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MODELLING AND SIMULATION OF AN ON-ORBIT EXPERIMENT FOR TESTING A NOVEL ENGINE TECHNOLOGY

Abstract

The paper describes the design and modelling of an on-orbit mission experiment for testing a novel engine technology in space, which will be tested as a payload of an in-orbit CubeSat carrier. The development of an orbit and attitude simulator is exploited to model the expected on-orbit results on the response of the attitude control of the carrier satellite during the different phases of the experiment, under the effect of natural perturbations and the expected thrust action of the novel engine. The analysis of the simulator results, in terms of rotation of the satellite under the effect of the engine, and of the in-flight data allow to reconstruct a model of the engine thrust. The simulation tool developed at Politecnico di Milano is built in Matlab and Simulink, it is initially designed as a general orbit and attitude simulator to propagate the free dynamics under the effect of the main environment perturbations modelled. The tool is then adapted to simulate the on-orbit experiment given the information on the novel engine expected action and the mass and structure properties of the carrier satellite, its sensors and actuators sets and its PID attitude control system. Input switches to the simulator allow to turn on and off the environment perturbations to determine the main influences on the dynamics. The orbital motion develops under the influence of the Earth's tides-free spherical harmonics gravity attraction; the atmospheric drag that acts on the satellite in Low-Earth-orbit, adopting the NRLMSISE-00 atmosphere model; the solar radiation pressure cannonball model, accounting for eclipse phases, and third body attraction of the Moon and the Sun, modelled as point-masses. The attitude dynamics is perturbed by the gravity gradient torque generated by a spherically symmetric Earth gravity field; the torques generated by atmospheric drag and solar radiation pressure acting on each satellite surface, simply modelled as a cuboid; and the disturbances of the IGRF geomagnetic field model. Each element of the simulator is validated prior to the on-orbit experiment and adapted to the case at hand matching orbit and attitude data from a previous similar mission of the satellite carrier. During each phase of the mission experiments, the simulator is validated both in free and controlled motion to accurately reproduce the on-orbit outcome and then exploited to predict the mission results and analyse the in-flight data on the satellite state and attitude evolution and control action. Goal is to model the novel engine thrust profile through a reverse engineering approach. The phases of the mission will be described and the inflight data shown.