

**PLANETARY PROTECTION FOR FUTURE HUMAN MISSIONS TO MARS-- ADDRESSING STRATEGIC KNOWLEDGE GAPS AND PROVIDING NEEDED INPUT FOR FUTURE SYSTEMS, OPERATIONS AND EQUIPMENT**

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**Introduction:** COSPAR planetary protection (PP) principles and implementation guidelines for human Mars missions require protection of Mars from forward contamination during operations and exploration, protection of astronaut health and safety throughout the long duration mission, and safeguarding of Earth from back contamination upon return. Engineers and scientists have begun to analyze how these requirements will constrain the diverse systems, operations and equipment necessary for future missions. While experiences from ISS and other activities in Earth orbit provide a strong foundation for planning missions back to planetary surfaces (the first time since the Apollo program), planetary protection requirements for human missions introduce an assortment of new challenges and data gaps, particularly due to new scientific understanding about microbial life and environmental conditions on potentially habitable solar system bodies, like Mars.

A number of recent NASA and international workshops and studies have identified particular concerns associated with planetary protection needs, including information associated with human health and life support requirements; EVA, surface operations, contamination mitigation methods; plans for in situ resource utilization (ISRU); equipment and procedures for science exploration, sample collection, and laboratory handling; and quarantine methods, containment, and systems intended to avoid back contamination of Earth.

It is clear that additional science research will be essential for closing strategic knowledge gaps and contributing to productive human missions that maximize science return. Such research can be accomplished during robotic precursor missions, by research and experiments on ISS, or even in labs or analogue sites on Earth.

This presentation summarizes recent information under discussion by NASA and international groups about science and technology needs for meeting PP constraints on future human missions. Precursor science data will be important input for the upcoming NASA process for drafting a Planetary Protection Procedural Instruction (NPI) for Human Extraterrestrial Missions.

Among the key science research areas identified are those that increase information on survival of spacecraft and human associated terrestrial organisms

and their molecular components in ambient martian environments; information on sterilization and monitoring capabilities for wastes materials and mission associated equipment and samples; information on distribution of water on Mars, at both the large- and micro-scales, both near-surface and deeper; and information on near and far-field contamination transport.

Filling strategic science gaps with focused investigations will be important for eventual mission designs and operations that control, mitigate or eliminate risks in many cross-cutting areas in all phases of the mission.