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Space systems — Prevention of break-up of unmanned spacecraft

Systèmes spatiaux — Prévention de l'éclatement des navettes sans pilote

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Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

An ever-increasing number of man-made items are orbiting the Earth and bring with them ever-increasing risk of collisions. This can have implications on the operational requirements of both manned and unmanned spacecraft.

One potential source of space debris is the break-up of unmanned spacecraft both during and after the end of their operational lives. This break-up could be due either to external collisions or to internal factors caused by the existence of stored energy sources onboard the spacecraft. A cloud of debris from a single spacecraft having broken up poses a significantly greater threat of collision than the original spacecraft.

This International Standard defines the requirements to reduce the probability of a spacecraft breaking up, both during and after its operational life. It also defines the requirements for passivation of the spacecraft, which is the process by which all sources of stored energy are removed.

Space systems — Prevention of break-up of unmanned spacecraft

1 Scope

This International Standard defines the requirements to reduce the risk of in-orbit break-up of unmanned spacecraft, both during and after their operational lives. The aim would be met by reducing the possibility of a break-up caused by an unplanned internally caused event and by depleting to a safe level all the sources of stored energy at the end of a spacecraft's life. This International Standard is designed for use in planning, verifying, and implementing the prevention of break-up of a spacecraft.

This International Standard applies only to unmanned spacecraft operating in Earth orbit. It does not apply to manned space vehicles or launch vehicle orbital stages. Additionally, it does not cover nuclear power sources within spacecraft.

This International Standard is not applicable to fragmentation as a result of external particle impacts (which includes fragmentations triggered by external particle impact but powered by internal energy sources).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14623, *Space systems - Pressure vessels and pressurized structures — Design and operation*

ISO 24638, *Space systems — Pressure components and pressure system integration*

ISO 24113:2011, *Space systems — Space debris mitigation requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24113:2011 and the following apply.

3.1
acquiring organization
organization that plans and manages the development and acquisition contracts for the space system

Note 1 to entry: The responsibilities of the acquiring organization include the engineering and technical aspects of the space system's design and operations.

3.2
break-up probability
combined probability of the occurrence of all anomalous events, excluding meteoroid or debris impact, that leads to the generation of orbital debris

3.3
passivation
elimination of all stored energy on a space system to reduce the chance of break-up

Note 1 to entry: Typical passivation measures include venting or burning excess propellant, discharging batteries, and relieving pressure vessels.

4 Implementation

4.1 Design process

In accordance with ISO 24113, the spacecraft shall be designed to prevent break-ups while in orbit, both before end of life and after the end of life.

The spacecraft shall be designed to prevent break-ups while in orbit until its end of life, in accordance with probability levels defined in ISO 24113:2011, 6.2.2.1, and to enable passivation before its end of life. Calculations shall be performed to determine the accidental break-up probability. Annex A reports an example of an acceptable detailed evaluation approach.

The design process and the definition of the operations (including operational and disposal phases) shall prevent potential failures which could occur during operational life, but also after the end of life. All onboard sources of stored energy, such as residual propellants, batteries, high-pressure vessels, self-destructive devices, flywheels, and momentum wheels, shall be depleted or safed and permanently deactivated once they are no longer required for the mission operation.

The spacecraft provider shall produce a break-up prevention plan. This plan shall be reviewed and updated as part of the normal spacecraft design review process. The acquiring organization/operator shall be involved with these design reviews and approve the proposed solutions. All management shall be done in accordance with ISO 24113.

When producing the break-up prevention plan, a system level risk assessment approach shall be used. Each source of stored energy shall be considered: what potential failure modes could result in an in-orbit break-up of the spacecraft (including post-disposal phase) and what can be performed to mitigate the risk in the design, operational, and disposal phases of the mission as well as after the end of life. Annex A provides further details regarding producing the plan.

The plan shall be developed by considering each item containing stored energy. The design shall take into account the following influences:

— the environmental extremes expected to be encountered during the operational life and following passivation, but excluding re-entry phase;

— mechanical degradation during the mission and following passivation;

— chemical decomposition;

— the effect of potential failure modes of the spacecraft during the mission, and what effect they would have on the ability to passivate the spacecraft.

The robustness of the design shall be confirmed during the design review process, to ensure that adequate reliability and quality control has been performed to inhibit any failure that could lead to a break-up event with a probability as defined in ISO 24113.

4.2 Verification

Throughout the ground phases of a mission, i.e. design, manufacture, AIT (Assembly, Integration, and Test), and launch, the implementation of the break-up prevention plan shall be reviewed. All the hardware and software designed specifically for the purpose of break-up prevention should be verified either by test, demonstration, analysis, or simulation (in that order of preference).

4.3 Prevention of break-ups until end of life

4.3.1 Monitoring during operations

For the operations of the spacecraft, procedures should be defined to allow monitoring of the relevant parameters of each subsystem, which has been identified as a possible source of space debris generation, in order to detect malfunctions.

The risk of potential malfunctions shall be considered within the break-up prevention plan, which shall include a contingency plan to mitigate against the risk of the malfunction causing a break-up.

The following items should, as a minimum, be monitored from the ground, if applicable:

— pressure and temperature in the tanks;

— parameters (temperature and voltage) of batteries to detect failures;

— parameters to detect failure modes of the orbit and attitude control system.

4.3.2 Debris mitigation measures in the case of malfunction

In the event of in-orbit malfunctions which could lead to 1) break-up or 2) the loss of operating function, possible debris mitigation measures should be studied and implemented (reduction of orbital lifetime or removal from a protected orbit region and passivation at the end of disposal).

At the time when satellite operation is concluded either purposefully or due to malfunction and other disposal actions have been completed, passivation shall be performed.

4.4 Prevention of break-up after end of life

Prevention of break-up after mission is guaranteed through the passivation process, which shall be completed at an appropriate point during the disposal phase. A passivation procedure shall be produced prior to the end of the design phase. Prior to the disposal phase, this shall be updated to take into account any failures that have occurred during the mission and that affect the ability to passivate the spacecraft.

No operations that will generate orbital debris of greater than 1 mm in size shall be performed during the passivation process, excepting the release of frozen propellant.

5 Stored energy sources

5.1 Systems storing energy

The following systems are most likely to cause the break-up of a spacecraft:

— electrical systems, especially batteries;

— propulsion systems and associated components;

— pressurized systems;

— rotating mechanisms.

It should be noted that this International Standard does not cover nuclear power sources on spacecraft.

