Planetary Protection for Discovery Phase A Studies

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26 May2011

NASA Planetary Protection Policy:
Protect Science, Protect the Earth

NASA Policy Directive 8020.7G:

- "The conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized."
  - *avoid forward contamination: don't "discover" life we brought with us*
- "In addition, the Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from another planet or other extraterrestrial sources."
  - *avoid backward contamination: don't contaminate the Earth*
- "Therefore, for certain space-mission/target-planet combinations, controls on organic and biological contamination carried by spacecraft shall be imposed in accordance with directives implementing this policy."
  - *tailor requirements by target location and mission type: don't require unnecessary measures*

International Obligations

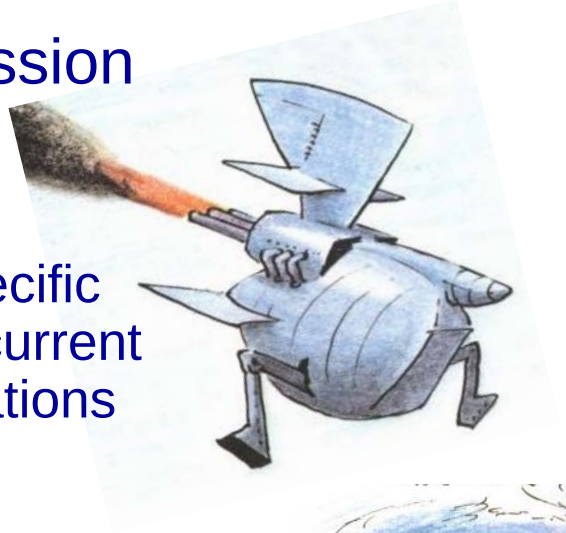
- The Outer Space Treaty of 1967
  - Proposed to the UN in 1966; Signed in January 1967
  - Ratified by the US Senate on April 25th, 1967
  - Article IX of the Treaty states that:

    "...parties to the Treaty shall pursue studies of outer space including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose..."

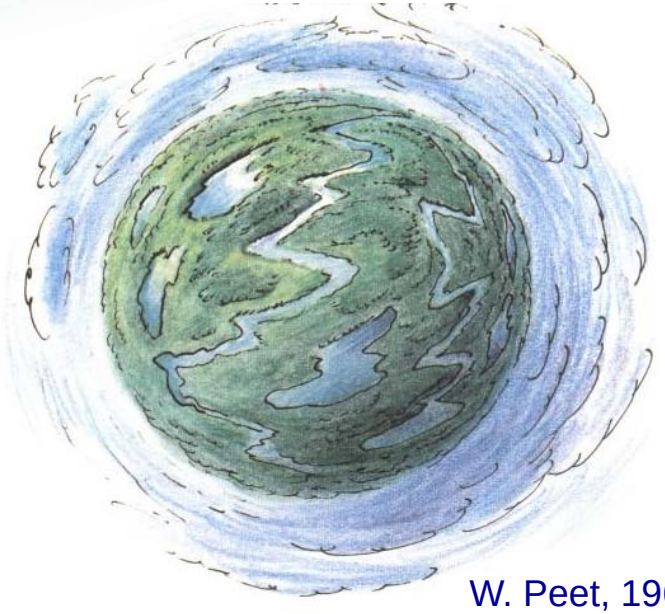
- The Committee on Space Research of the International Council for Science maintains an international consensus policy on planetary protection
  - COSPAR policy represents an international scientific consensus, based on advice from national scientific members, including the US Space Studies Board
  - COSPAR is consultative with the UN (through UN COPUOS and the Office of Outer Space Affairs) on measures to avoid contamination and protect the Earth under the Treaty
  - NASA and ESA policies specify that international robotic missions with agency participation must follow COSPAR policy, providing a consensus basis for requirements
  - COSPAR policy requires an inventory of microbial diversity carried on spacecraft

NASA Requirements: Planetary Protection Mission Constraints

- Depend on the nature of the mission and on the target planet



- Assignment of categories for each specific mission/body is to “take into account current scientific knowledge” via recommendations from advisory groups (SSB, PPS).
- Examples of specific measures include:
  - Constraints on spacecraft operating procedures
  - Spacecraft organic inventory and restrictions
  - Reduction of spacecraft biological contamination
  - Restrictions on the handling of returned samples
  - Documentation of spacecraft trajectories and spacecraft material archiving



W. Peet, 1967

NPR 8020.12D: Planetary Protection Mission Categories

PLANET PRIORITIES		MISSION TYPE	MISSION CATEGORY
A	Not of direct interest for understanding the process of chemical evolution. No protection of such planets is warranted.	Any	I
B	Of significant interest relative to the process of chemical evolution, but only a remote chance that contamination by spacecraft could jeopardize future investigations. Documentation is required.	Any	II
C	Of significant interest relative to the process of chemical evolution and/or the origin of life and forwhich scientific opinion provides a significant chance of contamination which could jeopardize future investigations. Substantial documentation and mitigation is required.	Flyby, Orbiter	III
		Lander, Probe	IV
All	Any Solar System Body	Earth-Return	V

"restricted" or "unrestricted"

Planetary Protection Documentation Schedule

Mission Categorization

- Communicate with PPO in pre-Phase A
- Formal request to PPO during Phase A (discuss implementation by SRR)
- Categorization letter received by KDP B

Planetary Protection Plan (II-V)

- Drafted during Phase B (consult with PPO)
- Released by PDR (included in review)
- Approved by KDP C

Pre-launch Planetary Protection Report

- due 90 days prior to Launch; (Launch Certification at FRR for Cat. III-Vr)

Post-launch Planetary Protection Report

- due 60 days post Launch

Extended Mission Planetary Protection Plan

- Approved prior to end of original Phase E (KDP F)

End-of-Mission Report

- due 60 days after End of Mission

Categorizations are Determined

- On a mission-by-mission basis
- Based on recommendations from the Planetary Protection Subcommittee of the NASA Advisory Council
- Considering advice from the Space Studies Board of the National Research Council

Category II Requirements for Small Bodies

Documentation:

- Planetary Protection Plan (what the project will do)
- Prelaunch Planetary Protection Report (what was done so far)
- Postlaunch Planetary Protection Report (spacecraft working?)
- End-of-Mission Report (where did it go, where is it now)

Standard spacecraft assembly procedures (cleanrooms, etc.)

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Requirements for Sample Return Missions

Category V

All Earth-return missions. The concern for these missions is the protection of the terrestrial system, the Earth and the Moon (The Moon must be protected to retain freedom from requirements on Earth-Moon travel.)

Subcategories:

- "Unrestricted Earth Return"
  - For solar system bodies deemed to have no potential for life
  - Requirements on the outbound phase only (typically Cat. II)
- "Restricted Earth Return"
  - Absolute prohibition of destructive impact upon return
  - Containment throughout the return phase of all returned hardware which directly contacted the target body or unsterilized material from the body
  - Containment of any unsterilized sample, collected and returned to Earth
  - Post-mission analyses of the unsterilized sample, under strict containment using the most sensitive techniques. If any sign of existence of a non-terrestrial replicating entity, is found, the returned sample must remain contained unless treated by an effective sterilizing procedure.

Category III/IV Requirements for Mars

Category III: Mars orbiters are required either to meet orbital lifetime requirements* or to carry a total bioburden of $\leq 5 \times 10^5$ spores total, including surface, mated, and embedded bioburden

** Defined as 20 years after launch at greater than or equal to 99% probability, and 50 years after launch at greater than or equal to 95% probability.*

Category IV for Mars is subdivided into IVa, IVb, and IVc:

- Lander systems not carrying instruments for the investigations of extant martian life may carry $\leq 3 \times 10^5$ surface spores, and ≤ 300 spores per m^2 (Cat. IVa)
- Lander systems searching for life (Cat. IVb) or entering special regions (IVc) must reduce this by a further 10^4
- Impacting hardware may carry $\leq 5 \times 10^5$ spores total, including surface, mated, and embedded bioburden

Category III/IV Requirements for Icy Moons

- Requirements for spacecraft targeting icy moons shall be imposed to reduce the probability of introducing a single viable organism into any liquid water body to less than $1x10^{-4}$ per mission
- Analyses must cover a sufficient duration to ensure all organisms are dead
- The physics of multi-moon systems destabilizes orbits, so analyses must address the potential for contamination under off-nominal scenarios or after the mission ends

This may require pre-launch microbial reduction

Calculations must consider:

1. Microbial burden at launch (number and type)
2. Survival of contaminating organisms during cruise
3. Organism survival in the radiation environment of the active mission
4. Probability of surviving impact or landing on the target body
5. Mechanisms of transport to the subsurface

The Space Studies Board is working to identify relevant factors and provide guidance on parameters

Assumptions must be conservative

Other Considerations

- All missions crossing Mars orbit must document a $1x10^{-4}$ probability that launch vehicle hardware could impact Mars for a period of 50 years after launch
- End-of-mission scenarios that account for the disposition of a radioisotope power source may choose to demonstrate orbital lifetime beyond the effective lifetime of the heat source, a burn-up/break-up analysis demonstrating that the heat source would not create a biological contamination concern, or directed disposal of the spacecraft into an object that is not of concern for biological contamination

Missions must address the potential for creating an habitable environment, or facilitating transport to such locations, if a heat source is present

The Basic Rationale for Planetary Protection Precautions

(as written by Bart Simpson, Dec. 17, 2000, “Skinner’s Sense of Snow”)

Science class should not end in tragedy....
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