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A NANOSATELLITE OPERATING IN THE VAN ALLEN BELT: THE LESSON LEARNED FROM THE ASTROBIO CUBESAT MISSION

Abstract

The 3U AstroBio CubeSat (ABCS) was a nanosatellite mission funded by the Italian Space Agency with the goal of validating novel lab-on-chip technologies and analytical methods for research in astrobiology using CubeSat platforms. ABCS was launched on July 13th, 2022, as a secondary payload of

the Vega-C. It was deployed in a circular orbit with an altitude of about 5900 km and an inclination of about 70°, crossing the inner Van Allen belt. In this harsh environment, it was known from the design stages that the operative life of the satellite could be significantly shorter than that expected in low Earth orbits. Consequently, two major challenges characterized the ABCS mission: (i) the need to ensure for the payload an operative environment with atmospheric pressure and regulated temperature, required by the chemical reagent, and (ii) the need to operate the payload in the shortest possible time from the deployment, to prevent any early failure caused by high-energy particles in the Van Allen belt. The design of innovative solutions to meet the mission requirements and the analysis of their performance from flight data are the subject of this research. The payload was housed in a hermetically sealed box, ensuring both the ambient pressure environment and shielding from the ionizing radiation. A closed loop thermal control system was implemented inside the box, relying on convective heat transfer to modulate the radio beacon interval generating enough power to heat the box and keep it within the temperature range [+5, +25] °C. Flight data indicate that the system operated correctly and was pivotal in ensuring proper operative conditions. The ABCS firmware implemented self-check and self-repair routines to autonomously manage the critical errors arising from the charged particle irradiations using a scheduler based on evaluating the satellite status. The use of RADFETs onboard allowed monitoring the radiation dose and validating the performance of both the firmware design and the box shielding effect. The lab-on-chip device consisted of a glass substrate on which an origami microfluidic paper-based analytical device (μPAD) is attached. To prevent degradation, test chemicals were deposited in a dry form in the layers of the μPAD and the fluid was delivered, by means of pumps, only during the experiments. Wet sensors were included to verify the delivery of the fluid and allowed validating that the device properly operated, even though experiments data were not collected due to an anomaly under investigation.