INTERNATIONAL STANDARD

ISO 27875

First edition
2010-03-01

Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages

Systèmes spatiaux — Gestion du risque de la rentrée pour les étapes orbitales des véhicules spatiaux non habités et des lanceurs spatiaux

Reference number
ISO 27875:2010(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword iv
Introduction v
1 Scope 1
2 Normative references 1
3 Terms and definitions 1
4 Re-entry risk management 2
4.1 General 2
4.2 Re-entry safety programme 2
4.3 Re-entry safety oversight and management 2
4.4 Re-entry risk assessment and mitigation plan 2
5 Risk assessment 3
5.1 General 3
5.2 Safety requirements 3
5.3 Process and resources for analysis 3
5.4 Estimation of risk 4
5.5 Risk decision and actions 4
6 Risk-reduction measures 6
6.1 General 6
6.2 Controlled re-entry 6
6.3 Structural design measures to reduce re-entry survivability 6
6.4 Notification 6
7 Nonconformities processing 6
Annex A (normative) Required content of the re-entry risk assessment and mitigation plan 7
Annex B (normative) Compliance matrix 11
Bibliography 12

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 27875 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

According to international treaties, the “launching state” is liable for damage or injuries caused by unmanned spacecraft and launch vehicle orbital stages that re-enter the Earth's atmosphere. In addition, commercial operators are subject to the national safety regulations or laws of the launching country that relate to re-entry of spacecraft and launch vehicle orbital stages. In order to minimize damage and injury from re-entering spacecraft and launch vehicle orbital stages, it is the responsibility of all parties (developers, manufacturers, space service providers, satellite operators and launch service providers) to take preventive measures during spacecraft design and space operations.

Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages

1 Scope

This International Standard provides a framework with which to assess, reduce and control the potential risks that spacecraft and launch vehicle orbital stages pose to people and the environment when those space vehicles re-enter the Earth's atmosphere and impact the Earth's surface. It is intended to be applied to the planning, design and review of space vehicle missions for which controlled or uncontrolled re-entry is possible. Objects that separate during the ascent phase and impact the ground are addressed in ISO 14620-2. This International Standard complements ISO 14620-1 and ISO 17666.

This International Standard is not applicable to spacecraft containing nuclear power sources[1)].

NOTE Useful background information for this International Standard is available in ISO 24113.

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 14620-1, *Space systems — Safety requirements — Part 1: System safety*

ISO 17666, *Space systems — Risk management*

3 Terms and definitions

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

3.1
controlled re-entry
type of re-entry where the time of re-entry is controlled and the impact of debris is confined to a designated ground zone

NOTE This International Standard does not cover specific design to be retrieved, such as the Space Transportation System.

3.2
launch vehicle orbital stage
stage of a launch vehicle that can be injected into orbit

1) Such spacecraft are controlled by the *Principles Relevant to the Use of Nuclear Power Sources in Outer Space*, (General Assembly resolution 47/68 of 14 December 1992), A/RES/47/68 47 U.N.

3.3
re-entry
process in which atmospheric drag escalates deceleration of a spacecraft or launch vehicle orbital stage leading to its destruction or return to Earth

3.4
spacecraft
system designed to perform specific tasks or functions in space

3.5
uncontrolled re-entry
type of re-entry where the time and ground zone of impact are not controlled

4 Re-entry risk management

4.1 General

Re-entry risk management shall be conducted as a part of a system safety programme based on ISO 14620-1 under the concept of risk management based on ISO 17666.

4.2 Re-entry safety programme

In addition to the safety activities required by ISO 14620-1, a re-entry safety programme shall be established to ensure:

a) minimization of damage and injuries caused by re-entering spacecraft or launch vehicle orbital stages;

b) corrective action for risks assessed to exceed programme or mission thresholds.

4.3 Re-entry safety oversight and management

The safety representative defined in ISO 14620-1 or equivalent person or section shall have access to the safety data, approve the plans and the results of the work, and report the status to the head of organization. At each design and operation phase, a review committee shall review the result of the safety assessment and the plan for the next phase, and endorse the decision to proceed to the following phase. Required input data, purpose of review and output shall be defined for each review. The requirements in this International Standard may be tailored before their application. The results of tailoring, however, shall be subject to the agreement of the responsible departments, the safety representative and the customer, if required.

4.4 Re-entry risk assessment and mitigation plan

A re-entry risk assessment and mitigation plan (RRAMP) through project life cycle shall be prepared as part of the safety data package specified in ISO 14620-1.

The RRAMP will define the work plan corresponding to each requirement in this International Standard and detailed schedules of critical activities (design, analysis and testing reviews) throughout the life of the programme. The required contents of the RRAMP are given in Annex A and the compliance between this International Standard and the RRAMP is described in Annex B.

The RRAMP shall be approved by the safety representative, the head of project management and the customers. The RRAMP will change and evolve as the project proceeds.

5 Risk assessment

5.1 General

Because the general concept for risk assessment is given in ISO 17666, this clause supplements specific requirements related to re-entry matter using terms (risk scenario, risk magnitude, risk decision and actions, etc.) defined in ISO 17666.

5.2 Safety requirements

Specific re-entry safety requirements imposed contractually, voluntarily or by national or international authorities shall be identified and applied, and where possible, quantified with threshold parameters. Deliberate re-entry risk assessment actions (analyses, reports, etc.) shall be defined and scheduled. A compliance matrix between safety requirements and system design and operation plan, which includes achieved quantitative results, threshold values, consequences of not meeting thresholds and the probability that those consequences would be realized, shall be maintained.

The expected output is the assessment parameters (e.g. risk to people on the ground and the associated mathematical parameters) and the thresholds for them or the concept for risk decision and actions according to the probability and severity of consequences.

5.3 Process and resources for analysis

Analysis corresponding to the safety requirements shall be conducted with the following approved processes, methods, tools, models and data.

a) Description and justification of analysis tools and approach, including

   1) algorithms for trajectory, aerodynamic, aerothermodynamic and thermal analyses, object physical characteristics and aerodynamic and thermal properties for re-entry trajectory and heating analysis,

   2) requisite physical characteristics and aerodynamic and thermal properties for trajectory and thermal analyses,

   3) treatment of component thermal shielding and vehicle disassembly during the break-up process,

   4) atmosphere model,

   5) human population distribution model and definition of casualty area,

   6) criteria for eliminating any vehicle components from the risk analyses, and

   7) any other criteria or assumptions that affect the assessment of casualty;

b) mission-dependent assumptions, if not defined in routine procedure, including

   1) attitude mode (e.g. tumbling, side-on stable),

   2) contribution of oxidation to the heating rate, and

   3) conditions of the break-up process and sequence;

c) specific vehicle and orbit data, including

   1) initial orbit,

   2) initial temperature,

3) detailed identification of the spacecraft or launch vehicle orbital stage including its components (e.g. propellant tanks, pressurized vessels, major structural elements) and their construction, mass, dimensions, shapes, material properties (e.g. melting point, density), connectivity, mutual shielding and nesting and other factors (e.g. aerodynamic drag coefficient, coefficients for average heating), and

4) properties of small but potentially surviving and hazardous objects that are likely to be released during re-entry.

NOTE If the safety requirements identify a risk scenario other than ground casualty, an adequate process is added to the above set.

5.4 Estimation of risk

According to the risk defined in 5.2, the risks of re-entry (probability of occurrence and severity of consequences) shall be estimated and reported as follows:

a) critical components with their characteristics, in enough detail to conduct trajectory and thermal analyses (e.g. mass, shape, dimensions);

b) results of analyses including an estimate of the characteristics of the fragments likely to survive re-entry (e.g. mass, shape, dimensions, velocity, kinetic energy at impact);

c) probability of hazard and severity of consequence estimated according to the risk scenario identified by safety requirements;

d) in the case of a planned controlled re-entry

1) a prediction of the ground area to be affected by the falling objects,

2) a hazard analysis for the circumstance when the re-entry is controlled successfully, and

3) a hazard analysis for the circumstance when the re-entry is not controlled successfully;

e) in the case of onboard radioactive substances, toxic substances or any other environmental pollutants, an assessment of the effects that they have on the Earth's environment, including human health.

5.5 Risk decision and actions

The risk magnitude shall be determined by the severity and probability of a hazard. For each risk scenario the risk decision and actions corresponding to the risk magnitude estimated in 5.4 shall be determined, documented and approved by a safety representative.

The result of the assessment shall be expressed in a risk assessment matrix.

The rough concept for risk decision and actions for typical ground casualties and ground pollution is shown in Figure 1.

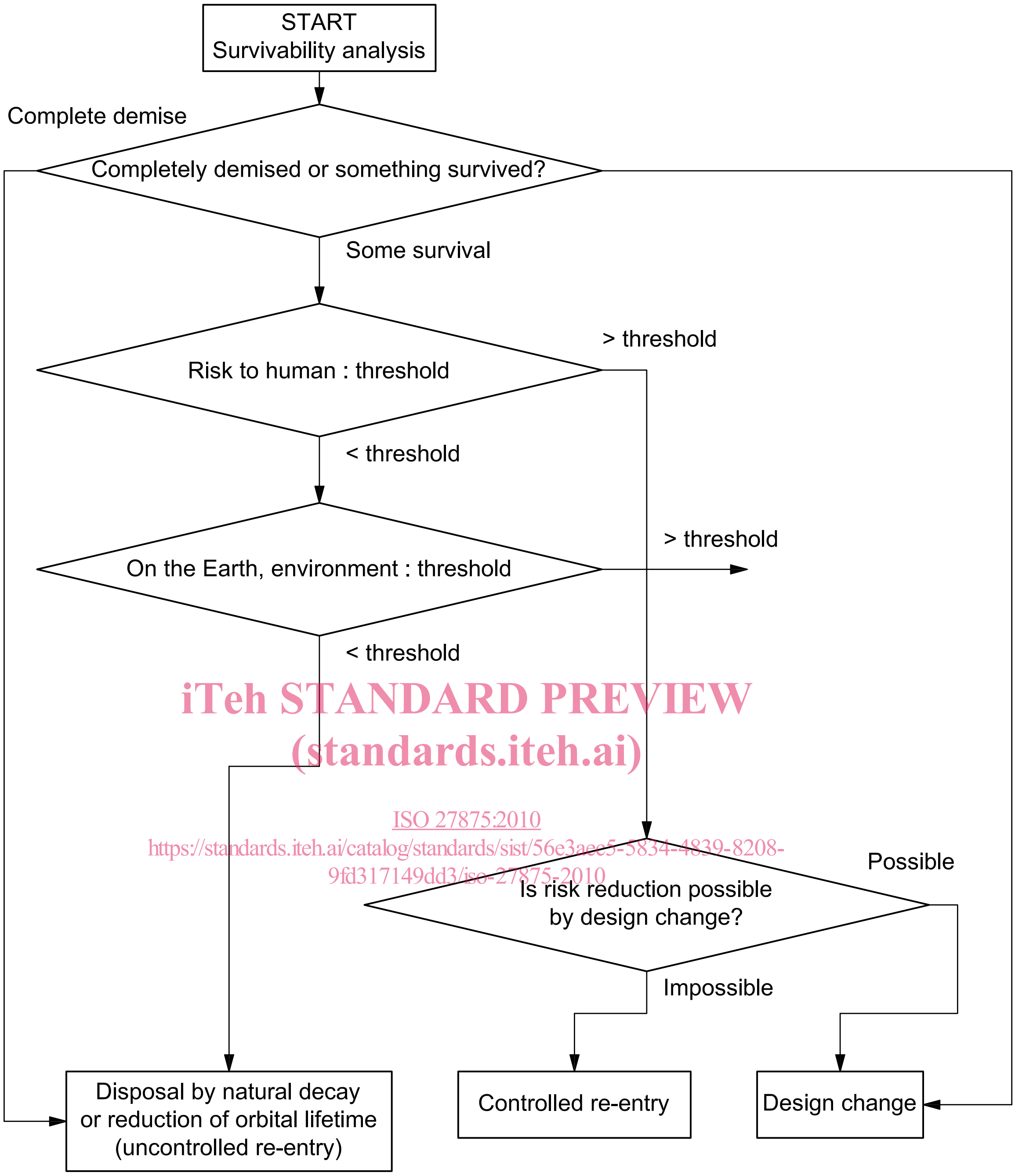

Figure 1 — Flow for risk assessment and disposal planning