



The COSPAR Panel on Planetary Protection Briefing at the SSB CoPP meeting

Athena Coustenis, Chair
Gerhard Kminek and Niklas Hedman, Vice-Chairs



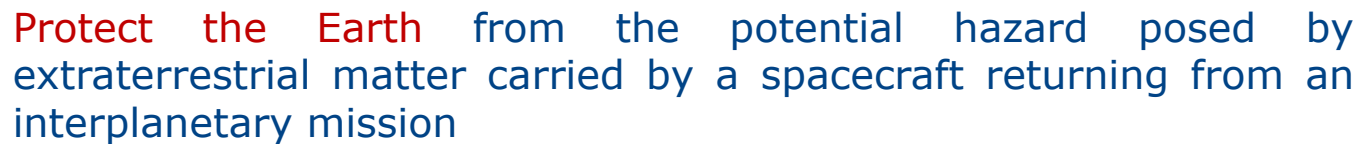
Table of Contents

- Rationale for planetary protection
- Framework for planetary protection and the COSPAR PP Policy
- The COSPAR Panel on Planetary Protection: membership and operations
- Reporting to COSPAR
- Planetary protection categories
- The Moon categorisation and survey





- *Protect our investment in space science & exploration*
- *Unique opportunity to learn more about the origin of life in a way that is no longer possible on Earth*



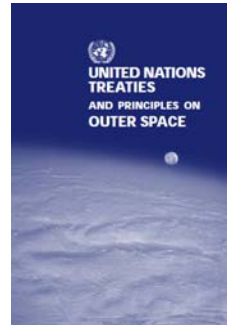
- Simple prudence - protect the Earth!
- In line with the precautionary principle of environmental protection

Bart Simpson, Dec. 17, 2000, "Skinner's Sense of Snow"



Framework for planetary protection

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



Article IX "...parties to the Treaty shall pursue studies of outer space including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose..."

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

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





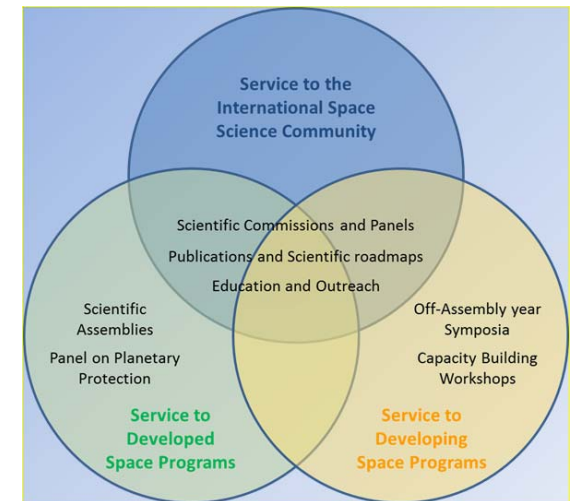
COSPAR at a glance

The **Purpose** of COSPAR, by its Charter from the International Council for Science (ICSU), is to promote at 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

The **Objectives** of COSPAR are achieved mainly through the organization of scientific assemblies and publications

The **Organizational Structure** of COSPAR consists of:

- Scientific Commissions - representing each and every scientific discipline involved in space research
- Panels - designed to deal with crosscutting issues that can affect particular segments of the international space research community, and often for which there is an urgent need for input





COSPAR planetary protection policy

A special case among the Commissions and Panels in the COSPAR structure is the Panel of Planetary Protection which serves an important function for space agencies pursuing the exploration of the planets. **COSPAR PPP maintains and promulgates a planetary protection policy for the reference of spacefaring nations to guide compliance with the Outer Space Treaty ratified today by 110 nations, 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.





COSPAR Panel on Planetary Protection

- The primary objective of the Panel within COSPAR is to **develop, maintain, and promote the COSPAR policy and associated requirements** that must be achieved to protect against the harmful effects of forward and backward contamination.
- 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.**





Scope and Objectives of the Panel on Planetary Protection

- 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; the best and most cost effective means to adhere to the COSPAR planetary protection requirements 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 UN Outer Space Treaty.
- However, the Panel should make every effort, through symposia, workshops, and topical meetings at COSPAR Assemblies, to provide an **international forum for the exchange of information on the best practices** for adhering to the COSPAR planetary protection requirements.
- Through COSPAR **the Panel will inform the international community**, e.g., the Committee on the Peaceful Uses of Outer Space (COPUOS) of the United Nations, as well as various other bilateral and multilateral organizations, of policy consensus on planetary protection.





COSPAR Panel on Planetary Protection ToRs

- The ToRs ensure a good balance between representatives appointed by space agencies and scientists
- The Panel, led by a Chair with the support of two Vice Chairs, consists of **appointed members who represent national or international space agencies and representatives of COSPAR Scientific Commissions B – *Space Studies of the Earth-Moon System, Planets and Small Bodies of the Solar Systems*, and F-Life Sciences as Related to Space.**
- The COSPAR Bureau formally appoints the Panel leadership and members.





Panel on Planetary Protection Membership

- Chair: Athena Coustenis
- Vice-Chairs: Niklas Hedman (UNOOSA) and Gerhard Kminek (ESA)
- Nine members appointed by space agencies:

France/CNES	Michel Viso
Germany/DLR	Petra Rettberg
India/ISRO	P. Sreekumar (TBR)
Italy/ASI	Eleonora Ammannito
Japan/JAXA-ISAS	Masaki Fujimoto
Russia	Vyacheslav K. Ilyin
USA/NASA	James Green
UKSA	Karen Olson-Francis
China/CNSA	Lei Li (TBR)
- Nine scientists representing members of SC B and SC F

Olivier Grasset (France, SC B)	Alex Hayes (USA, SC B)
Maria-Paz Zorzano (Sweden/Spain, SC B)	Maxim Zaitsev (Russia, SC B)
Olga Prieto-Ballesteros (Spain, SC B)	Akihiko Nakamura (Japan, SC B&F)
François Raulin (France, SC F)	Peter Doran (USA, SC B)
Kanyan Xu (CAST)	
- Ex-officio member: Colleen Hartmann, NASEM SSB & ASEB Board Director





Panel on Planetary Protection Membership

- New structure : Open Session with presentation and discussion open to interested parties (including private sector: i.e. Space X and Blue Origin) and Closed Session for further deliberations and decisions
 - *Three in person meetings: Pasadena GA, and two in Vienna (2019)*
 - *Two virtual Executive meetings in 2020 (Full panel members): 17 June 2020 and*
 - *Upcoming meeting: 13 November 2020*

In particular, in 2019 we got a briefing from A. Stern who presented the NASA PPIRB report and we exchanged and discussed it with the Panel.

Then, we were also informed about the NASEM Assessment of the PPIRB and we exchanged with the committee's Chair J. Alexander



New COSPAR Policy updated official document published in the August 2020 SRT issue

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

COSPAR PPP Briefing at the SSB CoPP meeting
23 September 2020





Planetary Protection of the Outer Solar System (PPOSS)

→ European Commission funded a project led by the European Science Foundation with DLR/Germany, INAF/Italy, Eurospace, Space Technology/Ireland, Imperial College London (UK), China Academy of Space Technology (partner), and NAS-SSB (observer)

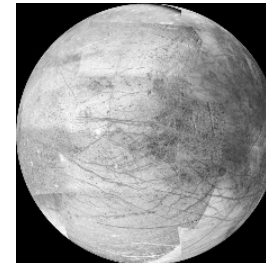
→ Recommended a revision of the planetary protection requirements for missions to Europa and Enceladus, based partly on the NAS-SSB 2012 Icy Bodies Report

→ The PPOSS recommendations were presented to the ESA PPWG and to COSPAR

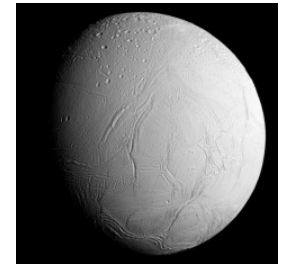
→ The ESA PPWG submitted a written assessment of the PPOSS recommendation to COSPAR

→ COSPAR was involved throughout the multi-year-long process and at the end updated the requirements for missions to Europa and Enceladus

*New COSPAR Policy updated official document
published in the August 2020 SRT issue*



Credit: NASA/JPL/Galileo



Credit: NASA/JPL/Cassini

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

COSPAR PPP Briefing at the SSB CoPP meeting
23 September 2020



Martian Moons eXploration (MMX- JAXA)



- 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
- At a later stage, JAXA started 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
- The result of the ESA-JAXA-NASA coordinated activities and the result of the NAS-ESF review were presented to the ESA Planetary Working Group (PPWG) and to COSPAR
- The ESA PPWG submitted a written assessment of the proposed categorization to COSPAR
- 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)





Reporting to COSPAR

It is recommended that COSPAR members inform COSPAR when establishing planetary protection requirements for planetary missions, and

also that COSPAR members provide information to COSPAR within a reasonable time not to exceed six months after launch about the procedures and computations used for planetary protection for each flight and again within one year after the end of a solar-system exploration mission about the areas of the target(s) which may have been subject to contamination.

Reports should include, but not be limited to, the following information:

- 1. The estimated bioburden at launch, the methods used to obtain the estimate (e.g., assay techniques applied to spacecraft or a proxy), and the statistical uncertainty in the estimate*
- 2. The probable composition (identification) of the bioburden for Category IV missions, and for Category V "restricted Earth return" missions*
- 3. Methods used to control the bioburden, decontaminate and/or sterilize the space flight hardware*
- 4. The organic inventory of all impacting or landed spacecraft or spacecraft-components, for quantities exceeding 1 kg*
- 5. Intended minimum distance from the surface of the target body for launched components, for those vehicles not intended to land on the body*
- 6. Approximate orbital parameters, expected or realized, for any vehicle which is intended to be placed in orbit around a solar system body*
- 7. For the end-of-mission, the disposition of the spacecraft and all of its major components, either in space or for landed components by position (or estimated position) on a planetary surface*





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

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 remote¹ chance that contamination carried by a spacecraft could compromise future investigations

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 significant² chance of contamination which could compromise future investigations

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 significant² chance of contamination which could compromise future investigations

Category V: Two subcategories exist - unrestricted Earth return for solar system bodies deemed by scientific opinion to have no indigenous life forms, and restricted Earth return for all others

¹Implies 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

²Implies 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 categories

Category I: Flyby, Orbiter, Lander: Undifferentiated, metamorphosed asteroids; others TBD

Category II: Flyby, Orbiter, Lander: Venus; Moon (with organic inventory); 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, Orbiters: Mars; Europa; Enceladus; others TBD

Category IV: Lander Missions: Mars; Europa; Enceladus; others TBD

Category V: Any Earth-return mission.

"Restricted Earth return": Mars; Europa; Enceladus; others TBD

"Unrestricted Earth return": Venus, Moon; others TBD

[†]Additional analysis is required.

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





MOON EXPLORATION

Current Categorization for the Moon



Post 2008 robotic missions to the Earth's Moon are assigned Planetary Protection **Category II (with organic inventory)**

- **Category II** because of the interest in chemical evolution
- **Category II (with organic inventory)** because of the potential to contaminate volatiles that are used to study chemical evolution

Requirements for lunar missions:

- No technical planetary protection requirements or constraints on mission operation or end-of-life dispositions
- Requirements for documentation (plans, reports)
- Requirements for an organic inventory, i.e. list of materials on the spacecraft, including volatiles released by a propulsion or life support system

Description of Organic Inventory



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

Delivery Mechanisms to the PSR



1. Large impacts may generate their own collisional atmospheres and this transient atmosphere can subsequently condense out on the Permanently Shadowed Regions - PSR (Ong *et al.*, 2010; Prem *et al.*, 2015)
2. Ballistic migration of molecules across the surface (Butler, 1997; Crider and Vondrak, 2002; Schörghofer, 2014)

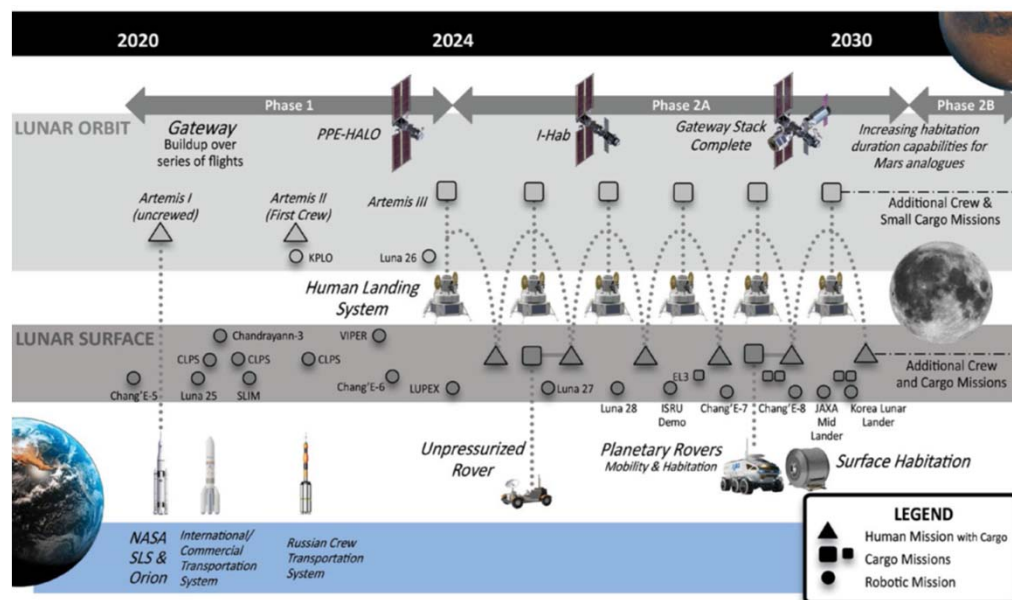
Review of Category & Requirements

Planetary Protection



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

- Based on ESA Planetary Protection Working Group (PPWG) advice & discussions within the Panel, COSPAR initiated stakeholder consultation
- Result of the COSPAR stakeholder consultation, as well as inputs received by LEAG and the CoPP will be considered by the COSPAR PPP in the review of the COSPAR Planetary Protection Category & Requirements for the Moon



ISECG, GER Supplement August 2020

Lunar Exploration Analysis Group



Request went out to 25 LEAG/CAPTEM members, 8 (11) responded

Questions	Vote	Notes
Are the volatiles in the Permanently Shadowed Regions (PSR) on the Moon of significant interest in the study of chemical evolution?	Yes	
Are you concerned that contamination carried by a spacecraft to the Moon could compromise future investigations to study chemical evolution?	Yes (No)	No-votes described stated that: <ul style="list-style-type: none">• "Most geological studies do not need to be overly concerned...but clearly not ideal for studying lunar volatiles..."• "Given the Category II documentation for lunar mission...any contamination from those lander engines can be estimated"
Are you concerned about the long-term degradation of organic materials?	Yes/No	No-votes described stated that: <ul style="list-style-type: none">• Amount is "miniscule"• "It takes millions of years for the materials to degrade"
Are you concerned about organic volatiles released by certain types of propellants?	No/Yes	No-votes described stated that: <ul style="list-style-type: none">• "Only in the volatile rich areas"• "No – because they will be documented"• Propellant was not an issue for Apollo samples

Lunar Exploration Analysis Group



Request went out to 25 LEAG/CAPTEM members, 8 (11) responded, cont.

Questions	Vote	Notes
Would an organic material list describing the kinds and amounts of organic materials on a spacecraft mitigate your concerns?	Yes (No)	No-votes described stated that: <ul style="list-style-type: none">• "Only partially...There is so much we don't know"• "The Category II designation for the Moon is sufficient. No change needed"
Would establishment of lunar PSR protected areas with controlled access and avoidance of unnecessary contamination (e.g., obsolete parts of spacecraft like used propulsion stages) mitigate your concerns?	No/Yes	No-votes described stated that: <ul style="list-style-type: none">• "Perhaps, but it may be important to look into possibility of using propellant less likely to emit compounds of interest"• "No. There may be contaminants derived from more distant sources. These still need to be documented"• "No. Attempting to assert pre-emptive designation of protected areas on the Moon is not a good idea since there would be so many different actors on the scene with different agendas"
Are you concerned about the either controlled or uncontrolled introduction and release of biological materials (living and dead) into the lunar system?	No/Yes	

Lunar Exploration Analysis Group



Request went out to >700 registered recipients, 31 responded

Questions	Vote	Notes
Are the volatiles in the Permanently Shadowed Regions (PSR) on the Moon of significant interest in the study of chemical evolution?	Yes Maybe	
Are you concerned that contamination carried by a spacecraft to the Moon could compromise future investigations to study chemical evolution?	Yes/No	No-votes described stated that: <ul style="list-style-type: none">• "There are mitigation methods such as documenting contamination knowledge..."• "...properly acquired core samples should be protected from volatile products"• "Mass balance suggest this is not a realistic concern"• No if good, but not extreme, protocols are followed"
Are you concerned about the long-term degradation of organic materials?	Yes/No	No-votes described stated that: <ul style="list-style-type: none">• "...not worry about degradation of such materials noticeable affecting the environment around the spacecraft on the timescale of exploration"
Are you concerned about organic volatiles released by certain types of propellants?	Yes (No)	No-votes described stated that: <ul style="list-style-type: none">• "...can be well understood if documented and characterized"

Lunar Exploration Analysis Group



Request went out to >700 registered recipients, 31 responded, cont.

Questions	Vote	Notes
Would an organic material list describing the kinds and amounts of organic materials on a spacecraft mitigate your concerns?	Yes (No)	No-votes described stated that: <ul style="list-style-type: none">• "Only if coupled with a model how these materials could be transferred to the sample site. If there is no transfer mechanism, this does not matter"
Would establishment of lunar PSR protected areas with controlled access and avoidance of unnecessary contamination (e.g., obsolete parts of spacecraft like used propulsion stages) mitigate your concerns?	Yes/No	Statements: <ul style="list-style-type: none">• "Controlled access will help but won't entirely avoid contamination. Any spacecraft landed or crashed anywhere on the Moon will outgas, portions of the outgassed vapor will eventually end up in the PSRs. But, diverting spent hardware away from impact on the Moon is a big help"• "I strongly recommend an international agreement be sought and supported to restrict lunar polar investigations to only ONE pole until the character, form, and abundance of any volatiles present are well known and documented"
Are you concerned about the either controlled or uncontrolled introduction and release of biological materials (living and dead) into the lunar system?	-	

Preliminary Conclusions – Work in Progress



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

- The result of the LEAG consultation is in line with the current COSPAR Planetary Protection Category & Requirements for the Moon
- There might be a rationale to reduce the organic inventory documentation to volatile products of the propulsion and life support system

COSPAR Lunar Questionnaire Status



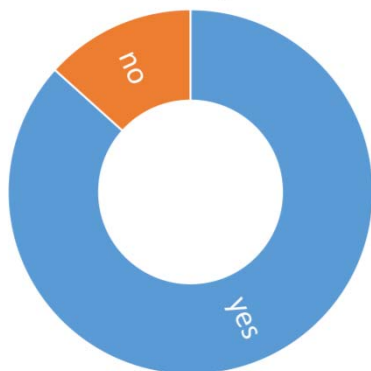
COSPAR consultation received 90 responses (not including LEAG)

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

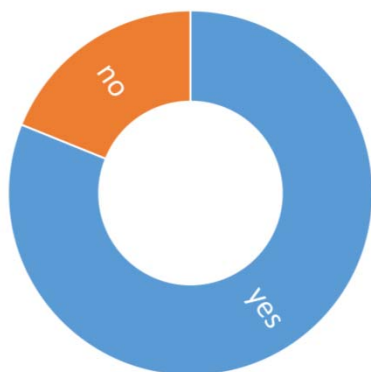
COSPAR Lunar Questionnaire Status



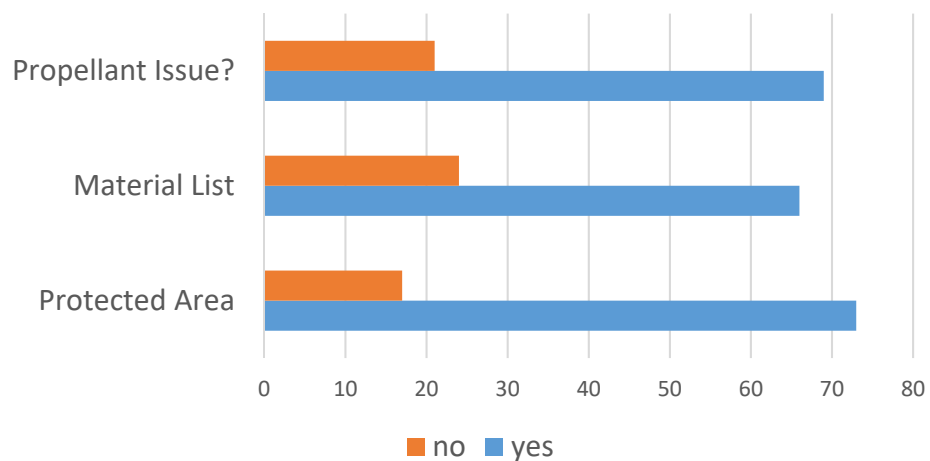
Interested in lunar polar volatiles?



Concerned about contamination?



Mitigation of Issue



Preliminary Conclusions – Work in Progress



- There is still interest in the lunar polar volatiles
- There is concern about contaminating the lunar polar volatiles
 - ❖ Concern about spacecraft propellant seems to be dominant
- Mitigation measures in terms of mission organic/volatile inventory and protected zones are equivalent

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

- There might be a rationale to reduce the organic inventory documentation to volatile products of the propulsion and life support system

Preliminary Conclusions – Work in Progress



- The result of the COSPAR stakeholder consultation and the LEAG consultation are in line with the current COSPAR Planetary Protection Category & Requirements for the Moon
- There might be a rationale to reduce the organic inventory documentation to volatile products of the propulsion and life support system
 - Discussion point - what to do with used spacecraft elements/propulsion stages/end-of-life dispositions (no requirement like now, new avoid hitting the PSR requirement, new avoid hitting the Moon requirement,...)



Things to remember

- Planetary protection is about protecting planetary science and the Earth
- 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
- Planetary protection categories and requirements are not cast in stone and evolve over time as new information becomes available, i.e. check the latest version at the start of a new project
- COPUOS in its 2017 report noted the long-standing role of COSPAR in maintaining the Planetary Protection Policy as a reference standard for spacefaring nations and in guiding compliance with Article IX of the Outer Space Treaty

