Paper ID: 52820
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IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (6)

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RAPID FUNCTIONAL VERIFICATION OF ATTITUDE CONTROL ALGORITHMS ON A SPACECRAFT MOTION PLATFORM WITH CONTROL MOMENT GYROSCOPES

Abstract

Advanced requirements for attitude control of future spacecraft, e.g. high agility or large flexible structures, force the development of cutting edge control methods, such as innovative steering approaches for control moment gyros (e.g. novel momentum based steering) or control of flexible appendages. Experimental verification of prototype algorithms on the ground based satellite demonstrator INTREPID allows a quick increase of the technology readiness level. This aims at the development of new algorithms for unprecedented challenges, applications and hardware architectures. The model-based development is thus verified by hardware in the loop tests with INTREPID, which is a three degrees of freedom motion platform.

The INTREPID satellite demonstrator emulates the spacecraft attitude dynamics on ground. It is fully equipped with four control moment gyros for agile and precise attitude control, an automated mass-balancing system, gravity torquers (emulating magnetic torquers) for offloading of the control moment gyros, an inertial measurement unit and a star tracker like absolute attitude determination system. It is fully integrated into a model-based development environment in Matlab/Simulink and enables rapid prototyping and functional verification of new attitude control architectures and algorithms for future missions.

The functional verification of attitude control algorithms through hardware experiments requires the scaling of the algorithm parameterization and scenarios from the dimensions of a specific mission to the satellite demonstrator. This paper discusses and evaluates different aspects of the parameterization and scenario scaling for meaningful and representative experiments for realistic study cases. This addresses for example functionality and stability of the closed-loop, damping of flexible modes as well as the functionality of optimal steering laws for arrays with more than three physically constrained CMGs.

Experimental verification with the help of appropriate scaling laws has proven to provide a significant advantage in the early development of innovative attitude control algorithms, especially for highly agile missions.