NASA Office of Planetary Protection Update: Planetary Protection and the Moon-to-Mars Strategy

Dr. J. Nick Benardini
Planetary Protection Officer

Dr. Erin Lalime
Acting Deputy Planetary Protection Officer

Dr. J. Andy Spry
Planetary Protection Senior Scientist, BQMI

NASEM Committee of Planetary Protection Fall Meeting

Washington, DC

December 9, 2025

Bottom Line Up Front

Problem – The current prescriptive planetary protection technical requirements not sufficient for large robotic (>1500m^2), crewed, or in-situ resource utilization missions.
Solution – A performance-based framework is required for mission design and execution for both forward and backward PP.

- Disclaimer – this is **NOT** "The Strategy" but rather the current state of the work to-date.
  - *Moon-to-Mars is our #1 priority*
  - *Work in progress & we are continuing to adapt!*
  - *We see how the dots can get connected between policy, risk decision making, technology, etc…*
  - *The ongoing planning and decision making puts us in a position to lead the discipline in the paradigm shifts that will enable the next generation of Mars missions.*
- Overarching Office of PP principles / work philosophy
  - *Agency level dialogue with key stakeholders (e.g., ESDMD, SMD, OCHMO, etc.) to develop Agency plans, overall strategy, technology development, etc.*
  - *Adapting and evaluating PP strategy to mission timelines / scenarios for demo, cargo and crew missions.*
    (i.e., "what-if → then what"?)
  - *Engaging with the science community to ensure that intent and best practices are aligned with scientific consensus.*
  - *Collaborative work with US commercial & NASA partnered missions, FAA consultations, COSPAR.*

Moon-to-Mars

Credits: NASA

Multifaceted Moon-to-Mars PP Current Approach

Policy

- NASA
- COSPAR
- Science community intent
- US Government Interfacing

Risk Management

- Establishing Agency Level Risk Posture
- Decision making package

Technology Development (Knowledge Gap Management)

- Technology development plan responsive to risk posture
- International coordination
- NASA coordination

PP Tools

- Forward PP Framework
- Back PP Framework

Engineering

- Current Performance
- Systems engineering trade space

OPP Document Tree

Link to NASA Planetary Protection policy and guidance documents at www.sma.nasa.gov

NPD 8700.1F
NASA Policy for Safety and Mission Success
Effective Date July 28, 2022
Expiration Date: July 28, 2028

NASA Policy Directives (NPDs)
- Documents Agency policy statements
- Describe what is required by NASA management to achieve NASA's vision, mission, and external mandates

NPR 8715.24
Planetary Protection Provisions for Robotic Extraterrestrial Missions
Effective Date September 24, 2021
Expiration Date: September 24, 2026

NASA Procedural Requirements (NPRs)
- Provide detailed procedural requirements to implement policy
- Guide how policy directives are implemented in the context of specific missions

NASA Standards
- Provide technical requirements
- Each NASA Technical Standard is assigned to a Technical Discipline

NASA-STD-8719.27
Implementing Planetary Protection Requirements for Space Flight
Effective Date: August 30, 2022

NASA-HDBK-20240016475
NASA Planetary Protection Handbook
Effective Date: January 24, 2025

NASA Handbooks
- Companion documents to NPRs and NASA Standards
- Provide supporting material such as guidelines, lessons learned, procedures, and recommendations

Policy
- NASA
- COSPAR
- Science community intent
- US Government Interfacing

All published documents found in NODIS: https://nodis3.gsfc.nasa.gov/ or the OPP website: https://sma.nasa.gov/sma-disciplines/planetary-protection#PolicyGuidance

CANCELED - NID 8715.129 ("Mars NID")
Biological Planetary Protection for Human Missions to Mars

NID 8715.129 (“Mars NID”) - Biological Planetary Protection for Human Missions to Mars

A NASA Interim Directive (NID) is a temporary policy that provides guidance or establishes requirements for specific actions, policies, or programs at NASA.

- **NID 8715.129 Guidance**
  - *Established applicability of PP objectives for crew missions*
  - *NASA is aligned with general COSPAR PP Policy Paradigms*
    - *BPP is the highest priority*
    - *Human contamination will be inevitable on Mars – not possible for fully closed loop systems*
    - *Crew will be exposed to Mars*
- **NID 8715.129 Specific Actions**
  - *Develop risk-informed decision-making strategies for human missions to Mars*
  - *Evaluate and manage knowledge gaps to include a TRL development cycle and open data policies*
  - *Determine if a precursor mission is necessary*
- **Agency Activities since June 2020**
  - *NASA Standard 8719.27 and NASA-HDBK-20240016475 –both robotic and crew applicable, paves the way for alternative risk-based approaches*
  - *Moon-to-Mars White Paper Briefing: Planetary Protection Considerations (Winter FY26 release)*
  - *Moon-to-Mars Architecture Definition Document with annual updates (Winter FY26 release)*
  - *Science and Planetary Protection in Advance of Human Missions Workshop Report*
  - *Siegel et al., 2025, Status update of NASAs assessment of the biological contamination threat of crewed Mars surface missions, LSSR 45: 25-33.*
  - *Spry et. al, 2024. Planetary Protection Knowledge Gap Closure Enabling Crewed Missions to Mars. Astrobiology 24(3).*

Policy

- NASA
- COSPAR
- Science community intent
- US Government Interfacing

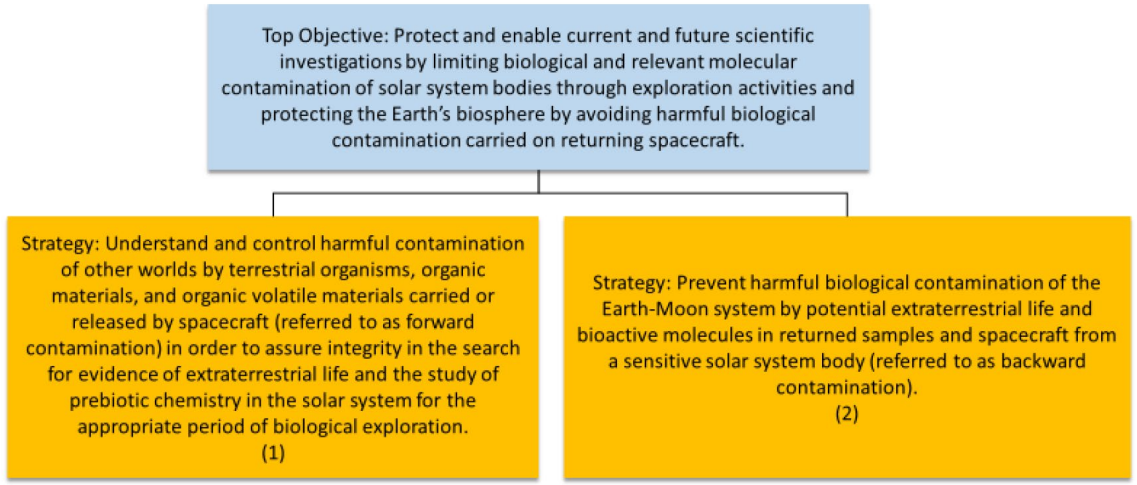
NID 8715.129 has provided guidance for actions and policy of PP for crew mission to Mars.

Planetary Protection Policy

- Policy for crew missions have the same forward and backward objectives hierarchy top-level as robotic missions (see NPR 8715.24 P.1 and NASA-STD 8719.27 Figure 1-1).

- **The details of the implementation, requirements, and associated verification activities for crewed missions are not fully defined.**

- **Policy Work Ahead**
  - ☑ DONE! Risk-based and performance-based flexibility added during the recent updates to pave the way for crew compliance!
    - Administrative add of crew applicability to NPR 8715.24.
    - Development of detailed technical requirements and implementation for crew specifics needed.
    - COSPAR Policy alignment and update.



NASA STD 8719.27 §4.1 & 4.2: "*Acceptable methodologies include prescriptive or performance based (e.g., assurance case) approaches.*"

Policy

- NASA
- COSPAR
- Science community intent
- US Government Interfacing

Risk Management

- Technical background and analysis for decision making package coming together.
  - *Identifying what the decision makers may need from technical staff to make an informed decision. Back to basics – PP 101, PP is enabling missions, common definitions (see next chart)*
  - *Working to understand current state of robotic contamination (see PP tools section)*
- Forward and Backward Planetary Protection Risk Posture still two high priority topics that are being pursed by the Mars Architecture Team.
- Architecture Concept Review 2025 (ACR25; being held this week) – seeking approval for an Agency level endorsement of the “Moon-to-Mars White Paper Architecture-Driven Planetary Protection Considerations” to be released in the upcoming ACR25 data package.

Risk Management

Establishing Agency Level Risk Posture

Decision making package

Moon-to-Mars Architecture Site

PP 101 Example: What are we protecting / safeguarding?

Forward Planetary Protection

- Policy -“Harmful contamination”
- Science objective. Enable current and future science – signal to noise ratio, false positives drive policy.
- What are we protecting
  - *Biological organisms, no replication – impacting current or future science*
  - *Biological organisms, replication – falling off s/c and inoculating Mars*
  - *Biological organisms, replication – cellular debris generating organics impacting future or current science*
  - *Organics – impacting current or future science*
- What we are NOT protecting
  - *Environmental regulations at large (e.g., not a Green Peace initiative or the Mars Protection Agency)*
  - *Trash, waste or other*

Backward Planetary Protection

- Policy – “adverse impacts to the environment”
- Safety objective. Biothreat to Crew and Earth’s environment drive policy.
- What we are protecting
  - *Biological organisms, replication – Mars origin material inoculating Earth’s Biosphere*
- What we are NOT protecting
  - *Toxicological impacts (e.g., dust irritations in lungs)*

Risk Management

Establishing Agency Level Risk Posture

Decision making package

Technology Knowledge Gap Management

- PP knowledge gap efforts have shifted from a capture / identification of gaps to planning:
  1. *defining the desired outcome/end state for each gap,*
  2. *developing a technology development cycle with associated resource estimate,*
  3. *developing a tracking tool to capture activities, and*
  4. *working within the Agency and internationally to account for activities and strategic planning.*
- Work to-go
  - *Reach a common understanding within the community on the end states for each gap.*
  - *Extended capture work with NASA-ESA-JAXA to the remaining community.*
  - *Brief out findings to Agency stakeholders with the objective to develop an internal plan to manage PP Policy gaps.*
  - *Leverage PP Research and Technology Steering Group to integrate needs across Agency.*

Technology Development (Knowledge Gap Management)

- Technology development plan responsive to risk posture
- International coordination
- NASA coordination

International Coordination of Knowledge Gaps

ESA, JAXA, NASA and COSPAR PPP have started management and mitigation activities of crew policy knowledge gaps.

Developed tracking worksheet that captures

- gaps
- sub-tasks,
- desired outcomes

Distilled the knowledge gap update into active, planned and opportunities for engagement.

Coordination and collaboration is paramount to managing crew knowledge gaps for to ensure that science and safety objectives/intent is agreed upon internationally.

Organizations like COSPAR, International Mars Exploration Work Group, and International Collaboration Space and Exploration Coordination Group helping to bridge those collaborations.

Actively soliciting inputs in these working group meetings.

Agencies are starting to ramp up 2026 planning for mission concepts, concept reviews, instrument announcements of opportunity, research solicitations, and directed tasking.

>$20M of investments across agencies are being planned

Helpful to streamline these efforts to maximum the return of engineering and science in 2026 and beyond.

Technology Development (Knowledge Gap Management)

- Technology development plan responsive to risk posture
- International coordination
- NASA coordination

PP Tools – Framework for Forward and Backward PP Risk

- Probabilistic tools need to be developed to enable Mars exploration.

	Current	Future Needs

Forward	• Viking Pc analysis (reports)
	• Pc parameter assessment 1990s and special region
	• Europa Clipper model
		• Modernize Mars Pc working model
		  • Updated Mars mathematical framework
		  • Updated biological & environmental parameters

Backward	• Robotic break the chain assurance framework • Sample Safety Assessment	• Crewed break the chain • Crew safety • Biosphere safety

Framework needs developed to:
- Harmonize and standardize the PP process.
- Assess the current state of Mars contamination through robotic exploration.
- Inform risk posture trade space.
- Inform technology developments and parameters by assessing modeling sensitivities/uncertainties.
- Support mission planning and execution.

PP Tools

Forward PP Framework

Back PP Framework

- Capturing and characterizing contamination
  - *What is the current performance in terms of biological and organic contamination and characterization*
    - *Does that pose a risk to science?*
  - *Understanding the trade space and technology advancements that may impact that performance.*
- Continuing to support technology development efforts where PP may be a stakeholder.
- Siegel et al., 2025, Status update of NASAs assessment of the biological contamination threat of crewed Mars surface missions, LSSR 45: 25-33.

Sample trash tile, compressed to <1/8th of the original volume, by the Heat Melt Compactor. NASA Ames Research Center/Dominic Hart

EVA Swab On Ground Testing of the EMU Wrist Joint Sampling. NASA

Engineering

Current Performance

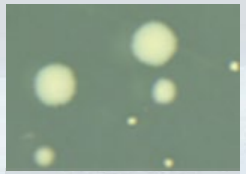
Systems engineering trade space

For Discussion…

- The essential and next best thing(s) to do
  - *Assuming something is better than nothing and building out from the top-level PP objectives what are the must haves from a science perspective?*
    - *Evolving past spores; microbial dark matter etc…*
      - *Where are the technology sweet spots to ensure verifiable requirements?*
      - *Detection and analysis method must align with the risk.*
  - *What opportunities do you envision with additional resources that could benefit the science community (e.g., increase return of investment, tighten up uncertainty in models etc.)?*
- Identification of next steps for probability of contamination parameter feedback.
  - *Probability of growth? Recommendation of special region parameters to start – temp, availability of water, etc.*
- Spring 2026 Meeting Thoughts?
  - *Continued Moon-to-Mars Strategy Discussion and infusing mission architecture information*
    - *ESDMD - Strategy and Architecture Office*
    - *ESDMD - Mars Architecture Team*
    - *HMTA - Health and Medical Technical Authority*
  - *Science deep dive into probability of growth parameters*

Resources Available Through The OPP Website

Articles



What Are Spores?

How to Build a Clean Spacecraft

Cleanroom Gowning or How to Dress in the Cleanroom

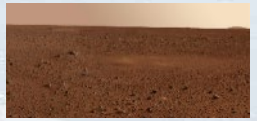
Ground Support Equipment

Protecting the Planet: Planetary Protection vs. Planetary Defense

OSIRIS REx Sample Return Doesn't Pose a Risk to Earth's Biosphere

Bioburden Accounting Tool Release

Organic Inventory Workshop



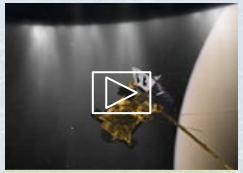
PP Crewed Knowledge Gaps

COSPAR PP Policy Update

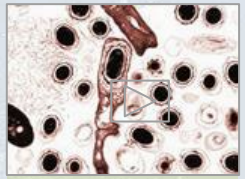
Updated Handbook Release

Lunar Reporting Forms

Videos



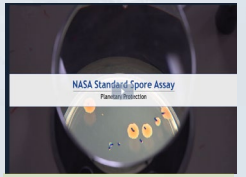
Planetary Protection: An Introduction



Just How Small is a Spore?

Forward and Backward PP Overview

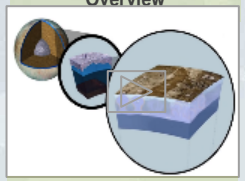
Behind the Spacecraft Perseverance



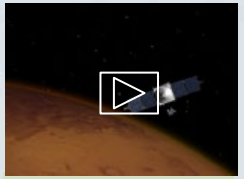
PP Spore Assay

Mission Design and PP Categorization

Probability of Impact



Ocean Worlds



End of Mission Disposition

Planetary Protection: Handbook Update Webinar

Missions & Studies

Mission Reports

NASEM Study Reports

https://sma.nasa.gov/sma-disciplines/planetary-protection

Questions?