29th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Spacecraft for Deep-Space Exploration (8)

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EVOLUTION OF BIOLOGICAL SATELLITES: FROM LOW EARTH ORBIT TO NASA'S BIOSENTINEL DEEP SPACE MISSION

Abstract

NASA has set its sights on human exploration in deep space with the Artemis missions, with an ambitious plan to put astronauts back on the Moon and to eventually land human missions on Mars. Such missions will require significant countermeasures, likely both technological and biomedical, to protect biology from chronic radiation exposure. Small satellites like CubeSats can inform these countermeasures by querying relevant space environments with model organisms over relevant durations.

NASA has launched five biological CubeSats into low Earth orbit (LEO) from GeneSat-1 in 2006 to EcAMSat in 2017. Each one of these missions increased our understanding of the effects of spaceflight, while refining technologies and imparting valuable lessons to the next generation of CubeSats. The Artemis 1 rocket will carry ten CubeSats, each of them with its own objective. One in particular, BioSentinel, will conduct the first study of the biological response to interplanetary space radiation beyond LEO since Apollo 17.

Once it reaches its heliocentric orbit – after a short lunar fly-by – BioSentinel 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 cells will be activated by growth medium addition at different time points throughout the mission. Growth and metabolic activity will be tracked continuously via optical density.

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.

BioSentinel is supported by NASA's Advanced Exploration Systems.