



DPC: 25/30479062 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Introduction

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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 27875

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*

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2025-06-19

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
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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).

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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*.

This third edition cancels and replaces the second edition (ISO 27875:2019 and amendment 1 for replacement [Formula \(3\)](#) published 2020).

The main changes compared to the previous edition are as follows:

- A description explaining the entire analysis process has been added. (Sub-clause [5.3](#) a))
- An informative description for the selection of the Earth model and the atmospheric model have been added corresponding to the difference of controlled or uncontrolled re-entry. (Sub-clause [5.3](#) b))
- As risks other than casualty due to impact on the human body, the following risks have been added (Sub-clause [5.6](#), [6.1](#)) and design measures to reduce each risk have been described. (Sub-clause [6.4](#))
 - a) Radioactive substances,
 - b) Floating objects,
 - c) Pressurized or explosive objects, and
 - d) Hazardous chemical substances.
- In [Annex B](#), for more detailed description, informative [Table B.1](#) "Example of a severity-of-consequence scoring scheme for re-entry event" has been revised. ([Annex B](#) / [B.2](#))
- In [Annex C](#), explanation for "Expected number of casualties per unit casualty area as example" has been added with a chart. ([Annex C](#) / [C.6](#))
- Design for demise during re-entry has been added as [Annex D](#),
- "Example of report of the re-entry risk assessment for design review" has been attached as [Annex E](#).

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 the re-entry of spacecraft and launch vehicle orbital stages. To minimise damage and injuries from re-entering spacecraft and launch vehicle orbital stages, all parties (i.e., developers, manufacturers, space service providers, satellite operators, and launch service providers) should take preventive measures during design and operations.

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

1 Scope

This document provides a framework with which to assess, reduce, and control the potential risks that spacecraft and launch vehicle orbital stages (referred to hereinafter as “space vehicles”) 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 inevitable.

This document is applicable to following objects in assessing their risk to the ground:

- a) objects re-entering from orbit,
- b) launch vehicles (including payloads, other objects separated during the ascent phase, etc.) that are mentioned in flight safety activities under ISO 14620-2,^[1] 6.2; and
- c) interplanetary spacecraft returning to Earth.

This document complements ISO 14620-1 and ISO 17666.

NOTE 1 This document does not apply to systems with wings and control functions intended for targeted landing.

NOTE 2 Useful background information for this document is available in ISO 24113.

2 Normative references

The following documents are referred to in the text in such a way that some or all 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 14620-1, *Space systems — Safety requirements — Part 1: System safety*

ISO 17666, *Space systems — Risk management*

United Nations, *Principles Relevant to the Use of Nuclear Power Sources in Outer Space*, (General Assembly resolution 47/68 of 14 December 1992), A/RES/47/

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

TS 6434, *Space systems — Design, testing and operation of a large constellation of spacecraft*

3 Terms and definitions

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

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

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

3.1

controlled re-entry

type of re-entry where the time of re-entry is sufficiently controlled so that the impact of any surviving debris on the surface of the Earth is confined to a designated area

Note 1 to entry: The designated area is usually an uninhabited region such as an ocean.

3.2

expected number of casualties (Ec)

number of people who are predicted to be killed or seriously injured by the re-entry per a project or program

Note 1 to entry: The calculation of Ec is complex. Organizations use different processes to estimate Ec based on methods deemed applicable by the organizations. (see [5.5.1](#) and [Annex C](#))

Note 2 to entry: The medical profession has defined a number of different injury scoring systems to distinguish the severity of an injury. Broadly, a serious injury is one of such severity that hospitalisation is required.

Note 3 to entry: Typically, the assessment of Ec will be conducted every re-entry event. However, when a project or program the multiple objects would cause re-entry per one project or programme, the approving agent authority might require assessing the total Ec of all re-entry objects.

Note 4 to entry: In the case of large constellation, the quantity of spacecraft in a constellation program and associated high numbers of ground impacts dictate that the total Ec per a program might be assessed in line with thresholds set by the approving agent.

[SOURCE: ISO TS 6434 5.2.5 modified – Note 4 to entry has been added.]

4 Re-entry risk management

4.1 General

Re-entry risk management shall be conducted according to ISO 17666, which is briefly explained in [Annex B](#). This document mainly focuses on the estimation of the risk of casualty and partly on ground pollution. This document also presents requirements for when controlled re-entry would be conducted to reduce risk. This document acts as a part of a system safety programme based on ISO 14620-1, 4.4.

4.2 Re-entry safety programme

In addition to the safety activities required by ISO 14620-1, 4.4, a re-entry safety programme shall be established to ensure:

- a) minimisation of damage and injuries caused by re-entering spacecraft or launch vehicle orbital stages; and
- b) suggestions for corrective actions regarding risks assessed as exceeding safety requirements.

4.3 Re-entry safety oversight and management

As required in ISO 14620-1, 4.3, safety representatives shall be appointed. Safety representatives shall be responsible for safety activities, have the right to access related data, and be authorized to reject any project document, stop any project activities, or interrupt hazardous operations. As required in ISO 14620-1, 4.4, at each design or operation phase, a review committee should review the result of the safety assessment, review the plan for the next phase, and endorse the decision to proceed to the following phase. If there are requirements that cannot be met, a request for deviation or waiver is generated and reviewed, and the space vehicle is disposed according to ISO 14620-1, 4.10.6.

4.4 Re-entry risk assessment and mitigation plan

4.4.1 Preparation of the plan

A Re-entry Risk Assessment and Mitigation Plan (RRAMP) shall be prepared and updated throughout the project life cycle as part of the safety data package specified in ISO 14620-1,4.10.5.

The RRAMP will define the work plan corresponding to each requirement in this document and detailed schedules for critical activities (design, analysis and testing reviews) throughout the life of the project. Typical contents of the RRAMP are given in [Annex A](#).

4.4.2 Authorization of the plan

The RRAMP shall be approved by the safety representative, the head of project management, and the customers. The RRAMP will be changed and evolved as the project progresses.

4.5 Re-entry risk management concept

The scoring schemes for the severity of consequence of re-entry hazards are defined by the national authority. Based on ISO 17666, risk is assessed by the risk magnitude expressed as the combination of its severity and likelihood (see [Annex B](#), and ISO 17666).

The scoring is typically related to the casualty area (see [5.5.1.2](#)) in the case of casualty risk, damage of properties in the case of social risk, or pollution on the ground in the case of environmental risk (for example, see [Table B.1](#), or ISO-17666:2016, Figure 3.). Generally, a risk index will be defined as a combination of severity and likelihood, and a risk magnitude will be defined for each risk index.

For assessing re-entry risk:

- In the case of uncontrolled re-entry, E_c is calculated as a function of the casualty area, orbital inclination, and population density. Since the re-entry cannot be avoided without control, likelihood is fixed as the probability of occurrence of 1,0, and the risk index is equivalent to the E_c . Section 6.5.2 describes assessment procedures for casualty risk in the case of uncontrolled re-entry. [Section 5.6](#) for environmental risk.
- In the case of controlled re-entry, E_c is calculated in the same manner as for the uncontrolled re-entry (i.e., is a function of the casualty area, orbital inclination and population density), but the E_c is weighted by reliability of functions and sufficiency of propellants needed for controlling the re-entry. (See [Annex B](#) or ISO 17666:2016, Figure 4). [Section 7.4](#) describes assessment procedures for casualty risk in the case of controlled re-entry.

Proposed actions may be defined for each risk index (See [Table B.3](#) and [B.4](#), or ISO 17666:2016, Figure 6.)

5 Risk assessment in the case of uncontrolled re-entry

5.1 General

A safety assessment shall be conducted to evaluate the risks associated with an uncontrolled re-entry and to determine the need for design improvements or a controlled re-entry. The safety assessment should include the following:

- a) Identification of the safety requirements,
- b) Identification of a standardized process and resources for analysis,
- c) Identification of system/mission dependent parameters,
- d) Estimation of risk, and
- e) Risk decision and actions.

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

5.2 Identification of safety requirements

5.2.1 Identification of requirements

Specific re-entry safety requirements imposed contractually, voluntarily, or by national or international authorities shall be identified, and where possible, quantified with threshold parameters.

5.2.2 Risk assessment plan

Re-entry risk assessment actions (analyses, reports, etc.) shall be defined and scheduled, and a compliance matrix that correlates safety requirements against the system design and operation plan, which includes achieved quantitative results, threshold values, consequences of violating 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 its associated mathematical parameters) and their thresholds, or the concept for risk decision and the actions according to the severity of consequences and the likelihood of occurrence.

NOTE 1 Several national governments and space agencies adopt 0,000 1 persons as an acceptable upper limit for Ec.

NOTE 2 Generally, on-board radioactive substances, toxic substances, and any other hazardous materials are considered when evaluating and limiting the potentially adverse effects of re-entry on the Earth's environment.

5.3 Identification of a standardized process and resources for analysis

5.3.1 Standardized process and resources for analysis

A standardized process to identify the safety requirements established by national or international authorities shall be implemented by the entity which conducts the analysis. The standardized process shall designate methods, tools, models, physical characteristics and properties of materials, as typically shown in the followings.

5.3.2 Typical methods, Analysis tools, Analytic conditions, etc.

5.3.2.1 General procedure:

- 1) In the case of uncontrolled re-entry, trajectory and thermal analyses are started from the "re-entry interface point" where the atmospheric density will increase to generate aerodynamic heating. (Defined typically at 120 km in altitude). At that point, deployment devices will be separated by the aerodynamic drag force. When decaying down to lower than approximately 100 km, structural breakup of the space system due to the thermal effect and aerodynamic drag force will begin. In this document, this point is called as the initial structural breakup point, and world entities have assumed that this break-up point is at the altitude 78 km as a de-facto value, unless it can be determined on technical grounds to define it another way. At this point, it is assumed that all the components are separated from the parent body. In the case that a certain component installed inside another component, such component is assumed to be thrown to the outer stream when the original component experiences structural break-up (it may be called as the second break-up point). Survivability analysis for each component shall follow to identify the objects that can survive re-entry.
- 2) In the case of controlled re-entry, the time and location of footprint shall be planned, and re-entry maneuverer shall be conducted according to the plan. The trajectory analysis starts at the end of final re-entry manoeuvre, and thermal analysis continues from the point where aerodynamic heating can be expected. The analysis shall proceed in same way as for an uncontrolled re-entry.

- 3) The survivability analysis shall be followed by estimation of casualty risk (E_c) and shall include a risk assessment for other hazards (e.g., radioactive substances, floating objects, explosion of surviving objects and the environmental pollution due chemical substances).
- 4) The results of the above procedures shall be used to develop the total E_c that covers all of the re-entry objects predicted to survive plus an assessment of hazards associated with other hazards.

5.3.2.2 Analysis tools, models, and approach, including:

- 1) algorithms for trajectory, aerodynamic, aerothermodynamic, and thermal analyses for re-entry trajectory and thermal analyses,
- 2) requisite physical characteristics, aerodynamic properties, and thermal properties for trajectory and thermal analyses,

NOTE Physical characteristics and properties are given by the authority of individual entity or national authorities. ISO provides ISO 23020^[3] for test method to obtain physical properties of materials or component for break-up models.

- 3) Earth model and atmospheric model;

For both controlled and uncontrolled re-entry, the effects of the differences in the Earth or atmospheric models are observed in the results of re-entry analysis. These difference are observed primarily in simulations of controlled re-entries. Application of these models may be selected as shown in [Table 1](#), depending on the characteristics of systems and descending trajectories.

However, the error caused by differences in Earth's gravity and the physical characteristics of the atmosphere shall be adequately assessed, and enough margins shall be assured.

Table 1 — Applicable Earth models and atmospheric models (Informative)

	Controlled re-entry	Uncontrolled re-entry
Earth model	a detailed Earth model (considering non-spherical component of the earth gravity), defined with; a) Earth's equatorial radius, b) Earth's gravitational constant, c) zonal harmonic function J2 term, d) zonal harmonic function J3 term, e) zonal harmonic function J4 term. as example.	Perfect sphere or the detailed model (When applying the detailed model, the worst-case latitude of the re-entry interface point, in which minimum amount of heat absorption will be obtained, will be used.)
Atmospheric model	(1) The atmospheric density, pressure and their variations provided from a reliable model (such as the NASA-Earth Global Reference Atmospheric Model) specific to time and geographic region. Wind model possibly applied. (2) U.S. Standard Model 1976, MSIS Model, or another reliable model with considering the variations of the density and pressure	U.S. Standard Model, MSIS Model, or another reliable model. (It is not necessarily needed to consider the variations of atmospheric density and pressure.)

- 4) any constants or formulae for perturbations on the decaying trajectory,
- 5) human population distribution model (See [C.5](#)),
- 6) definition of casualty area (see [5.5.1.2](#) for a typical definition of casualty area), and
- 7) reduction in mass, size, and deformation due to ablation during re-entry.

NOTE The following methods show lower survivability than the lumped mass approach.:

- (a) Dividing the object into several layers and removing the outer layer when it absorbs the latent heat of fusion after the outer layer reaches the melting temperature, or

- (b) The object to be heated is left until it reaches the melting temperature, and the outer surface is peeled off according to the amount of latent heat absorbed. This process usually ends when the outer 90 % is removed, followed by a lumped-mass approach.
- 8) definition of the techniques and assumptions used to estimate the E_c (e.g., year of re-entry, population model, casualty area).

5.3.2.3 Analytic conditions, assumptions, or criteria for assessment

Due to the complexity of re-entry physics and material responses, detailed analyses are necessary to obtain accurate estimates of aerodynamic and thermal phenomena. If there are technical uncertainties or insufficient resources, then simplified models, analytic conditions, criteria, or assumptions are applied.

The following conditions are assumed as given, for example:

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

NOTE Depending on the functions of the tool, but in the case that actual attitude is unknown, random tumbling mode is selected. However, “broadside and spinning motion” will be applied to the long rod, and “end-on and spinning motion” may be applied to thin circular plate.

- 2) contribution of oxidation to the heating rate,

NOTE There is no standardized value of the oxidation efficiency. However, since the effect is absolutely expected, so that ignoring the effect seems to be too conservative. Usually, it is assumed to be 0,4 or 0,5.

- 3) standard conditions of the structural break-up process and sequence (e.g., de-facto altitude of the aerodynamic and thermal break-up point where the space vehicle is assumed to be disjoined into a set of components, a specific value acquired from the analysis, etc.),

NOTE For the complicated system that the specific value of structural break-up point can't be obtained from the analysis, the altitude of the break-up point is widely assumed to be 78 km according to the observation data. There have been other attempts to monitor the impact of break-up with on-board sensors. In the case of a simple structure such as propellant tank, the structural break-up point will be estimated with thermal analysis.

- 4) initial temperature when the analysis starts,

NOTE Usually in the world agencies, 300 K tend to be applied.

- 5) criteria for eliminating any components from the risk analyses due to their low survivability; and

NOTE 1 On-board electro and electronic components whose mass of the structure member occupy just 30 - 40 % of total mass. Residual mass is occupied by semi-conductors, wire harness, or non-metallic plate that are easy to demise. So, there is no need to wait to judge demise until it will absorb 100 % of latent heat of fusion.

NOTE 2 A wire harness longer than 1 m will demise during normal re-entry, and the other harness shorter than 1 m will not reach minimum impact energy if it would survive.

- 6) threshold for minimum impact energy that causes casualty.

NOTE Usually in the world agencies, 15 J tends to be applied as the threshold.

5.4 Identification of system / mission dependent parameters

The following data shall be obtained from those organizations that are responsible for the design and operation of a space vehicle:

- a) the object's physical characteristics, aerodynamic properties, and thermal properties,
- b) orbital characteristics which define the initial point of re-entry analysis,
- c) detailed characteristics of the space vehicle including its components (e.g., propellant tanks, pressurized vessels, major structural elements) and their architecture, mass, materials, dimensions,