INTERNATIONAL STANDARD

ISO 22010

First edition
2007-12-15

Space systems — Mass properties control

Systèmes spatiaux — Contrôle des propriétés de masse

Reference number
ISO 22010:2007(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 22010 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard establishes the minimum requirements for providing adequate control of the mass properties of space systems to meet mission requirements. In addition, many recommended practices that add value to the mass properties monitoring tasks are presented. Throughout this International Standard, the minimum essential criteria are identified by the use of the key word “shall.” Recommended criteria are identified by the use of the key word “should,” and while not mandatory, are considered to be of primary importance in providing timely and accurate mass properties support for contracts. It is advisable that deviations from the recommended criteria only occur after careful consideration and thorough evaluation have shown alternative methods to be satisfactory.

The requirements can be tailored for each specific space programme application.

Space systems — Mass properties control

1 Scope

This International Standard describes a process for managing, controlling and monitoring the mass properties of space systems. The relationship between this management plan and the performance parameters for mass properties to be met throughout the mission is described. Ground handling, dynamics analysis and test set-ups that rely on accurate mass properties inputs are identified. This International Standard covers all programme phases from pre-proposal through to end of life.

2 Normative references

The following referenced documents are indispensable for the application 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 22108, *Space systems — Non-flight items in flight hardware — Identification and control*

3 Terms and definitions

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

3.1
basic mass properties
best engineering estimate based on an assessment of the most recent baseline design, excluding mass growth allowance

3.2
calculated properties
mass properties determined from released drawings or controlled computer models

3.3
contractor limit
predicted mass plus a contractor margin to allow for uncertainties during the design cycle

3.4
contractor margin/system margin
difference between the contractor limit and the predicted mass

3.5
customer reserve
allowance defined by the customer according to the agreements of the contract

3.6
estimated properties
mass properties determined from preliminary data, such as sketches or calculations from layout drawings

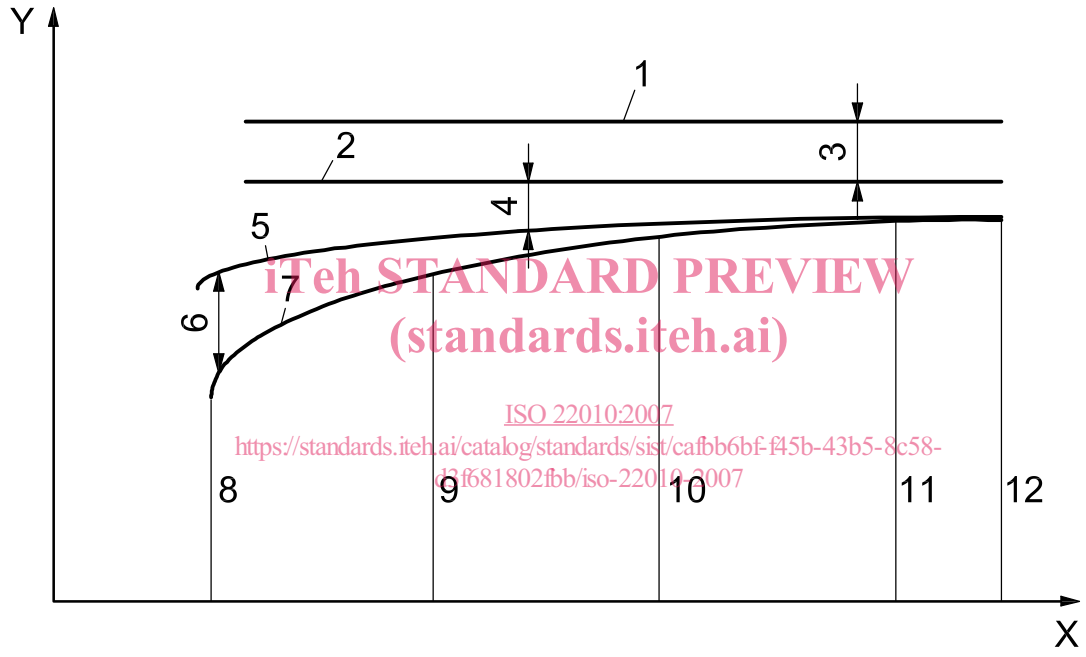
3.7
mass control parameters
factors used as an indicator of the basic mass, predicted mass and margins/limits for a space system

See Figure 1.

3.8
mass growth allowance
predicted change to the basic mass of an item, based on an assessment of the design and fabrication status of the item and an estimate of the in-scope design changes that may still occur

NOTE 1 This mass growth allowance is not intended to be a tolerance.

NOTE 2 Figure 1 is an illustration of related terms commonly used in reporting mass properties during the development of space systems hardware.



Key

X time
Y mass
1 mission limit
2 contractor limit
3 customer reserve
4 contractor margin/system margin
5 predicted mass
6 growth allowance
7 basic mass
8 authorization to proceed
9 preliminary design review
10 critical design review
11 actual mass
12 system delivery

Figure 1 — Mass control parameters

3.9
mass properties
mass, centre of gravity, moments of inertia, and products of inertia

3.10
mass properties categories
criteria used to indicate the confidence in or maturity of the design

3.11
measured properties
mass properties determined by measurement or by comparison of nearly identical components, for which measured mass properties are available

3.12
mission limit
maximum mass that can satisfy all of the mission performance requirements

3.13
predicted mass
sum of the basic mass and the mass growth allowance, intended to estimate the final mass at system delivery

3.14
space systems
launch vehicles, satellites, space vehicles, or components thereof

4 Symbols and abbreviated terms

ACS	attitude control system, alternative definition below
AOCS	attitude and orbit control system
AIAA	American Institute of Aeronautics and Astronautics
ANSI	American National Standards Institute
ATP	authorization to proceed
CAD	computer aided design
CDR	critical design review
CFE	customer furnished equipment
GSE	ground support equipment
IPT	integrated product team
MPCB	mass properties control board
NTE	not to exceed
PDR	preliminary design review
SAWE	Society of Allied Weight Engineers
TPM	technical performance measurement

5 Mass properties control plan

5.1 General

A mass properties control plan shall be documented.

A mass properties control plan shall be based on the critical parameters that need to be controlled. In some cases, that may only be mass. In the extreme, a spin-stabilized space system may have a set of requirements that warrants control of all the mass properties, including final measurements of mass, centre of mass, and moments and products of inertia. The depth and detail of analysis, reporting and testing shall reflect the critical parameters.

5.2 Control process

5.2.1 Basis of the process

The mass properties control process shall be started in the pre-proposal or conceptual design phases, where an initial mass budget is established. A proposal team may be established so as to guide subsystem and component mass allocations and the launch vehicle selection process, if applicable. This team should be supported by other members who have experience in the allocation process.

NOTE Space system mass is a prime concern. Without early mass properties control, there is a significant risk of performance, schedule, and/or cost problems later in the programme.

The control process after authorization to proceed (ATP) may include one or more of the following elements:

a) understanding of the flow-down of requirements that affect mass properties analysis and test plans;

b) a mass reduction plan;

c) implementation of a Mass Properties Control Board (MPCB);

d) mass allocation and trend analysis;

e) mass properties monitoring;

f) subcontractor mass control.

Application of some of the more stringent elements listed above is contingent on available mass and stability margins, cost considerations and the planned verification (measurement versus analysis) schema. The various elements and their applicability are discussed in the following subclauses.

5.2.2 Requirements definition

There shall be a review of all requirements that affect mass properties including, but not limited to, the contractual, attitude control, mission and ground handling requirements. Different space systems designs have different mass properties requirements.

EXAMPLE A space system that is spin-stabilized throughout its mission requires a finer balance than one that is three axis stabilized.

5.2.3 Mass reduction plan

After establishing a credible mass summary during the proposal phase, a database shall be used with the tools necessary to develop a predicted mass for the space system at delivery. A contractor or system mass margin against the contractor limit shall be determined. If the mass margin is not sufficient, a rigorous mass reduction programme should be initiated. In this case, the programme office should fully support the effort.

NOTE Mass reduction is generally a costly undertaking, therefore it is advisable that programme offices allocate a sufficient budget to accomplish the goal. A historical database of previous weight reduction ideas is advisable.

5.2.4 Mass Properties Control Board (MPCB)

In conjunction with a mass reduction plan, an MPCB may be convened to audit the mass properties database, critically review designs for optimum mass, and perform cost/mass trades as well as review margins. The MPCB should have programme office and systems engineering representation. Some of the MPCB members should also have experience with this process. The MPCB should have the authority to direct design changes that reduce mass, within the considerations of cost, schedule and technical performance. MPCB members should attend all design reviews to ensure that mass optimisation is considered.

5.2.5 Mass allocation and trend analysis

One of the most effective ways of controlling mass is to set maximum, “not to exceed” (NTE), allocations at the subsystem or unit level. With reference to Figure 1, if the contractor margin at the beginning of the programme is small or negative, it may be necessary to challenge each subsystem so as to ensure that the contractor limit will not be exceeded. The same idealized chart can be used to represent each subsystem’s mass NTE allocation. These technical performance measurement (TPM) charts should be used to monitor the progress of each subsystem. If the predicted mass exceeds the NTE allocation, mass reduction is necessary; in some cases, a re-allocation among subsystems may solve the problem. This trend analysis is particularly critical prior to preliminary design review, when designs are still evolving and mass reduction efforts are less costly.

5.2.6 Mass properties monitoring

For programmes with adequate margins in all mass properties parameters, a simple mass history chart and a table showing the predicted mass properties versus the requirements will suffice. The chart and table should be included in periodic reports to the customer (see 5.3.6).

5.2.7 Subcontractor mass properties control

The prime contractor shall be involved in the development of NTE masses in the procurement specification that is issued to subcontractors. If additional controls, such as centre of mass or inertia, are required, those NTE values shall also be added to the specification and contract. The status of the critical values shall be reported by the subcontractor in periodic reports as specified by the contractor. If mass reduction is needed to bring the deliverable items within specification, the programme office may want to set up regular meetings with the subcontractor (including a mass review board) until the problem is mitigated, or until all avenues for meeting the specification have been exhausted. Incentives and penalties against specification values written into the contract may be of use.

5.3 Documentation

5.3.1 General

Mass properties documentation consists of plans and reports. Plans define the programme management methods for controlling, reporting and measuring mass properties. Reports provide visibility into the hardware configuration and design maturity through the development process.

5.3.2 Control plan

The overall control plan described in 5.1 and 5.2 shall be documented so as to provide an organized process that can be implemented early in the development phase and carried through to hardware delivery. The control plan should contain the applicable elements of the control process outlined in 5.2, as applicable, as well as a reporting plan and a verification plan.