31st IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Generic Technologies for Small/Micro Platforms (6A)

Author: Mr. Ivelin Penchev
Space Inventor, Denmark

Dr. Mads Taul
Space Inventor, Denmark
Mr. Jens Duedahl Nielsen
Space Inventor, Denmark
Mr. Johan De Claville Christiansen
Space Inventor, Denmark

AUTOMATED REACTION WHEEL DESATURATION USING VECTORING ELECTRIC PROPULSION IN GEO

Abstract

Reaction wheel off-loading is necessary for ensuring controllability, reducing power consumption, and increasing reaction wheel lifetime. Existing strategies for reaction wheel off-loading in GEO require the use of extra propellant for thrusting in specific attitudes or the use of additional actuators or mechanisms. This paper presents a method for reaction wheel momentum dumping using electric propulsion with thrust vectoring, and on-orbit data from verifying the method on a geostationary CubeSat. The algorithm provides wheel off-loading regardless of spacecraft attitude, and without the need for extra propellant, since it is integrated into the nominal station keeping and orbit slot transfer maneuvers. The algorithm consists of an initial step for calculating the thruster misalignment with respect to the spacecraft's center of mass. Then, the optimal thrust angles are computed based on real-time reaction wheel momentum data and thruster characteristics. As a final step, the change in thrust direction is given as input to the attitude control system, which aligns the new thrust vector to the desired direction of thrust, which ensures that the original maneuver performance is not compromised. The paper presents data and lessons learned from implementing and verifying the algorithm on the GS-1 CubeSat during a GEO orbit slot transfer phase. The data shows that during one day of nominal maneuvers, the algorithm can dump up to 30% of the total reaction wheel momentum capacity. This allows for a decrease in the reaction wheel power by more than 50% since lower momentum allows for reducing the reaction wheel operating speed. Integrating the algorithm in the nominal maneuver procedure alleviates the need to perform specific momentum dumping maneuvers, thereby decreasing satellite downtime. Furthermore, lowering the satellite net momentum reduces the effects of gyroscopic stiffness, thereby improving controller settling time during attitude changes.