INTERNATIONAL STANDARD

ISO 14200

Second edition

Space environment (natural and artificial) — Process-based implementation of meteoroid and debris environment models (orbital altitudes below GEO + 2 000 km)

Environnement spatial (naturel et artificiel) — Lignes directrices pour une mise en œuvre fondée sur les processus des modèles environnementaux des météoroïdes et des débris (altitudes d'orbite inférieures à GEO + 2 000 km)

PROOF/ÉPREUVE

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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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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 second edition cancels and replaces the first edition (ISO 14200:2012), which has been technically revised.

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

— removal of impact risk assessment requirements;

— in Annexes A and B, information on space debris environment models has been updated (SDEEM 2015 and SDEEM 2019);

— debris flux models: The latest version of each model is briefly described. Descriptions of historical models have been moved to NOTEs or deleted;

— since this document now focuses on models that have been developed primarily for impact flux assessment, those models whose main purpose is to study the long-term evolution of the space debris environment have been deleted.

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

Every spacecraft in an Earth orbit is exposed to a certain flux of micrometeoroids and man-made space debris. Collisions with these particles take place with hypervelocity. Many meteoroid and space debris environment models have been studied and developed which describe populations of meteoroids and/or space debris. Those models can be used for estimation the impact flux required when selecting the spacecraft operation orbit, evaluation the impact flux in a specific orbit, prediction of the frequency of collision avoidance operations, and estimate of the impact flux required for protection design. However, there are different methods in existence for reproducing the observed environment by means of mathematical and physical models of release processes, for propagating orbits of release products, and for mapping onto spatial and temporal distributions of objects densities, transient velocities, and impact fluxes. Until a specific standard for the space debris environment is defined, a common implementation process of models should be indicated.

This document specifies a common implementation process for meteoroid and space debris environment models. In the first edition, requirements were also included relating to impact risk assessment. However, with the publication of ISO 16126 in 2014, such requirements were no longer necessary in this document, and so they have been removed. The second edition now focuses on models used for estimating the impact flux.

Space environment (natural and artificial) — Process-based implementation of meteoroid and debris environment models (orbital altitudes below GEO + 2 000 km)

1 Scope

This document specifies a common process for selecting and implementing meteoroid and space debris environment models used in the impact flux assessment for design and operation of spacecraft and other purposes. This document provides guidelines and requirements for the process.

2 Normative reference

There are no normative references in this document.

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:

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

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

3.1
impact flux
number of impacts per unit area per unit time

3.2
mass density
mass per unit volume

3.3
meteoroid
small celestial body of natural origin

Note 1 to entry: Generally, a meteoroid is a solid, rocky object of a size considerably smaller than an asteroid and considerably larger than an atom.

Note 2 to entry: It is thought that most meteoroids result from the disintegration and fragmentation of comets and asteroids orbiting the sun, whereas others are collision impact debris ejected from bodies such as the Moon or Mars.

3.4
meteoroid environment model
type of analysis model that computationally simulates the *meteoroid* (3.3) population orbiting the sun

Note 1 to entry: Typically, this type of model is used to predict the flux of meteoroids on a target object in space, such as a spacecraft.

3.5
space debris
DEPRECATED: orbital debris
objects of human origin in Earth orbit or re-entering the atmosphere, including fragments and elements thereof, that no longer serve a useful purpose

Note 1 to entry: Spacecraft in reserve or standby modes awaiting possible reactivation are considered to serve a useful purpose.

[SOURCE: ISO 24113:2019,[1] 3.23]

3.6
space debris environment model
type of analysis model that computationally simulates the *space debris* (3.5) population

Note 1 to entry: Typically, this type of model is used to predict the flux of space debris on a target object in space, such as a spacecraft.

3.7
spacecraft
system designed to perform a set of tasks or functions in outer space, excluding launch vehicle

[SOURCE: ISO 24113:2019 3.25]

3.8
traceability
ability to trace the history, application or location of an object

[SOURCE: ISO 9000:2015[2],3.6.13, modified — Notes 1 and 2 to entry have been removed.]

4 Abbreviated terms

AU	astronomical units
CME	chemistry of meteoroid experiment
ESA	European Space Agency
EuReCa	European retrievable carrier
GEO	geostationary earth orbit
GUI	graphical user interface
HAX	haystack auxiliary radar
HST-SA	Hubble space telescope solar array
HST (SM1)	Hubble space telescope (service mission 1)
HST (SM3B)	Hubble space telescope (service mission 3B)
IMEM	interplanetary meteoroid engineering model
ISS	international space station
LDEF	long duration exposure facility
LEO	low earth orbit
MASTER	meteoroid and space debris terrestrial environment reference

MEM	meteoroid engineering model
NASA	National Aeronautics and Space Administration
ORDEM	orbital debris engineering model
PROOF	program for radar and observation forecasting
SDEEM	space debris environment engineering model
SSN	space surveillance network
SSP	space station program
STS	space transportation system

5 Procedures for the selection and implementation of meteoroid and space debris environment models

5.1 General

Meteoroid and space debris environment models can be used to estimate the impact fluxes of meteoroids and space debris on a spacecraft. This flux information can be used in

a) the selection of the spacecraft operation orbit in mission analysis,

b) the evaluation of the safety of specific orbit(s),

c) the prediction of the frequency of collision avoidance operations, and

d) the design of suitable impact protection, especially for critical components.

There is a variety of environment models available, each with its own set of characteristics and capabilities. 5.2 and 5.3 specify procedures that are available to guide a user in the selection and implementation of a suitable model.

5.2 Selection procedure

5.2.1 The customer and the supplier of the spacecraft shall coordinate in selecting the meteoroid and space debris environment models that are applied to their project and agree to the conclusion.

5.2.2 To select a suitable environment model, the capabilities of available candidate models should be considered.

NOTE Annex A describes the capabilities of some meteoroid environment models and Annex B describes the capabilities of some space debris environment models.

5.2.3 Models other than those listed in Annexes A and B may be used.

5.2.4 When selecting an environment model, the following should be considered:

a) transparency of the characteristics of the model;

b) whether the model is used by a national space agency;

c) whether the model is maintained on a regular and frequent basis;

d) the format of the output flux data, including its suitability for transfer to another model, such as an impact risk analysis code;

e) the ease of use of the model.

5.2.5 When selecting an environment model, consideration should be given to the fact that there can be significant differences in the calculated fluxes among the available candidate models. The customer and/or the supplier should compare the fluxes of several models. See A.3 and B.3.

NOTE The choice of model to be applied depends on the mission objectives and requirements of the customer (and the supplier, if necessary). For example, to achieve adequate safety margin in the design of a spacecraft or its subsystems, it is reasonable to select the model with the highest flux values when analysing the risk caused by space debris and meteoroid impacts. This ensures that the worst-case scenario is evaluated. On the other hand, in the case of in situ debris sensor design, the worst-case scenario is achieved by using the model that generates the lowest impact flux values, since it results in the smallest observation opportunity. Finally, when selecting the operational orbit of a spacecraft by comparing the impact flux for each candidate orbit, the model can be chosen according to criteria other than the magnitude of its flux values. This is because the analysis involves relative fluxes.

5.3 Implementation procedure

5.3.1 Traceability of the implementation of the meteoroid and space debris environment models shall be assured, including during all design and operation phases, if applied to a spacecraft.

5.3.2 When applying a model to calculate meteoroid or space debris impact fluxes, a record of the following shall be kept:

a) the justification of the selected model;

b) all input and output parameters and their values for each analysis case;

c) any assumptions made regarding the input parameters and the technical justification for the assumptions;

d) any corrections and/or additional assumptions made to output parameters, their technical justification, and details of correction methods and their effects on the results.

NOTE Output parameters can be corrected by applying a safety factor, life factor or margin of safety. Such corrections can also be applied to the debris population, especially if there has been a sudden large increase in the population due to a debris generation event that has not yet been modelled.

e) The results of the impact flux assessment and the methodology used.

5.3.3 The records shall be evaluated and confirmed by reviewers during the appropriate review stages of a project.

6 International project

For an international project, the following items should be agreed amongst member bodies before starting the project:

a) the applicable meteoroid and space debris environment models for the project;

b) the method of maintenance of the meteoroid and space debris environment models.

Annex A
(informative)

Capability of some meteoroid environment models

A.1 Model overview

A.1.1 Gruen et al. model

The Gruen model[3] assumes an isotropic meteoroid distribution that is based on lunar crater, zodiacal light and in situ measurement data.

A.1.2 Divine model

The Divine model[4] assumes a non-isotropic distribution that is based on five populations in particle mass, inclination, eccentricity and perihelion distance.

A.1.3 Divine-Staubach model

The Divine-Staubach model[5] is a follow-up of the Divine model, using new data from GALILEO and ULYSSES dust detectors.

A.1.4 NASA SSP-30425 model

The SSP-30425 (Space Station Program Natural Environment Definition for Design) model[6] describes a space environment for ISS design.

A.1.5 IMEM model

Dikarev used an improved and controlled data set and applied refined mathematical methods in order to describe three-dimensional distributions of orbital elements (instead of the mathematically separable distributions of Divine)[7].

A.1.6 MEM model

Near 1 AU fluxes are calibrated from the Gruen model. A constant mass density of 1,0 g/cm^3 is assumed and the velocity distributions are independent from the particle sizes[8][9].

A.2 Model specifications

Table A.1 shows specifications of meteoroid models listed in A.1.

Table A.1 — Meteoroid model specifications

Model specifications	Model					
	Gruen et al.[3]	Divine[4]	Divine-Staubach[5]	SSP 30425[6]	IMEM[7]	MEM[8][9]
Sporadic or stream	Sporadic	Sporadic	Sporadic	Sporadic	Sporadic	Sporadic

[a] Force of the Earth's gravitational field that attracts meteoroids, changes their trajectories, and therefore increases the flux