

Use Of The Operational Air Quality Monitor (AQM) For In-Flight Water Testing Project

Center Innovation Fund: JSC CIF (Also Includes JSC IRAD) Program
Space Technology Mission Directorate (STMD)

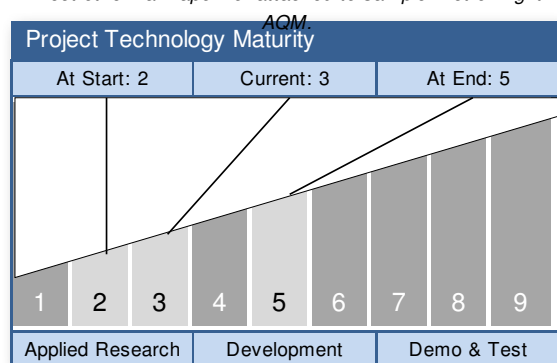
National Aeronautics and
Space Administration



ABSTRACT

A primary requirement for manned spaceflight is Environmental Health which ensures air and water contaminants, acoustic profiles, microbial flora, and radiation exposures within the cabin are maintained to levels needed for crew health and for vehicle system functionality. The reliance on ground analyses of returned samples is a limitation in the current environmental monitoring strategy that will prevent future Exploration missions beyond low-Earth orbit. This proposal attempts to address this shortcoming by advancing in-flight analyses of water and air. Ground analysis of in-flight, air and water samples typically employ vapor-phase analysis by gas...***Read more on the last page.***

Electrothermal Vaporizer attached to sample inlet of flight



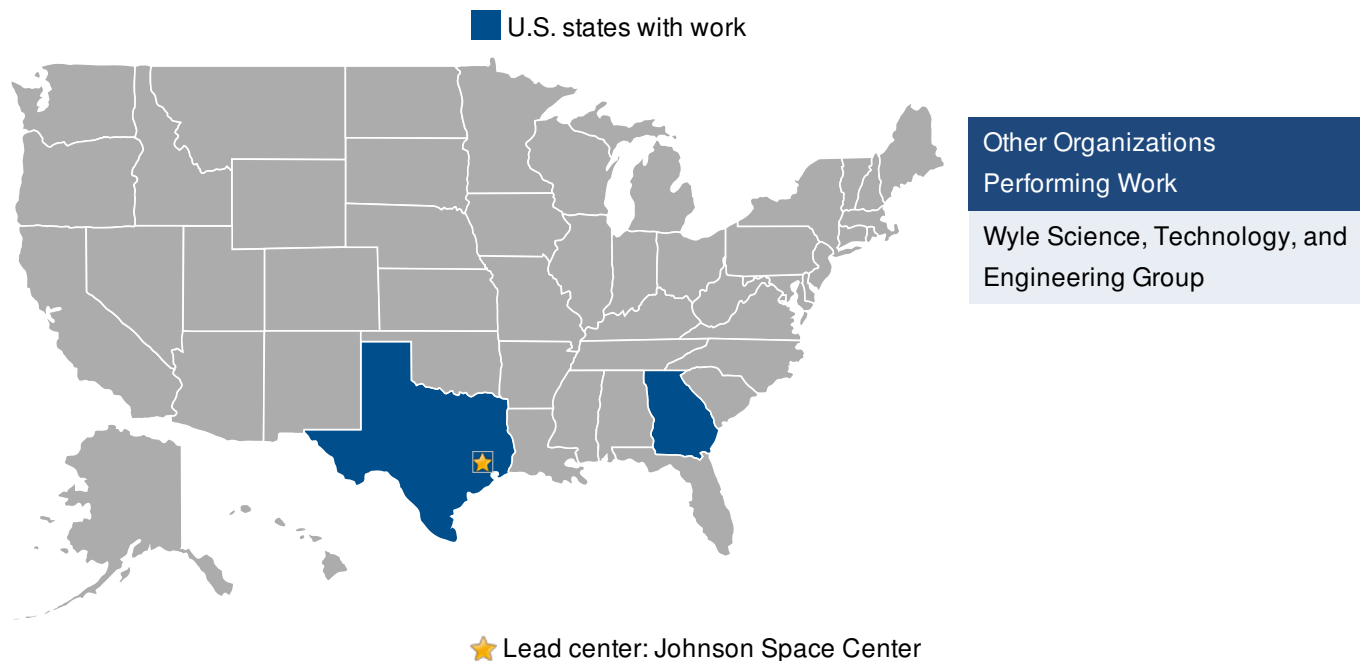
Technology Area: Human Health, Life Support & Habitation Systems
TA06 (Primary)
Science Instruments, Observatories & Sensor
Systems TA08 (Secondary)

ANTICIPATED BENEFITS

To NASA funded missions:

An in-flight analytical system capable of gas and liquid analyses will provide a means to ensure the air and water meet the requirements for proper environmental health for crew. Current, analytical technology for managing the environmental health of manned spacecraft is limited and highly specialized, providing a limited amount of information on the state of environmental health. The Total Organic Carbon Analyzer (TOCA) and the Colorimetric Water Quality Monitoring Kit (CWQMK) are used to examine only two aspects of water quality, total organic carbon and biocide concentration, respectively, on-board ISS. A comprehensive analysis of ISS potable water...

[Read more on the last page.](#)



DETAILED DESCRIPTION

Currently, the Air Quality Monitor (AQM) on-board ISS provides this specific information for a number of target compounds in the air. However, there is a significant subset of common target compounds between air and water. Naturally, the following question arises, "Can the AQM be used for both air and water quality monitoring?" Previous directorate-level IR&D funding led to the development of a water sample introduction method for mass spectrometry using electrothermal vaporization (ETV). This vaporization source allows analytes in water samples to enter the gas phase, where they can be analyzed using a variety of techniques. This project will focus on the integration of the ETV with a ground-based AQM. The capabilities of this integrated platform will be evaluated using a subset of toxicologically important compounds.

The ETV unit was constructed using two glass tubes and a nichrome ribbon powered by a programmable DC power supply (G W Instec, PSM-3004). The nichrome ribbon was threaded through two 3-mm-wide, 1-cm-long slot cuts on the inner tube placed 1.5 cm past the inlet. The ribbon was held securely by compressing it between the...

MANAGEMENT

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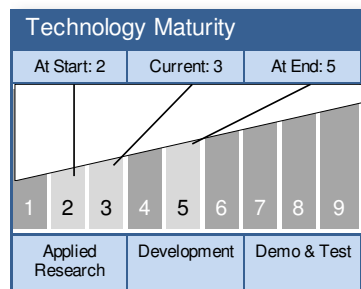
DETAILED DESCRIPTION (CONT'D)

inner tube and two halves of an outer glass tube. These halves were held together using a flexible metal clamp. Inside the inner tube the ribbon was slightly curved, and an indent (1 mm diameter) was made on its surface for depositing a measured liquid sample drop. The ribbon was positioned in the upper half of the inner tube in such a way that the edge of the ribbon faced the front (inlet) side of the ETV unit. Holes (1 mm diameter) were made on the outer and inner glass tubes for sample introduction and were aligned with the ribbon indent.

The viability of the ETV approach for the analysis of water analytes was demonstrated using a ground-based, laboratory scale analyzer (reference: Dwivedi, P. et al. "Electro-Thermal Vaporization Direct Analysis in Real Time-Mass Spectrometry for Water Contaminant Analysis During Space Missions," *Analytical Chemistry*, **85**, 9898-9906 (2013)). The work in this proposal will extend that effort and interface the EVT to a ground version of the current, in-flight AQM. Liquid sample will be introduced via a pipet through the sample injection port and placed onto the nichrome ribbon heated to a set temperature by an external, programmable power supply. Upon vaporization of the water sample, the target analytes will be swept into the AQM Sample-In port using nitrogen carrier gas. A vapor-phase analysis can then be performed by the AQM to identify and quantify the target analytes in the water samples. Parameters to be optimized include water sample size, carrier gas sweep rate, and ribbon temperature. The operating parameters of the vapor-phase analysis performed by the AQM will also need to be modified for this type of sampling methodology. A simple two-position valve attached to the ETV and a diverter tube will allow for manual selection of either a water sample through the ETV or an air sample through the diverter tube. The primary objective of this effort is to evaluate the viability of the EVT with ground-based, flight hardware. A proof-of-concept unit capable of water and air analysis utilizing the ETV will be developed. The target water analytes to be used in this work will come from a list provided by the water SMEs in the Toxicology and Environmental Chemistry Laboratories at JSC. These analytes are commonly observed in the ground analysis of water samples from ISS. A preliminary engineering evaluation of this set-up could potentially be performed with the goal of formulating a viable plan of integrating the ETV to the control software and power supply of the AQM. This plan could serve as a starting point for further development. This work will advance this project from a TRL of 3 to a TRL of 5.

TECHNOLOGY DETAILS

Use of the Operational Air Quality Monitor (AQM) for In-Flight Water Testing



TECHNOLOGY DESCRIPTION

- The primary objective of this effort is to evaluate the viability of the EVT with ground-based, flight hardware. A proof-of-concept unit capable of water and air analysis utilizing the ETV will be developed. The target water analytes to be used in this work will come from a list provided by the water SMEs in the Toxicology and Environmental Chemistry Laboratories at JSC. These analytes are commonly observed in the ground analysis of water samples from ISS. A preliminary engineering evaluation of this set-up could potentially be performed with the goal of formulating a viable plan of integrating the ETV to the control software and power supply of the AQM. This plan could serve as a starting point for further development. This work will advance this project from a TRL of 3 to a TRL of 5.
- This technology is categorized as a hardware subsystem for manned spaceflight
- Technology Area
 - TA06 Human Health, Life Support & Habitation Systems (Primary)
 - TA08 Science Instruments, Observatories & Sensor Systems (Secondary)

CAPABILITIES PROVIDED

Advanced in-flight water analysis will fill a gap in the current environmental health monitoring strategy and potentially eliminate return samples. This technology has a very high potential for infusion into ISS and Exploration Programs.

...

Performance Metrics		
Metric	Unit	Quantity
Identify and Quantify Target Water Analytes	ea	13

TECHNOLOGY DETAILS

POTENTIAL APPLICATIONS (CONT'D)

Favorable results of integrating the ETV with a ground-based flight AQM can potentially lead to a modified inlet system that can be retrofitted to existing flight hardware, extending water-monitoring capabilities in a cost-effective manner. This has the potential to reduce down-mass associated with ISS operations as well as potentially meeting the needs of Exploration-class missions within their vehicle-imposed constraints. Given the small size of the AQM and its ability to operate on battery power, the ETV can expand the capability of a highly capable field instrument for gas analysis to include the ability to analyze liquids as well.

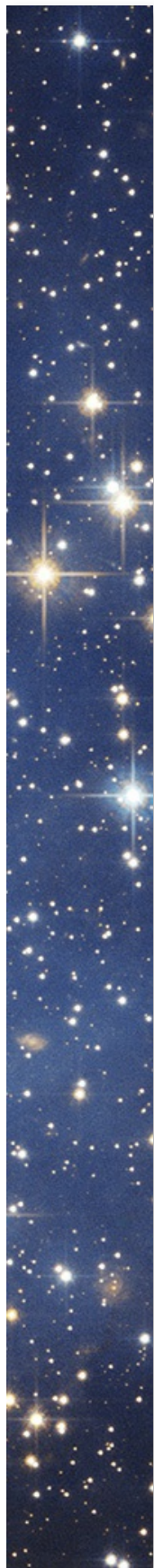


IMAGE GALLERY

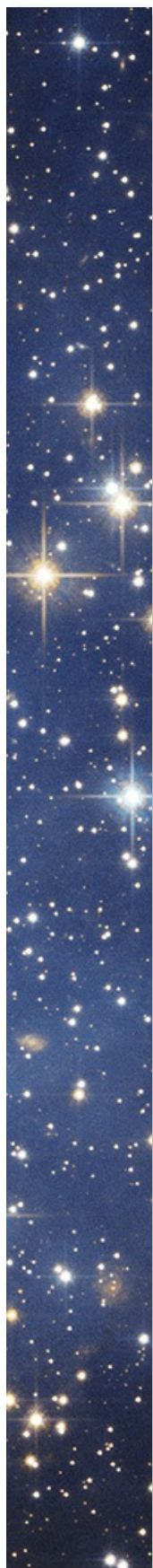


ETV-AQM

ABSTRACT (CONTINUED FROM PAGE 1)

chromatography-mass spectrometry (GC-MS) to identify and quantify organic compounds present in the samples. We envision the use of newly-developed direct ionization approaches as the most viable avenue leading towards an integrated analytical platform for the monitoring of water, air, and, potentially bio-samples in the cabin environment. Development of an in-flight instrument capable of analyzing air and water samples would be the logical next step to meeting the environmental monitoring needs of Exploration missions.

Currently, the Air Quality Monitor (AQM) on-board ISS provides this specific information for a number of target compounds in the air. However, there is a significant subset of common target compounds between air and water. Naturally, the following question arises, "Can the AQM be used for both air and water quality monitoring?" Previous directorate-level IR&D funding led to the development of a water sample introduction method for mass spectrometry using electrothermal vaporization (ETV). This project will focus on the integration of the ETV with a ground-based AQM. The capabilities of this integrated platform will be evaluated using a subset of toxicologically important compounds.



ANTICIPATED BENEFITS

To NASA funded missions: (CONT'D)

constituents requires sample return and subsequent ground analysis. This technology will provide crew the means to monitor water quality in real-time during flight.

To NASA unfunded & planned missions:

This reliance on ground analysis of returned samples and the limited information obtained from current in-flight hardware are major weaknesses in the management of environmental health on manned spacecraft and also make this approach incompatible with long duration missions beyond low-Earth orbit. This proposal attempts to address this shortcoming by developing a combined air/water analyzer for the in-flight monitoring of volatile organic compounds. Extending this to include an already developed, miniaturized plasma ion-source coupled to the electrothermal vaporizer and a detection system is a very powerful tool that will enable unfunded/planned missions. It is a capability that provides environmental monitoring capability with a means to perform advanced analyses of solids, liquids, and gases, sampled at destinations.

To other government agencies:

Given the small size of the AQM and its ability to operate on battery power, the ETV can expand the capability of a highly capable field instrument for gas analysis to include the ability to analyze liquids as well.

To the commercial space industry:

An electrothermal vaporizer (ETV) coupled to a detection system such as the Air Quality Monitor (AQM) results in a very powerful, cost-effective, enabling tool for environmental monitoring. Characteristics such as low power needs, portability and battery-ops capable, low mass and volume, minimal-to-no consumables, and advanced capabilities are highly desirable to space and terrestrial applications. It will be designed for the non-expert thereby providing advanced analytical capability to the layman.

To the nation:

An electrothermal vaporizer (ETV) coupled to a detection system such as the Air Quality Monitor (AQM) results in a very powerful, cost-effective, enabling tool for environmental monitoring. However, this system has advanced capabilities designed for the non-expert that requires low power,...

ANTICIPATED BENEFITS

To the nation: (CONT'D)

minimal-to-no consumables, is portable and battery-ops capable, and has low mass and volume. Such systems provide the layman and the researchers alike the analytical tools necessary to obtain real-time data as needed to deepen their understanding of complex problems.

