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INNOVATIVE ARCHITECTURE OPTIMIZATION APPROACH FOR HIGHLY RELIABLE SATELLITE ATTITUDE CONTROL

Abstract

A reliable attitude control is mandatory for the success of each satellite mission. In order to perform a correct satellite system reliability analysis, the reliability of an Attitude and Orbit Control Subsystem (AOCS) needs to be estimated by a series of three system blocks in a reliability block diagram representing each of the three system axes. If the integrated AOCS actuators, such as reaction wheels, magnetorquers or thrusters, fail to provide the required torque for a certain maneuver along one system axis, the satellite can no longer be stabilized or correctly reoriented resulting in an inoperable overall system condition.

However, due to continuously changing environmental and system conditions during satellite operation, the identification of component failure and performance degradation scenarios leading to an insufficient torque generation is a challenging task. For example, the magnitude and direction of Earth's magnetic field vector, influencing the impact of a satellite's magnetorquers on the overall torque generation process, depends on a satellite's in-orbit position. Because of this, the maximum torque of each magnetorquer is continuously changing especially in the case of elliptical and inclined orbits, so that potential simplifications can no longer be assumed due to the high variations. Furthermore, in the case of integrated gas thrusters, the reliability of torque generation depends on the initial propellant mass, the thruster's propellant consumption per in-orbit maneuver and the number of in-orbit maneuvers during the overall satellite mission. Thus, in the case of propellant shortage, the reliability of a thruster system is no longer given.

In order to face these challenges in AOCS reliability analysis and reliability optimization, the Institute of Space Systems (IRAS) of TU Braunschweig and reliability consultant company SAREL Consult GmbH developed, as part of the current transfer project MiRel (Mission Reliability), a new methodological approach for an AOCS reliability analysis including the contribution of each AOCS actuator to the overall torque generation process for each system axis. The approach especially considers the actuators' orientation inside the satellite system and their individual degradation processes. With the help of an additional importance analysis, critical components inside the AOCS architecture can be identified due to their contribution to overall system reliability, allowing a cost-efficient system reliability optimization by simple reorientation or reinforcement of the AOCS actuators. The following paper will give an overview over the described methodological approach and its upcoming implementation in a software tool for future application in space industry.