Office of Planetary Protection Update

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 on Planetary Protection

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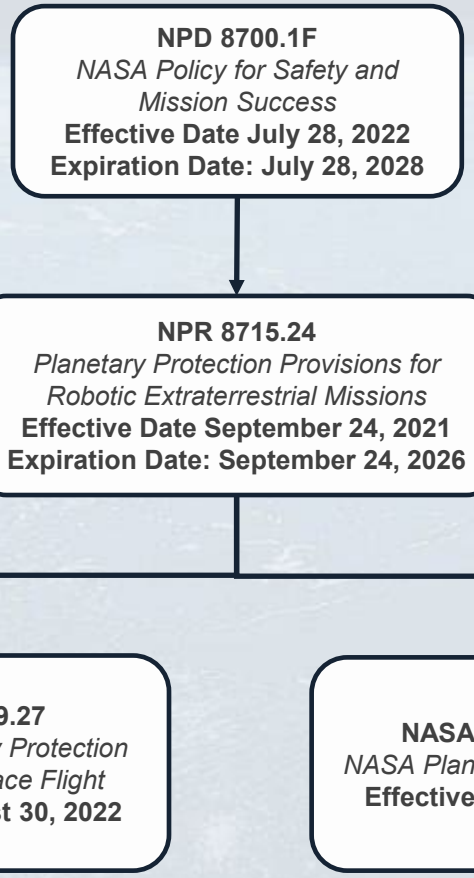
Overview

- Policy
- Lunar Implementation
- Mars Strategy
  - *Moon to Mars*
  - *Low-cost Mars*
- Metagenomics in Spaceflight

OPP Document Tree

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



NASA Policy Directives (NPDs)

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

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 Handbooks

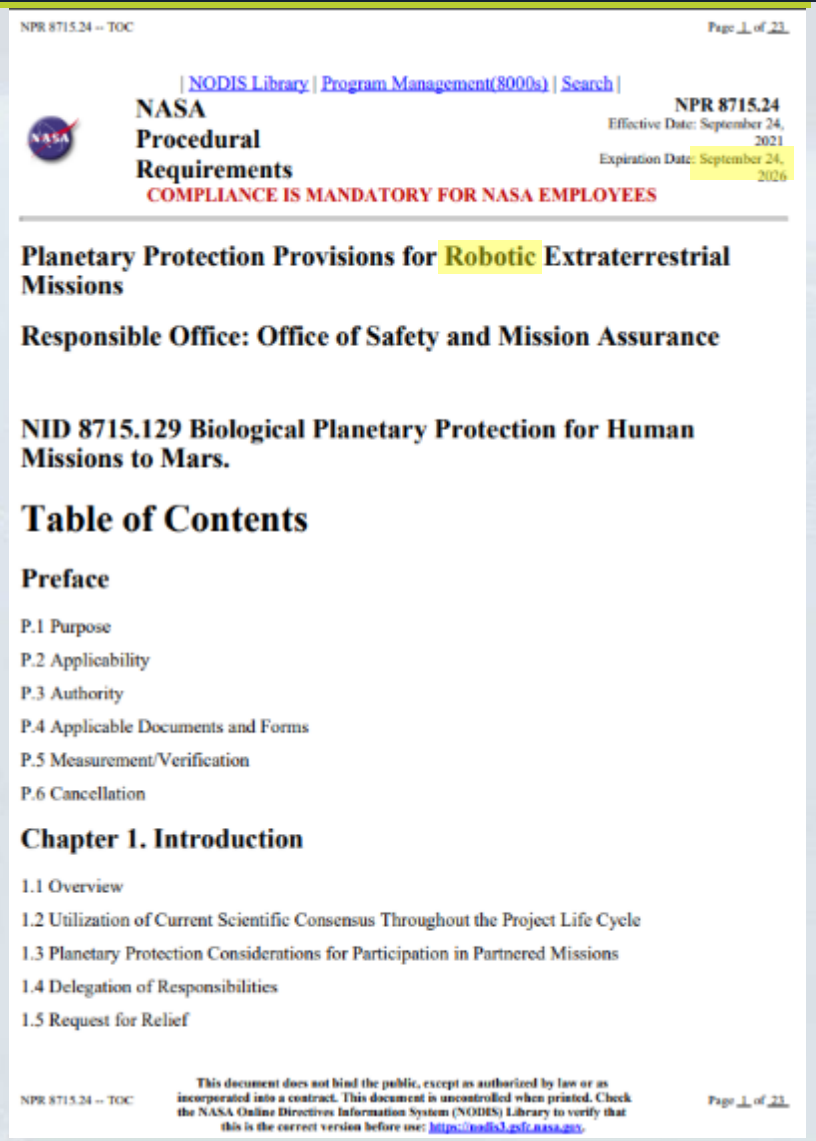
- Companion documents to NPRs and NASA Standards
- Provide supporting material such as guidelines, lessons learned, procedures, and recommendations

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

NPR 8715.24 Updates Coming Soon….

- PP Robotic NPR being expanded to include crewed applicability
- "something that can be solved today" approach –
  - *adding applicability,*
  - *editorial updates, and*
  - *minor technical updates.*
- Goal to have a draft in ~4-6 months for NASA internal review.



NPR 8715.24 -- TOC Page 1 of 23

| NODIS Library | Program Management(8000s) | Search |

NASA Procedural Requirements

NPR 8715.24
Effective Date: September 24, 2021
Expiration Date: September 24, 2026

COMPLIANCE IS MANDATORY FOR NASA EMPLOYEES

Planetary Protection Provisions for Robotic Extraterrestrial Missions

Responsible Office: Office of Safety and Mission Assurance

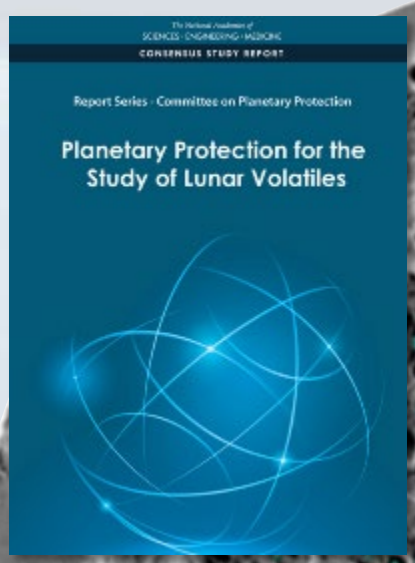
NID 8715.129 Biological Planetary Protection for Human Missions to Mars.

Table of Contents

Lunar

Lunar Requirements Forward Contamination / Science Drivers

- *Lunar research seeks to understanding prebiotic evolution and the origin of life.*
- *Potential "harmful contamination" threat assessment*
  - *<u>Organic Contamination.</u> Spacecraft operations can pose a potential threat of organic contamination of permanently shadowed regions (PSRs)*
    - *Spacecraft landing on the lunar surface could transfer volatiles to polar cold traps. Can occur through vacuum venting, materials off gassing, and thruster induced plume interactions.*
    - *Enables exploration as organics could pose a threat to ISRU resulting in impurities for water, fuel extraction, etc…*
  - *<u>Biological contamination.</u> Period of biological exploration for the Moon is over. Biological are not of concern:*
    - *Surface does not support life or the proliferation of terrestrial organisms brought to the Moon*
    - *Crewed missions and biological payloads are not a concern for PP compliance*
    - *Biological cleanliness reporting is not required*



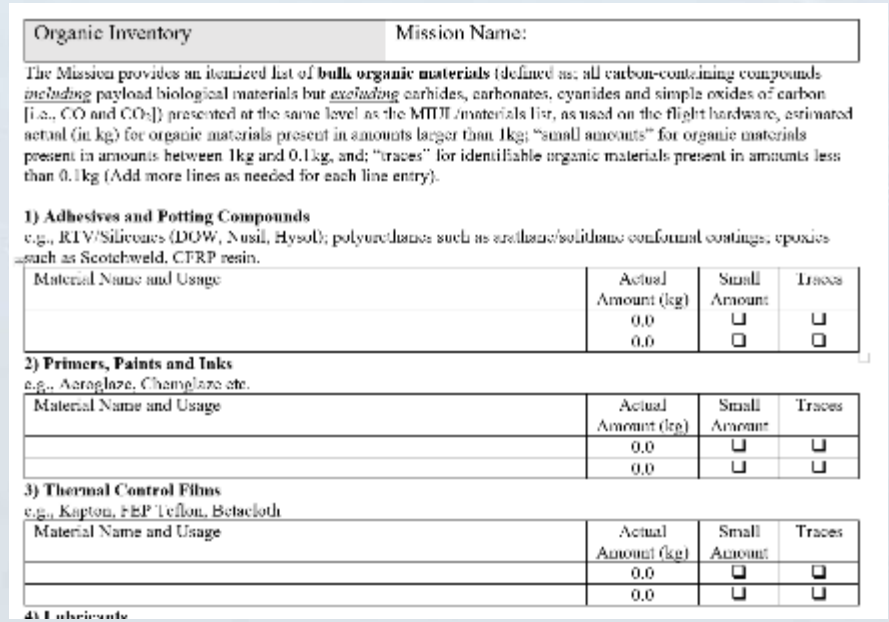
- Organic Inventory Reporting Requirements

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

- No limits on the types or quantities of organics.
- Anticipated reporting at pre-launch (estimate) and end of mission (actual update from model and disposal plan).

Current Reporting Implementation

- Reporting can be easy as a template to capture (from existing MIUL)
  - *Key organic compounds and estimated size bins (if actuals unknown)*
- Purpose is to serve as a first step to document lunar activities that future scientists can leverage as a reference to help contextualize tomorrow's science findings.
- We cannot predict everything the scientists will need, but it's a starting point.
- Not intended to be an exhaustive or precise but a place to starting
  - *Rough order of magnitude and simple volatile reporting of what's in the tanks needed*
- Reports are archived for future reference with appropriate release sensitivities noted for proprietary, ITAR, etc.
- International coordination of reports could be brokered through COSPAR Panel on PP as needed.



Organic Inventory | Mission Name:

The Mission provides an itemized list of **bulk organic materials** (defined as: all carbon-containing compounds *including* payload biological materials but *excluding* carbides, carbonates, cyanides and simple oxides of carbon [i.e., CO and CO_2]) presented at the same level as the MIUL /materials list, as used on the flight hardware, estimated actual (in kg) for organic materials present in amounts larger than 1kg; "small amounts" for organic materials present in amounts between 1kg and 0.1kg, and; "traces" for identifiable organic materials present in amounts less than 0.1kg (Add more lines as needed for each line entry).

1) Adhesives and Potting Compounds

e.g., RTV/Silicones (DOW, Nusil, Hysol); polyurethanes such as urethane/solithane conformal coatings; epoxies such as Scotchweld, CFRP resin.

Material Name and Usage	Actual Amount (kg)	Small Amount	Traces
	0.0	☐	☐
	0.0	☐	☐

2) Primers, Paints and Inks

e.g., Aeroglaze, Chemglaze etc.

Material Name and Usage	Actual Amount (kg)	Small Amount	Traces
	0.0	☐	☐
	0.0	☐	☐

3) Thermal Control Films

e.g., Kapton, FEP Teflon, Betacloth

Material Name and Usage	Actual Amount (kg)	Small Amount	Traces
	0.0	☐	☐
	0.0	☐	☐

4) Lubricants

Lunar exploration cadence and complexities are starting to call into question the value and intent of reporting.

Mission Design and Operational Complexities Increasing

- Data and reporting flow within a mission architecture
- Operational – orbiting, surface, EVA, etc
- Payload, cargo, crew
- Collaborative environment – NASA, NASA-partnered, commercial, etc.

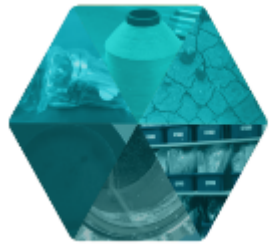
PP Reporting is something missions are already doing - ***"we already have that data"***

- Materials Identification and Usage List (MIUL)
- Manifest
- Packing Lists
- Contamination Control Analyses

Engaging the Community: Organic Inventory Workshop – February 27-28, 2024

- **Goal**

  To establish the current science and engineering approaches and begin to assess whether the current PP requirements address the needs to enable current and future science investigations.

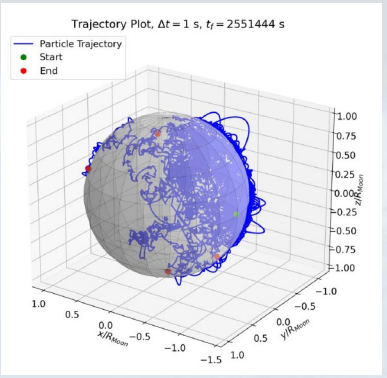


PLANETARY PROTECTION
ORGANIC INVENTORY WORKSHOP
FEBRUARY 27-28, 2024 - NASA HEADQUARTERS

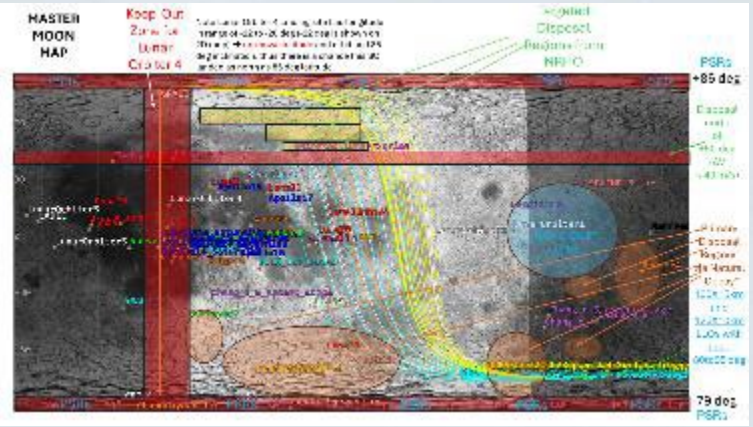
- **Objectives**
  - Evaluate the current organic inventory and archiving requirements in NASA PP Policy.
  - Provide a modernized, updated scientific and engineering balanced rationale and approach to capturing molecular contamination to enable current and future science investigations.
  - Identify knowledge gaps or additional policy inconsistencies that need to be addressed.
- **Workshop**
  - ~60 attendees from AMES, GSFC, HQ, JSC, JPL, KSC, LaRC, MSFC and industry.
  - All presentation files uploaded to the workshop agenda page.

Lunar Organic Footprint Contamination and End-of-Missions Concepts

- **A High-Level Model for the Organic Footprint of Lunar Landing Vehicles: "How far does the footprint of a lunar landing vehicle extend?" "Does the end of mission disposal play a factor in harmful contamination?**
- **Lunar Contamination Modeling**
  - *Lunar lander gas dynamic vacuum venting organic contamination.*
  - *Landing site characterization models for considerations of adsorption or organics and residence times.*
  - *Lunar Descent Engine Thruster Plume induced contamination.*
- **Orbiter end of mission orbits and Lunar surface disposal**
  - *Assessment of frozen and stable orbits*
  - *Identification of Predictable lunar impact behavior*



"Free Molecular Monte Carlo Model for Lunar Contaminant Transport and Deposition in Permanently Shadowed Regions" – Raphael Alves Hailer



Lunar sites of interest factoring in predictable orbital decay analyses – Anthony Genova

Next Steps….

- Moon to Mars Program PP Implementation
  - *Continue to work with the Moon to Mars SMA Team on streamlining reporting (e.g., reporting organics for the first mission and then differences only from subsequent architecture?)*
- Workshop – partnership with ESA to continue the conversation…

Mars

Enabling Crew to Mars

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.

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
- Definition package

Technology Development (Knowledge Gap Management)

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

PP Tools

- Forward PP Framework
- Back PP Framework

Engineering

- Current Performance
- Systems engineering trade space

PP Tools – Framework for Forward and Backward PP Risk

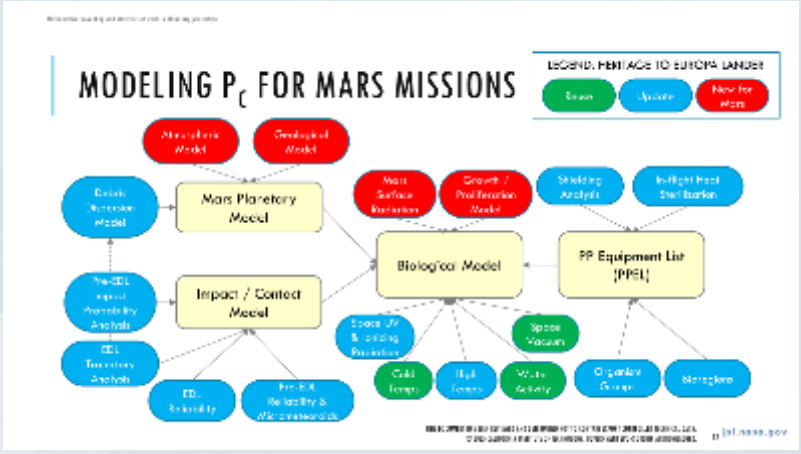
- Probabilistic tools need to be developed to enable Mars exploration.

	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 • 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.



Example of the network of submodels and analysis required for Mars missions.
Image credit: NASA/JPL Mike DiNicola

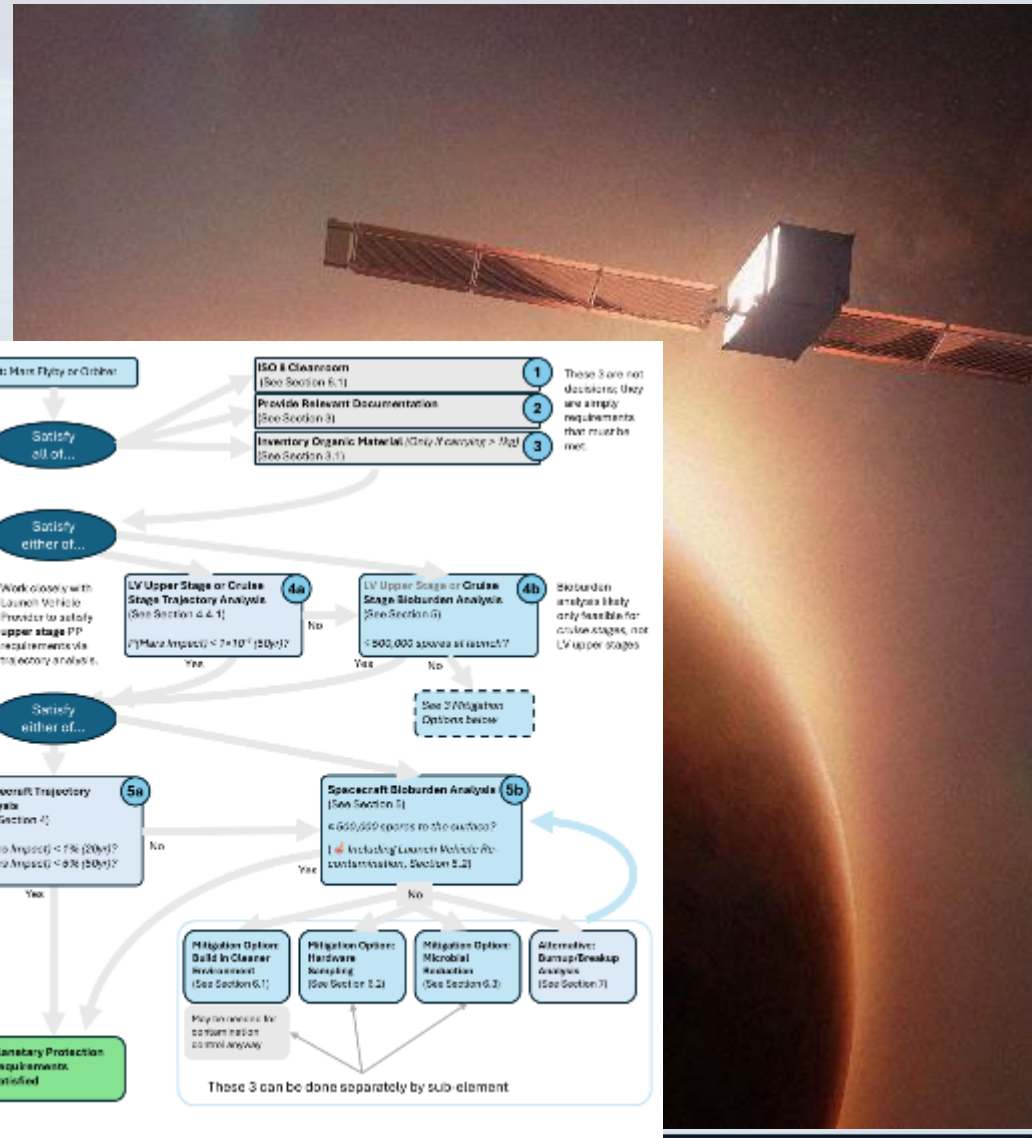
PP Tools

Forward PP Framework

Back PP Framework

Mars PP Primer: A Quick-Start Guide for Lower-Cost Orbiters or Flybys

- This primer is designed as a quick-start guide. It offers:
  - *A streamlined decision framework for Category III missions*
  - *Practical tools, including Planetary Protection Equipment List (PPEL) templates (Appendix B) to help teams estimate their spacecraft's bioburden*
  - *Clear entry points to compliance without requiring exhaustive familiarity with every planetary protection document*
- The intended audience includes:
  - *Commercial and international mission developers with limited prior experience in planetary protection*
  - *Small, resource-constrained project teams seeking early clarity on requirements*
  - *Mission designers exploring trajectory options, environmental controls, or bioburden mitigation strategies*



Metagenomics In Space Flight

OPP Metagenomics Activities

- Leading and continuing to partner with the international community, industry and NASA on –omics-based approaches
- Solution driving towards a multi-use omics tool for safety critical decision making.
  - *Astrobiology - life detection*
  - *Biological Physical Sciences*
  - *Health and Medical – built environment, human microbiome*
  - *Planetary Protection – robotic spacecraft cleanliness assessments, crew monitoring, samples safety assessment*
- Activities
  - *PP AWG*
  - *Community Workshops*

Planetary Protection Analysis Working Group (PP-AWG)

WHY

Develop consensus international standards for bioburden assessment (wetlab and drylab).

WHO

Original ~25 SMEs from USA, NASA, Europe, ESA, COSPAR, JAXA, Japan

Now open to students, post-docs, citizen scientists, researchers, AWG members.

WHAT

Ultra-low biomass protocols, DNA-free reagent development, contamination workflows, bioinformatics, data sharing, and risk predictions for Moon-to-Mars missions.

WHEN

Main Mtg: 2nd Thursday ea/Month (6a PT, 3p CET, 11p JST)
Sub-Groups: Meet and work separately

4 Co-Chairs

Dr. Haley Sapers
haley.sapers@nau.edu
Northern Arizona Univ.

Dr. Stefan Green
Stefan_Green@rush.edu
Rush Univ.

Dr. Alex Mahnert
alexander.mahnert@medunigraz.at
Medical Univ. Graz

Dr. Scott Tighe
Scott.Tighe@uvm.edu
University of Vermont

To Join:

https://tinyurl.com/3xkywbu2

More AWG Info:

https://awg.osdr.space/about

THREE SUB-GROUP PROJECTS

1 DNA Extraction

High-performance protocols for gram-positive cell lysis. Microbial standards for ultra-low biomass. DNA-free reagents via vendor partnerships (Promega, Qiagen, Zymo, Omega Bio-tek).

2 Noise Mitigation

Statistical design of experiments for sample/control selection. Lambda DNA spike-in optimization. Library prep limits and carrier DNA utility. Wetlab contamination mitigation.

3 Bioinformatics

Consensus metagenomics pipelines. Reference genome databases. AI/ML risk detection algorithms. Public data/protocol sharing via NASA OSDR and metadata standards.

Continued Workshop and Community Engagements

NASA Metagenomics Technical Interface Meeting

Jan 27-29; 2.5-day meeting hosted by JPL to review robotic, low-biomass -omics approaches with over 75 participants across NASA, NIST, and US academia and industry.

USG Collaborations

NIST engagement and evaluation for developing an –omics-based supplement / replacement to the NASA Standard Spore Assay

International Metagenomics in Spaceflight Workshop #2

Nov 2-6 2026, 3–4-day virtual meeting @ Caltech

Key objectives: Align towards a common verification method, update status of roadmap activities, continue to streamline –omics disciplines.

2026 Metagenomics in Spaceflight Workshop

- Workshop planning underway! Sessions may include:
  - *Roadmap and current progress*
  - *State-of-the-Art*
  - *Standardized Practices*
  - *Safety Critical Decision Making*
  - *Technology Needs*
  - *Dark Matter*
- November 2-6, 2026, Hybrid meeting at Caltech, Pasadena, CA.

Questions?