

Three-Axis Solar Sail Control

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Three-axis control of a solar-sail-driven interplanetary spacecraft is proposed. The attitude control system will be responsible for ensuring that the steering angle between the force and velocity vectors is within the tolerance necessary for an interplanetary voyage. This steering angle is dependent on the mission parameters and the orbital position of the spacecraft. It, and the sun vector, will be treated as external commands to the system. The spacecraft will perform all its thrusting in the orbit plane.

The primary actuation mechanism will be a gimbaled control boom between the sail subsystem and the spacecraft bus, which contains the majority of the spacecraft mass. Roll stabilization will be provided by vanes at the edges of the sail. Star trackers and gyros will be the sensors that determine attitude and rate.

The state-space model is expected to have 8 states: the sail attitude (three Euler angles), sail angular rate (three axes), the gimbal angle, and the gimbal angle rate. Depending on the vane implementation, there may be up to two more states for vane angles.

The sail and boom will be modeled as rigid bodies, justified by the slow actuation of the gimbal throughout the flight. The sail will be modeled as a thin plate, rather than a billowed sail. Gravity gradient and solar pressure torques (about the non-steered axis) will be controlled against. Disturbance torques from thruster firings may also be modeled.

The state-space model will be obtained in a similar manner to that presented by Wie. The equations of motion for a gimbaled thrust vector are obtained for the yaw axis. The vanes for pitch and roll control will also be implemented similarly, but in such a way that the roll and pitch control torque-coupling can be compensated for.

System performance will be judged by the response to errors, both with a step-error and a flight-like error where the steering angle constantly-but-slowly changes. Mitigation of disturbance torques will also be examined.

Bibliography

Bong Wie. "Solar Sail Attitude Control and Dynamics, Part Two", Journal of Guidance, Control, and Dynamics, Vol. 27, No. 4(2004), pp. 536-544.