Key Technologies (7)
Key Technologies (2) (2)

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DESIGN AND ANALYSIS OF A BIO-INSPIRED BOOM OF THE DEORBIT MODULE FOR A SMALL SATELLITE

Abstract

The present paper proposes an innovative design of a de-orbit mechanism for a nanosatellite to address the issue of space debris. The satellite is of 30 x 30 x 15 cm, weighs less than 5 kg and is placed in LEO at 650 km polar sun synchronous orbit. The proposed method involves, unfurling a sail of 6m2 area from a stowed condition guided and supported by a boom controlled by a motor. The increased surface area causes more drag force to act on the satellite hence causing it to lower its altitude into the denser regions of the atmosphere wherein the friction due to particulates causes it to incinerate. Mission analysis using AGI's STK predicts a decay time of 337 days with the dragsail which is within the required time as set by the IADC guidelines. A new idea for the cross-section geometry of the boom is implemented which is inspired by nature i.e., from a palm leaf in which the leaf blade is analogous to the boom and the leaf stalk (petiole) that runs longitudinally and offers stiffness but is also flexible enough to bend easily. The similar analogy is applied to the tape spring boom at the center of which is a small thin strip of flexible metal along its length bonded using a sheath. Theoretical values of stresses, area moment of inertia, and elastic energy are compared with FEA results under different boundary conditions. Cases with different loading conditions including drag force, tension due to the sail on the boom, and solar radiation pressure is also analyzed. The proposed design fits into a compact and modular space which can be accommodated on the satellite without interfering with other subsystems.