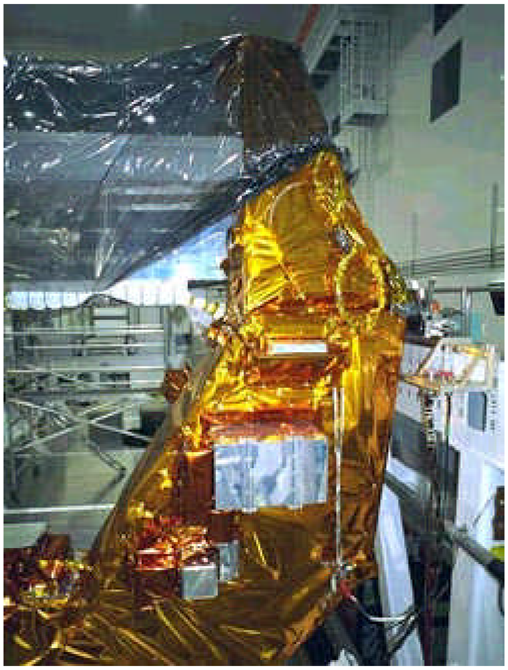
Hubble Space Telescope Program on STS–95 Supported by Space Acceleration Measurement System for Free Flyers

John Glenn's historic return to space was a primary focus of the STS–95 space shuttle mission; however, the 83 science payloads aboard were the focus of the flight activities. One of the payloads, the Hubble Space Telescope Orbital System Test (HOST), was flown in the cargo bay by the NASA Goddard Space Flight Center. It served as a space flight test of upgrade components for the telescope before they are installed in the shuttle for the next Hubble Space Telescope servicing mission. One of the upgrade components is a cryogenic cooling system for the Near Infrared Camera and Multi-Object Spectrometer (NICMOS). The cooling is required for low noise in the receiver's sensitive electronic instrumentation. Originally, a passive system using dry ice cooled NICMOS, but the ice leaked away and must be replaced. The active cryogenic cooler can provide the cold temperatures required for the NICMOS, but there was a concern that it would create vibrations that would affect the fine pointing accuracy of the Hubble platform.

The Microgravity Science Division of the NASA Glenn Research Center at Lewis Field was contacted to supply an acceleration measurement system to characterize the vibrations of the cooler. These measurement systems have traditionally supported microgravity payloads flown by Glenn. The acceleration data is provided to the experimenters so that they can evaluate the influence of the microgravity environment on their experiments. Researchers in the fluids, combustion, materials, and life science disciplines all conduct experiments in the microgravity environment of space to enhance the understanding of fundamental physical phenomena. However, events such as spacecraft maneuvers, equipment operations, atmospheric drag, and crew movement on manned flights can disturb experiments.

The system chosen to meet the HOST requirements was the Space Acceleration Measurement System for Free Flyers (SAMS–FF). SAMS–FF is a compact, low-power system that offers high-resolution acceleration measurements and a flexible, modular system for easy adaptation to a variety of spacecraft. It also complements SAMS–II, which is being designed and developed for the International Space Station. SAMS–FF has the heritage of the original SAMS, which flew on the shuttle 20 times and on the Russian space station Mir. The system had an initial test flight of a sounding rocket in 1997 and also flew on NASA's KC–135 reduced-gravity aircraft.

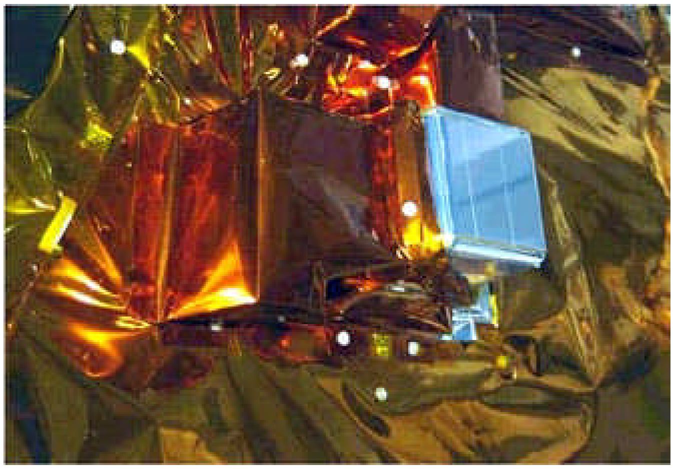


HOST payload with SAMS–FF ready for integration on the space shuttle for STS–95. The SAMS–FF control and data acquisition unit can be seen in the lower left corner.

The SAMS–FF system flown on this flight as part of the HOST payload consisted of a control and data acquisition unit (CDU) and two triaxial sensor heads (TSH's). The CDU is a rugged PC/104-based embedded computer system, which is physically small with a modular construction. The CDU controls the flow of data from the sensors, stores data, and has ports for control and external interfaces. A real-time operating system from QNX Software Systems Ltd. was used. This version of the CDU used a Flash memory card, which has no moving parts. Power converters and filters were located in the base of the unit, supplying power to the PC/104 stack and the sensors. This system was similar to the system flown on the previous flights, except for the addition of a hermetic housing to seal the unit in dry nitrogen for protection from the vacuum of space in the shuttle's cargo bay.

The TSH consists of three AlliedSignal QA3000 accelerometers mounted orthogonally on a small housing, a 3-in. cube. The TSH contains signal conditioning and conversion circuits for processing the analog acceleration signal from the accelerometer into digital data. One 24-bit delta-sigma analog-to-digital converter is used for each accelerometer's signal. This design provides sufficient resolution to measure the small microgravity ($<1\times 10^{-6}$) acceleration forces. The TSH's were configured at a bandwidth of approximately 100 Hz to capture specific resonant frequencies in the Hubble Space Telescope's optical system. The digitized signals were processed by a microcontroller and sent back to the CDU through a serial interface. The TSH was adapted for this flight similarly to the CDU, with a hermetic housing.

Testing conducted for the mission consisted of TSH characterization, environmental testing, and integration testing. The TSH characterization tests plotted the filter response and the noise floor. The environmental testing consisted of traditional thermal and vibration testing to test workmanship and screen infant mortality. After the system was delivered, it was tested with the HOST payload for both proper system operation and integrated payload screening.



SAMS–FF control and data acquisition unit mounted on the HOST payload.

The HOST payload controlled the operation of the system during flight, through a discrete interface. This type of interface was chosen to allow independent development and verification of the two systems. Once power was applied to the system and the CDU was booted, controllers from the ground could command the system to record data and could observe the operating status of the system. HOST conducted a series of data sessions, each approximately 255 sec long. These data sessions corresponded to various operating cycles of the HOST cryocooler. Several discrete interface lines served as counters of the recording sessions completed to ensure that the data storage was optimally utilized.

A total of 43 measurement sessions were conducted during the HOST mission. The data gathered from each of these sessions were complete and anomaly free. They were analyzed by the Principal Investigator Microgravity Services group and then provided to the HOST team. Data gathered by SAMS–FF on STS–95 have been invaluable in determining how the cryocooler may affect the precise alignment capabilities of the Hubble Space Telescope. They indicate that the vibration is not a problem, and the decision was made to install the cryocooler on the Hubble during the third servicing mission.

For more information, visit us http://www.grc.nasa.gov/WWW/MMAP/SAMSFF/samsff.html.

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