SUMMARY OF THE 2005 LIFE SUPPORT AND HABITATION AND PLANETARY PROTECTION WORKSHOP. J.A. Hogan, NASA Ames Research Center, MS239-15, Moffett Field, CA 94035
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Introduction: As seen in previous human lunar and Mars surface robotic missions, Planetary Protection (PP) guidelines will serve as a strong driver in the design and operation of human exploration missions to Mars and other solar bodies. Likewise, science objectives such as the search for evidence of past or present extraterrestrial life can also impact mission design. Therefore PP and science requirements for human missions need to be established well in advance of a mission to facilitate the timely and cost-effective design and execution of compliant spacecraft, habitation systems and surface operations.

The PP requirements development process necessitates a thorough knowledge of potential forward and back contaminants, contamination pathways and a current understanding of the biological potential of the solar body. While numerous considerations are involved in PP policy development, there are (at least) three key research and technology development programs that require close consideration and collaboration. First is the human life support program, which is responsible for managing air, water and solid wastes, and providing food and thermal control. Secondly, the extravehicular activity (EVA) program is tasked with developing portable life support systems to enable human mobility, including suits and rovers. EVA activities will generate forward and back contamination potential via human and equipment ingress/egress operations and leakage. Finally, the monitoring and environmental control program is responsible for developing methods that facilitate the monitoring of contaminants relevant to established PP and scientific guidelines. Together, these three areas will strongly interface with each other and will affect, and be affected by, PP considerations.

Workshop Background and Objectives: Because of the lack of discrete PP regulations for proposed human Mars missions, members of these three communities concluded that establishing a dialogue that enabled PP requirements development was necessary. To this end, a workshop entitled the "Life Support & Habitation and Planetary Protection Workshop" was convened at the Center for Advanced Space Studies in Houston, TX on April 27-29, 2005[1]. Participants included representatives from government, private industry and academia. A major objective of the workshop was to initiate communication, understanding, and a working relationship between the life support, monitoring and control, EVA and the PP communities regarding the effect of PP policy development and implementation requirements for future human missions. It was also intended to define top-level PP concerns and issues associated with both forward and back contamination, and determine their likely effects on hardware development and operations for the first human mission to Mars. This included the identification of PP requirements that will be needed to guide future technology development in advance of the first human mission. The workshop was also designed to identify management approaches to reduce the risk of developing systems prior to full definition of PP policies, as well as critical research areas and gaps in science or technology capability. Participants were provided initial assumptions to provide defined boundaries during deliberations.

Summary of Overall Workshop Findings: An array of findings and recommendations were generated during the workshop. The top-level areas included the examination and identification of potential forward and backward contaminants and associated release pathways. Mitigation techniques for both forward and backward contamination were also discussed and identified. Participants identified crucial factors likely to impede hardware and system development with respect to potential PP requirements. Finally, key research and technology needs resulting from PP requirements were identified. Top-level findings include:

- While there is a lack of explicit PP policies and requirements for human missions to Mars, it is possible to outline a conceptual approach and provide preliminary guidelines for planners and designers. The development of more specific guidelines will occur in response to information from research and technology development activities coupled with findings from precursor robotic missions.
- PP requirements for Mars missions will likely be very different than those used during Apollo missions. Early and regular coordination between the PP, scientific, planning, engineering, operations and medical communities is needed to develop practicable and effective designs for human operations on Mars. Coordination will bring numerous mutual advantages to the various programs such as identifying common needs for new technologies (e.g., among planetary science exploration, human mission operations, and PP).
- Significant amounts of materials will originate from human life support and mobility systems that can be

classified as forward contamination in both PP and scientific terms. All materials from the Martian environment are considered to be potential sources of back contamination (e.g., soil, airborne particulates). Forward and back contamination pathways include: leakage from habitat, airlocks and other vessels; egress/ingress of humans, materials and equipment; EVA operations; surface storage/disposal of wastes; gas venting (nominal and contingency); and thermal systems. Unintentional discharges may occur via events such as equipment failures, micrometeorite impacts, and rapid depressurization events.

Additionally, there was general consensus among participants regarding the need to establish requirements for both PP and scientific investigations early in the development cycle, as they significantly affect system design, technology trade options, development costs and possibly mission architecture. Of particular concern were the areas of discharge and disposal limits, backward contamination limits, and *in situ* resource utilization (ISRU). It is necessary to identify and define what will be regarded as contaminants by both PP and science communities. In addition, there is a clear need to develop a classification system of zones of biological, scientific, contamination and operational importance prior to and during human missions. Finally, data on protocols and systems used for quarantine of crew and hardware upon Earth return were identified as significant system drivers.

It was concluded that it was not possible to provide quantitative PP guidelines at the time of the workshop, as PP requirements will evolve in response to numerous factors. Instead, a tentative conceptual approach consistent with current PP requirements was proposed which asserts that human missions to Mars shall not affect or otherwise contaminate "special regions" of Mars, primarily through the use of cleaning operations and prudent landing site selection. It was also proposed that calculations based on this approach will determine the tolerable levels of contamination allowed for specific aspects of any particular human mission. Specific details of the approach are to be determined, but will involve close collaboration with the scientific community, and the evaluation of unavoidable levels of human-associated contaminants and their implications.

To facilitate the process of developing a quantitative set of PP requirements, the life support community indicated the need to further define initial material inventory, process products and by-products, release mechanisms associated with forward contamination, and the need to incorporate back contamination controls into system design and operations. The EVA community focused on the need to identify and control forward/backward contamination regarding suits and rovers from vent/leakage constituents. The environmental monitoring and control group noted the need for detection standards, response time requirements, and the challenges of identifying organisms that represent back contamination.

It was noted that long-duration lunar missions can provide a relevant test-bed for many mission technologies. It was suggested that mission planners address PP technology on the Moon in a manner that mimics Martian exploration, despite the comparatively relaxed PP requirements of lunar missions. Finally, it was cautioned that in planning long-term design and operations strategies, it will be critical to avoid pursuing two separate and costly technology pathways—one for the Moon and the other for Mars.

The intent of this presentation is to provide the participants of this workshop a brief summary of previous work on the topic[1,2], and to provide a base for furthering the overall investigation and PP requirements development. This presentation will provide an overall summary of the previous workshop that includes workshop objectives, starting assumptions, findings and recommendations. Specific result topics include the identification of knowledge and technology gaps, research and technology development needs, potential forward/backward contaminants and pathways, mitigation alternatives, and PP requirements definition needs.

References:

[1] Hogan, J.A. et al. (2006) NASA/TM-2006-213485. [2] Hogan, J.A. et al. (2006) ICES Tech. Paper 2006-01-2007.