PD ISO/TR 18146:2015

BSI Standards Publication

Space systems — Space debris mitigation design and operation guidelines for spacecraft

urrently in preview, click buy full vers

bsi.

...making excellence a habit.™

National foreword

This Published Document is the UK implementation of ISO/TR 18146:2015.

The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2015. Published by BSI Standards Limited 2015

ISBN 978 0 580 88121 3

ICS 49.140

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 October 2015.

Amendments issued since publication

Date	Text affected

urrently in preview, click buy full versi

TECHNICAL REPORT

ISO/TR 18146

First edition
2015-10-01

Space systems — Space debris mitigation design and operation guidelines for spacecraft

Systèmes spatiaux — Conception de mitigation des débris spatiaux et lignes directrices de manoeuvre de la navette

urrently in preview, click buy full versi

Reference number
ISO/TR 18146:2015(E)

© ISO 2015

Currently in preview, click buy full version

COPYRIGHT PROTECTED DOCUMENT

© ISO 2015 – Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword ..... **vi**

Introduction ..... **vii**

1 Scope **1**

2 Related documents and abbreviated terms and symbols **3**
- 2.1 Overview of ISO debris-related standards 3
- 2.2 ISO debris-related standards as of February 2015 3
- 2.3 Other relevant ISO standards 4
- 2.4 Other documents 4
- 2.5 Abbreviated terms and symbols 5

3 Requirements in ISO standards and system-level methodologies for complying with them **6**
- 3.1 General 6
- 3.2 Design for limiting the release of objects 7
  - 3.2.1 Requirements 7
  - 3.2.2 Work breakdown 8
  - 3.2.3 Identification of released objects and design measures 8
  - 3.2.4 Design measures 9
  - 3.2.5 Monitoring during operation 9
  - 3.2.6 Preventing failure 9
- 3.3 Break-up prevention 10
  - 3.3.1 Requirements 10
  - 3.3.2 Work breakdown 10
  - 3.3.3 Identification of the sources of break-up 10
  - 3.3.4 Design measures 11
  - 3.3.5 Monitoring during operations 11
  - 3.3.6 Disposal operations 11
- 3.4 Disposal at the end of operation 11
  - 3.4.1 Requirements 11
  - 3.4.2 Work breakdown 12
  - 3.4.3 Estimation of the orbital lifetime and definition of a disposal plan 13
  - 3.4.4 Function to remove spacecraft to disposal orbit. 14
  - 3.4.5 Reliability of accomplishing disposal manoeuvre 14
  - 3.4.6 Function to monitor critical parameters 15
  - 3.4.7 Decision-making to terminate operations and for execution of disposal operations 15
  - 3.4.8 Disposal sequence 15
  - 3.4.9 Registration according to the UN treaty 15
  - 3.4.10 Specific subjects for GEO mission 15
- 3.5 Ground safety from re-entering objects 15
  - 3.5.1 Requirements 15
  - 3.5.2 Work breakdown 15
  - 3.5.3 Identification of requirements 16
  - 3.5.4 Hazards analysis 16
  - 3.5.5 Design measures 17
  - 3.5.6 Specific design for controlled re-entry in subsystem level 18
  - 3.5.7 Notification 18
  - 3.5.8 Conduct controlled re-entry and monitoring 18
- 3.6 Collision avoidance 18
  - 3.6.1 Background 18
  - 3.6.2 Recommendation 19
  - 3.6.3 Work breakdown 19
  - 3.6.4 Estimation of collision probability 20
  - 3.6.5 Design measures 20
  - 3.6.6 Procedures for collision avoidance 21

Currently in preview, click buy full version

3.6.7 Detection of risk ... 21
3.6.8 Avoidance and return manoeuvres ... 21
3.7 Protection against the impact of micro-debris ... 22
3.7.1 Background ... 22
3.7.2 Recommendation ... 23
3.7.3 Work breakdown ... 23
3.7.4 Preventive measures ... 23
3.8 Quality and reliability assurance ... 24

4 Debris-related work in the development cycle ... 25
4.1 Concept of debris-related work in phased planning ... 25
4.2 Mission analysis phase (phase 0 or pre-phase A) ... 28
4.2.1 General ... 28
4.2.2 Debris-related work ... 28
4.3 Feasibility phase (phase A) ... 29
4.4 Definition phase (phase B) ... 29
4.4.1 Work in phase B ... 29
4.4.2 Work procedure ... 29
4.5 Development phase (phase C) ... 30
4.5.1 Work in phase C ... 30
4.5.2 Conditions ... 31
4.6 Production phase (phase D) ... 31
4.6.1 Work in phase D ... 31
4.6.2 Qualification review ... 32
4.7 Utilization phase (phase E) ... 32
4.7.1 Launch preparation ... 32
4.7.2 Lift-off time ... 33
4.7.3 Initial operation ... 33
4.7.4 Normal operation ... 33
4.7.5 Decision to terminate operations ... 33
4.7.6 Process for extending mission operations ... 34
4.8 Disposal phase (phase F) ... 34

5 System-level considerations ... 35
5.1 Mission design ... 35
5.2 Mass allocation ... 35
5.3 Propellant allocation ... 36
5.4 Power allocation ... 36

6 Subsystem/component design and operation ... 36
6.1 General ... 36
6.2 Debris-mitigation measures and subsystem-level actions for realizing them ... 37
6.3 Propulsion subsystem ... 37
6.3.1 Debris-related design ... 37
6.3.2 Considerations for propulsion subsystems ... 37
6.3.3 Consideration in component design ... 41
6.4 Attitude and orbit control subsystem ... 43
6.4.1 Debris-related designs ... 43
6.4.2 Considerations for AOCS ... 43
6.4.3 Considerations in component design ... 44
6.5 Power-supply subsystem ... 44
6.5.1 Debris-related designs ... 44
6.5.2 Considerations for power-supply subsystems ... 45
6.5.3 Considerations in component design ... 46
6.6 TT&C subsystem ... 47
6.6.1 Debris-related designs ... 47
6.6.2 Considerations for TT&C subsystems ... 47
6.6.3 Considerations in component design ... 48
6.7 Structural subsystem ... 48
6.7.1 Debris-related design ... 48

urrently in preview, click buy full versi

 © ISO 2015 – All rights reserved

6.7.2 Considerations for structural subsystems 49
6.8 Thermal-control subsystem 49
6.8.1 Debris-related design 49
6.8.2 Considerations for thermal-control subsystem 50

urrently in preview, click buy full versi

© ISO 2015 – All rights reserved

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. www.iso.org/directives

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. www.iso.org/patents

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

currently in preview, click buy full version

© ISO 2015 – All rights reserved

Introduction

Coping with debris is essential to preventing the deterioration of the orbital environment and ensuring the sustainability of space activities. Effective actions must also be taken to ensure the safety of those on the ground from re-entering objects that were disposed of from low-Earth orbit.

Recently, the orbital environment has become so deteriorated by debris that action must be taken to prevent damage due to the impact. Collision avoidance manoeuvres should be taken to avoid large debris (larger than 10 cm, for example), which can be observed from the ground. Spacecraft design should protect against micro-debris (even smaller than 1 mm) that can cause critical damage to vulnerable components.

The following ISO standards and technical reports cover these issues: ISO 24113, *Space systems — Space debris mitigation requirements*; ISO/TR 16158, *Space systems — Avoiding collisions with orbiting objects*; ISO 16126, *Space systems — Assessment of the survivability of unmanned spacecraft against space debris and meteoroid impacts to ensure successful post-mission disposal*. Other ISO documents, introduced in Clause 2, are currently being developed to encourage debris mitigation and protection from debris impact. Table 1 shows those requirements together with the recommendations in the United Nations Space Debris Mitigation Guidelines and the Inter-Agency Space Debris Coordination Committee (IADC) space debris guidelines referred to in the UN guidelines.

Reliability and quality shortfalls have resulted in fragmentation events that generated thousands of fragments. ISO 24113 and other debris-mitigation guidelines make the assumption that space hardware quality and reliability issues have been addressed by other management programs. But for low-cost or low-criticality missions, spacecraft of reduced quality have been developed. The failure of such spacecraft may not pose critical damage to their owners but they may adversely affect the environment and impair the sustainability of space activities. This Technical Report suggests activities that can improve reliability and quality sufficiently to avoid this problem. This aspect of space-debris mitigation is particularly important for micro-satellites developed by universities and newcomers to space activities.

urrently in preview, click buy full versi

© ISO 2015 – All rights reserved

urrently in preview, click buy full versi

Space systems — Space debris mitigation design and operation guidelines for spacecraft

1 Scope

This Technical Report contains non-normative information on spacecraft design and operational practices for mitigating space debris.

This Technical Report is a supporting document to the family of international standards addressing space debris mitigation (see 2.2). The purpose of these standards is to minimize the creation of additional space debris by ensuring that spacecraft and launch vehicle orbital stages are designed, operated and disposed of in a manner that prevents them from generating debris throughout their orbital lifetime.

This Technical Report can be used to guide spacecraft engineers in the application of these space debris mitigation standards. Table 1 lists the main debris mitigation requirements defined in the standards and compares them to equivalent recommendations published by the United Nations and the Inter-Agency Space Debris Coordination Committee.

In Clause 3, the main space debris mitigation requirements are reported and discussed. Clause 4 provides guidance for life-cycle implementation of space debris mitigation related activities.

In Clause 5, the system level aspects stemming from the space debris mitigation requirements are highlighted, while in Clause 6, the impacts at subsystem and component levels are detailed.

Where it is not directly required by existing ISO standards but considered relevant to spacecraft operations, design and debris mitigation, content in this Technical Report is labelled as such with “[information]”.

© ISO 2015 – All rights reserved