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Planetary protection: Elements for cost minimization

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Abstract

In line with the UN Outer Space Treaty (article IX of the Outer Space Treaty—London/Washington January 27, 1967) [United Nations Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty") referenced 610 UNTS 205—resolution 2222(XXI) of December 1966 [1]] and with COSPAR recommendations, for ethical, safety and scientific reasons, exploration of the solar system needs to comply with planetary protection constraints in order to avoid extraterrestrial bodies contamination, particularly biological contamination by terrestrial microorganisms. It is also required to protect Earth from an eventual contamination carried by return systems or samples. The search for life in extraterrestrial samples, in situ or in the frame of sample return missions, must be conducted in order to state with the maximum possible confidence, because the discovery or the non-discovery of life in sample has a direct impact on updations of planetary protection specifications for future missions. This last requirement imposes consequently also for implementation in order to preserve extra terrestrial sample properties, protecting also indirectly exobiological science.

These constraints impose to set up unusual requirements for project teams involved in such solar system exploration missions, requirements based on hardware sterilization, sterile integration, organic cleanliness, microbiological and cleanliness control, the use of high-reliability system in order to avoid crashes, the definition of specific trajectories and their control, recontamination prevention, etc. Implementation of such requirements induces costs, difficult to estimate, but which can be important depending on the solar system target and the mission definition (fly-by, orbiter or lander).

The cost impact of a planetary protection program could be important if some basic rules are not taken into account enough early and consequently, upon past experience, some recommendations can be proposed here in order to manage properly such programs and to minimize their cost.

1. Organization and management

1.1. Outer Space Treaty

Planets, including Earth, and in general all extraterrestrial bodies contamination avoidance are referring to the Outer Space Treaty, particularly to

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the 610 UNTS 205 (January 27, 1967) [1] and to the A/RES/34/68 (December 05, 1979) [2]. These Treaties are handled at United Nation (UN) level and, at least for the first one, have been ratified by practically all nations involved in space exploration.

1.2. COSPAR

Committee of Space Research (COSPAR) has been built by the "International Scientific Council", gathering space agencies and scientific organizations involved in space activities all around the world [8]. COSPAR is observer for the UN and reports regularly after its periodic Scientific Assemblies where planetary program are presented. One of the tasks of the planetary protection session at the Scientific Assembly is also to propose or to update planetary protection recommendations in order to have the approbation of the COSPAR Scientific Council. According to the above-mentioned article IX of the Outer Space Treaty, which is very general, the COSPAR planetary protection policy main goal is to give to project teams guidelines in order to avoid the biological contamination of planets, and more generally of all extraterrestrial bodies and of the Earth [3–7]. These recommendations depend on the explored body and the type of mission.

1.3. Space agencies

Using the COSPAR recommendations, the task of the space agencies, through their planetary protection organization, is to write generic and precise specifications for project teams [9], which have to implement them into each concerned project.

2. Requirements

2.1. Extra-terrestrial environment preservation

By analogy with Mars missions, the main requirements [9] are based on the following topics:

- *Orbiter crash probability limitation or sterilization* (*bioload reduction*)—*see Fig.* 1: If the crash probability specification is not met, systems intended to fall on the target body must be decontaminated in surface and in depth. Based principally on scientific considerations, this specification imposes to perform trajectory analysis associated with probability assessments, or to perform and verify sterilization processes.

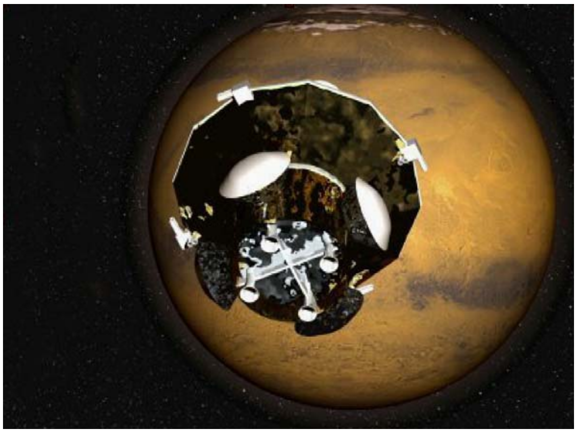

Fig. 1. Mars spacecraft arriving at Mars (photo CNES).

- *Sterilization/biocleaning of lander*: As precedently, the decontamination level must take into account the probability of survival of the most resistant of terrestrial microorganisms in the concerned environment. Sterilization methods must be used with verification of their biological efficiency and lander equipment must be qualified with some margin in order to ensure their survival to the sterilization process. Biocleaning must be easily performed and controlled.
- *Integration in sterile environment*: If the landers are not sterilized in one time after their final integration, they must be integrated into a cleanroom maintained in sterile condition using periodic microbiological monitoring and performing integration facility biocleaning. Operator clothes must be sterile (Fig. 2) and access, including material access, are subject to stringent procedures in order to prevent the cleanroom recontamination.
- *Microbiological control*: Periodical microbiological assessments must be performed on flight hardware in order to verify if the contamination level is within the specification. If not, surface biocleaning must be performed during integration. The traceability of all monitoring must be kept and the final assessments must demonstrate that the specification is met.