

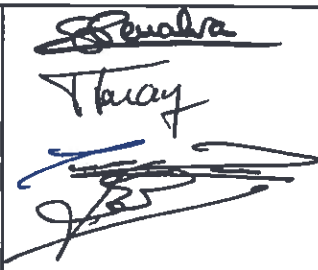
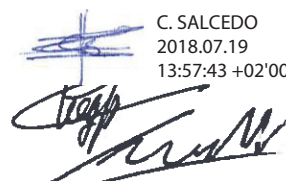


ISIS

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ISIS EQUIPMENT MECHANICAL & THERMAL ENVIRONMENT, AND TEST REQUIREMENTS

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FOREWORD

ISIS (Initiative for Space Innovative Standards) is a set of specification documents established by CNES, Airbus Defence & Space, and Thales Alenia Space France, hereafter called the Partners, with the goal of rationalizing space housekeeping services, from onboard equipment to in-orbit operations, and with the ultimate goal of decreasing overall mission costs.

This documentation is intended to serve as a guide to future mission specific specifications, in order to introduce performance requirements in coherence with incremental evolutions of the industrial satellite platforms product lines, and as to ultimately allow for standardized spacecraft operations.

The ISIS documentation was developed in compliance with the European ECSS standards and is meant to become gradually applicable to future space missions, in function of their needs and capability.

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Requirement Identifier	Paragraph Number	TBC Comment
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TBD TABLE

Requirement Identifier	Paragraph Number	TBD Comment
[ISIS-EVTR-REQ-30028 (v.2)]	3.2.3	allowable maximum loads TBD by the prime.

	7.3	§ ESD Tests
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1. INTRODUCTION

1.1. PURPOSE

This specification provides the mechanical-thermal-electrical-ATOX environment that an equipment unit can experience during its lifetime, from ground to in-orbit phases. It applies to equipment units designed for use in the frame of a mission compatible with the ISIS referential.

The predicted environments are based on the current experience from programs already developed by CNES, AIRBUS DEFENCE and SPACE and THALES ALENIA SPACE. They can be used as an envelope for initial development, i.e. no mission-specific can be considered at this stage.

This specification addresses all internal electronic, electrical and RF units, batteries and external units such as Star Trackers or antennas to be mounted on the Platform or on the Payload. This specification does not apply to the Structure, Propulsion Module and Solar Array.

This specification establishes also the design rules and test requirements that equipment shall be submitted to, in order to demonstrate its ability to withstand the relevant environment without damage.

In case of conflicts between applicable documents, the unit specification shall have precedence over this environment & tests specification.

1.2. REQUIREMENT NUMBERING AND VERIFICATION

Each requirement within this document is associated with the following fields.

- Requirement Number,
- Intended Verification Method.

The Requirement Number has the form ISIS-EVTR-REQ-nnnnn where nnnnn is a unique number assigned incrementally.

The Intended Verification Method codes are as follows:

- T – Test (including demonstration),
- A – Analysis (including similarity),
- R – Review,
- I – Inspection.

The requirement text follows the requirement number. If tables are considered as part of requirement they are referenced clearly in the text and inserted after and separated from the requirement and are managed as free text attached to the identifier requirement.

All document elements not presented in the format explained above are not requirements and will not be verified or tracked.

1.3. ABBREVIATED TERMS

For the terms and definitions, see chapter 3 of RD-2.

AL Acceptance Test Load

APTC	Ambiant Pressure Temperature Cycling
ATOX	ATomic OXygen
CFRP	Carbon Fabric Reinforced Plastic
CME	Coefficient of Moisture Expansion
CoG	Center of Gravity
CTE	Coefficient of Thermal Expansion
DGMM	Design Geometrical Mathematical Model
DLL	Design Limit Load
DUL	Design Ultimate Load
DTMM	Design Thermal Mathematical Model
DYL	Design Yield Load
ECSS	European Cooperation for Space Standardization
EEE	Electronic, Electrical, Electromechanical
ESA	European Space Agency
EVTR	EnVironment and Test Requirements
FM	Flight Model
GDIR	General Design and Interface Requirements
GSE	Ground Support Equipment
GMM	Geometrical Mathematical Model
IGMM	Interface Geometrical Mathematical Model
ITMM	Interface Thermal Mathematical Model
I/F	Interface
LL	Limit Load
NA	Not Applicable
NRB	Non-conformance Review Board
PSD	Power Spectral Density
PFM	Proto Flight Model
PTR	Post Test Review
QA	Quality Assurance
QL	Qualification Test Load
QM	Qualification Model
QS	Quasi Static
RMS	Root Mean Square
SPENVIS	SPace ENVironment Information System
SRS	Shock Response Spectrum
SSO	Sun Synchronous Orbit
S/C	Spacecraft

TBC	To Be Confirmed
TBD	To Be Defined
TB	Thermal Balance
TCS	Thermal Control System
TV	Thermal Vacuum
TMM	Thermal Mathematical Model
TRR	Test Readiness Review
TRP	Temperature Reference Point
VTC	Vacuum Temperature Cycling

1.4. REQUIREMENT MATURITY

The present document has been jointly written by CNES, Airbus Defence & Space and Thales Alenia Space in the frame of the ISIS project, on the basis of their experience gained on past programmes, and accounting for ECSS-E-ST-10-03C standards, which has been tailored for the needs of ISIS standard.

All requirements have been consolidated, thus requirements maturity can be considered as high, and the document can be made applicable.

2. DOCUMENTARY REFERENCE SYSTEM

2.1. APPLICABLE DOCUMENTS

Index	Reference	Title of document
AD-1	ECSS-Q-ST-20-07	Quality and Safety Assurance for space test centers
AD-2	ECSS-Q-ST-70-01	Cleanliness and contamination control

2.2. REFERENCE DOCUMENTS

Index	Reference	Title of document
RD-1	ISIS-SL-TS-468-CNES	ISIS General Design and Interface Requirements (GDIR)
RD-2	ECSS-E-ST-10-03C	ECSS Testing
RD-3	ISIS-SL-TS-469-CNES	ISIS EMC specifications

3. ENVIRONMENTAL DESIGN REQUIREMENTS

3.1. GENERAL ENVIRONMENTS

3.1.1. Transportation and storage

ISIS-EVTR-REQ-30004 v : 1

The unit shall be designed to withstand a relative humidity of 60% maximum during storage and transport.

Verification : **R**

ISIS-EVTR-REQ-30005 v : 1

The unit shall be designed in compliance with the cleanliness requirements specified by the applicable Product Assurance Specification.

ISIS-EVTR-REQ-30006 v : 1

The S/C units flight H/W shall be designed to withstand a minimum on-ground lifetime of 10 years, including storage duration of 7 years.

Verification : **R**

ISIS-EVTR-REQ-30007 v : 2

During transport prior to integration on the spacecraft or payload, the unit shall withstand the acceptance temperature range of $[-35, +65]^{\circ}\text{C}$

Verification : **A**

3.1.2. On-ground phase (including testing)

ISIS-EVTR-REQ-30008 v : 1

During integration and other AIV activities (excluding thermal tests), the unit shall withstand temperature range of $[+10, +30]^{\circ}\text{C}$

ISIS-EVTR-REQ-30009 v : 2

Unless otherwise specified, all measurements and tests shall be made at room ambient atmospheric pressure, temperature and relative humidity conditions, within $22 \pm 3^{\circ}\text{C}$ and $55 \% \pm 10 \% \text{ RH}$ conditions.

ISIS-EVTR-REQ-30010 v : 2

Whenever these conditions must be closely controlled in order to obtain reproducible results, a reference temperature of 22°C , a relative humidity of 55% and an atmospheric pressure of 1013 hPa shall be used together in order to remain in the temperature & humidity range as hereabove required including measurement uncertainties.

3.1.3. Depressurization Phase

Decreasing atmospheric pressure from launch pad level conditions down to vacuum will occur at a rate dependent on the flight profiles and venting schedule.

ISIS-EVTR-REQ-30011 v : 1

Units mounted on the S/C shall be designed to withstand without degradation an external depressurization rate inferior or equal to 70 hPa/s and an inside over pressure inferior or equal to 150 hPa by reference to outside ambient pressure.

Verification : **T**

3.2. MECHANICAL ENVIRONMENTS

This section defines the mechanical environments the unit will be subjected to during its lifetime.

It specifies the generic requirements in a context where the launcher might not be known yet, and/or the spacecraft mechanical analyses are not performed yet.

Where necessary, the panel mass density where the unit is installed has been taken into account.

3.2.1. Ground Operations loads

This section defines the mechanical environments, which the units and their GSE will be subjected to during normal ground operations.

The ground operation phase begins with the units manufacturing and ends before launch. It includes all the manufacturing, assembly, integration and verification (AIV) and storage activities.

The unit the transportation container and MGSE are exposed to dynamic loads during the required transportation modes (road, air, train...) and handling operations.

ISIS-EVTR-REQ-30012 v : 1

The units and associated transport containers shall be sized to survive transportation and handling QL levels as defined in Table 3.2-1.

Ground Events	Vertical	Horizontal
Ground Transportation	± 3.0 g	± 2.0 g
Air Transport	± 5.0 g	± 2.0 g

Table 3.2-1: Unit Transport QL Level Loads

Comment :

- If not otherwise specified, these loads must be understood as a field of acceleration to be applied to the unit being transported/handled, regardless of orientation of the unit own axis (i.e. for unit in vertical transport/hoisting configuration Z unit is parallel to transport/hoisting vertical axis acceleration, for unit in horizontal transport/hoisting configuration Z unit is parallel to transport/hoisting horizontal axis acceleration);

- Gravity (1g) is included in vertical axis loads (minus sign is downward);
- Loads along horizontal and vertical axis must be applied simultaneously for all signs combinations (horizontal load can have any direction in the horizontal plane).

Verification : **A, T**

ISIS-EVTR-REQ-30013 v : 1

Vertical and horizontal loads, for transport and handling, shall be considered as acting simultaneously (un-attenuated input to MGSE).

Verification : **A, T**

ISIS-EVTR-REQ-30014 v : 1

All MGSE, containers, transportation and handling methods shall be such that flight hardware for which it is intended, never experience any environmental condition outside the QL levels as defined in Table 3.2-1.

Verification : **A, T**

ISIS-EVTR-REQ-30015 v : 1

For containers, the shock requirement is a drop of 100 mm onto concrete of one corner of the container, with another corner of the container lying on the concrete floor.

Verification : **A, T**

ISIS-EVTR-REQ-30016 v : 1

The transportation containers shall be designed to ensure that the flight unit contained within them are undamaged by shocks as defined in ISIS-EVTR-REQ-30015 (the unit is protected from shocks).

Verification : **A, T**

3.2.2. Launch Phase

3.2.2.1. Introduction

Quasi-static and low frequency flight limit accelerations that the units will encounter during launch and early orbit phase, are covered by sine vibrations loads for units.

Dynamic (sine and random) qualification accelerations that the units will encounter during launch and early orbit phase, are define for internally mounted units and according to type of units (mass).

Note that currently no dynamic environment (other than direct acoustic at satellite level) is defined for units mounted externally or on appendages.

3.2.2.2. Sine Environment

3.2.2.2.1. On-Board Electronics Units

ISIS-EVTR-REQ-30017 v : 1

The levels given in § 5.6.2 shall be used for sine vibration qualification. The levels apply at the interface with the structure. If brackets or fixation devices are provided with the unit, the interface is the bracket/fixation device interface.

Rationale : Implicit ECSS-E-ST-10-03c 5.2a and ECSS-E-ST-10-03c 5.4a

Comment : The test duration is 2 Oct/min per axis for qualification and 4 Oct/min per axis for acceptance and protoflight. The qualification levels apply on PFM, STM, EM, QM or EQM pending model philosophy. The acceptance levels applied on FMs.

Verification : **A, R, T**

ISIS-EVTR-REQ-30018 v : 1

Notching requests shall be managed via the RFW process.

Verification : **A, R, T**

3.2.2.2.2. External units and appendages

ISIS-EVTR-REQ-30035 v : 1

Units located on appendices or on external bus secondary support structure or support bracket shall be designed to withstand without degradation the sinusoidal environment defined in Table 5.2-1.

Verification : **A, T**

ISIS-EVTR-REQ-30036 v : 1

Appendages (i.e. antennas, solar arrays, ...) shall be designed to withstand without degradation the sinusoidal environment defined in Table 5.2-1.

Verification : **A, T**

3.2.2.2.3. Propellant Tanks

ISIS-EVTR-REQ-30037 v : 1

Propellant tanks shall be designed to withstand without degradation Random vibration loads defined in Table 5.2-1 (TBC).

Verification : **A, T**

3.2.2.3. Random Vibration Environment

3.2.2.3.1. On-Board Electronics Units

ISIS-EVTR-REQ-30019 v : 1

The levels given in §5.6.3 (Table 5.6-3) shall be used for random vibration qualification. The levels apply at the interface with the Structure. If brackets or fixation devices are provided with the unit, the interface is the bracket/fixation device interface.

Rationale : Implicit ECSS-E-ST-10-03c 5.2a and ECSS-E-ST-10-03c 5.4a

Comment : The test duration is 2 min per axis for qualification and 1 min per axis for acceptance and protoflight. The qualification levels apply on PFM, STM, EM, QM or EQM pending model philosophy. The acceptance levels applied on FM.

Verification : **R, T**

3.2.2.3.2. External Units and Appendages

ISIS-EVTR-REQ-30038 v : 1

Unit located on appendices or on an external bus secondary support structure or support bracket shall be designed to withstand without degradation Random vibration loads defined in Table 5.2-2.

Verification : **A, T**

ISIS-EVTR-REQ-30039 v : 1

When mounted on appendages or secondary structure having a stiffness below 300 Hz (i.e. antennas, solar arrays, ...) units shall be designed to withstand without degradation the random environment defined in Table 5.2-2.

Verification : **A, T**

ISIS-EVTR-REQ-30040 v : 1

When mounted externally, without proximity to other units and/or mounted on rigid secondary structures (externally or internally) units shall be designed to withstand without degradation the random environment defined in Table 5.2-2.

Verification : **A, T**

3.2.2.3.3. Propellant tanks

ISIS-EVTR-REQ-30041 v : 1

Propellant tanks shall be designed to withstand without degradation Random vibration loads defined in Table 5.2-2 (TBC).

Verification : **A, T**

3.2.2.4. Shock

The spacecraft units are subject to shocks, caused by spacecraft separation from the launch vehicle upper stage and from spacecraft appendices deployment.

ISIS-EVTR-REQ-30020 v : 1

The levels given in § 5.6 shall be used for shock qualification. The levels apply at the interface with the structure. If brackets or fixation devices are provided with the unit, the interface is the bracket/fixation device interface.

Rationale : Implicit ECSS-E-ST-10-03c 5.2a and ECSS-E-ST-10-03c 5.4a

Verification : **A, R, T**

ISIS-EVTR-REQ-30021 v : 1

The unit supplier shall produce a list of the unit shock sensitive components as : relays and switches (sensitive to chatter, transfer or permanent damage), brittle materials (crystals, ceramics, glass, wire leads, brittle epoxies), mechanisms.

Verification : **A, R, T**

ISIS-EVTR-REQ-30022 v : 1

The qualification to shock has to be demonstrated through shock testing. Qualification based on heritage based on a very similar unit qualification testing may be proposed and have to be agreed by the customer case by case.

Verification : **A, R, T**

ISIS-EVTR-REQ-30023 v : 1

Shock testing shall be performed with a metal-metal or pyro testing device providing the following shock characteristics: absolute positive and negative g-peaks within 20% and attenuation of 90% of the g-levels after 15 ms.

Verification : **A, R, T**

ISIS-EVTR-REQ-30024 v : 1

In case that bouncing of relays may lead to interruption of signal or voltage drop during shock event, the electronic unit shall provide tolerance w.r.t. relay bouncing e.g. < 10msec by means of solid state switch or filter capacity.

Verification : **A, R, T**

ISIS-EVTR-REQ-30025 v : 1

Units shall be designed and tested to withstand without degradation the shock response spectrum specification given in Table 5.6-5.

Comment : Note 1: Number of shocks is defined as 3 shocks per axis for EQM / QM approach and 1 shock per axis for PFM approach. FM approach do not required shock testing.

Note 2: Shocks are applicable independently to each axes X, Y and Z.

Note 3: Depending on the measured shock response spectrum on a control rejection axis, subsequent specific shock test for this axis may be omitted with agreement of customer.

Verification : **A, R, T**

ISIS-EVTR-REQ-30026 v : 1

Units shall not produce or initiate shocks at release, deployment and latching higher than 50% of the SRS defined in Table 5.6-5.

Verification : **A, R, T**

ISIS-EVTR-REQ-30027 v : 1

Self-induced shocks shall be measured in a frequency band from 100 Hz to 5000 Hz in the vicinity of the release mechanism.

Verification : **A, R, T**

3.2.3. Quasi-static loads and thermoelastic loads for in-orbit phase

In-orbit environment, if and when they exist, are specific to each units and defined in the Unit Requirement

Specification document.

ISIS-EVTR-REQ-30028 v : 2

The unit shall be compatible with internal loads due to thermo-elastic deformation up to an allowable maximum loads TBD by the prime.

Verification : **A**

Maturity: **TBD** on : **allowable maximum loads TBD by the prime.**

3.3. THERMAL ENVIRONMENTS

3.3.1. Launch phase environment

3.3.1.1. Thermal Environment under fairing

ISIS-EVTR-REQ-30029 v : 1

During launch phase, the unit shall withstand mechanical loads in combination with TRP temperature range of [+5, +35]°C

3.3.1.2. Thermal Environment after fairing jettison

ISIS-EVTR-REQ-30030 v : 1

The thermal control of any external unit accommodated outside the S/C shall take into account the free-molecular aerothermal flux which occurs after fairing jettison during launch phase.

Comment : Note 1: The corresponding input in term of fluxes is given in the curve hereafter with 1135 W/m² as initial value (this flux curve is to be confirmed by each mission according to its choice of Launch vehicles in particular in case of re-ignitions of the launcher last stage).

Note 2: This flux is calculated as free molecular heating action on a plane surface perpendicular to the velocity direction.

Note 3: The solar radiation, albedo and earth infrared radiation after the fairing has been jettisoned are not accounted for in this flux curve.

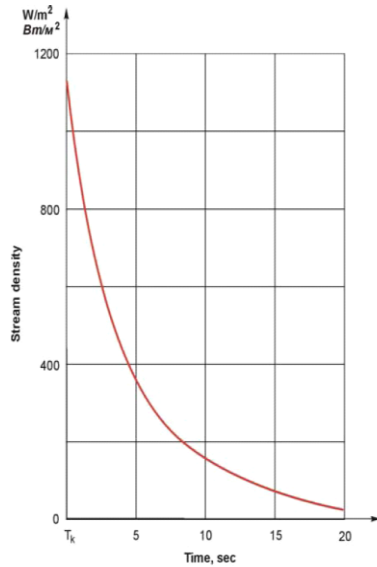


Figure 3.3-1: Free-molecular aerothermal flux

Nota 4 : Plume Heat Flux from Launcher shall also be considered when applicable in addition to aerothermal flux

3.3.2. In-orbit phase

ISIS-EVTR-REQ-30031 v : 1

The thermal control of any external unit accommodated outside the S/C shall take into account the solar flux as follows

- 1428 W/m² in winter solstice;
- 1316 W/m² in summer solstice;
- 1367 W/m² in equinox (spring or autumn).

ISIS-EVTR-REQ-30032 v : 1

The thermal control of any external unit accommodated outside the S/C shall take into account the Earth albedo (solar radiation reflected from the Earth) with an average albedo value of 0.35 in hot sizing case and 0.25 in cold sizing case.

ISIS-EVTR-REQ-30033 v : 1

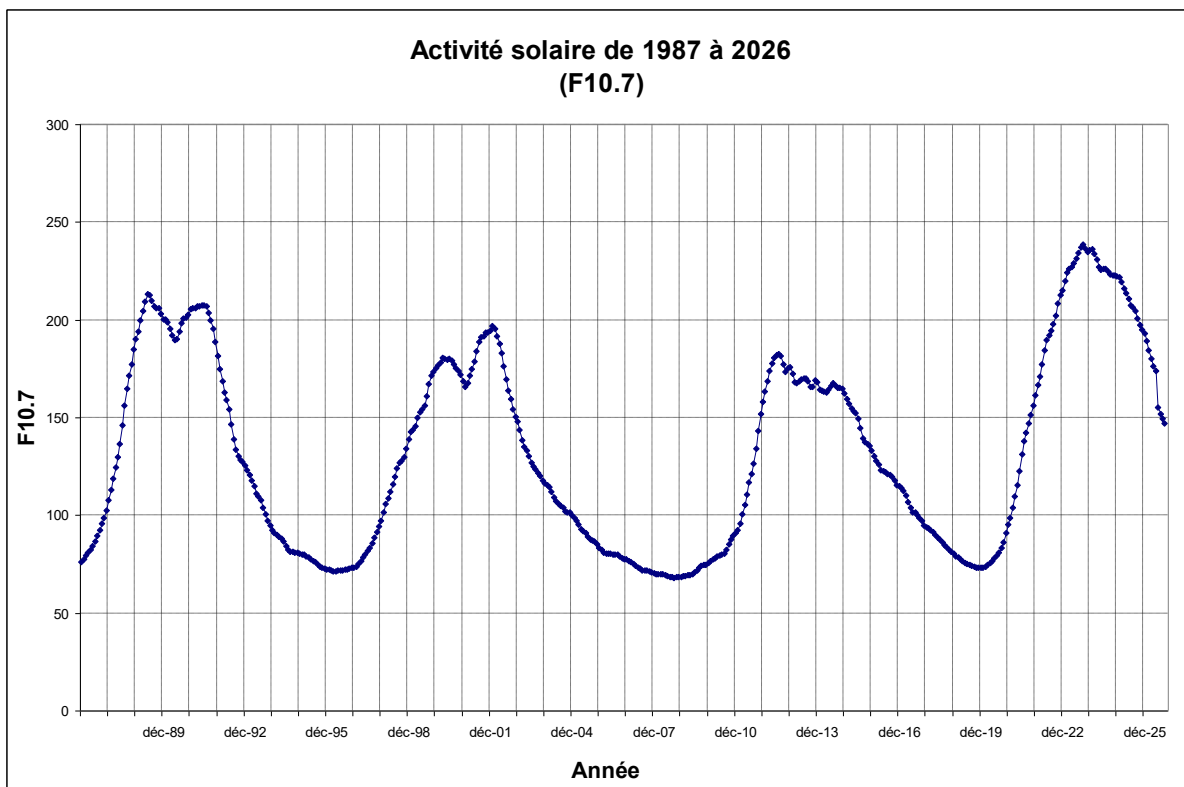
The thermal control of any external unit accommodated outside the S/C shall take into account the Earth emitted IR radiation of 200 W/m^2 (Earth temperature = 244 K) in cold sizing case and 275 W/m^2 (Earth temperature = 264 K) in hot sizing case.

Comment : Note: For orbit inclination inferior to 30° , a multiplicative factor of 1.15 is applied in coherence with flight measurements (for example, with CNES THERME experiment).

3.4. ATOMIC OXYGEN ENVIRONMENT

The external surfaces of a spacecraft receive a dose of ATomic OXygen (ATOX) which can be critical for materials at low altitudes. ATOX fluence has been computed on a ISIS sizing case, with the following inputs:

- The environment model is NRLMSISE-00 with a wind model HWM93;
- A complete solar cycle with high activity (11 year duration), see figure below;
- The sizing case in term of altitude: 500 km;
- A SSO (Sun Synchronous Orbit) with a solar time at ascending node of 6h;
- A 3-axis permanent geocentric attitude and taking into account only the V+ (ram face);
- A uncertainty of 15% (ECSS preconisation including calculation and environment model uncertainties).



The fluence on the ram face with ESA SPENVIS tool with the inputs described above is $1.10^{+22} \text{ atoms.cm}^{-2}$ (including 15% of uncertainties).

The unit shall withstand without degradation an ATOX dose of 1.10^{+22} atoms.cm⁻².

Verification : **A**

4. GENERAL TESTING REQUIREMENTS

This chapter is tailored from Chapter 4 of RD-2. The major modifications refer to as the suppression of the Post-Test Review (PTR) and the suppression of « space segment element » related requirements as this document only applies to units.

4.1. TEST PROGRAMME

ISIS-EVTR-REQ-40001 v : 2

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

Rationale : ECSS-E-ST-10-03C 4.1a

Verification : *R*

ISIS-EVTR-REQ-40002 v : 1

AIT Plan (AITP) and test specifications shall be derived from the product requirements, verification plan and Verification Control Document (VCD).

Rationale : ECSS-E-ST-10-03C 4.1c

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

Verification : *R*

ISIS-EVTR-REQ-40003 v : 1

Test procedures shall be derived from test specifications and AIT Plan.

Rationale : ECSS-E-ST-10-03C 4.1d

Verification : *R*

ISIS-EVTR-REQ-40004 v : 2

Test programme and its implementation shall be in conformance with safety requirements of "Product Assurance and Safety Requirement Referential for ISIS Flight Segment - Volume 1" chapter 9 "SAFETY REQUIREMENTS" (ISIS-SYS-SP-037-CNES) and ECSS-Q-ST-20-07.

Rationale : ECSS-E-ST-10-03C 4.1e

Verification : *R*

4.2. DEVELOPMENT TEST PRIOR QUALIFICATION

ISIS-EVTR-REQ-40005 v : 1

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

Rationale : ECSS-E-ST-10-03C 4.2a

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

Verification : *R*

ISIS-EVTR-REQ-40006 v : 1

Development tests shall not be conducted on qualification or flight models or parts of it.

Rationale : ECSS-E-ST-10-03C 4.2b

Verification : *R*

ISIS-EVTR-REQ-40007 v : 1

Records of test configuration, test results and other pertinent data shall be maintained.

Rationale : ECSS-E-ST-10-03C 4.2c

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

Verification : *R*

4.3. TEST MANAGEMENT

4.3.1. General

ISIS-EVTR-REQ-40008 v : 1

The Supplier shall assign clear responsibility for the implementation of the test programme.

Rationale : ECSS-E-ST-10-03C 4.3.1a

Verification : *R*

ISIS-EVTR-REQ-40009 v : 1

The Customer, or its duly appointed representative, shall have the right to participate to all test phases.

Rationale : ECSS-E-ST-10-03C 4.3.1b

Verification : **R**

4.3.2. Test reviews

4.3.2.1. Test programme

ISIS-EVTR-REQ-40010 v : 1

The test programme shall include the following formal reviews:

- Test Readiness Review (TRR),
- Test Review Board (TRB).

Rationale : ECSS-E-ST-10-03C 4.3.2.1c modified with suppression of PTR

Comment : 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.

Verification : **R**

4.3.2.2. Test Readiness Review (TRR)

ISIS-EVTR-REQ-40011 v : 1

The TRR shall be held before the start of the test activity to verify that all conditions allow to proceed with the test.

Rationale : ECSS-E-ST-10-03C 4.3.2.2a

Verification : **R**

ISIS-EVTR-REQ-40012 v : 1

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 non-conformances 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.

Rationale : ECSS-E-ST-10-03C 4.3.2.2b

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

Verification : **R**

ISIS-EVTR-REQ-40013 v : 1

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.

Rationale : ECSS-E-ST-10-03C 4.3.2.2c

Verification : **R**

ISIS-EVTR-REQ-40014 v : 1

All the open points shall be clearly identified and actions assigned with closure date before the execution of the test.

Rationale : ECSS-E-ST-10-03C 4.3.2.2d

Verification : **R**

ISIS-EVTR-REQ-40015 v : 1

The output of the TRR shall be a decision to proceed with the test or not.

Rationale : ECSS-E-ST-10-03C 4.3.2.2e

Verification : **R**

4.3.2.3. Post Test Review (PTR)

Deleted for ISIS, PTR is not required.

4.3.2.4. Test Review Board (TRB)

ISIS-EVTR-REQ-40016 v : 1

A TRB shall be held to review all results and conclude on the test completeness and achievement of objectives.

Rationale : ECSS-E-ST-10-03C 4.3.2.4a

Verification : **R**

ISIS-EVTR-REQ-40017 v : 1

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.

Rationale : ECSS-E-ST-10-03C 4.3.2.4b

Verification : *R*

ISIS-EVTR-REQ-40018 v : 1

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.

Rationale : ECSS-E-ST-10-03C 4.3.2.4c

Verification : *R*

4.3.3. Test documentation

Not applicable for ISIS

4.3.4. Anomaly or failure during testing

ISIS-EVTR-REQ-40019 v : 1

Any failure or anomaly during testing shall be recorded.

Rationale : ECSS-E-ST-10-03c 4.3.4a

Verification : *R*

ISIS-EVTR-REQ-40020 v : 1

All non-conformances shall be managed in conformance with ECSS-Q-ST-10-09.

Rationale : ECSS-E-ST-10-03c 4.3.4b

Verification : *R*

ISIS-EVTR-REQ-40021 v : 1

The NRB shall decide on the necessity and extent of any retest activity in order to demonstrate the correctness of the disposition made.

Rationale : ECSS-E-ST-10-03c 4.3.4c

Verification : **R**

ISIS-EVTR-REQ-40022 v : 1

Any unusual or unexpected behaviour shall be evaluated to determine the existence of any trend potentially leading to anomaly or failure situation

Rationale : ECSS-E-ST-10-03c 5.1d

Verification : **A, R**

4.3.5. Test data

ISIS-EVTR-REQ-40024 v : 1

The test data shall be compared across major test sequences for trends or evidence of anomalous behaviour of the test setup.

Rationale : Implicit ECSS-E-ST-10-03c 4.3.5c

Verification : **A, I, R**

ISIS-EVTR-REQ-40025 v : 1

Test measurements and the environmental conditions on the products shall be recorded for subsequent evaluation.

Rationale : ECSS-E-ST-10-03c 4.3.5a

Verification : **R**

ISIS-EVTR-REQ-40026 v : 1

A database of parameters shall be established for trend analysis.

Rationale : ECSS-E-ST-10-03c 4.3.5b

Verification : **R**

4.4. TEST CONDITIONS, TOLERANCES, AND ACCURACIES

4.4.1. Test conditions

ISIS-EVTR-REQ-40028 v : 1

Test conditions shall be established using predicted environment plus margins.

Rationale : ECSS-E-ST-10-03c 4.4.1a

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

Verification : **A, I, R**

ISIS-EVTR-REQ-40029 v : 1

Tests shall be performed simulating the mission envelope, including operational and non-operational conditions with margins.

Rationale : ECSS-E-ST-10-03c 4.4.1b

Verification : **R**

ISIS-EVTR-REQ-40030 v : 1

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 durations.

Rationale : ECSS-E-ST-10-03c 4.4.1c; the example within the note concerns Thermal Control; vocabulary is corrected; the example is improved (heat conduction through gazes and limited test facilities).

Comment : In this case, the test levels and durations are modified based on analyses. For example to prevent effects of conductive or convective heat transfer that reduce temperature differences through gazes, in particular when a test facility does not allow a sufficient high vacuum environment.

Verification : **R**

ISIS-EVTR-REQ-40031 v : 1

Cleanliness and contamination control for test programmes shall conform to ECSS-Q-ST-70-01.

Rationale : ECSS-E-ST-10-03c 4.4.1d

Verification : **R**

ISIS-EVTR-REQ-40032 v : 1

The quality and safety management system used to operate and maintain test facility(ies) shall be recognized by the Customer.

Rationale : ECSS-E-ST-10-03c 4.4.1e

Comment : Note1 : « Recognize » correspond to the « Ground Operations and Safety Survey » activities performed in the AIT and safety frame ».

Note2 : For example, in accordance to quality and safety management system requirements from ECSS-Q-ST-20-07.

Verification : **R**

ISIS-EVTR-REQ-40033 v : 1

Test facilities, tools and instrumentation shall not prevent to fulfil the tests objectives.

Rationale : ECSS-E-ST-10-03c 4.4.1f

Verification : **R**

ISIS-EVTR-REQ-40034 v : 1

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).

Rationale : ECSS-E-ST-10-03c 4.4.1g

Verification : **R**

ISIS-EVTR-REQ-40035 v : 1

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.

Rationale : ECSS-E-ST-10-03c 4.4.1h

Verification : **R**

4.4.2. Test tolerances

ISIS-EVTR-REQ-40036 v : 1

Test tolerances bands shall be specified in test error budgets and agreed by the Customer prior to start of test.

Rationale : ECSS-E-ST-10-03c 4.4.2a

Verification : **R**

ISIS-EVTR-REQ-40037 v : 1

For the purpose of ISIS-EVTR-REQ-30032, test tolerances shall be justified by reference to the uncertainty budget and confidence level of the measurement instrument(s) used.

Rationale : ECSS-E-ST-10-03c 4.4.2b

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

Verification : **R**

ISIS-EVTR-REQ-40038 v : 1

The accuracy of instrument and test equipment used to control or measure the test parameters shall be in general, one order of magnitude better than the tolerance for the variable to be measured.

Rationale : Implicit ECSS-E-ST-10-03c 4.4.2b

Verification : **I, R**

ISIS-EVTR-REQ-40039 v : 1

Quantitative requirements demonstrated by measured test values shall account for test inaccuracies and tolerances, and be compared with the specified requested values.

Rationale : ECSS-E-ST-10-03c 4.4.2c

Verification : **R**

ISIS-EVTR-REQ-40040 v : 1

The tolerances specified in Table 4.4-1 shall be applied to the test values.

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

Test parameters	Tolerances
8. Microvibration	
Acceleration	±10 %
Forces or torque	±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	± 4 % of the set value
in reference volume	± 6 % of the set value
11. Infrared flux	
Mean value	± 3 % on reference plane(s)
12. Test duration	-0/+10 %

Table 4.4-1: Allowable tolerances

Rationale : ECSS-E-ST-10-03c 4.4.2d

Verification : *R*

ISIS-EVTR-REQ-40041 v : 1

Changes to the tolerances specified in Table 4.4-1 shall be approved by the Customer.

Rationale : ECSS-E-ST-10-03c 4.4.2e

Comment : For example, when tolerances of Table 4.4-1 are detected to be inconsistent with test accuracy values of Table 4.4-1.

Verification : *R*

4.4.3. Test accuracies

ISIS-EVTR-REQ-40042 v : 1

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

Rationale : ECSS-E-ST-10-03c 4.4.3a

Verification : **R**

ISIS-EVTR-REQ-40043 v : 1

The accuracy of test instrumentation shall be verified in accordance with approved calibration procedures, with traceability to international measurement standards.

Rationale : ECSS-E-ST-10-03c 4.4.3b

Verification : **I, R**

ISIS-EVTR-REQ-40044 v : 1

All test instrumentation shall be within the normal calibration period at the time of the test.

Rationale : ECSS-E-ST-10-03c 4.4.3c

Verification : **I, R**

ISIS-EVTR-REQ-40045 v : 1

Any anomaly of test instrumentation, detected at the first calibration sequence after the test, shall be reported.

Rationale : ECSS-E-ST-10-03c 4.4.3d

Verification : **R**

ISIS-EVTR-REQ-40046 v : 2

The accuracy of measurement shall be as follows:

1. as per Table 4.4-2 for the parameters listed, or
2. at least one third of the tolerance of the variable to be measured.

Test parameters	Accuracy
1. Mass	
Space segment equipment	± 0,1 % for masses > 10kg ± 10 g for masses up to and equal to 10kg
2. Centre of gravity (CoG)	
Space segment equipment	Within a 1 mm radius sphere
3. Moment of inertia (MoI)	
Space segment equipment	± 10 % for each axis
4. Leak rate	One magnitude lower than the system specification, in Pa m ³ 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	± 15 %
1,3 10 ⁻³ hPa to 1,3 hPa	± 30 %
< 1,3 10 ⁻³ hPa	± 80 %
8. Acceleration (steady state) and static load	± 10 %
9. Frequency for mechanical tests	± 2 % (or ±1 Hz whichever is greater)
10. Acoustic noise	± 0,1dB
11. Strain	± 10 %
12. EMC	Distance: ± 10 % Frequency: ± 2 % Amplitude measurement receiver: ± 2 dB Amplitude measurement system (includes measurement receivers, transducers, cables, connectors) : ± 3 dB Time (waveforms): ± 10 % Resistors: ± 5 % Capacitors: ± 20 %
13. ESD	

Table 4.4-2: Test accuracies

Rationale : ECSS-E-ST-10-03c 4.4.3e

Comment : The values of Table 4.4-2 are typical from test centre capabilities.

Verification : **I, R**

4.5. TEST OBJECTIVES

4.5.1. General requirements

ISIS-EVTR-REQ-40047 v : 1

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

Rationale : ECSS-E-ST-10-03c 4.5.1a

Comment : Note 1: The model philosophy, including model definition, is detailed in ECSS-E-HB-10-02.

Note 2: The test programme shall include test objectives and success criteria.

Verification : **R**

4.5.2. Qualification testing

ISIS-EVTR-REQ-40048 v : 1

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

Rationale : ECSS-E-ST-10-03c 4.5.2a, for space segment equipment only

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

Verification : **R, T**

ISIS-EVTR-REQ-40049 v : 1

Qualification testing shall be conducted on dedicated qualification models except when using protoflight approach.

Rationale : ECSS-E-ST-10-03c 4.5.2b

Verification : **R, T**

ISIS-EVTR-REQ-40050 v : 1

Qualification testing shall be completed and design improvements or modification incorporated and qualified prior to the authorization for the flight product manufacturing.

Rationale : ECSS-E-ST-10-03c 4.5.2c

Verification : **R, T**

ISIS-EVTR-REQ-40051 v : 1

Upon achievement of qualification the design files shall not be modified.

Rationale : ECSS-E-ST-10-03c 4.5.2d

Verification : **R**

ISIS-EVTR-REQ-40052 v : 1

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.

Rationale : ECSS-E-ST-10-03c 4.5.2e

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

Verification : **R, T**

ISIS-EVTR-REQ-40053 v : 2

The qualification test levels and durations shall be as specified in Table 4.5-1.

No	Test	Levels	Duration	Number of applications	NOTES
1	Life	Expected environment and maximum operational load	For duration and cycles: For mechanisms, apply ECSS-E-ST-33-01 Table 4-3 For batteries, apply ECSS-E-ST-20	1 test	
2	Static load	KQ x Limit Load The qualification factor KQ is given in ECSS-E-ST-32-10 clause 4.3.1	As needed to record data (10 seconds minimum)	Worst combined load cases	Worst combined load cases are determined by analysis
3	Spin	$\sqrt{KQ}$ x spin rate The qualification factor KQ is given in ECSS-E-ST-32-10	As specified by the project	1 test	
4	Transient	KQ x Limit Load The qualification factor KQ is given in ECSS-E-ST-32-10 clause 4.3.1	As needed to record data	As specified	
5	Random vibration	Maximum expected spectrum +3 dB on PSD values If margins higher than 3 dB are specified by the Launcher Authority, they apply.	2 minutes	On each of 3 orthogonal axes	
6	Acoustic	Maximum expected acoustic spectrum +3 dB If margins higher than 3 dB are specified by the Launcher Authority, they apply	2 minutes	1 test	
7	Sinusoidal vibration	KQ x Limit Load Spectrum The qualification factor KQ is given in ECSS-E-ST-32-10 clause 4.3.1	sweep at 2 Oct/min, 5 Hz - 140 Hz	On each of 3 orthogonal axes	

No	Test	Levels	Duration	Number of applications	NOTES
8	Shock	Maximum expected shock spectrum +3 dB qualification margin (See note 1)	Duration representative of the expected environment (See note 2)	The number of shock application covering the complete life cycle of the FM H/W in all 3 orthogonal axes. (See note 3)	NOTE 1: Qualification programme test of space segment elements can include a test where the shock generative device is activated. This test is performed with no margins to consolidate the shock specification of the space segment equipment unit. NOTE 2: Typical duration is between 20ms and 30ms. NOTE 3: The number of applications can effectively take two values: 1, in case the space segment equipment unit will only be exposed to the flight shock event ; or 3, in case the space segment equipment unit will also be exposed to a qualifying shock test at space segment element level (including a provision for an additional retest should then be considered).
9	Microvibration susceptibility	Maximum predicted environment	As needed for susceptibility determination	As specified by the project.	
10	Leak	MDP	pressure maintained for 30 minutes as minimum		
11	Proof pressure	jproof x MDP For the proof factor (jproof), apply ECSS-E-ST-32-02 Tables 4-1 to 4-9.	5 minutes minimum hold time	The number of pressure application covering the complete life cycle of the FM HW.	

No	Test	Levels	Duration	Number of applications	NOTES
12	Pressure cycling	MDP	50 cycles or 4 x the number of planned pressure cycles expected in one service life, whichever is greater	1 test	
13	Design burst pressure	jburst x MDP For the burst factor (jbust), apply ECSS-E-ST-32-02 Tables 4-1 to 4-9.	30 seconds as minimum	1 test	
14	Burst	Pressure increased until burst occurs	Until burst occurs	1 test	On dedicated model or on QM (if performed on QM, this destructive test will be the last test to be done)
15	Vacuum temperature cycling (VTC or thermal vacuum)	TQ level corresponds to extreme unit temperature at which the unit fulfills all specified requirements. Lower qualification margin than +/-5 °C may be used for temperature below -170 °C. Higher qualification margin than +/- 5 °C may be used for temperature above 120 °C.	8 cycles or 1 or more cycles if combined with earth atmospheric pressure cycles For solar panels, 10 cycles	1 test	
16	Ambient pressure temperature cycling (APTC or thermal cycling or thermal ambient)	TQ level corresponds to extreme unit temperature at which the unit fulfills all specified requirements. Lower qualification margin than +/-5 °C may be used for temperature below -170 °C. Higher qualification margin than +/-5 °C may be used for temperature above 120 °C.	8 cycles or 8 cycles minus the number of cycles performed during the VTC test	1 test	

No	Test	Levels	Duration	Number of applications	NOTES
17	EMC	See ECSS-E-ST-20-07 clause 5.4	See ECSS-E-ST-20-07 Clause 5.4	1 test	
18	ESD	See ECSS-E-ST-20-06 See ECSS-E-ST-20-07 clause 5.2.1. for ESD test See ECSS-E-ST-20-08 for the solar array and solar panels	See ECSS-E-ST-20-06 See ECSS-E-ST-20-07 clause 5.2.1. for ESD test See ECSS-E-ST-20-08 for the solar array and solar panels	1 test	
19	Passive Intermodulation	See ECSS-E-ST-20 clause 7.4		See ECSS-E-ST-20 clause 7.4	
20	Corona and arc discharge	Maximum operational voltage and maximum RF output power for RF equipment sweep over the critical pressure range over 10 hPa to 0, 1 hPa	10 to 15 minutes	1 test	For a given frequency, minimum gap within the space segment equipment unit, and given pressure a Paschen curve is defined. This curve has a minimum of power within the pressure range.

NOTE: The table does not include tests for some ambient conditions such as humidity and toxic offgassing because they are performed exposing the hardware to the environment without margin.

Table 4.5-1: Qualification test levels and durations

Rationale : ECSS-E-ST-10-03c 4.5.2f, for equipment only

Comment : The test durations identified in Table 4.5-1 are the minimum values.

Verification : **R**

4.5.3. Acceptance testing

ISIS-EVTR-REQ-40054 v : 1

Acceptance testing shall be performed to provide evidence that the space segment equipment performs in accordance with the specifications in the intended environments with the specified acceptance margins.

Rationale : ECSS-E-ST-10-03c 4.5.3a for space segment equipment only

Verification : **R**

ISIS-EVTR-REQ-40055 v : 1

Acceptance testing shall be performed on each flight product, except the one used as Protoflight, to assure freedom from workmanship defects and flawed materials in conformance with ECSS-E-ST-10-02.

Rationale : ECSS-E-ST-10-03c 4.5.3b

Verification : **R**

ISIS-EVTR-REQ-40056 v : 1

The acceptance programme shall be performed, after a qualification programme has been completed (refer § 4.5.2 "Qualification testing" or § 4.5.4 "Protoflight testing").

Rationale : ECSS-E-ST-10-03c 4.5.3c

Comment : The FM is built from the same design file than the QM or the PFM used for qualification, as specified in the ECSS-E-ST-10-02.

Verification : **R**

ISIS-EVTR-REQ-40057 v : 2

The acceptance test levels and durations shall be as specified in Table 4.5-2.

No	Test	Levels	Duration	Number of applications	NOTES
1	Random vibration	Maximum expected spectrum +0dB on PSD values	1 minute	On each of 3 orthogonal axes	
2	Acoustic	Maximum expected acoustic spectrum +0dB	1 minute	1 test	
3	Sinusoidal vibration	KA x Limit Load Spectrum The acceptance factor KA is given in ECSS-E-ST-32-10 clause 4.3.1	Sweep at 4 Oct/min, 5 Hz - 140 Hz	On each of 3 orthogonal axes	
4	Microvibration susceptibility	Maximum predicted environment	As needed for susceptibility determination	As specified by the project.	
5	Leak	MDP	Pressure maintained for 30 minutes as minimum		
6	Proof pressure	jproof x MDP For the proof factor (jproof), apply ECSS-E-ST-32-02 Tables 4-1 to 4-9.	5 minutes minimum hold time	1	
7	Vacuum temperature cycling (VTC or thermal vacuum)	$T_{max}^{A op/NOp} = T_{max}^{A op/NOp} + 5^{\circ}\text{C}$ $T_{min}^{A op/NOp} = T_{min}^{A op/NOp} - 5^{\circ}\text{C}$ Lower acceptance margin than +/-5 °C, may be used for temperature below -170 °C. Higher acceptance margin than +/-5 °C may be used for temperature above 120 °C.	4 cycles or 1 or more cycles if combined with earth atmospheric pressure cycles For solar panels, 5 cycles (See note)	1 test	Note: The number of cycles is modified on the following cases: 1. In case the solar panel design or manufacturing process or manufacturer does not have flight heritage, 10 cycles are performed., 2. In case the solar panel qualification is performed on one panel only, 10 cycles are performed as acceptance test 3. In case of significant flight heritage on design, processes and manufacturers it can be reduced to 3 cycles

No	Test	Levels	Duration	Number of applications	NOTES
8	Ambient pressure temperature cycling (APTC or thermal cycling or thermal ambient)	$T_{max}^A _{op/NOp} = T_{max}^A _{op/NOp} + 5^{\circ}\text{C}$ $T_{min}^A _{op/NOp} = T_{min}^A _{op/NOp} - 5^{\circ}\text{C}$ Lower acceptance margin than $\pm 5^{\circ}\text{C}$ may be used for temperature below -170°C . Higher acceptance margin than $\pm 5^{\circ}\text{C}$ may be used for temperature above 120°C .	4 cycles or 4 cycles minus the number of cycles performed during the VTC test	1 test	.
9	EMC	Apply ECSS-E-ST-20-07 clause 5.4	Apply ECSS-E-ST-20-07 Clause 5.4	1 test	
10	Passive intermodulation	For equipment see ECSS-E-ST-20 clause 7.4		See ECSS-E-ST-20 clause 7.4	
11	Corona and Arc discharge	Maximum operational voltage and maximum RF output power for RF equipment Sweep over the critical pressure range over 10 hPa to 0,1 hPa	10 to 15 minutes	1 test	For a given frequency, minimum gap within the space segment equipment unit, and given pressure a Paschen curve is defined. This curve has a minimum of power within the pressure range.
NOTE: The table does not include tests for some ambient conditions such as humidity and toxic offgassing because they are performed exposing the hardware to the environment without margin.					

Table 4.5-2: Acceptance test levels and durations

Rationale : ECSS-E-ST-10-03c 4.5.3d for space segment equipment only

Comment : The test durations identified in Table 4.5-2 are the minimum values.

Verification : **R**

4.5.4. Protoflight testing

4.5.4.1. Overview

Protoflight testing is the combination of the qualification and acceptance testing objectives on the first flight model.

The protoflight approach can be applied at each level of decomposition of space system.

4.5.4.2. Requirements

ISIS-EVTR-REQ-40058 v : 1

Protoflight testing shall be performed on the first flight model to provide evidence that the space segment equipment performs in accordance with the specifications in the intended environments with the specified qualification margins and to confirm its readiness for delivery and subsequent usage, being free from workmanship defects and flawed materials.

Rationale : ECSS-E-ST-10-03c 4.5.4.2a for space segment equipment only

Comment : This evidence is used, in addition 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).

Verification : **R**

ISIS-EVTR-REQ-40059 v : 1

In case destructive tests are needed (e.g. burst test), a representative model different from the PFM shall be used.

Rationale : ECSS-E-ST-10-03c 4.5.4.2b

Comment : This model can be simplified but needs to be fully representative of the function to be tested.

Verification : **R**

ISIS-EVTR-REQ-40060 v : 2

The protoflight test levels and durations shall be as specified in Table 4.5-3.

No	Test	Levels	Duration	Number of applications	NOTES
1	Life	Expected environment and maximum operational load	For duration and cycles: For mechanisms, apply ECSS-E-ST-33-01 Table 4-3. For batteries, apply ECSS-E-ST-20	1 test	
2	Spin	$\sqrt{KQ}$ x spin rate The qualification factor KQ is given in ECSS-E-ST-32-10	As needed to record data	On each of 3 orthogonal axes	
3	Transient	KQ x Limit Load The qualification factor KQ is given in ECSS-E-ST-32-10 clause 4.3.1	As needed to record data	As specified	
4	Random vibration	Maximum expected spectrum +3 dB on PSD values If margins higher than 3 dB are specified by the Launcher Authority, they apply.	1 minute	On each of 3 orthogonal axes	
5	Acoustic	Maximum expected acoustic spectrum +3 dB If margins higher than 3 dB are specified by the Launcher Authority, they apply	1 minute	1 test	
6	Sinusoidal vibration	KQ x Limit Load Spectrum The qualification factor KQ is given in ECSS-E-ST-32-10 clause 4.3.1	sweep at 4 Oct/min, 5 Hz – 140 Hz	On each of 3 orthogonal axes	

No	Test	Levels	Duration	Number of applications	NOTES
7	Shock	Maximum expected shock spectrum +3 dB margin (See note 1)	As specified by the project. (See note 2)	1 test	NOTE 1: Qualification programme test of space segment elements can include a test where the shock generative device is activated. This test is performed with no margins to consolidate the shock specification of the space segment equipment unit. NOTE 2: Typical duration is between 20ms and 30ms.
8	Microvibration susceptibility	Maximum predicted environment	As needed for susceptibility determination	As specified by the project.	
9	Leak	MDP	Pressure maintained for 30 minutes as minimum		
10	Proof pressure	jproof x MDP For the proof factor (jproof), apply ECSS-E-ST-32-02 Tables 4-1 to 4-9.	5 minutes minimum hold time	1 test	
11	Vacuum temperature cycling (VTC or thermal vacuum)	TQ level corresponds to extreme unit temperature at which the unit fulfills all specified requirements. Lower qualification margin than +/-5 °C may be used for temperature below -170 °C. Higher qualification margin than +/-5 °C may be used for temperature above 120 °C.	4 cycles or 1 or more cycles if combined with ambient pressure cycles For solar panels, 10 cycles	1 test	

No	Test	Levels	Duration	Number of applications	NOTES
12	Ambient pressure temperature cycling (APTC or thermal cycling or thermal ambient)	TQ level corresponds to extreme unit temperature at which the unit fulfills all specified requirements. Lower qualification margin than +/-5 °C may be used for temperature below -170 °C. Higher qualification margin than +/-5 °C may be used for temperature above 120 °C.	4 cycles or 4 cycles minus the number of cycles performed during the VTC test	1 test	
13	EMC	See ECSS-E-ST-20-07 clause 5.4	See ECSS-E-ST-20-07 clause 5.4	1 test	
14	ESD	See ECSS-E-ST-20-06 See ECSS-E-ST-20-07 clause 5.2.1. for ESD test See ECSS-E-ST-20-08 for the solar array and solar panels	See ECSS-E-ST-20-06 See ECSS-E-ST-20-07 clause 5.2.1. for ESD test See ECSS-E-ST-20-08 for the solar array and solar panels	1 test	
15	Passive Intermodulation	See ECSS-E-ST-20 clause 7.4		See ECSS-E-ST-20 clause 7.4	
16	Corona and arc discharge	Maximum operational voltage and maximum RF output power for RF equipment sweep over the critical pressure range over 10 hPa to 0,1 hPa	10 to 15 minutes	1 test	For a given frequency, minimum gap within the space segment equipment unit, and given pressure a Paschen curve is defined. This curve has a minimum of power within the pressure range.

NOTE: The table does not include tests for some ambient conditions such as humidity and toxic offgassing because they are performed exposing the hardware to the environment without margin.

Table 4.5-3: Protoflight test levels and durations

Rationale : ECSS-E-ST-10-03c 4.5.4.2c for space segment equipment only

Comment : Note 1: The general approach is to select:

- test levels: as qualification levels;
- test durations: as acceptance durations.

Note 2: The test durations identified in Table 4.5-3 are the minimum values.

Verification : **R**

4.6. RETESTING

4.6.1. Overview

ECSS-E-ST-10-02 identifies several situations, in which re-verification is required. However, as the scope and the nature of retesting differ so much, test requirements are defined on a case-by-case basis. Examples of cases involving retesting are described in paragraphs 4.6.2 to 4.6.5 below.

4.6.2. Implementation of a design modification after completion of qualification

ISIS-EVTR-REQ-40061 v : 1

The Configuration Control Board (CCB), as per ECSS-M-ST-40, shall convene to evaluate and decide the extent of the qualification test sequence to be repeated.

Rationale : ECSS-E-ST-10-03c 4.6.2a

Verification : *R*

4.6.3. Storage after protoflight or acceptance testing

ISIS-EVTR-REQ-40062 v : 1

The Supplier shall identify the testing requirements during storage and post-storage.

Rationale : ECSS-E-ST-10-03c 4.6.3a

Comment : These requirements can be identified in the User Manual.

Verification : *R*

ISIS-EVTR-REQ-40063 v : 1

Periodic tests shall be assessed and performed with a frequency accounting for:

1. space segment equipment degradation, and
2. specific personnel know-how maintenance.

Rationale : ECSS-E-ST-10-03c 4.6.3b

Verification : *R*

ISIS-EVTR-REQ-40064 v : 1

Storage configuration shall be agreed with the Customer in particular for the deployable mechanisms.

Rationale : ECSS-E-ST-10-03c 4.6.3c

Verification : **R**

ISIS-EVTR-REQ-40065 v : 1

The periodic tests during storage shall cover:

1. overall functional test,
2. testing of the rotating parts,
3. power consumption measurement,
4. TT&C space segment subsystem through tests caps (space segment element switched ON),
5. testing of the propulsion space segment subsystem pressure through the telemetry,
6. visual inspection of the separately stored space segment equipment in a suitable clean work area,
7. contamination tests on the contamination probes.

Rationale : ECSS-E-ST-10-03c 4.6.3d

Comment : Note for 7: Example of age sensitive space segment equipment: Travelling Wave Tubes, batteries and special lubricated mechanisms valves and motors.

Verification : **R**

ISIS-EVTR-REQ-40066 v : 2

Any additional test to the ones listed in ISIS-EVTR-REQ-40065 shall be identified for Customer approval.

Rationale : ECSS-E-ST-10-03c 4.6.3e

Verification : **R**

ISIS-EVTR-REQ-40067 v : 1

The storage procedure shall be submitted to the Customer for approval.

Rationale : ECSS-E-ST-10-03c 4.6.3f

Verification : **R**

4.6.4. Equipment to be re-flown

Not applicable for ISIS.

4.6.5. Flight use of qualification space segment equipment

ISIS-EVTR-REQ-40068 v : 1

Use of qualification space segment equipment shall not be allowed unless agreed by the Customer.

Rationale : ECSS-E-ST-10-03c 4.6.5a for space segment equipment only

Verification : **R**

ISIS-EVTR-REQ-40069 v : 1

Additional testing of qualification space segment equipment subsequently selected for flight shall be compatible with the residual life.

Rationale : ECSS-E-ST-10-03c 4.6.5b for space segment equipment only

Comment : This is done when the Customer considers the risk acceptable.

Verification : **R**

ISIS-EVTR-REQ-40070 v : 1

In case of refurbishment or disassembly the qualification space segment equipment shall be subjected to an acceptance re-testing to be agreed with the customer.

Rationale : ECSS-E-ST-10-03c 4.6.5c for space segment equipment only

Comment : The extend of the acceptance testing depends on the item past history and on the extend of the modification.

Verification : **R**

5. MECHANICAL TEST REQUIREMENTS

These requirements, when relevant, are applicable to all mechanical environments and tests definition.

ISIS-EVTR-REQ-50001 v : 2

The success criteria for resonance search before and after environmental test shall be:

1. Less than 5% in frequency shift, for modes with an effective mass greater than 10 %;
2. Less than 20 % in amplitude shift for modes with an effective mass greater than 10%

Rationale : ECSS-E-ST-10-03c 5.5.2.3d

Verification : *R*

ISIS-EVTR-REQ-50028 v : 1

In addition to the requirement ISIS-EVTR-REQ-50001, Differences between QM and FMs resonances shall lower than :

± 10 % in frequency

± 25 % in amplitude

Rationale : ECSS-E-ST-10-03c 5.5.2.5c

ISIS-EVTR-REQ-50002 v : 1

Detailed visual checks shall be carried out prior and after test to check for visual damage.

Rationale : ECSS-E-ST-10-03c 5.5.2.5d / ECSS-E-ST-10-03c 5.5.2.6f

Verification : *R*

5.1. TEST CONDITIONS

ISIS-EVTR-REQ-50003 v : 1

The unit shall be mounted on a rigid vibration adapter. Prior to installation of the unit to be tested, an empty fixture vibration test shall be performed.

Verification : *A, I, T*

5.2. PHYSICAL PROPERTIES MEASUREMENTS

ISIS-EVTR-REQ-50004 v : 1

The dimensions and interfaces of the unit shall be physically measured using tools and techniques that conform to the required accuracy, as specified in table 4.4-2.

Rationale : Implicit ECSS-E-ST-10-03c 5.5.2.1a

Verification : **A, R, T**

ISIS-EVTR-REQ-50005 v : 1

The mass of the unit shall be physically measured using tools and techniques that conform to the required accuracy, as specified in table 4.4-2.

Rationale : Implicit ECSS-E-ST-10-03c 5.5.2.1a

Verification : **A, R, T**

~~ISIS-EVTR-REQ-50006 v : 2~~

~~DELETED : The center of gravity of the unit, with respect to the unit reference coordinate system, shall be physically measured using tools and techniques that conform to the required accuracy, as specified in Table 4.4-2.~~

~~**Rationale :** Implicit ECSS-E-ST-10-03c 5.5.2.1a~~

~~**Comment :** For units with simple shape the center of gravity can be determined by calculation.~~

~~**Verification :** **A, R, T**~~

~~ISIS-EVTR-REQ-50007 v : 2~~

~~DELETED : The momentum of inertia of the unit, with respect to the unit center of gravity, shall be determined using tools and techniques that conform to the required accuracy as specified in table 4.4-2.~~

~~**Rationale :** Implicit ECSS-E-ST-10-03c 5.5.2.1a~~

~~**Comment :** For units with simple shape the momentum of inertia can be determined by calculation.~~

~~**Verification :** **A, R, T**~~

ISIS-EVTR-REQ-50008 v : 1

The unit shall be in launch configuration, unless this configuration cannot be reproduced on ground.

Rationale : ECSS-E-ST-10-03c 5.5.2.1b

Verification : **A, R, T**

5.3. SINUSOIDAL VIBRATION TEST

ISIS-EVTR-REQ-50009 v : 1

Sinusoidal vibration tests shall be conducted in launch configuration for all axes.

Rationale : ECSS-E-ST-10-03c 5.5.2.5a

Verification : **R**

ISIS-EVTR-REQ-50010 v : 1

A resonance search shall be performed before and after the sinusoidal vibration test to determine resonance frequencies to evaluate the unit integrity.

Rationale : ECSS-E-ST-10-03c 5.5.2.5b

Verification : **R**

ISIS-EVTR-REQ-50011 v : 1

The induced cross axis excitation shall be monitored to check that the response in the cross axis does not exceed the specification in table 5.6-2.

Rationale : ECSS-E-ST-10-03c 5.5.2.5e

Verification : **R**

5.4. RANDOM VIBRATION TEST

ISIS-EVTR-REQ-50012 v : 1

Random vibration tests shall be conducted in launch configuration for all axes.

Rationale : ECSS-E-ST-10-03c 5.5.2.3a

Verification : **R**

ISIS-EVTR-REQ-50013 v : 1

The induced cross axis accelerations at the attachment points shall be limited to the maximum test levels specified for the cross axis.

Rationale : ECSS-E-ST-10-03c 5.5.2.3b

Verification : **R**

ISIS-EVTR-REQ-50014 v : 1

In order to evaluate the unit integrity, a resonance search shall be performed before and after the random vibration test.

Rationale : ECSS-E-ST-10-03c 5.5.2.3c

Verification : *R*

5.5. SHOCK TEST

ISIS-EVTR-REQ-50015 v : 1

Equipment powered during the event where the shock is produced, shall be powered during the test.

Rationale : ECSS-E-ST-10-03c 5.5.2.6b

Verification : *R*

ISIS-EVTR-REQ-50016 v : 1

The equipment shall be mounted to a fixture using its normal mounting points.

Rationale : ECSS-E-ST-10-03c 5.5.2.6c

Verification : *R*

ISIS-EVTR-REQ-50017 v : 1

A resonance search shall be performed before and after the shock vibration test to determine resonance frequencies to evaluate the unit integrity.

Rationale : Implicit ECSS-E-ST-10-03c 5.5.2.6g

Verification : *R*

ISIS-EVTR-REQ-50018 v : 1

The induced cross axis excitation shall be monitored to check that the response in the cross axis does not exceed the specification.

Rationale : ECSS-E-ST-10-03c 5.5.2.6h

Comment : depending on the measured shock response spectrum on a control rejection axis, subsequent specific shock test for this axis may be omitted with agreement of customer.

Verification : *R*

ISIS-EVTR-REQ-50019 v : 1

The homogeneity of the shock around the equipment under test shall be monitored by at least one pair of sensors at opposite corners of the equipment.

Rationale : ECSS-E-ST-10-03c 5.5.2.6i

Verification : **R**

5.6. MECHANICAL TESTS LEVELS

5.6.1. General

The mechanical tests specification hereafter is not applicable to specific units like big Propellant tanks, Pressurant tanks, Solar Arrays and larges appendices.

This specification distinguishes Units on Primary structure from Units on Secondary structures (equipment on mast, antenna, etc.) which are light equipment by definition.

ISIS-EVTR-REQ-50020 v : 1

The mechanical test levels hereafter shall only be applicable to units with frequency > 140 Hz.

Verification : **R**

ISIS-EVTR-REQ-50021 v : 1

Units mounted on the spacecraft shall withstand sine resonance search test level without degradation as defined in Table 5.6-1.

AXIS / UNIT MASS	FREQ. RANGE (HZ)	REASONANCE SEARCH LOW LEVEL SINE TEST (LLS)
Perpendicular and Parallel to mounting plane		
Units	(5-2000)	0.5g
	Sweep rate	2 Oct/min per axis

Table 5.6-1: Resonance search low level sine environment for units

Comment : A sweep down after sweep up may be requested in case non-linearity is suspected in unit behaviour.

Verification : **T**

ISIS-EVTR-REQ-50022 v : 1

Functional tests shall be conducted after full level exposure (i.e functional test is performed after the last sine low levels) in the three axes.

Verification : **T**

ISIS-EVTR-REQ-50023 v : 1

TBC with MOIs :

~~Deleted for Myriade Evolutions, no electronic units active at Launch.~~

Maturity: TBC on : Requirement to be confirmed and defined

5.6.2. Sine tests levels

ISIS-EVTR-REQ-50024 v : 1

Units mounted on the spacecraft shall withstand sine tests levels without degradation as defined in Table 5.6-2.

AXIS / UNIT MASS	FREQ. RANGE (HZ)	ACCEPTANCE TEST LEVEL (AL) ACCELERATION	PROTO FLIGHT TEST LEVEL (PFM) ACCELERATION	QUALIFICATION TEST LEVEL (QL) ACCELERATION
Perpendicular and Parallel to mounting plane				
Units on Primary structure (except propulsion Tanks)	(21-100)	20 g	25 g	25 g
	Sweep rate	4 Oct/min per axis	4 Oct/min per axis	2 Oct/min per axis

Table 5.6-2: Sine environment for units - AL / PFM / QL

Comment : A sweep down after sweep up may be requested in case non-linearity is suspected in unit behaviour.

Verification : A, R, T

5.6.3. Random Tests levels

ISIS-EVTR-REQ-50025 v : 1

Units mounted on the spacecraft shall withstand random tests levels without degradation as defined in Table 5.6-3 and Table 5.6-4.

AXIS / UNIT MASS (without margins)	FREQ. RANGE (HZ)	ACCEPTANCE TEST LEVEL (AL) ACCELERATION	PROTO FLIGHT TEST LEVEL (PFM) ACCELERATION	QUALIFICATION TEST LEVEL (QL) ACCELERATION
Perpendicular to mounting plane				
Unit mass = 0.5 kg	20-100	+ 3 dB/Oct.	+ 3 dB/Oct.	+ 3 dB/Oct.
	100-300	0.96 g ² /Hz	1.5 g ² /Hz	1.5 g ² /Hz
	300-2000	-5 dB/Oct.	-5 dB/Oct.	-5 dB/Oct.
	—	23.44 g _{RMS} (1σ)	29.3 g _{RMS} (1σ)	29.3 g _{RMS} (1σ)
	Duration	60 s per axis	60 s per axis	120 s per axis
Unit 0.5 kg < mass = 3 kg	20-100	+ 3 dB/Oct.	+ 3 dB/Oct.	+ 3 dB/Oct.
	100-300	0.64 g ² /Hz	1 g ² /Hz	1 g ² /Hz
	300-2000	-5 dB/Oct.	-5 dB/Oct.	-5 dB/Oct.
	—	19.14 g _{RMS} (1σ)	23.93 g _{RMS} (1σ)	23.93 g _{RMS} (1σ)
	Duration	60 s per axis	60 s per axis	120 s per axis
Unit 3 kg < mass = 10 kg	20-100	+ 3 dB/Oct.	+ 3 dB/Oct.	+ 3 dB/Oct.
	100-300	0.32 g ² /Hz	0.5 g ² /Hz	0.5 g ² /Hz
	300-2000	-5 dB/Oct.	-5 dB/Oct.	-5 dB/Oct.
	—	13.5 g _{RMS} (1σ)	16.88 g _{RMS} (1σ)	16.88 g _{RMS} (1σ)
	Duration	60 s per axis	60 s per axis	120 s per axis
Unit mass > 10 kg	20-100	+ 3 dB/Oct.	+ 3 dB/Oct.	+ 3 dB/Oct.
	100-300	0.192 g ² /Hz	0.3 g ² /Hz	0.3 g ² /Hz
	300-2000	-5 dB/Oct.	-5 dB/Oct.	-5 dB/Oct.
	—	10.5 g _{RMS} (1σ)	13.12 g _{RMS} (1σ)	13.12 g _{RMS} (1σ)
	Duration	60 s per axis	60 s per axis	120 s per axis

Table 5.6-3 - Random Environment for Units - Perpendicular to mounting plane - AL/ PFM / QL

AXIS / UNIT MASS (without margins)	FREQ. RANGE (HZ)	ACCEPTANCE TEST LEVEL (AL) ACCELERATION	PROTO FLIGHT TEST LEVEL (PFM) ACCELERATION	QUALIFICATION TEST LEVEL (QL) ACCELERATION
Parallel to mounting plane				
Unit mass = 10 kg	20-100	+ 3 dB/Oct.	+ 3 dB/Oct.	+ 3 dB/Oct.
	100-300	0.16 g ² /Hz	0.25 g ² /Hz	0.25 g ² /Hz
	300-2000	-5 dB/Oct.	-5 dB/Oct.	-5 dB/Oct.
	—	9.6 g _{RMS} (1σ)	12 g _{RMS} (1σ)	12 g _{RMS} (1σ)
	Duration	60 s per axis	60 s per axis	120 s per axis
Unit mass > 10 kg	20-100	+ 3 dB/Oct.	+ 3 dB/Oct.	+ 3 dB/Oct.
	100-300	0.096 g ² /Hz	0.15 g ² /Hz	0.15 g ² /Hz
	300-2000	-5 dB/Oct.	-5 dB/Oct.	-5 dB/Oct.
	—	7.42 g _{RMS} (1σ)	9.28 g _{RMS} (1σ)	9.28 g _{RMS} (1σ)
	Duration	60 s per axis	60 s per axis	120 s per axis

Table 5.6-4: Random environment for units - Parallel to mounting plane - QL / PFM / AL

Comment : Random levels are determined with the nominal mass (no design margin) of units in a conservative way.

Verification : **A, R, T**

5.6.4. Shock tests levels

ISIS-EVTR-REQ-50026 v : 1

The Mechanical Tests specification here-after is applicable to all type of Equipment at 100mm min from shock source.

ISIS-EVTR-REQ-50027 v : 1

Units mounted on the spacecraft shall withstand shock tests levels without degradation as defined in Table 5.6-5.

AXIS / UNIT MASS	FREQ. (HZ)	ACCEPTANCE TEST LEVEL (AL) ACCELERATION	PROTO FLIGHT TEST LEVEL (PFM) ACCELERATION	QUALIFICATION TEST LEVEL (QL) ACCELERATION
Perpendicular and Parallel to mounting plane				
Units on Primary structure (except propulsion Tanks) Q=10	100	N/A	20g	20 g
	2000	N/A	2000g	2000g
	10000	N/A	2000g	2000g
	Number of test	N/A	1 shock per axis	3 shock per axis (*)

(*) Depending on the measured shock response spectrum on a control rejection axis, subsequent specific shock test for this axis may be omitted with agreement of customer.

Table 5.6-5: Shock response spectrum at unit interface - Qualification Level

Rationale : Implicit ECSS-E-ST-10-03c 5.5.2.6d

Verification : **A, R, T**

6. THERMAL ENVIRONMENTAL TESTING REQUIREMENTS

Reference document RD-1 and paragraph 5.1 below define all notions and terms used in this chapter.

6.1. DEFINITION OF TERMS RELATIVE TO THERMAL ENVIRONMENTAL TESTING

6.1.1. Introduction of the different possible thermal tests

This paragraph specifies only two temperature cycling tests:

- Thermal Vacuum at a pressure of 10^{-5} hPa or less, also called Vacuum Temperature Cycling (VTC)
- Thermal Ambient, also called "Thermal Cycling" or Ambient Pressure Temperature Cycling (APTC).

Note: a temperature cycling test can combine, if needed and without any test setup and configuration change, until three complementary thermal tests:

- a Thermal Balance (TB) test.
- a standardized burn-in test dedicated to reach required operating duration at specified TRP hot temperature level.
- a non-standardized test dedicated to temperature dependent performances verification by adding temperature stabilizations at wanted TRP temperature levels.

6.1.2. Terms specific to space thermal testing

- **dwelt time**: duration necessary to ensure that internal parts or subassembly of a space segment equipment unit 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
- **temperature cycle**: transition from an initial temperature to the same temperature, with excursion within a specified range
- **Thermal Balance**: test conducted in stabilized (steady state or periodic) or transient conditions to verify the adequacy of (i.e. to validate) the thermal mathematical model and the adequacy of (i.e. to qualify) the thermal design, and the TCS capability to maintain thermal conditions within established mission limits

6.2. THERMAL ENVIRONMENTAL TESTS SETUPS AND CONFIGURATIONS

ISIS-EVTR-REQ-60001 v : 1

For conductively controlled units, the temperature at baseplate unit TRP shall be driven by the controlled support (see Figure 6.2-1).

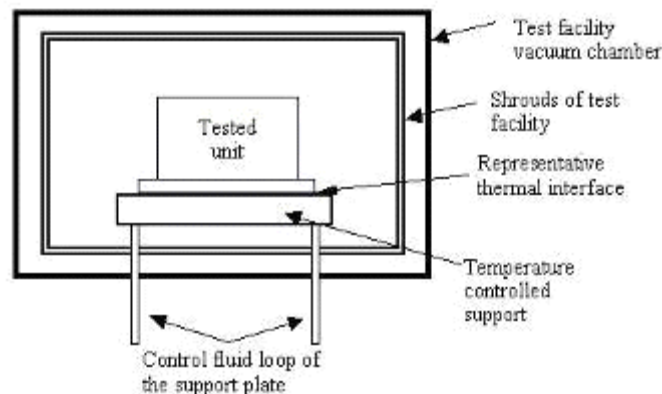


Figure 6.2-1: Unit Thermal Test Arrangement

Comment : In that case the chamber shrouds if any, are either set:

- at the same controlled support temperature level when the unit is homogeneous in temperature,
- at the same temperature than the skin average temperature of the unit housing when the unit is non-homogeneous and purely conductively controlled,
- or can be left at ambient temperature when the unit housing is thermally insulated.

Verification : **A, I, R, T**

ISIS-EVTR-REQ-60002 v : 1

For purely radiatively controlled units, the adjustable chamber shroud temperature shall drive the unit TRP temperature (see Figure 6.2-1).

Comment : The unit is thermally insulated from the controlled support.

Verification : **A, I, R, T**

ISIS-EVTR-REQ-60003 v : 1

For mixed (conductively and radiatively) controlled units, the temperature at baseplate unit TRP shall be driven by the controlled support while the radiative sink temperature is set on the chamber shroud (see Figure 6.2-1).

Comment : The value of the radiative sink temperature is given by each unit specification.

Verification : **A, I, R, T**

ISIS-EVTR-REQ-60004 v : 1

The conductively controlled unit shall be mounted to a thermally controlled heat sink using the flight design (fillers consistent with the unit specification).

Comment : The filler provider (if any) and the applicable mounting procedure (if needed) can be discussed and agreed between the supplier and the customer within the test specification.

Verification : **A, I, R, T**

ISIS-EVTR-REQ-60005 v : 1

The heat sink plate and the chamber shroud if any shall be thermally black coated (except for contact areas).

Verification : **A, I, R, T**

6.3. TEMPERATURE CYCLING TESTS PROFILES, LEVELS AND DURATIONS

6.3.1. Temperature cycling general requirements (levels and durations)

ISIS-EVTR-REQ-60006 v : 1

In conformance with the unit model under test (QM, PFM or FM), the unit supplier shall apply different TRP temperature levels and different numbers of temperature cycles.

Verification : **R, T**

ISIS-EVTR-REQ-60007 v : 1

In conformance with S4.4 about test tolerances and measurements uncertainties, the unit supplier shall instrument, monitor and control each TRP such that the test specimen experiences actual TRP temperature levels:

- equal to or beyond the required minimum and maximum qualification or acceptance levels.
- less severe than 4°C beyond the required minimum and maximum qualification or acceptance levels.

Comment : Doing that, uncertainties and tolerances are not cumulative ; as an example with a TRP acceptance level specified at +55 °C:

- the required temperature measurement uncertainty is $\pm 2^{\circ}\text{C}$.
- then the allowed TRP temperature measured band is [+55 °C; +59 °C].

Verification : **R, T**

6.3.2. Qualification Vacuum Temperature Cycling (or qualification Thermal Vacuum)

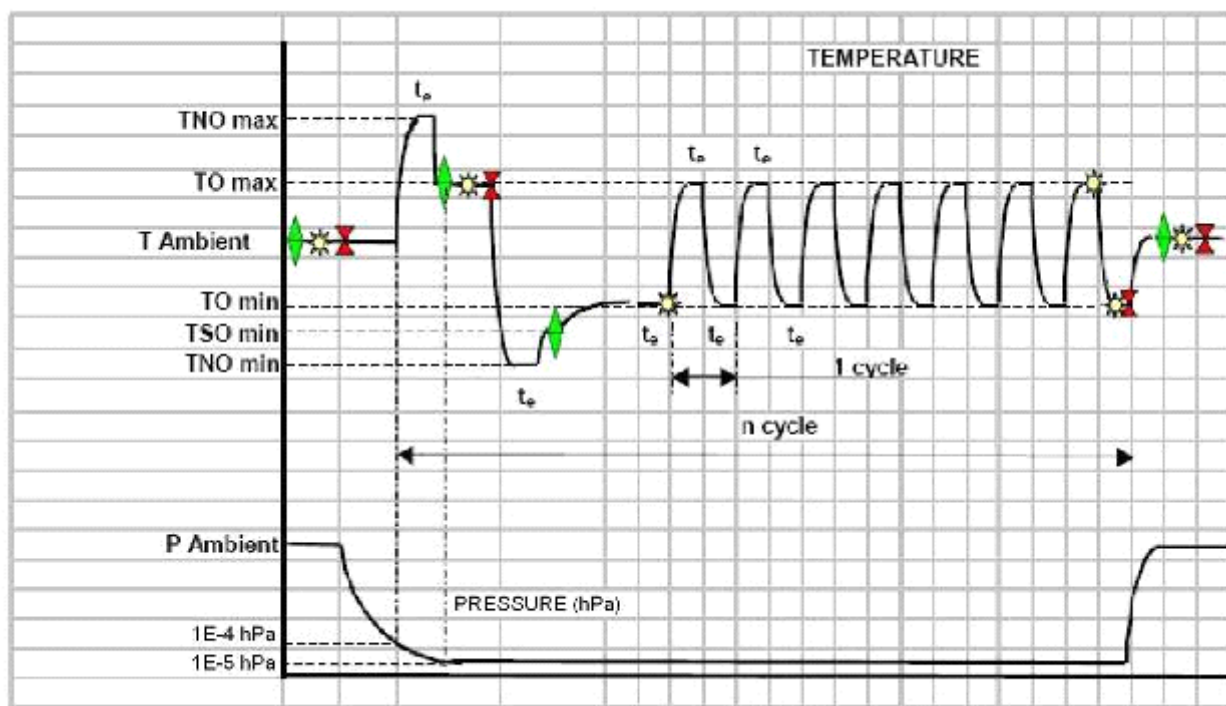
ISIS-EVTR-REQ-60008 v : 1

The following VTC step by step procedure, as defined in Table 6.3-1 and in Figure 6.3-1, shall apply with 8 operating temperature cycles at qualification levels.

1	Functional and performance tests under ambient conditions
2	Unit switch-off
3	Decrease of pressure to 10^{-4} hPa
4	Decrease of pressure to 10^{-5} hPa and increase of TRP temperature to maximum operating level (TO-max)
5	Unit switch-on (a few °C before temperature stabilisation to avoid over swing)
6	Temperatures stabilisation (including internal temperatures)
7	Functional and performance tests
8	Unit switch-off
9	Increase of TRP temperature to maximum non-operating level (TNO-max)
10	Temperatures stabilisation (including internal temperatures)
11	Decrease of TRP temperature to maximum operating level (TO-max)
12	Temperatures stabilisation (including internal temperatures)
13	Unit switch-on
14	Functional test and performance test
15	±0.5% Bus power variation test/power consumption test
16	Unit switch-off
17	Decrease of TRP temperature to minimum non-operating level (TNO-min)
18	Temperatures stabilisation (including internal temperatures)
19	Increase of TRP temperature to minimum switch-on level (TSO-min)
20	Unit switch-on
21	Increase of TRP temperature to minimum operating level (TO-min)
22	Temperatures stabilisation (including internal temperatures)

23	Functional and performance tests
24	Increase of TRP temperature to maximum operating level (TO-max)
25	Temperatures stabilisation (including internal temperatures)
26	Functional and performance tests
27	Decrease of TRP temperature to minimum operating level (TO-min)
28	Temperatures stabilisation (including internal temperatures)
29	Functional and performance tests
30	Repeat steps 24, 25, 27 and 28 - six times for Qualification test (to achieve n=8) - two times for Protoqualification test (to achieve n=4) - two times for Acceptance test (to achieve n=4)
31	Functional and performance tests
32	Unit switch-off
33	Increase of pressure and temperature to ambient conditions
34	Unit switch-on
35	Functional and performance tests under ambient conditions
36	Unit switch-off

Table 6.3-1: VTC step by step procedure (for qualification, protoqualification and acceptance)



Note: with $n = 8$ for qualification and $n = 4$ for proto-qualification and acceptance

Figure 6.3-1: VTC test profile

T	TRP temperature
TNO-max	Maximum Non-Operating*
TNO-min	Minimum Non-Operating*
TO-max	Maximum Operating*
TO-min	Minimum Operating*
TSO-min	Minimum Switch-On*
T Ambient	Ambient Temperature
P	Pressure
	Functionnal and Performance tests
	Switch-on
	Switch-off

(*) Qualification or Acceptance TRP temperatures

Table 6.3-2: Nomenclature for Table and Figure 6.3-1

Comment : The first cycle includes temperature stabilizations under non operating and operating conditions.

Verification : **R, T**

6.3.3. Acceptance Vacuum Temperature Cycling (or acceptance Thermal Vacuum)

ISIS-EVTR-REQ-60009 v : 1

The following VTC step by step procedure, as defined in Table 6.3-1 and in Figure 6.3-1, shall apply with 4 operating temperature cycles at acceptance levels.

Comment : The first cycle includes temperature stabilizations under non operating and operating conditions.

Verification : **R, T**

6.3.4. Protoqualification Vacuum Temperature Cycling (or protoqualification Thermal Vacuum)

ISIS-EVTR-REQ-60010 v : 1

The following VTC step by step procedure, as defined in Table 6.3-1 and in Figure 6.3-1, shall apply with 4 operating temperature cycles at qualification levels.

Comment : The first cycle includes temperature stabilizations under non operating and operating conditions.

Verification : **R, T**

6.4. TEMPERATURE CYCLING TESTS IMPLEMENTATION REQUIREMENTS

6.4.1. Requirements applicable to VTC and APTC tests

ISIS-EVTR-REQ-60011 v : 1

Thermal balance phase(s), if required in the unit technical specification, shall be included in the VTC test.

Rationale : ECSS-E-ST-10-03c 5.5.4.1b; modified; LEO ISIS missions are only under space vacuum and editorial modifications (VTC and TCS term is "temperature difference")

Comment : e.g. for very dissipative equipment, equipment with important temperature differences at vacuum conditions.

Verification : **R, T**

ISIS-EVTR-REQ-60012 v : 1

All space segment equipment unit temperatures shall refer to the temperature reference points.

Rationale : ECSS-E-ST-10-03c 5.5.4.1c; modified; editorial (English grammar)

Verification : **I, R, T**

ISIS-EVTR-REQ-60013 v : 1

The space segment equipment unit temperatures shall be defined for the following conditions:

- 1- minimum and maximum operating qualification and acceptance;
- 2- minimum and maximum non-operating qualification and acceptance;
- 3- minimum switch ON and maximum (as relevant).

Rationale : ECSS-E-ST-10-03c 5.5.4.1d; modified; editorial (English grammar)

Verification : **I, R, T**

ISIS-EVTR-REQ-60014 v : 1

The test level shall take into account the test tolerances as specified in Table 4.4-2 without aggravation by adding to the test tolerances the test measurement accuracies specified in ISIS-EVTR-REQ-60007.

Rationale : ECSS-E-ST-10-03c 5.5.4.1e; modified for clarification

Verification : **R, T**

ISIS-EVTR-REQ-60015 v : 1

The temperature rate of change shall be lower than 20 K per minute and higher than 3K per minute.

Rationale : ECSS-E-ST-10-03c 5.5.4.1f; modified; obviously, a minimum temperature rate of change is necessary

Verification : **R, T**

ISIS-EVTR-REQ-60016 v : 1

Functional test shall only start after a dwell time greater or equal to 2 hours.

Rationale : ECSS-E-ST-10-03c 5.5.4.1g

Verification : **R, T**

ISIS-EVTR-REQ-60017 v : 1

Test profile, test configuration, number of cycles, extreme temperatures, temperature rate of change, stability criteria, dwell time duration, tests to be performed and success criteria shall be defined in the test specification.

Rationale : ECSS-E-ST-10-03c 5.5.4.1h

Verification : **R, T**

ISIS-EVTR-REQ-60018 v : 1

The test profile shall include a non operating cycle.

Rationale : ECSS-E-ST-10-03c 5.5.4.1i

Verification : **R, T**

ISIS-EVTR-REQ-60019 v : 1

The space segment equipment unit shall be subjected to functional test before and after the thermal test(s).

Rationale : ECSS-E-ST-10-03c 5.5.4.1j; modified; editorial (English grammar)

Verification : **R, T**

ISIS-EVTR-REQ-60020 v : 1

Functional tests shall be performed as a minimum at hot and cold operating temperatures.

Rationale : ECSS-E-ST-10-03c 5.5.4.1k; modified; editorial (English grammar)

Comment : Tests during transition are subjected to case-by-case decision.

Verification : *R, T*

ISIS-EVTR-REQ-60021 v : 1

Cold (and hot if required in the unit technical specification) switch on capabilities shall be demonstrated.

Rationale : ECSS-E-ST-10-03c 5.5.4.1l; modified in coherence with documentation tree

Verification : *R, T*

ISIS-EVTR-REQ-60022 v : 1

In case of internal redundancy, thermal tests shall be performed on both chains taking into account the type of redundancy (e.g. hot or cold).

Rationale : ECSS-E-ST-10-03c 5.5.4.1m

Verification : *R, T*

ISIS-EVTR-REQ-60023 v : 1

In case of cross-strapped configurations, requirements for testing shall be agreed with the customer.

Rationale : ECSS-E-ST-10-03c 5.5.4.1n

Verification : *R, T*

ISIS-EVTR-REQ-60024 v : 1

The space segment equipment unit operative configuration during the test shall be the most severe one in the power time domain and from the power consumption point of view.

Rationale : ECSS-E-ST-10-03c 5.5.4.1o; modified; editorial (English grammar)

Verification : *R, T*

ISIS-EVTR-REQ-60025 v : 1

Monitoring for corona shall be conducted during chamber pressure reduction for space segment equipment units that are critical with regards to corona effect.

Rationale : ECSS-E-ST-10-03c 5.5.4.1p; modified; editorial (English grammar and APTC)

Comment : For APTC test, this is justified by the fact that ambient pressure can be lower than Earth

atmospheric pressure.

Verification : **R, T**

ISIS-EVTR-REQ-60026 v : 1

Test methods and test set-up shall be defined according to the thermal environment characteristics, the TCS thermal design and the space segment equipment unit itself.

Rationale : ECSS-E-ST-10-03c 5.5.4.1q; modified; editorial (English grammar)

Verification : **I, R, T**

ISIS-EVTR-REQ-60027 v : 1

The test set-up shall ensure appropriate orientation for space segment equipment containing two-phase heat transport equipment (e.g. heat pipe).

Rationale : ECSS-E-ST-10-03c 5.5.4.1r; modified; editorial (English grammar and correct technical term "two-phase")

Comment : This means that the two-phase heat transport equipment unit is horizontal or works in reflux mode.

Verification : **I, R, T**

6.4.2. Requirements applicable to VTC test

ISIS-EVTR-REQ-60028 v : 1

VTC shall be performed for space segment equipment whose operation occurs in space vacuum environment at any time of its lifetime, except for some FM for which APTC at the Earth atmospheric pressure is allowed provided that the unit is compliant with the requirements ISIS-EVTR-REQ-60032, ISIS-EVTR-REQ-60034 and ISIS-EVTR-REQ-60035).

Rationale : ECSS-E-ST-10-03c 5.5.4.2a; modified; editorial (test name) and important exception allowing APTC under conditions explicated in three added clauses.

Verification : **R, T**

ISIS-EVTR-REQ-60029 v : 1

Space segment equipment shall be tested at a pressure of 10^{-5} hPa or less.

Rationale : ECSS-E-ST-10-03c 5.5.4.2b

Verification : **R, T**

ISIS-EVTR-REQ-60030 v : 1

Vacuum and temperature conditions and test set-up shall be such as to avoid contamination of the equipment unit.

Rationale : ECSS-E-ST-10-03c 5.5.4.2c; modified; editorial (English grammar); here, conditions are temperature and vacuum.

Verification : **I, R, T**

6.4.3. Requirements applicable to APTC test

ISIS-EVTR-REQ-60031 v : 1

Climatic conditions shall be such as to avoid condensation on the item under test.

Rationale : ECSS-E-ST-10-03c 5.5.4.3c.

Verification : **I, R, T**

ISIS-EVTR-REQ-60032 v : 1

Earth atmospheric pressure temperature cycling shall not replace VTC:

- either if calibrations of flight parameters are necessary during thermal tests;
- or if performance measurements require vacuum testing.

Verification : **A, R, T**

ISIS-EVTR-REQ-60033 v : 1

If, after approval of the customer, earth atmospheric pressure temperature cycling replaces VTC, the unit supplier shall provide updated criteria if necessary for the performance measurements under earth atmospheric pressure.

Verification : **A, R, T**

ISIS-EVTR-REQ-60034 v : 1

To replace VTC by earth atmospheric pressure temperature cycling, the unit supplier QA experts shall demonstrate, for approval by the customer QA experts, that materials, EEE components, mechanical parts and processes are insensitive to space vacuum concerning the probability to precipitate youth and workmanship latent defects.

Verification : **A, I, R, T**

ISIS-EVTR-REQ-60035 v : 1

If earth atmospheric pressure temperature cycling replaces VTC (see hereabove requirements), the unit supplier shall compensate the unit temperatures homogenization by internal gaseous conduction or by internal free convection; in particular, at hottest or critical internal points).

Comment : Note 1: The unit supplier can use two temperature compensation implementation methods:

- 1.) by thermal analyses as required by ISIS-EVTR-REQ-40030;

2.) if mathematical modelling of internal gaseous conduction or of internal free convection is uncertain, by checking that the temperature instrumentation (if necessary, by adding internal thermocouples) allows the internal temperatures compensation and monitoring.

Note 2: If the hottest point compensation induces violating critical temperature limits on colder points, VTC is mandatory.

Note 3: The unit supplier justifies and discusses, for approval by the customer thermal experts, the internal temperatures compensation foreseen implementation.

Verification : **A, R, T**

7. ELECTRICAL TEST REQUIREMENTS

7.1. EMC TESTS

EMC tests are specified in RD-3.

7.2. MAGNETIC TESTS

Magnetic tests are specified in RD-3.

7.3. ESD TESTS

Maturity: TBD on : § ESD Tests

TBD

7.4. PASSIVE INTERMODULATION TESTS

ISIS-EVTR-REQ-70001 v : 1

The passive intermodulation test shall be performed in conformance with ECSS-E-ST-20, paragraph 7.4.

Rationale : ECSS-E-ST-10-03c 5.5.5.4a

Verification : **R, T**

7.5. MULTIPACTION TESTS

ISIS-EVTR-REQ-70002 v : 1

The multipaction test shall be performed in conformance with ECSS-E-20-01.

Rationale : ECSS-E-ST-10-03c 5.5.5.5a

Verification : **R, T**

7.6. CORONA AND ARC DISCHARGE TESTS

ISIS-EVTR-REQ-70003 v : 1

Corona and arc discharge test shall be performed for space segment equipment exposed to the critical low pressure atmosphere according to relevant Paschen curves during its lifetime.

Rationale : ECSS-E-ST-10-03c 5.5.5.6a

Comment : Demonstration of margin for corona and arc discharges effect is mainly achieved by analysis, and by component/ sub assembly or development model level test.

Verification : *R, T*

DIFFUSION LIST

Name	Entity
CNES DIFFUSION	
<i>Projet Standard ISIS</i>	
ANSALAS Carole	DSO/AQ/IM
CHARMEAU Marie Claire	DSO/AVI/CC
GELIE Paul	DNO/OP/SSO
LAUTIER Elisabeth	DSO/AQ/IM
LOUBEYRE Jean-Philippe	DSO/AVI/CC
MARTIN Christian	DSO/AQ/BA
MESNAGER Jean-Michel	DSO/SC/ATH
SALCEDO Corinne	DSO/OT/MLN
<i>ISIS Ground Product line</i>	
<i>MISSIONS</i>	
BOISNARD Laurent	DSO/OT/CSO
GUENEGO Philippe	DSO/OT/CER
COURRAU Etienne	DSO/OT/CER
MORO Pascale	DSO/OT/MLN
ALBOUYS Vincent	DSO/OT/SWO
TELLO Magali	DSO/OT/SWO
TYROU Véronique	DSO/OT/MLN

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Diffusion Thales Alenia Space Cannes	
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<i>pour diffusion interne à :</i>	
BARBET Vincent	TAS