

Attitude Control System for the Solar Cruiser and Future Solar Sail Missions

Keith Clements, Daniel Tyler, Benjamin Diedrich, Juan Orphee, Andy Heaton

NASA George C. Marshall Space Flight Center, Huntsville, AL, 35808, USA

NASA's Marshall Space Flight Center (MSFC) is developing the Solar Cruiser solar sail mission to continue to mature solar sail propulsion. Solar Cruiser is a 95kg spacecraft capable of deploying a 1654 square meter solar sail. Solar Cruiser will demonstrate science observation capabilities and navigation in sub Lagrange Point (L1) halo-orbits. Solar Cruiser sail technology can be scaled to larger solar sail missions, including attitude control system and sail membrane and boom technology. Larger solar sails could be used to image the solar poles, enabling Solar Polar Imager (SPI) missions currently prohibitively expensive for propellant-based propulsion methods. Similarly, solar sails can be used to create artificial equilibria and indefinite station-keeping at locations sunward of Lagrange Point one, L1, along the Sun-Earth line (SEL), which can provide space-weather monitor and prediction and reveal discoveries about our Sun and solar system. To achieve the high characteristic acceleration required for larger solar sail missions such as SPI, a solar sail area of approximately 7000 square-meters would be needed. In comparison, the largest solar sail flown to date is the JAXA's IKAROS mission with a 196 square-meters sail. Attitude control on SPI-size sail poses challenges, including station keeping under solar sail induced torques and thrust vector pointing. In this study, the scalability of the Solar Cruiser sail attitude control architecture to larger sails is studied, such as pointing control performance, mass and power requirements. Solar Cruiser attitude control actuators include propellant-based, such as ion engines, and propellantless options which create differential solar pressures to generate spacecraft torques. Propellantless attitude control includes active translation of the center of mass, Reflectivity Control Devices (RCDs), and tip vanes. The study summarizes the scalability characteristics of the different attitude control architectures for larger solar sail missions.