3rd COSPAR Meeting on Refining Planetary Protection Requirements for Human Missions

and

Addressing Planetary Protection Knowledge Gaps in *Microbial and Human Health Monitoring (MHHM)*

Lunar and Planetary Institute (LPI)

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Refining Planetary Protection Requirements for Human Missions:
Addressing Knowledge Gaps on Microbes & Human Health Monitoring (MHHM)

Executive Summary

COSPAR (the Committee on Space Research) and its space agency partners are supporting a multi-year stepwise process to identify, prioritize and plan the research and technology development needed to address planetary protection (PP) requirements for human missions beyond Earth orbit. The objective is to incrementally move from the current *qualitative* COSPAR PP "Principles and Guidelines" towards the development of *quantitative* PP *requirements* for future human missions to locations like Mars. The workshops and meetings in this series have involved participants from COSPAR, the US National Aeronautics and Space Administration (NASA), European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA) and other international space agencies, as well as the scientific/technical community, and commercial/private stakeholders.

This report provides detailed findings of the 3rd COSPAR meeting on Refining PP Requirements for Human Missions, which focused on addressing the specific knowledge gaps (KGs) associated with Microbial and Human Health Monitoring (MHHM). In the planetary protection context, microbial monitoring of the crewed environment is needed to ensure that the systems remain within acceptable limits for: mitigating contamination threat to Mars; being a healthy and functional environment for the crew to live in, and; not being contaminated by martian microbiology (should it exist). Similarly, microbial monitoring for human health is needed to ensure that it is possible to tell if a sick crew member just has a stomach upset, or if they are potentially infected by a putative martian organism, prior to their returning to Earth. The three day meeting was held May 14-16, 2019 at Lunar and Planetary Institute (LPI) in Houston, TX, and included a combination of plenary presentations and small group sessions that built upon the findings of earlier workshops in this series (2015, 2016 and 2018) as well as provided updated mission and science information.

The *first part of the meeting* was dedicated to reviewing the meeting series as a whole, summarizing findings of earlier meetings and establishing goals for this MHHM meeting. The discussion focused on developing plans for tasks to be completed over a notional timeline to address all identified KGs, in MHHM as well as those involving the natural transport of microbial contaminants on Mars, and in spacecraft technology and operations related to PP. Plenary presentations included information about COSPAR and its Planetary Protection Panel (PPP), as well as talks by multiple agency and industry

representatives on the current state-of the-art technologies for studying microbes and future mission opportunities for closure of KGs related to PP.

The *second part of the meeting* was a series of smaller breakout sessions designed to address specific KG's related to MHHM. The primary objective of these sessions was to determine the level of operational monitoring of microbes associated with crew and crewed vehicles is needed to address the MHHM KGs in the near term, with emphasis on gathering baseline data on the International Space Station (ISS), the Orion Spacecraft, Gateway and subsequent vehicles. The breakout group discussions were guided by a set of pre-planned questions and points for consideration to help steer the conversations (eg. type of data and information needed; equipment and materials; frequency and location of sampling; sample processing and data analysis considerations). Separate subgroup findings were compiled in a plenary session to outline a plausible path forward for filling KGs based on realistic milestones.

The overall findings of this 3rd COSPAR meeting on MHHM indicate that KGs regarding microbes and human health will continue to apply to both forward contamination (in combination with contamination transport models) and backward contamination for human mission to Mars. There are significant synergisms between Earth safety concerns (planetary protection) and issues relevant to assessing crew health status on long duration missions. The outcome of the deliberations indicated that:

- ISS is the only existing, useful test-bed to obtain long term baseline data and trends useful for preparing for human missions beyond Earth orbit;

- Current routine microbial monitoring on ISS is limited in *scope* (number of crew and locations on ISS), *depth* (details of microbial populations) and *frequency*, of data collection;

- Systematic microbial monitoring of ISS crews and associated ISS environments is needed more frequently to obtain statistically relevant data over long time-periods and multiple crew complements;

- Existing instruments and technologies can be used (ex. MinION, Oxford Nanopore with flight heritage on ISS) to monitor microbial levels for these purposes, and;

- It is possible to build upon what is already in use on ISS—including associated processes, consumables and crew time-needs, which are already well understood.

The way forward for addressing MHHM KGs in a timely manner includes a step-wise approach built on:

- Data-mining activities of existing ISS databases to establish starting points for ISS sampling (frequency, number of samples) and to write revised sampling and analysis procedures using the MinION equipment (or other flight heritage systems).
- Integration of the data-mining information and MinION procedure outputs (above) to create an updated microbial monitoring plan for the ISS and crew that would address the MHHM KG.
- Discussion of flight opportunities with ISS partners.
- After gathering data on the ISS and before humans are sent to Mars, initiation of similar microbial monitoring beyond Earth's orbit to study the radiation environment (e.g., Gateway) and conditions on a lifeless surface (e.g., Moon), which the groups considered complementary and 'must-have' continuation information.

The product of this activity will be a data set that, first, establishes what microbial cleanliness is needed for the crewed environment (and informs the technology, operational protocols and mitigations to achieve that cleanliness). Second, it would enable a risk-based assessment of crew health and the need to quarantine (or not) individuals or the whole crew at any point in the mission.

It is clear that the high priority technology development activities for developing future quantitative PP requirements on human missions have a broad range of considerations. Findings from this COSPAR meeting series and associated studies will help in the generation of a roadmap that can guide closure of KGs across key technology areas. By addressing the identified KGs, it will be possible to generate updated information critical to the development of future quantitative, implementable PP requirements for human mission beyond Earth's orbit. This collective information will also contribute to a variety of other PP considerations, ranging from landing zone planning; to in situ science and sample containment; through to design of contaminant mitigation, extravehicular activities (EVA), Environmental Control and Life Support System (ECLSS) and vehicle technologies; and In-Situ Resource Utilization (ISRU), habitat and spacecraft operations.

The full report will be posted on line soon.