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**Abstract: BioSentinel Deep Space CubeSat Mission**

The BioSentinel mission was recently launched aboard the SLS launch vehicle (LV) as part of the Artemis-1 campaign. This 6U CubeSat carries yeast cells to analyze the effects of radiation at large distances from Earth, becoming the first biological payload in Deep Space. Prelaunch activities included mission design updates, orbit determination rehearsals and the development of a tracking schedule in coordination with the Artemis-1 payload office and the Deep Space Network (DSN). An important influence on the trajectories of Artemis I secondaries was the uncertainty associated with deployment from the Interim Cryogenic Propulsion System (ICPS), the upper stage of the SLS LV. The ICPS was rotating at a rate of 1 rpm; there was also uncertainty in the spin axis attitude, which translated into an unknown clock angle of deployment. The variability in this angle and magnitude of deployment implied the existence of a non-negligible risk of a lunar impact, which was evaluated for various potential launch dates.

On November 16th 2022 BioSentinel successfully deployed from ICPS and the navigation team started to receive tracking data from the DSN and ESA antennas. Soon after deployment, the spacecraft was tumbling and entered safe mode. The mission team recovered the spacecraft and after four tracking passes, we solved for a first ephemeris that was sent to the DSN for better tracking of the spacecraft. After propagating this first ephemeris solution, we determined that we avoided impact with a margin of a few hundred km from the lunar surface. More tracking data over the next few days allowed for a more refined orbit solution predicting a periselene altitude of 406 km and a lunar eclipse lasting 36.5 minutes. Therefore, BioSentinel operators avoided any correction maneuvers on the trajectory and successfully tracked and guide the spacecraft.

The spacecraft performed a nominal lunar flyby which provided the pertinent energy to achieve a final Earth-trailing heliocentric orbit. Over the course of two weeks, the mission operators corroborated that the subsystems were functioning as expected after the lunar eclipse and the large ΔV incurred. Science operations started once the mission achieved the nominal orbit in Deep Space.

This paper discusses in detail the BioSentinel flight performance, as well as the challenges and lessons learned prior to and during this CubeSat mission.