

BioSentinel: Leading the Way for Deep Space CubeSat Missions

National Aeronautics and Space Administration



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Mission Overview

BioSentinel, a 6U spacecraft launched on Artemis-I in November 2022, is one of the longest operating CubeSats beyond cislunar space. The successful subsystem design with COTS components has become a template for future deep space missions, and the lessons learned from over a year and a half of operations enable their improved performance.

Enabling Extended Mission Operations

Preparation, planning, and a robust design allowed BioSentinel to achieve its unprecedented performance as an SLS secondary payload:

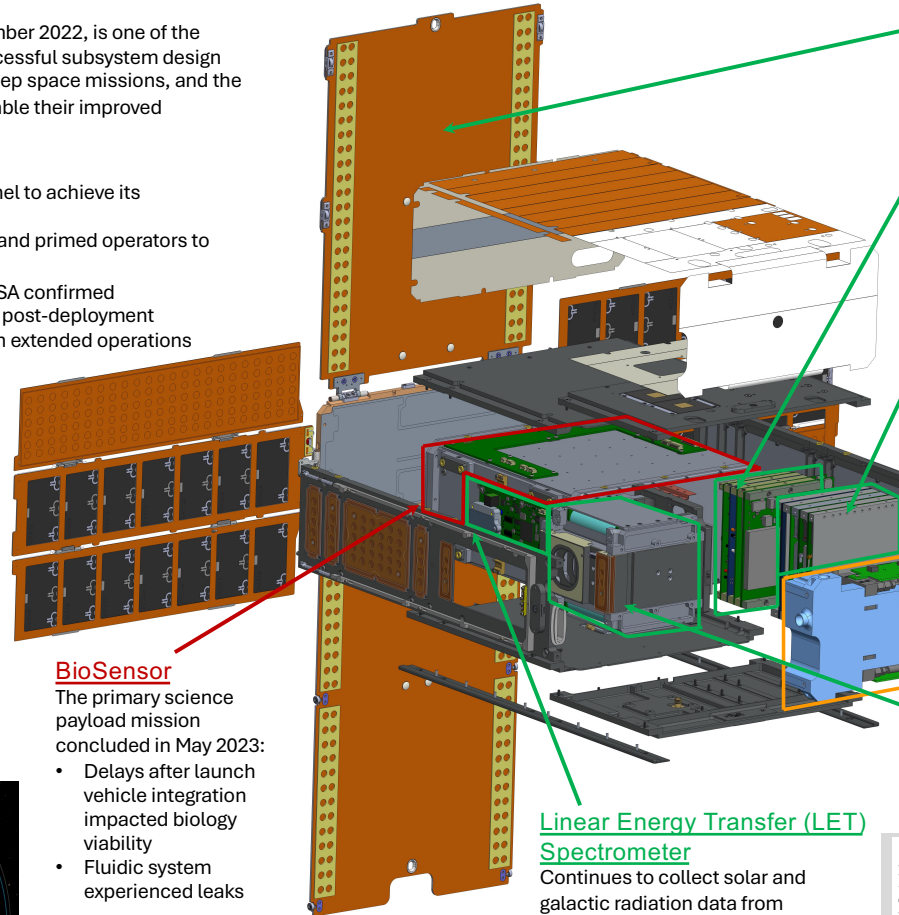
- Mission Operations simulations identified potential risks and primed operators to respond quickly to in-flight anomalies
- Pre-launch antenna and interface testing with DSN and ESA confirmed communications and prepared for the critical early hours post-deployment
- A simple ConOps and lean team provide cost-efficiency in extended operations

Summary & Conclusions

- BioSentinel has proven capability hosting 4U payloads on 6U bus
- Similar COTS parts can be used on future deep-space missions based on BioSentinel flight heritage

Lessons learned from extended operations suggest key areas to enhance performance:

- Flexible flight software architecture capable of being modified on orbit
- Payload lessons applied to LEIA mission to relocate and isolate fluidic systems; mitigating humidity risks
- Propulsion system lessons applied to Starling with simplified control electronics & heater placement
- Fewer comm passes with increased duration reduces costs, increases data return, and efficiently uses DSN



Electrical Power Subsystem (EPS)

SpectroLab XTJ Prime Solar Cells, Panasonic Li-Ion Battery Cells, and a custom-built suite of control boards:

- Components have exceeded lifetime expectations
- No unexplained resets, shutdowns or other anomalies

Command & Data Handling (C&DH)

Two board set; Space Dynamics Lab UT700 LEON3-FT Single Board Computer and Interface eXpansion Card (IXC):

- Software performing as expected and subsystem functioning well
- No unexplained reboots or single event upsets

Iris Radio

JPL and SDL developed radio optimized for DSN operations:

- Performing well throughout mission
- Thermal limitations keep pass durations to < 3hrs
- Supporting DSN beacon and multiple uplinks testing

Propulsion System

Trailblazing 3D-printed composite cold gas propulsion system enabled efficient use of the limited space available in the CubeSat:

- Valve failed closed at launch has impacted autonomous momentum management

Attitude, Direction & Control Subsystem (ADCS)

Blue Canyon Technologies XACT system with Star Tracker:

- Ground software uses momentum prediction tools to compensate for stuck prop valve
- Infrequent reboots causing minimal impact to operations

Linear Energy Transfer (LET) Spectrometer

Continues to collect solar and galactic radiation data from heliocentric orbit:

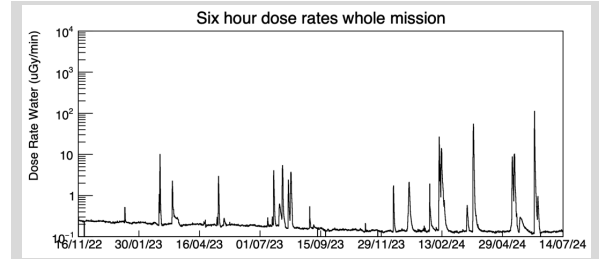
- Provides longitudinally distributed measurements of solar particle events during solar maximum
- Dataset is valuable for model validation and future mission planning

BioSensor

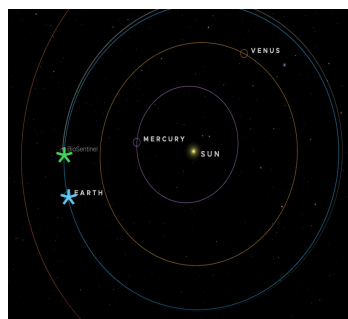
The primary science payload mission concluded in May 2023:

- Delays after launch vehicle integration impacted biology viability
- Fluidic system experienced leaks

The BioSentinel team appreciates the support of the NASA's Exploration Systems Development Mission Directorate – Mars Campaign Office through mission development, launch and science operations. The NASA Ames Engineering Directorate and contractors for providing the team, resources, and facilities to execute the mission. The DSN for continuing to provide excellent service during extended mission operations. JSC RadWorks for providing analysis of the LET radiation data. And finally, NASA's Science Mission Directorate – Heliophysics Division for their continuing support of the extended mission.



BioSentinel Absorbed dose rates in water averaged on 6-hour cadence since mission start. Figure courtesy of Stuart George (NASA JSC) and the SRAG REM Team



BioSentinel is 29.5 million miles (47.5 million km) away from the Earth as of August 7, 2024



BioSentinel's Location



BioSentinel Website

Functioning Well - Some Issues - Primary Science Mission