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Space sustainability

Planetary protection

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Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering, product assurance and sustainability 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 ECSS-U-ST-20C Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

Disclaimer

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Introduction

Sustainability in the context of space activities is a concept that becomes more relevant. Planetary protection regulations have applied this concept at the international scale already for over half a century.

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 Committee on Space Research (COSPAR) provides a forum for international consultation and has formulated a planetary protection policy with associated requirements as an international standard to guide compliance with Article IX of the Outer Space Treaty.

COSPAR's planetary protection policy and associated requirements are based on two rationales:

1. *The Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from an interplanetary mission (backward planetary protection).*
2. *The conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized (forward planetary protection).*

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.

1 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 constraints of a space project in conformance with ECSS-S-ST-00.

2 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-40	Space product assurance - Safety
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
IADC-WD-00-03	Interagency Debris Committee Protection Manual

3 Terms, definitions and abbreviated terms

3.1 Terms from other standards

a. For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 apply.

b. For the purpose of this Standard the following terms and definitions from ECSS-Q-ST-70-53 apply:

1. micro-organism

c. For the purpose of this Standard the following terms and definitions from ECSS-Q-ST-70-58 apply:

1. bioburden
2. biodiversity
3. sterilization

3.2 Terms specific to the present standard

3.2.1 assay

collection and analysis of biological contamination with a specified procedure

3.2.2 controlled condition

condition that avoids degradation of material samples and that allows traceability of flight project hardware

3.2.3 encapsulated bioburden

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

NOTE 1 Examples are bioburden inside paints, conformal coatings, thermal coatings, adhesives, composite materials, closed-cell foam.

NOTE 2 The encapsulated bioburden of ALM manufactured materials is currently unknown.

3.2.4 exposed surfaces

internal and external surfaces free for gas exchange

3.2.5 extant life

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

3.2.6 extinct life

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

3.2.7 highly controlled

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

3.2.8 inbound leg

<CONTEXT: sample return missions>

part of the mission returning to Earth

3.2.9 life detection investigation

scientific investigations that can detect signatures of life

3.2.10 Mars special region

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

[COSPAR's Planetary Protection Policy, Space Research Today, 200, 2017 [2]]

NOTE See also parameter and feature definition in clause 4.3.

3.2.11 mated surfaces

surfaces joined by fasteners rather than by adhesives

3.2.12 normally controlled

use of gowning equivalent to the specific cleanroom particulate class

3.2.13 organic material

material that contain either covalent C-H or C-C bonds and functional groups

NOTE Organic material can fall in several of the material groups of a DML.

3.2.14 outbound leg

<CONTEXT: sample return missions>

part of the mission leaving Earth

3.2.15 planetary protection approval authority

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

NOTE Such an entity is a space agency or federal agency, i.e. customer, under delegation by the government signatory of the UN Outer Space Treaty.

3.2.16 planetary protection category

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

NOTE Different requirements are associated to the various categories.

3.2.17 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

NOTE 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.

3.2.18 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

3.2.19 safety critical function

function that can lead to the risk of releasing unsterilized material from a specific solar system body and flight hardware exposed to unsterilized material from a specific solar system body into the terrestrial environment

3.2.20 services

launch services, communication services and relay functions provided

3.2.21 swab

tool to collect biological contamination with a specific procedure

NOTE See also 3.2.1 “assay”.

3.2.22 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

3.2.23 water activity

ratio of the vapour pressure of water in a material to the vapour pressure of pure water at the same temperature

3.2.24 wipe

tool to collect biological contamination with a specific procedure

NOTE See also 3.2.1 “assay”.

3.3 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
BAT	Best Available Technique
CDR	critical design review
COSPAR	Committee on Space Research
DHMR	dry heat microbial reduction
DML	declared material list
DRD	document requirements definition
ECSS	European Cooperation for Space Standardization
ESA	European Space Agency
FAR	flight acceptance review
FRR	flight readiness review
ISO	International Organization for Standardization
LRR	launch readiness review
MSR	Mars sample return
NASA	National Aeronautics and Space Administration
PPAA	planetary protection approval authority
PRA	Probabilistic Risk Assessment
PRR	preliminary requirements review
SB	small body
SRR	system requirements review
SSB	space studies board
STP	standard temperature and pressure
VCD	verification control document

3.4 Nomenclature

The following nomenclature applies throughout this document:

a. The word "shall" is used in this Standard to express requirements. All the requirements are expressed with the word "shall".

b. The word "should" is used in this Standard to express recommendations. All the recommendations are expressed with the word "should".

NOTE It is expected that, during tailoring, recommendations in this document are either converted into requirements or tailored out.

c. The words "may" and "need not" are used in this Standard to express positive and negative permissions, respectively. All the positive permissions are expressed with the word "may". All the negative permissions are expressed with the words "need not".

d. The word "can" is used in this Standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

NOTE In ECSS "may" and "can" have completely different meanings: "may" is normative (permission), and "can" is descriptive.

e. The present and past tenses are used in this Standard to express statements of fact, and therefore they imply descriptive text.

4 Principles

4.1 Planetary protection roles, responsibilities, and accountabilities

4.1.1 COSPAR

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].

4.1.2 Customer level

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

- Issue or 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.

4.1.3 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:

- Propose to the customer 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.

4.2 Planetary protection category definitions

4.2.1 Overview

The different planetary protection categories reflect the level of interest and concern that terrestrial contamination can compromise the conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants. Each planetary protection category comes with a set of planetary protection requirements. The planetary protection 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.

4.2.2 Category I

4.2.2.1 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.

4.2.2.2 Applicability

S-type asteroids, Io, Mercury.

4.2.2.3 Type of requirements to be considered

None.

4.2.3 Category II

4.2.3.1 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.

4.2.3.2 Applicability

Venus, Moon (with organic material 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 and Enceladus), 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).

4.2.3.3 Type of requirements to be considered

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

4.2.4 Category III

4.2.4.1 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.

4.2.4.2 Applicability

Mars, Europa, Enceladus.

4.2.4.3 Type of requirements to be considered

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

4.2.5 Category IV

4.2.5.1 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 investigations), and IVc (missions accessing Mars special regions).

4.2.5.2 Applicability

Mars, Europa, Enceladus.

4.2.5.3 Type of requirements to be considered

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

4.2.6 Category V

4.2.6.1 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.

NOTE 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 from the Earth to the Moon.

4.2.6.2 Applicability

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

4.2.6.3 Type of requirements to be considered

a. 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).

b. 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 suitable techniques to cope with required sensitivity. 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.

c. Requirements for the outbound phase are typically Category IV.

4.3 Mars special regions

4.3.1 Introduction

Mars special regions definition is based on [2].

NOTE See also definition 3.2.10 “Mars special region”.

4.3.2 Parameter and features definition for Mars special region definitions

a. The physical parameters delineating applicable water activity and temperature thresholds are:

1. Lower limit for water activity: 0,5
2. Lower limit for temperature: -28 °C; no upper limit defined
3. Timescale within which limits can be identified: 500 years

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

1. Gullies (taxon 2-4) and bright streaks associated with gullies, (see NOTE 1)
2. Subsurface cavities
3. Subsurface below 5 metres
4. Confirmed and partially confirmed Recurrent Slope Lineae (RSL), (see NOTE 2)

NOTE 1 Description for Gully taxon [3]

NOTE 2 Observational evidence for Recurrent Slope Lineae (RSL), adapted from [4]:

- Confirmed: observed simultaneous incremental growth of flows on a warm slope, fading, and recurrence of this sequence in multiple Mars years
- Partially confirmed: observed either incremental growth or recurrence
- Candidate: slope lineae that resemble RSL but where observations needed for partial confirmation are currently lacking

c. 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

d. 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 Requirements

5.1 Management requirements for all missions

ECSS-U-ST-20_1430001

a. The PPAA shall provide to the supplier planetary protection related obligations of relevant external authorities.

ECSS-U-ST-20_1430002

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

ECSS-U-ST-20_1430003

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

ECSS-U-ST-20_1430004

d. The Planetary Protection Requirements document shall be subject to approval by the PPAA and released at the latest at SRR.

ECSS-U-ST-20_1430005

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

NOTE The customer of 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.

ECSS-U-ST-20_1430006

f. Impact of significant changes in the mission concept on the planetary protection requirements and implementation approach shall be assessed by the supplier and are subject to approval by the PPAA.

ECSS-U-ST-20_1430007

g. 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.

5.2 Generic technical requirements

5.2.1 Flight hardware assembly

ECSS-U-ST-20_1430008

a. Except as specified in 5.3.2.1d, all flight hardware subject to planetary protection constraints shall be assembled and maintained until and including launch in ISO class 8 cleanrooms “in operation”, or better, as specified in ECSS-Q-ST-70-01.

5.2.2 Probability of impact

ECSS-U-ST-20_1430009

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

ECSS-U-ST-20_1430010

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

1. Single and multiple pass analysis;
2. Hardware, software and operational reliability;
3. Meteoroid impacts and effects on spacecraft reliability;
   (a) Meteoroid model (e.g., IMEM 1.1) and parameters (fluence, directionality, velocity, density and margins) as defined in the project applicable environmental specifications
   (b) Damage equations in IADC-WD-00-03 for the damage assessment
4. Spacecraft state including location, and velocity vector;
5. Manoeuvre and planet and satellite ephemeris uncertainty;
6. Stochastic variability of the atmospheric density with the amplitude of the Solar cycle estimated for the mission and sun epoch.

NOTE 1 Different meteoroid models are used depending on the mission profile; dedicated models are currently developed for the Jovian system.

NOTE 2 Requirements that need a probability of impact analysis to demonstrate compliance are described in 5.3.2.1d, 5.3.2.1e.1, and 5.3.3.1b.4.

5.2.3 Probability of contamination

ECSS-U-ST-20_1430011

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

NOTE Description how compliance to this requirement will be demonstrated needs to be described in the Planetary Protection Plan DRD in B.2.1a.3.(e).

5.3 Technical requirements for specific missions

5.3.1 Moon missions

ECSS-U-ST-20_1430012

a. 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.

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

5.3.2 Mars missions

5.3.2.1 General requirements

ECSS-U-ST-20_1430013

a. An organic materials inventory of bulk constituents present on the spacecraft in quantities ≥1 kg shall be provided by the supplier in conformance with DRD in Annex H.

NOTE This requirement is not applicable in case requirement 5.3.2.1e.1 is met.

ECSS-U-ST-20_1430014

b. A 50 gram sample for each organic material used on the spacecraft in quantities ≥25 kg shall be provided by the supplier and stored by the customer under controlled conditions for 50 years after launch.

NOTE This requirement is not applicable in case requirement 5.3.2.1e.1 is met.

ECSS-U-ST-20_1430015

c. Compliance to all bioburden requirements shall be verified pre-launch.

NOTE 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.

ECSS-U-ST-20_1430016

d. The probability of impact on Mars by any element not assembled and maintained in at least ISO class 8 conditions shall be ≤ $1x10^{-4}$ for the first 50 years after launch for nominal and off-nominal flight conditions.

NOTE Examples are upper stages.

ECSS-U-ST-20_1430017

e. One of the following conditions shall be met:

1. The probability of impact on Mars by any part of a spacecraft assembled and maintained in ISO class 8 conditions, 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 for nominal and off-nominal flight conditions.
2. The total bioburden of the spacecraft on Mars, including surface, mated, and encapsulated bioburden, is ≤ $5x10^{5}$ bacterial spores.

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

5.3.2.2 Requirements for Mars surface missions

5.3.2.2.1 Overview

Requirements in clause 5.3.2.2.2 are applicable to all Mars surface missions. Additional requirements apply depending on the mission objective 5.3.2.2.3 and location on Mars 5.3.2.2.4.

5.3.2.2.2 General

ECSS-U-ST-20_1430018

a. The bioburden of the landed system on Mars shall be ≤ $3x10^{5}$ bacterial spores on exposed internal and external surfaces.

NOTE Attention – for bioburden allocations to hardware and payload suppliers take into account re-contamination during different on-ground phases (e.g., testing at sub-system and system level, launch).

ECSS-U-ST-20_1430019

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

NOTE 1 Attention – for bioburden allocations to hardware and payload suppliers take into account re-contamination during different on ground phases (e.g., testing at sub-system and system level, launch).

NOTE 2 Attention – for large spacecraft systems the average bioburden to meet requirement 5.3.2.2.2a needs to be much lower than 300 bacterial spore/m².

ECSS-U-ST-20_1430020

c. The supplier shall provide an analysis or assessment 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.

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

ECSS-U-ST-20_1430021

d. Planned 3-sigma pre-launch landing ellipses shall be evaluated and documented 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.

NOTE This means at least no areas or volumes meeting the parameter definition for Mars Special Regions or already described features that can be treated as Mars Special Regions can be within the 3-sigma landing ellipse.

ECSS-U-ST-20_1430022

e. The evaluations specified in 5.3.2.2.2c and 5.3.2.2.2d shall be based on the latest scientific evidence and include an assessment of the extent to which the temperature and water activity values specified for Mars Special Regions are separated in time.

ECSS-U-ST-20_1430023

f. The evaluation specified in 5.3.2.2.2d 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.

5.3.2.2.3 Surface missions with life detection

ECSS-U-ST-20_1430024

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

1. The bioburden of the surface system on Mars 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.
2. The average bioburden of the subsystems that are involved in the acquisition, delivery, and analysis of samples used for life-detection investigations is either:

   (a) ≤ 0,03 bacterial spores/m², or

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

   NOTE The contamination level driven by the particular life-detection investigation needs to be described in the Planetary Protection Plan DRR, Annex B.

ECSS-U-ST-20_1430025

b. The specific contamination level driven by the nature and sensitivity of the particular life-detection investigation described in 5.3.2.2.3a.1 and 5.3.2.2.3a.2(b) shall be subject to review and approval by the PPAA.

ECSS-U-ST-20_1430026

c. Recontamination prevention of the subsystems specified in 5.3.2.2.3a.2 and the samples to be analysed shall be in place until the end of the life-detection investigations.

5.3.2.2.4 Surface missions accessing Mars special regions

ECSS-U-ST-20_1430027

a. If a Mars special region is within the 3-sigma landing ellipse, the bioburden of the entire surface system on Mars shall be ≤ 30 bacterial spores on exposed internal and external surfaces.

ECSS-U-ST-20_1430028

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

1. The bioburden of the entire surface system on Mars is ≤ 30 bacterial spores on exposed internal and external surfaces.
2. The subsystems which directly contact the Mars special region are sterilized to levels specified in 5.3.2.2.4b.1, and a method of preventing their recontamination prior to accessing the Mars special region is in place.

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

ECSS-U-ST-20_1430029

c. 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:

1. The bioburden of the entire surface system on Mars is ≤ 30 bacterial spores on exposed internal and external surfaces, and
2. The total surface, mated, and encapsulated bioburden level on Mars is ≤ 30 + 1,5 x 10^4 bacterial spores.

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

5.3.2.3 Mars sample return missions

ECSS-U-ST-20_1430030

a. Requirements in clause 5.3.2.2.3 shall be applied to the outbound leg of a Mars sample return mission.

ECSS-U-ST-20_1430031

b. 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 catastrophic in accordance with ECSS-Q-ST-40.

NOTE The categorization of this severity level is not because a catastrophic consequence is expected but only following the precautionary principle due to the large number of unknowns.

ECSS-U-ST-20_1430032

c. Safety critical functions as defined in 3.2.19 shall be treated as severity function criticality level 1 in accordance with ECSS-Q-ST-40.

ECSS-U-ST-20_1430033

d. 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.

NOTE 1 Rational for this requirement is to "break the chain of contact" between Mars and Earth.

NOTE 2 Source and context for numerical values in [5].

NOTE 3 The term 'particle' includes material from Mars and flight hardware exposed to material from Mars.

NOTE 4 If the size requirement of 0,01 µm cannot be met without decreasing the overall level of assurance for the non-release of such a particle, the release of a single unsterilised particle of up to 0,05 µm can be considered as a potentially tolerable systems-level adjustment, assuming that it has been demonstrated that this size is the lowest achievable at a reasonable cost (BAT approach) and it has been independently reviewed.

ECSS-U-ST-20_1430034

e. A quantitative PRA shall be conducted as part of evaluating the risk of releasing unsterilized material from Mars and flight hardware that has been exposed to unsterilized material from Mars into the terrestrial environment.

ECSS-U-ST-20_1430035

f. No unsterilised portion of the materials returned from Mars shall be released from containment unless approved by the PPAA.

5.3.2.4 Guidelines for human Mars missions

5.3.2.4.1 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.

5.3.3 Europa and Enceladus missions

5.3.3.1 Missions to Europa and Enceladus

ECSS-U-ST-20_1430036

a. The probability of inadvertent contamination of a subsurface ocean by viable terrestrial organisms shall be $\leq 1 \times 10^{-4}$ per mission.

ECSS-U-ST-20_1430037

b. The calculation of the probability specified in 5.3.3.1a 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;

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

NOTE 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.

ECSS-U-ST-20_1430038

c. When computing the calculation of requirement 5.3.3.1b the estimate for poorly known parameters shall be subject to approval by the customer and the PPAA.

5.3.3.2 Europa and Enceladus sample return missions

5.3.3.2.1 Overview

No quantitative requirement to protect the terrestrial environment from Europa or Enceladus material has been issued at the time of writing this standard.

5.3.3.2.2 Requirements

ECSS-U-ST-20_1430039

a. Requirements in clause 5.3.2.2.3, shall be applied to the outbound leg of a sample return mission.

ECSS-U-ST-20_1430040

b. The severity of potential consequences of releasing unsterilized material from Europa or Enceladus and flight hardware that were exposed to unsterilized material from Europa or Enceladus into the terrestrial environment shall be categorised as catastrophic in accordance with ECSS-Q-ST-40.

NOTE The categorization of this severity level is not because a catastrophic consequence is expected but only following the precautionary principle due to the large number of unknowns.

ECSS-U-ST-20_1430041

c. Safety critical functions as defined in 3.2.19 shall be treated as severity function criticality level 1 in accordance with ECSS-Q-ST-40.

ECSS-U-ST-20_1430042

d. No unsterilised portion of the materials returned from Europa or Enceladus shall be released from containment unless approved by the PPAA.

5.3.4 Missions to small Solar system bodies

5.3.4.1 General

ECSS-U-ST-20_1430043

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

NOTE 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.

ECSS-U-ST-20_1430044

b. 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”:

1. Does scientific evidence indicate that there was never liquid water in or on the target body?
2. Does scientific evidence indicate that metabolically useful energy sources were never present?
3. Does 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 scientific evidence indicate that subsequent to the disappearance of liquid water, the target body has been subjected to extreme temperatures >160 °C?
5. Does scientific evidence indicate that there is or was sufficient radiation for sterilization of terrestrial life forms?
6. 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?

ECSS-U-ST-20_1430045

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

5.3.4.2 Small solar system bodies restricted Earth return missions

5.3.4.2.1 Overview

No quantitative requirement to protect the terrestrial environment from Europa or Enceladus material has been issued at the time of writing this standard.

5.3.4.2.2 Requirements

ECSS-U-ST-20_1430046

a. Category IVb requirements in clause 5.3.2.2.3, shall be applied to the outbound leg of a sample return mission.

ECSS-U-ST-20_1430047

b. The severity of potential consequences of releasing unsterilized material from specific small solar system bodies and flight hardware that has been exposed to unsterilized material from specific small solar system bodies into the terrestrial environment shall be categorised as catastrophic in accordance with ECSS-Q-ST-40.

NOTE The categorization of this severity level is not because a catastrophic consequence is expected but only following the precautionary principle due to the large number of unknowns..

ECSS-U-ST-20_1430048

c. Safety critical functions as defined in 3.2.19 shall be treated as severity function criticality level 1 in accordance with ECSS-Q-ST-40.

ECSS-U-ST-20_1430049

d. No unsterilised portion of the materials returned from Mars shall be released from containment unless approved by the PPAA.

5.4 Planetary protection procedures

5.4.1 Bioburden controlled environments

ECSS-U-ST-20_1430050

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

5.4.2 Bioburden assessment

ECSS-U-ST-20_1430051

a. 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.

ECSS-U-ST-20_1430052

b. 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.

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

ECSS-U-ST-20_1430053

Table 5-1: 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/cm^3
Source specific encapsulated spore density	Electronic piece parts:	3-150 spores/cm^3
	Other non-metallic materials:	1-30 spores/cm^3
Source specific enclosed surface spore density, e.g. a box closed in the specific environment	ISO class 8 cleanroom, highly controlled:	500-5000 spores/m^2
	ISO class 8 cleanroom, normally controlled:	5000-10^5 spores/m^2
	Uncontrolled environment:	10^5-10^6 spores/m^2
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/m^2
	ISO class 7 cleanroom or better, normally controlled:	500 spores/m^2
	ISO class 8 cleanroom, highly controlled:	1 000 spores/m^2
	ISO class 8 cleanroom, normally controlled:	10 000 spores/m^2
	Uncontrolled environment:	10^5 spores/m^2

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 and microbial sampling.

ECSS-U-ST-20_1430054

c. 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.

ECSS-U-ST-20_1430055

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

1. Five swabs for each surface area on flight hardware of 0,1 m^2;
2. A proportionate number, but at least one swab, for each surface area on flight hardware smaller than 0,1 m^2;
3. One wipe for each surface area on flight hardware in the size range of 1 m^2;
4. Two wipes for each individual surface area on flight hardware per 10 m^2.

NOTE 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.

ECSS-U-ST-20_1430056

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

ECSS-U-ST-20_1430057

f. 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.

5.4.3 Biodiversity assessment

ECSS-U-ST-20_1430058

a. 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.

5.4.4 Bioburden reduction

ECSS-U-ST-20_1430059

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

ECSS-U-ST-20_1430060

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

ECSS-U-ST-20_1430061

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

ECSS-U-ST-20_1430062

d. 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.

5.5 Documentation

ECSS-U-ST-20_1430063

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

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

NOTE 2 Documenting the implementation of planetary protection requirements is not limited to the dedicated planetary protection documents but needs to be reflected in the affected project documentation, e.g., management plan, quality plan, AIV and AIT plan, VCD.

ECSS-U-ST-20_1430064

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

NOTE 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.

NOTE 2 Content of the customer level planetary protection report to COSPAR is described in the COSPAR Planetary Protection Policy [2].

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

5.6 Reviews

ECSS-U-ST-20_1430066

a. 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.

ECSS-U-ST-20_1430067

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

1. Subsequent to sample collection and prior to a manoeuvre to enter a Earth return trajectory;
2. Prior to commitment for Earth entry.

NOTE 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.

NOTE 2 The planetary protection reviews can be part of regular project reviews.

5.7 Nonconformances and waivers

ECSS-U-ST-20_1430068

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

ECSS-U-ST-20_1430069

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

ECSS-U-ST-20_1430070

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

ECSS-U-ST-20_1430071

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

Annex A (normative) Planetary protection requirements - DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirements 5.1b and 5.5a (Table 5-2).

A.1.2 Purpose and objective

The purpose of the planetary protection requirements document is to provide the set of planetary protection requirements, tailored ECSS-U-ST-20 to the specific project for use in industrial contracts.

A.2 Expected response

A.2.1 Scope and content

ECSS-U-ST-20_1430072

a. The planetary protection requirements document shall include at least the following items:
   1. Mission description
      (a) Scientific objectives and payload description
      (b) Mission type fly-by, orbiter, lander, Earth return
      (c) Description of mission phases
      (d) Description of launch vehicle and launch site
      (e) Identification of targeted and encountered Solar system bodies
      (f) Identification and use of nuclear heat and power sources
      (g) Identification and use of aerobraking and aerocapture manoeuvres
      (h) Description of entry, descent and landing phases

(i) Description of intended landing site and expected landing accuracy

(j) Intended final disposition of all launched hardware

(k) Description of international cooperation

2. Planetary protection category
3. Planetary protection management requirements, tailored ECSS-U-ST-20
4. Technical planetary protection requirements, tailored ECSS-U-ST-20
5. Planetary protection methods and procedures, tailored ECSS-U-ST-20
6. Planetary protection documentation and reviews, tailored ECSS-U-ST-20

NOTE Planetary protection requirements for the payload are usually described in the payload interface requirements.

A.2.2 Special remarks

ECSS-U-ST-20_1430073

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

Annex B (normative) Planetary protection plan - DRD

B.1 B.1 DRD identification

B.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5a (Table 5-2).

B.1.2 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.

B.2 Expected response

B.2.1 Scope and content

ECSS-U-ST-20_1430074

a. The planetary protection plan shall include the following items:
   1. Mission description.
   2. Assessment of the consequences to implement the planetary protection requirements with respect to design, development, schedule and operations.
   3. General implementation approach:
      (a) Planetary protection management and organisation.
      (b) Description of bioburden control approach for all major flight hardware elements, including payload and launch recontamination.
      (c) Description of bioburden allocations with identified margins and uncertainties for all major flight hardware elements.

(d) Description of bioburden control approach and/or contamination control approach for life-detection investigation, in accordance with ECSS-U-ST-20 requirement 5.3.2.2.3a.

(e) Description of probability of impact analysis, in accordance with ECSS-U-ST-20 requirements 5.2.2a, 5.2.2b, 5.3.2.1d, 5.3.2.1e including:

(1) 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;

(1) 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.

(f) Description of probability of contamination analysis, in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.2.2.2c, d, e, f, 5.3.2.2.3c and 5.3.3.2.2a.

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

(h) 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.

4. Planetary protection documentation and reviews, in accordance with ECSS-U-ST-20 requirements in clauses 5.5 and 5.6.
5. Identify planetary protection activities and events in the project schedule.
6. Compliance matrix against the planetary protection requirements.
7. Analysis and conclusions of consequences for planned non-conformances or waivers.
8. Verification matrix against the planetary protection requirements.

B.2.2 Special remarks

ECSS-U-ST-20_1430075

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

ECSS-U-ST-20_1430076

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

ECSS-U-ST-20_1430077

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

ECSS-U-ST-20_1430078

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

Annex C (normative) Planetary protection implementation plan - DRD

C.1 DRD identification

C.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5a (Table 5-2).

C.1.2 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.

C.2 Expected response

C.2.1 Scope and content

ECSS-U-ST-20_1430079

a. The planetary protection implementation plan shall include the following items:
   1. Flight system description
      (a) Hardware description
         (1) System and sub-system description, including payload
         (2) Planetary protection description vs. subsystem names
      (b) Criteria for exposed surfaces and planetary protection accountable volumes
      (c) Mission planetary protection issues as they are intended to be implemented, accounting for the following data:

(1) Probability of impact analysis, in accordance with ECSS-U-ST-20 requirements 5.2.2a, 5.2.2b, 5.3.2.1d, 5.3.2.1e;
(2) Probability of contamination analysis in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2.2a;
(3) Spacecraft induced special regions, in accordance with ECSS-U-ST-20 requirement 5.3.2.2.2c;
(4) Landing site selection;
(5) Draft organic material inventory in accordance with ECSS-U-ST-20 requirements 5.3.1a, 5.3.2.1a.

2. Description of Facilities

(a) Formal system including
(1) Risk assessment;
(2) Alerts and action levels;
(3) Control approach.

(b) Commissioning

(c) Operation

3. Bioburden control plan for the flight system

(a) Bioburden allocation including:
(1) Exposed surface bioburden allocation;
(2) Total bioburden allocation;
(3) Hardware exceptions.

(b) Sampling and Assay plan including:
(1) Fraction of exposed surfaces sampled;
(2) Number of samples;
(3) Sampling site selection;
(4) Sampling schedule.

(c) Statistical treatment of the assay results including:
(1) Case for total spore count greater than one;
(2) Case for total spore count of zero or one;
(3) Case for treatment of bulk assay;
(4) Basis for bioburden density standard deviation;
(5) Assay results acceptance guidelines.

(d) Bioburden assessment, in accordance with ECSS-U-ST-20 requirements 5.4.1a, and requirements from clause 5.4.2 including:
(1) Calculation of surface bioburden density and number of spores from assay data;
(2) Surface bioburden density and number of spores without assay data;
(3) Surface bioburden density and number of spores for hardware treated by a bioburden reduction procedures;
(4) Encapsulated bioburden density and number of spores with assay data;
(5) Encapsulated bioburden density and number of spores without assay data.

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

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

   (a) Spacecraft hardware subject to bioburden reduction processes;

   (b) Process analysis;

   (c) Process verification and control;

   (d) Recontamination prevention approach.

5. General implementation approach for the flight system

   (a) Pre-AIV, AIT and launch operations including:
      (1) General approach at hardware manufacturing sites;
      (2) General approach at Customer, supplier and instrument provider site.

   (b) AIV, AIT and launch operations including:
      (1) Acceptance criteria;
      (2) General approach at Customer and supplier and payload provider site;
      (3) General approach at test site;
      (4) General approach at launch site.

   (c) Inside surface of the launch vehicle fairing, launch vehicle air conditioning, and white room air conditioning.

   (d) Upper stage and propulsion module.

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

C.2.2 Special remarks

None.

Annex D (normative) Pre-launch planetary protection report - DRD

D.1 DRD identification

D.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5a (Table 5-2).

D.1.2 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.

D.2 Expected response

D.2.1 Scope and content

ECSS-U-ST-20_1430080

a. The pre-launch planetary protection report shall include the following items:
   1. Deviation from planetary protection requirements and plan;
   2. Deviation from the planetary protection implementation plan;
   3. Results of contamination control measures, including raw and processed data of bioburden assays for the entire product tree;
   4. Update of probability of impact analysis, in accordance with ECSS-U-ST-20 requirements 5.2.2a, 5.2.2b, 5.3.2.1d, 5.3.2.1e;
   5. Update for probability of contamination analysis in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2.2a;
   6. Organic materials inventory, in accordance with ECSS-U-ST-20 requirements 5.3.1a, 5.3.2.1a;
   7. Conclusions of the report.

D.2.2 Special remarks

None.

Annex E (normative) Post-launch planetary protection report - DRD

E.1 DRD identification

E.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5a (Table 5-2).

E.1.2 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.

E.2 Expected response

E.2.1 Scope and content

ECSS-U-ST-20_1430081

a. The post-launch planetary protection report shall include the following items:
   1. Ground processing affecting bioburden control;
   2. Last verification assay results;
   3. Launch events affecting bioburden control;
   4. Post Launch effects within the deployment and in orbit commissioning timeframe;
   5. Conclusions of the report.

E.2.2 Special remarks

None.

Annex F (normative) Extended mission planetary protection report - DRD

F.1 DRD identification

F.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5a (Table 5-2).

F.1.2 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.

F.2 Expected response

F.2.1 Scope and content

ECSS-U-ST-20_1430082

a. The extended mission planetary protection report shall include the following items:
   1. Deviation from planetary protection requirements and plan;
   2. Deviation from the planetary protection implementation plan;
   3. Update of probability of impact analysis, in accordance with ECSS-U-ST-20 requirements 5.2.2a, 5.2.2b, 5.3.2.1d, 5.3.2.1e;
   4. Update for probability of contamination analysis, in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2.2a;
   5. Conclusions of the report.

F.2.2 Special remarks

None.

Annex G (normative) End-of-mission planetary protection report - DRD

G.1 DRD identification

G.1.1 Requirement identification and source document

This DRD is called from ECSS-U-ST-20 requirement 5.5a (Table 5-2).

G.1.2 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.

G.2 Expected response

G.2.1 Scope and content

ECSS-U-ST-20_1430083

a. The end-of-mission planetary protection report shall include the following items:
   1. 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;
   2. Deviation from planetary protection requirements and plan;
   3. Deviation from the planetary protection implementation plan;
   4. Update of probability of impact analysis in accordance with ECSS-U-ST-20 requirements 5.2.2a, 5.2.2b, 5.3.2.1d, 5.3.2.1e;
   5. Update for probability of contamination analysis, in accordance with ECSS-U-ST-20 requirements 5.2.3a, 5.3.3.2.2a;
   6. Conclusions of the report.

G.2.2 Special remarks

None.

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

2. An indication of the minor chemical species and quantity.

H.2.2 Special remarks

None.

Annex I (informative)
Guidelines for human Mars missions

General implementation guidelines for human missions to Mars include:

a. 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.

b. 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.

c. 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.

d. Neither robotic systems nor human activities can contaminate special regions on Mars.

e. 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.

f. 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.

g. An on-board crewmember can be given primary responsibility for the implementation of planetary protection provisions affecting the crew during the mission.

h. 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.

Bibliography

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