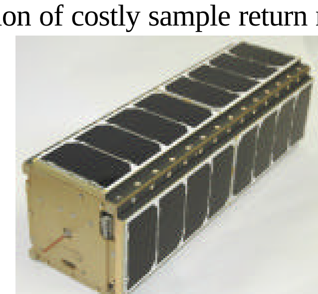
GeneSat-1 Flight Test Demonstration

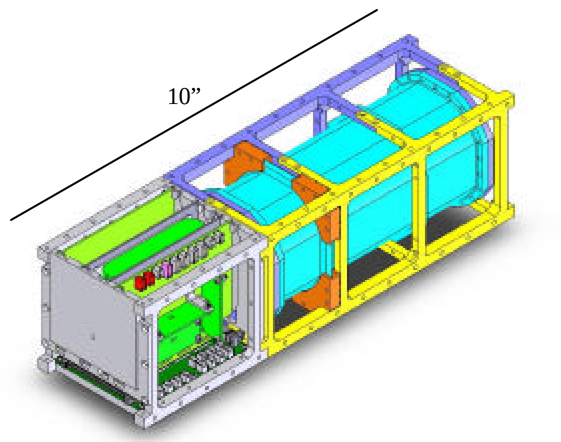
A collaboration of NASA, industry, and local universities is developing a fully-automated, miniaturized spaceflight system that provides life support, nutrient delivery, and performs assays for genetic changes in *E. coli*. Flying multiple missions as secondary payload using this low-cost approach will lead to better understanding of the biological effects of the spaceflight environment, particularly space radiation and reduced gravity, enabling countermeasure development, which is a critical need for safe long-duration crewed space missions.

Background

Advances in miniaturization of key technologies coupled with the emergence of secondary payload launch opportunities for small spacecraft offer a accelerated, low-cost approach for space exploration technology demonstrations. In addition, integrating the novel investigative tools provided by cellular genetics into these small spacecraft platforms results in a powerful tool for understanding the effects of deep space environments on biological systems and, therefore, reducing future risk to human explorers. Key features of this combination of genetic probes and small spacecraft include:

- Generation of large data sets from modest biological sensors
- Unique applications enabled by genetic characterization for molecular medicine as potential countermeasures
- Multiple replicates integral to a robust measurement strategy
- Reduction of the reliance on human-tended architectures to enhance reliability and accuracy
- Addition of sophisticated microanalytical methods and small-platform computational power to reduce Exploration risk elements
- Reduction of costly sample return requirements





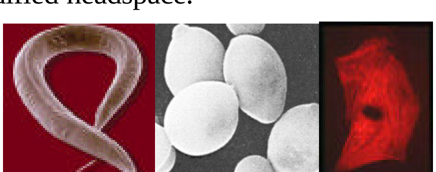
GeneSat-1 Flight Article (solar panels removed)

Technology Overview

The GeneSat-1 Team at Ames Research Center is designing and developing miniature biological stasis, growth, and analysis systems along with the necessary life support (culturing) capabilities to study gene and protein expression in model small/micro organisms. The system is fully self-contained and autonomous, and transmits results to Earth, requiring no specimen return. The main project components are technology demonstration subsystems including quantitative fluorescent imagers, microfluidic networks, liquid arrays for the replicate study of multiple genetic constructs, and miniature environmental control and power management systems.

At the core of the GeneSat-1 demonstration platform is an integrated analytical fluidics card assembly. It includes a media pump, valves, microchannels, filters, membranes, and wells to maintain the biological viability of various microorganisms. An integrated thermal control system maintains the biological specimens at physiological temperatures. The internal environment is monitored via a suite of sensors, and finally, expressions of genetic signals are detected by a miniaturized optical detection system.

The GeneSat-1 Engineering Development Unit (EDU) is shown in the picture above. The pressure vessel (cylinder) contains the integrated fluidics, optical sensors, and electrical/mechanical subsystems. Thermal management is provided by internal heaters and controllers. The internal volume is sealed and provides humidified air to exchange with the microwells via a gas-permeable membrane. Other parameters measured include pressure, temperature at various locations, acceleration and limited radiation environment. Light sources (LEDs) and detectors for the fluorescent optical assay are located outside the humidified headspace.



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Future technology modules will enable small gene/protein array analyzers, imaging systems, and small spacecraft systems that can be carried as secondary payloads on planned missions, and specific reference-experiment protocols designed for the study of genetic changes arising from the unique space environment. Near-term plans include support for mammalian cell cultures, to allow characterization of gene/protein profiles of these highly relevant systems.

Relevance to Exploration Systems

For safe, long-duration space missions, the debilitating effects of the environment such as bone density loss, muscle atrophy, and a stressed immune system must be addressed. In terrestrial medicine, powerful recent advances in therapeutics have come from detailed understanding of biological mechanisms and pathways at the molecular level. The use of low-cost, small-size, autonomous secondary payload concepts provides a means to study biological changes of fundamentally well-understood microorganisms and mammalian cells at the gene/protein level. Such knowledge will be key to the development of effective countermeasures to the deleterious effects of long-duration space travel.

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