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Space systems — Estimation of orbit lifetime

~~*Élément introductif — Élément central — Élément complémentaire*~~

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~~This~~Systèmes spatiaux — Estimation de la durée de vie en orbite

FDIS stage

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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~~document 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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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 ~~first (ISO 27852:2009) and~~ second (ISO 27852:2016) ~~editions~~edition, which has been technically revised.

The main changes are as follows:

— ~~—~~ ~~Clarified~~clarified that this ~~standard~~document does not apply to non-LEO protected regions (e.g. GEO~~).~~);

~~— — — Updated to meet ISO's new extensive editing directives.~~

— ~~—~~ ~~Harmonized~~harmonized terms and definitions with those in ISO 24113 ~~parent document.~~;

— ~~—~~ ~~Updated~~updated to harmonize with IADC [1] ~~[i]~~ and United Nations [2] – [3] ~~[ii] – [iii]~~ guidelines~~.~~;

~~— — Added a section on .~~

— added a subclause on the use of the recommended solar forcing dataset for the Coupled Model Intercomparison Project 6.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Constraining estimated orbit lifetime of human-made objects is increasingly important as space debris continues to increase (as documented in Annex A~~Annex A)~~) and as such is one of the central tenets of the global space debris mitigation strategy. This document is a supporting document to ISO 24113~~[iv]~~ ~~and~~, its derivative spacecraft disposal standard ISO~~-23112~~~~[v]~~ 23312 and launch vehicle upper stage disposal technical report ISO~~-~~/TR 20590~~-[vi]~~. The purpose of this document is to provide a common, consensus-based approach to determining orbit lifetime, one that is sufficiently precise and easily implemented for the purpose of demonstrating conformity with ISO 24113. This ~~project~~document offers standardized guidance and analysis methods to estimate orbital lifetime for all LEO-crossing orbit classes. ~~Note that this~~This document only deals with orbit lifetime issues (orbit decay out of orbits crossing the LEO protected region); for other important requirements related to how long a space object will, or will not, cross or occupy a protected region, the user is directed to ISO 24113 and its derivative ISO 23312.

Space systems — Estimation of orbit lifetime

1 Scope

This document describes a process for the long-duration orbit lifetime prediction of orbit lifetime for spacecraft, launch vehicles, upper stages and associated debris in LEO-crossing orbits after mission phase (including any mission lifetime extensions).

The document also clarifies:

a) a) modelling approaches and resources for solar and geomagnetic activity modelling;

b) b) resources for atmosphere model selection;

c) c) approaches for spacecraft ballistic coefficient estimation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of 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 24113, *Space systems — Space debris mitigation requirements*

ISO 23312, *Space systems — Detailed space debris mitigation requirements for spacecraft.*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions contained in section 3.1 apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
disposal
actions performed by a *spacecraft* (3.1.22(3.1.22)) or *launch vehicle orbital stage* (3.1.9(3.1.9)) to permanently reduce its chance of accidental break-up and to achieve its required long-term clearance of the *protected regions* (3.1.17[as defined in ISO 24113].)

Note 1 to entry: Actions can include removing stored energy and performing post-mission orbital manoeuvres.

3.1.2
disposal phase
interval between the *end of mission* (3.1.5(3.1.5)) of a *spacecraft* (3.1.22(3.1.22)) or *launch vehicle orbital stage* (3.1.9(3.1.9)) and its *end of life* (3.1.4.)

3.1.3
Earth orbit
bound or unbound Keplerian *orbit* (3.1.14) with Earth at a focal point, or Lagrange point orbit which includes Earth as one of the two main bodies.

3.1.4
end of life
instant when a *spacecraft* (3.1.22(3.1.22)) or *launch vehicle orbital stage* (3.1.9(3.1.9):):

a) a) is permanently turned off, nominally as it completes its *disposal phase* (3.1.2(3.1.2),),

b) b) completes its manoeuvres to perform a *controlled re-entry* (3.1.18(3.1.18)) into the Earth's atmosphere, or

c) c) can no longer be controlled by the operator.

3.1.5
end of mission
instant when a *spacecraft* (3.1.22(3.1.22)) or *launch vehicle orbital stage* (3.1.9():3.1.9):

a) a) completes the tasks or functions for which it has been designed, other than its *disposal* (3.1.1(3.1.1),),

b) b) becomes incapable of accomplishing its *mission* (3.1.12(3.1.12),), or

c) c) has its *mission* (3.1.12(3.1.12)) permanently halted through a voluntary decision.

3.1.6
GEO
Earth orbit (3.1.3(3.1.3)) having zero inclination, zero eccentricity, and an orbital period equal to the Earth's sidereal rotation period.

3.1.7
high area-to-mass
having a ratio of area to mass exceeding 0,1 m^2/kg.

3.1.8
launch vehicle
DEPRECATED: launcher
system designed to transport one or more payloads into outer space.

3.1.9
launch vehicle orbital stage
complete element of a *launch vehicle* (3.1.8(3.1.8)) that is designed to deliver a defined thrust during a dedicated phase of the launch vehicle's operation and achieve *orbit* (3.1.14.)

Note 1 to entry: Non-propulsive elements of a launch vehicle, such as jettisonable tanks, multiple payload structures or dispensers, are considered to be part of a launch vehicle orbital stage while they are attached.

3.1.10
LEO-crossing orbit
orbit (3.1.14Orbit) having perigee within the LEO protected zone, defined as an *orbit* (3.1.14)i.e. with perigee altitude of 2 000 km or less.

Note 1 to entry: As shown in Figure A.3, orbits having this definition encompass the majority of the high spatial density spike of *spacecraft* (3.1.22(3.1.22)) and *space debris* (3.1.20(3.1.20).).

3.1.11
long-duration orbit lifetime prediction
orbit lifetime (3.1.15(3.1.1)) prediction spanning two *solar cycles* (3.1.19(3.1.19)) or more (e.g., 25-year orbit lifetime).)

3.1.12
mission
set of tasks or functions to be accomplished by a *spacecraft* (3.1.22(3.1.22)) or *launch vehicle orbital stage* (3.1.19(3.1.19),), other than its *disposal* (3.1.1(3.1.1))

3.1.13
mission phase
phase where the space system fulfils its *mission* (3.1.12,), beginning at the end of the launch phase and ending when the space system no longer performs its intended mission or purpose.

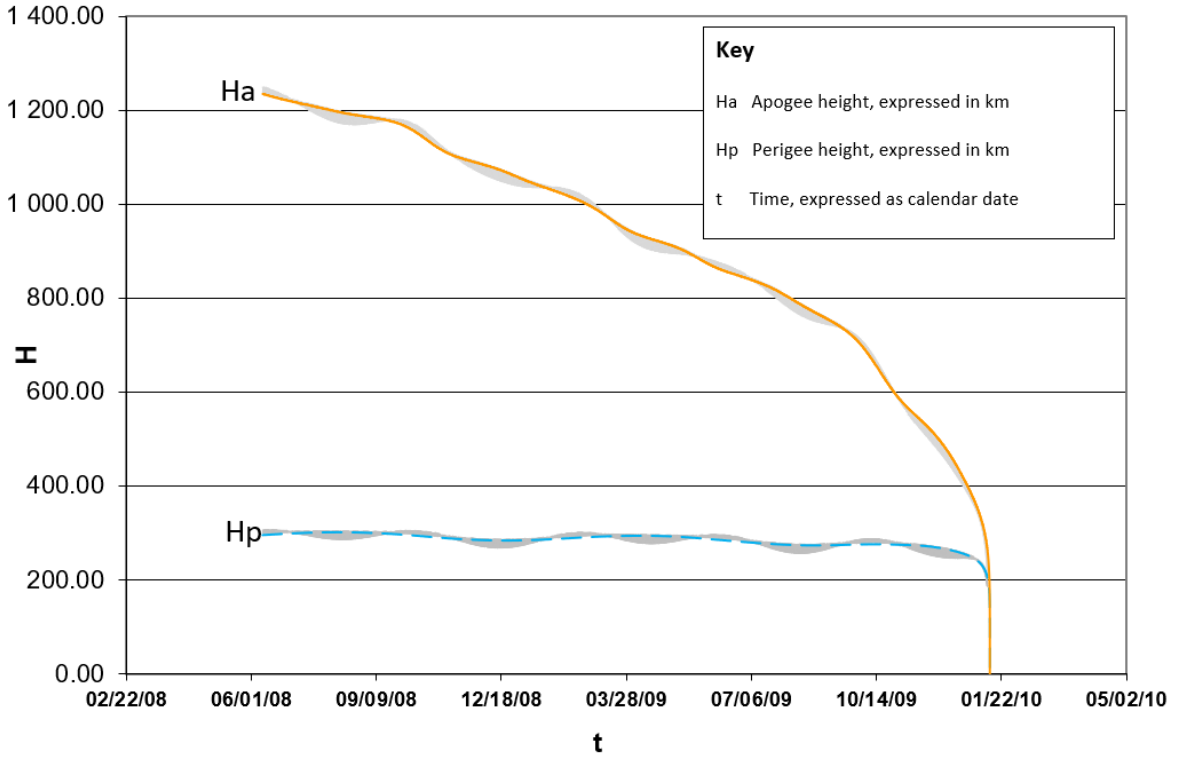
3.1.14
orbit
A regular recurring path that a *space object* (3.1.21(3.1.21)) takes about its primary attracting body.

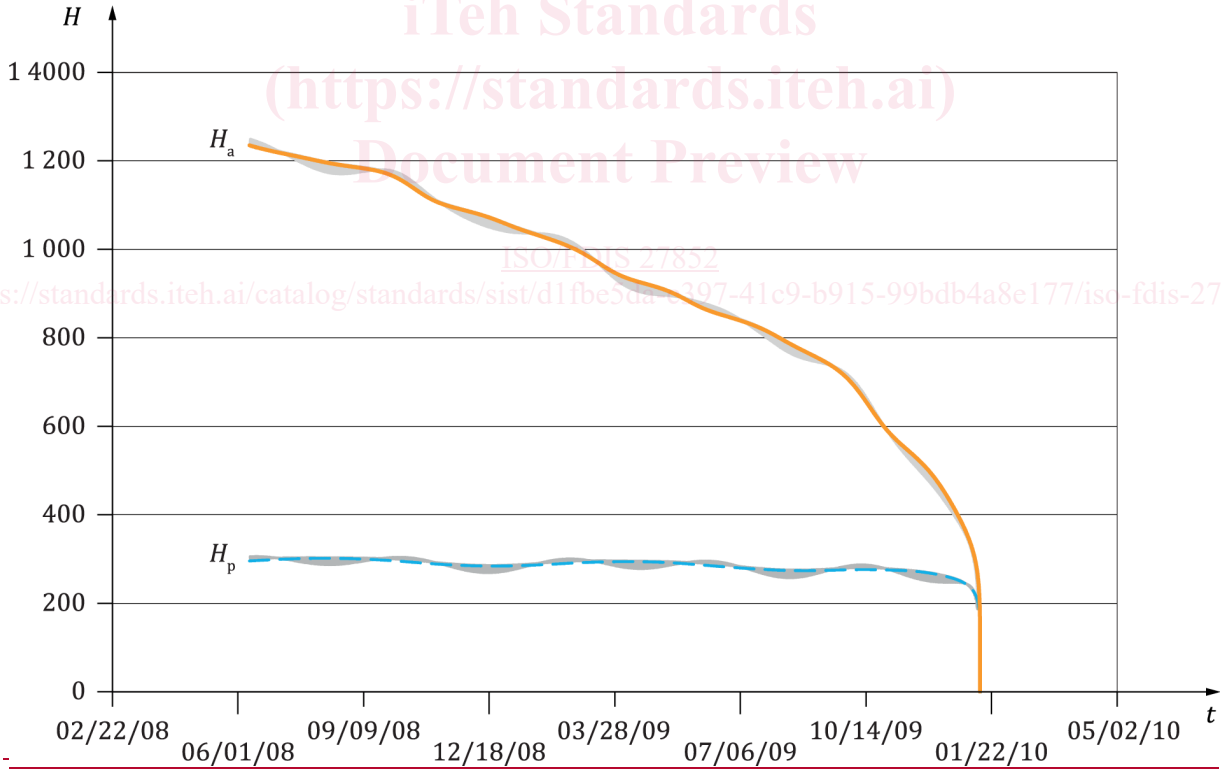
3.1.15
orbit lifetime
elapsed time between the orbiting *spacecraft's* (3.1.22(3.1.22)) initial or reference position and its *re-entry* (3.1.18.)

Note 1 to entry: Examples of "initial position" are the injection into *orbit* (3.1.14) of a spacecraft (3.1.22) or *launch vehicle orbital stage* (3.1.9(3.1.9),), or the instant when *space debris* (3.1.20(3.1.20)) is generated. An example of a "reference position" is the orbit of a spacecraft or launch vehicle orbital stage at the *end of mission* (3.1.5(3.1.5).).

Note 2 to entry: The orbit's decay is typically represented by the reduction in perigee and apogee altitudes (or radii) as shown in Figure 1.

Note 3 to entry: Ballistic flight re-entry typically begins at 25 km to 50 km altitude.





Key

t time, expressed as calendar date

H_a apogee height, expressed in km

H_p perigee height, expressed in km

Figure 1 — Sample of orbit lifetime perigee and apogee decay profile

3.1.16
post-mission orbit lifetime
duration of the *orbit* (3.1.14(3.1.14)) after completion of the *mission phase* (3.1.13(3.1.13).)

Note 1 to entry: The *disposal phase* (3.1.2(3.1.2)) duration is a component of the post-mission duration.

3.1.17
protected region
region in outer space that is protected with regard to the generation of *space debris* (3.1.20(3.1.20)) to ensure its safe and sustainable use in the future.

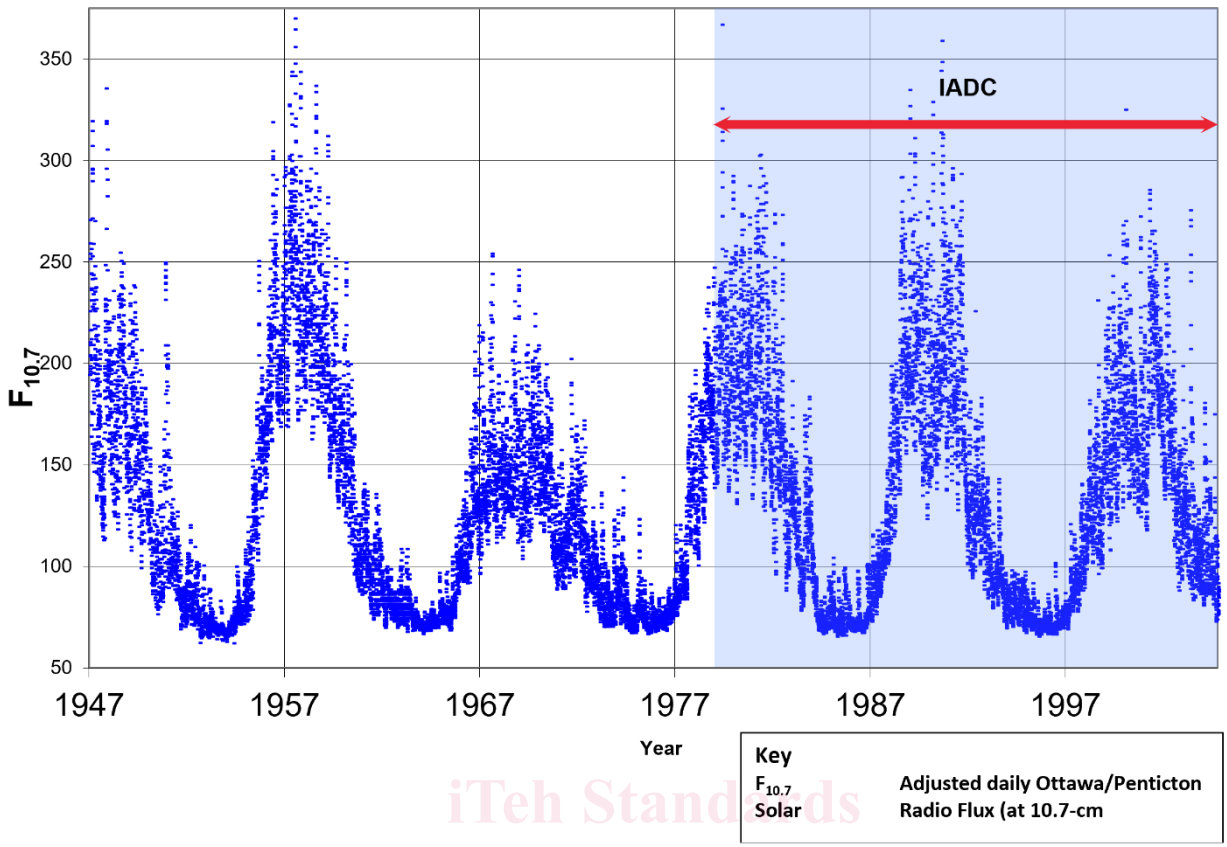
3.1.18
re-entry
permanent return of a *space object* (3.1.21(3.24)) into the Earth's atmosphere.

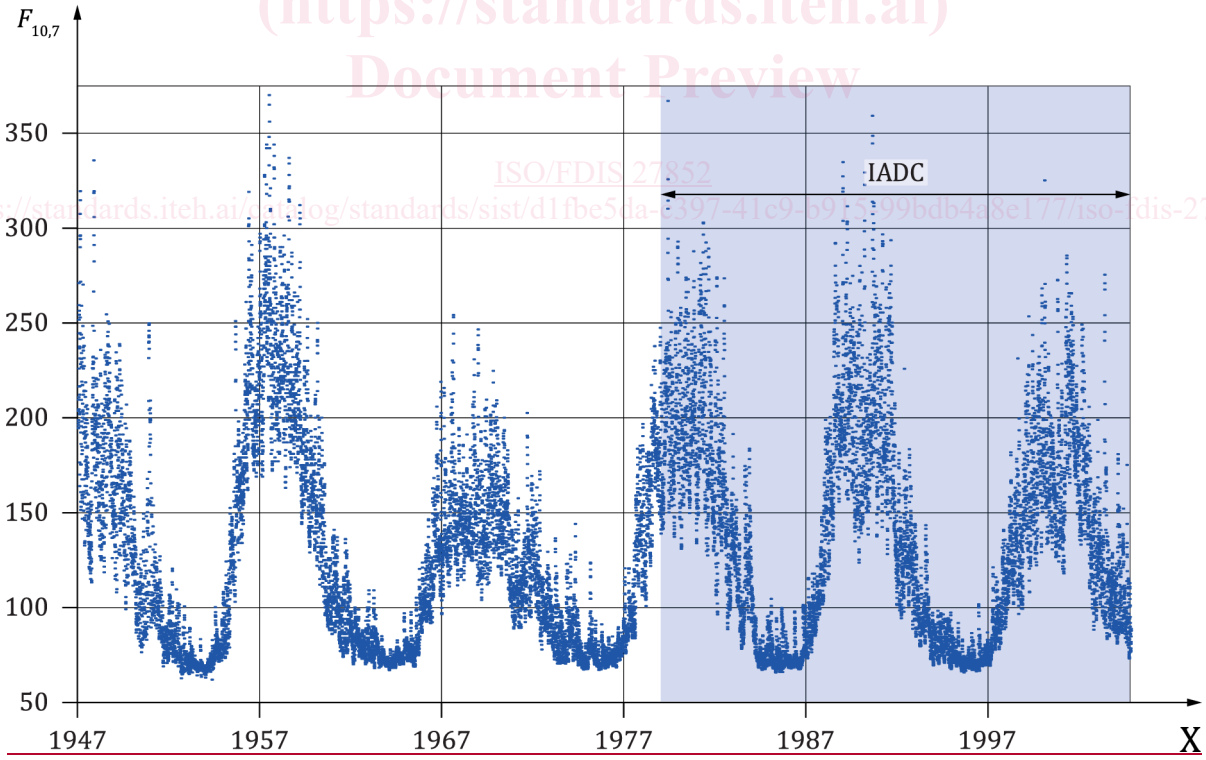
Note 1 to entry: Several alternative definitions are available for the delineation of a boundary between the Earth's atmosphere and outer space.

3.1.19
solar cycle
≈11-year time period which encompasses the 13-month oscillatory variation of solar radio flux, as observed by monthly sunspot number and highly correlated with the 13-month running mean of measurements taken at the 10,7 cm wavelength.

Note 1 to entry: Historical records back to the earliest recorded data (1945) are shown in Figure 2.

Note 2 to entry: For reference, the 25-year *post-mission orbit lifetime* (3.1.16(3.1.15)) constraint specified in ISO 24113 is overlaid onto the historical data; it can be seen that multiple solar cycles are encapsulated by this long-time duration.





Key