

Dynamic Sampling of Trace Contaminants During the Mission Operations Test of the Deep Space Habitat

Extended Abstract #13365

Oscar Monje

Air Revitalization Laboratory, ESC Team QNA, Kennedy Space Center, FL 32891, USA

Simo Valling, Jim Cornish

Gasmet Technologies, Inc., 1410 Taschereau Blvd 202, La Prairie, QC, Canada

INTRODUCTION

The atmospheric composition inside spacecraft during long duration space missions is dynamic due to changes in the living and working environment of crew members, crew metabolism and payload operations. A portable FTIR gas analyzer was used to monitor the atmospheric composition within the Deep Space Habitat (DSH) during the Mission Operations Test (MOT) conducted at the Johnson Space Center (JSC). The FTIR monitored up to 20 gases in near- real time. The procedures developed for operating the FTIR were successful and data was collected with the FTIR at 5 minute intervals. Not all the 20 gases sampled were detected in all the modules and it was possible to measure dynamic changes in trace contaminant concentrations that were related to crew activities involving exercise and meal preparation.

OVERVIEW

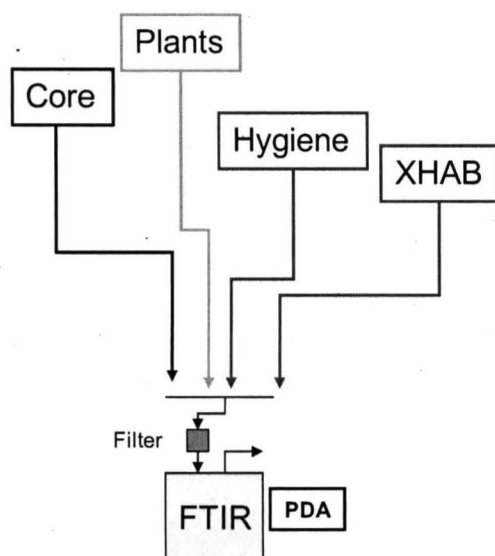
The Deep Space Habitat (DSH) is an Earth-based analog research platform used for evaluating habitation-related exploration technologies that will enable human exploration to multiple destinations (e.g. asteroids, Lagrange points, the Moon or Mars). The Deep Space Habitat is a prototype of a future habitat that houses astronauts performing specific manned mission scenarios. During the Mission Operations Test (MOT), four crew members lived inside the DSH at JSC for two weeks simulating the return trip to Earth from an asteroid.

Trace contaminant control and monitoring technologies represent an important area for deep space exploration missions. Reliable, near real-time trace contaminant monitors and event monitors are needed for ensuring that the crew is not exposed to harmful chemicals. A portable FTIR spectrometer was deployed during the DSH MOT to continuously record the composition of the air within several compartments of the DSH. The air quality data collected during the MOT will be used to develop future air revitalization subsystems for DSH. The FTIR was used to identify and quantify the trace contaminant loads observed on DSH.

Experimental Methods

FTIR has long been established as an accurate technology for the measurement of gaseous emissions from industrial processes, thus, this test investigated the feasibility of deploying a portable FTIR system for monitoring dynamic changes in composition occurring during a 2-week long manned mission. FTIR has been used on the international space station to monitor trace contaminants in near real time^{1,2}. The Gasmeter DX4040 analyser enables identification and quantification of multiple gaseous compounds simultaneously and accurately, with results available in seconds.

The Deep Space Habitat is a one story habitat unit with an approximate volume of 56 cubic meters. The HDU-DSH shell includes inflatable loft for additional habitation volume. The shape of the DSH shell is cylindrical with a vertically oriented axis. It has a 5.0 meter inner diameter, 2.0 meter barrel height, and 0.65 meter end domes on top and bottom for total height of 3.3 m. The DSH prototype shell is made of composite fiberglass resin-infused shell attached to 8 double 0.8 cm thick steel ribs.



Procedures for zeroing the FTIR, for data collection and storage, and for moving the FTIR from location to location were established. During integration of the FTIR into the DSH MOT timeline, the DSH MOT personnel were trained in these procedures. An application was devised whereby 20 gases were monitored continuously using a 5 minute averaging scheme: water vapor, carbon dioxide, carbon monoxide, nitrous oxide, methane, ethylene, pentane, toluene, o-xylene, p-xylene, acetic acid, formaldehyde, acetaldehyde, acetone, methanol, ethanol, acetonitrile, acrylonitrile, dichloromethane, and ammonia. The FTIR was either physically relocated to a new location or the plumbing was changed so that a different location was

monitored. The FTIR was zeroed using N₂ gas every time it was relocated. The FTIR was operated from a PDA via Bluetooth connection. Data was downloaded to a PC on a daily basis.

Results and Discussion

During the MOT, the Veggie plant atrium was monitored for 3 days, however, the DSH was inhabited only during the 1st day. The 1st day the crew was asleep, they woke up at 6AM, proceeded to exercise and then a meal was planned at 12 noon. The crew finished their activities at 4 pm and the DSH was uninhabited for 2 days (Fig 1).

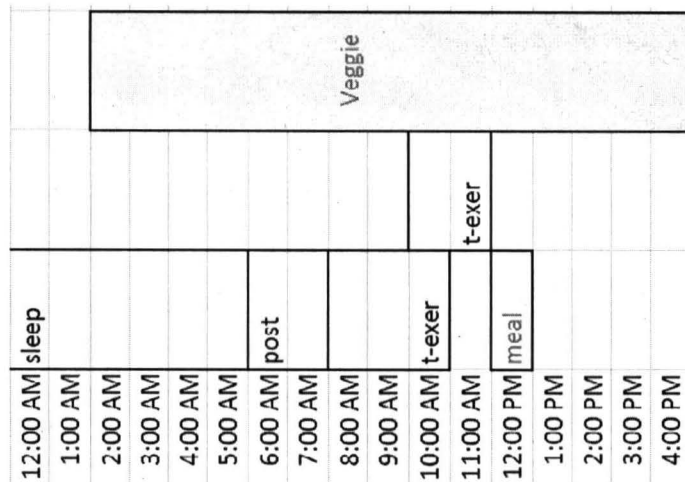


Fig 1. During the 1st day of the Veggie location, the crew awoke at 6AM and crew members began exercising by 8AM. The crew then gathered for a meal and the DSH was left vacant for 2 days.

Dynamic changes in the concentration of trace contaminants show that the FTIR was able to track crew activities (exercise and cooking) taking place during the timeline (Fig 2). There were large increases in CO₂ and ethanol concentrations when members of the crew exercised (~92 hrs). A lunch meal took place at ~98-100 hrs, which showed that pentane, ethylene, and ammonia were released during meal preparation (Fig 2).

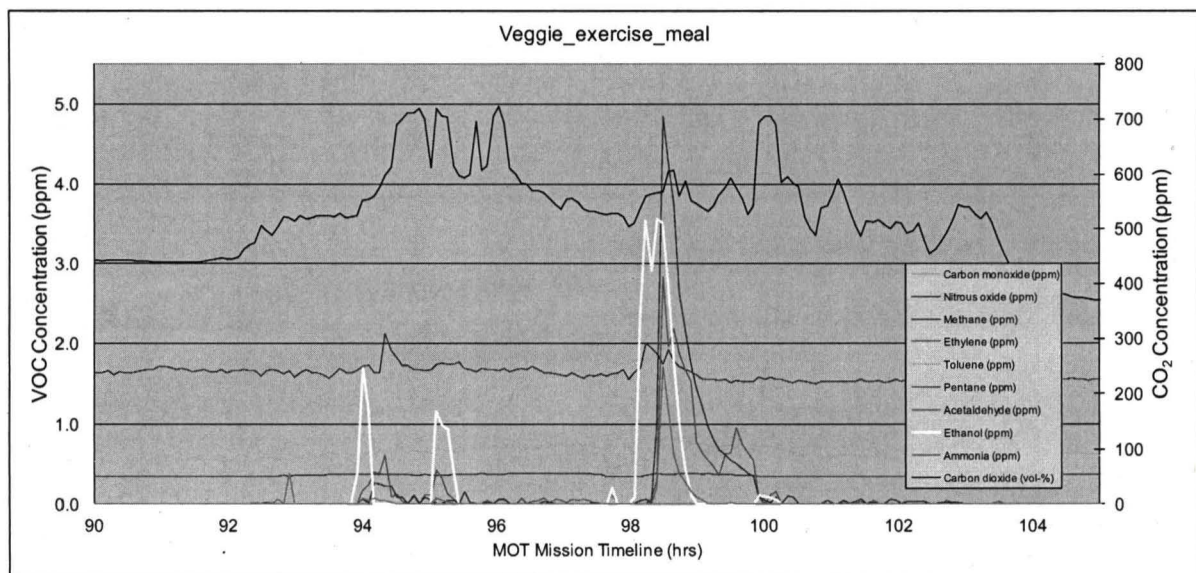


Fig 2. The 1st day of the Veggie location illustrates dynamic changes associated with exercise and meal preparation during the DSH MOT (high concentrations of CO₂, ethanol, pentane and ammonia).

The source of pentane during preparation of lunch is unknown, but pentane emissions have been reported from polystyrene foam. Emissions of ethylene and ammonia were also observed at the same time. The ethanol (wipes) and CO₂ emissions are indicators of the exercise activities taking place in the DSH.

SUMMARY

The dynamic measurements of habitat trace contaminants made using the portable FTIR show that crew activities like meal preparation, hygiene, and exercise result in short duration emissions of target trace contaminants. Hygiene and exercise events are characterized by spikes in CO₂ and ethanol concentration³. Meal preparation events, on the other hand, were characterized by short emissions of pentane, ammonia, and ethylene. The data shows that deploying an FTIR in DSH is warranted for capturing dynamic changes in trace contaminants in a habitat.

ACKNOWLEDGMENTS

The authors would also like to thank Tracy Gill at KSC, Kristina Rojdev at JPL, and the MSFC ARREM AES Project for important contributions to the success of this study.

REFERENCES

- 1 Stuffer T, Mosebach H, Kampf D, Honne A, Schumann-Olsen H, Kaspersen K, Supper W, Tan G. 2008. SAE Technical Paper. 2008-01-2042.
- 2 Honne A, Schumann-Olsen H, Kaspersen K, Clausen S, Mosebach H, Kampf D, Stuffer T, Supper W, Tan G. 2009. SAE International Journal of Aerospace. 2009; 1:178-192.
- 3 Perry JL, Peterson BV. 2003. SAE Technical Paper 2003-01-2650.

KEYWORDS

FTIR, trace contaminant, air quality, spacecraft