Acronym: VCAM

Payload Title: Vehicle Cabin Atmosphere Monitor

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Category: Technology Development for Exploration

Sub-Category: Environmental Monitoring on ISS

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Sponsoring Agency: National Aeronautics and Space Administration (NASA)

Increment(s) Assigned: 18

Brief Research Summary (PAO): Vehicle Cabin Atmosphere Monitor (VCAM) identifies gases that are present in minute quantities in the International Space Station (ISS) breathing air that could harm the crew's health. If successful, instruments like VCAM could accompany crewmembers during long-duration exploration missions to the Moon or traveling to Mars.

Research Summary:

- The closed environment of the International Space Station (ISS) must be monitored for contamination to ensure the health of the crew living and working on ISS.

- Contamination of the ISS environment can be caused by off-gassing of vapors from items (plastics, tape, etc.), as well as microbes (bacteria and fungi) growth inadvertently carried to ISS on the crew and supplies.

- Testing of the air, water and surface of ISS for contaminants will alert the crew of a significant increase in contaminant particles on ISS. The crew can change out the air filters, clean surfaces and treat the water on ISS to prevent illness from the increased contaminants.

- Experience in monitoring the ISS environment provides a new understanding of the closed environment and will be applied to operations of future spacecraft.
- Operating Vehicle Cabin Atmosphere Monitor (VCAM) on the ISS will validate it (a miniature gas chromatograph/mass spectrometer) as a viable sensor for the ISS and future long-

duration missions to the Moon, and Mars. VCAM uses an analytical instrument to detect chemicals at the spacecraft maximum allowable concentration.

Detailed Research Description: To successfully live and work in the environment of the International Space Station (ISS), the environment must be monitored to ensure the health of the crewmembers. Crewmembers can be more sensitive to air pollutants because of the closed environment. Pollutants in environment are magnified on the ISS because the exposure is continuous.

VCAM can provide a means for monitoring the air within the enclosed environments, such as the ISS, Crew Exploration Vehicle (CEV), a Lunar Habitat, or another vehicle traveling to Mars. Its miniature preconcentrator, gas chromatograph (GC), and mass spectrometer can provide unbiased detection of a large number of organic species. VCAM's software can identify whether the chemicals are on a targeted list of hazardous compounds and their concentration. Its performance and reliability on orbit along with the ground team's assessment of its raw data and analysis results will validate its technology for future use and development.

VCAM pulls in air from the ISS cabin through an inlet port embedded in its front panel; the air passes through a particulate filter for analysis. Onboard software evaluates targeted compounds that need to be monitored for the crew health.

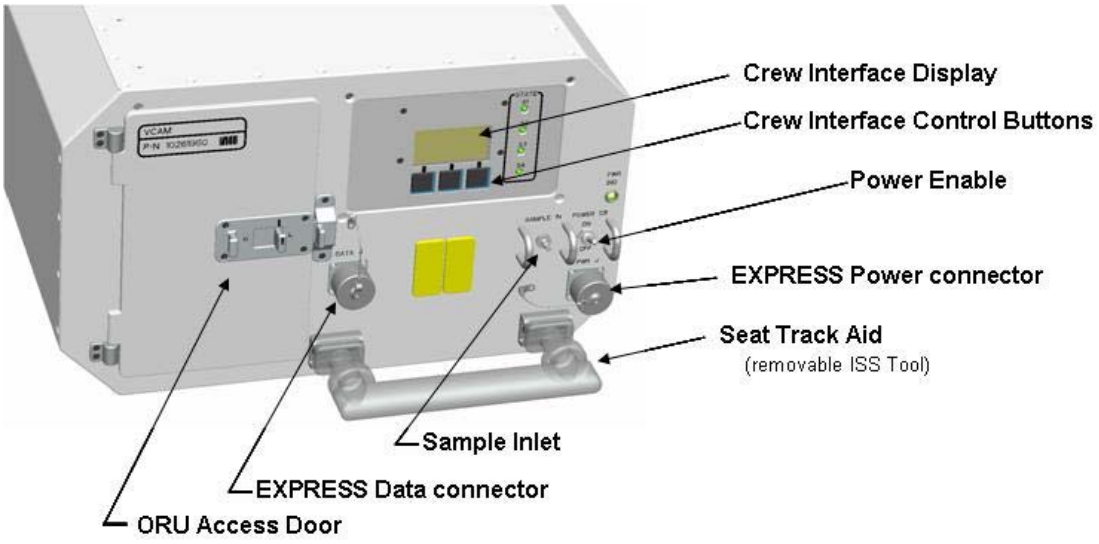
A VCAM calibration gas is used to periodically quantify how the preconcentrator, GC, and mass spectrometer are actually performing. The raw data, calibration data, and analysis results are all sent to the ground for further assessment to validate the instrument's detection, identification, and quantification results.

The VCAM system is a stand-alone instrument that operates autonomously but can be commanded by either crew or ground personnel. It carries its own gas supplies for sampling operations, cleaning, and calibration. Several VCAM processors control the measurement and analysis processes, monitor housekeeping sensors and actuate the valves that control the flow of gas. Commercial backing and turbo-molecular drag pumps maintain the vacuum required to do ion-based mass spectroscopy.

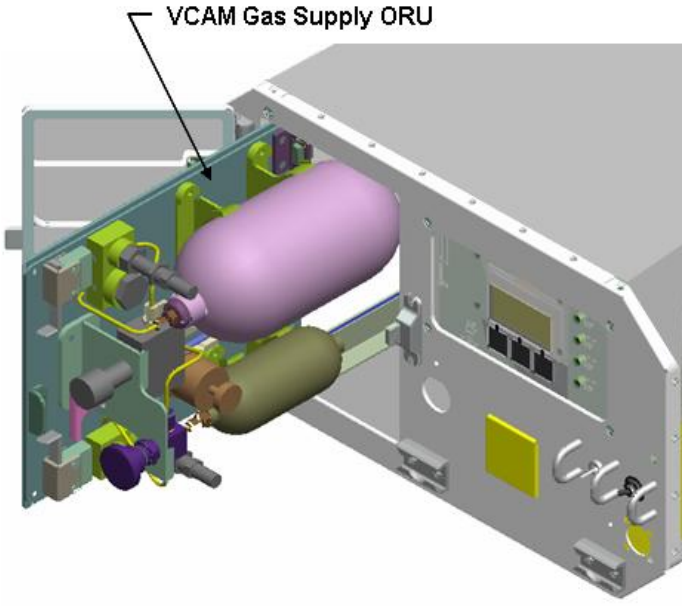
VCAM is a microwave oven-sized payload which weighs 25 kg and requires 70 to 180 W of power for its operation. VCAM will be installed in an Expedite the Processing of Experiments on Space Station (EXPRESS) Rack and operate for at least twelve months; it will use the rack's conditioned air for heat dissipation and its ethernet link for receiving commands from the ground and transmitting data. VCAM's front panel provides the instrument's operational interface with the crew: an LED display showing the instrument status and a multi-button system for navigating its control menus; an access door enables the crew to replace the VCAM gas supply orbital replacement unit (ORU) after twelve months of nominal operations.

Project Type: Payload

Images and Captions:



Artist's rendering of the VCAM front panel.



Artist's rendering of the VCAM Gas Supply Orbital Replacement Unit**.**

Operations Location: ISS Inflight

Brief Research Operations:

- The crew installs VCAM into an EXPRESS Rack and powers it on. VCAM operates on an internal schedule, taking an air measurement from the air in front of the instrument once each day. Approximately 40 minutes will be required for the sampling and analysis.

- The resulting data (mass spectra) are analyzed on board and gases are identified. The raw instrument data, analyzed data, and housekeeping data are sent to the ground teams for assessment.

- VCAM uses an internal calibration gas to regularly self-characterize its instrument components. The crew can use a sample bag to collect an air sample from further away and attach it to the VCAM front panel for analysis.

- The instrument can be controlled by crew or ground personnel. After twelve months the crew can replace the internal gases used to operate, clean, and calibrate the instrument.

Operational Requirements: VCAM will collect an air sample on average once per day. The raw data and on-board analysis, as well as housekeeping data, will be sent to the ground for assessment. VCAM's internal gas supply is sized to last for twelve months; less frequent measurements will result in slightly longer operational periods.

Operational Protocols: VCAM pumps cabin air into its preconcentrator, a charcoal bed to which many of the chemicals in the air stick (adsorb). After several minutes the preconcentrator is warmed slightly to remove nitrogen, oxygen, and water; then it is heated very quickly to drive the chemicals off into a flow of pure helium gas. This puff of gas mixture flows through a 10-meter capillary with a special internal coating (gas chromatographic column) that separates the chemical families from each other over a twenty minute period. The gas is pulled into the mass spectrometer where it is ionized by an electron beam; the resulting ions are held in the Ion Trap and then ejected based upon their mass-to-charge ratio; the charged mass fractions, characteristic of the original gas, are collected by a high-voltage detector. Fifty mass spectra are collected each second and averaged; the total number of ions ejected each second (over the twenty minutes of gas flow resulting from the original puff of gas) produces a chromatogram. Software in VCAM compares these two pieces of raw data to its standard library to identify the chemical and uses the number of ions to determine the concentration is the air.

Review Cycle Status: PI Reviewed

Space Applications: VCAM will protect crewmembers by informing them of the slow build up of potentially harmful chemical in their breathing air. While VCAM's library contains species that engineers know to be present in the various life-support systems, VCAM can provide data that allow ground scientists to identify compounds that were not expected. These same functions of detection, identification, and quantification can be utilized in the event of a chemical spill or release.

Earth Applications: Instruments larger than VCAM monitor the air in enclosed systems on Earth (e.g., submarines). Small portable units are used in the field to monitor the environment.

Previous ISS Missions: The Volatile Organic Analyzer (VOA), a similar instrument has been used to monitor the ISS environment since Expedition 1.

Results Summary:

Results Publications:

Related Publications:
Abbasi T, Christensen M, Villemarette M, Darrach M, Chutjian A. Trace Gas Analyzer for Extra-Vehicular Activity. Society of Automotive Engineers Technical Paper Series, Warrendale, PA. 2001 ;2001-10-2405.

Orient OJ, Chutjian A. A Compact, High-Resolution Paul Ion Trap Mass Spectrometer with Electron-Impact Ionization. The Review of Scientific Instruments. 2002 ;*73:* 2157.

Shortt BJ, Darrach MR, Holland PM, Chutjian A. Miniaturized Gas Chromatograph-Paul Ion Trap System: Applications To Environmental Monitoring. Society of Automotive Engineers Technical Paper Series, Warrendale, PA. 2005 ; 2005-00-0000.

Web Sites:

Related Payloads: Environmental Monitoring

Last Update: 6/20/2007