Planetary Protection Guidelines for Ocean World Missions

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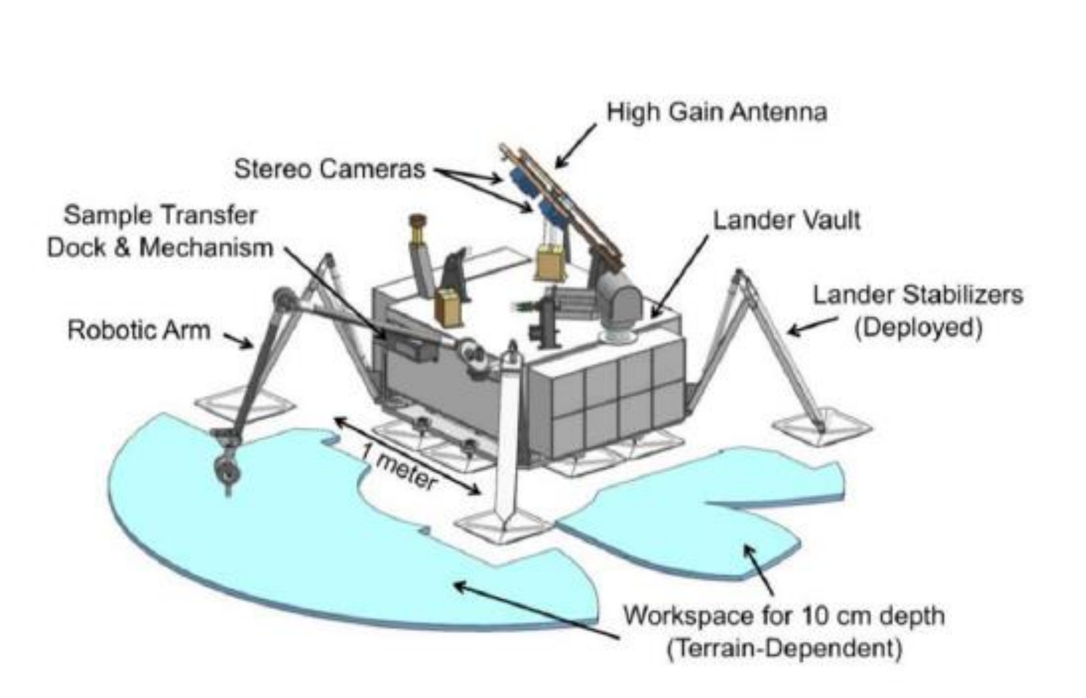


Europa Lander Engine Plume Interactions with the Surface and Vehicle
Hoey, Wong, Lam, and Carlos E. Soares (IEEE 2020)

Meeting U.S. Obligations in Space Exploration
1967 Outer Space Treaty

- Proposed to the UN in 1966
- Signed at Washington, London, Moscow on January 27, 1967
- Entered into force October 10, 1967

- Article I: *There shall be freedom of scientific investigation in outer space…and States shall facilitate and encourage international co-operation in such investigation.*

- Article IX: *…States Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth …*

- Article VI: *…The activities of non-governmental entities in outer space, including the moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty.*

NASA's Current 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

Moon NID

NID 8715.128
Planetary Protection Categorization for Robotic and Crewed Missions to the Earth's Moon
Expiration Date: July 9, 2021

Mars NID

NID 8715.129
Biological Planetary Protection for Human Missions to Mars
Expiration Date: July 9, 2021

NPR 8715.XX
Will replace NPR 8020.12D and NID 8020.109A
Planetary Protection Provisions for Robotic Extraterrestrial Missions
Expiration Date: TBD
Status: In NASA review

NASA-STD-87XX.XX
Implementing Planetary Protection Requirements for Space Flight
Expiration Date: TBD
Status: In development

NASA-HDBK-6022
Handbook for the Microbial Examination of Space Hardware
Expiration Date: N/A
Status: Revision planned

Draft Planetary Protection Standard

4.5.6.1 Category III missions conducting a fly-by or gravity assist of Europa, Enceladus, or other sensitive icy worlds shall demonstrate a probability of contamination of a liquid water body or other potentially habitable environment by a 1.0×10^{-4} probability of an inoculation event for 1,000 years.

a. Bioburden of relevant viable organisms at launch

b. Cruise survival for contaminating organisms

c. Organism survival in the radiation environment adjacent to the target

d. Probability of encountering/landing on the target, including spacecraft reliability

e. Probability of surviving landing/impact on the target

f. Mechanisms and timescales of transport to the subsurface

g. Organism survival and proliferation before, during, and after subsurface transfer

Draft Planetary Protection Standard

4.5.6.1 (previous slide)

Note: Typically, this is initially addressed through a probability of impact assessment (also at 1.0×10^{-4}), but other methodologies may be required if this approach is insufficient from the items above (e.g., ISO 15026-2 assurance case, semi-quantitative logic).

ISO = International Organization of Standards

Although new to planetary protection, the assurance case approach is widely used in other areas of technical authority in NASA's Office of Safety and Mission Assurance

Draft Planetary Protection Standard

4.6.4.2 Category IV landed missions to Europa, Enceladus, or other sensitive icy worlds…

(generalize wording)

a. less than a 1.0×10^{-4} probability of an inoculation event for 1,000 years including all aspects in 4.6.4.1 and details of the planned operational activities on the surface and subsurface.

b. bioburden level of the entire landed system likely set at Mars IVa but with credit for post-launch bioburden reduction on the basis of environmental conditions experienced in deep space. Mission can propose genomic or metagenomic analysis as an alternative to spore-assay bioburden accounting.

Planetary Protection of the Outer Solar System (POSS)

CATEGORY III/IV/V REQUIREMENTS FOR EUROPA

The biological exploration period for Europa and Enceladus is considered to be 1,000 years (National Research Council, 2012); these periods should start at 1995 for Europa and 2004 for Enceladus (orbit insertion of the first missions orbiting their systems). Requirements for Europa and Enceladus flybys, orbiters and landers, including bioburden reduction, shall be applied in order to reduce the probability of inadvertent contamination of an Europan or Enceladan ocean to less than $1x10^{-4}$ over 1,000 years.

EU PPOS briefing document p 10-11

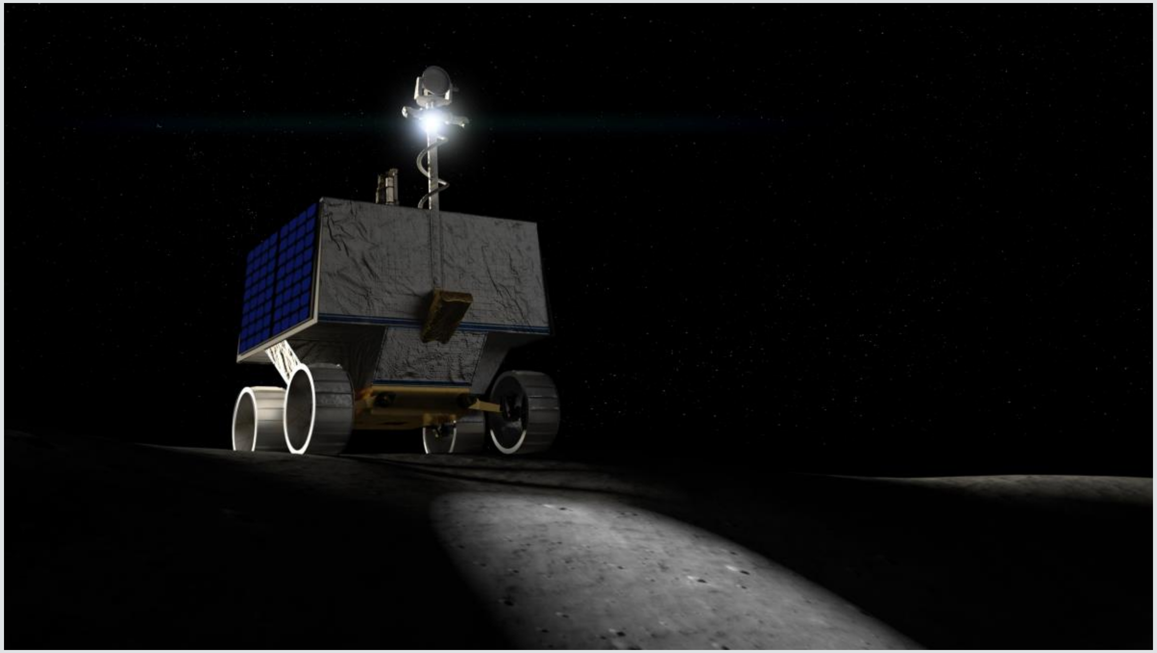
COSPAR Planetary Protection Policy

June 2020

9.Category III/IV/V requirements for Europa and Enceladus

9.1. Missions to Europa and Enceladus Category III and IV. The biological exploration period for Europa and Enceladus is defined to be 1000 years; this period should start at the beginning of the 21st century.

Lunar Exploration as a Proving Ground for Mars and Europa

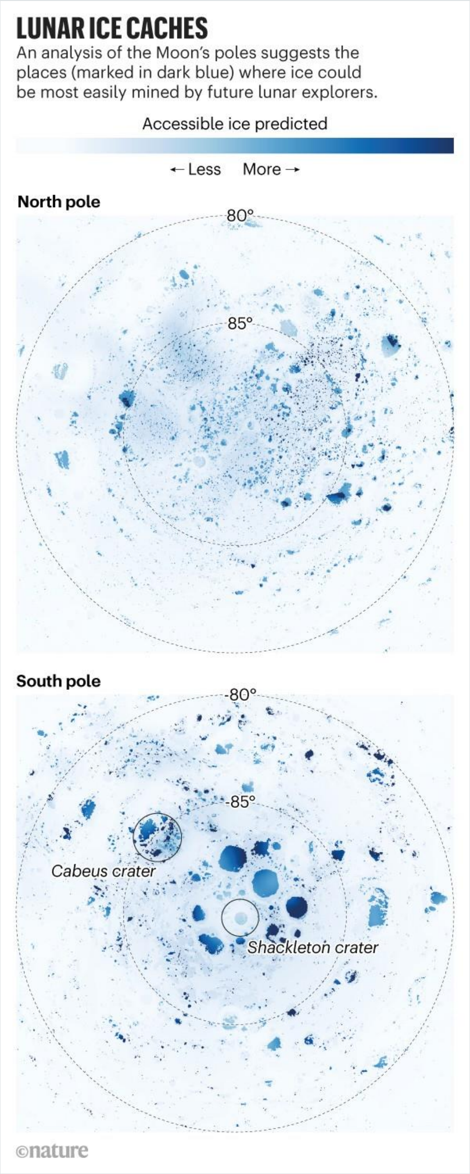


Volatiles Investigating Polar Exploration Rover (VIPER) is a NASA mobile drilling robot to be deployed at a site near the south pole of the Moon.

Astrobiotic Technology of Pittsburgh is under a CLPS contract for landing.

Image Credit. NASA Ames/Daniel Rutter

Given science concerns about volatile contamination from exploration, what is the appropriate international mechanism to persuade launch providers to report combustion products during landings and launches?



Will increasing traffic to the Moon contaminate its precious ice?

Scientists seek guidance on exploring frozen caches at the lunar poles responsibly.

Alexandra Witze

Nature News
5 January 2021

Committee on Planetary Protection (CoPP) at National Academies

CoPP was formed in 2020 to cover aspects of planetary environments, life sciences, spacecraft engineering, technology, and science policy relevant to the control of biological cross-contamination arising from robotic missions and human exploration and utilization of solar system bodies.

Report Series: Committee on Planetary Protection: Planetary Protection for the Study of Lunar Volatiles (2020)

CoPP Finding 1: The scientific potential of the Moon's poles and PSRs is significant, including for studies of prebiotic chemical evolution that have long been within the scope of national and international planetary protection policy.

Volatiles from Landing-Engine Plumes

Europa's near-vacuum environment permits rapid expansion of descent engine plumes, facilitating plume self-interactions and impingements onto the moon's surface and onto both the descent stage and lander vehicles.

- Erosion and/or ablation of surface ices beneath and around the Lander vault
- Removal of particles or grains from the Europan surface and the transport of such material up toward the Lander
- Contamination of Europa's surface and sensitive Lander instrumentation with exhaust byproduct
- Torques and convective heat fluxes induced by engine plume impingement directly onto the Lander itself during bridled descent.

Europa Lander Engine Plume Interactions with the Surface and Vehicle
William A. Hoey, Anthony T. Wong, Rebekah L. Lam, and Carlos E. Soares
IEEE 2020

US Interagency Coordination of a National Planetary Protection Strategy

In July 2020, The White House Office of Science and Technology Policy (OSTP) and the National Space Council (NSpC) invited NASA and some 15 other agencies and offices to participate in an interagency working group (IWG). In December 2020 a National Strategy for Planetary Protection was released.

The strategy addresses 21st Century stakeholders and technical capabilities likely to impact the protection of the Earth and other planetary bodies from harmful biological contamination during space exploration.

NASA participants on IWG: Mike Gold (OIIR), Margaret Kieffer (OIIR), Lisa Pratt (OSMA), Ursula Rick (SMD)

https://www.whitehouse.gov/wp-content/uploads/2020/12/National-Strategy-for-Planetary-Protection.pdf