SIST

SLOVENSKI STANDARD
SIST EN 16603-60-30:2015

01-november-2015

Vesoljska tehnika - Zahteve za satelitski AOCS (sistem obvladovanja orbitalne lege /satelita/)

Space engineering - Satellite AOCS requirements

Raumfahrttechnik - Anforderungen an Satelliten-AOCS

Ingénierie spatiale - Exigences pour le système de contrôle d'attitude et d'orbite d'un satellite

Ta slovenski standard je istoveten z: EN 16603-60-30:2015

ICS:

33.070.40	Satelit	Satellite
49.140	Vesoljski sistemi in operacije	Space systems and operations

SIST EN 16603-60-30:2015 en,fr,de

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16603-60-30

September 2015

ICS 49.140

English version

Space engineering - Satellite AOCS requirements

Ingénierie spatiale - Exigences pour le système de contrôle d'attitude et d'orbite d'un satellite

Raumfahrttechnik - Anforderungen an Satelliten-AOCS

This European Standard was approved by CEN on 16 November 2014.

CEN and CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN and CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN and CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN and CENELEC members are the national standards bodies and national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

CEN-CENELEC Management Centre:
Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 16603-60-30:2015 E

Table of contents

Tables

European foreword

This document (EN 16603-60-30:2015) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-60-30:2015) originates from ECSS-E-ST-60-30C.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2016, and conflicting national standards shall be withdrawn at the latest by March 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The Attitude and Orbit Control System (AOCS) requirements for the development of space programmes are typically part of the Project Requirements Document. The level of completeness and the level of detail vary very much from project to project.

This Standard provides a baseline for the AOCS requirements which are used in the specification and the validation process.

The Standard is intended to be used for each programme as an input for writing the Project Requirements Document. It includes all subjects related to AOCS:

- Functional and FDIR requirements
- Operational requirements
- Performance requirements
- Verification requirements
- Documentation requirements

1 Scope

This Standard specifies a baseline for the attitude and orbit control system requirements to be used in the Project Requirements Document for space applications.

Project requirements documents are included in business agreements, which are agreed between the parties and binding them, at any level of space programmes, as described in ECSS-S-ST-00.

This Standard deals with the attitude and orbit control systems developed as part of a satellite space project. The classical attitude and orbit control systems considered here include the following functions:

- Attitude estimation
- Attitude guidance
- Attitude control
- Orbit control

- Orbit estimation, called Navigation in this document, can be part of the function for missions which explicitly require this function
- Acquisition and maintenance of a safe attitude in emergency cases and return to nominal mission upon command

The present Standard does not cover missions that include the following functions:

- Real-time on-board trajectory guidance and control
- Real-time on-board relative position estimation and control

Example of such missions are rendezvous, formation flying, launch vehicles and interplanetary vehicles.

Although the present document does not cover the above mentioned types of mission, it can be used as a reference document for them.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revision of, any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system - Glossary of terms
EN 16603-10	ECSS-E-ST-10	Space engineering - System engineering general requirements
EN 16603-10-03	ECSS-E-ST-10-03	Space engineering - Testing
EN 16603-60-10	ECSS-E-ST-60-10	Space engineering - Control performances
EN 16603-70-11	ECSS-E-ST-70-11	Space engineering - Space segment operability

3 Terms definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this Standard, the terms and definitions from ECSS-ST-00-01, ECSS-E-ST-10 and ECSS-E-ST-60-10 apply.

In particular, the following terms are used in the present Standard, with the definition given in the ECSS-E-ST-60-10:

- Absolute knowledge error (AKE)
- Absolute performance error (APE)
- Relative knowledge error (RKE)
- Relative performance error (RPE)
- Robustness

3.2 Terms specific to the present Standard

The definitions given in this clause are specific to the present Standard and are applicable for the understanding of the requirements. Other names or definitions may be used however during the development of space programmes.

3.2.1 attitude and orbit control system (AOCS)

functional chain of a satellite which encompasses attitude and orbit sensors, attitude estimation and guidance, attitude and orbit control algorithms, attitude and orbit control actuators

NOTE 1 The AOCS can include an orbit estimation function usually called Navigation.

NOTE 2 The AOCS can include additional items such as AOCS dedicated computer and AOCS application software, depending on satellite architecture.

3.2.2 AOCS mode

state of the AOCS for which a dedicated set of equipment and algorithms is used to fulfil operational objectives and requirements

3.2.3 AOCS functional simulator

fully numerical simulator used to verify the AOCS design, algorithms, parameters and performances

NOTE The AOCS functional simulator can be a collection of unitary numerical simulators, provided that a full coverage of the verification is ensured.

3.2.4 avionics test bench

facility dedicated to the validation of the avionics and its constituents

NOTE 1 The avionics content and definition can vary from one programme to another. It includes as a minimum the platform on-board computer and platform software, the Data Handling functions, the AOCS sensors and actuators.

NOTE 2 This facility includes numerical models and/or real hardware representative of flight units. The avionics test bench is used to validate the AOCS behaviour in real-time conditions, including hardware-software interfaces.

3.2.5 AOCS end-to-end tests

tests defined to validate complete AOCS loops on the satellite, including all the real components such as hardware, software and wiring

NOTE End-to-end tests can be performed in open loop or closed loop.

3.2.6 flight dynamics (FD)

functionalities performed on ground in support of on-board AOCS/GNC

NOTE Examples include orbit manoeuvres computation, guidance, AOCS/GNC TC generation and ephemerides.

3.2.7 guidance navigation and control functions (GNC)

functions in charge of targeted orbit and attitude computation, attitude and orbit determination, attitude and orbit control

NOTE GNC versus AOCS: the term AOCS is commonly used when the orbit guidance is not performed on board, which is the case for standard LEO, MEO and GEO missions. GNC is commonly used for the on-board segment, when the satellite position is controlled in closed loop, for instance in case of rendezvous and formation flying. The GNC term can be also used for the whole function, distributed between on-board and ground systems.

3.2.8 sensitivity analysis

identification of the parameters which impact the AOCS performance, and assessment of their individual contribution to this performance

NOTE 1 Only the dominating contributors are of interest. These contributors can include:

- Noise, bias and misalignment, for the AOCS sensors and actuators
- Satellite mass properties
- Satellite configuration variation, e.g. solar array position, sensors and actuators configuration
- Measurements outages
- Environmental conditions
- External and internal disturbances

NOTE 2 The AOCS performance can be for instance:

- Pointing accuracy
- Duration of a manoeuvre
- Fuel consumption

NOTE 3 The objective is to have an order of magnitude of the contribution, and this can be achieved by analysis, simulation or test.

3.2.9 worst case analysis

deterministic analysis to identify a set of parameters, disturbances and initial conditions, which, when combined at some given values within their nominal operational range, define a worst case situation or scenario for the evaluation of AOCS performances

NOTE 1 The parameter variations and disturbances are as defined for the sensitivity analysis, and their selection can rely on a sensitivity analysis.

NOTE 2 The initial conditions can be for instance:

- Angular rates
- Initial angular momentum
- Sun, Earth or planetary positions
- Orbit parameters

NOTE 3 The worst case scenarios depend on the considered AOCS performance.

3.2.10 tranquilization phase

phase following an attitude manoeuvre, or possibly an orbit correction manoeuvre, during which the full attitude performance is not yet achieved

3.3 Abbreviated terms

The following abbreviated terms are defined and used within this document:

Abbreviation	Meaning
AOCS	attitude and orbit control system
AKE	absolute knowledge error
APE	absolute performance error
ATB	avionics test bench
CDR	critical design review
CoM	centre of mass
DDF	design definition file
DJF	design justification file
DRD	document requirements definition
ECEF	Earth centred Earth frame
EM	engineering model
FDIR	failure detection, isolation and recovery
FD	flight dynamics
FM	flight model
FMECA	failure mode, effects and criticality analysis
GEO	geostationary orbit
GNC	guidance navigation and control
GNSS	global navigation satellite system
H/W	hardware
I/F	interface
ICD	interface control document
LEO	low Earth orbit
LEOP	launch and early orbit phase
MCI	mass, CoM and inertia
MEO	medium Earth orbit
MRD	mission requirements document
P/L	payload
PDR	preliminary design review
PRD	project requirements document
QR	qualification review
RKE	relative knowledge error
RPE	relative performance error
S/C	spacecraft

Abbreviation	Meaning
S/W	software
SRD	system requirements document
SSUM	space segment user manual
TBD	to be defined
TBS	to be specified
TC	telecommand
TM	telemetry
UM	user manual
VCD	verification control document
VP	verification plan

3.4 Nomenclature

The following nomenclature applies throughout this document:

a. The word "shall" is used in this Standard to express requirements. All the requirements are expressed with the word "shall".

b. The word "should" is used in this Standard to express recommendations. All the recommendations are expressed with the word "should".

NOTE It is expected that, during tailoring, all the recommendations in this document are either converted into requirements or tailored out.

c. The words "may" and "need not" are used in this Standard to express positive and negative permissions, respectively. All the positive permissions are expressed with the word "may". All the negative permissions are expressed with the words "need not".

d. The word "can" is used in this Standard to express capabilities or possibilities, and therefore, if not accompanied by one of the previous words, it implies descriptive text.

NOTE In ECSS "may" and "can" have completely different meanings: "may" is normative (permission), and "can" is descriptive.

e. The present and past tenses are used in this Standard to express statements of fact, and therefore they imply descriptive text.

4 Principles

4.1 Purpose and applicability

The purpose of this Standard is to provide a baseline for the attitude and orbit control system requirements to be used in the Project Requirements Document for space programmes at all levels of the customer-supplier chain above AOCS.

It is intended to be applied by the highest level customer to the prime contractor, for instance through the MRD or SRD.

This Standard is not directly applicable to the AOCS contractor, whose contractual specification document is a PRD derived from this Standard.

Considering the large variety of space missions, the large variety of AOCS functions and AOCS performances, and the variety of industrial organizations, it is not possible to propose AOCS requirements directly adapted to each situation. Therefore this document specifies a requirement on each subject, to be tailored, as explained in clause 4.2.

This Standard contains a number of "TBS" requirements, especially in clause 5.3, because these requirements cannot be generically defined. Numerical values and the performance statistical interpretation depend on each specific project.

4.2 Tailoring

For each mission, it is necessary to adapt the specified requirements through a complete tailoring process, that is

- to decide if a requirement is necessary, taking into account the specific functionalities required for the mission. For instance, if a mission requires an on-board navigation function, then requirements dedicated to this function or to an on-board GNSS receiver are applicable. As another example, clause 5.3 contains a list of typical performance requirements, which can be useful for some missions but unnecessary for others.
- to decide whether the requirement might be better placed in a statement of work rather than in a specification.
- to adapt the numerical values of a requirement, considering the exact performances required for the mission.