Title

**General Design and Interface Requirements Specification (GDIR)**

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1. INTRODUCTION AND SCOPE

1.1 Note to User
This document outlines the unit/equipment level general requirements for the GAIA spacecraft. Each unit/equipment specification will identify the specific requirements from this document that are applicable to that unit/equipment.

1.2 Introduction
GAIA mission will create an extraordinarily precise three-dimensional map of about one billion of stars throughout our Galaxy and beyond. In the process, it will map their motions, which encode the origin and subsequent evolution of our Galaxy. GAIA mission objectives are to build a catalog containing astrometric measurements (position, parallax, proper motions) of objects bright up to magnitude 20 ($m_v = 20$). Accuracies in the order of 10 microarcseconds at magnitude 15 are foreseen. Multi colour multi epoch photometry and radial velocities for objects brighter than magnitude 17 will also be measured. The velocity accuracy for the radial velocity measurement will be 1 km/s for stars of magnitude 15. Through comprehensive photometric classification, it will provide the detailed physical properties of each star observed: characterizing their luminosity, temperature, gravity and elemental composition. This massive stellar census will provide the basic observational data to tackle an enormous range of important problems related to the origin, structure, and evolutionary history of our Galaxy.

Additional scientific mission objectives include the detection and orbital classification of thousands of extra solar planetary systems, a comprehensive survey of objects ranging from huge number of minor bodies in our solar system, through galaxies in the nearby Universe, to some 500 000 distant quasars. It will also provide a number of stringent new tests of general relativity and cosmology.

GAIA measurement geometry


GAIA will be operated around the L\textsubscript{2} lagrangian point of the Earth - Sun system for at least 5 years, relying on the proven principles of ESA's HIPPARCOS mission.

1.3 Scope

This document contains the contractually relevant requirements and constraints for the GAIA project. This includes:

- The design and interface requirements of subject hardware
- The general testing and verification requirements

Requirements within this document are shown in an italic font. Each requirement is proceeded by a summary line that contains the following fields, delimited by "/":

- \textlt{<Doors Requirement Number>} GDI-xyz. This is a unique number, assigned consecutively
- \textlt{<Created From>} Shows parent requirement
- \textlt{<Test Method>} T= Test, A = Analysis, I = Inspection, R = Review of Design,

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

The trace to the upper level requirements (Upper Links), shall be managed using the following format:

- \textlt{AAA-NNNN} where AAA is a label associated to the upper document and NNNN the requirement identifier of this upper level.
- \textlt{CREATED} key word if the requirement has no link with upper level

All document elements not presented in the format explained above are not requirements and will not be verified or tracked.
2. APPLICABLE AND REFERENCE DOCUMENTS.

Applicable and reference documents will be found in units relevant Statement of Work (SoW).

The following ECSS documents are applicable for GAIA:

- ECSS-E-10 Part 6A: Space Engineering - System Engineering - Functional & Technical Specifications
- ECSS-E-10 Part 1B: Space Engineering - System Engineering - Requirements & Process
- ECSS-E-10-02A: Space Engineering - Verification
- ECSS-E-10-03A: Space Engineering - Testing
- ECSS-E-10-04A: Space Engineering - Space Environment
- ECSS-E-20A: Space Engineering - Electrical and Electronic
- ECSS-E-30 part 1A: Space Engineering - Mechanical - Thermal Control
- ECSS-E-30 part 2A: Space Engineering - Mechanical - Structural
- ECSS-E-30 part 3A: Space Engineering - Mechanical - Mechanisms
- ECSS-E-30 part 5.1A: Space Engineering - Mechanical - Propulsion
- ECSS-E-30 part 6A: Space Engineering - Mechanical - Pyrotechnics
- ECSS-E-30 part 7A: Space Engineering - Mechanical - Mechanical Parts
- ECSS-E-30 part 8A: Space Engineering - Mechanical - Materials
- ECSS-E-30-01A: Space Engineering - Fracture Control
- ECSS-E-40 part 1B: Space Engineering - Software - Part1: Principles and Requirements
- CCSDS 121.0-B.1: Lossless Compression
- ECSS-E-50-12A: Space Engineering - Spacewire - Links, nodes, routers and networks
- PSS-04-104: Ranging
- CCSDS.131.0-B-1: TM Synchronisation and Channel Coding, Blue Book
- ECSS-E-60A: Space Engineering - Control Engineering
- MIL1553-B-Notice 4: On-Board Interfaces
- ECSS-E-70-41A: Space Engineering - Telemetry and Telecommand Packet Utilisation
- ECSS-E-20-08A: Space Engineering - Photovoltaic Assemblies and Components
- ECSS-Q-80B: Software Product Assurance
- CCSDS.132.0-B-1: TM space data link protocol, Issue 1 September 2003
- CCSDS.232.0-B-1: TC space data link protocol, Issue 1 September 2003
- CCSDS.133.0-B-1: Space Packet Protocol, Issue 1 September 2003
- ECSS-E40 Part 2B: Space Engineering - Software - Part 2: Document Requirements Definition
3. GENERAL DESIGN AND INTERFACE REQUIREMENTS

3.1 General Design Requirements

This section contains requirements relating to:

- Venting
- Parts, material and process
- Engineering standards
- Handling, packing and transportation
- Reliability, availability, maintainability, safety
- Identification and marking
- Workmanship

Note, Product Assurance (PA) requirements are specified within the PA Requirements for Sub-Contractors which are applicable to Sub-Contractors through the Statement of Work (SOW). However, descriptive PA issues may be found within this document.

3.1.1 Lifetime

GDI-31/CREATED

The on-ground lifetime of flight hardware is defined as the duration between unit delivery and satellite launch.

GDI-32/CREATED

The Unit shall meet the requirements of this specification after a minimum on-ground lifetime of 4 years including up to 1.5 years in storage.

GDI-33/CREATED

The in-orbit lifetime of the satellite is defined as the duration from launcher separation until the end of the mission.

GDI-34/SRS-753/SRD-MAS-1

The unit shall be designed with positive margins of safety to meet the requirements of this specification for a minimum in-orbit lifetime of 5.5 years (6 months of transfer and commissioning and 5 years on station) with all other consumables able to meet an in-orbit lifetime of 6.5 years.

GDI-2700/

The units shall be compatible with a storage period of at least 5 months in launch configuration without maintenance.

GDI-35/CREATED

Maintenance during storage shall be as limited as possible and, if required, shall be identified by the supplier for approval by the customer.

3.1.2 Design Safety

GDI-37/CREATED

The unit shall be designed and fabricated with compatible materials in such a manner that all hazards associated with the unit are eliminated, minimised and controlled.
General safety requirements for units are as follows:

- All guards and covers provided for personal protection shall be clearly marked to indicate the voltage potential.
- Adequate shielding of control equipment and critical equipment is needed to prevent initiation of explosive devices from induced currents.

### 3.1.3 Venting

Adequate venting is provided to preserve the structural integrity of the S/C, assemblies or units to withstand a maximum depressurisation rate during LV ascent of 85 mbar/s.

The unit shall be able to operate within a pressure range of 1 bar to < 1E-10 bar. It shall have a suitable venting provision that is ≥ 2mm² venting hole area per litre volume.

Outgassing vents shall be < 5mm diameter and > 1.5mm diameter. They shall be located close to but not within the unit mounting plane.

For all relevant thermal hardware, explicitly MLI, tapes and heatermats, venting provisions shall be incorporated.

Unless a cavity is hermetically sealed adequate means of venting shall be provided in the design. The method of venting shall prevent the contamination of the cavity by the external environment and prevent the release of contaminants from the cavity.

Structural members (honeycomb panels, in particular) shall include provisions to enable venting of any hermetically sealed volumes during launch ascent.

Any items that do not include venting provisions shall be treated as sealed containers, and adequate safety margins shall be demonstrated by analysis or by a 1.5 atm proof test.

### 3.1.4 Interchangeability

All spacecraft units of the same part or configuration number shall be interchangeable in terms of form, fit and functions. The units must be of the same qualification status and reliability in order to meet the interchangeability requirement.

### 3.1.5 Identification & Marking

The unit hardware shall be identified with a nameplate in order to achieve configuration traceability. The identification shall contain the following information:

- Name Of Manufacturer
- Project Name
- Part Number
• Serial Number
• Date Of Manufacture

Each Individual unit shall be marked with a serial number. For standard parts and where the physical size of an item precludes identification of the hardware itself, a 'bag and label' technique shall be used (up to final integration).

GDI-2253/

The unit identification nameplate shall be mounted on the connector face, visible when installed on the unit. Its location shall be noted on the ICD. The identification shall be legible with unaided eye from 0.5m distance. The identification label shall meet all the requirements relevant to the unit.

GDI-2254/

For the particular case of connector identification, the following requirements shall apply:

• Each unit or bracket is required to bear visible connector labels closely adjacent to the appropriate connector in order to allow a correct mating of the corresponding harness connector.
• For each unit or bracket, the connector identification shall be three alphanumeric characters:
  a. The first character is “J” for fixed (hard-mounted) connectors and “P” for mobile connectors.
  b. The two last characters consist of a 2 digits sequential number starting from 01.
• The location and content of the above described connector identification labels shall be included in the ICD of the relevant unit.

3.1.6 Accessibility/Maintainability

GDI-52/CREATED

The design of the unit, the position of the connectors, grounding studs and of the attachments etc. shall provide sufficient accessibility to enable the mounting and removal of the unit with standard tools.

The unit configuration itself shall not hinder the installation and removal of the attachment bolts.

Where this requirement cannot be applied, the unit supplier shall provide a kit of tools as a part of the unit MGSE such that the mounting bolts can be tightened from an accessible position.

GDI-53/CREATED

The equipment shall be designed to require a minimum of special tools and test equipment to maintain calibration, perform adjustments and accomplish fault identification.

GDI-54/CREATED

No field maintenance, servicing or adjustment shall be required within three months of launch.

3.1.7 Transportation, Handling and Storage

All requirements on Transportation, Handling and Storage can be found in the PA Requirements document for subcontractors. A subset or the key requirements is gathered below.

3.1.7.1 Transport

GDI-2272/

The unit containers, covers (for optics and exposed connectors) and packaging shall be environmentally controlled / monitored (vibration, shock, temperature, pressure, humidity, electrical static discharge and contamination) and instrumented to ensure that the environments encountered during shipping and storage do not exceed expected flight (acceptance) levels.
GDI-2273/

The transport container shall ensure that the environment during transportation shall be maintained within the envelope of the defined launch mechanical environment (flight acceptance levels), i.e. transportation shall not drive the design.

GDI-2274/

The storage container shall be designed to protect the unit without causing deterioration for the specified storage period. During storage the unit shall be stored under the following conditions:

- Pressure: 970 mbar to 1050 mbar
- Temperature: 20°C ± 10°C
- Humidity: 45% ± 15%
- Cleanliness: Class 100,000 or better

3.1.7.2 Unit packing

GDI-2275/

Where applicable blanking caps shall be fitted to any ports. Blanking caps shall be labelled and instructions included in the Handling and Transportation Procedures, to ‘Remove Before Flight or Test’ as applicable.

GDI-2276/

All units shall be packaged to ensure that it is sealed in a dry inert atmosphere using non-contaminating materials. The packing of the units shall be such that:

- The pre-cleaned unit shall first be placed in a bag and sealed within,
- The protected unit shall then be placed in a second bag with a dehydrating agent and a label stating "OPEN IN A CONTAMINATION CONTROLLED ENVIRONMENT",
- The second bag shall also be sealed,

The sealing of both bags shall be performed in cleanroom conditions (class 100,000 at least for the first bag) and a dry atmosphere.

The double packaged units shall then be placed in a container that shall protect against all risk of degradation during transport and storage.

3.1.7.3 Container identification

GDI-2277/

Each container shall be labelled, tagged or marked to show at least the following:

- Name Of Manufacturer
- Project Name
- Unit Name / Model
- Part Number
- Serial Number
- Date Of Manufacture
- Astrium Purchase Order Number
- Contact Number (where applicable)
• Quantity or weight (kg)

GDI-2278/

In addition to the above, the container shall also be labelled with the statement:

"ONLY TO BE OPENED IN CLEANROOM CONDITIONS"

Any recommendations necessary for the protection of the unit

3.1.7.4 Handling

GDI-2271/

Units weighing more than 10 kg shall be equipped with handling points (e.g. threaded bushes) that will enable the connection of special handles provided by the unit supplier for use during the (de) integration of the unit.

As any other piece of hardware used only during ground operations, such handles shall be clearly identified as non-flight item (red anodised and a red flag carrying the notation "NOT FOR FLIGHT" attached to them).

Such items shall be clearly identified on the relevant Interface Control Drawing.

3.1.7.5 Thermally Conductive Materials

GDI-70/CREATED

Unless justified and agreed beforehand, any thermally conducting interface filler, used between a unit and the surface on which it is mounted, shall be of non-curing gasket type rather than a grease or curing rubber/adhesive. Units must use a bonding strap even if the gasket is electrically conducting.

3.1.7.6 Magnetic Materials

Information deleted.

GDI-2280/

Requirement deleted.

GDI-2281/

Requirement deleted.

3.1.7.7 Seals

GDI-75/CREATED

Any seals used shall comply with all the applicable requirements of this specification, particularly regarding propellant and simulant compatibility and out-gassing.

GDI-76/CREATED

Any seals requiring periodic replacement during ground activities, and especially prior to launch, shall be identified to the Customer. The Unit supplier shall provide any procedures and special tooling required for replacement of seals.

3.1.7.8 Lubricants and Sealants

GDI-78/CREATED

No lubricants shall be used without the prior written agreement of the Customer.
3.1.7.9 Screw Locking

GDI-80/CREATED

All fasteners used on the unit shall be locked by adequate measures. This includes fixations of units onto the structure.

GDI-2270/

All screw type hardware used on the unit shall be locked by adequate measures.

3.2 Mechanical Design and Interface Requirements

GDI-82/CREATED

All drawings, specifications and engineering data shall only use the International System of Units (SI units), with the exception of accelerations which may be expressed in terms of multiples of g (gravity).

GDI-83/CREATED

Units shall be compliant with ECSS-E30 Part 2A, and shall be compatible with mechanical testing.

GDI-84/CREATED

Following testing the unit shall be inspected to confirm no physical damage.

GDI-87/CREATED

No unit shall generate microvibration loads at its baseplate interface.

3.2.1 Structural Design

3.2.1.1 General Requirements

GDI-91/CREATED

The following failure modes, for units at all levels of integration, shall be prevented:

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

Note(*): Thermo-elastically induced interface slip of avionics units mounted on SCM panels can be accepted.

GDI-92/CREATED

The unit shall be designed to withstand the environments 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).

GDI-2282/
The design of the units handling and transportation devices shall be such as to produce loads far lower than the predicted flight loads

Note:  
1- Manufacturing and assembly induced loads shall also be minimised or properly relieved.

2- Test induced stresses are usually the most important factor limiting the life of structural items, particularly fracture critical items. The design should therefore also consider the case of replacement of these critical parts.

3- Structural dimensioning of the units shall consider critical combination of simultaneously acting loads (e.g. mechanical and thermal, vacuum)

GDI-93/CREATED
Requirement deleted, see GDI-2297

GDI-94/CREATED
Wherever practical a fail safe design based on redundant structural elements shall be used. A design implementation is considered fail safe if the failure of one structural element in the load path does not affect the stiffness of the structure significantly and does not cause remaining structural elements to fail under the new load distribution.

In the event of a redundant attachment failure the remaining structure shall only need to demonstrate the ability to sustain limit loads (i.e. safety factor = 1) without degrading performance.

GDI-95/CREATED
In cases where a failsafe design cannot be implemented, the load path shall be verified to be safe life. Corresponding structural elements shall be tracked as potential fracture critical items (PFCI's). The following items are PFCI's:

• pressurised systems;
• rotating machinery;
• fasteners in safe life design implantations;
• items fabricated using welding, forging or casting used at limit stress levels 25% of the ultimate tensile strength;
• non-metallic structural items.

GDI-2045/CREATED
All potential fracture critical items shall be subject to a fracture control programme in accordance with the requirements of 'Space Engineering - Fracture Control', ECSS-E-30-01A.
3.2.1.2 Mass properties

GDI-2284/

A mass justification shall be provided indicating what is the design driver for all the items representing more than 10% of the total mass (i.e. existing design re-used, stiffness, strength under sine or random or..., performance like stability...).

GDI-98/SRS-753/ SRD-MAS-1

All mass estimations shall be accompanied by the definition of the design maturity of the concerned item (categories as per module or equipment SOW). The margin to be added to each item estimated mass for budget consolidation shall follow the rules expressed in Table 3.2-1.

The mass budget shall be reported to the customer through the datasheet as defined in APPENDIX A: MICD.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>DESIGN MATURITY</th>
<th>MARGINS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Existing weighed hardware</td>
<td>0%</td>
</tr>
<tr>
<td>A</td>
<td>Build to Print from Existing Hardware</td>
<td>2%</td>
</tr>
<tr>
<td>B</td>
<td>Design based on existing hardware requiring minor modification</td>
<td>5%</td>
</tr>
<tr>
<td>C</td>
<td>Detailed Design / Design based on existing H/W requiring major modification</td>
<td>15%</td>
</tr>
<tr>
<td>D</td>
<td>Preliminary Design / Equipment not yet developed</td>
<td>20%</td>
</tr>
</tbody>
</table>

Table 3.2-1: Mass Budget Consolidation Margins

GDI-100/CREATED

The mass of an item must be measured with the following accuracy:

- Item mass up to 10 kg : ±0.005 kg
- Item mass from 10 to 20 kg : ±0.010 kg
- Item mass from 20 to 50 kg : ±0.020 kg
- Item mass from 50 to 100 kg : ±0.050 kg
- Item mass from 100 to 350 kg : ±0.100 kg

3.2.1.3 Centre of Gravity and Moment of Inertia

GDI-102/CREATED

All COG and MOI estimates shall be accompanied by the definition of the design maturity of the concerned item (categories as per module or equipment SOW). The uncertainty of each item COG and MOI calculation for budget consolidation shall follow the rules expressed in Table 3.2-2.

They shall be reported to the customer through the relevant mass, CoG and inertia properties datasheet defined in APPENDIX A: MICD.

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>DESIGN MATURITY</th>
<th>COG UNCERTAINTY</th>
<th>MOI UNCERTAINTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>D/C</td>
<td>Preliminary Design / Detailed Design</td>
<td>3 mm radius sphere</td>
<td>±20% for each axis</td>
</tr>
<tr>
<td>B</td>
<td>Design based on Existing H/W</td>
<td>2 mm radius sphere</td>
<td>±10% for each axis</td>
</tr>
<tr>
<td>A</td>
<td>Existing Hardware</td>
<td>1 mm radius sphere</td>
<td>±3% for each axis</td>
</tr>
</tbody>
</table>

Table 3.2-2: Unit CoG and MoI uncertainty
The unit centre of gravity shall be determined with an accuracy of ±1mm.

The unit moment of inertia shall be determined with an accuracy of ±3%.

3.2.1.4 Stiffness requirement

3.2.1.4.1 Definitions and General Requirements

The spacecraft is designed to ensure full decoupling between eigen-frequencies of lower level assemblies and minimize the deformations due to gravity release (1g – 0g).

Minimum natural frequency requirements are imposed upon the S/C, assemblies and units for the following reasons:

- To avoid coupling between spacecraft and instrument structure,
- To ensure predictable dynamic responses for the design of the structure and units
- To avoid excessive loads and deflections,
- To avoid unacceptable micro-vibration behaviour

Units fixed on a rigid interface shall have their first main resonant frequency above 150Hz. Local modes (effective mass < 10% total rigid mass) between 100Hz and 150Hz might be accepted after evaluations.

The stiffness requirements shall be demonstrated taking into account definition and analysis uncertainties as follows:

- A margin of 15% shall be taken into account for frequency computation with finite element software (e.g. NASTRAN), and more than 30% for hand calculations. Special care shall be emphasized on the boundary conditions representativity.
- Assumptions shall be presented taking into account the worst cases for material data base characteristics (e.g. Young Modulus or thickness) or proven measurements from the manufacturer.
- Mass figures shall include the actual predicted margins as per Section 2.1.1.2

3.2.1.4.2 Mechanical Analysis

Finite Elements Models (FEM) shall be prepared to support the mechanical and configuration activities at spacecraft level and to validate the performance at spacecraft level. FEM shall be prepared in NASTRAN format.

The adequacy of the FEM to predict thermo-elastic deformations of the expected order of magnitude shall be demonstrated.

The FEM of the represented item in its launch configuration shall be detailed enough to ensure an appropriate derivation and verification of the design loads and of the modal response of the various structural elements of the spacecraft up to 140 Hz.
**GDI-2542/MRD STR-210**

The FEM of the equipment shall be verified and correlated against the results of the modal survey carried out at component, sub-assembly and complete spacecraft level. The quality criteria for the test-analysis correlation shall ensure that the dynamic response predictions employing the test validated mathematical model are compliant with the accuracy requirements here reported:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUALITY CRITERION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental bending modes</td>
<td>MAC : &gt; 0.90 &lt; 3%</td>
</tr>
<tr>
<td></td>
<td>Eigenfrequencies deviation :</td>
</tr>
<tr>
<td>Modes with effective mass &gt; 10% of the total mass (Q &gt; 25)</td>
<td>MAC : &gt; 0.85 &lt; 5%</td>
</tr>
<tr>
<td></td>
<td>Eigenfrequencies deviation :</td>
</tr>
<tr>
<td>For the other modes in the relevant frequency range (goal)</td>
<td>MAC : &gt; 0.80 &lt; 10%</td>
</tr>
<tr>
<td></td>
<td>Eigenfrequencies deviation :</td>
</tr>
<tr>
<td>Cross orthogonality check</td>
<td>Diagonal terms : &gt; 0.90 &lt; 0.10</td>
</tr>
<tr>
<td></td>
<td>Off-diagonal terms :</td>
</tr>
<tr>
<td>Damping</td>
<td>To take measured values as input for the response analysis.</td>
</tr>
<tr>
<td></td>
<td>To use realistic test inputs for this purpose.</td>
</tr>
<tr>
<td>Interface force and moment measurements (for modes with effective masses &gt; 10% of total mass, if Force Measurement Device is used)</td>
<td>Deviations of interface forces and moments &lt; 10%</td>
</tr>
</tbody>
</table>

**GDI-2544/MRD STR-220**

Reduced FEM mathematical models to be employed in dynamic response predictions shall represent the detailed FEM in compliance with the model quality criteria here reported:
<table>
<thead>
<tr>
<th>ITEM</th>
<th>QUALITY CRITERION</th>
</tr>
</thead>
</table>
| Frequency and modal masses of fundamental lateral, longitudinal and torsional modes | Effective mass :  > 5%  
Eigenfrequencies deviation :  < 3% |
| For other modes up to 100 Hz | Effective mass :  > 10%  
Eigenfrequencies deviation :  < 5% |
| Modes of reduced FEM (within frequency range of interest) | Total effective mass wrt total rigid mass  > 90% |

**GDI-2546/MRD STR-230**

Adequate models to calculate Centre of Mass and Moment of Inertia shall be prepared to support the mechanical and configuration activities at Mechanical Bus level.

### 3.2.1.5 Strength Requirements

#### 3.2.1.5.1 Definitions and General Requirements

**GDI-2354/**

The design load factor philosophy of the GAIA spacecraft shall be as illustrated in Figure 3.2-1.
Figure 3.2-1: Definition Of Loads

The Flight or Ground Limit Load, LL, is the load that can be encountered during the life of the structure that results from the flight or ground environments. These are expected to be during the launch phase but also include combinations of thermally induced loads, preloads, inertia loads (e.g. for mechanisms).

Qualification Load, QL is equal to the Limit Load multiplied by the qualification factor, FOSQ, where the FOSQ is equal to the design factor. (Where design loads are not measured by FE analysis and a protoflight qualification approach is not applied then the Qualification Load is equal to the Design Load)

Design Load, DL is derived by the multiplication of the (Flight) Limit Load by the relevant factors of safety. These include the Design Factor, FOSD and where appropriate an Uncertainty Factor, FOSUN where design loads are generated using FE analyses. For equipments/assemblies following a protoflight development philosophy, an additional Protoflight Factor of Safety, FOSPF shall be applied to the LL to cover additional risks for equipments/assemblies following a protoflight development philosophy.

i.e. The Design Load = Limit Load x FOSD x (FOSUN x FOSPF where applicable).

Yield Load, YL is derived by the multiplication of the Design Load by the relevant Yield Factor of Safety, FOSY. The loads/stresses resulting from the application of design yield loads shall be compared to the yield or 0.2% proof/stress appropriate to the component.

Ultimate Load, UL is derived by the multiplication of the Design Load by the relevant Ultimate Factor of Safety, FOSU.
Yield Factor of Safety, $FOS_Y$ ensures that unacceptable risks of yielding during testing to the Design Load are eliminated.

Ultimate Factor of Safety, $FOS_U$ ensures that unacceptable risks of ultimate failure during testing to the Design Load are eliminated.

Additional Factor of Safety, $K_{ADD}$ are additional factors applied for specific applications.

GDI-2366/

GAIA equipment mechanical testing shall take into account an Acceptance Factor, $K_A$ of 1.0 applied to the Limit Loads.

GDI-2367/MRD STR-160

GAIA equipment mechanical testing shall take into account a Qualification Factor, $K_Q$ of 1.5 for ground events and of 1.3 for flight events applied to the Limit Loads.

GDI-2368/

An additional Protoflight Factor of Safety, $FOS_{PF}$ of 1.1 shall be taken into account when items are to be qualified using a protoflight approach.

3.2.1.5.2 Margin Of Safety & Safety Factors

GDI-2370/MRD STR-152

For all Gaia elements the design factor, $FOS_D = 1.5$ shall be applied to the limit loads.

GDI-2371/

Where design loads are generated using FE analyses, then an additional Uncertainty Factor, $FOS_{UN}$ shall be added to the Design factor, where $FOS_{UN} = 1.1$.

GDI-2372/MRD STR-120, 150

The GAIA hardware shall be able to withstand, without failure (including structural collapse, rupture or other inability to sustain ultimate loads, significant permanent deformation or deformation detrimental to the specified performances) the worst case expected combination of the required loads and associated environments encountered during ground and in-orbit operational phases and taking into account all safety factors specified in Table 3.2-3. These include manufacturing, assembly, testing, transport, launch and in-orbit operations.
<table>
<thead>
<tr>
<th>Structure type / sizing case</th>
<th>FOSY</th>
<th>FOSU</th>
<th>FOSY for verification by analysis only</th>
<th>FOSU for verification by analysis only</th>
<th>Additional factors $K_{ADD}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallic structures</td>
<td>1.1</td>
<td>1.25</td>
<td>1.25</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Composite structures (uniform material)</td>
<td>1.25</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composite structures (uniform material)</td>
<td>1.5</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandwich structures:</td>
<td>1.25</td>
<td>1.25</td>
<td>1.5</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>- Face wrinkling</td>
<td>1.25</td>
<td>1.25</td>
<td>1.5</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>- Intracell buckling</td>
<td>1.25</td>
<td>1.25</td>
<td>1.5</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>- Honeycomb shear</td>
<td>1.25</td>
<td>1.25</td>
<td>1.5</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Glass/Ceramic structures</td>
<td>2.5</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(uniform material)</td>
<td>2.5</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joints and Inserts</td>
<td>1.25</td>
<td>1.25</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Failure</td>
<td>1.25</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Gapping</td>
<td>1.25</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Sliding</td>
<td>1.25</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressurized hardware</td>
<td>1.1</td>
<td>1.25</td>
<td>1.25</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>for the interface loads</td>
<td>1.25</td>
<td>1.25</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global buckling</td>
<td>2.0</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Following assumptions shall be taken into account:

1) Applicable failure criteria have to be agreed with the customer
2) This coefficient applies to concentrated stresses
3) These materials have strength properties which are highly dependant of the manufacturing process and of the surface quality
4) This coefficient applies to general stress analysis on internal pressure and external loads. For damage tolerance or safety analysis, refer to ECSS-E30-02
5) For global buckling, the factor of safety does not include any knock down factor which is included in the result of the buckling analysis

Table 3.2-3: Design Safety Factors
GDI-2374/

Deleted, see Table 3.2-3

GDI-2375/

All mechanical elements shall demonstrate positive margins of safety when calculated as follows:

\[
\text{MoS} = \frac{\text{Allowable load/stress}}{\text{Applied load/stress x safety factors (FOSN x KADD)}} - 1
\]

Where:

- Allowable load is the allowable load (or stress) under specified functional conditions (e.g. yield, ultimate),
- Applied load is the computed or measured load (or stress) under defined load conditions plus design/protoflight/uncertainty factors as appropriate, i.e. the Design Load (DL),
- Safety factors (denoted FOSn) are the applicable factors of safety applicable to the specified load condition (e.g. yield (FOSY), ultimate (FOSU)),

GDI-2378/

This Requirement has been Deleted.

GDI-2379/

This Requirement has been Deleted.

GDI-2380/

The margins of safety for all elements of the unit to all design loads shall be reported in a single document.

GDI-2381/

All bolts shall be sized to prevent sliding under mechanical & thermal environments.

GDI-2502/

Initially conservative friction coefficients regarding minimum and maximum preload versus clamping and bolt allowables shall be considered for preliminary sizing of the bolts, unless an actual friction coefficient has been measured.

GDI-2382/

Wherever applicable, rules for general design of bolts, screws and inserts, from ESA PSS-01-303, ESA PSS-03-1202 and ESA PSS-03-208 shall be used.

GDI-2383/

In addition, in case of combined loads due to thermal differential loading the unit internal allowable loads shall be considered to verify bolts, nuts and inserts strength and evaluated as follows:

\[
\left( \frac{T}{Tm} \right)^2 + \left( \frac{S}{Sm} \right)^2 + \left( \frac{M}{Mm} \right)^2 \leq 1
\]
where $T$, $S$ and $M$ are applied values including safety factors, and $T_m$, $S_m$ and $M_m$ are maximum allowable tension, shear and moment respectively. Alternatively to tension ($T$, $T_m$), values for compression ($C$, $C_m$) shall be applied which ever is the more critical.

Method for evaluation of dimensioning loads/stresses to be considered to verify mechanical sizing takes into account that applied loads (i.e. design yield/ultimate loads multiplied by additional safety factors) are sum vectors applied along the worst spatial direction at the unit or part of unit c-o-g.

The units shall be designed with positive margins of safety under the yield and ultimate load conditions. These loads will be combined with potential thermal loads deduced by analysis from the environment seen during the entire on-ground and in-orbit life.

The mechanical and thermal environment applicable to the mechanical sizing of the units are defined in Section 4.

The design loads for the structure elements are to be derived by the unit manufacturer according to the loads as defined in Section 4.1.2 and 4.2.3, and the dynamic behaviour of the unit/assembly.

The internal loads (thermo elastic, pre-stressed mounting,...) shall be defined by the unit manufacturer. The applied loads shall be those imposed by worst-case mass distribution i.e. accounting for mass uncertainties and design maturity.

For the computation of the design loads the maximum margin shall be included in the unit mass and inertia properties as defined in Section 3.2.1.2 and Section 3.2.1.3.

For sine and random vibrations, the mechanical sizing shall be performed with peak values. For random vibrations, the peak value is equal to 3 times the rms value unless otherwise specified.

For sine and random vibrations, the mechanical sizing shall be performed with peak values. For random vibrations, the peak value is equal to 3 times the rms value unless otherwise specified.

3.2.1.6 Alignment and Stability

The stability of the equipment shall comply with requirements as defined in TBD and shall be dimensioned in accordance with the spacecraft pointing requirements.

The following causes of misalignment shall be analysed and quantified:

- Setting due to mounting procedure,
- Setting due to launch distortion,
- Misalignment due to gravity release,
- Thermal deformation under in-orbit temperatures,
- Ageing,
- Composite structure deformation due to moisture release in-orbit.
3.2.2 Design Requirements

3.2.2.1 Attachment Requirements

GDI-160/CREATED

For the preliminary determination of the requested number of bolt for the attachment of a unit, it will be considered that under a 1g environment in any direction, the tensile load per interface bolt of that unit shall not exceed 10 N.

GDI-161/CREATED

The attachment points shall provide a controlled surface contact between the units and the structure to allow control of thermal conditions on the units as well as electrical bonding. This contact shall be maintained under all operating conditions, taking into account loading resulting from the different thermal coefficient of expansion between dissimilar materials.

GDI-162/CREATED

The interface plane flatness of a unit shall be better than 0.1mm, i.e. all attachment points shall be in a common plane within ±0.05 mm.

GDI-163/CREATED

The mechanical mounting interface shall be consistent with the thermal and EMC design requirements.

In particular, the contact area shall be free of paint.

GDI-164/CREATED

The unit bolts type and number shall be defined to withstand the worst-case environmental conditions as defined in Section 4. Sizing rules of Section 3.2.1 shall be applied.

For the attachment on the support, units shall use M5 bolts preferably. The use of other bolt types might be acceptable, but shall be reviewed and agreed on a case-by-case basis.

GDI-165/CREATED

Unless otherwise specified all units shall be through bolted into threaded inserts. Positional tolerances of inserts shall be such that they are centred on a pitch circle diameter of 0.1mm from a panel reference point.

GDI-2132/CREATED

To minimise CoG uncertainty of the unit when mounted on the panel the bolt hole dimensions shall be such that:

- 1 hole (Reference Hole) shall be drilled tight tolerance (for any unit having a side of greater than 300mm then the reference hole shall be located at the centre of the longest face);
- 1 hole, located on the same side of the unit but at further end from Reference Hole shall be slotted, with the slot aligned towards Reference Hole,
- All other holes will be loosely tolerated to account for insert/hole position uncertainties and thermo-elastic deformation.

Unit hole dimensions and tolerances are as defined in Table 3.2-4.
Table 3.2-4: Units Interface Bolts Clearances

<table>
<thead>
<tr>
<th>Interface Clearance</th>
<th>M4 bolts</th>
<th>M5 bolts</th>
<th>M6 bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hole size</td>
<td>4.3 ± 0.1mm</td>
<td>5.3 ± 0.1mm</td>
<td>6.4 ± 0.1mm</td>
</tr>
<tr>
<td>Positional tolerance of diameter</td>
<td>0.1mm</td>
<td>0.1mm</td>
<td>0.1mm</td>
</tr>
<tr>
<td>Positional tolerance of inserts</td>
<td>0.1mm</td>
<td>0.1mm</td>
<td>0.1mm</td>
</tr>
</tbody>
</table>

GDI-168/CREATED

Unless special conditions override, the thickness of the unit mounting feet shall be at least 3.0 mm.

GDI-169/CREATED

For the unit mounting, provision shall be made for under head for flat washers of :
- 12.0 mm diameter for M6 bolts and above;
- 10.0 mm diameter for M5 bolts;
- 8.0 mm diameter for M4 bolts.

GDI-2123/CREATED

Unit Lug/Hole Design Requirements:
Unit mounting hole requirements shall be as follows:
- Angle of attachment hole: 90° ±0.5°
- Dist. Between attachment holes and unit sidewall:
  - M4 ≥ 8mm
  - M5 ≥ 9mm
- Free width between webs: M4 ≥ 16mm; M5 ≥ 18mm; edge radius 0.5mm.
- Spot face of upper lug surface (for washer): M4 = 11+0.5/-0.1mm; M5 = 13+0.5/-0.1mm.
- Spot face parallelism w.r.t mounting plane: = 0.05
- Counterbore depth: 0.2 + 0.1/-0.0
- Surface roughness: = 1.6 microns R.A.
- Torque Levels applied to bolts:
  - M4: 2.3 ± 10% Nm
  - M5: 5.0 ± 10% Nm

GDI-170/CREATED

Sufficient clearance shall be allowed between mechanical parts to cover design, manufacturing, assembly tolerances, alignment translation/rotation ranges and environmental displacements.

GDI-171/CREATED

Requirement deleted

GDI-173/GAIA-EST-RD-00496 section 8.7

Fasteners shall be procured and tested according to approved aerospace standards.
Fasteners shall comply with the requirements of ECSS-Q-70-46A

Fasteners smaller than diameter 5 mm shall not be used in safe life applications

Titanium alloy fasteners shall not be used in safe life applications

The Flight equipment shall be able to survive:
- 2 times all mechanical acceptance tests
- plus 2 times all mechanical qualification tests (to cover System PFM Testing)
- plus one launch.

3.2.2.2 Alignment Requirements

Units requiring alignment with an accuracy better than ±0.25° shall carry reflecting mirrors. These mirrors constitute the unit optical reference. The optical reference design shall comply with Table 3.2-5 requirements.

Fixed mirrors shall be delivered with easily mountable/dismountable protective covers for AIV activities.

Dismountable mirrors shall demonstrate repeatability of their orientation accuracy.

<table>
<thead>
<tr>
<th>Finish</th>
<th>Optically polished</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flatness</td>
<td>Within lambda/4</td>
</tr>
<tr>
<td></td>
<td>(sodium yellow lambda = 589 nanometres)</td>
</tr>
<tr>
<td>Optical reference axes knowledge w.r.t unit axes</td>
<td>&lt; 50 µrad</td>
</tr>
<tr>
<td>Minimum area</td>
<td>10 * 10 mm</td>
</tr>
<tr>
<td>Minimum thickness</td>
<td>4 mm</td>
</tr>
</tbody>
</table>

Table 3.2-5: Optical Reference Design Requirements

Optical references are required to withstand all the environments supported by the unit with stability better than ±15 µrad with respect to each of the 3 unit axes.

Location of optical references for units shall be agreed between customer and subcontractor through the MICD. In particular, the useful faces of the optical reference shall be clearly visible at higher-level assembly integration and identified in top assembly drawings that shall form a part of MICD.

The alignment errors shall be included in pointing and localisation errors as established in the unit alignment and pointing error budget.
Units which require alignment accuracy of ±0.25° or better shall be equipped with adjustment means (or suitable interface for the incorporation of such means) as part of the unit.

When the unit alignment is achieved by the use of angled brackets, screw adjusters, and/or shims, they shall be designed and supplied as parts of the unit, unless provided as an integral part of the unit.

When shims have to be machined at end of alignment, 5 sets of spare shims with maximum possible thickness shall be provided to account for possible iteration or mistake.

3.2.2.3 Electrical connectors

All electrical connectors shall be located at a minimum distance of 25mm from the unit mounting plane in order to avoid problems with cable routing and cable harness support fixation.

When connectors are located above 80mm from the unit interface, the equipment supplier shall define tyraps on the unit sides to support the harness. The mechanical ICDs shall clearly identify the tyraps and the associated harness routings. (to be submitted to Prime for approval, because of harness curvature radius….)

Connectors shall be arranged in such a way that the harness connectors can be mated and demated easily without special tools and without touching any neighbouring connectors.

The minimum free space around each connector shall be 10mm to allow spacers and covers installation

Unit shall offer means to mechanically lock male and female connectors, in order to prevent inadvertent disconnection.

3.2.3 Mechanical / Optical Interface Control Documents

The mechanical and optical configuration and its interface requirements and dimensions, shall be fully detailed in one (or more) Interface Control Drawing(s) that shall be fully referenced by the unit supplier.

This drawing shall detail all co-ordinate systems utilised and their relationship to each other, together with the principal unit interfaces.

The content of the mechanical and optical ICD shall conform to appendices A and D respectively.

Interfaces will be subjected to a formal inspection, using interface data sheets in respect to mechanical, thermal, electrical and optical properties and any other details that proves useful (see appendices A, B, C and D respectively). These data sheets, specimens of which will be provided in MICD, TICD, EICD and OICD, respectively, will be completed by the unit contractors and then brought together into ICDs, for the various units.

The issues of ICDs have to be released as defined in the relevant unit Statement of Work.
One of the attachment holes on a unit shall be specified as the reference hole and must carry the identification letter R. This shall be clearly indicated on the mechanical interface drawings.

The reference hole shall support the Unit Reference Frame.

The unit reference frame shall have its origin at the unit reference hole (R) and shall be in accordance with Figure 3.2-2.

The unit alignment reference frame shall have its origins at the centre of the optical cube and shall be in accordance with Figure 3.2-2.

The dimensioning of the attachment hole pattern shall be specified with respect to the Unit Reference Frame.

Interface Control Drawings shall be provided to the customer, with the following media and file formats:

- Operating system: HP Unix compatible
- Media type: CD-ROM (other media to be agreed on a case-by-case basis)
- File format (by order of preference):
  a. CATIA EXP
  b. 3D IGES
  c. STEP
  d. 2D DXF
  e. 2D IGES

3.2.4 Mechanical Mathematical Model Requirements

This section defines the requirements for the preparation, and the delivery of the Finite Element mathematical models of the assemblies and units in order to incorporate them into the higher-level assembly.
3.2.5  Mechanism design

3.2.5.1 General Requirements

GDI-2568/MRD MEC-010

All assemblies featuring parts moving under the action of a commandable internal force(s) shall be considered as mechanisms. These items shall comply with ECSS-E-30 Part 3A.

GDI-2569/MRD MEC-020

The functional performance of the mechanisms shall be described with:

- Kinematics variables of the motion, i.e. as acceleration, velocity, displacement;
- Dynamic variables, i.e. forces and torque applied to the various mobile parts;
- Steady State parameters of the initial and final status of the motion, i.e. relative position or relative velocity wrt a well identified interface;
- Physical parameters (e.g. mass, inertia, spring force, friction, hysteresis, adhesion) that entail the kinematic variables.

GDI-2571/MRD MEC-030

Release mechanisms (e.g. pyrotechnics) shall be capable of being manually operated for test purposes. In case one-shot initiators are used, simple re-installation of a new device on the spacecraft shall be possible.

GDI-2572/MRD MEC-040

The mechanism design shall be compatible with operations in ambient and thermal vacuum conditions and gravity in any orientation.

GDI-2573/MRD MEC-050

The mechanism shall feature a feedback technique enabling to unambiguously determine its position.

GDI-2574/MRD MEC-060

When latching mechanisms rely on a preload to be applied during launch, a method of monitoring (and adjusting if necessary) shall be provided for the spacecraft AIV.

GDI-2575/MRD MEC-070

The use of pyrotechnics shall be avoided as far as practicable.

GDI-2576/MRD MEC-080

In case pyrotechnics and other one-shot devices are used, an arm/execute mechanism shall be implemented.
GDI-2309/
Mechanisms shall be functionally analysed to determine loads deriving from their activation, both in orbit or on ground, as applicable.

GDI-2310/
Mechanisms shall be designed to the same criteria as all other structural items.
They shall be also compliant with the EMC and cleanliness requirements.

GDI-2311/
They shall therefore:

• withstand without degradation all the environments they will be subjected to during their life,
• be designed with the same loads and safety factors as other structural items,
• fulfil the minimum frequency requirement section 4.2.1 in their stowed condition (same margin applicable),
• be subjected to fracture mechanics procedures as required by safety analysis.
Elements to be deployed in orbit (or otherwise showing important changes in their configuration between the launch and the orbital phase) shall also be verified under orbital environmental loads.

3.2.5.1.1 Lifetime requirement
GDI-2129/SRS-1656
Actuators (electrical, mechanical, thermal and others) shall be sized to provide throughout the operational lifetime and over the full range of travel actuation torques (or forces) which exceed at least two times the combined factored worst case resistive torque or forces in addition to any required deliverable output torque or force (Tc or Tf):

GDI-2165/SRD-MEC-1;SRD-MEC-2
The lifetime of a mechanism shall be demonstrated by test in the appropriate environment. The requirements of ECSS-E-30 Part 3A are applicable. The adequacy of the lifetime of Commercial Off the Shelf (COTS) items with respect to this requirement shall be demonstrated.

3.2.5.2 Torque margin requirement
GDI-2128/SRS-1656
In order to derive the factored worst case quasi-static resistive torques (or forces) the components of resistance, considered worst case conditions, shall be multiplied by the following minimum uncertainty factors:

<table>
<thead>
<tr>
<th>Component</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inertia, I_T or I_F</td>
<td>1.1</td>
</tr>
<tr>
<td>Spring, S</td>
<td>1.2</td>
</tr>
<tr>
<td>Friction, F_R</td>
<td>3.0 (*)</td>
</tr>
<tr>
<td>Hysteresis, H_Y</td>
<td>3.0 (*)</td>
</tr>
<tr>
<td>Harness/Other, H_A</td>
<td>3.0 (*)</td>
</tr>
<tr>
<td>Adhesion, H_D</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Note: Factors marked (*) may be reduced to 1.5 if the resistive forces/torques can be satisfactorily determined by test.
Where the minimum required actuation Torque/Force is given by:

\[ T_{\text{MIN}}/F_{\text{MIN}} = 2.0 \times (1.1 \times T/F + 1.2 \times S + 3 \times (F_R + H_V + H_A + H_D)) + T_L/F_L \]

**GDI-2126/SRS-1656**

For dynamic torques (or forces) then the following applies:

Torque/Force is given by:

\[ T_{\text{MIN}}/F_{\text{MIN}} = 2.0 \times (1.1 \times T/F + 1.2 \times S + 3 \times (F_R + H_V + H_A + H_D)) + 1.25 \times T_D/F_D \]

Where \( T_D \) and \( F_D \) refer to required deliverable output torque or force.

**GDI-2314/**

The Supplier of recurring units shall provide torques/forces margin and minimum factors requirements used to design its unit.

### 3.3 Thermal Design and Interface Requirements

#### 3.3.1 Definition of Temperatures and Terms

**3.3.1.1 Radiatively Controlled Unit**

**GDI-239/CREATED**

In the frame of GAIA, all units shall be radiatively controlled units, except PAA and recurring units. This applies in particular without specificities for units having a dissipative power density of less than 50 W/m² at the unit baseplate.

**3.3.1.2 Conductively Controlled Unit**

**GDI-241/CREATED**

All units which were conductively controlled in previous applications shall quantatively state about their capability to be radiatively controlled in accordance with environmental conditions depicted in section 4.3.2.

**3.3.1.3 Isothermal Unit**

As far as possible thermal gradients across the baseplate has to be minimised i.e. the unit has to be designed to be isothermal.

**GDI-244/CREATED**

For radiative units the temperature difference between all points of the unit case and baseplate shall be less than 3°C.

**GDI-245/CREATED**

For conductive units the temperature difference between all points of the unit baseplate shall be less than 3°C.

**GDI-246/CREATED**

For units not fulfilling GDI-244/245 additional thermal nodes shall be introduced at the baseplate, which represent areas with a temperature derivation < 3K inside these areas. The temperature difference shall be defined for each thermal node of the unit baseplate.
3.3.1.4 Temperature Reference Point (TRP)

**GDI-248/CREATED**

The temperature reference point (TRP) shall be selected on the unit external surface, preferably close to a mounting bolt, such that its temperature reflects the average unit housing temperature (no hot or cold spot). The temperature reference point shall be measured during the thermal acceptance and qualification tests.

The temperature reference point will be maintained within the specified temperature limits by the S/C thermal control during flight.

3.3.2 Thermal Interface Requirements

3.3.2.1 Conductive Interface

**GDI-252/CREATED**

The mounting interface shall comply with the mechanical and EMC requirements.

**GDI-253/CREATED**

Unit mounting areas shall not be painted or anodised, in order to obtain a good conductive thermal contact with the Spacecraft.

**GDI-254/CREATED**

All units dissipating significantly through their baseplate shall have a smooth and plain baseplate to give full contact for the thermal control requirements.

**GDI-255/CREATED**

Local heat flux shall not be greater than 1.5x specified base plate average heat flux, with an absolute peak local flux of less than 1600 W/m². The base plate heat flux is defined as the ratio of the thermal dissipation versus effective contact area when the unit is in the test configuration.

3.3.2.2 Radiative Interface

The heat exchange and the desired internal unit temperature are achieved by the selection of finishes.

**GDI-258/CREATED**

Units shall be designed with an emittance > 0.8 (black)

**GDI-2582/CREATED**

Units shall demonstrate compliance to their design/acceptance/qualification temperature range for the radiative and conductive environment of Table 4.3-1.

3.3.2.3 Internal Temperature Monitoring

**GDI-260/CREATED**

Temperature monitoring of selected points within a unit shall be provided by the Unit Supplier to cover the following cases:

- Unit operational health and safety monitoring.
- Unit operational temperature and performance monitoring.

**GDI-261/CREATED**

The location, type and electrical interface of all devices used for unit temperature measurement and control shall be defined in the ICD.
3.3.3 Thermal Design Requirements

**GDI-2657**

The units shall take into account the following definitions of Table 3.3-1
Environmental Temperature  This is the radiative interface temperature experienced by the units.

Operating Temperature (TFO)  This temperature shall be maintained at the TRP by S/C thermal control whilst the unit is operating. This temperature shall be independent of unit operating modes.

Non-Operating Temperature (TNF)  This temperature shall be maintained at the TRP by S/C thermal control when the unit is not operating.

Unit Switch-on Temperature (TSU)  The unit supplier shall specify if the non-operating temperature range at the TRP can prevail at the time of unit switch-on or if an alternative temperature range must apply at switch-on.

Predicted Temperature Limits  This is the nominal temperature range the unit may experience, taking into account the worst case combination of modes, environment and parameter degradation, excluding failure cases.

Design or Extreme Worst Case Temperature Limits  This is the extreme temperature range the unit may experience, taking into account in addition uncertainties in parameters (like view factor, surface properties, contamination, radiation environment, conductance, dissipation).

Qualification Temperature Limits  This is the extreme worst case temperature range (defined for the operating and non-operating mode of the unit) for which a unit is guaranteed to function nominally, fulfilling all required performances with the required reliability.

Acceptance Temperature Limits  The acceptance temperature range, defined for the operating and non-operating mode of the unit, is obtained from the qualification temperature range after substraction of suitable qualification margin. This is the extreme temperature range that a unit may be allowed to reach, but not exceed, during all envisaged mission phases (based on worst case assumptions).

Table 3.3-1: Units Temperatures and Limits Definition


The units shall be designed such that all internal heat sources have the required thermal couplings to the external surfaces of the unit to comply with the interface requirements of Section 3.3.2.1 and Section 3.3.2.2 and their own unit requirements in terms of temperature and heat exchange.

GDI-264/CREATED

Hot spots on the external surface of the unit are to be taken into account at the unit level. In designing the unit and ascertaining the optimum flow paths, the unit design shall take due account of the method of mounting and the relative exchanges with the environment by both conduction and radiation.

The objective of the unit thermal analysis is to demonstrate that internal components have acceptable temperatures when the unit itself (i.e. case or base plate) is at its operating temperature limits, with a reasonably representative distribution of the heat flow to the external environment.

GDI-2656/

In the absence of any uncertainty analysis an initial uncertainty margin of 10°C shall be retained in general to derive the Design or Extreme Worst Case Temperature Limits from the Predicted Temperature Limits by analysis. For external units highly dependent and sensitive to material properties the initial uncertainty margin shall be 20°C.

GDI-2079/CREATED

For units located outside of the Focal Plane Assembly, the average dissipation of the unit operating has to remain stable during a “T” period of time (T being comprised between 10 seconds and 6 hours, and defined as a “sliding window” over any S/C science operational period). The dissipation shall not vary by more than 2.0% when bus voltage varies by up to 0.5%.

3.3.4 Thermal Control

3.3.4.1 General

GDI-2555/MRD THE-010

The equipment thermal control shall comply with ECSS-E-30 part 1A taking into account the ECSS tailoring for Gaia.
The equipment thermal control shall be achieved primarily by passive means (i.e., coating, MLI, conductive paths, insulating washers, etc.), supplemented by heaters and thermistors. In particular, the use of devices using moving masses or fluids, such as cryo-coolers, thermoswitches, heat pipes or fluid loops is expressly forbidden for unit thermal control.

GDI-2557/MRD THE-040

The equipment thermal control design shall permit analysis by mathematical models.

GDI-2558/MRD THE-045

The equipment thermal control must be testable on ground.

GDI-2559/MRD THE-045

If special equipment is required to evacuate the heat during the spacecraft functional tests under ambient environment, they shall be compatible with the cleanliness requirements.

GDI-2560/MRD THE-045

No thermal control item shall prevent the spacecraft from being operated/tested under an attitude required by the thermal environment test.

GDI-2561/MRD THE-050

Deviations and temporal degradations from the nominal values of external and internal fluxes, thermo-optical properties, heat capacitances, and conductive and radiative couplings shall be taken into account in the thermal analysis.

GDI-2562/MRD THE-060

A Thermal Reference Point (TRP) shall be defined and instrumented for all units. This TRP shall be selected such that its temperature reflects the general thermal status of the equipment (preferably at the mounting interface of the unit).

GDI-2563/MRD THE-060

The TRP temperature also called "interface temperature" shall be predicted by analysis. The TRP shall therefore be represented in the mathematical models by a thermal node.

GDI-2564/MRD THE-060

In addition, the TRP temperature shall be monitored during the thermal test performed at any level.

GDI-2565/MRD THE-070

The equipment thermal control shall include and monitor sufficient flight temperature sensors to evaluate its in-orbit performance.

GDI-2566/MRD THE-080

The design limits of units are equal to the qualification limits decreased at both ends by a margin of 10°C.

GDI-2567/MRD THE-080

The design limits of units are equal to the acceptance limits decreased at both ends by a margin of 5°C.
3.3.4.2 Thermal Analysis

GDI-2552/MRD THE-090

Mathematical models in ESARAD and ESATAN shall be prepared to support the thermal analyses as necessary.

GDI-2553/MRD THE-100

The Geometrical and Thermal Mathematical Models (GMMs and TMMs) of the equipment shall be verified by test and correlated against the measured data as per ECSS-E-30 part 1A.

3.3.5 Thermal Interface Control Documents

GDI-267/CREATED

All thermal hardware mounted on the unit shall be identified in the ICD, for example:

- Heaters
- Temperature Sensors
- Low Emissivity Tape
- Multi Layer Insulation Blanket

GDI-269/CREATED

All unit thermal interfaces shall be described within a unit thermal interface control document as per APPENDIX B: TICD.

3.3.6 Thermal Mathematical Model Requirements

3.3.6.1 Thermal Interface Modeling

This section defines the requirements for the preparation, and the delivery of the Thermal Mathematical Models of the assemblies and units in order to incorporate them into the higher-level assembly thermal mathematical model. They are completed by requirements contained into the applicable document ref. GAIA.ASD.SP.SAT.00008.

GDI-2091/CREATED

The use of the ESARAD and ESATAN software packages is recommended for all thermal analyses and shall be required for all deliverable thermal mathematical models.

GDI-272/CREATED

The Thermal mathematical model shall be provided for non-isothermal units in accordance with the following rules:

- Reduced model of maximum 7 nodes (or otherwise agreed between the unit supplier and the customer)
- Node definition and heat capacity
- Conductive coupling
- External geometry, thermal characteristics and radiative coupling
- Heat dissipation for each node and operating modes, including significant transient cases and failure cases

GDI-273/CREATED

Units:
All units used in thermal models (geometrical and thermal mathematical models) will conform to the International System units (SI units).

In particular for:

- Radiative coupling: square meters
- Temperature: Kelvin (or Celsius)
- Power: Watts
- Energy: Joules
- Dimensions: meters
- Mass: kg

For all other parameters, measurement units shall be declared by the supplier.

### 3.3.6.2 Thermal Model Correlation

**GDI-275/CREATED**

The detailed thermal model of a unit shall be verified and correlated with a thermal test. The correlation criteria shall be:

- ± 3°C on the temperatures
- ± 10 % on the required heater power

### 3.3.6.3 Reduced Thermal Model

**GDI-277/CREATED**

The consistency between reduced and detailed thermal model shall be demonstrated by:

- The temperature difference less than ± 2 degrees.
- The required heater power less than ± 10%.

**GDI-278/CREATED**

The convergence of the thermal models shall be demonstrated.

### 3.4 Optical Design and Interface Requirements

#### 3.4.1 Optical Design Requirements

#### 3.4.1.1 General Optical Design

**GDI-282/CREATED**

For each optical surface, the physical dimension shall be oversized with regard to the useful optical dimension by at least 1mm along both axes.

#### 3.4.1.2 Materials

**GDI-284/CREATED**

Glass types and material quality shall be selected to comply with the performance requirement in terms of spectral transmittance and spatial environment. Glass selection and related optical configuration optimisation shall be performed in accordance with the environment requirements (as defined in Section 4. ).
The use of stain sensitive glasses shall be avoided

The use of optical cements shall be avoided as far as possible. If their use is nevertheless necessary, the contractor shall demonstrate their qualification to Gaia requirements (ageing, thermal cycles, radiation dose, etc…). Reference to their use for other space programmes shall also be mentioned.

3.4.1.3 Coatings

Coatings shall be designed such that performance, as measured at ambient conditions on ground, are maintained in the space environment.

Metallic layers of the coatings, if any, shall be grounded.

Thermo-optical properties of the coatings shall be compatible with the thermal control design requirements.

High efficiency anti-reflective coatings shall be applied to all free refractive surfaces.

Sensitivity of coatings to polarisation effects associated to the incidence angle shall be determined and validated.

3.4.1.4 Performances

The optical performance of the unit shall be verifiable on ground under ambient pressure and Earth gravity conditions.

Alignment and interface with regard to other optical units shall be maintained between clean room conditions and space environment. Note that residual defocus or misalignment induced by ambient air or gravity conditions remains acceptable as long as it has been clearly identified and as removable means to compensate it during alignment and test on ground are provided. Compensation means shall not affect performed alignment nor measured performance.

3.4.2 Optical Interface Requirements

The unit supplier shall provide the optical interface data in the optical data sheet format as provided in APPENDIX D: OICD.

The free mechanical aperture of optical surfaces shall be oversized with respect to the minimum clear aperture by at least 2 mm along both axes to avoid any stray reflection on the mechanical parts. The minimum clear aperture is determined according to the input beam characteristics, specified FOV, pupil (dimensions, location and decentring if any), alignment and long term stability.
3.4.3 Optical Mathematical Model Requirements

GDI-302/CREATED

The unit supplier shall use an optical model for numerical simulation of the unit. This model shall be established using the complete set of latest specifications and tolerances that are available about the unit. The model shall include not only the actual optical elements but also intermediate image planes, intermediate pupil imaging planes wherever applicable.

GDI-303/CREATED

The numerical model shall be developed preferably in Code V® or ZEEMAX® or using a software providing a simple export capability into one of these two softwares.

GDI-304/CREATED

The numerical model shall be used for the evaluation of the unit's optical performance. Actual glass characteristics as measured by the glass supplier shall be included. Performance analyses shall take into account the diffraction effects, misalignments and manufacturing tolerances.

3.5 Electrical Design and Interface Requirements

The following section defines the general electrical interface requirements for the Units located in the Gaia satellite:

3.5.1 General Requirements

GDI-308/CREATED

All electrical performances are specified under Worst-Case End-Of-Life conditions, unless otherwise explicitly notified.

GDI-309/CREATED

Beginning-Of-Life criteria shall be derived by the Unit Supplier from the specified parameters for testing and acceptance of all on-board units.

All interfaces are referenced by a specific Interface Code. Table 3.5-1 below lists all the standard interfaces:
### Table 3.5-1: Standard Interfaces

<table>
<thead>
<tr>
<th>Interface Code</th>
<th>Interface Designation</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCA (LCL)</td>
<td>Regulated Latching Current Limiter Power Class A:</td>
<td>1A</td>
</tr>
<tr>
<td>LCB (LCL)</td>
<td>Regulated Latching Current Limiter Power Class B:</td>
<td>2A</td>
</tr>
<tr>
<td>LCC (LCL)</td>
<td>Regulated Latching Current Limiter Power Class C:</td>
<td>3A</td>
</tr>
<tr>
<td>LCD (LCL)</td>
<td>Regulated Latching Current Limiter Power Class D:</td>
<td>5A</td>
</tr>
<tr>
<td>LCE (LCL)</td>
<td>Regulated Latching Current Limiter Power Class E:</td>
<td>8A</td>
</tr>
<tr>
<td>LCF (LCL)</td>
<td>Regulated Latching Current Limiter Power Class F:</td>
<td>10A</td>
</tr>
<tr>
<td>FCA (FCL)</td>
<td>Regulated Foldback Current Limiter Power Class A:</td>
<td>1A</td>
</tr>
<tr>
<td>FCB (FCL)</td>
<td>Regulated Foldback Current Limiter Power Class B:</td>
<td>2A</td>
</tr>
<tr>
<td>MIL</td>
<td>MIL-STD-1553B Interface</td>
<td></td>
</tr>
<tr>
<td>SBDL</td>
<td>Standard Balanced Digital Link</td>
<td></td>
</tr>
<tr>
<td>USL</td>
<td>UART Serial Link Interface</td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>Pulse Per Second Interface</td>
<td></td>
</tr>
<tr>
<td>SYNC</td>
<td>Synchronization Clock Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>AN1</td>
<td>Analogue TM Acquisition -5V to +5V</td>
<td></td>
</tr>
<tr>
<td>AN2</td>
<td>Analogue TM Acquisition 0V to +5V</td>
<td></td>
</tr>
<tr>
<td>AN3</td>
<td>Analogue TM Acquisition -10V to +10V</td>
<td></td>
</tr>
<tr>
<td>ANY</td>
<td>Temperature Acquisition Type 1: YSI 44907/YSI-44908 (TBC)</td>
<td></td>
</tr>
<tr>
<td>ANP</td>
<td>Temperature Acquisition Type 2: PT-1000</td>
<td></td>
</tr>
<tr>
<td>ANF</td>
<td>Temperature Acquisition Type 3: Fenwall (TBC)</td>
<td></td>
</tr>
<tr>
<td>ANT</td>
<td>Temperature Acquisition Type 4: PT-200</td>
<td></td>
</tr>
<tr>
<td>SHP</td>
<td>Standard High Power On/Off Command</td>
<td></td>
</tr>
<tr>
<td>EHP</td>
<td>Extended High Power On/Off Command</td>
<td></td>
</tr>
<tr>
<td>SLP</td>
<td>Standard Low Power On/Off Command (TBC)</td>
<td></td>
</tr>
<tr>
<td>RSA</td>
<td>Relay Status Acquisition</td>
<td></td>
</tr>
<tr>
<td>RLD</td>
<td>Digital Bi-Level TM Acquisition (TBC)</td>
<td></td>
</tr>
<tr>
<td>XCT</td>
<td>X-Band Digital TC Channel IF</td>
<td></td>
</tr>
<tr>
<td>RLS</td>
<td>Receiver Lock Status IF</td>
<td></td>
</tr>
<tr>
<td>XTM</td>
<td>X-Band Digital TM Channel IF</td>
<td></td>
</tr>
<tr>
<td>PYR</td>
<td>Pyro Interface</td>
<td></td>
</tr>
<tr>
<td>SMD</td>
<td>Shape Memory Device Interface</td>
<td></td>
</tr>
<tr>
<td>MDD</td>
<td>Motor Actuator Device Interface</td>
<td></td>
</tr>
<tr>
<td>LVC</td>
<td>Latch Valve Command Interface</td>
<td></td>
</tr>
<tr>
<td>LVS</td>
<td>Latch Valve Status Interface</td>
<td></td>
</tr>
<tr>
<td>FCVC</td>
<td>Flow Control Valve Command Interface</td>
<td></td>
</tr>
<tr>
<td>MEC</td>
<td>Main Engine Flow Control Valve Command Interface</td>
<td></td>
</tr>
<tr>
<td>PTS</td>
<td>Pressure Transducer Supply Interface</td>
<td></td>
</tr>
<tr>
<td>PTA</td>
<td>Pressure Transducer Acquisition Interface</td>
<td></td>
</tr>
<tr>
<td>PBA</td>
<td>Battery Power Interface</td>
<td></td>
</tr>
<tr>
<td>PSA</td>
<td>Solar Array Power Interface</td>
<td></td>
</tr>
<tr>
<td>SCS</td>
<td>Solar Cell Sensor Interface (TBC)</td>
<td></td>
</tr>
</tbody>
</table>
3.5.2 Power Interface Requirements (LC & FC)

All primary power bus protection is centralised, through the use of a latching current / fold-back current limiters LCL/FCL which are commanded and monitored in the PCDU. Each primary or redundant half of a unit will be assigned to an LCL or FCL as appropriate.

3.5.2.1 Regulated Power Requirements

Primary Power is provided from a fully regulated DC main bus. The power is distributed via:

- On/Off switchable latching current limiters (LCL’s)
- Automatic ON current limiters (FCL’s).

GDI-2046/Derived from SRS-529

The design of the FCLs and of all essential loads supplied by the FCL’s shall not be prone to any lock-up phenomenon requiring recovery via the removal of external power. This requirement to be verified at unit level.

During all mission phases, the spacecraft power bus voltage will be regulated to 28V +/-0.14V (+/- 0.5%) at the main regulation point.

GDI-2696/

During all mission phases the spacecraft power bus voltage will not vary by more than +/-0.25% over any 6 hour period with the spacecraft loads at constant power.

During anomaly conditions the Bus voltage can fall to the battery voltage

GDI-2104/ECSS-E-20A § 5.6.f

The spacecraft fully regulated bus shall have a nominal ripple voltage in the time domain below 0.5% peak to peak of the nominal bus voltage.

GDI-2103/ECSS-E-20A § 5.6.e

For load changes of up to 50% of the nominal load current, the bus voltage transients shall not exceed 1% of the nominal bus voltage.

GDI-2133/SRS-538

The bus voltage shall remain within 5% of its nominal value during all source transients and load transients in nominal operation with a recovery time of 2ms.

GDI-339/CREATED

If undervoltage protection is implemented by the load, then this protection shall not interact with the main bus undervoltage protection. The load shall not switch off its DC/DC converter for voltages in the specified operating range:

- \( V > \text{minimum specified operating Voltage} - 1V \)

Appropriate Hysteresis shall be implemented for switch on. Detailed timing of automatic switch-on after under voltage switch-off if implemented shall be defined and agreed via unit Interface Control Document.
GDI-340/CREATED

In case of an inductive load, when considering the bus impedance mask, the load shall prevent an over-voltage generation. The maximum over voltage emission shall not exceed 0.5V above the maximum specified DC bus voltage.

GDI-341/CREATED

The load shall not be irreversibly degraded for any standing or fluctuating voltage as defined in Table 3.5-3 (point -27).

Note: If required by the load, primary power under-voltage and over-voltage protection has to be provided by the load.

GDI-342/CREATED

No fuse protection shall be implemented.

GDI-343/CREATED

Primary current protection shall not be implemented on the DC/DC converter of a load, which is connected to an LCL or FCL output. Input filters to be properly designed according to the capability of the FCL or LCL.

GDI-344/CREATED

The contractor shall design the load side of the LCL interface to be compliant to the characteristics as defined in Table 3.5-2 and Table 3.5-3.

GDI-346/CREATED

All power converters shall be designed to allow operation in synchronised mode or if not possible, the design shall be referred to the Prime before implementation.

GDI-347/CREATED

The free-running frequency shall be limited to ±10% of the nominal frequency.

GDI-348/CREATED

The as designed free-running frequency and frequency variations shall be defined and agreed in the unit Interface Control Document.

GDI-349/CREATED

Units connected to LCL’s or FCL’s shall be designed taking into account the source impedance depicted in Table 3.5-2.
<table>
<thead>
<tr>
<th>Req</th>
<th>Source Circuit Specification</th>
<th>Verif’n.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-a</td>
<td>Bus Voltage range during anomaly conditions</td>
<td>34V to 18V at PCDU main regulation point.</td>
<td>A,T</td>
</tr>
<tr>
<td>-b</td>
<td>Bus Voltage range during nominal conditions</td>
<td>For all loads 28V +/-0.14V at PCDU main regulation point.</td>
<td>A,T</td>
</tr>
<tr>
<td>-2</td>
<td>LCL Current (Imax) (*1)</td>
<td>LCL class A (LCA): 1A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-3</td>
<td>LCL Current (Imax) (*1)</td>
<td>LCL class B (LCB): 2A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-4</td>
<td>LCL Current (Imax) (*1)</td>
<td>LCL class C (LCC): 3A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-5</td>
<td>LCL Current (Imax) (*1)</td>
<td>LCL class D (LCD): 5A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-6</td>
<td>LCL Current (Imax) (*1)</td>
<td>LCL class E (LCE): 8A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-7</td>
<td>LCL Current (Imax) (*1)</td>
<td>LCL class F (LCF): 10A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-8</td>
<td>Overcurrent Limitation (I&lt;sub&gt;o&lt;/sub&gt;)</td>
<td>1.25 (+/-10%) x Imax</td>
<td>A,T</td>
</tr>
<tr>
<td>-9</td>
<td>Current Limitation Response Time</td>
<td>3 to 5μs (TBC) (no active current limitation) for LCA, LCB, LCC, LCD, LCE and LCF</td>
<td>A,T</td>
</tr>
<tr>
<td>-10</td>
<td>Deleted</td>
<td>Deleted</td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Trip-Off Time (*2)</td>
<td>8ms ≤ t ≤ 15ms (fixed value) for LCA, LCB, LCC, LCD, 5mS ≤ t ≤ 8ms (TBC) for LCE &amp; LCF</td>
<td>A,T</td>
</tr>
<tr>
<td>-12</td>
<td>Deleted</td>
<td>Deleted</td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Response to Bus Undervoltage</td>
<td>Non-Essential load LCLs shall automatically switch OFF and remain OFF for Bus voltage &lt; 25.5V and be re-enabled automatically for Bus voltage &gt;26V. Essential Load LCLs shall automatically switch OFF for Bus voltage &lt;24.5V and be re-enabled automatically for Bus voltage &gt;25V. OFF response time shall be &lt;0.5mS, ON response time shall be &lt;10mS. Switching voltage tolerance shall be &lt;0.25V</td>
<td>A,T</td>
</tr>
<tr>
<td>-14</td>
<td>Voltage Drop from main regulation point to PCDU output</td>
<td>≤ 0.25V (TBC) for LCA, LCB, LCC</td>
<td>A,T</td>
</tr>
<tr>
<td>-15</td>
<td>Voltage Drop from main regulation point to PCDU output</td>
<td>≤ 0.28V (TBC) for LCD</td>
<td>A,T</td>
</tr>
<tr>
<td>-16</td>
<td>Voltage Drop from main regulation point to PCDU output</td>
<td>≤ 0.31V (TBC) for LCE &amp; LCF</td>
<td>A,T</td>
</tr>
<tr>
<td>-17</td>
<td>Stability</td>
<td>The LCL shall be unconditionally stable in to any capacitive load and inductive loads of at least 200uH (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-18</td>
<td>Fault Voltage Emission</td>
<td>0V to 34V (TBC)</td>
<td>A</td>
</tr>
<tr>
<td>-19</td>
<td>Fault Voltage Tolerance</td>
<td>0V to 35V</td>
<td>A, T</td>
</tr>
</tbody>
</table>

Table 3.5-2: Regulated Bus LCL Power Interface Characteristics (Source Circuit Spec)
**INTERFACE DATA SHEET**

<table>
<thead>
<tr>
<th>Req</th>
<th>Load Circuit Specification</th>
<th>Verif'n.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20a</td>
<td>Bus Voltage range during anomaly conditions</td>
<td>A,T 1.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The load shall not be damaged when subjected to any bus voltage in the range 0V to 34V (including harness drop and LCL voltage drop), steady state or at any rate of change.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-20b</td>
<td>Bus Voltage range during nominal conditions</td>
<td>A,T 1.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The load shall provide full performance for a primary input voltage range of 28.14V to 26.86V (including harness drop).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The load shall remain functional but not necessarily comply with full performance requirements when provided with a primary voltage input between 26.86V and 24.40V (TBC) for Non-Essential loads and 26.86V and 23.40V (TBC) for Essential loads (both cases including LCL and harness drop).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-21</td>
<td>Input Characteristic of Load Input Filter</td>
<td>A,T 1.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input filter shall be designed in accordance to the (CurrentxTime) capability of the LCL and EMC performances and shall ensure dI/dt requirement of GDI-895 is not exceeded</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effective input inductance shall not exceed 150uH (TBC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-22</td>
<td>Input Current Settling Time</td>
<td>A,T 1.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Following switch ON, if the user current exceeds the LCL current limit value of GDI-350 (-8) the LCL will enter its current limiting mode and start charging the user's input filter with a current Ic = 1.25 (+/- 10%) x Imax]. The user shall ensure that, under this condition, its input filter reaches the nominal steady state within: t &lt; 5ms (TBC) for LCA, LCB, LCC, LCD and t &lt; 2ms (TBC) for LCE and LCF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-23</td>
<td>Deleted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-24</td>
<td>Maximum Current allowed for User</td>
<td>A,T 1.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beside switch-on peak duration performances listed above (Input Current Settling Time) the maximum current loads over the Nominal Input Voltage Range shall be:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- STEADY State: 0.90 max</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- PEAK: 1.05 x Imax</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Where peak duration is less than the minimum limiting time of the LCL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-25</td>
<td>Current Limiter</td>
<td>A 1.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No active control loop within the load shall limit the load current when the LCL is in its current limiting mode.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-26</td>
<td>Fault voltage emission</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.5V above maximum specified DC bus voltage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-27</td>
<td>Fault voltage tolerance</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0V to 40V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.5-3: Regulated Bus LCL Power Interface Characteristics (Load Circuit Spec)**
At the point of regulation, the impedance of the voltage-regulated bus, operating with one source (battery or solar array) shall be below the impedance mask shown in Figure 3.5-1.

Figure 3.5-1: Regulated Primary Bus Source Impedance (at the Main Regulation Point)

The contractor shall design his side of the Regulated FCL interface to be compliant to the characteristics as defined in the Interface Datasheet "FCL", Table 3.5-4 below.
### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req</th>
<th>Source Circuit Specification</th>
<th>Verifn.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1a</td>
<td>Bus Voltage range during anomaly conditions</td>
<td>34V to 18V at the PCDU main regulation point.</td>
<td>A</td>
</tr>
<tr>
<td>-1b</td>
<td>Bus Voltage range during nominal conditions</td>
<td>28V +/-0.14V at the PCDU main regulation point.</td>
<td>A,T</td>
</tr>
<tr>
<td>-2</td>
<td>FCL Current (Imax) (*1)</td>
<td>FCL class A (FCA): 1A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-3</td>
<td>FCL Current (Imax) (*1)</td>
<td>FCL class B (FCB): 2A (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-4</td>
<td>Overcurrent Limitation (Im,knee)</td>
<td>1.25 x Imax (fixed value) (TBC)</td>
<td>A,T</td>
</tr>
<tr>
<td>-5</td>
<td>Foldback Current (Ib)</td>
<td>0.15 to 0.6 (TBC) x Im,knee (fixed value)</td>
<td>A,T</td>
</tr>
<tr>
<td>-6</td>
<td>Current Limitation Response Time</td>
<td>&lt; 3 µs (no active current limitation during this period)</td>
<td>T</td>
</tr>
<tr>
<td>-7</td>
<td>Trip-Off Time</td>
<td>Deleted</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Undervoltage Limitation</td>
<td>20V at main regulation point.</td>
<td>A,T</td>
</tr>
<tr>
<td>-9</td>
<td>Voltage Drop between main regulation point and PCDU output.</td>
<td>≤ 0.5 V (TBC) for currents up to 0.9 Im,knee</td>
<td>A,T</td>
</tr>
<tr>
<td>-10</td>
<td>Fault voltage Emission</td>
<td>0V to 34V</td>
<td>A</td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance</td>
<td>0V to 35V</td>
<td>A</td>
</tr>
</tbody>
</table>

### Load Circuit Specification

<table>
<thead>
<tr>
<th>Req</th>
<th>Load Circuit Specification</th>
<th>Verifn.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-12a</td>
<td>Bus Voltage Range during anomaly conditions</td>
<td>The load shall not be damaged when subjected to any bus voltage in the range 0V to 34V (including harness drop and FCL voltage drop), steady state or at any rate of change.</td>
<td>A</td>
</tr>
<tr>
<td>-12b</td>
<td>Bus Voltage Range during nominal conditions</td>
<td>The load shall provide full performance for a primary input voltage range of 28.14V to 19.0 V (including harness voltage drop and FCL drop).</td>
<td>A,T</td>
</tr>
<tr>
<td>-13</td>
<td>Current Limiter</td>
<td>No active control loop within the load shall limit the load current during the FCL is in its foldback limiting mode.</td>
<td>A</td>
</tr>
<tr>
<td>-14</td>
<td>Fault voltage emission</td>
<td>0.5V above the maximum specified DC bus voltage.</td>
<td>A</td>
</tr>
<tr>
<td>-15</td>
<td>Fault voltage tolerance</td>
<td>0V to 34V</td>
<td>A</td>
</tr>
</tbody>
</table>

### Harness Specification

- **Wiring Type**: Twisted Pair (TP)
- **Voltage drop (harness)**: \( \leq 0.5V \) (TBC) at \( Im,knee \)

### Notes:

(*1): Steady-State, excluding switch on transients

Fault Voltages shall be verified by Worst Case Analysis.

---

**Table 3.5-4: Regulated Bus FCL Power Supply Interface Characteristics**
Following switch-ON, and during input filter charging, the user shall ensure that the instantaneous load characteristic never crosses the foldback region (see Figure 3.5-3):

![FCL Characteristics](image)

**3.5.2.2 Power Consumption Requirements**

The power allocation for each unit is given in the unit specification, it covers all the operating modes and the mean and peak (long and short) figures. Note that:

- **Mean** represents the average consumption over 5 minutes (inclusive of heater power)
- **Short peak** represents the power demand within 1 msec
- **Long peak** represents the power demand within 100 msec

**GDI-361/CREATED**

The compliance versus the power allocations shall be established by taking into account the worst-case conditions within the qualification temperature range and the in-orbit lifetime including radiation effects.

**GDI-362/CREATED**

For each power interface circuit, the following consumption shall be calculated:

- Nominal consumption using nominal component values calculated at the estimated operational temperature
- Worst case consumption using worst case component values and temperature

**GDI-363/CREATED**

A power consumption test shall be required at temperature extremes during environmental testing on flight equipment with the unit running in operationally representative state.
3.5.2.3 Tolerance to Power Bus Failures

GDI-365/CREATED

When a unit is internally redundant, and the supply to one of the internal redundant modules fails, the unit shall be able to fulfil all its performances and functionality when switched to the redundant part.

3.5.2.4 Initial Electrical Status

GDI-367/CREATED

Upon application of power in nominal conditions all electronic equipment shall have a safe initial configuration and electrical status that is fully defined, reproducible and reported in the ICD’s.

3.5.2.5 Special Case: Secondary Power Supplied Units

The following requirements apply only in the case where an electrical unit supplies secondary power lines to another unit.

GDI-370/CREATED

It shall be possible to switch on the source unit without having to connect an external load to its power outputs. The output voltages shall correspond to their nominal values under these conditions.

GDI-371/CREATED

The source unit shall be protected against short-circuits on the secondary power lines (either differential or to the mechanical ground).

GDI-372/CREATED

The supplied unit and Electrical I/F shall withstand without damage the supply voltages generated in case of source unit failure, as specified in the unit technical specification.

3.5.3 Standard Signals

3.5.3.1 General Conventions

The signal provider is referred to as Driver. In the case where the signal is provided by a passive device, this device is more particularly called Source (see Figure 3.5-4).

The signal user is referred to as Receiver. In the case where the signal is used by a passive device, this device is more particularly called Load (see Figure 3.5-4).

![Figure 3.5-4: Typical Link Definition](image-url)
Specified driver (or source) characteristics shall be considered at the output of the driver (or source), with the specified load.

All data and signal interface drivers shall survive a short circuit to driver ground, receiver ground or structure without permanent degradation.

The unit shall tolerate active signal I/Fs when unpowered without any permanent degradation.

In case the electrical architecture does foresee cross strapping on interface level the interfaces shall ensure proper function with ‘both interfaces powered’ and ‘one interface unpowered’.

In case no load is specified, the characteristics are to be considered with the driver output in open circuit.

Timing

Signal duration and rise and fall times are defined as follows:

Signal duration: The signal pulse width is defined as the time between the voltage crossing points of fall and rise time to 50 % of the measured full amplitude. See Figure 3.5-5.

Signal rise and fall time: The rise and fall time of a digital signal are defined as the time duration between 10% and 90% of the nominal voltage swing. See Figure 3.5-6.

The delay between two signals is defined as the time between the voltage crossing points 50% at the full amplitude level.

Figure 3.5-5: Definition of Signal Pulse Width Td
3.5.3.2 Harness Capacitance

GDI-391/CREATED

*Interface signal drivers shall consider the capacitive loading by the harness; the worst-case design performance shall comply with the values as specified in Figure 3.5-7 for a Twisted Shielded Pair.*

![Figure 3.5-7: Harness Capacitance](image)

\[
C_1 = 150 \text{ pF} \\
C_2 = 1.6 \text{ nF} \\
\text{Core to core cap} = \left( \frac{C_1 + C_2}{2} \right) = 950 \text{ pF} \\
\text{Core to shield cap} = \frac{C_1 \cdot C_2}{C_1 + C_2} = 1.75 \text{ nF}
\]
3.5.4 Connectors General Design Requirements

3.5.4.1 Harness

GDI-395/CREATED
Cables falling into different EMC classifications shall be assembled to different (separate) cable bundles and connectors. If this is not feasible and wires of different classifications use the same connector, the separation shall be implemented by a row of grounded pins in between.

GDI-396/CREATED
All cable bundles shall be routed as close as possible to the structure ground plane/ground rail respectively, in order to reduce the common mode noise.

GDI-397/CREATED
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.

GDI-398/CREATED
The DC resistance between the single cable shield and the shield ground point (at the connector, unit case, PCB or intermediate points) shall be ≤ 10 mΩ.

GDI-399/CREATED
The structure termination of shields shall be made via connector housing. When multiple shielding is used, each shield shall be grounded separately.

3.5.4.2 Connector Types

GDI-401/CREATED
All connectors mounted on units shall be D*MA** connectors except for coaxial links which shall use SMA type connectors.

For power lines with currents greater than 15Amps circular connectors shall be used, e.g. according ESA SCC 3401/056 25-19 (AWG 12).

Exception to this requirement may be granted for High voltage connectors.

GDI-402/CREATED
All flight connectors shall be designed to withstand without damage at least 55 mate / demate cycles.

GDI-2158/CREATED
Individual mate/demates shall be recorded in a mate/demate log.

GDI-2157/CREATED
The number of times flight connectors are mated / demated before delivery shall not exceed 5, except by prior agreement with S/C Prime.

GDI-2156/CREATED
If by prior agreement with S/C Prime the number of mates / demates is to exceed 5, then visual inspection of the connectors and connector contacts shall be performed after every 5 mate / demates and the results of the inspection shall be recorded in the mate / demate log.

GDI-403/CREATED
Different connector classes shall be implemented in order to separate the different type of links: Power, Signal, and Pyros.
Classifications: Power and signal lines shall be gathered into the following EMC classes:

- class 1: power (primary / secondary)
- class 2: digital signals, high level analogue signals (except RF)
- class 3: pyrotechnics
- class 4: low level analogue signals (except RF)
- class 5: RF signals (via coaxial lines, waveguides, microwave transmission lines)

Signals falling into different EMC classifications shall be assembled to separate connectors and cable bundles.

If not feasible, the separation shall be achieved by a row of grounded pins and the cables shall split into their respective categories as soon as they leave the connector or connector backshell.

Sensitive, "high quality" secondary power should not be routed with primary power in the same bundle. In case of such power a distinction as follows is recommended:

- Class 1a: Primary Power
- Class 1b: Secondary Power

3.5.4.3 Connector Characteristics

GDI-405/CREATED

Connectors at interfaces shall be clearly identified in particular in the ICD and GA drawing. This applies to equipment connectors as well as to interface brackets connectors.

GDI-406/CREATED

Connectors shall not be a source of single point failures.

GDI-407/CREATED

Equipment or structure-mounted connectors shall be male, except those supplying or distributing power or coaxial cable connectors, which shall be female.

GDI-408/CREATED

Male and female connectors shall be mechanically locked together to prevent inadvertent disconnection.

GDI-409/CREATED

Active lines together with their return shall be on adjacent contacts to facilitate cable twisting and shielding.

GDI-410/CREATED

Connectors shall be made of Non magnetic material

GDI-411/CREATED

For any unit connector which contains a number of free pins:

- At least one free pin shall be internally connected to the mechanical chassis of the unit by a resistance lower than 10mΩ
- At least one connector free pin shall be internally connected to the secondary 0V of the unit (if applicable).
GDI-412/MRD EDR-120

Nominal and redundant lines shall have separated connectors. Where existing qualified units are used that do not have separated connectors as described, any waiver request will be treated on a case by case basis taking into account failure propagation effects.

Harness bundles will be split as soon as they exit the connector in all cases.

3.5.4.4 Connector Mounting

GDI-414/CREATED

All electrical connectors shall be located at a minimum distance of 25mm from the unit-mounting plane in order to avoid problems with cable routing and cable harness support fixation.

When connectors are located above 80mm from the unit interface, the equipment supplier shall define tie-wraps on the unit sides to support the harness. The mechanical ICD’s shall clearly identify the tie-wraps and the associated harness routings.

GDI-415/CREATED

Connectors shall be arranged in such a way that the harness connectors can be mated and demated easily without special tools and without touching any neighbouring connectors.

The minimum free space around each connector shall be 10mm to allow for installation of spacers and covers.

GDI-416/CREATED

Mechanical methods in conjunction with identification markings shall be employed to prevent incorrect mating of connectors.

GDI-417/CREATED

Connector savers shall be utilized on all flight standard connectors to minimize the number of times a flight connector is mated/demated during the unit and subsystem integration activities. The unit manufacturer shall provide these savers.

GDI-418/CREATED

The connection shield ground pin to case shall be as short as possible in order to minimize its effectiveness to act as an antenna, receiving and/or transmitting shield currents. The maximum allowable length is 6cm.

3.5.4.5 Test Connectors

GDI-420/CREATED

Test connectors shall have sufficient protection to prevent from any potential hazards to the unit during testing via the unit test set. The protection shall be in the form of current limiting resistors, diodes or protection via the test set when other forms of protection are not practical. The unit supplier is responsible for the protection provided.

GDI-421/CREATED

Test connectors shall be protected by EMC metal covers attached to fixation bolts

GDI-422/CREATED

The metallic protection cover shall be capable of flight operation.
3.5.5 Standard Interfaces

3.5.5.1 ECSS-E-50-12A: SpaceWire

This section specifies the physical interconnection and the data communications protocols related to the SpaceWire links.

It specifies the applicability and tailors as required the following protocol layers as specified in the ECSS-E-50-12A:

- **Physical layer**: defines connectors, cables, cable assemblies, and printed circuit board tracks.
- **Signal layer**: defines signal encoding, voltage levels, noise margins, and data signalling rates.
- **Character layer**: defines the data and control characters used to manage the flow of data across a link.
- **Exchange layer**: defines the protocol for link initialisation, flow control, link error detection and link error recovery.
- **Packet layer**: defines how data for transmission over a SpaceWire link is split up into packets.
- **Network layer**: defines the structure of a SpaceWire network and the way in which packets are transferred from a source node to a destination node across a network. It also defines how link errors and network level errors are handled.

<table>
<thead>
<tr>
<th>Space Wire Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
</tr>
<tr>
<td>Packet</td>
</tr>
<tr>
<td>Exchange</td>
</tr>
<tr>
<td>Character</td>
</tr>
<tr>
<td>Signal</td>
</tr>
<tr>
<td>Physical</td>
</tr>
</tbody>
</table>

GDI-2388/

The applicable version of the ECSS-E-50-12A SpaceWire standard shall be the version dated 24 January 2003.

3.5.5.1.1 Terms, Definitions & Abbreviated Terms

GDI-2387/ECSS-E-50-12A, §3

The terms, definitions, abbreviated terms and conventions of the ECSS-E-50-12A SpaceWire standard §3 shall apply.
3.5.5.1.2 Physical Layer

3.5.5.1.2.1 Cables
GDI-2396/ECSS-E-50-12A, §5.2

The cable definition and construction requirements of the ECSS-E-50-12A SpaceWire standard § 5.2 shall apply.

3.5.5.1.2.2 Connectors
GDI-2400/ECSS-E-50-12A, §5.3

The connector definition and construction requirements of the ECSS-E-50-12A SpaceWire standard § 5.3 shall apply.

3.5.5.1.2.3 Cable Assembly
GDI-2402/ECSS-E-50-12A, §5.4

The cable assembly requirement of the ECSS-E-50-12A SpaceWire standard § 5.4 shall apply with the following precisions regarding §5.4.2:

- the maximum length of the flight SpaceWire cable assembly between the Payload Module (PLM) Focal Plane Assembly (FPA) and the Video Processor Units (VPU) shall be less than 5 m (TBC).
- the maximum length of the flight SpaceWire cable assembly between the Video Processor Units (VPU) and the Payload Data Handling Unit (PDHU) shall be less than 5 m.
- the maximum length of the flight SpaceWire cable assembly between the Payload Data Handling Unit (PDHU) and the Central Data Management Unit (CDMU) shall be less than 5 m.

GDI-2662/CREATED

For each unit external SpaceWire link connector(s), it shall be possible to connect, in parallel to the functional SpaceWire link, a SpaceWire link analyser on unit SpaceWire connector level and through a SpaceWire cable/link of up to 10 meters.

3.5.5.1.2.4 Printed Circuit Board (PCB) & Backplane Tracking
GDI-2404/ECSS-E-50-12A, §5.5

The PCB and backplane tracking requirements of the ECSS-E-50-12A SpaceWire standard § 5.5 shall apply.

3.5.5.1.3 Signal Layer

3.5.5.1.3.1 Low Voltage Differential Signaling (LVDS)
GDI-2406/ECSS-E-50-12A, §6.1

All the SpaceWire links shall use Low-Voltage Differential Signaling (LVDS) with electrical characteristics as specified in ANSI/TIA/EIA-644.
Note: TIA/EIA-644 balanced (differential) interface [LVDS] defines the electrical layer (Receiver and Transmitter) only.

**GDI-2407/CREATED**

*The LVDS driver and receiver interfaces shall be designed in accordance with the following ratings:*

![Diagram of LVDS interface](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{OD}$</td>
<td>Output differential voltage: the amplitude result of $(DO^+)$ - $(DO^-)$</td>
<td>247</td>
<td>454</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{OS}$</td>
<td>Offset voltage: the common-mode voltage of the LVDS output</td>
<td>1.125</td>
<td>1.375</td>
<td>V</td>
</tr>
<tr>
<td>$V_{OD}$</td>
<td>[Change to $V_{OD}$]</td>
<td>50</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>$V_{OS}$</td>
<td>[Change to $V_{OS}$]</td>
<td>50</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>$I_{SH}$</td>
<td>Short circuit current</td>
<td>24</td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>$t_{DF}$</td>
<td>Output rise/fall times (200 Mbps)</td>
<td>0.26</td>
<td>1.5</td>
<td>ns</td>
</tr>
<tr>
<td>$t_{DF}$</td>
<td>Output rise/fall times (&lt;200 Mbps)</td>
<td>0.26</td>
<td>50% of $t_{ni}$†</td>
<td>ns</td>
</tr>
<tr>
<td>$I_{IN}$</td>
<td>Input current</td>
<td>20</td>
<td>1</td>
<td>µA</td>
</tr>
<tr>
<td>$V_{TH}$</td>
<td>Receive threshold voltage</td>
<td>+100</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>$V_{PG}$</td>
<td>Input voltage range</td>
<td>0</td>
<td>2.4</td>
<td>V</td>
</tr>
</tbody>
</table>

† $t_{ni}$ is unit interval (i.e. bit width).

Note: The typical output voltage swing is 350mV at better than 200Mbps into a 100 ohm load, across a distance of about 10 meters.

### 3.5.5.1.3.2 Failsafe Operation of LVDS

**GDI-2410/ECSS-E-50-12A, §6.2**

*The LVDS failsafe operation requirements of the ECSS-E-50-12A SpaceWire standard § 6.2 shall apply.*
GDI-2408/CREATED

No LVDS configuration involving more than one (1) LVDS driver and one (1) LVDS receiver. The LVDS link shall be point to point link. In case if not possible, the Prime shall be informed and shall agree on the implementation of such LVDS link.

3.5.5.1.3.3 Signal Coding


The signal coding requirements of the ECSS-E-50-12A SpaceWire standard § 6.3, § 6.4 and §6.5 shall apply with the precisions below.

GDI-2413/ECSS-E-50-12A, §6.3

The data-strobe system shall carry an ‘encoded’ clock as shown in figure below. The receiving device shall synchronise to the incoming data (asynchronous).

![Signal Coding Diagram](attachment://signal_coding_diagram.png)

Note: The strobe line shall change state each time when the next bit on the accompanying data line has the same value than its previous one. (Clock recovery by X-ORing)

GDI-2412/ECSS-E-50-12A, §6.4

A SpaceWire data interface shall consist of a link input (DS-DE-link) and a link output (DS-DE-link), each comprising two differential point-to-point connections issued from the active data source:

- **DS_Data** (serial bit stream)
- **DS_Strobe**  (decoded strobe)
3.5.5.1.3.4 Data Signalling Rate

Definition: The data signalling rate is the rate at which the bits constituting control and data characters are transferred across a link.

GDI-2416/ECSS-E-50-12A, § 6.6.5

After a reset or disconnect the SpaceWire link transmitter shall initially commence operating at a data signalling rate of \([10 \pm 1]\) Mbps.

GDI-2515/ECSS-E-50-12A, § 6.6.1

The lower limit to data signalling rate shall be 2 Mbps.

Note: the standard requires it to be > 1.18 Mbps, i.e., 1/850ns that is the disconnect detection timeout.

GDI-2418/CREATED

After the link connection has been established successfully (i.e., the exchange layer state machine is in the Run state, the transmitter operating data signalling rate shall be set to \(\geq 100\) Mbps for the point-to-point SpaceWire links implemented between the PLM Focal Plane Assembly (FPA) and the VPUs.

NB: the specified data signalling rate is more than twice the advertised application data rate.

GDI-2419/CREATED

After the link connection has been established successfully (i.e., the exchange layer state machine is in the Run state, the transmitter operating data signalling rate shall be set to \(\geq 100\) Mbps for the point-to-point SpaceWire links implemented between the VPUs and the PDHU.

NB: the specified data signalling rate is more than 20 times the advertised application data rate. This is to ensure a good schedulability of the SpW network involving routing within the Payload data handling processor.

GDI-2420/CREATED

After the link connection has been established successfully (i.e., the exchange layer state machine is in the Run state, the transmitter operating data signalling rate shall be set to \(\geq 40\) Mbps for the point-to-point SpaceWire links implemented between the PDHU and the CDMU.
NB: the specified data signalling rate is more than twice the advertised application data rate.

3.5.5.1.3 Skew & Jitter

Definitions

- Jitter: random errors in the timing of a signal.
- Skew: difference in time between the edges of two signals which should ideally be concurrent.

3.5.5.1.4 Character Layer

Bits are transmitted as groups called ‘characters’. They represent the smallest usable unit of information. Characters are used by the higher layers of the protocol to transmit data or to control the transmission of a continuous sequence of characters on the link.
3.5.5.1.4.1 Data Characters, Control Characters & Codes
GDI-2398/ECSS-E-50-12A, §7.2, §7.3

The data character, control character and control code requirements of the ECSS-E-50-12A SpaceWire standard § 7.2 and §7.3 shall apply.

Data Characters

Control Characters

Control Codes

Each byte shall be transmitted “little endian” i.e. least significant bit LSB first, most significant bit MSB last.

Note: NULL is transmitted whenever a link is not sending data or control tokens, to keep the link active and to support link disconnect.

3.5.5.1.4.2 Parity Coverage
GDI-2427/ECSS-E-50-12A, §7.4

The parity bit coverage requirements of the ECSS-E-50-12A SpaceWire standard § 7.4 shall apply.

3.5.5.1.4.3 First Null Token after Reset or Link Error
GDI-2430/ECSS-E-50-12A, §7.5

The first Null Token transmitted after reset or link error shall be as follows:

After Power on, the DS link outputs shall hold both the data and strobe signals at logic ‘0’ (i.e. the reset level) until started/operating. The first bit transmitted after a reset state shall be a zero (which implies that the first transition -low to high - is on the strobe line).
3.5.5.1.4.4 Time Interface

As Gaia implements a dedicated, ultra-stable, clock distribution unit, no use of the ECSS-E-50-12A SpaceWire standard time interface provision is imposed. Features specified in §7.7 and §8.12 of the standard can be used wherever necessary for synchronisation between modules of an on-board unit.

3.5.5.1.5 Exchange Layer

The exchange level is responsible for making a connection across a link and for managing the flow of data across the link.

3.5.5.1.5.1 Link-characters & Normal-Characters

GDI-2454/ECSS-E-50-12A, §8.2

The requirements related to the separation of SpaceWire L-Chars and N-Chars as specified in ECSS-E-50-12A § 8.2 shall apply, i.e.,:

- **L-Chars** = used by exchange layer and not passed to the next layer, "Packet Layer":
  - Flow Control Token (FCT)
  - Escape (ESC)
  - NULL = ESC + FCT
  - Time Code = ESC + Data Character

- **N-Chars** = passed to the "Packet Layer":
  - Data Characters
  - Normal Enf Of Packet (EOP)
  - Error End Of Packet (EEP)

3.5.5.1.5.2 Flow Control

GDI-2455/ECSS-E-50-12A, §8.3

The requirements related to the SpaceWire link flow control as specified in ECSS-E-50-12A §8.3 shall apply.

GDI-2457/CREATED

Any on-board SpaceWire node shall expand the exchange layer flow control up to the packet layer such that an end-to-end flow control is established.

GDI-2495/CREATED

The SpaceWire link interface "Credit Counter" and "Outstanding Counter" as specified in ECSS-E-50-12A § 8.3 shall be accessible to the host system.

GDI-2496/CREATED

The highest order of priority for transmission of characters shall be as follows:

- **Time Code**, whenever SpaceWire is used for synchronising remote nodes from the CDMU
- **FCTs**, otherwise.
3.5.5.1.5.3 End-to-End Data Flow Architecture

GDI-2500/CREATED

The host system on SpaceWire TX side shall contain output data buffering in case the receiver at the other end is not ready to accept characters.

GDI-2510/CREATED

The SpaceWire node TX Output Buffer shall be controlled such as to validate incoming packets of information (e.g., CCSDS packets, consistent scientific data packet, etc.) before they are queued up in the buffer.

GDI-2511/CREATED

The host systems on both ends shall allow for the maintenance and the recovery of the synchronisation of the data packet exchanges (CCSDS, consistent scientific data packet, etc.) between the two (or n) SpaceWire nodes.

GDI-2512/CREATED

No desynchronisation of CCSDS packet handling nor science data packet handling shall occur in case a packet is longer or shorter than indicated in its header. Erroneous packet discarding is tolerated.

GDI-2456/ECSS-E-50-12A, §8.4

The host system on SpaceWire RX side shall contain input data buffering computed as a function of the following parameters:

- SpaceWire link data signalling rate
- Throughput
- Number of packets/sec
• Data packet length
• Possible host system interrupt rate taking into account CPU burden, duration of non-interruptible tasks, etc.
• Handshaking criteria between SpW Codec/Buffer and host system (e.g., FIFO half-full and EOP received)

3.5.5.1.5.4 State Machine

GDI-2513/ECSS-E-50-12A, §8.5

Any on-board SpW node shall provide link management and link data flow control in accordance with the state machine of ECSS-E-50-12A §8.5.

GDI-2514/ECSS-E-50-12A, §8.5.3.1

Any on-board SpW node shall accept the following types of reset of the SpaceWire link interface state machine and flushing of the associated TX/RX buffers:
• power on reset
• hardware reset
• software commanded reset

GDI-2517/CREATED

The reset of the SpaceWire link interface state machine and flushing of the associated TX/RX buffers shall be accessible through ground TC.

3.5.5.1.5.5 Autostart / Link Initialisation

GDI-2448/ECSS-E-50-12A, §8.6 and §8.7

The requirements related to the SpaceWire link autostart / link initialisation as specified in ECSS-E-50-12A §8.6 and §8.7 shall apply.

GDI-2518/CREATED

A SpaceWire link interface shall start
• on command from the host system
• automatically on receipt of a NULL

3.5.5.1.5.6 Normal Operation

GDI-2519/ECSS-E-50-12A, §8.6 and §8.7

The requirements related to the SpaceWire link normal operation as specified in ECSS-E-50-12A §8.8 shall apply.

3.5.5.1.5.7 Error Detection

GDI-2520/ECSS-E-50-12A, §8.9.1 and §8.9.2

On exchange level, an on-board SpaceWire node shall detect the following errors and react in resetting and re-initialising to recover character synchronisation and flow control:
• Disconnect Error
  - No RX clock transition for more than 850 ns
- Parity Error
- Parity bit error
- Escape Error
- ESC character should only be used to form a NULL (ESC, FCT) or time-code (ESC, Data)
- ESC followed by any character other than FCT or data character is an error
- Credit Error
- If there is no room in SpaceWire link interface RX buffer for data received then an error must have occurred which affected the FCTs
- Empty Packet Error
- EOP or EEP followed by another EOP or EEP
- Represents an empty packet
- Not permitted

GDI-2524/ECSS-E-50-12A, §8.9.4

The "exchange of silence" procedure - upon error detection the initialisation state machine disables the transmitter and receiver therefore causing a disconnection and error recovery at the other end of the SpaceWire link - shall be implemented in accordance with ECSS-E-50-12A §8.9.4 and its performance made visible to upper SpaceWire protocol layers.

GDI-2522/ECSS-E-50-12A, §8.9.5

The reporting of errors to the upper levels - packet and network layers - shall be done in accordance with ECSS-E-50-12A §8.9.5.

GDI-2521/CREATED

Errors that can affect the synchronisation on packet level and network level shall be reported to the relevant level.
3.5.5.1.5.8 Exception Conditions

GDI-2525/ECSS-E-50-12A, §8.10

The requirements related to the SpaceWire link exception conditions specified in ECSS-E-50-12A §8.10 shall apply.

3.5.5.1.5.9 Link Timing

GDI-2526/ECSS-E-50-12A, §8.11

The requirements related to the SpaceWire link timing specified in ECSS-E-50-12A §8.11 shall apply with the following time-out specifications:

- disconnect time-out ≤ 1,000 ns
- exchange time-out ≤ values specified in §8.11.3.

3.5.5.1.5.10 Time Distribution

N/A

3.5.5.1.6 Packet Layer

3.5.5.1.6.1 SpaceWire Packet Composition

GDI-2536/ECSS-E-50-12A, §9.2.1

The SpaceWire packet format shall be in accordance with §9.2.1 of ECSS-E-50-12A:

- <DESTINATION><CARGO><END OF PACKET MARKER>
- <DESTINATION>: not required in case of point-to-point SpaceWire links
- Path addressing: specification of physical path, e.g., router port number.
- Logical addressing: specification of the destination node.
- <CARGO>: data transferred from source to destination, i.e., a CCSDS Packet or a Science Packet.
- <END OF PACKET MARKER>: indicates the end of the SpaceWire packet.

GDI-2499/ECSS-E-50-12A, §9.2.1

Whichever SpaceWire supporting device is used, the “cargo area” of a SpaceWire packet as defined in §9.2.1 of ECSS-E-50-12A shall always consist of an even number of 16-bit words delivered by the successive “data characters”.

Note: this is to allow for SMCS332 packet size restrictions in case it is used in lieu of the SMCS332SpW.

3.5.5.1.6.2 CCSDS Packet

GDI-2530/CREATED

For any on-board SpW node featuring CCSDS packetisation, a SpaceWire packet shall encapsulate one and only one CCSDS packet.
3.5.5.1.6.3  Science Packet

GDI-2532/CREATED

For any on-board SpW node featuring science data packetisation, a SpaceWire packet shall encapsulate one and only one science packet.

3.5.5.1.6.4  Maintenance of Synchronisation on SpaceWire Packet Level

GDI-2523/CREATED

Any on-board SpaceWire node shall provide means to re-synchronise, on command from the host or automatically, on SpaceWire packet level:

• SpW packet flushing from TX buffer (transmitter may be in the middle of sending a packet), or TX buffer flushing if packet flushing is not possible: in any case, flushing shall be made such as to protect the buffer from host access during flushing.

• Received SpW truncation with EEP (receiver may have been receiving a packet).

3.5.5.1.6.5  Maintenance of Synchronisation on CCSDS Packet Level

GDI-2534/CREATED

Any on-board CCSDS-packetised SpaceWire node shall provide means to re-synchronise, on command from the host or automatically, on CCSDS packet level:

• CCSDS packet flushing from TX buffer (transmitter may be in the middle of sending a packet), or TX buffer flushing if packet flushing is not possible: in any case, flushing shall be made such as to protect the buffer from host access during flushing.

• Received CCSDS packet discarding, or discarding of a datablock = n x CCSDS packets if not possible. Discarding shall be made such as to protect the RX buffer from other end access during discarding.

3.5.5.1.7  Network Layer

3.5.5.1.7.1  Network Topology for GAIA SpaceWire Implementation

GDI-2535/CREATED

Wherever n SpaceWire nodes (e.g., instruments or instrument constituents) communicate with a master, dual-redundant, SpaceWire node, the SpaceWire network shall implement routing as shown on the figure below:
3.5.5.1.7.2 Implementation of Routing as per ECSS

GDI-2591/ECSS-E-50-12A, §10.2.4

Wherever SpaceWire routing is implemented inside a unit, it shall be done in accordance with §10 of ECSS-E-50-12A. Implementation of SpaceWire routing inside a unit shall have no impact on interface definition between this unit and SpaceWire nodes communicating with it.

3.5.5.1.8 SpaceWire Standard Supporting Devices

3.5.5.1.8.1 SMCS & IEEE-1355 Standard

GDI-2442/CREATED

Any SpaceWire implementation of the existing European SMCS332 and SMCS116 (SMCSlite) on board Gaia shall take into account the corrections of the known anomalies of these circuits. This shall be done by using the work-arounds specified by the Vendor below or by introducing work-arounds on host system level.

3.5.5.1.8.2 SMCS & SpaceWire

GDI-2441/CREATED

The European SMCS332SpW and SMCS116SpW shall be the preferred SpaceWire communications controllers for the Gaia mission.

Acceptable waiver justifications to the use of these devices are as follows:

- off-the-shelf equipment featuring SMCSlite or SMCS332
- SMCS332SpW / SMCS116SpW development/validation failures.

The initial SMCS332 and SMCS116 (or SMCSlite) components are used today on-board several spacecrafts. Their functional blocks are fully in line with an on-board network based on point-to-point links connection but they still suffer from IEEE-1355 legacy. Therefore, ESA initiated upgrades on the basis of the SpaceWire Codec VDHL core. The main drivers for these two new devices, named SMCS332SpW and SMCS116SpW, are as follows:

- Pin compatibility to existing SMCS332 / SMCSlite
- Correction of known anomalies of the existing SMCS332 / SMCSlite.

SCMS332SpW Performances

<table>
<thead>
<tr>
<th>SMCS332SpW ASIC</th>
<th>Implementation in Atmel M22RT gate array</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max gate count</td>
<td>480 Kgaates</td>
</tr>
<tr>
<td>0.5 µm CMOS process</td>
<td></td>
</tr>
<tr>
<td>Radiation Tolerance</td>
<td>up to 100 Krad</td>
</tr>
<tr>
<td>SEE free cells to 100 MeV</td>
<td></td>
</tr>
<tr>
<td>LU immune to 70 MeV</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>Data signaling rate up to 200 Mbps</td>
</tr>
<tr>
<td>Power</td>
<td>max 190 mA at 5.5V at maximum rate</td>
</tr>
<tr>
<td>5V and 3.3V supply voltage</td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>196-pin ceramic Quad Flat Pack 25 mil pin spacing</td>
</tr>
</tbody>
</table>

SMCS116SpW Performances
3.5.5.1.8.3  SpaceWire VHDL Core

GDI-2587/CREATED

In case of custom SpaceWire controllers implemented in FPGA or ASIC, they shall be built upon the ESA VHDL Core IP distributed by ESA.

3.5.5.2  MIL-STD-1553 Bus Interfaces (MIL)

The MIL-STD-1553 Bus features 2 different Buses, one Nominal and one Redundant. Only one bus is active at any time. A single Bus Controller (BC) supported by the OBC manages each bus. All the other units are connected to the bus as Remote Terminals (RT).

GDI-426/CREATED

Each data bus subscriber equipment shall comply with MIL-STD-1553 B + Notice 3 standard.

GDI-427/CREATED
All units (BC or RT) shall be configured in long stub, transformer-coupled, connection.

GDI-2177/CREATED
The maximum length of the long stub shall be 6 meters.

GDI-2176/CREATED
Only one RT shall be connected to a stub cable.

GDI-428/CREATED
Each BC and RT (N&R) shall be connected to both 1553 buses (N&R). See Figure 3.5-9.

GDI-429/CREATED
Each stub shall be grounded inside each RT or BC derivation by a redunded resistor.

GDI-430/CREATED
The RT address shall be programmable on an external connector.

GDI-431/CREATED
The 1553-bus shall be connected on separate connectors. No other signals shall be on these connectors.

GDI-2139/CREATED
The 1553-bus shall be connected on separate connectors. No other signals shall be on these connectors.

1553B Data bus connector Nominal & Redundant

Unless otherwise agreed with Astrium, the connection between a remote terminal equipment and the MIL-STD-1553 B bus stubs shall be performed via a Cannon 9 P equipment connector, according to the following pin function:
<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1553 B bus prime</td>
</tr>
<tr>
<td>2</td>
<td>not connected</td>
</tr>
<tr>
<td>3</td>
<td>not connected</td>
</tr>
<tr>
<td>4</td>
<td>not connected</td>
</tr>
<tr>
<td>5</td>
<td>1553 B bus redundant</td>
</tr>
<tr>
<td>6</td>
<td>1553 B bus prime return</td>
</tr>
<tr>
<td>7</td>
<td>not connected</td>
</tr>
<tr>
<td>8</td>
<td>not connected</td>
</tr>
<tr>
<td>9</td>
<td>1553 B bus redundant return</td>
</tr>
</tbody>
</table>

Unless otherwise agreed with the Prime Contractor, the remote terminal address definition shall be performed on a dedicated Cannon 9 S equipment connector, according to the following pin function:

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>remote terminal address bit n° 4 (MSB)</td>
</tr>
<tr>
<td>2</td>
<td>remote terminal address bit n° 3</td>
</tr>
<tr>
<td>3</td>
<td>remote terminal address bit n° 2</td>
</tr>
<tr>
<td>4</td>
<td>remote terminal address bit n° 1</td>
</tr>
<tr>
<td>5</td>
<td>remote terminal address bit n° 0 (LSB)</td>
</tr>
<tr>
<td>6</td>
<td>remote terminal address parity bit</td>
</tr>
<tr>
<td>7</td>
<td>secondary OV</td>
</tr>
<tr>
<td>8</td>
<td>secondary OV</td>
</tr>
<tr>
<td>9</td>
<td>not connected</td>
</tr>
</tbody>
</table>

Concerning remote terminal address definition pins (bits 4 to 0 and parity), a logical « 1 » level shall be obtained by floating the corresponding pin (no connection at harness connector level); adequate filtering shall be provided inside the unit on those signals. A logical « 0 » level shall be obtained by connecting the corresponding pin to the secondary OV pin at harness level; the current in each remote terminal address definition pin shall not exceed 10 mA when programmed to logical level « 0 ».

An implementation example of an address coding connector is shown in Figure 3.5-8. All Address and Parity lines have pull up resistors, so that a '0' on a line is coded by connecting it to common secondary return (secondary zero volt), as shown below. The type of Parity is odd.
Figure 3.5-9: 1553 Bus Nominal and Redundant Relationship

GDI-434/CREATED

The unit shall be compatible with the setup as defined in Figure 3.5-10.
3.5.5.2.1 BC/RT Test Requirements

3.5.5.2.1.1 Qualification Test

Several levels of 1553_B bus interfaces are considered at this level depending on the level of qualification of each "chip set" implemented in the unit (each 1553 function being split in 3 parts: One ASIC or equivalent in charge of protocol handling, one transceiver in charge of the electrical driver/reception function and one transformer)

A level: Both ASIC (or equivalent) and transceiver have already been qualified successfully in a space program towards the MIL 1553B standard validation test plan (refer to AD3)

B level: Only the ASIC (or equivalent) has been qualified.

C level: ASIC has not been qualified.
For each part assessed as already qualified, the sub contractor shall provide the qualification documentation and shall demonstrate the qualification completeness.

The tests corresponding to MIL-HDBK-1553 Section 100 RT validation test plan shall be performed for the unit validation (EQM or PFM), as defined in following requirements.

These tests shall be performed only in ambient conditions if qualification of the 1553B chip set has been demonstrated in an environment compatible to the GAIA unit one. If not these tests shall be performed during temperature qualification tests of the unit itself.

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1.1 Amplitude</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1.2 Rise time/ fall time</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1.3 Zero crossing stability</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1.4 Distortion, overshoot and ringing</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1.5 Output symmetry</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
### GDI-2468/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output characterisics</td>
<td>5.1.1.6</td>
<td>Output noise</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2469/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output characterisics</td>
<td>5.1.1.7</td>
<td>Output isolation</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2470/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output characterisics</td>
<td>5.1.1.8.1</td>
<td>Power ON/OFF noise</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2471/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output characterisics</td>
<td>5.1.1.8.2</td>
<td>Power ON response</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### GDI-2472/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output characterisics</td>
<td>5.1.1.9</td>
<td>Terminal response time (note 2)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Note 2**: This test is not applicable to BC.

### GDI-2473/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553</th>
<th>Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output characterisics</td>
<td>5.1.1.10</td>
<td>Frequency stability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### GDI-2474/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553 Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input characteristics</td>
<td>5.1.2.1.1 Zero crossing distortion</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2475/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553 Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input characteristics</td>
<td>5.1.2.1.2 Amplitude variations</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2476/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553 Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input characteristics</td>
<td>5.1.2.1.3.1 Trapezoidal</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2477/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553 Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input characteristics</td>
<td>5.1.2.1.3.2 Sinusoidal</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2478/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553 Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input characteristics</td>
<td>5.1.2.2 Common mode rejection</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

### GDI-2479/

<table>
<thead>
<tr>
<th>MIL-HDBK-1553 Section 100</th>
<th>Level A</th>
<th>Level B</th>
<th>Level C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input characteristics</td>
<td>5.1.2.3 Input impedance</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Note 1: Functional test through 1553B interface shall be performed.

### 3.5.5.2.1.2 Acceptance Test

For the acceptance test, only tests defined hereafter shall be applied whatever the heritage level is.

#### GDI-2485/

<table>
<thead>
<tr>
<th>Output characteristics</th>
<th>5.1.1.1</th>
<th>Amplitude</th>
<th>X</th>
</tr>
</thead>
</table>

#### GDI-2486/

<table>
<thead>
<tr>
<th>Output characteristics</th>
<th>5.1.1.2</th>
<th>Rise time/ fall time</th>
<th>X</th>
</tr>
</thead>
</table>

#### GDI-2487/

<table>
<thead>
<tr>
<th>Output characteristics</th>
<th>5.1.1.3</th>
<th>Zero crossing stability</th>
<th>X</th>
</tr>
</thead>
</table>

#### GDI-2488/

<table>
<thead>
<tr>
<th>Output characteristics</th>
<th>5.1.1.4</th>
<th>Distortion, overshoot and ringing</th>
<th>X</th>
</tr>
</thead>
</table>

#### GDI-2489/

<table>
<thead>
<tr>
<th>Output characteristics</th>
<th>5.1.1.5</th>
<th>Output symmetry</th>
<th>X</th>
</tr>
</thead>
</table>

#### GDI-2490/

<table>
<thead>
<tr>
<th>Output characteristics</th>
<th>5.1.1.6</th>
<th>Output noise</th>
<th>X</th>
</tr>
</thead>
</table>
3.5.5.3 Standard Balanced Digital link (SBDL)

**GDI-438/CREATED**

The SBDL link interface is dedicated to serial digital links or synchronisation signals. This link is based on the RS422 standard. The SBDL Link interface is shown in Figure 3.5-11.

![SBDL Link Diagram](image)

**Figure 3.5-11: SBDL Link**

Although the line is symmetrical the two wires are identified as true line and complementary line.

The true line is the non-inverted output of the driver.

The complementary line is the inverted output of the driver.

The status (Vdiff = Vtrue - Vcomp) of the signal is defined High (Logic “1”) when the true line has a positive « 1 » level w.r.t the ground and the complementary line has a « 0 » level versus the ground.

The low level of the SBDL (logic “0”) is conversely when the true line has a « 0 » level and the complementary line has a « 1 » level.
The contractor shall design his side of the Standard balanced Digital Link (SBDL) interface to be compliant to the characteristics as defined in Interface Datasheet "SBDL", Table 3.5-5 and Table 3.5-6 below.

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit type: CMOS RS422 line driver (complementary outputs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recommendation: HS-26C/CT/CLV31 RH ESD class 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transmission Type: Differential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Diff. output volt. Logic &quot;0&quot; (1): $-5.5 \text{ V} \leq V_{od} \leq -1.75 \text{ V}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Diff. output volt. Logic &quot;1&quot; (1): $+1.75 \text{ V} \leq V_{od} \leq +5.5 \text{ V}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Source impedance: 120 Ohm ± 5% incl. driver source impedance and series resistors (for 120 Ohm line adaptation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Rise and Fall time (2): $t_r, t_f \leq 20 \text{ ns for } T_b &gt; 200 \text{ ns}$, otherwise $0.1 \times T_b$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Short circuit current: Short circuit proof, max: 150 mA (each terminal to ground)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Leakage current $&lt; 100 \mu\text{A}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Common mode output $&lt; 3\text{V}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Fault voltage emission (3): 0 V to $+7 \text{ V}$</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance: $-0.5 \text{ V} \text{ to } +7 \text{ V}$ (through 1 KOhm)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>OFF state tolerance: OFF transmitter shall withstand an ON receiver even with failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>ON state tolerance: ON transmitter shall withstand an OFF receiver</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.5-5: SBDL Driver specification
### INTERFACE DATA SHEET

**IF Designation:** Standard Balanced Digital Link  
**IF-Code:** SBDL

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
</table>
| -14 | Circuit type: Differential CMOS RS422 line receiver  
Recommendation: HS-26C/CT/CLV32 RH ESD class 1 |
| -15 | Fail-safe: Receiver shall detect a static logic “1” level when inputs are in open circuit condition |
| -16 | Input impedance (4): DC: $\geq 6$ KOhm incl. input series resistors  
AC: 120 Ohm in series with 50 pF |
| -17 | Diff. input level Logic “0”: $-10$ V $\leq V_{id} \leq -0.6$ V |
| -18 | Diff. input level Logic “1”: $+0.6$ V $\leq V_{diff} \leq +10$V |
| -19 | Common mode range: $-4$V $\leq V \leq +7$V |
| -20 | Fault voltage emission (3): $-0.5$V to $+7$V (through 1 KOhm) A |
| -21 | Fault voltage tolerance: $-12$V $\leq V_{diff} \leq +12$V A |
| -22 | OFF-state tolerance: OFF receiver shall withstand an ON transmitter even with failure |
| -23 | ON-state tolerance: ON receiver shall withstand an OFF transmitter |
| -24 | Wiring Type (5): Twisted Shielded Pair (TSP) R |
| -25 | Shielding: Shield at backshell on driver and receiver side R |

**Notes:**

1. With load 6 KOhm; however, driver circuit shall provide +/-1.8V min when loaded with 100 Ohms assuming no output series resistors.
2. With load 120 Ohm.
3. Special attention has to be paid to failure modes of the interface circuit power supply.
4. Proposed input series resistors (Ris): 1 KOhm $\pm 1\%$
5. or TwinAx (TCX) (120 Ohm balanced shielded lines acc. ESA/SCC 3902/002)

Fault Voltages shall be verified by Worst Case Analysis.

---

**3.5.5.4 UART Serial Link (USL)**

UART's are used for digital transfer between units through a serial link (see Figure 3.5-12)

**GDI-450/Created**

*The UART RS-422 serial link shall be composed of two 2 signals, one Transmit Data Line (TD) and one Receive Data Line (RD) as seen from the OBC (see Figure 3.5-12).*
The UART RS-422 Serial Link Interface shall be implemented using Standard Balanced Link (SBDL) interface. The contractor shall design his part of the interface to be compliant to the characteristics as given by the Interface Data Sheet “SBDL”.

The contractor shall design his part of the UART RS-422 Serial Link interface to be compliant to the following data transmission characteristics:

- Asynchronous protocol (according to RS232 but SBDL signal-levels)
- Data flow control by software
- Start Bit
- 8 Data Bits
- no Parity Bit
- 1 Stop Bit
- Data Rate (each link): selectable 19.2k / 38.4k / 57.6k / 76.8k Bauds.

Figure 3.5-13 shows an example for data transmission via the UART Serial Link (AB hex):

When no data is being transmitted, the line status shall be "Logical 0".

The line status (TD, RD) of the Asynchronous protocol shall correspond to the SBDL signal levels as follows:

"Logical 0": SBDL true line at high level, comp line at low level.
"Logical 1": SBDL true line at low level, comp line at high level.
Figure 3.5-13: Example Data Transmission (Input/Output of RS-422)

Note: Figure 3.5-13 is an example for data transmission (signal level of non-inverting TRUE output/input of the RS-422 transmitter/receiver). The COMP output/input is inverted with respect to the above timing diagrams.

GDI-1274/Created

The OBC shall be able to send commands on the Transmit Data Line (TD) even during data reception on the Receive data Line (RD).

GDI-1275/Created

No data repetition mechanism in both directions shall be supported by the OBC and the user, respectively.

GDI-1276/Created

Command messsages sent by the OBC to the user and HK measurement data received by the OBC shall be transmitted in continuous blocks without time gaps between the bytes of a block.

3.5.5.5 Timing Pulses

3.5.5.5.1 Synchronisation or Datation Pulses (PPS)

These signals are used for synchronisation or datation purposes

GDI-460/Created

The Pulse Per Second (PPS) Interface shall be implemented using Standard Balanced Link (SBDL) interface. The contractor shall design his part of the interface to be compliant to the characteristics defined in Table 3.5-7 (Interface Data Sheet "PPS"): 
**INTERFACE DATA SHEET**

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>IF-Code: PPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Electrical Characteristics: SBDL Driver (1)</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Frequency: 1 Hz +/- 1%</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Jitter: &lt; 1.3 µs</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Duty Cycle: 50% +/- 5%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver. Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
<td>Electrical Characteristics: SBDL Receiver (1)</td>
<td></td>
</tr>
</tbody>
</table>

**Harness Specification**

-6 Wiring Type (2): Twisted Shielded Pair (TSP) R
-7 Shielding: Shield at backshell on driver and receiver side R

**Notes:**

1. Interface characteristics as defined in Interface Data Sheet "SBDL".
2. or TwinAx (TCX) (120 Ohm balanced shielded lines)

---

**Table 3.5-7: Pulse Per Second Interface Data Sheet**

GDI-462/CREATED

*The active level shall be High level*

GDI-463/CREATED

*The synchronisation edge shall be the rising edge*

GDI-464/CREATED

*The pulse width shall be ≥900 ns*

The synchronisation reference is the leading edge of the Pulse Per Second signal as defined in Figure 3.5-14 below. This point of time defines the time stamp.

**Figure 3.5-14: Pulse Per Second Synchronisation Reference**

3.5.5.5.2 **Synchronization Clock Interface (TBC)**

Interface details to be written. (TBC)
3.5.5.6 Housekeeping Analog Acquisitions

Analogue acquisition interfaces are used for the acquisition by the OBC of information from Users in the form of a voltage varying between two defined limits. This voltage is sampled on a regular basis, converted from analogue to digital and coded as an 11 or 12 bit word (unipolar or bipolar acquisition).

The interface shall consist of a differential link (single ended emitter, differential receiver). See Figure 3.5-15.

![Figure 3.5-15: Housekeeping Interface (differential link)](image)

3.5.5.6.1 Analogue Telemetry Acquisition (AN1)

Analogue Telemetry Acquisition -5V to +5V Interface.

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "AN1", Table 3.5-8 and Table 3.5-9 below.

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit type: Single ended driver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer: DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Zero reference: Signal ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Signal range: -5V to +5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Output impedance: ≤ 1 KOhm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Short circuit current: Short circuit proof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission: -12V to +12V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Fault voltage tolerance: -16.5V to +16.5V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>OFF-state tolerance: OFF driver shall withstand an ON receiver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>ON-state tolerance: ON driver shall withstand an OFF receiver</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.5-8: Analog Driver specification 1
**INTERFACE DATA SHEET**

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-11</td>
<td>Circuit type: Differential receiver with multiplexed input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Transfer: DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Acquisition range: -5V to +5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Absolute accuracy (1): ≤ 1 % FSR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Noise: &lt; 8mV rms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| -16 | Input differential impedance: During acquisition: ≥ 1 MOhm  
Outside acquisition: ≥ 1 MOhm  
Switched OFF receiver (unpowered): ≥ 1 KOhm |      |      |
| -17 | Input capacitance: < 250 pF during acquisition  
< 180 pF otherwise |      |      |
| -18 | Receiver bandwidth: ≤ 500Hz @ 3dB |      |      |
| -91 | Acquisition rate: consecutive and different acquisitions every 128 µsec with full performance |      |      |
| -20 | Fault voltage emission: -16 V to +16 V (through 1.5 KOhm) | A    |      |
| -21 | Fault voltage tolerance: -14V to +14V | A    |      |
| -22 | OFF-state tolerance: OFF receiver shall withstand an ON driver |      |      |

**Harness Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Wiring Type: Twisted Shielded Pair (TSP)</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-23</td>
<td>Shielding: Shield at backshell on driver and receiver side</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

(1) incl. offset-, gain-, nonlinearity-, drift- errors; FSR: full scale range.

Table 3.5-9: Analog Receiver specification 1

3.5.5.6.2 Analogue Telemetry Acquisition (AN2)

GDI-1210/CREATED

Analogue Telemetry Acquisition 0V to +5V Interface.

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "AN2", Table 3.5-10 and Table 3.5-11 below.
<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit type: Single ended driver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer: DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Zero reference: Signal ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Signal range: 0 V to +5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Output impedance: (\leq 1\ \text{KOhm})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Short circuit current: Short circuit proof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission: -12V to +12V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Fault voltage tolerance: -16.5V to +16.5V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>OFF-state tolerance: OFF driver shall withstand an ON receiver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>ON-state tolerance: ON driver shall withstand an OFF receiver</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.5-10: Analog Driver specification 2
### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-11</td>
<td>Circuit type: Differential receiver with multiplexed input</td>
</tr>
<tr>
<td>-12</td>
<td>Transfer: DC coupled</td>
</tr>
<tr>
<td>-13</td>
<td>Acquisition range: 0V to +5V</td>
</tr>
<tr>
<td>-14</td>
<td>Absolute accuracy (1): ≤ 1 % FSR</td>
</tr>
<tr>
<td>-15</td>
<td>Noise: &lt; 8mV rms</td>
</tr>
<tr>
<td>-16</td>
<td>Input differential impedance: During acquisition: ≥ 1 MOhm Outside acquisition: ≥ 1 MOhm Switched OFF receiver (unpowered): ≥ 1 KOhm</td>
</tr>
<tr>
<td>-17</td>
<td>Input capacitance: ≤ 1.2 uF</td>
</tr>
<tr>
<td>-18</td>
<td>Receiver bandwidth: ≤ 500Hz @ 3dB</td>
</tr>
<tr>
<td>-19</td>
<td>Acquisition rate: consecutive and different acquisitions every 128 µsec with full performance</td>
</tr>
<tr>
<td>-20</td>
<td>Fault voltage emission: -16 V to +16 V (through 1.5 KOhms) A</td>
</tr>
<tr>
<td>-21</td>
<td>Fault voltage tolerance: -14V to +14V A</td>
</tr>
<tr>
<td>-22</td>
<td>OFF state tolerance: OFF receiver shall withstand an ON driver</td>
</tr>
</tbody>
</table>

### Harness Specification

| -23 | Wiring Type: Twisted Shielded Pair (TSP) R |
| -24 | Shielding: Shield at backshell on driver and receiver side R |

Notes:

(1) incl. offset-, gain-, nonlinearity-, drift- errors; FSR: full scale range.

---

**Table 3.5-11: Analog Receiver specification 2**

**3.5.5.6.3 Analogue Telemetry Acquisition (AN3)**

GDI-1211/CREATED

Analogue Telemetry Acquisition -10V to +10V Interface.

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "AN3", Table 3.5-12 and Table 3.5-13 below.

---

### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit type: Single ended driver</td>
</tr>
<tr>
<td>-2</td>
<td>Transfer: DC coupled</td>
</tr>
<tr>
<td>-3</td>
<td>Zero reference: Signal ground</td>
</tr>
<tr>
<td>-4</td>
<td>Signal range: -10V to +10V</td>
</tr>
<tr>
<td>-5</td>
<td>Output impedance: ≤ 1 KOhm</td>
</tr>
<tr>
<td>-6</td>
<td>Short circuit current: Short circuit proof</td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission: -12V to +12V A</td>
</tr>
<tr>
<td>-8</td>
<td>Fault voltage tolerance: -16.5V to +16.5V A</td>
</tr>
<tr>
<td>-9</td>
<td>OFF-state tolerance: OFF driver shall withstand an ON receiver</td>
</tr>
<tr>
<td>-10</td>
<td>ON-state tolerance: ON driver shall withstand an OFF receiver</td>
</tr>
</tbody>
</table>

**Table 3.5-12: Analog Driver specification 3**
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Table 3.5-13: Analog Receiver specification 3

3.5.5.7 Temperature Acquisitions (ANY, ANP, ANF, ANT)

These acquisitions are used for thermal control (control and monitoring) and also for unit monitoring. There are four options:

- **Type 1 (IF-Code "ANY")**: Thermistor type: YSI-44907/-44908 (10KOhm @25°C)
- **Type 2 (IF-Code "ANP")**: Thermistor type: PT-1000 (1000 Ohm @ 0°C)
- **Type 3 (IF-Code "ANF")**: Thermistor type: Fenwell (15KOhm @25°C)
- **Type 4 (IF-Code "ANT")**: Thermistor type: PT-200 (200 Ohm @ 0°C)

Note: For use with thrusters and main engine only.

GDI-482/CREATED

The signal shall be transmitted via twisted shielded pairs. The cable shield is connected at both sides of the interface to chassis ground.

GDI-483/CREATED

The temperature acquisition interface circuitry, as well as the interconnecting harness, shall be as shown in Figure 3.5-16.
3.5.5.7.1 Thermistor Type1: YSI-44907/-44908 (ANY)

Temperature Acquisition Type 1: YSI 44907/YSI-44908 (ANY) Interface.

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "ANY", Table 3.5-14 and Table 3.5-15 below.

Table 3.5-14: Option 1: Source Circuit Specification
### Table 3.5-15: Option 1: Receiver Circuit Specification

#### 3.5.5.7.2 Thermistor Type 2: PT-1000 (ANP)

**GDI-487/CREATED**

Temperature Acquisition Type 2: PT-1000 (ANP) Interface.

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "ANP", Table 3.5-16 and Table 3.5-17 below.

<table>
<thead>
<tr>
<th>Req</th>
<th>Circuit Type</th>
<th>Operating temp range</th>
<th>Fault voltage tolerance</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Thermistor PT1000 (1KOhm @ 0°C), two wire connection</td>
<td>-160°C to +150 deg C</td>
<td>-16.5 V to +16.5 V</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer</td>
<td>DC coupled</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Integrated Interface Data Sheet (IIDS)**

<table>
<thead>
<tr>
<th>IF Designation</th>
<th>Temperature Acquisition Type 2: PT-1000</th>
<th>IF-Code</th>
<th>ANP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req</td>
<td>Driver Circuit Specification</td>
<td>Ver.</td>
<td>Iss.</td>
</tr>
<tr>
<td>-1</td>
<td>Circuit Type</td>
<td>Thermistor PT1000 (1KOhm @ 0°C), two wire connection</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer</td>
<td>DC coupled</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.5-16: Option 2: Source Circuit Specification
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Table 3.5-17: Option 2: Receiver Circuit Specification

3.5.5.7.3 Thermistor Type 3: Fenwall (ANF)

GDI-1216/CREATED

Temperature Acquisition Type 3: Fenwall (ANF) Interface.

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "ANF", Table 3.5-18 and Table 3.5-19 below.

Table 3.5-18: Option 3: Source Circuit Specification
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Table 3.5-19: Option 3: Receiver Circuit Specification

3.5.5.7.4 Thermistor Type 4: PT-200 (ANT)

GDI-2136/CREATED

Temperature Acquisition Type 4: PT-200 (ANT) Interface.

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "ANT", Table 3.5-20 and Table 3.5-21 below.

Table 3.5-20: Option 4: Source Circuit Specification
IF Designation: Temperature Acquisition Type 4: PT-200

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>Circuit Type</td>
<td>Conditioning circuitry</td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Transfer</td>
<td>DC coupled</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Measurement range</td>
<td>-200°C to +850°C (equivalent to 39 Ohm to 781 Ohm)</td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Resolution</td>
<td>at least 0.5K / LSB</td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Measurement chain accuracy</td>
<td>better than +/- 5K</td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Measurement current</td>
<td>≤ 300 µA (permanent)</td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Acquisition rate</td>
<td>consecutive and different acquisitions every 128 µsec with full performance</td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Receiver bandwidth</td>
<td>≤ 350 Hz @ 3dB</td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Fault voltage tolerance</td>
<td>-14V to +14V</td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Fault voltage emission</td>
<td>-16 V to +16 V (through 1.5 KOhms)</td>
<td></td>
</tr>
</tbody>
</table>

Harness Specification

-16 Wiring Type: Twisted Shielded Pair (TSP)

-17 Shielding: Shield at backshell on driver and receiver side

Notes:

Fault Voltages shall be verified by Worst Case Analysis.

Table 3.5-21: Option 4: Receiver Circuit Specification

3.5.5.8 Relay Commands (SHP, EHP, SLP)

The purpose of the Standard High Power On/Off Command interface is to transfer a pulse from the driver to the user, which can be used to switch/drive high power loads such as relays or optocoupler, e.g. for decentralised power switching or unit configuration purposes.

**GDI-493/CREATED**

*The High Power On/Off Command source shall be referenced to driver signal ground.*

**GDI-494/CREATED**

*The High Power On/Off Command receiver shall be isolated from any user electrical reference.*

**GDI-495/CREATED**

*The High Power On/Off Command receiver shall be equipped with appropriate circuits in order to suppress any switching transients, in particular those due to inductive loads such as relays, which may cause the current drive capability, or the over voltage capability of the source to be exceeded.*

**GDI-496/CREATED**

*The High Power On/Off Command source shall be short circuit proof for short circuits to source or receiver signal ground and structure.*

**GDI-1220/CREATED**

*The Standard High Power On/Off Command interface shall implement diodes at the level of the driver (e.g. by means of 2 serial diodes or equivalent) to allow unit external Or-ing of commands.*

3.5.5.8.1 Standard High Power On/Off Command (SHP)

**GDI-497/CREATED**

*Standard High Power On/Off Command:*
The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "SHP", Table 3.5-22 and Table 3.5-23 below.

### Table 3.5-22: Standard High Power Command Source Specification

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type: Single ended driver return over wire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Signal Transfer: DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Zero Reference: OBC signal ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Output Voltage: Active level: 22 V to 28V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Quiescent level: 0V to 0.5V with a leakage current of max. 100µA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Pulse Width: 32 to 64ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Output Voltage Rise / Fall Times: $t_{\text{rise}} \leq 500\mu s$ $t_{\text{fall}} \leq 1000\mu s$ when connected to load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Current Drive Capability: $\geq 180\text{mA}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Short Circuit Output Current: $\leq 400\text{mA}$ during pulse, after that $\leq 100\mu A$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Output Impedance (1): $100\text{K} \Omega \pm 10%$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance: -2V to +35V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Fault voltage emission: 0V to +32V</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

**Harness Specification**
-21 Wiring Type: Twisted Shielded Pair (TSP) R
-22 Shielding: Shield at backshell on driver and receiver side R

**Notes:**
1. If circuit is powerless or output voltage is off.
2. In case of optocoupler as receiver.

Fault Voltages shall be verified by Worst Case Analysis.

### Table 3.5-23: Standard High Power Command Receiver Specification

Relay commands are used for decentralised power switching or unit configuration purposes. See Figure 3.5-17.
3.5.5.8.2 Extended High Power On/Off Command (EHP)

Extended High Power On/Off Command:

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet “EHP”, Table 3.5-24 and Table 3.5-25 below.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Driver Circuit Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type: Single ended driver return over wire</td>
</tr>
<tr>
<td>-2</td>
<td>Signal Transfer: DC coupled</td>
</tr>
<tr>
<td>-3</td>
<td>Zero Reference: OBC signal ground</td>
</tr>
<tr>
<td>-4</td>
<td>Output Voltage: Active level: 22V to 28V</td>
</tr>
<tr>
<td>-5</td>
<td>Quiescent level: 0V to 0.5V with a leakage current of max. 100µA</td>
</tr>
<tr>
<td>-6</td>
<td>Pulse Width: 512 ms</td>
</tr>
<tr>
<td>-7</td>
<td>Output Voltage Rise / Fall Times: $t_{rise} \leq 500\mu s$, $t_{fall} \leq 1000\mu s$ when connected to load</td>
</tr>
<tr>
<td>-8</td>
<td>Current Drive Capability: $\geq 360mA$</td>
</tr>
<tr>
<td>-9</td>
<td>Short Circuit Output Current: $\leq 600mA$ during pulse, after that $\leq 100\mu A$</td>
</tr>
<tr>
<td>-10</td>
<td>Output Impedance (1): 100KOhm ± 10%, &lt;50pf</td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance: -2V to +35V</td>
</tr>
<tr>
<td>-12</td>
<td>Fault voltage emission: 0V to +32V</td>
</tr>
</tbody>
</table>

Table 3.5-24: Extended High Power Command Source Specification
### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-13</td>
<td>Circuit Type (2):</td>
<td>relay</td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Transfer:</td>
<td>DC coupled</td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Levels: (at unit input terminals)</td>
<td>activated at ( \leq 18)V and Pulse Width ( \leq 30)ms (for max. current of 360mA)</td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>Quiescent level:</td>
<td>no activation for ( \leq 100) µA</td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>Max. Current:</td>
<td>(&lt; 360)mA</td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>Filter (2):</td>
<td>Pulses up to 10V, 1ms shall not activate the switch function</td>
<td></td>
</tr>
<tr>
<td>-19</td>
<td>Fault voltage emission:</td>
<td>0V to +32V</td>
<td>A</td>
</tr>
<tr>
<td>-20</td>
<td>Fault voltage tolerance:</td>
<td>-2V to +35V</td>
<td>A</td>
</tr>
</tbody>
</table>

#### Harness Specification

| -21 | Wiring Type:                    | Twisted Shielded Pair (TSP) | R |
| -22 | Shielding:                     | Shield at backshell on driver and receiver side | R |

**Notes:**
- (1): If circuit is powerless or output voltage is off.
- (2): In case of optocoupler as receiver.

Fault Voltages shall be verified by Worst Case Analysia.

---

**Table 3.5-25: Extended High Power Command Receiver Specification**

### 3.5.5.8.3 Standard Low Power On/Off Commands (SLP)

The purpose of the Low Power On/Off Commands interface is to transfer a pulse from the driver to the user.

**GDI-509/CREATED**

*The Low Power On/Off Command source shall be referenced to driver signal ground.*

**GDI-510/CREATED**

*The Low Power On/Off Command receiver shall be isolated from any user electrical reference.*

**GDI-511/CREATED**

*The Low Power On/Off Command receiver shall be equipped with appropriate circuits in order to suppress any switching transients, in particular those due to inductive loads such as relays, which may cause the current drive capability, or the over voltage capability of the source to be exceeded.*

**GDI-512/CREATED**

*The Low Power On/Off Command source shall be short circuit proof for short circuits to source or receiver signal ground and structure.*

**GDI-1252/CREATED**

*Standard Low Power On/Off Command:*

*The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "SLP", Table 3.5-26 and Table 3.5-27 below.*
### Table 3.5-26: Standard Low Power Command Source Specification

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Single ended driver return over wire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Signal Transfer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Zero Reference:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OBC signal ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Output Voltage:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Active level: 2.5V to 25.1V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Quiescent level:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0V to 0.5V with a leakage current of max. 100µA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Pulse Width:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32 to 64ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Output Voltage Rise / Fall Times:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t_{rise}, t_{fall} \leq 500\mu s )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Current Drive Capability:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \geq 100\text{mA} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Short Circuit Output Current:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \leq 150\text{mA} ) during pulse, after that ( \leq 100\mu\text{A} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Output Impedance (1):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100KOhm ( \pm 10% )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-2V to +35V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Fault voltage emission:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0V to +32V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Harness Specification

- **Wiring Type:** Twisted Shielded Pair (TSP)
- **Shielding:** Shield at backshell on driver and receiver side

**Notes:**
1. If circuit is powerless or output voltage is off.
2. In case of optocoupler as receiver.

**Fault Voltages shall be verified by Worst Case Analysis.**

### Table 3.5-27: Standard Low Power Command Receiver Specification

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-13</td>
<td>Circuit Type (2):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Transfer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Levels:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(at unit input terminals)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>activated at &gt;2.5V and Pulse Width ( \leq 30\text{ms} ) (for max. current of 100mA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>Quiescent level:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>no activation for ( \leq 100\mu\text{A} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>Max. Current:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \leq 150\text{mA} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>Filter (2):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pulses up to 2V, 1ms shall not activate the switch function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-19</td>
<td>Fault voltage emission:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0V to +7V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-20</td>
<td>Fault voltage tolerance:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.5V to +7V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- **Harness Specification**

**3.5.5.9 Relay Status Acquisitions (RSA)**

The status is provided by users in the form of a relay dry contact or optocoupler.

**GDI-1229/CREATED**

*The open/closed status of a relay/switch contact (or optocoupler) shall be acquired via the Relay Status Acquisition inputs for conversion into one bit being "1" or "0", respectively using a pull-up resistor. The comparing input is referenced to signal ground. A closed contact corresponds to a "0" level and an open contact to a "1" level.*

Figure 3.5-18 below presents the principle of relay status acquisitions.
**Figure 3.5-18: Principle of Relay Status Acquisition**

**GDI-516/CREATED**

Relay Status Acquisition

*The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet “RSA”, Table 3.5-28 and Table 3.5-29.*

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Relay Status Acquisition</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit type:</td>
<td>Relay contact (floating) or optocoupler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer</td>
<td>DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Closed Status:</td>
<td>Relay: Resistance ≤ 50 Ohm Optocoupler: voltage level &lt; 1.0 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Open Status:</td>
<td>Resistance ≥ 1 Mohm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Current capability:</td>
<td>≥ 10 mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Fault voltage tolerance:</td>
<td>-16.5 V to +16.5 V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission:</td>
<td>Not applicable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3.5-28: Relay Status Acquisition Source Specification:**
### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-8</td>
<td>Circuit type: Single ended with pull-up resistor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Transfer: DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Input voltage threshold (1): 1.4 to 3.3V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Output voltage: 3.7 to 5.5V via series resistor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Output current: 0.5 to 1.0 mA (for switch resistance 0 to 50 Ohm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Fault voltage emission: -16 V to +16 V (through 1.5 KOhm)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Fault voltage tolerance: -3 V to +14 V</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

**Harness Specification**

-15 Wiring Type: Twisted Pair (TP) | R

**Notes:**

1. The receiver shall detect a closed switch for any switch resistance in the range 0 to 50 Ohm.
2. The receiver shall detect an open switch for any resistance greater than 1 MOhm.

Fault Voltages shall be verified by Worst Case Analysis.

---

### 3.5.5.10 COMMS Interfaces (TT&C)

### 3.5.5.10.1 X-Band Digital TC Channel Interface (XTC)

**GDI-527/CREATED**

> The X-Band Digital TC Channel shall consist of 3 signals. (For these signals the following abbreviations shall be used):

- Data (DCD)
- Clock (DCC)
- Data Valid (DCE) [Enable/Channel Active]

**GDI-1283/CREATED**

> The X-Band Digital TC Channel shall be transmitted via Standard Balanced Digital Link Interfaces (TBC) as defined in Section 3.5.5.3.

For information the relationship between the Data Valid, Clock and Data signals within the X-Band XTC channel is as shown in the typical timing diagram shown in Figure 3.5-19.
Acquisition Sequence

Non modulated

RF-Carrier

Command Data Train

Lock Status

Data Valid

Clock

Data NRZ-L

B0 B1 Bn

T3 T1

Tc Ts Th

T2 T4

Figure 3.5-19: X-Band Digital TC Timing Diagram

T1 =< 128 bit
T2 between 1 bit and 128 bit
T3 = 500ms
T4 = 100ms
Tc = 250µs +/- 5% (for a 4kbps uplink)
Ts = 10µs min
Th = 20µs min

Note 1: The clock is running as soon as the LOCK STATUS is "high" and it will run until LOCK STATUS falls to "low".
Note 2: The bit clock stability shall be better than +/- 5% as soon as DATA VALID is "high" and until DATA VALID falls to "low".
Note 3: The ESA standard requires an acquisition sequence of 128 bits. This value can be increased by adding an idle sequence (min. 8 bits) after the acquisition sequence.

3.5.5.10.2 X-Band Receiver Lock Status Interface (RLS)
The Receiver Lock Status Signal is issued by the X-Band Transponder and will be acquired by the OBC.

GDI-535/CREATED

The X-Band Receiver Lock Status signal shall be transmitted via Standard Digital Link interface (TBC) as defined in Section 3.5.5.3.
3.5.5.10.3  X-Band Digital TM Channel Interface (XTM)

GDI-538/CREATED

The X-Band Digital TM Channel shall consist of 2 signals. (For these signals the following abbreviations shall be used):

- Data (DMD)
- Clock (DMC)

GDI-539/CREATED

The X-Band Digital TM channel shall be transmitted via Standard Balanced Digital Link interfaces (TBC) as defined in Section 3.5.5.3.

3.5.5.11  Pyrotechnics (PYR)

3.5.5.11.1  General Concept

GDI-1255/CREATED

Items which require pyrotechnic release shall incorporate Electro-Explosive Devices (EED’s) as an integral part of the item.

GDI-1256/CREATED

All EED’s shall be initiated via the spacecraft dedicated pyrotechnic circuitry.

GDI-1257/CREATED

Only qualified initiators shall be accepted for use, subject to Prime/ESA approval.

GDI-1258/CREATED

Only one firing command to a single filament shall be provided at a time.

GDI-1259/CREATED

Redundancy shall be provided for each function by duplication up to at least the initiators.

GDI-1260/CREATED

The Pyro electronic interface, as well as the interconnecting harness including Antistatic Resistor, shall be as shown in Figure 3.5-20. (The safe plug configuration is indicated by dashed lines.)

GDI-2701/

Nominal and redundant pyrotechnic items shall be procured from 2 separate batches.
3.5.5.11.2 EED Interface Characteristics

GDI-1264/CREATED

Pyro Firing Characteristics

*The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet “PYR”, Table 3.5-30.*

---

**INTERFACE DATA SHEET**

<table>
<thead>
<tr>
<th>Req</th>
<th>Source Circuit Specification</th>
<th>IF-Code: PYR</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Firing Pulse Duration: (24 ± 2)ms</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Repetition Rate: &gt; 100ms</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Firing Current: 4.5A &lt; I_{fire} &lt; 6.0A</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Grounding Resistor: 1MOhm to structure ground</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-5</td>
<td>Max No-Fire Current: 1A for 5 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>All Fire Current: 4.0A within 20msec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Input Resistance: R_i &lt; 1.3Ohm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Isolation Resistance: &gt; 2MOhm at 250±5% VDC for &gt; 15s</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Harness Specification**

| -9  | Wiring Type: Twisted Shielded Pair (TSP) | R     |
| -10 | Antistatic Resistor: 300Ohm < R_{AS} < 390Ohm |     |

**Notes:**

(1) Applicable for maximum drive/sink current of 200\(\mu\)A
(2) Between filaments and EED-case before firing
(3) Implemented in the pyro harness (between Squib and Safe/Arm plug)

Fault Voltages shall be verified by Worst Case Analysis.
3.5.5.11.3 Shape Memory Device Interface (SMD)

GDI-2163/CREATED

SMD Firing Characteristics:

The contractor shall design their side of the interface to be compliant to the characteristics as defined in Interface Datasheet "SMD", Table 3.5-31.

<table>
<thead>
<tr>
<th>Source Circuit Specification</th>
<th>Page 1 / 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF Designation:</td>
<td>Shape Memory Device Interface</td>
</tr>
<tr>
<td>Actuation Pulse Duration:</td>
<td>40ms</td>
</tr>
<tr>
<td>Repetition Rate:</td>
<td>N/A</td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>5.0A max</td>
</tr>
<tr>
<td>Grounding Resistor:</td>
<td>TBD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Receiver Circuit Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max No-Actuation Current:</td>
<td>TBD</td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>$I_{\text{actuate}} &lt; 5.0A \text{ for } 40\text{ms}$</td>
</tr>
<tr>
<td>Input Resistance:</td>
<td>$4.1 &lt; R_i &lt; 9 \text{ Ohms}$</td>
</tr>
<tr>
<td>Isolation Resistance:</td>
<td>TBD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harness Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring Type:</td>
<td>Twisted Shielded Pair (TSP)</td>
</tr>
<tr>
<td>Antistatic Resistor:</td>
<td>TBD</td>
</tr>
</tbody>
</table>

Table 3.5-31: Shape Memory Device Characteristics

3.5.5.11.4 Motor Actuator Device Interface (MDD)

GDI-2161/Created

Motor Actuator Characteristics:

The contractor shall design their side of the interface to be compliant to the characteristics as defined in Interface Datasheet "MDD", Table 3.5-32.

<table>
<thead>
<tr>
<th>Source Circuit Specification</th>
<th>Page 1 / 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>IF Designation:</td>
<td>Motor Drive Device Interface</td>
</tr>
<tr>
<td>Actuation Pulse Duration:</td>
<td>Commandable to maximum 2 sec</td>
</tr>
<tr>
<td>Repetition Rate:</td>
<td>N/A</td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>$0.3A &lt; I_{\text{actuate}} &lt; 1.0A$</td>
</tr>
<tr>
<td>Grounding Resistor:</td>
<td>TBD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Receiver Circuit Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max No-Actuation Current:</td>
<td>TBD</td>
</tr>
<tr>
<td>Actuation Current:</td>
<td>1.0A max over 2sec</td>
</tr>
<tr>
<td>Input Resistance:</td>
<td>$2.0 &lt; R_i &lt; 20 \text{ Ohm}$</td>
</tr>
<tr>
<td>Isolation Resistance:</td>
<td>TBD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harness Specification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring Type:</td>
<td>Twisted Shielded Pair (TSP)</td>
</tr>
<tr>
<td>Antistatic Resistor:</td>
<td>TBD</td>
</tr>
</tbody>
</table>

Table 3.5-32: Motor Actuator Device Characteristics
3.5.5.12 Digital Bi-Level TM Acquisitions (BLD)

GDI-523/CREATED

Each bi-level digital channel shall be used to acquire one of a number of discrete status signals from the OBC users.

GDI-1232/CREATED

The OBC shall acquire via the Bi-Level Digital Acquisition inputs the "High"/"Low" status of a user for conversion into one bit being "1" or "0", respectively.

GDI-1233/CREATED

Each channel shall be allocated to a specific bit position within an 8-bit telemetry word in such a way, that the channel which has the lowest address number is put at the MSB location (bit 0).

GDI-524/CREATED

Bi-level Digital Interface

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "BLD", Table 3.5-33 and Table 3.5-34.

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>IF Designation: BI-Level TM Acquisition</th>
<th>IF-Code: BLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit type: Single ended</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer</td>
<td>DC coupled</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Low Level Output Voltage</td>
<td>0V ≤ VOL ≤ 0.5V (Logical &quot;0&quot;)</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>High Level Output Voltage</td>
<td>4.5V ≤ VOH ≤ 5.5V (Logical &quot;1&quot;)</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Output Impedance:</td>
<td>≤ 7.5KOhm</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Fault voltage tolerance:</td>
<td>-16.5V to +16.5V</td>
<td>A</td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission:</td>
<td>-1V to +12V</td>
<td>A</td>
</tr>
</tbody>
</table>

Table 3.5-33: Bi-level Digital Source Specification:
Table 3.5-34: Bi-level Digital Receiver Specification:

### 3.5.5.13 AOCS Interfaces

**GDI-1775/CREATED**

The driver function shall implement an arming and firing mechanism to avoid an FCV or LV command activation in case of single failure or inadvertent command.

**GDI-1776/CREATED**

The arming and firing commands shall be implemented by segregated function.

**GDI-1777/CREATED**

There shall be no failure propagation from the driver function to any PT, LV or FCV.

**GDI-1778/CREATED**

The Driver shall implement free wheeling diodes in the electrical command I/F’s with the FCV and LV.

### 3.5.5.14 Propulsion Interfaces

**GDI-1287/CREATED**

The Latch Valve Command outputs shall provide redundant freewheeling diodes at the output lines.

**GDI-1288/CREATED**

Each Latch Valve Command interface, main and redundant, shall be able to be cross-strapped with the same Latch Valve coil interface. Therefore protection features shall be implemented to avoid failure propagation between the main and the redundant command type interface respectively.
3.5.5.14.1.1 Latch Valve Commands (LVC)

**GDI-1289/CREATED**

The contractor shall design his part of the Latch Valve Open / Close Command interface to be compliant to the characteristics as defined in Table 3.5-35. (Interface Data Sheet "LVC"; Driver: OBC, Receiver: Latch-Valve):

**INTERFACE DATA SHEET**

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type</td>
<td>Single Ended Driver</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer</td>
<td>DC Coupled</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Switching Voltage</td>
<td>28V ± 10%</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Quiescent Voltage</td>
<td>0V ± 0.5V</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Output Current Capability</td>
<td>≥ 1.1A</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Pulse Duration</td>
<td>50 to 100ms (to be confirmed by supplier)</td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Fault Voltage Tolerance</td>
<td>0V to 40V up to 1sec (single pulse)</td>
<td>A</td>
</tr>
<tr>
<td>-8</td>
<td>Fault Voltage Emission</td>
<td>0V to 40V</td>
<td>A</td>
</tr>
</tbody>
</table>

**Req Receiver Circuit Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9</td>
<td>Circuit Type: Valve coil (floating)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Pull in voltage (1): &lt; 22VDC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Input voltage quiescent: &lt; 0.5VDC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Response Time: ≤ 20ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Open/Close Coil Resistance (DC) (2): 60 to 380 Ohms (to be confirmed by supplier)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Open/Close Coil Inductance: 250 to 750mH (to be confirmed by supplier)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Isolation: ≥ 1Mohm (switching voltage to structure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>No change of state voltage: 32V for up to 100µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>Max Fault Voltage Tolerance: 40V applied for up to 1s</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>Max Fault Voltage Emission: 0V to 40V</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

**Harness Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Wiring Type (3): Twisted Shielded Pair (TSP)</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
<td>Shielding: Shield at back shell on driver/at structure on receiver side</td>
<td>R</td>
</tr>
</tbody>
</table>

**Notes:**

1. The latch valve shall latch safely for the given pulse
2. Supplier to state nominal value and tolerance at ambient conditions.
3. One TSP for OPEN, one TSP for CLOSE, on latch valve flying leads of 1m length

Fault voltages shall be verified by WCA.

---

Table 3.5-35: Latch Valve Interface Specification:

3.5.5.14.1.2 Latch Valve Status Interface (LVS)

**Latch Valve Status**

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "RSA", Table 3.5-28 and Table 3.5-29.
3.5.5.14.2 Flow Control Valve Interfaces (FCV)

GDI-1436/CREATED

The Flow Control Valve Command outputs shall provide redundant freewheeling diodes at the output lines.

GDI-1437/CREATED

The contractor shall design his part of the Flow Control Valve Command interface to be compliant to the characteristics as defined in Table 3.5-36. (Interface Data Sheet "FCV"; Driver: OBC, Receiver: Flow Control Valve):

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type</td>
<td>Single Ended Driver</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer</td>
<td>DC Coupled</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Active (On-time) Voltage</td>
<td>$28\text{V} \pm 4\text{V}$</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Quiescent (Off-time) Voltage</td>
<td>$0\text{V} \pm 1\text{V}$</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Pulse Duration (on-time)</td>
<td>Programmable in the range: 5ms to continuous</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Rise/Fall times (10-90%)</td>
<td>$\text{T}_{\text{rise, fall}} \leq 1\text{ms}$</td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Fault Voltage Tolerance</td>
<td>$0\text{V} \text{ to } 40\text{V}$</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Fault Voltage Emission</td>
<td>$0\text{V} \text{ to } 42\text{V}$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9</td>
<td>Circuit Type</td>
<td>Valve coil (floating)</td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Pull in voltage (1):</td>
<td>$\leq 22\text{VDC}$</td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Drop Out Voltage (2):</td>
<td>$&gt; 3\text{VDC}$</td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Response Time</td>
<td>$&lt; 20\text{ms}$</td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Max Pulse Duration (3):</td>
<td>continuous</td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Coil Resistance (4):</td>
<td>60 to 380 Ohms (to be confirmed by supplier)</td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Coil Inductance (4):</td>
<td>250 to 750mH (to be confirmed by supplier)</td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>No change of state voltage:</td>
<td>$42\text{V}$ for up to $100\mu\text{s}$</td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>Insulation Resistance (Coil to Case):</td>
<td>$&gt; 100 \text{Mohm (at 500V DC } \pm 10% \text{ and 21°C } \pm 3\text{°C})}$</td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>Max Fault Voltage Tolerance</td>
<td>$0\text{V} \text{ to } 42\text{V}$</td>
<td></td>
</tr>
<tr>
<td>-19</td>
<td>Max Fault Voltage Emission</td>
<td>$0\text{V} \text{ to } 40\text{V}$</td>
<td></td>
</tr>
</tbody>
</table>

Harness Specification

-19 | Wiring Type (3):              | Twisted Shielded Pair (TSP) |
-20 | Shielding:                    | Shield at back shell on driver/at structure on receiver side |

Notes:

1. Thruster FCV must be fully open at this voltage
2. Thruster FCV must remain open down to this voltage
3. Thruster FCV must withstand the on-time voltage range for this duration
4. Supplier to state nominal value and tolerance at ambient conditions.

Fault voltages shall be verified by WCA

Table 3.5-36: Flow Control Valve Interface Specification:
3.5.5.14.3 Pressure Transducer Interface's (PTS, PTA)

3.5.5.14.3.1 Pressure Transducer Acquisition Interface (PTA)

GDI-1590/CREATED

Internal test acquisitions shall be provided to allow the OBC processor module to check the health of the reference voltages and the good functioning of the analogue/digital-converter.

GDI-1591/CREATED

Pressure Transducer Acquisition Interface (PTA):

The contractor shall design his part of the interface to be compliant to the characteristics as defined in Table 3.5-37 (Interface Data Sheet “PTA”):
### INTERFACE DATA SHEET

**IF Designation:** Pressure Transducer Acquisition Interface (0V to +5V)  
**IF-Code:** PTA

**Driver Circuit Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Circuit Type</th>
<th>Transfer</th>
<th>Zero Reference</th>
<th>Signal Range</th>
<th>Common Mode Voltage</th>
<th>Output Impedance</th>
<th>Short Circuit Current</th>
<th>Fault Voltage Emission</th>
<th>Fault Voltage Tolerance</th>
<th>OFF State Tolerance</th>
<th>ON State Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Single Ended Driver</td>
<td>DC Coupled</td>
<td>Signal Ground</td>
<td>0V to +5V (± 1)</td>
<td>0V to +4V</td>
<td>≤ 1kΩhm</td>
<td>Short Circuit Proof</td>
<td>-12V to +12V</td>
<td>-16.5V to +16.5V</td>
<td>OFF driver shall withstand an ON receiver</td>
<td>ON driver shall withstand an OFF receiver</td>
</tr>
<tr>
<td>-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>-7</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Receiver Circuit Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Circuit Type</th>
<th>Transfer</th>
<th>Acquisition Range</th>
<th>Common Mode Range</th>
<th>Absolute Accuracy (1)</th>
<th>Input Differential Impedance</th>
<th>Input Capacitance</th>
<th>Receiver Bandwidth</th>
<th>Acquisition Rate</th>
<th>Max Fault Voltage Emission</th>
<th>Max Fault Voltage Tolerance</th>
<th>OFF State Tolerance</th>
</tr>
</thead>
</table>
| -10 | Differential Receiver with multiplexed input | DC Coupled | 0V to +5V | 0V to +5V | ≤ 0.3% FSR | During acquisition: ≥ 1MOhm  
Outside acquisition: ≥ 1MOhm  
Switched OFF receiver (unpowered): ≥ 100KΩhm | ≤ 1.2μF | ≤ 500Hz @ 3dB | Consecutive and different acquisitions every 128μsec with full performance | -16V to +16V through 1.5KΩhm | -14V to +14V | OFF receiver shall withstand an ON driver |
| -11 |              |          |                |              |                   |                              |                   |                  |                        |                        |                    |                    |
| -12 |              |          |                |              |                   |                              |                   |                  |                        |                        |                    |                    |
| -13 |              |          |                |              |                   |                              |                   |                  |                        |                        |                    |                    |
| -14 |              |          |                |              |                   |                              |                   |                  |                        |                        |                    |                    |

**Harness Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Wiring Type (3):</th>
<th>Shielding</th>
</tr>
</thead>
<tbody>
<tr>
<td>-19</td>
<td>Twisted Shielded Pair (TSP)</td>
<td>Shield at back shell on driver/at structure on receiver side</td>
</tr>
<tr>
<td>-20</td>
<td></td>
<td>R</td>
</tr>
</tbody>
</table>

**Notes:**  
(1) Incl offset, gain, nonlinearity, drift errors, FSR: full scale range  
Fault voltages shall be verified by WCA

---

**Table 3.5-37: Pressure Transducer Acquisition Specification:**
3.5.5.14.3.2 Pressure Transducer Supply Interface (PTS)

**GDI-1790/CREATED**

The contractor shall design his part of the Pressure Transducer Supply Interface to be compliant to the characteristics as defined in Table 3.5-38 (Interface Data Sheet "PTS"; Driver: OBC, Receiver: Pressure Transducer):

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type: Single Ended Driver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer: DC Coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Switching Voltage: 28V ± 4V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Quiescent Voltage: 0V ± 0.5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Output Current Capability: 1.1A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Pulse Duration: continuous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Fault Voltage Emission: 0V to 40V</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Fault Voltage Tolerance: 0V to 40V</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

**Req** Receiver Circuit Specification

<table>
<thead>
<tr>
<th>Req</th>
<th>Receiver Circuit Specification</th>
<th>Ver.</th>
<th>Iss.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9</td>
<td>Circuit Type: Valve Coil (floating)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Input Voltage Quiescent: &lt; 0.5V DC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Resistance (DC) (1): 40 to 100 Ohms (to be confirmed by supplier)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Inductance (1): 250 to 750mH (to be confirmed by supplier)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Isolation: &gt; 1Mohm (switching voltage to structure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Max Fault Voltage Emission: 40V applied for up to 1s</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Max Fault Voltage Tolerance: 0V to 40V</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

**Harness Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Harness Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-16</td>
<td>Wiring Type: Twisted Shielded Pair (TSP)</td>
</tr>
<tr>
<td>-17</td>
<td>Shielding: Shield at back shell on driver/at structure on receiver side</td>
</tr>
</tbody>
</table>

Notes:

(1) Supplier to state nominal value and tolerance at ambient conditions.

Fault voltages shall be verified by WCA

**Table 3.5-38: Pressure Transducer Supply Specification:**

3.5.5.14.4 Main Engine Interface

**GDI-1774/CREATED**

Deleted

Deleted

3.5.5.15 Battery Power Interface (PBA)

**GDI-2150/CREATED**

Deleted

Deleted
3.5.5.16  Solar Array Power Interface (PSA)

GDI-2152/CREATED

Deleted

Deleted

3.5.6  Electrical Interface Control Document

GDI-558/CREATED

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 of APPENDIX C: EICD.

3.5.7  EMC Requirements

GDI-2154/CREATED

In order to achieve compliance with the requirements of Section 4.5, equipment internal design must employ standard EMC good design practices in respect of internal layout, shielding, filtering, bandwidth limitation and frequency planning.

In particular:

• The frequency response of all interface circuits shall be limited by design to only that which is essential for the operation of the equipment.

The following sections give the specific design requirements pertaining to interfaces to the spacecraft.

3.5.7.1  Bonding

Bonding is the method by which adjacent conductive elements are electrically connected in order to minimise any potential differences and flow of electrical currents. If dissimilar materials are bonded, the relative areas of the anode and the cathodes are important and finishing should be applied on both materials.

GDI-562/CREATED

The bond shall be resistant against corrosion and shall have an adequate cross section to carry fault currents of 1.5 times the unit/circuit protection device for an indefinite time.

GDI-563/CREATED

Metallic parts of each electrical equipment chassis (case) shall be mutually bonded together by direct metal contact (preferred method) or bonding strap. Bonding interfaces shall be designed to achieve a contact resistance of 2.5 mΩ or less per bonding junction (including strap, if used).

GDI-564/CREATED

Joint faces shall be flat and clean before assembly; the only permitted surface finishes for joint faces are (preference order):

• alodine 1200 for aluminium alloys,
• clean metal except for Aluminium alloys.

GDI-565/CREATED
All non-electrical equipment shall be bonded to the structure by direct metallic contact with less than
1kΩ.

GDI-566/CREATED
Each electrical equipment chassis (case) shall be bonded to the GRR by means of a bonding strap or
direct metal contact. The bonding interfaces shall not exceed a chassis to GRR bonding resistance of
5mΩ. The bond strap shall have a maximum length to width ratio of 5:1.

GDI-567/CREATED
Metallic receptacles of connectors shall be electrically bonded to the equipment case with a DC
resistance of 2.5mΩ or less. The DC resistance between a connector backshell and the connector
body shall be 2.5mΩ or less.

3.5.7.1.1 Ground Reference Rail

GDI-569/CREATED
Electrical bonding throughout CFRP structure shall be achieved by means of a continuous metallic
Ground Reference Rail (GRR).

GDI-2715/CREATED
the GRR shall be attached at less than or equal to every 150mm to the panels by a M4 bolt.
Further mechanical fixings may be required at the ends of the rails

GDI-570/CREATED
The resistance between any adjacent parts of the GRR shall never exceed 2.5 mOhm (DC).

GDI-571/CREATED
The resistance between any two points of the GRR shall be lower than 10 mOhm.

3.5.7.1.2 Cable and Harness Shields

GDI-573/CREATED
Where shielded wires are used, the shield shall be of a braided construction, selected to provide an
optical coverage of at least 85%.

GDI-574/CREATED
The maximum unshielded length of any shielded wire shall not exceed 2.5cm. Cable shields shall be
grounded at both ends. Where shielded cable pass through intermediate connectors, the shield shall
pass through the interface on dedicated pins.

GDI-575/CREATED
Daisy chaining of shield terminations shall be avoided. If this is not feasible due to connector
limitations, a maximum of three shields of similar electrical interfaces are allowed for daisy chaining.

GDI-576/CREATED
Shields shall not be used as an intentional current carrying conductor and not as return lines for
power and signal with the exception of the RF coaxial lines.
3.5.7.1.3 Structure Parts

GDI-578/Created

Conductive structure components shall be electrically bonded to each other by direct metal to metal contact, or via the use of a bond strap.

GDI-1990/Created

The DC resistance between two mating metal structure parts shall be <2.5 mΩ. The minimum size of the contact area shall be 1cm².

GDI-1991/Created

Across moveable parts, a bond strap shall be applied to ensure an electrical contact is made between those parts with a DC resistance of <25 mΩ.

GDI-1992/Created

For CFRP structure without shielding function, the bonding resistance between any CFRP parts and the local GRR shall be less than 100 Ohm measured at DC.

GDI-2093/

This Requirement has been Deleted.

GDI-2092/Created

For CFRP structure used for electromagnetic shielding, the bonding resistance shall be less than 100mΩ between any adjacent parts and the local GRR.

GDI-1989/Created

Metal fittings shall be bonded to the structure with a DC resistance of < 10 mΩ.

GDI-579/Created

Metal fittings shall be bonded to CFRP with a DC resistance of < 10 Ω.

GDI-2105/Created

The DC resistance from any metal structure part and the structure ground reference located close to the separation plane shall be <25mΩs.

GDI-2094/Created

The DC resistance between any other conductive component that does not perform an electrical function, i.e CFRP, CFK, conductive coatings etc and the spacecraft structure shall be < 1 kΩ.

GDI-1993/Created

The GRR shall be attached at less than or equal to every 150mm to the panels by an M4 bolt. Further mechanical fixings may be required at the ends of the rails. The DC resistance between the rail and the local CFRP shall be < 100 mΩ.

GDI-1994/

This Requirement has been Deleted

GDI-1995/

This Requirement has been Deleted
3.5.7.1.4 Mechanical Parts

GDI-581/CREATED

Mechanical Parts without electrical nor shielding function shall show a bonding resistance of less than 1 kOhm between any adjacent parts and the local GRR.

GDI-582/CREATED

Mechanical Parts used for electromagnetic shielding shall show a bonding resistance of less than 2.5 mOhm between any adjacent parts and the local GRR (or connector bracket).

3.5.7.2 Grounding and Isolation

3.5.7.2.1 General

GDI-585/CREATED

Each unit shall provide a grounding point, which is easily accessible even when all harness connectors have been installed.

GDI-586/CREATED

CFRP and SiC shall not be used as an electrical bonding path. Grounding rails shall be used as bonding path.

3.5.7.2.2 Electrical and Electronic Unit Requirement

GDI-588/CREATED

The structure of electrical and electronic unit shall form a continuous conductive metallic shield for the electronics with a resistance between the different covers and the bonding stud at the box side not exceeding 2.5 mΩ (DC).

GDI-589/CREATED

Openings for drainage, ventilation, etc... shall never exceed 5mm diameter per hole and distances between screws for lids, etc... shall never exceed 30mm for flat mounted lids. Conductive surfaces are required on each bonding surface (each screw). Lids with an overlap of more than one centimetre require only a maximum 10-centimetre distance between the bond screws.

GDI-590/CREATED

All units shall have a M4 bonding stud

GDI-591/CREATED

The design of this bonding stud shall allow the connection of a bonding strap with length to width ratio of less than 5 to 1 with a contact area of more than 1cm².

3.5.7.2.3 Insulating materials

GDI-593/CREATED

Space exposed insulating material having a bulk resistivity higher than 1E13 Ω/m or a surface resistivity greater than 1E9 Ω/square shall not be used.

3.5.7.2.4 Thermal parts

GDI-595/CREATED

MLI:
MLI shall carry at least 1 conductive layer and each conductive layer shall be bonded to structure to avoid electrical charge differential.

GDI-596/CREATED

MLI:
The grounding points shall be in a minimum of 2 locations (opposite corners), such that no piece of blanket is >1m away from a grounding point. No blanket shall exceed 2 sq m in size, each blanket shall be individually grounded to the structure.

GDI-597/CREATED

MLI:
The resistance between each bonding point and the structure shall be lower than 100mΩ.

GDI-598/CREATED

MLI:
The resistance between each bonding point and each point of a metallic conductive layer shall be lower than 100Ω.

GDI-599/CREATED

PAINTS:
Refer to Section 3.5.7.2.3 above.

GDI-600/CREATED

HEATERS & THERMISTORS:
Heaters, thermistors and other discrete thermal components shall be isolated from structure with:
- Resistance >= 10MΩ.

GDI-2143/CREATED

To avoid failure due to disbonding, heater matts shall be single element.

GDI-2144/CREATED

Heater mats shall be designed to produce a minimum magnetic field.

3.5.7.3 Primary and Secondary Power Lines

Even if the EGRS (Electrical Ground Reference Structure) impedance is very low, it is better to minimize the currents in the EGRS in order to minimize the common mode voltage. This is also to avoid creating magnetic fields.

3.5.7.3.1 Primary Power Lines

Grounding: power buses supplied by the platform PSS (Power Sub-System) are considered as primary power. This power will be referenced to structure at one point only within the PSS. This grounding shall be within the power control unit of the PSS.

GDI-605/CREATED

Isolation: Within all units the primary power buses shall be isolated. There shall be no direct connection between the primary power bus zero volt and the unit’s chassis.

GDI-606/CREATED

Isolation: All units (except PCDU) shall maintain a galvanic isolation of at least 1MΩ shunted by not more than 50 nF between:
Primary power positive and chassis,
Primary power return and chassis
Primary power and secondary power (line and return).

The insulation requirements shall be measured at 5 Vdc and 5V 10 kHz for the capacitance.

It is recommended to use static shields between primary and secondary windings of transformers to reduce the capacitive coupling between primary and secondary side. This static shield should be connected to the primary power return line by means of a low inductance strap.

3.5.7.3.2 Secondary Power Lines

GDI-609/CREATED
Grounding: All secondary supplies, inside a unit, shall be connected to unit structure.

GDI-1988/CREATED
Equipment with its own dedicated DC - DC converter shall ground the secondary power return at a single location.

GDI-610/CREATED
Isolation: prior to connection of the unit internal starpoint, the isolation between the secondary power return and unit chassis shall be at least 1MΩ in parallel with a capacitance of less than or equal to 50nF.

GDI-2106/CREATED
After grounding, the impedance between the unit secondary zero volt taken at the level of the transformer and the unit structure (bonding stud) shall be less than 5mΩ. To be tested at board level.

GDI-611/CREATED
Secondaries distributed between units (1 supplier; 1 receiver): The distribution shall be at ONE point only. In the baseline, the grounding point is located at the supplier. However, Both units (supplier and receiver) shall provide the capability of this grounding point. Implementation of this point will be defined at Project level. Specific care shall be taken to avoid grounding loops between these units (isolation of other interface signals: differential type have to be taken into account)

GDI-612/CREATED
Secondaries distributed between units (1 supplier; several receivers): The distribution shall be a starpoint system for power line and return. Specific care shall be taken to avoid grounding loops between these units (isolation of other interface signals: differential type have to be taken into account)

GDI-614/CREATED
Grounding diagram including zero volts interconnection and detailed implementation shall be described in the EICD

- For each unit,
- For each assembly.

GDI-615/CREATED
The symbols in Figure 3.5-21 below shall be used in the production of the grounding diagram in order to obtain unified drawings.
3.5.7.3 Signal Interfaces

**GDI-617/CREATED**

Signal circuits interfacing between Satellite equipment shall follow the distributed star point grounding concept, see Figure 3.5-22.

**GDI-618/CREATED**

Where single-ended signal transmitters are used, independent signal returns are required. Ground reference lines shall not be used as signal returns. The signal receivers shall insulate the signal lines from power ground (differential amplifier, opto-coupler, solid state relay, transformer).

**GDI-619/CREATED**

The use of common signal return paths is only permitted for groups of signals belonging to the same family (analogue, digital, etc.) and originating from the same unit.
3.5.7.3.4 EGSE Grounding and Isolation

GDI-621/CREATED

EGSE signal and power circuits interfacing with flight hardware shall simulate the original flight interfaces w.r.t. Impedance, power and signal characteristics, timing, grounding and isolation (See Figure 3.5-22) and test harness design.

Figure 3.5-22: Grounding Concept
3.5.7.4 Magnetic Moment

GDI-1997/CREATED

Each equipment shall be designed and fabricated to preclude or minimise both permanent and stray magnetic fields (due to DC current loops).

Deleted.

GDI-1998/CREATED

Deleted.

3.6 Operations Design and Interface Requirements

3.6.1 Bit / Byte Numbering Convention

GDI-632/CREATED

In all project specific documentation including commented code, the following convention shall be applied:

- Bit 0 in a byte shall be the most significant bit and bit 0 shall be transmitted first.
- Byte 0 in data fields shall be the most significant byte, and byte 0 shall be transmitted before byte 1.

Figure 3.6-1 below shall apply

<table>
<thead>
<tr>
<th>Bit_0 (MSbit)</th>
<th>Bit_N-1(LSbit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte_0 (MS byte)</td>
<td>Byte_1 (LS byte)</td>
</tr>
</tbody>
</table>

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

transmitted first

Figure 3.6-1: Bit / Byte Numbering Convention

GDI-634/CREATED

During file transfer, within any data type structure, bytes shall be transmitted in ascending order, i.e. byte 0 before byte 1 etc.

3.6.2 Operational Functions

3.6.2.1 Handling of Operational Configuration, Modes and States

An operational mode/state represents an operationally well defined and, within certain limitations, a stable configuration as concerns mechanical, thermal, electrical and functional conditions.

Modes/States are defined on satellite, instrument, subsystem and unit level as appropriate and form operational entities, which are defined by a list of conditions.

A repetitive but fixed sequence of functions may define a mode/state, provided that other conditions remain stable.
Convention: The terminology “mode” is to be used when mode management is provided by SW, while the terminology “state” is to be used when the functionality is provided by HW.

GDI-638/CREATED

Mode/State transitions: Transitions from one mode/state to another are initiated by defined events and depend only on source and destination mode/state and on actual conditions.

The transition time from one mode/state to another is defined by the time triggering the event and the time where all conditions for the new mode/state are fulfilled.

GDI-639/CREATED

The unit supplier shall identify appropriate modes/states and transitions between them for the unit.

GDI-640/CREATED

At all times, equipment and units shall be in a clearly identified operational mode/state of both hardware and software. The unit shall provide sufficient telemetry to allow unambiguous identification of its mode/state and transitions.

GDI-641/CREATED

In addition, modes and the mode transitions managed by on-board software shall be observable and the necessary data shall be available in the telemetry.

GDI-642/CREATED

The unit supplier shall identify all internal and external events triggering a mode/state transition.

GDI-643/CREATED

The unit supplier shall identify all transition times between modes/states.

GDI-644/CREATED

Mode/State transitions with duration longer than 10 seconds shall be indicated in the telemetry.

GDI-645/CREATED

It shall be possible to command the unit into each of its operation states by means of a single telecommand.

3.6.2.2 Commandability

3.6.2.2.1 General

GDI-648/CREATED

Commandability is characterised by the set of commands to a system, satellite, instrument, subsystem or unit, which allows modification of its configuration (i.e. status, parameters, settings and/or mode). The correct level of commandability allows the Operational Ground Segment to set the satellite, instrument, subsystem or unit in the hardware and software configuration appropriate to fulfil the mission.

GDI-649/CREATED

In operating states of the unit, it shall be possible to command all on-board devices, switchable elements (e.g. relays), equipment and sub-units individually and externally.

GDI-650/CREATED

In addition, in non-operating states of the unit, especially if the unit is OFF, it shall be possible to command all on-board devices and switchable elements (e.g. relays), individually and directly from external.
GDI-651/CREATED

Individual switching of switchable elements (e.g. relays) shall be possible even in the case that automatic switching is implemented for nominal operation.

GDI-652/CREATED

The on-board reception, processing and execution of a telecommand to on-board devices, equipment and units shall not affect the performance of other ongoing processes within the item.

GDI-653/CREATED

The function of a command shall not change throughout the mission and shall not depend of any previous command history. Flip/flop or toggle commands as well as multi-stable commands (i.e. commands for which effect depends on previous state of the function) are not allowed.

This applies to switchable elements as well as memory/register loads.

GDI-654/CREATED

A single command may be used to initialise a change in configuration via on-board logic only if the individual switching elements are accessible by external commands.

For example: one command can switch two units if the individual unit switches are also commandable from external.

Exceptions to this rule shall be agreed with the customer on a case-by-case basis.

GDI-655/CREATED

Commands with variable bit-fields meaning shall not be used.

GDI-656/CREATED

Nominal and the redundant functions or equipments of a unit shall be commanded by the same number, type and format of telecommand.

GDI-657/CREATED

The unit design shall avoid any conflict between a command register update by the S/W and the command acquisition by the unit. The register update shall be possible at any time according to the communication protocol.

3.6.2.3 Observability

3.6.2.3.1 General

GDI-660/CREATED

Observability is characterised by the set of telemetry (housekeeping information) that is provided by a system, satellite, instrument, subsystem or unit, which allows information about its overall status. The correct level of observability allows the Operational Ground Segment to get the appropriate data for the satellite, instrument, subsystem or unit for taking any action if required.

GDI-661/CREATED

The unit shall provide in its housekeeping telemetry all data required for the monitoring and execution of all nominal and foreseen contingency operations throughout the entire mission.

GDI-662/CREATED

The unit shall provide the necessary instrumentation to allow the ground or the next higher operational level to determine at any time the precise and current status of the unit including software parameters (if applicable)
GDI-663/CREATED
Telemetry measurement sensors shall be designed such that they provide the full performance range with a suitable resolution compatible with the parameter to be measured. This resolution shall be determined taking into account the needs for real time control and for performances and lifetime evaluation.

GDI-664/CREATED
It shall be possible to determine the status of the unit (w.r.t. HW and SW), without the need of any older data knowledge (e.g. telecommand history, history of autonomous processes).

GDI-665/CREATED
Essential (high-priority) telemetry data enabling a reliable determination of the current status of on-board vital equipment under all circumstances shall be provided by the unit irrespective of its mode/status.

GDI-666/CREATED
Telemetry shall always be provided to identify unambiguously the conditions required for execution of all possible configuration dependent telecommands.
Note: A configuration dependent telecommand is defined as a telecommand that should only be executed if a particular subsystem or instrument condition is satisfied.

GDI-667/CREATED
Status information in telemetry shall be provided from direct measurements from operating units rather than from secondary effects. This is in particular essential for the status of all on-board relays.

GDI-668/CREATED
Any TM processing required at a higher operational level shall be defined.

GDI-669/CREATED
Telemetry shall always be available to determine the health status of all units that manage the generation and routing of (other) telemetry data.

GDI-670/CREATED
When a key parameter is derived on-board from several inputs, each input shall be available in the telemetry in addition to the parameter itself.

3.6.2.3.2 Telemetry Acquisition

GDI-672/CREATED
The TM acquisition process by the data bus shall neither modify the contents of the telemetry H/W register (no status re-initialisation) nor the unit configuration; acquisitions with a commanding effect are forbidden.

GDI-673/CREATED
The unit design shall avoid any conflict between the acquisition of a telemetry register by the S/W and the register update by the unit. The register acquisition shall be possible at any time according to the communication protocol.

GDI-674/CREATED
TM acquisitions with conditional meaning shall not be used.

GDI-675/CREATED
The value of a telemetry parameter shall be transmitted in contiguous bits within one packet.
Analog TM Acquisition:

Analog TM acquisitions shall have a measurement range and an accuracy (w.r.t. time, sampling frequency, resolution, etc.) appropriate to allow handling of nominal operation and detection of anomalies.

Acquisition of safety critical analog parameters of a unit shall be possible even when the unit is OFF.

The values of currents or voltages readings shall be representative and valid irrespective of the status of the unit.

The calibration curve of an analog parameter shall be unique: it shall not depend on the status of the unit nor on the value of another parameter.

3.6.2.3.3 Observability of Hardware Configuration

At switch on, the configuration of the unit at elementary function level shall be clearly defined and observable and available under a single telemetry identifier.

In case a unit includes several elementary functions (i.e. converter, bus coupler etc.) the detailed configuration shall be available in a single telemetry identifier.

The configuration of any on-board device and any switching element shall be known in a non-ambiguous way, without the need of any older data knowledge.

Any configuration command register shall be observable by a corresponding telemetry parameter.

The acquisition of the unit configuration/state shall be possible irrespective of the unit status.

The acquisition of an ON/OFF status for a relay shall be independent of the unit status.

If the unit controls the redundancy configuration or the power of its sub-units, the redundancy setting or power status shall be identified in an unambiguous way in the telemetry.

Nominal and redundant functions shall be observable by the same number, type and format of telemetry.

3.6.2.3.4 Observability of Commands

Commands to the unit shall be acknowledged in an unambiguous manner. The acknowledgement shall either be performed:
• On bus protocol level (e.g. MIL-STD 1553B)
• On Packet Utilisation Standard (PUS) level if unit SW is involved
• Or on a level, where the effect of the command can be identified unambiguously

GDI-691/CREATED
Acknowledgement of commands shall be direct (i.e. not relying on the operation of other units or on the previous commanded state) and accurately relevant.

GDI-692/CREATED
The association between command acknowledgement acquisition and respective command shall be clearly identified by the unit supplier.

GDI-693/CREATED
Successful execution of a command to the unit shall be notified to the next higher operational level

GDI-694/CREATED
Failures in the acceptance and/or the execution of commands to the unit shall be notified to the next higher operational level

3.6.2.3.5 Converters Observability

GDI-695/CREATED
Sufficient data to monitor the converters shall be available in the telemetry as:
• Secondary voltage
• Primary current
• Relay status
• Temperature

3.6.2.4 Safety Critical and Hazardous Functions

Hazardous functions are those that could cause loss of mission, mission degradation or damage to unit, equipment, facilities or personnel, when being executed at the incorrect time.

Critical commands are defined as commands which invoke hazardous functions and for which inadvertent execution (erroneous transmission), incorrect execution (aborted transmission or transmission in wrong order), or loss of function may cause loss of nominal mission or, during the ground phase, presents hazards for personnel.

For instance, critical commands include pyrotechnics firing, propulsion (hydrazine) activation, etc

GDI-700/CREATED
All critical commands shall be identified at equipment, subsystem or unit level for further analyses at system level.

GDI-701/CREATED
The execution of any unit command or command sequence, correct or incorrect, shall not lead to permanent equipment or unit damage.

GDI-702/CREATED
Commanding of critical commands shall be implemented by at least 2 separate and independent commands.
The level of implementation shall be discussed on a case-by-case basis

**GDI-703/CREATED**

The status of inhibition of safety critical functions shall be monitored and readable in a non-ambiguous way even if the function is not powered.

**GDI-704/CREATED**

Units shall provide an unambiguous health status of potentially hazardous functions in a dedicated TM identifier.

### 3.6.2.5 Handling of Memories

**GDI-706/CREATED**

Any part of installed RAM's shall be readable by memory read commands.

**GDI-707/CREATED**

Any part of installed RAM's shall be overwriteable by memory load commands.

**GDI-708/CREATED**

Any part of installed ROM's shall be readable by memory read commands.

**GDI-709/CREATED**

For failure investigation, it shall be possible to switch the equipment into a mode in which the memory can be dumped and sufficient to identify errors as appropriate.

### 3.6.2.6 Autonomy

**GDI-711/CREATED**

Apart from failure situations, the unit shall operate autonomously, including nominal data acquisition and data transmission.

**GDI-712/CREATED**

All parameters used for autonomous operations and processes, including FDIR functions, shall be updateable by command and available in telemetry.

### 3.6.2.7 Automatic Functions

**GDI-714/CREATED**

It shall be possible to inhibit and to override all automatic functions including FDIR functions and the necessary data to monitor these functions must be available in the telemetry.

**GDI-715/CREATED**

All actions generated by automatic on-board logic (hardware or software) shall be inhibitable, reversible, by command.

Exceptions shall be discussed on a case-by-case basis.

**GDI-716/CREATED**

The automatic function design shall be such that no single point failure can cause the loss of the primary function and of the automatic function provided as back up.

**GDI-717/CREATED**

Telemetry shall be associated to all automatic functions enabling the ground to be informed of all the actions of the automatic function and of their enabled/inhibited status.
In addition, any input used by the automatic function shall be observable.

GDI-718/CREATED
For all the automatic logic using several criteria in an “OR” configuration inhibition shall be possible individually and independently for each criteria.

GDI-719/CREATED
The capability to change all on board logic (hardware and software) thresholds at any time shall be provided.

3.6.2.8 Time Synchronisation

GDI-721/CREATED
If the unit has operationally not been synchronised to the on-board Master clock after a power reset or switch-on this shall be indicated to the next higher operational level.

GDI-722/CREATED
If the unit has the function, all information on how to synchronize a units internal clock to an external clock shall be supplied.

GDI-723/CREATED
Timing information provided in Housekeeping telemetry of the unit shall allow the correlation from on-board time to UTC with an accuracy necessary for command & control operations and compliant with any unit datation requirements.

3.6.2.9 Fault Management / FDIR

3.6.2.9.1 Unit Fault Protection

GDI-726/CREATED
Any unit shall be able to withstand (i.e. remain in a safe state, without any requirement on performances, and except in case of unit failure due to another cause), interruptions of the cyclic management by the OBSW for an indefinite period, regardless of the configuration it was left.

GDI-727/CREATED
Any unit shall be able to withstand (i.e. remain in a safe state, without any requirement on performances, and except in case of unit failure due to another cause), interruptions of the data bus operation for an indefinite period, regardless of the configuration it was left.

GDI-728/CREATED
It shall be possible to repeat any command several times without disturbing its nominal execution, even in case of timing constraints. No configuration change, no temporary or permanent degradation of the function performance must result from any command repeatability that would respect data bus constraints.

3.6.2.9.2 Unit Self Tests

GDI-730/CREATED
All units that perform regular self-tests shall report the result in a single TM identifier.

3.6.2.9.3 Failure Detection, Isolation and Recovery (FDIR) Functions

FDIR functions are those functions, which implement the failure detection, isolation and recovery actions. The FDIR functionality is set up at both unit and system levels and is defined within the overall Operations
Concept of the Gaia spacecraft. The implementation of the FDIR function is based on specific system needs, e.g. the time to react, which is the maximum time to end a recovery action guaranteeing the hardware integrity.

GDI-733/CREATED

*FDIR functions shall be implemented in a hierarchical manner, i.e. failure detection, isolation and recovery shall be implemented to a certain degree on unit level.*

GDI-734/CREATED

*The unit shall automatically detect any failure, which makes it deviate from its nominal configuration and operating status. This includes HW and SW failures.*

GDI-735/CREATED

*At unit level failures shall be detectable by adequate and comprehensive monitoring (e.g. for switchable elements) and the capability for failure isolation and recovery action shall be provided.*

GDI-736/CREATED

*Failure detection algorithms shall report in event telemetry all parameter values considered necessary for the ground analysis of the failure.*

GDI-737/CREATED

*Failures which require a reaction time less than 10s shall be monitored through a hardware device (Watchdog, current limiter etc..)*

GDI-738/CREATED

*Failure which requires a reaction time between 10s and 48h shall be monitored by on board software implemented in the unit or by SW in the higher operational level.*

GDI-739/CREATED

*Failure isolation shall be performed at switchable items level*

GDI-740/CREATED

*Any FDIR actions on unit level shall be reported to the next higher operations level. This includes in particular redundancy switching.*

GDI-741/CREATED

*The need for intervention of higher levels to react on failure situations which cannot be handled at unit level shall be clearly identified and communicated to the next higher operational control level. The reaction time for such a higher-level intervention shall be identified.*

3.6.3 Other Requirements

3.6.3.1 Inputs to Design Justification File

GDI-744/CREATED

*The unit supplier shall provide a design justification for the operations relevant part. For each telemetry/telecommand and their parameters a functional description shall be given with the reason of the choice.*

*It shall be proved that the location of the acquisition and its characteristics (dynamic, bandwidth, resolution, frequency variation in case of failure) can satisfy the operational requirements and is appropriate for all modes (normal and contingency modes, safe modes..)*
3.6.3.2 Inputs to Operational Database

GDI-746/CREATED

The unit supplier shall provide inputs to the Operational Database or fill in a customer provided Database. This data shall be provided through a defined and agreed numerical format (based on Excel or ASCII files). The detailed format is to be defined by the Customer.

GDI-747/CREATED

Data to be provided (the list is not exhaustive):

- For TM: Mnemonic, description, addressing, coding, calibration, bandwidth, validity conditions, monitoring limits.
- For TC: Mnemonic, description, addressing, coding, calibration, execution conditions, execution checking.

3.6.3.3 Operation Manual

GDI-749/CREATED

The unit supplier shall provide an Operations Manual covering all operational aspects (in-flight and on-ground) for the unit. As a minimum, the following information shall be provided:

- Functional Description of the unit (HW and SW)
- Description of modes, states and transitions
- Commandability (TC list) and Observability (TM list)
- Nominal and Contingency Operations
- Operational Constraints
- FDIR implementation
- On-Ground Handling

GDI-750/CREATED

The following standardization (Table 3.6-1) shall be used for the coding of 2-state status:
### Table 3.6-1: Meaning of Status Bits

<table>
<thead>
<tr>
<th>Meaning of status bit 0</th>
<th>Meaning of status bit 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit or function OFF</td>
<td>Unit or function ON</td>
</tr>
<tr>
<td>Redundant</td>
<td>Nominal</td>
</tr>
<tr>
<td>Disconnected</td>
<td>Connected</td>
</tr>
<tr>
<td>Switch open</td>
<td>Switch closed</td>
</tr>
<tr>
<td>Faulty status</td>
<td>Correct status</td>
</tr>
<tr>
<td>Not selected</td>
<td>Selected</td>
</tr>
<tr>
<td>Absence</td>
<td>Presence</td>
</tr>
<tr>
<td>Backward</td>
<td>Forward</td>
</tr>
<tr>
<td>Left</td>
<td>Right</td>
</tr>
<tr>
<td>Unused</td>
<td>Used</td>
</tr>
<tr>
<td>Still</td>
<td>Moving</td>
</tr>
<tr>
<td>Plus</td>
<td>Minus</td>
</tr>
<tr>
<td>Disarmed</td>
<td>Armed</td>
</tr>
<tr>
<td>Inactive</td>
<td>Active</td>
</tr>
<tr>
<td>Inhibited</td>
<td>Enabled</td>
</tr>
</tbody>
</table>

#### 3.7 Software Design & Interface Requirements

The requirements in this section apply to the following items:

- all on-board software products, including (but not restricted to) central computer software and payload DHS software.
- any on-board unit embedding software.

The on-board software includes the in-flight software as well as the ground test software.

#### 3.7.1 General

**GDI-2181/MRD 5.18.1**

All software production and test shall follow the ESA Software Standards ESA ECSS-E-40 and ESA ECSS Q-80.

**GDI-2182/MRD 5.18.1 tailored**

All on-board software running in sub-systems shall be developed using the same development environment, except where explicitly exempted, e.g., under the following conditions:

- **SW embedded within an off-the-shelf** unit (e.g., a Star Tracker, a transponder).
- **specific processor selection due to high-performance requirements** (e.g., image processing).

Note: the standard development environment comprises standard processor type, standard development language, and standard software development tools.
GDI-2183/MRD 5.18.1

The on-board software shall be developed using a high-level language, except where explicitly exempted.

GDI-2184/MRD 5.18.1

The use of a non high-level language code (e.g., assembler) in the SW shall be shown to be absolutely necessary to achieve the required performance. Agreement with ESA and EADS-Astrium shall be achieved before implementation.

GDI-2185/MRD 5.18.1

The on-board software shall be implemented with a layered structure separating hardware, software, input/output drivers, basic services, and general mission services.

3.7.2 Flight Processor Resource Sizing

GDI-2192/MRD SYS-510

During development, flight processors providing computing resources for any on-board unit shall be sized for worst-case utilisation not to exceed the capacity shown below, measured as a percentage of total available resource capacity:

<table>
<thead>
<tr>
<th>Resource/Phase</th>
<th>Unit PDR / SW</th>
<th>Unit CDR / SW</th>
<th>Unit QR / SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM memory</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
</tr>
<tr>
<td>EEPROM memory</td>
<td>50%</td>
<td>60%</td>
<td>70%</td>
</tr>
<tr>
<td>CPU</td>
<td>30%</td>
<td>50%</td>
<td>70%</td>
</tr>
<tr>
<td>I/O bandwidth</td>
<td>30%</td>
<td>50%</td>
<td>70%</td>
</tr>
<tr>
<td>Bus utilisation</td>
<td>30%</td>
<td>50%</td>
<td>70%</td>
</tr>
</tbody>
</table>

GDI-2193/CREATED

Any on-board software shall provide the capability to monitor the resource utilisation.

GDI-2194/CREATED

The resource utilisation monitor shall be available for downlink in telemetry.

GDI-2196/MRD 5.18.3 tailored

Sizing of the software resources shall be done in accordance with the worst-case predicted operational scenario of the software covering:

- TM/TC traffic
- On-Board Control Procedures (OBCP) execution
- Incoming/outgoing data throughput over MIL-STD-1553B (command/control)
- SpaceWire link throughput (interface with the payload)
- Serial link throughput (command/control)
- FDIR periodic load (cyclic surveillances, parameter/event monitoring)
- FDIR sporadic load when processing errors or failures
- Diagnosis (oversampling, memory cell acquisition, off-line health checking)
- Pure computational load (control laws).
3.7.3  Robustness

3.7.3.1  Infinite Loops

GDI-2197/MRD 5.1.8.3

The on-board software shall protect itself against infinite loops, computational errors and possible lock
ups resulting from an undetected hardware failure.

GDI-2218/CREATED

Whenever possibility of Warm Restart is implemented, the on-board software shall perform a Cold
Restart in lieu of the Warm Restart in case the Warm Restart count equals or exceeds a
predetermined value changeable in flight.

3.7.3.2  Overload

GDI-2198/CREATED

Any on-board software product shall provide a table-driven means for verifying proper execution of
critical software tasks or functions, and perform a corrective action in the event that one or more of
the critical tasks fails to meet dynamic performance requirements.

Note: In order to make this implementable, it is admitted to suspend selected minor tasks (e.g., low-
priority TM) or slow down some processes (e.g., add a few seconds to the deadline of MTL TCs)
temporarily during the time needed to absorb the overload.

GDI-2199/CREATED

If and only if the overload situation cannot be absorbed within programmable $\Delta T$, the software shall
perform or cause the transition to a safe mode.

3.7.4  Events

GDI-2214/CREATED

The on-board software shall provide a means to filter (discard) individual event messages..

GDI-2215/CREATED

The on-board software shall maintain counters for:

- the total number of event messages generated,
- the number of event messages discarded because of queue overflow,
- the number of event messages discarded by filters.

3.7.5  Initialisation

GDI-2226/CREATED

Any on-board unit embedding software shall provide for separate Cold Restart and Warm Restart
initialisation processing.

GDI-2228/CREATED

The Cold Restart shall start execution from a hardware reset caused by (i) a power off/on cycling, or
(ii) a processor switchover.

GDI-2229/CREATED

The Warm Restart shall start from a software command.
GDI-2230/CREATED

The Warm Restart shall perform a processor reset and therefore clear the SW internal flags and any accumulated "garbage" that might be still present in the processor memory since the last commanded reboot.

GDI-2227/MRD 5.1.8.3

The Cold Restart and the Warm Restart initialisation shall restore the same default TM contents.

GDI-2234/

At a predictable stage of the initialisation, the software code to boot up a processor shall execute as loaded in RAM from non-volatile memory.

3.7.6 Testability

GDI-2205/CREATED

Any on-board unit embedding software shall provide a built-in SpaceWire test access port, allowing high-speed loading and dumping of processor memory to support AIT and pre-launch testing.

3.7.7 SW Maintainability

3.7.7.1 Version Number

GDI-2209/CREATED

All software products shall store their version number on board.

GDI-2212/CREATED

The flight software version number shall be retrievable, either in H/K telemetry or table dump.

GDI-2208/CREATED

The flight software version number shall be modified whenever the software was modified.

3.7.7.2 In Flight SW Modification

GDI-2186/MRD 5.18.1 tailored

Any on-board unit embedding software shall support in flight modifications of this software, with the unique exemption of the PROM part of the Basic Input/Output System (BIOS).

GDI-2187/MRD 5.18.1

The on-board software shall be structured such that modifications to any individual code module have minimum impact on other modules.

GDI-2231/MRD 5.1.8.3

Any on-board unit embedding software shall support direct patching, including areas where memory management is used.

GDI-2232/MRD 5.1.8.3

Any on-board unit embedding software shall support the dump to ground of any element of the on-board memory, initiated by telecommands.

GDI-2201/CREATED

Any on-board unit embedding software shall be reprogrammable in flight to allow for new versions of software to be loaded from the ground without computer restart.
3.7.7.3 Ease of SW Operations & Modifications

GDI-2206/CREATED

Wherever possible, the software shall be table-driven for ease of operation and modification.

GDI-2210/CREATED

All on-board software data that are anticipated to be modified or examined by ground operators shall be organised as tables.

GDI-2211/CREATED

The on-board software shall have knowledge of the location of each table such that ground operators need only reference a table number (for the entire table), or a table number and position within the table (for a partial table).

Note: the software maintains table physical memory locations such that the ground can load and dump tables without the knowledge of where the data resides in physical memory, and no ground software or database change shall be required when the data is relocated due to a re-compilation of the on-board software.

GDI-2207/CREATED

Software-implemented limits and triggers for anomaly responses shall be readily accessible and changeable by ground command.

3.7.8 SafeGuard Memory (SGM) Maintainability

GDI-2223/CREATED

In case of Cold Restart, any on-board unit embedding software shall preserve necessary contextual data tables and command sequences in a non-volatile memory called SafeGuard Memory (SGM).

GDI-2224/CREATED

The on-board software shall implement SGM data structures such that individual segments of tables can be logically dumped and reloaded from the ground.

3.7.9 Independent SW Validation (ISV)

GDI-2188/MRD 5.18.1

The software components that are critical for the mission and the spacecraft safety shall be verified by an Independent Software Verification (ISV) Team different from the software supplier.

3.7.10 SW Maintenance Products

GDI-2189/MRD 5.18.1

All on-board software, including new and reused SW, shall be delivered to ESA and EADS-Astrium in source form, including all building scripts necessary to regenerate the on-board image. All supporting documentation shall also be delivered to ESA and EADS-Astrium.

GDI-2190/MRD 5.18.1

All on-board software resident in ASIC, FPGA, or other specified circuits (including firmware and development language) shall be delivered to ESA and EADS-Astrium in source form including all supporting test harness and documentation.

GDI-2233/MRD 5.1.8.4

The SW maintenance environment shall provide the means to generate and prepare SW patches or full SW Images for uplink to the spacecraft.
GDI-2235/MRD 5.1.8.4

All software licenses for any software used to develop and test the on-board software shall be maintainable at the same version and issue over the full life of the mission at a freeze point in the schedule and be deliverable with the corresponding documentation. The freeze point will be established after common agreement.

GDI-2236/MRD 5.1.8.4

For any on-board unit embedding software, a software development and maintenance facility shall be delivered to ESA, that contains all the source codes, executables, and test scenarios and results used for SW qualification and delivery.

GDI-2237/MRD 5.1.8.4

The software development and maintenance facility shall include the patch/modification tools necessary in order to modify and patch the software in flight.
4. ENVIRONMENT DESIGN REQUIREMENTS

GDI-2315/
All component of the spacecraft shall be designed to withstand all environment encountered during its entire lifetime, including: manufacturing, handling, transportation, testing, launch and in orbit operations. It shall be ensured that manufacturing, handling and transportation loads shall not be design drivers with the exception of the interface points with the MGSE.

4.1 Ground operation phase

GDI-2318/
To allow validation and integration operations, all equipment shall withstand a number of mounting/dismounting, operating hours and switch ON/OFF cycles after delivery:

- Maximum number of mechanical mounting/dismounting: 10
- Maximum number of electrical connecting/disconnecting: 50
- Maximum number of operating hours: 5000h (electronic equipment), 10 000h (electromechanism)
- Maximum number of switch ON/OFF cycles: 1000

4.1.1 Thermal and climatic environment

GDI-2320/
For AIV and storage, the climatic conditions shall be as follows:

- Temperature
  - Storage: -40°C to +60°C
  - Integration: +10°C to +30°C
- Relative humidity: 40% to 65%
- Pressure: Ambient

GDI-2321/
Assembly, integration and verification of flight hardware shall be carried out in climatically controlled areas.

Flight hardware shall be stored in climatically controlled areas only

GDI-2322/
During transport prior to integration on the spacecraft, all units shall be kept within following climatic conditions:

- Temperature: -40°C to +60°C
- Relative humidity: <65%
- Pressure: 70 to 110 kPa
- Rate of pressure change: < 3.5 kPa/sec
- In no circumstance the dew point shall be reached.
The flight hardware transportation containers shall be designed to limit the spacecraft and payload transportation environment to less than the values contained in this section, when subjected to the following terrestrial thermal and climatic environments:

- External temperatures -40°C to +65°C
- Altitude of up to 15000 m may be experienced during air transport
- Pressure rate of change during air transportation may reach 143 Pa/s during ascent or descent.
- Relative humidity 0 % to 95 %.

4.1.2 Mechanical environment

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

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

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

The equipment/assembly and associated transport containers shall be sized to survive transportation and handling loads as defined in Table 4.1-1.

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

<table>
<thead>
<tr>
<th>GROUND EVENT</th>
<th>VERTICAL (*)</th>
<th>HORIZONTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Transportation</td>
<td>± 3.0 g</td>
<td>± 2.0 g</td>
</tr>
</tbody>
</table>

(*) Vertical is the direction parallel to the gravity.

Table 4.1-1: Limit Accelerations for Ground Operations

For the loads case (1) listed above, the spacecraft shall also be considered fully integrated and mated to an integration adaptor, with the following characteristics:

- Adaptor mass : 200 kg (including test clamping band).
- Adaptor c.o.g. location : -0.5 m along Zs, below launcher separation plane.

For local design of Spacecraft hoisting points, specific safety factor defined in this specification shall be considered.

During ground transportation the equipments shall withstand without damage the limit shock loads defined in Table 4.1-2.
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<table>
<thead>
<tr>
<th>MODE</th>
<th>DIRECTION</th>
<th>AMPLITUDE (g)</th>
<th>HALF PERIOD (msec)</th>
<th>PULSE SHAPE</th>
<th>PULSES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>±X</td>
<td>±4.0</td>
<td>20</td>
<td>Saw Tooth</td>
<td>1</td>
</tr>
<tr>
<td>Ground</td>
<td>±Y</td>
<td>±4.0</td>
<td>20</td>
<td>Saw Tooth</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>±Z</td>
<td>±4.0</td>
<td>20</td>
<td>Saw Tooth</td>
<td>1</td>
</tr>
<tr>
<td>Transportation</td>
<td>±Y</td>
<td>±4.0</td>
<td>20</td>
<td>Saw Tooth</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>±Z</td>
<td>±4.0</td>
<td>20</td>
<td>Saw Tooth</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 4.1-2: Instrument Transportation Limit Shock Load**

**GDI-2327/**

All MGSE, containers, transportation and handling methods shall be such that flight hardware for which it is intended, never experience any environmental condition outside the defined envelope above.

**GDI-2328/**

Sine and random vibrations: the unit transport container shall be designed to ensure that the loads experienced by the flight unit are limited to the constant acceleration levels defined above.

**GDI-2329/**

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

The transportation containers shall be designed to ensure that the flight unit contained within is protected from and shall be undamaged by shocks.

**GDI-2663/**

Fatigue loads: in case of a launch from Baikonur, the SVM and the PLM instrument shall survive with sufficient life time allowable the low frequency cycling loads of Table 4.1-3, multiplied by a life factor of 4.

<table>
<thead>
<tr>
<th>Number of ground cycles at PLM Instrument CoM</th>
<th>Amplitude (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Lateral</td>
<td>260000</td>
</tr>
<tr>
<td>Longitudinal (Xs)</td>
<td>400000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of ground cycles at S/C CoM</th>
<th>Amplitude (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>Lateral</td>
<td>260000</td>
</tr>
<tr>
<td>Longitudinal (Xs)</td>
<td>400000</td>
</tr>
</tbody>
</table>

**Table 4.1-3: Low Frequency Cycling Loads**

**GDI-2665/**

Sloshing environment: in case of a launch from Baikonur, the SVM and in particular the propellant tanks shall be fully functional after being submitted to the low frequency sine vibration loads of Table 4.1-4. If required, the propellant tank orientation and the propulsion tubing shall be selected/optimised to minimise the potential for gas trapping in liquid sections during this phase.
### Table 4.1-4: Low Frequency Ground Sine Loads

<table>
<thead>
<tr>
<th>Sine Vibration Loads at S/C Separation Plane (g)</th>
<th>Frequency Band (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 to 2</td>
</tr>
<tr>
<td>Y and Z (1)</td>
<td>0,1</td>
</tr>
<tr>
<td>X</td>
<td>0</td>
</tr>
</tbody>
</table>

Note 1: a gravity field of 1 g static shall be added on the vertical component

### 4.2 Launch and Early Operation phase

The LEOP phase extends from separation of the spacecraft from the launcher upper stage until the end of the deployment and initial check out of the spacecraft.

#### 4.2.1 Pressure Environment

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

For Soyuz-Fregat, the typical slope of the static pressure within the fairing is shown in Figure 4.2-1.

![Figure 4.2-1: Variation of fairing static pressure during ascent phase](image)

*Units mounted on the S/C shall be designed to withstand without degradation, a de-pressurization rate of 70mbar/s maximum and a Δ-P of 150mbar over ambient.*
4.2.2 Contamination

GDI-782/CREATED

Cleanliness requirements are as defined in the PA requirements

4.2.3 Mechanical environment

The equipment environments are a function of their location on the launch composite. For S/C mounted equipments, the applicable location is identified in the specific unit specification and the environments for each location are given below.

For all equipments/assemblies:

- tests in the in plane axis refers to quasi-static, vibration or shock testing in a direction parallel to the equipment mounting plane,
- tests in the out of plane axis refers to quasi-static, vibration or shock testing in a direction orthogonal to the equipment mounting plane.

4.2.3.1 Quasi static and low frequency loads

GDI-799/CREATED

The quasi-static and low frequency flight limit accelerations that all units on the S/C Structure will encounter during launch and early orbit phase are compiled in Table 4.2-1.

The loads are applied:

- At the unit c-o-g,
- Along the worst spatial direction w.r.t resulting reactions/stresses.

Structural dimensioning of units shall consider critical combination of simultaneously acting loads. The safety factors to be used for design dimensioning purpose are defined in Section 3.2.1.5.

<table>
<thead>
<tr>
<th>Axis</th>
<th>Design Load</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of plane</td>
<td>DLO = 80 / [(unit mass)^0.4]</td>
<td></td>
</tr>
<tr>
<td>In Plane (3)</td>
<td>DLI = DLO * 2/3</td>
<td>General Case</td>
</tr>
<tr>
<td>In Plane (3)</td>
<td>DLI = (H_CoG/W_footprint)^0.5 x DLO</td>
<td>If H_CoG/W_footprint &gt;0.5</td>
</tr>
</tbody>
</table>

Notes:

1. see table GDI-813 for "g_rms_a", lines for out of plane input.
2. see table GDI-813 for "g_rms_a", lines for in plane input.

In case of slim/tall units or units mounted on high brackets, when the footprint width and/or length is smaller than 2 times the CoG offset, then DLI = (H_CoG/W_footprint)^0.5 x DLO shall be used instead of DLI for the considered direction(s).

Table 4.2-1: Quasi-static Loads
4.2.3.2 Dynamic Environment

The launch will induce dynamic vibration loads at the unit interfaces. The levels of these dynamic excitations depend on both the launcher type and the dynamic couplings between the launcher, the satellite and/or instrument/lower level sub-assemblies on which the units are mounted.

The dynamic (vibration) levels that apply at units interface are defined:

- In Table 4.2-2 for sinusoidal vibration
- In Table 4.2-3 for random vibration

4.2.3.2.1 Sinusoidal Environment

GDI-808/SRD-LAU-1; SRD-STRE-2

All units mounted on the SCM structure shall be designed and tested to withstand, without degradation, the sinusoidal environment as defined in Table 4.2-2. The safety factors to be used for design dimensioning purposes are defined in Section 3.2.1.5.2.

<table>
<thead>
<tr>
<th>Axis</th>
<th>Frequency [Hz]</th>
<th>Qualification</th>
<th>Limit Loads = Acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of plane</td>
<td>5-20</td>
<td>12.9 mm</td>
<td>9.9 mm</td>
</tr>
<tr>
<td></td>
<td>20-100</td>
<td>21 g</td>
<td>16 g</td>
</tr>
<tr>
<td>In Plane</td>
<td>5-20</td>
<td>8.6 mm</td>
<td>6.6 mm</td>
</tr>
<tr>
<td></td>
<td>20-100</td>
<td>13.9 g</td>
<td>10.7 g</td>
</tr>
<tr>
<td>Sweep Rate</td>
<td>2 Oct/min.</td>
<td></td>
<td>4 Oct/min.</td>
</tr>
<tr>
<td></td>
<td>1 sweep-up</td>
<td></td>
<td>1 sweep-up</td>
</tr>
</tbody>
</table>

Note: The above assumes a SOYUZ qualification factor of 1.3

Table 4.2-2: Sinusoidal Environment Levels

Protoflight environment is defined as qualification levels at acceptance sweep rate.

4.2.3.2.2 Random Environment

GDI-812/CREATED

Units shall be designed and tested to withstand, without degradation, the random environment as defined in Table 4.2-3. The safety factors to be used for design dimensioning purposes are defined in Section 3.2.1.5.2.
<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>Limit Loads = Acceptance Level</th>
<th>Qualification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Duration: 60 s each axis</td>
<td>Duration: 120 s each axis</td>
</tr>
<tr>
<td></td>
<td>PSD [g^2/Hz]</td>
<td>Overall [g RMS]</td>
</tr>
<tr>
<td></td>
<td>g-rms_a (a)</td>
<td>g-rms_q (a)</td>
</tr>
<tr>
<td>20 - 100</td>
<td>+3 dB/ Oct</td>
<td>+3 dB/ Oct</td>
</tr>
<tr>
<td>100 - 400</td>
<td>PSD_a (a)</td>
<td>PSD_q (a)</td>
</tr>
<tr>
<td>400 - 2000</td>
<td>-6 dB/ Oct</td>
<td>-6 dB/ Oct</td>
</tr>
</tbody>
</table>

Note (a): The values for PSD_a, PSD_q, g-rms_a and g-rms_q are given in the table below.

<table>
<thead>
<tr>
<th>Assembly/ unit</th>
<th>axis</th>
<th>Limit Loads = Acceptance Level</th>
<th>Qualification Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>equipment on TEP's</td>
<td>in plane</td>
<td>PSD_a [g^2/Hz]</td>
<td>g-rms_a [g]</td>
</tr>
<tr>
<td>mass &lt; 1.5 kg</td>
<td>out of plane</td>
<td>0.11</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.25</td>
<td>13.0</td>
</tr>
<tr>
<td>equipment on TEP's</td>
<td>in plane</td>
<td>0.077</td>
<td>7.2</td>
</tr>
<tr>
<td>mass 1.5 - 5 kg</td>
<td>out of plane</td>
<td>0.175</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.044</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.1</td>
<td>8.2</td>
</tr>
<tr>
<td>equipment on TEP's</td>
<td>in plane</td>
<td>0.125</td>
<td>9.2</td>
</tr>
<tr>
<td>mass &gt; 5 kg</td>
<td>out of plane</td>
<td>0.625</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.125</td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.35</td>
<td>15.4</td>
</tr>
<tr>
<td>equipment on other panels</td>
<td>in plane</td>
<td>0.088</td>
<td>7.7</td>
</tr>
<tr>
<td>mass &lt; 1.5 kg</td>
<td>out of plane</td>
<td>0.2</td>
<td>11.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.088</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2</td>
<td>11.6</td>
</tr>
<tr>
<td>equipment on other panels</td>
<td>in plane</td>
<td>0.02</td>
<td>3.7</td>
</tr>
<tr>
<td>mass 1.5 - 5 kg</td>
<td>out of plane</td>
<td>0.05</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.02</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05</td>
<td>5.8</td>
</tr>
<tr>
<td>equipment on other panels</td>
<td>in plane</td>
<td>0.125</td>
<td>9.2</td>
</tr>
<tr>
<td>mass &gt; 5 kg</td>
<td>out of plane</td>
<td>0.625</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.125</td>
<td>9.2</td>
</tr>
<tr>
<td>Propellant and CG Tank</td>
<td>all directions</td>
<td>0.02</td>
<td>3.7</td>
</tr>
<tr>
<td>Pressurant Tank</td>
<td>all directions</td>
<td>0.05</td>
<td>5.8</td>
</tr>
</tbody>
</table>

NOTES:

1. Units: Battery, PCDU, TRSP, RDFU, EIU, CDMU, APU, CDU, PDHU, Gyros are accommodated on the Tangential Equipment Panels (TEP’s).

2. Units: Star Trackers, DSS, LGA, SREM, SSPA, PAA, MPE (if FEEP option) and all propulsion components are accommodated on other panels or appendages.

3. If the ratio R of CoG height divided by footprint width is greater than 0.5 than the in plane PSD_ip shall be R*PSD_oop with a maximum PSD_oop of 0.25g^2/Hz.

4. If the provider of an off-the-shelf equipment cannot demonstrate compliance with a.m. qualification spectra the provider is requested to present random load heritage of the equipment. An investigation will be performed on system side for potential reduction of the random loads by consideration of the dedicated position on the SVM.

**Table 4.2-3: Random Environment Levels**

Protoflight environment is defined as qualification levels for acceptance duration.
4.2.3.2.3 Acoustic environment

Units shall be designed and tested to withstand, without degradation, the acoustic environment as defined in Table 4.2-4 hereafter. The safety factors to be used for design dimensioning purposes are defined in Section 3.2.1.5.2.

<table>
<thead>
<tr>
<th>Acoustic Vibration Environment</th>
<th>Limit Load = Acceptance Level (dB)</th>
<th>Qualification Level (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Octave Band (Hz) (Centre Frequency)</td>
<td>(duration = 1 mn)</td>
<td>(duration = 2 mn)</td>
</tr>
<tr>
<td>31.5</td>
<td>125</td>
<td>128</td>
</tr>
<tr>
<td>63</td>
<td>132</td>
<td>135</td>
</tr>
<tr>
<td>125</td>
<td>134</td>
<td>137</td>
</tr>
<tr>
<td>250</td>
<td>136</td>
<td>139</td>
</tr>
<tr>
<td>500</td>
<td>134</td>
<td>137</td>
</tr>
<tr>
<td>1000</td>
<td>125</td>
<td>128</td>
</tr>
<tr>
<td>2000</td>
<td>121</td>
<td>124</td>
</tr>
<tr>
<td>4000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Overall Level (Ref.: dB = 2x10^{-5} Pa)</td>
<td>141</td>
<td>144</td>
</tr>
</tbody>
</table>

Table 4.2-4: Acoustic Vibration Environment Levels

4.2.3.2.4 Shock Environment

The spacecraft/instrument is subjected to shocks, principally during its separation from the launch vehicle upper stage.

The shock levels resulting from the launch vehicle shock spectrum at the spacecraft interface plane create a shock at the unit/satellite interface as defined below.

GDI-818/CREATED

Units mounted on the S/C Structure shall be designed to withstand without degradation the qualification shock response spectrum (SRS) defined in Table 4.2-5. The SRS is applicable to each axes X, Y and Z (independently).

GDI-2504/

Units mounted on the PLM Tore shall be designed to withstand without degradation the qualification shock response spectrum (SRS) defined in Table 4.2-5. The SRS is applicable to each axes X, Y and Z (independently).

GDI-2505/

Units mounted on the Thermal Tent shall be designed to withstand without degradation the qualification shock response spectrum (SRS) defined in Table 4.2-5. The SRS is applicable to each axes X, Y and Z (independently).
4.2.4 Thermal environment

The thermal flux on the launcher will be:

- Under fairing < 800 W/m² isotrope (during 3 mn)
- After fairing jettison < 1135 W/m² during 7 mn, in addition to the Earth albedo and IR radiation

During the Launch and early Operation phase, the spacecraft units will be kept within their design temperature limits. Unless otherwise specified in an equipment specification, the levels of Table 4.3-1 have to apply.

GDI-2602/

*For units having a view factor to external space, the solar and terrestrial fluxes of Table 4.3-3 shall be considered*
4.2.5 Electromagnetic and radio frequency environment

The electromagnetic and radio-frequency environment is covered by the electromagnetic and radio frequency requirement.

4.3 In orbit Environment

4.3.1 In orbit mechanical loads

4.3.1.1 Quasi-static & Thermo-elastic Loads

During orbit and attitude correction manoeuvres, units shall be able to withstand the following dynamic environments:

**Linear Acceleration:**
- All axes: 0.03 m/s²

**Angular Velocity:**
- About all S/C axes: 3.0°/s (launcher separation)

**Angular Acceleration:**
- All axes: 1.0°/s²

These events can act simultaneously, and are applied at unit CoG.

The unit shall be compatible with internal loads generated due to thermo-elastic deformation up to a maximum load on any foot of 2000N assuming that it is clamped to a thermally rigid panel (i.e. CTE = 0).

(Applicable only to units mounted on Mechanical Bus CFRP panels).

4.3.1.2 Micro-vibrations

Equipment generating micro-vibrations shall not be used on GAIA. Any equipment that produces micro-vibrations shall only be allowed in exceptional cases for specific phases of the missions and subject to Prime approval.

4.3.1.3 Dynamical disturbances

In equipment operating mode, any potential equipment source of spacecraft dynamic and thermoelastic disturbance shall be identified.

Once the equipment operational conditions have been reached, use of equipment items which are potential source of dynamical and thermoelastic disturbances (such as -but not limited to- switches, heatpipes, electrical load variations) shall be avoided.
4.3.2 In orbit thermal

**GDI-841/CREATED**

*During the In Orbit phase, the spacecraft units TRP will be kept within their design temperature limits. Unless otherwise specified in an equipment specification, the levels of Table 4.3-1 shall apply.*

<table>
<thead>
<tr>
<th></th>
<th>Min Op</th>
<th>Max Op</th>
<th>Min Non-Op</th>
<th>Max Non-Op</th>
<th>Min Start up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance Temperature limits</td>
<td>-15</td>
<td>+55</td>
<td>-35</td>
<td>+65</td>
<td>-35</td>
</tr>
<tr>
<td>Qualification Temperature limits</td>
<td>-20</td>
<td>+60</td>
<td>-40</td>
<td>+70</td>
<td>-40</td>
</tr>
</tbody>
</table>

**Table 4.3-1: Thermal Qualification & Acceptance Levels**

**GDI-2583/**

*During the In Orbit phase, the spacecraft units will face mostly a thermally radiative environment. Unless otherwise specified in an equipment specification, the levels of Table 4.3-2 shall apply.*

<table>
<thead>
<tr>
<th>UNIT</th>
<th>UNIT SINK TEMPERATURE (°C)</th>
<th>UNIT CONDUCTIVE HEAT FLOW (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HOT</td>
<td>COLD</td>
</tr>
<tr>
<td>PDHU</td>
<td>19</td>
<td>-5</td>
</tr>
<tr>
<td>APU</td>
<td>20</td>
<td>-3</td>
</tr>
<tr>
<td>CDMU</td>
<td>22</td>
<td>-2</td>
</tr>
<tr>
<td>EIU</td>
<td>22</td>
<td>-2</td>
</tr>
<tr>
<td>SREM</td>
<td>9</td>
<td>-16</td>
</tr>
<tr>
<td>BATTERY</td>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>PCDU</td>
<td>21</td>
<td>-2</td>
</tr>
<tr>
<td>TRSP 1</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>TRSP 2</td>
<td>20</td>
<td>-4</td>
</tr>
<tr>
<td>RFDU</td>
<td>22</td>
<td>-3</td>
</tr>
<tr>
<td>TDE</td>
<td>21</td>
<td>-3</td>
</tr>
<tr>
<td>STR 1</td>
<td>21</td>
<td>-2</td>
</tr>
<tr>
<td>STR 2</td>
<td>20</td>
<td>-4</td>
</tr>
<tr>
<td>GYRO 1</td>
<td>23</td>
<td>-1</td>
</tr>
<tr>
<td>GYRO 2</td>
<td>22</td>
<td>-2</td>
</tr>
<tr>
<td>GYRO 3</td>
<td>21</td>
<td>-3</td>
</tr>
</tbody>
</table>

**Table 4.3-2: Unit sink temperature - Unit conductive heat flow**

**GDI-2603/**

*For units having a view factor to external space, the solar and terrestrial fluxes of Table 4.3-3 shall be considered.*
### 4.4 Radiation Environment

Basic data on the radiation environment for the transfer trajectory and the final operational location at L2 are provided. These data should be sufficient for assessing radiation damage and single event effects, as defined in ECSS-E-10-04a and ECSS-E-10-12. The data should also be useful for assessing payload effects.

#### 4.4.1 Introduction

The radiation environment of an L2 mission scenario for the GAIA mission is presented. It consists of two phases, the transfer and the operational phases. The transfer phase consists of a single 190 km, 61° inclination circular parking orbit, and the transfer from this to the L2 point. The operational phase consists of the 6-year Lissajous type of orbit around the Lagrangian point L2 of the Sun-Earth system.

#### Transfer Phase

Only the trapped particle belt environment has been considered for the transfer phase, consisting of the parking orbit and the transfer trajectory. Due to geomagnetic shielding effects and the short duration of this phase compared to the operational phase, the solar protons are neglected and instead are included in the operational phase of the mission. Similarly due to geomagnetic shielding effects, the galactic cosmic ray (GCR) environment during the transfer phase is less harsh than during the operational phase and so the GCR environment of the operational phase can be considered the baseline spectra for the entire mission.

#### Operational Phase

For the operational phase around L2, the spacecraft is only subject to cosmic rays and particles from solar particle events. This location is outside of the region of effective geomagnetic shielding and the trapped radiation belts and can be considered to be an interplanetary environment.

The JPL 1991 model has been used with a 90% confidence level over a 6-year period to calculate the total solar proton fluence spectrum for the operational phase.

The CREME-96 software suite has been used to produce the Linear Energy Transfer spectrum for the operational phase for the conditions of solar minimum, solar maximum (quiet- no solar proton event), solar maximum-worst week, and solar maximum-peak 5-minute flux. As the GAIA mission is principally during solar maximum activity, the LET spectrum for quiet time solar maximum is appropriate for Single Event Upset and Latch-Up rate calculations for nominal operational conditions, while the worst-week and peak spectra are appropriate for calculating the worst-case rates.
The radiation environment for the mission is shown in Section 4.4.3.1. Each unit shall be designed to withstand a radiation exposure that is twice the expected radiation environment during the mission (i.e. Radiation Damage Margin (RDM) = 2). This applies to all types of radiation damage, including ionising dose (total and low dose) and displacement damage.

Both trapped protons (Figure 4.4-3) and trapped electrons (Figure 4.4-6) contribute to the total ionizing dose damage.

4.4.2 GAIA Radiation Environment

Following the initial transfer post launch to L2, the mission duration will be 5.5 years, with a possible one year extension.

4.4.2.1 Galactic Cosmic Ray (GCR) and Solar Energetic Particle Environment

Cosmic rays originate outside the solar system. Fluxes of these particles are low, but as they include heavy, energetic (HZE) ions of elements such as iron, they cause intense ionisation as they pass through matter, and are difficult to shield. The solar wind serves to attenuate the fluxes, providing an anti-correlation with the solar cycle. Single event upsets and latch ups are the dominant effects of cosmic rays on spacecraft electronics. Even though the flux is low, over several years the fluence of particles can reach levels which are hazardous to sensitive devices.

The Cosmic Ray Effects on Micro Electronics (CREME-96) suite of programs [12] provides a comprehensive set of Linear Energy Transfer (LET) spectrum, including the treatment of geomagnetic shielding and material shielding. An upset/hit rate computation is based on the path length distribution in a sensitive volume. A simplified trapped proton induced SEU rate is also provided by the model. Calculating these upset rates, though, requires detailed information about the electronic components concerned and is beyond the scope of this analysis.

Table 4.4-1: Parameters used for CREME96 simulation

<table>
<thead>
<tr>
<th>Cosmic Ray and Solar Energetic Particle Models: CREME96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spacecraft shielding: 1 g/cm² or 0.66 g/cm² Aluminium</td>
</tr>
<tr>
<td>Ion range: Z = 1 and Z = 2 to 92</td>
</tr>
<tr>
<td>Geomagnetic shielding: quiet magnetosphere</td>
</tr>
</tbody>
</table>

| GDI-1946/CREATED |

The integral LET spectra generated using CREME96 (excluding proton effects) are shown in Figure 4.4-1 for 1 g/cm² Aluminium shielding.

This data should be used for analysis of Single Event Effects in most components not susceptible to proton induced upset, typically those which have a sensitivity threshold above 15 MeV - cm²/mg.)
Figure 4.4-1: The Galactic cosmic ray Linear Energy Transfer (LET) integral spectrum for the GAIA mission for different levels of activity: nominal (GEO quiet), worst week, worst day and peak 5-minute flux. This LET spectrum in silicon has been calculated assuming a shielding of 1 g/cm².
Figure 4.4-2: CREME 96 Galactic Cosmic Ray LET Spectra for the GAIA mission for the different levels of activity, nominal (GEO quiet), worst week, worst day, and peak 5 minute for a component shielded by 1 g/cm²

4.4.2.2 Trapped Proton Environment during transfer

The radiation belts encircle the Earth and contain particles trapped in its magnetic field. An inner belt contains mainly energetic protons with energies up to several hundred MeVs. This belt is reasonably stable in time and extends to a geocentric distance of 4-REarth. The outer belt consists primarily of energetic electrons of energies up to a few MeVs. By contrast, this outer, electron, belt is highly dynamic, being subject to storms and injection events that follow solar-terrestrial disturbances. The electron belt extends to near the magnetopause at about 10 R Earth radii.
The trapped radiation models employed were those developed in the early ‘70s by Vette and colleagues for NASA (AP8 for protons). These models were used to provide orbit averaged particle spectra after mapping the satellite orbit into geomagnetic co-ordinates through the Jenson and Cain 1960 geomagnetic field model and the Cain 120-term 1966 IGRF geomagnetic field model projected to 1970.

Figure 4.4-3: Average trapped proton spectrum for the transfer from 190 km circular orbit to L-2 over the first day of the transfer trajectory, mission without shielding

4.4.2.3 Solar Proton Environment on station

Solar protons are products of solar events, with energies in excess of several hundred MeV and peak fluxes in excess of $10^6$ Protons/cm$^2$/sec for protons with energies greater than 10 MeV. These events, though, are relatively rare, occurring primarily during periods of solar maximum activity, which commences 2.5 years before sunspot maximum and lasting for seven years. The duration of individual events is usually on the order of days. The large fluxes of energetic protons and heavier ions can contribute a large dose, increase upset rates in electronics and increase radiation induced background noise in detectors.

The solar flare proton model used was that recently developed by Feynman et al. at JPL. This model uses a data set spanning three solar cycles. Spacecraft engineers are replacing the older King model as the standard solar flare model with the JPL model. Note that whereas the trapped particle models represent the best estimate of the average environment, the solar proton model is a risk assessment model. For GAIA, the results are at a 90% confidence level (so there is a 10% chance of their being exceeded).
Figure 4.4-4: Solar Proton Fluence spectra for the 6.5-year operational mission at a 90% confidence level.

**without shielding**
The radiation belts encircle the Earth and contain particles trapped in its magnetic field. The outer belt consists primarily of energetic electrons of energies up to a few MeVs. By contrast, this outer, electron, belt is highly dynamic, being subject to storms and injection events that follow solar-terrestrial disturbances. The electron belt extends to near the magnetopause at about 10 R Earth radii.

Figure 4.4-6 shows the mission average integral electron spectra without shielding using the AE-8 models. The trapped radiation models employed were those developed in the early '70s by Vette and colleagues for NASA. These models were used to provide orbit averaged particle spectra after mapping the satellite orbit into geomagnetic co-ordinates through the Jenson and Cain 1960 geomagnetic field model and the Cain 120-term 1966 IGRF geomagnetic field model projected to 1970.
Figure 4.4-6: Average trapped electron spectrum for the transfer from 190 km circular orbit to L-2 over the first day of the transfer trajectory.

4.4.3 Long Term Effect Considerations

4.4.3.1 Ionizing Dose Depth Curve

Total ionizing dose as a function of Aluminum thickness have been computed using Shieldose-2 code included in SPENVIS software. Proton and electron spectra presented in Figure 4.4-3, Figure 4.4-4 and Figure 4.4-6 were considered as input. Shielding shape considered by Shieldose-2 corresponds to a solid sphere with a detector located in its center. The following figure presents the total dose deposition in the detector as a function of the solid sphere thickness, tabulated values are provided in GDI-2064.

GDI-1966/CREATED

The radiation environment for the mission shall be as shown in Figure 4.4-7 and Figure 4.4-8 and each unit shall be designed to withstand a radiation exposure as described in Section 4.4.

Figure 4.4-7: Ionising dose (Rads in Silicon) for the 6.5-year extended operational phase of the mission as a function of spherical aluminium shielding thickness.
4.4.3.2 Displacement Damage

High energetic protons can induce permanent damage by displacement in the active material bulk (Silicon, GaAs, or other). Estimation of displacement effects are based on the equivalent proton or neutron fluence curve deduced from Non Ionizing dose-depth curve. Such a curve is presented in Figure 4.4-9 and Figure 4.4-10. Mission hypothesis are similar to the ones used for ionizing dose depth curve.

Figure 4.4-9: Non Ionising Energy Loss as a function of shielding thickness for the GAIA mission.
4.4.4 Rules for Design and Performance

**GDI-876/Created**

*No protective shielding by the outer panels of the satellite shall be assumed.*

**GDI-877/Created**

*Unit shall take into account the shielding provided by its own casing*

4.4.5 Radiation Sensitive Components

**GDI-1969/Created**

*The Subcontractor shall implement a Radiation Hardness Assurance programme at his level, documented by a Radiation Hardness Assurance plan, including specific additional de-rating and design rules. It shall be submitted to ASTRIUM for approval.*

**GDI-1970/Created**

*All parts shall be reviewed by the Subcontractor to establish their ability to meet the hardness criteria according to the radiation environment as defined in Section 4.4.*

**GDI-1971/Created**

*The Subcontractor shall issue a Radiation Assessment document identifying all sensitive components with regard to relevant radiation effects (total dose, heavy ions, protons), their impact and giving the adequate solution (local shielding, design solution, specific test, RVT, ...) for the relevant equipment.*

---

**Figure 4.4-10:** Non-Ionising Energy Loss (NIEL) equivalent 10 MeV proton fluence as a function of shielding thickness for the GAIA mission

<table>
<thead>
<tr>
<th>Shielding Thickness [mm Al]</th>
<th>Non-Ionising Energy Loss [MeV/μg(Si)]</th>
<th>Equivalent 10 MeV protons</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>9.78E+09</td>
<td>1.42E+12</td>
</tr>
<tr>
<td>0.1</td>
<td>5.07E+09</td>
<td>7.35E+11</td>
</tr>
<tr>
<td>0.2</td>
<td>2.33E+09</td>
<td>3.38E+11</td>
</tr>
<tr>
<td>0.3</td>
<td>1.61E+09</td>
<td>2.34E+11</td>
</tr>
<tr>
<td>0.4</td>
<td>1.21E+09</td>
<td>1.76E+11</td>
</tr>
<tr>
<td>0.5</td>
<td>9.34E+08</td>
<td>1.35E+11</td>
</tr>
<tr>
<td>0.6</td>
<td>7.42E+08</td>
<td>1.08E+11</td>
</tr>
<tr>
<td>0.8</td>
<td>5.09E+08</td>
<td>7.38E+10</td>
</tr>
<tr>
<td>1</td>
<td>4.23E+08</td>
<td>6.13E+10</td>
</tr>
<tr>
<td>1.5</td>
<td>3.09E+08</td>
<td>4.40E+10</td>
</tr>
<tr>
<td>2</td>
<td>2.41E+08</td>
<td>3.49E+10</td>
</tr>
<tr>
<td>2.5</td>
<td>1.93E+08</td>
<td>2.79E+10</td>
</tr>
<tr>
<td>3</td>
<td>1.64E+08</td>
<td>2.30E+10</td>
</tr>
<tr>
<td>4</td>
<td>1.20E+08</td>
<td>1.74E+10</td>
</tr>
<tr>
<td>5</td>
<td>9.03E+07</td>
<td>1.31E+10</td>
</tr>
<tr>
<td>6</td>
<td>7.96E+07</td>
<td>1.15E+10</td>
</tr>
<tr>
<td>7</td>
<td>7.07E+07</td>
<td>1.02E+10</td>
</tr>
<tr>
<td>8</td>
<td>6.26E+07</td>
<td>9.06E+09</td>
</tr>
<tr>
<td>9</td>
<td>5.73E+07</td>
<td>8.31E+09</td>
</tr>
<tr>
<td>10</td>
<td>5.26E+07</td>
<td>7.62E+09</td>
</tr>
<tr>
<td>12</td>
<td>4.48E+07</td>
<td>6.44E+09</td>
</tr>
<tr>
<td>14</td>
<td>3.91E+07</td>
<td>5.66E+09</td>
</tr>
<tr>
<td>16</td>
<td>3.41E+07</td>
<td>4.94E+09</td>
</tr>
<tr>
<td>18</td>
<td>3.07E+07</td>
<td>4.45E+09</td>
</tr>
<tr>
<td>20</td>
<td>2.73E+07</td>
<td>3.95E+09</td>
</tr>
</tbody>
</table>
4.4.5.1 Total Dose

**GDI-1975/CREATED**

The total dose to be taken into account is defined in Section 4.4.3 of this specification for the lifetime of the mission. Comparison between component type Total Dose Sensitivity (TDS) and Total Dose Level (TDL) to be received by parts within equipment is required for all active EEE part types used by Subcontractor.

- Parts are considered suitable if their Total Dose Sensitivity is greater than twice the dose received.
- Other parts shall be submitted to a RVT (Radiation Verification Test).

A sector analysis shall be performed in order to determine the TDL at part level.

4.4.5.2 Single Event Effects (SEE)

**GDI-1977/CREATED**

Parts are considered SEE immune when the \( \text{LET}_{th} \) is greater than 70 MeV.cm\(^2\)/mg. Parts are considered sensitive to heavy ion and proton induced SEE when the \( \text{LET}_{th} \) is lower than 15 MeV.cm\(^2\)/mg.

**GDI-1978/CREATED**

The component shall be designed to tolerate GCR, proton and heavy ion induced SEEs in accordance with the fluxes given in Section 4.4.2.1, Section 4.4.2.2 and Section 4.4.2.3. Parts subject to SEE shall be analysed and/or tested for latchup and/or Single Event Upset (SEU). Where EEE parts are not compliant with the radiation requirements specified in this section, the design must compensate for or tolerate the effects (e.g. by latch-up switches and/or autonomous software recovery methods).

4.4.5.3 Single Event Latch-up

**GDI-1980/CREATED**

Devices which are known to be susceptible to latch-up’s shall not be used, however the use of SEL sensitive devices is accepted if the Latch Up Rate (LUR) follows: \( \text{LUR} < 10\% \lambda_{dev} \).

\( \lambda_{dev} \): intrinsic device failure rate, as determined using MIL HDBK217, or based on experimental set of reliability data to be submitted to ASTRIUM approval. Latch up protection circuitry can be used only after project acceptance.

4.4.5.4 Non Destructive Single Event (Single Event Upset, Single Event Transient...)

**GDI-1982/CREATED**

Part types shall be acceptable according to the acceptance criteria for SEP, i.e. the error rate is compatible with the mission. If this is not the case, part replacement or implementation of proper countermeasure is required: error correction, design hardening, any solutions at equipment or system level lowering the maximum error rate are acceptable so that part types will be acceptable.

**GDI-2681/CREATED**

Memory circuits shall have sufficient error detection and correction capability for protection against SEU such that the circuit performance goals are not affected by these errors.
4.4.5.5 Single Event Burnout (SEB) and Single Event Gate Rupture (SEGR)

GDI-1984/CREATED

For SEB and SEGR, error rate prediction techniques are not mature and require project approval before use. Radiation assurance is then based on de-rating rules of maximum operating values.

If no acceptable SEGR and SEB data exist,

- If MOSFETs from HARRIS/INTERSIL/FAIRCHILD or International Rectifier (generation III or generation IV), the Vds voltage must be at least 50% lower than the maximum Vds (with VDS max<200V) and Vgs>0V (N-channel MOSFETs) or Vgs<0V (P-channel MOSFETs)
- In any other cases, rule as presented in document "Radiation Hardness Assurance Requirements for EEE components in the frame of GAIA Program - ref. GAIA-ASF-SP-SAT-00044" to be found in annex to PA requirements shall be applied.

If SEGR and SEB acceptable data exist,

Acceptable evaluation phase data will give drain to source threshold voltages (Vdsth) versus LET and gate to source voltage (Vgs), for static ON and static OFF case temperature. Worst case Vdsth(WC) will be defined.

The derating is to maintain Vds over the full design life time as:

\[ Vds \leq 0.80 \times Vdsth(WC) \]

with

a) \( |Vgs| < |Vgsmax| \) used during testing for Vdsth(WC) estimate
b) \( T_{test} < T_{case} \) where \( T_{test} \) is the case temperature used during testing, for Vdsth(WC) estimate.

4.4.5.6 Displacement Damage

GDI-1986/CREATED

Parametric and functional sensitivity of an EEE part will be estimated for \( X \) MeV equivalent proton fluence level. \( X \) usually being 1 or 10, any other value should be submitted to project approval before use.

All types shall be categorized as follows, displacement damage equivalent fluence being compared to displacement damage sensitivity fluence:

- Group 1: \( 2 \times \) proton fluence level < sensitivity fluence level
  - No generic requirements.
- Group 2: \( 1.5 \times \) proton fluence level < sensitivity fluence level < \( 2 \times \) proton fluence level
  - Lot testing.
- Group 3: Sensitivity fluence level < \( 1.5 \times \) proton fluence level
  - Part not acceptable as is.

Shielding of parts, replacement, or any other solutions shall be found in order to transfer part from group 3 to group 1 or 2.

GDI-1987/CREATED

The reset or data corruption occurrence rate due to Single Event Upset (SEU) shall not exceed \( 1 \times 10^{-4} \) per day. Any exceptions shall be subjected to Astrium for approval on a case by case basis.
4.5 EMC Environment

4.5.1 EMC Performance Requirements

4.5.1.1 Inrush Current

Inrush current at unit switch on shall not exceed the following characteristics:

- Rate of change of current, $\frac{dI}{dt} < 2 \text{ A/µs}$
- Total charge $Q < 4 \text{ms}^* I$, for the input filter settling time of $t < 4 \text{ms}$ (where $I = \text{LCL Trip-Off Class in Amps}$)
- for LCL class F, the total charge $Q$ is TBD

The $\frac{dI}{dt}$ shall be guaranteed without overstress and without any source current limitation and in the presence of any Bus voltage $\frac{dV}{dt}$

4.5.1.2 Voltage Transients

Conducted voltage transients on the primary power bus, appearing during nominal mode switching (excluding ON / OFF) shall be $\leq 1 \text{ Vpp}$ when measured with at least 10 MHz bandwidth.
4.5.1.3 Conducted Emissions on Regulated Power Bus

4.5.1.3.1 Conducted Emissions on Power Leads, Frequency Domain

Conducted narrow band current emissions (differential mode) in the frequency range 30 Hz - 50 MHz appearing on the unit’s primary power lines shall not exceed the limits of Figure 4.5-2. At frequencies below 10 kHz the CE shall be:

- The figure is applicable for units upto 30W power consumption.
- For units demanding more than 30W power, the figure can be scaled proportionally to the actual power demand over the entire frequency range, with an increase in dB given by $20 \log \left( \frac{P}{30} \right)$.

The emissions shall be measured up to 100 MHz (50-100 MHz) for information only.

![Differential Mode Graph](image)

Figure 4.5-2: Conducted Emission Power Lines, NB, and Differential Mode

Conducted narrow band current emissions (common mode) in the frequency range 10 kHz - 50 MHz appearing on the unit’s primary power lines shall not exceed the limits of Figure 4.5-3. The emissions shall be measured up to 100 MHz (50 - 100 MHz) for information only.
4.5.1.3.2 Conducted Emissions on Power Leads, Time Domain

GDI-907/CREATED

Time domain conducted differential mode voltage ripple on the primary power bus distribution outlets, measured between positive and return lines, shall be $\leq 100$ mVpp. The voltage ripple shall be measured with at least 50 MHz bandwidth.

Time domain conducted differential mode voltage ripple from the PCDU measured at the primary power bus distribution outlets when connected to a dummy load, shall be $\leq 140$ mVpp. The voltage ripple shall be measured with at least 50 MHz bandwidth.

GDI-908/CREATED

For Primary Power users, time domain conducted emissions, differential mode (ripple and spikes) shall be $\leq 300$ mVpp. The voltage ripple shall be measured with at least a 50 MHz bandwidth.

GDI-2709/CREATED

Time domain current emissions shall be $< 10\%$ of the units current consumption or 300 mApp, whatever is less.

GDI-2717/

In case of internal redundancy, time domain emission tests shall be performed in both nominal and redundant configurations of the unit

4.5.1.4 Conducted Emissions on Secondary Power Lines

The following requirement only applies in the case where an electrical unit supplies secondary power lines to another unit.
4.5.1.4.1 CE for Secondary Power Supply Units, Frequency Domain

**GDI-918/CREATED**

The maximum voltage emission levels for secondary power supplies shall be less than:

- 20mV RMS from 30Hz up to 50MHz in differential mode.
- 20mV RMS from 5 kHz up to 50 MHz in common mode.

The secondary supplies shall be loaded by the representative (R,L,C) loads specified in the unit interface specifications.

Grounding of the load networks shall be representative of the flight configuration for these measurements.

4.5.1.4.2 CE for Secondary Power Supply Units, Time Domain

**GDI-920/CREATED**

The voltage ripple and spikes on secondary power supplies shall be less than:

- 50mVpp in a 50 MHz bandwidth, in differential mode.
- 50mVpp in a 50 MHz bandwidth, in common mode.

The secondary supplies shall be loaded by the representative (R,L,C) loads specified in the unit interface specifications.

Grounding of the load networks shall be representative of the flight configuration for these measurements.

4.5.1.5 Conducted Emissions Signal lines Common Mode

**GDI-2711/CREATED**

Conducted Narrow band conducted emissions (common mode) in the frequency range 10 kHz - 50 MHz as measured on the unit’s signal bundles shall not exceed the limits of Figure 4.5-4.

The emissions shall be measured up to 100 MHz (50 - 100 MHz for information only)

This requirement applies also to secondary power bundles
4.5.2 Radiated Emissions - E field

The unit shall not exceed the specified limits in the range 14 kHz - 20GHz. Testing above 1GHz is not required if the unit does not employ any intentional frequencies above 100MHz and if the emissions at frequencies between 0.5 and 1GHz are at least 20dB below the limit.

The limit of the downlink frequency is relaxed 75dBuV/m for the SSPA.

The launcher radiated emission limits only apply to those units that are powered at launch.

The limits are given in Figure 4.5-5 and GDI-2704.

The frequencies resp. frequency bands noted below may only be used by the item identified.

For all other units or equipment, the use of these frequencies resp. frequency bands shall be avoided.

- 192 MHz +/- 576 kHz    TM Tx, stage II of Soyuz / launch site
- 248 MHz +/- 744 kHz    TM Tx, stage III of Soyuz / launch site
- 2805 MHz +/- 3 MHz     Tx, position measurement system of Soyuz launcher / launch site
- 2725 MHz +/- 1 MHz     Rx, position measurement system of Soyuz launcher / launch site
- 3410.3 MHz             Tx of trajectory measuring devices of Fregat
- 5754.9 MHz             Rx of trajectory measuring device of Fregat
- 6380 MHz               TM Tx of first system of Fregat
- 643 MHz                TM Tx of second system of Fregat
- 7190 MHz - 7235 MHz    Spacecraft X-Band receiver
- 8450 MHz - 8500 MHz    Spacecraft X-Band transmitter
Figure 4.5-5: Radiated Emissions E-Field, NB

**GDI-2704/**

*On board Receiver Notch:*

20 dBµV/M between 7190 and 7235 MHz  

Note: Launcher RE limits notches of:

- 20 dBµV/M between 1570 and 1620 MHz  
- 19 dBµV/M between 1573 and 1616 MHz  
- 46 dBµV/M between 1620 and 1782 MHz  
- 50 dBµV/M between 2723.45 and 2727.55 MHz  
- 36 dBµV/M between 5754.87 and 5754.94 MHz

are to be considered in addition, only applicable to units switched on during launch

4.5.3 Radiated Emissions - H field  
**GDI-926/Created**

The radiated H field generated by Units, shall be below the following limit:

110dBpT at 50Hz falling linearly on a log frequency scale to 70dBpT at 50KHz.

4.5.4 Radiated Emissions Fluctuations - E Field  
**GDI-2013/Created**

Any specific requirements on E-field will be detailed in the individual equipment specification

4.5.5 Radiated Emissions Fluctuations - H Field  
**GDI-2022/Created**

Any specific requirements on H-field will be detailed in the individual equipment specification
4.5.6 Radiated Susceptibility - E field

GDI-928/CREATED

The unit shall not show any malfunction or deviation from the specified performance when irradiated with the following E-fields:

- **Payloads**: 10kHz to 18GHz: 2V/m rms
- **Platform**: 10kHz to 18GHz: 2V/m rms (unit suppliers may alternatively prefer to verify non susceptibility to low frequencies by a combination of analysis and design and to only test over the range 30MHz to 18GHz. If such an approach were to be proposed by the supplier it shall be agreed in advance with the prime).

The radiated E-field shall be amplitude modulated by a sine wave at 1kHz with a modulation depth of 30%.

GDI-2705/CREATED

The unit shall not show any malfunction or deviation from the specified performance when irradiated with the following E-fields:

- **X band Transmitter 8450 - 8500 MHz**: 30 V/m

GDI-929/CREATED

No unit that is powered On at launch shall show any malfunction or deviation from the specified performance when irradiated with the launcher E-fields as listed in Table 4.5-1.

No unit shall show any malfunction or deviation from the specified performance when irradiated with the XBS transmitter E-field as listed in Table 4.5-1.
<table>
<thead>
<tr>
<th>Frequency range, MHz</th>
<th>Max. LV E field emissions (dB, μV/m)</th>
<th>Transmitters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Диапазон частот, МГц</td>
<td>Максимальное радиоизлучение РН, дБ×мкВ/м</td>
<td>Передатчики</td>
</tr>
<tr>
<td>0.001-195</td>
<td>60</td>
<td>Launch vehicle radio telemetry systems SKUT-40 – UPM</td>
</tr>
<tr>
<td>195-215</td>
<td>130</td>
<td>Система РТСЦ (ША575БГ, ША575БЕ)</td>
</tr>
<tr>
<td>215-400</td>
<td>60</td>
<td>Launch vehicle digital Telemetry systems – RTSTs (Sha575BE)</td>
</tr>
<tr>
<td>400-620</td>
<td>80</td>
<td>Fregat Radio telemetry systems (TMC-M4, TMC-M6)</td>
</tr>
<tr>
<td>620-650</td>
<td>140</td>
<td>Радиотелеметрическая система РН СКУТ-40 – УПМ</td>
</tr>
<tr>
<td>650-1000</td>
<td>80</td>
<td>Радиотелеметрическая система РН СКУТ-40 – УПД</td>
</tr>
<tr>
<td>1000-1004</td>
<td>135</td>
<td>Радиотелеметрическая система РН СКУТ-40 – УПД</td>
</tr>
<tr>
<td>1004-1250</td>
<td>80</td>
<td>Радиотелеметрическая система РН СКУТ-40 – УПД</td>
</tr>
<tr>
<td>1250-2750</td>
<td>100</td>
<td>Радиотелеметрическая система РН СКУТ-40 – УПД</td>
</tr>
<tr>
<td>2750-2850</td>
<td>120</td>
<td>Система ВТИ РБФ РДМ 38Г6</td>
</tr>
<tr>
<td>2850-3409</td>
<td>100</td>
<td>Система ВТИ РБФ ППУ ША840М</td>
</tr>
<tr>
<td>3409-3411</td>
<td>130</td>
<td>Система ВТИ РБФ ППУ ША840М</td>
</tr>
<tr>
<td>3411-10000</td>
<td>100</td>
<td>Система ВТИ РБФ ППУ ША840М</td>
</tr>
</tbody>
</table>

Table 4.5-1: Specific Radiated Susceptibility Levels

4.5.7 Radiated Susceptibility - H field

**GDI-932/CREATED**

*Units shall not be susceptible when submitted to the following perturbation:*

- 50Hz to 50kHz: 140 dbpT

4.5.8 Units linked by Secondary Power Lines

**GDI-934/CREATED**

*When secondary lines power a unit, the unit shall be tested with twice the maximum noise (or ripple) identified in the relevant power specification between these 2 units.*

**GDI-935/CREATED**

*When a unit delivers secondary lines, the unit shall demonstrate under all EMC susceptibility tests (especially conducted susceptibility on PPB) that the maximum noise (or ripple) identified in the relevant power specification between these 2 units is not exceeded.*
4.5.9 Conducted Susceptibility Power Lines

4.5.9.1 Conducted Susceptibility Sine Wave - Differential Mode

**GDI-938/CREATED**

Primary power bus powered units shall not exhibit any failures, malfunctions or unintended responses when sine wave voltages of 1 Vrms in the frequency range 30 Hz - 50 MHz (modified combination of MIL-STD-461C CS01 and CS02 requirements) are developed across the power input terminals (differential mode).

The applied sine wave shall be amplitude modulated (30% AM) with a modulation frequency of 1 kHz in the frequency range from 50 kHz - 50 MHz.

The frequency sweep rate shall be adjusted based on the characteristics of all unit's internal frequencies but not be faster than 3 min/decade.

Prior to performing the test the supplier shall account for the capability of the unit in determining the maximum current limit.

The requirement shall also be considered met when:

1) Frequency range 30 Hz - 50 kHz:
   - The specified test voltage levels cannot be generated but the injected current has reached 1A (rms), or lower if deemed unsafe by analysis, and the equipment is still operating nominally

2) Frequency range 50 kHz - 50 MHz:
   - A 1-watt source of 50W impedance cannot develop the required voltage at the unit's power input terminals, and the unit is still operating nominally.

4.5.9.2 Conducted Susceptibility Sine Wave - Common Mode

**GDI-2000/CREATED**

Primary power bus powered units shall not exhibit any failures, malfunctions or unintended responses when sine wave voltages of 200 mVrms in the frequency range 10 kHz - 50 MHz are injected between the primary power return and structure (common mode).

Prior to performing the test the supplier shall account for the capability of the unit in determining the maximum current limit.

The applied sine wave shall be amplitude modulated (50% AM) with a modulation frequency of 1 kHz in the frequency range from 50 kHz - 50 MHz.

The frequency sweep rate shall be adjusted based on the characteristics of the units internal frequencies, but not faster than 3 min/decade

The injected current shall be limited to 1A (rms), or lower if deemed unsafe by analysis, if necessary the voltage shall be reduced.

4.5.9.3 Conducted Susceptibility - Transient

**GDI-2007/CREATED**

The unit shall not exhibit any malfunctions, degradation of performance or deviation beyond the tolerance indicated in its individual specification when transient voltages typically shaped as shown in (Figure 4.5-6) are applied to the unit power leads.
GDI-2009/Created

**Transient Type 1**

With reference to (Figure 4.5-6), T shall be 10μs ±10%. The pulse repetition frequency of the waveform shall range from 5Hz - 10Hz and the test duration shall be at least 3 minutes.

Vmax shall be ±/−28V superimposed on the nominal bus voltage.

GDI-2010/Created

**Transient Type 2**

With reference to (Figure 4.5-6), T shall be 700μs ±10%. The pulse repetition frequency of the waveform shall range from 5Hz to 10Hz and the test duration shall be at least 3 minutes.

Vmax shall be ±/−2.5V for differential mode superimposed on the nominal bus voltage.

4.5.9.4 CE / CS on Interface signal lines

GDI-944/Created

No unit shall exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when subjected to the conducted and radiated susceptibility tests defined in Section 4.5.

In particular:

- Signal levels at unit signal outputs shall remain within the tolerances defined in Section 3.5 for each signal interface type when subjected to the susceptibility tests.

- Units shall continue to meet their performance requirements in the presence of levels of noise induced by the susceptibility testing appearing additionally at their signal inputs for all valid levels of signal input defined in Section 3.5 (i.e. maximum/minimum source signal level plus induced signal).

GDI-2089/Created

The unit shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated in its individual specification when sinusoidal currents with an amplitude as defined in Figure GDI-2001 are applied to the signal lines. The test signals may be applied to a harness associated with an individual connector or to groups of such harnesses as dictated by the physical configuration of the unit.

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4.5.10 Secondary Power Lines Susceptibility

The following requirements only apply in the case where an electrical unit supplies secondary power lines to another unit

4.5.10.1 CS Sinewave injection for secondary power supply units

GDI-949/CREATED

The conducted susceptibility specification for secondary power supplied units shall be at least:

- 200 mV RMS from 30 Hz up to 50 MHz in differential mode,
- 100 mV RMS from 5 kHz up to 50 MHz in common mode.

Prior to performing the test the supplier shall account for the capability of the unit in determining the maximum current limit.

4.5.10.2 Requirement at subsystem or system level

GDI-951/CREATED

In addition, a margin of at least +6dB shall be demonstrated in frequency domain between the supplier highest emission levels and the supplied unit susceptibility level.

4.5.11 DC Magnetic Requirements

Deleted.

GDI-954/CREATED

Deleted.

GDI-956/CREATED

Deleted.

It is not intended to use high permeable shielding foil for the harness.

GDI-958/CREATED

The use of relays shall be limited to the most critical functions, which cannot be handled by solid state switching.

GDI-959/CREATED

Deleted.

4.5.12 ESD Susceptibility

ESD susceptibility testing is only applicable to Qualification Model and Engineering Model unit builds only. It shall not be performed on Proto Flight or Flight unit builds.

Heritage data may be submitted for review if no Qualification Model or Engineering Model is to be built.

GDI-962/CREATED

The unit shall not be susceptible when submitted to the following perturbations:

- Radiated discharges (10 kV, 10 mJ, Test Duration > 3 min, with a repetition rate of 10 arcs/min) at 30 cm
4.5.13 Corona and Multipaction Requirements

4.5.13.1 Multipaction Discharge

GDI-2687/
All high power output equipment and components (> 1W) shall be free from the effects of multipaction or gas discharge.

GDI-2688/
This shall be demonstrated up to 6dB above the peak operating power levels with waveforms representative of operational signals in pulse duration and PRF. A reduced PRF may be used from peak power up to the 6dB margin whilst maintaining the mean power level.

GDI-2689/
All power levels between 10 W (or a minimum significantly below the theoretical threshold) and the 6 dB margin above peak operating power shall be tested. This may be achieved by slow ramping between these limits so as to ensure no multipaction resonance regions are omitted.

GDI-2690/
All multipaction tests shall be performed in the presence of electron seeding.

4.5.13.2 Corona Gas Discharge

Between any two conductors corona or gas discharge can be assumed not to occur in air at the following voltage stress for the following values of atmospheric pressure x gap between conductors as shown in Figure 4.5-7

<table>
<thead>
<tr>
<th>Maximum safe voltage</th>
<th>Pressure x Gap (standard atmospheres x mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>140 V peak</td>
<td>1 Atm.mm (e.g. 1 atmosphere, 1 mm gap)</td>
</tr>
<tr>
<td>60 V peak</td>
<td>0.3 Atm.mm (e.g. 1 atmosphere, 0.3 mm gap)</td>
</tr>
<tr>
<td>11 V peak</td>
<td>Regardless of pressure</td>
</tr>
</tbody>
</table>

Figure 4.5-7: Gas Discharge - Safe Voltage / Pressure x gap

GDI-2693/
Equipments and sub-systems shall be free from gas discharge during ground testing, launch, early orbit and when in orbit for the lifetime of the satellite
Adequate venting shall be provided to ensure that the gas pressure in any corona critical regions do not remain within the range $1 \times 10^{-2}$ to $0.8 \times 10^5$ N/m$^2$ when the equipment is operating. This requirement ensures that if the equipment is corona free at 1 atmosphere then it will also be corona free at air pressures less than $1 \times 10^{-2}$ N/m$^2$.

If the above requirements GDI-2693 and GDI-2694 cannot be met then flight representative samples shall be tested at twice the maximum voltage stress to ensure that corona does not occur. In this case the Prime contractor shall be consulted and approve the corona test procedure.

4.5.14 Micrometeoroid environment

The micrometeoroid environment for the mission shall be as shown in Figure 4.5-8 and Figure 4.5-9.

**Figure 4.5-8:** Cumulative number of meteoroid impacts for 6.5 years at L2 per m$^2$ from 1 side to a randomly oriented surface for a range of minimum particle sizes as obtained by the Grün model; A density of 2.0 g/cm$^3$ and spherical shape were used to convert masses to diameter.
<table>
<thead>
<tr>
<th>Mass, m [g]</th>
<th>Diameter, D [cm (ρ = 2 g/cm³)]</th>
<th>Fluence, N [m⁻² ∙ 6.5 years]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0E-18</td>
<td>9.65E-07</td>
<td>5.72E+07</td>
</tr>
<tr>
<td>1.0E-17</td>
<td>2.12E-06</td>
<td>8.32E+06</td>
</tr>
<tr>
<td>1.0E-16</td>
<td>4.57E-06</td>
<td>1.29E+06</td>
</tr>
<tr>
<td>1.0E-15</td>
<td>9.65E-06</td>
<td>2.51E+05</td>
</tr>
<tr>
<td>1.0E-14</td>
<td>2.12E-05</td>
<td>5.49E+04</td>
</tr>
<tr>
<td>1.0E-13</td>
<td>4.57E-05</td>
<td>1.81E+04</td>
</tr>
<tr>
<td>1.0E-12</td>
<td>9.65E-05</td>
<td>7.48E+03</td>
</tr>
<tr>
<td>1.0E-11</td>
<td>2.12E-04</td>
<td>3.24E+03</td>
</tr>
<tr>
<td>1.0E-10</td>
<td>4.57E-04</td>
<td>1.36E+03</td>
</tr>
<tr>
<td>1.0E-09</td>
<td>9.65E-04</td>
<td>6.57E+02</td>
</tr>
<tr>
<td>1.0E-08</td>
<td>2.12E-03</td>
<td>2.57E+02</td>
</tr>
<tr>
<td>1.0E-07</td>
<td>4.57E-03</td>
<td>6.57E+01</td>
</tr>
<tr>
<td>1.0E-06</td>
<td>9.65E-03</td>
<td>1.03E+01</td>
</tr>
<tr>
<td>1.0E-05</td>
<td>2.12E-02</td>
<td>1.01E+00</td>
</tr>
<tr>
<td>1.0E-04</td>
<td>4.57E-02</td>
<td>7.16E-02</td>
</tr>
<tr>
<td>1.0E-03</td>
<td>9.65E-02</td>
<td>4.11E-03</td>
</tr>
<tr>
<td>1.0E-02</td>
<td>2.12E-01</td>
<td>2.12E-04</td>
</tr>
<tr>
<td>1.0E-01</td>
<td>4.57E-01</td>
<td>1.03E-05</td>
</tr>
<tr>
<td>1.0E+00</td>
<td>9.65E-01</td>
<td>4.94E-07</td>
</tr>
</tbody>
</table>

**Figure 4.5-9:** Cumulative number of meteoroid impacts for 6.5 years at L2 per m² from 1 side to a randomly oriented surface for a range of minimum particle sizes as obtained by the Grün model; A density of 2.0 g/cm³ and spherical shape were used to convert masses to diameter.

GDI-2686/

A damage assessment based on the micrometeoroid environment provided in Figure 4.5-8 and Figure 4.5-9 shall be carried out for units and items with direct exposure to free space.
5. UNIT LEVEL TEST REQUIREMENTS

5.1 General

5.1.1 Test Definition

5.1.1.1 Qualification tests

Qualification of the design shall be accomplished using representative flight configuration hardware and software. The objective of the qualification shall be to demonstrate the capability of all hardware items to provide all specified performances under all environment and interface conditions and to survive their full operational life. The test specimen shall be subjected to qualification loads. The test conditions shall not exceed design margins of safety nor excite unrealistic failure modes.

Items which can be qualified by an applicable qualification history, by similarity to qualified items, or purely by analysis, may require only limited qualification testing or even none. However, all safety critical items must be fully qualified by test.

Qualification testing shall be conducted at the relevant level according to the requirements defined in this section.

5.1.1.2 Acceptance Tests

Environmental acceptance testing shall be performed on all deliverable flight and flight spare hardware.

The objectives of acceptance testing are:

- Demonstrate freedom from manufacturing and workmanship errors.
- Demonstrate that hardware and software performance comply with design specifications.
- During environmental acceptance testing, conditions or effects, similar to the mission environment shall be simulated.

Acceptance testing shall be conducted at the relevant level according to the requirements defined in this section.

5.1.1.3 Functional Performance Tests

The objective of the test item functional performance test is to verify the performance of the item/unit during the test program.

Satisfactory and un-degraded functional performance before, during and after the specified environmental loads are required prior to approval for qualification or acceptance.

An initial and a final functional performance test shall be conducted at the beginning and at termination of each environmental test.

Intermediate functional performance tests, which may be simplified, may take place in order to show successful test results concerning the previous test step.

A functional performance test may run continuously for such tests, where the unit would be active, when this environment occurs (e.g. thermal). The test shall be conducted under standard laboratory conditions.
The tests shall be performed in compliance with approved test procedures, which reflect the verification criteria of the particular test item/unit specification. Beside electrical performance, all mechanical functions operated electrically shall be commanded and shall function.

Failure detection, isolation and recovery functions shall be tested to the maximum extent possible without destroying the test article.

Functional test will be performed by operating all required operational modes. Unit interface functions will be simulated. Unit performance will be checked considering at least:

- All required modes
- Begin/end of life power
- Maximum/minimum load
- Effects of power and subsystem switching
- Redundancies
- Emergency/safety modes
- Power protection
- Variation of input parameters
- Software if applicable

5.1.2 Test Facilities Requirements

GDI-973/CREATED

Any test facility to be used within the instrument assembly or unit test programme shall be capable to perform the required test within the specified limits and shall not impact the test objective or degrade the test article performance.

5.1.2.1 Accuracy of Test Instrumentation

GDI-975/CREATED

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

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. Instrumentation which will run out of calibration during the planned test time shall be not used.

5.1.2.2 Tolerances of Test Parameters

GDI-977/ECSS-E-10-03A

The allowed test condition tolerances shall be applied to the specified nominal test values. Unless otherwise specified, the maximum allowable tolerances on test conditions or measurements shall be as per Table 5.1-1 and Table 5.1-2. The tolerance on test parameters specifies the maximum allowable range within which the specified test level (input level) or measurement (output) may vary and excludes instrument accuracy.
# Tolerances of Test Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Temperature Range</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-200°C to -50°C</td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td></td>
<td>Temperature</td>
<td>Temperature</td>
</tr>
<tr>
<td>-200°C to -50°C</td>
<td>-4°C / 0°C</td>
<td>0°C / +4°C</td>
</tr>
<tr>
<td>-50°C to +100°C</td>
<td>-3°C / 0°C</td>
<td>0°C / +3°C</td>
</tr>
<tr>
<td>+100°C to +370°C</td>
<td>-4°C / 0°C</td>
<td>0°C / +4°C</td>
</tr>
<tr>
<td>(b) Pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above 1.3 x 10^-2 Pa (1 Torr)</td>
<td>±15%</td>
<td></td>
</tr>
<tr>
<td>1.3 x 10^-1 to 1.3 x 10^2 Pa</td>
<td>±30%</td>
<td></td>
</tr>
<tr>
<td>Less than 1.3 x 10^-1 Pa</td>
<td>±80%</td>
<td></td>
</tr>
<tr>
<td>(c) Relative Humidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±5%</td>
<td></td>
</tr>
<tr>
<td>(d) Acceleration</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 / +10%</td>
<td></td>
</tr>
<tr>
<td>(e) Vibration Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random</td>
<td>±5% or 1 Hz</td>
<td>(whichever the greater)</td>
</tr>
<tr>
<td>Sine</td>
<td>±2% from 10 to 2000 Hz</td>
<td></td>
</tr>
<tr>
<td>(f) Vibration level</td>
<td>Sine Vibration Amplitude:</td>
<td>±10 % g peak</td>
</tr>
<tr>
<td></td>
<td>Sweep Rate</td>
<td>±5%</td>
</tr>
<tr>
<td>Random Vibration Acceleration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Spectral Density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualification of Test Parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 to 500 Hz (25 Hz or narrower)</td>
<td>+3.0 dB / -1.0 dB</td>
<td>+1.5 dB / -3.0 dB</td>
</tr>
<tr>
<td>500 to 2000 Hz (50 Hz or narrower)</td>
<td>+3.0 dB / -1.0 dB</td>
<td>+1.5 dB / -3.0 dB</td>
</tr>
<tr>
<td>Random Overall g rms</td>
<td>±10%</td>
<td>±10%</td>
</tr>
<tr>
<td>(g) Acoustic Noise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sound Pressure Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/3 octave band (centre frequency)</td>
<td>+3.0 dB / -1.0 dB</td>
<td></td>
</tr>
<tr>
<td>overall</td>
<td>±1.5 dB</td>
<td></td>
</tr>
<tr>
<td>(h) Test Duration Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 / +10%</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1-1: Tolerances of Test Parameters
### Tolerances

<table>
<thead>
<tr>
<th>(i)</th>
<th>Shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Response spectrum amplitude (1/6 octave centre frequency)</td>
</tr>
<tr>
<td></td>
<td>± 6.0 dB (with 30% of the response spectrum centre frequency amplitudes greater than nominal test specification)</td>
</tr>
<tr>
<td></td>
<td><strong>Shock duration</strong></td>
</tr>
<tr>
<td></td>
<td>= 20 ms</td>
</tr>
<tr>
<td></td>
<td>0 / +20%</td>
</tr>
<tr>
<td></td>
<td>&gt; 20 ms</td>
</tr>
<tr>
<td></td>
<td>0 / +10%</td>
</tr>
<tr>
<td></td>
<td><strong>Shock level</strong></td>
</tr>
<tr>
<td></td>
<td>0 / +20%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(j)</th>
<th>Solar Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Solar intensity distribution in ref. plane</td>
</tr>
<tr>
<td></td>
<td>±4%</td>
</tr>
<tr>
<td></td>
<td>Solar intensity distribution in ref. volume</td>
</tr>
<tr>
<td></td>
<td>±6%</td>
</tr>
<tr>
<td></td>
<td>Solar intensity stability</td>
</tr>
<tr>
<td></td>
<td>±1%</td>
</tr>
<tr>
<td></td>
<td>Solar intensity stability (absolute)</td>
</tr>
<tr>
<td></td>
<td>±3%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Type</th>
<th>Wavelength (Angstrom)</th>
<th>Percent Of Total Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Far Ultraviolet</td>
<td>1 - 2.000</td>
<td>0.008</td>
</tr>
<tr>
<td></td>
<td>Near Ultraviolet</td>
<td>2.000 - 3.800</td>
<td>6.995</td>
</tr>
<tr>
<td></td>
<td>Visible</td>
<td>3.800 - 7.000</td>
<td>39.88± TBD %</td>
</tr>
<tr>
<td></td>
<td>Near Infrared</td>
<td>7.000 - 10.000</td>
<td>22.59</td>
</tr>
<tr>
<td></td>
<td>Infrared</td>
<td>10.000 - 20.000</td>
<td>24.02</td>
</tr>
<tr>
<td></td>
<td>Far Infrared</td>
<td>20.000 - 100.000</td>
<td>6.45</td>
</tr>
</tbody>
</table>

| (k)  | Force (static)            | ±3/-0%                |
|      |                           |                       |
|      |                           |                       |

| (l)  | C.o.G.                    | See Section 3.2.1     |
|      |                           |                       |

| (m)  | M of I.                   | See Section 3.2.1     |
|      |                           |                       |

| (n)  | Forces and Moments (dyn.) | +3/-0%                |
|      |                           |                       |

| (o)  | Pressure                  | ±5 % of max. specified value |
|      |                           | ±5%                        |

| (p)  | Flow Rate                 | ±5%                       |
|      |                           |                           |

| (q)  | Leakage                   | ±10⁻² scc/s He at 1013 hPa pressure differential, if not otherwise specified |
|      |                           |                           |

| (r)  | Mass                      | See Section 3.2.1.2       |
|      |                           |                           |

| (s)  | Dimensions                | Length                   | < 0.125 mm               |
|      |                           |                         |                         |

| (t)  | Balancing                 | Static                  | < 0.25 mm               |
|      |                           | Dynamic                 | < ±0.1°                 |
|      |                           |                         |                         |

| (u)  | Angular Measurements     | 0.5 arc min with respect to each axis of the reference system of the facility if not otherwise specified |
|      |                           |                         |                         |

Table 5.1-2: Tolerances of Test Parameters (continued)
5.1.2.3 Facility Ambient Condition

**GDI-981/CREATED**

Unless otherwise specified herein, all measurements and tests shall be made at room ambient atmospheric pressure, temperature and relative humidity conditions, whereby 22 ± 3°C and 55 ± 10% RH shall not be exceeded. Whenever these conditions must be closely controlled in order to obtain reproducible results a reference temperature of 21°C, a relative humidity of 50 % and an atmospheric pressure of 1013 hPa shall be used together with whatever tolerances are required to obtain the desired precision of measurement. Actual ambient test conditions should be recorded periodically during the test period.

The cleanliness requirements for the test items during assembly, integration, transport and test shall be in accordance with the PA requirements.

5.1.3 Test Execution

**GDI-983/CREATED**

Test execution shall be started only if all starting prerequisites have been positively accepted, i.e., if all HW under test and the associated support equipment, SW and documentation is found to be complete and ready for test start.

Prior to and after every environmental test activity a limited functional test and a through visual inspection are required on the basis of the related approved procedure. Before commencing any formal qualification or acceptance test, a Test Readiness Review meeting shall be convened. At this meeting, the status of the test item and all documentation shall be discussed and any discrepancies shall be assessed as to their effect on the representation of the test. All discrepancies and all decisions shall be minuted and accepted by all participants before permission to commence the test is granted.

After completion of all formal qualifications or acceptance tests a post-test review shall be convened. All test results shall be presented for review. In the case of any parameter being outside its specified range or any other evidence of failure the review shall take the form of a test failure review board.

In any case the meeting shall consider all the evidence, decide on the degree of success of the test and decide what further action if any is necessary.

5.1.4 Success Criteria

**GDI-985/CREATED**

The test is successfully performed if all measurement results are in accordance with the design requirements as stated in the particular unit design and performance specification and transformed into test requirements listed in the test specification.

Modifications, repair, replacement or refurbishment of an item, which failed an initial test, shall be subject to a retest. When it can be shown that the test interruption was caused by a GSE or software problem the retest shall be started from that point of GSE or software failure after appropriate repair has taken place and positive confirmation can be given for the nominal performance of the GSE item.

Any repetition of qualification or acceptance test needs the prior decision of the MRB responsible.

If not, the corrective action substantially affects the significance of results of previously completed tests in the sequence, such tests shall also be repeated.

5.2 Unit Tests

The preferred unit level test sequence is:
<table>
<thead>
<tr>
<th>Sequence</th>
<th>Test</th>
<th>Refer to GDIR section.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-test Inspection</td>
<td>Section 5.2.3.1.6</td>
</tr>
<tr>
<td>2</td>
<td>Initial Functional Performance Test</td>
<td>See Equipment Specification</td>
</tr>
<tr>
<td>3</td>
<td>Mechanical tests</td>
<td>Section 5.2.1.3, 5.2.1.4, 5.2.1.7</td>
</tr>
<tr>
<td>4</td>
<td>Depressurisation/Corona Discharge TBC</td>
<td>Corona Discharge is TBC see individual equipment spec if applicable.</td>
</tr>
<tr>
<td>5</td>
<td>Thermal Vacuum</td>
<td>Sections 5.2.2.2.1, 5.2.2.2.3, 5.2.2.2.2</td>
</tr>
<tr>
<td>6</td>
<td>EMC/RF</td>
<td>Section 5.2.3</td>
</tr>
<tr>
<td>7</td>
<td>Final Functional Performance Test</td>
<td>See Equipment Specification</td>
</tr>
<tr>
<td>8</td>
<td>Mass Properties Measurement</td>
<td>See Equipment Specification</td>
</tr>
<tr>
<td>9</td>
<td>Post-test Inspection</td>
<td>Section 5.2.3.1.6</td>
</tr>
</tbody>
</table>

Note: variations to this proposed test sequence shall be agreed with the Prime Contractor prior to the start of any unit level test programme.

GDI-2679/

The qualification and acceptance tests to be performed shall include the tests as listed in the table below. This list may be tailored with the approval of EADS Astrium depending on the category and maturity of each unit.
<table>
<thead>
<tr>
<th>Test</th>
<th>Qualification model</th>
<th>Acceptance model</th>
<th>notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass / Dimensions / Interfaces</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>CoG / MOI</td>
<td>T+A</td>
<td>T+A</td>
<td>Equipment data mode, except for specific equipment (large, heavy)</td>
</tr>
<tr>
<td>Sine Vibration</td>
<td>T+A</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Random vibration</td>
<td>T+A</td>
<td>T</td>
<td>Random or acoustic, depending on the type of unit</td>
</tr>
<tr>
<td>Acoustic noise</td>
<td></td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Shock</td>
<td>T</td>
<td>Vs</td>
<td></td>
</tr>
<tr>
<td>Depressurisation/corona discharge</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Cycling</td>
<td>-</td>
<td>-</td>
<td>Thermal cycling is deemed acceptable for a recurring unit being qualified in thermal vacuum</td>
</tr>
<tr>
<td>Thermal Vacuum</td>
<td>T+A</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td><strong>EMC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonding, Isolation</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Power consumption / Inrush</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Conducted Emission, FD</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Conducted Emission, transients</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Conducted Emission, common mode</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Conducted Susceptibility, FD</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Conducted Susceptibility, transients</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Conducted Susceptibility, common mode</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>Radiated Emission, E field</td>
<td>T</td>
<td>T/A/R</td>
<td></td>
</tr>
<tr>
<td>Radiated Emission, H field</td>
<td>T</td>
<td>T/A/R</td>
<td></td>
</tr>
<tr>
<td>Radiated Susceptibility, E field</td>
<td>T</td>
<td>T/A/R</td>
<td></td>
</tr>
<tr>
<td>Radiated Susceptibility, H field</td>
<td>T</td>
<td>T/A/R</td>
<td></td>
</tr>
<tr>
<td>ESD</td>
<td>T</td>
<td>Vs/A</td>
<td></td>
</tr>
<tr>
<td>RFC</td>
<td>T</td>
<td>T</td>
<td>For RF units only</td>
</tr>
<tr>
<td><strong>Electrical interfaces</strong></td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td><strong>Functional / performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional tests</td>
<td>T</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>HW / SW tests</td>
<td>T</td>
<td>T</td>
<td>For equipment with embedded SW, tests representing the HW/SW qualification of the equipment</td>
</tr>
<tr>
<td>RF tests</td>
<td>T</td>
<td>T</td>
<td>Specific RF testing for TT&amp;C units</td>
</tr>
<tr>
<td>Pyro / release tests</td>
<td>T</td>
<td>T</td>
<td>As relevant</td>
</tr>
<tr>
<td>Deployment tests</td>
<td>T</td>
<td>T</td>
<td>For deployable items</td>
</tr>
<tr>
<td>Propulsion tests</td>
<td>T</td>
<td>T</td>
<td>For propulsion items (functional checks, cleanliness, pressure proof test, leak test)</td>
</tr>
<tr>
<td>Optical tests</td>
<td>T</td>
<td>T</td>
<td>For optical items, optical properties ; also includes straylight</td>
</tr>
<tr>
<td><strong>Life tests</strong></td>
<td>T</td>
<td>Vs</td>
<td>For mechanisms</td>
</tr>
</tbody>
</table>

**Legend:**
- **T** verified by Test
- **A** verified by Analysis
- **R** verified by Review of design
- **Vs** verified by Similarity
- **T/A** Test or Analysis
- **T/A/R** Test or Analysis or Review
- **T+A** Test and Analysis
5.2.1 Mechanical Environment Tests

5.2.1.1 Vibration Test Set Up

GDI-989/CREATED

The unit under test shall be mounted (to a rigid fixture, see below) as in flight configuration. The unit attachment hardware (bracket, cabling, tubing, etc.) shall be included in the tests (to a reasonable extent) to achieve dynamic similarity of the unit to actual installation.

Cabling, tubing etc. shall be attached to the unit as required for operating or monitoring functions; but fixed in such a way to the fixture or auxiliary supports that no higher loads are excited than in actual installation configuration.

GDI-990/CREATED

At least one triaxial sensor shall be mounted on the unit under test to monitor the response on the units.

GDI-991/CREATED

At least two axis aligned sensors shall be mounted on the test fixture adjacent to the unit to monitor the test level input.

GDI-992/CREATED

All units powered on during launch shall be powered on during mechanical equipment testing in the same operational configuration. The unit electrical performance shall be monitored during the test.

5.2.1.2 Test Fixture

For the purposes of this specification a vibration test fixture is defined as a massively stiff structural component of the MGSE which transforms the standard interfaces of the vibration generator, or slip table, to the mounting interface of the test item in the launch configuration and can transmit the vibration inputs faithfully to the test item without introducing significant changes to those inputs.

GDI-995/CREATED

The test item shall be attached to the vibration exciter table by means of a rigid test fixture capable of transmitting the vibration conditions specified herein. The test fixture shall be designed to minimise fixture response at resonance within the test frequency range.

GDI-996/CREATED

The variation of transmissibility between test item mounting points shall not exceed a factor of +3 dB between 5 and 500 Hz and +6 dB between 500 and 2000 Hz, provided that the total cumulative bandwidth, which exceeds +3 dB does not exceed 300 Hz. Cross talk shall not exceed the input.

GDI-997/CREATED

Adequate fixture design and specimen installation are the responsibility of the unit subcontractor as part of the verification activities. The fixture shall be described in the test procedure.

GDI-998/CREATED

A pre-test of the empty fixture shall be performed to verify the correct dynamic behaviour of the fixture and the proper function of the control loop.

5.2.1.3 Frequency Search

GDI-1000/CREATED

Frequency search tests shall be conducted in order to:
• Identify the unit frequency content and correlate results with FEM predictions,
• Estimate the Q_factors associated to the main modes,
• Establish a basis for frequency content comparison between test runs and allow eventual interface settling anomaly evaluation,

In particular, the knowledge of the results of the main unit frequencies and associated Q_factors measured during the first frequency search test along each axis is of prime importance to lead properly higher level tests.

GDI-1002/CREATED

Frequency search tests shall be conducted along each of the three mutually perpendicular axes one at a time at least prior to and after performing the tests.

The frequency search tests are defined in Table 5.2-1.

In order to allow better Q_factor estimation, the frequency search test level shall be adjusted in order to avoid notching on the main eigen modes.

<table>
<thead>
<tr>
<th>Frequency Search Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (Hz)</td>
</tr>
<tr>
<td>5 to 2000</td>
</tr>
</tbody>
</table>

Table 5.2-1: Frequency Search Spectrum Definition

5.2.1.4 Vibration Tests Level

GDI-1005/CREATED

For units the vibration test levels that are applied at the unit interface are identified, both for acceptance and qualification and shall be as:

• In Table 4.2-2 for sinusoidal vibration
• In Table 4.2-3 for random vibration
• In Table 4.2-5 for shock

5.2.1.5 Sine And Random Vibration Test

GDI-1011/CREATED

Sine and random vibration tests shall be performed separately on the three axis.

GDI-1012/CREATED

Prior and after sine and random vibration qualification and acceptance tests a low level sine frequency search test shall be performed according to requirements GDI-1000 and GDI-1002. Care shall be taken in adjusting the level before test such that resonant modes do not lead to unit overstress or Q-factors erroneous estimation.

GDI-1013/CREATED

Before applying full levels, a test at intermediate level shall be applied. For qualification testing, the intermediate levels shall be set as the acceptance (flight limit) levels. For acceptance testing, the intermediate levels shall be the acceptance levels divided by 2 for sine vibrations and by 4 the power spectral densities for random vibrations.
This Requirement has been Deleted.

The vibration facility shall include a shock free abort device mounted onto the shaker to prevent the unit from hazardous over testing potentially induced by facility failure.

5.2.1.6 Shock Tests

Units shall demonstrate by test their ability to withstand the shock acceleration levels as defined in Section 4.2.3.2.4 of this document.

Prior and after shock tests a low level sine frequency search test shall be perform according to requirements GDI-1000 and GDI-1002. Care shall be taken in adjusting the level before test such that resonant modes do not lead to unit overstress or Q-factors erroneous estimation.

5.2.1.7 Static tests

Static tests shall be performed by applying the specified sinusoidal level defined in the low frequency range, whose amplitude generates acceptance/qualification quasi-static loads.

5.2.2 Units Thermal Environment Tests

Unit temperature levels for acceptance and qualification tests are defined in Table 4.3-1. These temperatures refer to the temperature reference point.

5.2.2.1 Thermal Test Setup

The temperatures shall be selected and controlled such that the test item experiences actual temperatures equal to or beyond the minimum and maximum qualification/acceptance temperatures. This shall be guaranteed by temperature monitoring at the temperature reference point and additional points as agreed with the customer.

The test arrangement shall be as shown in Figure 5.2-1 (conductively controlled) or GDI-2600 (radiatively controlled).

The unit shall be bolted to a thermally controlled heat sink using the flight design.

On all external surfaces flight representative thermal hardware shall be applied.

The heat sink (HS) plates shall be black painted (except for the contact area) as well as the chamber shroud.
GDI-1029/CREATED

The conductive heat sink temperature and the chamber shroud temperature shall be controlled in order to give as a minimum qualification/acceptance temperatures at the unit temperature reference point(s).

GDI-1030/CREATED

For vacuum tests the pressure inside the chamber shall be less or equal than 1E-5 torr.

---

**Figure 5.2-1: Unit Thermal Test Arrangement - Conductively Controlled**

**Figure 5.2-2: Unit Thermal Test Arrangement - Radiatively Controlled**

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5.2.2.2 Thermal Test Sequences

5.2.2.2.1 Qualification Thermal Vacuum

GDI-1034/CREATED

Unit’s suppliers shall perform Thermal Vacuum (TV) qualification tests at unit level to demonstrate the performance of the units in an extreme thermal vacuum environment by simulating minimum and maximum qualification temperatures. (See Table 5.2-3 for test parameters)

The thermal qualification test could be used for the unit thermal model verification and correlation purpose.

GDI-1036/CREATED

The TV test on unit level shall be performed as in Table 5.2-2.

GDI-1037/CREATED

The qualification temperatures for the different units are defined in Table 4.3-1. All temperatures refer to the temperature reference point.

GDI-1038/CREATED

The units shall be tested following the thermal vacuum test sequence, as shown in Figure 5.2-3. All temperatures are qualification temperatures.
<table>
<thead>
<tr>
<th></th>
<th>TV Qualification Test Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Performance test under ambient conditions</td>
</tr>
<tr>
<td>2.</td>
<td>Unit switch-off</td>
</tr>
<tr>
<td>3.</td>
<td>Decrease of pressure to 0.013 Pa</td>
</tr>
<tr>
<td>4.</td>
<td>Decrease of pressure to 0.0013 Pa and increase of temperature to maximum operating level (TO-MAX)</td>
</tr>
<tr>
<td>5.</td>
<td>Unit switch-on</td>
</tr>
<tr>
<td>6.</td>
<td>Temperature stabilisation</td>
</tr>
<tr>
<td>7.</td>
<td>Performance test</td>
</tr>
<tr>
<td>8.</td>
<td>Unit switch-off</td>
</tr>
<tr>
<td>9.</td>
<td>Increase of temperature to maximum non-operating level (TNO-MAX)</td>
</tr>
<tr>
<td>10.</td>
<td>Temperature stabilisation</td>
</tr>
<tr>
<td>11.</td>
<td>Not applicable</td>
</tr>
<tr>
<td>12.</td>
<td>Not applicable</td>
</tr>
<tr>
<td>13.</td>
<td>Decrease of temperature to maximum operating level (TO-MAX)</td>
</tr>
<tr>
<td>14.</td>
<td>Temperature stabilisation</td>
</tr>
<tr>
<td>15.</td>
<td>Performance test</td>
</tr>
<tr>
<td>16.</td>
<td>+/- 0.5% Bus Power variation test/power consumption test.</td>
</tr>
<tr>
<td>17.</td>
<td>Unit switch-off</td>
</tr>
<tr>
<td>18.</td>
<td>Decrease of temperature to minimum non-operating level (TN0-MIN)</td>
</tr>
<tr>
<td>19.</td>
<td>Temperature stabilisation</td>
</tr>
<tr>
<td>20.</td>
<td>Increase of temperature to minimum switch-on level (TSO-MIN)</td>
</tr>
<tr>
<td>21.</td>
<td>Unit switch-on</td>
</tr>
<tr>
<td>22.</td>
<td>Increase of temperature to minimum operating level (TO-MIN)</td>
</tr>
<tr>
<td>23.</td>
<td>Temperature stabilisation</td>
</tr>
<tr>
<td>24.</td>
<td>Performance test</td>
</tr>
<tr>
<td>25.</td>
<td>Increase of temperature to maximum operating level (TO-MAX)</td>
</tr>
<tr>
<td>26.</td>
<td>Temperature stabilisation</td>
</tr>
<tr>
<td>27.</td>
<td>Performance test</td>
</tr>
<tr>
<td>28.</td>
<td>Decrease of temperature to minimum operating level (TO-MIN)</td>
</tr>
<tr>
<td>29.</td>
<td>Temperature stabilisation</td>
</tr>
<tr>
<td>30.</td>
<td>Performance tests</td>
</tr>
<tr>
<td>31.</td>
<td>Repeat steps 25, 26, 28, 29 six times</td>
</tr>
<tr>
<td>32.</td>
<td>Performance test</td>
</tr>
<tr>
<td>33.</td>
<td>Unit switch-off</td>
</tr>
<tr>
<td>34.</td>
<td>Increase of pressure and temperature to ambient conditions</td>
</tr>
<tr>
<td>35.</td>
<td>Unit switch-on</td>
</tr>
<tr>
<td>36.</td>
<td>Performance test under ambient condition</td>
</tr>
<tr>
<td>37.</td>
<td>Unit switch-off</td>
</tr>
</tbody>
</table>

**Table 5.2-2: TV Qualification Test Sequence**
### Table 5.2-3: Thermal Vacuum Qualification Test Parameters

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>ABBREVIATION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cycles</td>
<td>n</td>
<td>8</td>
</tr>
<tr>
<td>Dwell Time</td>
<td>t(_E) (hours)</td>
<td>2</td>
</tr>
<tr>
<td>Temperature Rate of change</td>
<td>dT/dt (°C/min)</td>
<td>5 to 20</td>
</tr>
</tbody>
</table>

#### Figure 5.2-3: Thermal Vacuum Test Sequence

Figure 5.2-3: **Thermal Vacuum Test Sequence**
Table 5.2-4: Nomenclature to Figure 5.2-3 above

5.2.2.2.2 Acceptance Thermal Vacuum

GDI-1044/CREATED

Unit suppliers shall perform thermal vacuum (TV) acceptance tests on unit level in order to detect material and workmanship defects prior to installation.

GDI-1045/CREATED

The thermal vacuum acceptance test shall be performed in the same way as specified above for the thermal vacuum qualification test, with the following modifications:

- Acceptance temperatures shall be applied instead of qualification temperatures. The acceptance temperatures for the different units are defined Table 4.3-1.
- The number of thermal cycles applicable to the TV acceptance test is \( n = 4 \)

Step 30 in the test sequence is modified to: “Repeat steps 24 to 29 two times”

On a case-by-case basis, and after approval of the customer, thermal vacuum can be replaced by thermal tests at ambient pressure. This will however be forbidden if calibrations of flight parameters are necessary during thermal tests. In any case, this replacement shall require demonstration of consistency between thermal vacuum measurements and thermal at ambient pressure ones. Specific acceptance criteria for the performance measurements shall be computed.
5.2.2.2.3 Protoflight Thermal Vacuum

In case qualification is performed on FM the following requirements apply.

GDI-1049/CREATED

Unit suppliers shall perform thermal vacuum (TV) protoflight tests on unit level in order to qualify the unit.

GDI-1050/CREATED

The thermal vacuum protoflight test shall be performed in the same way as specified above for the thermal vacuum qualification test, with the following modifications:

- The number of thermal cycles applicable to the TV protoflight test is \( n = 4 \)
- Step 30 in the test sequence is modified to: “Repeat steps 24 to 29 two times”

On a case-by-case basis, and after approval of the customer, thermal vacuum can be replaced by thermal tests at ambient pressure. This will however be forbidden if calibrations of flight parameters are necessary during thermal tests. In any case, this replacement shall require demonstration of consistency between thermal vacuum measurements and thermal at ambient pressure ones. Specific acceptance criteria for the performance measurements shall be computed.

5.2.3 Electromagnetic Compatibility Tests

5.2.3.1 General EMC Test Requirements

5.2.3.1.1 EMC Development Test

GDI-1057/CREATED

Development tests may be performed to evaluate the design approach, indicate critical areas where design improvement is required, assure compliance with the design requirements, confirm and support analytical methods or generate essential design data at an early stage.

5.2.3.1.2 EMC Qualification Test

GDI-1059/CREATED

Qualification tests for PFM shall be performed as specified in the applicable equipment SOW.

5.2.3.1.3 EMC Acceptance Test

GDI-1061/CREATED

Acceptance tests for FM shall be performed as specified in the applicable equipment SOW.

5.2.3.1.4 EMC Integration Test

GDI-1063/CREATED

In order to ensure the proper grounding of the secondary power to the unit structure (refer to Section 3.5.7.3.2) a bonding test shall be performed during unit assembly.

5.2.3.1.5 Retest Criteria

GDI-1065/CREATED

A retest may be required in case a test result is not as expected resulting in an NCR. The retest of the test article shall be defined by the Non-conformance Review Board (NRB) in accordance with the Non-conformance Control Procedure as defined in the PA requirements.
5.2.3.1.6 Pre and Post Test Inspection

GDI-1067/CREATED

*The pre- and post-test inspection is specified in the Product Assurance Requirements*

5.2.3.1.7 Test Sequence

The test sequence is defined in the unit requirement specification and in the statement of work (SOW).

The order of the EMC tests is at the supplier’s discretion, although it is recommended that emission tests are performed first since they provide the earliest indication of problems due to inadequate shielding or filtering. ESD tests should be performed last due to the risk of component failure.

GDI-2155/CREATED

*The actual EMC test sequence shall be agreed with the customer.*

5.2.3.2 Test Facility

5.2.3.2.1 EMC Test Environment

GDI-1072/CREATED

*All EMC tests shall be conducted at standard ambient conditions as specified in Section 4.*

5.2.3.2.2 Capabilities

GDI-1074/CREATED

*The test facilities used for the EMC test program shall be capable to perform the required tests within the specified limits and shall not impact the test objectives or degrade the performance of the test specimen.*

*For the radiated EMC tests the terrestrial electromagnetic noise levels shall be better than 6dB lower than those needed for the specified levels to be measured.*

5.2.3.3 Test Instrumentation

5.2.3.3.1 General Tolerances and Test Parameters

GDI-1077/CREATED

*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 tolerance specifies the allowable range within which the specified test parameter / level may vary and is exclusive of measurement equipment accuracy.*
5.2.3.3.2 Accuracy of the Test Measurement Equipment

GDI-1079/CREATED

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

- $\pm 2$ dB for levels
- $\pm 2$ % for frequencies.

All instrumentation to be used for qualification and acceptance tests shall be subjected to approve calibration procedures and shall be within the normal calibration periods at the time of test.

5.2.3.3.3 Special Requirements on the Test Equipment

GDI-1081/CREATED

Grounding of Test Equipment:

Measurement equipment shall use an isolation transformer on the AC power lines and a separate ground cable to the central ground point. The ground cable shall consist of braided cable.

GDI-1082/CREATED

Antenna Placement:

For radiated emission measurements no part of the measuring antenna shall be less than 1 m from any obstructions.

For radiated susceptibility tests no parts of the field generating and field-measuring antenna (for calibration purposes) shall be less than 1 m from any obstructions.

GDI-1083/CREATED

Receiver Bandwidth:

The following receiver bandwidth shall be used if not otherwise specified (Table 5.2-5):

Any deviation from the proposed bandwidths shall be recorded in the test report.

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Hz - 1 kHz</td>
<td>10 Hz</td>
</tr>
<tr>
<td>1 kHz - 10 kHz</td>
<td>30 Hz</td>
</tr>
<tr>
<td>10 kHz - 2.4 MHz</td>
<td>300 Hz</td>
</tr>
<tr>
<td>2.4 MHz - 30 MHz</td>
<td>3 kHz</td>
</tr>
<tr>
<td>30 MHz - 1 GHz</td>
<td>30 kHz</td>
</tr>
<tr>
<td>1 GHz - 40 GHz</td>
<td>100 kHz</td>
</tr>
</tbody>
</table>

Table 5.2-5: Receiver Bandwidth Specifications

GDI-1085/CREATED

Power Adjustment:

The primary power for unit level tests shall be adjusted for emission and susceptibility tests.
To 28 Volts for regulated power bus

5.2.3.3.4 Line Impedance Stabilisation Network (LISN):

GDI-1087/CREATED

For the conducted emission and susceptibility tests on unit level a LISN, simulating the primary power bus impedance, shall be used as shown in the relevant test set-up.

GDI-1090/CREATED

The LISN has to be designed and provided by the company responsible for the test. Prior to test the network impedance shall be measured in the relevant frequency range and attached to the test report.

GDI-2116/CREATED

Derivation of the bus impedance shall be performed as follows:

The bus impedance at the low frequency end shall be derived by dividing the maximum voltage drop from the appropriate LCL by its current rating (see Table 3.5-2). This value shall then be multiplied by 0.65 to allow for typical LCL actual performance, and then 20 milliohms shall be added to allow for the regulated primary bus source impedance at the main regulation point. This results in the following values (TBC):

<table>
<thead>
<tr>
<th>LCL Class</th>
<th>Impedance at low frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>180 milliohms</td>
</tr>
<tr>
<td>B</td>
<td>100 milliohms</td>
</tr>
<tr>
<td>C</td>
<td>75 milliohms</td>
</tr>
<tr>
<td>D</td>
<td>60 milliohms</td>
</tr>
<tr>
<td>E</td>
<td>50 milliohms</td>
</tr>
<tr>
<td>F</td>
<td>TBD milliohms</td>
</tr>
</tbody>
</table>

This value is intercepted by the sloping portion of the graph which is determined by the harness impedance and reaches a maximum value of 100 Ohms at 10 MHz, thereafter remaining constant. A tolerance of +/- 20% shall be allowed on the actual LISN performance.

A typical bus impedance is shown in Figure 5.2-4.

Figure TBD

Figure 5.2-4: LISN Impedance for Regulated Primary Power Bus

5.2.3.3.5 Test Conditions

The purpose of the test is to demonstrate the compliance with the EMC performance requirements of Section 4.5.1 of this document.

GDI-1095/CREATED

The equipment under test shall be switched on in the normal switch-on sequence and shall operate in suitable operational modes w.r.t. the particular EMC test purpose.

GDI-1096/CREATED

For emission testing the unit shall operate within a mode, which allows the maximum amount of generated interferences (voltage, current, field).
For susceptibility testing the suitable operational mode shall be that mode which maximises the response of the equipment under test to the particular environment being created.

After testing the equipment shall be switched off using the normal switch-off sequence.

Both operational modes shall provide operational conditions, which result in an adequate test data profile of the generated interference and susceptibility of unwanted signal outputs or degradation of equipment performance that could exist during unit functional operation.

The particular test set-up shall represent the flight configuration as close as possible. Power, signal and other circuits grounding shall be in compliance with the grounding requirements as described in Section 3.5.7.2 of this document.

5.2.3.3.6 Susceptibility Testing

General Aspects:

Each item (unit to satellite), which is subjected to EMC/RFC tests, shall provide for susceptibility tests, provisions to monitor the item under test for malfunctions/degradation of performance.

In particular all EGSE (including unit tester), shall provide quick look capabilities. The “quick look” capabilities shall allow during testing, possibility of verifying whether the item under test shows any malfunction.

A detailed data evaluation may be performed off-line.

The applicable pass/fail criteria for susceptibility tests shall be identified in the test procedure.

Data Acquisition:

The item under test shall be monitored for any indication of malfunction or degradation of performance.

In the event any out of tolerance conditions are encountered during susceptibility testing, the following information is to be recorded:

- test signal level and frequency
- parameters exceeded
- out of tolerance levels
- allowable limits
- interference threshold (the level of test signal at which the exceeded parameter returns to "within allowable tolerance”).

5.2.3.4 Specific EMC Test Requirement

5.2.3.4.1 Electrical Bonding

The purpose of this test is to verify the DC resistance of the bonding interfaces specified in Section 3.5.7.1.
GDI-1107/CREATED

The bonding test shall be performed with the unit under test (UUT or EUT) switched off. The measurements shall be done with the four-wire method and with both directions of polarity.

GDI-1108/CREATED

The bonding test shall be performed without any harness connection.

5.2.3.4.2 Isolation

The purpose of this test is to measure the isolation of primary and secondary power lines from ground in order to verify the requirements of Section 3.5.7.2.

GDI-1111/CREATED

The isolation test shall be performed with the UUT switched off, but all interfaces connected (i.e. EGSE, unit interconnection for subsystem level). The measurement shall be done with both directions of polarity.

*Figure 5.2-5 shows the principle test set-up for isolation measurements.*

---

**Figure 5.2-5: Test Set-up for the Isolation Measurement**

5.2.3.4.3 Conducted Emissions on Power Lines

5.2.3.4.3.1 CE on Primary Power Lines

The purpose of the test is to demonstrate the compliance of the differential and common mode conducted emissions on primary power lines with the requirements defined in Section 3.5.7.3 and Section 4.5.1.
GDI-1116/CREATED

UUT operation shall be selected in order to maximise the level of conducted interference appearing on the power lines, while remaining within the normally expected operating range.

The test set-ups are shown in Figure 5.2-6 (frequency domain) and Figure 5.2-7 (time domain).

GDI-1118/CREATED

Ripple and transient interference tests on the power lines shall be performed using standard current probe measurement techniques for each DC power lead.

Figure 5.2-6: Test Set-up for Conducted Emission on Primary Power Lines, Frequency Domain
5.2.3.4.3.2 CE on Secondary Power Lines

The purpose of this test is to measure the conducted emissions (ripple)

- On the secondary power input of a unit.
- On the secondary power output of a unit providing power to another unit.

and demonstrate the compliance with the requirements defined in Section 4.5.9.

GDI-1123/CREATED

UUT operation shall be selected in order to maximise the level of conducted interference appearing on the power lines, while remaining within the normally expected operating range.

GDI-1124/CREATED

When the secondary power provider and user need to be tested individually, the secondary power output shall be terminated with a load, representing the load impedance of the nominal secondary power user.

Alternatively the test can be performed when the secondary power provider and user are connected together and operating.
The test set-ups are shown in Figure 5.2-8 (unit secondary power input) and Figure 5.2-9 (unit secondary power output).

![Diagram]

**Figure 5.2-8: Test Set-up for CE on Secondary Power Lines, and Secondary Power Input**

For frequency domain measurements replace oscilloscope with EMI receiver and differential amplifier.
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Figure 5.2-9: Test Set-up for CE on Secondary Power Lines, Time Domain, and Secondary Power Output

5.2.3.4.4 Conducted Susceptibility, Signal Harnesses, Bulk Current Injection

The purpose of this test will demonstrate the noise immunity of signal bundles to the specified interference levels of bulk current injection of Section 4.5.9.4 above.

GDI-2090/CREATED

The mode selection for susceptibility testing shall be such as to maximise the response of the UUT to the particular environment created.

The test set-up is shown in Figure 5.2-13, with the exception that the current probes are located around the appropriate signal harness(es).

5.2.3.4.5 Conducted Susceptibility on Power Lines

The purpose of this test is to demonstrate the noise immunity of primary power lines to the specified interference levels of Section 4.5.11.

GDI-1133/CREATED

The mode selection for susceptibility testing shall be such as to maximise the response of the UUT to the particular environment being created.

GDI-1134/CREATED

The test set-ups are shown in Figure 5.2-10 (CS01; Continuous Wave 30Hz...50 kHz), Figure 5.2-11 (CS02; Continuous Wave 50 kHz...50 MHz), Figure 5.2-12 (CS06; Transients) and Figure 5.2-13 (Bulk Current Injection). Note: Use Figure 5.2-13 for common mode voltage, but locate current probes on connection between equipment signal reference (0V) and ground plane.
Figure 5.2-10: Test Set-up for Conducted Susceptibility on Power Lines; CS01; CW 30Hz...50 kHz
Figure 5.2-11: Test Set-up for Conducted Susceptibility on Power Lines; CS02; CW 50 kHz...50 MHz
Figure 5.2-12: Test Set-up for Conducted Susceptibility on Power Lines; CS06; Transient
5.2.3.4.6 Conducted Susceptibility on Secondary Power Lines

The purpose of this test is to demonstrate the noise immunity of primary power lines to the specified interference levels of Section 4.5.10.

GDI-1140/CREATED

The mode selection for susceptibility testing shall be such as to maximise the response of the UUT to the particular environment being created.

GDI-1141/CREATED

The test set-ups are shown in Figure 5.2-14 (CS01; Continuous Wave 30Hz...50 kHz), Figure 5.2-15 (CS02; Continuous Wave 50 kHz...50 MHz).
Figure 5.2-14: Test Set-up for Conducted Susceptibility on Sec. Power lines, CS01, 30 Hz - 50 kHz

Figure 5.2-15: Test Set-up for Conducted Susceptibility on Sec. Power Lines, CS02, 50 kHz - 50 MHz
5.2.3.4.7 Radiated Emission, Electric Field

This test is to be used to measure the E-field radiated emission of the test specimen to demonstrate the compliance with the requirements of Section 4.5.2.

**GDI-1151/CREATED**

*UUT operation shall be selected in order to maximise the level of radiated interference appearing on the power lines, while remaining within the normally expected operating range.*

*The test set-up is shown in Figure 5.2-16.*

![Figure 5.2-16: Test Set-up for Radiated Emission, Electric Field](image)

5.2.3.4.8 Radiated Emissions, E-Field Fluctuations

The preferred test method to determine the fluctuations of the E-field in the instrument measurement bandwidth is shown in Figure 5.2-16, with the exception that the antenna and receiver are replaced by an appropriate sensor and detection system.

5.2.3.4.9 Radiated Emission, Magnetic Field

**GDI-1155/CREATED**

*UUT operation shall be selected in order to maximise the level of radiated interference appearing on the power lines, while remaining within the normally expected operating range. The test set-up is shown in Figure 5.2-17.*

---

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5.2.3.4.10 Radiated Emissions, Magnetic Field Fluctuations

The preferred test method to determine the fluctuations of the H-field in the instrument measurement bandwidth is shown in Figure 5.2-16, with the exception that the antenna and receiver are replaced by an appropriate sensor and detection system.

5.2.3.4.11 Radiated Susceptibility, Electric Field

This test will demonstrate the immunity of the test specimen to incident electric fields, when irradiated with field strength specified in Section 4.5.6.

GDI-1159/CREATED

UUT operation shall be selected in order to maximise the response of the test specimen to the particular environment being created. The test set-up is shown in Figure 5.2-18.
5.2.3.4.12 Radiated Susceptibility, Magnetic Field

This test will demonstrate the immunity of the test specimen to incident magnetic fields, when irradiated with field strength specified in Section 4.5.7.

GDI-1163/CREATED

Figure 5.2-18: Test Set-up for Radiated Susceptibility, Electric Field

5.2.3.4.12 Radiated Susceptibility, Magnetic Field

This test will demonstrate the immunity of the test specimen to incident magnetic fields, when irradiated with field strength specified in Section 4.5.7.

GDI-1163/CREATED

Figure 5.2-18: Test Set-up for Radiated Susceptibility, Electric Field

5.2.3.4.12 Radiated Susceptibility, Magnetic Field

This test will demonstrate the immunity of the test specimen to incident magnetic fields, when irradiated with field strength specified in Section 4.5.7.

GDI-1163/CREATED

UUT operation shall be selected in order to maximise the response of the test specimen to the particular environment being created. The test set-up is shown in Figure 5.2-19.
5.2.3.4.13 Electrostatic Discharge (ESD)

The ESD test, radiated discharges, will demonstrate the compliance of the test specimen with the requirements of Section 4.5.7.

GDI-1167/CREATED

*UUT operation shall be selected in order to maximise the response of the test specimen to the particular environment being created. Figure 5.2-20 shows principle test set-up for radiated ESD test and Figure 5.2-21 for conducted ESD test.*
5.2.3.4.14 Magnetic Moment

This test will be used in order to show the compliance of the test specimen with the referring magnetic requirement as given in the equipment specification.
If accepted by the customer, verification by similarity is possible. It is recommended to measure the test specimen in a magnetic coil facility or to use other adequate test methods in order to show compliance with the requirement. The selected test method has to be accepted by the customer.

**GDI-1173/CREATED**

*Verification by similarity may be applied to equipment or subsystems coming from other programs, where re-use as it is or re-use with only little modification is proposed. An analysis of the test results of the previous programme shall be carried out against the unit requirement.*

For information the following evaluations are given:

A mean magnetic field will be derived for each measurement axes according to the equation

\[
B_x = \frac{B(+) + B(-)}{2}, \quad B_y = \frac{B(+) + B(-)}{2}, \quad B_z = \frac{B(+) + B(-)}{2}
\]

The total magnetic field (magnitude of magnetic field vector) can be calculated according to the equation

\[
|B| = \sqrt{B_x^2 + B_y^2 + B_z^2}
\]

For comparison with the specified limit the result shall be referred to 1 m using the equation

\[
B(\text{at} \text{1m}) = B(\text{at } r) r^3
\]

,where \(r\) = measurement distance in meters.

The magnetic moment vector shall be derived from the following equations:

\[
\begin{align*}
M_x &= 5 \cdot r^3 \cdot B_x \\
M_y &= 5 \cdot r^3 \cdot B_y \\
M_z &= 5 \cdot r^3 \cdot B_z \\
|\mathbf{M}| &= \sqrt{M_x^2 + M_y^2 + M_z^2}
\end{align*}
\]

5.2.4 Life Test

**GDI-1185/CREATED**

*A life test shall be required for all the assemblies concerned by wear-out phenomenon during the operation lifetime (on-ground and on board).*

5.2.5 Space Conditioning

**GDI-1187/CREATED**

*Space conditioning shall be performed whenever design choices for a unit or an assembly induce behaviour differences between in flight environment and on-ground environment.*

**GDI-1188/CREATED**

*The contractors shall propose the corresponding tests program, submitted to customer approval.*
For example, but without limitation to, materials moisture release, outgassing & strain releases shall be conducted whenever necessary.
**CHANGE LOG**

**Modified Objects**

In the following table modifications to the Object Text attribute are shown using red line markup. For other attributes the new value and the old value are shown in separate columns.

The codes used in the object type (OT) column are: Rq = Requirement, Inf = Information, Hd = Heading, Ah = Applicability Matrix Heading, Ar = Applicability Matrix Requirement

<table>
<thead>
<tr>
<th>Identifier</th>
<th>Attribute</th>
<th>OT</th>
<th>New Text</th>
<th>Old Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDI-193</td>
<td>Object Text</td>
<td>Inf</td>
<td>This section defines the requirements for the preparation, and the delivery of the Finite Element mathematical models of the assemblies and units in order to incorporate them into the higher-level assembly mathematical model. They are <strong>in a preliminary status for this now issue, deleted and will be transferred into a stand alone document at a later stage GAIA.ASD.SP.SAT.00007</strong>.</td>
<td></td>
</tr>
<tr>
<td>GDI-239 section 3.3.1.1</td>
<td>Object Text</td>
<td>Rq</td>
<td>In the frame of GAIA, all units shall be radiatively controlled units, except PAA and recurring units. This applies in particular without specificities for units having a dissipative power density of less than 50 W/m².</td>
<td></td>
</tr>
<tr>
<td>GDI-243 section 3.3.1.3</td>
<td>Object Text</td>
<td>Inf</td>
<td>As far as possible thermal gradients across the baseplate shall be minimised i.e. the unit shall be designed to be isothermal.</td>
<td></td>
</tr>
<tr>
<td>GDI-243 section 3.3.1.3</td>
<td>Object Type</td>
<td>Inf</td>
<td>Information Requirement</td>
<td></td>
</tr>
<tr>
<td>GDI-246 section 3.3.1.3</td>
<td>Object Text</td>
<td>Rq</td>
<td>For non units not fulfilling GDI-isothermal244/245 units additional thermal nodes shall be introduced at the baseplate, which represent areas with a reference temperature derivation &lt; 3K inside these areas. The temperature difference shall be defined for each thermal node of the unit baseplate.</td>
<td></td>
</tr>
<tr>
<td>GDI-248 section 3.3.1.4</td>
<td>Object Text</td>
<td>Rq</td>
<td>The temperature reference point (TRP) shall be selected on the unit external surface, preferably close to a mounting bolt, such that its temperature reflects the average unit housing temperature (no hot or cold spot). The temperature reference point shall be used as a reference for the thermal acceptance and qualification tests.</td>
<td></td>
</tr>
<tr>
<td>GDI-261 section 3.3.2.3</td>
<td>Object Text</td>
<td>Rq</td>
<td>The location, type and electrical interface of all devices used for unit temperature measurement and control shall be defined in the ICD.</td>
<td></td>
</tr>
<tr>
<td>GDI-263 section 3.3.3</td>
<td>Object Text</td>
<td>Rq</td>
<td>The units shall be designed such that all internal heat sources have the required thermal couplings to the external surfaces of the unit to comply with the interface requirements of Section 3.3.2.1 and Section 3.3.2.2 and their own unit requirements in terms of temperature and heat exchange.</td>
<td></td>
</tr>
<tr>
<td>GDI-303 section 3.4.3</td>
<td>Object Text</td>
<td>Rq</td>
<td>The numerical model shall be developed preferably in Code V® or ZEEMAX®, or using a software providing a simple export capability into one of these two softwares.</td>
<td></td>
</tr>
<tr>
<td>GDI-311 section 3.5.1</td>
<td>OLE</td>
<td>Inf</td>
<td>Figure/Table modified</td>
<td></td>
</tr>
<tr>
<td>Identifier</td>
<td>Attribute</td>
<td>OT</td>
<td>New Text</td>
<td>Old Text</td>
</tr>
<tr>
<td>------------</td>
<td>-----------</td>
<td>----</td>
<td>---------------------------------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>GDI-334</td>
<td>Object</td>
<td>Hd</td>
<td>Regulated Power Requirements</td>
<td>Sunlight Regulated Power Requirements</td>
</tr>
<tr>
<td>section 3.5.2.1</td>
<td>Heading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDI-335</td>
<td>Object</td>
<td>Inf</td>
<td>Primary Power is provided from a <strong>sunlight</strong> fully regulated DC main bus. The power is distributed via:</td>
<td></td>
</tr>
<tr>
<td>section 3.5.2.1</td>
<td>Text</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDI-338</td>
<td>Object</td>
<td>Rq</td>
<td>All units connected to the <strong>sunlight</strong> fully regulated bus shall ensure full performance for a power bus voltage at the unit power input as specified in Table 3.5-3 and Table 3.5-4.</td>
<td></td>
</tr>
<tr>
<td>section 3.5.2.1</td>
<td>Text</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDI-346</td>
<td>Object</td>
<td>Rq</td>
<td>All power converters shall be designed to allow operation in <strong>either free-running or-synchronised</strong> mode or if not possible, <strong>this</strong> design shall be referred to the Prime before implementation.</td>
<td></td>
</tr>
<tr>
<td>section 3.5.2.1</td>
<td>Text</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDI-349</td>
<td>Intended</td>
<td>Rq</td>
<td>TA</td>
<td>A</td>
</tr>
<tr>
<td>section 3.5.2.1</td>
<td>Verification</td>
<td></td>
<td>Method</td>
<td></td>
</tr>
<tr>
<td>GDI-350</td>
<td>OLE</td>
<td>Inf</td>
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<td></td>
</tr>
<tr>
<td>section 3.5.2.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDI-351</td>
<td>OLE</td>
<td>Inf</td>
<td>Figure/Table modified</td>
<td></td>
</tr>
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<td>section 3.5.2.1</td>
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<td>GDI-353</td>
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<td>section 3.5.2.1</td>
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<tr>
<td>GDI-412</td>
<td>Object</td>
<td>Rq</td>
<td>Nominal and redundant lines shall have separated connectors. Where existing qualified units are used that do not feasible to have separated connectors as described, connectors may be waived. Any request for redundant functions will be treated on a case by case basis taking into account failure propagation effects. Harness bundles will be physically split as and soon as isolated as from they each exit other than the connector in all cases.</td>
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<tr>
<td>section 3.5.4.3</td>
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<td>Inf</td>
<td>Figure/Table modified</td>
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<td>section 3.5.5.3</td>
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<td>GDI-474</td>
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<td>Inf</td>
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<td>section 3.5.5.6.1</td>
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<td>GDI-475</td>
<td>OLE</td>
<td>Inf</td>
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<td>section 3.5.5.6.2</td>
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<td>GDI-476</td>
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<td>section 3.5.5.6.2</td>
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<tr>
<td>GDI-494</td>
<td>Object</td>
<td>Rq</td>
<td>The High Power On/Off Command receiver shall be isolated from any user electrical reference.</td>
<td></td>
</tr>
<tr>
<td>section 3.5.5.8</td>
<td>Text</td>
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<tr>
<td>GDI-532</td>
<td>section</td>
<td>Inf</td>
<td>T1 &lt;= 128 bit</td>
<td>T2 between 1 bit and 128 bit</td>
</tr>
<tr>
<td>3.5.5.10.1</td>
<td>section</td>
<td></td>
<td>T3 = 500ms</td>
<td>T4 = 100ms</td>
</tr>
<tr>
<td></td>
<td>section</td>
<td></td>
<td>Tc = 2500µs +/- 5% (for a 24kbps uplink)</td>
<td>Ts = 10µs min</td>
</tr>
<tr>
<td></td>
<td>section</td>
<td></td>
<td>Th = 20µs min</td>
<td>Note 1: The clock is running as soon as the LOCK STATUS is &quot;high&quot; and it will run until LOCK STATUS falls to &quot;low&quot;.</td>
</tr>
<tr>
<td></td>
<td>section</td>
<td></td>
<td>Note 2: The bit clock stability shall be better than +/- 5% as soon as DATA VALID is &quot;high&quot; and until DATA VALID falls to &quot;low&quot;.</td>
<td>Note 3: The ESA standard requires an acquisition sequence of 128 bits. This value can be increased by adding an idle sequence (min. 8 bits) after the acquisition sequence.</td>
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<td></td>
</tr>
<tr>
<td>GDI-799</td>
<td>section</td>
<td>Rq</td>
<td>The quasi-static and low frequency flight limit accelerations that all units on the S/C Structure will encounter during launch and early orbit phase are compiled in GDI Table 4.2-8001.</td>
<td>The loads are applied:</td>
</tr>
<tr>
<td>4.2.3.1</td>
<td>section</td>
<td></td>
<td></td>
<td>- At the unit c-o-g,</td>
</tr>
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<td></td>
<td>section</td>
<td></td>
<td></td>
<td>- Along the worst spatial direction w.r.t resulting reactions/stresses.</td>
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<td>section</td>
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<td></td>
<td>Structural dimensioning of units shall consider critical combination of simultaneously acting loads.</td>
</tr>
<tr>
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<td>section</td>
<td></td>
<td></td>
<td>The safety factors to be used for design dimensioning purpose are defined in Section 3.2.1.5.</td>
</tr>
<tr>
<td>GDI-800</td>
<td>section</td>
<td>Inf</td>
<td></td>
<td>Table 4.2-1: Quasi-static Loads</td>
</tr>
<tr>
<td>4.2.3.1</td>
<td>section</td>
<td></td>
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<tr>
<td>GDI-841</td>
<td>section</td>
<td>Rq</td>
<td>During the In Orbit phase, the spacecraft units TRP will be kept within their acceptance design temperature limits. Unless otherwise specified in an equipment specification, the levels of Table 4.3-1 shall apply.</td>
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<tr>
<td>4.3.2</td>
<td>section</td>
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<tr>
<td>GDI-842</td>
<td>section</td>
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<td></td>
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<tr>
<td>4.3.2</td>
<td>section</td>
<td></td>
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</tr>
<tr>
<td>GDI-847</td>
<td>section</td>
<td>Rq</td>
<td>The radiation environment for the mission is shown in Section 4.4.3.1. Each unit shall be designed to withstand a radiation exposure that is twice the expected radiation environment during the mission (i.e. Radiation Damage Margin (RDM) = 2). This applies to all types of radiation damage, including ionising dose (total and low dose) and displacement damage.</td>
<td>Protective shielding by the outer panels of the satellite of 1.42mm Al equivalent shall be assumed.</td>
</tr>
<tr>
<td>4.4.1</td>
<td>section</td>
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<tr>
<td>GDI-865</td>
<td>section</td>
<td>Inf</td>
<td>High energetic protons can induce permanent damage by displacement in the active material bulk (Silicon, GaAs, or other). Estimation of displacement effects are based on the equivalent proton or neutron fluence curve deduced from Non Ionizing dose-depth curve. Such a curve is presented in Figure 4.4-9 and Figure 4.4-10. Mission hypothesis are similar to the ones used for ionizing dose depth curve.</td>
<td>Figure 4.4-9: Total equivalent 10 MeV proton fluence encountered during Non the ionising transferEnergy from Loss thea 190a krfuonction circifurnal parking shielding orbit thickness tofor the operational L2GAIA orbitmission.</td>
</tr>
<tr>
<td>4.4.3.2</td>
<td>section</td>
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<tr>
<td>GDI-866</td>
<td>section</td>
<td>Inf</td>
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<tr>
<td>GDI-876</td>
<td>section 4.4.4</td>
<td>Object Text</td>
<td>Rq <strong>No protective</strong> shielding by the outer panels of the satellite of 1 mm Al equivalent over 4π steradians shall be assumed.</td>
<td><strong>Protective</strong> shielding by the outer panels of the satellite of 1 mm Al equivalent over 4π steradians shall be assumed.</td>
</tr>
<tr>
<td>GDI-877</td>
<td>section 4.4.4</td>
<td>Object Text</td>
<td>Rq <strong>Any unit</strong> Unit shall take into account the shielding provided by the <strong>its spacecraft own casing</strong></td>
<td><strong>New Text</strong> Unit shall take into account the shielding provided by the spacecraft own casing</td>
</tr>
<tr>
<td>GDI-894</td>
<td>section 4.5.1.1</td>
<td>Object Heading</td>
<td>Hd Inrush Current</td>
<td>Inrush Current</td>
</tr>
<tr>
<td>GDI-895</td>
<td>section 4.5.1.1</td>
<td>Object Text</td>
<td>Rq Inrush current at unit switch on shall not exceed the following characteristics:</td>
<td>Inrush current at unit switch on shall not exceed the following characteristics:</td>
</tr>
<tr>
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<td></td>
<td>Rate of change of current, $\frac{dI}{dt} &lt; 2 \text{ A/\mu s}$</td>
<td>Rate of change of current, $\frac{dI}{dt} &lt; 2 \text{ A/\mu s}$</td>
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<td></td>
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<td>Total charge $Q &lt; 4\text{ms}*I$, for the input filter settling time of $t &lt; 4\text{ms}$ (where $I =$ LCL Trip-Off Class in Amps)</td>
<td>Total charge $Q &lt; 4\text{ms}*I$, for the input filter settling time of $t &lt; 4\text{ms}$ (where $I =$ LCL Trip-Off Class in Amps)</td>
</tr>
<tr>
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<td></td>
<td>for LCL class F, the total charge $Q$ is TBD</td>
<td>for LCL class F, the total charge $Q$ is TBD</td>
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<td>The $\frac{dI}{dt}$ shall be guaranteed without overstress and without any source current limitation and in the presence of any Bus voltage $dV/dt$</td>
<td>The $\frac{dI}{dt}$ shall be guaranteed without overstress and without any source current limitation and in the presence of any Bus voltage $dV/dt$</td>
</tr>
<tr>
<td>GDI-902</td>
<td>section 4.5.1.3.1</td>
<td>Object Text</td>
<td>Rq Conducted narrow band current emissions (differential mode) in the frequency range 30 Hz - 50 MHz appearing on the unit's primary power lines shall not exceed the limits of Figure 4.5-2.</td>
<td>Conducted narrow band current emissions (differential mode) in the frequency range 30 Hz - 50 MHz appearing on the unit's primary power lines shall not exceed the limits of Figure 4.5-2. at frequencies below 10 kHz the CE shall be:</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>The figure is applicable for units up to 30W power consumption.</td>
<td>The figure is applicable for units up to 30W power consumption.</td>
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<td>For units demanding more than 30W power, the figure can be scaled proportionally to the actual power demand over the entire frequency range, with an increase in dB given by $20 \log (P/30)$</td>
<td>For units demanding more than 30W power, the figure can be scaled proportionally to the actual power demand over the entire frequency range, with an increase in dB given by $20 \log (P/30)$</td>
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<td></td>
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<td>The emissions shall be measured up to 100 MHz (50-100 MHz) for information only</td>
<td>The emissions shall be measured up to 100 MHz (50-100 MHz) for information only</td>
</tr>
<tr>
<td>GDI-903</td>
<td>section 4.5.1.3.1</td>
<td>OLE</td>
<td>Inf Figure/Table modified</td>
<td>Figure/Table modified</td>
</tr>
<tr>
<td>GDI-904</td>
<td>section 4.5.1.3.1</td>
<td>Object Text</td>
<td>Rq Conducted narrow band current emissions (common mode) in the frequency range 310 kHz - 50 MHz appearing on the unit's primary power lines shall not exceed the limits of Figure 4.5-3.</td>
<td>Conducted narrow band current emissions (common mode) in the frequency range 310 kHz - 50 MHz appearing on the unit's primary power lines shall not exceed the limits of Figure 4.5-3.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>The emissions shall be measured up to 100 MHz (50 - 100 MHz) for information only</td>
<td>The emissions shall be measured up to 100 MHz (50 - 100 MHz) for information only</td>
</tr>
<tr>
<td>GDI-905</td>
<td>section 4.5.1.3.1</td>
<td>OLE</td>
<td>Inf Figure/Table modified</td>
<td>Figure/Table modified</td>
</tr>
<tr>
<td>GDI-907</td>
<td>section 4.5.1.3.2</td>
<td>Object Text</td>
<td>Rq Time domain conducted differential mode voltage ripple aton the primary power bus distribution outlets from any power user, measured between positive and return lines, shall be £ 100 mVpp.</td>
<td>Time domain conducted differential mode voltage ripple aton the primary power bus distribution outlets from any power user, measured between positive and return lines, shall be £ 100 mVpp. The voltage ripple shall be measured with at least 50 MHz bandwidth.</td>
</tr>
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<td>Time domain conducted differential mode voltage ripple from the PCDU measured at the primary power bus distribution outlets when connected to a dummy load, shall be £ 140 mVpp. The voltage ripple shall be measured with at least 50 MHz bandwidth.</td>
<td>Time domain conducted differential mode voltage ripple from the PCDU measured at the primary power bus distribution outlets when connected to a dummy load, shall be £ 140 mVpp. The voltage ripple shall be measured with at least 50 MHz bandwidth.</td>
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<tr>
<td>GDI-908 section 4.5.1.3.2</td>
<td>Object Text</td>
<td>Rq</td>
<td>Time domain conducted voltage spikesFor on Primary the Power primary users, power line bus domain distribution conducted outlets emissions, measured differential between mode positive (ripple and return lines spikes) shall be £ 15300 mVpp. The voltage spikes ripple shall be measured with at least a 50 MHz bandwidth.</td>
<td></td>
</tr>
<tr>
<td>GDI-918 section 4.5.1.4.1</td>
<td>Object Text</td>
<td>Rq</td>
<td>The maximum voltage emission levels for secondary power supplies shall be less than: · 20mV RMS from 30Hz up to 50MHz in differential mode, · 20mV RMS from 5 kHz to 50 MHz in common mode. The secondary supplies will shall be loaded by the representative (R, L, C) loads specified in the unit interface specifications. Grounding of the load networks shall be representative of the flight configuration for these measurements.</td>
<td></td>
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<tr>
<td>GDI-920 section 4.5.1.4.2</td>
<td>Object Text</td>
<td>Rq</td>
<td>The voltage ripple and spikes on secondary power supplies shall be less than: · 50mVpp in a 50 MHz bandwidth, in differential mode, · 50mVpp in a 50 MHz bandwidth, in common mode. The secondary supplies will shall be loaded by the representative (R, L, C) loads specified in the unit interface specifications. Grounding of the load networks shall be representative of the flight configuration for these measurements.</td>
<td></td>
</tr>
<tr>
<td>GDI-922 section 4.5.2</td>
<td>Object Text</td>
<td>Rq</td>
<td>The unit shall not exceed the specified limits in the range 14 kHz - 20GHz. Testing above 1GHz is not required if the unit does not employ any intentional frequencies above 100MHz and if the emissions at frequencies between 0.5 and 1GHz are at least 20dB below the limit. The limit of the downlink frequency is relaxed 75dBmV/m for the SSPA. The launcher radiated emission limits only apply to those units that are powered at launch. The limits are given in Figure 4.5-45 and GDI-2704</td>
<td></td>
</tr>
<tr>
<td>GDI-923 section 4.5.2</td>
<td>Object Text</td>
<td>Inf</td>
<td>The frequencies resp. frequency bands noted below may only be used by the item identified. For all other units or equipment, the use of these frequencies resp. frequency bands shall be avoided. · 192 MHz +/- 576 kHz TM Tx, stage II of Soyuz / launch site · 248 MHz +/- 744 kHz TM Tx, stage III of Soyuz / launch site · 2805 MHz +/- 3 MHz Tx, position measurement system of Soyuz launcher / launch site · 2725 MHz +/- 1 MHz Rx, position measurement system of Soyuz launcher / launch site · 3410,3 MHz Tx of trajectory measuring devices of Fregat · 5754,9 MHz Rx of trajectory measuring device of Fregat · 6380 MHz TM Tx of first system of Fregat · 643 MHz TM Tx of second system of Fregat · 713590 MHz - 721035 MHz Spacecraft X-Band receiver · 838450 MHz - 847500 MHz Spacecraft X-Band transmitter</td>
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</table>
Primary power bus powered units shall not exhibit any failures, malfunctions or unintended responses when sine wave voltages of 1 Vrms in the frequency range 30 Hz - 50 MHz (modified combination of MIL-STD-461C CS01 and CS02 requirements) are developed across the power input terminals (differential mode).

The applied sine wave shall be amplitude modulated (30% AM) with a modulation frequency of 1 kHz in the frequency range from 50 kHz - 50 MHz.

The frequency sweep rate shall be adjusted based on the characteristics of all unit’s internal frequencies but not be faster than 3 min/decade.

Prior to performing the test the supplier shall account for the capability of the unit in determining the maximum current limit.

The requirement shall also be considered met when:

1) Frequency range 30 Hz - 50 kHz:

   The specified test voltage levels cannot be generated but the injected current has reached 1A (rms), or lower if deemed unsafe by analysis, and the equipment is still operating nominally.

2) Frequency range 50 kHz - 50 MHz:

   A 1-watt source of 50W impedance cannot develop the required voltage at the unit’s power input terminals, and the unit is still operating nominally.

The conducted susceptibility specification for secondary power supplied units shall be at least:

- 200 mV RMS from 30 Hz up to 50 MHz in differential mode,
- 100 mV RMS from 5 kHz up to 50 MHz in common mode.

Prior to performing the test the supplier shall account for the capability of the unit in determining the maximum current limit.
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<tr>
<td>GDI-1269</td>
<td>section</td>
<td></td>
<td>During all mission phases the spacecraft is in sunlight, and the spacecraft power bus voltage will be regulated to 28V +/-0.14V (+/-0.5%) at the main regulation point.</td>
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<tr>
<td>GDI-1270</td>
<td>section</td>
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<td>During launch and eclipse anomaly phases conditions the bus voltage will can follow fall to the battery voltage as it discharges.</td>
<td></td>
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<tr>
<td>GDI-1946</td>
<td>section</td>
<td></td>
<td>The integral LET spectra generated using CREME96 (excluding proton effects) are shown in Figure 4.4-1 and Table GDI-2080 for 1 g/cm² Aluminium shielding. This data should be used for analysis of Single Event Effects in most components not susceptible to proton induced upset, typically those which have a sensitivity threshold above 15 MeV - cm²/mg.).</td>
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</tr>
<tr>
<td>GDI-1951</td>
<td>section</td>
<td></td>
<td>Trapped Proton Environment during transfer</td>
<td>Trapped Proton Environment during trasfer</td>
</tr>
<tr>
<td>GDI-1958</td>
<td>section</td>
<td></td>
<td>Figure 4.4-34: Solar Proton Fluence spectra for the six 6.5-year operational mission at a 90% confidence level. without shielding</td>
<td></td>
</tr>
<tr>
<td>GDI-1958</td>
<td>section</td>
<td></td>
<td>Figure 4.4-5: Solar Proton spectrum for the GAIA mission</td>
<td></td>
</tr>
<tr>
<td>GDI-1965</td>
<td>section</td>
<td></td>
<td>Total ionizing dose as a function of Aluminum thickness have been computed using Shieldose-2 code included in SPENVIS software. Proton and electron spectra presented in Figure 4.4-23, Figure 4.4-34 and Figure 4.4-46 were considered as input. Shielding shape considered by Shieldose-2 corresponds to a solid sphere with a detector located in its center. The following figure presents the total dose deposition in the detector as a function of the solid sphere thickness. Tabulated values are given in Appendix H: Radiation Tables (13-GDI-2064).</td>
<td></td>
</tr>
<tr>
<td>GDI-1966</td>
<td>section</td>
<td></td>
<td>The radiation environment for the mission shall be as shown in Figure 4.4-57 and Figure 4.4-8 and each unit shall be designed to withstand a radiation exposure as described in Section 4.4.</td>
<td></td>
</tr>
<tr>
<td>GDI-1977</td>
<td>section</td>
<td></td>
<td>Parts are considered SEE immune when the LETth is greater than 1070 MeV.cm²/mg. Parts are considered sensitive to heavy ion and proton induced SEE when the LETth is lower than 15 MeV.cm²/mg.</td>
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<tr>
<td>GDI-1980</td>
<td>section</td>
<td></td>
<td>Devices with which LETthare forknown SELto be is less susceptible 60 to 100 MeVcm²/mg up’s shall not be used. Devices, with however the LETth use forof SEL between 60 and 100 MeV.cm²/mg sensitive maydevices beis usedaccepted if the Latch Up Rate (LUR) follows: LUR &lt; 10% ldev. where ldev: intrinsic device failure rate, as determined using MIL HDBK217, or based on experimental set of reliability data to be submitted to ASTRIUM for approval. Latch up protection circuitry can be used only after project acceptance.</td>
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</table>
For SEB and SEGR, error rate prediction techniques are not mature and require project approval before use. Radiation assurance is then based on de-rating rules of maximum operating values. If no acceptable SEGR and SEB data exist, the Vds voltage must be at least 50% lower than the maximum Vds (with VDS max<200V) and Vgs>0V (N-channel MOSFETs) or Vgs<0V (P-channel MOSFETs).

If acceptable SEGR and SEB data exist, acceptable evaluation phase data will give drain to source threshold voltages (Vdsth) versus LET and gate to source voltage (Vgs), for static ON and static OFF case temperature. Worst case Vdsth(WC) will be defined. The derating is to maintain Vds over the full design lifetime as:

\[ V_{ds} \leq 0.80 \times V_{dsth}(WC) \]

with

- \( |V_{gsl}| < |V_{gsmax}| \) used during testing for Vdsth(WC) estimate
- \( T_{test} < T_{case} \) where \( T_{test} \) is the case temperature used during testing, for Vdsth(WC) estimate.

The primary unit power bus powered units shall not exhibit any malfunction, failure, degradation or malfunction of performance unintended or responses deviation when beyond the wave tolerance voltages indicated in Table I. MOSFETs from HARRIS/INTERSIL/FAIRCCHILD or International Rectifier (generation III or generation IV), the Vds voltage must be at least 50% lower than the maximum Vds (with VDS max<200V) and Vgs>0V (N-channel MOSFETs) or Vgs<0V (P-channel MOSFETs).

The design of the FCLs and of all essential loads (i.e. those supplied from by the FCL’s) shall not be prone to any lock-up phenomenon requiring recovery via the removal of external power. This requirement to be verified at unit level.
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<tr>
<td>GDI-2046</td>
<td>Intended Verification Method</td>
<td>Rq</td>
<td>Note: Launcher RE limits notches of: 20 dBµV/M between 1570 and 1620 MHz, 19 dBµV/M between 1573 and 1616 MHz, 46 dBµV/M between 1620 and 1782 MHz, 50 dBµV/M between 2723.45 and 2727.55 MHz, 36 dBµV/M between 5754.87 and 5754.94 MHz, are to be considered in addition, only applicable to units switched on during launch.</td>
<td></td>
</tr>
<tr>
<td>GDI-2054</td>
<td>Object Text</td>
<td>Inf</td>
<td>Figure 4.4-1: The Galactic cosmic ray Linear Energy Transfer (LET) integral spectrum for four conditions: GAIA solar mission minimum, for solar different maximum, levels solar of proton activity: event nominal (GEO quiet), worst week and week, solar worst proton day event and peak 5-minute flux. This LET spectrum in silicon has been calculated assuming a shielding of 1 g/cm².</td>
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<td>Figure/Table inserted</td>
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<td>GDI-2064</td>
<td>Object Text</td>
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<td>Figure 4.4-8: Total ionising dose (Rads in Silicon) for the 6.5-year extended operational phase of the mission as a function of spherical aluminium shielding thickness.</td>
<td></td>
</tr>
<tr>
<td>GDI-2078</td>
<td>Object Text</td>
<td>Inf</td>
<td>Figure 4.4-7: Ionising dose (Rads in Silicon) for the 6.5-year extended operational phase of the mission as a function of spherical aluminium shielding thickness.</td>
<td></td>
</tr>
<tr>
<td>GDI-2079</td>
<td>Object Text</td>
<td>Rq</td>
<td>Average For units located outside of the Focal Plane Assembly, the average dissipation of the unit operating with has to remain stable external during load over “T” any period of time period (T being comprised between 10 seconds and 20006 seconds hours, and defined as a &quot;sliding window&quot; over any S/C science operational period). The dissipation shall not vary by more than 0.25% when bus voltage varies by up to 0.5%.</td>
<td></td>
</tr>
<tr>
<td>GDI-2104</td>
<td>Object Text</td>
<td>Rq</td>
<td>The spacecraft sunlight fully regulated bus shall have a nominal ripple voltage in the time domain below 0.5% peak to peak of the nominal bus voltage.</td>
<td></td>
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<tr>
<td>GDI-2116</td>
<td>section</td>
<td>5.2.3.3.4</td>
<td>Derivation of the bus impedance shall be performed as follows: The bus impedance at the low frequency end shall be derived by dividing the maximum voltage drop from the appropriate LCL by its current rating (see Table 3.5-2). This value shall then be multiplied by 0.65 to allow for typical LCL actual performance, and then 20 milliohms shall be added to allow for the regulated primary bus source impedance at the main regulation point. This results in the following values (TBC): LCL Class: Impedance at low frequency: A 180 milliohms B 100 milliohms C 75 milliohms D 60 milliohms E 50 milliohms F TBD milliohms This value is intercepted by the sloping portion of the graph which is determined by the harness impedance and reaches a maximum value of 100 Ohms at 10 MHz, thereafter remaining constant. A tolerance of +/- 20% shall be allowed on the actual LISN performance.</td>
<td></td>
</tr>
<tr>
<td>GDI-2128</td>
<td>section</td>
<td>3.2.5.2</td>
<td>In order to derive the factored worst case quasi-static resistive torques (or forces) the components of resistance, considered worst case conditions, shall be multiplied by the following minimum uncertainty factors: Inertia, IT or IF: 1.1 Spring, S: 1.2 Friction, FR: 3.0 (<em>) Hysteresis, HY: 3.0 (</em>) Harness/Other, HA: 3.0 (<em>) Adhesion, HD: 3.0 Note: Factors marked (</em>) may be reduced to 1.5 if the resistive forces/torques can be satisfactorily determined by test.</td>
<td></td>
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<tr>
<td>GDI-2159</td>
<td>section</td>
<td>5.2</td>
<td>The verification test matrix is provided in the unit requirement specification and the statement of work (SOW). The preferred unit level test sequence is: Note: variations to this proposed test sequence shall be agreed with the Prime Contractor prior to the start of any unit level test programme.</td>
<td></td>
</tr>
<tr>
<td>GDI-2164</td>
<td>section</td>
<td>3.5.2.1</td>
<td>Figure TBD Figure 3.5-2: Primary Power Lines Source Impedance (at the Unit Power Input Connectors)</td>
<td>Figure/OLE deleted</td>
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<tr>
<td>GDI-2173</td>
<td>section</td>
<td>4.4.3.2</td>
<td>Figure 4.4-10: Non-Ionising Dose Energy Loss (NIEL) equivalent 10 MeV proton fluence for the transfer trajectory from the L2GAIA orbit, mission</td>
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<td>GDI-2188</td>
<td>Object Text</td>
<td>Rq</td>
<td>The software components that are critical for the <strong>mission and the spacecraft</strong> safety shall be verified by an Independent Software Verification (ISV) Team different from the software supplier.</td>
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<td>GDI-2234</td>
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<td>TBD</td>
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<td>GDI-2285</td>
<td>Object Text</td>
<td>Inf</td>
<td>The spacecraft is designed to ensure full decoupling between eigen-frequencies of lower level assemblies and minimize the deformations due to gravity release (1g?0g). Minimum natural frequency requirements are imposed upon the S/C, assemblies and units for the following reasons:</td>
<td>To avoid excessive loads and deflections, To avoid unacceptable micro-vibration behaviour</td>
</tr>
<tr>
<td>GDI-2311</td>
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<tr>
<td>GDI-2338</td>
<td>Object Text</td>
<td>Rq</td>
<td>Units shall be designed and tested to withstand, without degradation, the acoustic environment as defined in Table <strong>Acoustic Vibration Environment</strong> 4.2-4 hereafter. The safety factors to be used for design dimensioning purposes are defined in Section 3.2.1.5.2.</td>
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<td>GDI-2348</td>
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<td>TBD</td>
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<td>GDI-2373</td>
<td>Object Text</td>
<td>Inf</td>
<td><strong>Following assumptions shall be taken into account:</strong> 1) Applicable failure criteria have to be agreed with the customer 2) This coefficient applies to concentrated stresses 3) These materials have strength properties which are highly dependant of the manufacturing process and of the surface quality 4) This coefficient applies to general stress analysis on internal pressure and external loads. For damage tolerance or safety analysis, refer to ECSS-E30-02 5) For global buckling, the factor of safety does not include any knock down factor which is included in the result of the buckling analysis** Table 3.2-3: Design Safety Factors</td>
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<td>GDI-2374</td>
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<td>GDI-2408 section 3.5.5.1.3. 2</td>
<td>Object Text</td>
<td>Rq</td>
<td>No LVDS configuration involving more than one (1) LVDS driver should be and implemented— one in (1) case LVDS this receiver is The demonstrated LVDS as link an shall inevitable be implementation point into shall point be link. done In as case shown if cannot the possible, figure the below. Prime shall be such informed and implementation shall caused agreement major on link the initialisation implementation problems of on such previous LVDS projects link.</td>
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<td>GDI-2408 section 3.5.5.1.3. 2</td>
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<td>Rq</td>
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<td>GDI-2508 section 4.2.4</td>
<td>Object Text</td>
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<td>During the Launch and early Operation phase, the spacecraft units will be kept within their accepted design temperature limits. Unless otherwise specified in an equipment specification, the levels of Table 4.3-1 shall have to apply.</td>
<td></td>
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<tr>
<td>GDI-2508 section 4.2.4</td>
<td>Object Type</td>
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<td>Information Requirement</td>
<td>Requirement</td>
</tr>
<tr>
<td>GDI-2552 section 3.3.4.2</td>
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<td>Mathematical models in ESARAD—THERMICA and ESATAN shall be prepared to support the thermal analyses as necessary.</td>
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<td>GDI-2555 section 3.3.4.1</td>
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<td>The equipment thermal control shall comply with ECSS-E-30 part 1A taking into account the ECSS tailoring for Gaia.</td>
<td></td>
</tr>
<tr>
<td>GDI-2562 section 3.3.4.1</td>
<td>Object Text</td>
<td>Rq</td>
<td>A Thermal Reference Point (TRP) shall be defined and instrumented for all units. This TRP shall be selected such that its temperature reflects the general thermal status of the equipment (preferably at the mounting interface of the unit).</td>
<td></td>
</tr>
<tr>
<td>GDI-2567 section 3.3.4.1</td>
<td>Object Text</td>
<td>Rq</td>
<td>The design limits of units are equal to the acceptance limits decreased at both ends by a margin of 5°C.</td>
<td></td>
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<tr>
<td>GDI-2582 section 3.3.2.2</td>
<td>Object Text</td>
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<td>Units shall demonstrate compliance to their design/acceptance/qualification temperature range for the radiative and conductive environment of GDI-2558 Table 4.3-1.</td>
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<td>GDI-2583 section 4.3.2</td>
<td>Object Text</td>
<td>Rq</td>
<td>During the In Orbit phase, the spacecraft units will face mostly a thermally radiative environment. Unless otherwise specified in an equipment specification, the levels of Table UNIT SINK TEMP 4.3 UNIT CONDUCTIVE HEAT FLOW 2 shall apply.</td>
<td></td>
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<td>Figure/Table deleted</td>
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The units shall take into account the following definitions of GDI Table 3.3-2681.

Fatigue loads: in case of a launch from Baikonur, the SVM and the PLM instrument shall survive with sufficient life time allowable the low frequency cycling loads of Tables GDI-266Table 4.1-3, multiplied by a life factor of 4.

This section defines the requirements for the preparation, and the delivery of the Thermal Mathematical Models of the assemblies and units in order to incorporate them into the higher-level assembly thermal mathematical model. They are in a preliminary status for this issue, and completed will by requirements transferred contained into a stand-alone applicable document at a later stage GAIA.ASD.SP.SAT.00008.

The qualification and acceptance tests to be performed shall include the tests as listed in the table below. This list may be tailored with the approval of EADS Astrium depending on the category and maturity of each unit.

Memory circuits shall have sufficient error detection and correction capability for protection against SEU such that the circuit performance goals are not affected by these errors.

The micrometeoroid environment for the mission shall be as shown in Figure GDI-2684 and table GDI-2685.

Cumulative number of meteoroid impacts for 6.5 years at L2 per m2 from 1 side to a randomly oriented surface for a range of minimum particle sizes as obtained by the Grn model; A density of 2.0 g/cm3 and spherical shape were used to convert masses to diameter.

Cumulative number of meteoroid impacts for 6.5 years at L2 per m2 from 1 side to a randomly oriented surface for a range of minimum particle sizes as obtained by the Grn model; A density of 2.0 g/cm3 and spherical shape were used to convert masses to diameter.
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<td>GDI-2686 section 4.5.14</td>
<td>Requirement</td>
<td>A damage assessment based on the micrometeoroid environment provided in figure GDI-2684 and table GDI-2685 shall be carried out for units and items with direct exposure to free space.</td>
</tr>
<tr>
<td>GDI-2687 section 4.5.13.1-1</td>
<td>Requirement</td>
<td>All high power output equipment and components (&gt; 1W) shall be free from the effects of multipaction or gas discharge.</td>
</tr>
<tr>
<td>GDI-2688 section 4.5.13.1-2</td>
<td>Requirement</td>
<td>This shall be demonstrated up to 6dB above the peak operating power levels with waveforms representative of operational signals in pulse duration and PRF. A reduced PRF may be used from peak power up to the 6dB margin whilst maintaining the mean power level.</td>
</tr>
<tr>
<td>GDI-2689 section 4.5.13.1-3</td>
<td>Requirement</td>
<td>All power levels between 10 W (or a minimum significantly below the theoretical threshold) and the 6 dB margin above peak operating power shall be tested. This may be achieved by slow ramping between these limits so as to ensure no multipaction resonance regions are omitted.</td>
</tr>
<tr>
<td>GDI-2690 section 4.5.13.1-4</td>
<td>Requirement</td>
<td>All multipaction tests shall be performed in the presence of electron seeding.</td>
</tr>
<tr>
<td>GDI-2691 section 4.5.13.2-1</td>
<td>Information</td>
<td>Between any two conductors corona or gas discharge can be assumed not to occur in air at the following voltage stress for the following values of atmospheric pressure x gap between conductors as shown in Table GDI-2692.</td>
</tr>
<tr>
<td>GDI-2692 section 4.5.13.2-2</td>
<td>Information</td>
<td>[wdFCaption: Gas Discharge - Safe Voltage / Pressure x gap]</td>
</tr>
<tr>
<td>GDI-2693 section 4.5.13.2-3</td>
<td>Requirement</td>
<td>Equipments and sub-systems shall be free from gas discharge during: ground testing, launch, early orbit and when in orbit for the lifetime of the satellite</td>
</tr>
<tr>
<td>GDI-2694 section 4.5.13.2-4</td>
<td>Requirement</td>
<td>Adequate venting shall be provided to ensure that the gas pressure in any corona critical regions do not remain within the range 1 x 10-2 to 0.8 x 105 N/m2 when the equipment is operating. This requirement ensures that if the equipment is corona free at 1 atmosphere then it will also be corona free at air pressures less than 1 x 10-2 N/m2</td>
</tr>
<tr>
<td>GDI-2695 section 4.5.13.2-5</td>
<td>Requirement</td>
<td>If the above requirements GDI-2693 and GDI-2694 cannot be met then flight representative samples shall be tested at twice the maximum voltage stress to ensure that corona does not occur. In this case the Prime contractor shall be consulted and approve the corona test procedure.</td>
</tr>
<tr>
<td>GDI-2696 section 3.5.2.1</td>
<td>Requirement</td>
<td>During all mission phases the spacecraft power bus voltage will not vary by more than +/-0.25% over any 6 hour period with the spacecraft loads at constant power.</td>
</tr>
<tr>
<td>GDI-2697 section 3.2.5.1</td>
<td>Requirement</td>
<td>All release devices shall be tolerant to single failures.</td>
</tr>
<tr>
<td>GDI-2698 section 3.2.5.1</td>
<td>Requirement</td>
<td>The in-orbit deployed configuration of any mobile part shall be secured by an independent latching function.</td>
</tr>
<tr>
<td>GDI-2700 section 3.1.1</td>
<td>Requirement</td>
<td>The units shall be compatible with a storage period of at least 5 months in launch configuration without maintenance.</td>
</tr>
<tr>
<td>GDI-2701 section 3.5.5.11.1</td>
<td>Requirement</td>
<td>Nominal and redundant pyrotechnic items shall be procured from 2 separate batches</td>
</tr>
<tr>
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<tr>
<td>GDI-2704</td>
<td>Requirement</td>
<td>On board Receiver Notch: 20 dBµV/M between 7190 and 7235 MHz</td>
</tr>
<tr>
<td>GDI-2705</td>
<td>Requirement</td>
<td>The unit shall not show any malfunction or deviation from the specified performance when irradiated with the following E-fields: X band Transmitter 8450 - 8500 MHz : 30 V/m</td>
</tr>
<tr>
<td>GDI-2709</td>
<td>Requirement</td>
<td>Time domain current emissions shall be &lt; 10% of the units current consumption or 300 mApp, whatever is less.</td>
</tr>
<tr>
<td>GDI-2710</td>
<td>Heading</td>
<td>Conducted Emissions Signal lines Common Mode</td>
</tr>
<tr>
<td>GDI-2711</td>
<td>Requirement</td>
<td>Conducted Narrow band conducted emissions (common mode) in the frequency range 10 kHz - 50 MHz as measured on the unit's signal bundles shall not exceed the limits of Figure GDI-2712. The emissions shall be measured up to 100 MHz (50 - 100 MHz for information only) This requirement applies also to secondary power bundles</td>
</tr>
<tr>
<td>GDI-2712</td>
<td>Requirement</td>
<td>[wdFCaption: Conducted Emission on Signal Bundles, Common Mode]</td>
</tr>
<tr>
<td>GDI-2713</td>
<td>Information</td>
<td>[wdTCaption: Unit sink temperature - Unit conductive heat flow]</td>
</tr>
<tr>
<td>GDI-2715</td>
<td>Requirement</td>
<td>the GRR shall be attached at less than or equal to every 150mm to the panels by a M4 bolt. Further mechanical fixings may be required at the ends of the rails</td>
</tr>
<tr>
<td>GDI-2716</td>
<td>Requirement</td>
<td>In case of internal redundancy, conducted emissions test in frequency domain, differential mode and common mode, and time domain emission tests shall be performed in both nominal and redundant configurations of the unit</td>
</tr>
<tr>
<td>GDI-2717</td>
<td>Requirement</td>
<td>In case of internal redundancy, time domain emission tests shall be performed in both nominal and redundant configurations of the unit</td>
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**Deleted Objects**

- GDI-194 section 3.2.4 : Information
- GDI-195 section 3.2.4 : Information
- GDI-196 section 3.2.4 : Information
- GDI-197 section 3.2.4 : Requirement
- GDI-199 section 3.2.4.1 : Heading
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- GDI-201 section 3.2.4.1 : Requirement
- GDI-202 section 3.2.4.1 : Requirement
- GDI-203 section 3.2.4.2 : Heading
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- GDI-205 section 3.2.4.3 : Heading
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- GDI-209 section 3.2.4.4 : Requirement
- GDI-210 section 3.2.4.4 : Requirement
- GDI-211 section 3.2.4.5 : Heading
GDI-212 section 3.2.4.5 : Requirement
GDI-213 section 3.2.4.5 : Requirement
GDI-214 section 3.2.4.5 : Requirement
GDI-215 section 3.2.4.5 : Requirement
GDI-216 section 3.2.4.5 : Requirement
GDI-217 section 3.2.4.5 : Requirement
GDI-218 section 3.2.4.6 : Heading
GDI-219 section 3.2.4.6 : Information
GDI-220 section 3.2.4.6.1 : Heading
GDI-221 section 3.2.4.6.1 : Requirement
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GDI-227 section 3.2.4.6.4 : Requirement
GDI-228 section 3.2.4.6.5 : Heading
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GDI-230 section 3.2.4.6.6 : Heading
GDI-231 section 3.2.4.6.6 : Requirement
GDI-232 section 3.2.4.6.7 : Heading
GDI-233 section 3.2.4.6.7 : Requirement
GDI-234 section 3.2.4.7 : Heading
GDI-235 section 3.2.4.7 : Requirement
GDI-1154 section 5.2.3.4.9 : Information
GDI-1967 section 4.4.3.1 : Information
GDI-2001 section 4.5.9.2 : Information
GDI-2053 section 3.2.4.6.2 : Information
GDI-2060 section 3.2.4.8 : Heading
GDI-2065 section 3.2.4 : Information
GDI-2066 section 3.2.4.9-1 : Information
GDI-2067 section 3.2.4.9-2 : Requirement
GDI-2068 section 3.2.4.9-3 : Requirement
GDI-2069 section 3.2.4.9-4 : Requirement
GDI-2070 section 3.2.4.9-5 : Requirement
GDI-2071 section 3.2.4.9-6 : Requirement
GDI-2072 section 3.2.4.9-7 : Requirement
GDI-2074 section 3.2.4.8 : Requirement
GDI-2075 section 3.2.4 : Requirement
GDI-2095 section 3.2.4.7 : Requirement
GDI-2096 section 3.2.4.7 : Requirement
GDI-2097 section 3.2.4.7 : Requirement
GDI-2098 section 3.2.4.7 : Requirement
GDI-2099 section 3.2.4.7 : Requirement
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GDI-2101 section 3.2.4.7 : Requirement
GDI-2102 section 3.2.4.7 : Requirement
GDI-2114 section 3.2.4.6.1 : Information
GDI-2115 section 3.2.4.7 : Information
GDI-2172 section 4.4.3.1 : Information
GDI-2174 section 4.4.3.2 : Information
GDI-2175 section 4.4.3.2 : Information
GDI-2503 section 3.2.4.9 : Heading

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