Agenzia Spaziale Italiana	**PAYLOAD REQUIREMENTS DOCUMENT (PRD)**	Documento : DC-UOT-2022-007 Revisione : A Data : 28/01/2022 Pagina : 1 di 110

VERY HIGH RESOLUTION PAYLOAD

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1. INTRODUCTION

1.1. Scope of Document

This Payload Requirements Document (PRD) defines the Requirements for the Very High Resolution (VHR) Payload, which will form the basis for the Payload definition, design, development, operations and constraints.

This document specifies *what* the Payload must do, and the constraints it must operate within. It does not specify *how* the Payload should achieve the required behaviour.

1.2. Document Conventions

1.2.1. Language

The wording of statements in this specification determines the disposition of requirements:

“SHALL” and “SHALL NOT” are used to indicate a mandatory requirement.

“SHOULD” and “SHOULD NOT” indicate a recommendation, which is not mandatory.

“MAY” or “NEED NOT” indicate permission, or an option.

“WILL” indicates a statement of fact or intention.

1.2.2. Requirements Verification

Verification Methods are associated to the Platform-to-Payload Interface Requirements:

- [A] Analysis, including simulation and similarity
- [R] Review of Design
- [T] Test
- [I] Inspection

The verification methods are applicable to the specific level and are non-correlated to the verification method at lower levels. Unless stated otherwise, the values specified as “larger (or smaller) than” have to be interpreted as including the specified value, i.e. as "larger than or equal to/smaller than or equal to".

1.2.3. Requirements formatting and traceability

In this document, in order to provide traceability, all requirements are uniquely numbered and named with the following convention:

- VHR-PRD-PLD-xxxx, for the requirements related to the Payload;
- VHR-PRD-IRD-xxxx, for the requirements related to the Platform-to-Payload Interface;

- Requirement Title
- Statement of the requirement

Comment: Text (if any) expressing comments or clarifications or rationale material that do not form a part of the requirement and are intended for information only.

1.3. Acronyms and Definitions

See Annex 1.

2. DOCUMENTS

Applicable and Reference documents are uniquely identified by the following codes:

- Applicable Documents: AD-xx with "xx" being a sequential number
- Reference Documents: RD-xx with "xx" being a sequential number

2.1. Applicable Documents

[A.D. 1] Capitolato Tecnico

2.2. Reference Documents

The following documents, which provide useful reference information associated with this document and clarifications for correct understanding of the requirements expressed in the Applicable Documents, are provided for information only.

[R.D. 1] ECSS Glossary of Terms Doc. N° ECSS-S-ST-00-01C

NOTE: The documents is herein referenced for sake of traceability only; the relevant sections have been reflected in the present PRD and, therefore, this document will NOT be provided to the Contractor.

2.3. Requirements Hierarchy

Should any conflict arise between the requirements, the most stringent will prevail.

In any case the Contractor shall notify to the Customer such inconsistencies and make proposals for their solutions so that the Customer can take the most appropriate decisions.

3. Very High Resolution Payload Requirements

3.1. Payload Requirements

VHR-PRD-PLD-0010
Description
The Payload shall be designed as an operational Earth Observation Very High Resolution Optical Payload in the Visible-Near Infrared (VNIR) spectral range to be embarked and operated onboard a small platform.
Verification Method : R

VHR-PRD-PLD-0030
Lifecycle
The Payload Life Cycle shall foresee the following activities and mission phases:
- Design, Development, Integration, Verification and Validation (including Calibration);
- Launch;
- LEOP and Commissioning lasting 3 months;
- Operative Phase lasting 3 years overall.

Verification Method : R

VHR-PRD-PLD-0040
Development and Misson Phases
The Payload development activities shall progress through the following phases:
- Phase A – Feasibility (included in the RfQ package).
- Phase B – Preliminary Definition
- Phase C – Detailed Definition
- Phase D – Production/Ground Qualification testing and on-ground calibration
- Phase E1 – Flight Qualification / Commissioning and Pre-operative phase
- Phase E2 – Routine Operations (NOT covered by the present RfQ)

Verification Method : R

VHR-PRD-PLD-0060
Spectral Bands
The Payload shall be configured to acquire VNIR images with 5 spectral bands plus a panchromatic band, listed as follow with 5% tolerance on central wavelength and 3% on spectral width:

VNIR		
Band	Central wavelength [nm]	Spectral width [nm]
B1 – Blue	490	70
B2 – Green	560	35
B3 – Red	665	35
B4 – NIR1	842	120

The Bandwidth (nm) in the Table is the values measured at Full Width Half Maximum (FWHM).
Verification Method : R, T

VHR-PRD-PLD-0065
Spectral Bands
The Payload shall be configured to acquire PAN images listed as follow with 5% tolerance on central wavelength and 5% tolerance on spectral range:

PAN		
Band	**Central wavelength [nm]**	**Spectral range**
PAN	640	440-850

The Bandwidth (nm) in the Table is the values measured at Full Width Half Maximum (FWHM).
Verification Method : R, T

VHR-PRD-PLD-0100
VNIR Cross-Track Ground Sampling Distance
The across track spatial separation between pixel centres shall be no greater than 2 m at the nadir point on the ground track at sea level at the equator.
Verification Method : R, T

VHR-PRD-PLD-0110
VNIR Along-Track Ground Sampling Distance
The along track spatial separation between pixel centres shall be no greater than 2 m at the nadir point on the ground track at sea level at the equator.
Verification Method : R, T

VHR-PRD-PLD-0100
PAN Cross-Track Ground Sampling Distance
The across track spatial separation between pixel centres shall be no greater than 0.5 m at the nadir point on the ground track at sea level at the equator.
Verification Method : R, T

VHR-PRD-PLD-0110
PAN Along-Track Ground Sampling Distance
The along track spatial separation between pixel centres shall be no greater than 0.5 m at the nadir point on the ground track at sea level at the equator.
Verification Method : R, T

VHR-PRD-PLD-0090
Swath
The Payload shall guarantee a swath of at least 8 km and length of up to 8 km.
Verification Method : R, T

VHR-PRD-PLD-0130
Spectro-Radiometric Accuracy
The (absolute) calibrated accuracy of the top of atmosphere spectral radiance in the entire spectral range (VNIR) shall be better than 5% for unpolarized light.
Verification Method: R, T

VHR-PRD-PLD-0140
Spurious Signals
Following systemic correction, and when the input aperture to the VNIR imager is closed or when the imager is looking at deep space or dark ocean, the measured spectral distribution and the measured spatial distribution for all spatial samples within the field of view and for all spectral samples within the spectral range shall have zero mean and a standard deviation less than or equal to the Noise Equivalent Spectral Radiance (NESR).
Verification Method: R, T

VHR-PRD-PLD-0150
Polarization Sensitivity
The polarization sensitivity in the VNIR bands shall be equal or less than 5%.
Verification Method: R, T

VHR-PRD-PLD-0160
VNIR MTF
The along-track and across-track Spatial Modulation Transfer Function at the Nyquist frequency for VNIR, shall be greater than, or equal to 0.15 at any point in the across track swath for all recorded spectral bands at the sub-nadir point on the ground track at sea level at the equator.
Verification Method: R, T

VHR-PRD-PLD-0170
PAN MTF
The along-track and across-track Spatial Modulation Transfer Function at the Nyquist frequency for PAN, shall be greater than, or equal to 0.15 at any point in the across track swath at the sub-nadir point on the ground track at sea level at the equator.
Verification Method: R, T

VHR-PRD-PLD-0180
Spatial Registration of the Spectral Samples
Images of a point-like object on the ground in any two bands of the spectral range shall allow the spatial coregistration within 0.1 of the VNIR GSD, over the full field of view and over all operating conditions.
Verification Method: R, T

VHR-PRD-PLD-0200
Symmetrical observation
The observation in nadir-looking shall have a symmetrical field of view (FOV) with respect to the orbital plane.

Verification Method : R, T

VHR-PRD-PLD-0210
Squared Ground Sampling
The along- and across-track GSDs shall be identical to within 5% in all spectral channels.
Verification Method : R, T

VHR-PRD-PLD-0220
Stability of the Image Ground Sampling
The GSD at any position in the FOV shall not deviate from the nominal GSD over the specified satellite in-orbit lifetime by more than 1% in the along- and across-track directions.
Verification Method : R, T

VHR-PRD-PLD-0230
Radiance Levels
The radiance levels for the VNIR bands shall be better of the following values at Beginning Of Life (BOL) after commissioning:

Wavelength [nm]	Lref [W/sr/m2/micron]
475	139,2
555	115,2
660	97,2
865	52,96

Verification Method : R, T

VHR-PRD-PLD-0240
Dynamic Range – Dim Signal
The low end of the dynamic range for the VNIR bands shall be the minimum Level of radiance defined as Lmin:

Wavelength [nm]	Lmin [W/sr/m2/micron]
475	11
555	6,5
660	3,5
865	1

Verification Method : R, T

VHR-PRD-PLD-0250
Dynamic Range – Bright Signal
The high end of the dynamic range for the VNIR bands shall be the maximum Level of radiance expected over land targets without cloud contamination defined as Lmax_L:

Wavelength [nm]	Lmax_L[W/sr/m2/micron]

475	620
555	560
660	490
865	308

Verification Method : R, T

VHR-PRD-PLD-0260
Response Non-Linearity in Dynamic Range
Over the full dynamic range, the maximum deviation from linearity of the system shall be less than 1%.
Verification Method : R, T

VHR-PRD-PLD-0270
SNR stability
The End Of Life (EOL) SNR from 400 to 1000 nm shall at least 90% of the BOL SNR.
Verification Method : A

VHR-PRD-PLD-0280
SNR conditions
The SNR requirements for the VNIR bands shall apply for the defined radiance levels over land (Lref) and the following NEDL (Noise Equivalent Delta Radiance):

Wavelength [nm]	NEDL [W/sr/m2/micron]
475	0,9
555	0,72
660	0,6
865	0,48

Verification Method : R, T

VHR-PRD-PLD-0290
AMSD
When the VNIR imager is illuminated with a uniform source at a nominal wavelength, the root mean square deviation of the measured spatial distribution shall not exceed 1/SNR multiplied by the Average Measured Spatial Distribution (AMSD). The average, standard deviation and SNR, shall be calculated for all operable spatial/spectral elements at the nominal wavelength over the entire field of view.
Verification Method : R, T

VHR-PRD-PLD-0300
VHR-VNIR Calibration steps
The VHR-VNIR instrument shall support Calibration activities, namely:
- pre-flight (optical characterization during AIT)
- in-flight calibration

Verification Method : R, T

VHR-PRD-PLD-0310
Lunar Calibration
The Payload shall periodically acquire lunar images for calibration purposes for all active detectors pixels.
Verification Method : R, T

VHR-PRD-PLD-0320
Calibration with uniform source
When the VNIR imager is illuminated with a uniform source at an indicated wavelength, the difference between the measured spectral radiance for any spatial sample shall not exceed ±0.089/SNR of the average of the measured spectral radiance at the two adjacent spatial samples for 95% of all operable spatial/spectral elements at the nominal wavelength.
Verification Method : R, T

VHR-PRD-PLD-0330
Defective pixel for VNIR
There shall be no more than 25 defective elements in the FPA for VNIR (at End of Life (EOL)).
Verification Method : I

VHR-PRD-PLD-0340
Defective pixel for PAN
There shall be no more than 5 defective elements in the FPA for PAN (at End of Life (EOL)).
Verification Method : I

VHR-PRD-PLD-0350
Cluster of defective pixels
There shall be no cluster of defective elements 2 by 2 pixels or larger in the VNIR FPAs (at BOL).
Verification Method : I

VHR-PRD-PLD-0360
Cross talk
Optical cross-talk within and between the VNIR instrument paths shall be less than 3%.
Verification Method : R, T

VHR-PRD-PLD-0370
Optical imaging system
The Payload Optical imaging system shall be based on a design solution suitable for further improvements towards lower GSD (less than 50 cm).
Verification Method : A, R

VHR-PRD-PLD-0380
Maximum Off-nadir Angle during acquisitions
The Payload perform acquisitions with a maximum off-nadir angle of ± 30° measured at the centre of the swath.
Verification Method : R, T

VHR-PRD-PLD-0390
Payload mass
The Payload mass (including all Payload units and relevant harness) shall be less than or equal to 90 kg including all margins.
Verification Method : R, T

VHR-PRD-PLD-0395
Payload Products
The payload processing chain shall provide formatted data product from L0 up to L2D, including calibration data, ancillary data and file formatting information.
Verification Method : R, T

VHR-PRD-PLD-0400
Comply with Environmental Laws
Payload development and operation shall comply with the environmental laws relevant in the jurisdiction in which the work is being done.
Verification Method : R

VHR-PRD-PLD-0410
Comply with Export Control Regulations
Payload development shall comply with all Italian and international (e.g., ITAR) export control regulations.
Verification Method : R

VHR-PRD-PLD-0420
ITAR-free design baseline
Payload design shall not include ITAR restricted items, unless for economic, performance or single source procurement reasons the Contractor demonstrates that there are no valid alternatives ITAR-free; ITAR restricted items proposed by the Contractor will be evaluated by the Customer case by case.
Verification Method : R

VHR-PRD-PLD-0430
Restrict Access to Payload Resources
Access to Payload resources (physical and software) shall be restricted to persons authorized by ASI.
Verification Method : R

VHR-PRD-PLD-0440
End Of Life (EOL) and Worst-Case (WC) requirements

The requirements in this document, if not otherwise specified, shall be interpreted as End Of Life (EOL) and Worst-Case (WC) specifications.
Verification Method : A

VHR-PRD-PLD-0450
System Reliability
The probability of meeting Payload specifications at the end of its design life shall be greater than 0.65.
Verification Method : A

VHR-PRD-PLD-0460
Single point failure
No single failure of Payload units shall lead to the permanent loss of the capability to meet the mission requirements. The Payload Contractor shall report any exceptions.
Verification Method : R

3.2. Platform-to-Payload Interface Requirement Requirements

3.2.1. General Requirements

HYP-PRD-IRD-000010
Internation System of Units
All drawings, specifications and engineering data shall use the International System of Units (SI).
Verification Method : R

HYP-PRD-IRD-000020
Margin Policy
A sound margin policy shall be defined and documented. The payload budgets shall clearly identify the levels of margins at all levels.
Verification Method : R

HYP-PRD-IRD-000030
Reference Orbit
Reference Design Orbit shall be characterized by the following parameters:

- SSO @~300- 800 km;
- Frozen and repeating ground tracks.

Note: orbit detailed information shall be reported once Mission Requirements will be available from Agency.
Verification Method : R

3.2.2. Configuration and physical properties

HYP-PRD-IRD-000040
Payload Module compatibility
The payload envelope shall be compatible with Payload Module (PM) footprint up to 820 mm x 820 mm, excluding appendages/protrusions.
Verification Method : R

HYP-PRD-IRD-000070
Payload Envelope

The payload envelope dimensions shall be reported in the payload ICD and it shall include all static and dynamic effects under all specified environmental conditions.
Verification Method: R

HYP-PRD-IRD-000090
Maturity Margins Definition
The allocated mass percentage margins of uncertainty (at payload and unit level) shall be related to the maturity level of each item and particular topology as follows:

- 0-5 % for fully developed/ recurring items (ECSS category A);
- 5-10 % for items to be modified but designed on existing hardware (ECSS category B) or items that have passed PDR;
- 10-20 % for items to be developed (ECSS category C/D, depending on the maturity of the design);
- 30% for harness mass and harness electrical losses.

Note: as a general guideline for each of the above cases the higher threshold should be assumed but in principle any margin percentage could be acceptable (e.g. the S/S or equipment margin could be the result of a weighted function of the equipment/component margins).
Note: the mass margin shall be reported into the payload ICD.
Verification Method: R

HYP-PRD-IRD-000100
CoG/MoI Uncertainty Definition
All Center of Gravity (CoG) and Moment of Inertia (MoI) estimates shall be accompanied by the definition of the design maturity of the concerned item. The uncertainty of each item CoG and MoI calculation for budget consolidation shall follow the rules expressed in the following table:

CATEGORY	DESIGN MATURITY	CoG UNCERTAINTY	MoI UNCERTAINTY
D/C	Preliminary Design/Detailed Design	3 mm radius sphere	±20% for each axis
B	Design based on existing Hardware	2 mm radius sphere	±10% for each axis
A	Existing Hardware	1 mm radius sphere	±5% for each axis

Note: CoG and MoI shall be reported in the payload ICD.
Verification Method: R

HYP-PRD-IRD-000110
MoI/CPI Computation
Moments of Inertia (MoI) and Cross Products of Inertia (CPI) shall be computed for each assembly and unit referred to the reference system parallel to the unit/assembly reference axes and with its origin at the CoG for all in-flight configurations (with and without cover and removable parts).
Note: MoI and CPI shall be reported in the payload ICD.
Verification Method: R

HYP-PRD-IRD-000120

Pyrotechnic device
The payload shall not make use of pyrotechnic devices.
Verification Method : R

3.2.3. Lifetime Requirements

HYP-PRD-IRD-000130
Ground Storage
The payload shall be able to withstand on-ground storage under adequate environmental conditions up to 1 year requiring only minimum of maintenance activities.
Verification Method : R

HYP-PRD-IRD-000140
In-Orbit Lifetime
The payload shall be designed to meet all performance and functional requirements considering a lifetime on orbit of 3 years (extendable to 5) plus 3 months commissioning phase.
Note: 3 years is the overall mission duration from the end of commissioning.
This lifetime excludes any periods of on-ground storage and also excludes the AIT phase up to completion of Payload acceptance testing on ground.
Verification Method : R

HYP-PRD-IRD-000150
Platform pointing performance
The payload shall be designed considering a platform pointing performance as follows:

Pointing accuracy	*100 arcsec @ 3-sigma (0.028°)*
Pointing knowledge	*35 arcsec @ 3-sigma (0.01°)*
Pointing stability	*30 arcsec/sec (0.008°/sec)*

Table 1 Platform pointing performances

This performance does not consider alignment accuracy and knowledge between payload and platform.
Verification Method : R

HYP-PRD-IRD-000160
Platform mass memory capability
The platform mass memory capability for storage of payload is 2 Tbit (nominal) + 2 Tbit (redundant) data.
Verification Method : R

HYP-PRD-IRD-000170
Payload reliability
To comply with the Satellite reliability, the reliability of the payload shall be greater than TBD%.
Note: TBD is linked to overall Mission Reliability requirement, it shall be agreed with the Agency.
Verification Method : R

HYP-PRD-IRD-000180
Payload availability
To comply with the Satellite in-orbit availability, the availability of the payload shall be greater than TBD% including any planned and unplanned outages.
Note: TBD is linked to overall Mission Availability requirement, it shall be agreed with the Agency.
Availability is defined as the probability that the payload provides the required data service to the satellite, excluding the effects of non-recoverable failures (as per ECSS-Q-ST-30-09)
Verification Method : R

HYP-PRD-IRD-000200
Mechanism lifetime
Mechanism lifetime shall be demonstrated by test using the sum of predicted nominal ground test and health-check cycles (other than lifetime test) and the in orbit operation cycles. The number of predicted cycles shall be multiplied by the factors specified in ECSS-E-ST-33-01C.
Verification Method : T

HYP-PRD-IRD-000210
Mechanism test during Satellite AIT
It shall be possible to activate and verify the performance of mechanisms during the AIT campaign at satellite level including TVAC test.
Verification Method : R

3.2.4. Functional Requirements

HYP-PRD-IRD-000300
P/L Duty Cycle
The Payload shall be operated in orbit with a duty cycle respecting the orbit available average power and the available peak power.
Verification Method : A

HYP-PRD-IRD-000310
P/L Off Mode
In Off mode all the units shall be off; the payload shall not be powered.
Note: the applicability of this mode is to be discussed with the payload design authority
Verification Method : R

HYP-PRD-IRD-000320
P/L Stand-by Mode
The Stand-by mode shall be nominally entered after applying power to the Payload Electronics subsystem.
Note: the applicability of this mode is to be discussed with the payload design authority
Verification Method : R, T

HYP-PRD-IRD-000330
P/L Warm-up Mode

In the Warm-up mode the Payload electronics subsystem shall be controlled by the software in the platform. While in this mode, the payload electronics subsystem receives and interprets commands, generates housekeeping telemetries but no science data are generated.
Note: the applicability of this mode is to be discussed with the payload design authority
Verification Method : R, T

HYP-PRD-IRD-000340
P/L Safe Mode
Safe mode shall be automatically entered whenever a not nominal condition is encountered in any other modes excluding Stand-by mode.
Note: the applicability of this mode is to be discussed with the payload design authority
Verification Method : R, T

HYP-PRD-IRD-000350
P/L Test Mode
In Test mode the Payload shall perform like in the Operative mode but with dummy data instead of science data.
Note: the applicability of this mode is to be discussed with the payload design authority
Verification Method : R, T

HYP-PRD-IRD-000360
P/L Operative Mode
The payload shall support a unique Operative mode.
Note: the applicability of this mode is to be discussed with the payload design authority
Verification Method : R, T

HYP-PRD-IRD-000370
Payload Data Rate
The maximum allowed output peak data transfer rate shall not exceed 1280 Mbps (TBC).
Verification Method : R, T

3.2.5. Software Requirements

HYP-PRD-IRD-000380
Software version
The version of the payload on-board s/w shall be included in relevant payload TM packets
Verification Method : R, T

HYP-PRD-IRD-000390
PUS services
The payload shall comply with the Telemetry and Telecommand Packets Utilisation Standard (PUS), according to the followind standar services:

- PUS Service 1 - Requests Verification Service (RQVS). In this context, the service shall include the Ground TC acquisition, the preliminary TC packet verification, and the dispatching to the destination. *Note - The remaining part of the service (TC data consistency verification, TC operative plausibility, TC execution progress notifications, TC execution completion notifications) is distributed among the TC destinations.*

- PUS Service 2 - Device Access Service (DVAS).
- PUS Service 3 - Housekeeping and Diagnostic Data Reporting Service (HDRS).
- PUS Service 4 - Parameter Statistics Reporting Service (PSRS).
- PUS Service 5 - Event Reporting Service (EVRS).
- PUS Service 6 - Memory Management Service (MEMS).
- PUS Service 9 - Time Management Service (TMMS).
- PUS Service 11 - Time Scheduling Service (PBSS).
- PUS Service 12 - On-board Monitoring Service (OBMS).
- PUS Service 13 - Large Packet Transfer Service (LPTS) - TBC
- PUS Service 14 - Telemetry Forwarding Control Service (TMFS).
- PUS Service 15 - On-board Storage and Retrieval Service (OSRS).
- PUS Service 17 - Connection Test Service (CNTS).
- PUS Service 18 - Request Sequences Management Service (RSMS).
- PUS Service 19 - Event-Action Service (EVAS).
- PUS Service 22: Position-based Scheduling Service (PSS).
- Mission Service 130 - Commands Database Management Service (CDMS).
- Mission Service 131 - Orbit Management Service (ORMS).
- Mission Service 132 - Position Based Scheduling Service (PBSS).
- Mission Service 133 - Critical Commands Execution Support (CCES).
- Mission Service 134 - Commands Batch Execution Support Service (CBES).
- Mission Service 142 - Specific Payload Management Service

Note: usage of specific payload management service (Service 142) to be discussed with the payload design authority
Verification Method : R, T

3.2.6. Failure Detection, Isolation and Recovery (FDIR) Requirements

HYP-PRD-IRD-000400
Autonomous payload reconfiguration

Autonomous payload reconfiguration or corrective / saving action shall bring the payload in the closest state to operation in order to recover the nominal operations as quickly as possible (e.g., and as far as possible: thermal operational environment should be maintained; heating control should be kept on, mechanism should be placed in safe position).
Note: the applicability of this feature is to be discussed with the payload design authority
Verification Method : R, T

HYP-PRD-IRD-000410
Payload TM to support FDIR at satellite
The payload shall provide sufficient telemetry to support payload FDIR at satellite level.
Verification Method : R, T

HYP-PRD-IRD-000420
FDIR to minimise mission outages
The payload FDIR shall implement autonomous recovery mechanisms to minimise mission outages due to e.g., Single Event Effects (SEE) caused by the radiation environment (cosmic rays, solar flares, van Allen belts or South Atlantic Anomaly).
Note: the applicability of this requirement is to be discussed with the payload design authority, in conjunction with the agreed availability requirement
Verification Method : R

HYP-PRD-IRD-000430
FDIR functions enable/disable by ground
It shall be possible to enable / disable the on-board autonomous FDIR functions of the payload and recovery from anomaly by ground command.
Verification Method : R

HYP-PRD-IRD-000440
FDIR parameters reconfiguration
It shall be possible to re-configure the FDIR parameters of the payload.
Verification Method : R

3.2.7. Interfaces

3.2.7.1. Electrical interfaces

3.2.7.1.1. General Electrical Requirements

HYP-PRD-IRD-000500
Equipment power sources
The payload shall be connected to power source by dedicated and protected power lines.
Verification Method : I, R

HYP-PRD-IRD-000510

Power Protections General Requirement
The payload shall be designed considering that the power source is protected by Latching Current Limiters (LCLs) .
Verification Method : I, R

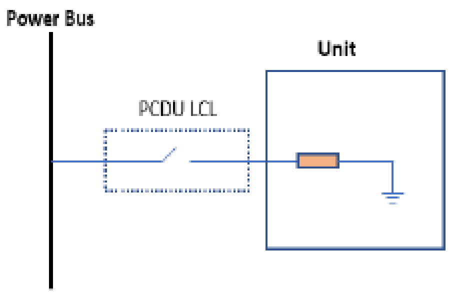
HYP-PRD-IRD-000520
Bus Voltage transient
The payload shall be designed and optimized to work over the operational bus voltage range and when submitted to all transients.
Verification Method : R, T

HYP-PRD-IRD-000530
Loads Undervoltage thresholds
Undervoltage protection circuits on the primary side of user DC/DC converters shall be avoided since the PCDU LCLs will provide all the necessary protection
In case of undervoltage protection is implemented by DC-DC converter interfaced with main bus, the load shall not switch off its DC/DC converter for voltages greater than 22V.
Appropriate Hysteresis shall be implemented for switch on.
Verification Method : A, T

HYP-PRD-IRD-000540
Current protection
The use of current protection circuits on the primary side of user DC/DC converters shall be avoided since the platform LCLs (inside PCDU) will provide all the necessary protection. If the use of protection circuits cannot be avoided, then the protection threshold shall be set:

- Higher than the PCDU LCL if user protection circuit is unique and supplies the whole unit (case 1 in next figure);
- Lower than the PCDU LCL if user is equipped of more parallel protection circuits, each of which protects different boards of the same unit (case 2 in next figure).

Moreover, tests must be performed with a representative PCDU LCL as early as possible.



CASE 1

Figure 1 LCL protection supplies whole unit

CASE 2

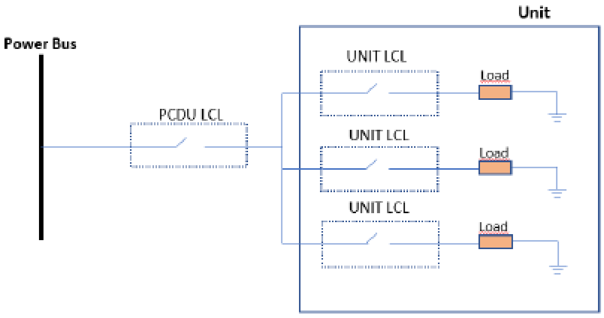


Figure 2 LCL protection supplies whole unit

Verification Method : A,T

HYP-PRD-IRD-000550
Number of P/L Heaters
Number of the P/L heaters lines shall be equal to 5N + 5R.
Note: max peak power shall be calculated according to HYP-PRD-IRD-000560 and voltage range HYP-PRD-IRD-000620.

Verification Method : R

HYP-PRD-IRD-000560
Heaters Fuses Classes
Following classes for P/L heaters fuses shall be provided:

Heater	Fuse size [A]
HEAT1_PYL	3.5
HEAT2_PYL	5
HEAT3_PYL	1.75
HEAT4_PYL	2.1
HEAT5_PYL	2.1

Table 2 Payload input heaters fuses classes

Verification Method : R

HYP-PRD-IRD-000570
Number of P/L thermistors
The thermistors provided by the platform to the payload for monitoring are 10 (nominal) + 10 (redundant).
Verification Method : R

HYP-PRD-IRD-000580
Protected Power Lines Users

Each equipment connected to a protected power lines, shall not draw more input nominal current than specified in Tab. Reported in HYP-PRD-IRD-000640 (Power Lines Protection Features).
Verification Method : A, R, T

HYP-PRD-IRD-000590
Users current limiters
No active control loop within the load shall limit the load current when the LCL is in its current limiting mode.
Verification Method : A, R, T

3.2.7.1.2. Power

HYP-PRD-IRD-000600
Payload Power Consumption
The power consumption in any operative condition of the payload shall be compatible with the total power resources available for payloads:

- Orbit average power consumption: from 100 W up to 200 W (depending on orbit altitude and operational conditions);
- Peak power consumption: up to 750 W.

Verification Method : T

HYP-PRD-IRD-000610
Payload Short Transient power peaks
Short transient power peaks shall not exceed 20% of the above-required power for a maximum duration of 100 msec.
Verification Method : T

HYP-PRD-IRD-000620
Bus Power Supplies
The payload shall be designed to operate without performance degradation considering the following bus power supplies (TBC):

- unregulated operative bus with voltage in the nominal range 22-36 V;
- regulated 5 V (only through PLIU);
- regulated 12 V (only through PLIU);
- regulated 28 V (only through PLIU)Note: regulated 50-100 V could be added as an option.

Verification Method : R, T

HYP-PRD-IRD-000630
Ripple on main power bus
The payload shall be compliant with a Main Power Bus ripple of 1% wrt to the nominal bus voltage.

Verification Method : A

HYP-PRD-IRD-000620
Payload protection
Payload shall be designed accounting for automatic switch off triggered by the platform (FDIR) TBC
Verification Method : R, T

HYP-PRD-IRD-000630
Power Cut-Off
Inadvertent power cut-off shall be tolerated by the payload without any damage or permanent degradation.
Verification Method : R, T

HYP-PRD-IRD-000640
Power Converter Current Protection
The use of current protection circuit on the primary side of user DC-DC converters shall be avoided since Platform LCLs (inside PCDU) will provide all the necessary protection, as reported in the following table (TBC):

UNIT	UNITS Qty	Lines Qty for each Unit		Total Lines		Voltage [V]	Protection Type	CLASS [A]
		M	R	M	R			
P/L I/F 1	1	1	1	1	1	28 (unreg)	LCL	30 A
P/L I/F 2	1	1	1	1	1	28 (unreg)	LCL	5 A
P/L additional	1	1	1	1	1	28 (unreg)	LCL	15 A

Table 3 Payload input power lines

Verification Method : R

HYP-PRD-IRD-000650
HDRM power lines
Up to 4 HDRM power lines (fused) for the payload are available (see RD 11 for ICD).
Verification Method : R

HYP-PRD-IRD-000660
Power Lines Protection Features
The LCL and HLCL and shall be sized in order to be compliant with the parameters shown in the following tables:

Characteristics	Unit	LCL classes									
		1	2	3	4	5	6	8	10	15	30
Unregulated bus voltage	V	22 to 36									
Class current	A	1	2	3	4	5	6	8	10	15	30
Nominal Threshold	A	1.25	2.50	3.75	5.00	6.25	7.50	10.00	12.50	18.75	37.50
Min limitation current	A	1.13	2.25	3.40	4.50	5.63	6.75	9.00	11.25	16.88	33.75
Max limitation current	A	1.44	2.88	4.30	5.75	7.19	8.63	11.50	14.38	21.56	43.13
Trip-off min	ms	10	10	8	6	3	3	3	3	2.5	1.5
Trip-off max	ms	20	16	12	12	8	8	8	8	6	4
Max Voltage Drop	V	0.30	0.50	0.65	0.70	0.40	0.40	0.50	0.70	1.00	1.00
Max Load Capacitance	µF	201	300	320	482	301	362	482	603	558	670

Characteristic	Unit	HLCL class
		2
Unregulated Bus voltage	V	22 to 36
Class current	A	2
Min limitation current	A	2.2
Max limitation current	A	2.8
Trip-off min	ms	0.5
Trip-off max	ms	2
Max load capacitance	µF	1

Table 4 LCLs and HLCL parameters

Verification Method : A,R, T

HYP-PRD-IRD-000670
Power Supply Gain and Phase Margin
The phase margin of switching DC-DC converters and power regulators shall be at least 50° with gain margin 10 dB in worst case conditions (@EOL).
Verification Method : A, R, T

HYP-PRD-IRD-000680
Protection Stability
The payload shall be designed considering that LCLs shall be unconditionally stable in presence of capacitive load (depending on LCL class) with a charge as specified in req. HYP-PRD-IRD-000690 and with an inductive load less than 100uH (TBC).
Verification Method : A, R, T

HYP-PRD-IRD-000690
Inrush Current Characteristics
Inrush current at payload switch on shall not exceed the following characteristics:

- Rate of change of current, dI/dt < 2 A/µs;
- Total charge Q < T*I_t, for the input filter settling time of T < 7 ms (where I_t is the LCL Trip-Off Class in Amps).

Verification Method : A, R, T

HYP-PRD-IRD-000700
Fault Voltage Tolerance
The payload power bus users shall be designed to withstand an input bus voltage of 22 V to 40 V with all transients without damage.
Verification Method : A, R, T

HYP-PRD-IRD-000710
Bus reverse voltage
The payload shall be protected against unintentional application of reversed voltage.
Verification Method : R, T

HYP-PRD-IRD-000720
Users Data
Payload shall provide detailed data of their input/output circuits configuration and components part values.
Verification Method : R

HYP-PRD-IRD-000730
Leakage current
The payload in “off” state shall not draw any current from the power source. In any case, if power switching is performed at the user component, a leakage current less than 3mA (TBC) drawn by the “off” unit will be permissible as long as the “off” unit does not feed current to other interconnected components.
Verification Method : A, R, T

HYP-PRD-IRD-000740
Redundancy
Nominal and redundant signals routing on the same PCB shall be avoided. When not possible, physical lay out must guarantee no failure propagation.
Verification Method : R

HYP-PRD-IRD-000750
Failure Propagation
Any risk of failure propagation shall be avoided.
Verification Method : R

HYP-PRD-IRD-000760
Nominal and Redundant Connectors
Nominal and redundant ways shall use separated connectors.
Verification Method : R

3.2.7.1.3. Connector requirements

HYP-PRD-IRD-000770
Definition
Connectors types shall be defined separately for equipment connectors, R.F. connectors, skin connectors and pyrotechnic connectors.
Verification Method : R

HYP-PRD-IRD-000780
Electrical ICD (EICD)
Interfaces will be formally controlled within the Electrical Interface Control Documents.
The Electrical Interface Control Document will present all the electrical properties and additional useful details for each unit through the electrical datasheets. The Recommended format is provided in APPENDIX A as a guide.
Verification Method : R

HYP-PRD-IRD-000790
Mechanical Locking
Male and female connectors shall be mechanically locked together, to prevent inadvertent disconnection.
Verification Method : I,R

HYP-PRD-IRD-000800
Accessibility
Connectors shall be accessible and easily mounting; the location shall be detailed in the ICD (Interface Control Document)
Verification Method : I,R

HYP-PRD-IRD-000820
Electrical connectors distance
Connectors installation shall keep into account at least 10 mm from shell to shell to allow proper mounting and tooling.
Verification Method : I,R

HYP-PRD-IRD-000830
Loads on connectors
Connectors shall not be used in mechanical load paths (i. e.: electrical connectors shall not be used to carry mechanical load to/from the structure).
Verification Method : I,R

HYP-PRD-IRD-000840
Assignment
The payload shall use separate connectors for TM/TC and Power.
Verification Method : R

HYP-PRD-IRD-000850

Power/data connectors 1

In case Units do not use separate connectors for power lines and data lines, the power lines shall be separated in the connector by a set of unused pins from signals and telemetry lines.

Verification Method : R

HYP-PRD-IRD-000860

Power/data connectors 2

Power connectors shall have shell size/gender type different from signal connectors so that incorrect mating of connectors should be excluded by design.

Verification Method : R

HYP-PRD-IRD-000870

Power/data connectors 3

No more than 90% of the available number of pins per connector shall be used.

Verification Method : R

HYP-PRD-IRD-000880

DC Connectors

Equipment mounted DC connectors shall be of the following types:

- Male: for those connectors "receiving" signals and/or power;
- Female: for those connectors "sending" signals and/or power and all unit test connectors.

Verification Method : I, R

HYP-PRD-IRD-000890

Connectors labeling

Connector labels shall ensure that no possibility of incorrect mating exists.

In order to avoid connectors mismatch, the connectors of the units shall be labeled as "Jxx" and the connectors of the harnesses shall be labeled as "Pxx", where "xx" is a progressive number.

Note: (a) the same connectors naming shall be used in the technical documentation

(b) connectors of redundant boards shall be labelled as "J1xx/P1xx", where "xx" is the same number of the nominal one.

(c) redundant connectors of the same board shall be labelled as "Jyy" where "yy" is "xx" + 10/20/30, etc.. depending on the numbers of the connectors on the board.

Verification Method : R

HYP-PRD-IRD-000900

Title : **Connectors savers**

Flight connector shall be protected by using connector savers and caps.

Note: connector saver and caps envelope shall be reported in the payload ICD.

Verification Method : R

3.2.7.1.4. Telecommands and data handling

HYP-PRD-IRD-000920

Payload Data Exchange - 1
The payload shall be able to exchange data (receive telecommands and send HK data) with the platform via dedicated interfaces and/or the spacecraft data handling bus.
Verification Method : R

HYP-PRD-IRD-000930
Payload Data Exchange - 2
For data exchange, the payload shall be compatible with at least one of the following interfaces :

- CAN Bus;
- High-speed serial link (HSSL);
- MIL-1553 link (as an option, CAN bus is preferred);
- Spacewire link.

Verification Method : R

HYP-PRD-IRD-000940
Payload Data Exchange - 3
Payload data and TM/TC data shall be exchanged with the platform via separate data interfaces.
Verification Method : R, T

HYP-PRD-IRD-000950
Payload Data Exchange - 4
Payload scientific data shall be delivered only onto the active bus to the platform upon internal telecommand request.

HYP-PRD-IRD-000960
Payload HK Data
Payload housekeeping data which are made available to the OBDH, shall include at minimum:

- Regulated current(s) and voltage(s);
- Unit temperature(s);
- Errors and warning for local monitored parameter;
- Unit death reports.
- Payload mode

Verification Method : R

HYP-PRD-IRD-000970
Payload Redundancy
The payload shall have two redundant interfaces (main and redundant).
Verification Method : R

3.2.7.1.5. Data BUS interfaces

The available Data Bus is:

- CANOPEN BUS

Applicable Bus for interface of payload equipments with CANOPEN bus.

3.2.7.1.6. Grounding requirements

The ground referencing system is not only a dc voltage reference but represents also an AC zero-potential system for high frequency and noise (i.e. noise caused by dc-dc converters). Grounding concept is based on Distributed Singl Point Grounding (DSGP) configuration as reported in fig. 4.3.

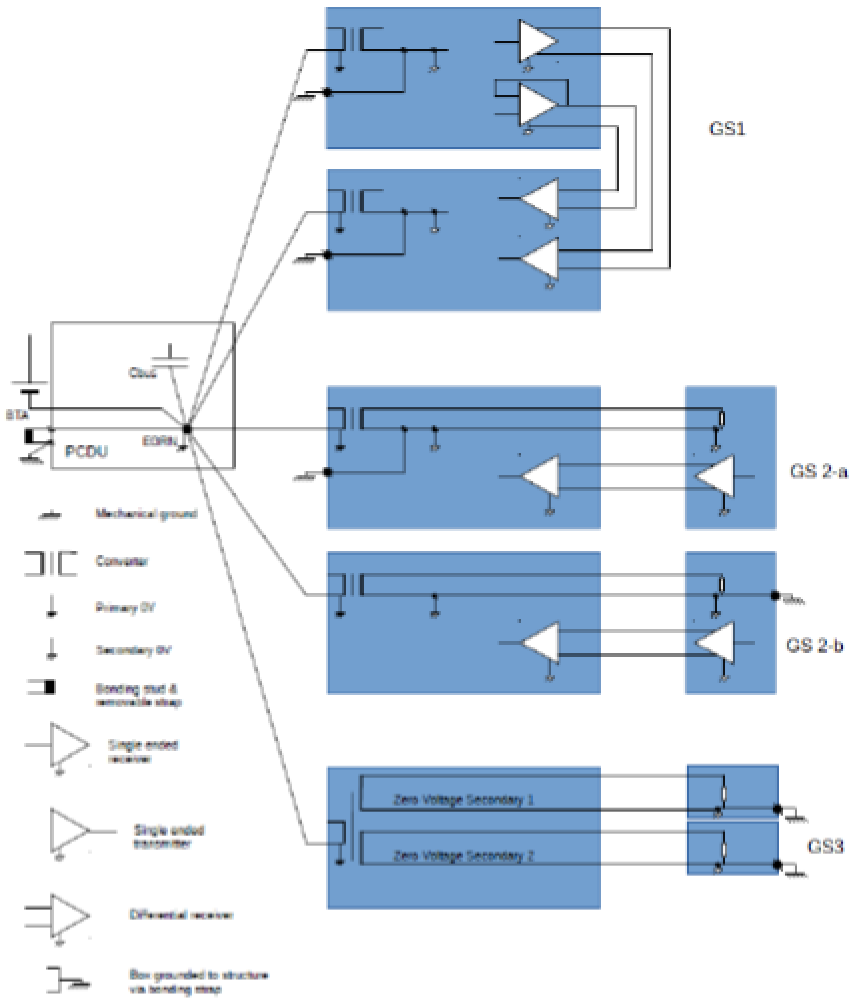


Figure 3 Grounding Concept

HYP-PRD-IRD-001000

Grounding network

Primary Power will be referenced to ground within the power S/S (PCDU side). The grounding of primary power lines is forbidden for all other users. The structure shall not used as a current return path for primary (or secondary) power as reported in Figure 3

Verification Method : R

HYP-PRD-IRD-001010
Distributed Single Point Power Grounding (DSPG)
The grounding concept shall be based on Distributed Single Point Grounding (DSGP) system as reported in Figure 3.
Verification Method : R

HYP-PRD-IRD-001020
Primary Power Lines EGRN Ground
The return of all the power lines shall be grounded to a single grounding point (EGRN) located at the negative side of bus capacitor within the PCDU.
Verification Method : R

HYP-PRD-IRD-001030
Primary Power Lines Isolation
Users of primary power shall isolate the power wires from the structure.
Verification Method : R

HYP-PRD-IRD-001040
Isolation values
The following reported isolation values shall be met:

BONDING RESISTANCE	INSULATION VALUES
Between any primary power supply pin and the bonding stud except for PCDU pins connectors	R ≥ 1 Mohm; C ≤ 50 nF
Between primary power and secondary power	R ≥ 1 Mohm; C ≤ 50 nF
Between secondary power lines and the box structure (applies only when the secondary power return is disconnected from the ground)	R ≥ 1 Mohm; C ≤ 50 nF

Table 5 Isolation values table

Verification Method : R, T

HYP-PRD-IRD-001050
Equipment grounding isolation
Each equipment using the primary power bus shall provide a dedicated power return line with the respect of the following isolation value:
Resistance > 1Mohm between:

- Primary power hot line/ positive pin and structure (chassis)
- Primary power return line/ pin 0V and structure (chassis)
- Primary power return line/ pin and any Redundant Power Primary return line/ pin in the same equipment

Capacitance < 50nF between:

- Primary power hot line/ positive pin and structure (chassis)
- Primary power return line/ pin 0V and structure (chassis)
- Primary power return line/ pin and any Redundant Power Primary return line/ pin in the same equipment

Verification Method : R, T

HYP-PRD-IRD-001060

Equipment grounding isolation measurement

The measurement of resistance shall be done by applying a differential DC voltage of 28V, for both polarities. During the measurements, the unit shall be disconnected from the power primary source in OFF condition configuration; the capacitance shall be measured by means of capacitance meter by considering a frequency of 1KHz.

Verification Method : R, T

3.2.7.2. Mechanical interfaces and environment

3.2.7.2.1. Payload reference frame

HYP-PRD-IRD-001100

Payload Optical Reference frame

The payload Optical Reference Frame shall be reported in the PL ICD.

Verification Method : R

HYP-PRD-IRD-001110

Payload Field Of View (FoV) and exclusion angles

The payload Field of View and exclusion angles shall be reported in the PL ICD. It is applicable to optical FOV, radiator FOV.

Note: Payload accommodation on the satellite platform shall shall prevent any obstruction to the payload optical FOVs and the radiator FOVs.

Verification Method : R

HYP-PRD-IRD-001120

Payload Physical Reference frame

The payload Physical Reference Frame shalle be reported in the ICD: it shall be body fixed, orthogonal and right-handed.

Verification Method : R

3.2.7.2.2. Mechanical interface

HYP-PRD-IRD-001130

Payload ICD

The payload ICD provided at unit level shall contain at least the following information:

- The nominal location of the center of mass, with tolerances
- Nominal moments of inertia, with tolerances
- Nominal Unit dimensions and mass, with tolerances
- Unit dimensions including connector saver
- All interfaces geometrical,material properties, surface finishing, Thermo Optical Properties, with tolerances
- Handling points specifications
- Unit baseplate thickness and dimensions
- Unit layout and method of fixation
- Screws type, material and tightening torque
- Contact area used as interface for thermal dissipation
- Thermal Reference Point (TRP)
- Mechanical Refence Frame (MRF), Optical Reference Frame (ORF), Alignment Refrence Frame (ARF)
- Payloaf FoV and exclusion angles
- Connector saver envelope
- Thermal Capacity

Verification Method : I, R

HYP-PRD-IRD-001140

Positioning points

At least 2 positioning points and (when necessary) shims shall be provided with location and tolerance consistent with positioning requirements.

Verification Method : R

HYP-PRD-IRD-001150

Alignment tolerances

The Contractor of the payload shall specify the alignment tolerances between the mating and the sensitive axis as well as between the dowel line and the sensitive axis (e.g. thrust axis).

Verification Method : R

HYP-PRD-IRD-001160

Drill template

The Contractor of the payload shall provide the Prime Contractor with a drilled template in accordance with the dowel positioning.

Verification Method : R

HYP-PRD-IRD-001170

Alignment adjustment request

Should some items require accurate alignment adjustment in situ the payload Contractor shall formulate a request to the Prime Contractor with proper justification.

Verification Method : R

HYP-PRD-IRD-001180

Alignment adjustment strategy

The adjustment process shall be defined in each case by common agreement between the payload Contractor and the Prime Contractor.

Verification Method : R

HYP-PRD-IRD-001190

Boxes attachment definition

The number and pattern of boxes attachment points shall be approved by the Prime Contractor.

Verification Method : R

HYP-PRD-IRD-001200

Number of attachment points

Each unit shall be mounted with as many female bi-hexagonal screws as needed to ensure a ratio "unit maximal mass / number of attachment points" below 1.5 kg.

Verification Method : R

HYP-PRD-IRD-001210

Threaded holes

Threaded holes an aluminum flanges shall be provided with stainless steel "helicoils" inserts, or equivalent allowing a large number of mounting/dismounting operations.

Verification Method : R

HYP-PRD-IRD-001220

Threads constraints

Payload units shall be compatible with the following spacecraft fixation points threads characteristics as defined for standard single insert and special inserts:

Standard	Usable Thread length (mm)	Bolt penetration (mm)
M4	7.5	7.5
M5	9.5	9.5
M6	11.5	11.5
M8 x 1	15.9	15.9

Table 6 Standard single inserts dimensions table

Standard	Usable Thread length (mm)	Bolt penetration (mm)
M4	1.5 D	2 D
M5	1.5 D	2 D

M6	1.5 D	2 D
M8 x 1	1.5 D	2 D

Table 7 Special single inserts dimensions table

Verification Method : R

HYP-PRD-IRD-001230

Tightening torques

For all the joining elements the related tightening torque shall be reported in the design documentation, keeping into account the installation conditions (lubrication, retaining elements, etc.).

Verification Method : R

HYP-PRD-IRD-001240

Tightening torques - Testing

Tightening torques on screws that shall be removed for testing purposes (e.g.: I/F screws) could be reduced of 20% of the nominal value to avoid damaging the units due to mounting/dismounting operations. This applies only to testing related operations and not for the final integration, when nominal values shall be taken into account.

Verification Method : R

HYP-PRD-IRD-001250

Contact areas location

The contact area between boxes and structure shall be at the area of the lugs.

Verification Method : R

HYP-PRD-IRD-001260

Protrusions avoidance

Protrusions of the units below the mount area plane shall be avoided

Verification Method : R

HYP-PRD-IRD-001270

Thermal relevance of contact areas

If for thermal reasons larger areas are requested, the contact area (complete bottom face) shall meet the following requirements unless there are other mechanical or electrical constraints:

- flatness of 0.1 mm/100 mm (for mounted box and structure in area of mounting plane);
- overall mounting surface flatness < 0.2 mm;
- contact surface roughness < 3.2 micrometers (2.5 mm for contact surface w/o thermal interfiller).

Exceptions are subject to approval by the Prime Contractor.

Verification Method : I

HYP-PRD-IRD-001290

Damping supports

No damping supports external to the payload unit shall be used.

Verification Method : R

HYP-PRD-IRD-001300
Interface Holes Minimum Inter Axis Distance
Payload units shall shall respect this minimum inter axis fixation points:

Standard	Minimum Inter Axis Distance [mm]
M4	35
M5	40
M6	45
M8	50

Table 8: Hole Inter Axis

Verification Method : R

3.2.7.2.3. Mechanical design requirements

HYP-PRD-IRD-001310
Payload Failure Modes
The following failure modes, for payload at all levels of integration, shall be prevented:

- Permanent deformation (yield);
- Rupture;
- Instability;
- Gapping of bolted joints;
- Degradation of bonded joints;
- Loss of alignment of units that are subjected to alignment stability requirements, distortion violating any specified envelope;
- Distortion causing functional failure or short circuit.

Verification Method : A, R, T

HYP-PRD-IRD-001320
Payload Mass
The actual mass of payloads QM, FM or PFM shall not deviate from the nominal value by more than:

- 0.5% for masses > 20 kg;
- 0.1 kg for masses > 10 kg and < 20 kg;
- 1% for masses > 1 kg and < 10 kg;
- 10 g for masses < 1 kg.

Verification Method : A, T

HYP-PRD-IRD-001330
Payload Mass Measurement Accuracy
The masses shall be measured with an accuracy of:

- ±0.1 % for masses > 50 kg;
- ±0.05 % for masses > 10 kg and < 50 kg;

- ±1 g for masses < 10 kg.

Verification Method : A, T

HYP-PRD-IRD-001340
Payload CoG -1
The location of the center of mass for units intended for EM, Flight and Flight Spare(s) shall not deviate from the nominal location by more than 1.0 mm radius sphere.
Verification Method : A, T

HYP-PRD-IRD-001350
Payload CoG -2
The center of mass location shall be measured with an accuracy of 0.5 mm, counted as spherical error/ all 3 axis combined
Verification Method : A, T

HYP-PRD-IRD-001360
Payload First Resonance Frequency
The first resonance frequency of the Payload sub-units shall be higher than 140 Hz TBC.
Note: excluding appendages and antennas
Verification Method : A, T

HYP-PRD-IRD-001370
Payload First Resonance Frequency – design maturity margin (before)
The analytically predicted first eigen-frequency of the Payload shall be at least 15 % higher than the minimum specified requirement before any modal survey / coupled loads analysis results are available.
Note: This is a design maturity margin to cover prediction analysis uncertainties before any modal survey / coupled loads analysis results are available.
Verification Method : A, T

HYP-PRD-IRD-001380
Payload First Resonance Frequency – design maturity margin (after)
The first main eigen-frequency of the Payload shall be higher than the minimum specified requirement with the following margins:

- At least 5 % for Payload modes with iso-static mounts;
- At least 10 % for Payload modes with complex shapes or orders.

Note: This requirement is not cumulative with the previous one and it only applies after modal survey / coupled loads analysis results are available.
Verification Method : A, T

HYP-PRD-IRD-001390
Payload Disturbance Torque
Disturbance torque generated by the rotation of any payload units (e.g. calibration mechanism, carousel) shall respect the following constraints :

- max torque absolute value shall be below TBD Nm

• integration of disturbance torque between T0 and any time up to the end of the rotation shall remain below XXX Nms (Note : by definition, the integration of disturbance torque during the whole duration of rotation is null)
Note: to be discussed if applicable with payload design authority
Verification Method : A, T

HYP-PRD-IRD-001400
Payload generated shock
The shocks generated by the payload, e.g. due to unlocking of mechanisms, shall be less than the levels repoted in the specific shock requirement of this IRD.
Verification Method : A, T

3.2.7.2.4. Mechanical environment

HYP-PRD-IRD-001500
General Mechanical Environment
The payload unit shall be designed to withstand the environment it will encounter during its lifetime without degradation of its performance, and without detrimental influence on the spacecraft or any other unit.
The following shall be taken into account:

- Fabrication and assembly loads (e.g. welding, interference fitting);
- Handling and transportation loads;
- Test loads (including thermal stresses);
- Launch loads (vibration (including shock), thermal and depressurisation);
- Operational loads (including thermal, attitude and orbit control induced loads);
- Structural dimensioning of the units shall consider critical combination of simultaneously acting loads (e.g. mechanical and thermal).

Verification Method : A, R, T

HYP-PRD-IRD-001510
QL Definition
Qualification loads QL and acceptance loads AL shall be as a minimum:

•QL = KQ× LL final for qualification;

•QA = KA× LL final for acceptance;

•where LL final is the best knowledge of the LL as resulting from the structural analysis performed at system level (which shall take into account the launch vehicle input loads plus the related safety margins).

Verification Method : R

HYP-PRD-IRD-001520
Sine Loads
The payload shall be designed to withstand the high level sine vibration environment].

In-plane Sine load		
Frequency [Hz]	Amplitude [g] - Qualification	Amplitude [g] - Acceptance
1-28	10 mm p-p	-
28	16	12.8
125	16	12.8
Sweep duration	2 oct/min	4 oct/min
Out-of-plane Sine load		
Frequency [Hz]	Amplitude [g] - Qualification	Amplitude [g] - Acceptance
1-16	10 mm p-p	-
16	5.00	4.00
70	5.00	4.00
70	15	12
125	15	12
Sweep duration	2 oct/min	4 oct/min

Table 9 Sine Loads

Verification Method : A, T

HYP-PRD-IRD-001530
Sine notching
Notching of the sine vibration level shall be considered in order not to exceed the payload quasi-static interface loads (qualification).
Any proposed notching shall be agreed with the Customer.

Verification Method : A, T

HYP-PRD-IRD-001540
Random Vibration Environment
The payload shall be designed to withstand the random vibration environment specified.

Random load		
Frequency [Hz]	Amplitude [g2/Hz] - Qualification	Amplitude [g2/Hz] - Acceptance
20	0.080	0.040
130	0.35	0.175
400	0.35	0.175
2000	0.023	0.0115
gRMS	15.97	11.29
Test duration	2 min	1 min

Table 10 Random Loads

Verification Method : A, T

HYP-PRD-IRD-001550

Random notching

Notching of the random vibration level shall be considered in order not to exceed the payload quasi-static interface loads (qualification).

Any proposed notching shall be agreed with the Customer.

Verification Method : A, T

HYP-PRD-IRD-001560

Acoustic Loads

The following acoustic loads shall be considered in the design:

Octave Center Frequency [Hz]	Acoustic Loads Qualif.	Test Tolerance [dB]
31.5	133	-2; +4
63	138	-1; +3
125	137	-1; +3
250	142	-1; +3
500	144	-1; +3
1000	139	-1; +3
2000	132	-1; +3
4000	129	-1; +3
8000	126	-1; +3
120 sec	OASPL 148	-1; +3

Table 11 Acoustic Environment

Note: all loads are qualification loads. Only applicable for larger surface and external appendages.

Verification Method : A, T

HYP-PRD-IRD-001570

Shock Environment

The P/L shall be designed to withstand the shock vibration environment specified.

Shock load	
Frequency [Hz]	Amplitude [g] - Qualification
100	100

1600	1500
10000	1500
Q	10

Table 12 Shock Loads

Note: All loads are qualification loads.
Test tolerance -3dB/+6dB applies across the full spectrum, with the lower test tolerance tailored to 0dB up to the corner frequency of 1000Hz. This in order to guarantee minimum qualification margin of 3dB within the critical range of the unit/equipment
Verification Method : A, T

HYP-PRD-IRD-001580
Quasi-static loads
The payload shall be designed to withstand the quasi-static loads specified.
Verification Method : A, T

HYP-PRD-IRD-001590
Quasi-static loads
The Paylaod shall be designed to withstand the following Quasi Static Loads along each axis:

Payload Mass [kg]	Qualification Value [g]
1	53
3	43
5	33
10	28
15	23
20	18

Table 13 QS Loads

Verification Method : A, T

3.2.7.3.Thermal interface and environment

HYP-PRD-IRD-001600
Payload Thermal Control System
In all operational modes, the payload shall perform its own thermal control, and implement the necessary thermal control functions and hardware (thermal sensors; thermistors; heaters; MLI; radiators; control laws and algorithms).
Verification Method : R

HYP-PRD-IRD-001610
Payload Survival heaters lines

The payload shall provide the necessary interfaces to allow the Satellite to continuously control the payload survival heaters to limit the non operating temperature. This thermal protection shall be performed in all payload modes, including payload OFF and SAFE mode.
Verification Method : R

HYP-PRD-IRD-001620
Thermal decoupling
The thermal control decoupling of the payload itself, including radiative and conductive decoupling (by MLI's and insulating washers) from satellite in order to minimise mutual interaction, shall be under the responsibility of the payload supplier.
The maximum thermal exchanges (conductive and radiative) between payload and platform shall be clearly reported by Contractor and agreed with Prime.
Note: for equipment, the satellite/platform thermal control design and analysis at unit level shall be limited to the Temperature Reference Points (TRPs).
Verification Method : R

HYP-PRD-IRD-001630
Thermal requirements at payload mounting interfaces
The payload Contractor shall clearly report specific requirements at payload mounting interfaces with platform:

- Temperature range of platform mounting plate/mounting feet
- Temperature variation (spatial and temporal) between mounting positions/mounting feet

Verification Method : R

HYP-PRD-IRD-001640
Internal temperatures responsibility
The internal temperatures distribution and the hot spots on the external housing shall be under the responsibility of the payload Contractor.
Verification Method : R

HYP-PRD-IRD-001650
Thermo-optical properties responsibility
The thermo-optical characteristic of the payload units shall be defined by the thermal control subsystem. Payload contractor is responsible for the application of a coating compliant with thermal requirements.
Verification Method : R

HYP-PRD-IRD-001660
Temperature limits definition
The thermal design of payload units shall comply with temperature limits and temperature margins as defined hereafter:

- Calculated temperature limits

The calculated temperature limits of a unit are the extreme temperatures, temperature gradients and transients that can be expected during the various mission phases These temperatures are calculated for all mission phases by a Thermal Mathematical Model (TMM). These calculations include the effects of extreme case combination w.r.t. environmental and operating mode conditions (BOL/EOL conditions, unit dissipations, voltage of power available for heaters…) but excluding failure cases. These worst case conditions will be determined and justified by the thermal control responsible.

• Predicted temperature limits

The predicted temperature limits of a unit are equal to the calculated temperature extended at both ends of the range by an appropriate uncertainty margin (UM).
Predicted Temperature = Calculated Temperature + UM (Uncertainty Margins) = Design Temperature
These predicted temperatures defines the design temperature limits.
This Uncertainty margin (UM) represents the temperature uncertainty resulting from uncertainties in thermal mathematical modeling, thermal parameters or tolerances and shall be estimated by performing a sensitivity analysis. In case of no sensitivity analysis available, an UM of +/-10°C shall be considered.
Verification Method : R

HYP-PRD-IRD-001670
Design temperature definition
The design temperature limits of a unit are the extreme temperatures, temperature gradients and transients that the unit shall tolerate during its specified lifetime for the various modes (operational, non-operational, switch-on). This temperature range represents the requirements for the satellite thermal design activities.

• Acceptance temperature limits

The operating and non-operating acceptance temperature limits of a unit are equal to the design temperature limits over the lifetime extended at both ends of the range by the Acceptance Margin (AM). The acceptance temperature limits are the extreme temperature that a unit can reach , but never exceed, during all envisaged mission phases (based on worst case assumptions).
Acceptance Temperature = Design Temperature + AM (Acceptance Margin)

• Qualification temperature limits

The operating and non-operating qualification temperature limits of a unit are equal to the acceptance temperature limits over the lifetime extended at both ends of the range by the Qualification Margin (Q.M.). As its qualified temperature limits, a unit is guaranteed to function nominally fulfilling all required performances with the required stability.

• Switch-on qualification temperature

The switch on qualification temperature is the lowest temperature at which an equipment may have power applied to it, or be activated during thermal qualification test.
Qualification Temperature = Acceptance Temperature + QM (Qualification Margin)
Verification Method : R

HYP-PRD-IRD-001680
Acceptance margin
The acceptance margin shall be +/- 5°C.
Verification Method : R

HYP-PRD-IRD-001690HYP-PRD-IRD-000710
Qualification margin

The qualification margin shall be +/- 5°C.
Verification Method : R

HYP-PRD-IRD-001700
TRPs
All temperature requirements of units shall refer to specific points of these units.
For isothermal equipment, the reference temperature is associated to the temperature of the single thermal node, in which has been modeled the equipment in the overall satellite thermal model
For non-isothermal equipment, the reference temperature is associated to the temperatures of the required and more detailed modeling of the equipment in the overall satellite thermal model.
Verification Method : R

HYP-PRD-IRD-001710
TRP location
The location of these reference points shall be defined by the unit responsible such that their temperatures can be related to the general thermal status of the unit and the critical unit components.
Verification Method : R

HYP-PRD-IRD-001720
TRP at baseplate
Preferably one of the unit reference points shall be located on the baseplate close to unit fixation points. When not indicated, the Reference Hole shall be the Temperature Reference Point.
Verification Method : R

HYP-PRD-IRD-001730
TCS properties description
Geometrical, thermo-optical and thermal properties, contact area, dissipated power for various modes and qualification temperature range shall be defined in IDS and/or ICD.
Verification Method : R

HYP-PRD-IRD-001740
Emissivity tolerance
The emissivity value shall be guaranteed at ± 0.02.
Verification Method : R

HYP-PRD-IRD-001750
Dissipation tolerance
Specific dissipation power and radiative area shall be guaranteed at ± 5%.
Verification Method : I

HYP-PRD-IRD-001760
Mathematical models responsibility
Unit thermal control is under their manufacturer's responsibility. Analysis of units thermal control shall be conducted using mathematical models.
Verification Method : R

HYP-PRD-IRD-001780
TMM definition
Detailed Thermal Mathematical Models (DTMM) and Detailed Geometrical Mathematical Models (DGMM) of payload units shall be created for analytical predictions representative of all the phases of the mission, including ground tests.
Verification Method : R

HYP-PRD-IRD-001790
TMM correlation /1
The TMM models shall unambiguously identify the flight and the test monitoring points.
Verification Method : R

HYP-PRD-IRD-001800
TMM delivery
Reduced Thermal Mathematical Models (TMM) and Geometrical Mathematical Models (GMM) shall be established and delivered to the Prime Contractor for units dissipating more than 10 W.
Verification Method : R

HYP-PRD-IRD-001810
TMM correlation /2
The detailed DTMM and DGMM shall be correlated against the environmental test results.
Verification Method : A

HYP-PRD-IRD-001820
Thermal loads
The payload units shall be designed to withstand the thermal environment (radiative and conductive) defined according to the mission scenario and orbit.Note: payload thermal environment is strongly dependant from Mission Requirement Document and payload accommodation. To be discussed and agreed between Prime Contractor and Payload Contractor.
Verification Method : A, T

HYP-PRD-IRD-001830
Thermal cycling/vacuum testing
The payload shall withstand without failure or degradation thermal cycling/vacuum tests considering the temperature limits specified in ECSS-E-ST-10-03C.
Verification Method : T

3.2.7.4. On-ground Environment Requirements

HYP-PRD-IRD-001900
On-ground environment
The payload shall withstand the environment specified in next table:

	Satellite AIT Activities	Transportation

	Satellite AIT Activities	Transportation
Pressure [mbar]	970 to 1050	200 to 1050
Humidity [%]	40 to 60	40 to 60
Temperature [°C]	23 ± 3	20 ± 10
Cleanliness	TBD	TBD

Table 14 On Ground Environment

Verification Method : R

HYP-PRD-IRD-001910
On-ground loads
The payload shall withstand the AIT activity loads specified in next table:

Cases		Applied Acceleration [g]
Hoisting	Vertical	-1.5
	Horizontal	±0.2
On integration test fixture with short and slow running	Vertical	-1.1
	Horizontal	±0.2
On dollies and trolleys	Vertical	-1.5
	Horizontal	±0.2
Container transportation	Vertical	-1 ± 2
	Horizontal in main moving direction	±1.5
	Horizontal perpendicular to main moving direction	±1.0

Table 15 On Ground Loads

Verification Method : T

3.2.7.5. In-Orbit Environment Requirements

HYP-PRD-IRD-001920
In-orbit environment definition
The payload shall be compatible with the in-orbit environment. The Space Environment defined by the ECSS Standard shall be used with respect to the definitions of:

- Atomic oxygen environment
- Charged Particle Radiation
- Magnetospheric Particles
- Cosmic Rays
- Atmosphere
- Atmospheric Density
- Plasma
- Solar Activity
- Gravity field

- Magnetic field
- Thermal Environment
- UV Radiation

where applicable.
Verification Method : R

HYP-PRD-IRD-001930
venting(launch)
Payload unit design shall provide adequate venting solution to preserve the structural integrity of the payload unit during launch depressurization in the ascent phase. The Unit shall be able to safely operate within a pressure range of 1 bar to 1E-10 bar.

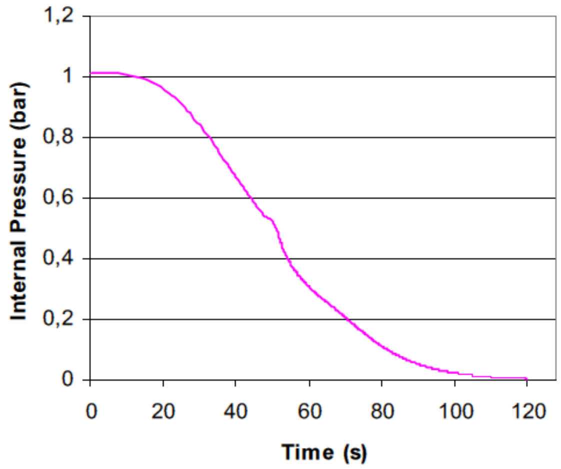


Figure 4 Variation of static pressure inside fairing

Verification Method : A

HYP-PRD-IRD-001940
Depressurisation rate (launch)
Unit shall withstand the depressurisation with a maximum depressurisation rate of 40 mbar/s.
Verification Method : A, T

HYP-PRD-IRD-001950
Venting hole area
Venting provision greater that $2mm^2$ hole area per litre of volume shall be implemented in payload unit.
Verification Method : I

HYP-PRD-IRD-001960
Debris
The payload shall be designed and implemented as to mitigate the risk of space debris, including collision, release and damage on ground, according to ECSS-U-AS-10-C.
To comply with relevant ECSS, the payload shall not generate and release any debris into space, such as pyrotechnic cutters or bolts; one-shot protective covers or shutters.

Verification Method : R

3.2.8. EMC Requirements

HYP-PRD-IRD-002000
S band and X band compatibility
The payload shall be compatible with, and immune to interferences caused by the following Transmitters / Emitters embarked on the satellite:

- S band
- X band
- Ka band

Verification Method : R

HYP-PRD-IRD-002010
Signal Interface Grounding
Signal circuits shall follow the distributed single point ground.
The signal interface shall be defined according to the following principle:

- Balanced transmitters / Differential receivers;
- Unbalanced transmitters (e.g. single ended) / Differential receivers with high input impedance.

Verification Method : R

HYP-PRD-IRD-002020
Bonding Junctions
The DC resistance between mating parts is reported in the next table as a function of the mating material.

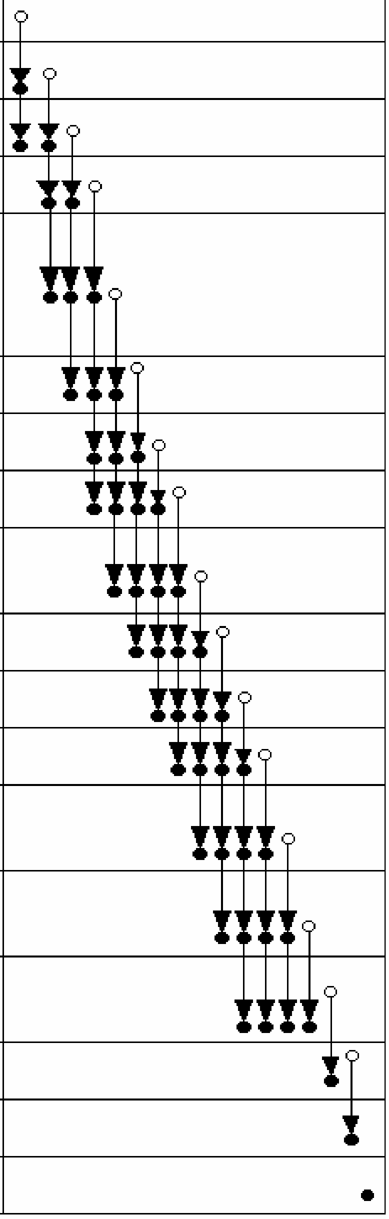
Junction	Bonding method	Maximum DC resistance
Metal – Metal	Screw \ Rivet	2.5 mΩ
	Conductive Glue	25 mΩ
Metal – CFRP	Screw \ Rivet	100 Ω
	Conductive Glue	200 mΩ
CFRP – CFRP	Screw \ Rivet	1kΩ
	Conductive Glue	200 kΩ
Quartz – Metal	Conductive Glue	200 kΩ
Non Conductive – Metal	Conductive Glue	1kΩ
Multiple Junction	Sum of resistance value of each junction	

Table 16 Bonding Junctions DC Resistance

Verification Method : R, I

HYP-PRD-IRD-002030
Bonding Method
Bonding shall be made by direct metal to metal surface contact, preferably, or by the use of bond straps if necessary. In general bonds, which are designed for referencing of circuitry (RF, DC and Signal ground), shall be assembled so that DC resistance of 2.5 mΩ per junction is achieved. To prevent corrosion, bonding of dissimilar materials should be avoided (i.e. use the same group in the

electromechanical series). If dissimilar metals cannot be avoided, particular attention shall be paid to valence potential delta levels. It is, therefore, important that materials are properly chosen and the junction correctly assembled in order to reduce the valence potential delta levels of the dissimilar metal mating surfaces.

Group No.	Metallurgical Category	EMF (Volt)	Anodic Index (0.01V)	Compatible Couples (see note below)
1	Gold, solid and plated; gold platinum alloys; wrought platinum	+0.15	0	
2	Rhodium plated on silver-plated copper, graphite	+0.05	10	
3	Silver, solid or plated; high silver alloys	0	15	
4	Nickel, solid or plated; monel metal high nickel-copper alloys, titanium	-0.15	30	
5	Copper, solid or plated; low brasses or bronzes; silver solder; German silver; high copper-nickel alloys; nickel-chromium alloys; austenitic corrosion resistant steels	-0.20	35	
6	Commercial yellow brasses and bronzes	-0.25	40	
7	High brasses and bronzes: naval brass; Muntz metal	-0.30	45	
8	18 percent chromium type corrosion-resistant steels	-0.35	50	
9	Chromium, plated; tin, plated; 12 percent chromium type corrosion - resistant steels	-0.45	60	
10	Tin-plate; terneplate, tin-lead solder	-0.50	65	
11	Lead, solid or plated; high lead alloys	-0.55	70	
12	Aluminium, wrought alloys of the duralumin type	-0.60	75	
13	Iron, wrought, gray or malleable; plain carbon and low alloy steels, armco iron	-0.70	85	
14	Aluminium, wrought alloys other than duralumin type; aluminium, cast alloys of the silicon type	-0.75	90	
15	Aluminium, cast alloys other than silicon type; cadmium, plated and chromated	-0.80	95	
16	Hot-dip-zinc plate; galvanized steel	-1.05	120	
17	Zinc, wrought; zinc-base die-casting alloys; zinc, plated	-1.10	125	
18	Magnesium and magnesium-base alloys, cast or wrought	-1.60	175	

Note:

○'= Indicates the most cathodic members of the series

●'= Indicates an anodic member

Arrows indicate the anodic direction

Verification Method : R, I

HYP-PRD-IRD-002040

Joint Faces

Joint Faces shall be clean and flat before assembly. The permitted surface finishes are:

- Gold plate on the base metal.
- Clean metal (except magnesium).

An electrically conductive protective finish (Surtec or similar according to MIL-C-5541) can be used on all bonding surface where non-conductive films or oxides may develop between the metal surfaces forming the joint. Protective finishes must not act as an electrical insulator between surfaces used for bonding.

Verification Method : R, I

HYP-PRD-IRD-002050

Items contact areas

Any anti-corrosion finishing (e.g. anodising) shall be removed from joint faces before install the following elements:

- Supports (contact areas shall be unpainted).
- Connector Bracket (contact areas shall be unpainted).
- Electronic Units (contact areas relevant to bonding strap and insert shall be unpainted).
- RF Switches, waveguides, mechanical parts (contact areas shall be unpainted).
- Panel Skins circular areas for overall harness shield bonding relevant to cables crossing S/C structure.

Verification Method : R, I

HYP-PRD-IRD-002060

Bonding Strap

The bond straps shall be sized to carry any fault current (150% of circuit protection device rating) for an indefinite time. The bonding strap shall be designed according to the following:

- length less than 10 cm (in any case as short as possible);
- length to width ratio shall be preferably 5:1;
- preferably made of silver plated copper braid.

Verification Method : R, I

HYP-PRD-IRD-002070

Equipment Bonding Stud

Each active unit shall provide a bonding stud to enable the bonding during tests and system integration. The bonding stud shall be close to the mounting plane.

Note: bonding stud shall be reported in the payload ICD

Verification Method : R, I

HYP-PRD-IRD-002080

Bonding between Adjacent Unit Case Parts

For each particular unit case all conductive parts shall be bonded to each other either by direct (metal-to-metal) or indirect bonding (via conductive jumper). The DC resistance between adjacent unit case parts shall be 2.5 mΩ.
Verification Method : R, T

HYP-PRD-IRD-002090
Bonding of Unit Cases DC Resistance
All Powered units shall be bonded to spacecraft structure via an adequate bonding strap.

- The DC resistance between the equipment bonding stud and the nearby spacecraft structure shall be less than 2.5 mΩ.
- The maximum resistance between unit connector receptacle and unit bonding stud shall be <10 mΩ.
- The DC resistance between the unit housing and the vehicle bonding attachment point shall be less than 20 mΩ.

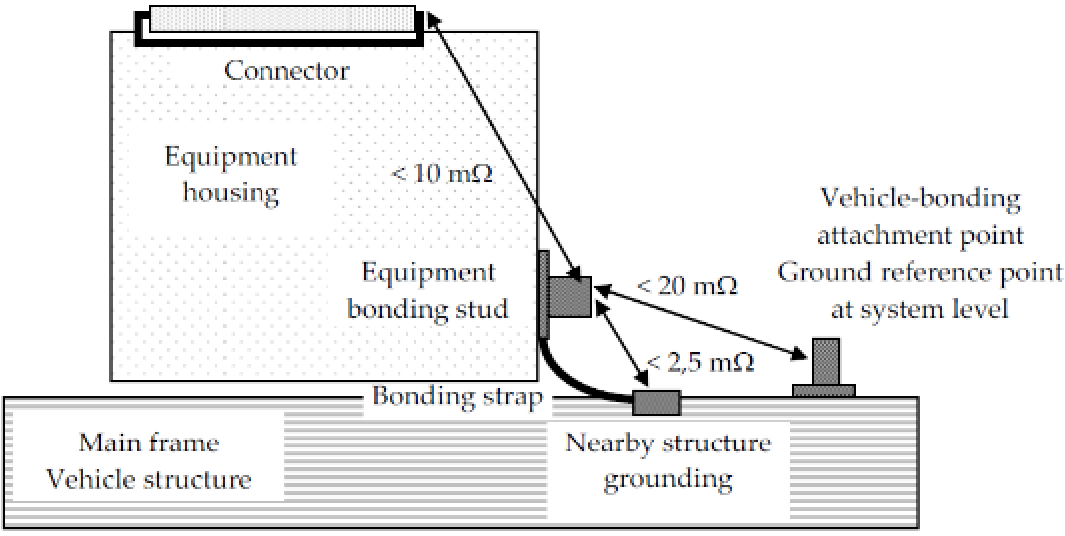


Figure 5 Equipment Bonding

This requirement applies to the following cases:

- Thermally isolated units by thermal filler
- Unit mounted on CFRP or non conductive parts in general
- Unit mounted directly on S/C metal structure (metal to metal contact)
- The preferred solution for Unit bonding is the metal to metal contact between unit mounting feet and panel structure, without any insulating material interposed between.
- If some thermal filler has to be interposed between unit and S/C structure the SIGRAFLEX shall be used. Thermal filler information shall be reported in payload ICD.
- The use of two or more bonding straps or jumpers in series is not permitted.

Verification Method : R, I

HYP-PRD-IRD-002100
Bonding of Antenna Bodies
Structure items as antenna appendages and antenna bodies with composite fibers shall be bonded to satellite metal structure with less than 1 kΩ.
Structure items as metallic antenna appendages and antenna bodies shall be bonded to satellite metal structure with less than 25 mΩ.
Verification Method : R, I, T

HYP-PRD-IRD-002110
Bonding of movable parts
Across movable parts a bonding conductor shall be used to ensure a defined electrical contact between those parts. The DC resistance across movable parts shall be <1 **Ω**.
Verification Method : R, I, T

HYP-PRD-IRD-002120
Bonding between overall harness Shield and Backshell
If overall Harness shield is used, bonding of cable shields shall be connected to ground at both ends through the equipment connector body using an EMI backshell that provides for circumferential bonding of shields, or using a halo-ring. Fully close metallic backshell enclosure shall be used. Shield ground leads shall be forbidden in order to prevent any perturbation inside the equipment.
The DC resistance between metallic connector backshell and overall harness shield shall be less than 500m**Ω**.
Verification Method : R, I

HYP-PRD-IRD-002130
Bonding between Single Cable Shield and Backshell
The junction between the single cable inner shield and its shield ground point on backshell shall be implemented via a soldering. The single cable shield shall be soldered internally to the connector backshell via the shortest connection and no longer than 3 cm.
The use of external Pigtail is not allowed.
Shields bonding to connector backshell shall be performed with the resistance max value of 50 mΩ.
Verification Method : R, I

HYP-PRD-IRD-002140
Harness crossing the S/C structure
If Harness routing foresees to pass from internal to external S/C structure, for EMI purpose it is mandatory to interrupt overall harness shield and to bond it separately to external and internal panel skin. The bonding resistance between overall harness shield and panel skin shall be less than 10 m**Ω**.

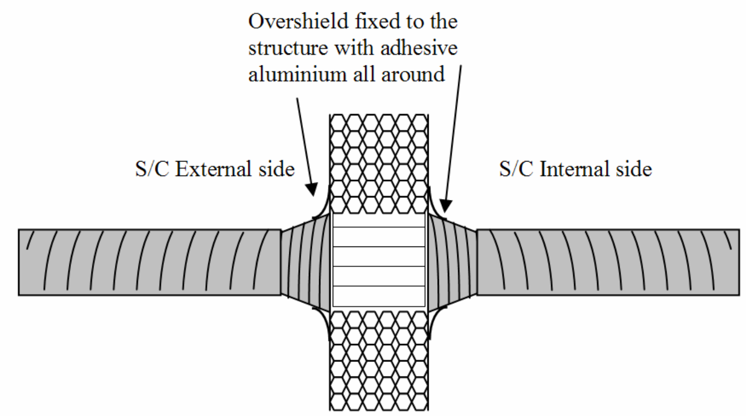


Fig. 3.1 –
Figure 6 Harness crossing the S/C structure

Verification Method : R, I, T

HYP-PRD-IRD-002150
Unit Connectors
Fully close metallic connector receptacle enclosure shall be used. The use of ground pin at unit side shall not be allowed (if present, it shall not be routed into harness).
Verification Method : R, I

HYP-PRD-IRD-002160
Bonding Resistance of Connector Backshell to Equipment Case or Connector Bracket
The connector backshell shall exhibit a DC resistance lower than 7.5 mΩ (via connector receptacle) to equipment case or connector bracket when connected.

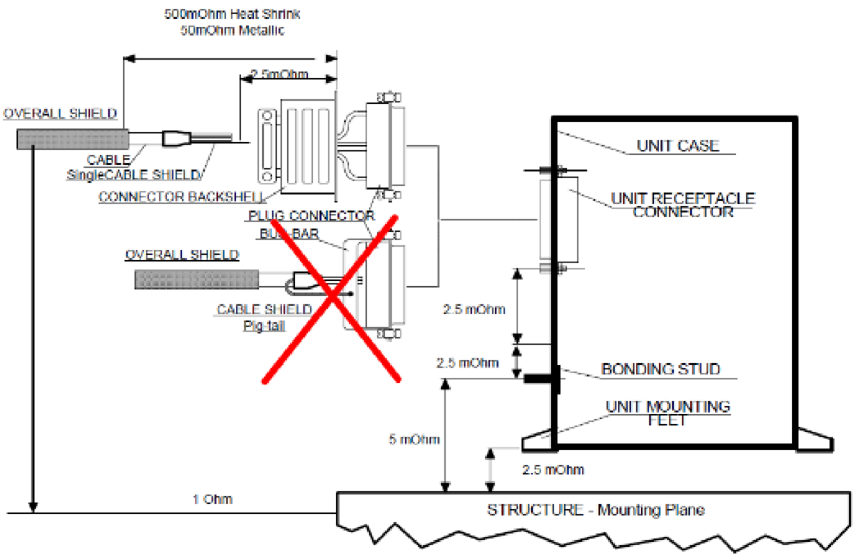


Figure 7 Unit, Backshell, Harness Bonding
Verification Method : T

HYP-PRD-IRD-002170

EMC Classes

Power and signal lines shall be grouped into the following EMC classes.

Signal type	EMC Class		
Power	1	A	Primary Power lines (Bus users)
		B	Secondary voltage power lines (I>=500 mA)
		C	Solar Array/power supply link
		D	Batteries/PCDU
		E	Motor supply lines (SADM)
		F	Heaters (>= 15W)
TM/TC signal f<100 KHz	2	A	Analog acquisition
		A	Unipolar ANalog acquisition
		A	Bipolar ANalog acquisition
		A	CSS current
		A	SADM Optical switch
		A	Digital Bi level
		A	Alarm DR Type
		A	A Direct Digital Relay
		A	Matrix Digital Relay
		A	Temp
		A	Betatherm G15K489
		A	DP GC 15K
		A	PT 200
		A	YSI 44031
		A	ASA 311P 18 10K
		A	RW speed Digital tachometer telemetry
		A	LV Status signal
		A	High Level Command
		A	Low Level Command
		A	ANalog Command
		A	MUltipleXer Command
		A	Tq RW Command
		A	MTB current command
		A	LV command
		A	Thruster Command
		B	Heaters (<15W)
		B	Secondary voltage power lines (I<500 mA)
EED	3		PYRO signal
Sensitive TM/TC signal f>100 KHz	4	A	RS422
		A	RS485-CAN
		A	SBDL
		A	Alarm SBDL type
		A	Pulse Per Second
		A	ML 16 – DS 16 ClocK
		A	Memory Load Data
		A	Memory Load Sample
		A	Digital Serial Data
		A	Digital Serial Sample
		B	Bus B1553
RF signal (via coaxial cables, tri-axial cables, …)	5		RF
Sensitive TM/TC signal f>1Mbps (SPW)	6		SPW
High Voltage	7		Power Lines with voltage > 100V

Table 17 –EMC Classes

Verification Method : R, I

HYP-PRD-IRD-002180

Separation of different classes of cables

Cables falling into different EMC Classifications shall be assembled to different (separate) cable bundles and connectors. Pyro-routing shall be separated to the maximum possible extent.

Bundles distances reported in the following table shall be used to define the cable layout. The bundle distances are edge to edge minimum separation (where possible).

EMC Class	EMC Parallel Class	Sparation distance D (mm) per parallel run L(mm)			
		L<40	40<L<80	80<L<140	L>140
1	2	30	50	70	90
1	3	10	30	50	70
1	4	10	30	50	70
1	5	70	90	110	130
1	6	70	90	110	130
1	7	10	30	50	70
2	3	10	30	50	70
2	4	10	30	50	70
2	5	50	90	130	150
2	6	50	90	130	150
2	7	40	60	80	100
3	4	10	30	50	70
3	5	10	30	50	70
3	6	10	30	50	70
3	7	20	40	60	80
4	5	20	40	60	80
4	6	20	40	60	80
4	7	20	40	60	80
5	6	70	90	110	130
5	7	80	100	120	140
6	7	80	100	120	140

Table 18 Cable of different classes separation

Verification Method : R, I

HYP-PRD-IRD-002190

Harness Routing
All cable bundles shall be routed as close as possible to the structure, ground plane and ground rail respectively, in order to reduce the common mode noise. Where bundle must cross each other, the crossing angle between different categories shall be as close as possible to 90°.
Payload harness routing shall be agreed with Prime Contractor according to payload accomodation on platform.
Verification Method : R, I

HYP-PRD-IRD-002200
Wiring through Connectors
In wiring through connectors all leads shall be kept as close as possible to their return (i.e. twisted wires shall be routed on adjacent pins), to obtain good self-cancellation and to minimize the wire loop. When wires with different EMC Classes have to be allocated to the same connector, they shall be physically separated as much as possible within the connector. As a minimum, power, and signals and telemetry shall be separated in the connector by a set of unused pins in order to avoid failure propagation. Pyro circuits shall not be routed in multiple connectors except with other pyro circuits.

Verification Method : R, I

HYP-PRD-IRD-002210
Twisting of Wires
Twisting of the active wire around the referring return wire shall be used in order to reduce magnetic susceptibility and emission. In case that several lines share the same return line they shall be twisted with the return line. Leads belonging to class 1,2,3,4,6 shall be twisted.

MINIMUM TWISTS/METER			
AWG SIZE	2 WIRES	3 WIRES	4 WIRES
12	22	15	12
14	25	20	12
16	35	22	15
18	40	25	20
20	50	35	25
22	55	50	30
24	62	55	50
26 TO 28	70/100	62/90	55/80

Table 19 Design guidelines for wiring twisting

Verification Method : R, I

HYP-PRD-IRD-002220
Shielding of Wires
1. For each cable bundle containing wires of class 1,2,3 shall be used the overall shield.
2. For leads belonging to class 1,2,3,4,6 a inner single shield shall be used (class 1 applies only for SAR power lines). These shields shall cover the twisted pair or twisted group rather than individual wires. The maximum unshielded length of any shielded wire shall not exceed 2.5 cm.
3. All harness cables passing external to S/C structure shall be overall shielded. The shield has to be interrupted when passing through S/C structure.

4. RF cable external to S/C shall use braided shield.
5. Shields shall not be used as intentional current-carrying conductors and not as return lines for power and signal with exception of the RF coaxial lines.

This shielding requirement is not applicable for the lines already shielded via a box case.
Verification Method : R, I

HYP-PRD-IRD-002230
Non Magnetic Metal Case
Each equipment shall be closed in an electrically conductive and non magnetic metallic case which form an all enclosing shield for electromagnetic fields generated by the equipment. The metallic unit case thickness shall be suitably sized to provide a shielding effectiveness useful to comply the satellite radiated requirements reported in this document.
Verification Method : R, I

HYP-PRD-IRD-002240
Case Aperture
The case shall not contain any apertures other than those essential for connectors, sensor viewing or outgassing vents.
Verification Method : R, I

HYP-PRD-IRD-002250
Floating Conductive Parts
Floating metallic parts and intrinsically conductive parts (like carbon) shall be avoided. The DC resistance to structure shall be in all cases lower than 100 kΩ to prevent static charging.
Verification Method : R, I, T

HYP-PRD-IRD-002260
Space Exposed items
Any space exposed surface or surface coating with the only exception of the solar arrays shall be conductive and grounded to satellite structure.
Space exposed surfaces shall have a surface resistance <= $10^9\Omega$/square.
Any cable electrically exposed outside the main spacecraft body shall be protected/filtered to prevent damage within the related electronic equipment
Verification Method : R, I, T

HYP-PRD-IRD-002270
Use of Dielectric Materials
In the following list are indicated the dielectric materials which use should be minimized in order to reduce the occurring of an ESD event:

- Standard Teflon (FEP, PTFE, FLPO, TEFZEL).
- Uncoated Kapton (thickness> 50um).
- Epoxy glass.
- Silica cloth.

For dielectric materials which are placed in contact with a more conductive material, the resistivity of the dielectric shall be adequate to produce a < 1kV absolute potential w.r.t. spacecraft ground.
Verification Method : R, I, A, T

HYP-PRD-IRD-002280
Internal Charging Analysis/Assessment
In case of isolated conductive areas an internal charging analysis shall be performed to verify no ESD risk. In addition an analysis/assessment shall be performed to verify the absence of charging on internal harness dielectrics.
Verification Method : A

HYP-PRD-IRD-002290
Use of Non-magnetic Materials
Non-magnetic materials shall be used whenever possible:

1. The use of ferro-magnetics shall be avoided wherever possible for parts, components, and equipment structure. Non-magnetic materials shall be used; if magnetic materila cannot be avoided, they shall be selected avoiding soft magnetic material.
2. Aluminum and its alloys, fiber class, CFRP, magnesium and its alloys, titanium and its alloys are all non-magnetic. These are among the most desirable materials to use structurally.
3. Steel or other magnetic materials shall be avoided. If the use of steel in the mechanical hardware is unavoidable, it shall be stainless steel of proven non-magnetic characteristics.
4. The use of stainless steel screws is allowed except on magnetic sensitive units (e.g. magnetometer sensor heads).
5. All materials considered for use in the units or experiments, not previously known to be satisfactory shall be carefully tested prior to their use.
6. It is not intended to use high permeable shielding foil for the harness.
7. The use of relays shall be limited to the most critical functions which cannot be handled by solid state switching.

Verification Method : R, I

HYP-PRD-IRD-002300
Use of Non-magnetic Connectors
It is generally required to use

- non-magnetic class B or better connectors
- coaxial connectors with similar magnetic performance to class B.

Verification Method : R, I

HYP-PRD-IRD-002310
Use of Self-compensating Heater Mats

Only self-compensating w.r.t. magnetic fields heater mats shall be used.
Verification Method : R, I

HYP-PRD-IRD-002320
Use of Self-compensating Arrangement
Self-compensating effects with regard to DC magnetic fields by using proper geometrical arrangement shall be implemented in the layout / arrangement wherever feasible; e.g.:

- arranging magnetic parts anti-parallel in order to get self-compensation effect;
- arranging batteries in opposite directions
-

Verification Method : R, I

HYP-PRD-IRD-002330
Magnetic Moment of Palyload
The complete payload shall not show a DC Magnetic moment greater than 0.85 Am^2 per each reference axis. The total DC moment shall not exceed 1.5 Am^2 in amplitude. The supplier shall characterize the payload magnetic moment on each axis.
Verification Method : T

HYP-PRD-IRD-002340
Equipment magnetic moment

Design of units, PCB's and harness avoids or at least minimizes current loops. Three verification methods are acceptable:

- Test.
- Analysis: identification of all critical magnetic materials and related magnetic moment contribution and vectorial sum of the magnetic moment of the units' magnetic items.
- Similarity: verification by similarity may be applied to equipment or subsystems coming from other programs, where re-use as is or re-use with only little (magnetic) modification proposed.

Verification Method : A

HYP-PRD-IRD-002350
EMC SETUP
The applicable setup valid at PCB, Equipment and Tray level for conducted and radiated test verifications shall be the ones indicated in ECSS-E-ST-20-07C Rev. 1, § 5.4 "Equipment and subsystem level test procedures".
Verification Method : R

HYP-PRD-IRD-002360
EMC Test Matrix

EMC test campaign applicable at unit/PCB level shall be in line with the following table which identifies minimum test necessary for each model:

	EM/BB	EQM/QM	PFM	FM
Bonding, Isolation, In Rush	To be decided depending on the EM/BB flight representativity	X	X	X
Conducted Emission		X	X	X (Only frequency domain)
Conducted Susceptibility		X	X	Note 1
Radiated Emission		X	X	Note 1
Radiated Susceptibility		X	X	Note 1
ESD		X		

Note 1: For off-the shelf products these test are to be performed on the base of unit qualification status (to be decided at EQSR)
For units which foresee also PFM model these test have to be repeated in case of design modification

Table 20 EMC Test Matrix

Verification Method : R

HYP-PRD-IRD-002370

All EMC tests shall be performed interposing the LISN shown in the next figure between the EUT and the power supply, as required by the relevant test methods. The LISN, has the following functions in order of importance:

- Decoupling the equipment CE and CS signals from the facility/EGSE power supply: in other words, the CE measured on the EUT power lines, both in differential and common mode should originate from the EUT only; and the injected CS power should only contribute to test the EUT, without disturbing the facility/EGSE power supply;
- Making the impedance seen by the EUT independent of the facility/EGSE power supply impedance;
- Reproducing roughly the power line impedance of the actual installation:
  - ✓the series inductances represent the inductances of the wiring;
  - ✓the series resistances represent the resistances of the wiring and of the central protections;
  - ✓If no value is specified x = 2 μH and y = 0.1 Ω shall be used
- If the return line is grounded at the power source in the actual installation (star distribution), the return line of the LISN shall be grounded on the power source side

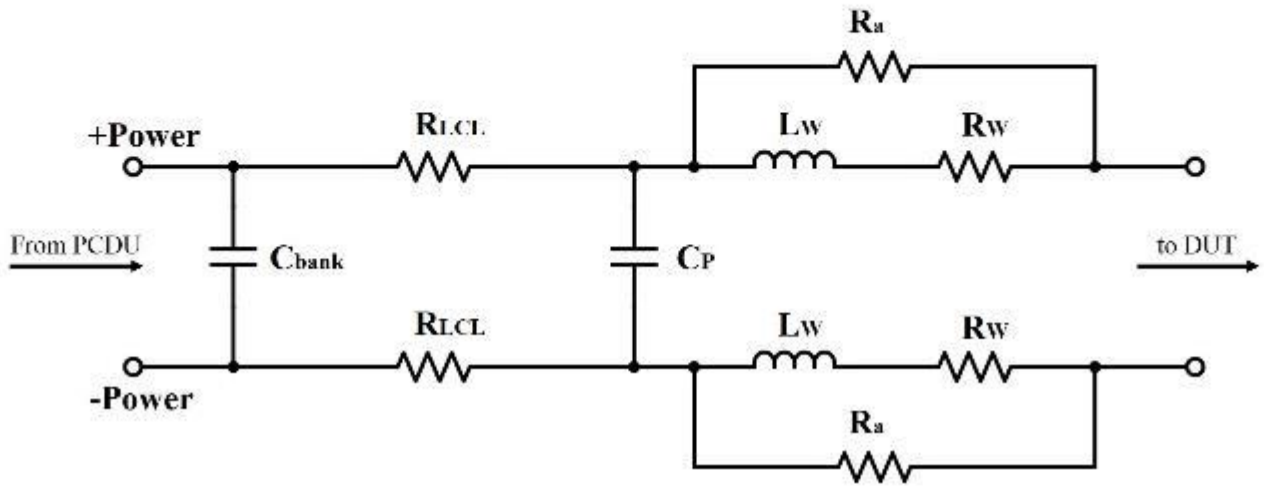


Figure 8 LISN Schematic

Verification Method : R

HYP-PRD-IRD-002380
EMC Test Instrumentation

The maximum allowable tolerance for the test parameters shall be as follows unless otherwise specified within this specification or the applicable equipment specification:

- voltage magnitude: 5 % of peak value;
- current magnitude: 5 % of peak value;
- RF amplitude: 2 dB;
- frequency: 2 % (except for notches);
- distances: 5 % or 5 cm, whichever is greater;
- test time: 0 - 10 %.

The accuracy of instruments and test equipment used to control or measure the EMC test parameters shall be:

- 2 dB for levels;
- 2 % for frequencies.

All instrumentation to be used for qualification and acceptance tests shall be subjected to approved calibration procedures and shall be within the normal calibration periods at the time of test.
The measurement receiver bandwidths listed in next table shall be used for emission testing (these bandwidths are specified at the 6 dB down points for the overall selectivity curve of the receivers).
Video filtering shall not be used to bandwidth limit the receiver response. If a controlled video bandwidth is available on the measurement receiver, it shall be set to its greatest value.
If receiver bandwidths larger than those in next table, no bandwidth correction factors shall be applied to test data due to the use of larger bandwidths.

Note: Larger bandwidths can result in higher measured emission levels.

Frequency Range	6 dB bandwidth	Dwell time	Minimum measurement time (analogue measurement receiver)
30 Hz - 1 kHz	10 Hz	0,15 s	0,015 s/Hz
1 kHz - 10 kHz	100 Hz	0,015 s	0,15 s/kHz
10 kHz - 150 kHz	1 kHz	0,015 s	0,015 s/kHz
150 kHz - 30 MHz	10 kHz	0,015 s	1,5 s/MHz
30 MHz - 1 GHz	100 kHz	0,015 s	0,15 s/MHz
Above 1 GHz	1 MHz	0,015 s	15 s/GHz

Table 21 Bandwidth and measurement time Frequency Range

Verification Method : R, I

HYP-PRD-IRD-002390
Threshold of Susceptibility

When susceptibility indications are noted in EUT operation, a threshold level shall be determined where the susceptible condition is no longer present. Thresholds of susceptibility shall be determined as follows and described in the EMI test report:

1. When a susceptibility condition is detected, reduce the interference signal until the EUT recovers.
2. Reduce the interference signal by an additional 6 dB.
3. Gradually increase the interference signal until the susceptibility condition reoccurs. The resulting level is the threshold of susceptibility.
4. Record this level, frequency range of occurrence, frequency and level of greatest susceptibility, and other test parameters, as applicable.

Verification Method : R, I

HYP-PRD-IRD-002400
EMC Test Facility Capabilities

The test facilities used for the EMC test programme shall respect the following recommendations.

A. With the test sample switched off, the ambient interference level shall be at least 6 dB below the allowable specified level. A shielded room may be used in order to meet the requirement specified above. Absorber materials may be used in shielded room to reduce reflections to the measurement antennas.
B. The Units and harness shall be placed on a conductive ground plane (made of copper or brass) with a length at least 2.5 m and a width at least 0.75m. The ground plane shall be bonded with a low inductive bond that shall have a resistance less than 5mW.
C. For the DC magnetic test the magnetic ambient shall be clean.

Verification Method : T

HYP-PRD-IRD-002410
Equipment EMC analysis and Control plan
The supplier shall deliver to the customer at minimum the following information:

1. EMC control plan, describing the proposed activities for the verification of the applicable EMC requirements in order to demonstrate that the current design of the Equipment is compatible with the EMC Specification;
2. EMC analysis, showing that the current design of the Equipment is compatible with the requirements of the applicable EMC Specification, identifying the critical areas and proposal for the technical solutions. The report shall cover a minimum the following topics:
    a) grounding and isolation;
    b) bonding;
    c) harness design rules;
    d) EMI Filtering sizing;
    e) Shielding / gasketing;
    f) ESD;
    g) radiated and conducted emissions;
    h) radiated and conducted susceptibility.

Verification Method : R

HYP-PRD-IRD-002420
PCB EMC Management and Plan document
The supplier shall deliver to the customer a dedicated document named "EMC Management and Plan" where the following design areas relevant to PCB EMC design are described and addressed:

- Description of EMC activity flow that is followed to achieve PCB compliance with applicable EMC requirements;
- Give evidence during all design phases of solutions (layout, filtering, ground reference etc) adopted to manage critical components or functionalities in order to meet applicable EMC requirements;
- Description of EMC Design rules that have been implemented at PCB level to meet conducted/radiated requirements;
- Guidelines for PCB layout;
- Adopted philosophy for grounding, bonding, gasketing and routing;
- Adopted philosophy for crosstalk minimization;
- Design Guidelines and corrective actions achieved from Power integrity Analysis and Signal Integrity Analysis.

The "EMC Management and Plan" document shall be reviewed by the Customer in a dedicated review.

Verification Method : R

HYP-PRD-IRD-002430
Radiated Emission E Field
The equipment shall not radiate electric fields in the frequency range 30 MHz - 18 GHz in excess of the limits shown in Figure below measured at 1 m distance. The setup shall be in accordance to ECSS-E-ST-20-07C Rev. 1.
The following Radiated Emission notch limits are applicable:

Frequency [MHz]	E-field (dBuV/m)
1176,45 ± 30	20
1227,60 ± 30	20
1575,42 ± 30	20
2025 - 2110	20
2200 - 2290	20
9100 - 10100	20
22600 - 23500	20

Table 22 Radiated emission notches at Rx band at 1 meter distance

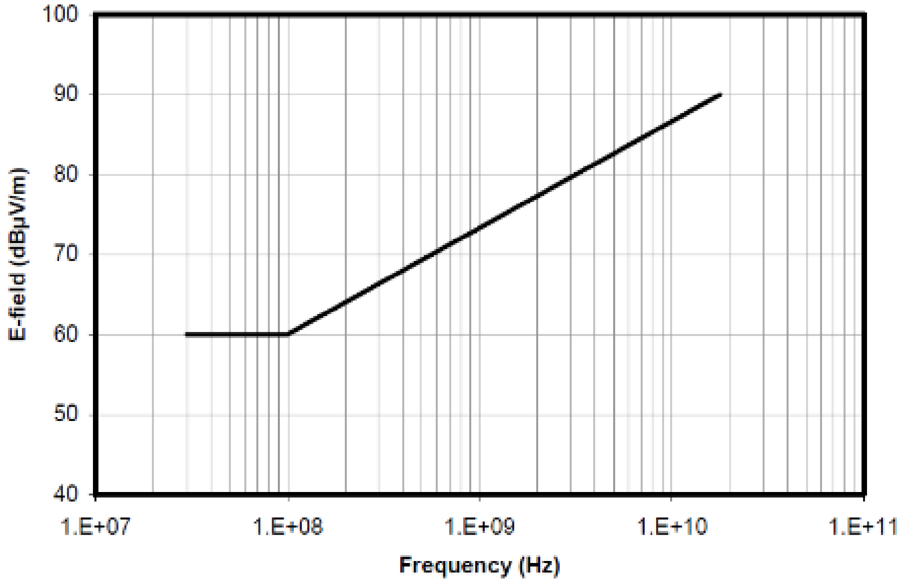


Figure 9 Radiated Emission E Field limit

Verification Method : A, T

HYP-PRD-IRD-002440
Radiated Susceptibility E Field
The Equipment shall not deviate from nominal performances when subjected to the following radiated susceptibility levels in the frequency range 14kHz – 18GHz. The electrical field shall be 30% amplitude modulated with 2 kHz square wave.
The amplitude of the test signal shall be as follows:

- equipment outside of the S/C main frame considered as a Faraday cage: 10 V/m;

- equipment inside the S/C main frame: 2 V/m (14KHz-1GHz) and 5 V/m (1GHz – 18GHz)

At Tx bands, the following RS level shall be also applied:

Frequency [MHz]	RS (V/m) (TBC)	
	Internal Unit	External Unit
2200 – 2290	10	20
8025 – 8400	15	30
22600 – 23500	20	40

Table 23 Radiated Susceptibility notches at Rx band

Above 30 MHz the requirement shall be met for both horizontally and vertically polarized fields.
The equipment switched on at launch shall also give the compliance to Launcher requirement.

Verification Method : A, T

HYP-PRD-IRD-002450

Differential Mode Conducted Emission, Frequency Domain on Main bus power lines

Conducted narrow band current emissions (differential mode) in the frequency range 30 Hz - 100 MHz appearing on the Unit/PCB positive and return power lines shall be within the limits of the following figure.

In the low frequency range the limit I_{CE} in units of dB referenced to 1 μA (dBμA) is function of the consumption I_{DC} (in amperes) of the equipment on the line:

- I_{DC} <1 A, I_{CE} = 80 dBuA;
- 1 A < I_{DC} < 100 A, I_{CE} = 80 + 20 log10(I_{DC}) dBuA.

The setup shall be according to of ECSS-E-ST-20-07C Rev. 1.

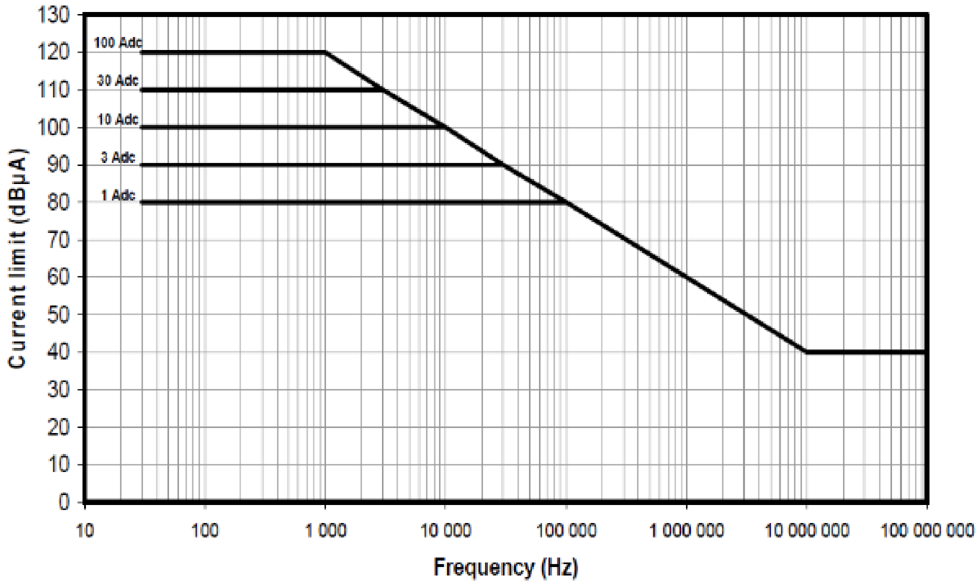


Figure 10 Conducted Emission differential mode frequency domain

Verification Method : A, T

HYP-PRD-IRD-002460

Common Mode Conducted Emission, Frequency Domain on Main bus power lines

Conducted narrow band current emissions (common mode) in the frequency range 100 kHz - 100 MHz appearing on the Unit/PCB on unit power bundles shall be within the limits of the following figure

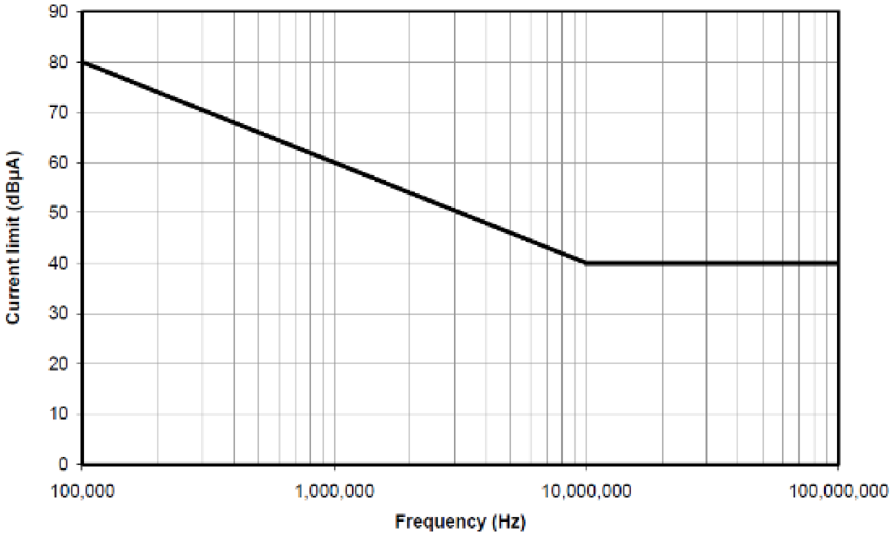


Figure 11 Conducted Emission common mode frequency domain

Verification Method : A, T

HYP-PRD-IRD-002470

Conducted Emission Time Domain Ripple

Unit/PCB steady state Voltage Ripple measured in nominal condition in time domain on each individual power line shall not exceed 0.1 Vpp. The voltage ripple shall be measured at the following frequencies:

- DC/DC converter frequency;
- TDMA/PRF frequency (when foreseen).

Verification Method : A, T

HYP-PRD-IRD-002480

Conducted Susceptibility Frequency Domain Differential Mode

The following levels shall be applicable for the susceptibility test on the power leads:

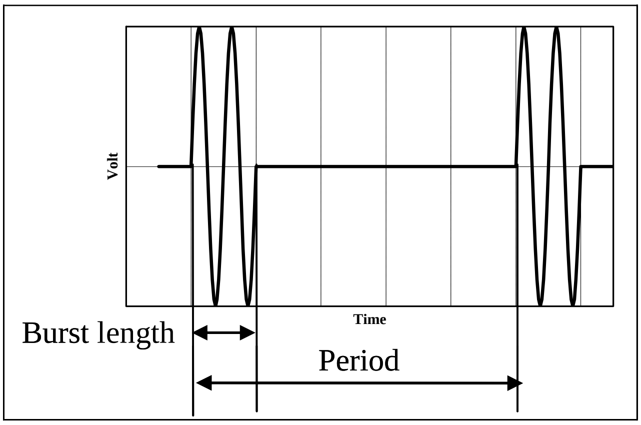
- the injected voltage level in differential mode is equal or larger than 1 Vrms;
- the injected voltage shall be in the frequency range 30 Hz-50 MHz;
- a limitation of the injected current before the specified voltage is reached is applied;
- the limit of current is 1 Arms.

During the injection, the equipment shall maintain nominal performances.
The setup shall be according to ECSS-E-ST-20-07C Rev. 1.

Verification Method : A, T

HYP-PRD-IRD-002490
Conducted Susceptibility Frequency Domain Common Mode Bulk Cable Injection (BCI), Power and Signal leads
The unit/PCB shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when a sinusoidal common mode signal in a frequency range 50 kHz-100 MHz (2 kHz 30% square wave modulated) is injected sequentially on each signal and power bundle connected to the EUT, using Bulk Current Injection (BCI) at the following levels:

- 3 Vpp is achieved between return line and chassis;
- a maximum of 3 App is achieved.



Recommended signal level: 3Vpp calibrated on the BCI jig loaded with 50 Ω.

Frequency range	Pulse repetition frequency	Duty cycle
50 kHz-1 MHz	1kHz	50% (square wave)
1 MHz-10 MHz	100 kHz	20%
10 MHz-100 MHz	100 kHz	5%

Figure 12 BCI – Signal characteristics

The setup shall be according to ECSS-E-ST-20-07C Rev. 1.

Verification Method : A, T

HYP-PRD-IRD-002500
Conducted Susceptibility Time Domain Transient
The short spikes on the input power lines of the EUT specified in this requirement are meant to cover with a margin the voltage transients that can happen as a consequence of other power bus users

switching on or off, or as a consequence of a short circuit happening somewhere else on the power bus, before the central protections can react.

The unit/PCB shall not exhibit any failures, malfunctions or unintended responses when transient voltages shown in figure below with the following characteristics are superimposed on the power bus inputs. The injection shall be parallel between positive and negative lines, injecting both positive and negative going pulses (one at a time):

- transient voltages ±100% Vbus;
- When a negative spike is applied, the absolute instantaneous transient voltage goes down to 0, never negative

- tests are performed with two spike durations at T=10 μs

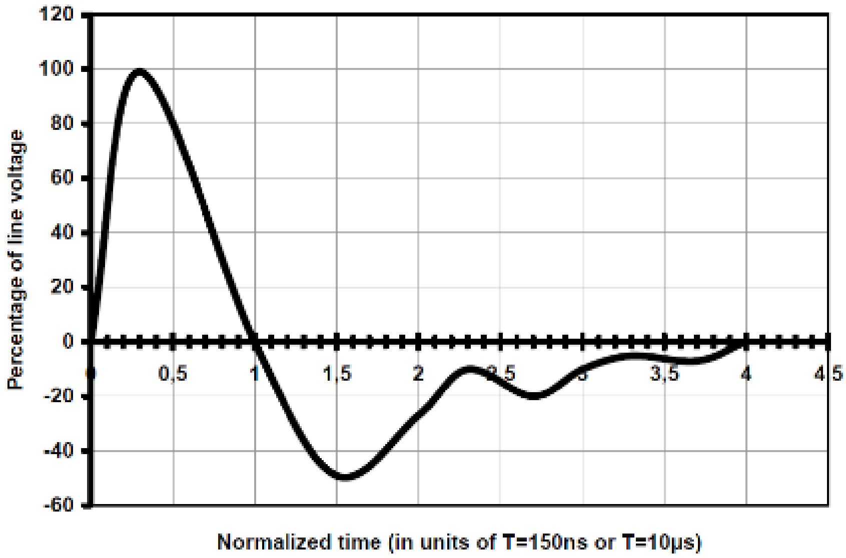


Figure 13 Conducted Susceptibility time domain: voltage spike in percentage of test bus voltage

Verification Method : A, T

HYP-PRD-IRD-002510

Conducted ESD

The unit shall not show any damage, malfunction or deviation from the specified performance when exposed to the following repetitive current pulses, passing through the unit chassis:

- magnitude 50 A, 16.5kV
- Minimum Energy Amount 6.8 mJ (16.5kV on 50 pF; discharge resistance of 330 Ω)
- rise time < 10 nsec
- duration 100 nsec
- repetition rate 0.1 - 10 Hz

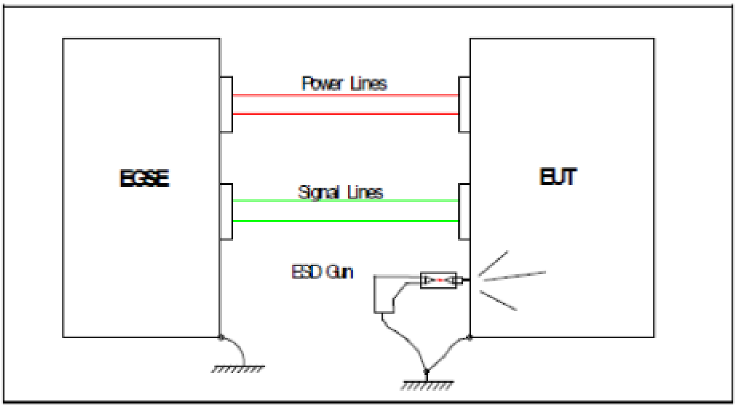


Figure 14 Conducted ESD Test Setup

Verification Method : T

HYP-PRD-IRD-002520

Radiated ESD

The unit shall not show any damage, malfunction or deviation from the specified performance when exposed to the following repetitive radiated discharges:

- magnitude 10 kV
- energy 2.5 mJ (10 kV on 50 pF)
- distance between source and unit 30cm
- repetition rate 0.1 - 10Hz

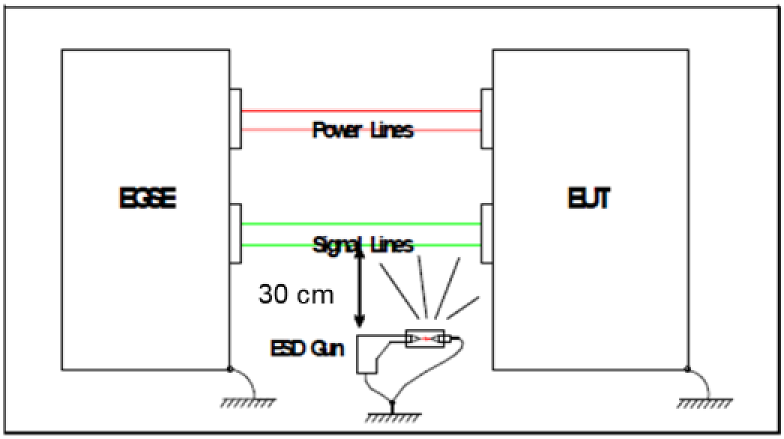


Figure 15 Radiated ESD Test Setup

Verification Method : T

3.2.9. Radiation requirements

The major factors that impact the design of the electronic systems are total dose ionization damage, single event phenomena, displacement damage, etc ..... The present document specifies the worst case

Natural Space Radiation Environment to be taken into account for satellite design, which is based on following assumptions:

•Mission start: 2019.

•Mission Lifetime: 3 years.

•Orbit parameters:

Orbit paramerer	Value
Period (s)	6052
Apogee altitude (Km)	800
Perigee altitude (Km)	800
Inclination	90°
Geomagnetic model	Jensen & Cain

Table 24 Orbital parameters

The polar inclination and the altitude determine the worst case natural radiation environment in terms of Total Ionizing Dose and Single Event Effects.
The worst case Atomic Oxygen environment is calculated at 350 Km altitude due to the interaction between Ultraviolet Radiation and hard O_3 molecules density. This interaction creates atomic oxygen molecules "O" very dangerous for polymeric compounds based on hydrocarbons that degrade surfaces.
The Atomic Oxygen Flux at 350 Km is about 5.0 E+21 atoms/cm2 yr)
The micro-satellites space radiation environment associated to above data is calculated using the CNES software OMERE version 4.2.2.0. This code is developed by TRAD company and can be obtained free of charge at www.trad.fr

3.2.9.1.General Radiation Requirements

HYP-PRD-IRD-003000
Radiation Environment Assumption
For the payload boxed configuration, requirements reported in this section take into account the following assumption:

- Any payload unit shall take into account the shielding effect provided by Satellite: 2mm Al equivalent thickness on each side around unit,
- It is assumed that any payload unit shall provide its own shielding: 2mm Al minimum thickness of the payload containing the components.

Note: for the payload exposed configuration, refer to req. HYP-PRD-IRD-003030.
Verification Method : A

3.2.9.2.Atomic Oxygen

HYP-PRD-IRD-003020
Atomic Oxygen
The Payload shall be designed to survive the Atomic Oxygen Fluence of 5.0E+21 atoms/cm^2-yr)
Verification Method : A

3.2.9.3. Total Ionized Dose

This section describes requirements for calculating Total Ionizing Dose Level (absorbed dose).
A Dose Depth Curve has been calculated, using SHIELDOSE-2 software, for an Aluminum Solid Sphere Shielding with a Silicon Detector located in the center of the sphere, using particle fluxes specified in the previous sections.

HYP-PRD-IRD-003030

Dose depth curve

Following chart and table show the dose depth curves; the curve/data labelled "total" shall be used for total absorbed dose calculation.

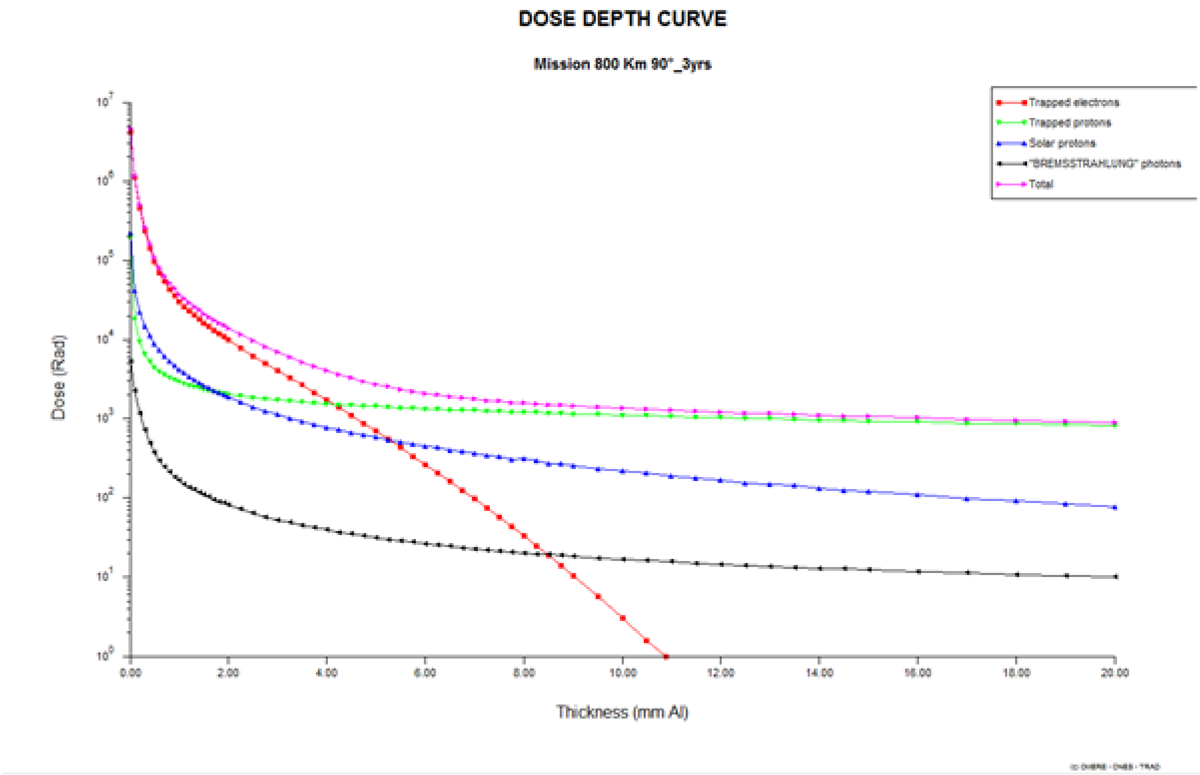


Figure 16 Dose Depth Curve

Thickness Al mm_Al	Trapped electrons rad	Trapped protons rad	Solar proton rad	Gamma photons rad	Total Dose rad
1,00E-02	4,27E+06	1,95E+05	2,28E+05	5,47E+03	4,70E+06
1,00E-01	1,14E+06	1,85E+04	4,37E+04	2,32E+03	1,20E+06
2,00E-01	4,74E+05	9,71E+03	2,29E+04	1,20E+03	5,08E+05
3,00E-01	2,45E+05	6,87E+03	1,53E+04	7,34E+02	2,68E+05
4,00E-01	1,47E+05	5,45E+03	1,15E+04	5,07E+02	1,65E+05
5,00E-01	9,91E+04	4,61E+03	9,18E+03	3,81E+02	1,13E+05
6,00E-01	7,22E+04	4,05E+03	7,56E+03	3,04E+02	8,41E+04
7,00E-01	5,56E+04	3,68E+03	6,44E+03	2,53E+02	6,60E+04
8,00E-01	4,46E+04	3,40E+03	5,55E+03	2,18E+02	5,38E+04
9,00E-01	3,69E+04	3,19E+03	4,89E+03	1,91E+02	4,52E+04
1,00E+00	3,13E+04	2,99E+03	4,31E+03	1,70E+02	3,88E+04
1,10E+00	2,70E+04	2,86E+03	3,92E+03	1,55E+02	3,39E+04
1,20E+00	2,36E+04	2,71E+03	3,50E+03	1,42E+02	3,00E+04
1,30E+00	2,09E+04	2,60E+03	3,21E+03	1,30E+02	2,68E+04
1,40E+00	1,86E+04	2,50E+03	2,93E+03	1,21E+02	2,41E+04
1,50E+00	1,67E+04	2,41E+03	2,71E+03	1,13E+02	2,19E+04
1,60E+00	1,50E+04	2,34E+03	2,52E+03	1,05E+02	2,00E+04
1,70E+00	1,36E+04	2,25E+03	2,32E+03	9,88E+01	1,82E+04
1,80E+00	1,23E+04	2,19E+03	2,18E+03	9,31E+01	1,68E+04
1,90E+00	1,12E+04	2,14E+03	2,05E+03	8,80E+01	1,55E+04
2,00E+00	1,02E+04	2,08E+03	1,92E+03	8,34E+01	1,43E+04
2,25E+00	8,07E+03	1,97E+03	1,66E+03	7,37E+01	1,18E+04
2,50E+00	6,44E+03	1,88E+03	1,45E+03	6,59E+01	9,84E+03
2,75E+00	5,17E+03	1,80E+03	1,28E+03	5,96E+01	8,31E+03
3,00E+00	4,17E+03	1,75E+03	1,16E+03	5,45E+01	7,14E+03
3,25E+00	3,37E+03	1,69E+03	1,04E+03	5,01E+01	6,16E+03
3,50E+00	2,73E+03	1,65E+03	9,49E+02	4,64E+01	5,38E+03
3,75E+00	2,20E+03	1,62E+03	8,75E+02	4,33E+01	4,74E+03
4,00E+00	**1,77E+03**	**1,58E+03**	**7,95E+02**	**4,06E+01**	**4,18E+03**
4,25E+00	1,42E+03	1,54E+03	7,33E+02	3,81E+01	3,73E+03
4,50E+00	1,13E+03	1,52E+03	6,87E+02	3,60E+01	3,37E+03
4,75E+00	9,00E+02	1,48E+03	6,32E+02	3,41E+01	3,05E+03
5,00E+00	7,12E+02	1,46E+03	5,98E+02	3,24E+01	2,81E+03
5,25E+00	5,62E+02	1,43E+03	5,53E+02	3,09E+01	2,58E+03
5,50E+00	4,42E+02	1,41E+03	5,18E+02	2,95E+01	2,40E+03

5,75E+00	3,47E+02	1,39E+03	4,90E+02	2,83E+01	2,25E+03
6,00E+00	2,72E+02	1,37E+03	4,64E+02	2,72E+01	2,13E+03
6,25E+00	2,12E+02	1,36E+03	4,43E+02	2,62E+01	2,04E+03
6,50E+00	1,65E+02	1,32E+03	4,05E+02	2,52E+01	1,91E+03
6,75E+00	1,28E+02	1,32E+03	3,98E+02	2,44E+01	1,87E+03
7,00E+00	9,92E+01	1,30E+03	3,76E+02	2,36E+01	1,80E+03
7,25E+00	7,64E+01	1,28E+03	3,54E+02	2,28E+01	1,73E+03
7,50E+00	5,87E+01	1,27E+03	3,42E+02	2,21E+01	1,69E+03
7,75E+00	4,48E+01	1,24E+03	3,17E+02	2,15E+01	1,62E+03
8,00E+00	3,41E+01	1,25E+03	3,20E+02	2,09E+01	1,63E+03
8,25E+00	2,58E+01	1,23E+03	3,05E+02	2,03E+01	1,59E+03
8,50E+00	1,94E+01	1,20E+03	2,80E+02	1,98E+01	1,52E+03
8,75E+00	1,46E+01	1,20E+03	2,74E+02	1,93E+01	1,50E+03
9,00E+00	1,09E+01	1,17E+03	2,58E+02	1,89E+01	1,46E+03
9,50E+00	5,95E+00	1,15E+03	2,40E+02	1,81E+01	1,42E+03
1,00E+01	3,18E+00	1,14E+03	2,26E+02	1,73E+01	1,38E+03
1,05E+01	1,65E+00	1,12E+03	2,13E+02	1,67E+01	1,35E+03
1,10E+01	8,28E-01	1,09E+03	1,96E+02	1,61E+01	1,31E+03
1,15E+01	4,00E-01	1,07E+03	1,83E+02	1,55E+01	1,27E+03
1,20E+01	1,86E-01	1,06E+03	1,74E+02	1,50E+01	1,25E+03
1,25E+01	8,35E-02	1,02E+03	1,58E+02	1,46E+01	1,20E+03
1,30E+01	3,64E-02	1,02E+03	1,53E+02	1,42E+01	1,19E+03
1,35E+01	1,53E-02	1,02E+03	1,48E+02	1,38E+01	1,18E+03
1,40E+01	6,18E-03	9,83E+02	1,35E+02	1,34E+01	1,13E+03
1,45E+01	2,35E-03	9,62E+02	1,27E+02	1,31E+01	1,10E+03
1,50E+01	8,31E-04	9,58E+02	1,24E+02	1,28E+01	1,09E+03
1,60E+01	8,01E-05	9,32E+02	1,13E+02	1,22E+01	1,06E+03
1,70E+01	7,72E-06	8,97E+02	1,01E+02	1,17E+01	1,01E+03
1,80E+01	9,31E-07	8,76E+02	9,35E+01	1,12E+01	9,81E+02
1,90E+01	1,32E-07	8,55E+02	8,64E+01	1,07E+01	9,52E+02
2,00E+01	1,20E-08	8,32E+02	7,97E+01	1,03E+01	9,22E+02
3,00E+01	0,00E+00	6,50E+02	4,06E+01	7,53E+00	6,98E+02
4,00E+01	0,00E+00	5,25E+02	2,48E+01	5,77E+00	5,56E+02
5,00E+01	0,00E+00	4,44E+02	1,71E+01	4,79E+00	4,65E+02
1,00E+02	0,00E+00	1,77E+02	4,39E+00	1,52E+00	1,83E+02

Table 25 Dose Depth table

Verification Method : A

HYP-PRD-IRD-003040

Total Dose hardness

In the payload boxed configuration, minimum Total Ionizing Dose Sensitivity (TIDS) ([FN: also known as "radiation hardness"]) for active parts shall be:

- TIDS ≥ 5 krad

Note: the calculated dose depth curve gives a total dose value @ 4 mm Al equivalent thickness (satellite shielding + Payload shielding); a safety margin of 1.2 is applied to this value, resulting in a minimum required hardness of 4.18 * 1.2 = 5 krad.

Note: this value is the expected one at payload level according to payload accommodation in a boxed confirguation (with shielding provided by Satellite). This is a starting point for payload supplier that, in case of more sensitive items, can perform detailed payload radiation analysis and indetify the shielding which provides compatible TID level with payload active parts.

Note: the payload exposed configuration, no shielding is provided by satellite structure so payload supplier has in charge the design of payload shielding to provide the required protection against TIDS, using curve in HYP-PRD-IRD-003030.

Verification Method : A

3.2.9.4. Single Event Phenomena (SEP)

Single Event Phenomena (SEP) are any disturbance of a circuit caused by the energy deposited by a high energy particle as it interacts with the sensitive portions of an electrical device. The response could be a soft error (a bit flip which can be reset), a latch-up which could destroy the device unless suitable precautions are taken (e.g. detecting a current surge and shutting off the power), etc.

This section describes requirements for calculating occurrence rate of Single Event Phenomena.

HYP-PRD-IRD-003060

SEP to be taken into account

The Payload supplier shall compute the occurrence probability of:

- SEU
- MBU
- SET
- SEFI
- SEL
- SEB
- SEGR
- SEDR

Verification Method : A

HYP-PRD-IRD-003070
SEP analysis policy - components
An analysis shall be performed to assess Single Event Phenomena at component level according to radiation policy reported in the EEE Requirements.
Verification Method : A

HYP-PRD-IRD-003080
SEP analysis policy - equipment
If SEP consequences at component level are not negligible, further analysis shall be performed to assess consequences at equipment level.
Verification Method : A

HYP-PRD-IRD-003090
SEP analysis policy - equipment
The equipment supplier shall guarantee that the Single Event phenomena does not produce out of specification at equipment level.
Verification Method : A

HYP-PRD-IRD-003100
SEP occurance rate
If consequences of a Single Event phenomena cause an out of specification, SEP occurrence rate shall be provided in terms of number of events per day
Verification Method : A

3.2.9.5. Galactic Cosmic Rays

Predictions of Galactic Cosmic Ray (GCR) fluxes in orbit are obtained using the new ISO GCR International standard which is pretty close to the GCR CRÈME-96 suite of programs (from Naval Research Laboratory). The GCR environment is calculated at Solar Minimum activity condition (worst case). Qualitatively, solar cycle variations have opposite effects on solar and galactic cosmic rays populations.
The cosmic rays environment is calculated in terms of integral Linear Energy Transfer (LET) spectrum, with the conditions described below.

- Single shielding thickness: 1.0 g/cm2
- Earth shadow: not included
- Geomagnetic condition: stormy
- Ion species: from Z=2 (He) up to Z=92 (U)

HYP-PRD-IRD-003110
SEP occurance rate calculation
Occurrence rate of SEP shall be calculated both in nominal and flare conditions.

Verification Method : A

HYP-PRD-IRD-003120

GCR LET spectrum in nominal conditions

For calculating occurrence rate of Single Event Upset & Transient effects in nominal conditions, following Integral LET spectrum for GCR shall be used:

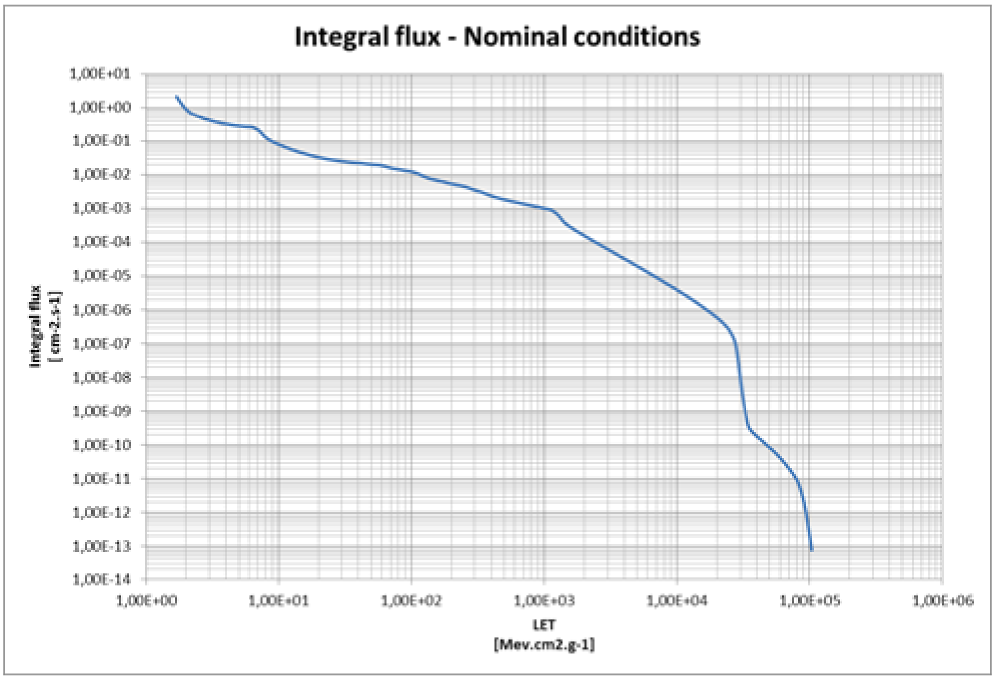


Figure 17 Integral LET Spectrum for Heavy Ions in nominal conditions

LET [Mev.cm2.g-1]	Integral flux [cm-2.s-1]	Differential flux [cm-2.s-1.(Mev.cm2.g-1)-1]
1,69E+00	2,17E+00	5,35E+00
1,89E+00	1,17E+00	2,01E+00
2,11E+00	7,49E-01	6,48E-01
2,36E+00	5,98E-01	3,71E-01
2,63E+00	5,01E-01	2,30E-01
2,94E+00	4,34E-01	1,55E-01
3,28E+00	3,84E-01	9,91E-02
3,67E+00	3,48E-01	6,59E-02
4,09E+00	3,21E-01	4,98E-02
4,57E+00	2,99E-01	2,94E-02
5,10E+00	2,84E-01	2,13E-02
5,70E+00	2,72E-01	1,39E-02
6,36E+00	2,63E-01	6,54E-02
7,10E+00	2,10E-01	9,49E-02
7,93E+00	1,35E-01	3,66E-02
8,86E+00	1,02E-01	1,94E-02
9,89E+00	8,25E-02	1,23E-02
1,10E+01	6,91E-02	8,92E-03
1,23E+01	5,82E-02	5,87E-03
1,38E+01	5,02E-02	4,13E-03
1,54E+01	4,39E-02	3,02E-03
1,72E+01	3,88E-02	2,16E-03
1,92E+01	3,47E-02	1,54E-03
2,14E+01	3,15E-02	1,01E-03
2,39E+01	2,91E-02	7,25E-04
2,67E+01	2,72E-02	5,86E-04
2,98E+01	2,54E-02	4,02E-04
3,33E+01	2,41E-02	2,68E-04
3,71E+01	2,31E-02	1,88E-04
4,15E+01	2,24E-02	2,46E-04
4,63E+01	2,12E-02	1,72E-04
5,17E+01	2,03E-02	9,92E-05
5,77E+01	1,97E-02	2,44E-04
6,45E+01	1,77E-02	2,79E-04
7,20E+01	1,57E-02	1,28E-04
8,04E+01	1,46E-02	1,22E-04
8,97E+01	1,35E-02	8,80E-05
1,00E+02	1,26E-02	1,26E-04
1,12E+02	1,10E-02	1,69E-04
1,25E+02	8,93E-03	8,77E-05
1,39E+02	7,64E-03	4,54E-05
1,56E+02	6,93E-03	3,80E-05
1,74E+02	6,28E-03	3,39E-05
1,94E+02	5,63E-03	2,37E-05
2,17E+02	5,11E-03	1,48E-05
2,42E+02	4,76E-03	2,00E-05
2,70E+02	4,13E-03	1,93E-05
3,02E+02	3,53E-03	1,27E-05
3,37E+02	3,11E-03	1,28E-05
3,76E+02	2,62E-03	8,78E-06
4,20E+02	2,25E-03	5,57E-06
4,69E+02	1,99E-03	4,09E-06
5,24E+02	1,77E-03	2,80E-06
5,85E+02	1,61E-03	2,15E-06
6,53E+02	1,47E-03	1,84E-06
7,29E+02	1,34E-03	1,45E-06
8,14E+02	1,22E-03	1,13E-06
9,09E+02	1,12E-03	1,09E-06

1,02E+03	1,01E-03	8,89E-07
1,13E+03	9,12E-04	1,37E-06
1,27E+03	6,66E-04	1,86E-06
1,41E+03	3,96E-04	7,11E-07
1,58E+03	2,84E-04	3,92E-07
1,76E+03	2,16E-04	2,55E-07
1,97E+03	1,67E-04	1,74E-07
2,20E+03	1,29E-04	1,19E-07
2,45E+03	1,00E-04	8,07E-08
2,74E+03	7,82E-05	5,64E-08
3,06E+03	6,11E-05	4,05E-08
3,41E+03	4,74E-05	2,81E-08
3,81E+03	3,69E-05	1,89E-08
4,26E+03	2,89E-05	1,35E-08
4,75E+03	2,26E-05	9,65E-09
5,31E+03	1,75E-05	6,66E-09
5,93E+03	1,36E-05	4,64E-09
6,62E+03	1,06E-05	3,33E-09
7,39E+03	8,14E-06	2,36E-09
8,25E+03	6,22E-06	1,55E-09
9,21E+03	4,81E-06	1,13E-09
1,03E+04	3,66E-06	7,67E-10
1,15E+04	2,79E-06	5,39E-10
1,28E+04	2,11E-06	3,82E-10
1,43E+04	1,57E-06	2,67E-10
1,60E+04	1,15E-06	1,74E-10
1,79E+04	8,42E-07	1,21E-10
1,99E+04	6,04E-07	8,93E-11
2,23E+04	4,07E-07	6,57E-11
2,49E+04	2,45E-07	4,90E-11
2,77E+04	8,81E-08	2,73E-11
3,10E+04	3,54E-09	8,69E-13
3,46E+04	3,84E-10	4,41E-14
3,86E+04	2,14E-10	1,62E-14
4,31E+04	1,45E-10	9,87E-15
4,82E+04	9,78E-11	5,88E-15
5,38E+04	6,66E-11	3,98E-15
6,00E+04	4,30E-11	2,64E-15
6,70E+04	2,55E-11	1,49E-15
7,49E+04	1,44E-11	9,33E-16
8,36E+04	6,69E-12	5,87E-16
9,33E+04	1,25E-12	1,13E-16
1,04E+05	7,88E-14	6,80E-18

Table 26 Integral LET Spectrum for Heavy Ions in nominal conditions

Verification Method : A

HYP-PRD-IRD-003130

GCR LET spectrum in solar flare conditions

For calculating occurrence rate of Single Event Upset & Transient effects in solar event (solar flare) conditions, following Integral LET spectrum for GCR shall be used:

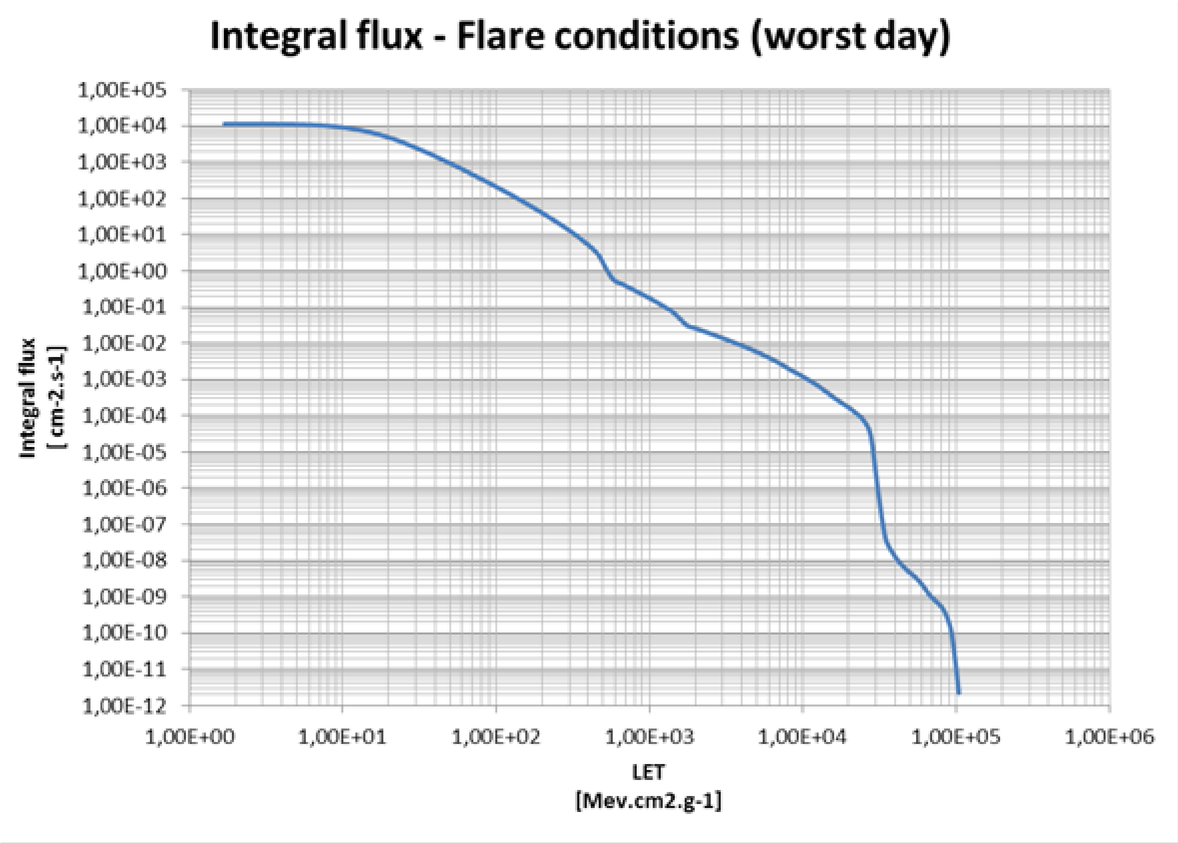


Figure 18 Integral LET Spectrum for Heavy Ions during solar event worst day

LET [Mev.cm2.g-1]	Integral flux [cm-2.s-1]	Differential flux [cm-2.s-1.(Mev.cm2.g-1)-1]
1,69E+00	1,12E+04	3,68E+00
1,89E+00	1,12E+04	9,43E+00
2,11E+00	1,12E+04	1,86E+01
2,36E+00	1,12E+04	3,29E+01
2,63E+00	1,12E+04	4,71E+01
2,94E+00	1,12E+04	7,17E+01
3,28E+00	1,12E+04	9,06E+01
3,67E+00	1,11E+04	1,22E+02
4,09E+00	1,11E+04	1,71E+02
4,57E+00	1,10E+04	2,03E+02
5,10E+00	1,09E+04	2,63E+02
5,70E+00	1,08E+04	2,96E+02
6,36E+00	1,06E+04	3,66E+02
7,10E+00	1,03E+04	4,16E+02
7,93E+00	1,00E+04	4,50E+02
8,86E+00	9,60E+03	4,96E+02
9,89E+00	9,12E+03	4,91E+02
1,10E+01	8,58E+03	5,27E+02
1,23E+01	7,94E+03	4,60E+02
1,38E+01	7,31E+03	4,90E+02
1,54E+01	6,56E+03	4,42E+02
1,72E+01	5,81E+03	3,88E+02
1,92E+01	5,08E+03	3,37E+02
2,14E+01	4,37E+03	2,79E+02
2,39E+01	3,71E+03	2,45E+02
2,67E+01	3,06E+03	1,80E+02
2,98E+01	2,53E+03	1,40E+02
3,33E+01	2,07E+03	1,03E+02
3,71E+01	1,69E+03	8,08E+01
4,15E+01	1,36E+03	5,92E+01
4,63E+01	1,09E+03	4,19E+01
5,17E+01	8,74E+02	3,10E+01
5,77E+01	6,98E+02	2,31E+01
6,45E+01	5,51E+02	1,72E+01
7,20E+01	4,28E+02	1,11E+01
8,04E+01	3,40E+02	8,16E+00
8,97E+01	2,67E+02	5,94E+00
1,00E+02	2,08E+02	4,19E+00
1,12E+02	1,62E+02	2,90E+00
1,25E+02	1,26E+02	2,12E+00
1,39E+02	9,71E+01	1,48E+00
1,56E+02	7,43E+01	1,04E+00
1,74E+02	5,64E+01	7,16E-01
1,94E+02	4,27E+01	5,02E-01
2,17E+02	3,19E+01	3,41E-01
2,42E+02	2,37E+01	2,32E-01
2,70E+02	1,75E+01	1,59E-01
3,02E+02	1,28E+01	1,09E-01
3,37E+02	9,16E+00	7,29E-02
3,76E+02	6,45E+00	4,94E-02
4,20E+02	4,40E+00	3,66E-02
4,69E+02	2,68E+00	2,80E-02
5,24E+02	1,15E+00	7,61E-03
5,85E+02	5,71E-01	1,84E-03
6,53E+02	4,53E-01	1,30E-03
7,29E+02	3,59E-01	9,34E-04

8,14E+02	2,84E-01	6,86E-04
9,09E+02	2,22E-01	4,90E-04
1,02E+03	1,73E-01	3,54E-04
1,13E+03	1,34E-01	2,60E-04
1,27E+03	1,01E-01	1,94E-04
1,41E+03	7,38E-02	1,63E-04
1,58E+03	4,73E-02	7,94E-05
1,76E+03	3,06E-02	2,27E-05
1,97E+03	2,62E-02	1,81E-05
2,20E+03	2,22E-02	1,41E-05
2,45E+03	1,88E-02	1,09E-05
2,74E+03	1,59E-02	8,27E-06
3,06E+03	1,34E-02	6,38E-06
3,41E+03	1,12E-02	5,01E-06
3,81E+03	9,32E-03	3,81E-06
4,26E+03	7,72E-03	2,95E-06
4,75E+03	6,34E-03	2,35E-06
5,31E+03	5,11E-03	1,77E-06
5,93E+03	4,07E-03	1,29E-06
6,62E+03	3,23E-03	1,02E-06
7,39E+03	2,48E-03	7,60E-07
8,25E+03	1,85E-03	4,32E-07
9,21E+03	1,46E-03	3,39E-07
1,03E+04	1,11E-03	2,36E-07
1,15E+04	8,46E-04	1,73E-07
1,28E+04	6,27E-04	1,23E-07
1,43E+04	4,54E-04	8,62E-08
1,60E+04	3,17E-04	4,89E-08
1,79E+04	2,31E-04	3,09E-08
1,99E+04	1,70E-04	2,33E-08
2,23E+04	1,19E-04	1,72E-08
2,49E+04	7,64E-05	1,36E-08
2,77E+04	2,98E-05	9,39E-09
3,10E+04	8,89E-07	2,37E-10
3,46E+04	4,32E-08	7,02E-12
3,86E+04	1,61E-08	1,78E-12
4,31E+04	8,45E-09	6,67E-13
4,82E+04	5,27E-09	3,21E-13
5,38E+04	3,56E-09	2,37E-13
6,00E+04	2,15E-09	1,55E-13
6,70E+04	1,12E-09	5,60E-14
7,49E+04	7,06E-10	3,66E-14
8,36E+04	4,03E-10	3,24E-14
9,33E+04	1,02E-10	9,58E-15
1,04E+05	2,20E-12	1,90E-16

Table 27 Integral LET Spectrum for Heavy Ions in solar flare conditions

Verification Method : A

3.2.9.6. Trapped electrons and protons

Average fluxes for both trapped electrons and protons are calculated using the AE8 NASA GSFC model; the geomagnetic field model used in calculation of trapped electron contribution is "Jensen Cain 1960.0"

HYP-PRD-IRD-003140

Trapped particles

For Single Event Upset & Transient effects, trapped protons and electrons spectrum along the orbit shall be taken into account.

Verification Method : A

HYP-PRD-IRD-003150

Trapped protons spectrum

For trapped protons spectrum, following chart/table apply.

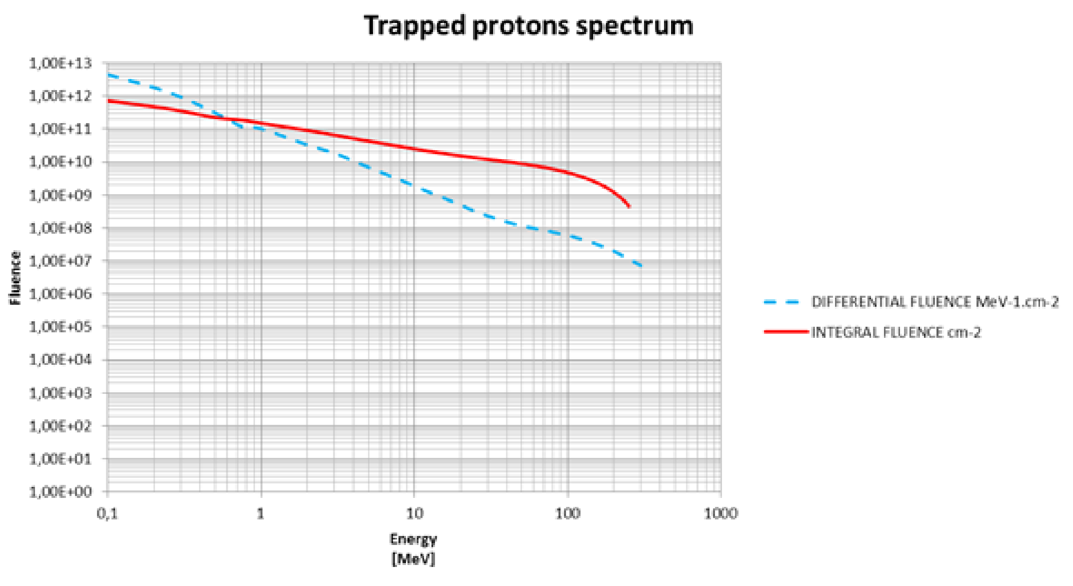


Figure 19 Trapped protons spectrum

Energy MeV	DIFFERENTIAL FLUENCE MeV-1.cm-2	INTEGRAL FLUENCE cm-2
0,1	4,47E+12	7,19E+11
0,25	1,29E+12	4,09E+11
0,5	3,13E+11	2,24E+11
0,75	1,18E+11	1,87E+11
1	1,02E+11	1,50E+11
2	3,31E+10	9,13E+10
3	1,87E+10	6,59E+10
4	1,07E+10	5,18E+10
5	7,00E+09	4,31E+10
6	4,95E+09	3,73E+10
7	3,72E+09	3,29E+10
8	2,89E+09	2,97E+10
10	1,88E+09	2,50E+10
12	1,32E+09	2,19E+10
15	8,73E+08	1,87E+10
17	6,81E+08	1,71E+10
20	4,91E+08	1,54E+10
25	3,18E+08	1,34E+10
30	2,34E+08	1,21E+10
35	1,83E+08	1,10E+10
40	1,52E+08	1,02E+10
45	1,31E+08	9,50E+09
50	1,17E+08	8,88E+09
55	1,06E+08	8,33E+09
60	9,80E+07	7,81E+09
70	8,44E+07	6,91E+09
80	7,42E+07	6,11E+09
90	6,59E+07	5,42E+09
100	5,92E+07	4,79E+09
125	4,48E+07	3,50E+09
150	3,38E+07	2,52E+09
175	2,58E+07	1,78E+09
200	1,98E+07	1,21E+09
225	1,48E+07	7,84E+08
250	1,14E+07	4,57E+08
275	9,03E+06	2,04E+08
300	7,28E+06	0,00E+00

Table 28 Trapped protons spectrum

Verification Method : A

HYP-PRD-IRD-003160

Trapped electrons spectrum

For trapped electrons spectrum, following chart/table apply.

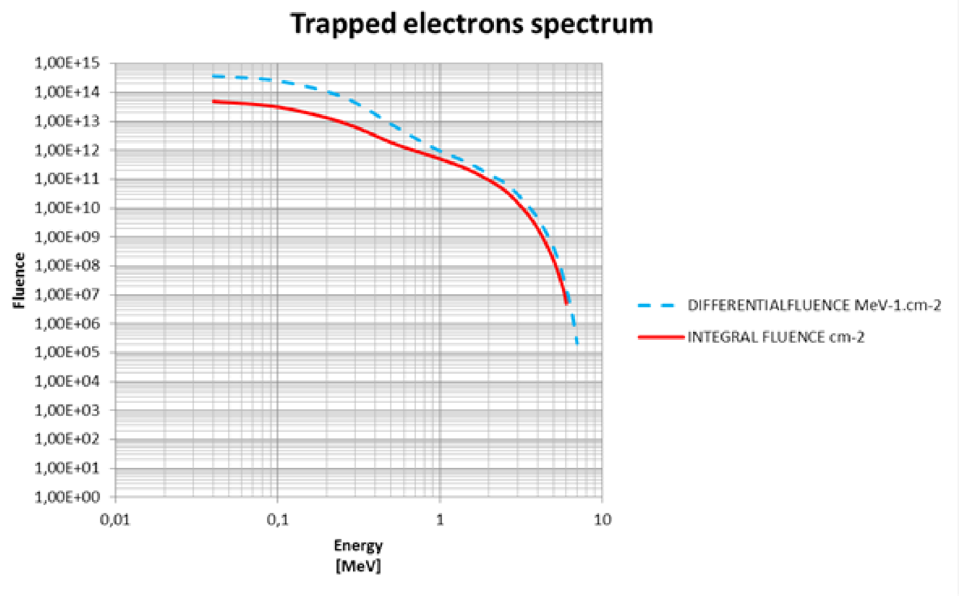


Figure 20 Trapped electrons spectrum

Energy MeV	DIFFERENTIALFLUENCE MeV-1.cm-2	INTEGRAL FLUENCE cm-2
0,04	3,71E+14	4,89E+13
0,1	2,50E+14	3,13E+13
0,25	7,10E+13	9,19E+12
0,5	7,94E+12	1,84E+12
0,75	2,12E+12	8,42E+11
1	9,46E+11	5,01E+11
1,5	3,60E+11	2,13E+11
2	1,51E+11	9,18E+10
2,5	7,44E+10	4,12E+10
3	3,04E+10	1,55E+10
3,5	1,20E+10	5,81E+09
4	4,48E+09	1,95E+09
4,5	1,45E+09	5,79E+08
5	4,29E+08	1,60E+08
5,5	1,00E+08	3,51E+07
6	1,63E+07	5,00E+06
6,5	2,47E+06	6,00E+04
7	2,07E+05	0,00E+00

Table 29 Trapped electrons spectrum

Verification Method : A

3.2.9.7. Solar protons

The Solar Proton fluence is calculated using the ESP model, 85% Confidence Level.

HYP-PRD-IRD-003170
Solar proton fluence
For Single Event Upset & Transient effects, Solar Proton fluence in both nominal and solar flare conditions shall be taken into account.

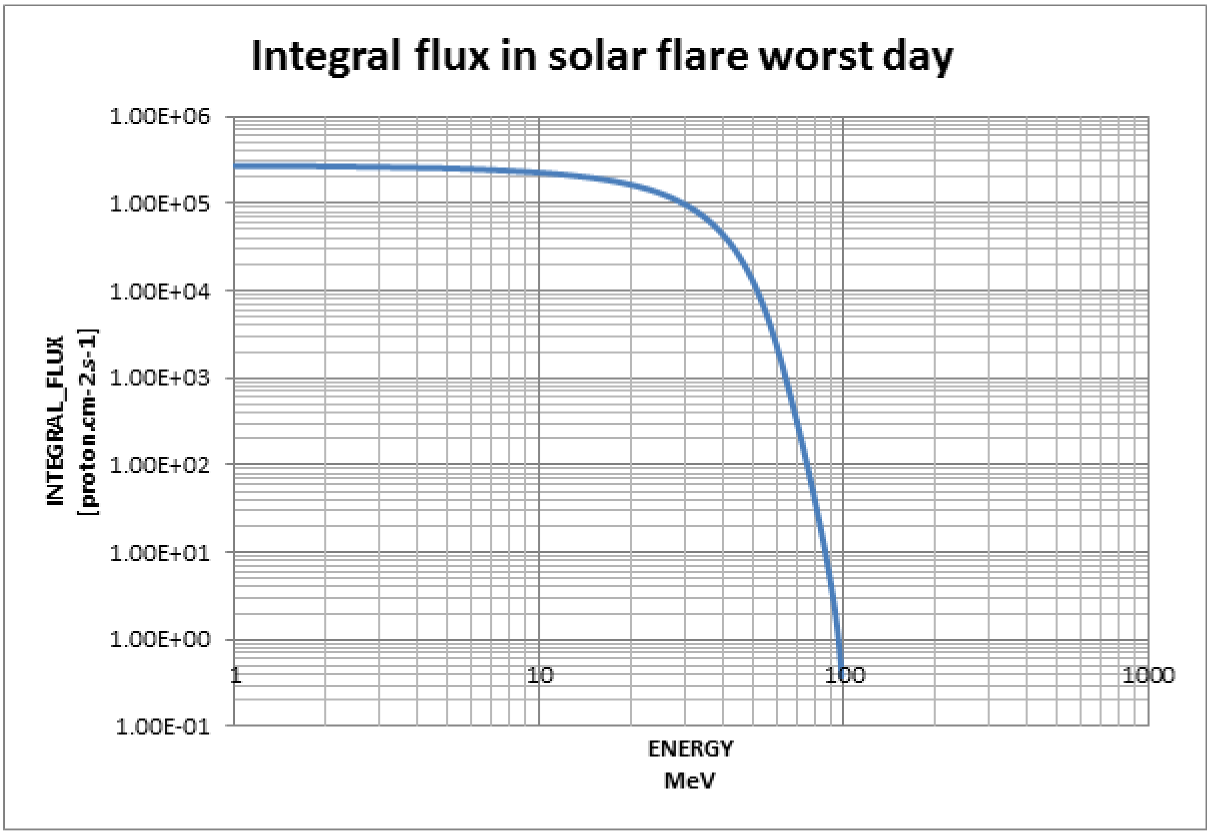


Figure 21 Solar proton fluence

ENERGY MeV	DIFFERENTIAL_FLUX [protons.MeV-1.cm-2.s-1]	INTEGRAL_FLUX [proton.cm-2.s-1]
1,00E+00	6,19E+04	2,70E+05
1,07E+00	5,99E+04	2,65E+05
1,15E+00	5,78E+04	2,61E+05
1,23E+00	5,58E+04	2,56E+05
1,32E+00	5,38E+04	2,51E+05
1,41E+00	5,18E+04	2,46E+05
1,51E+00	4,97E+04	2,41E+05
1,62E+00	4,77E+04	2,36E+05
1,74E+00	4,58E+04	2,31E+05
1,86E+00	4,38E+04	2,25E+05
2,00E+00	4,19E+04	2,19E+05
2,14E+00	3,99E+04	2,13E+05
2,29E+00	3,80E+04	2,07E+05
2,45E+00	3,62E+04	2,01E+05
2,63E+00	3,43E+04	1,95E+05
2,82E+00	3,25E+04	1,89E+05
3,02E+00	3,08E+04	1,83E+05
3,24E+00	2,90E+04	1,76E+05
3,47E+00	2,73E+04	1,70E+05
3,72E+00	2,57E+04	1,63E+05
3,98E+00	2,41E+04	1,56E+05
4,27E+00	2,26E+04	1,50E+05
4,57E+00	2,11E+04	1,43E+05
4,90E+00	1,96E+04	1,36E+05
5,25E+00	1,82E+04	1,30E+05
5,62E+00	1,69E+04	1,23E+05
6,03E+00	1,56E+04	1,17E+05
6,46E+00	1,44E+04	1,10E+05
6,92E+00	1,32E+04	1,04E+05
7,41E+00	1,21E+04	9,76E+04
7,94E+00	1,11E+04	9,15E+04
8,51E+00	1,01E+04	8,55E+04
9,12E+00	9,16E+03	7,96E+04
9,77E+00	8,28E+03	7,40E+04
1,05E+01	7,47E+03	6,85E+04
1,12E+01	6,71E+03	6,32E+04
1,20E+01	6,01E+03	5,81E+04
1,29E+01	5,35E+03	5,32E+04
1,38E+01	4,76E+03	4,85E+04
1,48E+01	4,21E+03	4,41E+04
1,58E+01	3,70E+03	3,99E+04
1,70E+01	3,25E+03	3,60E+04
1,82E+01	2,83E+03	3,23E+04
1,95E+01	2,46E+03	2,89E+04
2,09E+01	2,13E+03	2,57E+04
2,24E+01	1,83E+03	2,27E+04
2,40E+01	1,56E+03	2,00E+04
2,57E+01	1,33E+03	1,76E+04
2,75E+01	1,12E+03	1,53E+04
2,95E+01	9,45E+02	1,33E+04
3,16E+01	7,89E+02	1,15E+04
3,39E+01	6,55E+02	9,83E+03
3,63E+01	5,41E+02	8,38E+03
3,89E+01	4,43E+02	7,12E+03
4,17E+01	3,60E+02	6,00E+03
4,47E+01	2,91E+02	5,04E+03
4,79E+01	2,33E+02	4,20E+03
5,13E+01	1,85E+02	3,49E+03

5,50E+01	1,46E+02	2,88E+03
5,89E+01	1,14E+02	2,38E+03
6,31E+01	8,83E+01	1,95E+03
6,76E+01	6,77E+01	1,60E+03
7,24E+01	5,35E+01	1,31E+03
7,76E+01	4,07E+01	1,07E+03
8,32E+01	3,09E+01	8,71E+02
8,91E+01	2,35E+01	7,10E+02
9,55E+01	1,79E+01	5,80E+02
1,02E+02	1,36E+01	4,73E+02
1,10E+02	1,04E+01	3,86E+02
1,17E+02	7,90E+00	3,15E+02
1,26E+02	6,01E+00	2,57E+02
1,35E+02	4,58E+00	2,09E+02
1,45E+02	3,49E+00	1,71E+02
1,55E+02	2,65E+00	1,39E+02
1,66E+02	2,02E+00	1,13E+02
1,78E+02	1,54E+00	9,25E+01
1,91E+02	1,17E+00	7,54E+01
2,04E+02	8,92E-01	6,14E+01
2,19E+02	6,79E-01	5,01E+01
2,34E+02	5,17E-01	4,08E+01
2,51E+02	3,94E-01	3,32E+01
2,69E+02	3,00E-01	2,70E+01
2,88E+02	2,29E-01	2,20E+01
3,09E+02	1,75E-01	1,78E+01
3,31E+02	1,33E-01	1,44E+01
3,55E+02	1,02E-01	1,17E+01
3,80E+02	7,76E-02	9,43E+00
4,07E+02	5,92E-02	7,58E+00
4,37E+02	4,52E-02	6,07E+00
4,68E+02	3,45E-02	4,84E+00
5,01E+02	2,63E-02	3,83E+00
5,37E+02	2,01E-02	3,00E+00
5,75E+02	1,54E-02	2,33E+00
6,17E+02	1,18E-02	1,77E+00
6,61E+02	9,03E-03	1,32E+00
7,08E+02	6,94E-03	9,42E-01
7,59E+02	5,34E-03	6,35E-01
8,13E+02	4,09E-03	3,80E-01
8,71E+02	3,13E-03	1,72E-01
9,33E+02	2,40E-03	0,00E+00

Table 7- Solar proton fluence*Verification Method* : A

3.2.9.8.Total Non-Ionizing Dose (Displacement Damage)

This section describes requirements for calculating Total Non-Ionizing Dose Level (displacement damage).
Both protons and electrons can induce displacement damage in semiconductor devices. The part of deposited energy involved in displacement defects creation is called Non Ionizing Energy Loss (NIEL). The particles spectra have been converted into a Total Non-Ionizing Dose (TNID) depth curve using

OMERE code. This curve has been calculated for aluminum solid spheres shielding of various thicknesses.
Displacement Damage Equivalent Fluence (DDEF) curves are provided for Silicon (Si) and Arsenide Gallium (GaAS) material. For other materials, other particles at other energies, curves can be obtained from OMERE code or directly from Thales Alenia Space Radiation Effects Group.

3.2.9.8.1. Displacement Damage Equivalent Fluence

HYP-PRD-IRD-003180
Displacement Damage Equivalent Fluence for Si
To calculate TNID for Si components, following Displacement Damage Curve shall be used, which represents equivalent fluence of 10MeV-protons for given environment.

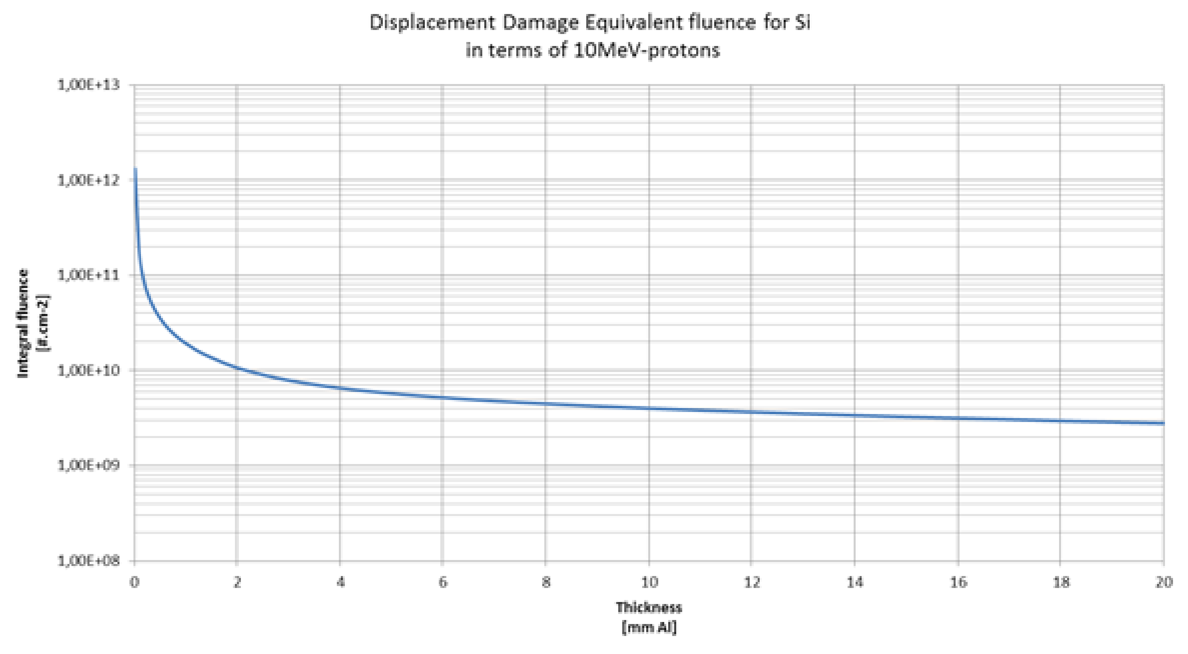


Figure 22 Displacement Damage Equivalent fluence for Si in terms of 10MeV-protons

Thickness [mm Al]	Integral fluence [#.cm-2] (Si)
1,00E-02	1,32E+12
1,00E-01	1,71E+11
2,00E-01	8,52E+10
3,00E-01	5,78E+10
4,00E-01	4,42E+10
5,00E-01	3,60E+10
6,00E-01	3,04E+10
7,00E-01	2,65E+10
8,00E-01	2,35E+10
9,00E-01	2,12E+10
1,00E+00	1,94E+10
1,10E+00	1,79E+10
1,20E+00	1,65E+10
1,30E+00	1,54E+10
1,40E+00	1,45E+10
1,50E+00	1,37E+10
1,60E+00	1,30E+10
1,70E+00	1,23E+10
1,80E+00	1,17E+10
1,90E+00	1,12E+10
2,00E+00	1,07E+10
2,25E+00	9,77E+09
2,50E+00	9,03E+09
2,75E+00	8,40E+09
3,00E+00	7,89E+09
3,25E+00	7,47E+09
3,50E+00	7,12E+09
3,75E+00	6,81E+09
4,00E+00	**6,54E+09**
4,25E+00	6,30E+09
4,50E+00	6,10E+09
4,75E+00	5,92E+09
5,00E+00	5,75E+09
5,25E+00	5,59E+09
5,50E+00	5,45E+09
5,75E+00	5,32E+09
6,00E+00	5,20E+09
6,25E+00	5,08E+09
6,50E+00	4,98E+09
6,75E+00	4,88E+09
7,00E+00	4,79E+09
7,25E+00	4,70E+09
7,50E+00	4,62E+09
7,75E+00	4,55E+09
8,00E+00	4,48E+09
8,25E+00	4,41E+09
8,50E+00	4,35E+09
8,75E+00	4,28E+09
9,00E+00	4,22E+09
9,50E+00	4,11E+09
1,00E+01	4,00E+09
1,05E+01	3,91E+09
1,10E+01	3,82E+09
1,15E+01	3,74E+09
1,20E+01	3,66E+09
1,25E+01	3,59E+09

1,30E+01	3,51E+09
1,35E+01	3,45E+09
1,40E+01	3,38E+09
1,45E+01	3,32E+09
1,50E+01	3,26E+09
1,60E+01	3,16E+09
1,70E+01	3,06E+09
1,80E+01	2,96E+09
1,90E+01	2,87E+09
2,00E+01	2,79E+09
3,00E+01	2,18E+09
4,00E+01	1,73E+09
5,00E+01	1,44E+09
1,00E+02	6,35E+08

Table 30 Displacement Damage Equivalent fluence for Si in terms of 10MeV-protons

Verification Method : A

HYP-PRD-IRD-003190

Displacement Damage Equivalent Fluence for GaAs

To calculate TNID for GaAs components, following Displacement Damage Curve shall be used, which represents equivalent fluence of 10MeV-protons for a given environment.

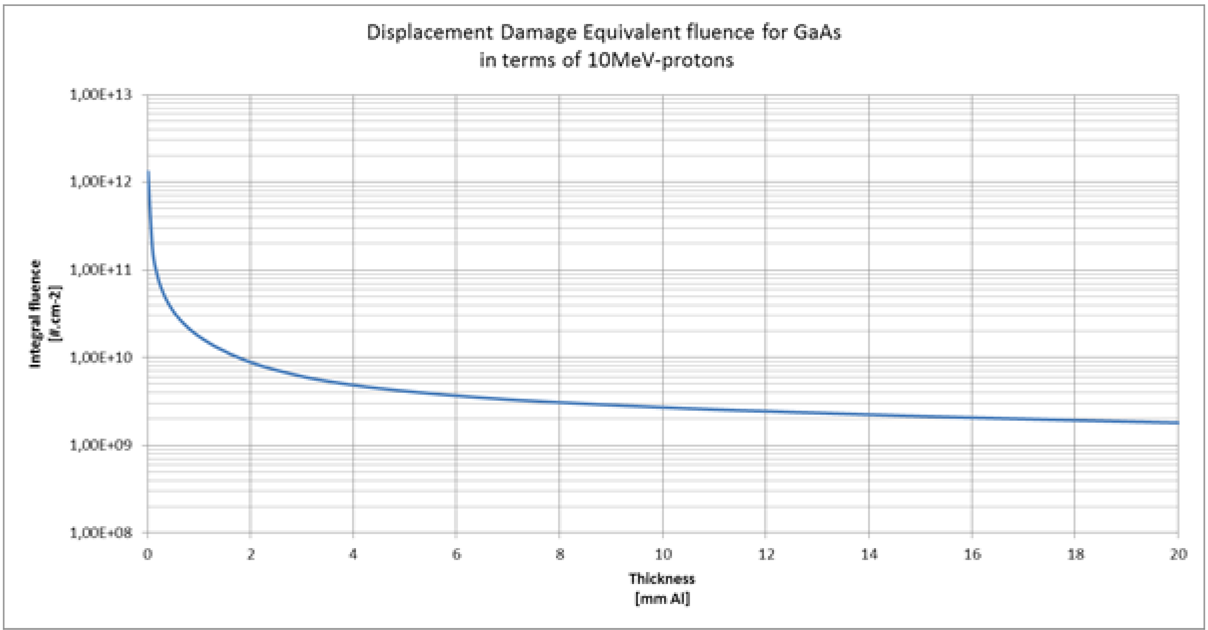


Figure 23 Displacement Damage Equivalent Fluence for GaAs

Thickness [mm Al]	Integral fluence [#.cm-2] (GaAs)
0,01	1,32E+12
0,10	1,71E+11
0,20	8,40E+10
0,30	5,62E+10
0,40	4,24E+10
0,50	3,41E+10
0,60	2,84E+10
0,70	2,45E+10
0,80	2,15E+10
0,90	1,92E+10
1,00	1,74E+10
1,10	1,59E+10
1,20	1,46E+10
1,30	1,35E+10
1,40	1,26E+10
1,50	1,18E+10
1,60	1,10E+10
1,70	1,04E+10
1,80	9,81E+09
1,90	9,29E+09
2,00	8,83E+09
2,25	7,89E+09
2,50	7,18E+09
2,75	6,59E+09
3,00	6,10E+09
3,25	5,70E+09
3,50	5,38E+09
3,75	5,10E+09
4,00	**4,86E+09**
4,25	4,64E+09
4,50	4,46E+09
4,75	4,30E+09
5,00	4,15E+09
5,25	4,02E+09
5,50	3,90E+09
5,75	3,78E+09
6,00	3,68E+09
6,25	3,58E+09
6,50	3,49E+09
6,75	3,41E+09
7,00	3,33E+09
7,25	3,26E+09
7,50	3,20E+09
7,75	3,14E+09
8,00	3,08E+09
8,25	3,03E+09
8,50	2,98E+09
8,75	2,93E+09
9,00	2,88E+09
9,50	2,79E+09
10,00	2,71E+09
10,50	2,63E+09

11,00	2,56E+09
11,50	2,50E+09
12,00	2,45E+09
12,50	2,39E+09
13,00	2,34E+09
13,50	2,29E+09
14,00	2,24E+09
14,50	2,19E+09
15,00	2,15E+09
16,00	2,07E+09
17,00	2,00E+09
18,00	1,93E+09
19,00	1,87E+09
20,00	1,81E+09
30,00	1,40E+09
40,00	1,10E+09
50,00	9,08E+08
100,00	3,99E+08

Table 31 Displacement Damage Equivalent Fluence for GaAs

Maximum equivalent fluence behind 4mm Al is:

- 6,54E+09 p/cm2 for Si
- 4,86E+09 p/cm2 for GaAs

A safety margin of 1.2 is applied to the maximum value, leading to minimum accepted DDEF hardness of 6,54E+09 * 1.2 = 7.80E+09 p/cm2, approximated to 8.00E+09 p/cm2.

Verification Method: A

HYP-PRD-IRD-003200

Minimum DDEF hardness

Components in Si & GaAs shall have a minimum DDEF hardness of 8.0 E+09 protons/cm² in 10MeV protons.

Verification Method: A

3.2.10. Cleanliness Requirements

HYP-PRD-IRD-003300

Cleanability -1

Materials used in hardware fabrication shall be easily cleanable by solvent wiping (acetone, isopropyl alcohol or their mixture). Surface layers shall adhere tightly and have to resist flaking, possibly due to moderate abrasion and handling.

Verification Method: R

HYP-PRD-IRD-003310

Cleanability -2

The choice of manufacturing and integration sequences, techniques and processes (i.e. painting, coatings, surface finishing, late-step bonding operations) shall be governed by considerations concerning the compatibility with desired cleanliness levels, when applicable, unless the parts may be readily and easily cleaned afterwards.
Verification Method : R

HYP-PRD-IRD-003320
Corrosion resistant
Metallic materials used in hardware fabrication shall be corrosion resistant or they shall be opportunely coated / treated (i.e.: Ni-plating, chromate conversion coating, colorless anodizing, etc.). Cadmium, zinc and un-fused electro-plated tin shall not be used.
Verification Method : R

HYP-PRD-IRD-003330
Stainless steel parts passivation
Stainless steel parts shall be passivated in order to prevent pitting corrosion phenomena.
Verification Method : R

HYP-PRD-IRD-003340
Payload specific clanliness requirements
Specific cleanliness requirements from Payload during Platform/Satellite AIT and test campaign shall be clearly reported, discussed and agreed with the Prime contractor. The following lists reports some cleanliness issues that Payload supplier shall be addressed in Paylod documentation:

- Decontamination heater
- Purging lines
- Platform/Satellite AIT ISO room
- MOC/PAC samples

Verification Method : R

HYP-PRD-IRD-003350
Platform/ Satellite AIT in ISO 8
All Platform/Satellite AIT operations shall be carried out under controlled environmental conditions (ISO 8 cleanroom) for a duration as reported in lifetime requirement.
Verification Method : R

HYP-PRD-IRD-003360
MOC and PAC samples
Payload MOC and PAC samples procurement, accommodation and periodic measurements are under Payload supplier responsibility.

If additional MOC and PAC samples shall be placed on Platform during Platform/Satellite AIT phase, this shall be agreed with Prime Contractor
Verification Method : R

HYP-PRD-IRD-003370
Stainless steel passivation

Stainless steel parts shall be passivated in order to prevent pitting corrosion phenomena.
Verification Method : R

3.2.11. AIT requirements

3.2.11.1. Test requirements

HYP-PRD-IRD-004000
Payload Testing
The payload shall be designed in a way, so that it can be adequately tested at equipment level and above during and after integration to verify the specified functional performance in all modes of operation under all environmental conditions.
Verification Method : T

HYP-PRD-IRD-0004010
Handling Points
All the units and payloads with an overall mass higher than 5 kg shall be equipped with handling points allowing the connection to dedicated MGSE during all the AIV phase, including (eventual) dismounting.
Verification Method : I, R

HYP-PRD-IRD-0004020
Unit Level Tests -1
The content and sequence of unit level tests shall be defined by the supplier and presented in the test plan.
Verification Method : R

HYP-PRD-IRD-004030
Unit Level Tests -2
The procedures for the unit level tests shall cover as a minimum:

- All test steps planned to verify the required unit functions and performance;
- Traceability of proposed tests to technical requirements of this document;
- Description of test set-up;
- Test configuration of hardware;
- Accuracy of all characteristics measured during the test;
- Performance and calibration summary of test support equipment used.

Verification Method : I

HYP-PRD-IRD-004040HYP-PRD-IRD-000980
Unit Level Tests - 3
It shall be possible to test the redundant function of a closed unit.

Verification Method : I

HYP-PRD-IRD-004050
Test Points
Test/stimulus points shall be accessible without the need to modify the electrical configuration of an item of equipment and shall be suitably protected for flight operation.
Verification Method : I

HYP-PRD-IRD-004060
Flight Connectors
Flight connectors shall be protected by using connector savers and caps.
Verification Method : I

HYP-PRD-IRD-004070
Mechanism activation during AIT
It shall be possible to activate and verify the performance of mechanisms during the AIT campaign at platform/satellite level including TVAC test.
Verification Method : T

3.2.11.2. Handling, transportation and storage requirements

HYP-PRD-IRD-004100
Handling setup
All the units and payloads with an overall mass higher than 5 kg shall be equipped with handling points allowing the connection to dedicated MGSE during all the AIV phase, including (eventual) dismounting.
Verification Method : R

HYP-PRD-IRD-004110
Payload Containers -1
The payload shall be transported using a container to protect the flight hardware during transportation.
Verification Method : I

HYP-PRD-IRD-004120
Payload Containers -2
The payload containers, covers (for optics and exposed connectors) and packaging shall ensure that the environments encountered during shipping and storage do not exceed expected flight levels.
Verification Method : I

HYP-PRD-IRD-004130
Payload Protective Covers
If necessary the payload shall be delivered with dust protective cover. The covers shall be identified as “REMOVE BEFORE FLIGHT” items and shall be removed before flight according to ground operations procedures.

Verification Method : I

HYP-PRD-IRD-004140
Payload Maintenance
Maintenance during storage shall be as limited as possible and, if required, shall be identified by the supplier for approval by the customer.
Verification Method : R

HYP-PRD-IRD-004150
Payload Storage
Storage conditions shall be identified and specified in the relevant payload transportation, handling and storage procedure. In particular, special storage requirements other than the usual temperature/humidity for flight hardware shall be clearly specified (for example: charge condition (for batteries), vertical/horizontal position, gas filling/purging).
Verification Method : R

HYP-PRD-IRD-004160
Ground Environment -1
The unit shall be designed to withstand without damage or degradation in function a relative humidity of less than 60% during integration, test and transport phases.
Verification Method : R

HYP-PRD-IRD-004170
Ground Environment -2
The unit shall not be damaged or degraded in performance under common electronic, magnetic and environmental conditions which are present in an electronic laboratory.
Verification Method : R

3.2.11.3. Verification requirements

3.2.11.3.1. Mechanical Design Verification Requirements

HYP-PRD-IRD-004200
FEM eigenfrequencies
A structural Finite Element Model shall be delivered for subsystem and units. Principal modes are those modes with an effective modal mass > 5%.
Verification Method : A

HYP-PRD-IRD-004210
FEM accuracy
The FEM shall be detailed enough to ensure an appropriate derivation/verification of the design loads and the modal response for all important modes with an effective mass > 5 % of the total mass up to 2000 Hz.

Verification Method : A

HYP-PRD-IRD-004220
Detailed FE models
It shall be supported by additional and more detailed models for the analysis and design of specific aspects (strength verification, thermal stress analysis, thermo-elastic analysis, interface stiffness analysis, optical analysis, as required).
Verification Method : A

HYP-PRD-IRD-004230
Correlation criteria
As a result of that, the following criteria shall be satisfied:
- for the modes with an effective mass > 10% of the total mass:
  - frequency deviation < 3%;
  - error for damping factor < 20%;
  - Modal Assurance Criterium (MAC) > 0.9.
- for the modes with an effective mass > 5% of the total mass and an eigenfrequency < 100 Hz:
  - eigenfrequency deviation < 5%;
  - MAC > 0.9.

Verification Method : A

HYP-PRD-IRD-004240
Design loads verification
All the design loads applicable to the various parts, subassemblies or complete spacecraft shall be substantiated by analyses of significant events during the complete lifetime.
Note: Design loads be reassessed after each test at subassembly or system level.
Verification Method : A

HYP-PRD-IRD-004250
Minimum eigenfrequencies
The analytically predicted frequencies shall be higher than the minimum requirement specifications with positive margins.
Note: Predicted frequencies shall be reassessed after each test at subassembly or system level.
Verification Method : A

HYP-PRD-IRD-004260
Stress analysis criteria
The stress analysis shall demonstrate positive MOS and cover loads originating from mechanical, thermal and moisture description effects combined adequately together.
Verification Method : A

HYP-PRD-IRD-004270
Strength values criteria
Strength values used for analysis for selected materials shall be in accordance with the CoCs provided by the manufacturers of the unit
Verification Method : A

HYP-PRD-IRD-004280
Fatigue analysis
Fatigue analysis shall be carried out where relevant and demonstrate a positive reserve after application of 4 times the most constraining life cycles.
Verification Method : A

3.2.11.4. Integration requirements

HYP-PRD-IRD-004300
Red Tag Items -1
Items to be removed before flight (e.g. red tag items) shall be visible after integration with the spacecraft.
Verification Method : I

HYP-PRD-IRD-004310
Red Tag Items -2
All items to be removed before flight shall be identified in a maintained list including their integration status.
Note: each change of tagged items shall be treated as a change in configuration.
Verification Method : I

HYP-PRD-IRD-004320
Non-flight items
Integration or removal of non-flight items shall be possible without removing any equipment from the integrated spacecraft.
Verification Method : R

HYP-PRD-IRD-004330
Alignment
Alignment measurements shall be made with an accuracy better than 0.5°.
Verification Method : I

HYP-PRD-IRD-004340
Screw Type Hardware Locking
All screw type hardware used on the units shall be locked by adequate measures.
Verification Method : I

3.2.11.5. Alignment requirements

HYP-PRD-IRD-004500
Payload Alignment Devices
The payload shall provide the necessary means and devices (e.g. optical alignment cubes) to determine the alignment with respect to the satellite platform reference frames.
Verification Method : I

HYP-PRD-IRD-004510
Payload Alignment cubes position
The payload alignment cube(s) shall be positioned such that it is visible at payload delivery and at least two optical surfaces can be used for alignment between payload and Satellite.
The payload alignment cube(s) shall be reported in the ICD.
Verification Method : I

ANNEX 1: Acronyms and Definitions

Term	Meaning
Absolute Spectro-Radiometric Response	The slope responsivity versus wavelength of the instrument to input radiance traceable to primary national standards and includes all systematic errors of transfer. The response is the mean over all equivalent across track positions for each band of the operable spatial or spectral samples.
Acquisition	The act of acquiring data for a specific area of the ground, using one or more of the on-board sensors.
Acquisition Latency	The time from the submission of a well-formed user order up to and including the time that the corresponding image acquisition is stored in the on-board satellite data store.
Aerosol Optical Thickness (AOT)	The factor by which the aerosol reduces optical transmission.
Ancillary data	All the data other than instrument data which are required to perform an instrument's data processing. They include for example orbit data, attitude data, time information, spacecraft engineering data, calibration data and data from other instruments.
Area Access (Accessible area)	The area on the ground for which the system can collect data when requested to do so. The system can acquire data from any accessible area, subject to resource constraints and resolution of conflicting requests.
At-ground Radiance	The (spectral) or (in band) radiance measured at (or near) the ground at a 30° angle relative to the surface normal
Auxiliary data	Any Data obtained inside/outside the mission that is used in the data processing chain (e.g., GCP, DEM, calibration data, etc.)
Available Imaging time	The amount of imaging that can physically be accomplished per orbit, based on the limitations of the sensor and its ancillary equipment. It depends on downlink data architecture and rates, number of ground receiving stations, permissible amount of on-board data compression, size of on-board mass memory storage unit, and other variables.
Browse products	Subset of a larger data set generated for the purpose of allowing rapid interrogation of the data set by a potential user.
Calibration	Calibration is the act of using characterization measurements to convert the raw data into data traceable to national standards. It includes radiometric calibration, wavelength calibration, and correction for systematic error.

Term	Meaning
Calibration data	Any data required to calibrate an instrument including subsets of instrument science data, instrument characterization data, spacecraft characterization data, pre-flight instrument characterization measurements and in flight ground truth measurements.
Calibration Coefficients	Calibration coefficients are data that are used in a parametric model to effect systematic correction of level 0b data in order to obtain top of the atmosphere spectral radiance.
Calibration Mode	A spacecraft mode of operation during which the spacecraft is flown in an alternate attitude in order to perform calibration activities (i.e., Lunar calibration or yaw manoeuvres).
Certification	Certification is the process of confirming that a system, a component, or a process complies with its operational or performance requirements and is acceptable for use in full operations. Often is performed by a 3rd party to provide objective evaluation.
Characterization	Characterization is an ensemble of measurements to gather the information necessary to calibrate the instrument and determine its overall performance.
Data	For the purposes of the Payload, when the word 'data' is used without other qualifiers, it is used in its generic form as referring to digitally encoded information – other qualifiers are added in order to be more specific about the form and content of the data (i.e. 'ancillary data').
Data Processing Latency	The elapsed time between when the acquisition data has been collected by a sensor and stored on-board the satellite, and the delivery of the product to the requesting user. Any delays in users' communication structure are not included within this definition.
Defective Pixel	Any pixel from an element that is not considered operational (see definition of Operational Elements).
Detector Element (or Element)	An element of one or more focal plane detector arrays (PAN, VNIR or SWIR).
De-tumbling Mode	A spacecraft mode of operation during which the spacecraft angular rate (following separation from the launcher, or from an anomaly) is reduced and brought under control.

Term	Meaning
Digital Elevation Model (DEM)	Digital stored xyz-triples of a surface; z represents the elevation. For full definitions of the DEM levels, reference document "USGS Standards for Digital Elevation Models: Part 2 – Specifications, January 1998". Brief highlights of the definitions are included below: Level 1: • A vertical RMSE of 7 meters or less is the desired accuracy standard. A RMSE of 15 meters is the maximum permitted. • Absolute elevation error tolerance of 50 meters when compared to the true elevation. • Systematic errors within the stated accuracy standards are tolerated in level 1 DEM's. Level 2: • Elevation data sets that have been processed or smoothed for consistency and edited to remove identifiable systematic errors. • An RMSE of one-half contour interval is the maximum permitted, with no errors greater than one contour interval Level 3: • Derived from DLG data by using selected elements from both hypsography (contours and spot elevations) and hydrography • An RMSE of one-third of the contour interval is the maximum permitted, with no errors greater than two thirds contour interval
Digital Terrain Model (DTM)	Digital stored xyz-triples of the earth surface.
Elementary Instantaneous field of view (EIFOV)	The maximum along track angle by the maximum cross track angle subtended at any given time by a single detector element of the instrument (Comments: -The width of the slit (hyperspectral) or the detector height (Panchromatic or multi-spectral) determines the along track EIFOV. The width of a detector element determined the across track EIFOV. -Slit width in the along track direction = 2*F*tan(EIFOValong/2), where F is the effective focal length of the optics)
Estimated Spectral Radiance	The spectral radiance at a given wavelength estimated from a least squares (or other) interpolator centred about the given wavelength.
Field-of-Regard	The Field of Regard is the "corridor" (i.e. width on the ground) within which imaging can take place by pointing the sensor off-the nadir axis. The Field of Regard is determined by the swath of the instrument as well as the combined capability of the sensor and Satellite to point in the roll direction toward a pre-determined target.

Term	Meaning
Field of view (FOV) for a pushbroom imaging camera	The maximum along track angle by the maximum cross track angle subtended at any given time by the instrument, with the optical axis oriented at NADIR. (Comments: - The along track FOV is equal to the along track EIFOV. The width of the line of detectors perpendicular to the along track direction determine the "across track FOV". - The Relationship between the across track FOV and Swath is : SWATH = 2*H*tan(FOVcross/2))
Fixed Pattern Noise	The residual effects of uncompensated systematic correction, such as uniformity of spatial response, uniformity of spectral response and the static component of residual effects of incomplete compensation of spurious signals.
Full Width at Half Maximum (FWHM)	An expression of the extent of a function, given by the difference between the two extreme values of the independent variable at which the dependent variable is equal to half of its maximum value.
Geocoding	Registration of images to the reference geometry of a standard map projection. In this process the imagery is corrected for all source-dependent errors, transformed to the desired map projection, and re-sampled to a standard pixel size. (This also called georeferencing).
Geolocation	Process by which the information needed for determining the surface location of the image pixels is derived, but is not applied to the data.
Ground Motion Compensation	Motion compensation decreases the effective ground speed of the nadir trace. It can be used to decrease the along-track GSD for a particular dwell time (or detector frame rate); it requires that the instrument's pointing axis be able to rotate in the pitch direction while imaging. It can be achieved by 'nodding' the instrument (or entire Satellite) in the pitch direction. Yaw and roll stability and their impact on the spatial MTF must be taken into account. Motion compensation decreases the duty cycle for observation. The resulting signal levels are associated with the dwell time, which is no longer limited by the along-track GSD.
Ground Sampling Distance	Ground sampling distance is the maximum distance on the ground between the positions of two adjacent samples when the image centre is viewed in the nadir direction.
Image	For the purposes of the *Payload*, an image is defined as a collection of digital numbers that can be interpreted visually as representing a view of the ground being observed by one or more of the *PRISMA* sensors.
Image Data Take	The maximum time that the spacecraft can image in one acquisition. The image data take may be used to generate multiple product scenes.

Term	Meaning
Image Quality	For the purposes of the *Payload*, the term "Image Quality" is taken to include both the image data characteristics and the processing characteristics.
Imaging opportunity time	The amount of time when good quality images can potentially be taken of land areas, averaged over a long period of time. Cloud cover, night/day, times when the sun elevation angle is greater than 30 degrees, overflight over water versus land, are accounted for.
Indicated wavelength	The centre wavelength of the spectral response function for a given pixel.
Measured Spatial Distribution	The measured spectral radiance versus position for an indicated wavelength within the spectral range of the hyperspectral imager.
Measured Spectral Radiance	The spectral radiance calculated from the measured signal on a given pixel by combining the signal with known calibration coefficients in order to minimize all systematic errors of measurement.
Measured Spectral Distribution	The measured spectral radiance versus wavelength at an indicated spatial sample within the field-of-view of the Hyperspectral imager.
Metadata	Information about data or other information, that follows an approved standard providing a common set of terminology, definitions, and information about values to be provided.
Mission Mode	A spacecraft mode of operation during which the spacecraft is able to acquire mission imaging data.
Modulation Transfer Function (MTF)	Modulation is a measure of the relation between the dimmest and brightest portions of a sinusoidally varying scene or image. The sinusoid is a function of spatial frequency. The modulation transfer is the ratio of the modulation in an image to the modulation in the corresponding object. The transfer function is a function of the spatial frequencies in two dimensions and is not limited by causality. It describes the performance of a linear shift invariant system. The MTF is a measure of what is commonly called contrast. The Modulation transfer function (MTF) should be calculated as the two-dimensional Fourier transform of the two-dimensional point spread function.
Near-real Time	The lowest overall response time that the system could support if freed from operational constraints relating to acquisition and production priorities, downlink conflicts, etc.
Nominal wavelength	The average of the centre wavelengths for nominally equivalent pixels.
Noise Equivalent Delta Radiance (NEDR)	The uncertainty in Satellite measurements in terms of radiance units. The NEDR is usually a constant, regardless of the brightness of the scene being observed.

Term	Meaning
Noise Equivalent Delta Temperature (NEDT)	The uncertainty in Satellite measurements in terms of temperature units. The NEDT is a value which depends on the temperature of the scene being observed and is defined as the change in target temperature at the input to the optical system that would produce an equivalent signal change equal to the temporal noise at a specified signal level or for a specified target.
Noise Equivalent Spectral Radiance (NESR)	The spectral radiance at the input to the optical system that would produce an equivalent signal change equal to the temporal noise at a specified signal level or for a specified target.
Operable elements	An operable element is one which is consistent with the mean and standard deviation of all elements in the focal plane for specific critical parameters under conditions of broad band illumination. The critical parameters that identify operability may include: temporal noise, dark signal, relative response, full well capacity, etc. A robust procedure for identifying the central mode of the distribution (mean and standard deviation) shall be used so that all detector elements lying within ±2 standard deviations of the mean of each parameter are considered operable. Operability may be temperature dependant.
Operable spatial/spectral samples	Samples in a data cube arising from operable elements of the focal plane array.
Orbit Correction Mode	A spacecraft mode of operation during which the spacecraft performs orbit acquisition, drag make-up or inclination correction manoeuvres.
Overall Response Time	The time from submission of a correctly formed user order to the time that the output product is delivered. There are two main components to this time – see Acquisition Latency and Data Processing Latency.
Pixel	A sample in a three-dimensional data cube- two dimensions of which are spatial and the third is spectral.
Point-spread function (for a spatial bin)	The two-dimensional relative amplitude of the output for the binned spatial elements to a point-like source as the position of the point-like source varies about the nominal position for that bin. It includes all aspects of spatial and motion blur.
Point-spread function (for a spatial element)	The two-dimensional relative amplitude of the output for any spatial element to a point-like source as the position of the point-like source varies about the nominal position for that element. It includes all aspects of spatial and motion blur.
Point-like Source	A source of light whose angular subtense at the satellite, Dtheta, is Dtheta << IFOV, where IFOV is the nominal instantaneous field of view.

Term	Meaning
Polarisation Sensitivity	When each element is illuminated by a reference source using linear polarizers successively aligned parallel and perpendicular to the slit will cause two signals to be measured, Iparallel and Iperpendicular. The polarization sensitivity is given by: (Iparallel - Iperpendicular) / (Iparallel + Iperpendicular).
Pre-launch Mode	Beginning with the delivery of the spacecraft to the launch site and ending with the separation of the GSE umbilical, the spacecraft is considered in pre-launch mode. In this mode, the spacecraft may or may not be attached to the LV with GSE power and data lines attached or with a RF link. This mode is used to check out all systems prior to launch.
Product Levels Definitions	
Raw Data	Data in their original packets as received from the spacecraft.
Level 0a	Unprocessed data at full space-time resolution with supplemental information (i.e. ephemeris…) for the processing appended.
Level 0b	Level 0a data, reformatted to conform to 16 bit word boundaries for compatibility with standard analysis tools.
Level 1	Image data is radiometrically corrected and calibrated (radiance) data in physical units at full instrument resolution. Level 1 Products also include files containing: • Cloud mask information; • Glint mask information.
Level 2b	At ground spectral radiance data with geolocation data appended
Level 2c	Level 2c products include: • At ground spectral reflectance (Hyperspectral) • Aerosol Characterization (VNIR) • Water vapour map (Hyperspectral) • Cloud characterization
Level 2d	Geocoded Level 2c Products.
Level 3a	Application products comprising Geolocated bio-physical, bio-chemical, geo-physical, geo-chemical, environmental products derived from level 2c data.
Level 3b	Application products comprising geocoded bio-physical, bio-chemical, geo-physical, geo-chemical, environmental products derived from level 2c data.
Level 4	Application products modelling output and/or variables that are not directly measured by the instrument, or including time-sequenced analyses.

Term	Meaning
Prototype Products	Products generated as part of a research investigation. These may require more data or computing power than would be acceptable for standard products, and are only generated in special circumstances.
Quasi-monochromatic radiation	A source of light whose spectral bandwidth Dlambda is: Dlambda << lambda0, where lambda0 is the central wavelength.
Quick Look Products	Standard Products generated and distributed in near real time. These products are synonymous with the browse images generated for and presented in the catalogue browser. In the interest of rapid production, these may be degraded from normal image quality standards.
Re-look time	The time interval between successive observations of the same target area, using off-nadir pointing of the instrument (or Satellite).
Re-visit time	The time interval between two passes when the Satellite is able to image a specific target at the similar (allowing for seasonal variation) solar elevation angle and the same 'look' angle from the Satellite.
Safe-hold Mode	A spacecraft mode of operation during which the spacecraft enters a state where it is safe from a power, temperature and communications point of view. Can be entered either under command, or autonomously, but can only be exited under command.
Scene	The output product elements. Each scene is a single data acquisition. A scene may range from being nominally square (i.e. the number of along-track pixels and the number of across-track pixels are equal) up to being 200km in length. Longer acquisitions are broken into 200km scenes for file management and downlink.
Scene-based calibration	Calibration verification by viewing natural targets that have known spectral and radiometric characteristics. (Early literature often referred to this as vicarious calibration).
Signal	Signal strength is the photo-charge collected in a pixel arising from illuminating the hyperspectral payload. Spurious signals have been corrected and removed.
Signal-to-Noise Ratio (SNR)	The Signal-to-Noise Ratio is the ratio of the signal and temporal noise for each spectral band.
Spatial bin	Multiple spatial elements that are combined (binned) in the data processing system and reported by the instrument.
Spatial element	The linear dimensions of the rectangle intercepted at NADIR on the Earth surface by an EIFOV.
Spatial Registration	The RMS value of the shift between all corresponding spatial pixels acquired in the same image by the VNIR and SWIR imaging spectrometers.

Term	Meaning
Spatial resolution	At nadir- the full width at half maximum of the point spread function.
Spatial Width for a spatial bin	The FWHM of the point spread function for a spatial bin. (The FWHM may vary across the field of view).
Spatial Width of Spatia Element	The FWHM of the point spread function for a spatial element. (The FWHM may vary across the field of view).
Special Products	Products generated as part of a research investigation for a limited region or time period. These are only generated in special circumstances.
Spectral Band	Wavelengths interval inside the spectral range of interest to the user. Under higher resolving power it could be subdivided into smaller bands.
Spectral Channel	A single element or multiple spectral elements that are combined in the data processing system and reported by the instrument.
Spectral Element	A spectral element corresponds to a discrete measurement and corresponds to the wavelength interval associated with a spectral detector element.
Spectral Line Shape Function for a Spectral Channel	The relative amplitude of the output for any spectral channel responding to monochromatic radiation over a range of wavelengths about the nominal wavelength for that channel.
Spectral Line Shape Function for a Spectral element	The relative amplitude of the output for any detector element to quasi-monochromatic radiation over a range of wavelengths about the nominal wavelength for that element.
Spectral Oversampling	Spectral oversampling is the ratio of the spectral slit width to the spectral sampling interval. It is determined by the foreoptics design configuration and the slit width, relative to the spectral sampling interval. It affects both the SNR and the size of the focal plane arrays to be used. The factor may be chosen to minimise spectral aliasing.
Spectral range	Portion of electromagnetic spectrum in which the individual instruments operate without reference to implementation. It is defined by the extreme wavelengths of each instrument.
Spectral Resolution	The spectral interval at which two adjacent quasi-monochromatic spectral lines, with a defined minimum acceptable contrast between peaks and valley of the adjacent lines, are just resolvable according to the Rayleigh's criterion.
Spectral Response Function.	The relative response of a pixel over the range of wavelength.
Spectral Sampling Interval	The spectral interval between the centre wavelengths of two adjacent elements of the detector arrays in the nominal spectral direction.

Term	Meaning
Spectral Width of a Spectral Channel	The FWHM of the spectral line shape function for a spectral channel. It includes all aspects of spectral blur (size of individual elements, optical blur, nature of forming the spectral band from various spectral channels). (The FWHM may vary across the spectral range of a hyperspectral imager).
Spurious Signals	Offsets in the signal chain, dark signals, thermal emission, frame transfer smear and stray light.
Standard Products	The output products produced by the *Payload* – these include all product levels up to and including level 2d. These products form the input to the Value-added Application Product Segment for the generation of the Level 3 and 4 mission products.
Storage Mode	A spacecraft (non-operating) mode in which spacecraft is stored without propellant, un-powered with the battery removed and un-pressurized in such a way so as to prevent degradation of its components and to allow rapid transition to the pre-launch scenarios.
Sun Zenith Angle (SZA)	The vertical direction of the sun relative to the zenith expressed in degrees.
Tasking Latency	The minimum time between an accepted user request and the freezing of the acquisition plan.
Telemetry System Modes	Modes of operation of the spacecraft telemetry system. These include: • Standard Mode: all operational real time telemetry is transmitted • Diagnostic Mode : access is provided to special pre-determined data sets to allow the diagnosis of Bus behaviour. • Program View Mode: access is provided to view contents of Program Memories, Command Storage Capability (CSC) and parameters tables storage
Temporal Noise	The temporal noise is calculated by considering all sources within the instrument, including (a) random noise sources such as shot noise in the signal, detector and electronics readout noise and (b) the temporal component of residual effects of incomplete compensation of spurious signals.
Test Mode	A spacecraft mode of operation during which the spacecraft enters a state where it is able to be able to be tested on ground by simulating orbits in any of the defined operational scenarios.

Term	Meaning
Top of Atmosphere (TOA)	A given altitude where air becomes so thin that atmospheric pressure or mass becomes negligible. TOA is mainly used to help mathematically quantify Earth science parameters because it serves as an upper limit on where physical and chemical interactions may occur with molecules in the atmosphere. The actual altitude used for calculations varies depending on what parameter or specification is being analyzed. For example, in radiation budget, TOA is considered 20 km because above that altitude the optical mass of the atmosphere is negligible. In meteorology, a pressure of 0.1 mb is used to define this location. The actual altitude where this pressure occurs varies depending on solar activity and other factors (NASA definition).
Uniform Source(s) / Reference Source(s)	Source(s) of light with a uniform spatial distribution and with a black-body spectral distribution that varies smoothly vs. wavelength. Two spectral radiance levels are assumed: the spectral radiance level that best approximates spectral radiance of the typical and dim targets.
Validation	Confirmation through the provision of objective evidence that the requirements for a specific intended use or application have been fulfilled.