to the development of a specifically designed Whipple shield that can absorb the plasmatic cloud generated upon penetration, with the aim of removing small/micro debris. Although numerous studies have assessed the efficacy of hypervelocity shields in mitigating space debris, most have failed to concentrate on the capture mechanism of debris. To address this limitation, our proposed innovation suggests a novel approach that enables the removal of multiple pieces of debris in a single mission, thereby enhancing the efficiency and cost-effectiveness of debris removal.

The current paper discusses a numerical simulation aimed at determining the response of various geometrical arrangements of a four-layer debris removal architecture. The architecture comprises a sacrificial self-healing front layer, a self-healing stuffing layer, an adhesive foam layer, and a metallic layer for protection against larger debris. The self-healing front layer vaporizes most of the debris and serves as the first line of defence, regulating the state of the projectile after the primary impact. The self-healing stuffing layer vaporizes any debris that has bypassed the first impact. If any debris withstands both impacts, it becomes lodged in the next adhesively controlled foam layer, which can be manipulated to deorbit the debris. The amelioration for the front sacrificial self-healing layer has seen the usage of ceramic, metallic foams, and super composite mixture which augmented the durability, performance, and safety of the proposed architecture. The paper provides a comparative coverage of the proposed method with traditional small/micro debris removal techniques and assesses its feasibility for sustainable space debris removal from Earth's orbits. The ultimate goal of our research is to make a substantial contribution to the advancement of next-generation space debris removal systems and promote sustainable space debris management.