

Characterize Human Forward Contamination Project

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



ABSTRACT

Let's face it: wherever we go, we will inevitably carry along the little critters that live in and on us. Conventional wisdom has long held that it's unlikely those critters could survive the space environment, but in 2007 microscopic animals called Tardigrades survived exposure to space and in 2008 Cyanobacteria lived for 548 days outside the International Space Station (ISS). But what about the organisms we might reasonably expect a crewed spacecraft to leak or vent? Do we even know what they are? How long might our tiny hitch-hikers survive in close proximity to a warm spacecraft that periodically leaks/vents water or oxygen—and how might they mutate with long-duration exposure? Unlike the Mars rovers that we cleaned once and sent on their way, crew members will provide a constantly regenerating contaminant source. Are we prepared to certify that we can meet forward contamination protocols as we search for life at new destinations?

This project has four technical objectives:

1. **TEST:** Develop a test plan to leverage existing equipment (i.e. ISS) to characterize the kinds of organisms we can reasonably expect pressurized, crewed volumes to vent or leak overboard;
2. **ANALYSIS:** Develop an analysis plan to study those organisms in relevant destination environments, including spacecraft-induced conditions;
3. **MODEL:** Develop a modeling plan to model organism transport mechanisms in relevant destination environments;
4. **SHARE:** Develop a plan to disseminate findings and integrate recommendations into exploration requirements & ops.

In short, we propose a system engineering approach to roadmap the necessary experiments, analysis, and modeling up front--rather than try to knit together disparate chunks of data

ISSUE

We don't know what kind of organisms are actually leaking/venting from our current systems, how long those organisms could survive, or how far they may travel under destination conditions

Does proximity to a warm spacecraft matter? How close can crew get without compromising science? How far could our little hitchhikers spread?

The answers will drive element design (i.e. closed vs. open ECLS), where we place elements, and who/how we collect science samples

Issue Statement

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Management Team

Project Manager:

- Michelle Rucker

Co-Investigators:

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into a sensible conclusion after the fact.

ANTICIPATED BENEFITS

To NASA funded missions:

Understanding where and how organisms can escape from pressurized volumes--and whether they survive under destination conditions--will help inform several Advanced Exploration System projects, including Extravehicular Activity Technology, Deep Space Habitat, and Advanced Life Support.

To NASA unfunded & planned missions:

Preventing--or at least understanding--human forward contamination will help engineers meet planetary protection protocols as they design hardware, but will also help the science community understand how close exploration crews can get without compromising science objectives. These insights will help shape architectures and operations for future exploration missions.

To the commercial space industry:

Test, analysis, and modeling derived from this project will be of interest to both government and commercial exploration ventures.

To the nation:

This project will help the U.S. meet international planetary protection agreements.

DETAILED DESCRIPTION

The focus of this road-mapping effort will be "what can we do now with what we have?" For example, the micro-organisms inside the ISS are well-characterized...but no one has ever swabbed an ISS external vent to find out what (if anything) has managed to get outside. We can swab ISS vents now, without

Technology Areas

- Human Health, Life Support & Habitation Systems (TA06)
- Human Exploration Destination Systems (TA07)

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having to develop new hardware. If we take a sample and find nothing, that's good news!—it means that our environmental control and life support (ECLS) systems may already meet forward contamination requirements. If we do find organisms outside the ISS, it will be interesting to see how they compare with what we typically find inside. Are they the same? Or have they mutated? What corrective measures can we take to prevent external contamination? Once we know what manages to escape a typical spaceship, we can expose it to various destination environments and see how it's likely to behave. Then we can go one step further, and test those organisms in a spacecraft-induced environment to understand whether proximity to a warm, venting spaceship makes a difference. That will tell us how far away we must land from a sensitive area to mitigate forward contamination. We can also bring the modeling community into play and overlay destination weather models onto bacterial growth models to estimate how far microbes could be transported by, say, a small dust storm on Mars.

Another opportunity might be to take a sample from an Exploration EVA Suit during development testing and follow similar steps as outlined above: what organisms come out of a suit vent or leak from the suit? How close can EVA crew be to a sensitive site without compromising the science objectives? Data would tell us what modifications might be required to the suit *now*—early in the development phase—and avoid an expensive redesign later.

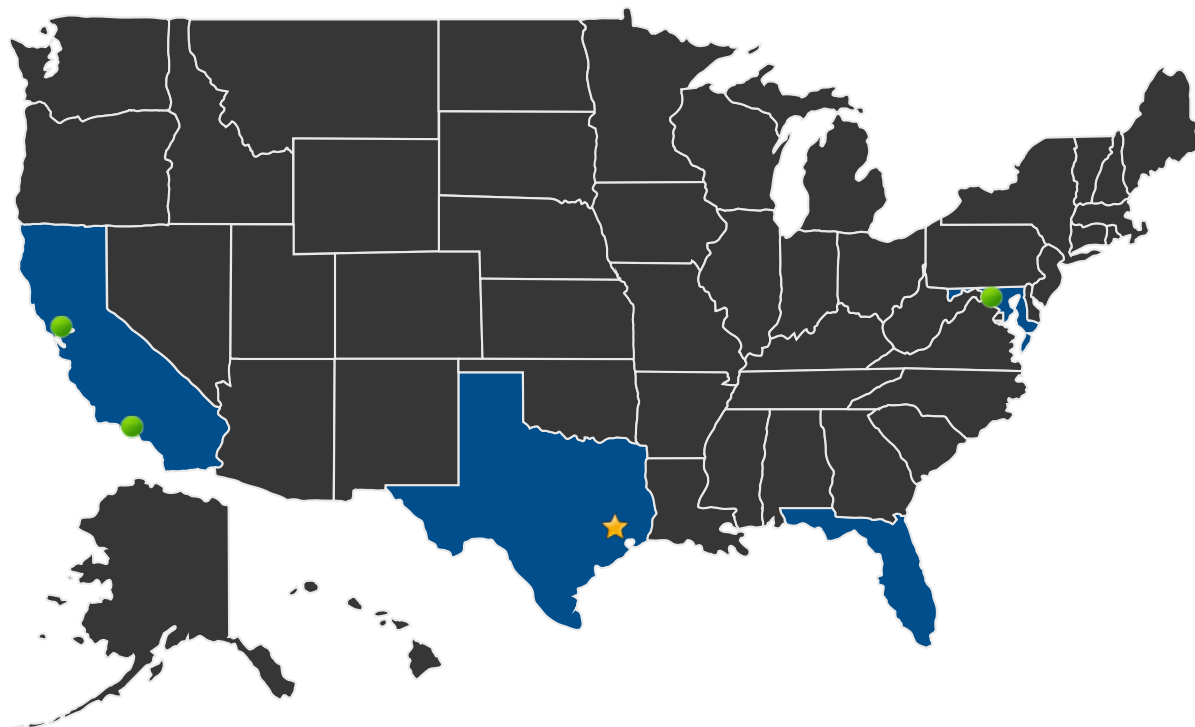
This project expects to produce a comprehensive test, analysis and modeling plan.

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U.S. LOCATIONS WORKING ON THIS PROJECT



■ U.S. States With Work ★ **Lead Center:**
Johnson Space Center

- **Supporting Centers:**
- Ames Research Center
 - Goddard Space Flight Center
 - Jet Propulsion Laboratory

Other Organizations Performing Work:

- SETI Institute (Mountain View, CA)
- The University of Florida

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PROJECT LIBRARY

News Stories

- Beer microbes Live 553 Days Outside ISS
 - (<http://www.bbc.co.uk/news/science-environment-11039206>)
- Creature Survives Naked in Space
 - (<http://www.space.com/5817-creature-survives-naked-space.html>)
- Space station research shows that hardy little space travelers could colonize Mars
 - (http://www.nasa.gov/sites/default/files/files/Fall_2014.pdf)

IMAGE GALLERY



New! FY15 R&D Project: Forward Contamination Integrated Test & Analysis

BACKGROUND
Some organisms can survive exposure to space environments! ... We also know that all crewed, pressurized volumes will leak or vent.

ISSUE
But we don't know what's actually leaking/venting from our current systems, how long those organisms could survive, or how far they may travel under destination conditions. The answers will drive element design (i.e. closed vs. open ECLSS), where we place elements, and who/how we collect science samples.

SOLUTION
FY15 JSC IRAD Project Approval (Lead: Michelle Rucker) ... Project Deliverables Integrated Test & Analysis Plan for FY14. Expect multiple FY15 spin-offs for targeted tests and analysis. Present at STMD Symposium on Future of Space Exploration.

HAB is in a unique position to integrate this work



Forward Contamination Project Overview

Tardigrade in Moss, Image Credit & Copyright: Nicole Ottawa & Oliver Meckes / Eye of Science / Science Source Images

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DETAILS FOR TECHNOLOGY 1

Technology Title

Advanced EVA Spacesuits

Technology Description

This technology is categorized as a hardware assembly for wearable applications

Advanced Extravehicular Activity (EVA) spacesuits that can protect the occupant from the environment *and* protect the environment from the occupant will become more important as humans begin exploring destinations that may have the potential to support life.

Capabilities Provided

The first step is to understand the mechanisms and risks involved in potentially releasing human contamination from our spacesuits. This will inform future suit hardware and operational procedure designs.

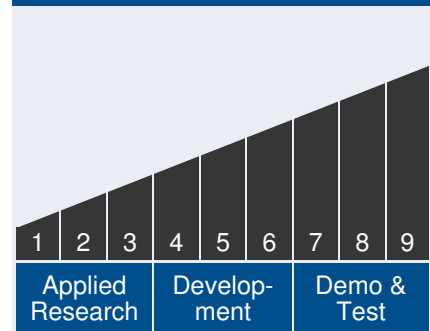
Potential Applications

Applications include exploration EVA suits intended for destinations that may support life.

Performance Metrics

Metric	Unit	Quantity
Ability of System to prevent contamination release	percent	TBD

Technology Maturity



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DETAILS FOR TECHNOLOGY 2

Technology Title

Advanced Life Support

Technology Description

This technology is categorized as a hardware subsystem for manned spaceflight

The results of this project will help inform advanced life support technology development for exploration missions.

Capabilities Provided

This project will help characterize the types of organisms that are typically vented or leaked from current spacecraft environmental control and life support systems--and provide insight into how to prevent it or mitigate the effects.

Potential Applications

Potential applications for this technology encompass all pressurized crew compartments used at exploration destinations--everything from space suits to habitats or pressurized Mars surface rovers.

Performance Metrics

Metric	Unit	Quantity
System ability to prevent contamination release	percent	TBD

