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NASA
Procedural
Requirements
COMPLIANCE IS MANDATORY FOR NASA EMPLOYEES

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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.

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Preface

P.1 Purpose

a. This directive defines NASA roles and responsibilities and the procedural requirements, informed by Committee on Space Research (COSPAR) Planetary Protection Policy and Guidelines (hereafter referred to as COSPAR policy and guidelines) and National Academies of Sciences, Engineering, and Medicine (NASEM) advice, to:

(1) Control the risk of harmful contamination to other bodies in the solar system, protecting the integrity of the search for and study of processes of chemical evolution or origin of life.

(2) Prevent potentially harmful consequences for humans and the Earth's environment due to the return of extraterrestrial samples from destinations or operations categorized as restricted Earth return.

P.2 Applicability

a. This directive is applicable to NASA Headquarters and NASA Centers, including Component Facilities and Technical and Service Support Centers. This language applies to Jet Propulsion Laboratory (JPL) (a Federally-Funded Research and Development Center (FFRDC)), other contractors, recipients of grants, cooperative agreements, and other agreements only to the extent specified or referenced in the applicable contracts, grants, or agreements.

b. This directive is applicable to all robotic missions that may encounter other solar system bodies in nominal and credible off-nominal scenarios, including those launched from human-rated spacecraft and platforms, secondary payloads deployed from Earth-orbiting robotic missions, those to and from the Earth's Moon, and those of robotic solar system exploration missions returning extraterrestrial samples to the Earth-Moon system. Credible off-nominal scenarios include those that could affect compliance with the probabilistic constraints informed by COSPAR policy and guidelines.

c. In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" denotes a discretionary privilege or permission, "can" denotes statements of possibility or capability, "should" denotes a good practice and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.

d. In this directive, all document citations are assumed to be the latest version unless otherwise noted. Use of more recent versions of cited documents may be authorized by the responsible Safety and Mission Assurance (SMA) Technical Authority (TA).

P.3 Authority

a. PD/NSC-25, Scientific or Technological Experiments with Possible Large-Scale Adverse Environmental Effects and Launch of Nuclear Systems into Space, dated December 14, 1977.

b. Procedures for Implementing the National Environmental Policy Act (NEPA), 14 CFR § 1216.3.

- c. NPD 1000.3, The NASA Organization.
- d. NPD 8700.1, NASA Policy for Safety and Mission Success.

P.4 Applicable Documents and Forms

None.

P.5 Measurement/Verification

Compliance with the requirements contained in this directive is continuously monitored by the Project-Level SMA TA and by the NASA Office of Safety and Mission Assurance (OSMA). Compliance is also verified as part of selected life-cycle reviews and by assessments, reviews, and audits of the requirements and processes defined within this directive.

P.6 Cancellation

- a. NPR 8020.12D, Planetary Protection Provisions for Robotic Extraterrestrial Missions, dated April 20, 2011.
- b. NID 8020.109A, Planetary Protection Provisions for Robotic Extraterrestrial Missions, dated March 30, 2017.
- c. NID 8715.128, Planetary Protection Categorization for Robotic and Crewed Missions to the Earth's Moon.

Chapter 1. Introduction

1.1 Overview

1.1.1 Planetary protection is the practice of protecting solar system bodies from harmful contamination by terrestrial materials to enable scientific exploration and protecting the Earth-Moon system from possible harmful extraterrestrial contamination that may be returned from other solar system bodies.

1.1.2 Planetary protection refers to the policy and practice of protecting 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. The main strategies are to:

- a. Understand and control harmful contamination of other worlds by terrestrial organisms, organic materials, and volatiles carried or released by spacecraft (referred to as forward contamination) in order to assure integrity in the search for evidence of extraterrestrial life and the study of prebiotic chemistry in the solar system for the appropriate period of biological exploration.
- b. Rigorously prevent harmful biological contamination of the Earth-Moon system by potential extraterrestrial life and bioactive molecules in returned samples from habitable worlds (referred to as backward contamination).

1.1.3 NASA will use risk-informed decision making processes defined in NPR 8000.4 for balancing the needs of scientific discovery, space exploration, commercial activities, and safety.

1.2 Utilization of Current Scientific Consensus Throughout the Project Life Cycle

1.2.1 Planetary protection categorization of NASA missions to solar system bodies, described in Appendix C of this document, is guided by the COSPAR policy and guidelines, as amended August 2020 (see for Appendix D additional information), as an accepted approach for demonstrating compliance with the Outer Space Treaty.

1.2.2 Assignment of a planetary protection category for a mission is based on current scientific consensus regarding the destination and mission operations, informed by COSPAR policy and guidelines, advice from the NASEM, and other expert advice.

1.2.3 Throughout the project life cycle and mission operations, the following project activities are to be consistent with the current scientific consensus:

- a. Categorization of planetary protection for NASA missions (see section 3.1.1). All missions to the Moon and beyond are assigned a categorization for the outbound phase. Missions returning samples to the Earth-Moon system are assigned a categorization for the return phase in addition to the outbound planetary protection mission category.
- b. Identification of applicable Agency planetary protection requirements, including any

considerations for tailoring of the mission's planetary protection requirements (see section 3.1.2).

c. Establishment and verification of the planned implementation activities to achieve compliance with applicable planetary protection requirements (see section 3.1.3).

d. Execution and oversight of the implementation demonstrating compliance with applicable planetary protection requirements throughout the project life cycle (see sections 3.2 and 3.3).

1.2.4 Significant new scientific discoveries made and accepted as current scientific consensus during project formulation, implementation, and operations may change constraints on a project throughout its life-cycle.

1.3 Planetary Protection Considerations for Participation in Partnered Missions

1.3.1 For each mission, planetary protection categorization and demonstration of compliance with applicable planetary protection requirements are the responsibility of the lead partner or agency. The lead partner or agency for a mission is established as part of the negotiations with all relevant parties to applicable contracts, grants, and agreements. If NASA is not the lead agency, then the lead partner or agency demonstrates compliance with the Outer Space Treaty. COSPAR policy and guidelines is an accepted approach for demonstrating compliance with the Outer Space Treaty.

1.3.2 NASA may provide hardware, services, data, funding, deep-space communication, and other resources to non-NASA missions to which this directive is applicable (including but not limited to resources agreements) provided that the recipient organization, whether governmental or private entity, uses reasonable efforts to implement planetary protection measures generally consistent with the COSPAR Planetary Protection Policy and Guidelines or the planetary protection measures NASA would take for like missions.

1.4 Delegation of Responsibilities

1.4.1 Unless specifically prohibited, responsibilities and requirements may be delegated. The stated role or actor remains accountable for its implementation and outcome.

1.4.2 Where an office or organization is stated as the actor of a requirement, the Official in Charge of that office or organization is responsible and accountable for the action and its outcome.

1.5 Request for Relief

NPR 8715.3, NASA General Safety Program Requirements (see for additional information), defines the process for requesting and granting relief from requirements within this directive and standards incorporated by reference herein.

Chapter 2. Roles and Responsibilities

2.1 Mission Directorate Associate Administrator

2.1.1 The Mission Directorate Associate Administrator (MDAA), as described in NPD 1000.3, The NASA Organization, is responsible and accountable for their assigned programs and projects. As part of this responsibility, the MDAA operating or sponsoring the mission:

- a. Provides, in coordination with the Planetary Protection Officer (PPO), planetary protection mission categorization to projects.
- b. Provides resources to achieve and assure compliance with applicable Agency planetary protection requirements based on the planetary protection mission categorization, including oversight by the Chief, SMA and the PPO.
- c. Consults with the appropriate interagency, commercial, and international partners, in coordination with the Office of International and Interagency Relations (OIIR), to negotiate a mission specific process for partnered missions.
- d. Coordinates with the PPO to support research and technology development to close knowledge gaps and develop planetary protection requirements for future missions.

2.2 NASA Project Manager

2.2.1 The NASA Project Manager is responsible for:

- a. Submitting planetary protection mission categorization requests to the MDAA, including notification of missions requiring planetary protection mission categorization to the PPO.
- b. Identifying applicable Agency planetary protection requirements, including an agreed upon set of accepted standards, consistent with the planetary protection mission categorization for review and concurrence by the authorities defined in section 3.1.2.
- c. Establishing the project's planned implementation to achieve compliance with identified planetary protection requirements using an agreed upon set of accepted standards and verified alternative approaches (see 2.2.1.b).

Note: Planetary protection mission categorization and the project's planned implementation are based on the utilization of current scientific consensus as described in section 1.2.

- d. Communicating and coordinating with the PPO to define timely independent verification and assurance activities and accommodating such activities throughout the project life cycle.
- e. Documenting the project's execution of the planned implementation throughout the project life cycle to achieve compliance with applicable Agency planetary protection requirements.

f. Identifying applicable Agency planetary protection requirements and establishing the corresponding compliant implementation for extended mission activities, if a project plans to extend its mission past the scheduled End of Mission (EOM) or add to the planned set of mission objectives.

2.2.2 NASA Program Managers flow risk acceptance down to NASA project offices as defined in their program-level documentation. When the responsible Mission Directorate or NASA program office has not established a NASA project office, any responsibilities or requirements levied on the NASA Project Manager in this directive are reverted to the NASA Program Manager.

2.3 Chief, Safety and Mission Assurance

2.3.1 The Chief, SMA, as described in NPD 1000.3, is responsible for advising the Administrator and other senior officials on matters related to risk, safety, and mission success and serves as the lead Technical Authority. As part of the responsibility to provide independent oversight of projects in support of safety and mission success, the Chief, SMA:

- a. Reviews for concurrence the project's planetary protection mission categorization request in coordination with the PPO.
- b. Consults with the Chief Health and Medical Officer on matters pertaining to biosafety and public health and the Chief Engineer on matters pertaining to robust control and containment of restricted Earth-return samples.
- c. Monitors the project's identification of applicable Agency planetary protection requirements, including an agreed upon set of accepted standards, consistent with the planetary protection mission categorization in coordination with the PPO.
- d. Tracks the project's execution of the planned planetary protection implementation throughout the project life cycle.
- e. Oversees the project's identification of applicable Agency planetary protection requirements for extended mission activities in coordination with the PPO, if a project plans to extend its mission past the scheduled EOM or add to the planned set of mission objectives.
- f. Advises the MDAA and other organizations across the Agency in the negotiation of a mission specific process for partnered missions with the appropriate interagency, commercial, and international partners.

2.3.2 The Chief, SMA established the Office of Planetary Protection (OPP) to support these responsibilities and designated the PPO to oversee this office in consultation with MDAA's.

2.4 Planetary Protection Officer

2.4.1 To assist the Chief, SMA in fulfilling their responsibilities to provide independent oversight of projects in support of safety and mission success, the PPO advises the Chief, SMA on all matters related to planetary protection. In addition, the PPO:

- a. Represents NASA in external technical activities in the area of planetary protection in coordination with organizations across the Agency, including Mission Directorates, the Office of International and Interagency Relations, the Office of General Counsel, and the Office of the Chief

Scientist. This includes taking a leadership role in advancing the planetary protection discipline in cooperation with other stakeholders, including:

- (1) Other U.S. Government agencies.
- (2) Commercial and private space industry organizations.
- (3) Other space-faring nations and space agencies.
- (4) International bodies, such as COSPAR.

b. Maintain NASA policy and subsidiary documentation related to planetary protection by consultation with oversight or advisory board.

c. Reviews for concurrence the proposer's or project's preliminary planetary protection mission categorization request.

d. Reviews for concurrence the project's or proposer's planetary protection mission categorization request, providing ongoing consultation on implementation throughout the project life-cycle.

e. Advises projects to ensure compliance with Agency planetary protection requirements and international agreements, including considerations for the tailoring of the Planetary Protection Requirements Document and formulation of the Planetary Protection Implementation Plan.

f. Oversees the project's identification of applicable Agency planetary protection requirements, including an agreed upon set of accepted standards, consistent with the planetary protection mission categorization.

g. Verifies the project's planned implementation and proposed use of alternative approaches is compliant with the identified applicable Agency planetary protection requirements.

h. Oversees the project's execution of the planned planetary protection implementation, by timely communication and coordination with the NASA Project Manager, to verify compliance with identified Agency planetary protection requirements throughout the project life cycle by defining and conducting independent verification and assurance activities (technical authority audits), which include:

(1) Performing independent verification assays of environments, facilities, and flight hardware independent of assays conducted by the project.

(2) Monitoring activities and facilities using baselines and trends in project data and, in response, recommending appropriate project actions based on accepted best practice.

(3) Observing significant development and qualification tests and project operations to verify conformance with planned activities.

i. Oversees the project's identification of applicable Agency planetary protection requirements for extended mission activities if a project plans to extend its mission past the scheduled EOM or add to the planned set of mission objectives.

j. In coordination with the MDAAs, establishes and supports research and technology development so that state-of-the-art methodologies are incorporated into the implementation of planetary protection activities.

k. Advises the MDAAAs and other organizations across the Agency in the negotiation of a mission-specific process for partnered missions with the appropriate interagency, commercial, and international partners.

2.5 Project-Level SMA Technical Authority

2.5.1 The Project-Level SMA TA is responsible for serving as a planetary protection discipline advocate as part of their overall responsibility to exercise SMA TA within projects. The Project-Level SMA TA:

- a. Advises projects to notify the PPO of missions requiring planetary protection mission categorization as early as proposal development and formulation architecture.
- b. Assuring that the formulation and execution of the project's planned implementation is technically sound and consistent with the established planetary protection mission categorization and associated SMA objectives.
- c. Facilitates planned independent verification and assurance activities conducted by the PPO to ensure the project's adequate execution of the planned planetary protection implementation throughout the project life-cycle.
- d. Coordinates with projects to identify events or conditions that may require further assessment or investigation by the PPO.

Chapter 3. Planetary Protection Procedural Requirements

3.1 Categorization and Planning

3.1.1 Planetary Protection Categorization for Missions (see Appendix C for further details and example target bodies)

3.1.1.1 The NASA Project Manager, in coordination with the Project-Level SMA TA, shall consult with the PPO regarding planetary protection mission categorization for the primary spacecraft as early as proposal development or architecture formulation but no later than Mission Concept Review (MCR) for assigned missions, and during Pre-Phase A for competed missions.

3.1.1.2 The NASA Project Manager, in coordination with the Project-Level SMA TA, shall consult with the PPO regarding planetary protection mission categorization for confirmed and selectable secondary payloads as early in the formulation process as possible.

Note: Late notification of complex secondary payloads or deployment of multiple SmallSats or CubeSats can add risk for successful outcomes and impact gate reviews of the primary mission.

3.1.1.3 The NASA Project Manager, with concurrence from the PPO, shall obtain preliminary planetary protection mission categorization from the MDAA as early as practical during mission concept development but no later than Mission Concept Review (MCR) for assigned missions, and during pre-Phase A for competed missions.

Note: In response to the planetary protection mission categorization request, the PPO may provide considerations to the project for tailoring of the PP Requirements Document and formulation of the PP Implementation Plan.

3.1.1.4 The NASA Project Manager, with concurrence from the authority defined in Table 3 1, shall obtain final planetary protection mission categorization from the MDAA as early as practical but no later than System Requirements Review (SRR). The final planetary protection mission categorization is documented in the Assurance Implementation Matrix required per NPR 8705.4 or, otherwise, appended to the (Preliminary) Project Plan required by NPR 7120.5.

3.1.1.5 Required elements to support the mission's planetary protection categorization assignment include:

a. Proposed planetary protection mission category.

b. A mission description that identifies:

(1) The target solar system body(ies) and location on the solar system body.

(2) Any other solar system bodies that would be encountered under the proposed spacecraft trajectory.

(3) In-space destinations within the Sun-Earth-Moon family of orbits (e.g., Lagrange points and halo orbits).

c. An overview of the proposed spacecraft hardware and concept of operations.

d. For sample return missions, rationale for proposing restricted or unrestricted sample return.

Note: Missions returning samples to the Earth-Moon system are assigned a categorization for the return phase in addition to the outbound planetary protection mission category.

e. Anticipated secondary payloads with independent propulsive capability.

f. An EOM scenario.

3.1.1.6 If there are any modifications to the required elements of the planetary protection mission categorization request (e.g., mission design or trajectory) after the final planetary protection mission categorization has been obtained, the NASA Project Manager shall reobtain final planetary protection mission categorization from the MDAA with concurrence from the authority defined in Table 3 1.

Table 3 1. Planetary Protection Documentation Authorities

Planetary Protection Documentation ¹	Planetary Protection Mission Category ²					
	Outbound				Inbound	
	I	II	III	IV	V(r)	V(u)
Final PP Mission Categorization	Concurrence from PPO		Concurrence from Chief, SMA based on recommendations from PPO			
PP Requirements Document	None required	Concurrence from PPO	Concurrence from Chief, SMA based on recommendations from PPO		Refer to outbound planetary protection mission category for concurrence authority	
PP Implementation Plan			Concurrence from PPO			
Pre-Launch PP Report			Concurrence from Chief, SMA based on recommendations from PPO			
Post-Launch PP Report						
Extended Mission PP Report						

End of Mission PP Report				
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.				

Table 3 2. Planetary Protection Document Schedule

Planetary Protection Documentation	Nominal Document Schedule ^{1, 2, 3, 4}							
	MCR	SRR	MDR	PDR	CDR	SMSR	PLAR	EOM
PP Mission Categorization ⁵	Preliminary	Final						
PP Requirements ⁶	Preliminary	Baseline						
PP Implementation Plan			Preliminary	Baseline	Update			
Pre-Launch PP Report						Final Report		
Post-Launch PP Report							Final Report	
Extended Mission PP Report								Prior to extended mission approval
End of Mission PP Report								Final Report

¹ Lifecycle based on NPR 7120.5, NASA Space Flight Program and Project Management Requirements (see NPR 7120.5 for additional information).

² The actual schedule for delivery of these documents is negotiable and is established in the PP Requirements Document.

³ In the case of a significant system or mission change, updates need to be provided in categorization and planning documents at the discretion of the OPP.

⁴ For restricted sample return missions, see also Section 3.4.4.

⁵ Alternate document schedules for this deliverable are provided in Section 3.1.1.3.

⁶ This deliverable schedule is driven by the requirements schedule defined in the NASA Systems Engineering Handbook.

3.1.2 Planetary Protection Requirements Document

3.1.2.1 The NASA Project Manager, with concurrence from the authority defined in Table 3 1, shall establish and document project-level planetary protection requirements consistent with the planetary protection mission categorization covering the project (spacecraft and launch vehicle) life-cycle, including the agreed upon set of accepted standards to achieve compliance, in the Planetary Protection Requirements Document by the schedule provided in Table 3 2.

Note 1: The PP Requirements Document includes an established schedule for the documents required in this directive. Table 3-2 provides a nominal schedule for reviews and documents, but the OPP works with each mission on time needed for reviewing documents prior to concurrence at the life-cycle reviews.

Note 2: Known non-compliances should be addressed by appropriate mitigations that are documented and agreed with the OPP well ahead of the review of the PP Requirements Document.

3.1.2.2 The PP Requirements Document should contain elements that are included in the agreed upon set of accepted standards.

3.1.2.3 The NASA Project Manager shall report planned and actual departures from the baseline PP Requirements Document to the Mission Directorate and the OSMA at Life-Cycle Reviews (LCRs) with any unresolved issues being raised at Key Decision Points (KDPs) throughout the project life-cycle.

3.1.3 Planetary Protection Implementation Plan

3.1.3.1 The NASA Project Manager, with concurrence from the authority defined in Table 3 1, shall specify planetary protection implementation activities in the PP Implementation Plan covering the project life-cycle (spacecraft and launch vehicle) that comply with project-level planetary protection requirements by the negotiated schedule in the PP Requirements Document (nominal schedule of reviews at which the project is expected to report is provided in Table 3 2).

3.1.3.2 The PP Implementation Plan should contain elements that are included in the agreed upon set of accepted standards.

3.1.3.3 The NASA Project Manager shall report planned and actual departures from the baseline PP Implementation Plan to the OSMA at planetary protection status meetings, with elevated reporting at LCRs and KDPs if there is potential to impact compliance of the whole project.

Note: Any departures from the baseline PP Implementation Plan need to be compliant with the PP Requirements Document across the project life-cycle. If these departures deviate from the baseline PP Requirements Document, departures from the baseline PP Requirements Document need to be reported in accordance with paragraph 3.1.2.3.

Note: Projects consult with the OPP to agree to the appropriate number and schedule of the planetary protection status meetings based on mission-specific objectives and design.

3.1.3.4 The NASA Project Manager shall coordinate with the PPO, as part of formulation of the PP Implementation Plan, to define timely independent verification and assurance activities to verify and

validate all aspects of planetary protection implementation, including bioburden measurements, modeling assumptions, and other implementation processes used to meet mission-specific standards for biological cleanliness, serving as the technical basis for the Pre Launch PP Report.

3.2 Verification, Assurance, and Pre-Launch Report Activities

3.2.1 The NASA Project Manager, in coordination with the Project-Level SMA TA, shall provide the PPO access to the spacecraft, facilities, and documentation to accommodate planned independent verification and assurance activities as well as anomaly investigations. The NASA Project Manager works with the PPO to plan additional data gathering activities and development of protocols to mitigate risk to planetary protection compliance.

3.2.2 The NASA Project Manager, in coordination with the Project-Level SMA TA, shall notify the PPO of any anomaly events relevant to planetary protection.

Note: The PPO, in coordination with the Project-Level SMA TA, decides which anomaly events need to be investigated and formally reported.

3.2.3 The NASA Project Manager, with concurrence from the authority defined in Table 3 1, shall document the project's execution of the planetary protection implementation activities in the Pre-Launch PP Report by the negotiated schedule in the PP Requirements Document (nominal schedule provided in Table 3 2).

3.2.4 The Pre-Launch PP Report should contain elements that are included in the agreed upon set of accepted standards.

3.2.5 Considerations that may impact compliance with planetary protection requirements are reported to the applicable SMA TA at Launch Readiness Reviews and Flight Readiness Reviews.

3.3 Post-Launch/End of Mission

3.3.1 The NASA Project Manager, with concurrence from the authority defined in Table 3 1, shall document the project's continued execution of the planetary protection implementation activities in the Post-Launch PP Report by the negotiated schedule in the PP Requirements Document (nominal schedule provided in Table 3 2).

3.3.2 The Post-Launch PP Report should contain elements that are included in the agreed upon set of accepted standards.

3.3.3 During mission operations, the NASA Project Manager, in coordination with the Project-Level SMA TA, shall notify the PPO of any discoveries or anomaly events relevant to planetary protection.

Note: The PPO, in coordination with the Project-Level SMA TA, decides which discoveries or anomaly events need to be reported, investigated, and assessed for modifications to planned operations.

3.3.4 If a project plans to extend its mission past the scheduled EOM or add to the planned set of mission objectives, the NASA Project Manager, with concurrence from the authority defined in Table 3 1, shall document the following in the Extended Mission PP Report by the negotiated schedule in the PP Requirements Document (nominal schedule provided in Table 3 2):

- a. Information on the new objectives.
- b. Compliance with established and any updated project-level planetary protection requirements.
- c. Continued execution of the planned planetary protection implementation activities.

Note: Based on their review of the Extended Mission PP Report, the appropriate authority defined in Table 3 1 may re-categorize the mission, which could require updates to the both the PP Requirements Document and the PP Implementation Plan. The intent is to have an open and transparent discussion of the proposed changes prior to a final decision on planetary protection impact of proposed extended mission.

3.3.5 The Extended Mission PP Report should contain elements that are included in the agreed upon set of accepted standards.

3.3.6 The NASA Project Manager, with concurrence from the authority defined in Table 3 1, shall document the project's continued execution of the planned planetary protection implementation activities in the EOM PP Report by the negotiated schedule in the PP Requirements Document (nominal schedule provided in Table 3 2).

3.3.7 The EOM PP Report should contain elements that are included in the agreed upon set of accepted standards.

3.4 Restricted Sample Return and Containment

3.4.1 For missions conducting restricted sample return preventing harmful biological contamination of Earth's biosphere is the highest priority.

3.4.2 For each restricted sample return mission, the MDAA shall establish and implement a strategy and design concepts to break the chain of contact with the target body, isolate, and robustly contain restricted samples. This strategy should be reviewable at MCR.

3.4.3 The MDAA, in coordination with the Chief, SMA and the PPO, shall negotiate a process to assure the safety and containment of Earth-return samples, governed under PD/NSC-25, Scientific or Technological Experiments with Possible Large-Scale Adverse Environmental Effects and Launch of Nuclear Systems into Space, in consultation with OIIR, relevant U.S. government agencies, and international partners.

3.4.4 The process to assure the safety and containment of Earth-return samples should address:

- a. Consideration of PD/NSC-25 and the Procedures for Implementing the National Environmental Policy Act (NEPA), 14 CFR § 1216.3.

b. Definition of an appropriate risk posture, comparative or otherwise, to inform decisions regarding the biological containment of returned samples.

c. Development, reporting, independent review, and acceptance by relevant authorities of an assurance case substantiating sufficient biological contamination control, including the information necessary to make informed decisions regarding:

(1) Initiation of return activities to the Earth-Moon system.

(2) Verification and validation of flight system return reliability.

(3) Recommendation to federal authorities for Earth entry and landing of returned samples.

(4) Post-landing assessment and verification of sample containment.

(5) Sample release from containment.

d. Participation by the appropriate federal and international authorities.

e. Presumption that returned samples contain hazardous biological material until the Sample Safety Assessment Report has been completed and reviewed.

Appendix A. Definitions

Accepted Standards. A body of standards either developed by NASA, other government agencies, or by industry to be utilized to identify technical requirements and implementation methods for planetary protection compliance.

Anomaly. An incident or event where observations, data, or analysis results are unexpected, not understood, or could be a potential threat to compliance with planetary protection requirements.

Assurance Case. A reasoned, auditable artefact that supports the contention that its top-level claim (or set of claims) is satisfied, including systematic argumentation and its underlying evidence and explicit assumptions that support the claim(s). Source: ISO/IEC/IEEE 15026-1:2019, Systems and software engineering – Systems and software assurance.

Bioactive Molecules. Biologically produced catalytic molecules that propagate by utilizing or altering terrestrial biological molecules, structures, or systems and could be a potential threat to the Earth's biosphere, including prions, viruses, gene-transfer agents, and other non-cellular molecular entities.

Bioburden. Population of viable organisms on or in spacecraft materials. Analogous to application in ISO 11139:2018(E) for healthcare products and devices.

Biological Contamination. Unwanted presence of biologically produced molecules carried by spacecraft hardware, including instruments and experiments, that compromise understanding of extraterrestrial environments.

Break the Chain of Contact. Prevent the transfer to the Earth-Moon System of all materials from another habitable world that are not sterilized or contained to Earth's biosphere.

Chemical Evolution. Process of transition from the initial state of the solar system to the present state, particularly with respect to the development of organic molecules and the formation of life.

Contamination. Unwanted material on the surface of a solid material, or incorporated into a solid, liquid, or gas.

Credible Off-Nominal Scenario. These scenarios cover cases where some condition could occur that results in the system performing in a way that is different from normal. This includes failures, low performance, unexpected environmental conditions, or operator errors that would affect compliance with the probabilistic constraints informed by COSPAR policy and guidelines.

Earth-Moon System. The Earth and the Moon (including artificial objects in orbit around either body) is considered as a single environment for planetary protection purposes in considering sample return from restricted sample return bodies (Mars, Europa, Enceladus, others to be determined) to protect the unrestricted travel within the system.

Earth's Biosphere. Habitable (inhabited or uninhabited) environments of the Earth.

Extraterrestrial Life. Propagating or metabolically active molecular system that is notionally carbon based and from outside the Earth's biosphere.

Habitable. An environment where physico-chemical limits (availability of water and biomolecule

building blocks, presence of an energy source/redox gradient, and permissive temperature and pH ranges) permit replication of carbon-based living organisms.

Harmful Contamination. Unwanted material on the surface of a solid material, or incorporated into a solid, liquid, or gas that damages the integrity of the study of chemical evolution and the origin of life, or that has negative consequences for humans and Earth's biosphere.

Mission Operations. Any activity, experiment, or process performed by the spacecraft in its operational lifetime or anticipated after EOM.

Organic Materials. All carbon-containing compounds excluding carbides, carbonates, cyanides and simple oxides of carbon (i.e., CO and CO₂).

Period of Biological Exploration. The period of time (decades to centuries) during which a solar system body is explored for signs of the origin of life and the history of prebiotic chemistry based on current scientific understanding consistent with COSPAR policy and guidelines.

Robust Containment. A strategy of utilizing dissimilar, redundant approaches to achieve an overall containment system that is minimally sensitive to engineering operations, stressful environmental conditions, and off-nominal scenarios in use from point-of-collection to containment in a receiving facility on Earth.

Sample. Any intentionally collected or unintentionally adhering physical material (including solids, liquids, and gases) that reach the spacecraft returning to the Earth-Moon system from other solar system bodies.

Solar System Body. A Solar System planet, moon or other exploration target for a spacecraft mission.

Terrestrial Organism. Self-propagating or metabolically active cellular system that is from the Earth's biosphere.

Appendix B. Acronyms

CDR	Critical Design Review
CERR	Critical Event Readiness Reviews
COSPAR	Committee on Space Research
EOM	End of Mission
FFRDC	Federally Funded Research and Development Center
JPL	Jet Propulsion Laboratory
KDP	Key Decision Point
LCR	Life-Cycle Review
MCR	Mission Concept Review
MDAA	Mission Directorate Associate Administrator
MDR	Mission Definition Review
OPP	Office of Planetary Protection
OSMA	Office of Safety and Mission Assurance
PDR	Preliminary Design Review
PLAR	Post-Launch Assessment Review
PPO	Planetary Protection Officer
PSR	Permanently Shadowed Region
SMA	Safety and Mission Assurance
SMSR	Safety and Mission Success Review
SRR	System Requirements Review
TA	Technical Authority

Appendix C. Provisional Mission Planetary Protection Categories

Planetary Target Priority Mission Type Planetary Protection Category (see Note 1 and Note 2)
Example Target Bodies

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 planets is warranted, and no requirements are imposed. Any

(Flyby, Orbiter, Lander) I • Undifferentiated, metamorphosed asteroids

- Io

Of significant interest relative to the process of chemical evolution but only a remote chance that contamination by spacecraft could compromise future investigations. Any

(Flyby, Orbiter, Lander) II • Earth's Moon (Cat. IIa & IIb)

- Venus
- Comets
- Asteroids (excluding undifferentiated, metamorphosed asteroids)
- Jupiter; Jovian Satellites (excluding Io, Ganymede and Europa)
- Saturn; Saturnian Satellites (excluding Titan and Enceladus)
- Uranus
- Uranian Satellites
- Neptune
- Neptunian Satellites (excluding Triton)
- Kuiper-Belt Objects

II*

(See note 3) • Jovian Satellites: Ganymede

- Saturnian Satellites: Titan
- Neptunian Satellites: Triton
- Pluto/Charon

Of significant interest relative to the process of chemical evolution and/or the origin of life and for which scientific opinion provides a significant chance that contamination by spacecraft could

compromise future investigations Flyby, Orbiter III • Mars

- Europa
- Enceladus
- Others to be determined

Lander, Probe IV • Mars (Cat. IVa, IVb & IVc)

- Europa
- Enceladus
- Others to be determined

Any Solar System Mission All Earth Return V(r):

Restricted Earth Return Restricted Earth Return:

- Mars
- Europa
- Enceladus
- Others to be determined

V(u):

Unrestricted Earth Return Unrestricted Earth Return:

- Earth's Moon
- Venus
- Most asteroids and comets (e.g., Bennu, Ryugu)
- Others to be determined

Notes:

- 1) Indicative of current scientific consensus and subject to administrative change
- 2) Although there is only one planetary protection category assigned to a mission, missions that target or encounter multiple planets, may have more than one set of planetary protection requirements for different parts of the mission.
- 3) Category II* is only a solar system target, not a category that is assigned to a mission. Missions targeting Category II* locations will be assigned a final categorization of II if the remote potential of contamination is demonstrated; otherwise, they will be assigned Category III or IV depending on mission intent.

Appendix D. References

D.1 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (the "Outer Space Treaty"), October 19, 1967, Article IX.

D.2 NPR 7120.5, NASA Space Flight Program and Project Management Requirements.

D.3 NPR 7123.1, NASA Systems Engineering Processes and Requirements.

D.4 NPR 8705.4, Risk Classification for NASA Payloads.

D.5 NPR 8715.3, NASA General Safety Program Requirements.

D.6 NID 8715.129, Biological Planetary Protection for Human Missions to Mars.

D.7 NASA/SP-2014-3705, NASA Space Flight Program and Project Management Handbook.

D.8 NASA/SP-2016-6105, NASA Systems Engineering Handbook.

D.9 Committee on Space Research (COSPAR) Planetary Protection Policy, as amended June 3, 2021.

D.10 ISO/IEC/IEEE 15026:2019, Systems and software engineering - Systems and software assurance.