IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

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DEVELOPMENT OF A HARDWARE-IN-THE-LOOP ATTITUDE CONTROL SIMULATOR FOR EIRSAT-1, A MAGNETICALLY ACTUATED 2U CUBESAT

Abstract

Hardware testing of satellite attitude control systems is a challenging problem because the attitude dynamics of a satellite in the space environment must be recreated under Earth's gravity. The usual approach is to simulate microgravity using a spherical air bearing, but this presents several difficulties. To eliminate gravitational disturbances requires very precise matching of the mass centre position and the bearing centre of pressure, so these test rigs are usually prohibitively expensive for CubeSat missions. In addition, a) the inertia properties of the hardware mounted on the test rig are different from those of the satellite in its final configuration; b) most rigs provide limited rotation in all but the vertical axis: c) the spherical air-bearing set-up is useful only for rigid spacecraft whose mass centre remains fixed with respect to mounting points; and d) the minute torques from magnetorquers are swamped by friction and disturbances. Therefore, many CubeSats rely solely on Processor-In-the-Loop testing of control algorithms.

This paper details the development of an attitude control testbed allowing Hardware-In-the-Loop (HIL) testing using an alternative to the air-bearing, addressing the associated difficulties. In this scheme the satellite ADCS hardware is mounted on a gimballed platform which rotates in all three degrees of freedom. The attitude dynamics of the spacecraft are well understood and can be simulated accurately in a real-time MATLAB/Simulink model. The real actuator outputs are sensed using a data acquisition system and fed into the simulation model which then commands the platform angles according to the

satellite dynamics. This scheme offers several advantages. Earth gravitational disturbances are eliminated. Satellites with flexible appendages and fuel sloshing dynamics may be tested. Disturbances to the attitude experienced in space may be modelled, including gravity gradient, solar pressure, internal magnetic dipole and aerodynamic torques. Exact physical properties of the satellite may be modelled. Slip rings on the gimbal platform allow continuous three-axis rotation.

Preliminary results are presented and compared with simulations for HIL testing of the EIRSAT-1 ADCS system. EIRSAT-1 (Educational Irish Research Satellite) is a 2U CubeSat. It is the first Irish satellite, being developed by students and staff at University College Dublin, under ESA's Fly Your Satellite! programme. EIRSAT-1 will test a novel control strategy called Wave-Based Control (WBC) which is particularly effective for controlling flexible systems.