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Author: Dr. Andres Mora Vargas
NASA Ames Research Center, United States

BIOSENTINEL: NASA'S FIRST DEEP SPACE BIOLOGICAL MISSION

Abstract

Since Apollo 17 in 1972, NASA has sent no humans or other biological organisms outside of Earth's protective magnetosphere. NASA's current Artemis program plans to put astronauts back on the Moon and eventually land human missions on Mars. One of the major challenges to long-duration crewed travel and habitation in deep space is an in-depth understanding of the biological effects of space radiation, often convoluted by the impact of reduced gravity. Such missions will require significant countermeasures, likely both technological and biomedical, to protect organisms from chronic radiation exposure. Small satellite missions like CubeSats can inform these countermeasures by investigating model organisms in relevant space environments.

The BioSentinel mission is comprised of four segments developed at NASA Ames Research Center: a 6U CubeSat (1U = 10-cm cube), an ISS payload launched in December 2021 and two ground units, one for the mission's CubeSat and one for the ISS payload. The last three segments have been operational since January 2022 and serve as experimental controls.

BioSentinel's 6U CubeSat is planned to launch as a secondary payload on the Artemis-1 rocket. It will be deployed on a lunar fly-by trajectory and into a heliocentric orbit. BioSentinel will be the first interplanetary satellite to study the biological response to space radiation outside Low Earth Orbit (LEO) in almost 50 years. BioSentinel is a complete, autonomous spacecraft capable of conducting experiments in deep space. Its 4U BioSensor payload is a fully automated and adaptable platform that can perform biological measurements with a range of microorganisms in multiple space environments, including the ISS, free flyers, and other platforms like the Lunar Gateway and lander vehicles.

Once it reaches its orbit, BioSentinel's CubeSat will measure the DNA damage response to ambient radiation in a model organism, the budding yeast Saccharomyces cerevisiae, which will be compared to information provided by an onboard radiation sensor and to data obtained in LEO (on ISS) and on Earth. Once in interplanetary space, fluidic cards containing desiccated yeast will be activated by growth medium addition at different time points throughout the mission. Growth and metabolic activity will be tracked continuously via optical measurements.

This paper describes BioSentinel's objectives, science, data management, and preliminary results from the ISS and ISS ground control segments.