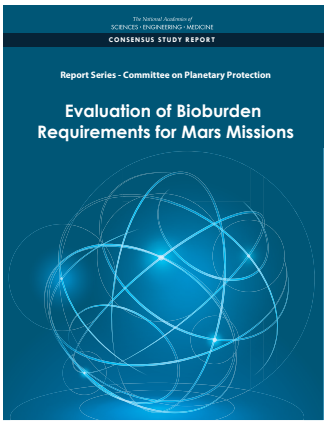
Consensus Study Report
HIGHLIGHTS
October 2021

Evaluation of Bioburden Requirements for Mars Missions



Mars—with its significant amount of water ice, evidence of past liquid water, and close proximity to Earth—is a critically important destination in the search for past or present extraterrestrial life. In order to preserve the integrity of experiments searching for life, missions to the surface of Mars are required to meet strict planetary protection requirements to reduce the amount of biological contamination brought from Earth (also called the "bioburden"). These requirements are essential to realizing NASA's solar system exploration goals and addressing profound questions on the origins of life. However, with a growing number of missions to Mars from both the public and private sectors, including potential human missions, a more nuanced approach could be applied to planetary exploration activities that pose less of a contamination risk. At the request of NASA, the National Academies' new report *Evaluation of Bioburden Requirements for Mars Missions* identifies criteria for determining whether robotic missions to certain areas of Mars could be subject to less stringent bioburden requirements.

Harsh conditions on much of the surface of Mars—including ultraviolet radiation, lack of persistent liquid water, and extreme temperatures—make survival, growth, and proliferation of terrestrial organisms on the surface unlikely. Regions below the surface appear to be the most promising environments for finding evidence of past or present Martian organisms. These regions include caves where water ice, salt, and brine deposits might exist, as well as potential aquifers deep underground. These subsurface areas are also the most likely to allow terrestrial organisms to survive and proliferate if they are given access to these potentially habitable environments.

Relaxed bioburden requirements could be appropriate for missions that do not access the subsurface, or for missions that only shallowly access the subsurface where no evidence of ice exists. To avoid contamination of subsurface access points and sites of astrobiological interest, a Mars mission with relaxed bioburden requirements would need to land and operate at a conservative distance from these locations.

CONCLUSION: Robotic Lander Bioburden Requirements Could Be Relaxed For Certain Mars Missions
Bioburden requirements could be relaxed if the following criteria are met:

1a) Mission activities do not include subsurface activities, OR

1b) For mission activities as deep as 1 meter, the landing site is in a location where no ice has been detected in prior remote sensing measurements (e.g., neutron or thermal data); AND

2) For both cases above, the landing site is a conservative distance from any subsurface access point, to be determined considering wind conditions for the location and season and best estimates of microorganism survival time in the surface UV environment.

Despite precautions taken to maintain a buffer distance from areas of astrobiological interest, missions with lower bioburden requirements would still need some pre-launch cleanliness requirements due to the uncertainty of models for microbial proliferation in the Martian subsurface, incomplete observational data, and possibility of off-target landings. In situ bioburden reduction, such as sterilizing drill bits between samples, may also present a cost-effective alternative or complement to pre-launch bioburden reduction measures. Such techniques for bioburden reduction and validation could be developed through NASA's planetary protection research and analysis program.

CONCLUSION: A Risk Management Approach Could be Used to Comply with Planetary Protection Requirements for Missions to Mars

After the planetary protection requirements for a mission to Mars are established, a risk management approach represents a method for the mission to meet those requirements, as an alternative to existing NASA planetary protection techniques. This approach would apply a risk management framework that:

Step 1. Identifies how the mission might produce harmful contamination

Step 2. Assesses the likelihood and consequence of those possibilities

Step 3. Ranks those risks by assigning a risk rating to each (from low to high)

Step 4. Identifies validated pre-launch and/or in-situ methods to mitigate each risk rated above a certain threshold (e.g., low-medium risk)

These conclusions about meeting planetary protection objectives and requirements apply specifically to missions for which NASA has responsibility for planetary protection. For commercial missions in which NASA has no role or connection, the U.S. government still needs to designate a regulatory agency with responsibility to authorize and continually supervise the space activities of nongovernmental entities in accordance with the Outer Space Treaty.

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This Report Highlights was prepared by the Space Studies Board (SSB) based on the report *Evaluation of Bioburden Requirements for Mars Missions* (2021). The study was sponsored by NASA. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of the sponsors. Download the report at **nap.edu/26336**.

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