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AN INNOVATIVE MISSION CONCEPT TO INFER UPPER THERMOSPHERE DENSITY USING A TORQUE-BALANCED CUBESAT

Abstract

As the number of spacecrafts in Low Earth Orbit increases, so does the need for high accuracy predictions of their trajectories to better calculate collision risks and reentry locations. Better knowledge of the upper thermosphere density is thus required to complement the existing data of opportunity collected by CHAMP, GRACE, GOCE and Swarm missions. The need for improved measurements and models of the thermosphere have been highlighted in many publications for years, but such studies onboard CubeSats have only recently begun to be implemented, such as with the launch of SOAR in 2021. The present proposed mission aims to prove CubeSat interest in such atmospheric issues. An innovative mission concept is proposed on a 6U CubeSat, based on the torque-balanced mechanism and relying on actuated solar panels, new fiber-optic gyroscopes and reaction wheels data. Two configurations are studied depending on altitude: the windmill configuration with counter-rotated panels and 0/90 configuration with a parallel and a perpendicular panel in respect to the airflow. This article validates the science case of a torque-balanced mission to infer air density of the upper thermosphere, and studies impacts of this innovative concept on mission design, especially power generation and attitude control. Feasibility of the concept is proved using a dynamic Simulink model adapted from the EntrySat mission, showing that at 600 km of altitudes, a retrieved density error of less than 3Such an innovative concept brings system constraints which are further elaborated in this article. Power and attitude control issues are developed to reunite scientific and engineering requirements. For power, a mission analysis is performed to show what is the range of possible power generation, and which choices have to be made to ensure a sufficient amount of power onboard for the entire mission. In terms of attitude control, regular solar panels flips are taking advantage of system design to desaturate the main working axis. However, the secondary axis felt a near-zero average torque but saturate slowly wheels on medium-term, implying a need to integrate an additional control instrument, such as thrusters. The article focuses on validating the science case, building a noise model of the experiment, and consolidating concept of operations by analyzing potential difficulties on attitude control and power generation. This includes creating a self-consistent overall spacecraft and mission model and performing simulations of the mission and experiments to demonstrate adequate performances. With this Phase 0 presentation of a torque-balanced mission to infer air density in the upper thermosphere, the authors call for more work in this field to make it a reality, in particular on attitude control.