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ATTITUDE DYNAMICS ANALYSIS OF AALTO-1 SATELLITE DURING DE-ORBITING EXPERIMENT WITH PLASMA BRAKE

Abstract

Aalto-1 is a University Cubesat mission carried out by a consortium of Finnish universities and RD institutions. The project is lead by Aalto University's School of Electrical Engineering. The satellite is designed to have a two-phased science mission. The first six months of the mission is dedicated to remote sensing experiments, executed with on-board imaging spectrometer and a radiation monitor.

The second mission phase is de-orbiting device test, conducted with Electrostatic Plasma Brake (EPB) instrument. This payload and de-orbiting concept is developed by the Finnish Meteorological Institute (FMI) and it is based on the principle of the electric solar wind sail. It uses of a long thin charged tether which will experience a Coulomb drag from the plasma whenever the plasma is moving with respect to the tether.

The de-orbiting device test is divided into four sub-phases to obtain all the needed measurements to prove this concept. The EPB experiment phase begins with spinning up of the satellite using magnetorquers to angular speed of 200 deg/s while maintaining the satellite's rotation vector parallel to Earth's. This is needed to keep the tether stretched by centrifugal force during the deployment. The EPB tether will then be deployed to a length of 10 m, using a motor in the EPB system. An analysis has been made to determine that the tether-plasma interaction can be observed from the change in the spin rate of the satellite. The tether will be activated close to the poles, with positive and negative voltages, in order to take advantage of the orientation of Earth's local magnetic field. The third sub-phase includes further reel-out of the tether up to a 100 m length.

In this last phase of the EPB experiment, the satellite's spin rate is brought down by tether extension to around 10 deg/s. The charged tether then exerts a force against the direction of orbital velocity and brakes the satellite into Earth's atmosphere. The collected satellite position, attitude, spin rate, EPB tether charge and satellite deceleration rate measurement data will be sent to the ground station during each pass. The dynamics, ADCS's operation and effects of the force exerted by the deployed and charged tether have been analysed in different phases. Also, the preliminary simulations of its behaviour coupled with the satellite's ADCS have been performed.