THE O/OREOS MISSION – ASTROBIOLOGY DATA COLLECTED IN LOW EARTH ORBIT.


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Introduction: The O/OREOS (Organism/Organic Exposure to Orbital Stresses) nanosatellite (Figure 1) is the first science demonstration spacecraft and flight mission of the NASA Astrobiology Small-Payload loads Program (ASP). On November 19, 2010, O/OREOS was launched successfully to a high-inclination (72°), 650-km Earth orbit aboard a US Air Force Minotaur IV rocket from Kodiak, Alaska. O/OREOS consists of three conjoined cubesat (each 1000 cm³) modules:

(i) a control bus
(ii) the Space Environment Survivability of Living Organisms (SESLO) experiment, and
(iii) the Space Environment Viability of Organics (SEVO) experiment.

Figure 1. O/OREOS – the first technology demonstration mission of the Astrobiology Small-Payload Program developed by the NASA Ames Small Spacecraft Division, an experienced science working group, and Ames-based supporting scientists.

The biological pay load, SESLO, tests how microorganisms survive and adapt to the environmental stresses of space, such as microgravity and ionizing radiation. The results will contribute to our understanding of the environmental limits of life and will address many aspects of biology in space and planetary protection. The organic photochemistry pay load, SEVO, monitors the evolution of biomarkers and other organic molecules that are exposed to space radiation. These studies are highly relevant to the study of carbon chemistry in space environments.

O/OREOS’ orbit takes it to regions of the Earth’s magnetosphere that are comparatively weak, so that the radiation dose rate on the spacecraft surface from the inner Van Allen belt of “trapped radiation” and from galactic cosmic radiation (GCR) can be as much as 14 Gy/day. The GCR consists of ~ 0.5 mGy/day of this, some 15 times greater than the GCR dose rate received at the International Space Station. O/OREOS is also exposed to full solar UV light for about 35% of the total time of the mission, which translates to more than 1500 h. The orbital thermal environment varies with orbital plane precession (~2.19°/day), but modeling suggests that the SEVO payload will never dip below 253 K nor above 303 K.

O/OREOS was built on a heritage of previous successful cubesat missions, such as GeoNeSat and PharmaSat, and benefitted from other experiments flown in Low Earth Orbit (LEO) and exposure facilities on the International Space Station. The science and technology rationale of O/OREOS supports NASA’s scientific exploration program by investigating the local space environment as well as space biology relevant to Moon and Mars missions. It also serves as a precursor for experiments on future small satellites, the ISS, future free-flyers and lunar surface exposure facilities.

Science and technology development of O/OREOS: O/OREOS’s biological experiment, SESLO, tests the potential for life to survive and adapt beyond Earth. In a sealed vessel at 1 atm, two types of microbes, Bacillus subtilis and Halorubrum chaoviatoris, each as wild-type and mutant, were launched in a desiccated state. At three timepoints after launch (two weeks, three months, and six months), an experimental module initiates, rehydrating the microbes with a nutrient broth and allowing them to grow. The first growth experiment was completed successfully in orbit on December 4, 2010 and is currently being evaluated and interpreted with the help of laboratory control experiments.

Aromatic organic compounds, including a subset of life’s precursor molecules, are widespread in our galaxy and beyond. O/OREOS’s organic experiment, SEVO, investigates the stability, modification, and degradation of biomarkers and aromatic compounds in four different model microenvironments analogous to interplanetary and planetary conditions. The SEVO payload consists of a 10-cm (1U) cube containing a 24-sample carrier carousel (Figure 2) and a highly-capable custom-designed UV-visible spectrometer.

The sample carrier is filled with individual sample cells containing desiccated, nutrient-broth-impregnated microorganisms and exposed to full fiducialization/irradiation and the ionizing particle radiation of space. Transmission spectroscopy, using the Sun as a source, is used to monitor changes in the organic films in situ on a weekly basis over the 6-month mission duration.
Four different organic films are used in the SEVO experiment, representing four different chemical classes of organic compounds: poly cyclic aromatic hydrocarbons (PAHs), quinones, porphyrins, and amino acids. These four different molecular classes and molecules were chosen because of their astrobiological and exobiological relevance. Organic samples were deposited in the form of thin films onto the magnesium fluoride windows of the cells. Figure 3 shows the absorption spectrum of a thin film of the PAH, isoviolanthrene, that is currently being investigated by the O/OREOS mission.

The organic samples are housed in “micro-environments” that mimic different space and planetary conditions: **Inert Cells** contain only photochemically inert argon, which acts as a surrogate for vacuum; **Surface Cells** were designed to explore the role of inorganic surface chemistry; **Atmosphere Cells** were designed to explore the effects of photochemically-induced gas-phase reactions on the stability of organic compounds; **Humid Cells** were designed to study the impact of water vapor photolysis, which drives reaction kinetics in many environments including planetary surfaces, on the degradation of organics.

Flight samples were assembled in the test and manufacturing facility at NASA Ames Research Center (Figure 4). Before flight integration with the satellite, the payload was put through a number of environmental tests including shock, vibration, and operation in a space-like thermal-and-vacuum environment. Additionally, various mission simulations were conducted to characterize the payload’s software, experiment sequence, and measurement performance.

Primary ground operations for the O/OREOS mission are performed by students at the Robotics Systems Laboratory of Santa Clara University using 3-m dishes on the university campus. A combination of limited onboard memory and comparatively high data generation rates represents a challenge for efficient data downlinking.

We will report on the flight assembly, payload integration, first operational phase, and the first science data of the O/OREOS missions. O/OREOS addresses several research avenues that provide important insights into astrobiology: organic chemistry in space, extraterrestrial delivery processes, the adaptation of life to the space environment, planetary protection, space exploration, and in situ monitoring technology. Further, O/OREOS measurements provide, for the first time, a real-time analysis of the photostability of organic molecules and biomarkers while demonstrating some of the opportunities available for small satellites in astrobiology/chemical space research programs. Website [http://ooreos. engr.scu. edu/dashboard. htm](http://ooreos. engr.scu. edu/dashboard. htm).