REFLECTIVITY CONTROL DEVICE (RCD) MOMENTUM MANAGEMENT FOR SOLAR CRUISER AND FUTURE SOLAR SAIL MISSIONS

Daniel Tyler*, Andrew Heaton†, Juan Orphee‡

Solar sails provide propulsion from solar photonic pressure without the need for propellant. This advantage can be reduced or eliminated if propellant is required for attitude control. The current state of the art for solar sail attitude control is that of the solar sail mission Near Earth Asteroid (NEA) Scout, which employs an Adjustable Mass Translator for pitch and yaw momentum management of reaction wheels, but must use a cold gas Reaction Control System for roll axis momentum management. It is highly desirable for solar sails to use an attitude control system that does not include propellant, so here we present a novel method of managing momentum on the roll axis.

For the upcoming Solar Cruiser solar sail mission, for roll axis momentum management we plan to use Reflectivity Control Devices (RCDs), thin-film Polyimide Liquid Crystal Devices that are capable of changing optical properties on command, thus affording the opportunity to provide "photonic only" control if placed appropriately on the surface of the sail. RCD design for roll momentum management is multifaceted, and must include performance (degree of change in optical properties), RCD array size, locations of clusters on the sail, orientation with respect to the sail plane, and orientation out of the sail plane. Here we provide an explanation of the basic technology, optimal orientation, sizing, and location of RCDs, results of trade studies for Solar Cruiser, lessons learned from Solar Cruiser, and scalability for future solar sail missions. RCDs will dramatically improve the performance of the Solar Cruiser Momentum Management System compared to that of NEA Scout and will continue to benefit other future solar sail missions.

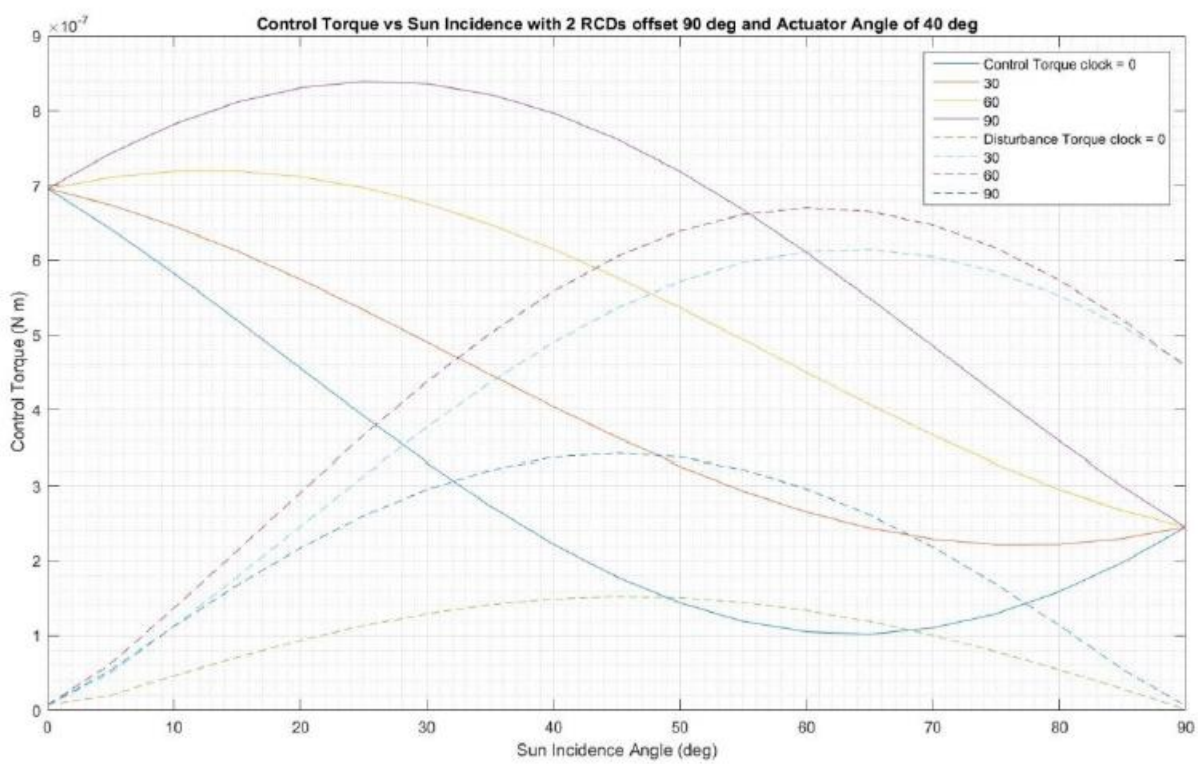

Figure 1) RCD Control Torque/Disturbance Torque Comparison of RCDs

* Aerospace Engineer, Guidance, Navigation and Mission Analysis Branch, NASA Marshall Space Flight Center, EV42 MSFC Huntsville, AL 35812.
† Team Lead and Senior Aerospace Engineer, Guidance, Navigation and Mission Analysis Branch, NASA Marshall Space Flight Center, EV42 MSFC Huntsville, AL 35812.
‡ Senior Aerospace Engineer, Guidance, Navigation and Mission Analysis Branch, NASA Marshall Space Flight Center, EV42 MSFC Huntsville, AL 35812.

Figure 1 shows performance of RCDs for control as a function of sail sun incidence angle and clock angle for a particular RCD design of a 90 degree offset angle and 40 degree actuator angle. The offset angle is the angle of two RCD surfaces with respect to each other in the plane of the sail, while the actuator angle is the angle out of the sail plane of both RCDs. In this study we attempted to find the minimum area of the RCDs to cover a disturbance torque up to the operational sail sun incidence angle limit of 50 deg. It can been seen that the RCDs meet or almost meet this requirement.