BioSentinel Mission Development of a Radiation Biosensor to Gauge DNA Damage and Repair Beyond Low Earth Orbit on a 6U Nanosatellite

Hugo Sanchez, Brian Lewis, Robert Hanel, NASA Ames Research Center, Moffett Field, CA, USA

BioSentinel Mission: “Canary in a Coal Mine”

- Quantify DNA damage from space radiation environment
- Space environment cannot be reproduced on Earth, omnidirectional, continuous, low flux, variety of particle types
- Health risk for humans spending long durations beyond LEO
- Radiation flux can spike 1000x during a solar particle event (SPE)

- Yeast assay: microfluidic arrays monitor DSB/repair
  - Three strains of S. cerevisiae: 2 controls, 1 engineered strain
  - Engineered strain quantifies double strand breaks (DSBs)
  - Wet and activate multiple banks of microwells over mission lifetime
  - Double strand break & associated repair enable cell growth & division
  - Reserve wells activated autonomously in case of SPE

- Correlate biological response with physical radiation measurements
  - Total Ionizing Dose (TID) sensor measures integrated deposited energy
  - Linear Energy Transfer (LET) spectrometer bins and counts particle events

Spacecraft Design: 6U Cubesat

- A “6U” (10 x 22 x 34 cm) nanosatellite
- First NASA biological study beyond low Earth orbit (LEO) in over forty years
- Results will be compared to data obtained in LEO (on International Space Station) and on Earth
- Active attitude control required for RF communication and solar power generation

Concept of Operations: Deep Space

- Secondary payload aboard Space Launch System (SLS) Exploration EM-1
- Launch from Kennedy Space Center (KSC)
- 12- to 18-month mission lifetime
- Earth-leading ~0.93 – 0.98 AU heliocentric orbit
- The 95% maximum dose probability with 1.85 mm of aluminum over 1 year is about 1.3 krad-Si.

Summary

- BioSentinel is a deep space cubesat mission that will require autonomous 3-DOF attitude control in a high radiation environment
- 35 failure modes identified in FMECA with 35 possible implementations of mitigations in flight software
- Action Points table developed with Boolean logic for watch point combinations