SOLAR ARRAY MODULE PLASMA INTERACTIONS EXPERIMENT (SAMPIE)

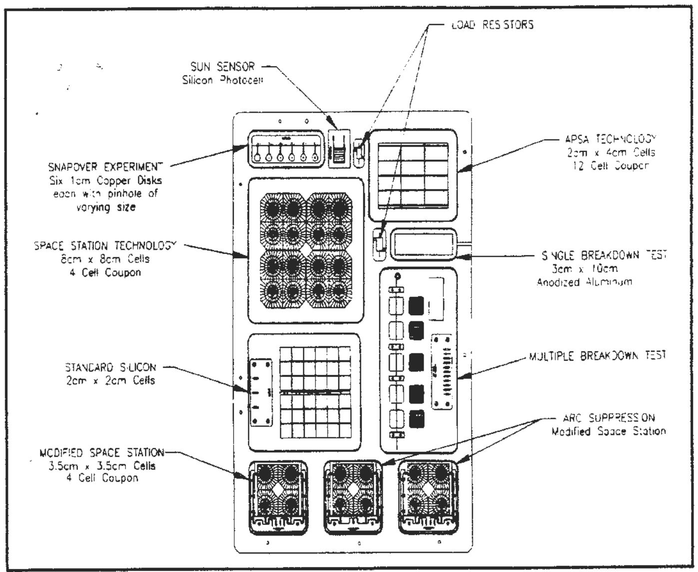
Developed By NASA Lewis Research Center
For The Space Technology Payload (OAST-2)
Aboard Space Shuttle Columbia (STS-62)

The Solar Array Module Plasma Interactions Experiment (SAMPIE) will gather key environmental interaction data to support the design and construction of high-voltage space power systems for operation in low Earth orbit. Specifically it will investigate and quantify the potentially damaging interactions between the space plasma (gases) found in low Earth orbit and the solar array surfaces of high-voltage space power systems.

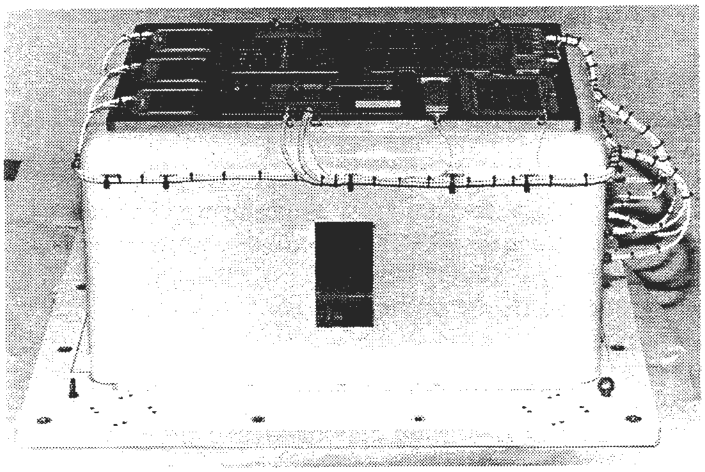
As satellites and spacecraft have evolved in size, weight and sophistication, so has the need for higher voltage space power systems. Because high-voltage power systems are much more efficient than low-voltage systems, they offer considerable weight savings and launch cost advantages.

Unfortunately, numerous ground and flight experiments have shown that some serious problems can occur when high-voltage space power systems come in contact with space plasma. Adverse effects include the parasitic loss of power ("**current collection**") and "**arcing**," (the generation of sparks). Arcing can damage power system materials, disrupt electrical current, and cause significant electromagnetic interference.

The growing demand for high-voltage power systems has challenged spacecraft designers to find ways to overcome the potentially disastrous effects of arcing and current collection.



An experiment plate on top of the SAMPIE enclosure contains mounted samples of the different solar array cell technologies to be tested. The metal enclosure houses most of the measuring instruments, a data acquisition system, a power distribution system, and related electronics.



In-Space Testing Is Critical

Engineers have traditionally relied on the use of ground-based test chambers to simulate plasma and other environmental conditions in low Earth orbit. But recent flight experiments involving conventional silicon solar arrays have revealed many differences between interactions that occur in the space environment and those studied in ground-based simulations. For example, when the PIX I and PIX II silicon solar arrays were tested in space, the arc rates were quite different and were generally higher than in similar ground-based tests. Thus, to provide the most reliable data possible, SAMPIE was designed as a flight experiment and included on the OAST-2 (Office of Aeronautics and Space Technology) payload on the STS-62 mission of the Space Shuttle Columbia.

Objectives

The long-range objective of SAMPIE is to help spacecraft designers find ways to minimize adverse environmental interactions between high-voltage space power systems and the plasma in low Earth orbit. Specifically, SAMPIE will investigate the arcing and current collection behavior of materials and geometries most likely to be used in the high-voltage power systems for the space station and other spacecraft in low Earth orbit. SAMPIE data will be used to extend and validate the computer-based models that space power system engineers use to predict plasma interactions.

Flight Hardware

The central element of the SAMPIE hardware package is a metal enclosure with an experiment plate affixed to its outer top surface. The box will be centrally mounted on top of the OAST-2 Hitchhiker carrier in the Shuttle's payload bay.

SAMPIE hardware also includes two electrical probes to measure plasma characteristics (such as density), temperature and Orbiter voltage with respect to the space plasma. Since SAMPIE will significantly disturb the space plasma conditions within about one meter in all directions, these probes are mounted about two meters away from the SAMPIE enclosure, on the side of the carrier.

Test Specimens

Experimenters will study how plasma interacts with a variety of specimens, including:

- **Thirty-six traditional 2 cm x 2 cm silicon solar cells.** These are the type of cells that have been used exclusively in the U.S. space program to date. Data will be taken from a four-cell coupon of 2 cm x 2 cm cells wired as a series string. A second, independent series string of 12 cells surrounds the inner four. A third series string of 20 cells, also independent, surrounds the entire assembly. By testing these strings independently and in various combinations, SAMPIE researchers hope to improve the ability to accurately predict the amount of "current collection" that may affect larger solar arrays.
- **Four 8 cm x 8 cm solar cells designed for use with the Space Station power system.** Researchers expect arcing to occur from the cell edges and will gather data on the arc rate and arcing threshold for these cells. Current collection from these cells is of special interest because it can dramatically affect the voltage of spacecraft with respect to their surroundings, such as space plasma.
- **Twelve 2 cm x 4 cm Advanced Photovoltaic Solar Array (APSA) Cells.** SAMPIE will test the behavior of these relatively new, very thin, lightweight solar cells. A germanium-coated Kapton material will be used to protect the cells from attack by atomic oxygen. Ground tests have shown that under some conditions, the coating leads to increased plasma current collection.
- **Modified solar cells** designed to resist arcing and collect less current.
- **Samples of typical metals** used in space, including the type of anodized aluminum that will be used on the space station.

How The Experiment Will Be Conducted

SAMPIE will be conducted during roughly 2-1/2 days of the 14-day STS-62 mission. On the eighth day of the mission, SAMPIE personnel at the Payload Operations Control Center (POCC) at NASA Goddard Space Flight Center in Greenbelt, MD will command the SAMPIE experiment to begain "bay-to-ram" operations. During this series of operations, Shuttle astronauts will fly the orbiter in a position that will enable space plasma to flow straight into ("ram") the experiment samples in the payload bay. As these"bay-to-ram" operations continue for the next 25 hours, SAMPIE personnel will monitor downlinked experiment data, including information on sample arcing, current collection measurements, and the heatlh and welfare of the experiment electronics. They will also send commands to the experiment during mission operations.

After the series of bay-to-ram tests have been completed, the astronauts will maneuver Columbia into a"bay-to-wake" attitude, in which the cargo bay will be kept in the shadow of the orbiter as it moves through the space plasma. This shadowing of the cargo bay will result in a very low density of space plasma. Bay-to-wake operations will last for about 12 hours. Upon completion of the bay-to-wake tests, SAMPIE will be turned off, its mission of STS-62 completed.

Ground Support

A six-member SAMPIE team will work in shifts at Goddard's POCC to monitor and control the experiment 24 hours a day. If any unexpected conditions arise, the experiment can be halted and restarted at any point, or the tests can be modified.

At the User Operations Facility at NASA Lewis Research Center, employees from the Center's Space Environmental Effects Branch will also observe the experiment in progress. They will be able to communicate with and advise the SAMPIE team at Goddard.

How The Data Will Be Used

From the SAMPIE flight data, engineers will determine the arcing threshold, arc rates, and magnitude of arc current for sample solar cell arrays. For these arrays, they will also measure plasma current collection as a function of voltage. SAMPIE will also gather data on the relationship between current collection and areas exposed to the space plasma. Other SAMPIE results will enable engineers to explore the relationships between the arcing threshold, arc rates, and arc strengths and the choice of metals used in power systems.

This wealth of in-space data from SAMPIE will help validate and refine the computer-generated "models" that engineers use to predict the results of plasma interactions. For example, accurate models are essential to determining the proper size of the plasma contactor "ground rod" on the space station. Ultimately, SAMPIE data will contribute to the development of reliable, long-lasting high-voltage power systems for the more sophisticated spacecraft of the future.

KEY PERSONNEL

Funding for SAMPIE has been provided through the In-STEP (In-Space Technology Experiments Program) of NASA's Office of Advanced Concepts and Technology. The goal of In-STEP is to evaluate and validate innovative space technologies and provide a better understanding of the effects of microgravity and the space environment.

The SAMPIE experiment was conceived, designed, built and tested at NASA Lewis Research Center, which has long been a leader in space power technology.

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