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Space systems — Prevention of break-up of unmanned spacecraft

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Foreward

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ISO XXXX was prepared by Technical Committee 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 un-manned 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 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 standard defines the requirements to reduce the risk of on-orbit break-up of un-manned 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 standard is designed for use in planning, verifying and implementing the prevention of break-up of a spacecraft.

This standard applies only to un-manned 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.

The document excludes fragmentation as a result of external particle impacts including fragmentations triggered by external particle impact but power by internal energy sources.

2 Normative references

The following referenced documents are indispensable for the application 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 14623:2003, Space Systems – Pressure vessels and pressurised structures – Design and operation

ISO 24638:2008, Space Systems – Pressure components and pressure system integration

ISO 21347:2005, Space systems – Fracture and damage control

ISO 24113:2011, Space systems – Space debris mitigation requirements

ISO 17666:2003, Space systems – Risk management

ISO 10795:2011, Space Systems – Programme management – Glossary of terms for use in ISO standards for space systems and operations

3 Definitions of terms

For the purposes of this document, the terms and definitions given in ISO 24113:2010 and the following apply.

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

NOTE - 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
The 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
The elimination of all stored energy on a space system to reduce the chance of break-up. Typical passivation measures include venting or burning excess propellant, discharging batteries and relieving pressure vessels.

4 Acronyms and Abbreviations

4.1 Abbreviations

The following abbreviations are used within this document

ISO	International Organization for Standardization
AIT	Assembly, Integration and Test

5 Implementation

5.1 Design process

In accordance with ISO24113, the spacecraft shall be designed to prevent break-ups whilst in orbit, both before end of life and after the end of life.

The spacecraft shall be designed to prevent break-ups whilst in orbit until its end of life, in accordance with probability levels defined in ISO24113 para 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 (informative) 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 organisation / 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 on 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. Industry best practice shall be used when considering each source. 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 ISO24113.

5.2 Verification

Throughout the ground phases of a mission, i.e. design, manufacture, AIT 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).

5.3 Prevention of break-ups until end of life

5.3.1 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 and 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:-

1. Pressure and temperature in the tanks
2. Parameters (temperature and voltage) of batteries to detect failures
3. Parameters to detect failure modes of the orbit and attitude control system.

5.3.2 Debris mitigation measures in the case of malfunction

In the event of in-orbit malfunctions which could lead to 1) break-up, 2) the loss of mission capability, or 3) the loss of orbit and / or attitude control 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 mission is concluded either purposefully or due to malfunction and other disposal actions have been completed, passivation shall be performed.

5.4 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 1mm in size shall be performed during the passivation process, excepting the release of frozen propellant.