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Planetary protection and Mars: requirements and constraints on the 2016 and 2018 missions, and beyond

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Abstract

The suite of missions being planned currently by NASA and ESA as a partnership under the name "ExoMars" include an orbiter and an entry, descent, and landing demonstrator module (EDM) for the 2016 "ExoMars Trace Gas Orbiter" mission (ExoMars TGO), as well as a highly capable rover to be launched in 2018 to address the original ExoMars objectives (including the Pasteur payload). This 2018 ExoMars rover is expected to begin a series of missions leading to the first sample return mission from Mars, also conducted jointly between NASA, ESA, and their partners (JMSR). Each of these missions and mission components has a role in enabling future Mars exploration, including the search for life or life-related compounds on Mars, and each of them has the potential to carry confounding biological and organic materials into sensitive environments on Mars. Accordingly, this suite of missions will be subjected to joint planetary protection requirements applied by both ESA and NASA to their respective components, according to the COSPAR-delineated planetary protection policy to protect Mars from contamination, and eventually to provide for the protection of the Earth from potential life returned in a martian sample. This paper will discuss the challenges ahead for mission designers and the mission science teams, and will outline some of the potential pitfalls involved with different mission options.

1. Introduction

A suite of missions is currently being planned by NASA and ESA in partnership. These missions are currently going forward under the name "ExoMars." The series includes an orbiter and an entry, descent, and landing demonstrator module (EDM) for the 2016 "ExoMars Trace Gas Orbiter" mission (ExoMars TGO), which is expected to be followed by a highly capable rover to be launched in 2018. This next rover will address science objectives original to the previously planned ExoMars mission (including the Pasteur payload), and those proposed by the US National Research Council in their decadal survey for planetary science [1] under the name "Mars Astrobiology Explorer-Cacher" (MAX-C). The 2018 rover is expected to begin a series of missions leading to the first sample return mission from Mars. These missions will also be conducted jointly between NASA, ESA, and their partners as elements of a Joint Mars Sample Return Program (JMSR).

Each of these referenced missions and mission components has a role in enabling future Mars exploration. Current planning and science requirements address their roles in extending the search for life and/or life-related compounds on Mars. As such, each of these missions will be potentially crucial in establishing the history of life (or non-life) on Mars. Concomitantly, each will have the potential to carry confounding biological and organic materials into sensitive environments on Mars, or into previously uncontaminated portions of their own sample-handling apparatus. Of course the intention of such missions is to study the potential for life on Mars, and not the potential for contamination to be brought from California, Florida, or Europe. As such, each of these missions will be subjected to joint planetary protection requirements applied by both ESA and NASA to their respective components, according to the COSPAR-delineated planetary protection policy [2] to protect Mars from contamination, and eventually to provide for the protection of the Earth from potential life returned in a martian sample.

There are a number of challenges ahead for mission designers and the mission science teams in meeting these planetary protection requirements, while successfully achieving mission and program objectives. Of course, the first requirement is to accept the requirements as “real” and then to plan to comply with them in an effective and technologically achievable manner. This paper will outline the various choices and challenges involved.

Missions will face the need for a reduction in the amount of microorganisms that they carry to the martian surface, and may (like the Mars Science Laboratory of 2011) be restricted in their choice of landing sites, depending on their specific characteristics. Mission and system designers will need to couple their promised systems capabilities with planning to ensure that any perennial heat sources that they may carry (as, for example, a power supply based on radioisotope thermal-electric systems) will not be the source of future contamination and the establishment of Earth organisms on or near the martian surface. As Mars science progresses, the further identification of Mars “Special Regions” (as defined by COSPAR [2]) is certainly feasible, especially given the identification of transient features on the martian surface that may be indicative of near-surface liquid water environments or other non-equilibrium conditions (cf., [3]).

Finally, the constraints on these planned or posited missions will need to take into account the requirements that will be imposed on the future JMSR, particularly by the requirement to demonstrate that a sample returned to Earth from Mars does not contain a hazard. The potential for Earth life to masquerade as life from Mars, after having taken the round-trip (in steerage, of course) is particularly problematic, since with know that Earth is bathed in living organisms, and that most of Earth’s microbial life is not well known or characterized. Requirements associated with sample return missions will inevitably be fed back to any mission seeking to collect samples for later return.

6. Summary and Conclusions

Planetary protection requirements for Mars are compelling in terms of future exploration programs seeking to conduct astrobiology-related science on Mars or on samples returned to Earth. Such requirements need to be appreciated now by all who would participate in the design and operations of such missions.

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References

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