22nd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Interactive Presentations - 22nd IAA SYMPOSIUM ON SPACE DEBRIS (IPB)

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POST-DOCKING SPACECRAFT SYSTEM IDENTIFICATION TO ENHANCE STACK ATTITUDE CONTROL

Abstract

In light of numerous matured satellites in geosynchronous orbit that remain operationally capable but possess ageing ADCS, there has been a notable surge in interest regarding Orbit Servicing. The present work proposes a design and verification approach for the inertial and mechanical properties identification of an orbiting stack composed by two docked spacecrafts, with only one of the two being in charge of the composite attitude control. As a case study, the mission extension between MEV-1 and Intelsat-901 is considered, and CAD models of both satellites are developed to emulate the inertial data. The dynamic is simulated considering each satellite as a rigid body, while the docking is represented by a visco-elastic link. System identification is approached by considering a white box model and the family of data-fitting algorithms using Nonlinear Programming. The strategy here proposed sees two dynamical models of increasing complexity: a single body model, which considers the assembly as a whole spacecraft, and a double body model, which considers each spacecraft individually, exploited to simulate the attitude dynamics. The system identification procedure follows five sequential steps, each retrieving the inertial data fed in the next. The core of the proposed approach is based on the actuation of known torques and forces, and the sampling of rotational velocities data to regress on. The first three steps follow the simplification of the single body model to retrieve an accurate estimation of the inertia matrix and the center of mass of the whole assembly. The fourth and fifth steps retrieve the inertia properties of each body and the mechanical properties of the link between the two satellites respectively. The architecture is tested on different orbital conditions: Geosynchronous Earth Orbit and Medium Earth Orbit, to assess the error-filtering capability of the fitting algorithm. A sensitivity analysis is carried out to explore the identification strategy robustness to uncertainties. Norm and orientation deviation in the control vector are considered, as well as angular velocity sensor measurements limited accuracy. The paper critically shows results on the use case adopted and on the test campaign occurred, to compare the control effectiveness before and after the identification procedures on different control modes: Inertial pointing, Repointing and Tracking. The control test certified an improvement in terms of time response after the system identification in each control mode, and a significant improvement in accuracy for inertial pointing mode.