NASA Planetary Protection Update

National Academy's Committee on Biological and Physical Sciences in Space

October 14, 2021

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Planetary Protection

Protect current and future scientific investigations by limiting biological and relevant molecular contamination of other solar system bodies through exploration activities and protecting the Earth's biosphere by avoiding harmful biological contamination carried on returning spacecraft, as described in the Outer Space Treaty.

Forward PP - Understand and control harmful contamination of other worlds by terrestrial organisms, organic materials, and volatiles from spacecraft

Backward PP - prevent harmful biological contamination of the Earth-Moon system by potential extraterrestrial life and bioactive molecules in returned samples

PP Requirements Protect Science and Evolve with Scientific Consensus – Lunar Missions

Sept. 1963 – Policy Change. Relaxed Full Sterilization Requirement. "Required Procedures"

- Clean-room assembly policies be adopted,
- Sporicidal agents be used when "appropriate", and
- Recontamination Prevention for launch processing - covering

PP Category III/IV*

July 1969 - The crew of Apollo 11 in quarantine after returning to Earth being visited by President Nixon. 21-day quarantine.

PP Category IV*
PP Category V Restricted*

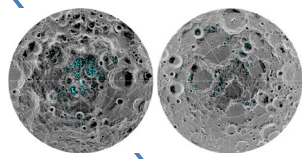
2004 - COSPAR PP Panel Investigate whether the permanently shaded areas near the lunar poles should be "protected" in the sense of imposing the mandatory record-keeping required under.

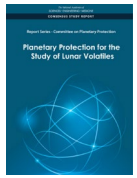
Proposed PP Category II

June 2021 COSPAR / NASA NPR Update

Category	Description	Volatiles Released by Propulsion System	Spacecraft Organic Inventory
II	Orbiter	--	--
IIa	Moon surface not IIb	Required	--
IIb	PSR and lunar poles	Required	Required

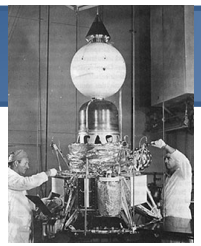
PP Category II, IIa, IIb





Apollo 15-17
PP Category I*
PP Category V Unrestricted*

Sept – Oct 2020 NASEM Study



December 23, 1960
Memo "Decontamination and sterilization procedures for lunar and planetary space vehicles." The memo was signed by Hugh L. Dryden.

PP Category III/IV*

July 1969 – Interagency Agreement on Back PP. Quarantine Provisions.

- Introduction of alien life forms to the Earth's biosphere could be catastrophic.
- Preserve Lunar sample science

PP Category V Restricted*

1983 – COSPAR Post-Apollo
PP Category I
PP Category V Unrestricted

2008 – COSPAR General Meeting
Lunar Reconnaissance Orbiter + LCROSS Impactor
Assign the Earth's Moon to Category II because of the potential for missions to disrupt polar volatile deposits (≥ 70 N & S latitude).

PP Category II

July 2020 NASA NID 8715.128

Table 1. NASA Mission Planetary Protection

Lunar Target Sensitivity	Mission PP Category
Not of direct interest for understanding the process of chemical evolution or where exploration will not be jeopardized by terrestrial contamination. No protection of such regions is warranted.	I-L
Of significant interest relative to the process of chemical evolution but only a remote chance that biological contamination by spacecraft could compromise future investigations. Reporting of biological materials is warranted.	II-L

Proposed PP Category I-L, II-L

*Notional Category

Technology and Research Highlights

- NASA Federated Board supporting the Office of Planetary Protection for Science Mission Directorate, Space Technology Mission Directorate and Human Exploration and Operations Mission Directorate coordination.
  - Concurred on integrated roadmaps and identified technology gaps for planetary protection.
  - Helped to balance and ensure funding responsibilities across the stakeholders.
  - Monitor PP technology progress and serve as a forum to resolve issues.
- Continued support from Planetary Science Division's PP ROSES Program, overlap in some areas with Space Biology
  - Continued funding, FY22 selections underway
- Coordinated and synergistic activities between BPS and Office of PP
  - Strategy is to address PP gaps, when appropriate, through existing objectives and awards.

PP Roadmap Tasks Interfacing with BPS

- Microbial Biology Monitoring and Control
  - Monitoring technology extensions to extremophiles
  - Microbial control in spacecraft systems
  - Microbial control in EVA systems
- Effects of weather on spread of microbes on Mars

BPS Transformative Science Area Interfaces with PP

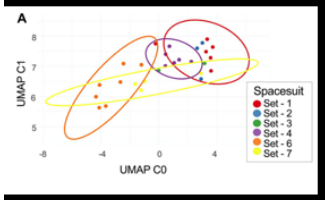
- "Omics" and Systems Biology
  - Genelab as an established collaboration space for sharing, storing and analyzing omics data
  - Future Scientific Collection potential for curation of PP samples and metadata
- Planet Responses to Lunar Regolith
  - Geomicrobiology investigations and interactions between microorganisms and geological substrates, microbial remediation to enable plant growth
  - Studies of biofilm formation on surfaces within the ISS
  - Ecosystem omics on response to space environment
- Artificial Intelligence / Machine Learning
  - Multi-omics data standardization and meta-analysis
- Automation and Miniaturization
  - Dual use capabilities for equipment for sampling, processing or analysis

Spaceflight Opportunities

- Lunar surface experiments –
  - Long-duration, lunar habitat and partial gravity testing
- Cis-lunar (e.g. Gateway) –
  - Long-duration, high radiation doses of ambient radiation
- Small / Cube Satellites
  - Opportunity to gain and refine additional environmental parameters (e.g., BioSentinel, Artemis-1 secondary payload to detect and measure the impact of the radiation environment in space on living organisms, growth and metabolic activity)
- ISS and commercial LEO platforms –
  - Microbe survival studies to the space environment to further develop microbial reduction parameters for PP model verification
  - Test microgravity protocols and astronaut interactions (e.g., EVA swab)

Synergistic Ongoing Research Example

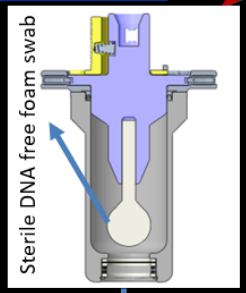
ISS External Microorganisms: A tool to Collect microbes from External Surfaces on the International Space Station (ISS)



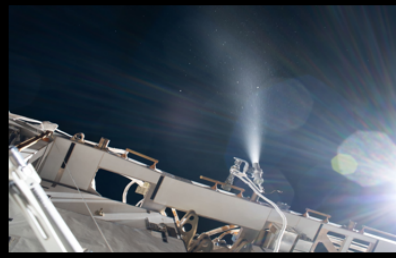
Danko, D., et al. (2021). *Frontiers in Microbiology*

Successfully testing the prototype at vacuum reveals that space suits are microbiologically indistinguishable from their testing environment.

- Some organisms including bacteria, fungi, and even tardigrades can survive prolonged exposure to space.
- The ISS releases microbes to space through vents and airlocks
- Does the ISS have an external microbiome? What does it look like?
- **Project Goals:**
  - Collect 6 samples + 2 controls from ISS external surfaces.
  - Return samples to Earth for next generation (amplicon and or metagenomic) DNA sequencing.
- **Expected Results**
  - Address planetary protection knowledge gaps and allow NASA to design life support systems that can be used on Mars without introducing unwanted contamination.
  - Teach us how microbes evolve in response to exposure to space and, therefore, potentially impact plants or animals, a Space Biology goal.
  - The tool can be used on future robotic and crewed missions to collect biological, chemical, and geological samples that address Space Biology and Astrobiology questions.
- We are approved to collect samples during EVAs planned for late 2022



0.22 µm filter to allow pressure equalization without contamination



Planned venting of coolant to space
iss064e041927 (March 13, 2021)

Credit: Aaron Regberg

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Looking Ahead…

- Office of Planetary Protection to organize and lead Microbial Management Integration Team with SMD (PSD and BPS), HEOMD (SE&I and HMTA) and STMD participants.
  - Technical interface for coordination and integration of activities related to microbial management and control, particularly as related to planetary protection of crewed Moon-to-Mars activities.
  - Report and exchange information of ongoing and/or planned activities related to the PP Capability Gap areas, as well as other PP-relevant R&TD tasks
- NASA Federated Board reporting