ECSS Training Session – 04.04.2022 - online

ECSS-U-ST-20C (1 August 2019)

Space sustainability

Planetary Protection

AGENDA

- Introduction to Planetary Protection, ECSS-U-ST-20C – 1hr
  Silvio Sinibaldi (ESA)

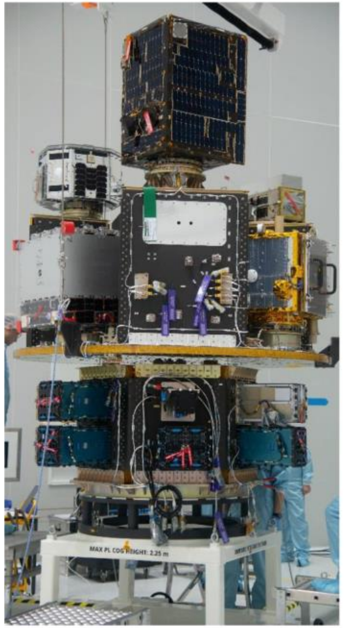
- Basic of Microbiology, bioburden assessment and bioburden reduction – 1hr
  Petra Rettberg (DLR)

- Planetary Protection and contamination control – 1hr
  Delphine Faye (CNES)

- Implementation of Planetary Protection Requirements – Case Study ExoMars – 1.5 hrs
  Diana Margheritis (TASI)

European Cooperation for Space Standardization (ECSS)

esa



AIRBUS

arianeGROUP

OHB

ThalesAlenia Space
a Thales / Leonardo company

... and many smaller companies

ECSS purpose

- develop and maintain a single set of consistent space standards
- recognized and applied for use by the entire European Space Community
- the European way of procuring space systems
- standards are made applicable by contract

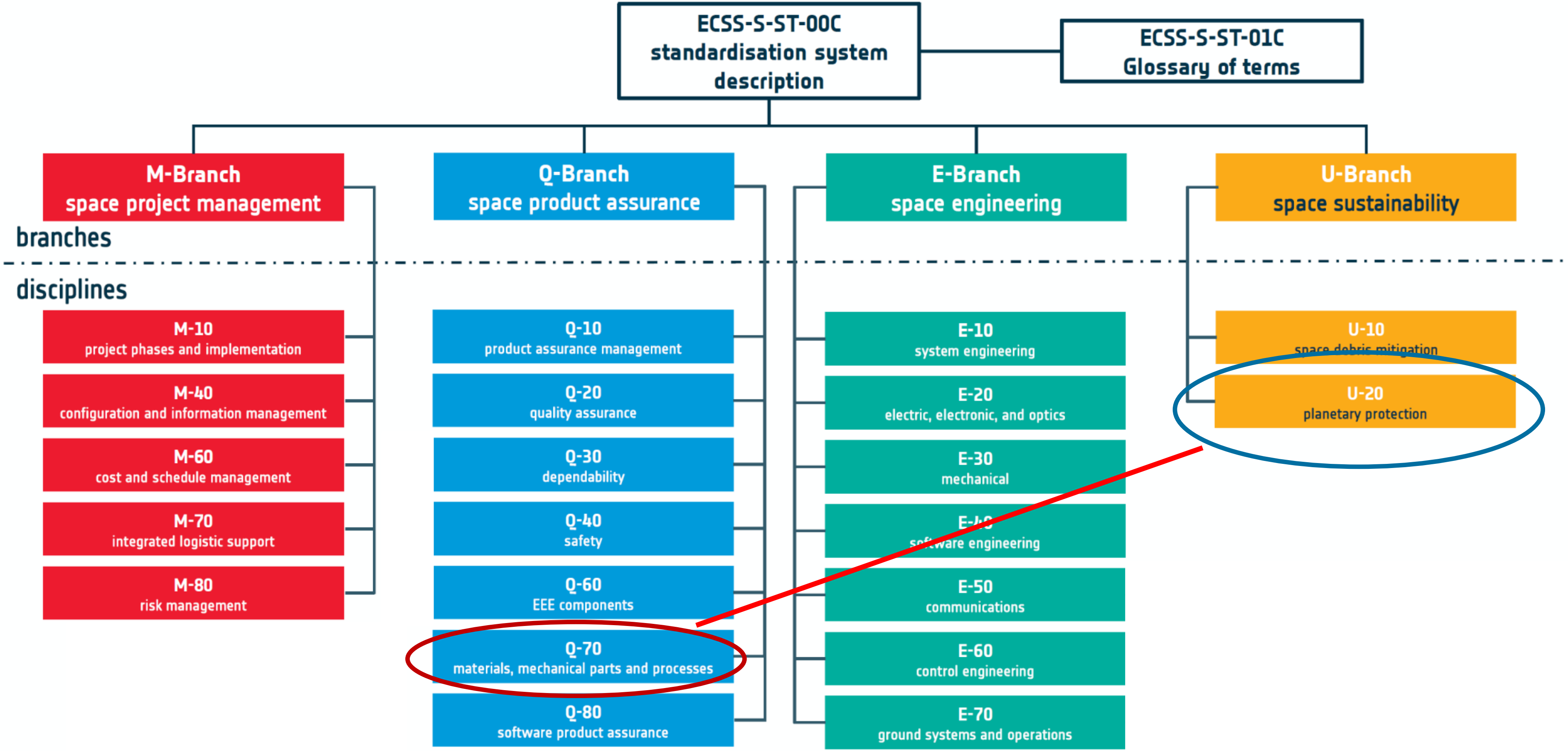
ECSS way of working

- capitalises on more than 40 years of experience in space projects
- developed through a partnership between the European Space Agency, National Space Agencies, and the European Space Industry
- liaison with CEN European Committee for Standardization ensures all ECSS standards become European Norms

ECSS

esa + ASD-EUROSPACE The Space group in ASD | agenzia spaziale italiana | cnes CENTRE NATIONAL D'ÉTUDES SPATIALES | DLR | Netherlands Space Office | Norsk Romsenter Norwegian Space Agency | UK SPACE AGENCY

ESA/ECSS Standardisation Documentation Structure



Legal framework for Planetary Protection

Ref. Introduction and Section 4.1 ECSS–U-ST-20C

UN Outer Space Treaty 1967

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

Article IX:

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

COSPAR (Committee of Space Research)

Ref. Introduction and Section 4.1 ECSS–U-ST-20C

UN Outer Space Treaty 1967

COSPAR (Planetary Protection Panel)

COSPAR PPP (Planetary Protection Panel) develops, maintains and promulgates a planetary protection policy for the reference of spacefaring nations to guide compliance with the Outer Space Treaty (UNCOPUOS, 2017)

Main goals:

- Do not jeopardise scientific investigation of possible extra-terrestrial life forms
- Protect Earth from the potential hazard posed by extra terrestrial matter carried by a spacecraft returning from an interplanetary mission.

Note: COSPAR Planetary Protection Policy and associated guidelines constitutes a voluntary non-legally binding. Implementation of engineering solutions are to be determined at the discretion of either the governmental organization responsible for undertaking the planetary mission or the regulatory authority tasked with authorizing and supervising the planetary mission undertaken by a private sector entity within that State’s jurisdiction.

International Planetary Protection Process

Ref. Introduction and Section 4.1 ECSS–U-ST-20C

esa

UN Outer Space Treaty (OST) 1967

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

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COSPAR (Planetary Protection Panel)

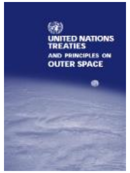
State parties to the UN OST or space agencies (ESA, NASA, JAXA, etc.)

- Support the science-based international consensus process
- Develop new guidelines and provide significant input to COSPAR

Planetary Protection Requirements Hierarchy at ESA

Ref. Section 4.1 ECSS–U-ST-20C

UN Outer Space Treaty



Guided by COSPAR PPP policy

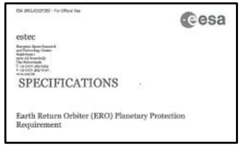
ESA Planetary Protection Policy

Levied on ESA Projects by the Planetary Protection Approval Authority

Planetary Protection Requirements ECSS-U-ST-20C

- Generated by the Projects
- Approved by the ESA Planetary Protection Approval Authority

ESA Projects – Planetary Protection Requirements



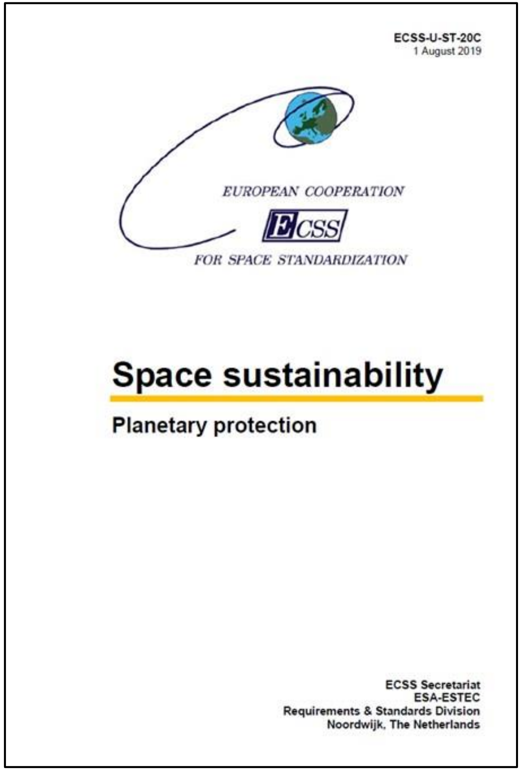
Planetary Protection ECSS Requirements Hierarchy

Planetary Protection Requirements ECSS-U-ST-20C

Lower-level (European) standards to help implementation of Planetary protection requirements – directly referenced to specific mission requirements as applicable

- ECSS-Q-ST-70-53C: Materials and hardware compatibility tests for sterilization processes
- ECSS-Q-ST-70-55C: Microbial examination of flight hardware and cleanrooms
- ECSS-Q-ST-70-56C: Vapor phase bioburden reduction of flight hardware
- ECSS-Q-ST-70-57C: Dry heat bioburden reduction of flight hardware
- ECSS-Q-ST-70-58C: Bioburden control of cleanrooms

Planetary Protection Requirements
ECSS-U-ST-20C


ECSS-U-ST-20C
1 August 2019

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space sustainability

Planetary protection

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

<u>ECSS-U-ST-20C (2019) Planetary Protection Requirements highlights:</u>

- In line with COSPAR guidelines;
- Listed in LEAS (List of ESA Approved Specification);
- It could be used by European Countries for their own missions or contribution to non-ESA-led missions;
- It is also available as EU standard - reference CEN 16604-20;

<u>It contains:</u>
- Planetary protection management requirements;
- Technical planetary protection requirements for robotic and human missions (forward and backward contamination);
- Planetary protection requirements related to procedures;
- Includes 80 individual ‘shall’ requirements and 8 DRDs
- Document Requirements Descriptions (DRD) and their relation to the respective reviews.

<u>Applicability of the document @ESA:</u>
- ESA spaceflight missions
- Contributions to ESA-led spaceflight missions
- ESA contributions to non-ESA-led spaceflight missions

Planetary Protection Categories (1/2)

(ref section 4.2 ECSS-U-ST-20C)

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 missions (fly-by, orbiters, landers) 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 requested by COSPAR policy;

Examples: Undifferentiated, metamorphosed asteroids; Io; others to-be-defined (TBD);

Category II: all types of missions (fly-by, orbiters, landers) 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[1] chance that contamination carried by a spacecraft could compromise future investigations;

Examples: Venus; Moon; Comets; Carbonaceous Chondrite Asteroids; Jupiter; Saturn; Uranus; Neptune; Ganymede*; Callisto; Titan*; Triton*; Pluto/ Charon*; Ceres; Kuiper-belt objects > ½ the size of Pluto*; Kuiper-belt objects < ½ the size of Pluto; others TBD;

*Additional analysis is required. The mission-specific assignment of these bodies to Category II must be supported by an analysis of the "remote" potential for contamination (a probability of introducing a single viable terrestrial organism of < 1 x 10-4)

Category III: flyby, orbiter and other 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;

Examples: Mars; Europa; Enceladus; others TBD;

"Remote" here 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

"Significant" here 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 Categories (2/2)

(ref section 4.2 ECSS-U-ST-20C)

Category IV: probe and lander to a target body of chemical evolution and/or origin of life interest and for which scientific opinion provides a significant chance of contamination which could compromise future investigations. See sub-category on next slides, IVa, IVb, IVc;

Examples: Lander Missions: Mars; Europa; Enceladus; others TBD;

Category V: any Earth-return missions. The concern for these missions is the protection of the terrestrial system, the Earth and the Moon. unrestricted Earth return for solar system bodies deemed by scientific opinion to have no indigenous life forms, and restricted Earth return for all others;

Examples: Any Earth-return mission. "Restricted Earth return": Mars; Europa; others TBD

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

"Remote" here 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

"Significant" here implies the presence of environments where terrestrial organisms could survive and replicate, and some likelihood of transfer to those places by a plausible mechanism

Category II – Example: Moon Organic Inventory (annex H)

Annex H (normative)
Organic materials inventory - DRD

H.1 DRD identification

H.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.3.1a.

H.1.2 Purpose and objective

The purpose of the organic materials inventory is to document the organic material on the spacecraft.

H.2 Expected response

H.2.1 Scope and Content

ECSS-U-ST-20_1430084

a. The organic material inventory shall include the following for each organic material present above a specified limit agreed with PPAA:
   1. Identity;
   2. Chemical composition;
   3. Usage, with respect to product tree;
   4. Mass estimate using the mass codes specified in ECSS-Q-ST-70-01;
   5. Rating and reference for outgassing for each item using ECSS-Q-ST-70-01;
   6. Supplier for each item.

ECSS-U-ST-20_1430085

b. For missions to the Moon, including fly-by-gravity assist, a description of the products released by the propulsion and life-support system, as applicable, into the lunar environment shall be provided, including:
   1. A quantitative and qualitative description of the major chemical species, and

Planetary Protection Requirements

Category II - Moon

COSPAR PP policy has been recently updated (3rd June 2021) to take into account scientific interest on Permanent Shadow regions and lunar poles

MOON	Type of mission	Requirements
Category II	Orbiter and Fly-by	Simple documentation as per Cat II
Category IIa	Lander not on Permanently Shadow Regions and lunar poles	Organic inventory of propulsion and attitude control system
Category IIb	Lander on Permanently Shadow Regions and lunar poles	Organic inventory of propulsion and attitude control system and entire spacecraft (quantity greater than 1.0 kg).

Planetary Protection Requirements

Ref. 5.3.2.2 ECSS-U-ST-20C

Mars mission – Category III. Fly-by & Orbiters

Launcher upper stage:
The probability of impact on Mars by any element not assembled and maintained in ISO level 8 conditions shall be $1x10^{-4}$ for the first 50 years after launch.

Fly-by / Gravity assist, orbiter:
One of the following conditions shall be met:

The probability of impact on Mars by any part of a spacecraft assembled and maintained in ISO level 8 cleanrooms, or better, is $1x10^{-2}$ for the first 20 years after launch, and $5x10^{-2}$ for the time period from 20 to 50 years after launch;OR

The total bioburden of the spacecraft, including surface, mated, and encapsulated bioburden, is $5x10^{5}$ bacterial spores

Important:

- Probability of impact "has an impact" on qualification of hardware (e.g. Solar arrays for aerobraking), trajectory design, spacecraft design (e.g. location of tanks, additional micrometeoroid protection)

- All activities necessary to perform a probability of impact analysis are interdisciplinary and require the interactions between different engineering disciplines.

Stay tuned for practical implementation examples

Planetary Protection Requirements

Ref. 5.3.2.2 ECSS-U-ST-20C

Mars mission – Category IV. Probes and Landers

Category IVa: Lander systems not carrying instruments for the investigations of extant Martian life are restricted to a surface bioburden level of ≤ 3 x 10^5 spores, and an average of ≤ 300 spores per square meter;
Note for projects: careful when allocate spores to subsystems, density vs total spores

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

Surface Bioburden of the entire landed system is restricted to a surface bioburden level of ≤ 30 spores, or to levels of bioburden reduction driven by the nature and sensitivity of the particular life-detection experiments, OR

Bioburden density of the subsystems which are involved in the acquisition, delivery, and analysis of samples used for life detection is either:

- ≤0.03 spores/m^2
- at a contamination level driven by the nature and sensitivity of the particular life-detection investigations. Example: ExoMars Rover Vehicle and UCZ (Ultra Clean Zone)

Note for projects: a method of preventing recontamination of the sterilized subsystems and the contamination of the material to be analysed is in place (that is the difficult bit to implement….)

Mars mission – Category IV. Probes and Landers

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:

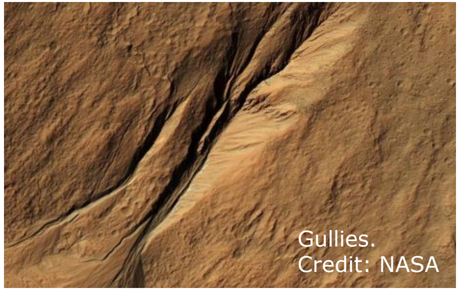
Definition of Special Region:
A Special Region is defined as a region within which terrestrial organisms are likely to replicate. Any region which is interpreted to have a high potential for the existence of extant Martian life forms is also defined as a Special Region.

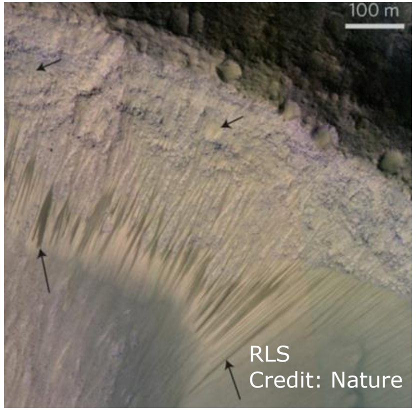
Given current understanding of terrestrial organisms, Special Regions are defined as areas or volumes within which sufficient water activity AND sufficiently warm temperatures to permit replication of Earth organisms may exist.
The physical parameters delineating applicable water activity and temperature thresholds are given below:

- Lower limit for water activity: 0.5;
- Lower limit for temperature: -28degC; No Upper limit defined

Planetary Protection Requirements

Mars mission – Category IV. Probes and Landers





Definition of Special Region:

Observed features to be treated as Special Regions until demonstrated otherwise:

- Gullies (taxon 2-4), and bright streaks associated with gullies
- Subsurface cavities
- Subsurface below 5 meters
- Confirmed and partially confirmed Recurrent Slope Lineae (RSL)

Features, if found, to be treated as a Special Region until demonstrated otherwise:

- Groundwater
- Source of methane
- Geothermal activity
- Modern outflow channel

Observed features that require a case-by-case evaluation before being classified as a Special Region:

- Dark streaks
- Pasted-on terrain
- Candidate RSL

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

Mars mission – Category IV. Probes and Landers

Category IVc: For missions which investigate Martian special regions, 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 bioburden level of ≤ 30 spores (internal and external surfaces);

Case 2. If the special region is accessed through horizontal or vertical mobility, either the entire landed system is restricted to a surface bioburden level of ≤ 30 spores (internal and external surfaces),

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.

Example: Mars special regions accessed with a Rover (horizontal mobility) or by drilling (vertical mobility).

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 bioburden level of ≤ 30 spores and a total (**surface, mated, and encapsulated**) bioburden level of ≤ 30 + (1.5 x 10^4) spores.

Mars mission – Category IV. Probes and Landers

Category IVc:

Planned 3-sigma pre-launch landing ellipses must be evaluated on a case-by-case basis as part of the (landing) site selection process, to determine whether the mission would land or come in contact within contamination range of areas or volumes meeting the parameter definition for Mars Special Regions or would impinge on already described features that must be treated as Mars Special Regions.

The evaluation must be based on the latest scientific evidence and in particular include an assessment of the extent to which the temperature and water activity values specified for Mars Special Regions are separated in time.

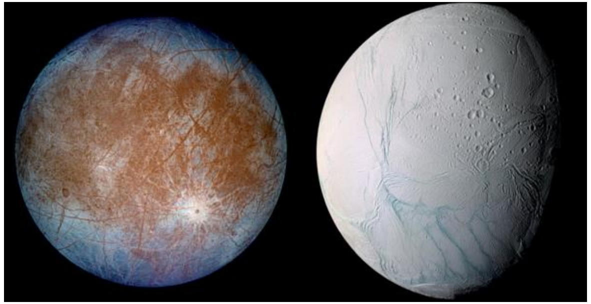
The evaluation must be updated during the mission whenever new evidence indicates that the landing ellipse and/or the operational environment contain or are in contamination range of areas or volumes meeting the parameter definition for Mars Special Regions or already described features that must be treated as Mars Special Regions

Planetary Protection Requirements

Mars mission – Summary

MARS		Surface spore [bacterial spores]	Spore density [spores/m2]	Organic inventory	probability of Impact	Comments
Fly-by, gravity assist manoeuvres	Cat. III	* ≤ $5x10^5$	NA	NA	* ≤ $1x10^{-4}$	If not assembled in ISO8 cleanroom (ex. Upper stages)
					* ≤ $1x10^{-2}$	For first 20 years
					* ≤ $5x10^{-2}$	From 20-50 years
Lander systems not carrying instruments for searching life	Cat. IV a	≤ $3x10^5$	≤ 300	YES	NA	Surface spore: On exposed internal and external surfaces
Lander Systems searching for Martian life	Cat. IV b	≤ 30 or driven by search-for-life instruments	≤ 0.03 or driven by the nature and sensitivity of search-for-life	YES	NA	Specific contamination level for search for life instruments (including organic contamination, TOC- Total Organic Carbon) shall be subject to review and approval by the PPAA
Lander Systems in special regions	Cat. IV c	≤ 30	iaw surface spore	YES	NA	Surface spore: Either the entire spacecraft (if directly landing on special regions or the elements accessing vertically or horizontally)
		* Either probability of impact or number of spores (i.e. NOT BOTH)		An organic materials inventory of bulk constituents ≥1 kg		

Europa and Enceladus – Category III & IV

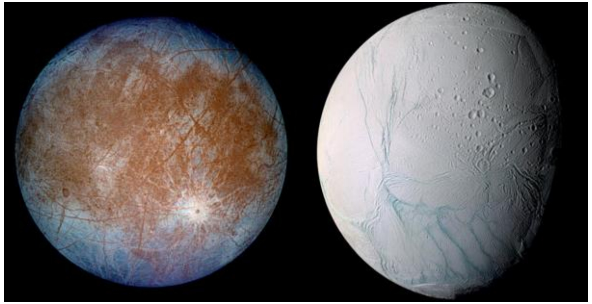


Requirements for Europa and Enceladus flybys, orbiters and landers, including bioburden reduction, shall be applied in order to reduce the probability of inadvertent contamination of a Europan or Enceladan ocean to less than 1×10^{-4} per mission.

The probability of inadvertent contamination of a Europan or Enceladan ocean of 1×10^{-4} applies to all mission phases including the duration that spacecraft introduced terrestrial organisms remain viable and could reach a subsurface liquid water environment.

The biological exploration period for Europa and Enceladus is defined to be 1000 years (starting at the beginning of 21st century)

Europa and Enceladus – Category III & IV



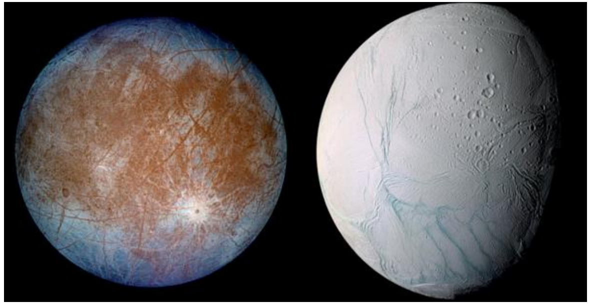
The calculation of the probability of inadvertent contamination shall address the following factors, at a minimum:

1. Bioburden at launch;
2. Cruise survival for bioburden;
3. Bioburden survival in the respective radiation environment;
4. Probability of landing on Solar system body;
5. The mechanisms and timescales of transport to the subsurface; AND
6. Bioburden survival and proliferation before, during, and after subsurface transfer.

Important: Methods of bioburden reduction reflect the type of environments found on Europa or Enceladus, focusing on terrestrial organisms most likely to survive on Europa or Enceladus, such with cold, desiccation and radiation tolerance.

Estimate for poorly known parameters shall be subject to approval by the customer and PPAA (Planetary Protection Approval Authority).

Europa and Enceladus – Category III & IV



Let’s not forget **Mars**… on our journey to Icy Moons…

See requirement for Mars - one of the following conditions shall be met by orbiters:

- The probability of impact on Mars by any element not assembled and maintained in ISO level 8 conditions (i.e. upper stage launcher) shall be $\leq 1x10^{-4}$ for the first 50 years after launch;

- The probability of impact on Mars by any part of a spacecraft assembled and maintained in ISO level 8 cleanrooms, or better, is 1x10-2 for the first 20 years after launch, and $5x10^{-2}$ for the time period from 20 to 50 years after launch.

Small Solar System Bodies

They represent a very large class of objects.
Imposing forward contamination controls on these missions is not warranted except on a case-by-case basis, so most such missions should reflect Categories I or II

Backward Planetary Protection Requirements

Category V – Earth Return Missions

Determination as to whether a mission is classified "Restricted Earth return" or not shall be undertaken with respect to the best multidisciplinary scientific advice. Specifically, such a determination shall address the following six questions for each body intended to be sampled:

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 CO_2 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

Planetary Protection Requirements

Category V – Restricted Earth Return

Sample return from solar system bodies deemed by scientific opinion to have the potential for indigenous life forms

MARS Sample Return Campaign

The concern is the possibility that a putative Martian organism inadvertently released from containment could produce large-scale negative pathogenic effects in humans, or could have a destructive impact on Earth's ecological systems or environments (NRC, 2009)

- The potential risks of large-scale effects arising from the intentional return of martian materials to Earth are primarily those associated with replicating biological entities;
- The potential for large-scale negative effects on Earth's inhabitants or environments by a returned martian life form appears to be low, but is not demonstrably zero. Consistent advice from various scientific advisory bodies (NRC 1997, NRC 2009, ESF 2012);
- Samples returned from Mars should be contained and treated as though potentially hazardous;
- No uncontained martian materials, including spacecraft surfaces that have been exposed to the martian environment, should be returned to the Earth-Moon system unless sterilized;
- Ensure independent oversight, including regulatory authorities

Planetary Protection Requirements

Category V – Mars Sample Return

Forward Planetary Protection:
Category IVb (Search For Life) shall be applied to the outbound leg of a Mars sample return mission.
Rationale: To avoid "false positives", as that would prevent distribution of the sample from containment and could lead to unnecessary increased rigor in the requirements for all later missions to that body.

Backward Planetary Protection:
Quantitative requirements: The probability that a single unsterilized Martian particle of ≥ 0,01 μm in diameter is released into the terrestrial environment shall be ≤ $1x10^{-6}$ for the first 100 years after launch from Mars, demonstrated with PRA (Probabilistic Risk Assessment);

Qualitative Requirements: The severity of potential consequences of releasing unsterilized material from Mars and flight hardware that has been exposed to unsterilized material from Mars into the terrestrial environment shall be categorised as level 1 in accordance with ECSS-Q-ST-40 (Safety).

- No single system failure or single operator error shall have critical or catastrophic consequences.
- There shall be no single fault within the system that can result in critical or catastrophic failure propagation to the remainder of the system or spacecraft.

Planetary Protection Requirements

Category V – Mars Sample Return

Backward Planetary Protection:

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. No un-contained 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.

Planetary Protection Requirements

See Annex I ECSS-U-ST-20C

Humans mission to Mars

At the time being, there are no specific requirements issued for human missions to Mars yet, but only general implementation guidelines, summarised as followed:

- Planetary protection goals should not be relaxed to accommodate a human mission to Mars, i.e. they become even more directly relevant to such missions—even if specific implementation requirements must differ;
- 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.

Since 2016, the COSPAR workshop series on "Planetary protection requirements for human extraterrestrial missions" has generated and refined a set of planetary protection (PP) knowledge gaps (KGs) in 3 different areas:

- microbial and human health monitoring (in habitat and in crew);
- microbial contamination control and mitigation in spacecraft systems, and;
- transport and survival of terrestrial life at Mars

Planetary Protection Requirements

Documentation

ECSS-U-ST-20C
1 August 2019

ECSS-U-ST-20_1430065

Table 5-2: Planetary protection documentation

Documentation	Preliminary	Final	PPAA Approval/Review	DRD ref.
Planetary Protection Requirements	PRR	SRR	A	Annex A
Planetary Protection Plan	SRR	PDR	A	Annex B
Planetary Protection Implementation Plan	PDR	CDR	R	Annex C
Pre-Launch Planetary Protection Report	FAR	FRR	R	Annex D
Post-Launch Planetary Protection Report		No later than 6 months after launch	R	Annex E
Extended Mission Planetary Protection Report		Before the commitment for the extended mission	R	Annex F
End-of-Mission Planetary Protection Report		No later than 6 months after end-of-mission	R	Annex G
Organic Materials Inventory	CDR	FRR	R	Annex H

QUESTIONS?

Back up Slides

Planetary Protection Requirements

Category II - Moon

COSPAR PP policy has been recently updated (3rd June 2021) to take into account scientific interest on Permanent Shadow regions and lunar poles

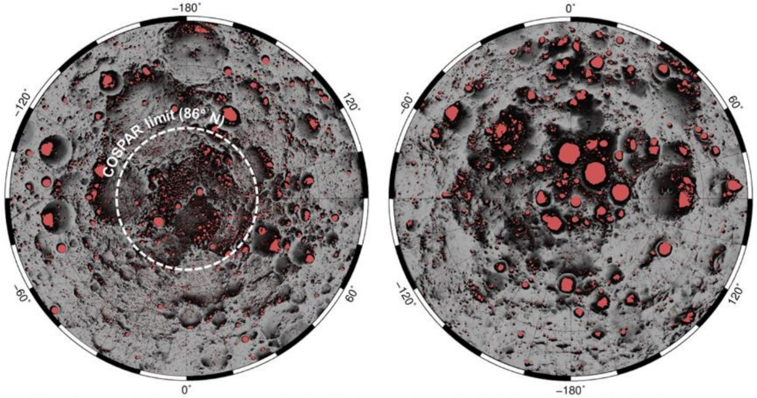


Fig. 1. Locations of permanent shadow (marked in red) overlaid on average solar illumination (grayscale) within 10□ latitude of the lunar North Pole (left) and South Pole (right). The northern latitude limit for COSPAR PPP Category II(b), 86□N, is indicated; the corresponding southern limit, 79□S, lies outside the area shown. Data from https://pgda.gsfc.nasa.gov/products/69 (see Mazarico et al).

8. Category II requirements for missions to the Moon

8.1 Orbiter and fly-by missions to the Moon [13]

Category II. Orbiter and fly-by missions to the Moon shall provide the planetary protection documentation described in Table 1. There is no need to provide an organic inventory.

8.2. Lander missions to the Moon [13]

Category II for the Moon is subdivided into IIa and IIb:

Category IIa. All missions to the surface of the Moon whose nominal mission profile does not access areas defined in Category IIb shall provide the planetary protection documentation described in Table 1 and an organic inventory limited to organic products that may be released into the lunar environment by the propulsion system,

Category IIb. All missions to the surface of the Moon whose nominal profile access Permanently Shadowed Regions (PSRs) and the lunar poles, in particular latitudes south of 79°S and north of 86°N shall provide the planetary protection documentation described in Table 1 and an organic inventory in line with chapter 3 [14].

Planetary Protection Requirements

Category II

Description: All types of missions to a target body for which there is significant scientific interest relative to the process of chemical evolution and the origins of life but for which scientific opinion provides only a remote chance that contamination by a spacecraft can compromise future investigations;

General requirements: Simple documentation, i.e. Planetary protection & implementation plan due at CDR (preliminary at PDR) . Pre launch, post launch, post encounter reports; end of mission reports

HOWEVER, All missions leaving Earth orbit must demonstrate compliance with impact probabilities or bioburden limits for Mars and probability of contamination limits for Europa & Enceladus

Example, for JUICE (Jupiter Icy Moons) *Category II* for Ganymede was supported by an analysis of the "remote" potential for contamination of liquid-water environments that may exist beneath the surface (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.