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**ECSS Secretariat**

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**Foreword**

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards. Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

This Standard has been prepared by the Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

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Change log

|  |  |
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| ECSS-U-ST-20C DFR120 December 2017 | Delivery of updated DFR (from 29Nov2017) after discussion with ES |
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Introduction

In 1958, the year after Sputnik, the National Research Council (NRC) of the US National Academy of Sciences (NAS) expressed its deep concern that initial exploration of the Moon and other celestial bodies can compromise future scientific exploration. The Council recommended to plan and conduct Solar system exploration so as to prevent their contamination. The resolution of the NRC was communicated to the Bureau of the International Council of Scientific Unions (ICSU). The ICSU formed an ad-hoc Committee on Contamination by Extraterrestrial Exploration (CETEX) and issued the first code of conduct for planetary protection in the autumn of 1958. The report was endorsed by the NAS Space Studies Board (SSB) and recommended that the newly established Committee On Space Research (COSPAR) of the ICSU assumes responsibility for matters of planetary protection.

The first spaceflight missions to use planetary protection requirements were the Ranger missions in 1961. Since then, various missions beyond Earth orbit had to implement planetary protection measures at different degrees – ranging from simple documentation to terminal sterilization of entire flight systems.

The legal basis 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).

The basic goals of planetary protection have remained unchanged:

1. Ensure that scientific investigations related to the origin and distribution of extraterrestrial life are not compromised, and
2. To protect Earth and its biosphere (including the Moon) from potential harmful extraterrestrial sources of contamination.
3. To meet these goals, spaceflight missions have to control
4. Forward contamination, contamination of celestial bodies other than the Earth by terrestrial life forms in the course of spaceflight missions, and
5. Backward contamination, contamination of the terrestrial biosphere by extraterrestrial life forms in the course of spaceflight missions.

This standard describes the planetary protection requirements for spaceflight missions based on the COSPAR planetary protection policy and requirements. The content of this document has been coordinated with the already existing ESA and NASA standards to ensure that requirements, documentation and reviews cover the needs and obligations of international partners for joint missions or contributions to a third party mission.

# Scope

This standard contains planetary protection requirements, including:

* Planetary protection management requirements;
* Technical planetary protection requirements for robotic and human missions (forward and backward contamination);
* Planetary protection requirements related to procedures;
* Document Requirements Descriptions (DRD) and their relation to the respective reviews.

This standard may be tailored for the specific characteristic and constrains of a space project in conformance with ECSS-S-ST-00.

# Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

|  |  |
| --- | --- |
| ECSS-S-ST-00-01 | ECSS System – Glossary of terms |
| ECSS-Q-ST-10-09 | Space product assurance – Nonconformance control system |
| ECSS-Q-ST-70-01 | Space product assurance – Cleanliness and contamination control |
| ECSS-Q-ST-70-53 | Space product assurance – Materials and hardware compatibility tests for sterilization processes |
| ECSS-Q-ST-70-55 | Space product assurance – Microbial examination of flight hardware and cleanrooms |
| ECSS-Q-ST-70-56 | Space product assurance – Vapour phase bioburden reduction of flight hardware |
| ECSS-Q-ST-70-57 | Space product assurance – Dry heat bioburden reduction of flight hardware |
| ECSS-Q-ST-70-58 | Space product assurance – Bioburden control of cleanrooms |

# Terms, definitions and abbreviated terms

## Terms from other standards

1. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.
2. For the purpose of this Standard the following terms and definitions from ECSS-Q-ST-70-53 apply:
	1. micro-organism
3. For the purpose of this Standard the following terms and definitions from ECSS-Q-ST-70-58 apply:
	1. bioburden
	2. biodiversity
	3. sterilization

## Terms specific to the present standard

1. assay

collection and analysis of biological contamination with a specified procedure

1. encapsulated bioburden

bioburden inside the bulk of non-metallic materials not manufactured with ALM

1. 1 Examples are bioburden inside paints, conformal coatings, thermal coatings, adhesives, composite materials, closed-cell foam.
2. 2 The encapsulated bioburden of ALM manufactured materials is currently unknown.
3. services

launch services, communication services and relay functions provided

1. exposed surfaces

internal and external surfaces free for gas exchange

1. extant life

form of life, or signatures thereof, whether metabolically active or dormant

1. extinct life

form of life, or signatures thereof, that is unambiguously no longer metabolically active or dormant

1. highly controlled

bioburden control of cleanroom by use of full body coverall, hood, face mask, gloves and boots, restricted access and dedicated cleaning

1. inbound leg

<CONTEXT: sample return missions>

part of the mission returning to Earth

1. life detection investigation

scientific investigations that can detect signatures of life

1. Mars special region

area or volume within which sufficient water activity and sufficiently warm temperatures to permit the replication of Earth organisms

1. In the absence of specific information, no special regions are currently identified on the basis of possible Martian life forms.

[COSPAR’s Planetary Protection Policy, Space Research Today, 200, 2017]

1. mated surfaces

surfaces joined by fasteners rather than by adhesives

1. normally controlled

use of gowning equivalent to the specific cleanroom particulate class

1. organic material

material that contain either covalent C-H or C-C bonds

1. Organic material can fall in several of the material groups of a DML.
2. outbound leg

<CONTEXT: sample return missions>

part of the mission leaving Earth

1. planetary protection approval authority

entity that specifies, for a given project, the planetary protection categorization, detailed technical planetary protection requirements, and reviews their implementation

1. Such an entity is typically a space agency or federal agency, i.e. customer, under delegation by the government as signatory of the UN Outer Space Treaty.
2. planetary protection category

category assigned to reflect the interest and concern that contamination can compromise future investigations and depends on the target body and mission type

1. Different requirements are associated to the various categories.
2. protected Solar system body

<CONTEXT: probability of impact analysis>

Solar system bodies, including planets and moons, for which there is significant scientific interest relative to the process of chemical evolution and the origins of life and for which scientific opinion provides a significant chance that contamination by a spacecraft can compromise future investigations

1. In accordance with this definition and the categories defined in 4.2, protected Solar system bodies are assigned to planetary protection category III and IV.
2. restricted Earth return

planetary protection sub-category V for sample return missions from Solar system bodies deemed by scientific opinion to have a possibility of harbouring indigenous life forms

1. unrestricted Earth return

planetary protection sub-category V for sample return missions from Solar system bodies deemed by scientific opinion to have no indigenous life forms

## Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

| Abbreviation | Meaning |
| --- | --- |
| AIT | assembly, integration and test |
| AIV | assembly, integration and verification |
| ALM | additive layer manufacturing |
| CDR | critical design review |
| CETEX | Committee on Contamination by Extraterrestrial Exploration |
| COSPAR | Committee on Space Research |
| DHMRDRD | dry heat microbial reductiondocument requirements definition |
| ECSS | European Cooperation for Space Standardization |
| ESA | European Space Agency |
| FAR | flight acceptance review |
| FRR | flight readiness review |
| ICSU | International Council of Scientific Unions |
| ISO | International Organization for Standardization |
| LRR | launch readiness review |
| MSR | Mars sample return |
| NAS | National Academy of Sciences |
| NASA | National Aeronautics and Space Administration |
| NRC | National Research Council |
| PPAA | planetary protection approval authority |
| PRR | preliminary requirements review |
| SB | small body |
| SRR | system requirements review |
| SSB | space studies board |
| STP | standard temperature and pressure |
| VCD | verification control document |

# Principles

## Planetary protection roles and responsibilities

### COSPAR

Today COSPAR maintains and promulgates a 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 and requirements in this area to guide compliance with the wording of the Outer Space Treaty [1]. Content of the Agency level planetary protection report to COSPAR is described in the COSPAR Planetary Protection Policy (COSPAR’s Planetary Protection Policy, Space Research Today, 200, 2017) [2].

### Customer level

The correct implementation of the planetary protection requirements is ensured by establishing a planetary protection organisation and management system with a Planetary Protection Approval Authority (PPAA) function to:

* Approve planetary protection categorization and requirements for flight projects.
* Perform assessments, in coordination with the implementing project, including inspections and reviews of facilities, equipment, procedures and practices as appropriate to ensure compliance with the planetary protection requirements.
* Verify the planetary protection compliance in the course of flight projects, prior to launch, and in the case of returning spacecraft prior to the return phase of the mission, prior to Earth entry, and again prior to the release of returned samples.
* Report to COSPAR on the planetary protection compliance of spaceflight missions.

### Supplier level

The supplier is responsible for the correct identification and implementation of the planetary protection requirements at project level.

In particular, the supplier is responsible to:

* Identify the planetary protection requirements specific to the project by tailoring this standard;
* Ensure the flow-down of planetary protection requirements to suppliers down the supply chain and payload providers;
* Define the planetary protection implementation and management approach;
* Define the planetary protection responsibilities within the project;
* Prepare project-level planetary protection documentation;
* Consider the implementation of the recommendations of reviews with respect to planetary protection aspects.

The inputs for the Planetary Protection Requirements Document are based on the following documents:

* Customer requirements from the business agreement document (including ECSS-U-ST-20),
* COSPAR policy and requirements for planetary protection,
* Additional requirements coming from the obligations of customer external planetary protection authorities.
1. This is the case for the missions developed with other space agencies.

## Planetary protection category definitions

The different planetary protection categories reflect the level of interest and concern that contamination can compromise future investigations. The categories and associated requirements depend on the target body and mission type combinations.

The following descriptions of Categories I to V are based on the COSPAR classification at the time of issuing this standard [2]. The latest and applicable classification and associated requirements are provided, for each particular case, by the PPAA.

### Category I

#### Description

All types of missions to a target body for which there is no significant scientific interest relative to the process of chemical evolution and the origins of life.

#### Applicability

S-type asteroids, Io, Mercury.

#### Requirements

None.

### 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.

#### Applicability

Venus, Moon (with organic inventory), Comets, P, D, and C-type asteroids, Jupiter, Jovian satellites (except Io, Europa, and Ganymede), Ganymede (with probability of contamination analysis), Saturn, Saturnian satellites (except Titan), Titan (with probability of contamination analysis), Uranus, Uranian satellites, Neptune, Neptunian satellites (except Triton), Triton (with probability of contamination analysis), Pluto and Charon (with probability of contamination analysis), Kuiper Belt Objects ≤ ½ size of Pluto, Kuiper Belt Objects > ½ size of Pluto (with probability of contamination analysis ).

#### Type of requirements to be considered

Simple documentation; probability of contamination analysis that can lead to Category III and IV requirements.

### Category III

#### Description

Fly-by and orbital missions to a target body for which there is significant scientific interest relative to the process of chemical evolution and the origins of life and for which scientific opinion provides a significant chance that contamination by a spacecraft can compromise future investigations.

#### Applicability

Mars, Europa, Enceladus.

#### Type of requirements to be considered

Detailed documentation, organic inventory, trajectory bias and orbital lifetime, bioburden control.

### Category IV

#### Description

Surface missions to a target body for which there is significant scientific interest relative to the process of chemical evolution and the origins of life and for which scientific opinion provides a significant chance that contamination by a spacecraft can compromise future investigations. Category IV for Mars is subdivided into Category IVa (basic requirements for all Mars surface missions), IVb (missions with life detection), and IVc (missions accessing Mars special regions).

#### Applicability

Mars, Europa, Enceladus.

#### Type of requirements to be considered

Detailed documentation, organic inventory, trajectory bias, orbital lifetime, bioburden control and sterilization for a large number of materials, parts and assemblies.

### Category V

#### Description

All Earth-return missions. For Solar system bodies deemed by scientific opinion to have no indigenous life forms, a subcategory “unrestricted Earth return” is defined. For all other Category V missions a subcategory “restricted Earth return” is defined.

#### Applicability

Restricted Earth return – Mars, Europa; Unrestricted Earth return - Venus, Moon, S-type asteroids, Io, Mercury.

#### Requirements

1. Unrestricted Earth return missions have planetary protection requirements on the outbound phase only, corresponding to the category of that phase (typically Category I or II).
2. For restricted Earth return missions there is a need for:
	1. Containment throughout the return phase of all returned hardware which directly contacted the target body or unsterilized material from the body;
	2. Containment of any unsterilized sample collected and returned to Earth;
	3. Conducting 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 non-terrestrial replicating entity is found, containment of the returned sample, unless treated by an effective sterilizing procedure.
3. Requirements for the outbound phase are typically Category IV.
4. The Earth’s Moon is considered part of the Earth-Moon system and has the same level of protection from backward contamination as the Earth to avoid planetary protection requirements for lunar missions.

## Mars special regions definition

Mars special regions are defined under following conditions:

1. The physical parameters delineating applicable water activity and temperature thresholds are:
	1. Lower limit for water activity: 0,5; upper limit: 1,0
	2. Lower limit for temperature: -28 °C; no upper limit defined
	3. Timescale within which limits can be identified: 500 years
2. Observed features to be treated as Special Regions until demonstrated otherwise:
	1. Gullies (taxon 2-4), and bright streaks associated with gullies
	2. Subsurface cavities
	3. Subsurface below 5 metres
	4. Confirmed and partially confirmed Recurrent Slope Lineae (RSL)
3. Features, if found, to be treated as a Special Region until demonstrated otherwise:
	1. Groundwater
	2. Source of methane
	3. Geothermal activity
	4. Modern outflow channel
4. Observed features that require a case-by-case evaluation before being classified as a Special Region:
	1. Dark streaks
	2. Pasted-on terrain
	3. Candidate RSL
5. Description for Gully taxon [3]
6. Observational evidence for Recurrent Slope Lineae (RSL), adapted from [4]:
	1. Confirmed: observed simultaneous incremental growth of flows on a warm slope, fading, and recurrence of this sequence in multiple Mars years
	2. Partially confirmed: observed either incremental growth or recurrence
	3. Candidate: slope lineae that resemble RSL but where observations needed for partial confirmation are currently lacking

# Requirements

## Management requirements for all missions

The supplier shall prepare a preliminary Planetary Protection Requirements document for approval by the PPAA in conformance with the DRD in Annex A during the Phase A and no later than the PRR.

For missions that target or encounter multiple Solar system bodies, the preliminary Planetary Protection Requirements document shall include all specifications for all the protected Solar system bodies.

The Planetary Protection Requirements document specified in the requirements 5.1a and 5.1b shall be in compliance with the following documents:

Requirements from clause 5 of ECSS-U-ST-20,

COSPAR planetary protection policy and requirements,

The obligations of relevant external planetary protection authorities

The approved Planetary Protection Requirements document, shall be released at the latest at SRR.

The delivery of hardware and services to a third-party mission with planetary protection constraints shall be subject to approval by the PPAA.

1. The mission lead of the third-part mission bears the overall planetary protection responsibility at mission level, including assigning, monitoring, reviewing and approving planetary protection categories and associated requirements.

Impact of significant changes in the mission concept on the planetary protection requirements and implementation approach shall be assessed by the supplier and conclusions concurred by the PPAA.

The PPAA, or its designated entity, shall conduct independent verification assays on flight hardware and controlled environments, including launch site, during the course of the project at times and intervals planned and agreed with the supplier.

## Technical requirements

### Flight hardware assembly

Except as specified in 5.3.2.2d, all flight hardware subject to planetary protection constraints shall be assembled and maintained until launch in ISO level 8 cleanrooms “in operation”, or cleaner, as specified in ECSS-Q-ST-70-01.

### Probability of impact analysis

A probability of impact analysis on protected Solar system bodies shall be performed and a report delivered for customer and PPAA review.

The probability of impact analysis specified in 5.2.2a shall include:

Single and multiple pass analysis;

Spacecraft reliability;

Meteoroid impacts;

* + 1. Meteoroid fluxes from the Grün model at 1 AU, scaled to the duration of the cruise phase, with an additional safety margin factor of 3
		2. Meteoroid density of 2,5 g/cm3
		3. Meteoroid velocity of 20 km/s and average impact angle of 45 degrees from the surface normal
		4. Damage equations in IADC protection manual for the damage assessment

Spacecraft state including location, and velocity vector;

Manoeuvre and planet and satellite ephemeris uncertainty;

Stochastic variability of the atmospheric density with the amplitude of the Solar cycle estimated for the mission and sun epoch as variable.

1. 1 The "Grün model" is described in reference document [5].
2. 2 The "Damage equations" are contained in IADC protection manual, see reference document [6].
3. 3 Different meteoroid models are used depending on the mission profile; dedicated models are currently developed for the Jovian system.

### Probability of contamination

Except where numerical requirements are otherwise specified in this document, the probability of contaminating a Solar system body with viable terrestrial micro-organisms shall be ≤ 1x10-3 over a period of 50 years after the arrival of the mission at the protected Solar system body.

## Specific missions

### Moon missions

An organic materials inventory of bulk constituents present in quantities above the limit agreed with the PPAA shall be provided by the project in conformance with DRD in Annex H.

1. This also applies to missions not going to the Moon but having a final disposition that would end up on the Moon

### Mars missions

#### Overview

Three types of missions to Mars are considered:

* Mars surface mission dealing with probes landing on Mars surface
* Mars sample return mission dealing with probes landing on Mars surface and sending Mars samples back to Earth
* Human Mars mission

#### General

An organic materials inventory of bulk constituents present on the spacecraft shall be provided by the project in conformance with DRD in Annex H.

A 50 gram sample for each organic material used on the spacecraft shall be stored under controlled conditions for 50 years after launch.

All bioburden constraints shall be verified pre-launch.

1. This verification is usually done on last physical access of the flight hardware or hardware elements, i.e., at delivery of flight hardware to next level contractor, delivery to launch site, and at the launch site prior to fairing closure.

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.

1. Examples are upper stages.

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.

The total bioburden of the spacecraft, including surface, mated, and encapsulated bioburden, is ≤ 5x105 bacterial spores.

1. This requirement is also applicable for fly-by and gravity assist manoeuvres.

#### Requirements for Mars surface missions

##### Overview

Requirements in clause 5.3.2.3.2 are applicable to all Mars surface missions. Additional requirements apply depending on the mission objective 5.3.2.3.3 and location on Mars 5.3.2.3.4.

##### General

The bioburden of the landed system shall be ≤ 3x105 bacterial spores on exposed internal and external surfaces.

The average bioburden of the landed system shall be ≤ 300 bacterial spores/m2 on exposed internal and external surfaces.

The supplier shall provide an analysis whether the spacecraft during nominal and off-nominal conditions has the potential to modify the local Martian environment in a way that can create a Mars special region.

1. Such an analysis is in particular important for spacecraft using radioisotope heat sources targeting areas with surface or sub-surface water ice.

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

The evaluation specified in 5.3.2.3.2d shall be based on the latest scientific evidence and include an assessment of the temperature and water activity values specified for Mars Special Regions are separated in time.

The evaluation specified in 5.3.2.3.2d shall be updated during the mission whenever new evidence indicates that the landing ellipse and the operational environment contain, or are in contamination range of areas or volumes meeting the parameter definition for Mars Special Regions.

##### Surface missions with life detection

For surface mission with life detection one of the following conditions shall be met:

The bioburden of the surface system is ≤ 30 bacterial spores on exposed internal and external surfaces, or at a contamination level driven by the nature and sensitivity of the particular life-detection investigations.

The average bioburden of the subsystems that are involved in the acquisition, delivery, and analysis of samples used for life-detection investigations is either:

≤ 0,03 bacterial spores/m2, or

at a contamination level driven by the nature and sensitivity of the particular life-detection investigations.

Recontamination prevention of the subsystems specified in 5.3.2.3.3a.2 and the samples to be analysed shall be in place until the end of the life-detection investigations.

##### Surface missions accessing Mars special regions

If the landing site is within a Mars special region, the bioburden of the entire surface system shall be ≤ 30 bacterial spores on exposed internal and external surfaces.

If a Mars special region is accessed through horizontal or vertical mobility, one of the following conditions shall be met:

The bioburden of the entire surface system is ≤ 30 bacterial spores on exposed internal and external surfaces.

The subsystems which directly contact the Mars special region are sterilized to levels specified in 5.3.2.3.4b.1, and a method of preventing recontamination of subsystems which directly contact the Mars prior to accessing the Mars special region is in place.

1. Example of accessing Mars special regions are by roving (horizontal mobility) or by drilling (vertical mobility).

If an off-nominal condition can cause a high probability of inadvertent biological contamination of a Mars special region by the spacecraft the bioburden shall be the following:

The bioburden of the entire surface system is ≤ 30 bacterial spores on exposed internal and external surfaces, and

The total surface, mated, and encapsulated bioburden level is ≤ 30 + 1,5 x 104 bacterial spores.

1. Example for off-nominal condition is a hard landing.

#### Mars sample return missions

Category IVb requirements in clause 5.3.2.3.3 shall be applied to the outbound leg of a Mars sample return mission.

Materials, including spacecraft surfaces that were exposed to the Martian environment, returned from Mars shall be treated as hazardous.

1. Hazardous defined by severity category “catastrophic” in ECSS-Q-ST-40.

No uncontained Martian materials, including spacecraft surfaces that were exposed to the Martian environment, shall be returned from Mars unless sterilized.

The probability that a single unsterilized particle of ≥ 0,01 μm in diameter is released into the terrestrial biosphere shall be ≤ 1x10-6.

1. As supported by [7]

No un-contained portion of the materials returned from Mars shall be distributed unless a programme of biohazard analysis, life-detection and sterilization is approved by the PPAA and carried out.

#### Guidelines for human Mars missions

#####  Overview

No specific requirements have been issued for human missions to Mars yet. General implementation guidelines for human missions to Mars are described in Annex I.

### Europa and Enceladus

#### Missions to Europa and Enceladus

The probability of inadvertent contamination of a subsurface ocean by viable terrestrial micro-organisms shall be ≤ 1 x 10-4 per mission.

The probability of inadvertent contamination specified in 5.3.3.1a shall apply to all mission phases including the duration that spacecraft introduced terrestrial organisms remain viable and can reach a sub-surface liquid water environment.

The calculation of the probability specified in 5.3.3.1a of inadvertent contamination shall address the following factors, at a minimum:

Bioburden at launch;

Cruise survival for bioburden;

Bioburden survival in the respective radiation environment;

Probability of landing on Solar system body;

The mechanisms and timescales of transport to the subsurface;

Bioburden survival and proliferation before, during, and after subsurface transfer.

1. Methods of bioburden reduction reflect the type of environments found on Europa or Enceladus, focusing on Earth extremophiles most likely to survive on Europa or Enceladus, such as cold, desiccation and radiation tolerant organisms.

When computing the calculation of requirement 5.3.3.1c the estimate for poorly known parameters shall be agreed with the customer and PPAA.

#### Europa and Enceladus sample return missions

Category IVb requirements in clause 5.3.2.3.3, shall be applied to the outbound leg of a sample return mission.

Materials, including spacecraft surfaces that were exposed to the environment of Europa, Enceladus or their plumes, returned from Europa or Enceladus shall be treated as hazardous.

1. Hazardous defined by severity category “catastrophic” in ECSS-Q-ST-40.

No uncontained Europan or Enceladan materials, including spacecraft surfaces that were exposed to the respective environment or plumes, shall be returned from Europa or Enceladus unless sterilized.

The probability that a single unsterilized particle of ≥ 0,01 μm in diameter is released into the terrestrial biosphere shall be ≤ 1x10-6.

1. This is based on recommendations received for Mars sample return, see requirement 5.3.2.4d.

No un-contained portion of the materials returned from Europa or Enceladus shall be distributed unless a programme of biohazard, life-detection and sterilization is approved by the PPAA and carried out.

### Missions to small Solar system bodies

#### General

Categorization of missions to small Solar system bodies shall be made on a case-by-case basis.

1. The small Solar system bodies (SB) not elsewhere discussed in this document represent a large class of objects. Most missions to SB are classified as Category I or Category II missions for forward contamination, and Category V, unrestricted Earth return, for backward contamination.

The mission shall be categorized as “restricted Earth return” if the answer to all the following six questions is "no" or “uncertain”, otherwise the mission is categorized as “unrestricted”:

Does scientific evidence indicate that there was never liquid water in or on the target body?

Does scientific evidence indicate that metabolically useful energy sources were never present?

Does 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?

Does scientific evidence indicate that subsequent to the disappearance of liquid water, the target body has been subjected to extreme temperatures >160 °C?

Does scientific evidence indicate that there is or was sufficient radiation for sterilization of terrestrial life forms?

Does scientific evidence indicate that there has been a natural influx to Earth, via meteorites, of material equivalent to a sample returned from the target body?

If a mission is categorized as “restricted Earth return” in accordance with 5.3.4.1b, containment procedures shall be applied to the mission as specified in requirements from clause 5.3.4.2

#### Restricted sample return missions

Category IVb requirements in clause 5.3.2.3.3, shall be applied to the outbound leg of a sample return mission.

Materials, including spacecraft surfaces that were exposed to the SB environment, returned from the SB shall be treated as hazardous.

1. Hazardous defined by severity category “catastrophic” in ECSS-Q-ST-40.

No uncontained SB materials, including spacecraft surfaces that were exposed to the SB environment, shall be returned from the SB unless sterilized.

The probability that a single unsterilized particle of ≥ 0,01 μm in diameter is released into the terrestrial biosphere shall be ≤ 1x10-6.

1. This is based on recommendations received for Mars sample return, see requirement 5.3.2.4d

No un-contained portion of the materials returned from the SB shall be distributed unless a program of biohazard, life-detection and sterilization is approved by the PPAA and carried out.

##  Planetary protection procedures

### Bioburden controlled environments

Requirements from clause 5 of ECSS-Q-ST-70-58 shall be applied for bioburden controlled environments.

### Bioburden assessment

Bioburden assessment on flight hardware shall be performed, using procedures "Swab assay 1 (standard swab assay)" or "Wipe assay 1 (standard wipe assay) "as per procedures D.1 and E.1 from Annex D and Annex E of ECSS-Q-ST-70-55.

If direct assays are not possible, estimation of the flight hardware bioburden using the highest number in the respective category of Table 5‑1 shall be used.

1. The encapsulated bioburden values in Table 5‑1 cannot be used for ALM produced hardware.

Table ‑: Bioburden estimation

|  |  |  |
| --- | --- | --- |
| Bioburden type | Specific environment | Bioburden value |
| Average encapsulated spores density (i.e. if no differentiation between electronic and non-electronic piece parts is made) | Non-metallic parts of the spacecraft:  | 130 spores/cm3 |
| Source specific encapsulated spore density | Electronic piece parts:  | 3-150 spores/cm3 |
| Other non-metallic materials: | 1-30 spores/cm3 |
| Source specific enclosed surface spore density, e.g. a box closed in the specific environment | ISO class 8 cleanroom, highly controlled:  | 500-5000 spores/m2 |
| ISO class 8 cleanroom, normally controlled:  | 5000-105 spores/m2 |
|  | Uncontrolled environment: | 105-106 spores/m2 |
| Average surface spore density for cleanroom classes “in operation” (exposed and mated but non-encapsulated) | ISO class 7 cleanroom or better, highly controlled:  | 50 spores/m2 |
| ISO class 7 cleanroom or better, normally controlled:  | 500 spores/m2 |
|  | ISO class 8 cleanroom, highly controlled:  | 1 000 spores/m2 |
|  | ISO class 8 cleanroom, normally controlled:  | 10 000 spores/m2 |
|  | Uncontrolled environment:  | 105 spores/m2 |
| NOTE 1: Manufacturing processes can potentially be used to claim a lower encapsulated bioburden either through high temperatures (see ECSS-Q-ST-70-57 for relevant specifications) or control of manufacturing environment.NOTE 2: Normally controlled: use of gowning equivalent to the specific cleanroom class.NOTE 3: Highly controlled: bioburden control of cleanroom by use of full body coverall, hood, face mask, gloves and boots, restricted access and dedicated cleaning.  |

Use of assay procedures not described in Annex D, Annex E, Annex F and Annex G of ECSS-Q-ST-70-55 shall be approved by the PPAA.

The number of samples to evaluate the bioburden for the flight hardware shall be agreed with the PPAA and meet the following conditions:

Five swabs for each surface area on flight hardware of 0,1 m2;

A proportionate number, but at least one swab, for each surface area on flight hardware much smaller than 0,1 m2;

One wipe for each surface area on flight hardware in the range of 1 m2;

Two wipes for each surface area on flight hardware per 10 m2.

1. Although the sampling plan is specific to the size and geometry of the sampled hardware, sampling at least 20 % of the surface area is a reasonable guideline. To reduce the conservatism in the overall bioburden calculations it is better to sample larger surface areas.

The methods for calculation surface bioburden and bioburden densities shall be agreed with PPAA.

Bioburden prior to the application of a bioburden reduction procedure shall be established by using procedures specified in requirements 5.4.2a or 5.4.2b.

### Biodiversity assessment

Biodiversity assessment on flight hardware and bioburden controlled environment(s) shall be performed using procedures D.3-D.6 for Swab assays and procedures E.3-E.6 for Wipe assays as per Annex D and Annex E of ECSS-Q-ST-70-55.

### Bioburden reduction

Dry heat microbial reduction shall be performed in compliance with requirements from clause 5 of ECSS-Q-ST-70-57.

Hydrogen peroxide microbial reduction shall be performed in compliance with requirements from clause 5 of ECSS-Q-ST-70-56.

Use of other bioburden reduction procedures shall be approved by the PPAA.

Evaluation of material and hardware compatibility with bioburden reduction procedures shall be performed in compliance with requirements from clause 5 of ECSS-Q-ST-70-53.

## Documentation

The planetary protection implementation activities shall be addressed in the relevant project documentation.

1. For example in management and quality plans, AIV and AIT plans, and VCD.

Planetary protection documentation shall be provided according to the matrix in Table 5‑2.

1. Table 5‑2 can be tailored to the respective project.

The supplier shall support the PPAA, for the preparation of the customer level planetary protection report of a mission.

1. 1 The report is delivered no later than nine months after launch to the President of COSPAR and the chair of the COSPAR panel on planetary protection.
2. 2 Content of the customer level planetary protection report to COSPAR is described in the COSPAR Planetary Protection Policy [2].

Table ‑: 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 |

## Reviews

Planetary protection implementation activities and applicable planetary protection documentation specified in Table 5‑2, including any documentation to support conclusions of analysis, shall be reviewed during regular reviews to which PPAA participates.

Planetary protection reviews shall be held for Earth return missions to authorize the different segments of the return phase:

Subsequent to sample collection and prior to a manoeuvre to enter a biased Earth return trajectory;

Prior to commitment for Earth entry.

1. 1 The objective of these reviews is to demonstrate that the mission continues to meet the planetary protection requirements in general, and Earth safety in particular.
2. 2 The planetary protection reviews can be part of regular project reviews.

## Nonconformances and waivers

ECSS-Q-ST-10-09 shall be applied for nonconformances and waivers.

All nonconformance related to planetary protection shall be specified as major nonconformance.

The disposition of nonconformances related to planetary protection requirements shall be subject to approval by the PPAA.

The approval of waivers related to planetary protection requirements shall be subject to approval by the PPAA.

1. (normative)
Planetary protection requirements document - DRD
	1. DRD identification
		1. Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirements 5.1a.

* + 1. Purpose and objective

The purpose of the planetary protection requirements document is to provide the set of planetary protection requirements, tailored to the specific project for use in industrial contracts.

* 1. Expected response
		1. Scope and content

The planetary protection requirements document shall include at least the following items:

Mission description

Scientific objectives and payload description

Mission type fly-by, orbiter, lander, Earth return

Description of mission phases

Description of launch vehicle and launch site

Identification of targeted and encountered Solar system bodies

Identification and use of nuclear heat and power sources

Identification and use of aerobraking and aerocapture manoeuvres

Description of entry, descend and landing phases

Description of intended landing site and expected landing accuracy

Intended final disposition of all launched hardware

Description of international cooperation

Planetary protection category

Planetary protection management requirements

Technical planetary protection requirements

Planetary protection methods and procedures

Planetary protection documentation and reviews

* + 1. Special remarks

The Mission description, specified in A.2.1a.1, may be covered by a reference to another project document.

1. (normative)
Planetary protection plan - DRD
	1. B.1 DRD identification
		1. Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5b.

* + 1. Purpose and objective

The planetary protection plan is the primary planning document describing how the project meets the planetary protection requirements. The planetary protection plan contains a consolidated planning for all mission phases involving all actors, including payload providers, launch service provider, and international partners for the applicable system architecture down to sub-system level.

* 1. Expected response
		1. Scope and content

The planetary protection plan shall include the following items:

Mission description.

Assessment of the consequences to implement the planetary protection requirements with respect to design, development, schedule and operations.

General implementation approach:

Planetary protection management and organisation.

Description of bioburden control approach for all major flight hardware elements, including payload and launch recontamination.

Description of bioburden allocations with identified margins and uncertainties for all major flight hardware elements.

Description of probability of impact analysis, in accordance with ECSS-U-ST-20 requirements 5.2.2a, 5.2.2b, 5.3.2.2d, 5.3.2.2e including:

Impact analysis for launcher and spacecraft elements against target bodies identified in the “planetary protection requirements” document, with analysis supporting the conclusions providing evidence that the selected approach is feasible for the specific mission;

If probability of impact approach is not possible or selected, break-up, burn-up and general atmospheric entry heating analysis providing evidence that the selected approach is feasible for the specific mission.

Description of probability of contamination analysis, in accordance with ECSS-U-ST-20 requirements 5.2.3a and 5.3.3.2a.

Description for methods and procedures to be used, in accordance with ECSS-U-ST-20 requirements in clause 5.4.

Description of planned requests for using methods, procedures or values not described in this standard, in accordance with ECSS-U-ST-20 requirements in clause 5.7.

Planetary protection documentation and reviews, in accordance with ECSS-U-ST-20 requirements in clauses 5.5 and 5.6.

Identify planetary protection activities and events in the project schedule.

Compliance matrix against the planetary protection requirements.

Analysis and conclusions of consequences for planned non-conformances or waivers.

Verification matrix against the planetary protection requirements.

* + 1. Special remarks

The Mission description, as per B.2.1a.1. may be covered by a reference to another project document.

The Assessment of the consequences, as per B.2.1a.2. may summarize the consequences with references to other project documentation for detailed descriptions.

The compliance matrix, as per B.2.1a.6. may be included in a project level compliance and verification matrix.

The Verification matrix as per B.2.1a.8. may be included in a project level compliance and verification matrix.

1. (normative)
Planetary protection implementation plan - DRD
	1. DRD identification
		1. Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5b.

* + 1. Purpose and objective

The purpose of the planetary protection implementation plan is to provide all relevant information about the detailed implementation (e.g. analysis, procedures and activities) of the planetary protection requirements in line with the planetary protection plan.

* 1. Expected response
		1. Scope and content

The planetary protection implementation plan shall include the following items:

Flight system description

Hardware description

System and sub-system description, including payload

Planetary protection description vs. subsystem names

Criteria for exposed surfaces and planetary protection accountable volumes

Mission planetary protection issues as they are intended to be implemented, accounting for the following data:

Probability of impact analysis, in accordance with ECSS-U-ST-20 requirements 5.2.2a, 5.2.2b, 5.3.2.2d, 5.3.2.2e;

Probability of contamination analysis in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2a;

Spacecraft induced special regions, in accordance with ECSS-U-ST-20 requirement 5.3.2.3.2c;

Landing site selection;

Draft organic material inventory in accordance with ECSS-U-ST-20 requirements 5.3.1a, 5.3.2.2a.

Description of Facilities

Formal system including

Risk assessment;

Alerts and action levels

Control approach

Commissioning

Operation

Bioburden control plan for the flight system

Bioburden allocation including:

Exposed surface bioburden allocation;

Total bioburden allocation;

Hardware exceptions

Sampling and Assay plan including:

Fraction of exposed surfaces sampled;

Number of samples;

Sampling site selection;

Sampling schedule

Statistical treatment of the assay results including:

Case for total spore count greater than one;

Case for total spore count of zero or one;

Case for treatment of bulk assay;

Basis for bioburden density standard deviation;

Assay results acceptance guidelines.

Bioburden assessment, in accordance with ECSS-U-ST-20 requirements 5.4.1a, and requirements from clause 5.4.2 including:

Calculation of surface bioburden density and number of spores from assay data;

Surface bioburden density and number of spores without assay data;

Surface bioburden density and number of spores for hardware treated by a bioburden reduction procedures;

Encapsulated bioburden density and number of spores with assay data;

Encapsulated bioburden density and number of spores without assay data;

Biodiversity assessment, in accordance with ECSS-U-ST-20 requirement 5.4.3a.

Bioburden reduction plan for the flight system, in accordance with ECSS-U-ST-20 requirements in clause 5.4.4

Spacecraft hardware subject to bioburden reduction processes

Process analysis

Process verification and control

Recontamination prevention approach

General implementation approach for the flight system

Pre-AIV, AIT and launch operations including:

General approach at hardware manufacturing sites;

General approach at Customer, supplier and instrument provider site

AIV, AIT and launch operations including:

Acceptance criteria;

General approach at Customer and supplier and payload provider site;

General approach at test site;

General approach at launch site

Inside surface of the launch vehicle fairing, launch vehicle air conditioning, and white room air conditioning

Upper stage and propulsion module

Updated list of the foreseen waivers and NCRs and the associated impact analysis.

* + 1. Special remarks

None.

1. (normative)
Pre-launch planetary protection report - DRD
	1. DRD identification
		1. Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5b.

* + 1. Purpose and objective

The purpose of the pre-launch planetary protection report is to demonstrate whether the project meets the planetary protection requirements, in particular bioburden allocations based on routine and verification assay results.

* 1. Expected response
		1. Scope and content

The pre-launch planetary protection report shall include the following items:

Deviation from planetary protection requirements and plan

Deviation from the planetary protection implementation plan

Results of contamination control measures, including raw and processed data of bioburden assays for the entire product tree

Update of probability of impact analysis, in accordance with ECSS-U-ST-20 requirements5.2.2a, 5.2.2b, 5.3.2.2d, 5.3.2.2e.

Update for probability of contamination analysis in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2a

Organic materials inventory, in accordance with ECSS-U-ST-20C requirements 5.3.1a,5.3.2.2a.

Conclusions of the report

* + 1. Special remarks

None.

1. (normative)
Post-launch planetary protection report - DRD
	1. E.1 DRD identification
		1. Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5b.

* + 1. Purpose and objective

The purpose of the post-launch planetary protection report is to account for effects of events from submission of the pre-launch planetary protection report.

* 1. Expected response
		1. Scope and content

The post-launch planetary protection report shall include the following items:

Ground processing affecting bioburden control

Last verification assay results

Launch events affecting bioburden control

Post Launch effects within the deployment and in orbit commissioning timeframe

Conclusions of the report

* + 1. Special remarks

None.

1. (normative)
Extended mission planetary protection report - DRD
	1. DRD identification
		1. Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5b.

* + 1. Purpose and objective

The purpose of the extended mission planetary protection report is to provide evidence that demonstrates the continued compliance with planetary protection requirements taking into account the activities identified for the extended mission phase.

* 1. Expected response
		1. Scope and content

The extended mission planetary protection report shall include the following items:

Deviation from planetary protection requirements and plan

Deviation from the planetary protection implementation plan

Update of probability of impact analysis, in accordance with ECSS-U-ST-20 requirements 5.2.2a,5.2.2b,5.3.2.2d,5.3.2.2e.

Update for probability of contamination analysis, in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2a.

Conclusions of the report

* + 1. Special remarks

None.

1. (normative)
End-of-mission planetary protection report - DRD
	1. DRD identification
		1. Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5b.

* + 1. Purpose and objective

The purpose of the end-of-mission planetary protection report is to describe the degree to which the project meets the planetary protection requirements throughout the complete mission.

* 1. Expected response
		1. Scope and content

The end-of-mission planetary protection report shall include the following items:

Disposition and condition of all launched flight hardware including the launcher upper stage, either in space describing the orbital parameters or for landed or impacting elements by position on the target body

Deviation from planetary protection requirements and plan

Deviation from the planetary protection implementation plan

Update of probability of impact analysis in accordance with ECSS-U-ST-20 requirements 5.2.2a,5.2.2b,5.3.2.2d,5.3.2.2e Update for probability of contamination analysis, in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2a

Conclusions of the report

* + 1. Special remarks

None.

1. (normative)
Organic materials inventory - DRD
	1. DRD identification
		1. Requirement identification and source document

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

* + 1. Purpose and objective

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

* 1. Expected response
		1. Scope and Content

The organic material inventory shall include the following for each organic material present above a specified limit agreed with PPAA:

Identity

Chemical composition

Usage, with respect to product tree

Mass estimate using the mass codes specified in ECSS-Q-ST-70-01

Rating and reference for outgassing for each item using ECSS-Q-ST-70-01

Supplier for each item

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:

A quantitative and qualitative description of the major chemical species, and

An indication of the minor chemical species and quantity

* + 1. Special remarks

None.

1. (informative)
Guidelines for human Mars missions

General implementation guidelines for human missions to Mars include:

1. Human missions carry microbial populations that vary in both kind and quantity. It is not 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 can be specified to address both forward and backward contamination concerns.
2. A quarantine capability for both the entire crew and for individual crewmembers can be provided during and after the mission, in case potential contact with a Martian life-form occurs.
3. A comprehensive planetary protection protocol for human missions can 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.
4. Neither robotic systems nor human activities can contaminate special regions on Mars.
5. Any uncharacterized Martian site can be evaluated by robotic precursors prior to crew access. Information can be obtained by either precursor robotic missions or a robotic component on a human mission.
6. Any pristine samples or sampling components from any uncharacterized sites or special regions on Mars can be treated according to current planetary protection category V, restricted Earth return, with the proper handling and testing protocols.
7. An on-board crewmember can be given primary responsibility for the implementation of planetary protection provisions affecting the crew during the mission.
8. Planetary protection requirements for initial human missions can 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 cannot be relaxed without scientific review, justification, and consensus.

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