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ELECTRIC SAIL PROPULSION FOR DEEP SPACE MISSIONS

Abstract

Electrostatic Sail (E-sail) propulsion extracts momentum from the solar wind, which has minimal speeds of 400 km/sec, through electrostatic repulsion of the positively charged solar wind ions. This momentum exchange is accomplished by an array of multi-kilometer length charged tethers biased to a high positive voltage. The positively charged solar wind protons are deflected by the electric field created around the tethers. This electric field grows in diameter as the spacecraft moves away from the sun; therefore, the E-sail effective area grows. The growth of the E-sail effective area allows the created propulsive force to decrease at a linear rate (1/r) up to distances of 20 AU as it moves away from the sun, unlike solar sail propulsion whose thrust decreases at a rate of 1/r2 but only to distances of 5 AU. This propulsive force is created without using propellant.

Although the thrust generated by an E-sail is low, it can be applied continuously over a period of years (depending on the type mission), and can push a 500 kg spacecraft to tremendous velocities—as high as 12 Astronomical Units (AU) per year—making the voyage to 600 AU in as few as 50 years after launch.

The NASA Marshall Space Flight Center recently completed a NASA Innovative Advanced Concept (NIAC) study in which all of the major system and subsystem level aspects of the Electric Sail were assessed and a maturation plan was developed. If implemented, Electric Sail propulsion could be a viable option for mission implementation within a decade. The MSFC effort included scaled plasma chamber experiments that validated the predicted performance of the E-Sail. Based on the testing, a physics model of the E-Sail was developed and used to predict system performance under varied conditions.