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ON-ORBIT ADCS SENSOR EVALUATION ON ESA'S OPS-SAT MISSION

Abstract

The 3U CubeSat OPS-SAT is an ESA spacecraft built by TU Graz and launched in December 2019 into a sun-synchronous (SSO) orbit. It is an open platform for on-orbit experiments, submitted by industry and universities. To boost technology development, OPS-SAT provides the opportunity to conduct tests directly in space on one of its many payloads: A coarse and fine attitude determination and control system (ADCS), S-Band, X-Band and UHF communication chain, a software designed radio (SDR), an optical uplink and an HD camera, all controlled by a powerful ARM based system on chip, coupled with an FPGA. OPS-SAT's coarse ADCS relies on four different types of sensors: A magnetometer, a gyroscope, a fine sun sensor (FSS) and a set of six photodiodes (PDs), one on each side of the spacecraft. Not without its teething problems, many adjustments had to be performed on the cADCS sensors, by modifying the outdated pre-launch calibration to improve sensor accuracy. On-orbit calibration of the magnetometer is performed by comparison of the measured magnetic field with the IGRF13 reference magnetic field with the least squares method, by putting the spacecraft in a defined operational state. The pre-launch calibration of the photodiodes uses a theoretical maximum light flux intensity and needed significant adjustment in flight, to allow for useful solar elevation angle detection. On a first iteration, the photodiodes are calibrated against the FSS as a relative reference. Further improvements are made by creating a geometrical model, combining a set of three PDs to represent the incoming solar vector and to derive the individual PD gains by parameter fit. As only learned during the mission, the calibration of the commercial off-the-shelf (COTS) FSS unit is unreliable. To improve the situation, the only option is to use on-orbit telemetry as a reference, resulting in lower overall accuracy, compared to proper ground calibration. A detailed analysis of the accuracy between cADCS outputs and sensor inputs is presented, by comparing the modelled reference magnetic field and sun vector with the data captured by the magnetometer and the optical sensors. This analysis is extended by comparing the original, pre-flight calibration with later improvements and by discussing the observed deviations in sensor accuracy during Eclipse season of the OPS-SAT SSO.