COSPAR POLICY DEVELOPMENT PROCESS

Presentation to the SSB
Committee to Review the PP Policy Development Processes
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COSPAR POLICY DEVELOPMENT PROCESS

- COSPAR policy and guidelines are established and amended through the process of resolutions
- An amendment to existing policy and guidelines can be considered if a COSPAR Associate or Bureau/Council member brings the underlying issue to the attention of the PP Panel Chair
- If the issue is complex, the Chair requests the convening of a COSPAR workshop to review, discuss, and evaluate the merits of the issue and the associated proposal for an amendment

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

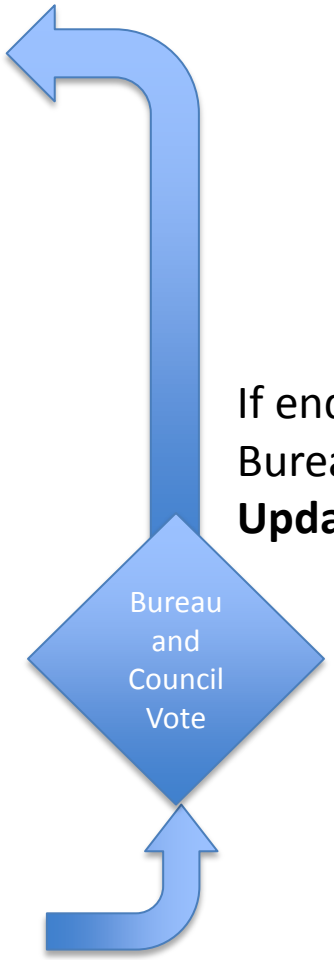
- Proposals for amendments may be based on new discoveries, the results of new research, or recommendations to Agencies by advisory bodies (internal or external)
- They may also be based on the identification of new implementation strategies and needs, the need for more detailed guidelines, and new challenges
- COSPAR Associates can be scientists or engineers, etc. who participate in COSPAR Assemblies

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- After a thorough discussion by a broad set of stakeholders, workshops may approve a proposed amendment and prepare a draft resolution to be presented to the COSPAR PP Panel at the COSPAR Scientific Assembly
- The PP Panel discusses the resolution (usually in a session and at the business meeting) and votes on its approval
- Accepted resolutions are then presented and explained to the COSPAR Bureau and if the Bureau approves, to the COSPAR Council

COSPAR Planetary Protection Policy Development*

- COSPAR Planetary Protection Policy
  (COSPAR Bureau- and Council-endorsed)
- New phenomena reported/new missions proposed/other external considerations
  (Peer reviewed scientific literature/request from private or public entity/recommendations from agency advisory groups)
- Possible study by a scientific organization and/or a COSPAR-sponsored workshop
  (May be solicited by space agencies and carried out by a National Scientific Institution or International Scientific Unions)
- Panel on Planetary Protection meeting
  (Panel business meeting at COSPAR Scientific Assemblies or dedicated COSPAR Panel Colloquium or workshop, involving representatives of the scientific community and other relevant stakeholders)
- Panel recommendation to Bureau & Council
  (At COSPAR Scientific Assemblies or at COSPAR Bureau meetings between Assemblies)



If endorsed by the Bureau and Council, **Update to Policy**

*Kminek, G. and Rummel, J.D. COSPAR's Planetary Protection Policy. *Space Research Today,* 193:7-19 (2015)

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR RESOLUTION 26.5

COSPAR Information Bulletin No. 20, 1964, p. 25-26

- **COSPAR "*accepts*, as tentatively recommended interim objectives, a sterilization level such that the probability of a single viable organism aboard any spacecraft intended for planetary landing or atmospheric penetration would be less than $1x10^{-4}$, and a probability limit for accidental planetary impact by unsterilized fly-by or orbiting spacecraft of $3x10^{-5}$ or less."**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR DECISION No. 16

COSPAR Information Bulletin No. 50, July 1969, p.15-16

- **COSPAR,**

- ***referring* to COSPAR Resolutions 26.5 and 26.7 of 1964, the Report of the Consultative Group on Potentially Harmful Effects of Space Experiments of 1966, and the Report of the same Group of 1967,**

- ***notes* with appreciation and interest the extensive work done by the Panel on Standards for Space probe Sterilization (now the Panel on Planetary Quarantine) and**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR DECISION No. 16 (cont.)

- ***accepts*** **as the basic objective for planetary quarantine of Mars and other planets deemed important for the investigation of extraterrestrial life, or precursors or remnants thereof, a probability of no more than $1x10^{-3}$ that a planet will be contaminated during the period of biological exploration. The period of biological exploration is assumed to be 20 years ending in 1988, and the number of missions to or near the planets is assumed to be 100. Further COSPAR**

- ***recommends*** **that, in order to meet this objective, members provide information to COSPAR within a reasonable time not to exceed six months after launch about the sterilization procedures and computations used for each flight.**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **COSPAR DECISION No. 14**
- COSPAR Information Bulletin No. 54, May 1970, p.12

- **COSPAR *recommends* "that the Jovian planets be treated with the same quarantine requirements (for flybys, orbiters or entry probes) as currently apply to Mars, the requirements be upheld until further information is available."**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR DECISION No. 9/76

COSPAR Information Bulletin No. 76, August 1976, p.14

COSPAR,

- ***noting*** **that in the exploration of the outer planets, the probabilities of growth of contaminating terrestrial micro-organisms are extremely low, reflecting the fact that the environments of these palnets appear hostile to all known biological processes,**
- ***noting*** **also that these environments do not preclude the possibility of *indigenous* life forms in some of these environments,**
- ***recognizing*** **that the search for life is a potentially valid objective in the exploration of the outer solar system,**
- ***recognizing*** **that the organic chemistry of these bodies remains of paramount importance to our understanding of the process of chemical evolution and its relationship to the origin of life,**
- ***recognizing*** **that study of the processes of the pre-biotic organic syntheses under natural conditions must not be jeopardized,**
- ***recommends*** **the use of the best available clean-room technology, comparable with that employed for the Viking mission, for all missions to the outer planets and their satellites.**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR INTERNAL DECISION No. 7/84

COSPAR,

- **considering that the Workshop on Planetary Protection, meeting on 2 July 1984, has proposed new COSPAR guidelines for planetary protection,**
- **noting that the commitment to protection of planets from biological contamination must be sustained, and**
- **noting that planetary protection guidelines must be responsive to current state of knowledge regarding planets**
- **decides that existing planetary protection guidelines (1964, 1966) be amended as follows: replace "the basic probability of one in one thousand that a planet of biological interest will be contaminated shall be used as the guiding criterion during the period of biological exploration..." with "for certain space mission/target planet combinations, controls on contamination shall be imposed in accordance with a specified range of requirements ...", in five categories as defined by D.L. DeVincenzi et al., Adv. Space Res., 3(8): 13 (1983). (See Attachment 1 to the Internal Decisions.)**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR INTERNAL DECISION No. 7/84 (cont.)

Attachment 1 to the 1984 Internal Decisions of COSPAR
(With Reference to Internal Decision 7/84)

New COSPAR Guidelines for Planetary Protection

- **1. Policy: Replace "The basic probability of one in one thousand that a planet of biological interest will be contaminated shall be used as the guiding criterion during the period of biological exploration..."**
- **with "For certain space mission/target planet combinations, controls on contamination shall be imposed in accordance with a specified range of requirements ..."**
- **2. Range of requirements: Five categories as defined by D.L. DeVincenzi et al., Adv. Space Res., 3(8): 13 (1983) excluding classifications).**
- **3. Classification: Assignment of specific mission/planet combinations to be determined by best multidisciplinary scientific advice.**
- **4. Reporting Requirements Unchanged.**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR DECISION No. 1/94

COSPAR Information Bulletin No. 131, July 1994, p.30

In keeping with the COSPAR Planetary Protection Policy adopted in Graz in 1984, and Noting:

- **1. That the Space Studies Board of the US National Research Council in 1992 recommended an update to the requirements for Mars planetary protection consistent with our current knowledge of Mars;**
- **2. That, at the 29th meeting of COSPAR in Washington in 1992, a resolution was adopted recommending the study of provisions for implementing planetary protection for mars missions;**
- **3. That a workshop on Mars planetary protection requirements, which included representatives of COSPAR, IUBS, national space agencies, planned Mars projects, and the International Mars Exploration Working Group - held in May 1994, concurred in the following amaendment to the provisions implementing the COSPAR .**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR DECISION No. 1/94 (cont.)

COSPAR Information Bulletin No. 131, July 1994, p.30

Recommends:

That COSPAR adopt the following amended version, as outlined in DeVincenzi, Stabekis & Barengoltz (1994: Paper F3.5.2):

Category III requirements are refined to include:

- **Mars orbiters will not be required to meet orbital lifetime requirements* if they achieve bioburden levels equivalent to the Viking lander pre-sterilization total bioburden. (*Now defined as 20 years after launch at greater than or equal to 99% probability, and 50 years after launch at greater than or equal to 95% probability.)**

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR DECISION No. 1/94 (cont.)

COSPAR Information Bulletin No. 131, July 1994, p.30

Recommends:

Category IV is subdivided into IVa and IVb with restrictions to be defined as::

IVa - Lander systems not carrying instruments for the investigations of extant Martian life are restricted to a biological burden no greater than Viking lander pre-sterilization levels, and

IVb - Lander systems carrying instruments for the investigation of extant Martian life are required to meet at least Viking lander post-sterilization biological burden levels, or levels of biological burden reduction driven by the nature and sensitivity of the particular life - detection experiments, whichever are more stringent.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- *COSPAR Planetary Protection Policy, 20 October 2002, as amended*

- **COSPAR PLANETARY PROTECTION POLICY**
  (20 October 2002; Amended 24 March 2005; 20 July 2008; March 2011)
- *APPROVED BY THE BUREAU AND COUNCIL, WORLD SPACE COUNCIL, HOUSTON, TEXAS, USA*
  (Prepared by the COSPAR/IAU Workshop on Planetary Protection, 4/02, with updates 10/02; 1/08; 3/11)
- **PREAMBLE**
- *Noting* that COSPAR has concerned itself with questions of biological contamination and spaceflight since its very inception, and
- *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 UN Space Treaty of 1967) states that:

  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. (UN 1967)

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- *therefore*, COSPAR maintains and promulgates this planetary protection policy for the reference of spacefaring nations, both as an international standard on procedures to avoid organic constituent and biological contamination in space exploration, and to provide accepted guidelines in this area to guide compliance with the wording of this UN Space Treaty and other relevant international agreements.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **POLICY**

- COSPAR,
- *Referring* to COSPAR Resolutions 26.5 and 26.7 of 1964, the Report of the Consultative Group on Potentially Harmful Effects of Space Experiments of 1966, the Report of the same Group of 1967, and the Report of the COSPAR/IAU Workshop of 2002,

- *notes* with appreciation and interest the extensive work done by the Panel on Standards for Space probe Sterilization and its successors the Panel on Planetary Quarantine and the Panel on Planetary Protection and

- *accepts* that for certain space mission/target body combinations, controls on contamination shall be imposed in accordance with a specified range of requirements, based on the following policy statement:

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- 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. Therefore, for certain space mission/target planet combinations, controls on contamination shall be imposed, in accordance with issuances implementing this policy. (DeVincenzi et al. 1983; COSPAR PP Workshop 2008; ESA PPWG 2008)

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- The five categories for target body/mission type combinations and their respective suggested ranges of requirements are described as follows, and in Table 1. Assignment of categories for specific mission/body combinations is to be determined by the best multidisciplinary scientific advice. For new determinations not covered by this policy, such advice should be obtained through the auspices of the Member National Scientific Institutions of COSPAR. In case such advice is not available, COSPAR will consider providing such advice through an *ad hoc* multidisciplinary committee formed in consultation with its Member National Scientific Institutions and International Scientific Unions:

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **Category I** includes any mission to a target body which is not of direct interest for understanding the process of chemical evolution or the origin of life. No protection of such bodies is warranted and no planetary protection requirements are imposed by this policy.

- **Category II** missions comprise all types of missions to those target bodies where there is significant interest relative to the process of chemical evolution and the origin of life, but where there is only a remote chance that contamination carried by a spacecraft could compromise future exploration. The requirements are for simple documentation only. Preparation of a short planetary protection plan is required for these flight projects primarily to outline intended or potential impact targets, brief Pre- and Post-launch analyses detailing impact strategies, and a Post-encounter and End-of-Mission Report which will provide the location of impact if such an event occurs. Solar system bodies considered to be classified as Category II are listed in the Appendix to this document.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **Category III** missions comprise certain types of missions (mostly flyby and orbiter) to a target body of chemical evolution and/or origin of life interest or for which scientific opinion provides a significant chance of contamination which could compromise a future biological experiment. Requirements will consist of documentation (more involved than Category II) and some implementing procedures, including trajectory biasing, the use of cleanrooms during spacecraft assembly and testing, and possibly bioburden reduction. Although no impact is intended for Category III missions, an inventory of bulk constituent organics is required if the probability of impact is significant. Category III specifications for selected solar system bodies are set forth in the Appendix to this document. Solar system bodies considered to be classified as Category III also are listed in the Appendix.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **Category IV** missions comprise certain types of missions (mostly probe and lander) to a target body of chemical evolution and/or origin of life interest or for which scientific opinion provides a significant chance of contamination which could compromise future biological experiments. Requirements imposed include rather detailed documentation (more involved than Category III), including a bioassay to enumerate the bioburden, a probability of contamination analysis, an inventory of the bulk constituent organics and an increased number of implementing procedures. The implementing procedures required may include trajectory biasing, cleanrooms, bioload reduction, possible partial sterilization of the direct contact hardware and a bioshield for that hardware. Generally, the requirements and compliance are similar to *Viking*, with the exception of complete lander/probe sterilization. Category IV specifications for selected solar system bodies are set forth in the Appendix to this document. Solar system bodies considered to be classified as Category IV also are listed in the Appendix.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **Category V** missions comprise all Earth-return missions. The concern for these missions is the protection of the terrestrial system, the Earth and the Moon. (The Moon must be protected from back contamination to retain freedom from planetary protection requirements on Earth-Moon travel.) For solar system bodies deemed by scientific opinion to have no indigenous life forms, a subcategory "unrestricted Earth return" is defined. Missions in this subcategory have planetary protection requirements on the outbound phase only, corresponding to the category of that phase (typically Category I or II). For all other Category V missions, in a subcategory defined as "restricted Earth return," the highest degree of concern is expressed by the absolute prohibition of destructive impact upon return, the need for containment throughout the return phase of all returned hardware which directly contacted the target body or unsterilized material from the body, and the need for containment of any unsterilized sample collected and returned to Earth.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Post mission, there is a need to conduct timely analyses of any unsterilized sample collected and returned to Earth, under strict containment, and using the most sensitive techniques. If any sign of the existence of a nonterrestrial replicating entity is found, the returned sample must remain contained unless treated by an effective sterilizing procedure. Category V concerns are reflected in requirements that encompass those of Category IV plus a continuing monitoring of project activities, studies and research (i.e., in sterilization procedures and containment techniques).

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Guidelines on the Implementation of an 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.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Further, COSPAR

- *Recommends* that COSPAR members inform COSPAR when establishing planetary protection requirements for planetary missions, and
- *Recommends* 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.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR will maintain a repository of these reports, make them available to the public, and annually deliver a record of these reports to the Secretary General of the United Nations. For multinational missions, it is suggested that the lead partner should take the lead in submitting these reports.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

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

  1. The estimated biological burden 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 biological burden for Category IV missions, and for Category V "restricted Earth return" missions.

  3. Methods used to control the biological burden, 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.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

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.

(COSPAR 1969, 1984, 1994; Rummel et al. 2002; Kminek and Rummel, 2015)

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **Appendix: Implementation Guidelines and Category Specifications for Individual Target Bodies**

- COSPAR,
- *Noting* that in the exploration of the outer planets, the probabilities of growth of contaminating terrestrial microorganisms are extremely low, reflecting the fact that the environments of these planets appear hostile to all known biological processes,
- *noting* also that these environments do not preclude the possibility of *indigenous* life forms in some of these environments,
- *recognizing* that the search for life is a potentially valid objective in the exploration of the outer solar system,

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- *recognizing* that the organic chemistry of these bodies remains of paramount importance to our understanding of the process of chemical evolution and its relationship to the origin of life,
- *recognizing* that study of the processes of the pre-biotic organic syntheses under natural conditions must not be jeopardized,
- *recommends* the use of the best available clean-room technology, comparable with that employed for the *Viking* mission, for all missions to the outer planets and their satellites.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **Appendix:**

  Category-Specific Listing of Target Body/ Mission Types

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Category I: Flyby, Orbiter, Lander: Undifferentiated, metamorphosed asteroids; Io; others to-be-defined (TBD)
- Category II: Flyby, Orbiter, Lander: Venus; Moon (with organic inventory); Comets; Carbonaceous Chondrite Asteroids; Jupiter; Saturn; Uranus; Neptune; Ganymede*; Callisto; 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; others TBD
  - "Unrestricted Earth return": Venus, Moon; others TBD
- *The mission-specific assignment of these bodies to Category II must be supported by an analysis of the "remote" potential for contamination of the liquid-water environments that may exist beneath their surfaces (a probability of introducing a single viable terrestrial organism of $< 1 \times 10^{-4}$), addressing both the existence of such environments and the prospects of accessing them.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- **Appendix:**
- Numerical Implementation Guidelines for Forward Contamination Calculations

  To the degree that numerical guidelines are required to support the overall policy objectives of this document, and except where numerical requirements are otherwise specified, the guideline to be used is that the probability that a planetary body will be contaminated during the period of exploration should be no more than $1x10^{-3}$. The period of exploration can be assumed to be no less than 50 years after a Category III or IV mission arrives at its protected target. No specific format for probability of contamination calculations is specified.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- CATEGORY III/IV/V REQUIREMENTS FOR MARS

  Missions to Mars

  Note: All bioburden constraints are defined with respect to the number of aerobic microorganisms that survive a heat shock of 80°C for 15 minutes (hereinafter "spores") and are cultured on TSA at 32°C for 72 hours.

  Category III. Mars orbiters will not be required to meet orbital lifetime requirements* if they achieve total (surface, mated, and encapsulated) bioburden levels of $\leq 5 \times 10^5$ spores.

  *Defined as 20 years after launch at greater than or equal to 99% probability, and 50 years after launch at greater than or equal to 95% probability. (DeVincenzi et al. 1994)

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Category IV for Mars is subdivided into IVa, IVb, and IVc:

Category IVa. Lander systems not carrying instruments for the investigations of extant Martian life are restricted to a surface biological burden level of $\leq 3 \times 10^5$ spores, and an average of ≤ 300 spores per square meter.

Category IVb. For lander systems designed to investigate extant Martian life, all of the requirements of Category IVa apply, along with the following requirement:

The entire landed system is restricted to a surface biological burden level of $\leq 30^*$ spores, or to levels of biological burden reduction driven by the nature and sensitivity of the particular life detection experiments,

OR

The subsystems which are involved in the acquisition, delivery, and analysis of samples used for life detection must be sterilized to these levels, and a method of preventing recontamination of the sterilized subsystems and the contamination of the material to be analyzed is in place.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Category IVc. For missions which investigate Martian special regions (see definition below), even if they do not include life detection experiments, all of the requirements of Category IVa apply, along with the following requirement:

  Case 1. If the landing site is within the special region, the entire landed system is restricted to a surface biological burden level of $\leq 30^*$ spores.

  Case 2. If the special region is accessed though horizontal or vertical mobility, either the entire landed system is restricted to a surface biological burden level of $\leq 30^*$ spores, OR the subsystems which directly contact the special region shall be sterilized to these levels, and a method of preventing their recontamination prior to accessing the special region shall be provided.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- If an off-nominal condition (such as a hard landing) would cause a high probability of inadvertent biological contamination of the special region by the spacecraft, the entire landed system must be sterilized to a surface biological burden level of ≤ 30* spores and a total (surface, mated, and encapsulated) bioburden level of $\leq 30 + (2 \times 10^5)$* spores.

  *This figure takes into account the occurrence of hardy organisms with respect to the sterilization modality. This specification assumes attainment of Category IVa surface cleanliness, followed by at least a four order-of-magnitude reduction in viable organisms. Verification of bioburden level is based on pre-sterilization bioburden assessment and knowledge of reduction factor of the sterilization modality.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Definition of "Special Region"

  A Special Region is defined as a region within which terrestrial organisms are likely to replicate. Any region which is interpreted to have a high potential for the existence of extant martian life forms is also defined as a Special Region. Given current understanding of terrestrial organisms, Special Regions are defined as areas or volumes within which sufficient water activity AND sufficiently warm temperatures to permit replication of Earth organisms may exist. The physical parameters delineating applicable water activity and temperature thresholds are given below:

  Lower limit for water activity: 0.5; Upper limit: 1.0

  Lower limit for temperature: -25C; No Upper limit defined

  Timescale within which limits can be identified: 500 years

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Observed features for which there is a significant (but still unknown) probability of association with liquid water, and which should be classified as special regions:

- Gullies, and bright streaks associated with gullies
- Pasted-on terrains
- Subsurface below 5 meters
- Others, to be determined, including dark streaks, possible geothermal sites, fresh craters with hydrothermal activity, modern outflow channels, or sites of recent seismic activity.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Spacecraft-induced special regions are to be evaluated, consistent with these limits and features, on a case-by-case basis.

- In the absence of specific information, no Special Regions are currently identified on the basis of possible Martian life forms. If and when information becomes available on this subject, Special Regions will be further defined on that basis (Kminek et al., 2008)

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Trajectory Biasing

The probability of impact on Mars by any part of the launch vehicle shall be $\leq 1x10^{-4}$ for a period of 50 years after launch.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Sample Return Missions from Mars

  Category V. The Earth return mission is classified, "Restricted Earth return."

  Unless specifically exempted, the outbound leg of the mission shall meet Category IVb requirements. This provision is intended to avoid "false positive" indications in a life-detection and hazard-determination protocol, or in the search for life in the sample after it is returned. A "false positive" could prevent distribution of the sample from containment and could lead to unnecessary increased rigor in the requirements for all later Mars missions.

  Unless the sample to be returned is subjected to an accepted, 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 toa receiving facility where it (they) can be opened under containment.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- The mission and the spacecraft design must provide a method to "break the chain of contact" with Mars. No uncontained hardware that contacted Mars, directly or indirectly, shall be returned to Earth. Isolation of such hardware from the Mars environment shall be provided during sample container loading into the containment system, launch from Mars, and any inflight transfer operations required by the mission.

  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.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Further Implementation Guidelines for Category V Missions

- If during the course of a Category V mission there is a change in the circumstances that led to its classification, or a mission failure, e.g.: new data or scientific opinion arise that would lead to the reclassification of a mission classified as "Unrestricted Earth return" to "Restricted Earth return," and safe return of the sample cannot be assured, OR

- The sample containment system of a mission classified as "Restricted Earth return" is thought to be compromised, and sample sterilization is impossible, then the sample to be returned shall be abandoned, and if already collected the spacecraft carrying the sample must not be allowed to return to the Earth or the Moon.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Principles and Guidelines for Human Missions to Mars

The intent of this planetary protection policy is the same whether a mission to Mars is conducted robotically or with human explorers. Accordingly, planetary protection goals should not be relaxed to accommodate a human mission to Mars. Rather, they become even more directly relevant to such missions—even if specific implementation requirements must differ. General principles include:

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- 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.
- For a landed mission conducting surface operations, it will not be possible for all human associated processes and mission operations to be conducted within entirely closed systems.
- Crewmembers exploring Mars, or their support systems, will inevitably be exposed to martian materials.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

In accordance with these principles, specific implementation guidelines for human missions to Mars include:

- Human missions will carry microbial populations that will vary in both kind and quantity, and it will not be practicable to specify all aspects of an allowable microbial population or potential contaminants at launch. Once any baseline conditions for launch are established and met, continued monitoring and evaluation of microbes carried by human missions will be required to address both forward and backward contamination concerns.
- A quarantine capability for both the entire crew and for individual crewmembers shall be provided during and after the mission, in case potential contact with a martian life-form occurs.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- A comprehensive planetary protection protocol for human missions should be developed that encompasses both forward and backward contamination concerns, and addresses the combined human and robotic aspects of the mission, including subsurface exploration, sample handling, and the return of the samples and crew to Earth.
- Neither robotic systems nor human activities should contaminate "Special Regions" on Mars, as defined by this COSPAR policy.
- Any uncharacterized martian site should be evaluated by robotic precursors prior to crew access. Information may be obtained by either precursor robotic missions or a robotic component on a human mission.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Any pristine samples or sampling components from any uncharacterized sites or Special Regions on Mars should be treated according to current planetary protection category V, restricted Earth return, with the proper handling and testing protocols.
- An onboard crewmember should be given primary responsibility for the implementation of planetary protection provisions affecting the crew during the mission.
- Planetary protection requirements for initial human missions should be based on a conservative approach consistent with a lack of knowledge of martian environments and possible life, as well as the performance of human support systems in those environments. Planetary protection requirements for later missions should not be relaxed without scientific review, justification, and consensus.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

CATEGORY III/IV/V REQUIREMENTS FOR EUROPA

Missions to Europa

- Category III and IV. Requirements for Europa flybys, orbiters and landers, including bioburden reduction, shall be applied in order to reduce the probability of inadvertent contamination of an europan ocean to less than 1×10^{-4} per mission. These requirements will be refined in future years, but the calculation of this probability should include a conservative estimate of poorly known parameters, and address the following factors, at a minimum:

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Bioburden at launch
- Cruise survival for contaminating organisms
- Organism survival in the radiation environment adjacent to Europa
- Probability of landing on Europa
- The mechanisms and timescales of transport to the europan subsurface
- Organism survival and proliferation before, during, and after subsurface transfer

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Preliminary calculations of the probability of contamination suggest that bioburden reduction will likely be necessary even for Europa orbiters (Category III) as well as for landers, requiring the use of cleanroom technology and the cleanliness of all parts before assembly, and the monitoring of spacecraft assembly facilities to understand the bioload and its microbial diversity, including specific problematic species. Specific methods should be developed to eradicate problematic species. Methods of bioburden reduction should reflect the type of environments found on Europa, focusing on Earth extremophiles most likely to survive on Europa, such as cold and radiation tolerant organisms (SSB 2000).

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Sample Return Missions from Europa
  Category V. The Earth return mission is classified, "Restricted Earth return."
  - Unless specifically exempted, the outbound leg of the mission shall meet the contamination control requirements given above. This provision should avoid "false positive" indications in a life-detection and hazard-determination protocol, or in the search for life in the sample after it is returned. A "false positive" could prevent distribution of the sample from containment and could lead to unnecessary increased rigor in the requirements for all later Europa missions.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Unless the sample to be returned is subjected to an accepted and approved sterilization process, the sample container must be sealed after sample acquisition, and a redundant, fail-safe containment with a method for verification of its operation before Earth-return shall be required. For unsterilized samples, the integrity of the flight containment system shall be maintained until the sample is transferred to containment in an appropriate receiving facility.
- The mission and the spacecraft design must provide a method to "break the chain of contact" with Europa. No uncontained hardware that contacted Europa, directly or indirectly, shall be returned to Earth. Isolation of such hardware from the europan environment shall be provided during sample container loading into the containment system, launch from Europa, and any inflight transfer operations required by the mission.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- 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 Europa 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 (SSB 1998).

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

CATEGORY REQUIREMENTS FOR SMALL SOLAR SYSTEM BODIES

Missions to Small Solar System Bodies

- Category I, II, III, or IV. The small bodies of the solar system not elsewhere discussed in thispolicy represent a very large class of objects. Imposing forward contamination controls on thesemissions is not warranted except on a case-by-case basis, so most such missions should reflect Categories I or II. Further elaboration of this requirement is anticipated.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Sample Return Missions from Small Solar System Bodies

- Category V. Determination as to whether a mission is classified "Restricted Earth return" or not shall be undertaken with respect to the best multidisciplinary scientific advice, using the framework presented in the 1998 report of the US National Research Council's Space Studies Board entitled, *Evaluating the Biological Potential in Samples Returned from Planetary Satellites and Small Solar System Bodies: Framework for Decision Making* (SSB 1998). Specifically, such a determination shall address the following six questions for each body intended to be sampled:

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

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

For containment procedures to be necessary ("Restricted Earth return"), an answer of "no" or "uncertain" needs to be returned to all six questions.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

For missions determined to be Category V, "Restricted Earth return," the following requirements shall be met:

Unless specifically exempted, the outbound leg of the mission shall meet contamination control requirements to avoid "false positive" indications in a life-detection and hazard-determination protocol, or in any search for life in the sample after it is returned. A "false positive" could prevent distribution of the sample from containment and could lead to unnecessary increased rigor in the requirements for all later missions to that body.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- Unless the sample to be returned is subjected to an accepted and approved sterilization process, the sample container must be sealed after sample acquisition, and a redundant, fail-safe containment with a method for verification of its operation before Earth-return shall be required. For unsterilized samples, the integrity of the flight containment system shall be maintained until the sample is transferred to containment in an appropriate receiving facility.
- The mission and the spacecraft design must provide a method to "break the chain of contact" with the small body. No uncontained hardware that contacted the body, directly or indirectly, shall be returned to Earth. Isolation of such hardware from the the body's environment shall be provided during sample container loading into the containment system, launch from the body, and any in-flight transfer operations required by the mission.

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

- 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 the body or its environment 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 (SSB 1998).

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR PP Meetings Outside of Biannual Assemblies (Since 2002)

2002: COSPAR/IAU Workshop on Planetary Protection, Williamsburg, Virginia, USA

2007: COSPAR Colloquium on Mars Special Regions, Rome, Italy

2008: COSPAR Workshop on Planetary Protection, Montréal, Québec, Canada

2009: COSPAR Workshop on Planetary Protection for Outer Planet Satellites and Small Solar System Bodies, Vienna, Austria

2009: COSPAR Workshop on Planetary Protection for Titan and Ganymede, Pasadena, California, USA

2010: COSPAR Workshop on Ethical Considerations for Planetary Protection in Space Exploration, Princeton, New Jersey, USA

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

COSPAR PP Meetings Outside of Biannual Assemblies
(Since 2002)

2011: COSPAR Workshop on an International Earth-based Research Program as a Stepping Stone for Global Space Exploration (with PEX), Washington, DC, USA

2012: COSPAR Planetary Protection Colloquium, Alpbach, Austria

2012: COSPAR Workshop on Developing a Responsible Environmental Regime for Celestial Bodies (with PEX), Washington, DC, USA

2013: COSPAR Workshop on Phobos-Deimos Sample Return Missions

2014: Second COSPAR Colloquium on Mars Special Regions, Montréal, Québec, Canada

2015: COSPAR Panel on Planetary Protection Colloquium, Bern, Switzerland

2016: COSPAR Workshop on Planetary Protection for Future Human Mars Missions, Houston, Texas

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

Planetary Protection Studies by the
US Space Studies Board (1990-2017)

1992: *Biological Contamination of Mars: Issues and Recommendations* (which reported advice on measures to protect Mars from contamination by Earth organisms, as well as overall policy guidance).

1997: *Mars Sample Return: Issues and Recommendations* (which reported advice to NASA on Mars sample return missions).

1998: *Evaluating the Biological Potential in Returned Samples from Planetary Satellites and Small Solar System Bodies: Framework for Decision Making* (which reported advice on sample return missions from small bodies, including places like Europa, asteroids, and comets).

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

2000: *Preventing the Forward Contamination of Europa* (which reported advice on measures to be taken to prevent the contamination of Europa by Earth organisms).

2002: *The Quarantine and Certification of Martian Samples* (which reported recommendations on actions to be taken to implement containment and biohazard testing measures recommended in 1997).

2006: *Preventing the Forward Contamination of Mars* (which reported advice on measures to be taken to prevent the contamination of Mars by Earth organisms).

2009: *Assessment of Planetary Protection Requirements for Mars Sample Return Missions* (which reported advice to NASA on Mars sample return missions).

COSPAR POLICY DEVELOPMENT PROCESS (cont'd)

2012: *Assessment of Planetary Protection Requirements for Spacecraft Missions to Icy Solar System Bodies* (which reported advice on measures to be taken to prevent the contamination of icy satellites in the outer solar system).

2015: *Review of the MEPAG Report on Mars Special Regions, jointly with the European Science Foundation* (which evaluated the report and made recommendations on how best to implement it in Mars exploration).