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Space systems — Disposal of satellites operating in or crossing Low Earth Orbit

Systèmes spatiaux — Disposition des satellites opérant dans ou à cheval de l'orbite terrestre basse

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Foreword

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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, *Space systems*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard prescribes requirements for planning, executing manoeuvres, and operations for the post-mission disposal of a spacecraft operating in or crossing Low Earth Orbit. Included are requirements relating to the initiation and successful execution of these disposal actions.

Space systems — Disposal of satellites operating in or crossing Low Earth Orbit

1 Scope

This International Standard focuses on the post-mission disposal of spacecraft operating in, or crossing, Low Earth Orbit (LEO). The disposal of orbital launch stages operating in, or crossing, LEO is not dealt with in this International Standard.

Post-mission disposal of an Earth-orbiting spacecraft broadly means removing the spacecraft from its operational orbit after the end of mission, manoeuvring it to a region of space where it is less likely to interfere or collide with other operational spacecraft or with orbital debris and passivating.

For a spacecraft operating in, or crossing LEO, there are six disposal options that might be used to ensure its compliance with orbital debris mitigation requirements (as stated in ISO 24113). In order of preference, these are the following:

a) retrieving it and performing a controlled re-entry to recover it safely on the Earth;

b) manoeuvring it in a controlled manner into a targeted re-entry with a well-defined impact footprint on the surface of the Earth to limit the possibility of human casualty;

c) manoeuvring it in a controlled manner to an orbit that has a decay lifetime short enough to meet all orbital debris mitigation requirements;

d) augmenting its orbital decay by deploying a device so that the remaining orbital lifetime is short enough to meet all orbital debris mitigation requirements;

e) allowing its orbit to decay naturally, given that all orbital debris mitigation requirements will be met without the need for a disposal manoeuvre or other action;

f) manoeuvring it in a controlled manner to an orbit with a perigee altitude sufficiently above the LEO protected region (i.e. a graveyard orbit) that long-term perturbation forces do not cause it to re-enter the LEO protected region within 100 years.

This International Standard specifies requirements for the following:

a) planning for disposal and passivation of spacecraft operating in LEO to ensure that final disposal is sufficiently characterized and that adequate propellant will be reserved for any propulsive manoeuvre required,

b) selecting a disposal orbit where the spacecraft will re-enter the Earth's atmosphere within the next 25-years, or where the spacecraft will not re-enter the protected region within the next 100-years, and

c) estimating, prior to launch, a 90 % or better probability of successfully executing the disposal manoeuvre.

Techniques for planning and executing space hardware disposal are provided that reflect current internationally accepted guidelines and consider current operational procedures and best practices.

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 23339, *Space systems — Unmanned spacecraft — Estimating the mass of remaining usable propellant*

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

ISO 27852, *Space systems — Orbit lifetime estimation*

ISO 27875, *Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages*

3 Terms and definitions

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

3.1
ballistic coefficient
product of the coefficient of drag and the average velocity-normal cross-sectional area divided by the mass (C_dA/m)

3.2
decay phase
period that begins at the end of life of a spacecraft, when it has been placed into its disposal orbit, and ends when the spacecraft has performed a re-entry

Note 1 to entry: Only applies for spacecraft performing re-entry.

3.3
disposal manoeuvre
action of moving a spacecraft to its disposal orbit

3.4
disposal orbit
orbit in which a spacecraft resides following the completion of its disposal manoeuvre

3.5
graveyard orbit
disposal orbit which locates a spacecraft outside of the protected region

3.6
passivation
act of permanently depleting or making safe all remaining on-board sources of stored energy in a controlled sequence

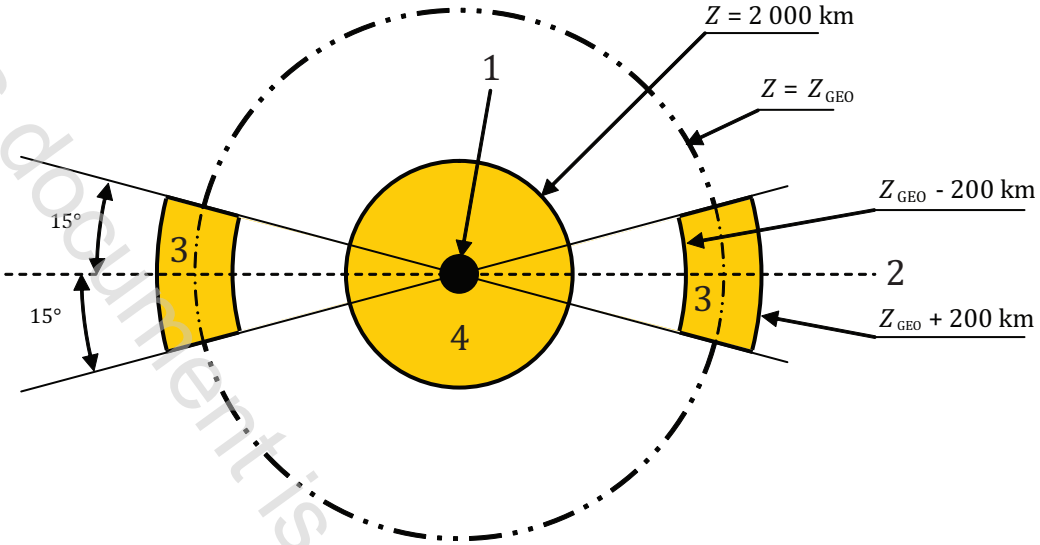
4 Symbols and abbreviated terms

Z	altitude above the surface of a spherical Earth
dV	delta velocity
EOMDP	end of mission disposal plan
GEO	geostationary orbit
LEO	Low Earth Orbit
SDMP	space debris mitigation plan

5 LEO protected region

The LEO protected region, defined by ISO 24113 and indicated in Figure 1, is the volume within a shell that extends from the surface of a spherical Earth (with a radius of 6 378 km) up to an altitude (Z) of 2 000 km.

Orbits in the LEO protected region tend to have a wide range of starting inclinations. In addition, due to the proximity of the Earth, orbits tend to be strongly perturbed, which cause their parameters to quickly change from the initial conditions. The combination of these two effects means that, while some orbits are more popular than others, any orbit within this volume can be populated.



Key

1 Earth
2 equator
3 LEO region
4 GEO region
Z altitude measured with respect to a spherical Earth whose radius is 6 378 km
Z_{GEO} altitude of the geostationary orbit with respect to a spherical Earth whose radius is 6 378 km

NOTE The dimensions in the figure are not to scale.

Figure 1 — View in the equatorial plane of Earth and the LEO and GEO protected regions (not to scale)

6 Primary requirements

6.1 General

If it is possible within the constraints of the design of a spacecraft, the following sub-clauses define the primary requirements to be placed on the operator of the spacecraft.

6.2 Ensuring execution of disposal actions

6.2.1 To ensure that a disposal plan is sufficiently characterized and that adequate propellant is reserved for any propulsive manoeuvre required, an end of mission disposal plan (EOMDP) shall be developed, maintained, and updated in all phases of a spacecraft mission.

6.2.2 The EOMDP shall form part of the Space Debris Mitigation Plan (SDMP) for the mission.