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**Space systems — Detailed space  
debris mitigation requirements for  
launch vehicle orbital stages**

*Systèmes spatiaux — Exigences détaillées pour la limitation des  
débris spatiaux relatifs aux étages orbitaux des lanceurs*

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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](http://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](http://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](http://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*.

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](http://www.iso.org/members.html).

## Introduction

This document was developed to support the implementation of the high-level space debris mitigation requirements in ISO 24113.

This document contains a detailed and practical set of requirements and recommendations to assist the space industry in conforming to the requirements in ISO 24113 which relate to launch vehicle orbital stages.

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# Space systems — Detailed space debris mitigation requirements for launch vehicle orbital stages

## 1 Scope

This document defines detailed space debris mitigation requirements and recommendations for the design and operation of launch vehicle orbital stages in Earth orbit.

The requirements defined in this document are applicable for:

- avoiding the release of space debris;
- disposing of a launch vehicle orbital stage after the end of its mission so as to avoid a break-up in orbit;
- disposing of a launch vehicle orbital stage after the end of its mission so as to minimize interference with the protected regions;
- safely re-entering a launch vehicle orbital stage.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24113, *Space systems — Space debris mitigation requirements*  
ISO 20893:2021  
https://standards.iteh.ai/catalog/standards/sist/d07f0117-0f04-4ea8-8c2a-72b2f69ee3c8/iso-20893-2021

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24113 and the following apply.

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

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

### 3.1

#### **decay orbit**

orbit that will result in the re-entry of a launch vehicle orbital stage

### 3.2

#### **disposal orbit**

orbit in which launch vehicle orbital stage resides following the completion of its disposal maneuvers

## 4 Avoiding the intentional release of space debris into Earth orbit during normal operations

**4.1** ISO 24113 specifies a limit for the total number of launch vehicle orbital stages and space debris objects that a launch vehicle may leave in Earth orbit during normal operations.

**NOTE** The space debris objects related to the launch include, but are not limited to, protective shrouds, inter-stage elements, clamp bands, jettisonable tanks, jettisonable attitude control or propellant settling systems.

4.2 If a launch vehicle, by design, leaves two launch vehicle orbital stages in Earth orbit during the launch of a single spacecraft, then at least one of the two stages shall be removed. It is preferred for both stages to be removed from orbit at the end of the launch vehicle's operations.

## 5 Avoiding break-ups in Earth orbit

### 5.1 Accidental break-up caused by an on-board source of energy

#### 5.1.1 General

The following elements of a launch vehicle orbital stage are most likely to cause an accidental break-up:

- a) residual propellants in propulsion systems;
- b) pressure gasses in vessels including propellant tanks, high-pressure gas bottles, and pressure lines;
- c) batteries;
- d) range safety system when not decoupled from command chain, i.e. computer order and necessary energy.

#### 5.1.2 Residual propellants in propulsion systems

5.1.2.1 Residual propellants shall be vented from a launch vehicle orbital stage as part of its passivation, the timing of such an operation being selected in order not to generate any adverse consequence to the stage or its payloads.

NOTE1 In case residual propellants are vented by combustion from the thrust chamber, the change of mixture ratio inside the chamber is a major factor of break-up risk of the thrust chamber.

NOTE2 In case residual propellants are vented in a sequential mode, without combustion, the pressure gradients of venting of liquid residual propellants are key control variables to avoid either boiling up or the generation of ice particle(debris) which can clog the passivation orifices and valves.

5.1.2.2 The venting of residual propellants shall be implemented in accordance with the requirements of launch vehicle orbital stage disposal.

NOTE Proper orientation of venting outlets can lower the final orbit and thus reduce the orbit lifetime of a launch vehicle orbital stage.

#### 5.1.3 Pressurized gasses in pressure vessels

Pressure vessels shall be designed in accordance with standardised procedures, and made safe by one or more of the following means (in order of preference):

- a) relieving the pressurized gasses totally, or
- b) relieving the pressurized gasses until the internal pressures are lower than their validated critical values, or
- c) designing with safety margins that do not allow rupture when considering thermal effects in orbit.

NOTE 1 Pressure vessels include propellant tanks and high-pressure gas bottles.

NOTE 2 ISO 14623 provides standardised procedures for pressure vessel design.

NOTE 3 Pressure vessel critical value<sup>[2][3]</sup> is the highest pressure under which an impact does not lead to an explosion, but a simple hole.



#### 5.1.4 Batteries

**5.1.4.1** The capacity margin of safety of batteries shall be evaluated in accordance with standardised design procedures to ensure mission safety and post-mission disposal.

NOTE ISO 17546 is an example of a lithium ion battery design standard.

**5.1.4.2** Batteries shall be designed and manufactured, both structurally and electrically, to prevent break-up.

#### 5.1.5 Range safety systems

**5.1.5.1** The definition and layout of the self-destruct explosive charge on a launch vehicle shall be such that it cannot reach its self-ignition temperature.

**5.1.5.2** The command receiver of a command self-destruct system in a range safety system shall be turned off soon after a launch vehicle has passed through a range safety area.

#### 5.1.6 Probability of accidental break-up due to internal causes

ISO 24113 specifies a limit for the probability of accidental break-up, due to an internal cause, that a launch vehicle orbital stage shall be designed to satisfy.

### 5.2 Accidental break-up caused by a collision

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**5.2.1** A launch vehicle orbital stage shall be launched to reduce the risk of collision among launch vehicle, injected payloads, mission related objects, and existing orbital objects (at least manned space systems) during ascent and after the injection according to the requirements set by approving agents.

NOTE Some approving agents use  $10^{-4}$  as the threshold for the risk of collision.

**5.2.2** Structural materials that generate less debris when impacted, should be preferentially considered in the design of a launch vehicle orbital stage.

## 6 Disposal of a launch vehicle orbital stage after the end of mission so as to minimize interference with the protected regions

### 6.1 Launch service provider — spacecraft mission designer coordination

**6.1.1** The spacecraft mission designer and the launch service provider shall jointly design the launch phase of the mission to enable disposal of the launch vehicle orbital stage.

**6.1.2** Using the information provided by the spacecraft mission designer (e.g. see ISO 14303, ISO 17401), the launch service provider shall estimate the orbit lifetime of all launch vehicle orbital stages, based on the spacecraft injection scenario and final orbit parameters at end of life (e.g. see ISO 27852).

**6.1.3** The launch service provider shall estimate the casualty risk for an uncontrolled re-entry of all launch vehicle orbital stages for which a controlled re-entry is not planned.

**6.1.4** The casualty risk for an uncontrolled re-entry of each launch vehicle orbital stage shall be computed using a standardised method.

NOTE ISO 27875 provides standardised methods for computing the casualty risk.

**6.1.5** The launch service provider and the spacecraft mission designer shall agree on the spacecraft separation and injection conditions, taking into account potential perturbations following spacecraft separation, so that the spent launch vehicle orbital stages can meet the disposal requirements specified in ISO 24113.

NOTE Perturbations can occur during post-separation maneuvers or stage passivation.

**6.1.6** Once the spacecraft mission designer has specified a desired injection orbit, the launch service provider shall present options (if available) for launch vehicle orbital stage disposal.

**6.1.7** In those instances where the specified injection orbit does not lead to satisfactory disposal options, the launch service provider and the spacecraft mission designer may explore alternative injection orbits that offer better conditions for disposal of the launch vehicle orbital stage.

NOTE If the spacecraft is to perform significant propulsive maneuvers subsequent to injection (e.g., orbit raising, inclination change, drift rate change, etc.), an alternative injection orbit can yield equivalent results and be acceptable to the spacecraft mission designer. A typical example would be a trade-off between orbital inclination and perigee altitude for a transfer orbit injection in which the velocity required to achieve the spacecraft final orbit remains unchanged. This type of coordination can lead to mutually beneficial solutions in terms of mission objectives and launch vehicle orbital stage disposal.

## 6.2 Selection of disposal option

### 6.2.1 Disposal to minimize interference with the geostationary Earth orbit (GEO) protected region

**6.2.1.1** The launch vehicle orbital stage shall be left in, or moved to, a disposal orbit, ensuring that it will remain outside of the GEO protected region for a period of at least 100 years.

**6.2.1.2** The time duration in the disposal orbit shall be counted from the instant at which the launch vehicle orbital stage's disposal maneuver is complete to the first instant at which its orbit penetrates the appropriate protected region in accordance with a standardised method.

NOTE ISO 27852 provides standardised methods for computing the time duration.

### 6.2.2 Disposal to minimize interference with the low Earth orbit (LEO) protected region

**6.2.2.1** ISO 24113 specifies the available disposal options for a launch vehicle orbital stage in the LEO protected region (with safe retrieval or controlled re-entry being the preferred options unless they are proved impossible).

**6.2.2.2** A launch vehicle orbital stage shall be directed to re-enter and impact in a safe area on the surface of the Earth via a controlled maneuver or sequence of maneuvers.

**6.2.2.3** If safe retrieval or controlled re-entry is not possible, and the casualty risk for a random re-entry of the launch vehicle orbital stage is lower than the value specified by an approving agent, then a launch vehicle orbital stage may be placed in a decay orbit that has an orbit lifetime of less than 25 years.

**6.2.2.4** The orbit lifetime of a launch vehicle orbital stage's decay orbit shall be calculated in accordance with a standardised method.

NOTE ISO 27852 provides standardised methods for computing the orbit lifetime.

**6.2.2.5** For the re-entry of a launch vehicle orbital stage (or any part thereof), a casualty risk analysis shall be approved by an approving agent.