Planetary Protection Requirements for Robotic and Human Missions

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Background

Planetary Protection involves the development and implementation of policies and requirements to protect solar system bodies from forward and backward contamination during human or robotic space missions.

As stipulated by the United Nations Outer Space Treaty (Article IX) and interpreted by the Committee on Space Research, over 100 nations abide by the treaty and its objectives.

In this context, responsible exploration of the solar system involves avoiding harmful contamination by:

1. *Carefully controlling **forward contamination** of other worlds by terrestrial organisms and organic materials carried by spacecraft to guarantee the integrity of the search and study of extraterrestrial life, if it exists.*
2. *Rigorously precluding **backward contamination** of Earth by extraterrestrial life or bioactive molecules in returned samples from habitable worlds to prevent potentially harmful consequences for humans and the Earth's biosphere.*

Implementation

The initial step is to categorize the mission based on their biological burden of contaminating planets of interest with the potential for microbial life. Based on the categorization of each mission (target body/mission type), the office of planetary protection ensures that missions involve:

1. Sterile (low biological burden) spacecraft.
2. The development of flight plans that protect planetary bodies of interest.
3. The development of plans to protect the Earth from returned extraterrestrial samples, and the formulation and application of space policy as it applies to Planetary Protection.

Planetary Targets/Locations	Mission Type	Mission Category
Undifferentiated, metamorphosed asteroids; Io; others TBD.	Flyby, Orbiter, Lander	I
Venus; Earth's Moon; Comets; non-Category I Asteroids; Jupiter; Jovian Satellites (except Io and Europa); Saturn; Saturnian Satellites (except Titan and Enceladus); Uranus; Uranian Satellites; Neptune; Neptunian Satellites (except Triton); Kuiper-Belt Objects (< 1/2 the size of Pluto); others TBD.	Flyby, Orbiter, Lander	II
Icy satellites, where there is a remote potential for contamination of the liquid-water environments, such as Ganymede (Jupiter); Titan (Saturn); Triton, Pluto and Charon (Neptune); others TBD.	Flyby, Orbiter, Lander	II*
Mars; Europa; Enceladus; others TBD (Categories IVa-c are for Mars).	Flyby, Orbiter	III
	Lander, Probe	IV(a-c)
Venus, Moon; others TBD: "unrestricted Earth return"	unrestricted Earth-Return	V (unrestricted)
Mars; Europa; Enceladus; others TBD: "restricted Earth return"	restricted Earth-Return	V (restricted)

planetaryprotection.nasa.gov

Past, Current, and Future Missions

Since the beginning of the space age NASA has complied with planetary protection requirements across more than 250 robotic and human missions especially those involving Mars, which is a planet with potentially habitable conditions for microbial life.

A sample of past, current, and future missions can serve to illustrate how planetary protection practices have been used to protect Mars regardless of mission target. This will illustrate planetary protection measures that are taken on a planetary mission basis.

Mission	Target Bodies	Category
Juno	Jupiter	II*
Mariners 4 and 9	Mars	III
Viking	Mars	IV (a-c)
MSR	Mars and Earth	V (restricted)
Human Exploration to Mars	Mars and Earth	TBD

•JUNO is a category II* robotic mission example due to the mission's indicated probability of impact limits for the Jovian Moons and Mars. Documentation such as a development of a flight plan and a measure of probability of impact to Mars were required.

•Mariners 4 and 9 are examples of a category III flyby mission that had Mars as a target body. The spacecraft required assembly in a 100K clean room and cleaning to maintain a low surface microbial burden.

•The Viking program is an example of a category IV(a-c) orbiter and lander missions. The landers required assembly in a 100K clean room and their surface cleanliness was maintained through wiping with isopropyl alcohol and monitored by assays. Such is the same for other IV (a-c) missions such as Mars Global Surveyor, Mars Odyssey, Mars Pathfinder, Mars Polar Lander, and Mars Exploration Rover Mission.

•Future missions such as the Mars Sample Return are examples of category V (restricted) missions. The missions will adhere to planetary protection and space policy requirements at all critical stages of the sample return mission.

•For human missions such as human exploration to Mars, planetary protection measures must be in place before any contact is made with Martian matter. Planetary Protection measures will have to be updated and refined to assure that there will be no risk of forward and backward contamination.

Figure 1. Although JUNO's target body was not Mars, the mission still complied with Planetary Protection measures to protect Mars due to probability of impact.

Summary

Since the recent reorganization of NASA's Office of Planetary Protection to the Office of Safety and Mission Assurance, there is a need for updating websites, revising training materials and courses, and considering how the international policies will apply to commercial missions specifically those with target bodies with potential for microbial life.

- Goals of this internship project where to gather, summarize and organize existing materials about planetary protection from the public domain.
- Another goal was to cover the history of planetary protection by considering how NASA center and partners are supporting planetary protection (lab capabilities, curations, methods, and techniques.)

Specifically, the objective of this document and compilation is to provide the Planetary Protection Office with a comprehensive summary of historical and current information to be used for multiple purposes.
The information was gathered in an inventory that was composed as a PDF file that can be found using the following link:
https://docs.google.com/document/d/1yfPMgwZtXdDVOZIqZpcYLsitVVLXvn8zGzJbKs5Se9l/edit?usp=sharing

Acknowledgements

The 2019 STEM Teacher and Researcher Program and this project were made possible through support from Chevron (www.chevron.com), the National Marine Sanctuary Foundation (www.marinesanctuary.org), the National Science Foundation through the Robert Noyce Program under Grant #1836335 and 1340110, the California State University Office of the Chancellor, and California Polytechnic State University in partnership with SETI Institute. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the funders. Special thanks to my mentor Margaret Race at the SETI institute.