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Space engineering - Ground systems and operations - Part 1: Principles and requirements

Raumfahrttechnik - Bodensysteme und Bodenbetrieb - Teil 1: Grundsätze und Anforderungen

Ingénierie spatiale - Systemes au sol et exploitation - Partie 1: Principes et exigences

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Space engineering - Ground systems and operations - Part 1: Principles and requirements

Ingénierie spatiale - Systèmes au sol et exploitation - Partie
1: Principes et exigences

Raumfahrttechnik - Bodensysteme und Bodenbetrieb - Teil
1: Grundsätze und Anforderungen

This European Standard was approved by CEN on 2 February 2004.

CEN 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 Central Secretariat or to any CEN 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 member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

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Foreword

This document (EN 14737-1:2004) has been prepared by CMC.

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of an identical text or by endorsement, at the latest by September 2004, and conflicting national standards shall be withdrawn at the latest by September 2004.

It is based on a previous version¹⁾ originally prepared by the ECSS Space Engineering Working Group, reviewed by the ECSS Technical Panel and approved by the ECSS Steering Board. The European Cooperation for Space Standardization (ECSS) is a cooperative effort of the European Space Agency, National Space Agencies and European industry associations for the purpose of developing and maintaining common standards.

This European Standard is one of the series of space standards intended to be applied together for the management, engineering and product assurance in space projects and applications.

EN 14737 "Space engineering – Ground systems and operations" is published in 2 Parts:

Part 1: Principles and requirements

Part 2: Document requirements definitions (DRDs)

Requirements in this European Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

The formulation of this European Standard takes into account the existing EN ISO 9000 family of documents.

The annexes A and B are informative.

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

1) ECSS-E-70 Part 1A

Introduction

Ground systems and operations are key elements of a space system and as such play an essential role in achieving mission success. Mission success is defined here as the achievement of the target mission objectives as expressed in terms of the quantity, quality and availability of delivered mission products and services within a given cost envelope.

Mission success requires successful completion of a long and complex process covering the definition, design, implementation, validation, in flight operations and post operational activities, involving both the ground segment and also space segment elements. It involves technical activities, as well as human and financial resources, and encompasses the full range of space engineering disciplines. Moreover it necessitates a close link with the design of the space segment in order to ensure proper compatibility between both elements of the complete space system.

This European Standard provides a high level description of all ground segment elements, the domain specific aspects of the associated engineering processes and defines related guidelines and requirements.

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1 Scope

Within the frame of the overall engineering standards for space missions, this European Standard contains the basic rules, principles and requirements to be applied to the engineering of the ground segment and mission operations, which form an integral part of the overall system implementing a space mission.

This European Standard includes development of ground segment, operations preparation activities, mission planning activities, mission evaluation activities, the conduct of operations proper, and all post-operational activities. The ground segment comprises the ground systems (i.e. all ground facilities, hardware and software) and all operational aspects such as personnel and related data repositories required on ground to perform mission operations.

For reasons of recognized commonality, ground segment within the meaning of this European Standard includes those elements and facilities required for the purpose of implementing the mission and fulfilling the missions requirements while the relevant space segments are in-orbit. It covers ground elements used for purposes of assembly, integration and verification of the space segment, to the extent needed for ground segment end-to-end verification activities. It also covers elements integrated into the ground segment after completion of space segment AIT; space segment AIT proper being considered outside the scope of this Standard.

It does not however cover the spacecraft activities and facilities interfacing the launch service segment. Furthermore, while this European Standard is applicable to all classes of missions it does not consider aspects that are specific to manned space missions.

This European Standard is structured as follows:

- identification of the ground systems and operations domain;
- overview of ground segment engineering processes in relation to the project life cycle;
- detailed description of specific aspects of the ground segment elements and engineering tasks.

When viewed from the perspective of a specific project context, the requirements defined in this European Standard should be tailored to match the genuine requirements of a particular profile and circumstances of a project.

NOTE Tailoring is a process by which individual requirements of specifications, standards and related documents are evaluated, and made applicable to a specific project by selection, and in some exceptional cases, modification of existing or addition of new requirements.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 13701:2001, *Space systems — Glossary of terms*.

EN 13290-4:2001, *Space project management — General requirements — Part 4: Project phasing and planning*.

EN 13292, *Space engineering — Policy and principles*.

EN 14160, *Space engineering — Software.*

EN ISO 14620-1, *Space systems — Safety requirements — Part 1: System safety (ISO 14620-1:2002).*

EN ISO 16091, *Space systems — Integrated logistics support (ISO 16091:2002).*

ECSS-E-10, *Space engineering — System engineering.*

ECSS-E-50 ²⁾ *Space engineering — Communication.*

EN 14725, *Space engineering — Verification.*

EN 14737-2:2004, *Space engineering — Ground systems and operations — Part 2: Document requirements definitions (DRDs).*

ECSS-Q-30A, *Space product assurance — Dependability.*

EN 14824, *Space engineering — Testing.*

ECSS-E-70-41A, *Space engineering — Ground systems and operations — Telemetry and telecommand packet utilization.*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 13701:2001 together with the following apply.

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3.1.1

assembly

process of mechanical mating hardware to obtain a low level configuration after the manufacturing process

NOTE See also EN 13701.

3.1.2

entity

combination of facility plus respective personnel or operations organization

3.1.3

facility

combination of ground system elements required by a ground operations organization to perform an operational task

3.1.4

flight operations

all activities related to the planning, execution and evaluation of the control of the space segment (or subsets thereof) when in orbit

3.1.5

ground operations

all activities related to the planning, execution and evaluation of the control of the ground segment (or subsets thereof) facility

²⁾ To be published.

EN 14737-1:2004 (E)**3.1.6****ground segment**

all ground facilities and personnel involved in the preparation or execution of mission operations

3.1.7**ground segment supplier**

organization responsible for the supply of the ground segment and operations

3.1.8**ground systems**

all ground infrastructure elements that are used to support the preparation activities leading up to mission operations, the conduct of mission operations and all post-operational activities

3.1.9**inspection**

verification method that determines conformance to requirements for constructional features, document and drawing conformance, workmanship and physical conditions without the use of special laboratory equipment, procedures or services

NOTE See also EN 13701.

3.1.10**integration and technical verification and validation**

part of the ground segment verification process completing the ground systems implementation phase, it also covers to the maximum possible extent operational aspects

NOTE 1 Its main objective is to confirm, through an incremental integration and testing process, the conformance of the ground systems to their requirements.

NOTE 2 It also provides preliminary validation of the ground systems and of their constituting elements.

3.1.11**mission**

specific function to be accomplished by a space system (i.e. definition of EN 13701 restricted to the space system) as characterized by its expected products in terms of quantity, quality and availability

3.1.12**mission exploitation**

activity consisting in the planning, utilization and evaluation of the products of the space mission

3.1.13**mission information**

all information required by the ground segment during both pre-launch and post-launch phases

NOTE 1 It typically includes, space segment design and operations characteristics, space segment test and operations procedures, telemetry and telecommand characteristics.

NOTE 2 It is composed of source data originating from the space segment customer and derived data produced by the ground segment teams.

3.1.14**mission operations**

all activities related to the planning, execution and evaluations of the control of the space and ground segments during phases E and F of a space system (i.e. combination of flight and ground operations)

3.1.15**mission operations data**

subset of the mission information used to execute the in-orbit operations (i.e. it includes, for example, operations procedures, rules and databases)

3.1.16**mission products**

products and services delivered by the space segment as the result of its in-orbit exploitation (e.g. communications services, science data and space samples)

3.1.17**operational validation**

ultimate part of the ground segment verification process, the objective of which is to establish the operational validation of the whole ground segment (including operations personnel) and its readiness to support the space mission in-orbit

3.1.18**space system customer**

highest level entity responsible for the complete space system comprising both the space and the ground segment (i.e. interfaces with the entity responsible for the ground segment through a customer to supplier relationship)

3.1.19**system engineering**

The application of System Engineering theory to a specific system
[ECSS-E-10A]

3.1.20**test**

verification method wherein requirements are verified by measurement of product performance and functions under various simulated environments

NOTE See also EN 13701.

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3.2 Abbreviated terms

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The following abbreviated terms are defined and used within this European Standard:

Abbreviation	Meaning
AIT	assembly, integration and test
CCSDS	Consultative Committee for Space Data Systems
COTS	commercial off-the-shelf
CRD	customer requirements document
CSSRD	customer services support requirements document
DDF	design definition file
DRD	document requirements definition
FCP	flight control procedure
FOP	flight operations plan
G/S	ground segment
GCS	ground communications subnet
GOP	ground operations plan

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GSBD	ground segment baseline definition
GSCDR	ground segment critical design review
GSEG	ground segment
GSPDR	ground segment preliminary design review
GSRR	ground segment requirements review
GSS	ground segment and operations supplier
GSTS	ground station system
GSTS-SSC	ground station system - space segment control
GSTS-ME	ground station system - mission exploitation
GSTS-M&C	ground station system - monitoring and control
GSTVVR	ground segment technical verification and validation review
GSTVRR	ground segment technical verification and validation readiness review
GSYS	ground system
HCI	human-computer interaction
I/F	interface
IOOR	in-orbit operations review
IOQR	in-orbit qualification review
LEOP	launch and early orbit phase
LORA	level of repair analysis
LS	logistic support
LSP	logistics support plan
MCC	mission control centre
MCOR	mission close-out review
MCS	mission control system
MEC	mission exploitation centre
MES	mission exploitation system
MOCD	mission operations concept document
MRD	mission requirements document
MTA	maintenance tasks analysis

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OAR	operations anomaly report
OCC	operations control centre
OCS	operation control system
OPS	operations
ORR	operational readiness review
OTP	operations training plan
OVP	operational validation plan
OVRR	operational validation readiness review
PCC	payload control centre
PCS	payload control system
RAMS	reliability, availability, maintainability and safety
RCMA	reliability centred maintenance analysis
REP	report
RF	radio frequency
SCOE	special check-out equipment
SDE	software development environment
SGICD	space-to-ground interface control document
SPEC	specification
SSC	space system customer
SSORD	space segment operability requirements document
SSUM	space segment user manual
SVF	software validation facility
TM/TC	telemetry/telecommand
TT&C	telemetry, tracking, and command

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4 Ground systems and operations domain

4.1 General

Within a space system, mission operations shall comprise the subset of mission engineering activities, identifiable for flight operations, ground operations and logistics engineering, which is required to operate the space segment. Mission operations implement the mission in accordance with the stated, implied or redefined mission objectives in terms of providing plans and services, conducting experiments, producing, providing and distributing materials or goods, or collecting data.

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In this context the domain of ground systems and operations covers the ground segment. In addition, it also considers those aspects of the space segment system of relevance to mission operations. In accordance with the definition of mission operations, launcher operations are not included in this domain.

4.2 Ground segment composition

The ground segment context is shown in Figure 1. The ground segment is composed of two main components.

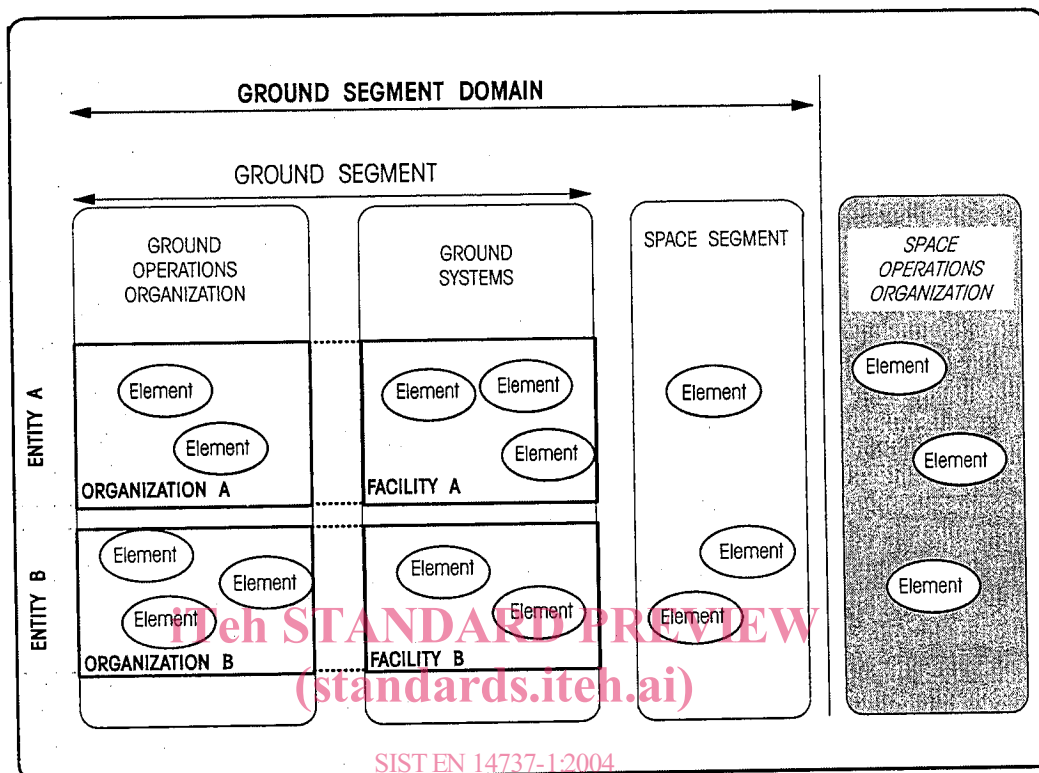
- Ground operations organizations, comprising the human resources performing the various operations tasks and preparing the mission operations data (e.g. procedures, documentation, mission parameters; mission description data).
- Ground systems, consisting of the major ground infrastructure elements that are used to support the preparation activities leading up to mission operations, the conduct of operations themselves and all post-operational activities. These systems grouped together from an organizational viewpoint constitute facilities.

Figure 1 indicates a direct correspondence between ground systems and operations organizations. The combination of an operations organization and its corresponding supporting facility constitutes a ground segment entity. An example of an entity is a control centre from where the elements of an operations organization control an element of the mission such as a space segment or ground station. In the case of space segment control, an element of the operations organization is the flight control team who uses the operations control system as a support facility.

NOTE The domain of ground systems and operations extends into the space segment as far as data, operational interfaces (e.g. operability issues of the spacecraft design) and mission products (i.e. products or services provided by the space segment) are concerned. This applies in particular to the on-board data handling functions. However it does not consider the space operations organization (e.g. astronauts).

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 Figure 1 — Ground segment context

4.3 Ground system elements

4.3.1 General

The ground systems, as shown in Figure 2, usually consist of the following main elements:

- Mission control system (MCS);
- Electrical ground support equipment (EGSE);
- Ground station system (GSTS);
- Ground communication subnet (GCS).

4.3.2 Mission control system (MCS)

The MCS shall comprise all the elements required to control the mission and to exploit its products. It should be logically decomposed in the following functional elements:

- a) Operations control system (OCS), mainly supporting planning, monitoring and control, and performance evaluation of the platform elements of the space segment. It also includes the flight dynamics support element which may be considered as a system in its own right.