Planetary Protection Knowledge Gaps for Human Extraterrestrial Missions:

Workshop Summary and Research Needs

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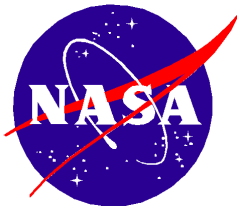
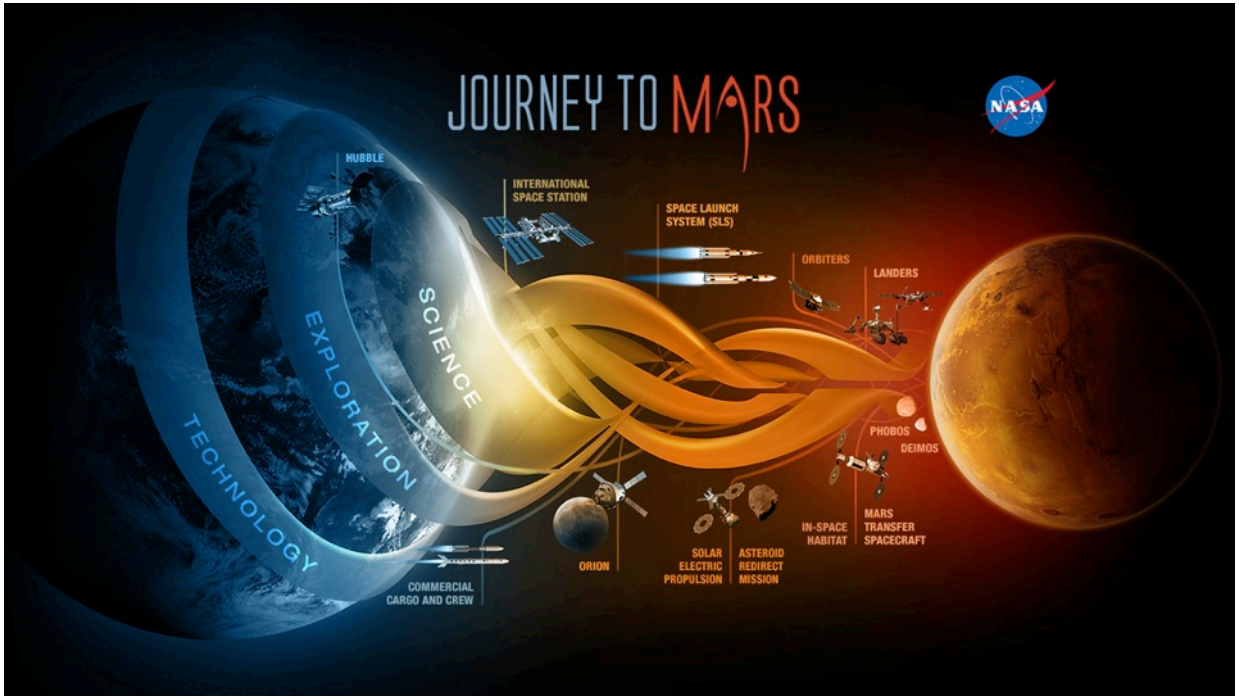


SSERVI- Exploration Science Forum
NASA ARC July 23, 2015

Overview

- Background & Context for PP & Humans Workshop
- Workshop Logistics & Objectives
- Focus on 3 Key Areas of Importance
- Looking Ahead:
  - ✓ Continuing Incremental Process toward NPRs
  - ✓ Anticipated Technical Report & Journal Articles
  - ✓ Future Opportunities for R&TD – Astrobiology Community



PP Requirements Well Established for Robotic Missions

NEXT: Need for PP Requirements for Human Missions

Translate COSPAR Principles/Guidelines into Requirements

2012: PP Subcommittee of NAC

Recommended need NPR Document for Human PP

HEOMD & PPO work together

2013: Recognize Knowledge Gap - Adopted Incremental Approach

NASA Policy Instruction: NPI 8020.7

CONTEXT: Future Human Missions & PP human missions

Build on NASA & ESA Workshops (2001-05)

ID Key Systems, Operations & Equipment Impacted by PP

Assess Current Capabilities and Knowledge Gaps***

• Biological Monitoring – ID microbes *in situ*	• Quarantine Facilities (Indiv. & Crew)
• Biodiagnostics, Medical Treatment (crew)	• Waste Disposal Processes/Containment
• Equipt. Decontam /Steriliation Methods	• Updated Human PP Protocol
• Advanced Life Support Systems (ALS)	• Understand Fwd/ Back Contam. Pathways
• Extravehicular Activity (EVA) & EVA Equipment	• Material Inventory (process products & streams; Habitat Leakage & Release)
• Spacesuit Designs (including ALS)	• Cleaning/Maintenance of Tools
• Ingress/Egress (crew, materials, equipt.)	• Biocontainment & Handling in Labs
• Drilling Equipment (subsurface sampling)	• Closed Loop & Recycling Capabilities to Minimize Mass
• Sample Containment, handling, transfer	• ISRU Systems
• Avoid Special Regions- Robotic Precursors	• Nominal/ Off Nominal Scenarios

*** 100+ applicable publications & reports and 4 significant workshops have contributed to current principles and assumptions for PP and human missions

COSPAR Principles for Human Missions to Mars

① Safeguarding the Earth from potential back contamination is the highest planetary protection priority in Mars exploration.

② The greater capability of human explorers can contribute to the astrobiological exploration of Mars only if human-associated contamination is controlled and understood.

③ For a landed mission conducting surface operations, it will not be possible for all human associated processes and mission operations to be conducted within entirely closed systems.

④ Crewmembers exploring Mars, or their support systems, will inevitably be exposed to Martian materials.

Current COSPAR Implementation Guidelines
for Human Missions to Mars (paraphrased)

a. Continuous monitoring and evaluation of terrestrial microbes will be needed to address forward and backward contamination concerns

b. A quarantine capability (for individuals & entire crew) is needed during and after the mission

c. Need to develop comprehensive planetary protection protocols for combined human and robotic aspects of mission

d. Neither robotic systems nor human activities should contaminate "Special Regions"

e. Uncharacterized sites should be evaluated by robotic precursors prior to crew access

f. Pristine samples or sampling components from uncharacterized sites or Special Regions should be treated as planetary protection category V, restricted Earth return

g. An onboard crewmember should be designated as responsible for implementing planetary protection measures during the mission

h. Planetary protection requirements will be based on conservative approach and not relaxed without scientific review, justification, and consensus

NPI = Pathway to Human Spaceflight Requirements

- Intention on the part of NASA to facilitate:

Key NPI Study Areas

- Developing capabilities to comprehensively monitor the microbial communities associated with human systems and evaluate changes over time;
- Developing technologies for minimizing/mitigating contamination release, including but not limited to closed-loop systems; cleaning/re-cleaning capabilities; support systems that minimize contact of humans with the environment of Mars and other solar system destinations;
- Understanding environmental processes on Mars and other solar system destinations that would contribute to transport and sterilization of organisms released by human activity.


WORKSHOP
Planetary Protection Knowledge Gaps for
Human Extraterrestrial Missions
March 24-26, 2015
NASA Ames Research Center
HEOMD & PPO
85 Attendees: 3 Sub-Group Focus Areas:
1. Microbial & Human Health Monitoring
2. Technology & Ops for Contamination Control
3. Natural Transport of Contamination on Mars

Overall Workshop Goals

- To identify our knowledge gaps with respect to human missions to Mars and planetary protection by:

1. Gathering and discussing information needed to help move closer to definitive (procedural/implementation) requirements for future human missions NPRs

2. Assessing the types and levels of research underway and/or needed to identify knowledge gaps in areas consistent with fulfilling COSPAR Principles and Guidelines for Human Missions to Mars

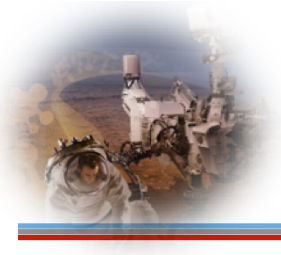
3. Building a network of expertise to help address planetary protection challenges for human exploration

Assess "State of Knowledge" & "Gaps"

- **Study Area #1: Human Health & Microbial Monitoring**
  - Monitoring growth and survivability of human & habitat associated microbial populations in space environments
  - Minimal mass/volume and low consumable/waste product biological assay techniques
  - Microbiome research and ability to detect extraterrestrial perturbations
  - Crew quarantine measures for preventing back contamination
  - Crew health and habitat microbiome impacts from Mars material

- **Study Area #2: Technology & Operations for Contamination Control**
  - Cleaning, sterilization, & re-contam. prevention technologies for in-situ application
  - ECLS loop closure and mitigation of spacecraft effluents
  - Contamination control tcchnologies for human surface mobility systems & spacesuits
  - Contamination control and localized special region prevention for support systems (ISRU, Power, etc.)
  - Human surface exploration- operational strategies for mitigating contamination
  - Sample containment and breaking-the-chain (BTC) of contact technologies

- **Study Area #3: Mars Environmental Effect Characterization**
  - Transport mechanisms on the Mars surface
  - Potential sterilization effects of the Mars environment
  - Environmental clean-up of inadvertent release of unsterilized terrestrial material



5 Guiding Sub-Group Questions

- What *PP R&TD areas are critical for each study area?*
- What work/research is *already underway?*
- Special info needed *for nominal vs. non-nominal situations?*
- *Are existing options for mitigating contamination adaptable* for planetary protection needs on the Martian surface?
- Are there any *significant stumbling blocks ahead* that are evident? (including coordination across PP, science exploration, engineering, operation & medical communities)

Objective: Identify Specific *Research Needed to Contribute towards Meeting COSPAR Planetary Protection Principles & Guidelines for Human Mars Missions*

Current Status of NPI Related Activities:

- Literature Review Completed
- Workshop Completed
- NASA Technical Report on Workshop - *in preparation*
  - Will be Posted on PP Website http://planetaryprotection.nasa.gov
- Three Journal articles *Advances in Space Research (ASR): Special Issue on PP:*
  - Summary of Literature Review on PP & Human Missions
  - Article: on recent Planetary Protection Knowledge Gaps Workshop
  - Overview of Systems Engineering & Planetary Protection in relation to future human exploration (cross-cutting coordination)

- Looking Ahead - NPI Process:
  - Create prioritized list of needed studies to inform requirements
  - Approval of studies for funding FY 2016
  - Iteration of draft requirements in parallel with studies

Additional Collaborative Outcomes To Date

- Successful Interdisciplinary Collaborations - HEOMD & PPO

① EVA SWAB TESTING ON ISS

- Development of Prototype Tool – How To Swab & Contain in Space
- In November?- Piggy Back on Spacesuit Testing
- To Test & Use on ISS Vents during EVA's (inside/outside vents)

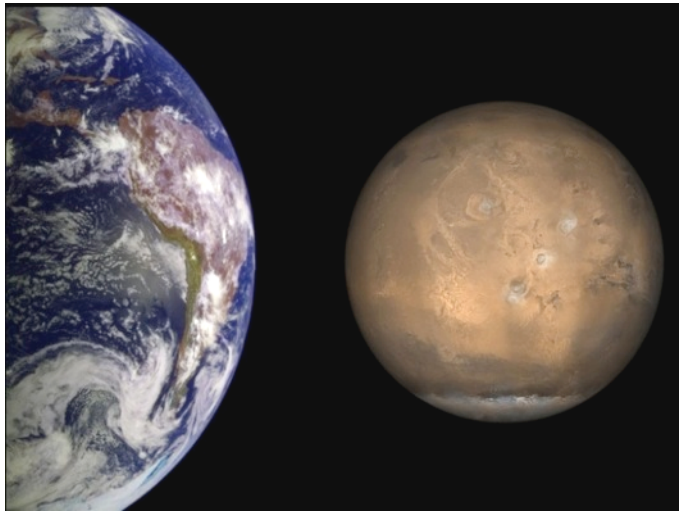
② MINI-DNA SEQUENCING - Microbial Dispersal Studies (away from Habs & Rovers)

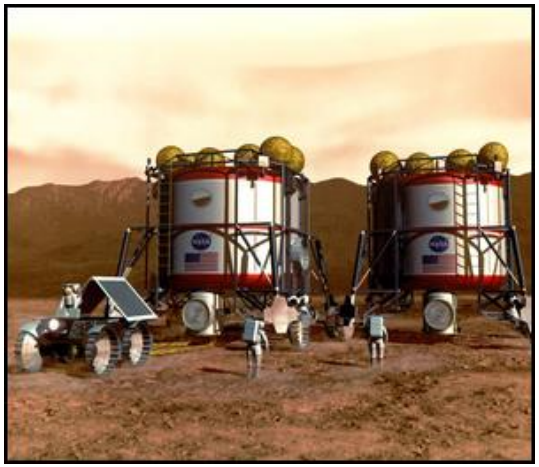
Arctic Field Tests - in Summer 2015 ?

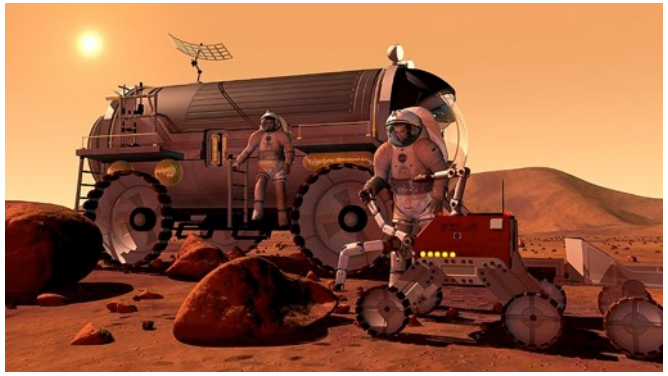
Later: Demo Low-cost DNA Sequencing for use on ISS & Space?

…. To be continued? Stay Tuned!

Questions?





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