PLANETARY PROTECTION KNOWLEDGE GAPS FOR HUMAN EXTRATERRESTRIAL MISSIONS: WORKSHOP SUMMARY AND RESEARCH NEEDS Margaret S. Race, SETI Institute, 189 Bernardo Ave., Mountain View, CA 94043 mrace@seti.org

During the course of planetary exploration, internationally required planetary protection measures are in place to prevent contamination that might confound the search for life on Mars, and to safeguard Earth from the return of potentially hazardous materials. While planetary protection requirements are in place for robotic missions there is presently insufficient scientific and technological knowledge to establish quantitative requirements for the development of crewed spacecraft and missions to Mars. To prepare for such future missions, NASA created the *NASA Policy on Planetary Protection Requirements for Human Extraterrestrial Missions* (NPI 8020.7) which outlines the need to increase knowledge in specific areas and help iteratively develop an appropriate set of requirements. Three particular areas needing research attention include 1) Microbial and human health monitoring , 2) Technology and operations for contamination control, and 3) Natural transport of contamination on Mars.

This presentation provides a detailed summary of a recent NASA workshop that was organized to capture the current state of knowledge in the key areas and identify additional research to appropriately inform planetary protection requirements development for the human exploration of Mars. The workshop focused on important questions related to developing new or improved methodologies that will be needed to accomplish future planetary protection goals while ensuring nimble and capable human missions. It also considered how to integrate information from robotic missions into the future mission designs in ways that address the conundrum of enabling human exploration while still protecting biologically sensitive sites. Finally, the findings also highlight what research must be done on microbiota of all types to more fully understand the implications of their transport to other worlds by robotic and human spacecraft. The information collected at this workshop, along with information from literature reviews and previous planetary protection workshops, will enable NASA to efficiently conduct studies that will define the initial set of planetary protection requirements for human missions

The workshop findings outline important science gaps that are likely to translate into future opportunities for research in multiple disciplinary areas of relevance to the Astrobiological community.