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Space systems — Space debris mitigation requirements

Systèmes spatiaux — Exigences de mitigation des débris spatiaux

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This fourth edition cancels and replaces the third edition (ISO 24113:2019), which has been technically revised.

The main changes are as follows:

- the addition of a term and definition for "expected number of casualties per re-entry" to replace the term "casualty risk";
- the modification of definitions for the terms "disposal phase", "Earth orbit", "end of life", "end of mission", "passivate" and "probability of successful disposal";
- the applicability of requirements in this document with respect to a space object that enters an unbound Keplerian orbit or leaves Earth orbit;
- the modification of a requirement relating to space debris left in Earth orbit by a launch vehicle after normal operations;
- minor changes to two of the requirements relating to accidental break-up caused by an on-board source of energy;
- changes to a requirement and NOTE concerning the assessment of the probability of impact-induced break-up of a spacecraft;
- the modification of a requirement and addition of a NOTE relating to the assessment of the probability that an impact will prevent the successful disposal of a spacecraft;
- the modification of a requirement and addition of a NOTE relating to the need for disposal capability/probability reassessment before extending the mission lifetime of a spacecraft;

- the addition of NOTES pointing out the need for and potential benefit of reducing orbital lifetime significantly below 25 years in the LEO protected region;
- the addition of a NOTE concerning the collision probability associated with a deployable device that augments the orbital decay of a spacecraft or launch vehicle orbital stage in the LEO protected region;
- the modification of a requirement relating to the assessment of the hazard caused by ground impact of any objects that are expected to survive re-entry;
- the specification of a threshold for the expected number of casualties during the re-entry of a spacecraft or launch vehicle orbital stage, and the addition of supplementary NOTES;
- the addition of a NOTE concerning the listed contents of the space debris mitigation plan;
- minor modifications to the two figures in [Annex A](#);
- updates to the Bibliography.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Space debris comprises all objects of human origin in Earth orbit or re-entering the atmosphere, including fragments and elements thereof, that no longer serve a useful purpose. The growing population of these objects poses an increasing hazard to mankind's use of space. In response to this problem, there is international consensus that space activities need to be managed to minimize collision risks among space objects and casualty risks associated with atmospheric re-entry of such objects. This consensus is embodied in space debris mitigation guidelines published by organizations such as the International Telecommunication Union (ITU),^[1] the Inter-Agency Space Debris Coordination Committee (IADC)^[2] and the United Nations (UN).^[4] The transformation of debris mitigation guidelines into engineering practice is a key purpose of this document.

The importance of this document can be seen within the context of four UN treaties^[5] that were established under the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) to govern the involvement of nations in space activities. These are the *Outer Space Treaty*, the *Liability Convention*, the *Registration Convention* and the *Rescue Agreement*. Through some of these treaties, a launching State has total liability for damage caused by its spacecraft or launch vehicle orbital stages (or any parts thereof) on the surface of the Earth or to aircraft in flight, as well as in outer space where fault can be proven.

All countries are encouraged to abide by these international agreements in order not to endanger or constrain existing and future activities in space. A launching State can choose to appoint licensing or regulatory authorities to administer its approach for complying with the above-mentioned UN treaties. In several launching States, these authorities have implemented national legislation to enforce the UN treaties. Such legislation can include the mitigation of space debris. Some launching States meet their obligations by appointing non-regulatory government bodies, such as national space agencies, to provide the necessary guidelines or requirements, including those for space debris mitigation.

The general aim of space debris mitigation is to reduce the growth of space debris by ensuring that spacecraft and launch vehicle orbital stages are designed, operated and disposed of in a manner that prevents them from generating debris throughout their orbit lifetime. Another aim of space debris mitigation is to ensure that space objects re-entering the Earth's atmosphere cause no harm. These aims are achieved by the following actions:

- a) avoiding the intentional release of space debris into Earth orbit during normal operations;
- b) avoiding break-ups in Earth orbit;
- c) removing spacecraft and launch vehicle orbital stages from protected orbital regions after the end of mission;
- d) performing the necessary actions to minimize the risk of collision with other space objects;
- e) reducing the risks associated with re-entry, e.g. to people, property and the Earth's environment.

Such actions are especially important for a spacecraft or launch vehicle orbital stage that has one or more of the following characteristics:

- has a large collision cross-section;
- remains in orbit for many years;
- operates near manned mission orbital regions;
- operates in highly utilized regions, such as protected regions;
- operates in regions of high debris population.

This document transforms these objectives into a set of high-level debris mitigation requirements. Methods and processes to enable conformance with these requirements are provided in a series of lower-level implementation standards.

Space systems — Space debris mitigation requirements

1 Scope

This document defines the primary space debris mitigation requirements applicable to all elements of unmanned systems launched into, or passing through, near-Earth space, including launch vehicle orbital stages, operating spacecraft and any objects released as part of normal operations.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

approving agent

entity from whom approval is sought for the implementation of *space debris* (3.23) mitigation requirements with respect to the procurement of a *spacecraft* (3.25), or its launch, or its operations in outer space, or its safe *re-entry* (3.22), or a combination of those activities

EXAMPLE Regulatory or licensing authorities; national or international space agencies; other delegated organizations.

3.2

break-up

event that completely or partially destroys an object and generates *space debris* (3.23)

3.3

controlled re-entry

type of *re-entry* (3.22) where the time of re-entry is sufficiently controlled so that the impact of any surviving debris on the surface of the Earth is confined to a designated area

Note 1 to entry: The designated area is usually an uninhabited region such as an ocean.

3.4

disposal

actions performed by a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13) to permanently reduce its chance of accidental *break-up* (3.2) and to achieve its required long-term clearance of the *protected regions* (3.21)

Note 1 to entry: Actions can include removing stored energy and performing post-mission orbital manoeuvres.

3.5

disposal manoeuvre

action of moving a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13) to a different orbit as part of its *disposal* (3.4)

3.6

disposal phase

interval between the *end of mission* (3.9) of a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13) and its *end of life* (3.8)

3.7

Earth orbit

bound or unbound Keplerian orbit with Earth at a focal point, or Lagrange point orbit which includes Earth as one of the two main bodies

3.8

end of life

instant when a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13)

- a) is permanently turned off, nominally as it completes its *disposal phase* (3.6),
- b) completes its manoeuvres to perform a *controlled re-entry* (3.3), or
- c) can no longer be controlled by the operator

Note 1 to entry: See [Annex A](#).

3.9

end of mission

instant when a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13)

- a) completes the tasks or functions for which it has been designed, other than its *disposal* (3.4),
- b) becomes incapable of accomplishing its *mission* (3.15), or
- c) has its mission permanently halted through a voluntary decision

Note 1 to entry: See [Annex A](#).

3.10

expected number of casualties per re-entry

DEPRECATED: re-entry casualty risk

number of people who are predicted to be killed or seriously injured by the *re-entry* (3.22) of a *space object* (3.24)

Note 1 to entry: The medical profession has defined a number of different injury scoring systems to distinguish the severity of an injury. Broadly, a serious injury is one of such severity that hospitalisation is required.

3.11

geostationary Earth orbit

GEO

Earth orbit (3.7) having zero inclination, zero eccentricity, and an orbital period equal to the Earth's sidereal rotation period

3.12

launch vehicle

DEPRECATED: launcher

system designed to transport one or more payloads into outer space

3.13

launch vehicle orbital stage

complete element of a *launch vehicle* (3.12) that is designed to deliver a defined thrust during a dedicated phase of the launch vehicle's operation and achieve orbit

Note 1 to entry: Non-propulsive elements of a launch vehicle, such as jettisonable tanks, multiple payload structures or dispensers, are considered to be part of a launch vehicle orbital stage while they are attached.

3.14**launching State**

State that launches or procures the launching of a *spacecraft* (3.25), or State from whose territory or facility a spacecraft is launched

Note 1 to entry: This definition is consistent with the definition in the UN Liability Convention^[5] and the UN General Assembly's Resolution 59/115 on the notion of the launching State^[6].

3.15**mission**

set of tasks or functions to be accomplished by a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13), other than its *disposal* (3.4)

3.16**mission lifetime extension**

postponement of the previously defined *end of mission* (3.9)

3.17**normal operations**

execution of the planned tasks or functions for which a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13) was designed

Note 1 to entry: Normal operations include the *disposal phase* (3.6).

3.18**orbit lifetime**

elapsed time between an orbiting *space object's* (3.24) initial or reference position and its *re-entry* (3.22)

Note 1 to entry: Examples of "initial position" are the injection into orbit of a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13), or the instant when *space debris* (3.23) is generated. An example of a "reference position" is the orbit of a spacecraft or launch vehicle orbital stage at the *end of mission* (3.9).

3.19**passivate**

<space debris mitigation> act of permanently depleting, irreversibly deactivating, or making safe all on-board sources of stored energy capable of causing an accidental *break-up* (3.2)

Note 1 to entry: Passivation is an effective measure for significantly reducing the chance of an accidental explosion that can generate *space debris* (3.23).

Note 2 to entry: Propellant tanks, batteries, high-pressure vessels, self-destruct devices, flywheels and momentum wheels are examples of on-board sources of stored energy capable of causing an accidental break-up. It is preferable to passivate such items as soon as they are no longer required for mission operations or post-mission *disposal* (3.4).

Note 3 to entry: A safe level of passivation is reached when any remaining stored energy cannot be expected to cause an accidental break-up.

Note 4 to entry: In the event of a collision, a passivated *space object* (3.24) is likely to create fewer space debris than a non-passivated space object.

3.20**probability of successful disposal**

probability that a *spacecraft* (3.25) or *launch vehicle orbital stage* (3.13) is able to complete all of the actions associated with its *disposal* (3.4)

Note 1 to entry: This probability is usually assessed before the launch of a spacecraft or launch vehicle orbital stage. It can also be reassessed after launch taking into consideration any changes in the operational status of hardware. This is particularly important when deciding whether to extend the *mission* (3.15) lifetime or postpone the *end of life* (3.8).

Note 2 to entry: The assessment of this probability includes consideration of uncertainties in the availability of resources, such as propellant, required for the disposal.

Note 3 to entry: The assessment of this probability can include consideration of the inherent reliability of equipment that is necessary to conduct the disposal, monitoring of the equipment, and operational remediation of any observed degradation or failure of the equipment.

**3.21
protected region**

region in outer space that is protected with regard to the generation of *space debris* (3.23) to ensure its safe and sustainable use in the future

**3.22
re-entry**

permanent return of a *space object* (3.24) into the Earth's atmosphere

Note 1 to entry: Several alternative definitions are available for the delineation of a boundary between the Earth's atmosphere and outer space.

**3.23
space debris**

DEPRECATED: orbital debris

objects of human origin in *Earth orbit* (3.7) or re-entering the atmosphere, including fragments and elements thereof, that no longer serve a useful purpose

Note 1 to entry: *Spacecraft* (3.25) in reserve or standby modes awaiting possible reactivation are considered to serve a useful purpose.

**3.24
space object**

object of human origin which has reached outer space

**3.25
spacecraft**

system designed to perform a set of tasks or functions in outer space, excluding *launch vehicle* (3.12)

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4 Symbols and abbreviated terms

4.1 Symbols

A/m aspect area to dry mass ratio (m^2kg^{-1})

C_R solar radiation pressure coefficient ($0 < C_R < 2$)

Z altitude measured with respect to a spherical Earth whose radius is 6 378 km

Z_{GEO} altitude of the geostationary Earth orbit with respect to a spherical Earth whose radius is 6 378 km

ΔH change in altitude (km)

4.2 Abbreviated terms

GEO geostationary Earth orbit

LEO low Earth orbit

LV launch vehicle

S/C spacecraft

SDMP space debris mitigation plan

5 General

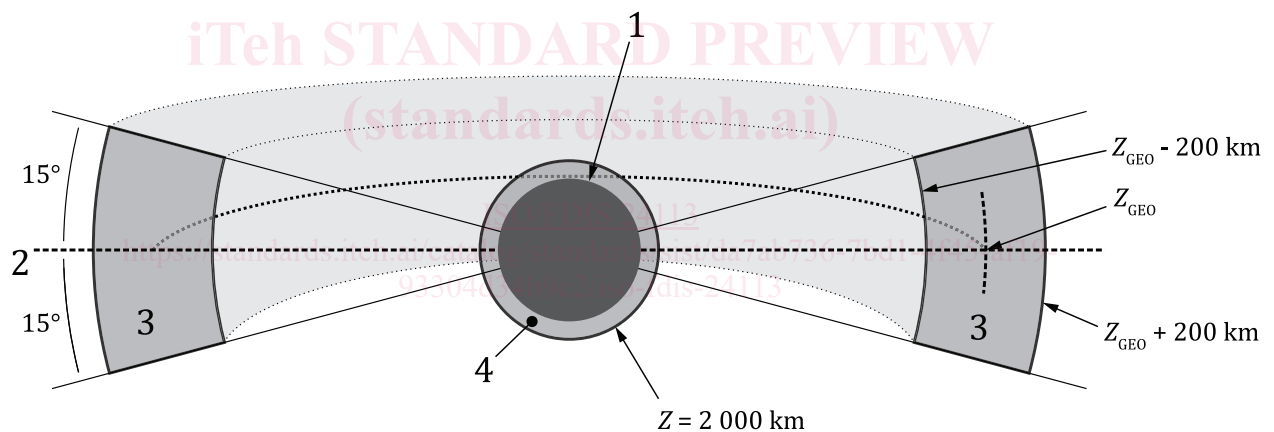
The requirements contained in this document are intended to reduce the growth of space debris by ensuring that spacecraft and launch vehicle orbital stages are designed, operated and disposed of in a manner that restricts them from generating debris throughout their orbit lifetime. The requirements are also intended to reduce the casualty risk on ground associated with atmospheric re-entry of space objects.

This document is the top-level standard in a family of standards addressing space debris mitigation. It is the main interface for the user, bridging between the primary space debris mitigation objectives and a set of lower level standards and technical reports that support conformance. The lower-level documents contain detailed requirements and implementation measures associated with the high-level requirements in this document.

6 Protected regions

6.1 General

The requirements in this document are concerned with limiting the production of space debris in Earth orbit. Particular emphasis is placed on the LEO and GEO regions, which are considered as protected regions with regard to the generation of space debris (see [Figure 1](#)). This is necessary to ensure their safe and sustainable use in the future.



Key

- 1 Earth
- 2 equatorial plane
- 3 GEO protected region
- 4 LEO protected region

NOTE The dimensions in the figure are not to scale.

Figure 1 — Three-dimensional view of the protected regions around the Earth

The requirements in this document do not apply to a space object that enters an unbound Keplerian orbit or leaves Earth orbit, provided that for at least 100 years after doing so:

- a) the space object does not cross the protected regions;
- b) the expected number of casualties from the space object's re-entry is assessed to be less than the threshold set in [7.3.4.3](#).