Planetary Protection Guidelines

Science Objectives for Human Exploration of Mars Workshop
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J. Nick Benardini
Planetary Protection Officer

Elaine Seasly
Deputy Planetary Protection Officer
J. Andy Spry
SETI Institute / NASA Planetary Protection Consultant

Planetary Protection Policy for Crewed Missions

Protecting solar system bodies from contamination by Earth life to enable scientific exploration and protecting Earth from possible harmful biological contamination that may be returned from other solar system bodies.

- The **intent of planetary protection is the same** whether a mission to Mars is conducted robotically or with human explorers.
  - Enable exploration and protecting both Mars + Earth's biosphere.

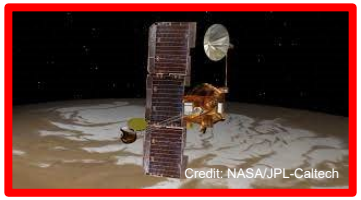
- Forward PP applies to crewed missions. Enabling scientific exploration through **managing the contamination** of Earth-based organisms of Mars for current and future missions.
  - It's not possible for all human-associated processes and mission operations to be conducted within closed systems – need to understand human contamination influence to guide decision making.
  - Monitor microbial communities, minimize/mitigate contamination release and environmental transport modeling required to manage contamination.
  - Precursor missions may be required to gain knowledge/establish baseline .
  - The more we know the more we can safely explore.

- Backward PP applies to crewed missions. **Protecting the Earth's biosphere from Mars contamination is the highest priority**.
  - Crew exploring Mars, and/or their support systems, will inevitably be exposed to martian materials – need to understand quarantine capabilities, sample containment handling and testing protocols.

Notional Forward PP Mars Exploration Trade Space

REQUIREMENTS

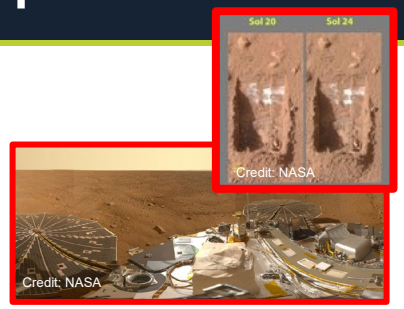
Prescriptive



Robotic - Mars Orbiter
PP Category III – Orbital Lifetime
Mars Odyssey

Robotic - Mars Orbiter
PP Category III – Bioburden
MAVEN mission

Robotic - Mars Lander / Rover
PP Category IVa
Mars Science Laboratory – Curiosity



Robotic - Mars Lander / Rover
PP Category IVc – Mars Special Region
Phoenix Lander

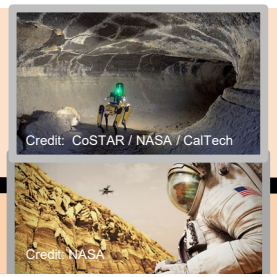
Robotic - Mars Lander
PP Category IVb –
Life Detection
Viking Lander

Knowledge Gaps

IMPLEMENTATION

Easier ← → **Challenging**

Crewed – Habitat / Close EVA Study



Crewed + Robotic -
Special Region Exploration

Crewed – Habitat / Far
(kilometers?) EVA Study

Crewed Special Region/Sampling for
life detection/In-situ life detection

Key
Robotic
Robotic + Crewed
Crewed

Performance Based

Notional Backward PP Mars Exploration Trade Space

REQUIREMENTS

Prescriptive

Knowledge Gaps

IMPLEMENTATION

Easier

Challenging

Performance Based

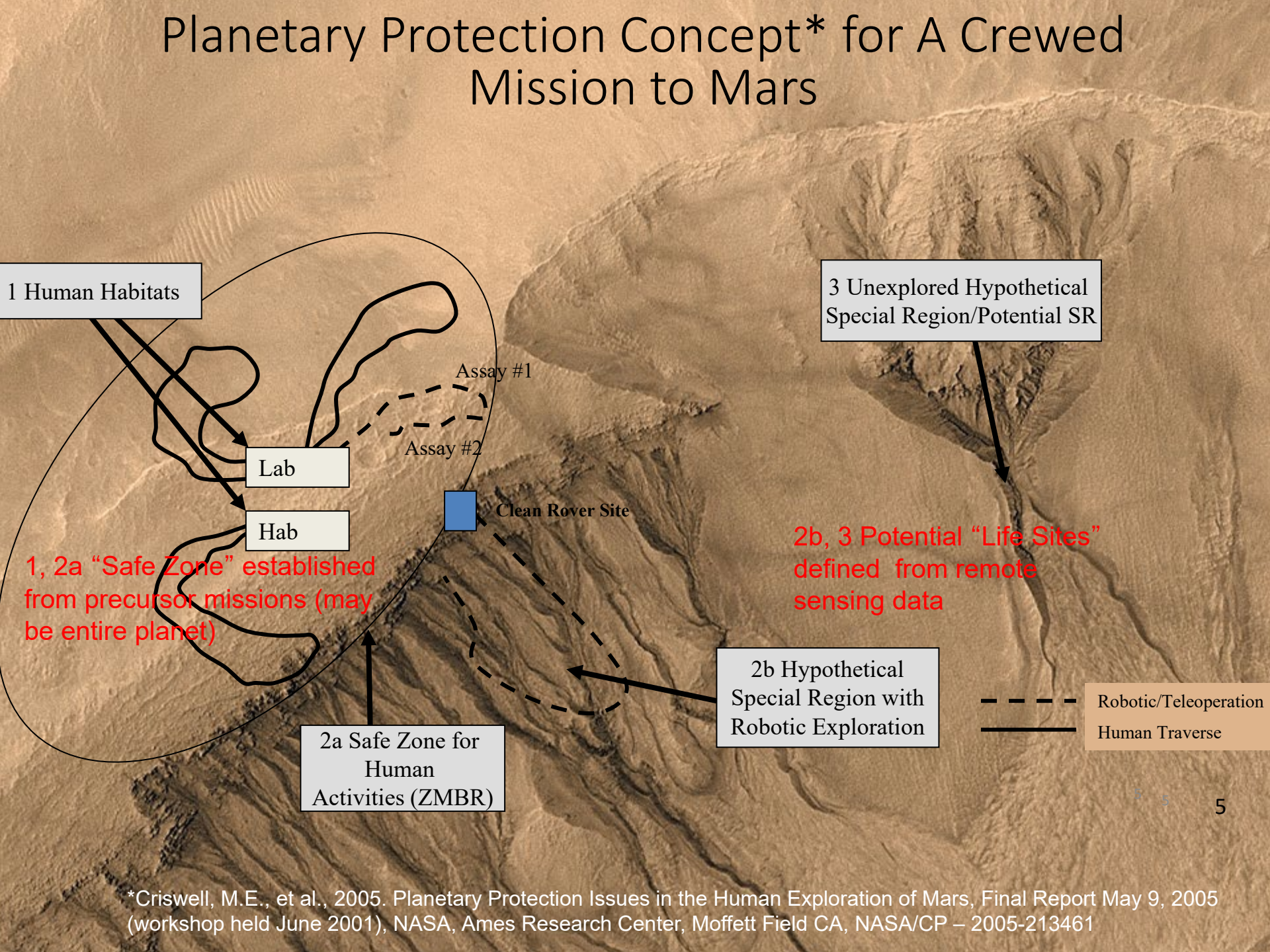
Robotic – PP Category V(r), MSR Campaign
Sample Hardware Cleanliness, Earth Return Safety Assurance

Crewed – Sample Return + Quarantine +
Onboard Sample Glove Box Assessment

Crewed – Sample Return + Quarantine +
Onboard Sample Assessment

Key
Robotic
Robotic + Crewed
Crewed

Planetary Protection Concept* for A Crewed Mission to Mars



*Criswell, M.E., et al., 2005. Planetary Protection Issues in the Human Exploration of Mars, Final Report May 9, 2005 (workshop held June 2001), NASA, Ames Research Center, Moffett Field CA, NASA/CP – 2005-213461

Mars Special Regions should NOT be contaminated

- **Special Regions** Areas or volumes within which sufficient water activity AND sufficiently warm temperatures to permit replication of terrestrial organisms may exist.
  - Water activity: lower limit, 0.5; upper limit, 1.0;
  - Temperature: lower limit, –28°C; no upper limit defined; and
  - Timescale within which limits can be identified: 500 years.

  No confirmed naturally occurring Special Regions on modern Mars – but some features remain "Uncertain"

- Uncertain Regions are treated as Special Regions until proven otherwise:
  - Sources of methane (if identified);
  - Recurring slope lineae;
  - Gullies and bright streaks associated with gullies;
  - Pasted-on terrains;
  - Caves, subsurface cavities and subsurface below 5 meters; and
  - Others, to be determined, including dark slope streaks, possible geothermal sites, fresh craters or sites of recent seismic activity.

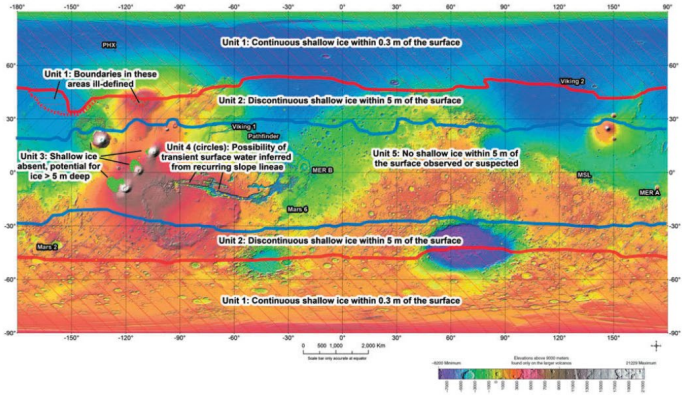


FIGURE 5.2 Map depicting geological features relevant to characterizing Special Regions on Mars. Indicated units describe shallow ground ice or potential transient surface water in terms of their depth below the surface and spatial continuity. The map base is MOLA digital elevation model of Mars (~463 m/pixel; Neumann et al. 2001) in simple cylindrical projection. Purple is low in elevation, and grey is higher elevation. Red and blue lines delineating regions are approximately 50 km in width. SOURCE: SR-SAG2 report (Rummel et al. 2014, Figure 45); courtesy of the Second MEPAG Special Regions Science Analysis Group.

National Academies of Sciences, Engineering, and Medicine 2015. *Review of the MEPAG Report on Mars Special Regions*. Washington, DC: The National Academies Press. https://doi.org/10.17226/21816.

Knowledge Gap Areas

- **Natural transport of contamination on Mars**
  - Understanding the environmental processes on Mars that contribute to transport, survival and replication of microbes released by human activities

- **Microbial and human health monitoring**
  - Evaluation and monitoring of microbial communities associated with human systems, both for their initial state and changes over time

- **Technology and operations for contamination control**
  - Designs, methods and procedures for controlling contamination release of human spacecraft systems

Path to Closing Knowledge Gaps and Establishing PP Requirements

Workshops Timeline

2015	2016	2018	2018 & beyond
NASA Workshop at Ames ✓	1st COSPAR Meeting at LPI ✓	2nd COSPAR Meeting at LPI ✓	COSPAR Working Meeting on Contamination Transport on Mars at LPI, May 2018 ✓ COSPAR Working Meeting on Microbial Monitoring & Health at LPI, May 2019 ✓ COSPAR Working Meetings on Spacecraft Systems (virtual) May 2020 and June 2022
Identification of Planetary Protection Knowledge Gaps for human missions to Mars	Refinement and prioritization of Planetary Protection Knowledge Gaps for human missions to Mars	Mission Opportunity identification for addressing Planetary Protection Knowledge Gaps for human missions to Mars	Measurements and Payload/Operation Concepts for addressing Planetary Protection Knowledge Gaps for human missions to Mars
What Knowledge Gaps…	…in what order…	…using what missions…	…to make what measurements…

…to establish the right quantitative and implementable planetary protection requirements for safe and sustainable exploration and utilization of Mars.

Path to Closing Knowledge Gaps and Establishing PP Requirements

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NASA Workshop at [illegible]mes ✓			COSPAR Working Meeting on Contamination Transport on Mars at LPI, May 2018 ✓
			Meeting on Microbial Monitoring [illegible]y 2019 ✓
			Meetings on Spacecraft Systems [illegible]and June 2022
Identification of Planetary Protection Knowledge Gaps for human missions to Mars	[illegible]ment and prioritization of Planetary Protection Knowledge Gaps for human missions to Mars	Mission Opportunity identification for addressing Planetary Protection Knowledge Gaps for human missions to Mars	Measurements and Payload/Operation Concepts for addressing Planetary Protection Knowledge Gaps for human missions to Mars
What Knowledge Gaps…	…in what order…	…using what missions…	…to make what measurements…

NASA will likely adapt COSPAR workshop findings in an update to the NID8715.129 to establish planetary protection requirements for the first crewed mission to Mars

…to establish the right quantitative and implementable planetary protection requirements for safe and sustainable exploration and utilization of Mars.

Summary

- Forward and backward contamination applies to crewed missions to enable exploration and protect Earth's biosphere from return samples.
- NID 8715.129 defines key assumptions and parameters.
- Robotic prescriptive requirements are impractical for crewed missions. Thus, knowledge/capability gaps have been defined to help further develop policy.
  - Requires the development of risk-informed decision-making implementation strategies to balance exploration, science, commercial activities and safety.
- PP shouldn't impede science planning activities: it just has to be balanced with the technology development to enable the science needs while meeting PP intent.

References

- NID 8715.129 – Biological Planetary Protection for Human Missions to Mars
- Committee on Space Research (COSPAR) Planetary Protection Policy, June 3, 2021
- Reports of the COSPAR workshop series on PP Knowledge Gaps for Crewed Mars Missions, downloadable from the Conference Documents section at https://sma.nasa.gov/sma-disciplines/planetary-protection
- National Academies of Sciences, Engineering, and Medicine 2015. Review of the MEPAG Report on Mars Special Regions. Washington, DC: The National Academies Press https://doi.org/10.17226/21816
- 2008 COSPAR Human Exploration Planetary Protection Guidelines
- Hogan, J.A. *et al.* (2006) NASA Technical Memorandum NASA/TM-2006-213485 Life Support and Habitation and Planetary Protection Workshop Final Report
- Criswell, M.E., et al., 2005. Planetary Protection Issues in the Human Exploration of Mars, Final Report May 9, 2005 (workshop held June 2001), NASA, Ames Research Center, Moffett Field CA, NASA/CP – 2005-213461
- National Academies Press (2002); Safe on Mars: Precursor Measurements Necessary to Support Human Operations on the Martian Surface http://www.nap.edu/catalog/10360.html

Backup

Knowledge-Based Robotic to Crewed Transition Assumptions*

- Human spaceflight hardware leaks (in nominal and off-nominal operation), so the old robotic paradigm of managing a fixed bioload is inappropriate.
- The introduction of a maintained temperate terrestrial environment at the martian surface affords the opportunity for many more organisms (in type and quantity) to escape into the martian environment.
- This exploration is taking place in a post-Mars Sample Return (MSR) context where martian life was NOT (yet?) discovered at the martian surface/shallow subsurface in returned Mars material, but we know a lot more about Mars from those samples.
- Knowledge gaps need to be understood and preferably closed before launch to protect science return and the Earth.

* Developed as ground rules for the 2020 COSPAR "4th Workshop on Refining Planetary Protection Requirements for Human Missions" – see the Conference Documents section at https://sma.nasa.gov/sma-disciplines/planetary-protection

NID 8715.129 – Biological PP for Human Missions to Mars
PP General Paradigm

a. “Safeguarding the Earth from potential back[ward] contamination is the highest planetary protection priority in Mars exploration.”

b. “The greater capability that human explorers can contribute to the astrobiological exploration of Mars is only valid if human-associated contamination is controlled and understood.”

c. “For a landed [human] mission conducting surface operations, it will not be possible for all human-associated processes and mission operations to be conducted within entirely closed systems.”

d. “[Humans] exploring Mars, and/or their support systems, will inevitably be exposed to martian materials.”