Advancing the COSPAR Policy on Planetary Protection measures for a safe and sustainable exploration

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

- *The COSPAR Panel on Planetary Protection*

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

Science and Planetary Protection
In advance of human missions Seminar
30 October-1 November 2024

COSPAR planetary protection Panel & Policy

The primary objective of the COSPAR Panel on Planetary Protection 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 is based upon the most recent, peer-reviewed scientific knowledge and should enable the exploration of the solar system, not prohibit it. The PPP does not specify the means for adherence to the COSPAR Policy and associated guidelines; this is left to the engineering judgment of the organization responsible for the mission.

The Panel provides, through workshops, publications and meetings, an international forum for the exchange of information on the best practices for adhering to the COSPAR planetary protection requirements including holding an active dialogue also with the private sector. The PPP has strong ties with other relevant bodies (e.g. NASEM SSB/CoPP).

BLUE ORIGIN

SPACEX

The COSPAR Panel on Planetary Protection, invited guests and attendees, including the provate sector, at The Inaugural International COSPAR Planetary Protection Workshop (April 2024), and at the COSPAR GA 2024 in Busan

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

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

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; Icy Worlds; 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*

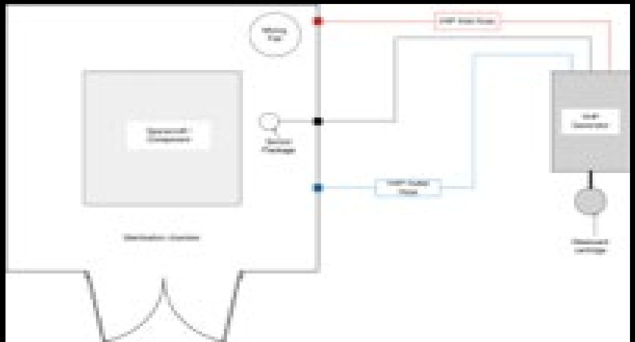
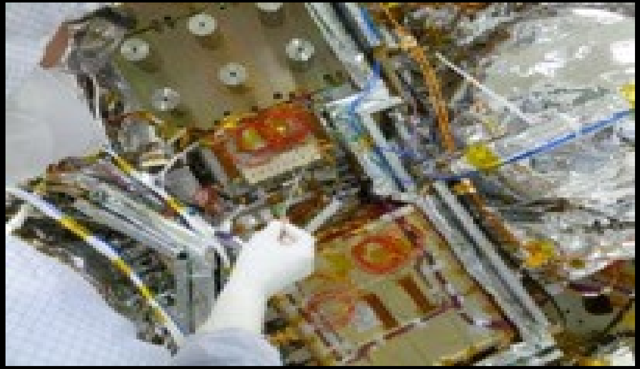
Category V: All Earth return: 2 subcategories - unrestricted return for solar system bodies deemed by scientific opinion to have no indigenous life forms (***e.g. Mars and Martian Moons***) and restricted return for all others

[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*

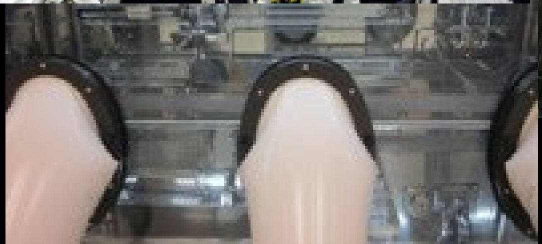
[2]*Implies the presence of environments where terrestrial organisms could survive and replicate, and some likelihood of transfer to those places by a plausible mechanism*

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

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.

Overview of COSPAR Panel on Planetary Protection Recent activities

COSPAR PPP reported activities 2019-2023

- ***Updated Planetary Protection for the Moon*** : *Space Res. Today Aug. 2021, 211, 14-20* *New subcategories for landers to protect in particular the Permanently Shadowed Regions (PSRs) and/or the lunar poles, in particular latitudes south of 79° S and north of 86° N*

- ***No change in Planetary Protection category for small bodies*** *PPP took the 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

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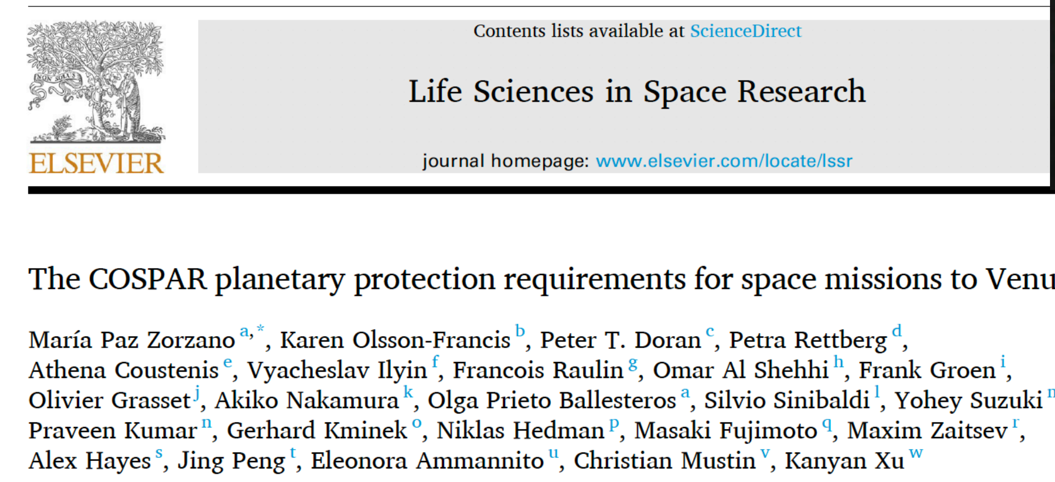
Zorzano Meier et al., 2023. LSSR 37, 18-24



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The COSPAR planetary protection requirements for space missions to Venus

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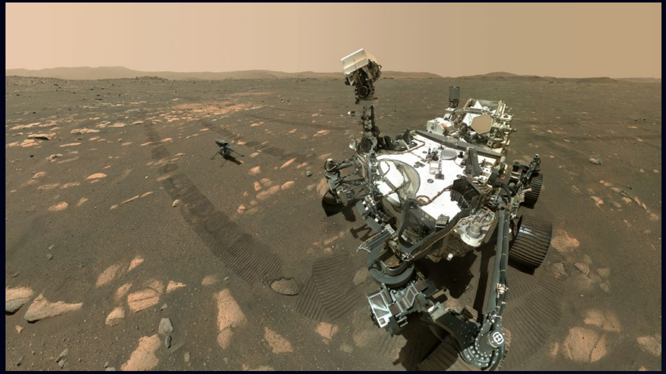
María Paz Zorzano[a,*], Karen Olsson-Francis[b], Peter T. Doran[c], Petra Rettberg[d], Athena Coustenis[e], Vyacheslav Ilyin[f], Francois Raulin[g], Omar Al Shehhi[h], Frank Groen[i], Olivier Grasset[j], Akiko Nakamura[k], Olga Prieto Ballesteros[a], Silvio Sinibaldi[l], Yohey Suzuki[m], Praveen Kumar[n], 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.*

Mars and its moons (sample return era)

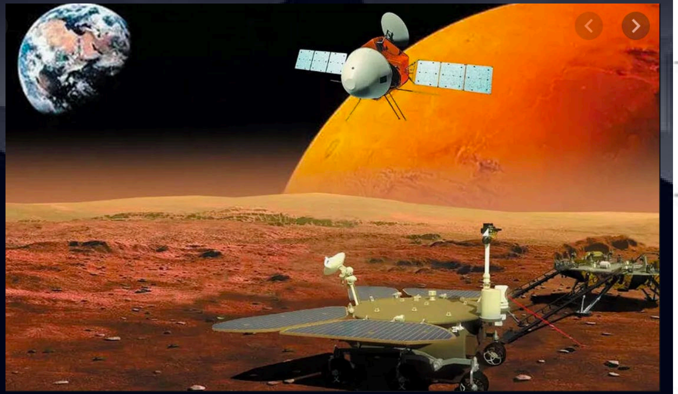
TGO-ESA – since 2016

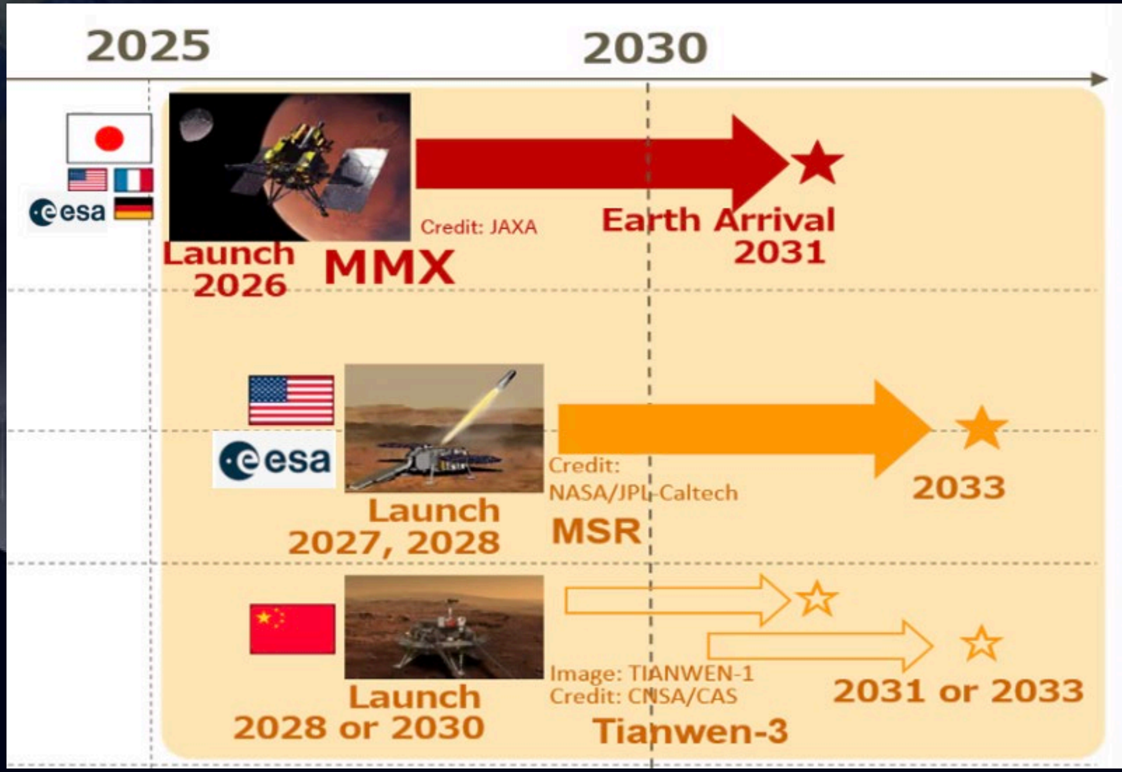
Mars 2020/Perseverance – NASA
since 18 Feb. 2021

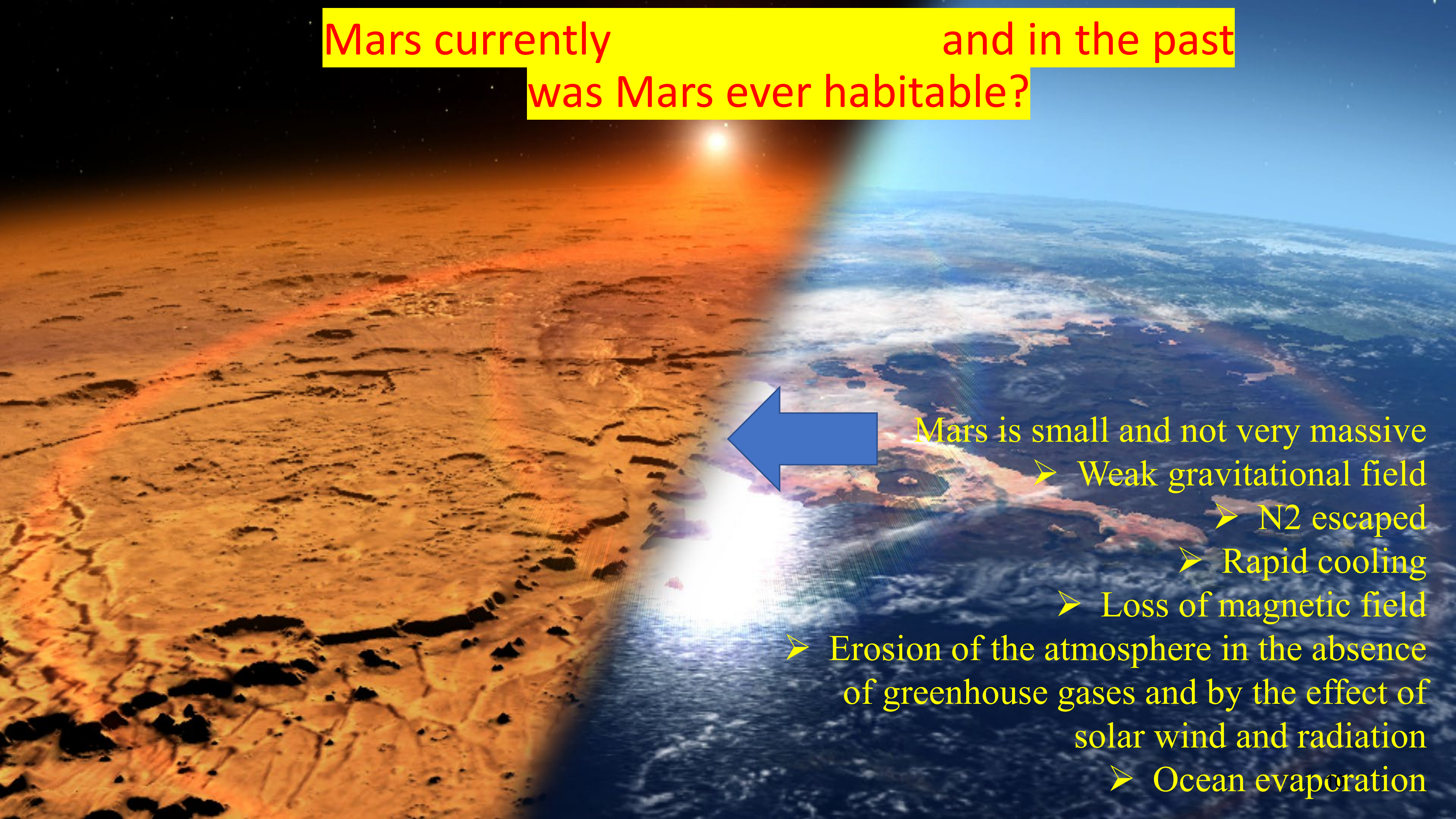


Al-Amal (Hope) – UAE
since 9 Feb. 2021

Tianwen-1 – China
since 10 Feb. 2021






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

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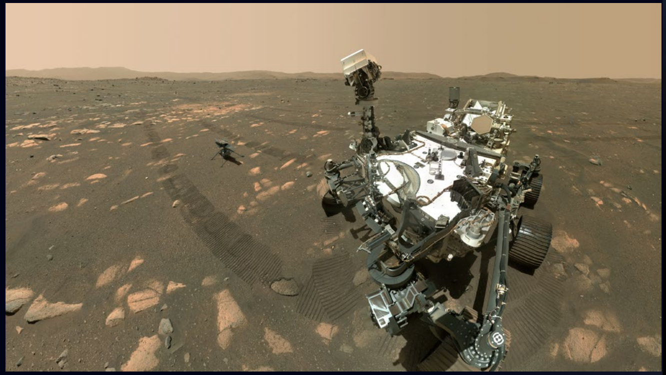

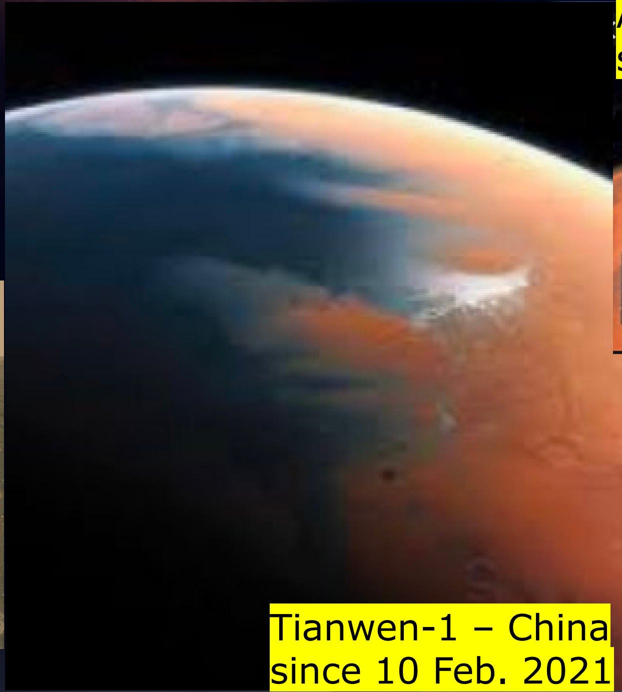

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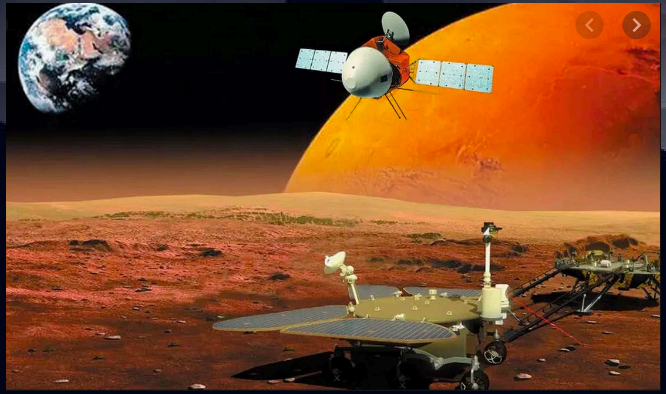
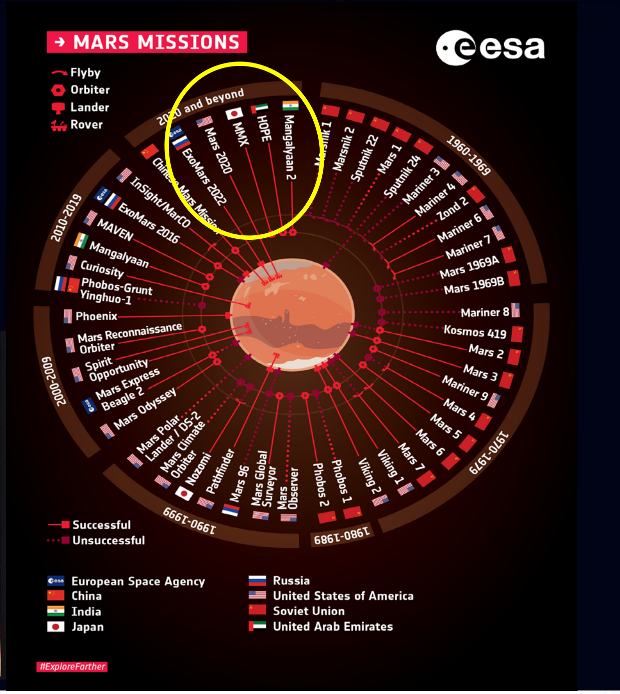
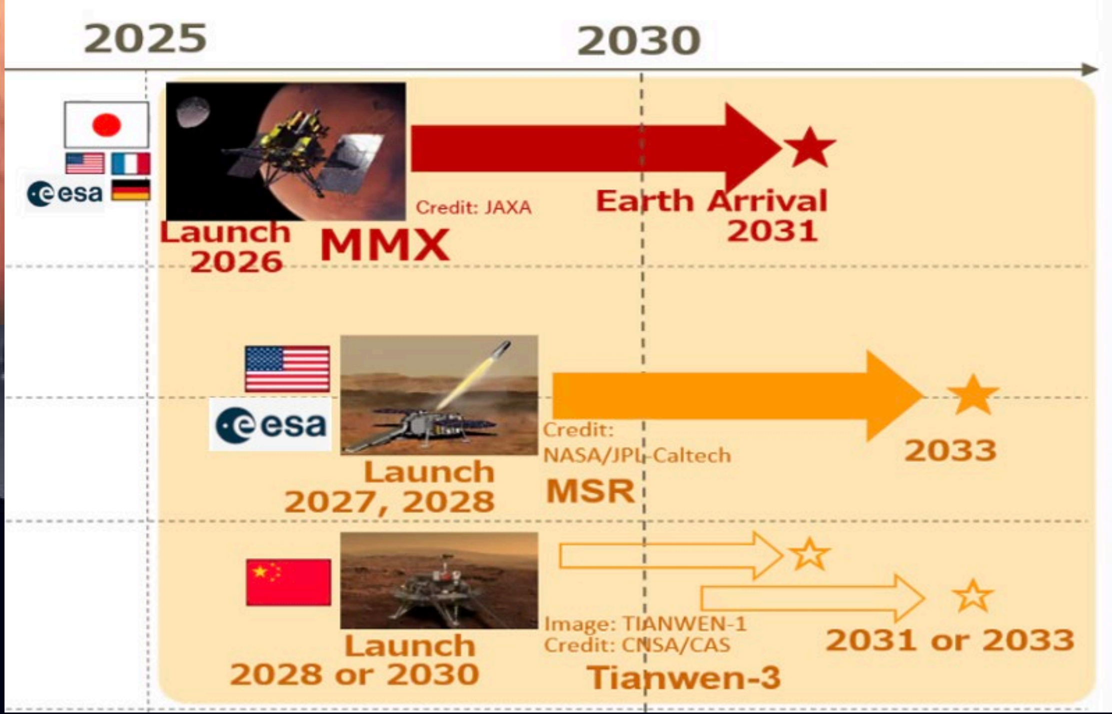
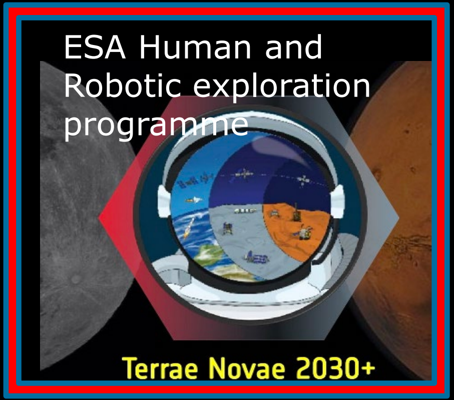






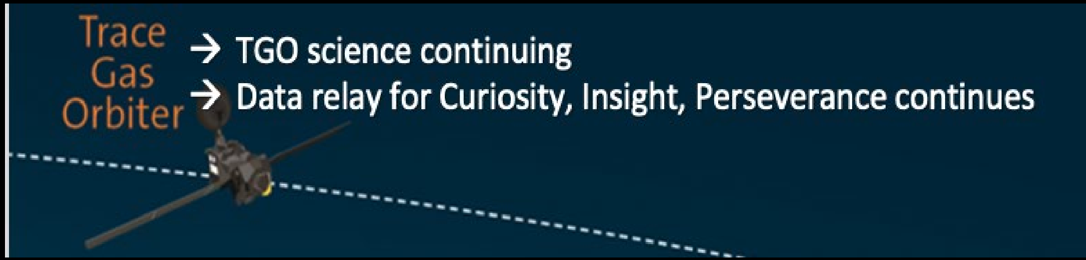


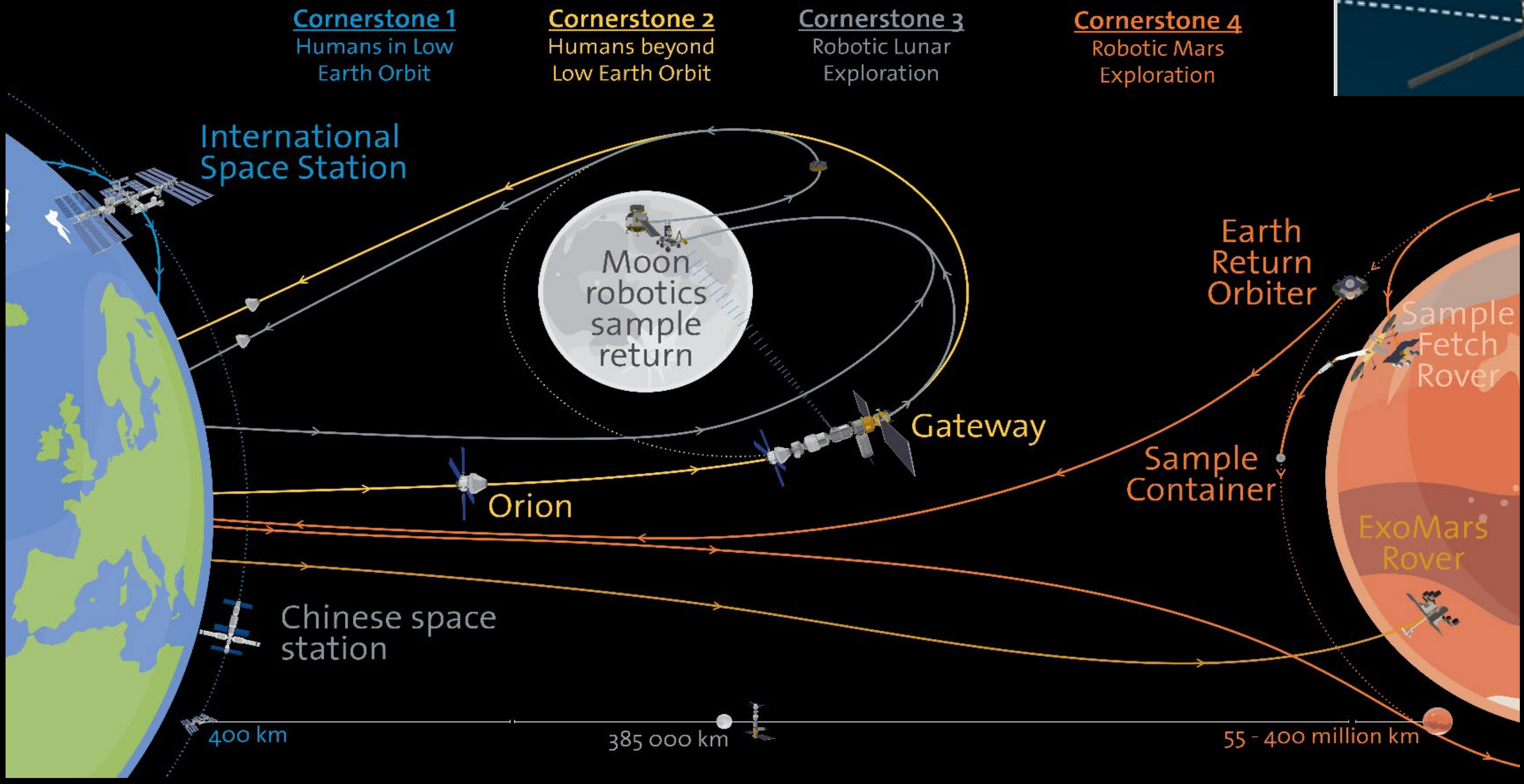
Future exploration of Mars

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

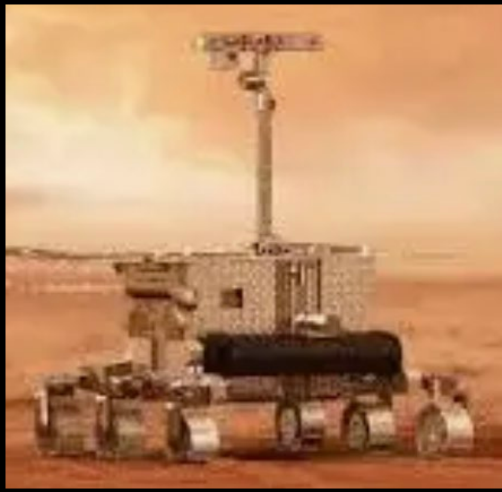
ESA's ExoMars programme





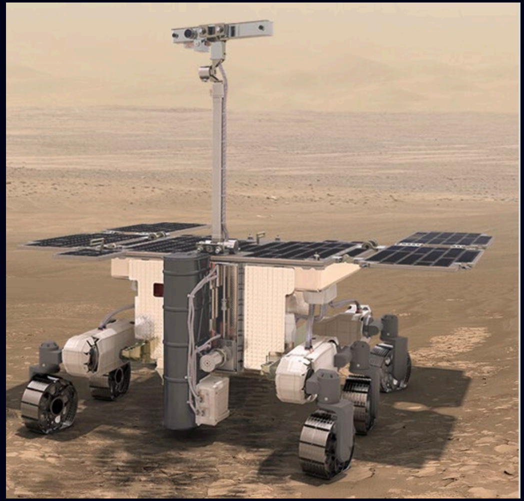
Rosalind Franklin Rover

2028: launch of the Rosalind Franklin Rover to Mars

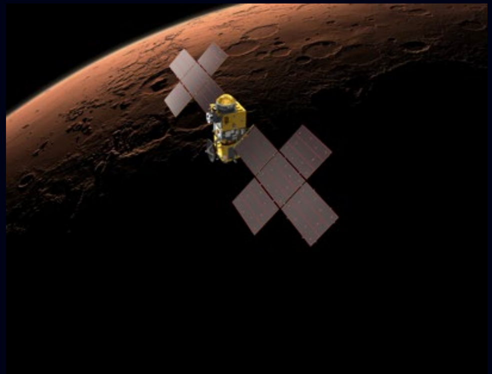


European Space Agency

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)***: **r**eturn of sample from Phobos (launch in 2026) : assigned planetary protection Cat. III for outbound and Cat V inbound : unrestricted Earth return.

See *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)

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

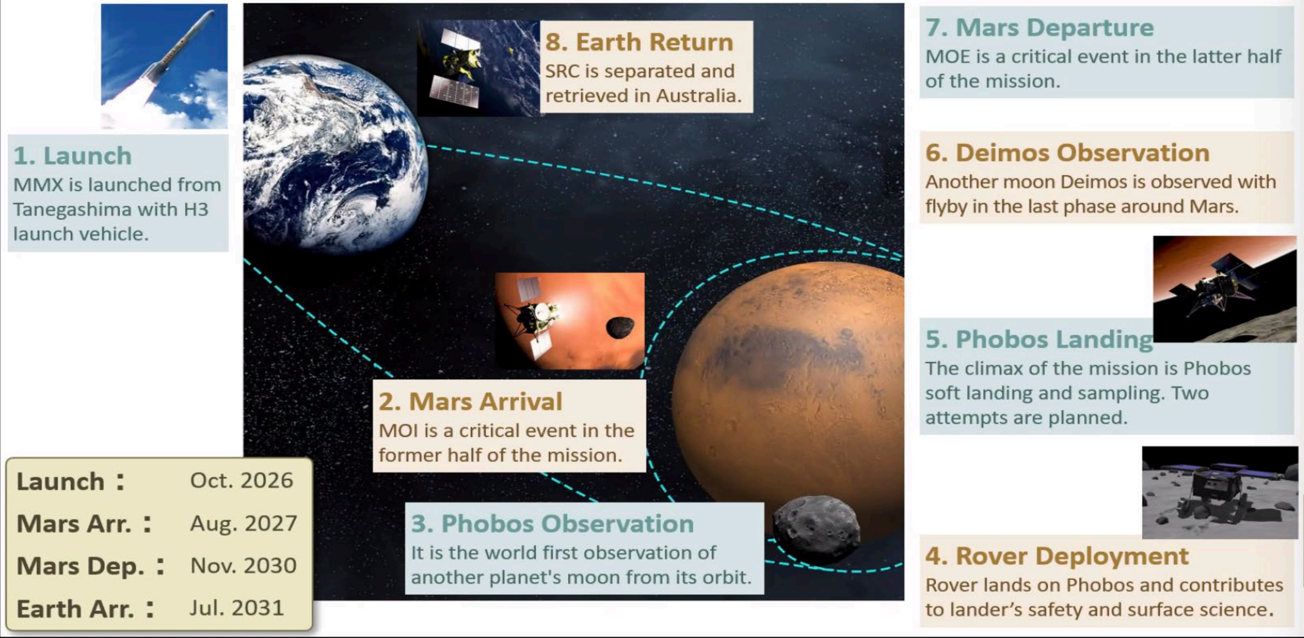
JAXA: Martian Moons eXploration

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

→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

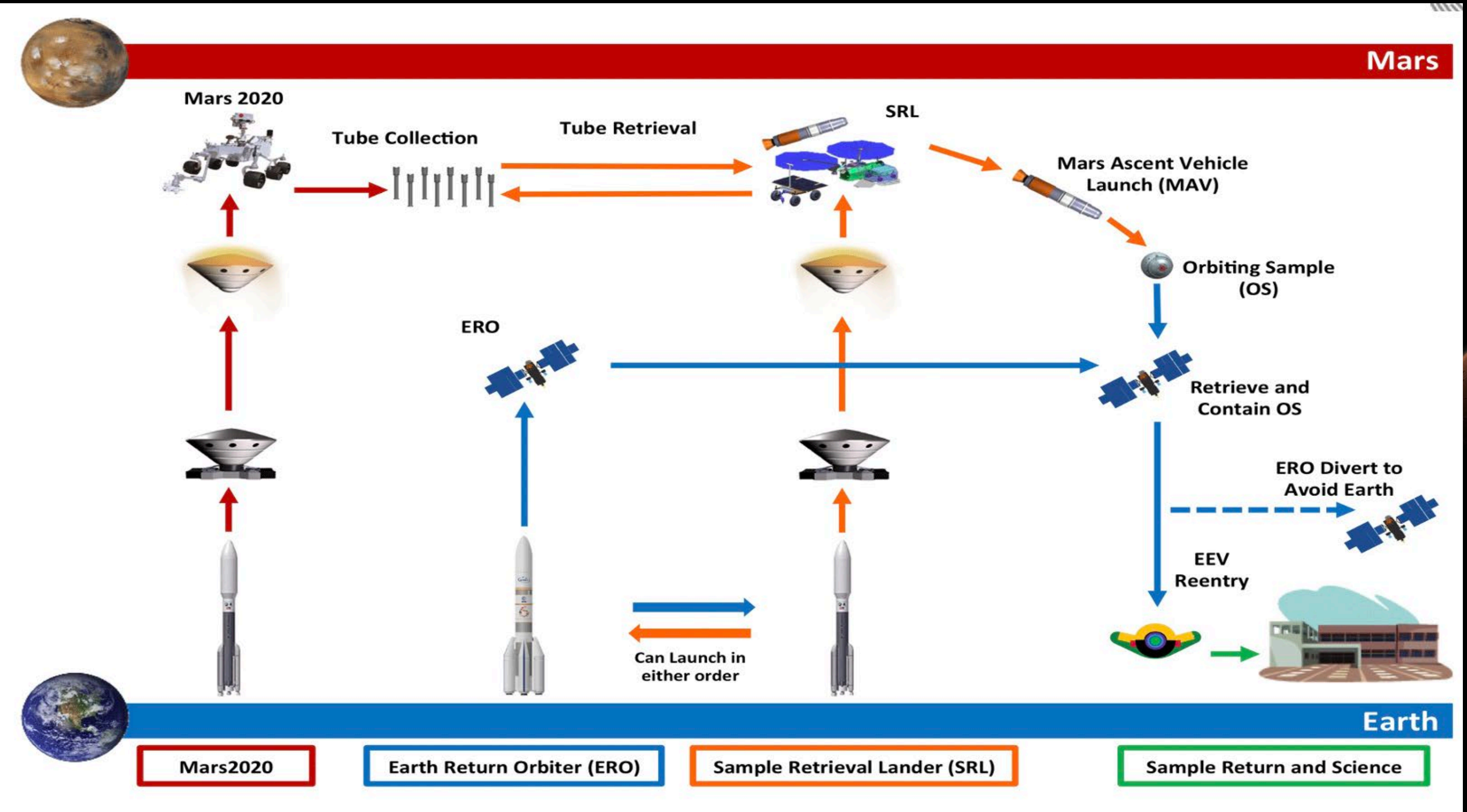
Conclusions based on the studies supported by ESA-JAXA-NASA :

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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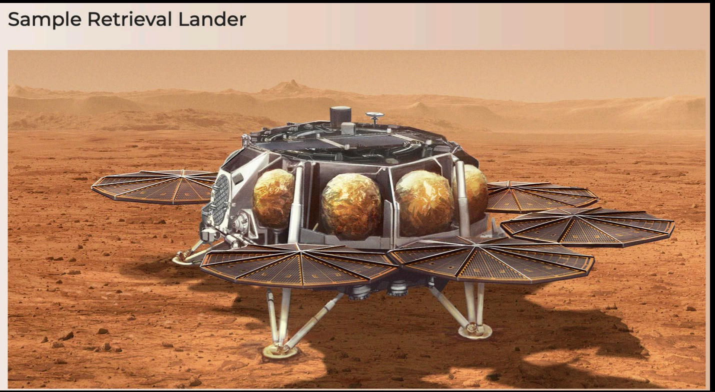

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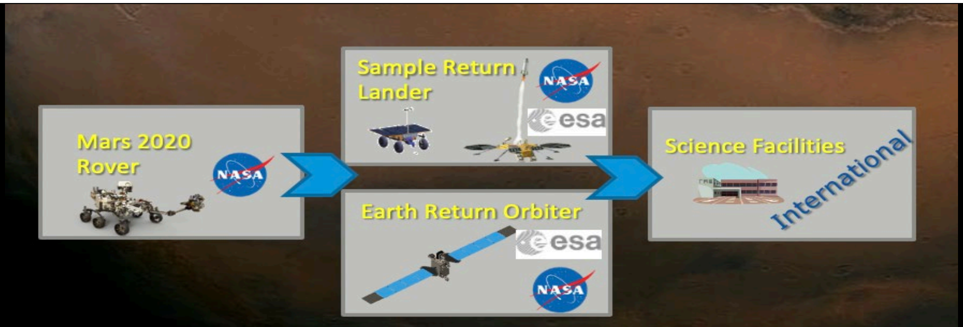
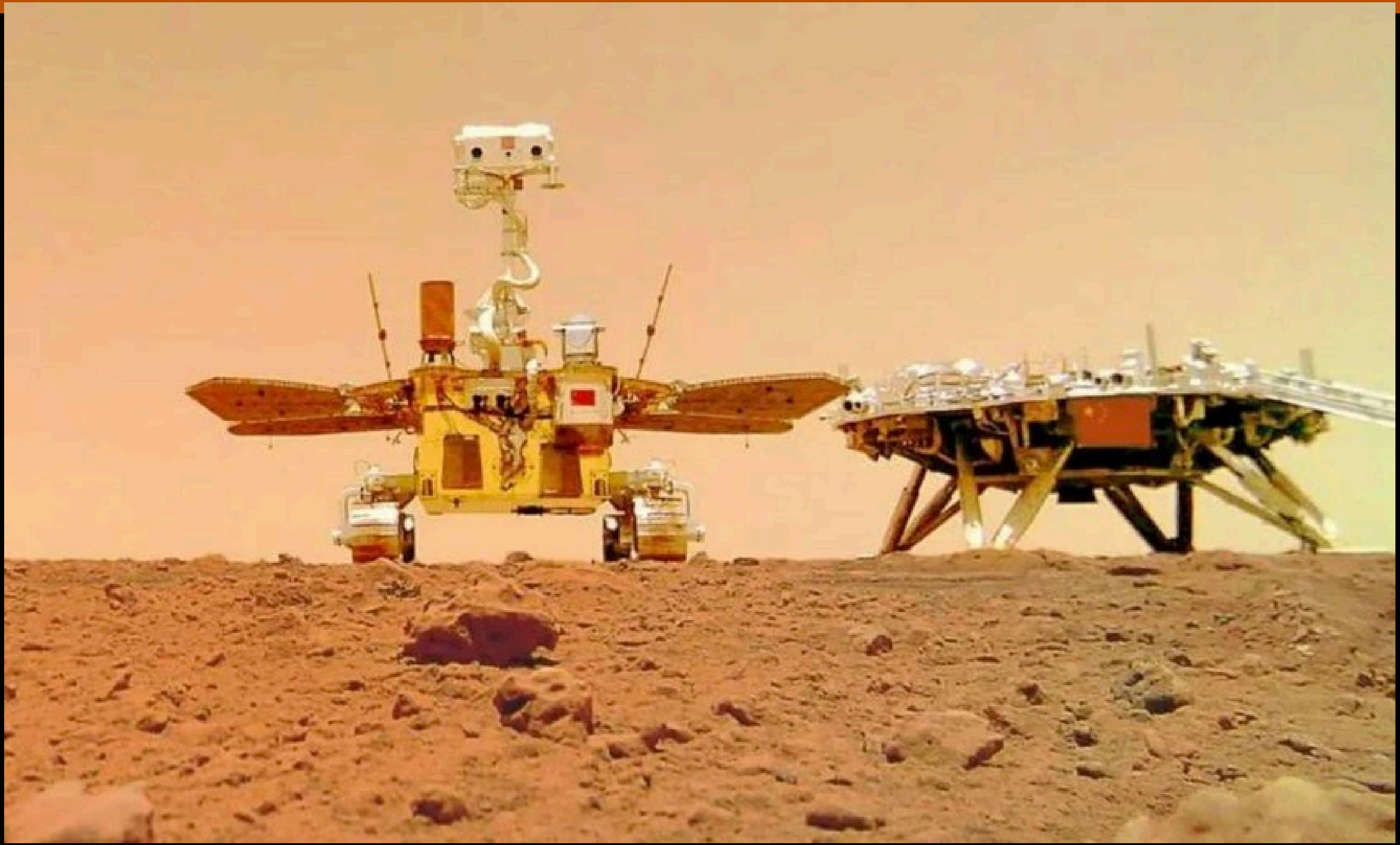


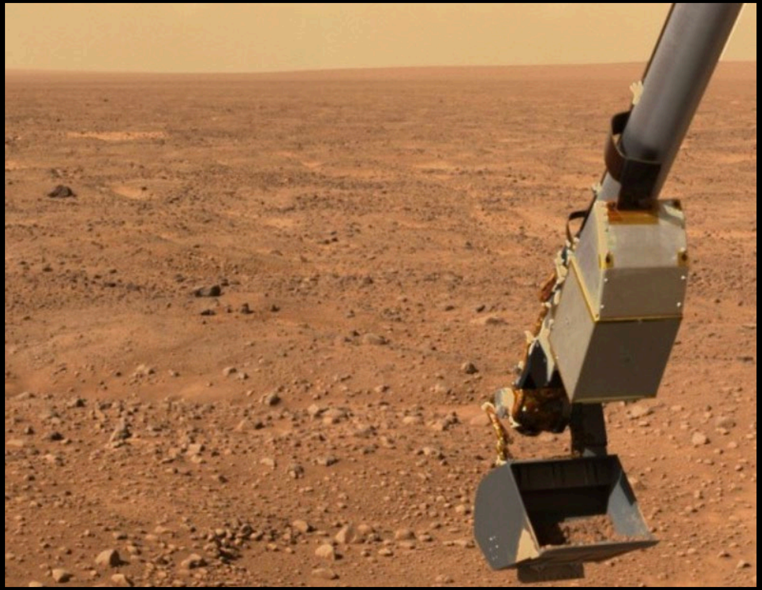
Strong collaboration between NASA and ESA

Chinese – 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

Mars Human exploration

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- 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 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 Meeting on "Planetary Protection Knowledge Gaps for Crewed Mars Missions" 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 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

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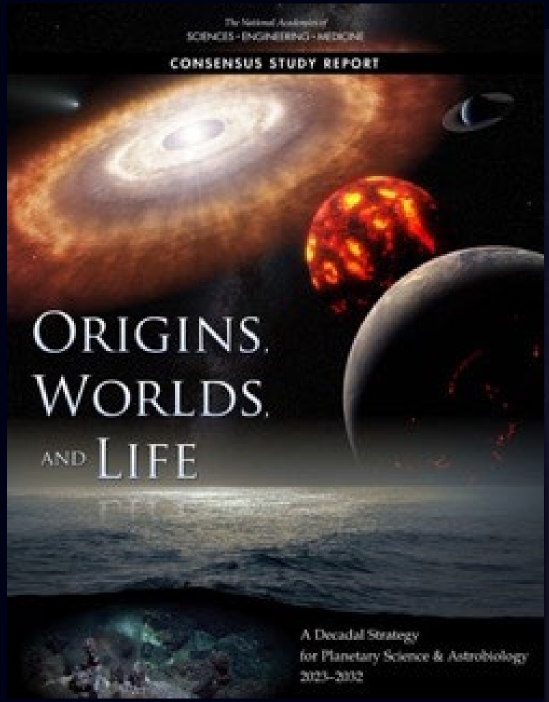
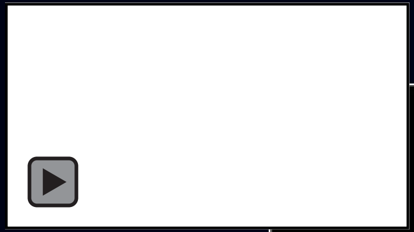
After Venus, Mars Robotic exploration and small bodies…

- **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.

Icy Worlds (not a cold case…)

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

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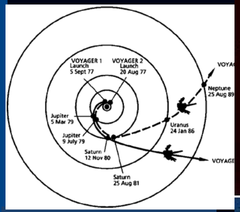
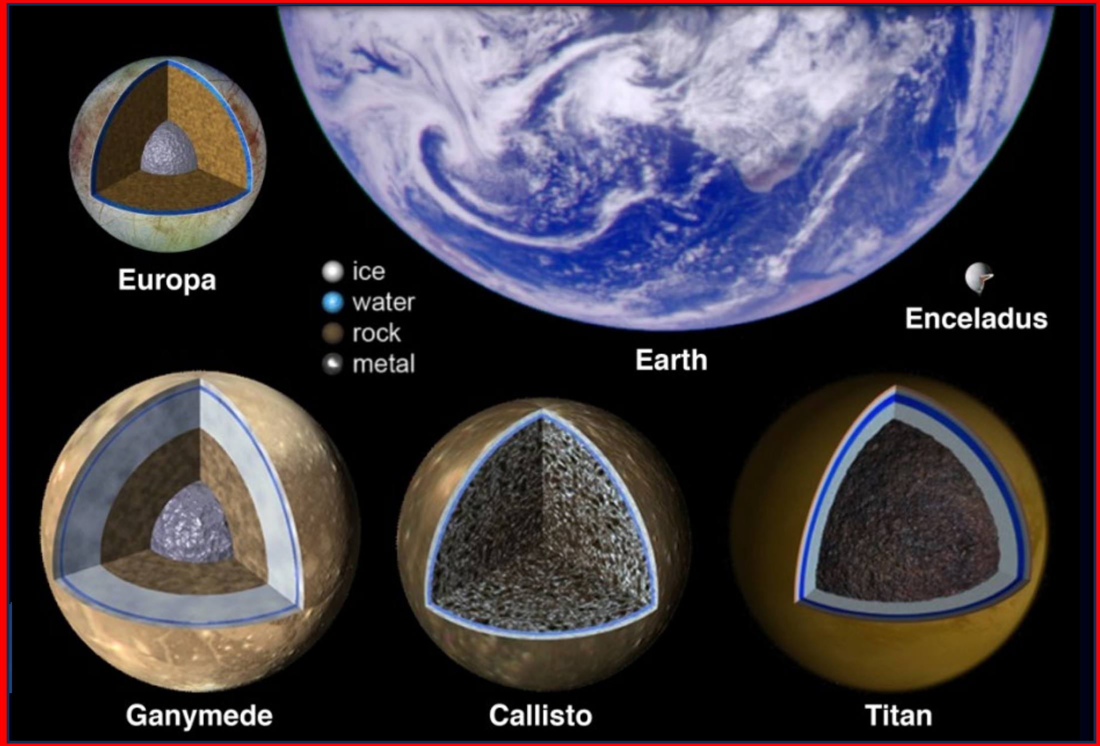
Giant planets and icy moons

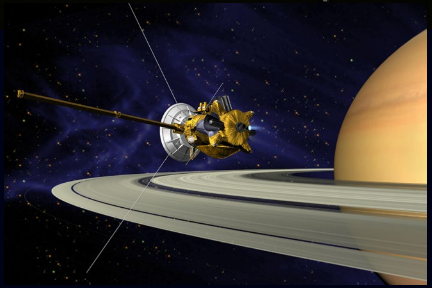


Voyager
1980s

Galileo
1995-2000

JUNO
2016-

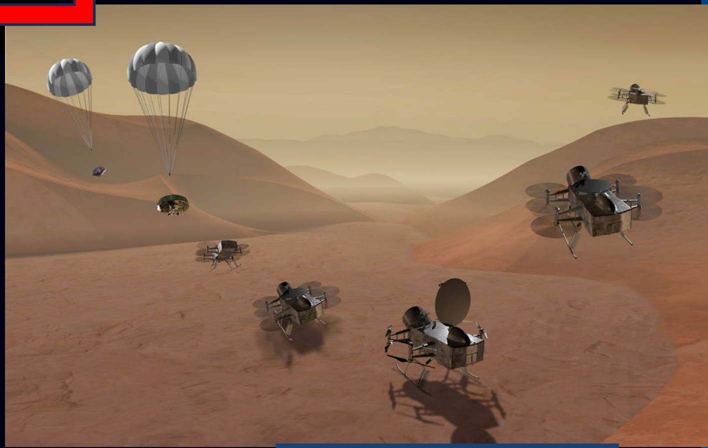




Cassini-Huygens
2004-2017

JUICE
Launched: 2023

Europa Clipper
Launch: 2024



Dragonfly
Launch: 2028

Planetary protection requirements Missions in the Jovian system

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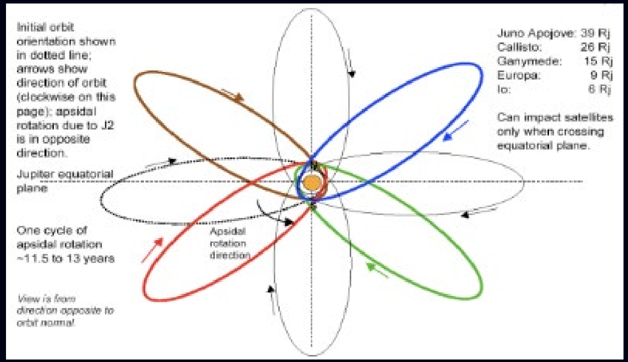
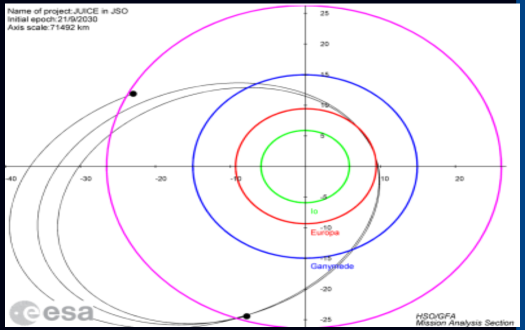
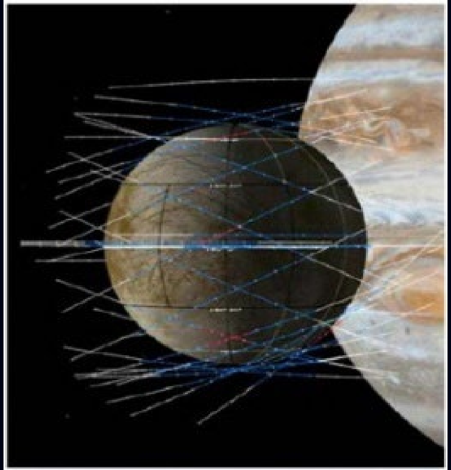
On site : JUNO: orbiter; main mission target is Jupiter; probabilistic risk assessment for final Jupiter de-orbit manoeuvre, assessment of sterilisation in natural Jovian environment, assessment of sterilisation during high velocity impact: Cat. II



En route : 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



To launch : 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



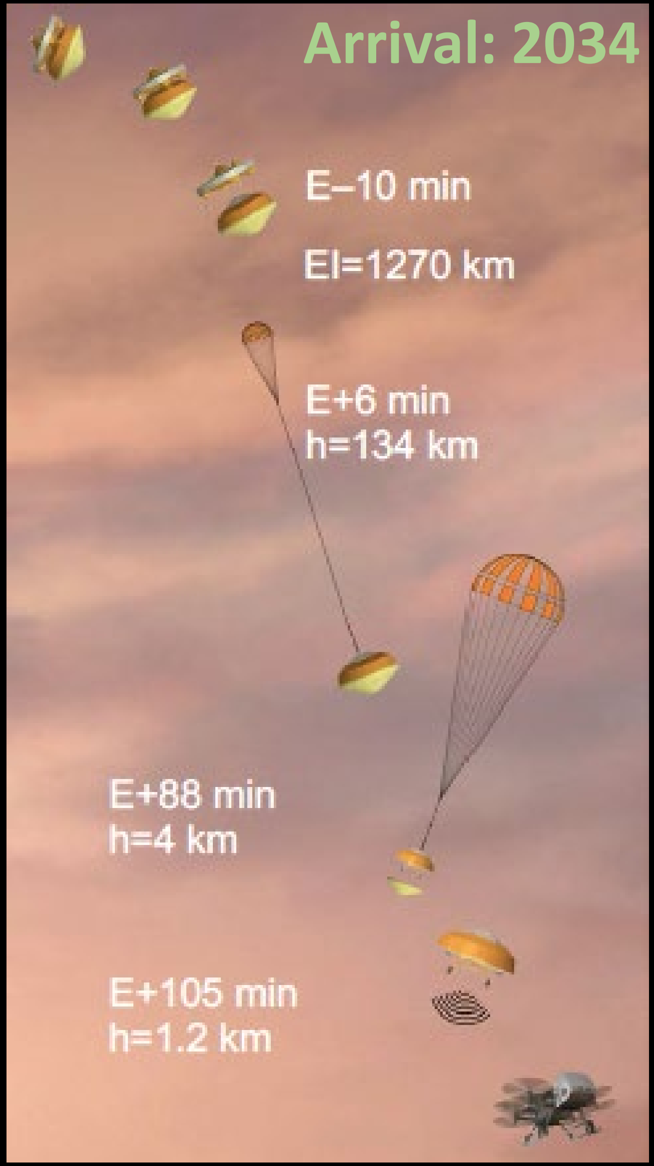
Categorisation of the Dragonfly mission to Titan

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 issued a new definition (**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 other findings include : *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, LSSR, 41 pp. 86–99)

Contents lists available at ScienceDirect
Life Sciences in Space Research
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

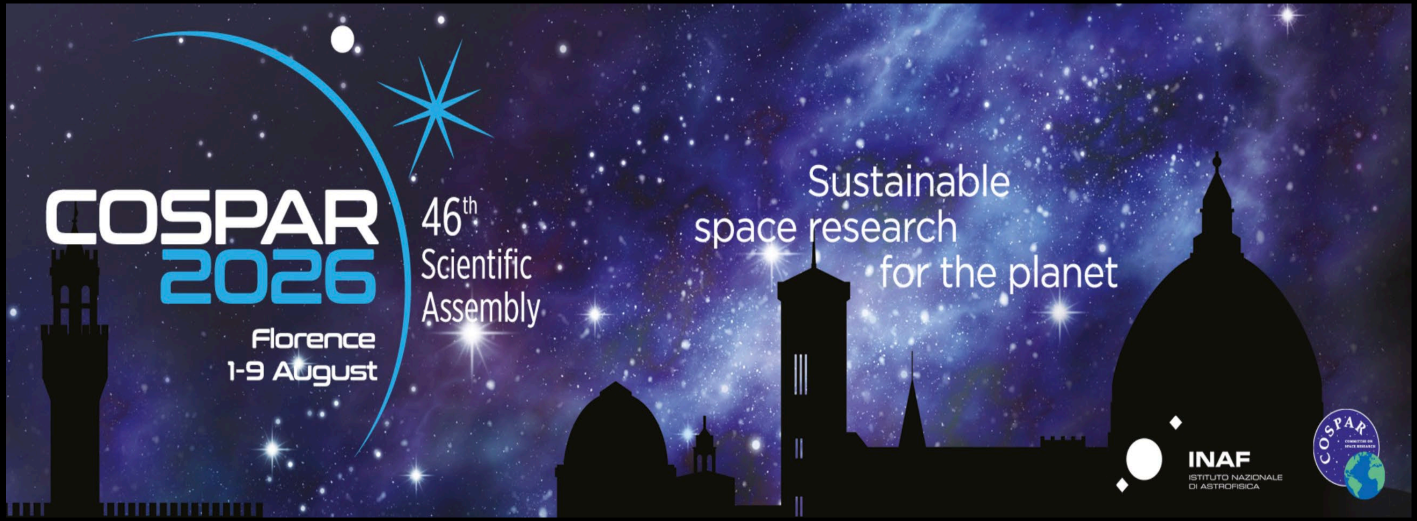
P.T. Doran[a,*], A. Hayes[b], O. Grasset[c], A. Coustenis[d], O. Prieto-Ballesteros[e], N. Hedman[f,1], O. Al Shehhi[g], E. Ammannito[h], M. Fujimoto[i], F. Groen[j], J.E. Moores[k], C. Mustin[l], K. Olsson-Francis[m], J. Peng[n], K. Praveenkumar[o], P. Rettberg[p], S. Sinibaldi[q], V. Ilyin[r], F. Raulin[s],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

- *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*
- *Have all missions consider the possibility of impact.*
- *Restructure or remove Category II* from the policy*
- *Establish that any sample return from an Icy World should be Category V restricted Earth return.*

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

COSPAR maintains a non-legally binding planetary protection policy and associated requirements to guide compliance with the UN Outer Space Treaty. The COSPAR Policy is the only international framework for planetary protection

The Policy will continue to be updated but not in a rushed process. We give thorough consideration to all arguments and scientific inputs to make an informed decision



In the meantime, there is need for community input on science findings and research reserves or recent reports. Open sessions at our meetings, Studies, Surveys, Workshops, Focused conferences?

And : 14-16 April - PPP Meeting in DLR, Köln, Germany
With sessions open to the public

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
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- 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.*
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- 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.