



The COSPAR Planetary Protection Requirements for Space Missions to Mars

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The Committee on Space Research's (COSPAR) Planetary Protection Policy (herein referred to as the Policy) has been developed through deliberation between the scientific community and the national space agencies to 1) ensure that scientific investigations of possible extra-terrestrial life forms, precursors, and remnants are not jeopardized; and 2) Earth is protected from the potential hazard posed by extra-terrestrial matter carried by a spacecraft returning from an interplanetary mission (COSPAR 2020). The COSPAR Panel on Planetary Protection (herein referred to as the Panel) regularly updates the Policy based on workshops and activities that are led by the community, or by national committees. For example, the requirements for the icy moons of the outer Solar System have been scrutinized as part of a European Commission's H2020 Programme (Rettberg et al 2019) and a National Research Council report (NRC 2012), which led to recommendations being made to COSPAR, which resulted in an update to the regulations (COSPAR 2020). Another example is the recent update of the regulations relating to the moon. The Panel conducted a dedicated community consultation that led to an updated Policy (COSPAR, 2021).

The Policy relating to Mars has received increased attention over recent years as missions to Mars are being more attainable. The number of missions and nations involved have grown significantly since 2003, and commercial missions from the private sector are becoming more plausible (Liu et al 2022). The Policy regulations have evolved over the decades, as our understanding of the planet has evolved. All missions to Mars have been divided into two categories: III, for orbiters and flybys and IV, for landers or probes, with the appropriate planetary protection requirements; whilst Mars return missions are designated as category V (restricted Mars return).

Due to recent reports published regarding the Mars planetary protection, e.g., Spry et al 2021; NAS, 2021, the Panel has taken this as an opportunity to reevaluate scientific data pertaining to the

subject of bioburden requirements on Mars and the implications that this has on the Policy and requirements. They focused on three key areas: 1) Biocidal effects of the martian environment; 2) stability of water and 3) transport of spacecraft bioburden. These areas were discussed in the context of survival of dormant and actively growing cells (Rummel et al 2014). Although harmful contamination is most likely to occur due to proliferation, dormant cells are also important as they can be transported to a potential habitable environment e.g., Special Regions (Rettberg et al 2016).

We contend that at present there is neither sufficient new evidence in the literature nor scientific community consensus to conclude that the bioburden recommendation for Mars needs to be changed at this point. However, the situation may change in the future with the examination of new data by the Panel. To date, several knowledge gaps that require new targeted research have been identified:

- Understanding the biocidal effects of Mars surface conditions.
- Measuring the effect of the atmosphere and dust storms on the kinetics of microbial survival (Spry et al 2021).
- Measuring the rate of dust accumulation and the impact this has on microbial survival kinetics.
- Meteorological investigations to develop, test and validate contamination transport models (Spry et al 2021).
- High resolution of the absolute water vapour content, temperature, and wind speed (Rivera-Valentin et al 2021).
- Understanding the thermodynamics of salt facilitated water vapour (Rivera-Valentin et al 2021).

- Mars simulation experiments to quantify the metabolic and reproduction rates of terrestrial organisms with ephemeral wetting events with and without salts.

We therefore suggest additional international community engagement to further refine this list of knowledge gaps.

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