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BIOGRAB: A BIODEGRADABLE ADHESIVE-BASED CUBESAT FOR SUSTAINABLE LOW EARTH ORBIT DEBRIS CAPTURE

Abstract

Low Earth orbit space junk, comprising hundreds of thousands of objects and aging spacecraft that move at high velocities, is one of the most critical threats to future and current satellite missions. The collision and fragmentation risk poses a threat to current and future operations and necessitates a low-cost and sustainable debris removal imperative. That is where BioGrab comes in—a novel CubeSat mission concept with a biodegradable adhesive for capture of small debris (on the order of 1–10 cm). In contrast to other capture devices that need massive mechanical parts or lasers, BioGrab's adhesive consists of organic polymers, and thus it degrades on re-entry naturally and leaves no toxic residue behind. This has a twofold benefit: it minimizes the potential to create secondary debris and is acceptable to global environmental goals. The CubeSat itself carries onboard a sensor package and artificial intelligence-based navigation system for real-time detection and tracking of debris. Having detected a target, BioGrab deploys an adhesive-coated patch or net to capture the debris and exert drag, which thereafter drags the CubeSat and the fragment it has captured into a controlled deorbit. Engaging passive deorbiting instead of fuel-burning maneuvers, BioGrab reduces operation complexity and cost remarkably. Most notably, the biodegradable nature of the adhesive addresses the primary challenge of space sustainability: keeping the cleanup of space debris from generating more orbital trash in the process. Extensive testing of the polymer's durability under extreme conditions—temperature cycling, vacuum exposure, and high-radiation levels—can establish its feasibility for multi-orbit missions. In addition, BioGrab's compact design makes it a prime candidate for rapid deployment as a single mission or as a constellation to target hotspots of orbital debris. In this way, BioGrab is an example of how forward-thinking engineering coupled with dedication to environmental stewardship can address and counteract one of the largest threats in our increasingly crowded orbital environment.