Paper ID: 50700
oral

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (5)

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CONTROL OF AN OVER-ACTUATED SPACECRAFT USING A COMBINATION OF A FLUID ACTUATOR AND REACTION WHEELS

Abstract

In 2017, Technische Universität Berlin has launched the first space-rated fluid-dynamic actuator on the TechnoSat mission. This type of actuator is unique with respect to its dynamic properties, as it offers a very high torque but limited angular momentum storage capabilities in comparison to reaction wheels. In combination with the tetrahedron reaction wheel assembly featured on the spacecraft, a unique combination of attitude control actuators has been formed. The spacecraft axis parallel to the fluid-dynamic actuator is over-actuated, featuring control actuators of contrasting nature which offers novel options in terms of spacecraft operations. However, with the camera axis on TechnoSat being aligned parallel to the actuator's axis of rotation, there is limited operational use to this setup.

With BEESAT-9, which is to be launched in 2019, Technische Universität Berlin currently plans to be the first institution to launch a CubeSat that features a set of three orthogonal reaction wheels and a single fluid-dynamic actuator for attitude control. The camera axis of BEESAT-9 is perpendicular to the actuator axis, and therefore allows the demonstration of the proposed novel modes of operation. Among the proposed modes is an artifical increase of the swath and the acquisition of stereo images of multiple, successive targets on the ground. Crucial to these operation scenarios is the control allocation between the reaction wheel assembly and the single fluid-dynamic actuator.

This paper first describes the proposed novel modes of operation that are enabled by the actuator combination realized on BEESAT-9, followed by a review of the state of the art of control allocation for over-actutated spacecraft. The main part of the paper comprises a description of the implementation of the dynamics models of the attitude control actuators and spacecraft, followed by a description of the implemented high-level control laws and control allocation methods. Finally, simulation results are appended and discussed in comparison to on-ground experiments conducted using the BEESAT-9 engineering model on an attitude control testbed.