Deep space radiation characterization onboard NASA's BioSentinel CubeSat

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ABSTRACT

BioSentinel is the first biological CubeSat developed to travel beyond low Earth orbit (LEO). It is one of ten secondary payloads deployed from NASA's Artemis I rocket on November 16, 2022. BioSentinel aims to develop an instrument capable of supporting biological organisms and to characterize the deep space radiation environment in preparation for future human exploration. To achieve these goals, the BioSentinel CubeSat carried two science payloads, a microfluidic-based instrument called BioSensor and a space radiation detector. In order to support, detect, and measure microbial cell growth and metabolic activity, the BioSensor has dedicated thermal control and optical measurement capabilities. The radiation detector measures the ionizing radiation dose and provides particle spectra based on their linear energy transfer (LET). Prior to Artemis I, identical instruments launched to the International Space Station (ISS) in late-2021, where they were successfully tested and validated. After launch and deployment, BioSentinel performed a lunar fly-by and reached a stable heliocentric orbit a few days later to initiate the science phase of the 6-month nominal mission. Even though all the payload and satellite instruments performed well early into the mission, the microfluidic subsystem inside the BioSensor experienced anomalies a few weeks after launch. It was decided to turn off the BioSensor to avoid compromising the other subsystems. The LET spectrometer continues to work nominally and has detected multiple solar particle events (SPEs) during the past 2.5 years and throughout solar maximum. As of July 2025, the satellite is currently at ~70 million kms from the Earth, communicating via the Deep Space Network (DSN) once per week. Despite its accomplishments, BioSentinel has faced many challenges that have contributed to lessons learned for upcoming missions beyond LEO, including the Lunar Explorer Instrument for space biology Applications (LEIA) mission, launching to the Moon on a commercial lander no earlier than 2027.

***Keywords*:** BioSentinel, biological CubeSat, deep space, space radiation, biosensor