UNDERSTANDING THE PROCESS AND DRIVERS FOR DEVELOPING HUMAN EXPLORATION PLANETARY PROTECTION REQUIREMENTS. M. A. Jones[1], D. W. Beaty[2], and L. E. Hays[2], [1]Biotechnology and Planetary Protection Group, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 (melissa.a.jones@jpl.nasa.gov), [1]Mars Program Office, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Introduction: The Planetary Protection Subcommittee of the NASA Advisory Council (NAC) recognized and recommended in May 2012 that a NASA Procedural Requirement should be developed to handle planetary protection requirements specific to proposed future human missions as a parallel document to 8020.12, Planetary Protection Provisions for Robotic Extraterrestrial Missions [1] under NASA Policy Directive 8020.7, Biological Contamination Control for Outbound and Inbound Planetary Spacecraft [2]. Between May 2012 and March 2013 the full NAC endorsed the recommendation and the NASA Administrator subsequently agreed [3]. However, the fact remains that there is insufficient knowledge in both scientific and technological domains to be able to set detailed planetaery protection requirements to the level that has been done for robotic missions in 8020.12. Therefore, NASA Policy Instruction (NPI) 8020.7, NASA Policy on Planetary Protection Requirements for Human Extraterrestrial Missions, was developed, which describes general policy guidelines and approaches as a placeholder until enough information is determined to generate a full requirements document (NPR) [3]. COSPAR also amended its original 2002 policy regarding proposed future human exploration of Mars, most recently in 2011; NASA missions are required to be consistent with this policy [3].

Getting to requirements: Fundamentally, requirements must be rooted in policy but also consider the current state of affairs on the target body as well as engineering realities. An approach to developing planetary protection requirements for human exploration would be to take a "systems view" approach to try to ensure all necessary requirements are accounted for across the "system." Those requirments can be flowed down through the required levels with an outcome of clearly implementable requirements to be met by the science and engineering team on the mission. This approach of using a typical systems engineering process for flow down of planetary protection requirements has been implemented recently on an upcoming Mars robotic mission with resounding success so far, and there are plans to take a similar approach on other missions. Therefore, it makes sense to advocate for utilization of a similar "systems view" approach for the development of planetary protection requirements for future human exploration.

In order to advance to actually developing requirements, it is often valuable to take key drivers into account, whether it be requirement drivers or process drivers. The paragraphs below describe some of the potential drivers that should be recoginized and discussed while addressing planetary protection requirements development for human missions.

Potential policy changes: According to the COSPAR Policy and Guidelines for Human Missions as denoted in Attachment A of NPI 8020.7, "The intent of planetary protection policy is the same whether a mission to Mars is conducted robotically or with human explorers. Accordingly, planetary protection goals should not be relaxed to accommodate a human mission to Mars. Rather they become even more directly relevant to such missions – even if specific implementation requirements must differ" [3]. The intent of the policy—the protection and preservation of the body being investigated as well as our home planet—is not likely to be arguably different between a robotic or human mission. However, has the feasibility of implementing similar robotic contamination requirements on a human mission been investigated in at least a bounding case format to fully understand the drivers? What are the limits of implementation for future proposed human missions versus robotic missions, potentially including resources? Is there potential that human exploration-related policy might drive changes to the robotic policy? For example, could there be changes in the level of contamination allowed, perhaps in specific areas of Mars? Would this level of investigation point to other noteworthy knowledge gaps?

Knowledge development: NPI 8020.7, Section 4, describes a set of study areas that are critical to obtain the information to proceed forward on developing requirements for human missions, with community input being sought for additional areas. The driver in this area is likely to be those items related to understanding environmental processes on Mars and other bodies.

While modeling capabilities have gotten better over time, scientist still depend on data from the body itself to understand and validate modeling efforts. To date, it has taken several decades of multiple Mars missions to get to where we are today, and perhaps (arguably) there is still a lot to learn to be able to understand even "transport and sterilization of organism released by human activity" on Mars [3]. How much data would

need to be collected from any notional human landing site, and how much needs to be collected from Mars in general? Data from the actual landing site is perhaps the best, but this would require making a final selection of a landing site 1-2 decades in advance of the launch. Therefore, a critical driver in developing policy, in particular requirements, may be determining what missions and experiments are necessarily performed at the target body, which may take many mission and decades to complete. This could place a lot of activity on the critical path that must be addressed by robotic precursors leading up to a future human mission. In addition, there is the question of what policy guidelines might need to be in place if we do not get the answers deemed necessary to proceed with a future human mission.

A roadmap for the path forward: NPI 8020.7, establishes the policy guidelines and describes the approach for obtaining the information needed over the "next few years" to draft an equivalent NPR for human missions [3], which includes a "path forward" section outlining the roadmap through which the NPR will be developed. It seems advantaegous and even critical that the process is started now, so that the requirements are ready when needed. However, given that there are likely to be several critical path items and schedule drivers (e.g., robotic precursor missions, required process steps, technology development needs), it might be a useful exercise to work the time problem backwards, given more resolved understanding of critical inputs and a given target goal date, to determine feasibility of developing a implementable set of requirements in an NPR in the next few years. It may emphasize schedule drivers, such as places where processes and technology development may be useful to prove out or develop on precursor missions (e.g., could the proposed Asteroid Redirect Robotic Mission be a "proving ground" for future humans to Mars missions?) and where development of some specific sections of the NPR may be well ahead or potentially lag behind, for some particular reason.

Conclusions: While work has begun to develop the necessary planetary protection requirements for proposed future human space exploration, particularly for Mars, through COSPAR policy ammendments, recommendations by the Planetary Protection Subcommittee, and development of NPI 8020.7, it is beneficial to take a systematic end-to-end approach ("system view") to determine the best path forward for planetary protection requirements development for future human missions. It is critical to determine as early as possible the driving factors (including some potential ones discussed above), and answer question about them as quantatively as possible for development of the process as well as the actual requirements. The advantage is that this would typically ensure a robust, stakeholder-supported process for developing a clear and implementable NPR detailing planetary protection requirements for proposed future human exploration.

References: [1] NPR 8020.12D, Planetary Protection Provisions for Robotic Extraterrestrial Missions (See NASA NODIS Library for current document). [2] NPD 8020.7G, Biological Contamination Control for Outbound and Inbound Planetary Spacecraft (See NASA NODIS Library for current document). [3] NPI 8020.7, NASA Policy on Planetary Protection Requirements for Human Extraterrestrial Missions (See NASA NODIS Library for current document).