EVA Swab Tool to Support Planetary Protection and Astrobiology Evaluations

NASA/Johnson Space Center/ Michelle Rucker, Drew Hood, Mary Walker
NASA-CalTech Jet Propulsion Laboratory/ Dr. Kasthuri Venkateswaran
University of Florida/ Dr. Andy Schuerger
Background

Issue: We have knowledge gaps!

- Weather/how microbes are released from crewed pressure systems

Why do we care?

- Informs Mars operational concepts
- Informs architecture decisions
- Informs landing site selection decisions

Strategic Knowledge Gap B5
Forward Contamination for Mars

Why do we care?

- How to protect the science
- Open vs. closed life support systems?
- How close can we operate to where life may be present?
First, We Need A Toolbox

Microbial sampling on Earth is simple

Sterile, wetted swab

Sampling in space is more complicated

Difficult to handle swab with bulky gloves

Wetted swab won’t work in a vacuum

Sample container has to maintain integrity when transiting from vacuum to pressure cabin

Extravehicular Activity (EVA) Gloves
Swab Tool Is Designed for EVA

1. Swab Tip Held in Sterile Container with Ball Detents
2. Tool Handle Snaps Into End Effector
3. Pull to remove Swab from Sterile Container
4. Slide Cover Forward and Squeeze Paddles to Release Swab Tip

Simple push-fit to engage swab tip, but dual-action required to release swab tip

IEEE Aerospace 2018, Session 2.06 Paper 2038
8-Sample Swab Kit

0.22 micron pore Microbial filter stack in bottom of each sample canister allows canisters to vent but remain sterile

6 canisters on top, 2 on bottom (not shown)
Form, Fit, Function Testing
• Suited subject in a Mark III suit at differential suit pressure

Swab Tip Environmental Testing
• Macrofoam + two other types of swab
• Bend and pull tests at temperatures from -73.3°C (-100°F) to 37.8°C (100°F)
• Testing indicated swabs would maintain integrity under expected loading, even at temperature extremes

Swab Tip Effectiveness
• Tests at JPL and JSC demonstrated dry macrofoam swab was at least as effective as standard wetted swabs
Extravehicular Mobility Unit (EMU)

Suit differential pressure

We need to characterize the suits before we send suited crew to sample anything else.

Saved cost by piggy-backing onto EMU-suited ISS crew training runs.
Suit joints & vents are the most likely microbial escape paths
- Microbes only need 0.5 to 1.0 μm gap
- Vents can be filtered, but joints can’t

Initial tests: did not modify any suit cleaning or handling protocols
Evaluations with EMU Suits

Click here to play video

IEEE Aerospace 2018, Session 2.06 Paper 2038 1
External Vacuum Swab Test

- Piggy-backed onto a 6-test Orion project series
  - Two different types of suits

Swab Tool
Sample Caddy
OCSS
Orion Crew Survival System
Entry Zipper
MACES
Modified Advanced Crew Escaped System
Design Improvements

- **End Effector-to-Canister Seal Redesign**
  - Seal retaining ring, alternate seal profile, or alternate seal type

- **End Effector Locking Device**
  - To ensure end effectors remain inside canisters during handling or shipping

- **Swab Re-Use Prevention**
  - Ratcheting device to prevent inadvertent re-use of a swab

- **Additional Caddy Handle**
  - For better operator control

Will be incorporated into flight design
Next Steps
Analysis, flight certification, and ISS swab

Culture and DNA analysis in progress

- Will feed results back to suit designers and publish test data
- Working with CASIS to identify potential commercial partners
  - Companies interested in looking for extremophiles outside ISS

ISS is seeking ideas for additional research that could be conducted after USOS increases to 4 crew (after September, 2017)

From: InnoCentive [mailto:no-reply@innocentive.com]
Sent: Thursday, August 24, 2017 4:44 PM
Subject: Award Announcement for NASA@work Challenge: Submit Your Research Idea to be Conducted on ISS!: Congratulations!

Congratulations, your submission to NASA@work Challenge: 2270 - has been awarded!

- Payload integration agreement in place for 2018
Conclusions

- Ground testing validated tool effectiveness and interface with pressurized EVA suits
  - Test subjects found tool straightforward to operate
  - Design improvements identified
  - Minimized development costs by repurposing retired hardware and piggy-backing onto flight crew training
  - Additional potential uses identified: astrobiology research and micrometeoroid/orbital debris evaluation

- Baseline suit microbial data collected
  - Supports development of human mission planetary protection protocols
Acknowledgements

The authors thank Douglas Terrier and the Science and Technology Mission Directorate, and a cross-organizational test and analysis team, including Mary Sue Bell, Alex Horvath, Justin Connolly, Bekki Bruce, Christian Castro, Dr. Aaron Regberg, Dr. Ganesh Babu Malli Mohan, and Dr. Camilla Urbaniak.