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

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Foreword

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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.

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 those requirements in ISO 24113 which relate to launch vehicle orbital stages.

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 purpose of this document is to enable conformance with those high-level space debris mitigation requirements in ISO 24113 that are relevant to launch vehicle orbital stages.

This document defines detailed requirements for the purpose of:

- 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 24113:2019, *Space systems — Space debris mitigation requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24113:2019 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

Space debris left in Earth orbit by a normally operated launch vehicle shall satisfy the conditions specified in ISO 24113.

NOTE 1 Elements including but not limited to protective shrouds, interstage elements, clamp bands, jettisonable attitude control or propellant settling systems should not be injected in orbit.

NOTE 2 In case of a launch vehicle by design leaves two launch vehicle orbital stages in orbit during the launch of a single spacecraft, then at most only one of the two stages should remain in orbit at the end of operations.

NOTE 3 A launch vehicle may be designed to leave one launch vehicle orbital stage and one multiple-payload-carrying structure in orbit during the launch of two or more spacecrafts.

5 Avoiding break-ups in Earth orbit

5.1 Intentional break-up

5.1.1 The intentional break-up of a launch vehicle orbital stage performing a controlled re-entry may be permitted if the resulting fragmentation would not be injected into orbit, and leads to a casualty risk which is lower than that for the complete stage.

NOTE A break-up caused naturally by aerodynamic forces during re-entry is not an intentional break-up.

5.1.2 During the design of a launch vehicle orbital stage, best efforts shall be made to select a concept of facilitating its demise at re-entry.

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

5.2.1 General

The following elements of a launch vehicle orbital stage are the 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.

5.2.2 Residual propellants in propulsion systems

5.2.2.1 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.

Residual propellants shall be vented in a proper way.

NOTE 1 If residual propellants are vented by combustion and exhausting from the thrust chamber, the break-up risk of combustion chamber should be considered, which caused by the change of mixture ratio inside it.

NOTE 2 If residual propellants are vented in a sequential mode, without combustion, the pressure gradients of venting of liquid residual propellants should be controlled so as to avoid boiling up or generation of ice particle (debris) and clogging the passivation orifices and valves.

5.2.2.2 Requirements of launch vehicle orbital stage disposal shall be considered in the implementation of residual propellants venting.

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

5.2.3 Pressurized gasses in pressure vessels

Pressure vessels such as tanks and high-pressure gas bottles shall be designed in accordance with proper rules(e.g., see ISO 14623), 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 Pressure vessel critical value[2][3] is the highest pressure under which an impact does not lead to an explosion, but a simple hole.

5.2.4 Batteries

5.2.4.1 The capacity margin of safety of batteries shall be evaluated considering the proper standards(e.g., see ISO 17546) for safety in mission and disposal actions.

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

5.2.5 Range safety systems

5.2.5.1 The self-destruct explosive charge on a launch vehicle shall be protected thermally to keep its temperature away from its self-ignition temperature.

5.2.5.2 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.

5.2.6 Probability of accidental break-up due to internal causes

A launch vehicle orbital stage shall be designed so that its probability of accidental break-up due to an internal cause does not exceed the limit specified in ISO 24113.

5.3 Accidental break-up caused by a collision

5.3.1 A launch vehicle orbital stage shall be designed and operated to reduce the risk of collision below the threshold set by approving agents.

NOTE An assessment should be performed to identify conjunctions between launch vehicle mission-related space objects and any other on-orbit object (at least including manned spacecraft) during the period from when a launch vehicle leaves the range safety area to its end of life.

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