Briefing and updates from 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 SSB/CoPP Meeting
5 December 2024

Vienna, Dec. 2023 &
Busan, July 2024

COSPAR Panel on Planetary Protection Members

Chair: Athena **Coustenis** (Paris Observ., FR; planetary sciences, astrobiology)

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

Invited commercial

Blue Origin

SpaceX

AIRBUS

ThalesAlenia Space

OHB

COSPAR
COMMITTEE ON
SPACE RESEARCH

Some context and space law

(Reminders of the international context …)

COSPAR

ORIGIN

After the USSR launched its first Earth Satellite in 1957 and thereby opened the space age, the International Council of Scientific Unions (ICSU), now the **International Science Council** (ISC), established its Committee on Space Research (COSPAR) during an international meeting in London in 1958. COSPAR's first Space Science Symposium was organized in Nice in January 1960 (see **https://cosparhq.cnes.fr/about/**).

PURPOSE

COSPAR's objectives are to promote on an international level scientific research in space, with emphasis on the exchange of results, information and opinions, and to provide a forum, open to all scientists, for the discussion of problems that may affect scientific space research. These objectives are achieved through the organization of Scientific Assemblies, publications and other means.

ROLE

COSPAR, as an entity that ignores political considerations and views all questions solely from the scientific standpoint, plays an important role as an interdisciplinary scientific organization, focusing on the progress of all kinds of research carried out with the use of space means (including balloons).

COSPAR contributions to COPUOS (PP-related historical examples)

- 1963-1964 COSPAR reporting under COPUOS/STSC item on potentially harmful effects of space experiments – 1963 COPUOS report (A/5549) and 1964 COPUOS report (A/5785) with inclusion of COSPAR Executive Council resolution (20 May 1964) and appendices:

COSPAR Consultative Group on Potentially Harmful Effects of Space Experiments covering a) Pollution of the upper atmosphere; b) Orbiting dipoles; c) Contamination of the Moon and planets

  - Panel on Standards for Space Probe Sterilization (precursor to the present Panel on Planetary Protection, PPP)

- 1984 and 1988 reports by COSPAR on environmental effects of space activities (A/AC.105/344 and A/AC.105/420)

- 1980-1991 comprehensive COSPAR reports on progress of space research (starting with A/105/298)

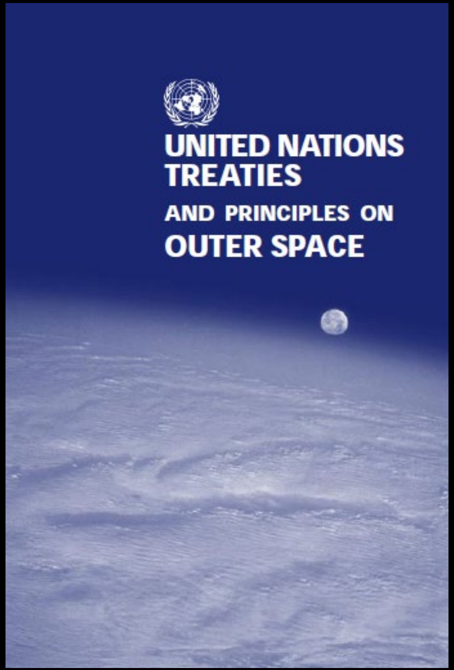
The Outer Space Treaty (OST)

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.

- 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"

- More recent times: COSPAR contributions to items on space weather, Near-Earth Objects, space debris, long-term sustainability of outer space activities

COSPAR Commissions & Panels of interest

Currently 8 Scientific commissions and 12 Panels

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/

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.*

Working sessions of the COSPAR Panel on Planetary Protection

The Panel provides, through workshops and meetings at COSPAR Assemblies and elsewhere, an international forum for the exchange of information on the best practices for adhering to the COSPAR planetary protection requirements. The PPP has strong ties with other relevant bodies world-wide (e.g. NASEM SSB/CoPP). Through COSPAR GA, focused meetings with Open Sessions and publications the Panel informs the international community, including holding an active dialogue also with the private sector.

The COSPAR Panel on Planetary Protection, invited guests and attendees at The Inaugural International COSPAR Planetary Protection Workshop (London, April 22-25, 2024), and at the COSPAR General Assembly, July 2024 in Busan, South Korea

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

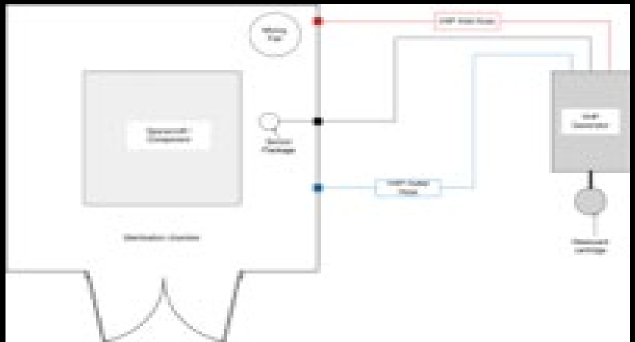
[1]*Implies the absence of environments where terrestrial organisms could survive and replicate, or a very low likelihood of transfer to environments where terrestrial organisms could survive and replicate*

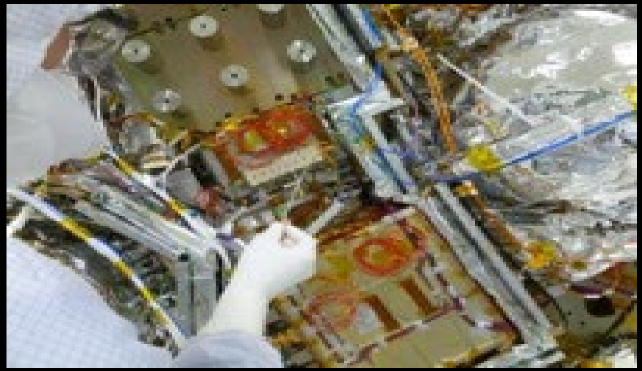
[2]*Implies the presence of environments where terrestrial organisms could survive and replicate, and some likelihood of transfer to those places by a plausible mechanism*

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 with examples
- Ultra cleaning of flight hardware, *ECSS-Q-ST-70-54C*
  - → Describes procedures how to clean flight hardware, in particular for life detection
- Microbial examination of flight hardware and cleanrooms, *ECSS-Q-ST-70-55C*
  - → Describes procedures how to measure the biological contamination (bioburden & biodiversity)
- 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/NASA

Overview of COSPAR Panel on Planetary Protection Recent activities

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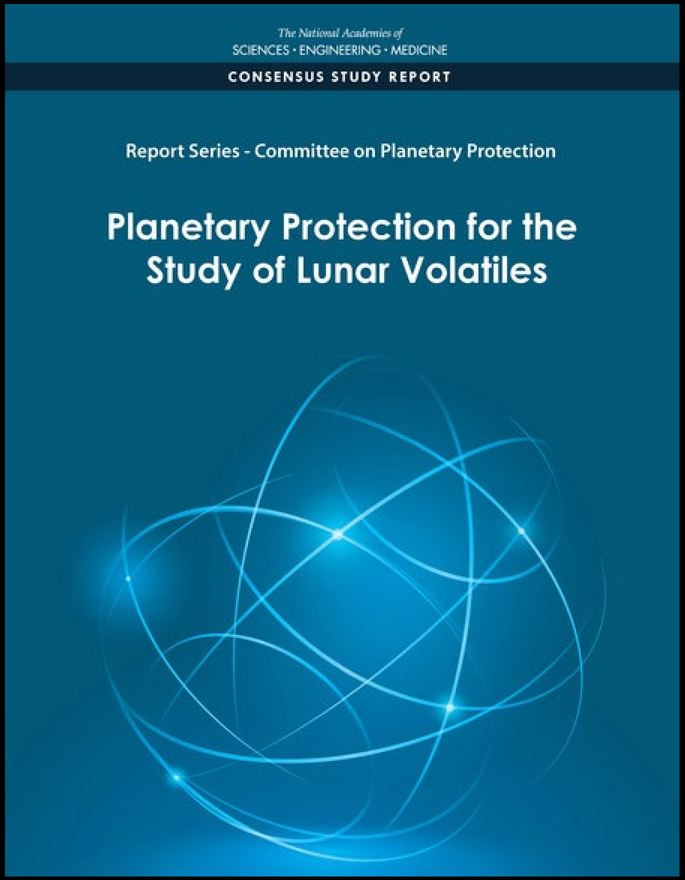
COSPAR PPP activities and in Response to CoPP reports : *the Moon*

Renewed interest in robotic and human missions to the Moon warranted a review of the current categorization and requirements



1st CoPP report on Planetary Protection for the Study of Lunar Volatiles (2020)

→ Based on ESA Planetary Protection Working Group (PPWG) advice & discussions within the Panel, COSPAR initiated stakeholder consultation

→ The PPP agreed with the findings of the CoPP's first report (2020) and used them as basis for updating the policy for the Moon

→ Results of the consultations with the community:

- There is 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

→ Result of the COSPAR stakeholder consultation, literature, as well as inputs received by LEAG, the CoPP studies and PPP meetings in 2020 and 2021 : The proposed changes were validated by the Panel and the Bureau in 2021 and an updated Policy with two new subcategories in Cat. II was issued

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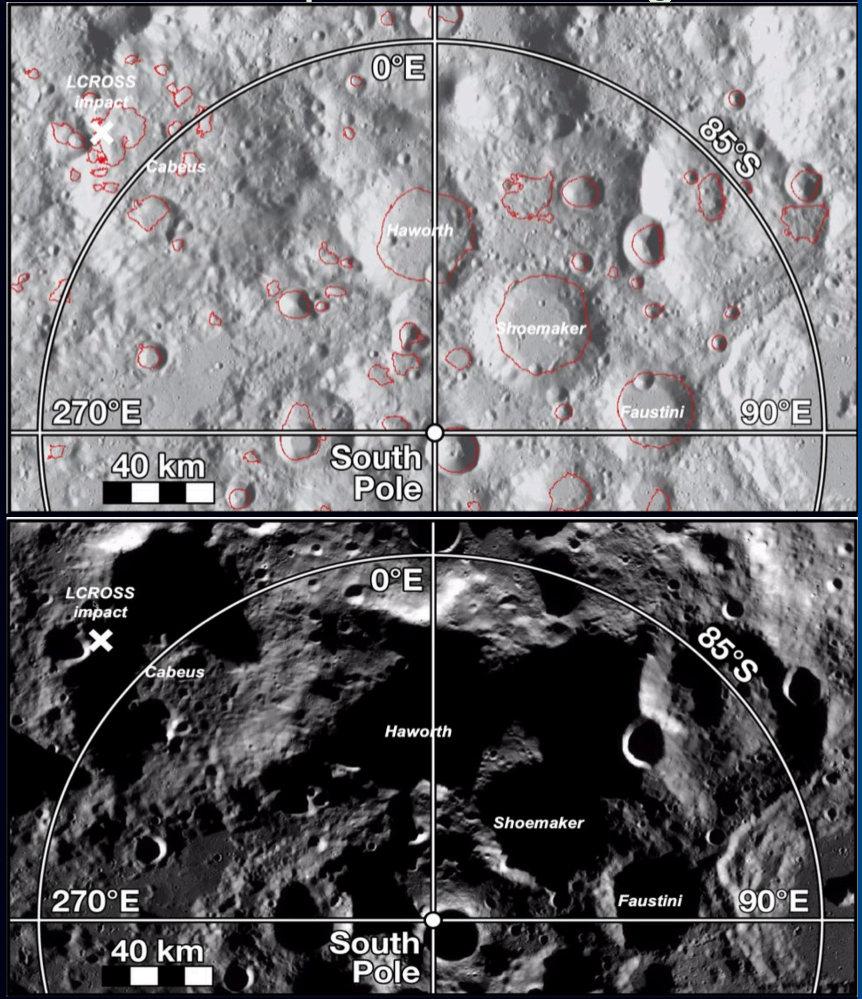
Updated planetary protection Policy for the Moon

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



Lander missions to the Moon :

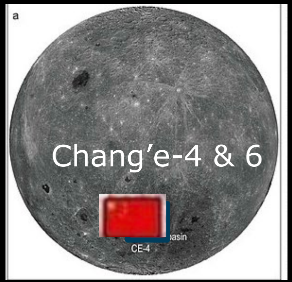
- *Category IIa*. All missions to the surface of the Moon whose nominal mission profile does not access areas defined in Category IIb shall provide the planetary protection documentation and an organic inventory limited to organic products that may be released into the lunar environment by the propulsion 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.*

Landing sites on the Moon and protected areas

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
Chang’e-6 : 41.6385°S 153.9852°W



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

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

COSPAR PPP activities and in conjunction to some CoPP reports

Small bodies and Venus

- ***No change in Planetary Protection category for small bodies***

  PPP took the 3d CoPP report into account 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.

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Planetary protection: an international concern and responsibility

Athena Coustenis[1*], Niklas Hedman[2], Peter T. Doran[3], Omar Al Shehhi[4], Eleonora Ammannito[5], Masaki Fujimoto[6], Olivier Grasset[7], Frank Groen[8], Alexander G. Hayes[9], Vyacheslav Ilyin[10], K. Praveen Kumar[11], Caroline-Emmanuelle Morisset[12], Christian Mustin[13], Karen Olsson-Francis[14], Jing Peng[15], Olga Prieto-Ballesteros[16], Francois Raulin[17], Petra Rettberg[18], Silvio Sinibaldi[19], Yohey Suzuki[20], Kanyan Xu[21] and Maxim Zaitsev[22]

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

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The COSPAR planetary protection requirements for space missions to Venus

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

- ***No change in the Planetary Protection category for Venus*** : *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.*

Missions to small bodies

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”.

A NASEM/SSB CoPP report titled “Planetary Protection Considerations for Missions to Small Bodies in the Solar System” was released in 2022 and a summary presented to the COSPAR Panel soon thereafter: *3rd CoPP report on Planetary Protection for missions to small bodies* (https://nap.nationalacademies.org/download/26714).

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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.

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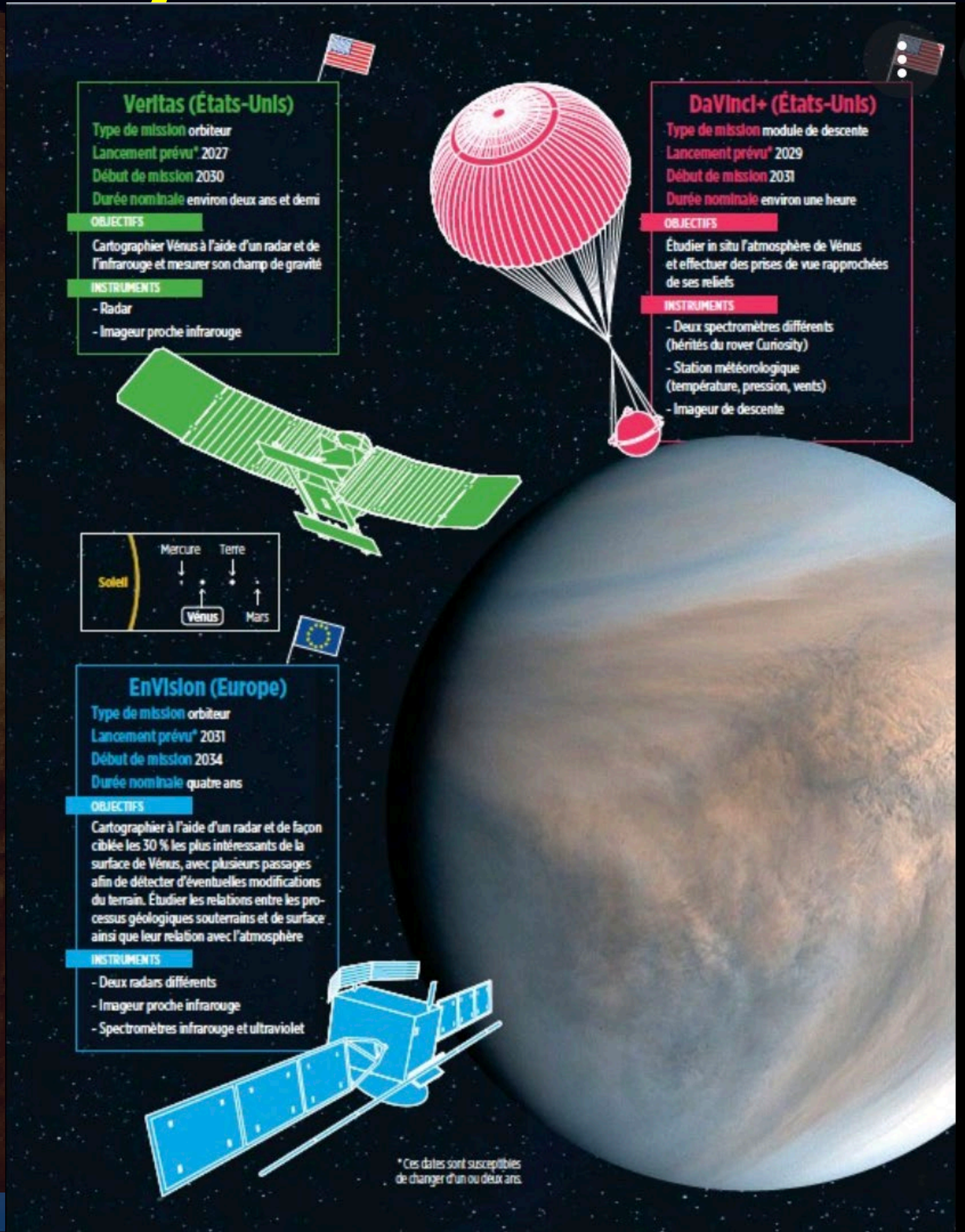
Venus habitability?

- <u>COSPAR PPP meeting : Feb. 2021</u>
- <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.



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.

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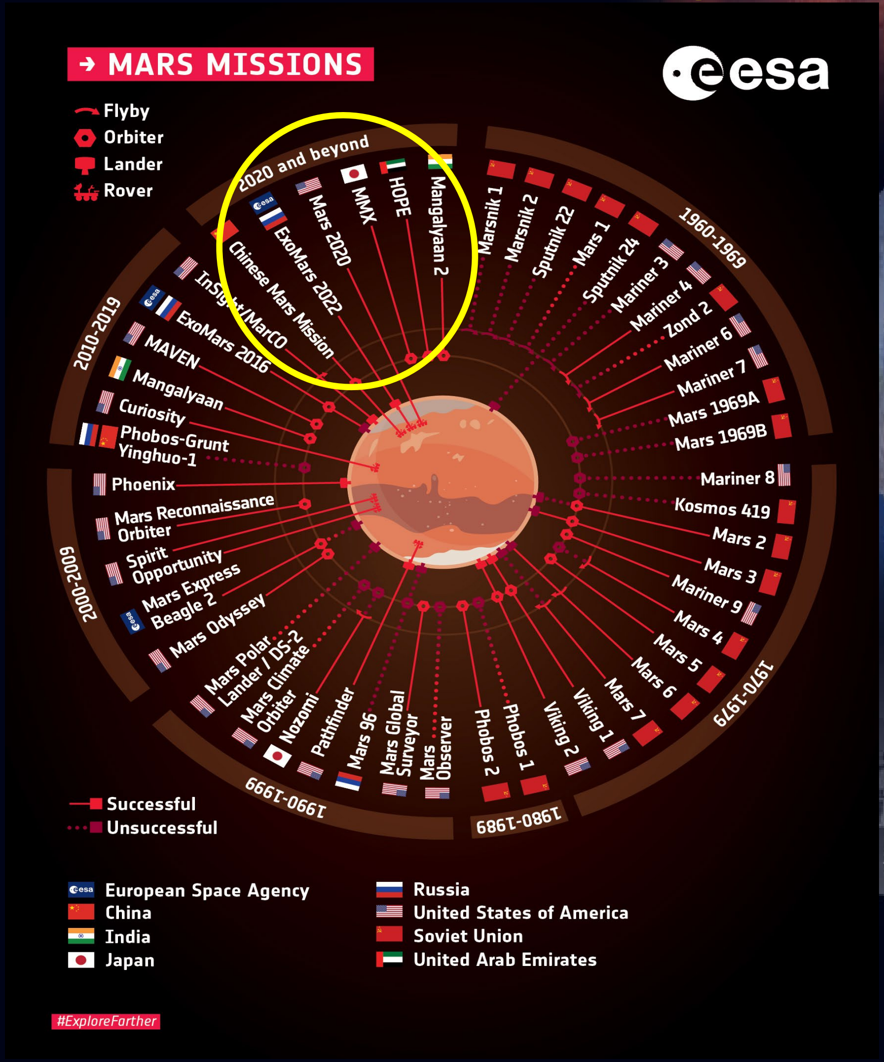
Based on the existing literature, we conclude that the environmental conditions within the Venusian clouds are orders of magnitude drier and more acidic than the tolerated survival limits of any known terrestrial extremophile organism. Because of this future orbital, landed or entry probe missions to 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

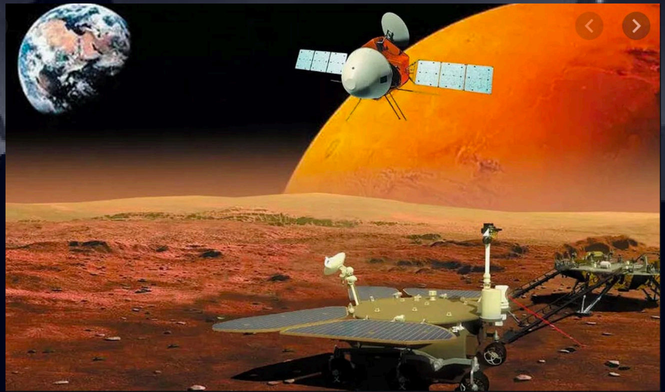
Zorzano Meier et al., 2023. LSSR 37, 18-24

Mars and its moons (sample return era)



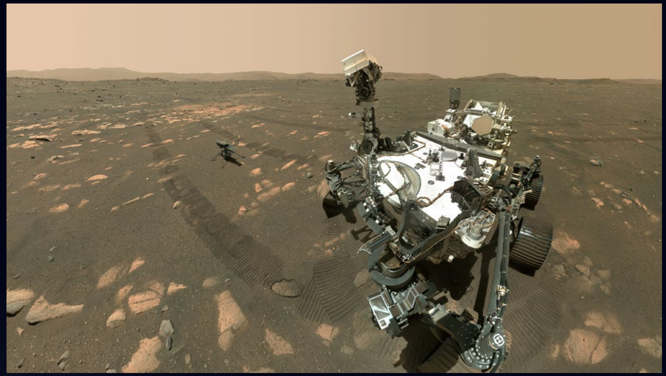
Al-Amal (Hope) – UAE
since 9 Feb. 2021

Tianwen-1 – China
since 10 Feb. 2021

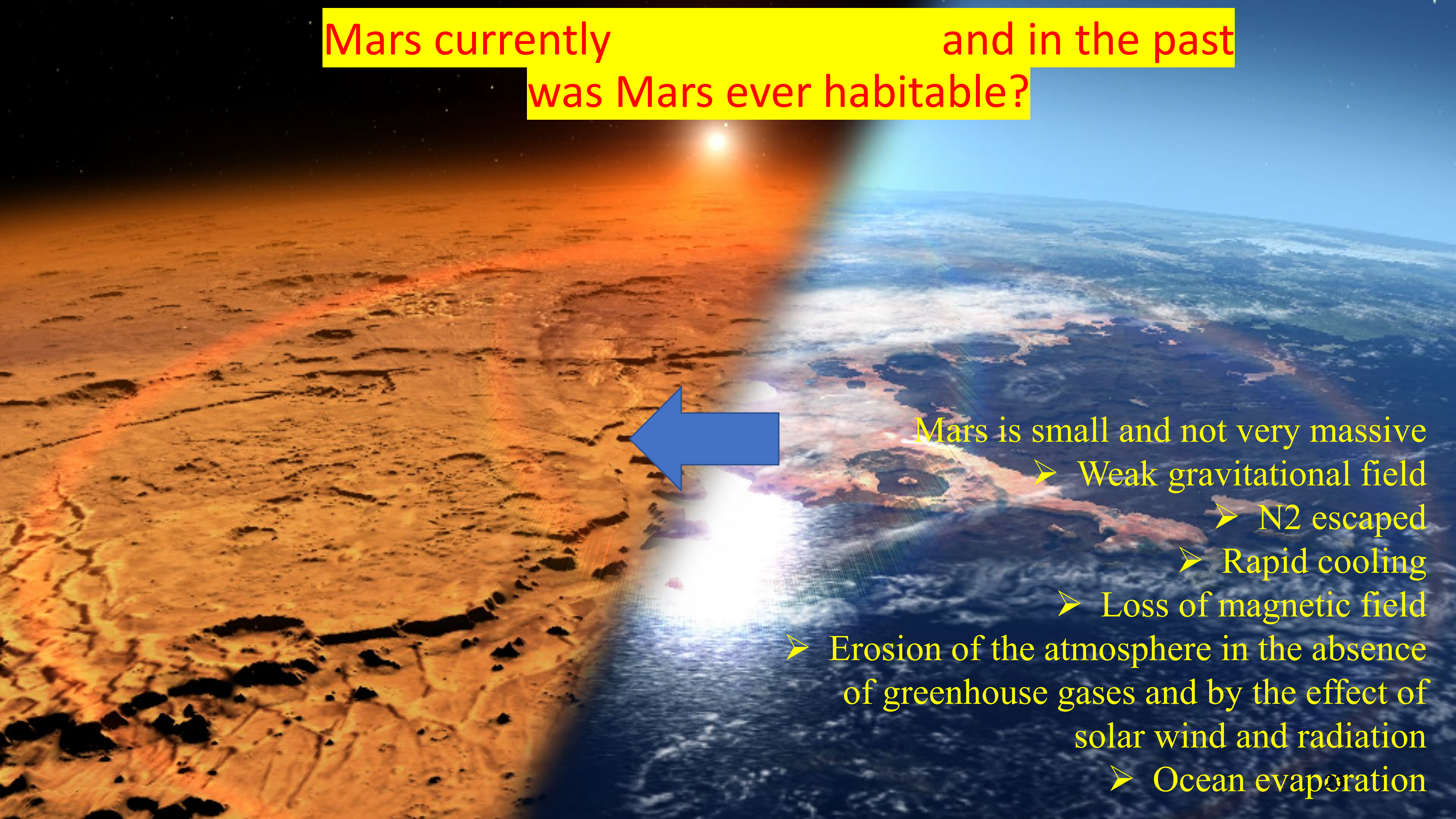


TGO-ESA – since 2016

Mars 2020/
sinc



Mars currently and in the past was Mars ever habitable?



Mars is small and not very massive

- Weak gravitational field
- N2 escaped
- Rapid cooling
- Loss of magnetic field
- Erosion of the atmosphere in the absence of greenhouse gases and by the effect of solar wind and radiation
- Ocean evaporation

2nd CoPP report: "Evaluation of Bioburden Requirements for Mars Missions"

The *CoPP report* is an in-depth contribution to the field of Mars planetary protection, especially on : Proliferation vs survival, in agreement with COSPAR policy and all past analysis of Special Regions (*e.g. Rummel et al. 2014*); Risk analysis is straightforward ; Focus on biocidal effects of the Martian surface and transport

A PPP subcommittee was formed to work on the Policy requirements for Mars exploration : K. Olsson-Francis, P. Doran, V. Ilyin, F. Raulin, P. Rettberg, M-P. Zorzano Meier. *It focused on two findings :*

Finding 2: The environment on Mars makes the survival, growth, and proliferation of terrestrial organisms on the surface, or suspended in the atmosphere, highly unlikely. However, transport of viable terrestrial organisms to potentially habitable subsurface environments, such as caves, creates a risk of harmful contamination.

Finding 4: Microbial transport and proliferation are highly unlikely in disconnected subsurface environments. Thus, relaxed bioburden requirements could be appropriate for missions that do not access the subsurface, or for missions that access the subsurface where no evidence of ice exists. Exceptions to this finding include buffer zones around subsurface access points and sites of astrobiological interest.

Some PPP observations (1)

- We do need to consider "modernizing" planetary protection requirements for Mars exploration (review new literature of observations and experiments, apply new techniques as they become available), especially for future human missions, but ***several areas of knowledge gaps*** identified.
- We agree with the CoPP report's findings *(Summary)*, i.e. "*planetary protection protocols aimed at avoiding contamination remain necessary to prevent compromising future investigations of extraterrestrial life. In addition, despite the increase in scientific information about Mars, much about its surface and subsurface remains underexplored, creating the need for caution in avoiding contamination harmful to future scientific investigations of extinct or extant life on Mars.*»
- PPP and CoPP findings thus agree on the need for increasingly urgent new information on several items pertaining to the survival, growth and proliferation of living organisms on Mars.
- The **PPP subcommittee of experts** assigned with the task to review the CoPP report in view of future adjustments to the COSPAR PP Policy for Mars put forward comments on the survivability of the microbes, the transport of *viable cells and spores* through the atmosphere and whether microorganisms can survive in the *water absorbed in salts*

Some PPP observations (2)

- In view of the above, the PPP subcommittee contended that there is **neither sufficient new evidence in the literature nor community consensus** to conclude that *"survival, growth, and proliferation of terrestrial organisms on the surface, or suspended in the atmosphere is highly unlikely (Finding 1)"*.
- It is possible that there are **many places to hide** on the geologically complex Martian surface, beyond just caves with openings visible from space.

Urgent need for data : in situ high-resolution meteorological data at the regional and global scale from Mars and ground-based testing (doesn't come for free…). Both aspects are not available yet, none of the current missions provide that.

As a first step, input from the community so as to identify needs and lead to a better understanding of such aspects of Martian exploration and to accordingly adapt the current Policy for Planetary Protection, the PPP invited collaboration with CoPP and other entities to promote, organize and sponsor studies, workshops and other activities as necessary. Findings were published.

The COSPAR planetary protection Policy for robotic missions to Mars

COSPAR
COMMITTEE ON SPACE RESEARCH

- 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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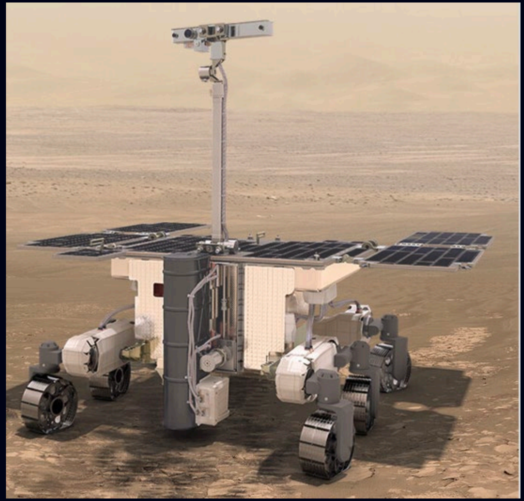
The COSPAR Planetary Protection Policy for robotic missions to Mars: A review of current scientific knowledge and future perspectives

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]

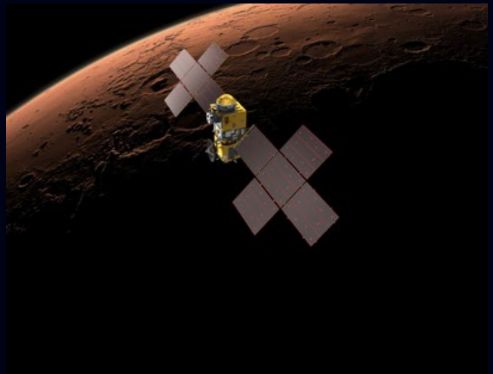
The COSPAR Panel on Planetary Protection will continue to work with the different national and international space agencies, the scientific community, and other stakeholders (e.g., the private sector and industry) to develop a roadmap for coordinating research activities addressing the identified knowledge 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

COSPAR PPP Mars-related recent activities



- ***Mars Robotic missions*** : Although the science underpinning the Policy is advancing, as highlighted in recent reports (e.g. NASEM 2021, Spry et al. 2021) and in the Panel's work, there are still several knowledge gaps that need to be addressed before they can be directly applied to accommodate the interest of the user. They 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*



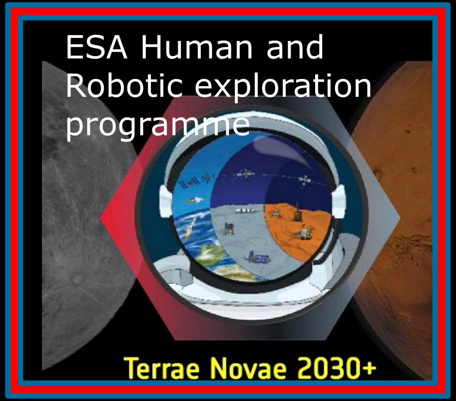
- ***Mars sample return and JAXA's Martian Moon Explorer (MMX)***: return of sample from Phobos (launch in 2026) : assigned planetary protection Cat. III for outbound and Cat V inbound : unrestricted Earth return.

See special issue *Life Sci. Space Res. 23 (2019)*

- ***Mars Crewed missions*** : Series of Workshops with COSPAR support.

A publication highlights the scientific measurements and data needed for knowledge gaps closure.

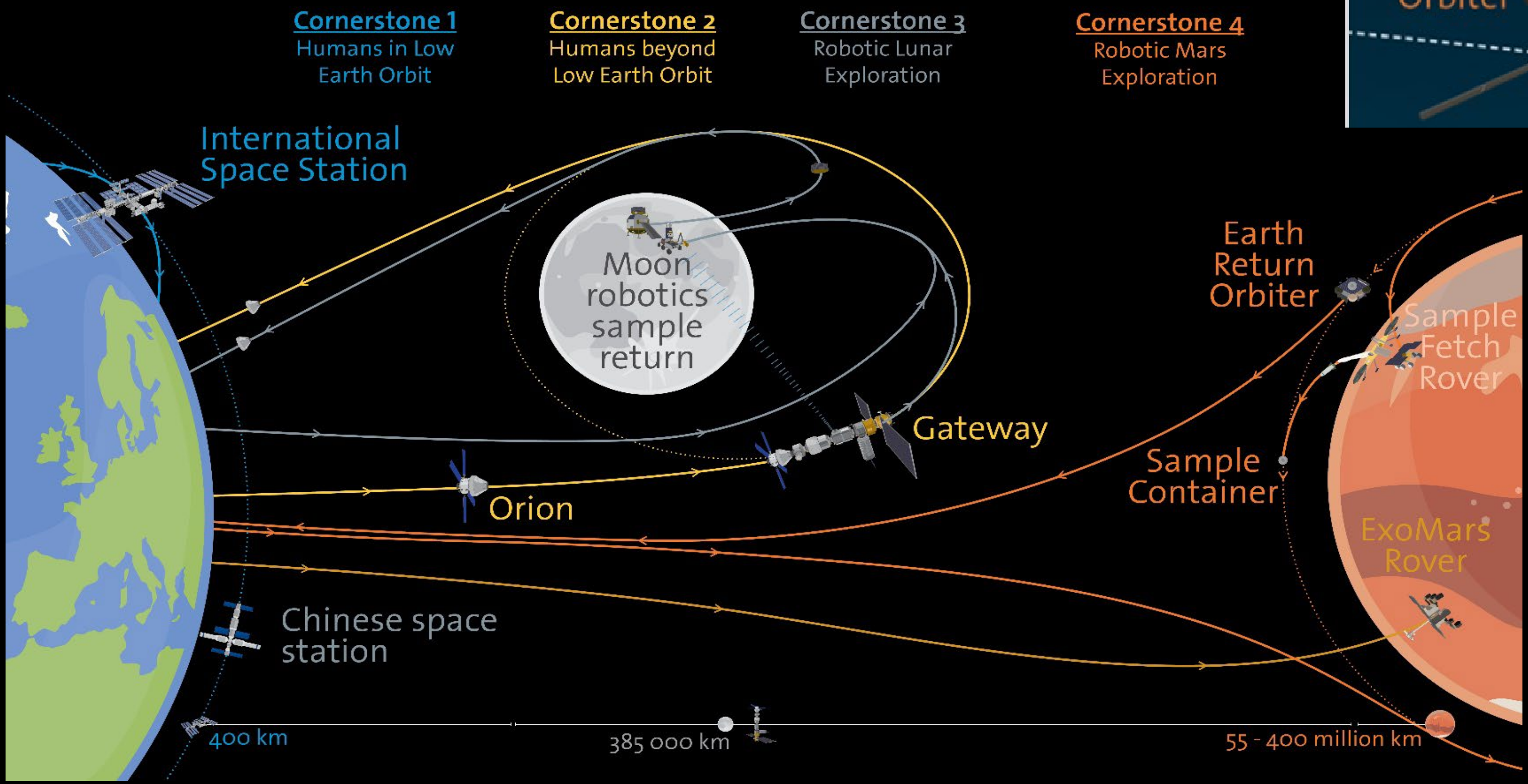
Spry et al. (2024, Astrobiology, 24(3):230-274. doi: 10.1089/ast.2023.0092)



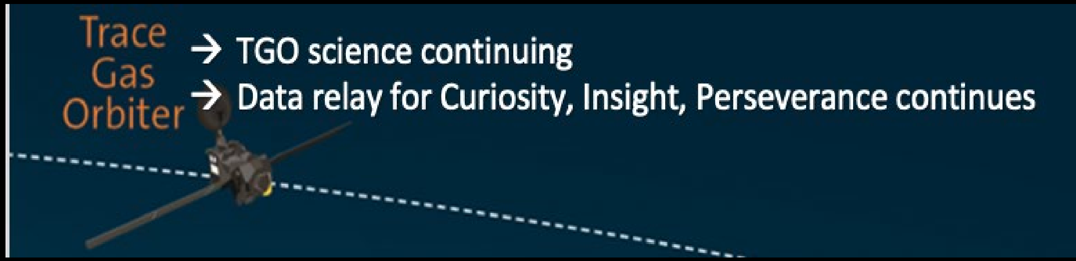
Future exploration of Mars

ESA’s Human and Robotic Exploration (HRE) programme

Missions to LEO, Moon and Mars like ExoMars/TGO (in operation); Rosalind Franklin Rover (to launch in 2028) and contributions to the MSR

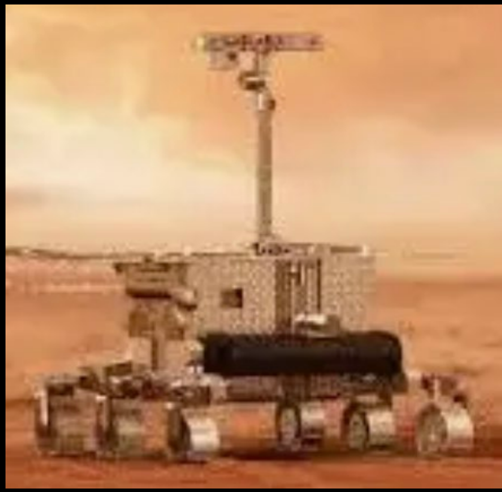


ESA’s ExoMars programme



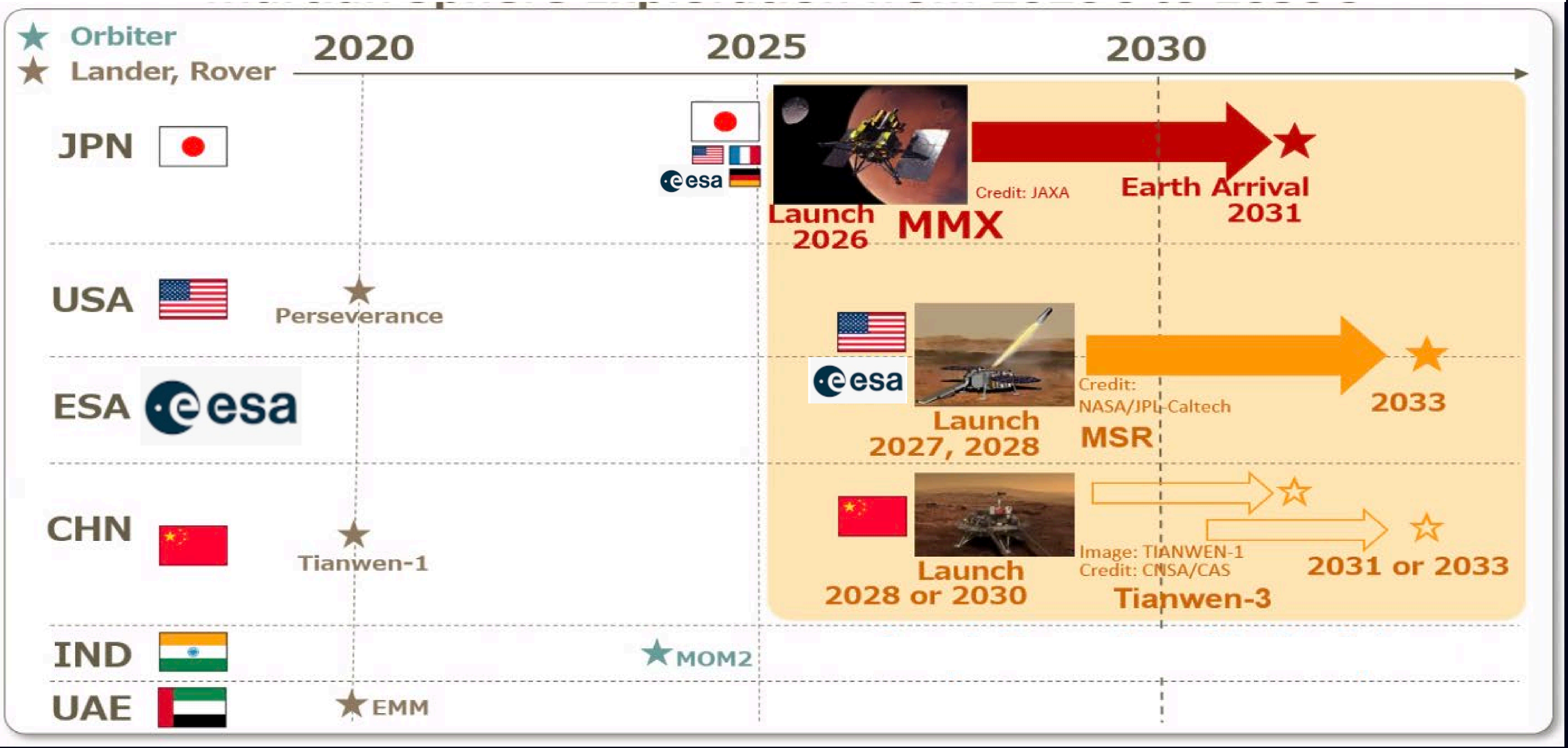
Rosalind Franklin Rover

2028: launch of the Rosalind Franklin Rover to Mars



European Space Agency

Martian & Moons exploration: sample return era



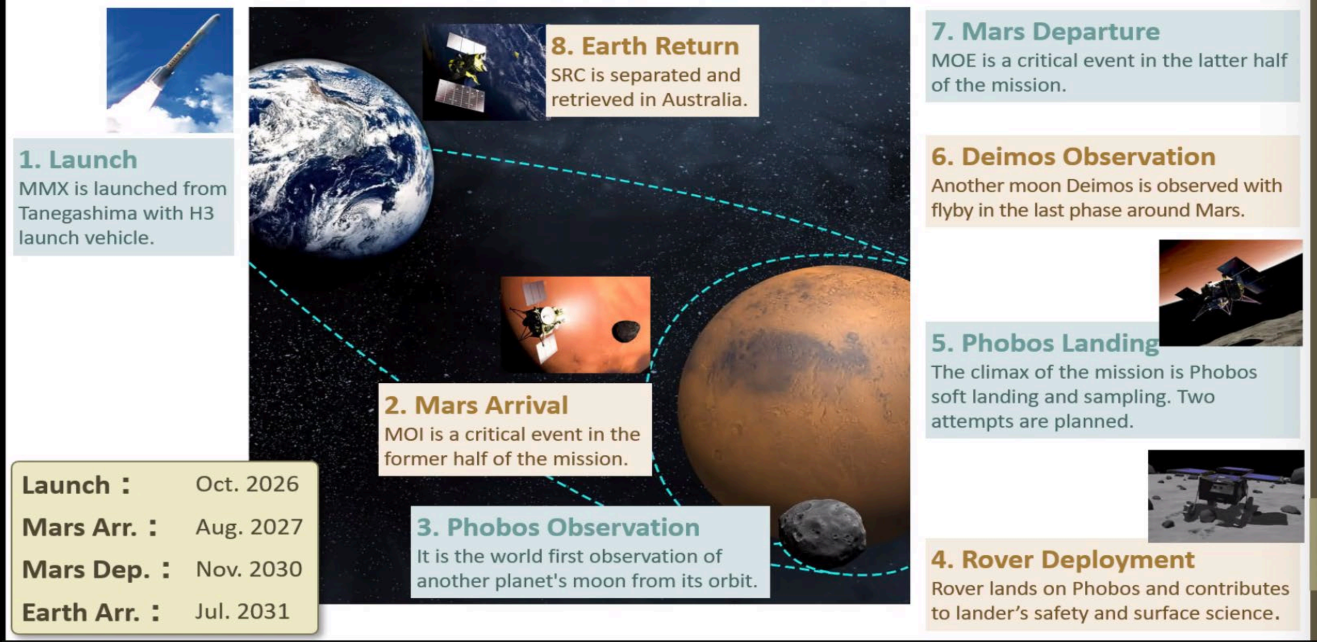
JAXA: Martian Moons eXploration

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.

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.



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: New aspects of policy and requirements", 2019. ***Life Sci. Space Res.*** *23*

JAXA's MMX mission PP categorisation
Sample return from Phobos

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→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

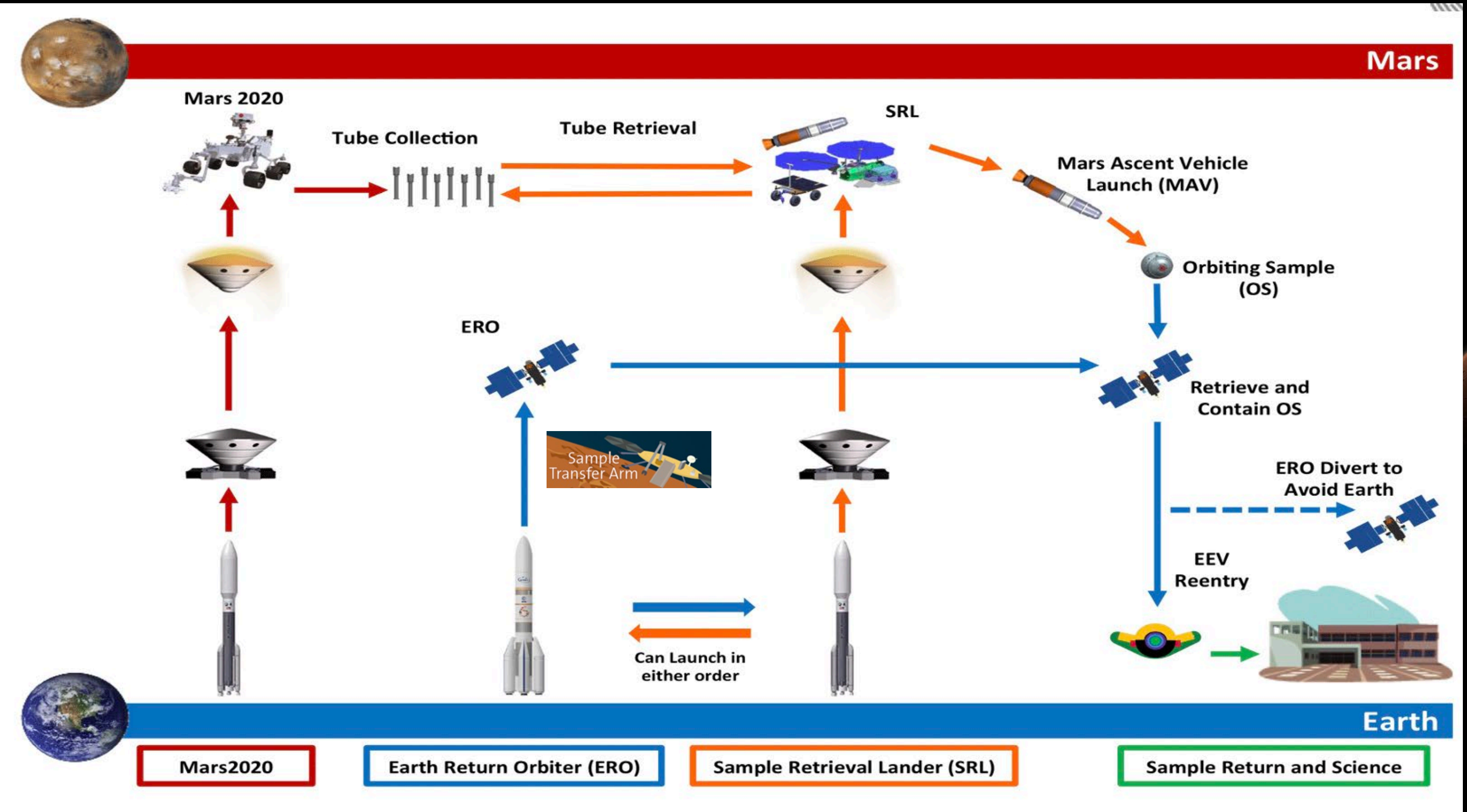
Conclusions based on the studies supported by ESA-JAXA-NASA :

1. Microbial contamination probability of collected samples from the Martian moons can be reduced to less than 10^{-6} (REQ10) by choosing appropriate sampling approaches. For example,
   a. To collect 100-g samples with a restriction of boring depth <5cm.
   b. To avoid recent craters when samples are collected.
   c. To limit the collected mass of samples below 30g (no restriction on sampling depth).
   d. Flight hardware assembly in ISO Level 8 cleanrooms.
2. Martian meteorites transported from Mars to Earth in the past 1 Myr have microbial contamination probability much higher by orders of magnitude (10^3 or more) than that of 100-g samples taken from the Martian moons. This means that natural influx equivalent to samples from Martian moons is continuously and frequently transported to the surface of the Earth.

*Compliance with the JAXA's Planetary Protection Standard that fully conforms to COSPAR PP Policy. Because of the above reasons, sample return from the Martian moons can be classified as **Unrestricted Earth Return**, provided that the total mass of samples is limited within 100 kg.*

*"Planetary protection: New aspects of policy and requirements", 2019. **Life Sci. Space Res.** 23*

NASA-ESA Mars generational exploration : the Mars Sample Return Campaign



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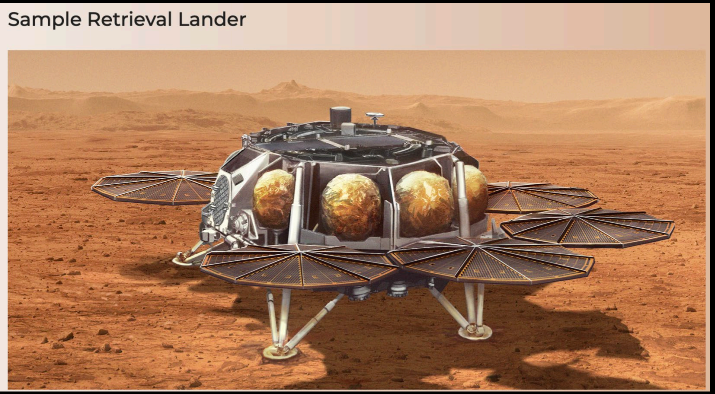
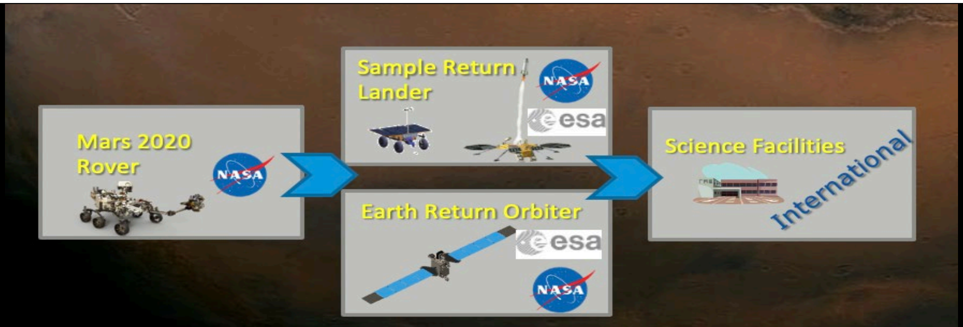


SRL

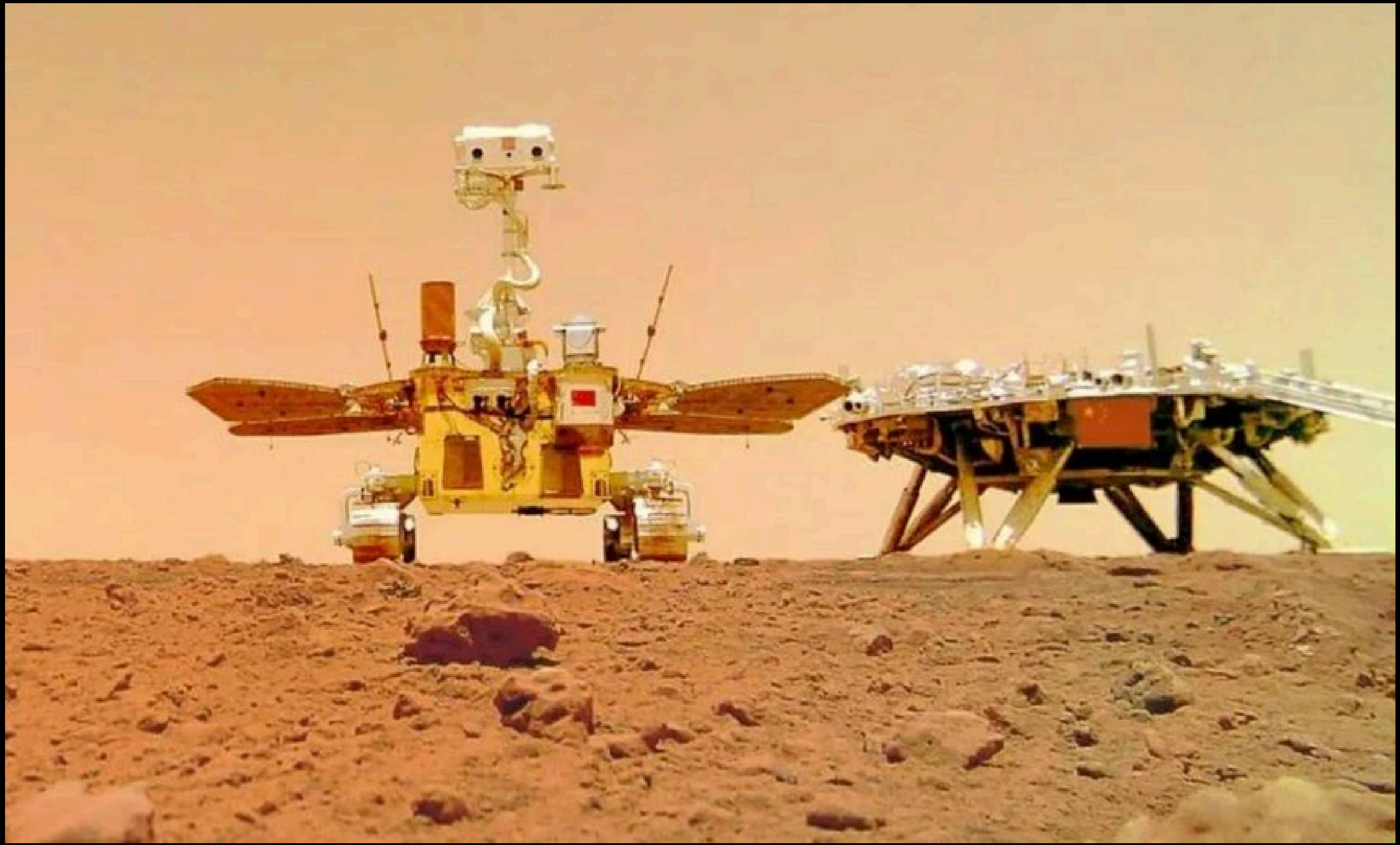


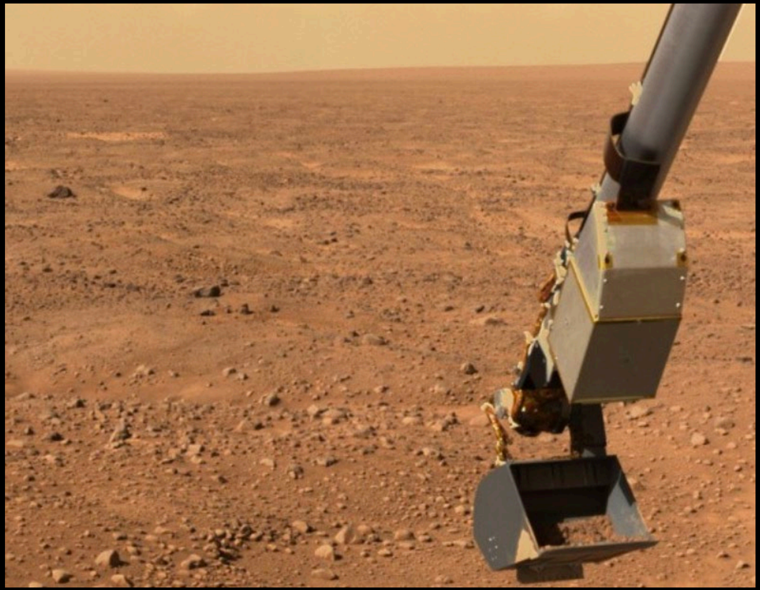
Strong collaboration between NASA and ESA

CAST : Tianwen-3 mission for Mars sample return

中国行星探测
Zhōngguó Xíngxīng Tàncè

中国行星探测
PEC
Emblem of Planetary Exploration of China
Reaching for the Planets





Two spacecraft (an orbiter/Earth-returner and a lander/ascent-vehicle) via two separate launches in 2028-2030 to Mars. Together, the two spacecraft will seek to obtain samples of Martian rocks and soil and then return the cached samples to Earth. The mission architecture is similar to MSR.

CAST has informed the PPP that all the PP measures applied to this mission are following COSPAR Policy guidelines

Planetary protection requirements for sample return from Mars : Cat V “Restricted Earth return”

- Unless specifically exempted, the outbound leg of the mission shall meet Category IVb requirements
- Unless the samples to be returned from Mars are subjected to an accepted and approved sterilization process, the canister(s) holding the samples returned from Mars shall be closed, with an appropriate verification process, and the samples shall remain contained during all mission phases through transport to a receiving facility where it (they) can be opened under containment
- The mission and the spacecraft design must provide a method to “break the chain of contact” with Mars, i.e. no uncontained hardware that contacted Mars, directly or indirectly, shall be returned to Earth
- Reviews and approval of the continuation of the flight mission shall be required at three stages: 1) prior to launch from Earth; 2) prior to leaving Mars for return to Earth; and 3) prior to commitment to Earth re-entry.
- For unsterilized samples returned to Earth, a program of life detection and biohazard testing, or a proven sterilization process, shall be undertaken as an absolute precondition for the controlled distribution of any portion of the sample

Sample Safety Assessment Framework

The COSPAR Sample Safety Assessment Framework (SSAF) was developed by a COSPAR appointed working group.

Purpose : evaluate if the presence of martian life can be excluded in samples returned by a mission to the red planet. The SSAF started from a positive hypothesis, which is complementary to the science null-hypothesis, and included four elements *(Kminek et al., 2022):*

1) Bayesian statistics, 2) subsampling strategy, 3) test-sequence, and 4) decision criteria.

The test-sequence capability covered self-replicating and non-self-replicating biology and biologically active molecules.

The SSAF is described at a level of detail to support planning activities for a Sample Receiving Facility (SRF) and for preparing science announcements, while at the same time acknowledging that further work is required before a detailed Sample Safety Assessment Protocol (SSAP) can be developed."

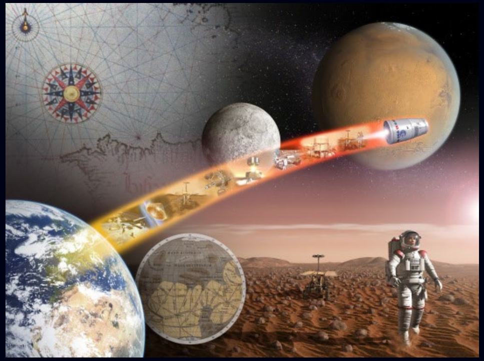
In order to effectively implement and optimize the SSAF three major open issues it is necessary to:

1) set a level of assurance to exclude the presence of martian life in the samples,
2) carry out an analogue test program, and
3) acquire relevant contamination knowledge from all future missions (like the Mars Sample Return) flight and ground elements.
4) The report from these proceedings was published in Astrobiology *(Kminek et al., 2022).*

Principles for human missions to Mars

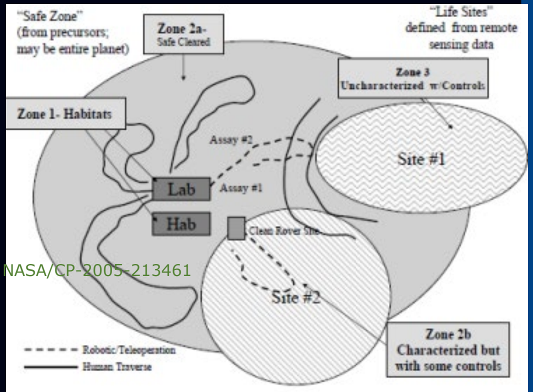
- ❑ The intent of the planetary protection policy is the same whether a mission to Mars is conducted robotically or with human explorers
- ❑ Planetary protection goals should not be relaxed to accommodate a human mission to Mars, i.e. they become even more directly relevant to such missions—even if specific 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

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.



Credit: ESA

Credit: NASA/Apollo 12



Credit: NASA/CP-2005-213461

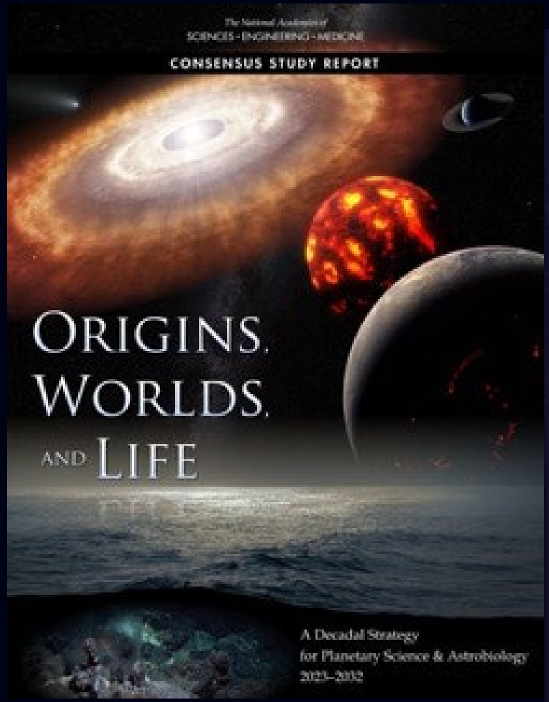
Mars Human exploration

- 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/.
- 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)*
- A report was issued after the June 2022 COSPAR-NASA Meeting on "Planetary Protection Knowledge Gaps for Crewed Mars Missions" and represented the completion of the 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 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 were published in *Spry et al. (2024, Astrobiology, 24(3):230-274. doi: 10.1089/ast.2023.0092)* with COSPAR support. This paper highlights the scientific measurements and data needed for knowledge gap closure.

Current and future considerations

After Venus, Mars Robotic exploration and small bodies…

- More Mars… (MSR, ExoMars, crewed missions etc…)
  - *New review of knowledge gaps*
- Implementation of Icy Worlds findings in Policy
- Updates to the Policy for case-by-case assessment
- Space resources (ISRU), other matters



Mimas

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

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Icy Worlds
(not a cold case…)

Europa Clipper objectives

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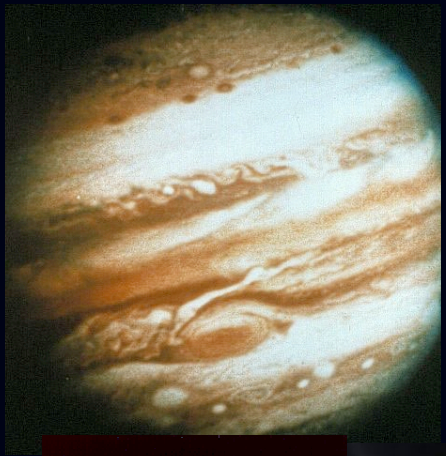
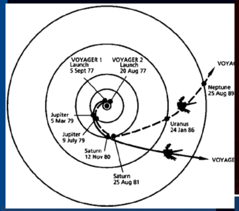
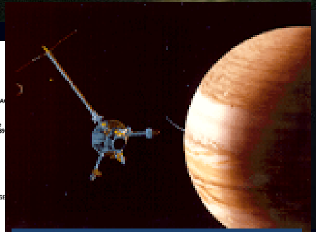
Giant planets and icy moons



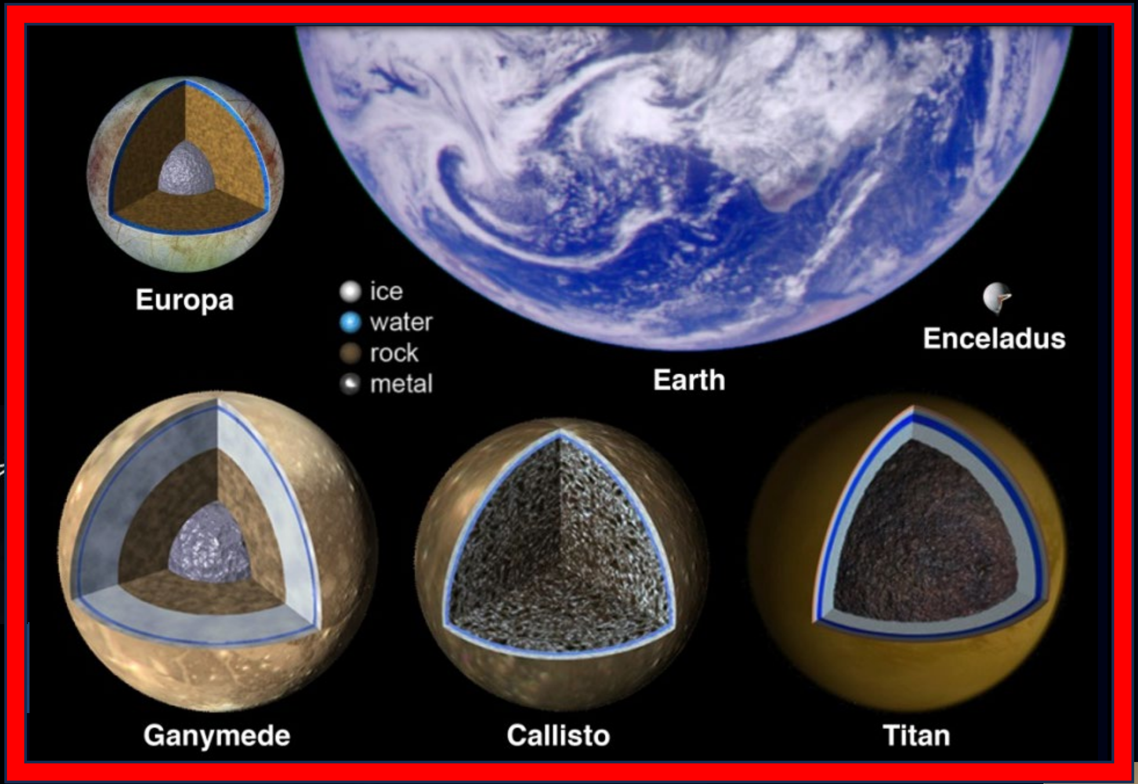


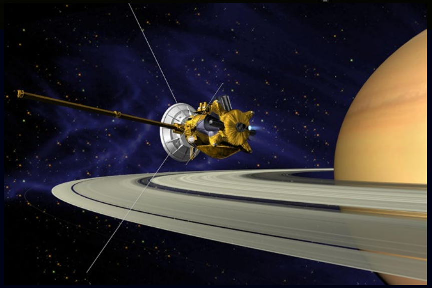
Voyager
1980s



Galileo
1995-2000

JUNO
2016-

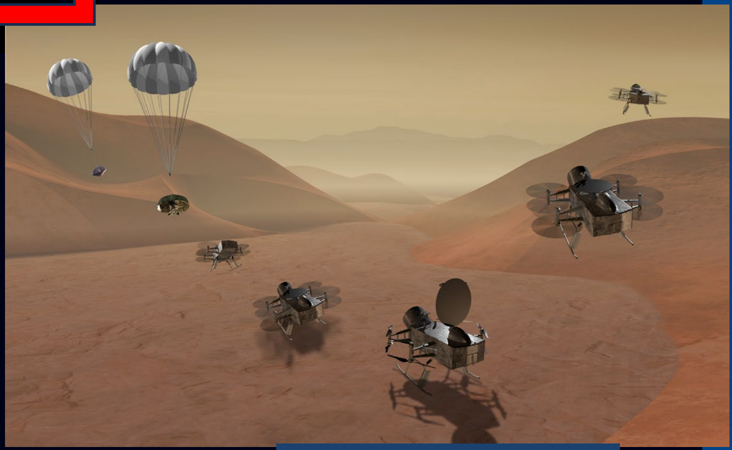




Cassini-Huygens
2004-2017

JUICE
Launched: April 2023

Europa Clipper
Launched Oct. 2024



Dragonfly
Launch: 2028

Planetary Protection of the Outer Solar System (PPOSS)

COSPAR
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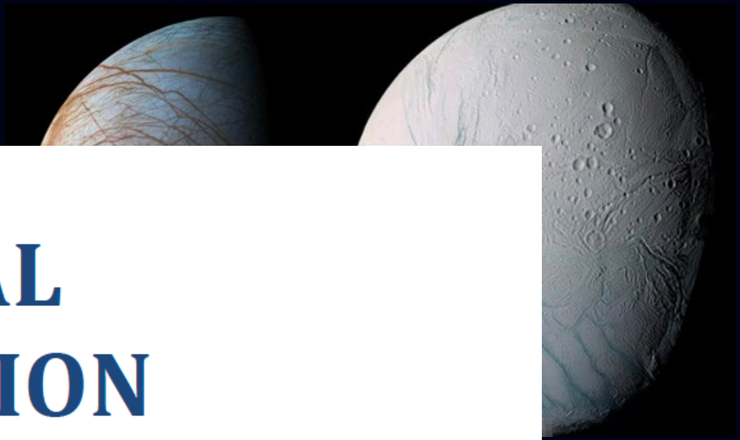
the EC with...
Technology/...
Academy of...

- Recommend... requirement... based partly... an ESA PPW...
- COSPAR wa... process and... missions to ...



...celadus

...definition of the ...entially allowing Earth

...ould be more specific

...ould be updated to ... exploration of

...ould acknowledge the ...ed Downward ...e of Europa and Enceladus.

...JPL/Cassini

THE INTERNATIONAL PLANETARY PROTECTION HANDBOOK

by

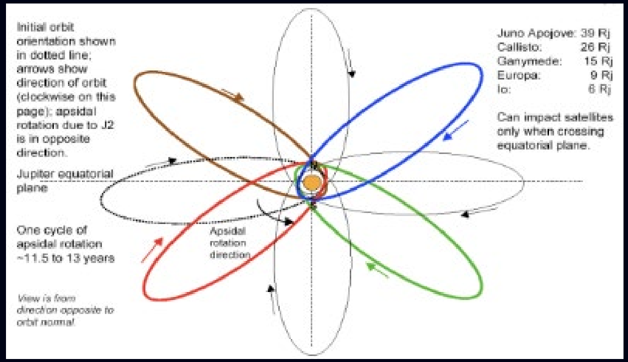
Gerhard Kminek (ESA, Noordwijk, The Netherlands), Jean-Louis Fellous (COSPAR, France), Petra Rettberg (DLR, Germany), Christine Moissl-Eichinger (Medical Univ. Graz, Austria), Mark A. Sephton and Samuel H. Royle (Imperial College London, UK), J Andy Spry (SETI Institute, CA, USA), Hajime Yano (ISAS/JAXA, 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

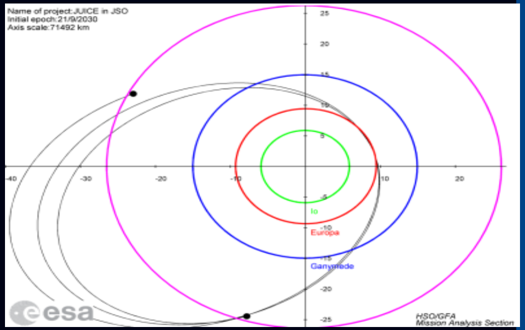
& The Internl PP Handbook: Dec. 2018

Planetary protection requirements Missions in the Jovian system

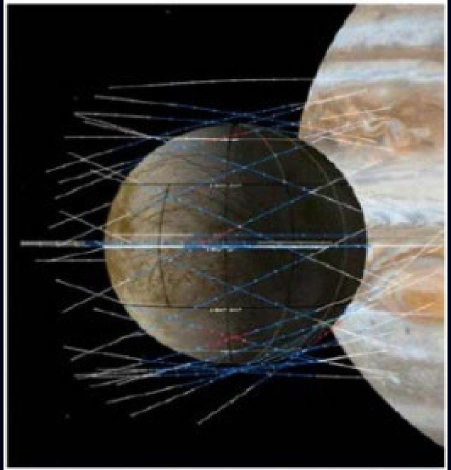
On site : **JUNO**: orbiter; main mission target is Jupiter; probabilistic risk assessment for final Jupiter de-orbit manoeuvre, assessment of sterilisation in natural Jovian environment, assessment of sterilisation during high velocity impact: Cat. II



En route (launched April 2023): **JUICE**: orbiter; main mission target is Ganymede, with 2 Europa fly-bys using Callisto transfers; reliability assessment for spacecraft failure, assessment of problematic species on flight hardware, assessment of sterilisation in natural Jovian environment : Cat. II* -> Cat. II



En route (launched Oct. 2024): **EUROPA CLIPPER**: orbiter; main mission target is Europa, with 45 Europa fly-bys; bioburden control of spacecraft before launch, assessment of sterilisation during flight : Cat. III



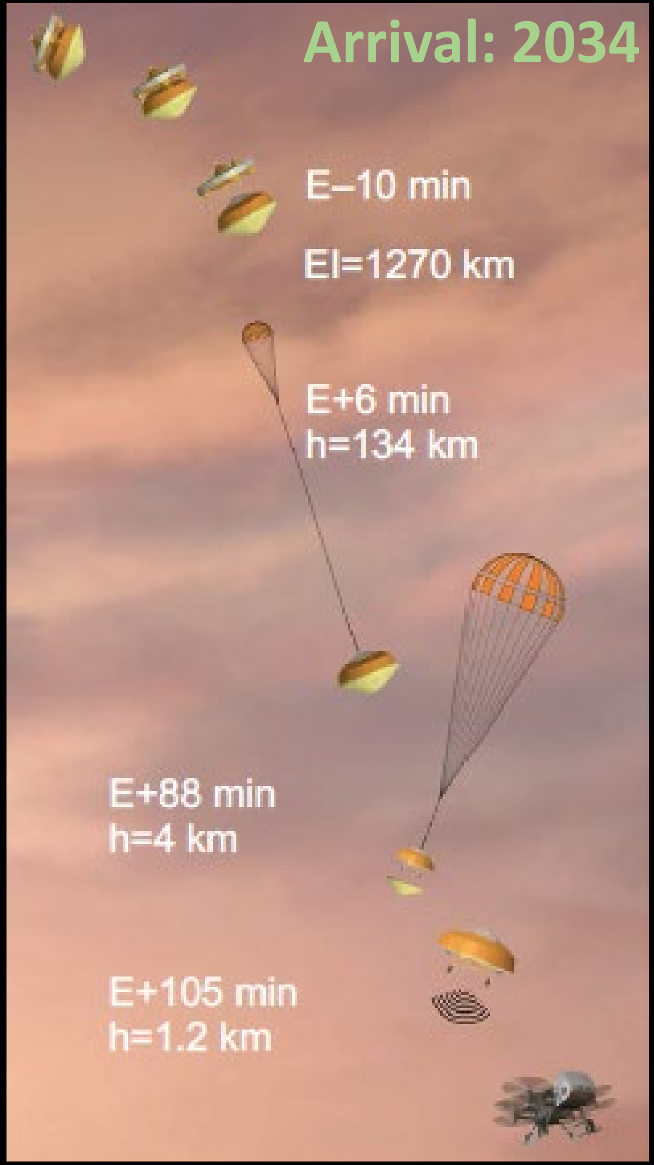
Categorisation of the Dragonfly mission to Titan

Review of the Planetary Protection Approach

Launch: 2028

Arrival: 2034

- Per NASA's planetary protection policy (NASA Procedural Requirements 8715.24), Dragonfly needs to comply with implementation requirements that are intended to prevent the organic and biological contamination of Titan, based on the best available scientific understanding of that possibility. This is intended to address the categorization of missions promulgated by the COSPAR Policy.
- After a careful and extensive review of the current scientific literature on Titan's atmospheric and geological processes, the authors of the internal NASA report provided several "findings" to be addressed in the proposal for the planetary protection plan for the Dragonfly mission, in order to provide a more comprehensive analysis of risks: most important risk is that bioburden could be transported from Dragonfly to habitable regions (e.g., the ocean)
- By considering various possible transport processes that could move material from Titan's surface to its subsurface liquid water ocean, the Dragonfly Proposal concluded that terrestrial microbes, if able to survive both the high temperatures experienced during entry and the profoundly cold temperatures on Titan's surface, would have a probability of less than 10^{-4} of reaching the ocean resulting in Dragonfly mission being classified in Category II.



Future exploration of Icy Worlds

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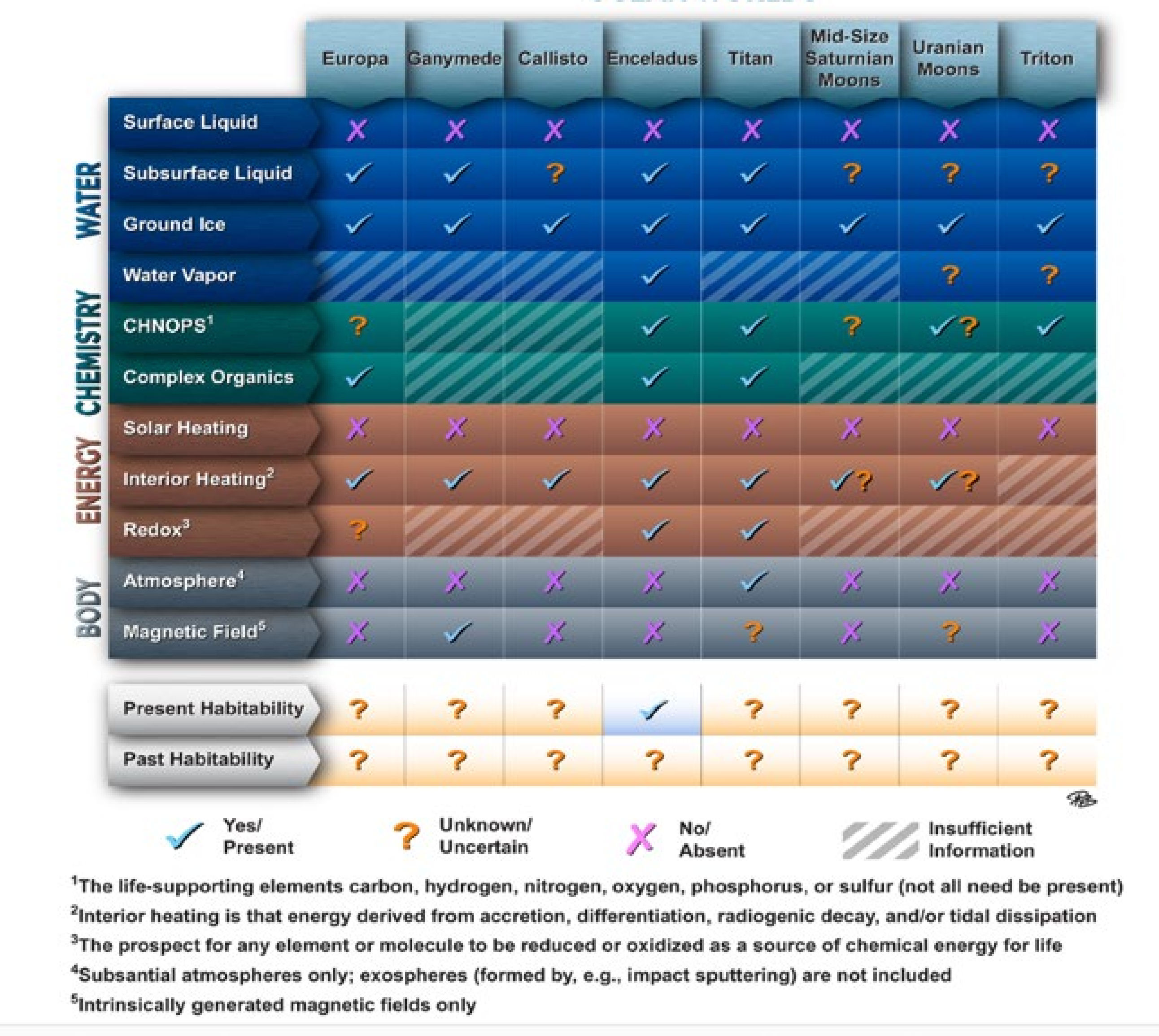
After the PPOSS study (*The Internl PP Handbook (Dec. 2018) ; & "Planetary protection: New aspects of policy and requirements" (2019) in Life Sci. Space Res. 23 & Space Res. Today 208 (2020)*) a Panel subcommittee considered the future exploration of Icy Worlds and Ceres

The Panel has been working on a thorough review of the current knowledge for Icy Moons+Ocean Worlds (**Icy Worlds**: *"Icy Worlds in our Solar System are defined as all bodies with an outermost layer that is believed to be greater than 50% water ice by volume and have enough mass to assume a nearly round shape."*) and is making proposals for a better coverage in the Policy

Findings were presented in different meetings and congresses and published

(Doran et al., 2024, LSSR, 41 pp. 86–99)



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

✓ Yes/ Present | ? Unknown/ Uncertain | X No/ Absent | (hatched) Insufficient Information

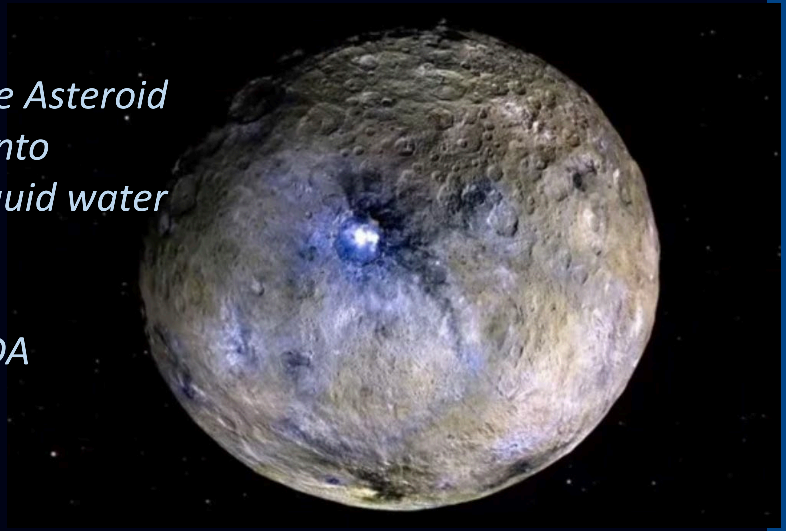
[1]The life-supporting elements carbon, hydrogen, nitrogen, oxygen, phosphorus, or sulfur (not all need be present)
[2]Interior heating is that energy derived from accretion, differentiation, radiogenic decay, and/or tidal dissipation
[3]The prospect for any element or molecule to be reduced or oxidized 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

Future exploration of Icy Worlds: Ceres

- While Ceres' outermost layer composition likely does not meet the >50% water ice requirement to be considered by the above definition, we include it in our policy discussions as it shares many of the characteristics and exploration objectives of the other Ocean Worlds – *Doran et al. 2024*
- A concern with Ceres was that current knowledge suggests that there are regions of Ceres' surface and near-subsurface that may not be predominantly composed of water ice, and water activity at the near surface in these regions may be below the LLAw.

Ceres, a dwarf planet in the Asteroid Belt, may be still holding onto pockets of a subsurface, liquid water ocean.
Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA



There is community consensus that Ceres is an icy body with an outermost layer that is predominantly water ice by volume. We note that from a policy perspective, categorizing Ceres as an Icy World represents a conservative approach. This classification focuses solely on temperature, without accounting for water activity, thereby limiting the identification of environments suitable for terrestrial organism replication. **We now include Ceres as an Icy World**

(Doran et al., 2024, LSSR, 41 pp. 86–99 and 2025, in preparation)

Missions to Icy Worlds (findings)

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COMMITTEE ON SPACE RESEARCH

Doran et al., 2024.

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

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

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

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

- Establish indices for the lower limits of Earth life wit 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)
- 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.

COSPAR POLICY ON PLANETARY PROTECTION

Prepared by the COSPAR Panel on Planetary Protection and approved by the COSPAR Bureau on 3 June 2021.

5. Environmental conditions for replication

Given current understanding, the physical environmental parameters in terms of water activity and temperature thresholds that must be satisfied at the same time to allow the replication of terrestrial microorganisms are:

− Lower limit for water activity: 0.5 (record was 0.62, now 0.585)

− Lower limit for temperature: -28˚C (10 degree buffer)

These numbers are based on exhaustive literature review made by MEPAG SR-SAG2 (Rummel et al. 2014), with follow-on reviews by a COSPAR Colloquium (Hipken and Kminek 2015) and U.S. National Academies/European Science Foundation joint panel (Rettberg et al. 2016)

LLAw = 0.5

LLT = -28°C

It’s all about temperature and connectivity

- Europa (Jupiter) clear evidence of connection on some timescale to fluids beneath
  T_{surf}=-143^{o}C (midday at equator, colder toward poles / other times)

- Enceladus (Saturn) plumes indicating connection
  T_{surf}=-193^{o}C (midday at equator, colder toward poles / other times)

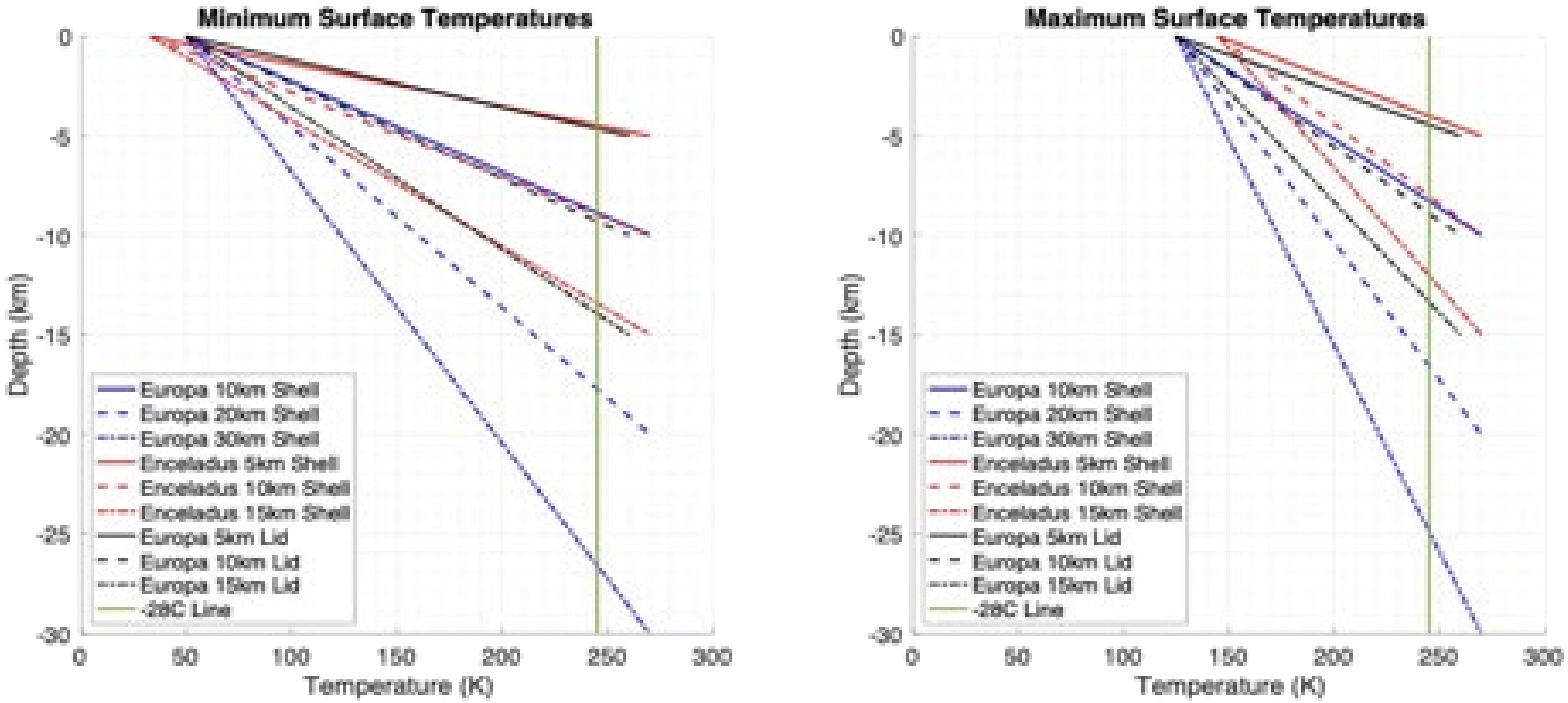
- Ganymede (Jupiter) internal ocean ~3 X larger than Europa, but lacks clear evidence of a connection
  T_{surf}=-113^{o}C (midday at equator, colder toward poles / other times)

- Titan (Saturn) internal ammonia-rich water but at ~-100C. Possible connection, but perhaps only one-way
  T_{surf}=-179^{o}C

- Callisto (Jupiter), possible deep (100 km) subsurface ocean.
  T_{surf}=-110^{o}C (midday at equator, colder toward poles / other times)

- Triton (Neptune), may (?) have an internal ocean about 100-150 km ice shell
  T_{surf}=-235^{o}C

How deep is LLT?



Modeling courtesy of Britney Schmidt and Jacob Buffo

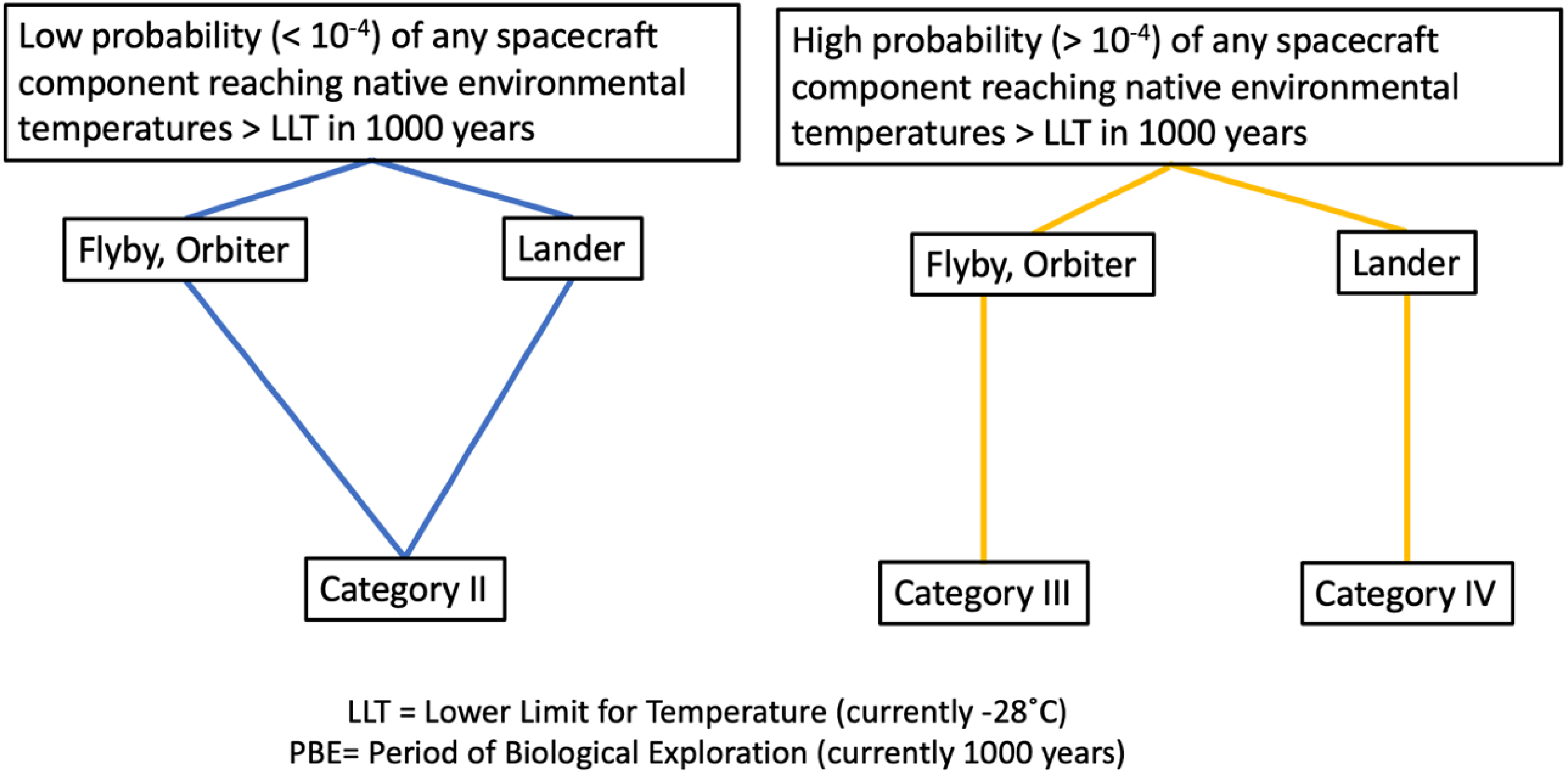


Figure 1: Revised decision tree for categorization of missions to Icy Worlds

(Doran et al., 2024, LSSR, 41 pp. 86–99)

Future exploration of Icy Worlds

List of Known or Suspected Icy Worlds and their current categorization (established categorizations listed in NASA Procedural Requirements (NPR) 8715.24 Appendix C)

Body	Category	Current Classification
2002 MS_4	Dwarf Planet[2], Cubewano[3] (TNO)[4]	II
Ariel	Moon of Uranus	II
Callisto	Moon of Jupiter	II
Ceres	Dwarf Planet	II
Charon	Moon of Pluto	II*
Dione	Moon of Saturn	II
Enceladus	Moon of Saturn	III/IV
Eris	Dwarf Planet, Scattered Disk Object (TNO)	II
Europa	Moon of Jupiter	III/IV
Ganymede	Moon of Jupiter	II*
Gonggong	Dwarf Planet, Scattered Disk Object (TNO)	II
Haumea	Dwarf Planet, Haumeid (TNO)	II
Iapetus	Moon of Saturn	II
Makemake	Dwarf Planet, Cubewano (TNO)	II
Mimas	Moon of Saturn	II
Miranda	Moon of Uranus	II
Oberon	Moon of Uranus	II
Orcus	Dwarf Planet, Plutino (TNO)	II
Pluto	Dwarf Planet, Plutino (TNO)	II*
Quaoar	Dwarf Planet, Cubewano (TNO)	II
Rhea	Moon of Saturn	II
Salacia	Dwarf Planet, Cubewano (TNO)	II
Sedna	Dwarf Planet, Sednoid (TNO)	II
Tethys	Moon of Saturn	II
Titan	Moon of Saturn	II*
Titania	Moon of Uranus	II
Triton	Moon of Neptune	II*

[1]https://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_8715_0024_&page_name=AppendixC
[2]Dwarf Planets are based on the list of 10 bodies designated as being Dwarf Planet with "near certainty" at https://web.gps.caltech.edu/~mbrown/dps.html as of January 24, 2024.
[3]Classical Kuiper Belt Object
[4]Trans-Neptunian Object

(Doran et al., 2024, LSSR, 41 pp. 86–99)

Conclusions and way forward for Icy Worlds

- Establish a new definition of Icy Worlds for use in Planetary Protection: "Icy Worlds in our Solar System are defined as all bodies with an outermost layer that is believed to be predominantly water ice by volume and have enough mass to assume a nearly round shape"
- 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 (currently 0.5 and -28oC, respectively).
- Establish LLT as a parameter to assign categorization for Icy Worlds missions (subject to 1000-year period of biological exploration).
- Establish any sample return from an Icy World as Category V restricted Earth return unless all six questions listed for small bodies can be answered as "no".
- *Develop policy incorporating these changes and new publication (Doran et al. in preparation)*

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The COSPAR PP Policy
(a living document…)

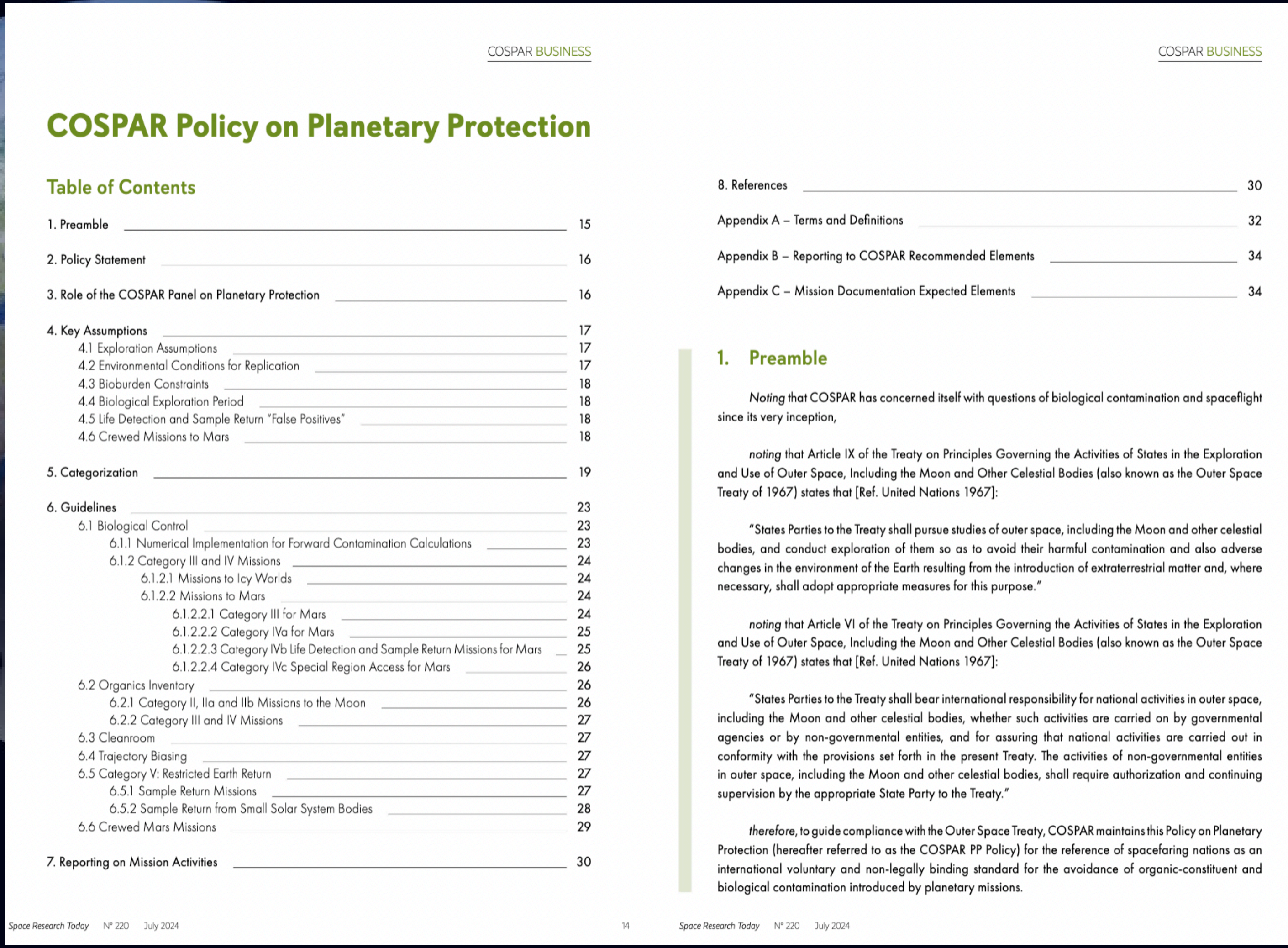
The COSPAR PP Policy: a living document

Objective was 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.
- 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.

New Policy

Published In SRT 220, 12 July 2024



COSPAR Policy on Planetary Protection

Table of Contents

1. Preamble

Noting that COSPAR has concerned itself with questions of biological contamination and spaceflight since its very inception,

noting that Article IX of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (also known as the Outer Space Treaty of 1967) states that [Ref. United Nations 1967]:

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

noting that Article VI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (also known as the Outer Space Treaty of 1967) states that [Ref. United Nations 1967]:

"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."

therefore, to guide compliance with the Outer Space Treaty, COSPAR maintains this Policy on Planetary Protection (hereafter referred to as the COSPAR PP Policy) for the reference of spacefaring nations as an international voluntary and non-legally binding standard for the avoidance of organic-constituent and biological contamination introduced by planetary missions.

Spreading the word…

Planetary protection is cool !

COSPAR PPP activities 2024 – communications/Workshops

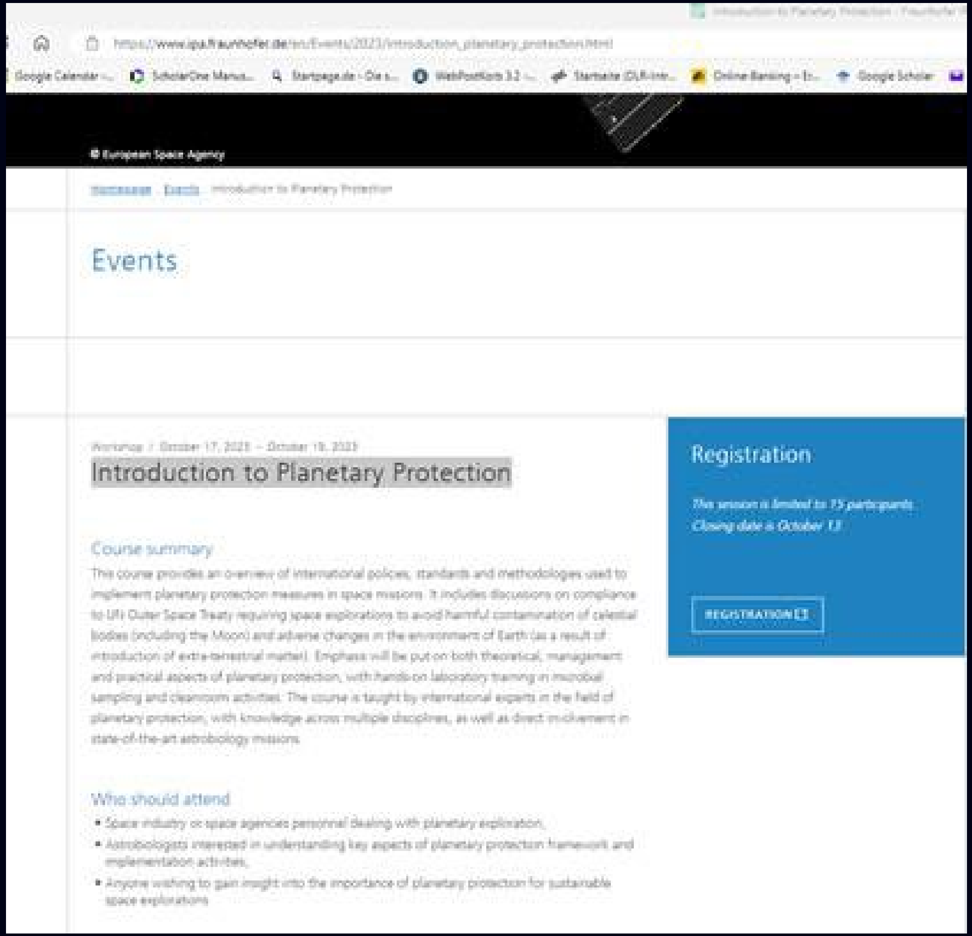
The ESA WS Planetary Protection Requirements for future exploration missions Workshop

Organised by S. Sinbaldi, presentation by P. Rettberg

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 2024

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

Planetary Protection presentations by P. Rettberg & N. Hedman

IAA 2024
13-20 July 2024

Presentation of PP by A. Coustenis

IAC 2024
13-18 Oct. 2024

Presentation of PP by A. Coustenis

OPAG Meeting,
19 June 2024

Presentation of PP Icy Worlds Policy suggestions by A. Coustenis

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

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

The 2024 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

Several talks from all interested parties at our PPP sessions !

Future PPP meetings

Also with Open Sessions in 2025 and 2026

PPP executive Meeting : 12 December 2024

2nd International COSPAR Planetary Protection Week :

14-16 April 2025, DLR/Cologne, Germany

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. Also, visit our Web site.**

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PPP Recent publications (extract)

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

- 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, 24(3):230-274. doi: 10.1089/ast.2023.0092).
- 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.
- Editorial to the New Restructured and Edited COSPAR Policy on Planetary Protection. Ehrenfreund, P., Worms, J.-C., Coustenis, et al., 2024. Space Research Today 220, July 2024, pp.10-36.