Implementation of Planetary Protection Requirements on Robotic Missions

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Background

Even before the passage of the United Nation's Outer Space Treaty (OST) in 1967, scientists internationally urged that space exploration and activities should avoid harmful biological and organic contamination that could interfere with searches for possible life beyond Earth. Over the decades, COSPAR (Committee on Space Research) has developed international planetary protection (PP) policies to protect against both forward and backward contamination—for robotic and human missions. In the U.S., NASA has been the governmental agency responsible for developing PP requirement and procedures applicable to both robotic and human missions beyond Earth orbit. These requirements and practices apply to all mission stages—from pre-launch planning and assessment to End of Mission (EOM) actions.

Mission Categorization

For planetary protection purposes, missions are categorized using a system developed by COSPAR (Committee of Space Research) which considers information on a mission type and intended planetary targets/locations. Categorizes I-IV focus on forward contamination, while Category V applies to round trip missions with their potential for backward contamination of Earth. Stringency of cleanliness and sterilization levels are set based on the viability of life forms on the planetary body, as well as the below information.

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

NASA and Planetary Protection Controls

Planetary protection policies and requirements are mandatory for all NASA robotic missions. The following provides a summary of how planetary protection is implemented within NASA.

From mission design and ATLO (assembly, test, launch operations), to EDL (entry, descent, and landing) and surface operations, and even at End of Mission going onwards, planetary protection measures dictate many of a mission's decisions and are abided by throughout the entire mission to minimize forward contamination.

1. Requesting a **mission categorization**
   - Depends on destination and mission type
2. **Planetary Protection Plan**
   - Describes plans for compliance with its planetary protection requirements
3. **Planetary Protection Implementation Plan**
   - Describes procedures, processes, analyses, and facilities used to implement the Planetary Protection Plan
   - Only necessary for Category III onwards
4. **End-of-Mission Report**

Some Planetary Protection Considerations

- ✓ Usage of cleanrooms and other microbial barriers
- ✓ Cleaning and sterilization of cleanroom facilities and spacecraft
- ✓ Preventing recontamination of spacecraft and their components
- ✓ Using bioburden assay methods to measure microorganisms
- ✓ Minimizing the unintentional impacts and contamination of solar system bodies

Planetary Protection Measures on Robotic Missions

The following are several examples of planetary protection requirements on robotic missions throughout various stages and aspects of a mission.

Below is a copy of a response letter to the MAVEN mission's Principal Investigator following the first step, requesting a PP categorization. As a Category III orbiter, MAVEN will not intentionally land on Mars, but nonetheless, must meet appropriate planetary protection requirements from the start.

PHOTO: NASA

The Mars Exploration Rover mission was a Category IVa mission for planetary protection purposes. One of its twin landers/rovers, Opportunity (MER-B), landed on Terra Meridiani. Its mission categorization was dependent on the destination and mission type. Below is a list of planning and documentation requirements for Category IVa missions.

Mission PP Category	Planning and Documentation
IV (lander, probe)	Mission Certification
	Planetary Protection Plan
	Planetary Protection Implementation Plan
	Pre-Launch Planetary Protection Report
	Post-Launch Planetary Protection Report
	*Planetary Protection Extended Mission Report (if applicable)
	End-of-Mission Report

During the final pre-launch deployment of the InSight rover's solar panels, implementation of planetary protection measures can be seen through the gowning, taping, and hardware handling during the solar panels' final testing.

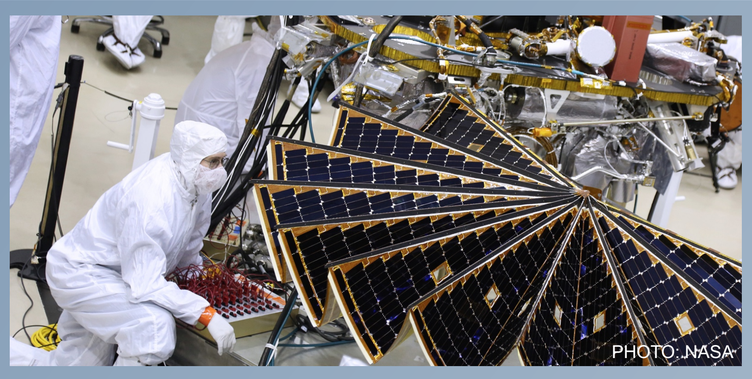


PHOTO: NASA

The Cassini-Huygens spacecraft was deliberately piloted into Saturn. Planetary protection End of Mission requirements were tailored to prevent the remote possibility that Cassini might later crash into Enceladus, Titan, or any of Saturn's other moons.

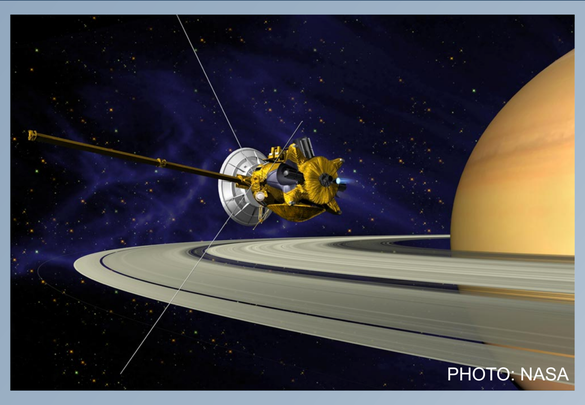


PHOTO: NASA

Contamination Control and Bioburden Reduction

Planetary protection aims to avoid the biological contamination of planetary bodies that may contain life. Some methods to ensure biological contamination control:

- Wipe with alcohol solution during assembly and preparation of launch
- Take microbiology tests to confirm requirements for biological cleanliness
- Use High-Efficiency Particulate Air (HEPA) filters

During ATLO (assembly, test, launch operations):
For the MER mission, planetary protection technicians took bioassays and sampled the spacecraft surfaces during assembly and prior to placement in the aeroshell to check for microbial spores. The bioburden could not exceed 300,000 bacterial spores on any surface.

PHOTO: NASA

During assembly, the heat shield (which protects the lander and rover from overheating upon entrance into the Martian atmosphere) must undergo dry heat sterilization. This is because the heat shield jettisons and remains on the surface.

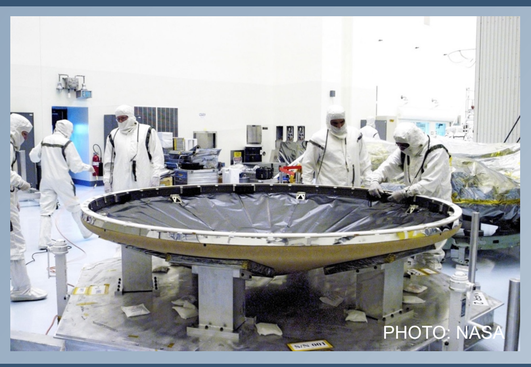
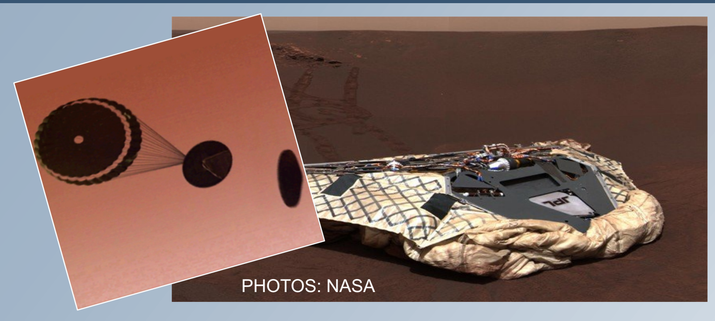


PHOTO: NASA

After EDL (entry, descent, landing), the parachute also remains on the Martian surface. This was why the parachute team sterilized it before placing it on the backshell of the lander.



PHOTOS: NASA

Summary

Planetary protection plays a critical role in a robotic mission. It is vital for responsible exploration, as well as for adherence to the Outer Space Treaty. There are multiple aspects of a mission, from start to even after it ends, that must comply with planetary protection requirements. Planetary protection application to robotic, human, commercial, and private missions will continue to evolve as new scientific information updates our understanding.

Future

As for future implications, this is still a transitional period. Protocols for human, commercial, and other non-governmental mission are still in development and will be addressed in future workshops.

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