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Optimizing Deployable Boom Designs For Stable Operation of Nano-Satellites

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Abstract

Many satellites require the use of deployable booms for various applications, such as separating a scientific payload from magnetic noise sources on the vehicle. However, their use on cube- and nano-satellites presents a number of challenges. These booms can significantly alter the inertial properties and therefore rotational stability of the system, impacting not only recovery from the initial three-axis tumble expected upon deployment into orbit, but also the maintenance of three-axis stabilisation during orbital operations. For spacecraft with limited control torque and small bus moments of inertia, the impact of the relatively large deployed boom can be significantly destabilising. Here we outline a process for the optimisation of the hosting of booms with lengths longer than the longest dimensions of the bus, using the boom to tune the inertial parameters of the boom plus bus system. The investigation builds on previous work designing an articulated deployable boom for CubeSatellite applications. Recommendations are made for design changes that allow the boom to be used to optimize the rotational stability of the overall system as desired. To provide context, the relationship between the mass properties of the system and rotational stability are also discussed.

The deployable boom presented in the case study is designed for use on 3U and 2U CubeSatellites, specifically the Ex-Alta 2, AuroraSat, and YukonSat student-led missions. The boom has a mass of 70 to 80 grams and carries a 55 gram scientific instrument. The boom has a two-member design, is mounted on the exterior of the spacecraft, and utilizes two joints to achieve a total length approximately twice that of the longest face of the CubeSat. The recommended design changes include the addition of two machined features that control the angle at which the elbow and shoulder joints rest in their respective fully deployed positions. The key considerations for the optimization include ensuring dominance of the nominally orbit-normal moment of inertia and the minimization of products of inertia with respect to the axes of the attitude control actuators. The design solution is independent of the other characteristics of the boom and does not affect the interface with the satellite, allowing the deployment angles to be easily modified late in the design cycle to optimize the finalized mass properties of the system.