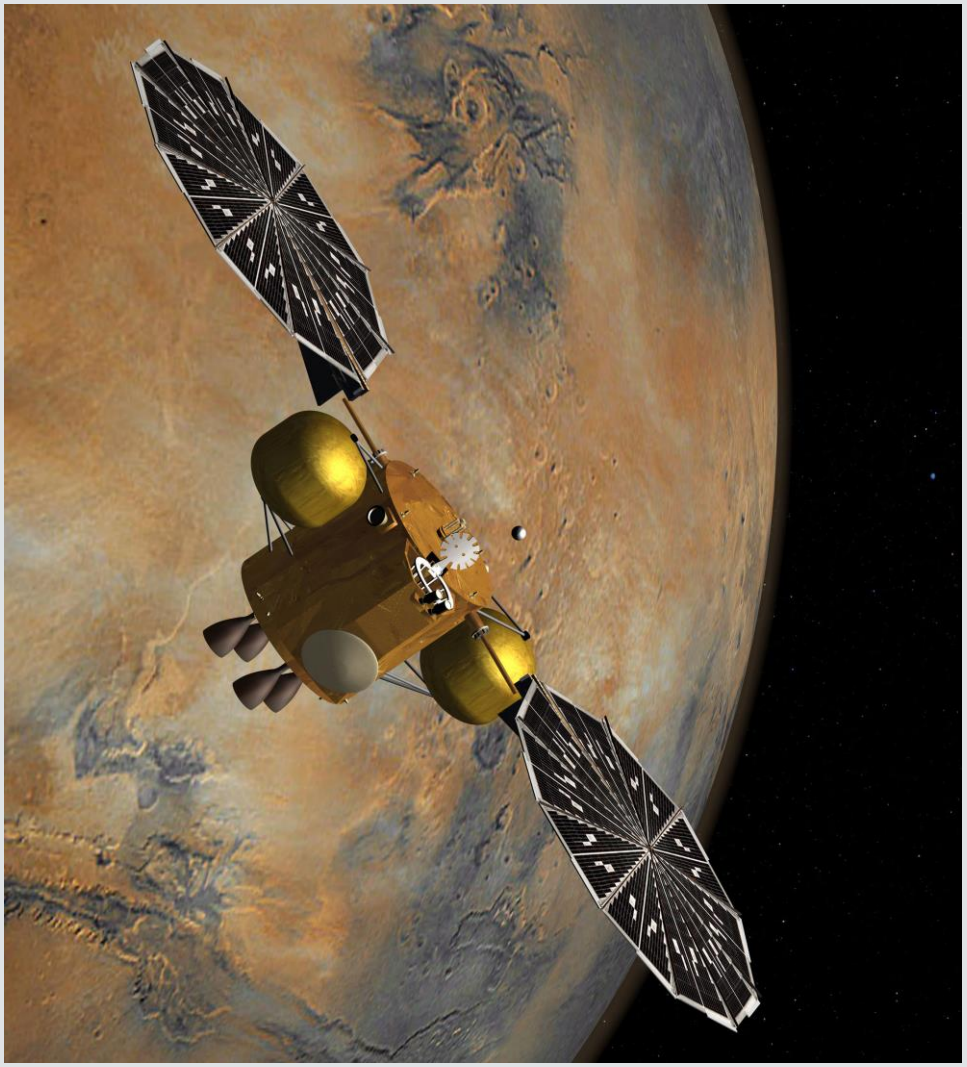

Artist concept of return orbiter capturing the OS

https://mars.nasa.gov/resources/3533/rendezvous-in-martian-orbit/

Office of Planetary Protection's Perspective on Bioburden Metrics for Landed Mars Spacecraft

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The Problem in a Nutshell

No currently available scientific data prove or disprove the hypothesis that present-day life exits on Mars.

Technical capabilities needed to reach and explore the surface of Mars are no longer limited to a handful of national space agencies.

Task: Martian Locations Potentially Suitable for Less Restrictive Bioburden

- Identify criteria for determining locations or regions on Mars that are potentially suitable for missions of less restrictive bioburden than the current requirements for Category IV.
- Illustrate the use of those criteria by identifying some potentially acceptable locations for reduced-bioburden missions.
- Consider the appropriateness of mission activities that occur beneath the Martian surface in these locations and how deep such mission activities should be allowed.

Landing Site Considerations

- Temperatures at the landing site and locations of mission activities are below -25°C, or water activity is less than 0.5 (water activity = water vapor pressure of a solution/vapor pressure of pure water)
- Mission activities will go no deeper than a certain distance below the surface.
- Landed spacecraft are not capable of melting the regolith.
- Proposed landing and/or mission activity sites do not contain geomorphological characteristics of flowing water, such as recurring slope lineae, etc.

Possible Validation Methods

- Observational data from orbiters, landers, rovers, and Earth-based observation;
- Modeling based on the most up-to-date knowledge of the Martian environment and its processes.

Task: Robotic Missions in Preparation for Human Mission

While the CoPP report should primarily focus on robotic missions, NASA would like to know the CoPP's views on whether these criteria may be useful (although likely not sufficient) when considering how human missions can be carried out without large-scale biological contamination of Mars.

U.S. Interagency Coordination on a National Planetary Protection Strategy

The White House Office of Science and Technology Policy (OSTP) and the National Space Council (NSpC) released a National Strategy for Planetary Protection in December 2020.

Objective 1: Avoid harmful forward contamination by developing and implementing risk assessment and science-based guidelines and updating the interagency payload review process.

Objective 2: Avoid backward contamination by developing a Restricted Return Program to protect against adverse effects on the Earth environment due to the potential return of extraterrestrial life.

Objective 3: Incorporate the perspective and needs of the private sector by soliciting feedback and developing guidelines regarding private sector activities with potential planetary protection implications.

Orbiting Sample (OS) Container Cleanliness

Tiger Team Challenge: What low level of terrestrial contamination can be reasonably assured if the seals on one or more tubes fail during landing and previously pristine martian material is released inside the OS but still available for study on Earth?

Co-Chairs Michael Meyer (Mars Exploration and MSR Programs) and Lisa Pratt (Planetary Protection Officer)

Participant affiliation: MSR Campaign (1), European academic (1), U.S. academic (2), DARPA (1), Center for Disease Control (1), U.S. Army Combat Capabilities Development Command (1), Ames RC (1), Goddard SFC (1), U.S. Geological Survey (1)

Note inclusion of participants from relevant agencies

Issues Related to Bioburden Methods and Metrics

- The NASA Standard Assay is insensitive (~ 80% zero values) and 300,000 landed limit on surfaces was established prior to knowledge of extremophiles and sequencing of uncultured organisms.
- Metagenomic assessment of spacecraft and facilities currently is hampered by bioburden levels at or below detection limits for commercial labs.
- Urgent need for modern molecular or spectral methods to rapidly detect and quantify a broad spectrum of terrestrial organisms carried by spacecraft.
- Assessment of the proposition that exploration of Mars has already reached a level of Earth contamination that justifies relaxation of risk posture.

Recommendations for Input on Bioburden Methods and Metrics

- Spry (SETI) on original rationale for hardy spore metric based on Viking treatment.
- Benardini (JPL) on comparative bioburden for landed Mars spacecraft.
- Banfield (UC Berkeley) Genomic exploration of bacteria and archaea that are only distantly related to known species.
- Venkat (JPL) or Singh (JPL) on genome sequencing of novel *Methylobacteriaceae* from plants grown on ISS.
- Martell Winters (Nelson Labs) on biological cleanliness metrics used for medical devises and food industry.

Draft Bioburden Accounting Standard for all Mars Missions

4.6.3.2 All Category IV (IVa, IVb, & IVc) missions to Mars shall meet one the following approaches [during landing and surface operations] in the PP Implementation Plan:

a. A bioburden approach that demonstrates through analysis the following for the entire landed system:

1) Exposed external and internal surface bioburden level is less than the following:

(a) 3.0×10^5 spores.

(b) 300 spores per m^2.

2) Total (surface, mated, and encapsulated) bioburden level is less than 5.0×10^5 spores.

Alternatives to Spore Bioburden Accounting

NASA-STD-87XX.XX
Implementing Planetary Protection Requirements for Space Fight
(generalized wording from draft)

4.6.3.3 Category IVb and IVc missions to Mars Special Regions or for life detection shall demonstrate additional bioburden processing in the PP Implementation Plan.

Note: One a case-by-case basis missions can either seek credit for post-launch bioburden reduction based on environmental conditions experienced in deep space and on the surface of Mars or propose genomic or metagenomics analysis as an alternative to spore bioburden accounting.

Uncertainty about the Sensitivity of Mars to Terrestrial Inoculation

- Martian radiation is probably lethal for terrestrial microorganisms if fully exposed, but spores in multilayers or covered by dust could survive for extended periods of time (e.g. EXPOSE-E studies)
- Martian dust storms elevate and globally redistribute dust particles so it is likely that fragments of biofilm material and cells/spores adhering to dust particles could be transported long distances.
- The surface of Mars is generally hostile for Earth microbes, but we lack information on the distribution and abundance of hospitable micro-environments and their connectivity to deeper protected environments (e.g. Rummel et al. 2014, SR-SAG2)