Recent activities of the COSPAR Panel on Planetary Protection

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

- *The COSPAR Panel on Planetary Protection*

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

at the Inaugural International COSPAR Planetary Protection Week

The Royal Society, London, UK, 22-24 April 2024

COSPAR Panels of interest

a) Social Sciences and Humanities (**PSSH**)

b) Space Weather (**PSW**)

c) Detrimental activities : (**PEDAS**) (incl.debris etc)

d) Planetary Protection : (**PPP**)

e) Panel on Exploration (**PEX**)

f) Committee on Industrial relations (**CIR**)

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

Some space law

(Reminders of the international context …)

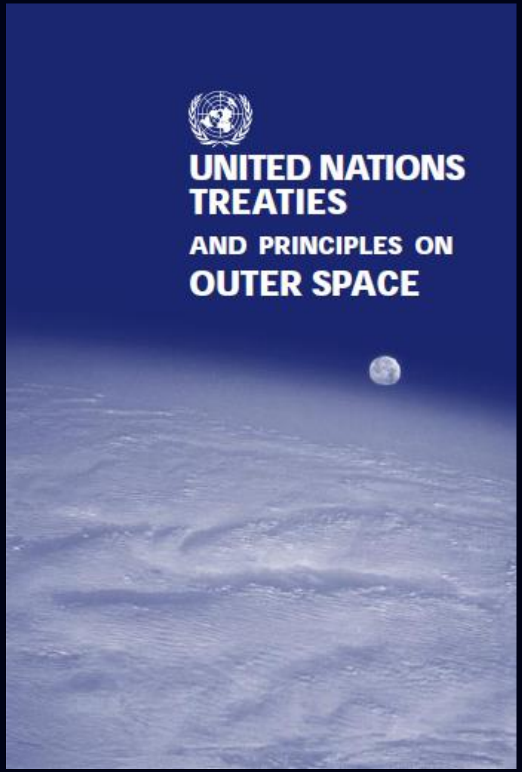
The Outer Space Treaty (OST)

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) entered into force in October 1967. As of 1 January 2024, 114 countries are parties to the treaty, while another 22 have signed but not ratified yet.

- Exploration and use of outer space – "province of all mankind" *(Article I)*
- Principle of non-appropriation *(Article II)*
- International law and UN Charter *(Article III)*
- Weapons of mass destruction/the Moon and other celestial bodies "exclusively for peaceful purposes"*(Article IV)*
- Astronauts as "envoys of mankind", phenomena constituting danger to astronauts (Article V)
- International responsibility for national activities in outer space *(Article VI)*
- International liability for damage *(Article VII)*
- Jurisdiction and control over objects launched into space *(Article VIII)*
- Cooperation and mutual assistance, due regard, harmful contamination and interference *(Article IX)*
- Opportunity for observation of flight of space objects *(Article X)*
- Information and notification (*Article XI*)
- Stations, installation, equipment and space vehicles on the Moon and other celestial bodies open on the basis of reciprocity (Article XII)

Framework for planetary protection

The legal basis and the goal for planetary protection was established in Article IX of the 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..."

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."

Planetary protection and the global governance of outer space activities (key examples)

- 1967 Outer Space Treaty (OST) Articles VI and IX

- 2017 report of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) 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 Article IX of the Outer Space Treaty (A/72/20, para. 332)

- 2019 COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities (Guideline D.1 Promote and support research into and the development of ways to support sustainable exploration and use of outer space):

“States and international intergovernmental organizations should consider appropriate safety measures to protect the earth and the space environment from harmful contamination, taking advantage of existing measures, practices and guidelines that may apply to those activities, and develop new measures as appropriate”

COSPAR planetary protection Panel & 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 114 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, subject to certification of compliance with the COSPAR planetary protection requirements by the national or international authority responsible for compliance with the Outer Space Treaty.*

COSPAR Panel on Planetary Protection Members

Chair: Athena **Coustenis** (Paris Observ., FR; planetology)

Vice-Chairs: Niklas **Hedman** (space law and policy) &

Peter **Doran** (LA State Univ., USA; Hydrogeology, Extreme Environments)

12 members appointed by space agencies, **11 experts + 3 ex-officio**

Canada/CSA	John Moores (engineering and planetary sciences)	France	Olivier Grasset (geodynamics, planetology)
netology)	Germany/DLR	Petra Rettberg (microbiology, astrobiology)	USA
Alex Hayes (pla			
obiology, medicine)	China/CNSA	Jing Peng (engineering)	Russia
Vyacheslav K. Ilyin (micro			
ology, astrobiology)	ESA	Silvio Sinibaldi (astrobiology)	Spain
Olga Prieto-Ballesteros (ge			
François Raulin (chemistry, planetology)	France/CNES	Christian Mustin (astrobiology)	France
Yohey Suzuki (microbiology)	India/ISRO	Praveen Kumar K (engineering science)	Japan
Lyle Whyte (Cold regions microbiology)	Italy/ASI	Eleonora Ammannito (planetologist)	Canada
Kanyan Xu (microbiology, biochemistry)	Japan/JAXA-ISAS	Masaki Fujimoto (space plasma physics)	China
Maxim Zaitsev (astrochem, organic chemistry)	Russia/Roscosmos	Natalia Khamidullina (Radiation conditions)	Russia
UAE	Jeremy Teo (mechanical and bio engineering)	UAE	Omar Al Shehh (engineering)
h, microbiology)	UK	Mark Sephton (astrobiology, organic geochem.)	UK/UKSA
Karen Olsson-Francis (astro			
pen (Bayesian data analysis, engineering)	COSPAR CIR Ex-officio	Michael Gold	USA/NASA
Frank Gr			
Colleen Hartman	UNOOSA		NASEM
Ex-officio	SB, ASEB & BPA Director	Ex-officio	

Operations of the COSPAR Panel on Planetary Protection

The Panel provides, through workshops and meetings also at COSPAR Assemblies, an international forum for the exchange of information on the best practices for adhering to the COSPAR planetary protection requirements. Through COSPAR the Panel informs the international community, including holding an active dialogue also with the private sector.

Since its restructuring in **mid-2018**, the Panel has had an average of **2-3 full meetings** per year and a large number of telecons between PPP Leads and parts of the Panel members, as well as with COSPAR Leadership.

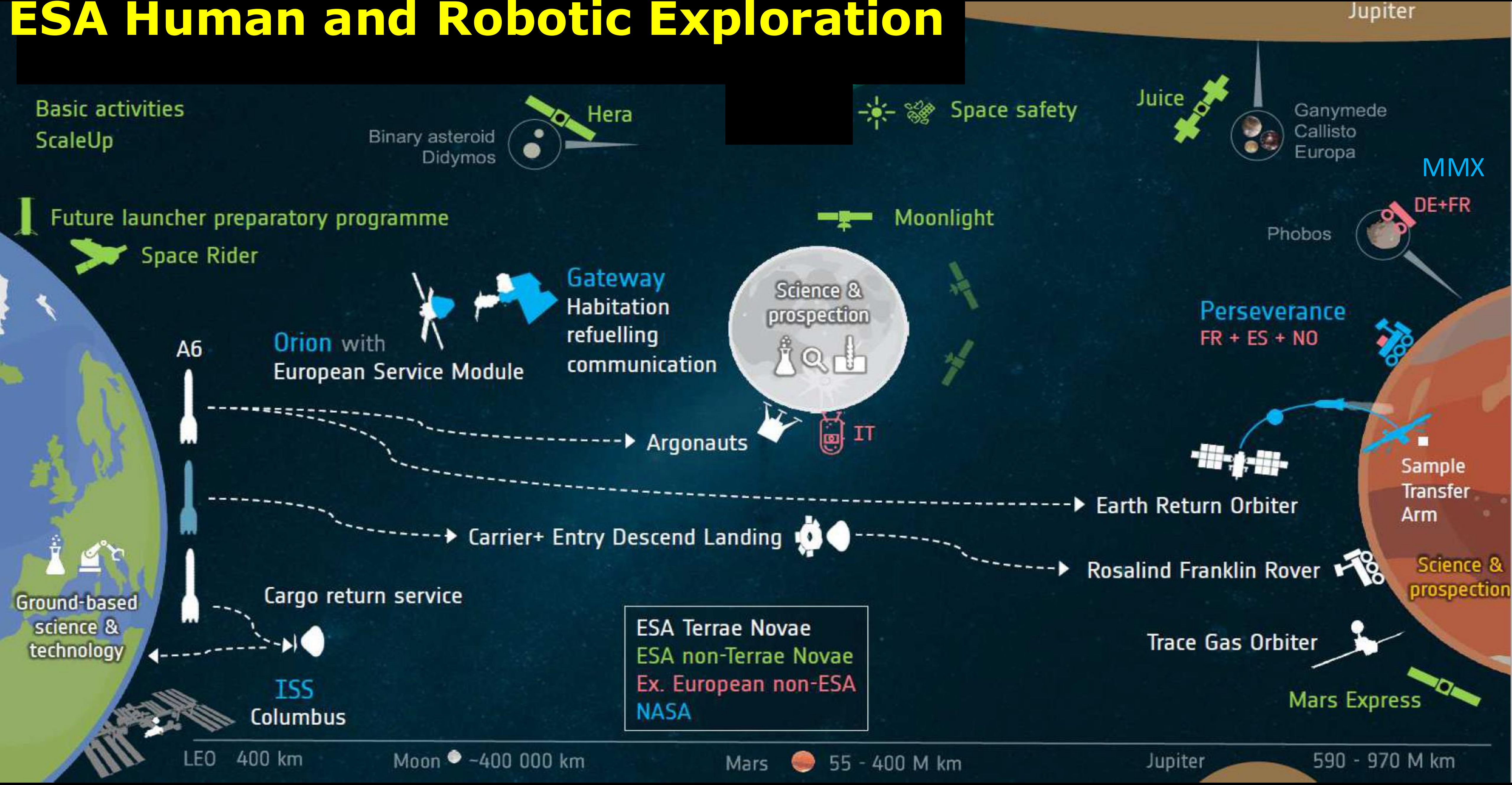
Several subcommittees work on different specific topics.

Community consultation by presentations in different meetings, surveys, workshops

The COSPAR Panel on Planetary Protection and guests: Dec. 2023, Vienna
https://cosparhq.cnes.fr/scientific-structure/ppp

Overview of COSPAR Panel on Planetary Protection Recent activities

ESA Human and Robotic Exploration



Planetary protection categories

The different planetary protection categories (I-V) reflect the level of interest and concern that contamination can compromise future investigations or the safety of the Earth; the categories and associated requirements depend on the target body and mission type combinations

Category I: All types of mission to a target body which is not of direct interest for understanding the process of chemical evolution or the origin of life; *Undifferentiated, metamorphosed* ***asteroids****; others*

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; ***Venus; Moon (with organic inventory only for landed missions at the poles and in PSRs)*** *Comets; Carbonaceous Chondrite Asteroids; Jupiter; Saturn; Uranus; Neptune; Ganymede†; Titan†; Triton†; Pluto/Charon†; Ceres; Kuiper-Belt Objects > 1/2 the size of Pluto†; Kuiper-Belt Objects < 1/2 the size of Pluto; others TBD*

Category III: Flyby (i.e. gravity assist) and orbiter missions to a target body of chemical evolution and/or origin of life interest and for which scientific opinion provides a significant[2] chance of contamination which could compromise future investigations; ***Mars; Europa; Enceladus; others TBD***

Category IV: Lander (and potentially orbiter) missions to a target body of chemical evolution and/or origin of life interest and for which scientific opinion provides a significant[2] chance of contamination which could compromise future investigations. 3 subcategories exist (IVa,b,c) depending on instruments, science investigations, special regions etc.; *Mars; Europa; Enceladus; TBD*

Category V: All Earth return: 2 subcategories - unrestricted return for solar system bodies deemed by scientific opinion to have no indigenous life forms (***e.g. Martian Moons***) and restricted return for all others

[1]Implies the absence of environments where terrestrial organisms could survive and replicate, or a very low likelihood of transfer to environments where terrestrial organisms could survive and replicate

[2]Implies the presence of environments where terrestrial organisms could survive and replicate, and some likelihood of transfer to those places by a plausible mechanism

More Moon

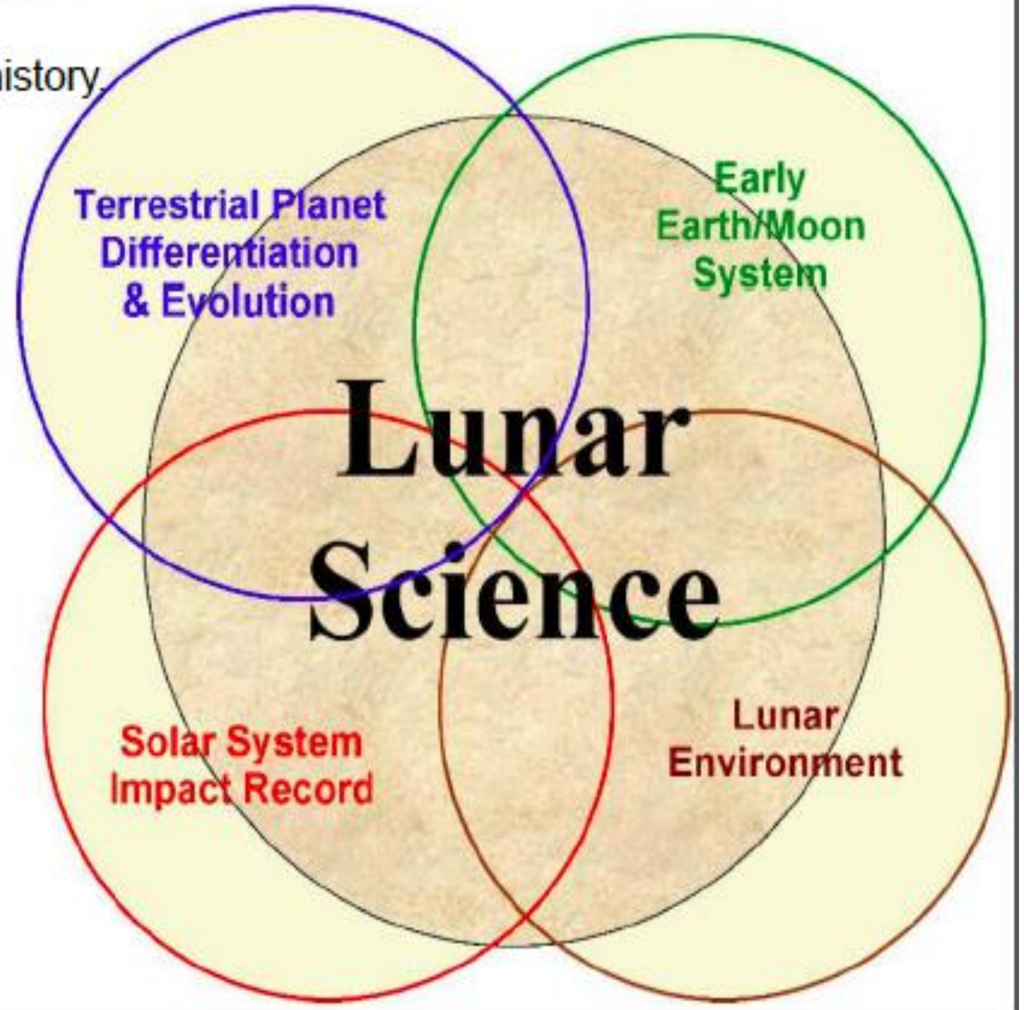
(take care of the poles and the PSRs !)

LUNAR SCIENCE

The Moon: Overarching Themes in Lunar Science

esa

- Been there – Done that! NO, we still have numerous questions!
- The Moon is a *witness* to 4.5 billion years of solar system history.
- The Moon presents a record of planetary *geologic processes in the purest form*
  - –Early crustal evolution
  - –Differentiation
  - –Impact craters
  - –Volcanic processes
  - –Regolith processes and early Sun
- The Moon provides accessible *unique environments*
  - –Polar regions
  - –Exosphere (atmosphere)
  - –Stable Platform for astronomy



(NRC, 2007) The scientific context for exploration of the Moon
http://www.nap.edu/catalog/11954.html

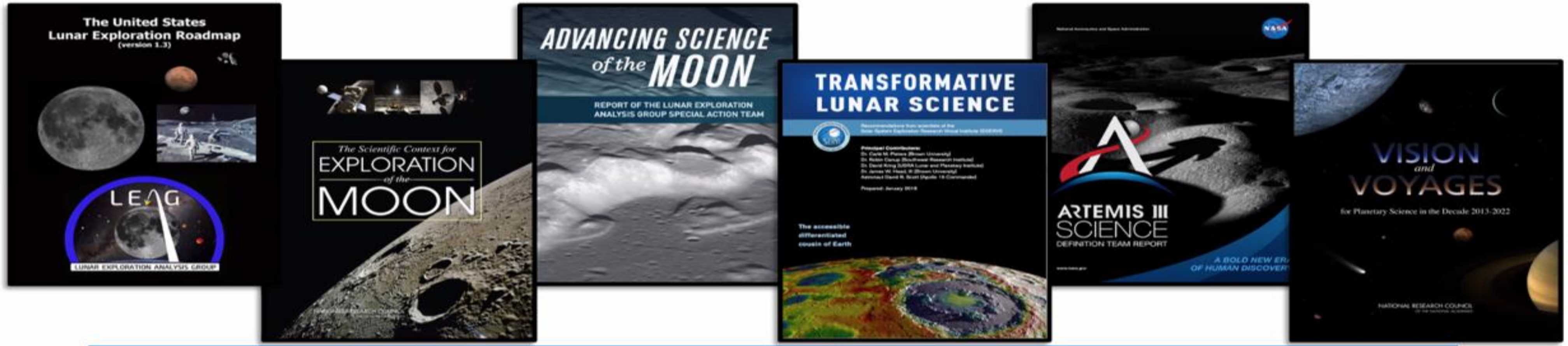
MOON SCIENCE

Property	Scientific Importance
Reference planetary body	The benchmark for how planetary bodies are formed and evolve
Common origin with Earth	Key to understanding the origin of Earth and Moon
Ancient surface	A unique witness plate to Earth's early history and the history of the Solar System
No atmosphere	Reference point for space-surface interactions and physics
Cold trapped volatiles including ice	A record of life-enabling chemistry in the Solar System
Radio quiet	Unique platform for astronomy
A source of resources	Materials on the Moon can be a source of water, propellant, metals, oxygen, which are key for sustainable exploration
Lunar surface environment	Natural laboratory for testing the impact of hypogravity and radiation on biological models in preparation for future long duration exploration

Table 1 - Summary of some of the key properties of the Moon and their relevance for the Moon as a destination for scientific research.

Community Guiding Documents

Study of lunar polar volatiles, with relevance to broader Solar System science objectives, is advocated in multiple guiding community documents.



Profound implications for understanding the history of volatile availability in the inner Solar System (including Earth), formation of inner planets, and expectations for the presence of water on other airless bodies in the Solar System and on exoplanets.

Hurley et al. 2020 white paper

Lunar cold traps provide an accessible, natural laboratory for analyzing volatiles found across the Solar System.

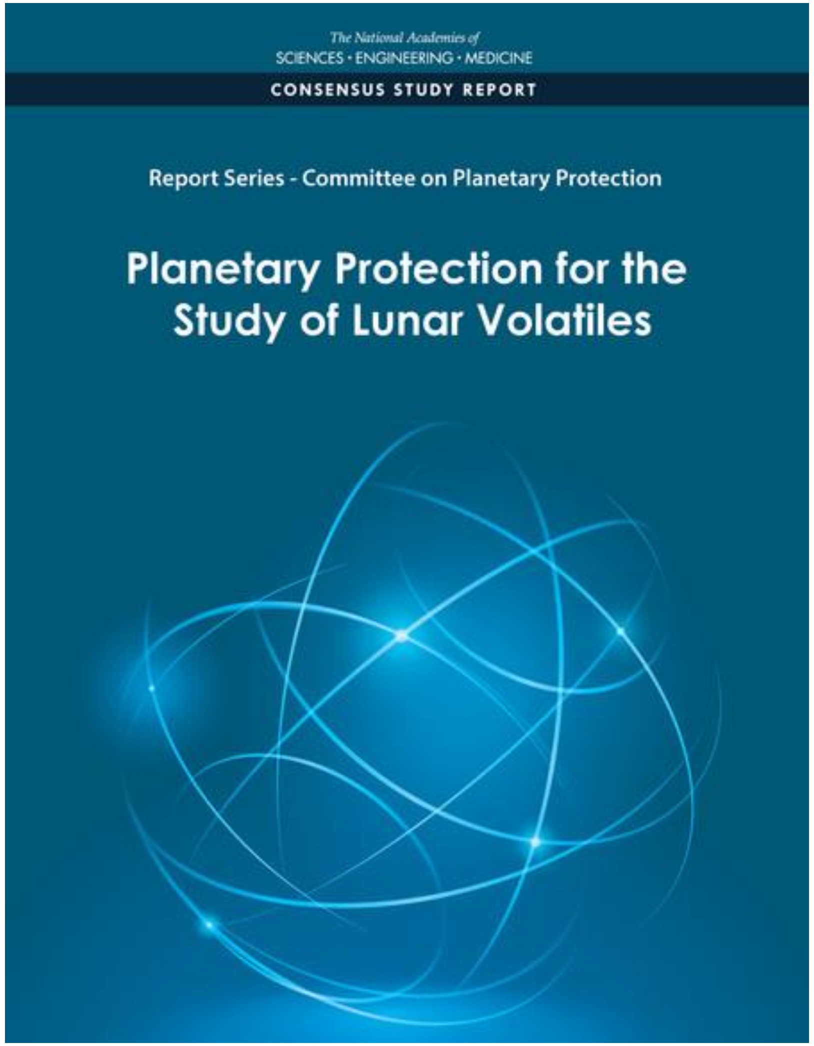
The low-temperature lunar poles are analogs for small bodies (comets, asteroids, trojans, centaurs), icy outer satellites (e.g., Europa, Enceladus), Kuiper Belt objects (e.g., Pluto), and the poles of Mercury—all targets that are also interesting due to the presence of various volatiles.

Permanently Shadowed Regions (PSR) on the Moon:

The Moon has:

- **Low obliquity (~1.5° from the ecliptic plane)**
- **Topography that creates permanently shadowed regions at high latitudes**

COSPAR PPP on Lunar exploration



1st NASEM SSB/CoPP report on Planetary Protection for the Study of Lunar Volatiles was presented to the PPP which agreed with the findings of the CoPP and used them as basis for updating the policy for the Moon

This was followed by the consultation of the community and several presentations and discussions (*PROCESS in detail hereafter)*
The proposed changes were validated by the Panel and the Bureau in 2021.

COSPAR & LEAG Consultation (2020)

About 120 responses received from many different countries

Questions	Yes	No	Abstain	
Are the volatiles in the Permanently Shadowed Regions (PSR) on the Moon of significant interest in the study of chemical evolution?	**78**	12	0	PSRs
Are you concerned that contamination carried by a spacecraft to the Moon could compromise future investigations to study chemical evolution?	**73**	17	1	Chemical evolution
Are you concerned about the long-term degradation of organic materials?	52	38	1	Degradation of organics
Are you concerned about organic volatiles released by certain types of propellants?	69	21	0	Propellants
Would an organic material list describing the kinds and amounts of organic materials on a spacecraft mitigate your concerns?	66	24	3	Inventory ?
Would establishment of lunar PSR protected areas with controlled access and avoidance of unnecessary contamination (e.g., obsolete parts of spacecraft like used propulsion stages) mitigate your concerns?	**73**	17	2	Protected areas ?
Are you concerned about the either controlled or uncontrolled introduction and release of biological materials (living and dead) into the lunar system?	61	29	1	Introduction of living or dead organisms

PSR Survey Conclusions:

- There is still interest in the lunar polar volatiles
- There is concern about contaminating the lunar polar volatiles
  - ❖ Concern about spacecraft propellant seems to be dominant
- Organic inventory seems to be a necessary and sufficient mitigation of the contamination concern
- Interesting ideas about protected zones

→ The result of the COSPAR stakeholder consultation and the LEAG consultation are in line with the current COSPAR Planetary Protection Category & Requirements for the Moon

- There was a rationale to reduce the organic inventory documentation to volatile products of the propulsion and life support system
- Discussion points to be assessed in the future - what to do with used spacecraft elements/propulsion stages/end-of-life dispositions; PSRs

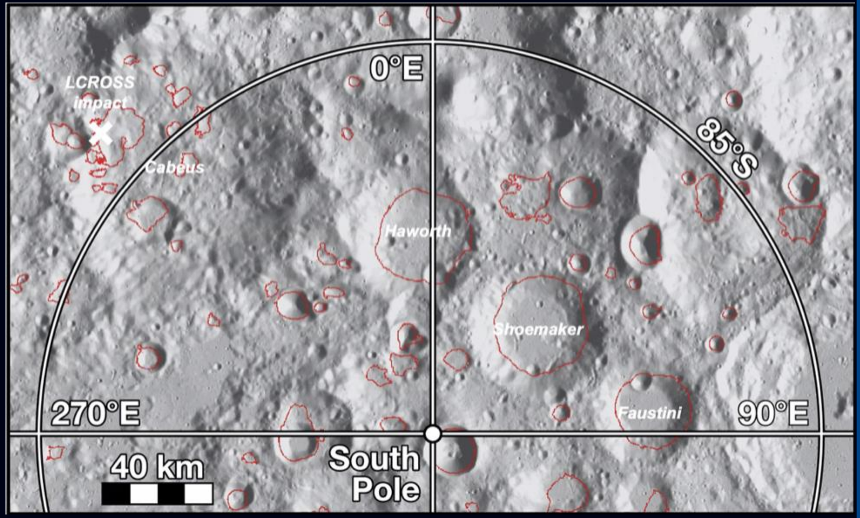
Description of Organic Inventory

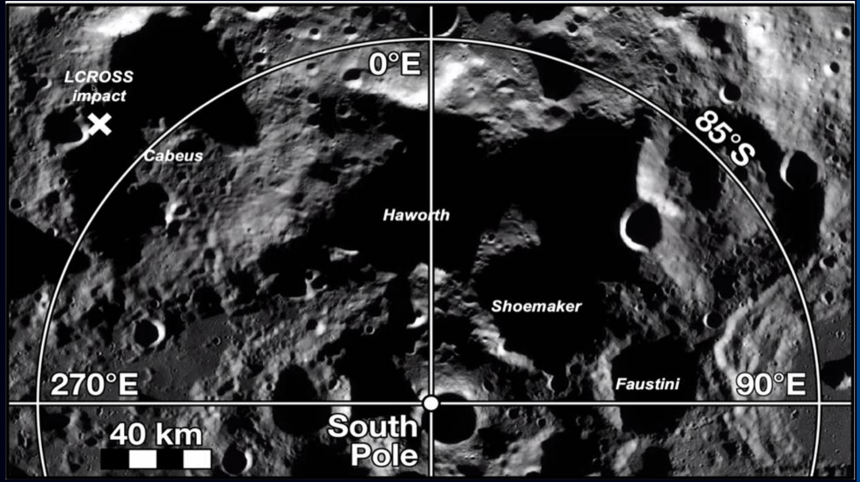
A spacecraft organic inventory includes a listing of all **organic materials** carried by a spacecraft which are present in a total mass **greater than 1 kg**. A complete inventory should include organic **products that may be released into the environment** of the protected solar system body by **propulsion and life support systems** (if present), and include a quantitative and qualitative description of major chemical constituents and the integrated quantity of minor chemical constituents present.

The COSPAR policy notes that "the requirements are for simple documentation only" and specifies an organic inventory of materials introduced by a mission. The scientific concern is not just direct contamination of impact sites but also the possibility of indirect contamination resulting from release of volatile compounds that could migrate in the lunar exosphere and be cold-trapped in the PSRs.

Updated planetary protection Policy for the Moon

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





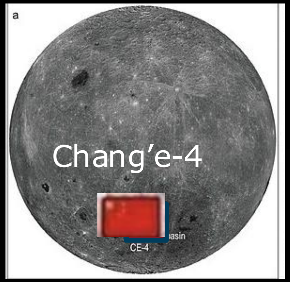
- *Category IIa*. All missions to the surface of the Moon whose nominal mission profile does not access areas defined in Category IIb shall provide the planetary protection documentation and an organic inventory limited to organic products that may be released into the lunar environment by the propulsion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

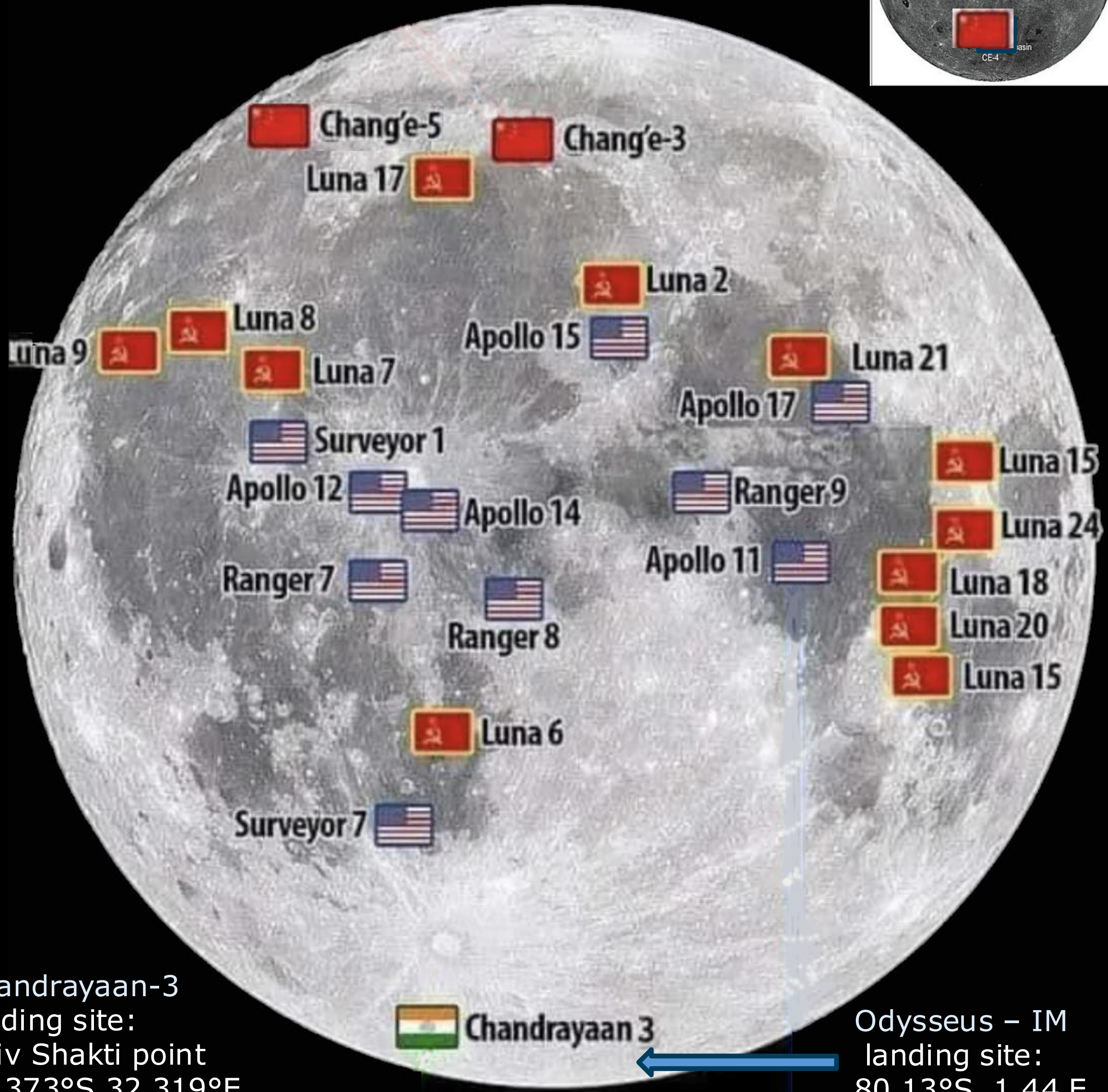
Updated COSPAR Policy published in Space Res. Today ***211****, 14-20 (Aug. 2021);* https://doi.org/10.1016/j.srt.2021.07.009.

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.*

Moon landing sites so far....

Chang’e-3 : 44.1214°N 19.5116°W
Chang’e-4: 45.444°S 177.599°E
Chang’e-5 : 43.0576°N 51.9161°W



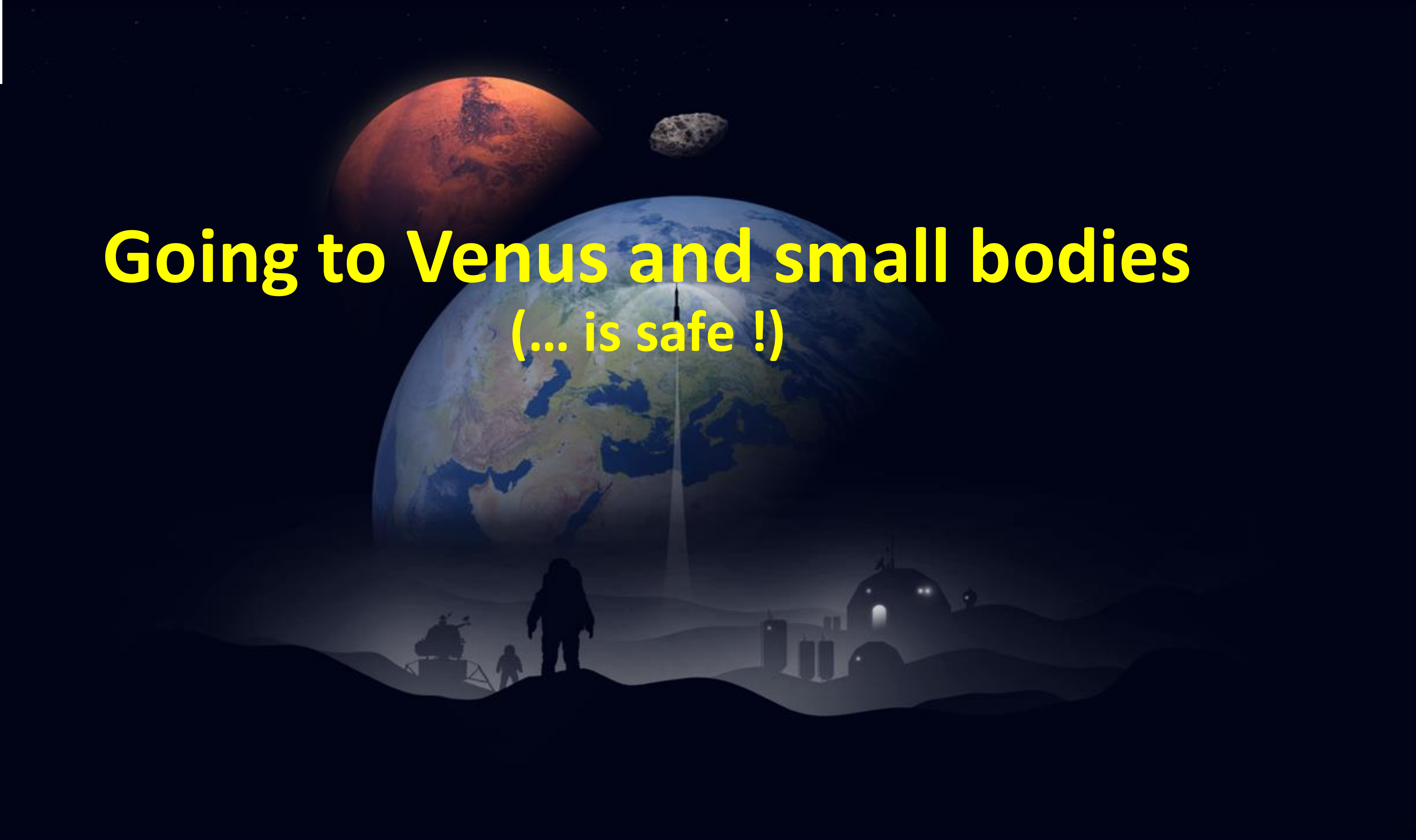


Chandrayaan-3 landing site: Shiv Shakti point 69.373°S 32.319°E

Odysseus – IM landing site: 80.13°S, 1.44 E

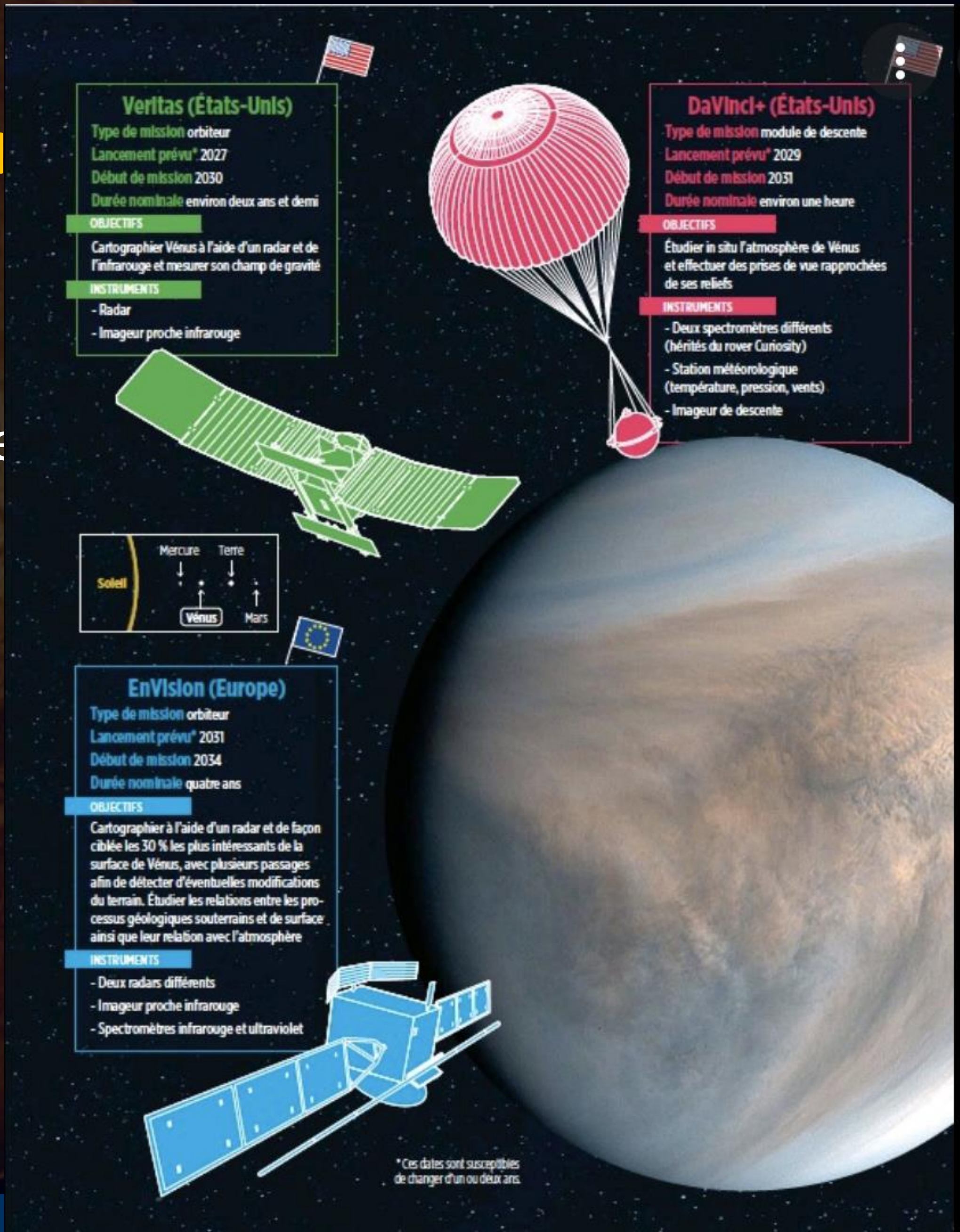
Going to Venus and small bodies

(… is safe !)



Venus habitability?

- <u>**Current Venus Cat. II**</u>
- COSPAR PPP studies since Feb. 2021 (subcommittee led by M-P Zorzano)
- <u>**Finding:**</u> **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).
- <u>**Recommendation**:</u> **unless there are new measurements that demonstrate water activity > 0.6 (RH> 60%), Venus clouds are not a concern for planetary protection ...because "life as we know" from Earth would not proliferate there.**
- *They are of course extremely interesting for planetary science, including atmospheric chemistry, P cycle, etc.*



Zorzano Meier et al., 2023, LSSR 37, 18-24

The COSPAR planetary protection requirements for space missions to Venus

The COSPAR Panel on Planetary Protection evaluated scientific data that underpins the planetary protection requirements for Venus and the implications of this on the current policy. The Panel has done a thorough review of the current knowledge of the planet's conditions prevailing in the clouds.


Life Sciences in Space Research 37 (2023) 18–24

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e COSPAR planetary protection requirements for space missions to Venus

ía Paz Zorzano [a,*], Karen Olsson-Francis [b], Peter T. Doran [c], Petra Rettberg [d], ena Coustenis [e], Vyacheslav Ilyin [f], Francois Raulin [g], Omar Al Shehhi [h], Frank Groen [i], vier Grasset [j], Akiko Nakamura [k], Olga Prieto Ballesteros [a], Silvio Sinibaldi [l], Yohey Suzuki [m], veen Kumar [n], Gerhard Kminek [o], Niklas Hedman [p], Masaki Fujimoto [q], Maxim Zaitsev [r], x Hayes [s], Jing Peng [t], Eleonora Ammannito [u], Christian Mustin [v], Kanyan Xu [w]

Based on the existing literature, we conclude that the environmental conditions within the Venusian clouds are orders of magnitude drier and more acidic than the tolerated survival limits of any known terrestrial extremophile organism. Because of this future orbital, landed or entry probe missions to Venus do not require extra planetary protection measures. This recommendation may be revised in the future if new observations or reanalysis of past data show any significant increment, of orders of magnitude, in the water content and the pH of the cloud layer

Zorzano Meier et al., 2023. LSSR 37, 18-24

Missions to small bodies

The small bodies of the solar system not elsewhere discussed in this policy represent a very large class of objects

The current COSPAR Policy for small bodies states that “imposing forward contamination controls on these missions is not warranted except on a case-by-case basis, so most such missions should reflect Categories I or II”.

Released in 2022 and presented to the COSPAR Panel in 2022: the: *3rd CoPP report on Planetary Protection for missions to small bodies* (https://nap.nationalacademies.org/download/26714).


Check for updates

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Planetary protection: an international concern and responsibility

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The CoPP report found that it is highly unlikely that small Solar System bodies harbor extinct or extant life or that terrestrial life could proliferate there. The Committee concluded that given the importance of some relatively primitive, volatile-rich, and organic-bearing small bodies to studies of prebiotic chemistry and the sparsity of current knowledge about them, there is no reason at this time to reduce the current categorizations (from Category II to Category I) for missions to small bodies. They did point out that larger objects like Ceres may be an exception. Knowledge about these larger objects is scant, and they should be assessed further before being visited, but for now, Category II is acceptable until further assessment.

PPP took the CoPP report into account at a meeting in 2022 and noted that the findings were compatible with the current policy. After thorough considerations and discussion by the Panel experts, it was decided that there was no need currently to change anything in the Policy as concerns small bodies.

Coustenis et al., 2023. Front. Astron. Space Sci. 10:1172546.

Missions to small bodies

From the NRC report 6 questions identified six parameters (liquid water, energy sources, organic compounds, temperature, radiation intensity, and natural influx to Earth) as relevant to its assessment and formulated the following six questions to help determine how returned samples should be handled.

1. Does the preponderance of scientific evidence indicate that there was never liquid water in or on the target body?
2. Does the preponderance of scientific evidence indicate that metabolically useful energy sources were never present?
3. Does the preponderance of scientific evidence indicate that there was never sufficient organic matter (or CO2 or carbonates and an appropriate source of reducing equivalents)[1] in or on the target body to support life?
4. Does the preponderance of scientific evidence indicate that subsequent to the disappearance of liquid water, the target body has been subjected to extreme temperatures (i.e., >160 °C)?
5. Does the preponderance of scientific evidence indicate that there is or was sufficient radiation for biological sterilization of terrestrial life forms?
6. Does the preponderance of scientific evidence indicate that there has been a natural influx to Earth, e.g., via meteorites, of material equivalent to a sample returned from the target body?

“Recommendation: For samples returned from Phobos and Deimos, Callisto, C-type asteroids, undifferentiated metamorphosed asteroids, differentiated asteroids, comets other than dynamically new ones, and interplanetary dust particles sampled near these bodies, a conservative, case-by-case approach should be used to assess the containment and handling requirements”

NRC report: Evaluating the Biological Potential in Samples Returned from Planetary Satellites and Small Solar System Bodies: Framework for Decision Making (1998)

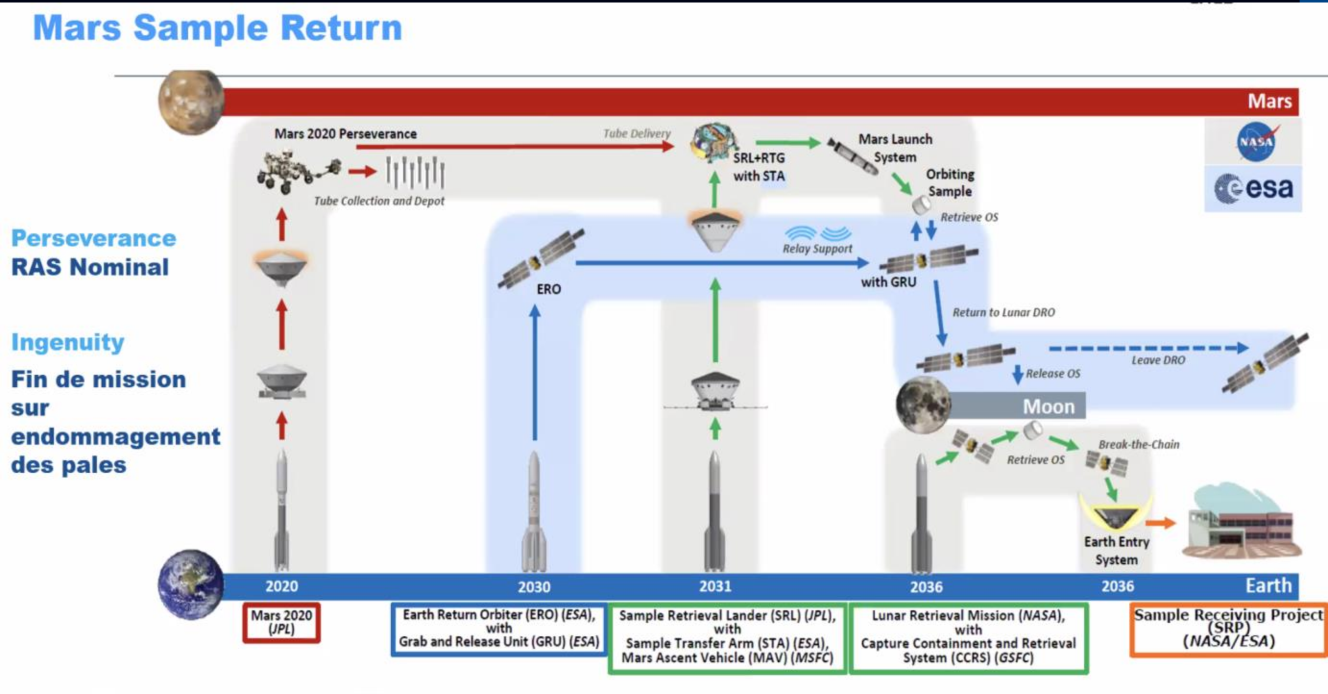
Current considerations

After Venus, Mars Robotic exploration and small bodies…

- Martian Robotic and human Exploration *(Olsson-Francis et al., 2023; Spry et al., 2024)*
- *MSR & ExoMars + other missions to Mars : PPP gets regular reports and will be a major item in future meetings.*
- *Icy Worlds Planetary Protection considerations*

ExoMars Rosalind Franklin Rover

Launch 2028



Mars and its moons
(sample return era)

The COSPAR planetary protection Policy for robotic missions to Mars

- In 2021, the Panel evaluated recent scientific data and literature regarding the planetary protection requirements for Mars and the implications of this on the guidelines. The group focused on three key areas:

1) Biocidal effects of the martian environment, 2) water stability, and 3) transport of spacecraft bioburden.

- These areas were discussed in the context of survival of dormant cells (where cells are either dormant or in a state of maintenance) vs proliferation (cells are actively defining) (National Academies of Sciences, Engineering, and Medicine. 2015; Rummel et al., 2014).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The COSPAR Planetary Protection Policy for robotic missions to Mars: A review of current scientific knowledge and future perspectives

Karen Olsson-Francis [a,*], Peter T. Doran [b], Vyacheslav Ilyin [c], Francois Raulin [d], Petra Rettberg [e], Gerhard Kminek [f], María-Paz Zorzano Mier [g], Athena Coustenis [h], Niklas Hedman [i], Omar Al Shehhi [j], Eleonora Ammannito [k], James Bernardini [l], Masaki Fujimoto [m], Olivier Grasset [n], Frank Groen [l], Alex Hayes [o], Sarah Gallagher [p], Praveen Kumar K [q], Christian Mustin [r], Akiko Nakamura [s], Elaine Seasly [l], Yohey Suzuki [s], Jing Peng [t], Olga Prieto-Ballesteros [g], Silvio Sinibaldi [f], Kanyan Xu [u], Maxim Zaitsev [v]

The COSPAR Panel on Planetary Protection will continue to work with the different national and international space agencies, the scientific community, and other stakeholders (e.g., the private sector and industry) to develop a roadmap for coordinating research activities addressing the identified knowledge gaps. This will include further characterisation of the biocidal effects at the surface of Mars, which needs to be addressed before *in-situ* reduction can be considered as an approach for bioburden control for robotic missions. Although the science underpinning the Policy is advancing, as highlighted in more recent reports (e.g. National Academies of Sciences, Engineering, and Medicine 2021, Spry et al. 2021) and in this paper, there are still several knowledge gaps that need to be addressed before they can be directly applied to accommodate the interest of the user. In brief, these knowledge gaps fall within three main themes, all of which will benefit from more measurements by space missions and ground-based observations: *Biocidal effects, contamination transport model and Mars environmental conditions*

Olsson-Francis et al., 2023. LSSR 36, 27-35

Recent Martian & Moons exploration: sample return

Martian Moons eXploration

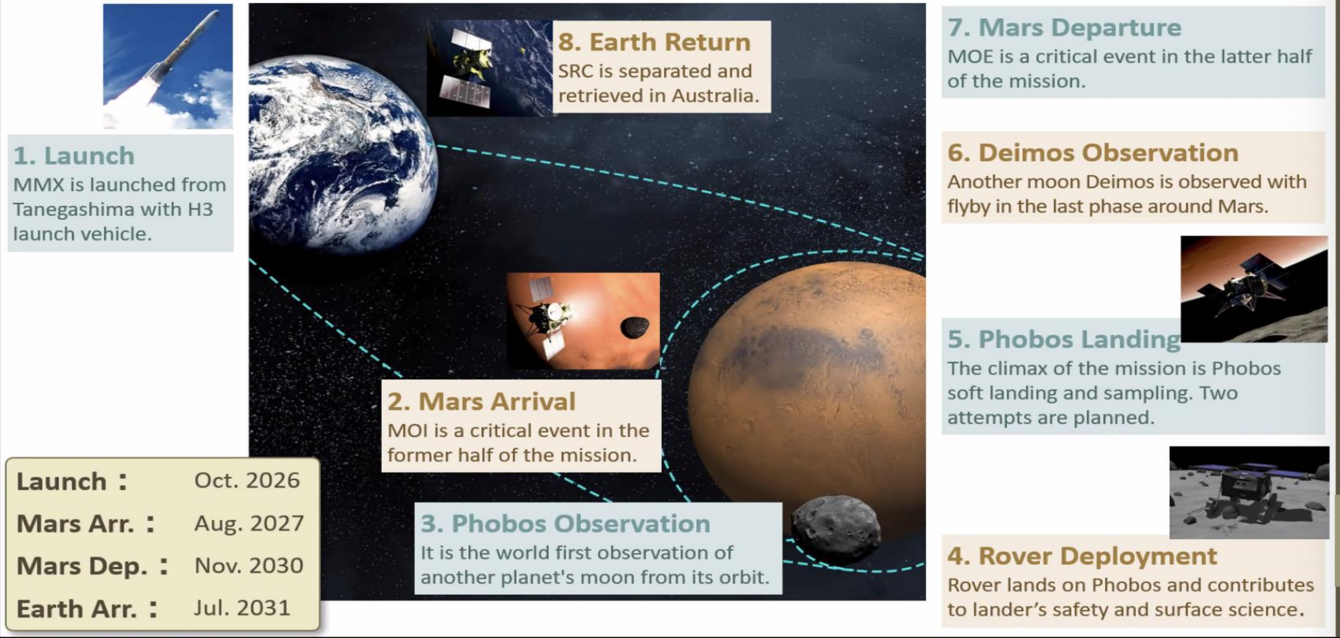
Three Major Items of MMX Mission Value

MMX is a **unique Martian sphere exploration** mission lead by Japan. It sets in its view of Martian moons, Martian life, and future crewed exploration in one mission.

As a result of the launch year change to FY2026, the development schedule was mainly revised. The system assembly and I/F Check begins in February, followed by the integration test in September.

Mission Profile

The mission is targeting the launch in 2026. A five-year trip is planned to retrieve samples back to Earth within three years of staying around Mars. The mission is full of critical and attractive events.

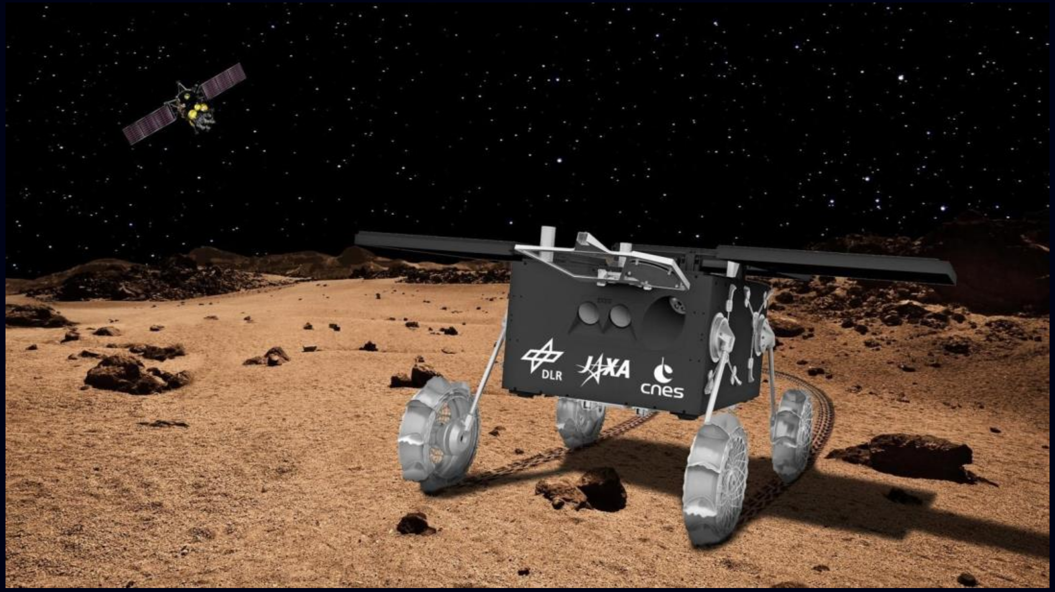


MMX-JAXA categorisation

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

→ To support a categorization, ESA initiated an activity with a science consortium 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. NASA supported the activity from the very beginning providing test materials and expert advice, followed by JAXA with their own experimental and modelling work supporting the overall assessment

→ The ESA-JAXA-NASA coordinated activities finished with an independent review by the NAS and the European Science Foundation presented to the ESA Planetary Working Group (PPWG) and to COSPAR



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

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

→ COSPAR was involved throughout the multi-year-long process and at the end assigned a planetary protection category specifically for the MMX mission (outbound Cat III and inbound Cat V: unrestricted Earth return)

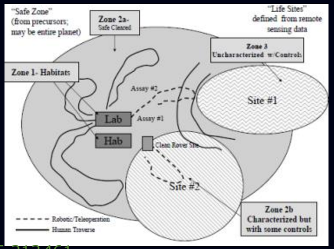
Planetary Protection requirements

Principles for Human Missions to Mars

- The intent of the planetary protection policy is the same whether a mission to Mars is conducted robotically or with human explorers
- Planetary protection goals should not be relaxed to accommodate a human mission to Mars, i.e. they become even more directly relevant to such missions—even if specific implementation requirements must differ. Human exploration of Mars will require additional planetary protection considerations to those for robotic missions.
- Safeguarding the Earth from potential back contamination is the highest planetary protection priority in Mars exploration
- The greater capability of human explorers can contribute to the astrobiological exploration of Mars only if human-associated contamination is controlled and understood

Credit: ESA

Credit: NASA/Apollo 12



Credit: NASA/CP-2005-213461

Establish engineering requirements through a series of NASA and COSPAR co-sponsored workshops on Planetary Protection for Human Missions to Mars to address knowledge gaps for planetary protection in the context of future human missions to Mars.

Mars Human exploration

- These interdisciplinary meetings considered the next steps in addressing knowledge gaps for planetary protection in the context of future human missions to Mars. Reports from these workshops are posted under Conference Documents at https://sma.nasa.gov/sma-disciplines/planetary-protection/.
- A report was issued after the June 2022 COSPAR Meeting on "Planetary Protection Knowledge Gaps for Crewed Mars Missions" (*Spry et al., 2022*) and represented the completion of the COSPAR series. This report aims to identify, refine, and prioritize the knowledge gaps that are needed to be addressed for planetary protection for crewed missions to Mars, and describes where and how needed data can be obtained.
- The knowledge gaps addressed in this meeting series fall into three major themes: "*1. Microbial and human health monitoring; 2. Technology and operations for biological contamination control, and; 3. Natural transport of biological contamination on Mars." (Kminek et al., 2017)*
- This approach was consistent with current scientific understanding and COSPAR policy, that the presence of a biological hazard in Martian material cannot be ruled out, and appropriate mitigations need to be in place. The findings will be published in *Spry et al. (2024, Astrobiology, in press)* with COSPAR support. This paper will highlight the scientific measurements and data needed for knowledge gap closure, updating and completing in more detail the material previously presented in the *Spry et al. (2021)* Planetary Science Decadal Survey white paper **(https://doi.org/10.3847/25c2cfeb.4a582a02).**

Spreading the word…

COSPAR PPP activities 2023-2024 – communications/Workshops

The ESA WS Planetary Protection Requirements
for future exploration missions Workshop

Organised by S. Sinbaldi, presentation by P. Rettberg

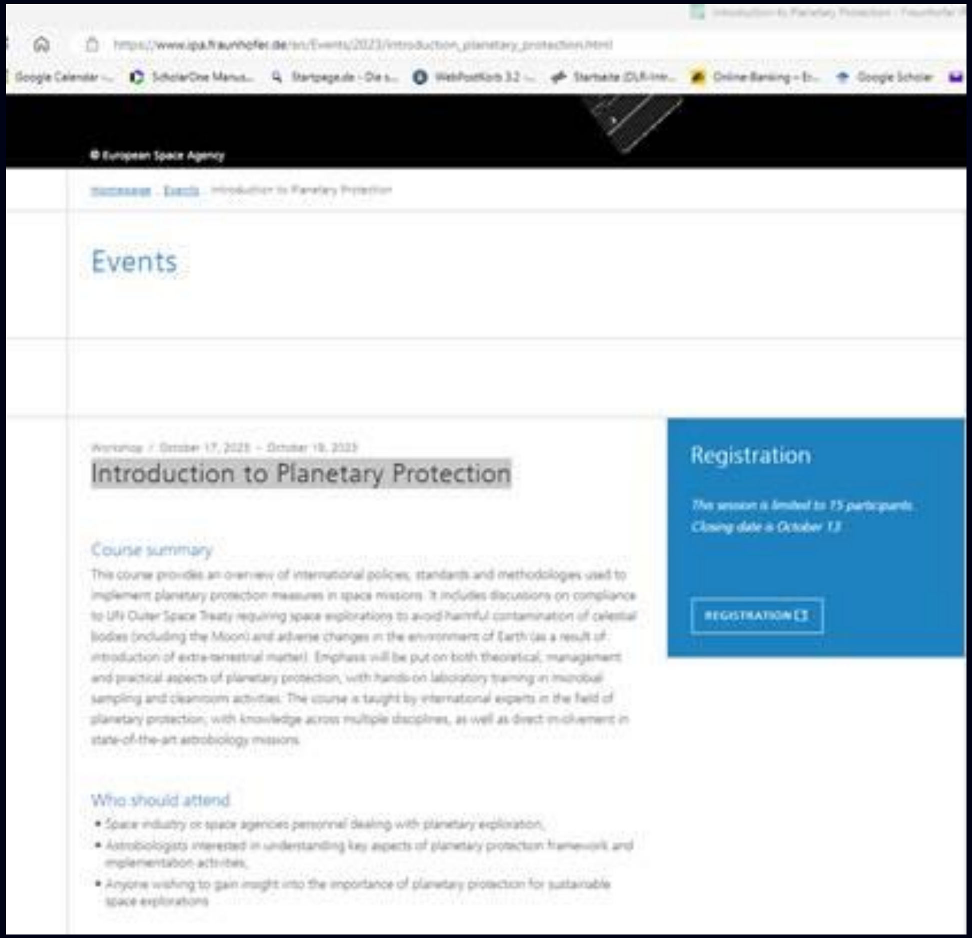
XIX International School of Astrobiology «Josep Comas i Solà».
Searching for Life on Ocean Worlds with a lecture titled:
Planetary Protection considerations for ocean worlds.

Talk by O. Prieto-Ballesteros

World Trade Institute (UniBE) Workshop on "The Economics and
Law of Space-Based Commerce”.
17-19 Jan. 2024 at ISSI, Bern

Talk by A. Coustenis, N. Hedman and J-C Worms

ESA PP course ‘Introduction to Planetary
Protection’ (Fraunhofer Institute, Stuttgart)



Organised by S. Sinbaldi,
presentations by N. Hedman & P. Rettberg

COSPAR PPP activities 2023-2024

UN-UNLUX SRW 2024
Working Group on Legal Aspects of Space Resource Activities

Planetary Protection presentations by P. Rettberg & N. Hedman

VAAM (Association for General and Applied Microbiology) workshop 'Big Bang… Microbes! & GeoBerlin 2023 conference

Plenary discussion on "plenary discussion about PP 'Should we colonize Mars? by P. Rettberg

The ESA metagenomic Workshop

Talk by K. Olsson-Francis

COSPAR PPP activities 2023-2024

EANA 2023 Sept. 2023

Talks on Planetary Protection by P. Rettberg & K. Olsson-Francis

The International Mars Exploration Working Group (IMEWG) – Nov. 2023

invited talk about 'Planetary protection' by K. Olsson-Francis

OPAG Meeting,
29 Nov. 2023

Presentation of PP Icy Worlds Policy suggestions by A. Hayes

LPSC 2024
11-15 Mar. 2024

Presentation of PP Icy Worlds Study by P. Doran

NASEM SSB/CoPP Meeting,
21 March 2024

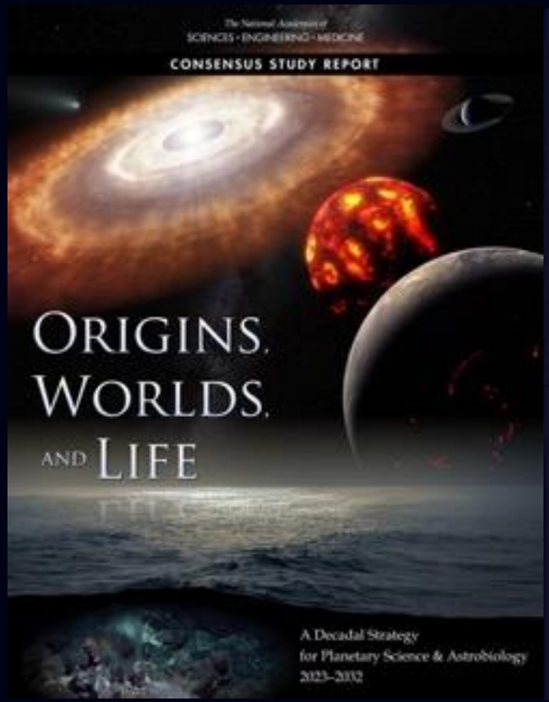
Presentation of PPP activitiies by P. Doran, N. Hedman, A. Coustenis

Future considerations
Looking ahead

Thinking to the future

After the updated Policy published in Aug. 2021, the Panel is considering new needs for guidance in space exploration.

- **More Mars…**
- **Implementation of Icy Worlds findings in Policy**
- **PP policy editorial review and restructuring**



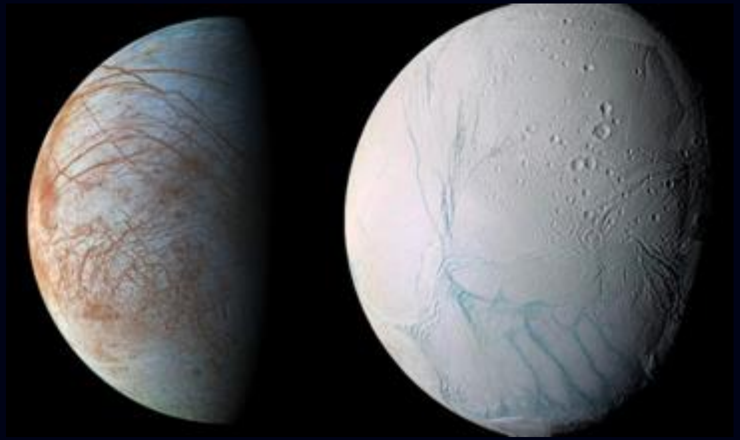
Mimas

Some themes have been showcased in the NASEM OWL 2022 and ESA's Voyage 2050.

Icy Worlds
(not a cold case…)

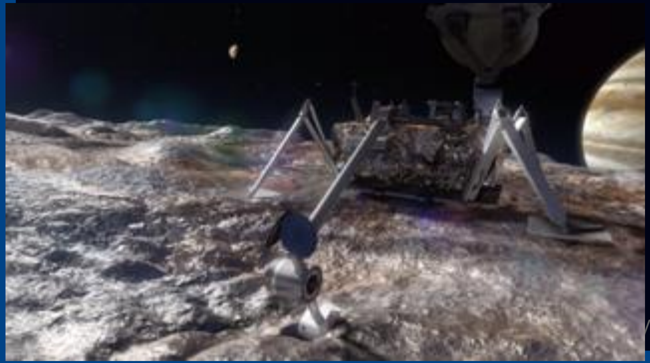
Planetary Protection of the Outer Solar System (PPOSS)

- 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 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 *Enceladus*

- *Category III and IV: 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 a Europan or Enceladan ocean to less than 1 x 10^{-4} per mission*
- *The probability of inadvertent contamination of a Europan or Enceladan ocean of 1x10^{-4} applies to all mission phases including the duration that spacecraft introduced terrestrial organisms remain viable and could reach a subsurface liquid water environnement*



Published in

Space Res. Today (2020) 208

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

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

& The Internl PP Handbook: Dec. 2018

Planetary Protection of the Outer Solar System (PPOSS)

THE INTERNATIONAL PLANETARY PROTECTION HANDBOOK

by

Gerhard Kminek (ESA, Noordwijk, The Netherlands), Jean-Louis Fellous (COSPAR, France), Petra Rettberg (DLR, Germany), Christine Moissl-Eichinger (Medical Univ. Graz, Austria), Mark A. Sephton and Samuel H. Royle (Imperial College London, UK), J Andy Spry (SETI Institute, CA, USA), Hajime Yano (ISAS/JAXA, Japan), Toshihiro Chujo (formerly JAXA, now Tokyo Institute of Technology, Japan), Diana B. Margheritis (Thales Alenia Space, Italy), John R. Brucato (INAF, Italy), and Alissa J. Haddaji (formerly COSPAR, now Harvard University, MA, USA)

An online-only supplement to *Space Research Today*, volume 205

- *Policy should include a generic definition of the environmental conditions potentially allowing Earth organisms to replicate*
- *implementation guidelines should be more specific on relevant organisms*
- *implementation guidelines should be updated to reflect the period of biological exploration of Europa and Enceladus*
- *implementation guidelines should acknowledge the potential existence of Enhanced Downward Transport Zones at the surface of Europa and Enceladus.*

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

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

& The Internl PP Handbook: Dec. 2018

Credit: NASA/JPL/Galileo

Future exploration of Icy Worlds

After the PPOSS study, a Panel subcommittee considered the future exploration of Icy Worlds and Ceres

The Panel has been working on a thorough review of the current knowledge for Icy Moons+Ocean Worlds (**Icy Worlds**: *a new definition and better arguments from the most recent findings to protect and explore*) and is making proposals for a better coverage in the Policy

(Doran et al., 2024, LSSR, 41 pp. 86–99. DOI: https://doi.org/10.1016/j.lssr.2024.02.002)

OCEAN WORLDS

		Europa	Ganymede	Callisto	Enceladus	Titan	Mid-Size Saturnian Moons	Uranian Moons	Triton
WATER	Surface Liquid	✗	✗	✗	✗	✗	✗	✗	✗
	Subsurface Liquid	✓	✓	?	✓	✓	?	?	?
	Ground Ice	✓	✓	✓	✓	✓	✓	✓	✓
	Water Vapor	▨	▨	▨	✓	▨	▨	?	?
CHEMISTRY	CHNOPS[1]	?	▨	▨	✓	✓	?	✓?	✓
	Complex Organics	✓	▨	▨	✓	✓	▨	▨	▨
ENERGY	Solar Heating	✗	✗	✗	✗	✗	✗	✗	✗
	Interior Heating[2]	✓	✓	✓	✓	✓	✓?	✓?	▨
	Redox[3]	?	▨	▨	✓	✓	▨	▨	▨
BODY	Atmosphere[4]	✗	✗	✗	✗	✓	✗	✗	✗
	Magnetic Field[5]	✗	✓	✗	✗	?	✗	?	✗
	Present Habitability	?	?	?	✓	?	?	?	?
	Past Habitability	?	?	?	?	?	?	?	?

✓ Yes/Present ? Unknown/Uncertain ✗ No/Absent ▨ Insufficient Information

[1]The life-supporting elements carbon, hydrogen, nitrogen, oxygen, phosphorus, or sulfur (not all need be present)
[2]Interior heating is that energy derived from accretion, differentiation, radiogenic decay, and/or tidal dissipation
[3]The prospect for any element or molecule to be reduced or oxidized as a source of chemical energy for life
[4]Subsantial atmospheres only; exospheres (formed by, e.g., impact sputtering) are not included
[5]Intrinsically generated magnetic fields only

Modified from NASEM Decadal. OWL, Courtesy of P. Byrne

Missions to Icy Worlds (findings)

After reviewing the current knowledge and the history of planetary protection considerations for Icy Worlds, the Panel subcommittee published its recommendations:

- Establish indices for the lower limits of Earth life with regards to water activity (LLAw) and temperature (LLT) and apply them into all areas of the COSPAR Planetary Protection Policy (These values are currently set at 0.5 and -28 ◦C and were originally established for defining Mars Special Regions)

Doran et al., 2024.

Life Sciences in Space Research 41 (2024) 86–99

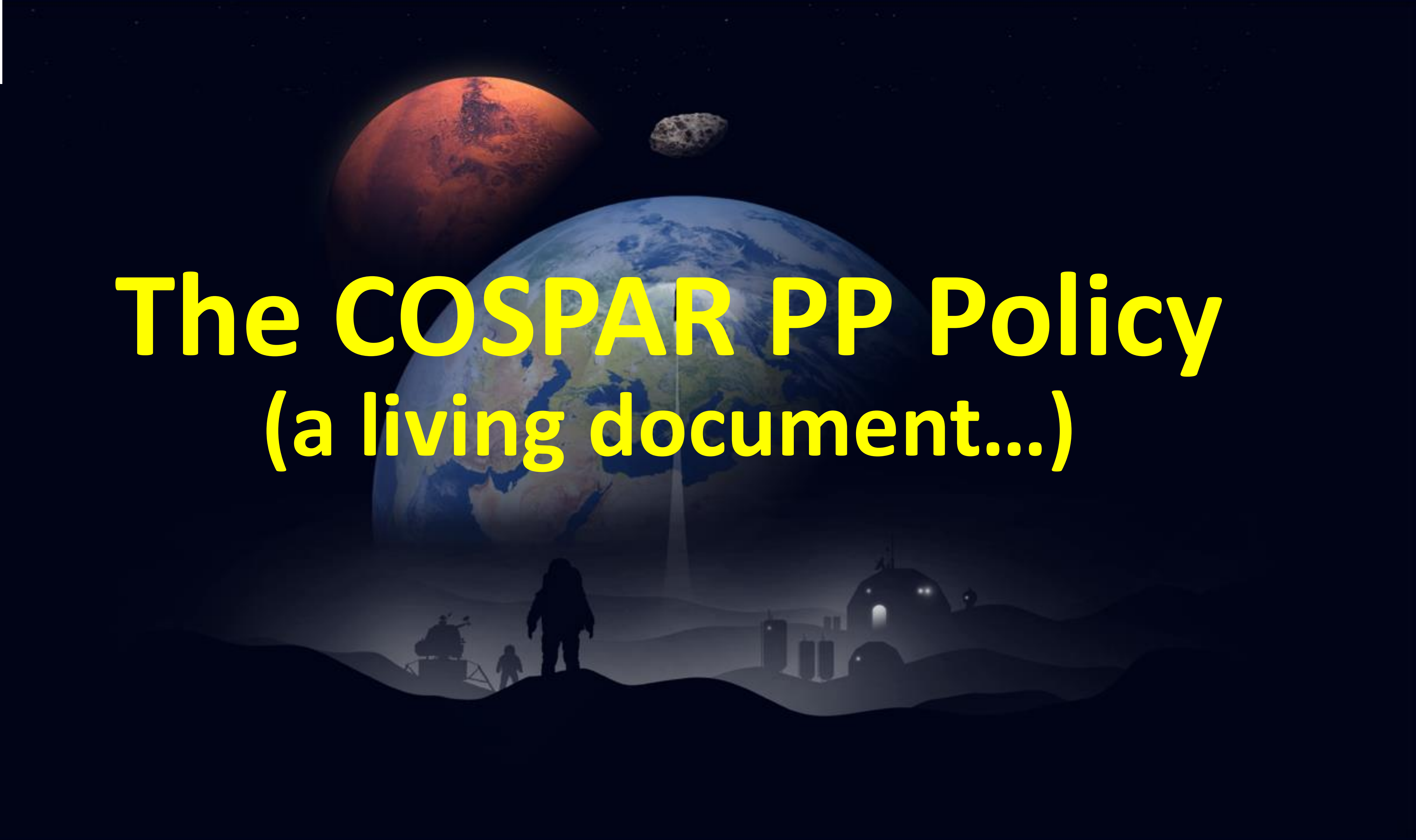
journal homepage: www.elsevier.com/locate/lssr

The COSPAR planetary protection policy for missions to Icy Worlds: A review of history, current scientific knowledge, and future directions

P.T. Doran[a,*], A. Hayes[b], O. Grasset[c], A. Coustenis[d], O. Prieto-Ballesteros[e], N. Hedman[f,1], O. Al Shehhi[g], E. Ammannito[h], M. Fujimoto[i], F. Groen[j], J.E. Moores[k], C. Mustin[l], K. Olsson-Francis[m], J. Peng[n], K. Praveenkumar[o], P. Rettberg[p], S. Sinibaldi[q], V. Ilyin[r], F. Raulin[s], Y. Suzuki[t], K. Xu[u], L.G. Whyte[v], M. Zaitsev[w], J. Buffo[x], G. Kminek[q], B. Schmidt

- Establish LLT as a parameter to assign categorization for Icy Worlds missions. The suggested categorization will have a 1000-year period of biological exploration, to be applied to all Icy Worlds and not just Europa and Enceladus as is currently the case.
- Have all missions consider the possibility of impact. Transient thermal anomalies caused by impact would be acceptable so long as there is less than 10^{-4} probability of a single microbe reaching deeper environments where temperature is >LLT in the period of biological exploration.
- Restructure or remove Category II* from the policy as it becomes largely redundant with this new approach,
- Establish that any sample return from an Icy World should be Category V restricted Earth return.

The COSPAR PP Policy
(a living document…)



COSPAR PP Policy editorial review and restructuring process

Objective to enhance the understanding and clarity of the Policy and associated guidelines for consistency and transparency, including by introducing a more objectives-driven and case-assured (vs. prescriptive) approach to the formulation and implementation of planetary protection controls.

- Clarifying the status of the Policy as a non-legally binding international standard; quoting both OST Article VI and IX.
- New chapters clarifying the role and function of COSPAR PPP; presenting key assumptions that form the basis for the technical guidelines; listing categorization considerations to capture the rationale and intent behind the categorization process.

COSPAR PP Policy editorial review and restructuring process

- Restructuring the Policy and associated guidelines with explanatory text. including graphics/tables on a) Planetary protection process overview (categorization and corresponding guidelines); b) Planetary protection categories in relation to target bodies; c) Guideline specification; d) Example of expected elements for mission documentation.

Review undertaken by a PPP Subcommittee (PPP Leadership, NASA, ESA and independent scientist members). Submitted in March 2024 to the COSPAR Bureau for validation and the Bureau approved on 20 March.

No changes to the requirements or guidelines in this new Policy.
Any changes will only intervene after the careful process described before in other cases. **The Policy will be published in the next SRT issue.**

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

The Policy will continue to be updated 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 or recent reports: Studies/Surveys/Workshop /Focused conferences?

- 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

- **We invite anyone interested to contact any PPP member for interactions and information on the latest policy and requirements.**

The Inaugural International COSPAR Planetary Protection Meeting:
22-24 April 2024 in London, The Royal Society

- **Monday 22 April**:
Welcome (UKSA); PPP Activities ; Probabilistic Risk Assessment ; Icy Worlds and astrobiology ; Limits of Life ; space missions to icy moons

- **Tuesday 23 April**: Mars Session: Habitability, agency reports on Mars Exploration ; Sample return facilities ; Robotic and human exploration of Mars ; Panel on PP in the commercial and private sector

- **Wednesday 24 April** : PPP Open session meeting : Activities and reports; briefing from space agencies; MSR ; Double Walled insulator ; Bayesian Statistics for PP ; Industry and commercial sector reports ; COSPAR 2024 Assembly and futur meetings

- **Thursday 25 April** *:* COSPAR PPP Closed session for members only and invited guests

Future meetings and activities

Next COSPAR General Assembly :

13-21 July 2024, Busan, South Korea

https://www.cospar-assembly.org/assembly.php

PPP.1 Policy *(Conveners: A. Coustenis & N. Hedman)*

16 July 2024 (with Open and Closed sessions)

PPP.2 Planetary Protection Mission Implementation and Status *(Conveners: S. Sinibaldi & F. Groen)*

17 July 2024

PPP.3 Planetary Protection Research and Development *(Conveners: P. Doran & K. Olsson-Francis)*

14 July 2024

PPP Business Meeting : 17 July lunch time

Please join us in Busan !

PPP Recent publications (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 exploration 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". *OpenAccessGovernment,* 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
- Olsson-Francis, K., Doran, P., et al., 2023. The COSPAR Planetary Protection Policy for missions to Mars: ways forward based on current science and knowledge gaps. *LSSR*, 36, p. 27-35.
- Zorzano M-P., et al., 2023. The COSPAR Planetary Protection Requirements for Space Missions to Venus. *LSSR*, 37, 18–24.
- Coustenis, A., et al., 2023. Planetary protection: Updates and challenges for a sustainable space exploration. *Acta Astron.*, 210, 446-452. https://doi.org/10.1016/j.actaastro.2023.02.035
- Coustenis, A., et al., 2023. Planetary Protection: an international concern and responsibility. Frontiers in Astronomy and Space Sciences, *Front. Astron. Space Sci. 10:1172546.*
- Spry, A., et al., 2024. Planetary Protection Knowledge Gap Closure Enabling Crewed Missions to Mars. Astrobiology, in press.
- Doran, P., et al. 2024. The COSPAR Planetary Protection Policy for missions to Icy Worlds: A review of current scientific knowledge and future directions. LSSR, 41 pp. 86–99.