Planetary Protection: updates and challenges for a sustainable space exploration

A. Coustenis, N. Hedman, P. Doran, and

- *The COSPAR Panel on Planetary Protection*

https://cosparhq.cnes.fr/scientific-structure/ppp

- 04 May 2022

COSPAR Panel on Planetary Protection Members

Chair Athena **Coustenis** (planetology)

Vice-Chairs: Niklas **Hedman** (UNOOSA, space law) & Peter **Doran** (LA State Univ., Hydrogeology, Extreme Environt)

Twelve members appointed by space agencies

Canada/CSA	Sarah Gallagher (X-ray astronomy)
Germany/DLR	Petra Rettberg (microbiology, astrobiology)
China/CNSA	Jing Peng (engineering)
ESA	Silvio Sinibaldi (astrobiology)
France/CNES	Christian Mustin (astrobiology)
India/ISRO	Praveen Kumar K (engineering scientist)
Italy/ASI	Eleonora Ammannito (planetologist)
Japan/JAXA-ISAS	Masaki Fujimoto (space plasma physics)
Russia/Roscosmos	Natalia Khamidullina (Radiation conditions)
UAESA	Omar Al Shehhi (engineering)
UK/UKSA	Karen Olsson-Francis (astrobiology, microbiology)
USA/NASA	Frank Groen (Bayesian data analysis, reliability engineering)

Nine scientists / experts

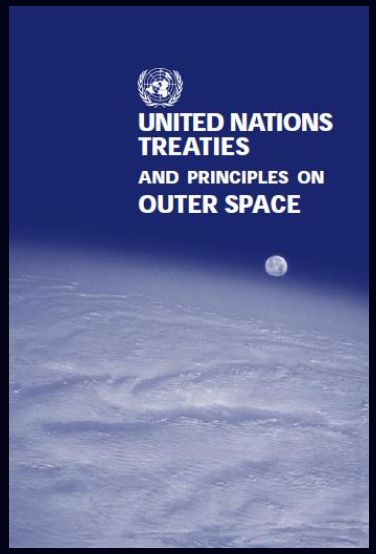
	Olga Prieto-Ballesteros (ES, geology, astrobiology)
Olivier Grasset (FR, geodynamics, planetology)	**François Raulin** (FR, chemistry, planetology)
Alex Hayes (USA, planetology)	**Kanyan Xu** (CN, microbiology, biochemistry)
Vyacheslav K. Ilyin (Russia, microbiology, medicine)	**Maxim Zaitsev** (RU, astrochem, organic chemistry)
Yohey Suzuki (JP, microbiology)	**Maria-Paz Zorzano** (ES, astrobiology, biophysics)

Ex-officio members: **Colleen Hartman,** NASEM SSB, ASEB & BPA Director

Michael **Newman**, UNOOSA and Michael **Gold**, COSPAR CIR

Framework for planetary protection

The legal basis and the goal for planetary protection was established in Article IX of the United Nations Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (Outer Space Treaty)



Article IX "...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 resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose..."

States are responsible for their national space activities, whether governmental or non-governmental, in accordance with Article VI of the Outer Space Treaty

Article VI: "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. 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."

COSPAR planetary protection policy

A special case among the Commissions and Panels in the COSPAR structure is the Panel of Planetary Protection (PPP) which serves an important function for space agencies pursuing the exploration of the planets. The primary objective of the COSPAR PPP is to develop, maintain, and promote the COSPAR policy and associated requirements for the reference of spacefaring nations and to guide compliance with the Outer Space Treaty ratified today by 112 nations, to protect against the harmful effects of forward and backward contamination, i. e.

- The conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized.
- In addition, the Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from an interplanetary mission.

- *This policy must be based upon the most current, peer-reviewed scientific knowledge, and should enable the exploration of the solar system, not prohibit it. The Panel has several meetings and invites all stakeholders including the private sector.*

- *It is not the purpose of the Panel to specify the means by which adherence to the COSPAR Planetary Protection Policy and associated guidelines is achieved; this is reserved to the engineering judgment of the organization responsible for the planetary mission.*

Planetary protection standards
(examples from ESA ECSS-Q-ST-70 and NASA-STD-8719.27)

Materials and hardware compatibility tests for sterilization processes, ECSS-Q-ST-70-53C
→ Describes how to test hardware compatibility and provides examples


Credit: ESA/ExoMars

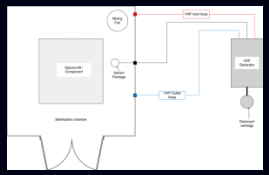
Ultra cleaning of flight hardware, ECSS-Q-ST-70-54C
→ Describes procedures how to clean flight hardware, in particular for life detection


Credit: ESA/ExoMars

Microbial examination of flight hardware and cleanrooms, ECSS-Q-ST-70-55C
→ Describes procedures how to measure the biological contamination (bioburden & biodiversity)


Credit: ESA/ExoMars

Vapour phase bioburden reduction for flight hardware, ECSS-Q-ST-70-56C
→ Describes hydrogen peroxide sterilisation procedures

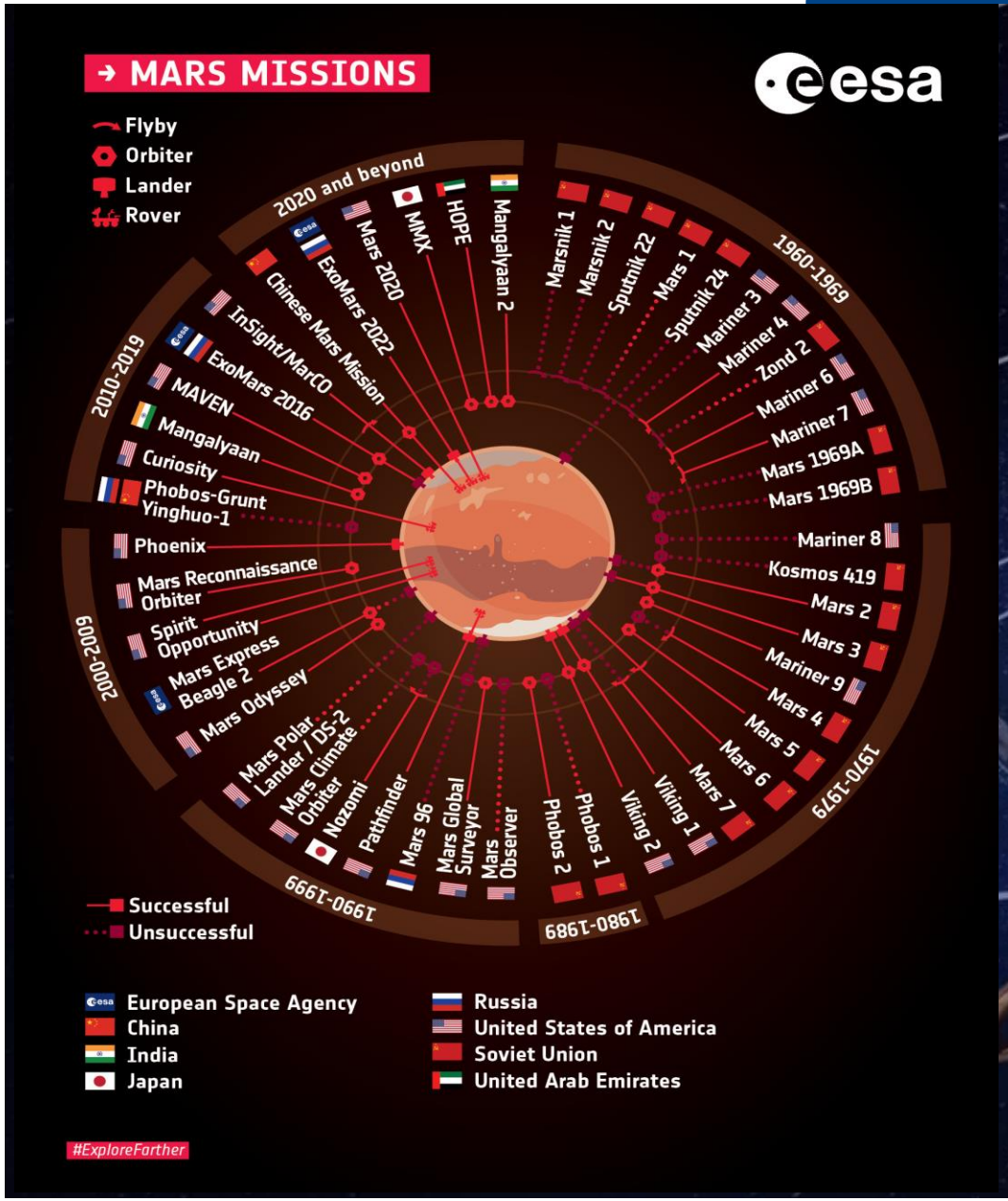


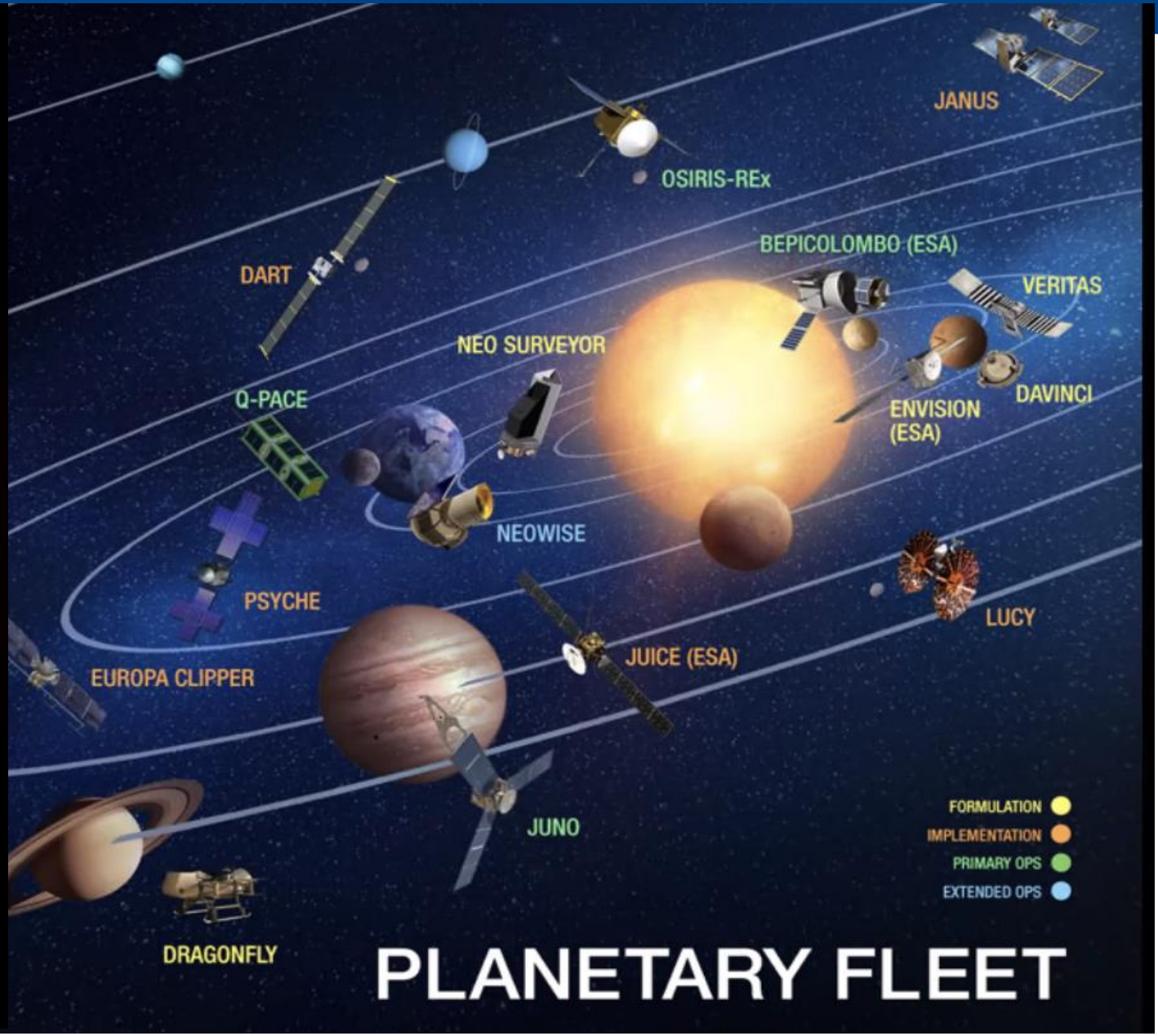
Dry heat bioburden reduction for flight hardware, ECSS-Q-ST-70-57C
→ Describes high temperature sterilisation procedures

Bioburden control for cleanrooms, ECSS-Q-ST-70-58C
→ Describes how to set-up and operate bioburden controlled cleanrooms



Credit: ESA/ExoMars

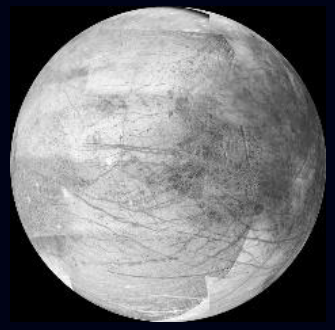




Combination of space missions by ESA and NASA (38; *Credit L. Glaze*) but more from other countries and agencies: Japan, Russia, India, China, UAE, Canada, other nations, etc…

Planetary Protection of the Outer Solar System (PPOSS)

- Project led by the European Science Foundation, funded by the EC with DLR/Germany, INAF/Italy, Eurospace, Space Technology/Ireland, Imperial College London (UK), China Academy of Space Technology and NAS-SSB
- Recommended a revision of the planetary protection requirements for missions to Europa and Enceladus, based based partly on the NAS-SSB 2012 Icy Bodies Report and on an ESA PPWG recommendation
- COSPAR was involved throughout the multi-year-long process and at the end updated the requirements for missions to Europa and Enceladus



Europa

Credit: NASA/JPL/Galileo

Enceladus

Credit: NASA/JPL/Cassini

***Published in Space Res. Today** 211, (Aug. 2021)*

"Planetary protection: New aspects of policy and requirements", 2019.

***Life Sci. Space Res.** 23*

The Internl PP Handbook: Dec. 2018

Martian Moon Explorer (MMX)

In 2019 ESA and JAXA studied sample return missions from Martian moons Phobos and Deimos

- ESA, NASA and JAXA supported scientific activities to evaluate the level of assurance that no unsterilized martian material naturally transferred to Phobos (or Deimos) is accessible to a Phobos (or Deimos) sample return mission, followed by an independent review by the NAS-ESF
- Outcome was presented to the ESA Planetary Working Group (PPWG) and to COSPAR, involved from the beginning
- assigned planetary protection category for the MMX mission : outbound Cat III and inbound Cat V: unrestricted Earth return)

Updated planetary protection Policy for the Moon

- Orbiter and fly-by missions to the Moon*: Category II*. There is no need to provide an organic inventory

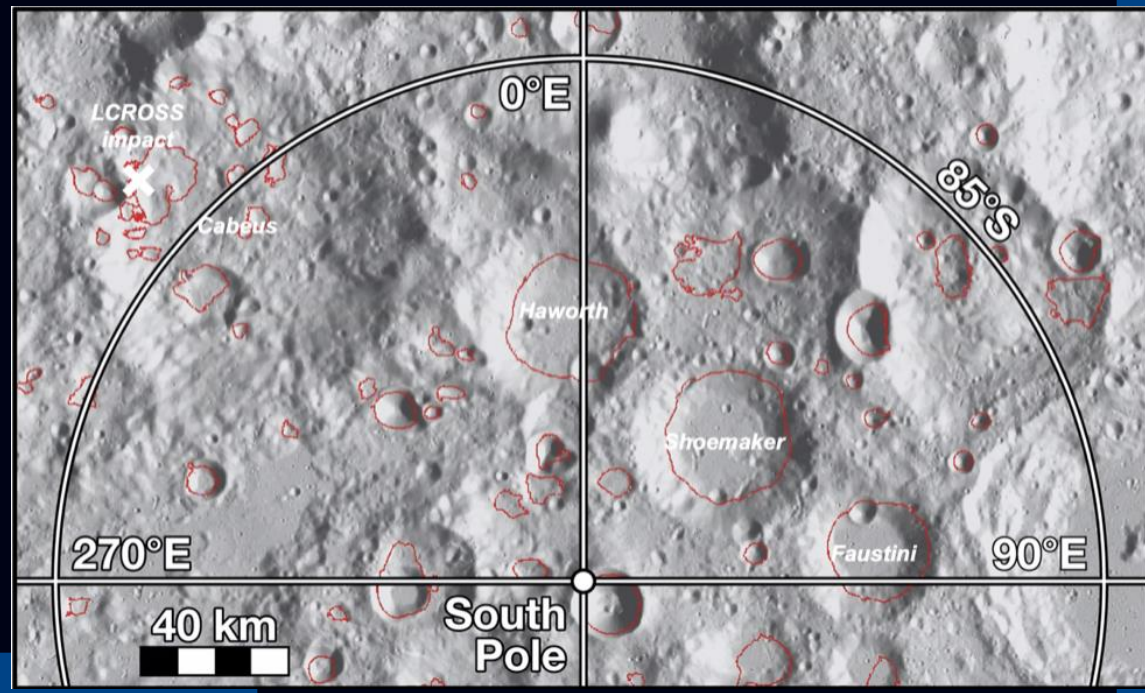
- Lander missions to the Moon :

- *Category IIa*. All missions to the surface of the Moon whose nominal mission profile does not access areas defined in Category IIb shall provide the planetary protection documentation and an organic inventory limited to organic products that may be released into the lunar environment by the propulsion system (relaxed requirements),
- *Category IIb*. All missions to the surface of the Moon whose nominal profile access Permanently Shadowed Regions (PSRs) and the lunar poles, in particular latitudes south of 79°S and north of 86°N shall provide the planetary protection documentation and full organic inventory

Category II: All types of missions (gravity assist, orbiter, lander) to a target body where there is significant interest relative to the process of chemical evolution and the origin of life, but where there is only a remote[1] chance that contamination carried by a spacecraft could compromise future investigations

The requirements are for simple documentation only.

Updated COSPAR Policy published in Space Res. Today ***211***, *14-20 (Aug. 2021);* https://doi.org/10.1016/j.srt.2021.07.009.

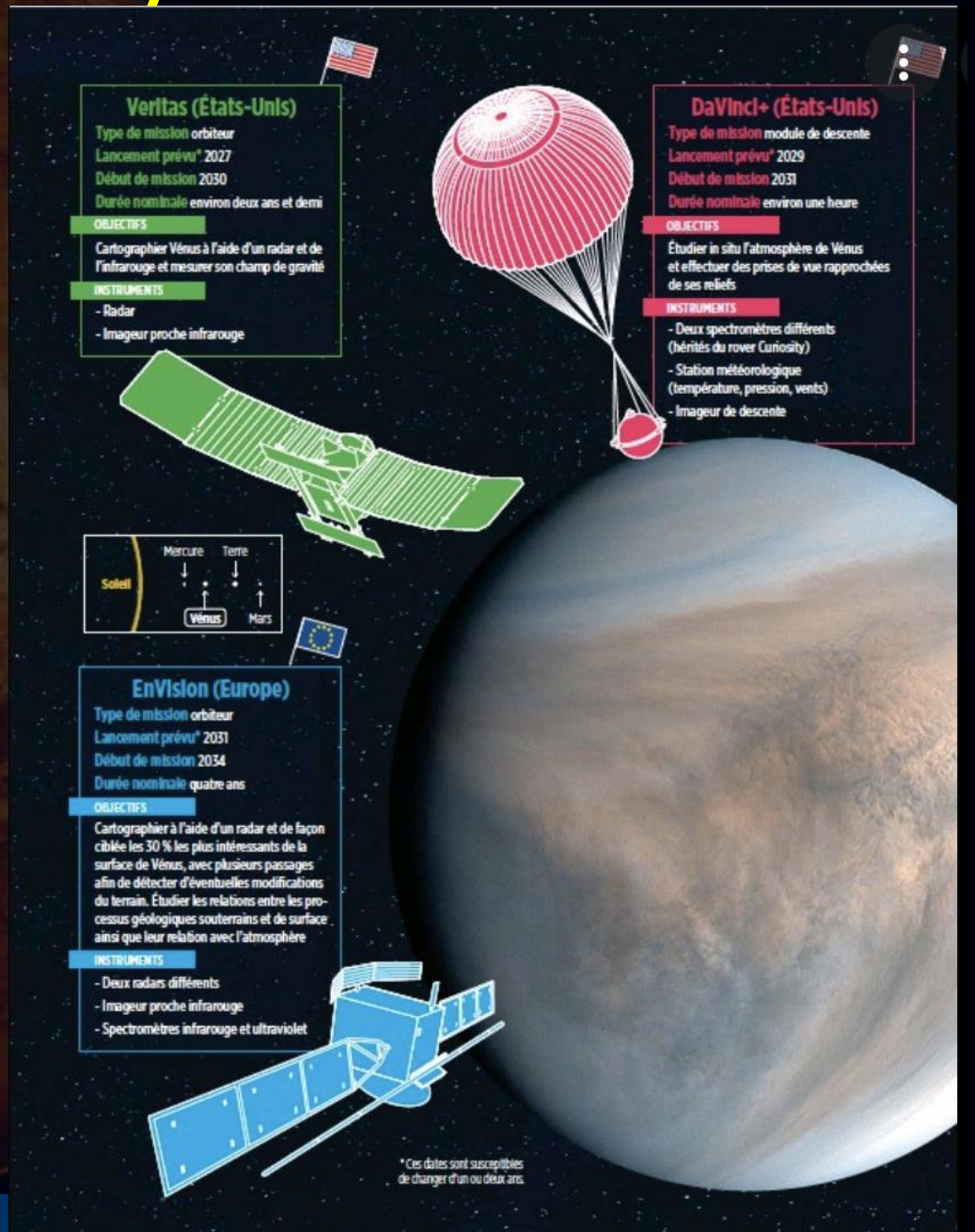


Venus habitability?

- Finding: **Based on the existing measurements VENUS CLOUDS ARE NOT SPECIAL REGIONS.** Due to the low level of water in the clouds where the temperatures are mild enough, life as we know, would not be able to replicate there even if there were nutrients available (and protection from radiation, sulfuric acid etc).
- Recommendation: **unless there are new measurements that demonstrate water activity > 0.6 (RH> 60%), Venus clouds are not a concern for planetary protection.** They are of course extremely interesting for planetary science, including atmospheric chemistry, P cycle, etc.

Hallsworth et al., 2021 : Nature Astronomy and Zorzano et al (in preparation)

Venus, poses no concern for planetary protection …because "*life as we know*" from Earth would not proliferate there

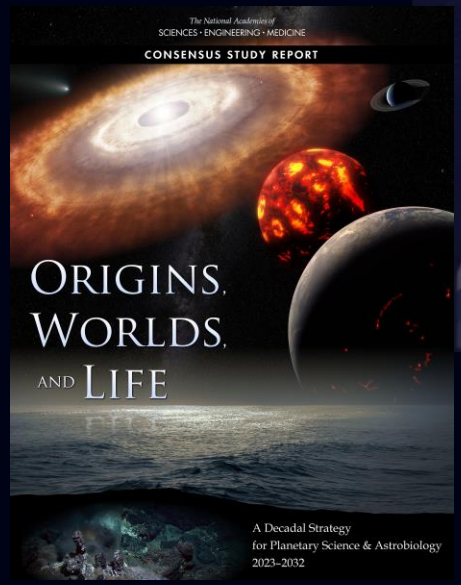


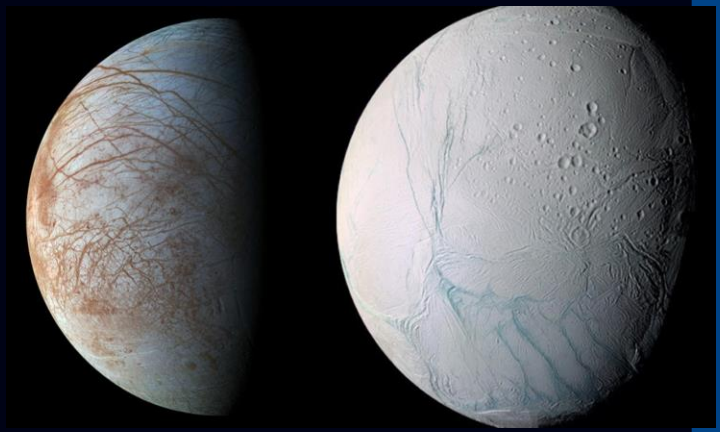
Future items for consideration

- After the updated Policy for the Moon published in Aug. 2021, the Panel will consider new needs for guidance in space exploration
- Recently the Panel discussed and will address in the future:
  - Martian Robotic and human Exploration *(Olsson-Francis, Doran et al. in preparation)*
  - Further exploration of the moons of giant planets

to evaluate any needs to update the Policy in general and on a case-by-case basis

- But not in a rushed process. We give thorough consideration to all arguments and scientific inputs and make an informed decision
- In the meantime, there is need for community input on science findings and research reserves regarding recent reports: Studies/Survey/Workshop/Focused conferences?





Planetary protection:
For sustainable space exploration and to safeguard our biosphere

- COSPAR maintains a non-legally binding planetary protection policy and associated requirements to guide compliance with the UN Outer Space Treaty. The COSPAR Policy is the only international framework for planetary protection
- COPUOS in its 2017 report noted the long-standing role of COSPAR in maintaining the Planetary Protection Policy as a reference standard for spacefaring nations and in guiding compliance with the Outer Space Treaty

Planetary protection categories and requirements are not cast in stone and evolve over time as new information becomes available, i.e. check the latest version at the beginning of a project.

- *Planetary protection technologies are for cleaning and sterilizing spacecraft and handling soil, rock and atmospheric samples. Precautions are taken against introducing microbes from Earth.*
- *At the same time, when the samples are returned to Earth, there is need to avoid backward contamination and preserve our biosphere*

PPP Recent publications and activities (extract)

https://cosparhq.cnes.fr/scientific-structure/panels/panel-on-planetary-protection-ppp/

- The COSPAR Panel on Planetary Protection, **2020**. « COSPAR Policy on Planetary Protection ». *Space Res. Today* 208, Aug. 2020
- The COSPAR Panel on Planetary Protection, **2020**. « Planetary Protection Policy: For sustainable space explo-ration and to safeguard our biosphere ». *Research Outreach* 118, 126-129.
- Coustenis, A., Hedman, N., Kminek, G., The COSPAR Panel on Planetary Protection, **2021**. "To boldly go where no germs will follow: the role of the COSPAR Panel on Planetary Protection".OAG, July 2021
- Fisk, L., Worms, J-C., Coustenis, A., Hedman, N., Kminek, G., the COSPAR PPP, **2021**.Updated COSPAR Policy on Planetary Protection. *Space Res. Today* 211, August 2021. doi.org/10.1016/j.srt.2021.07.009
- Coustenis, A., The COSPAR Panel on Planetary Protection, **2021**. « Fly me to the moon: Securing potential lunar water sites for research ». *OpenAccessGovernment,* Sept. 2021
- Coustenis, A., the COSPAR Panel on Planetary protection, **2021**. « Planetary Protection: an international concern and responsibility ». IAC Publications.
- Coustenis, A., Hedman, N., Kminek, G., **2021**. Planetary Protection: an International Concern and Responsibility. 72nd International Astronautical Congress 2021, Dubai, EAU, 25-29 Oct.
- Coustenis, A., Hedman, N., Kminek, G., The COSPAR Panel on Planetary Protection, **2022**. Updates to the COSPAR Planetary Protection Policy regarding Lunar exploration. Lunar Surface Science Workshop. 26–27 January.
- Coustenis, A., Hedman, N., Kminek, G., The COSPAR Panel on Planetary Protection, **2022**. The COSPAR planetary protection policy: ensuring the sustainability of scientific investigations in outer space. IAA/UT Space Traffic Management Conference.
- Coustenis, A., Hedman, N., Kminek, G., The COSPAR Panel on Planetary Protection, **2022**. The COSPAR Policy on Planetary Protection : updates for lunar exploration. 53rd Lunar and Planetary Science Conference (LPSC), March 7–11, 2022 (Virtual).
- Coustenis, A., Hedman, N., Kminek, G., The COSPAR Panel on Planetary Protection, 2022. The COSPAR planetary protection policy: ensuring the sustainability of scientific investigations in outer space. Space Resources Week, 3-5 May, Luxemburg (invited).
- COSPAR GA (July **2022** in Athens): several talks : Hedman et al., Olsson-Francis et al., Coustenis et al., etc
- IAC 2022 and UN/IAF Workshop (Sept. **2022** in Paris) : several presentations
- Olsson-Francis, K., Doran, P., et al., **2022**. The COSPAR Planetary Protection Policy for missions to Mars: ways forward based on current science and knowledge gaps. Submitted to LSSR.
- Zorzano M-P., et al., **2022**. The COSPAR Planetary Protection Requirements for Space Missions to Venus. Submitted to LSSR.