Planetary Protection

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What is Planetary Protection?

Planetary protection is:

- an International Agreement
- a NASA Policy Directive
- a series of requirements which robotic planetary flight missions must meet in order to be in compliance with NASA policy.

NASA Planetary Protection Policy

Policy

- Associate Administrator for Space Science, or designee, is responsible for overall administration
- Planetary Protection Officer is designee for managing and implementing
- is quantitative in nature and makes use of probabilistic model

NASA HQ Philosophy

- Planetary protection is a "way of life" in solar system exploration
  - it is integral to the endeavor, not an add-on or afterthought
  - NASA must police itself

Pioneer Mission to Venus

History of Planetary Protection

1958: Council of U.S. National Academy of Sciences resolution calling for the conduct of planetary exploration in a fashion which "...prevents contamination of celestial objects...."

1959: NASA adopts first policy calling for "...payloads which might impact a celestial body be sterilized before launching."

1964: COSPAR resolution calling for "...a sterilization level such that the probability of a single, viable organism aboard any spacecraft intended for planetary landing or atmospheric penetration would be less than $1x10^{-4}$, and a probability limit for accidental planetary impact by unsterilized flyby or orbiting spacecraft of $3x10^{-5}$ or less."

1966: COSPAR establishes the level of $1x10^{-3}$ as a reasonable overall objective for the cumulative probability of contamination of a planet during the period of biological exploration.

1967: International Space Treaty signed by U.S.

1967: NASA issues policy directives adopting 1966 COSPAR guidelines

1981: NASA PP Policy undergoes major revision (not formalized until 1999)

Legal Basis for Planetary Protection

- **1967 "Moon Treaty" obligates U.S.**
- **NPD 8020.7E NASA Planetary Protection Policy**
  - The Associate Administrator for Space Science, or designee, is responsible for overall administration
  - The designee for managing and implementing is the NASA PP Officer
  - Applies to NASA HQ and NASA Centers, including Component Facilities, and to NASA contractors where specified by contract

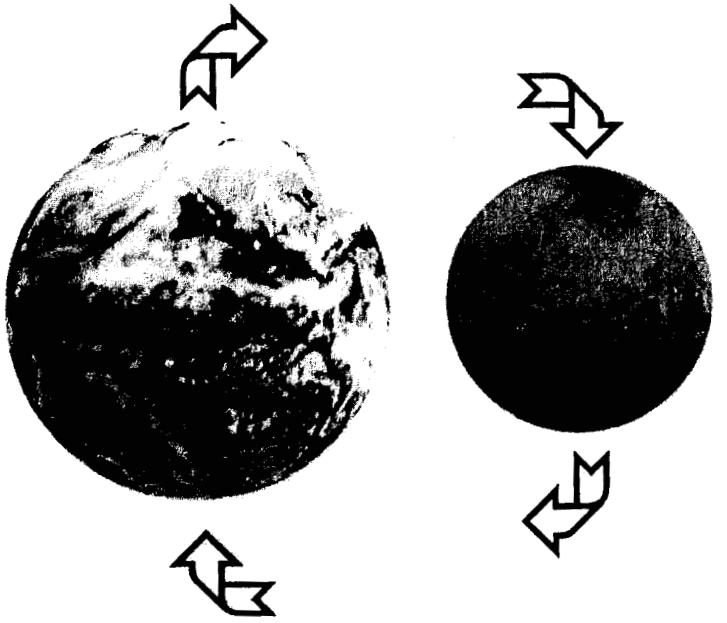
Current Focus of NASA Planetary Protection Policy

Forward contamination:

- preserve biological and organic conditions of other solar system bodies for future exploration.

Back contamination

- protect the Earth from potential extraterrestrial contamination in returned samples



NASA Planetary Protection Procedures and Guidelines

NPG 8020.12B sets out procedures and guidelines for implementing NASA's biological contamination control policies set out in NPD 8020.7E

Mission PP Categories

- **Category I:** Any mission type to Sun or Mercury
- **Category II:** Any mission type to Venus, Jupiter, Saturn, Uranus, Neptune, Pluto, outer planet satellites (except Europa), comets, asteroids
- **Category III:** Fly-bys or orbiters to Mars, Europa
- **Category IV:** Lander or probe to Mars or Europa
  - Cat. IVa: Without life-detection experiments
  - Cat. IVb: With life-detection experiments
- **Category V:** Earth return from any extraterrestrial solar system body (except the Moon)
  - Restricted Earth return
  - Unrestricted Earth return

Implementation of Compliance

- **Planning**
  - PP Plan, Subsidiary Plans, PP Implementation
- **Analysis**
- **Bacterial burden accounting**
- **Biological contamination control**
- **Reports and reviews**
- **Record keeping**

Planetary Protection vs. Contamination Control

- Contamination Control*
  - Particulate and molecular contamination on flight systems to ensure payload instruments proper function, CC requirements derived from science requirements
- Planetary Protection (forward contamination)
  - Requirements levied by NASA for benefit of **future** science
- Overlaps
  - Some but not all methodologies in common
  - PP interest in life detection and sample return

Points to Remember

- NASA HQ sets policy, project plans and implements to achieve compliance
- PP applies to all extraterrestrial robotic missions
  - Only Earth orbiters, lunar, and crewed missions exempted
- Requirements are fairly project-specific
- Introduce into project early
  - Get official category
  - Get requirements early

Points to Remember (cont.)

- Develop an *approach* to PP compliance that is integral to flight system and mission design
- Requirements apply to all the hardware, including instruments
- Record-keeping required for launch approval by NASA PPO and for End-of-Mission Report
- PP compliance for the mission does not end with launch

Is Planetary Protection Changing?

Planetary protection evolves as the planetary exploration program progresses and as planetary science advances—knowledge, measurement technologies, access to new places…

Technology Challenges Examples

- Cleaning methodologies that go beyond state of the art (SOA)
  - Cleaner
  - Materials compatibility
  - Maintainable
- Advances in sterilization technologies
  - Extremophiles
  - Materials compatibility
  - Prelaunch
  - In-flight
- Effective and reproducible sampling technologies, appropriate to the hardware

Technology Challenges Examples, cont.

- Technologies for quantitative and qualitative detection of biomolecules at better than SOA sensitivities
  - On the target surfaces
  - Sampled from the surfaces
  - Culture-based techniques
  - Non-culture-based techniques
- Technologies in support of sample return
  - "Breaking the chain of contact"
  - Verifiable containment (e.g. in-flight monitors)
  - Leak detection technologies
  - Quarantine testing and sample handling technologies

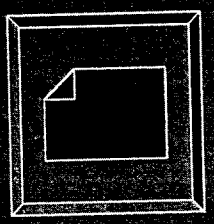
Technology Challenges Examples, cont.

- And others in a range of discipline areas:
  - Microbial ecology
  - Microbial diversity
  - Aseptic assembly
  - Cross-contamination modeling
  - Bioshields (devices/structures for avoidance of cross-contamination)
  - In-flight sample preservation
  - In-flight hazard protection
  - Navigation and EDL related technologies

In Summary

- Planetary protection is here to stay
- Instrument and spacecraft builders are often involved in design/implementation
- Technology gaps exist in many areas
- PP enabling technologies can often apply to other requirements or applications

QUESTIONS?



Comparison PP Requirements for Mars with PP Requirements for Europa

- Expect Europa PP requirements more rigorous than current Mars requirements
- Expect Europa PP requirements like previous Mars PP requirements (pre-Viking)
  - little data, especially on proliferation and growth
  - likely liquid water
- Exceptions:
  - period of biological exploration was optimistic for Mars, but too short to match Europa exploration timeline
  - spore burden set by NASA PP based on allowed P_c and specifications for natural environment reductions

Status of Europa PP Requirements

- **SSB Recommendations[1]:**
  - each spacecraft cleaned, sterilized and/or subjected to sufficient radiation prior to contact with Europa's surface so that the probability of contaminating the ocean (P_c) is less than 10^{-4}
  - alcohol wipes, sporicides, dry heat and H_2O_2 are satisfactory approaches
  - supplement with extremophile assays, esp. rad resistant
  - non-culture assay

[1] excerpt from *Preventing the Forward Contamination of Europa*, Space Studies Board, National Research Council, 2000. Note that these are not NASA PP requirements.

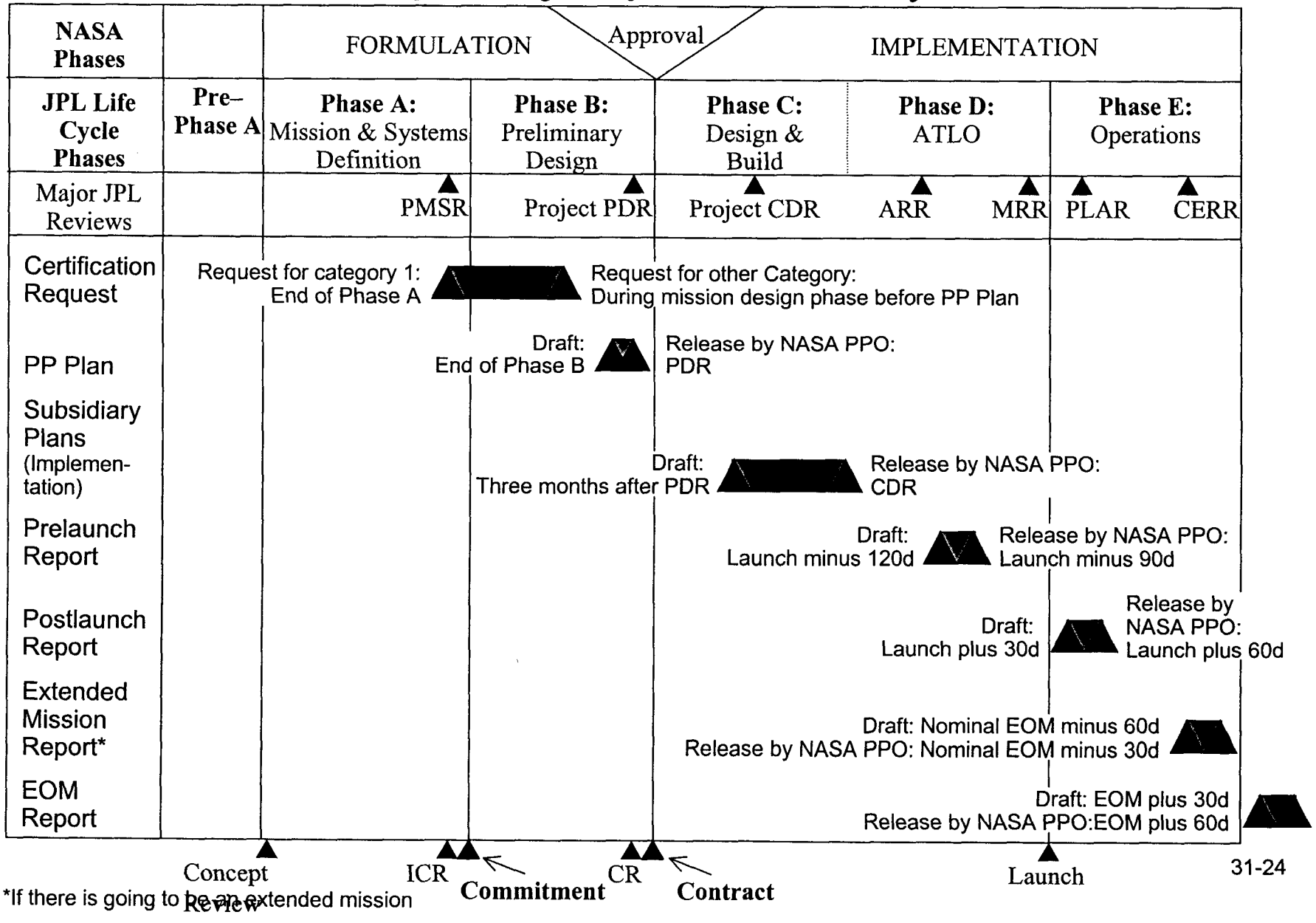
Preliminary Approach for Europa Orbiter (not approved)

- **Clean and assay all surfaces**
- **Dry heat microbial reduction wherever feasible**
- **Determine radiation resistant fraction**
- **Spacecraft radiation transport analysis**
- **Orbital lifetime set to meet 10^{-4} requirement based on above**

Probable PP Requirements for Europa Lander

- **Allowed burden at contact with surface, probability of 10^{-4} of one viable (total surface, mated and encapsulated)**
- **Allowable to use radiation environment in and on spacecraft as determined by project to set allowable burden, but only modest reduction for a lander expected**
- **Terminal sterilization of lander will probably be required**
- **Issue is how to design payload (and spacecraft) compatible with an acceptable sterilization modality**

The JPL Project Life Cycle: Planetary Protection



*If there is going to be an extended mission

Scope of Work for Planetary Protection

- Categories I and II
  - Little cost or risk, technically simple, but expert assistance needed
- Categories III and IVa
  - Significant costs and risks, technically difficult
  - Should delegate to single Project PP Manager
  - Implementation methods and required tasks cross several areas of typical Project WBS
- Categories IVb and V "restricted Earth return"
  - Great costs and risks, technically challenging
  - Should have one PP work element and manager

Scope of Work for Planetary Protection

I Certification of Category I Mission ONLY

II Documentation Only: PP Plan, Pre- and Postlaunch PP Report, End-of-Mission Report

III Implementing Procedures*: Trajectory Biasing, Clean Room Assembly, Microbial Reduction or Orbital Lifetime

Documentation: Same as Category II, plus Subsidiary Plans (as required)

IVa Implementing Procedures*: Trajectory Biasing, Clean Room Assembly, Selected Microbial Reduction, Organics Inventory and Archive

Documentation: Same as Category III, plus Subsidiary Plans

IVb Implementing Procedures*: Trajectory Biasing, Clean Room Assembly, System Microbial Reduction , Organics Inventory and Archive, Bioshield

Documentation: Same as Category III, plus Subsidiary Plans

V Implementing Procedures*: Outbound: Per category of outbound mission
Inbound: If "Unrestricted Earth Return," none, otherwise Prevention of sample contamination, breaking chain of contact, sample containment, and prevention of accidental release

Documentation: Outbound: Per category appropriate to outbound mission
Inbound: Certification for "Unrestricted Earth Return" OR Earth Safety Analysis Plan, Earth Return Pre-launch Report, Earth Pre-entry Report, Sample Pre-release Report, End-of-Mission (EOM) Report

*Europa Requirements are TBD