NASA Planetary Protection

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Nick Benardini
NASA Planetary Protection Officer

Elaine Seasly
NASA Deputy Planetary Protection Officer

Overview

- Policy Update
- Category II Requirements
- NASA Implementation of Small Solar System Body Missions
- Technology Update - Molecular Biology Workshop

NASA's Planetary Protection Policy Documents

NPD 8020.7G
Biological Contamination Control for Outbound and Inbound Planetary Spacecraft
(Revalidated 05/17/13 w/change 1)
Expiration Date: June 19, 2022

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
Replaced NPR 8020.12D/NID 8020.109A
Planetary Protection Provisions for Robotic Extraterrestrial Missions
Expiration Date: September 24, 2026
Effective Date September 24, 2021

NASA Procedural Requirements (NPRs)

- Provide detailed procedural requirements to implement policy
- Guide how policy directives are implemented in the context of specific missions

NID 8715.129 ("Mars NID")
Biological Planetary Protection for Human Missions to Mars
Expiration Date: July 9, 2022

NASA Interim Directives (NIDs)

- Documents an immediate, short-term statement of the Agency's policies, requirements, and identifies responsibilities for implementation
- Temporarily modify policy directives or implementation requirements

NASA Standards

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

NASA-STD-87XX.XX
Implementing Planetary Protection Requirements for Space Flight
Expiration Date: TBD
Status: Estimated Release ~5/22

NASA-HDBK-6022
Handbook for the Microbial Examination of Space Hardware
Expiration Date: N/A
Status: Revision planned. Last draft revision released Aug 17, 2010

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

= New Documents

Overview of NPR 8715.24 - Planetary Protection Provisions for Robotic Extraterrestrial Missions

Chapter 1. Introduction

1.1 Overview

1.2 Utilization of Current Scientific Consensus Throughout the Project

1.3 PP Considerations for Participation in Partnered Missions

1.4 Delegation of Responsibilities

1.5 Request for Relief

Chapter 2. Roles and Responsibilities

2.1 Mission Directorate Associate Administrator

2.2 NASA Project Manager

2.3 Chief, Safety and Mission Assurance

2.4 Planetary Protection Officer

2.5 Project-Level SMA Technical Authority

Chapter 3. Planetary Protection Procedural Requirements

3.1 Categorization and Planning

3.2 Verification, Assurance, and Pre-Launch Report Activities

3.3 Post-Launch/End of Mission

3.4 Restricted Sample Return and Containment

Chapter 1:

- Introduces risk-informed decision making
- Addresses how current scientific consensus is considered for missions
- Addresses missions with NASA partners / resources
- Baselines PP Relief using NASA General Safety Program Requirements

Chapter 2:

- Defines the key roles and responsibilities for executing PP
  - Previously, only the PPO role was defined
- Merges PP into the regular mission and project management structure

Chapter 3:

- Provides the process for obtaining mission PP categorization
- Addresses PP documentation, review, and concurrence throughout the project lifecycle
- Defines independent verification/assurance activities as well as anomaly investigations
- Addresses sample return break-the-chain BTC, containment and process.

COSPAR Policy on PP, June 2021

- Category II
  - Documentation
  - Impact Avoidance
  - **<u>NO</u>** Cleanroom
  - "*and contamination control measures*"

Table 1: Categories for solar system bodies and types of missions

	Category I	Category II	Category III	Category IV	Category V
Type of Mission	Any but Earth Return	Any but Earth Return	No direct contact (flyby, some orbiters)	Direct contact (lander, probe, some orbiters)	Earth Return
Target Body	See Category-specific listing	See Category-specific listing	See Category-specific listing	See Category-specific listing	See Category-specific listing
Degree of Concern	None	Record of planned impact probability and contamination control measures	Limit on impact probability Passive bioburden control	Limit on probability of non-nominal impact Limit on bioburden (active control)	If restricted Earth return: • No impact on Earth or Moon; • Returned hardware sterile; • Containment of any sample.
Representative Range of Requirements	None	Documentation only (all brief): • PP plan • Pre-launch report • Post-launch report • Post-encounter report • End-of-mission report	Documentation (Category II plus): • Contamination control • Organics inventory (as necessary) Implementing procedures such as:	Documentation (Category II plus): • P_c analysis plan • Microbial reduction plan • Microbial assay plan • Organics inventory	Outbound Same category as target body/ outbound mission Inbound If restricted Earth return:
(continued)			• Trajectory biasing • Cleanroom • Bioburden reduction (as necessary)	Implementing procedures such as: • Trajectory biasing • Cleanroom • Bioburden reduction • Partial sterilization of contacting hardware (as necessary)	Documentation (Category II plus): • P_c analysis plan • Microbial reduction plan • Microbial assay plan Implementing procedures such as:

Documentation

- NPR 8715.24 Table 3-1

<table>
<tr><th rowspan="3">Planetary Protection Documentation[1]</th><th colspan="6">Planetary Protection Mission Category[2]</th></tr>
<tr><th colspan="4">Outbound</th><th colspan="2">Inbound</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th><th>V(r)</th><th>V(u)</th></tr>
<tr><td>Final PP Mission Categorization</td><td colspan="2">Concurrence from PPO</td><td colspan="4">Concurrence from Chief, SMA based on recommendations from PPO</td></tr>
<tr><td>PP Requirements Document</td><td rowspan="7">None required</td><td rowspan="7">Concurrence from PPO</td><td colspan="3">Concurrence from Chief, SMA based on recommendations from PPO</td><td rowspan="7">Refer to outbound planetary protection mission category for concurrence authority</td></tr>
<tr><td>PP Implementation Plan</td><td colspan="3">Concurrence from PPO</td></tr>
<tr><td>Pre-Launch PP Report</td><td colspan="3" rowspan="5">Concurrence from Chief, SMA based on recommendations from PPO</td></tr>
<tr><td>Post-Launch PP Report</td></tr>
<tr><td>Extended Mission PP Report</td></tr>
<tr><td>End of Mission PP Report</td></tr>
</table>

[1] Some missions may be able to demonstrate compliance with planetary protection requirements with a reduced document set.
[2] See Appendix C for further details and example target bodies on Planetary Protection Mission Category definition.

- Compliance can be demonstrated with a reduced document set.
- Documentation appropriate for mission and category.

Avoidance of Contamination due to Inadvertent Impact Summary

While the standard is still under draft, we are still working with projects on identifying applicable requirements from COSPAR and NID 8020.109A.

Mars

- 5.1.3 For **all launch vehicle elements** leaving Earth's orbit, the probability of impacting Mars shall be **less than $1x10^{-4}$ for a period of 50 years**.
- 5.1.4 For **all spacecraft** crossing Mars orbit en route to other targets, the probability of impacting Mars shall be **less than $1x10^{-2}$ for a period of 50 years**.

Outer Planets

- 5.1.5 In the context of missions to icy satellites, "contamination" is defined as the introduction of a single viable terrestrial microorganism into a liquid-water environment.
- 5.4.1 PP Category II*, III and IV. (For an explanation of the II* designation, see section 5.2.2.1.) Requirements for flybys, orbiters, and landers to icy satellites, including bioburden reduction, shall be applied in order to reduce the **probability of inadvertent contamination of an ocean or other liquid water body to less than 1 x 10-4 per mission**.

Planetary Protection Category II Missions Requirements

Mission	Target Bodies	Planetary Protection Requirements	Engineering and Science Requirements (contamination control)
Deep Impact/EPOXI	Comets Tempel 1 & Hartley 2	Impact Avoidance + Documentation	Cleanroom Processing; Foreign Object Debris (FOD) Driver [1, 2]
New Horizons	Pluto/Charon	Impact Avoidance + Documentation	Cleanroom Processing; Payload driver[3]
OSIRIS-REx	Comets Wild 2 & Tempel 1	Impact Avoidance + Documentation	Cleanroom Processing; Science Sample Return driver[4]
Lucy	Eight asteroids, including one from the Main Belt and seven from the Trojan asteroids	Impact Avoidance + Documentation	Cleanroom Processing: Payload driver[5]

[1]https://deepimpact.astro.umd.edu/faq2.html. Note: "*Deep Impact is being assembled and tested in a Class 100,000 cleanroom…. The clothing requirements are in place to prevent contamination of the flight hardware from foreign object debris (FOD)*"
[2]KSC Press Release, Dec 22, 2004. http://www.spaceref.com/news/viewpr.html?pid=15761, Note: "For the media event, procedures for optically sensitive spacecraft must be followed by individuals entering the cleanroom where the spacecraft is being processed."
[3]McNutt et. al. 2007. The Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) on the New Horizons Mission. Note: "*class 10,000 or better clean room…instrument was kept under purge at all times*"
[4]Dworkin, J P et al. "OSIRIS-REx Contamination Control Strategy and Implementation." *Space science reviews* vol. 214,1 (2018): 19. doi:10.1007/s11214-017-0439-4. NOTE: "*To return a pristine sample*"
[5]https://www.nasa.gov/feature/goddard/2021/nasa-s-lucy-in-the-cleanroom Note: "*L'Ralph camera sits atop the spacecraft's Instrument Pointing Platform (IPP) that's used to aim Lucy's instruments in a specific direction - seen here in the clean room*"

NASA missions typically require cleanroom processing to support engineering and science cleanliness requirements, irrespective of PP requirements.

Contamination Control Driving Cleanroom Processing is Beneficial for Preventing Harmful Contamination for DAWN and JUNO

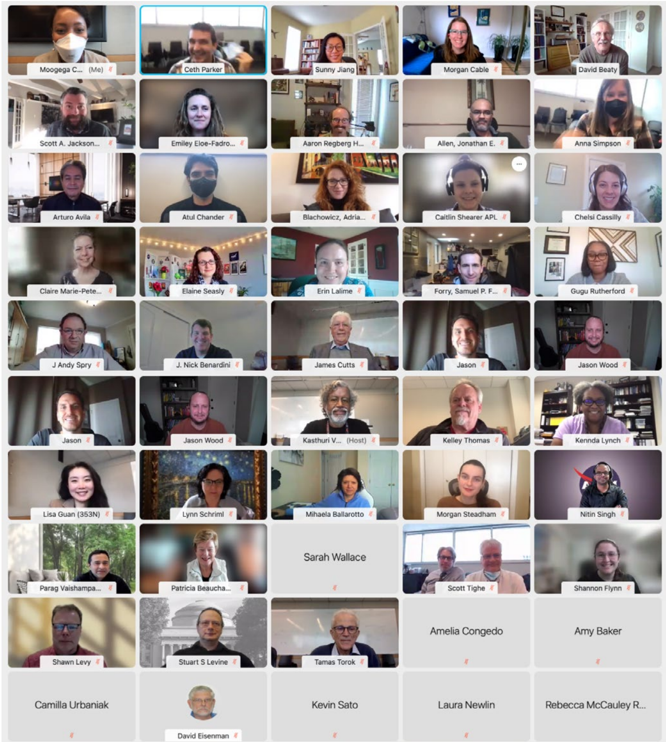
Mission	Target Bodies	Planetary Protection Requirements	Engineering and Science Requirements (contamination control)
DAWN	Asteroids Vesta & Ceres Cat III due to Mars flyby	Impact Avoidance + Documentation + Cleanroom + Organic inventory	Cleanroom Processing; FOD / Payload Driver
Psyche	Asteroid Psyche Cat III due to Mars flyby	Impact Avoidance + Documentation + Cleanroom + Organic inventory	Cleanroom Processing; FOD / Payload Driver
JUNO	• Cat II – Jupiter • **Extended Mission Cat III – Europa, Ganymede and Io**	Impact Avoidance[1] + Probability of Europa Contamination + Documentation + **Cleanroom + Organic inventory**	Cleanroom Processing; Payload driver

[1]Lam et al. 2008. Planetary protection trajectory analysis for the JUNO mission. AIAA/AAS Astrodynamics Specialist Conference Hawaii August 18-21, 2008.

Molecular Biology Technology Development Workshop – Jan 19th

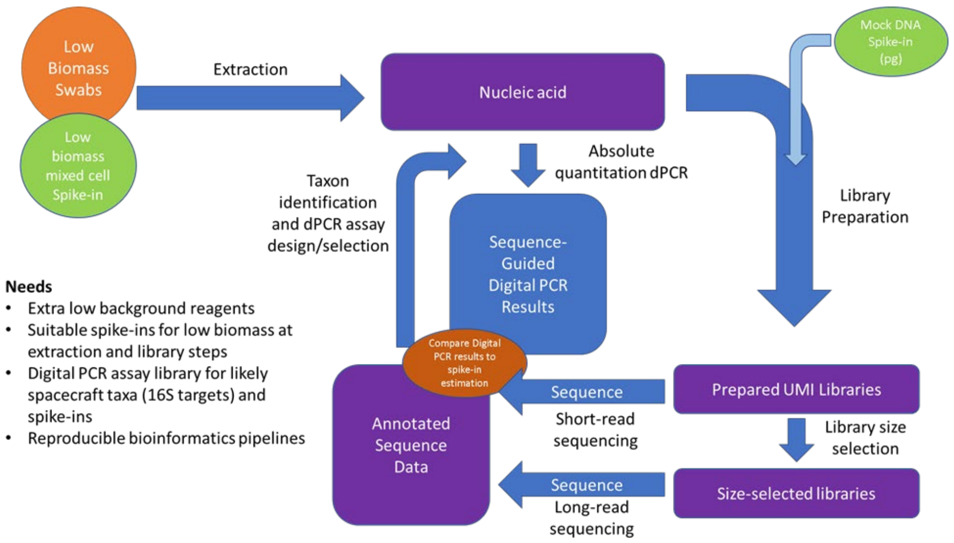
- Goals of the workshop were to:
  - assess the state of the practice of metagenomics and other advanced molecular techniques in the context of providing a validated framework to supplement the NASA spore assay and
  - to identify knowledge and technology gaps.
- Participants across NASA, Academia industry and USG.
- Panelists were a non-advocate board.

- Stefan Green, Rush U (Chair)
- Scott Tighe, UVM (co-Chair)
- Tamas Torok, LBNL (co-Chair)
- Scott Jackson, NIST
- Emiley Eloe-Fadrosh, JGI
- Jonathan Allen, LLNL
- Shawn Levy, Hudson Alpha
- Stuart Levine, MIT
- Lynn Schriml, U. Maryland
- Kelley Thomas, UNH
- Sunny Jiang, UC Irvine



Preliminary Findings from the Workshop

- A metagenomics workflow, in tandem with rapid targeted quantitative (digital) PCR, is appropriate for assessment of microbial bioburden on spacecraft surfaces.
- The workshop highlighted low biomass sampling, reagent contamination, and inconsistent bioinformatics data analysis as key areas for expanded technology development.
- This additional workflow for addressing Planetary Protection concerns would be a leap forward in technology advancement for the Planetary Protection discipline and benefit all future missions by appreciable increases in spacecraft functionality, reliability, and mission success.



- Workshop report will be submitted to Astrobiology April 2022.