

BS EN 16603-10-03:2014



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Space engineering — Testing

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National foreword

This British Standard is the UK implementation of EN 16603-10-03:2014. It supersedes BS EN 14824:2003 which is withdrawn.

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.

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Foreword

This document (EN 16603-10-03:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16603-10-03:2014) originates from ECSS-E-ST-10-03C.

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of an identical text or by endorsement, at the latest by February 2015, and conflicting national standards shall be withdrawn at the latest by February 2015.

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 will supersede EN 14824:2003.

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 requirements on the systems engineering process are gathered in ECSS-E-ST-10; while specific aspects are further elaborated in dedicated standards, in particular: ECSS-E-ST-10-06, ECSS-E-ST-10-02 and the present standard (ECSS-E-ST-10-03)

In the System Engineering branch (ECSS-E-10) this standard aims at a consistent application of on ground testing requirements to allow proper qualification and acceptance of space products

Experience has demonstrated that incomplete or improper on ground testing approach significantly increase project risks leading to late discovery of design or workmanship problem(s) or in-orbit failure(s).

Testing is part of the system engineering process as defined in ECSS-E-ST-10. This starts at the early phase of the mission when defining verification process in terms of the model philosophy and test sequence and ends at the last testing phase prior launch.

In the level of decomposition of a space system, this standard addresses the requirements for space segment element and space segment equipment.

The document is organised such that:

- clause 4 provides requirements for overall test programme, test management and test conditions, tolerances and accuracy;
- clause 5 provides requirements for Space segment equipment;
- clause 6 provides requirements for Space segment element;
- clause 7 provides requirements for Pre-launch testing.

Clauses 5 and 6 are organised as follows:

- general requirements for the products under test applicable to all models (clause 5.1 or 6.1);
- requirements applicable to qualification model (clause 5.2 or 6.2);
- requirements applicable to acceptance model (clause 5.3 or 6.3);
- requirements applicable to protoflight model (clause 5.4 or 6.4);
- detailed implementation requirements (clause 5.5 or 6.5);

In the clause providing requirements for each model (i.e. clauses 5.2, 5.3, 5.4, 6.2, 6.3 and 6.4), the first table of the clause:

- lists all types of test and defines their applicability and conditions;
- links to the second table of the clause that defines tests level and duration;
- provides reference to the clause defining the detailed implementation requirements for the given test (clause 5.5 or 6.5).

For space segment equipment, the required sequence of test, for each model, is defined after the two tables in clause 5.2, 5.3 or 5.4.

Since testing activities are part of the overall verification activities, test documentation to be produced (DRD's) are either specified in the ECSS-E-ST-10-02 (case of the test report) or in this document.

Annex D gives guidelines for performing the tailoring of this standard as well as the generation of the compliance and verification matrices.

1

Scope

This standard addresses the requirements for performing verification by testing of space segment elements and space segment equipment on ground prior to launch. The document is applicable for tests performed on qualification models, flight models (tested at acceptance level) and protoflight models.

The standard provides:

- Requirements for test programme and test management,
- Requirements for retesting,
- Requirements for redundancy testing,
- Requirements for environmental tests,
- General requirements for functional and performance tests,

NOTE Specific requirements for functional and performance tests are not part of this standard since they are defined in the specific project documentation.

- Requirements for qualification, acceptance, and protoflight testing including qualification, acceptance, and proto-flight models' test margins and duration,
- Requirements for test factors, test condition, test tolerances, and test accuracies,
- General requirements for development tests pertinent to the start of the qualification test programme,

NOTE Development tests are specific and are addressed in various engineering discipline standards.

- Content of the necessary documentation for testing activities (e.g. DRD).

Due to the specific aspects of the following types of test, this Standard does not address:

- Space system testing (i.e. testing above space segment element), in particular the system validation test,
- In-orbit testing,
- Testing of space segment subsystems,

NOTE Tests of space segment subsystems are often limited to functional tests that, in some case, are run on dedicated models. If relevant, qualification tests for space segment subsystems are assumed to be covered in the relevant discipline standards.

- Testing of hardware below space segment equipment levels (including assembly, parts, and components),
- Testing of stand-alone software,

NOTE For verification of flight or ground software, ECSS-E-ST-40 and ECSS-Q-ST-80 apply.

- Qualification testing of two-phase heat transport equipment,

NOTE For qualification testing of two-phase heat transport equipment, ECSS-E-ST-31-02 applies.

- Tests of launcher segment, subsystem and equipment, and launch facilities,
- Tests of facilities and ground support equipment,
- Tests of ground segment.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00. Annex D gives guidelines for performing this tailoring.

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 16603-10-02	ECSS-E-ST-10-02	Space engineering - Verification
EN 16603-20	ECSS-E-ST-20	Space engineering - Electrical and electronic
EN 16003-20-01	ECSS-E-20-01	Space engineering - Multipaction design and test
EN 16603-20-06	ECSS-E-ST-20-06	Space engineering - Spacecraft charging
EN 16603-20-07	ECSS-E-ST-20-07	Space engineering - Electromagnetic compatibility
EN 16603-20-08	ECSS-E-ST-20-08	Space engineering - Photovoltaic assemblies and components
EN 16603-31	ECSS-E-ST-31	Space engineering - Thermal control general requirements
EN 16603-32	ECSS-E-ST-32	Space engineering - Structural general requirements
EN 16603-32-02	ECSS-E-ST-32-02	Space engineering - Structural design and verification of pressurized hardware
EN 16603-32-10	ECSS-E-ST-32-10	Space engineering - Structural factors of safety for spaceflight hardware
EN 16603-32-11	ECSS-E-ST-32-11	Space engineering - Modal survey assessment
EN 16603-33-01	ECSS-E-ST-33-01	Space engineering - Mechanisms
EN 16601-40	ECSS-M-ST-40	Space project management - Configuration and information management
EN 16602-10-09	ECSS-Q-ST-10-09	Space product assurance - Nonconformance control system
EN 16602-20-07	ECSS-Q-ST-20-07	Space product assurance - Quality assurance for test centres
EN 16602-40	ECSS-Q-ST-40	Space product assurance - Safety
EN 16602-70-01	ECSS-Q-ST-70-01	Space product assurance - Cleanliness and

		contamination control
	ISO 3740:2000	Acoustics - Determination of sound power levels of noise sources - Guidelines for the use of basic standards

Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this standard, since ECSS-S-ST-00-01 has not been published at the time of the publication of this standard, the introduction part of the ECSS Glossary has been copied here.

For the purpose of this standard; the terms and definitions from ECSS-S-ST-00-01 apply, and in particular the following:

flight model

lifetime

protoflight model

qualification model

space segment element

space segment equipment

space segment subsystem

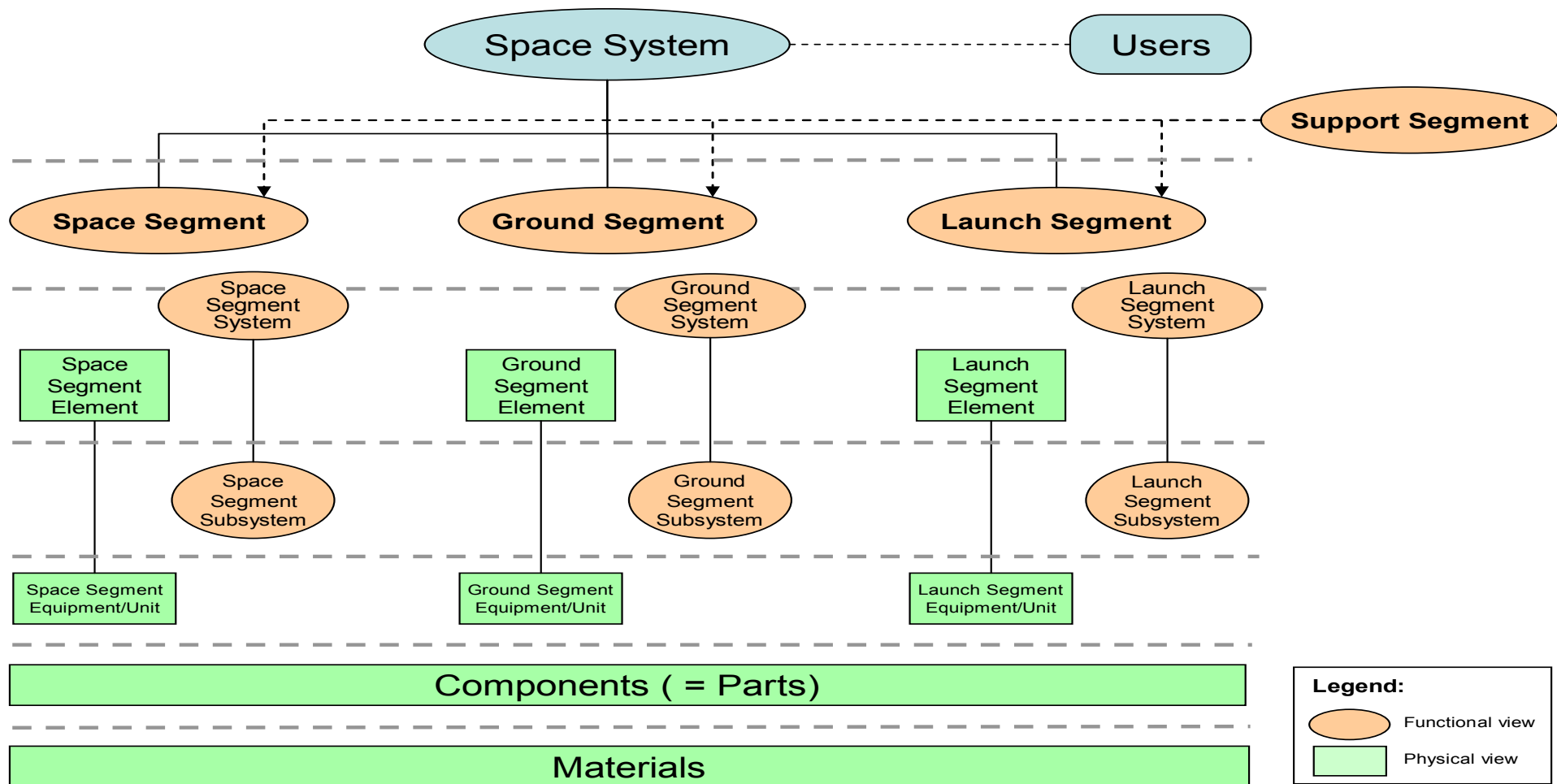
structural model

system

ECSS-S-ST-00-01C defines the highest-level system within a space project - i.e. the one at the mission-level - as the "Space System". The breakdown of a typical space system and the definition of standard terms for the constituent levels within the breakdown are given below (see Figure 3-1 and subsequent definitions).

For this standard only, the terms for the Space Segment are defined in 3.1.

Since any definition always includes some ambiguity and in order to allow the user of the testing standard to clearly classify the item under test in the right category (i.e. Space segment Element, or equipment the table below give a list of example (see Figure 3-2). This table, however, is not exhaustive



Note 1: Since software can belong to any level it is not apparent in this chart

Note 2: A subsystem can be split across two segments
e.g. TT&C subsystem split across Space and Ground segments

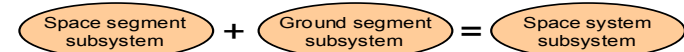


Figure 3-1: Space system breakdown

The following terms are copied from ECSS-S-ST-00-01C Draft 1.1. Cross-references in these terms are within ECSS-S-ST-00-01C Draft 1.1.

3.1.1 **system**

set of interrelated or interacting **functions** constituted to achieve a specified objective

3.1.2 **space system**

system that contains at least a **space**, a **ground** or a **launch segment**

NOTE Generally a space system is composed of all three segments and is supported by a support segment.

3.1.3 **space segment**

part of a **space system**, placed in space, to fulfil the **space mission** objectives

3.1.4 **space segment system**

system within a **space segment**

NOTE Examples are given in Annex B.1.

3.1.5 **space segment element**

element within a **space segment**

NOTE 1 A space segment element can be composed of several embedded space segment elements, e.g. a spacecraft is composed of instruments, a payload module and a service module.

NOTE 2 Examples are given in Annex B.1.

3.1.6 **stand-alone space segment element**

space segment element that performs its mission autonomously

NOTE For example: satellite, rover, lander.

3.1.7 **embedded space segment element**

space segment element that performs its mission as part of another **space segment element**

NOTE For example: platform, module, instrument, payload.

3.1.8 **space segment subsystem**

subsystem within a **space segment**

NOTE Examples are given in Annex B.1.

3.1.9 **space segment equipment**

equipment within a **space segment**

NOTE Examples are given in Annex B.1.

3.1.10 component

set of **materials**, assembled according to defined and controlled **processes**, which cannot be disassembled without destroying its capability and which performs a simple **function** that can be evaluated against expected performance **requirements**

NOTE 1 The term "part" is synonymous.

NOTE 2 The term "part" is preferred when referring to purely mechanical devices.

NOTE 3 The term "component" is preferred for EEE devices.

3.1.11 part

see "**component**"

3.1.12 material

raw, semi-finished or finished substance (gaseous, liquid, solid) of given characteristics from which processing into a component or part is undertaken

3.1.13 flight model (FM)

end **product** that is intended for flight

NOTE 1 The flight model is subjected to formal functional and environmental acceptance testing.

NOTE 2 More detailed information on the build standard and the use of this model is given in ECSS-E-HB-10-02.

3.1.14 lifetime

period, or number of cycles, over which a **product** is required to perform according to its specification

3.1.15 protoflight model (PFM)

flight model on which a partial or complete protoflight **qualification test** campaign is performed before flight

NOTE More detailed information on the build standard and the use of this model is given in ECSS-E-HB-10-02.

3.1.16 qualification model (QM)

model, which fully reflects all aspects of the **flight model** design, used for complete functional and environmental **qualification testing**

NOTE 1 A qualification model is only necessary for newly-designed hardware or when a delta qualification is performed for adaptation to the project.

NOTE 2 The qualification model is not intended to be used for flight, since it is overtested.

NOTE 3 More detailed information on the build standard and the use of this model is given in ECSS-E-HB-10-02.

3.1.17 structural model (SM)

structurally representative **model** of the **flight model** used for **qualification** of the structural design and for correlation with structural mathematical models

- NOTE 1 The system structural model usually consists of a representative structure, with structural dummies of the flight equipment, and also includes representative mechanical parts of other subsystems (e.g. mechanisms and solar panels).
- NOTE 2 The system structural model is also used for final validation of test facilities, GSE, and associated procedures.
- NOTE 3 More detailed information on the build standard and the use of this model is given in ECSS-E-HB-10-02.

space segment	space segment system	space segment element	space segment subsystem	space segment equipment (=unit)	component (=part)	material
product or item						
examples						
Data Relay Satellite System	spacecraft (physical view)	power	electronic unit (e.g. DHU, PCSU, PDU, ASIC ICU)	Aluminium		
Navigation Satellite System	satellite (physical view)	propulsion	thruster	hybrid		to be taken from Q60 & Q70
spacecraft (functional view)	payload	data handling	valve	integrated circuit		
satellite (functional view)	platform	thermal	battery	heat-pipe		
	instrument	structure	reflector	MLI		
	orbiter	AOCS	mechanism (when fully assembled)	structural panel		
	lander	Tm&Tc	vessel/tank	optical array		
	bay	optical	mirror/lenses/filters (assembly)	pyro components		
	module	RF	solar array (assembly) - see note	PCB		
		communication	antenna (assembly)	mirror		
			focal plane assembly	solar cell		
			telescope (assembly)	insert		
			solar panel (equipped) - see note	resistor		
			pressure vessels	diode		
			optical bench	transistor		
			RF filters	capacitor		
			LNA	thermistor		
			IMUX/OMUX	heater		
			OMT	propulsion fluidic		
			feeds			
			2 phases heat transport equipment			

NOTE A deployable solar array is an equipment composed of one or several solar panels (panel substrate and photovoltaic assembly), deployment mechanism including hinges, restrain and release mechanism, and yoke.

Figure 3-2: Space segment examples

For the purpose of this standard, the following terms and definitions from ECSS-E-ST-10-02 apply:

commissioning
model philosophy
test

For the purpose of this Standard, the following terms and definitions from ECSS-E-ST-31 apply:

acceptance temperature range
minimum switch ON temperature
predicted temperature range
qualification temperature range
temperature reference point

For the purpose of this Standard, the following terms and definitions from ECSS-E-ST-32 apply:

burst pressure
design burst pressure
factor of safety
limit load (LL)
maximum design pressure (MDP)
proof factor
proof pressure
proof test

3.2 Terms specific to the present standard

3.2.1 24-hour equivalent noise exposure level

equivalent sound pressure level (Leq) to which the crew members are exposed over a 24-hour period; expressed in dBA

NOTE 0 dBA corresponds to 20 µPa.

3.2.2 a-weighting

adjustments typically made to acoustic measurements to approximate the response of the human ear

3.2.3 abbreviated functional test (AFT)

See "reduced functional test (RFT)"

3.2.4 acceptance level

test level reflecting the maximum level expected to be encountered during the flight product lifetime increased by acceptance margins

3.2.5 acceptance margin

increase of the environmental, mechanical, thermal, electrical, EMC, or operational extremes above the worst case levels predicted over the specified product lifetime for the purpose of workmanship verification

NOTE 1 Margins can include an increase in level or range, an increase in duration or cycles of exposure, as well as any other appropriate increase in severity.

NOTE 2 For thermal acceptance margin refer also to ECSS-E-ST-31.

3.2.6 accuracy of measurement

degree of closeness between a measured quantity value and its true value

NOTE The accuracy depends from the measurement process (e.g. instrument or machine, operator, procedure; environmental conditions).

3.2.7 crewed space segment element

space segment design to ensure the safe presence of crew onboard

3.2.8 development test prior qualification

test to support the design feasibility and to assist in the evolution of the design

3.2.9 dwell time

duration necessary to ensure that internal parts or subassembly of a space segment equipment have achieved thermal equilibrium, from the start of temperature stabilisation phase, i.e. when the temperature reaches the targeted test temperature plus or minus the test tolerance

3.2.10 environmental tests

tests applied to a product simulating (together or separately) environmental conditions as encountered during its operational life cycle

NOTE Environmental tests cover natural and induced environments.

3.2.11 full functional test (FFT)

comprehensive test that demonstrates the integrity of all functions of the item under test, in all operational modes, including back-up modes and all foreseen transitions

NOTE 1 The main objectives of this test is to demonstrate absence of design manufacturing and integration error.

NOTE 2 FFT exists at the different level of decomposition of a space segment element. For satellite they also

called system functional test (SFT) or integrated system test (IST).

3.2.12 maximum expected acceleration

acceleration value determined from the combined effects of the steady state acceleration and the transient response of the item as it will experience during its life time

NOTE 1 This term is equivalent to limit load (as defined in E-ST-32).

NOTE 2 Examples of events during life time are transportation, handling, engine ignition, engine burnout, and stage separation.

3.2.13 maximum expected acoustic spectrum

maximum value of the time average root-mean-square (r.m.s.) sound pressure level (SPL) in each frequency band occurring inside the payload fairing, orbiter, or cargo bay, which occurs during flight events

NOTE 1 E.g. lift-off, powered flight or re-entry.

NOTE 2 The maximum expected acoustic environment test spectrum is specified in octave or 1/3 octave bands over a frequency range of 31,5 Hz to 10 kHz. The duration of the maximum environment is the total period when the overall amplitude is within 6 dB of the maximum overall amplitude.

3.2.14 maximum expected shock

worst cases of the collection of the shock at their mounting interface due to every possible cause

NOTE 1 For example: causes of shocks are stage, shroud or satellite separation pyro elements, non-explosive actuators, mechanisms with energy release, appendage latching, and fuel valves.

NOTE 2 Shocks can be characterized by their time histories, shock response spectrum, or impulse geometry.

NOTE 3 Refer to ECSS-E-HB-32-25 for additional information.

3.2.15 maximum expected random vibration spectrum

maximum expected environment imposed on the space segment element and space segment equipment due to broad band random forcing functions within the launch element or space segment element during flight or from ground transportation and handling

NOTE 1 E.g. lift-off acoustic field, aerodynamic excitations, and transmitted structure-borne vibration.

NOTE 2 A different spectrum can exist for different space segment equipment zones or for different axis. The space segment equipment vibration levels are based on vibration response measurements or model prediction made at the space segment

equipment attachment points during ground acoustic tests or during flight. The duration of the maximum environment is the total period during flight when the overall level is within 6 dB of the maximum overall level.

NOTE 3 The power spectral density is based on a frequency resolution of 1/6 octave (or narrower) bandwidth analysis, over a frequency range of 20 Hz to 2000 Hz.

3.2.16 maximum expected sinusoidal vibration environment

maximum expected environment imposed on the space segment element and space segment equipment due to sinusoidal and narrow band random forcing functions within the launch element or space segment element during flight or from ground transportation and handling

NOTE In flight, sinusoidal excitations are caused by unstable combustion, by coupling of structural resonant frequencies (POGO), or by imbalances in rotating space segment equipment in the launch element or space segment element. Sinusoidal excitations occur also during ground transportation and handling due to resonant responses of tires and suspension systems of the transporters.

3.2.17 multipaction

resonant back and forth flow of secondary electrons in a vacuum between two surfaces separated by a distance such that the electron transit time is an odd integral multiple of one half the period of the alternating voltage impressed on the surface

NOTE The effects of multipaction can be loss of output power up to reaching the multipaction breakdown voltage leading to the generation of spark.

3.2.18 notching

reduction of the input level or spectrum to limit structural responses at resonant frequencies according to qualification or acceptance loads during a vibration test

NOTE Notching is a general accepted practice in vibration testing to avoid over testing of the item under test. Implementation of notching is subject to customer approval and when relevant to Launcher authority approval

3.2.19 operational modes

combination of operational configurations or conditions that can occur during the product lifetime for space segment equipment or space segment element

NOTE For example: Power-on or power-off, command modes, readout modes, attitude control modes, antenna stowed or deployed, and spinning or de-spun.

3.2.20 performance test

test to verify that the item under test performs according to its specifications while respecting its operational requirements

NOTE Performance tests are mission specific therefore their details are not specified under this standard.

3.2.21 polarity test

test to verify the correct polarity of the functional chains (mainly AOCS) or equipment of the space segment element from sensors to actuators, through a number of interfaces and processing.

NOTE 1 A polarity error can be generated throughout the development process: interface documentation, design, H/W manufacturing, S/W development, satellite AIT, satellite database.

NOTE 2 A polarity error can be generated by any element of the functional chain: sensor or actuator design, sensor or actuator mounting, harness, interface units, software algorithms.

NOTE 3 Polarity inversion on Safe Mode control loops can cause a satellite loss.

NOTE 4 This term "sign test" is synonymous.

3.2.22 qualification level

test level reflecting the maximum level expected to be encountered during the flight product lifetime increased by qualification margins

NOTE For thermal the qualification margin applies on top of the acceptance margin.

3.2.23 qualification margin

increase of the environmental, mechanical, electrical, EMC, or operational extremes above the worst case levels predicted over the specified product lifetime for the purpose of design margin demonstration

NOTE 1 Margins can include an increase in level or range, an increase in duration or cycles of exposure, as well as any other appropriate increase in severity.

NOTE 2 This definition is not applicable for thermal aspects. Refer to ECSS-E-ST-31 for "qualification margin".

3.2.24 reduced functional test (RFT)

sub-set of the **full functional test** to verify the integrity of the major functions of the item under test, with a sufficiently high degree of confidence, in a relatively short time

NOTE The term "abbreviated functional test (AFT)" is synonymous.

3.2.25 residual life

time left before a product is no longer able to achieve minimum acceptable performance requirements, including availability

NOTE Criteria can be estimated in terms of serviceability or structural strength for example.

3.2.26 resolution

minimum readable value of a quantity on a measurement system

NOTE The resolution is accounted for in the accuracy.

3.2.27 resonance search

frequency sweep of low level sinusoidal vibrations to characterise main resonant modes for preparing the higher level runs, and to show possible deficiencies in workmanship, as a consequence of high level runs

NOTE Resonance search is also known as “signature test”, “low level sinusoidal vibration test”, “low level sine sweep”, “low level sweep” or “low level test”.

3.2.28 reverberation time (T60)

duration necessary for the sound level to decrease by 60 dB after the switch off of the sound source

3.2.29 shock response spectrum (SRS)

graphical representation of a transient waveform determined by the response of a set of single degree of freedom oscillators using a defined amplification factor Q

NOTE 1 The Shock Response Spectrum can be defined for any input or response parameters of interest (displacement, velocity, or acceleration). For aerospace structures it is common to define the input transient in terms of acceleration.

NOTE 2 The acceleration amplification factor Q is conventionally chosen equal to 10, corresponding to a factor of critical damping equal to 5 %. In situations when damping is known, Q can be chosen accordingly.

NOTE 3 The Shock Response Spectrum allows characterizing the shock effect in order to estimate its severity or its damaging potential.

NOTE 4 There are several representations of Shock Response Spectrum, including positive, negative, primary, residual and maximax. The latter SRS envelopes the previous four and is the most commonly used for shock testing.

3.2.30 sign test

see “polarity test”

3.2.31 temperature cycle

transition from an initial temperature to the same temperature, with excursion within a specified range

3.2.32 test block

aggregation of several tests grouped by discipline

3.2.33 tolerance

limiting or permitted range of values of a specified test level without affecting the test objectives

NOTE The tolerance is typically specified as deviation from a specified value, or as an explicit range of allowed values. Tolerance can be symmetrical, as in $40 \pm 0,1$, or asymmetrical, such as $40 -0,2/+0,1$.

3.3 Abbreviated terms

For the purposes of this Standard the following abbreviated terms apply.

Abbreviation	Meaning
AFT	abbreviated functional test
AIT	assembly, integration and test
AITP	assembly, integration and test plan
AIV	assembly, integration and verification
AVT	acceptance vibration test
CCB	configuration control board
CoG	centre of gravity
DRD	document requirements definition
EC	European Commission
EGSE	electrical ground support equipment
EM	engineering model
EMC	electromagnetic compatibility
EMCCP	electromagnetic compatibility control plan
EQM	engineering qualification model
ESD	electrostatic discharge
FFT	full functional test
FM	flight model
FOP	flight operation plan
GSE	ground support equipment
HFE	human factors engineering
HMI	human-machine interface

Abbreviation	Meaning
ICD	interface control document
KIP	key inspection point
LCDA	launcher coupled dynamic analysis
LEOP	launch and early orbit phase
MDP	maximum design pressure
MIP	mandatory inspection point
MoI	moment of inertia
NC	noise criterion
NCR	nonconformance report
NRB	nonconformance review board
OSPL	overall sound pressure level
PFM	protoflight model
PIM	passive intermodulation
PSD	power spectral density
PT	performance test
PTR	post test review
QM	qualification model
r.m.s.	root-mean-square
RF	radio frequency
RFT	reduced functional test
SEP	system engineering plan
SFT	system functional test
SPL	sound pressure level
SRS	shock response spectrum
SVT	system validation test
TB	thermal balance
TC	telecommand
TCS	thermal control system
TM	telemetry
TPRO	test procedure
TR	test review
TRB	test review board
TRP	temperature reference point
TRPT	test report
TRR	test readiness review
TV	thermal vacuum

Abbreviation	Meaning
T ^Q	qualification temperature
T ^A	acceptance temperature
T ^D	design temperature
T _{Op}	operating temperature
T _{NOp}	non-operating temperature
TSPE	test specification
TT&C	telemetry, tracking and command
TWT	travelling wave tube
VCD	verification control document
VP	verification plan

4

General requirements

4.1 Test programme

- a. A coherent test programme shall be established, encompassing each verification stage and level to implement the verification by testing.

NOTE 1 The testing programme is performed incrementally at different product decomposition levels.

NOTE 2 Refer to clause 3.1 for determining the type of item for which the test programme is defined (i.e. space segment equipment or space segment element), in particular the example table.

NOTE 3 The number and type of testing levels depends upon the complexity of the project and on its characteristics in accordance with the Verification programme (see ECSS-E-ST-10-02).

NOTE 4 The test programme documentation is defined in 4.3.3.

- b. The customer and the supplier shall agree the need to treat a space segment element as a space segment equipment.

NOTE This is typically the case for small instrument.

- c. AITP and test specifications shall be derived from the product requirements, verification plan and verification control document (VCD).

NOTE Verification plan and VCD are defined in ECSS-E-ST-10-02.

- d. Test procedures shall be derived from test specifications and AITP.
- e. Test programme and its implementation shall be in conformance with safety requirements of ECSS-Q-ST-40 and ECSS-Q-ST-20-07.

4.2 Development test prior qualification

- a. Development test of a product shall be completed prior to the start of its formal qualification testing.

NOTE Development tests are conducted over a range of operating conditions that can exceed the design range.

- b. Development tests shall not be conducted on qualification or flight models or parts of it.
- c. Records of test configuration, test results and other pertinent data shall be maintained.

NOTE This kind of information can be used for investigation when failure occurs during the qualification and acceptance, or for other investigations.

4.3 Test management

4.3.1 General

- a. The supplier shall assign clear responsibility for the implementation of the test programme.
- b. The customer, or its duly appointed representative, shall have the right to participate to all test phases.

4.3.2 Test reviews

4.3.2.1 Test programme

- a. The test programme shall be decomposed in blocks.

NOTE The general test programme is reviewed at the CDR as per ECSS-M-ST-10.

- b. The definition of the blocks of requirement 4.3.2.1a shall be agreed between the customer and supplier.

NOTE 1 Test block definition depends mainly on the item under test, the facility and the contractual agreement. A test block can include one or more tests. For equipment, usually one test block covers the full test programme.

NOTE 2 Typical test blocks for space segment elements are:

- Integration
- Alignment
- Leak/proof pressure
- Mechanical (Static load test, sinusoidal, acoustic, random, modal survey, shock)
- EMC conducted
- EMC radiated/auto-compatibility/RF
- Thermal (TB/TV test)
- Functional and performance test
- Final preparation

- c. Each test block shall include the following formal reviews:
1. test readiness review (TRR);
 2. post test review(s) (PTR);
 3. test review board (TRB).

NOTE 1 TRRs from several blocks can be combined, TRRs can also be combined with a PTR of the previous block.

NOTE 2 Depending on the nature of the test, the customer can decide to establish additional key-points between formal reviews. Typical examples are transition between level and axes in vibration tests and transition between test phases in TV/TB tests.

4.3.2.2 Test readiness review (TRR)

- a. A TRR shall be held before the start of the test activity to verify that all conditions allow to proceed with the test.
- b. The TRR shall address the following topics:
1. test documentation availability and suitability, including:
 - (a) approved AITP,
 - (b) approved test specification,
 - (c) test predictions (when relevant),
 - (d) approved test procedures (including contingency and emergency procedures),
 - (e) approved measurement point plan,
 - (f) approved test facility readiness report,
 - (g) approved test schedule, and
 - (h) acceptance data package of lower level items.
 2. item under test configuration;
 3. test configuration/set-up;
 4. inspection status report of KIP, MIP, or both;
 5. test facility, environmental conditions, test instrumentations, calibration, maintenance status;
 6. cleanliness condition, hazard and safety;
 7. ground support equipment (GSE) and infrastructures;
 8. status of nonconformances that affect the item under test, its associated GSE, or the test facility;
 9. waivers status, and deviations;
 10. personnel qualification and availability;
 11. results from test rehearsal using the test facility with or without the item under test, when relevant;

12. test pass/fail criteria completeness;
13. assignment of responsibilities;
14. test schedule.

NOTE 1 For 4.3.2.2b.1(f), the content of the facility readiness report is defined in ECSS-Q-ST-20-07.

NOTE 2 The level of details according to which each topic is addressed, is different for the general test programme TRR than for each block test TRR.

- c. The following parties shall participate to the TRR:
 1. the chairperson, who is the product assurance manager of the authority responsible for the test;
 2. product assurance from all involved parties;
 3. project engineer from all involved parties;
 4. AIT from all involved parties;
 5. specialists, when necessary from all involved parties;
 6. facility representative;
 7. other as relevant.

NOTE For example launcher authority for tests related to launcher interface or other company representative that will take over the responsibility of the hardware after delivery.

- d. All the open points shall be clearly identified and actions assigned with closure date before the execution of the test.
- e. The output of the TRR shall be a decision to proceed with the test or not.

4.3.2.3 Post test review (PTR)

- a. A PTR shall be held in order to formally declare the test completed and allow the release of the item under test and test facility for further activity.

NOTE The release of the test facility includes the breaking of the test configuration.

- b. The PTR shall address the following topics:
 1. verification that all test data were acquired, recorded, and archived in conformance with the test specification and test procedure requirements;
 2. verification that the process for test anomalies and NCRs, raised during the test, was initiated, and all needed inspection, test data and test configuration were acquired;
 3. confirmation that tests were performed according to the AITP, the test specification and the test procedures, with the exceptions of what is covered by agreed procedure variations or NCRs;
 4. status of compliance of the item under test to the relevant requirement;

5. post test status of GSE;
 6. post item under test configuration based on inspection and cleanliness report;
 7. identification of the open points with assignment of actions for their closure, as well as lessons learned drawn.
- c. The following parties shall participate to the PTR:
1. product assurance;
 2. project engineer;
 3. AIT;
 4. facility representative;
 5. other, including specialist, as relevant.

NOTE For example launcher authority for tests related to launcher interface or other company representative that will take over the responsibility of the hardware after delivery.

4.3.2.4 Test review board (TRB)

- a. A TRB shall be held to review all results and conclude on the test completeness and achievement of objectives.
- b. The TRB shall address the following topics:
1. test documentation availability, including:
 - (a) test report as per ECSS-E-ST-10-02 Annex C,
 - (b) facility report when relevant,
 - (c) inspection report including cleanliness report,
 - (d) list of NCRs,
 - (e) copy of NCRs raised during test with the related NRB minutes of meeting, and associated request(s) for waiver, and
 - (f) list of procedure deviations.
 2. compliance with the test specification, and variations to the AITP;
 3. status of compliance of the item under test to the relevant requirement;
 4. post test status of GSE;
 5. post item under test configuration based on inspection and cleanliness report;
 6. review of all still open NCRs raised during test in order to assess that there is no impact on the test objectives achievement;
 7. lessons learned to be drawn.
- c. The following parties shall participate to the TRB:
1. product assurance;
 2. project engineer;

3. AIT;
4. facility representative;
5. other, including specialist, as relevant.

NOTE For example launcher authority for tests related to launcher interface or other company representative that will take over the responsibility of the hardware after delivery.

4.3.3 Test documentation

4.3.3.1 General

Clauses 4.3.3.2 to 4.3.3.5 define the Test programme documentation (AITP, Test specification, Test procedure, and Test report) generated at all product levels.

These documents are derived from the System Engineering Plan (SEP) and from the Verification Plan (VP).

4.3.3.2 Assembly, integration and test plan (AITP)

- a. The supplier shall establish the AITP in conformance with the DRD in Annex A.

NOTE At space segment equipment level, the AITP can be called test plan.

- b. The agreed AITP shall be available, at the latest, for the TRR of the test programme.
- c. The way the requirement 4.3.3.2b is achieved shall be agreed between the customer and the supplier.

4.3.3.3 Test specification (TSPE)

- a. The supplier shall establish the test specification in conformance with the DRD in Annex B.
- b. The agreed test specification shall be available at the relevant test block TRR and on time to allow procedure preparation.
- c. The way the requirement 4.3.3.3b is achieved shall be agreed between the customer and the supplier.

4.3.3.4 Test procedure (TPRO)

- a. The supplier shall establish the test procedure in conformance with the DRD in Annex C.
- b. The test procedure, derived from the agreed test specification, shall be available at the relevant test block TRR.
- c. The way the requirement 4.3.3.4b is achieved shall be agreed between the customer and the supplier.

4.3.3.5 Test report (TRPT)

- a. The supplier shall establish the test report in conformance with the DRD in Annex C of ECSS-E-ST-10-02.

NOTE The test report describes test execution, results and conclusions in the light of the test requirements. It contains the test description and the test results including the as-run test procedures, the considerations and conclusions with particular emphasis on the close-out of the relevant verification requirements including any deviation.

- b. The test report shall be available prior to the TRB.

4.3.4 Anomaly or failure during testing

- a. Any failure or anomaly during testing shall be recorded.
- b. All nonconformances shall be managed in conformance with ECSS-Q-ST-10-09.
- c. The NRB shall decide on the necessity and extent of any retest activity in order to demonstrate the correctness of the disposition made.

4.3.5 Test data

- a. Test measurements and the environmental conditions shall be recorded for subsequent evaluation.
- b. A database of parameters shall be established for trend analysis.
- c. Trend analysis shall be performed using test data acquired across test sequences.

4.4 Test conditions, tolerances, and accuracies

4.4.1 Test conditions

- a. Test conditions shall be established using predicted environment plus margins.

NOTE This can be done using previous mission flight data, relevant ground environments, analytical prediction, relevant previous test results, or a combination thereof.

- b. Tests shall be performed simulating the mission envelope, including operational and non-operational conditions with margins.
- c. For items tested in an environment different from the one it is expected to operate, the possible differences in behaviour shall be accounted for in the test levels and duration.

NOTE In this case, the test levels and duration are modified based on analyses. For example to

prevent effects of convective heat transfer that reduce thermal gradients.

- d. Cleanliness and contamination control for test programmes shall conform to ECSS-Q-ST-70-01.
- e. The quality and safety management system used to operate and maintain test facility(ies) shall be recognized by the customer.

NOTE As example, in accordance to quality and safety management system requirements from ECSS-Q-ST-20-07.

- f. Test facilities, tools and instrumentation shall not prevent to fulfil the tests objectives.
- g. The EGSE or other support systems of the item under test shall:
 - 1. not jeopardize the results of tests;
 - 2. be immune to signals used for susceptibility tests;
 - 3. be designed to comply with the applicable legislation, including safety (e.g. EC Directives).
- h. The combination of test set-up, test levels durations, and operational modes shall not create conditions that can:
 - 1. induce failures of the item under test,
 - 2. lead to rejection of adequate item under test, or
 - 3. create hazardous conditions.

4.4.2 Test tolerances

- a. Test tolerances bands shall be specified in test error budgets and agreed by the customer prior to start of test.
- b. For the purpose of 4.4.2a test tolerances shall be justified by reference to the uncertainty budget and confidence level of the measurement instrument(s) used.

NOTE 1 EA-4/16 and EA-4/02 (section 2) guidelines can be used to build up the uncertainty budget.

NOTE 2 The tolerances specified in Table 4-1 are the allowable ranges within which the test parameters can vary, they include instrumentation accuracy.

- c. Quantitative requirements demonstrated by measured test values shall account for test inaccuracies and tolerances, and be compared with the specified requested values.
- d. The tolerances specified in Table 4-1 shall be applied to the test values.
- e. Changes to the tolerances specified in Table 4-1 shall be approved by the customer.

NOTE For example, when tolerances of Table 4-1 are detected to be inconsistent with test accuracy values of Table 4-2.

Table 4-1: Allowable tolerances

Test parameters	Tolerances
1. Temperature	Low High
above 80K	Tmin +0/-4 K Tmax -0/+4 K
T< 80 K	Tolerance to be defined case by case
2. Relative humidity	± 10 %
3. Pressure (in vacuum chamber)	
> 1,3 hPa	± 15 %
1,3 10 ⁻³ hPa to 1,3hPa	± 30 %
< 1,3 10 ⁻³ hPa	± 80 %
4. Acceleration (steady state) and static load	-0 / +10 %
5. Sinusoidal vibration	
Frequency (5 Hz to 2000 Hz)	± 2 % (or ±1 Hz whichever is greater)
Amplitude	± 10 %
Sweep rate (Oct/min)	± 5 %
6. Random vibration	
Amplitude (PSD, frequency resolution better than 10Hz)	
20 Hz - 1000 Hz	-1 dB / +3 dB
1000 Hz - 2000 Hz	± 3 dB
Random overall g r.m.s.	± 10 %
7. Acoustic noise	
Sound pressure level, Octave band centre (Hz)	
31,5	-2 dB /+4 dB
63	-1 dB /+3 dB
125	-1 dB /+3 dB
250	-1 dB /+3 dB
500	-1 dB /+3 dB
1000	-1 dB /+3 dB
2000	-1 dB /+3 dB
Overall	-1 dB /+3 dB
Sound pressure level homogeneity per octave band	+/- 2 dB
8. Microvibration	
Acceleration	±10 %

Test parameters	Tolerances
Forces or torque	$\pm 10 \%$
9. Audible noise (for Crewed Element only)	
Sound-power (1/3 octave band centre frequency)	
32,5 Hz - 160 Hz	± 3 dB
160 Hz – 16 kHz	± 2 dB
9. Shock	
Response spectrum amplitude (1/12 octave centre frequency or higher)	
Shock level	- 3 dB/ + 6 dB 50 % of the SRS amplitude above 0 dB
10. Solar flux	
in reference plane	$\pm 4 \%$ of the set value
in reference volume	$\pm 6 \%$ of the set value
11. Infrared flux	
Mean value	$\pm 3 \%$ on reference plane(s)
12. Test duration	-0/+10 %

4.4.3 Test accuracies

- a. Test accuracies shall be specified in test error budgets and agreed by the customer prior to test performance.

NOTE EA-4/16 and EA-4/02 (section 2) guidelines can be used to build up the overall test measurement accuracy.

- b. The accuracy of test instrumentation shall be verified in accordance with approved calibration procedures, with traceability to international measurement standards.
- c. All test instrumentation shall be within the normal calibration period at the time of the test.
- d. Any anomaly of test instrumentation, detected at the first calibration sequence after the test, shall be reported.
- e. The accuracy of measurement shall be as follows:
- as per Table 4-2 for the parameters listed, or
 - at least one third of the tolerance of the variable to be measured.

NOTE The values of Table 4-2 are typical from test centre capabilities.

Table 4-2: Test accuracies

Test parameters	Accuracy
1. Mass	
Space segment equipment and space segment element	$\pm 0,05 \%$ or 1 g whatever is the heavier
2. Centre of gravity (CoG)	
Space segment equipment	Within a 1 mm radius sphere
Space segment element	$\pm 2,5$ mm along launch axis ± 1 mm along the other 2 axes
3. Moment of inertia (MoI)	
Space segment equipment and Space segment element	$\pm 3 \%$ for each axis
4. Leak rate	One magnitude lower than the system specification, in $\text{Pa m}^3 \text{s}^{-1}$ at standard conditions (1013,25 Pa and 288,15 K).
5. Audible noise (for Crewed Element only)	
32,5 Hz to 160 Hz	± 3 dB
160 Hz to 16 kHz	± 2 dB
6. Temperature	
above 80 K	± 2 K
$T < 80$ K	Accuracy to be defined case by case
7. Pressure (in vacuum chamber)	
$> 1,3$ hPa	$\pm 15 \%$
$1,3 \cdot 10^{-3}$ hPa to $1,3$ hPa	$\pm 30 \%$
$< 1,3 \cdot 10^{-3}$ hPa	$\pm 80 \%$
8. Acceleration (steady state) and static load	$\pm 10 \%$
9. Frequency for mechanical tests	$\pm 2 \%$ (or ± 1 Hz whichever is greater)
10. Acoustic noise	$\pm 0,1$ dB
11. Strain	$\pm 10 \%$
12. EMC	See ECSS-E-ST-20-07 clause 5.2.1.
13. ESD	See ECSS-E-ST-20-06 See ECSS-E-ST-20-07 clause 5.2.1 for ESD test on space segment equipment.

4.5 Test objectives

4.5.1 General requirements

- a. The test programme shall be defined taking into account the agreed model philosophy.

NOTE The model philosophy, including model definition, is detailed in ECSS-E-HB-10-02.

- b. When preparing the overall test programme of a space segment element tests linked to compatibility with ground and launch segment shall also be included.

NOTE This covers in particular the system validation test.

4.5.2 Qualification testing

- a. Qualification testing shall be performed to provide evidence that the space segment element or equipment performs in accordance with its specifications in the intended environments with the specified qualification margins.

NOTE 1 The Qualification test programme requirements are defined in ECSS-E-ST-10-02 requirement 5.2.4.2b. and 5.2.4.2c.

NOTE 2 This evidence is used, further to analysis as relevant, to provide via verification reports (defined in ECSS-E-ST-10-02 Annex F) the elements for the close-out of the VCD (defined in ECSS-E-ST-10-02 Annex B).

- b. Qualification testing shall be conducted on dedicated qualification models except when using protoflight approach.
- c. Qualification testing shall be completed and design improvements or modification incorporated and qualified prior to the authorization for the flight product manufacturing.
- d. Upon achievement of qualification the design files shall not be modified.
- e. In case destructive tests are needed (e.g. Burst test), a representative model different from the QM shall be used or the test shall be performed at the end of the qualification programme.

NOTE This model can be simplified but needs to fully represent the function tested.

- f. The qualification test levels and durations shall be as specified in Table 5-2 for space segment equipment and in Table 6-2 for space segment element.

NOTE The test durations identified in Table 5-2 and Table 6-2 are the minimum values.