SPACE PROPULSION SYMPOSIUM (C4)
Advanced and Combined Propulsion Systems (8)

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HELIOGYRO-CONFIGURED SMALL SPACECRAFT SOLAR SAIL

Abstract

In order to enable long term multi-mission capabilities from a single space vehicle, there is a need to develop a highly efficient propulsion-navigation system that enables multi-mission capabilities, point-to-point operation and extended operational lifetime. The majority of space propulsion systems are fuel-based and require the vehicle to carry and consume fuel as part of the mission. Once the fuel is consumed, the mission is set. Alternatively, a method that derives its acceleration, velocity and direction from solar photon pressure using a solar sail to capture photon momentum, would eliminate the requirement of fuel and all the components needed to achieve single and multi-mission mission objectives. The study from MacNeal in the 1960s [1] theorized that the heliogyro-like architecture would be lighter, easier to stow, less costly to make, and less risky to deploy a large solar sail area than a square sail. Longer booms in a square sail configuration, result in both chaotic and uncontrollable deployment [2] with a burdensome increase in vehicle weight. With a heliogyro, the solar sail membrane is stowed as a roll of thin film that forms a blade when deployed, and each blade can extend up to kilometers [3, 4]. Thus, a benefit of using a heliogyro-configured solar sail propulsion technology is the mission scalability, as compared to the square versions, which are size constrained.

This paper introduces potential missions that can be achieved from heliogyro-configured solar sail spacecraft. It then presents 26 configurations of heliogyro small spacecraft solar sail, based on CubeSat-scale units from 3U to 48U (1U = a cube 10cm on each side) and compares their characteristic accelerations to IKAROS [5], and NanoSail-D [6]. Solar sail areas and total CubeSat masses are compared to their characteristic accelerations. The analysis in this paper predicts that one of the 26 configurations has the maximum and minimum characteristic accelerations of 270 and 130 times greater than the IKAROS, respectively. This same configuration has the maximum and minimum characteristic accelerations of 70 and 30 times higher than the NanoSail-D, respectively.

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