Planetary Protection and Dust Mitigation Panel:

EVA Technology Workshop 2017

October 18, 2017
Natalie Mary, Cassie Conley, Michelle Rucker, Ben Peters, Aaron Regberg
Panel Motivation and Panelists

- Motivation for Planetary Protection (C. Conley; Planetary Protection Officer)
- Layered Engineering Defense (N. Mary; moderator, XX/EVA Exploration Management Office Systems Engineering & Integration)
- Dust/Regolith for Surface Exploration and the xEMU (B. Peters, Pressure Garment Subsystem (PGS) Engineer, Space Suit and Crew Survival Systems Branch)
- Forward Contamination and Suit Swab (M. Rucker, XM/Exploration Mission Planning Office Systems Engineer and A. Regberg, XI/Astromaterials Research and Exploration Science Division Geomicrobiologist)
Planetary Protection

Cassie Conley
Planetary Protection Officer
Phased Approach: Be careful early; tailor later constraints using knowledge gained

• Humans have many interests at Mars; understanding potential hazards supports all of them
• Searching for Mars life becomes more difficult, the more Earth contamination is introduced
• Future colonization could be challenged, if unwanted Earth invasive species are introduced
  – Blocking aquifers
  – Consuming resources
  – Interfering with planned introductions

Planetary Protection Policy:
Protect the Earth, Avoid Harmful Contamination
Adding humans, policy has the same intent—but different implementation
Basic Motivation

Protect the Earth

Preserve Human Interests on Mars

Human Exploration Systems

Understanding of facts informs future developments

Earth Biology

Mars Environment
Notional Human Exploration Concept

1 Human Habitation

1, 2a “Safe Zone” from precursors (may be entire surface)

2a Safe Zone for Human Activities

Lab

Hab

Human Traverse

Robotic Traverse

“Clean” Rover Transfer Site

3 Unexplored Hypothetical Special Region/Potential SR

2b, 3 “Life Sites” defined from remote sensing data

2b Hypothetical Special Region with Robotic Exploration

Robotic/Teleoperation Human Traverse
Extravehicular Activity

Natalie Mary
EVA Exploration Management
Office Systems Engineering & Integration
Layered Engineering Defense Example

**What might “reasonable protective measures” look like for EVA and surface assets?**

This is an example of a layered defense plan – other protocols can be followed:

- **1\(^{st}\) Layer – Mission Architecture Design**
  - Avoidance of Special Regions (defined within X radius of lander/habitat prior to the mission)

- **2\(^{nd}\) Layer – Hardware Design**
  - EVA Suits will leak/vent – Engineering limits must be understood and intentionally accounted for
  - Sample tool collection/containment

- **3\(^{rd}\) Layer – Operational Design**
  - Suit ingress *directly* to habitable volumes should be eliminated to extent possible, examples of this include the dual chamber airlock and/or different airlock concepts
  - Sampling protocols limit inadvertent contamination
  - Leaving EVA suits on surface

- **4\(^{th}\) Layer – Contamination Control**
  - Conduct verifiable decontamination of EVA Hardware on a regular interval
  - Conduct exterior and interior cleaning
  - Utilize air quality contamination zones
Dust and the xEMU

Ben Peters
Pressure Garment Subsystem (PGS)
Engineer, Space Suit and Crew
Survival Systems Branch
Dust/Regolith for Surface Exploration

• System-wide dust protection is a key design driver for xEMU surface operations, and development of dust proof mechanisms, bearings, materials, and coatings coupled with specific operations and surface architecture development is critical for success.

• Dust Proofing on the xEMU should protect against the following damage mechanisms
  – Dust Abrasion
    • Dusty surface directly damages outer material, resulting in reduced properties, additional migration and damage to other layers.
    • Mitigate through patterning (twill weave common in clothes), base materials selection, and protective coatings
  – Dust Adherence
    • Can change the thermal performance of the system, or introduce regolith and dust into the airlock or cabin environment, potentially harming crew members.
    • Mitigate by making the surface cleanable, or control the surface charging
  – Dust Penetration/Permeation
    • Create abrasion risks to fabric layers or other captured features beneath the outer layer and create damage
    • Mitigate by choosing tighter-weaves, closing gaps in integration, or using coatings to fill space of fabric
    • Choose fabrics that don’t abrade other layers

• Current philosophy is fully integrated dust mitigation strategy with the TMG and exposed suit components

• Over garment, bunny suit, or “coveralls” could be considered as contingency or as an additional mitigation option for xEMU surface operations.
Wish List For xEMU Dust Environments

• Development of materials and coatings
• Dust-proof bearing and mechanism designs
• Softgoods designs and patterns for dust-mitigation
• Solutions to system level architecture and operations concepts, including airlocks and other surface architecture.
• Cleaning and maintenance operations for dirty surface environments
EVA Suit Studies
Human Forward Contamination Project

Michelle Rucker
XM/Exploration Mission Planning Office
Systems Engineer

Aaron Regberg
XI/Astromaterials Research and Exploration
Science Division Geomicrobiologist
Issue: we have knowledge gaps!

- Whether/how microbes are released from crewed pressure systems

Why do we care?

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

Project goal: get some data to fill in these gaps

- Data will help determine whether we’re ready to go to Mars, or if we need to change our systems or operational designs
New EVA Sample Kit
8-Sample Caddy and a Tool Handle

Repurposed Shuttle tile repair hardware!
Dual-action swab end effector release

6 swab canisters on top, 2 on bottom (not shown)
Tool Form, Fit, Function Test
With a Mark III Suit

Lab Environment (4.3 psid)

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

Culture Analysis
- No fungal spores detected
- Common skin bacteria detected
Space Suit Swab Testing
4.3 psi differential suit 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

Initial tests: did not modify any suit cleaning or handling protocols
Sample EMU Swab Test (4.3 psi differential pressure)

Click here to play video

7 test runs to date
Entry Zipper Swab Test (External Vacuum)

Click here to play video

5 test runs to date
Next Steps
Analysis, flight certify the Tool, and Swab ISS

- Additional EVA suit ground test “piggy-back” opportunities in FY18
- Will feed results back to suit designers and publish test data

Working with CASIS to identify potential commercial partners
  • Two companies have expressed interest in looking for extremophiles outside ISS

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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 - Submit Your Research Idea to be Conducted on ISS! has been awarded!
Thanks to Lots of Smart People

**JSC Orgs**
- XM, XI, XX, CB, EA, EC, ER, SK

**NASA Centers**
- JSC, JPL, ARC & GSFC

**External orgs**
- SETI Institute and University of Florida

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*Early career/student interns*
BACK UP
Airlock Options

• Airlock Options:
  – Conventional Dual Chamber Airlock
  – Suitlock/Rear-Entry Airlock
Questions

• What planetary protection (PP) related research activities or technical developments do you feel are critical for inclusion in your study area?
  – EVA needs Suit materials testing to understand chemical interaction
  – Cleaning tools design and procedural use definition is an unknown
  – Ingress/egress method design options need to be weighted from a Planetary Protection perspective

• What work/research is already underway?
  – Exploration EVA Suit design is ongoing, with requirements development and potential ISS EMU replacements in discussion

• Is special information or technology needed to plan for nominal vs. non-nominal situations?
  – Suit failure/Incapacitated crewmember operations must be pre-planned
  – A thorough dialogue is needed to evaluate how contingency operations would be conducted and still fulfil the intent of Planetary Protection guidelines
Questions

• Are existing human mission mitigation options and approaches adaptable for PP needs on the Martian surface?
  – Personal Protective Equipment for suit servicing is historically quite limited
  – Air flow control is has also been quite limited in flight

• Are there any significant stumbling blocks ahead that are evident? (Including coordination across PP, science exploration, engineering, operation and medical communities.)
  – Coordination across communities must be increased: Knowledge gained from current/future programs on Mars to documentation that can be applied to Exploration EVA development
    • Environments documentation is needed
    • Direction on simulants use for testing
  – Concurrence on testing of ingress/egress methods prior to use for the first time for mission success/planetary protection

• In your opinion, what still needs to be accomplished?
  – See Future Testing/Demonstrations and EVA Needs slides
Suggested Future Testing, Demonstrations and Coordination

• Suit Materials testing on Mars 2020 rover is being pursued
  – This by itself will likely not answer all questions associated with chemical compatibility

• Ground Testing and Analogs
  – Ingress/egress methods with suits on other side of bulkhead (Next Generation Airlock)
  – Coordination on the “best” combination of layered controls and technology concepts is highly desired
    • This should include nominal prevention and cleaning, contamination detection technology, detailed contamination control and removal/cleaning technology?
  – Cleaning/Sterilization must be compatible with the suit material limitations
  – Environment characterization-definition (properties of dust/dirt, dust storms, etc.)
  – Mars simulant (require knowledge, not necessarily Mars sample return)
    • Additives to trace backward contamination?
    • Chemical additives to understand materials degradation due to toxicity/corrosion?
  – Programmatic requirement for testing acceptable levels of dust within the habitable volumes
Suggested Future Testing, Demonstrations and Coordination

• EVA needs Planetary Protection support for ground testing prior to mission success
  – Dust mitigation testing should be done prior to Mars surface
  – This can be done at Cis-lunar proving grounds, Lunar Surface (IP missions), and Mars Moons

• Further evaluation of the Layered Engineering Defense Plan for Dust Mitigation is desired
  – Operational Design and Contamination Prevention
    • Need support for testing ingress/egress methods prior to use for the first time on Mars surface for planetary protection and mission success
    • Need special region locations for landing site selection
  – Exterior and Interior Cleaning and Protection
    • Need the technology identified for detection and contamination control and removal from Planetary Protection community (next level of detail from the COSPAR Planetary Protection Policy) to understand how it interfaces with the suit and testing needs
    • Need requirements for simulant use during testing from Planetary Protection community
  – Air Quality Contamination Zones
    • Need input/support on architecture zoning concepts