ExoMars Rover Vehicle

General Design and Interface Requirements
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1 INTRODUCTION AND SCOPE

1.1 Scope

This document, designated as General Design and Interface Requirements (specification), constitutes the general requirements for the various elements of the ExoMars Rover Vehicle. It has been prepared in accordance with the requirements of the SOW and the applicable documentation.

The document specifies the contractually relevant requirements as well as assumptions and constraints, which apply to the development, design, manufacturing, assembly, verification and delivery of the ExoMars Rover Vehicle, including module level, subsystem level, and unit level deliveries, to the extent specified in the governing specification for that deliverable.

In the case of conflicts between this specification and subsystem or unit specifications, this specification is superseded by the lower level specification. The conflict shall be reported to the Rover Vehicle prime.

The requirements in this document are directly generated from the DOORS module ‘Rover Vehicle Hardware GDIR’, baseline ‘2.1’ contained within the Astrium ExoMars Rover DOORS database.

1.2 Background to ExoMars Rover

1.2.1 ExoMars Objectives

Establishing whether life ever existed or is still active on Mars is one of the principal outstanding scientific questions of our time; it is also a necessary prerequisite to prepare for the future human exploration endeavours. The ExoMars mission will search for traces of past and present life, characterize the Mars geochemistry and water distribution, improve the knowledge of the Mars environment and geophysics, and identify possible surface hazards to future human exploration missions.

The Rover will carry a comprehensive suite of analytical instruments dedicated to exobiology and geological research. Over its planned 6 month life, the Rover will ensure a regional mobility (several kilometres) searching for traces of past and present life. It will do this by collecting and analysing samples from within surface rocks, and from underground, to a depth of 2 meters. The very powerful combination of mobility with the capability to access locations where organic molecules might be well preserved is unique to this mission.

1.2.2 Rover Function

The purpose of the Rover Module (RM) is to provide functionality required many of the core mission objectives.

Technology Objectives:

- Surface mobility
- Access to the subsurface to acquire samples
- Sample preparation and distribution for analyses by scientific instruments

Scientific Objectives:

- To search for signs of past and present life on Mars
- To investigate the water/geochemical environment as a function of depth in the shallow subsurface
- To investigate Martian atmosphere trace gases and their sources
1.3 Control of this Document

This document is prepared by Astrium Ltd. It will be maintained and distributed according to the RV Configuration and Data Management Plan. Once this document has been formally issues (at issue 1) changes and updates to this document will be made through a CCB process.

In this document:

- TBD (To Be Determined) indicates the need for data that are currently not available.
- TBC (To Be Confirmed) indicates that the data supplied are preliminary.

The requirements presented in this document are managed within the database on Astrium Ltd's DOORS server. This database interfaces with DOORS databases provide by the customer TAS-I to manage the links to applicable documents.

1.4 Format of Requirements

Requirements are specified throughout this document in a format as shown below:

RV-GDIR-XXXX / Customer Link / R : Requirement Title

Requirement Text ...

Where:

- RV-GDIR-XXXX: is the requirement identifier. “RV-GDIR” is the requirement code for this document and XXXX is a unique number that is assigned to each requirement. Once assigned, the number can never be reassigned.
- /Customer Link: provides the traceability to the parent requirement.
- / R,A,I,T: indicates the verification methods to be used to verify the requirements
  - R - Review
  - A - Analysis
  - I - Inspection
  - T - Test
- : Requirement Title: provides an individual heading of the requirement (if used).
- Requirement Text ...: The requirements should be traceable, unique, single, verifiable, unambiguous and referenced as necessary to other requirements. Notes and/or rationale may be added for clarification and explanation.

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

The documents listed here are available on request to the ExoMars Rover Vehicle Project Office.

In case of conflict between Normative References and this document the contractor shall inform the ExoMars Rover Vehicle Project Office for resolution.

2.1 Normative Documents

Normative References are directly applicable in their entirety to this document and are listed below as dated or undated references. These normative references may be cited at appropriate places in the text. For dated references, subsequent amendments to or revisions of any of these document apply to this statement of work only when incorporated in it by amendment or revision. For undated references, the latest signed version is applicable and must be incorporated by the contractor in the project baseline.

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2.2 Informative Documents

Informative References are applicable to this document only when specifically called up in the text with specific indications of the parts of the document that are to be applicable. Otherwise the documents are listed below for information only as an aid for the purpose of understanding. For dated references, subsequent amendments to or revisions of any of these document apply to this statement of work only when incorporated in it by amendment or revision. For undated references, the latest signed version is applicable and must be incorporated by the contractor in the project baseline pending the use of the document as explained above.

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3 GENERAL DESIGN AND INTERFACE REQUIREMENTS

3.1 General Design Requirements

This section contains requirements relating to:

- Venting
- Outgassing
- Parts, materials and processes
- Handling, packing and transportation
- Identification and marking
- Workmanship
- Reliability, Availability, Maintainability, Safety (RAMS)
- Engineering standards

RV-GDIR-203 / MS-METH-REQ-0120 / R

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 (Earth gravity acceleration) and temperatures which may be expressed in terms of °C.

3.1.1 Lifetime

RV-GDIR-4380 / RV-SYS-328, MS-METH-REQ-0150, MS-METH-REQ-0170 / R

All hardware shall be designed for a life during which it meets all its functional and performance requirements of a minimum of 5½ years preflight, 9 months cruise (TBC) and 218 sols on the Martian surface.

RV-GDIR-4381 / RV-SYS-329 / R

Hardware shall be designed to allow for a minimum of 36 months of testing and 30 month of storage from delivery to Astrium until launch.

RV-GDIR-138 / MS-METH-REQ-0180 / R

Equipment shall be designed to require no periodic maintenance for the entire duration of the ground life.

Note: Any maintenance required during storage shall be identified by the contractor for approval. Maintenance during storage should be as limited as possible.

3.1.2 Design Safety

RV-GDIR-140 / / R

Equipment shall be designed and fabricated with compatible materials in such a manner that all hazards associated with the equipment are minimised and controlled.

RV-GDIR-141 / / A

General safety requirements for electronic units are as following:

- 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

RV-GDIR-142 / I

All units that could represent a hazard to personnel shall be clearly marked as such.

3.1.3 RAMS

RV-GDIR-4382 / RV-SYS-276 / R

All hardware shall be single point failure tolerant.

Note: Redundancy concepts shall be considered to remove single-point failure whenever possible. The contractor shall clearly identify the items on which this cannot be respected and highlight it in the FMECA. Single point failure shall be identified by the contractor and agreed with the Prime Contractor.

RV-GDIR-145 / RV-SYS-277 / I

Failure propagation from a function to another shall be avoided by design:

• between primary and redundant functions
• from any function to another

Note: Identified failure propagation criteria are:

• electrical criteria (the parts of surrounding functions are overstressed)
• physical criteria (the parts of surrounding functions are overheated)

3.1.3.1 Disconnection

RV-GDIR-149 / R

The design shall ensure that the failed function can be switched off from the power supply (except cases specified).

3.1.3.2 Segregation

RV-GDIR-152 / R

Within a connector, a section of free pins shall separate main and redundant functions/signals in the case where separate connectors cannot be used. Note: Use of a single connector for both main and redundant functions shall be agreed with Astrium.

3.1.3.3 Detection

RV-GDIR-154 / A

All failures that are identified as potential causes of failure propagation shall be monitored in order to disconnect the failed item before propagation takes place.

RV-GDIR-155 / A

The detection and disconnection function shall be independent of the potential cause of the initial failure.
3.1.4 Venting

Adequate venting is provided to preserve the structural integrity of the spacecraft, assemblies or units during launch depressurisation and Martian atmosphere re-entry.

Note: Unless a cavity is hermetically sealed adequate means of venting will be provided in the design.

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

**RV-GDIR-159 / MS-METH-REQ-0230 / A,R**

A unit shall be able to vent within a depressure range of 1 bar to 1E-10 bar and repressurisation to 0.9E-2bar.

Note: Suitable venting provision that is nominally defined as ≥ 2mm² venting hole area per litre volume.

Note: For all relevant thermal hardware, explicitly MLI, tapes and heater mats, venting provisions shall be incorporated.

Note: Structural members (honeycomb panels, in particular) shall include provisions to enable venting of any hermetically sealed volumes during launch ascent and during Thermal Balance/Thermal Vacuum test.

**RV-GDIR-4988 / MS-METH-REQ-0230 / R**

All hardware shall have a suitable venting provision that is nominally ≥ 2mm² venting hole area per litre volume.

Note: For all relevant thermal hardware, explicitly MLI, tapes and heater mats, venting provisions shall be incorporated.

Note: Structural members (honeycomb panels, in particular) shall include provisions to enable venting of any hermetically sealed volumes during launch ascent and during Thermal Balance/Thermal Vacuum test.

**RV-GDIR-5296 / MS-METH-REQ-0230 / A**

Equipments shall be designed to withstand without degradation, a de-pressurization rate of 70mbar/s maximum (TBC) and a delta pressure of 150mbar above ambient.

**RV-GDIR-5297 / MS-METH-REQ-0230 / A**

Equipments shall be designed to withstand without degradation, a re-pressurization rate of TBD mbar/s maximum.

**RV-GDIR-4989 / / R**

Outgassing vents for units shall be between 1.5mm and 5mm in diameter and located close to but not within the unit mounting plane.

**RV-GDIR-161 / / R**

The venting path shall include a labyrinth seal to minimise the ingress of contaminates.

**RV-GDIR-4991 / MS-METH-REQ-0240 / R**

The venting path shall include a labyrinth path to minimise the ingress of contaminates.

Note: A labyrinth path is defined such that as a minimum there will not be a line-of-sight path between any vent hole and any sensitive surface (i.e. optical surface of an instrument or sensor).
3.1.5 Interchangeability

RV-GDIR-164 / / R

All Rover Vehicle units of the same part or configuration number shall be interchangeable in terms of form, fit and functions.

Note: Units must be of the same qualification status and reliability in order to meet the interchangeability requirement.

3.1.6 Identification & Marking

RV-GDIR-166 / / I

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

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

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

RV-GDIR-167 / / I

The unit identification nameplate shall be mounted on the connector face, visible when installed on the unit and is to be legible with unaided eye from 0.5m distance.

Note: The location of the nameplate shall be noted on the ICD. The identification label shall meet all the requirements relevant to the unit including compatibility with Planetary Protection requirements.

RV-GDIR-168 / / I

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.

3.1.7 Accessibility/Maintainability

RV-GDIR-170 / MS-METH-REQ-0180 / R

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.
Note: Where this requirement cannot be applied, the contractor 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.

RV-GDIR-5377 / MS-METH-REQ-0190 / R

Equipment shall be designed for installation and removal from the rover without disassembly of the equipment.

RV-GDIR-4480 / MS-METH-REQ-1530 / R

The design shall ensure that the field of view of any optical alignment cubes is unobstructed in all vehicle configurations when the alignment is required.

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

RV-GDIR-172 / / R

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

RV-GDIR-5378 / MS-METH-REQ-0200 / R

All external surfaces of flight hardware (excluding alignment references) shall have a surface treatment which shall prevent corrosion of the surface.

3.1.8 Transportation, Handling and Storage

3.1.8.1 Transport

RV-GDIR-175 / / R

Units shall be transported using a container specifically designed to protect the flight hardware during ground or air transportation.

RV-GDIR-176 / MS-METH-REQ-1880 / R

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, i.e. transportation shall not drive the design.

RV-GDIR-178 / / R

The storage container shall be designed to protect the unit without causing deterioration for the specified storage period.

RV-GDIR-5302 / / R

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: ISO 8 or better

Note: Cleanliness levels for containers will vary with on a case by case basis, see specific equipment specifications for more information.
3.1.8.2 Unit Packing

RV-GDIR-181 / / I

All units shall be packaged to ensure that it is sealed in a dry inert atmosphere using non-contaminating materials.

Note: The packing of the units will 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 (ISO 8 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.

3.1.8.3 Container Identification

RV-GDIR-183 / / I

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)
- The statement "ONLY TO BE OPENED IN CLEANROOM CONDITIONS AFTER TEMPERATURE STABILISATION"
- Any recommendations necessary for the protection of the unit

RV-GDIR-4481 / / I

The transport container shall have the statement:

- "ONLY TO BE OPENED BY PROJECT PA"

The protected unit shall be placed in a second bag with a dehydrating agent and a label stating:

- "OPEN IN A CONTAMINATION CONTROLLED ENVIRONMENT"
3.1.8.4 Handling

RV-GDIR-186 / MS-METH-REQ-1850, MS-METH-REQ-1860, MS-METH-REQ-1870 / R

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 contractor for use during the integration (or de-integration) of the unit.

Note: 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) and shall be compatible with the Planetary Protection processing required before entry into the BMF (Bio-Managed Facility). Such items shall be clearly identified on the relevant Interface Control Drawing. Items weighing more than 25kg will be lifted with the aid of hoisting provisions.

3.1.8.5 Protective Covers and Temporary Items

RV-GDIR-180 / MS-METH-REQ-1400 / R

Protective covers shall be provided to preclude the entrance of foreign particles to sensitive areas and to preclude damage during the handling, integration and test of the unit as required.

Note: These covers shall be either removable before test/flight or be part of the instrument and be deployed/retracted during the mission.

RV-GDIR-8426 / MS-METH-REQ-1390 / R

Temporary items (e.g. alignment reference, aperture covers, connector savers, spacers, braces, connector plugs, test connectors and tie down safety bolts) shall be removable without disassembly of the unit.

Note: All temporary items shall be clearly identified both on drawings and hardware, accompanied by a dedicated removal/installation procedure and listed on a dedicate parts list.

RV-GDIR-5455 / MS-METH-REQ-1420 / R

All items to be removed prior to test shall be coloured red and tagged stating, "REMOVE BEFORE TEST".

RV-GDIR-5456 / MS-METH-REQ-1420 / R

All items to be removed prior to flight shall be coloured red and tagged stating, "REMOVE BEFORE FLIGHT".

3.1.8.6 Thermally Conductive Materials

RV-GDIR-188 / / I,R

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.

Note: Units will use a bonding strap even if the gasket is electrically conducting.

3.1.8.7 Magnetic Materials

RV-GDIR-190 / / R

Magnetic materials shall only be used where necessary for unit operation.
Note: Magnetic materials must be avoided as far as is practical and the materials used must minimise the permanent, induced and transient magnetic fields. Any magnetic material used within the unit shall be reported to the Customer.

3.1.8.8 Seals and Life Limited Items

RV-GDIR-193 / / R

Any seals used shall comply with all the applicable requirements of this specification, particularly regarding out-gassing and Planetary Protection processes to be applied to the equipment.

RV-GDIR-194 / / R

Any life limited items requiring periodic replacement during ground activities, and especially prior to launch, shall be identified to Astrium.

Note: The contractor shall provide any procedures and special tooling required for replacement of seals. The design objective is that seal and life limited items should not need to be changed during the Rover AIT and Launch preparation activities.

3.1.8.9 Lubricants and Sealants

RV-GDIR-196 / MS-METH-REQ-1380 / R

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

3.2 Mechanical Design and Interface Requirements

3.2.1 Structural Design

RV-GDIR-204 / MS-METH-REQ-0310 / R

The structural design of the equipment shall be performed in compliance with [NR 12], [NR 06], [NR 07].

Note: The following documents provide guidelines to support the structural design of the equipment [IR 12], [IR 13], [IR 14], [IR 16] and [IR 17].

3.2.1.1 Stiffness Requirements

The Rover is designed to ensure decoupling between eigenfrequencies of lower level assemblies and minimise the deformations due to operating loads.

Minimum natural frequency requirements are imposed upon the Rover, sub-assemblies and units for the following reasons:

- To avoid coupling between Rover and units,
- To ensure predictable dynamic responses for the design of the structure and units
- To avoid excessive loads and deflections,
- To avoid unacceptable vibration behaviour during Mars surface operations

RV-GDIR-276 / MS-METH-REQ-0420 / T,A

Units fixed on a rigid interface shall have their first main resonant frequency above 140Hz unless otherwise specified.

Note: Local modes (effective mass < 10% total rigid mass) between 100Hz and 140Hz might be accepted by the customer after system level evaluation.
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.
- 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 3.2.2.1.

3.2.1.2 Strength Requirements

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,
- Vibration induced 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.

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 Rover or any other unit.

Note: The following will 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).

The structural margins of safety shall be applied to the design as specified in [NR 13].
All mechanical elements shall demonstrate positive margins of safety when calculated as follows:

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

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 FOS\text{\_N}) are the applicable factors of safety applicable to the specified load condition i.e. yield (FOS\text{\_Y}), ultimate (FOS\text{\_U}).

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

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

Note: 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.

Note: The design loads for the structure elements are to be derived by the contractor taking into account the specified mechanical environments and the dynamic behaviour of the unit/assembly.

Note: The internal loads (thermo elastic, pre-stressed mounting,...) shall be defined by the contractor. The applied loads must be those imposed by worst-case mass distribution, mass uncertainties and design maturity.

For sine and random vibrations, the mechanical sizing shall be performed with peak values.

Note: For random vibrations a peak value of 3 times the rms value shall be assumed.

Structural items shall be capable of surviving the accumulated load cycles induced during the lifetime with a scatter factor of 4.

Flight Model equipment shall be able to survive:
- 2 times all mechanical acceptance tests
- 2 times all mechanical qualification tests (to cover system testing)

in addition to the complete mission cycle.

Proto-Flight Model equipment shall be able to survive:
- 2 times all mechanical qualification tests (for acceptance durations)
- 2 times all mechanical qualification tests (to cover system testing)
in addition to the complete mission cycle.

RV-GDIR-5371 / / A

Engineering Qualification Model / Qualification Model equipment shall be able to survive:

- 2 times all mechanical qualification tests (for acceptance durations)
- 2 times all mechanical qualification tests (to cover system testing)

3.2.1.3 Fracture Control

RV-GDIR-5379 / MS-METH-REQ-0860 / R

Structural elements shall comply with the reduced fracture control programme as defined in [NR 04].

3.2.1.4 Alignment and Stability Requirements

Note: Stability requirements if applicable are defined in the equipment requirement specification.

RV-GDIR-409 / MS-METH-REQ-1000, MS-METH-REQ-1010, MS-METH-REQ-1030 / R

The following causes of misalignment shall be analysed and quantified by the contractor:

- Mounting procedure,
- Launch, Entry, Descent, Landing and Mars operations load environment,
- Deployment repeatability,
- Change in gravity environment (Earth to Mars and orientation),
- Thermal deformation due to thermal environment and temperature gradients,
- Ageing,
- Composite structure deformation due to moisture release

Note: Suitable uncertainty factors should be considered according to design maturity.

3.2.2 Mechanical Design Requirements

3.2.2.1 Mass Properties

RV-GDIR-4384 / MS-METH-REQ-1610 / R

The Mass predicted (Mp) of each unit/equipment shall be calculated as the sum of the Mass best engineering estimate (Mbee) and the Mass Maturity Margin (Mmm).

\[ Mp = Mbee + Mmm \]

where Maturity Mass Margin (Mmm) = \( \sum [(mass of unit)_i \times Mfi] \), where Mfi is the maturity factor of the unit i

RV-GDIR-4385 / / R

The Maturity Factor (Mfi) of a unit or equipment shall be calculated as follows:

- 5% for recurrent equipment ([NR 08] Category A/B) or unit/equipment passed CDR
- 10% for modified equipment ([NR 08] Category C) or unit/equipment passed PDR
- 20% for a new development
The mass of an item shall be measured with an accuracy of ±0.1% or ±1 grams (whichever is larger).

Note: Any difference between unit mass properties measurement test and unit flight configuration shall be identified and reported by the contractor.

Note: Any difference between unit mass properties measurement test and unit flight configuration shall be identified and reported by the contractor.

### Centre of Gravity and Moment of Inertia

The uncertainty of each item COG and MOI calculation for budget consolidation shall follow the rules expressed in Table 3-1.

Note: All COG and MOI estimates must be accompanied by the definition of the design maturity of the concerned item (categories as per module or equipment SOW). They shall be reported to the customer through the relevant mass, CoG and inertia properties data sheet using APPENDIX A: MICD as a guideline

<table>
<thead>
<tr>
<th>Category</th>
<th>Design Maturity</th>
<th>CoG Uncertainty</th>
<th>MOI Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Preliminary Design</td>
<td>5mm radius sphere</td>
<td>±30% for each axis</td>
</tr>
<tr>
<td>C</td>
<td>Detailed Design</td>
<td>3mm radius sphere</td>
<td>±20% for each axis</td>
</tr>
<tr>
<td>B</td>
<td>Design based on existing H/W</td>
<td>2mm radius sphere</td>
<td>±10% for each axis</td>
</tr>
<tr>
<td>A</td>
<td>Existing Hardware</td>
<td>1mm radius sphere</td>
<td>±5% for each axis</td>
</tr>
</tbody>
</table>

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%.

### Interface Requirements

The surface of a mounting plane shall be flat to within 0.1mm, with a local variation not exceeding 0.1mm over 100mm.

Note: Where the mounting surface consists of multiple attachment feet this requirement applies across all the feet.

The mounting surface of a unit shall have a surface roughness of less than 3.2µm.

The contact area for a unit mounting foot shall be greater than 100mm².

The thickness of a unit mounting foot shall be at least 3mm.
Unit mounting feet shall be designed to provide access to install and remove fasteners and washers.

Unit mounting surfaces shall not be painted or anodised.

Panel inserts shall be designed in accordance with [NR 14].

Fasteners shall be designed in accordance with [NR 15] and [NR 16].

Titanium alloy fasteners smaller than M5 shall not be used.

The tensile load per interface bolt of a unit mounted to a honeycomb sandwich panel shall not exceed 10N under a 1g environment in any direction.

Unit hole dimensions and tolerances shall be as defined in Table 3-2.

<table>
<thead>
<tr>
<th>Table 3-2: Unit Interface Dimensions and Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hole Size</td>
</tr>
<tr>
<td>M4 Bolts</td>
</tr>
<tr>
<td>M5 Bolts</td>
</tr>
<tr>
<td>M6 Bolts</td>
</tr>
</tbody>
</table>

Interface foot loads due to differential thermal expansion shall not exceed 2000N.

Note: If it is not possible to achieve the required flexibility, the interface design must be defined case by case and approved by the customer considering:

- CTE mismatch between unit baseplate and mounting panel
- Unit interface design and dimensions, foot spacing,
- Interface hole clearance and bolt tightening torque

Unit mounting hole/lugs shall be designed as defined in Table 3-3.

<table>
<thead>
<tr>
<th>Table 3-3: Mounting Hole Design Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle of attachment hole:</td>
</tr>
<tr>
<td>Distance between attachment holes and unit sidewall:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Free width between webs:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Angle of attachment hole: 90° ±0.5°
Spot face of upper log surface (for washer): M4 = 11 +0.5/-0.1mm, M5 = 13 +0.5/-0.1mm
Spot face parallelism w.r.t. mounting plane: 0.05mm
Flatness of attachment lugs w.r.t. mounting plane: 0.05mm
Counterbore depth: 0.2 +0.1/-0.0mm
Surface roughness: 1.6 microns R.A.
Torque levels applied to bolts: M4 = 2.3 ±10% Nm, M5 = 5.0 ±10% Nm

RV-GDIR-198 / MS-METH-REQ-1360 / I,R
All fasteners used on the unit shall be locked by adequate measures, this includes fixations of units onto the structure.
Note: Locking washers cannot be used.

3.2.2.5 Alignment Requirements

RV-GDIR-445 / / R
Units requiring alignment with an accuracy better than ±0.25° shall be equipped with reflecting surfaces as part of the unit.
Note: These reflective surfaces constitute the unit optical reference. The unit shall be delivered with easily mountable/dismountable protective covers on reflective surfaces for AIV activities. Fixed reflective surfaces should be used whenever possible. Dismountable mirrors shall demonstrate repeatability of their orientation accuracy.

RV-GDIR-446 / / R
Optical references are required to withstand all the environments supported by the unit with a stability better than ±15 µrad with respect to each of the 3 unit axes.
Note: Location and orientation with associated tolerances of optical references on units shall be agreed between customer and the contractor 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.
Note: The alignment errors shall be included in pointing and localisation errors as established in the unit alignment and pointing error budget.

RV-GDIR-449 / / R
The optical reference design shall comply with Table 3-4 requirements.

Table 3-4: Optical Reference Design Requirements

| Finish: | Optically polished |
| Flatness: | Within lambda/4 (sodium yellow lambda = 589 mm) |
| Optical reference axes knowledge accuracy w.r.t unit axes: | < 50 µrad |
| Minimum area: | 10 * 10 mm |
| Minimum thickness: | 4 mm |

Note: 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.

Note: When shims have to be machined at end of alignment, 5 sets of spare shims with maximum possible thickness shall be provided.
3.2.3 Mechanical Interface Control Documents

RV-GDIR-472 / MS-METH-REQ-0290 / R

The mechanical 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 contractor.

Notes:
1) This drawing shall detail all co-ordinate systems utilised and their relationship to each other, together with the principal unit interfaces.
2) The content of the Mechanical ICD shall conform in terms of content to Appendix A (format may be taken as a guideline).
3) Interfaces shall be subjected to a formal inspection, using interface data sheets in respect to mechanical properties (see Appendix A). These data sheets shall be completed by the contractor and then included in the unit Mechanical ICD.
4) 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)
   - Media format: TAR if DAT
   - File format (by order of preference):
     a. CATIA EXP
     b. STEP
     c. 2D DXF

RV-GDIR-5375 / MS-METH-REQ-0130 / R

Dimensional general tolerances shall conform to the standard [NR 17].

RV-GDIR-5376 / MS-METH-REQ-0140 / R

Manufacturing drawings shall conform to the standard [NR 18].

RV-GDIR-476 / MS-METH-REQ-0110 / R

The unit coordinate system (OU, XU, YU, ZU) shall be fixed relative to the unit geometry and use a right-handed orthogonal coordinate system defined as follows (see Figure 3-1):
   - One of the attachment holes of the unit shall be chosen as mechanical reference hole and shall be identified by an engraved letter “R” on the unit;
   - The origin (OU) shall be located at the centre of the reference hole at the level of the mounting interface plane;
   - The XU axis shall be perpendicular to the mounting interface plane, pointing positively toward the unit;

Note: The YU and ZU axes is oriented such that the unit will mostly be included inside the +YU/+ZU quadrant of the mounting interface plane. Moreover, if the unit has a rectangular shape, the +YU and +ZU axes are parallel to the unit.
General Design and Interface Requirements

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3.2.4 Mechanical Mathematical Model Requirements

RV-GDIR-483 / 

Finite elements models shall be provided for all units which have principal modes of vibration at frequencies less than 140Hz.

3.2.5 Mechanism Design

3.2.5.1 General Requirements

Note: Mechanisms shall be functionally analysed to determine loads deriving from their activation, both in orbit or on ground, as applicable.

RV-GDIR-487 / MS-METH-REQ-1050, MS-METH-REQ-1060, MS-METH-REQ-1070, MS-METH-REQ-1080, MS-METH-REQ-1090, MS-METH-REQ-1100, MS-METH-REQ-1140 / R

All assemblies featuring parts moving under the action of commandable internal force(s) will be considered as mechanisms and shall comply with Tailored ECSS-E-33-01C [NR 05].

Note: In case of conflict, the mechanisms requirements in this document take precedence over [NR 05].

RV-GDIR-5409 / MS-METH-REQ-0270 / T

Mechanisms shall be designed to prevent the ingress of airborne dust.

Note: If the ingress of dust can not be prevented then the contractor shall provide evidence that the mechanism will provided the required performance in a simulated Martian dust environment, equivalent to that expected throughout the nominal surface mission. Details of particle size and distribution can be found in §4 of [IR 01].

RV-GDIR-492 / MS-METH-REQ-1110 / R

Mechanisms shall feature a position sensor to unambiguously determine its position.

Note: This applies over the full working range.

RV-GDIR-493 / T,A

Mechanisms shall maintain their position without requiring power.
Note: For single shot devices it is assumed this will be achieved by an independent latching function.

RV-GDIR-5381 / MS-METH-REQ-1110 / R

Deployment mechanisms shall be designed to allow for contingency operations to correct deployment anomalies.

Note: Design features to achieve this should not introduce significant additional complexity and will be agreed with the customer following a review of failure modes and potential redundancy concepts.

RV-GDIR-5406 / / R

All mechanism motors shall be fitted with prime and redundant windings.

RV-GDIR-5410 / / T,A

Mechanisms shall meet their requirements with the Rover Vehicle inclined at up to ±25 degrees (in either axis) to the horizontal.

RV-GDIR-5411 / / A

Mechanisms shall be designed assuming a nominal life in the stowed configuration on the surface of Mars of 10 sols.

Rationale: To verify compatibility with (night time) thermal distortion loads induced in the stowed configuration.

3.2.5.2 Hold-down Release Devices

RV-GDIR-495 / RV-SYS-464, MS-METH-REQ-1160 / R

Hold-down release devices using Electro-Explosive Devices (EED's) pyrotechnic release actuators shall not be used.

Note: Hold-down release devices on the Rover must use Frangibolt or NEA release actuators.

RV-GDIR-494 / / R

Hold-down release devices that rely on a preload to be applied during launch shall provide a method of monitoring (and adjusting if necessary) the preload during AIV.

Note: In the case of multiple HDRMs restraining a mechanism, the contractor shall define the sequence in which the HDRMs are to be commanded to operate.

Note: The Rover Vehicle will implement an arm/execute mechanism on the drivers for one-shot devices.

RV-GDIR-5413 / / T,A

HDRMs shall be sized to prevent sliding under mechanical and thermal environments.

RV-GDIR-5430 / / R

The HDRM shall operate with the expected thermal induced relative displacements between the HDRM body and the tension rod.

RV-GDIR-5414 / / T,A

There shall be no gapping of the Hold Down Release System under the worst case combination of external yield loads (YL).
General Design and Interface Requirements

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Release mechanisms shall be capable of being manually operated for test purposes.

Note: In case one-shot devices are used (e.g. NEAs), simple re-installation of a new device on the spacecraft must be possible.

New unused/not refurbished HDRMs shall be used for flight.

The HDRM shall be designed to preclude any long term preload relaxation after any initial settling effects when mechanically loaded (proof loading) on installation and vibration.

When actuated, HDRMs shall not impart a shock greater than that shown in Table 3-5.

<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>SRS [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>4000</td>
<td>1000</td>
</tr>
<tr>
<td>10000</td>
<td>1000</td>
</tr>
</tbody>
</table>
RV-GDIR-5426 / / R

The force required to extract the tension rod from within the HDRM shall be less than 10N after the HDRM has been operated.

RV-GDIR-5429 / / R

The HDRM shall include a mechanism for extracting/ejecting the tension rod after release.

Rationale: The device deployment mechanism must not be used to extract the tension rod.

RV-GDIR-5427 / / R

The tension rod shall be captive after release and separation.

RV-GDIR-5412 / / T

Operation of HDRMs shall not release any debris or other material.

RV-GDIR-5431 / / R

The heritage/qualification status of the lubrication applied to mating/sliding surfaces within the HDRM shall be clearly demonstrated.

RV-GDIR-5424 / / R

In the event that refurbishable ground test HDRMs are supplied, then the ground test HDRMs shall be designed to be fully refurbishable, after release actuation, by the HDRM manufacturer up to a total of 25 times.

RV-GDIR-5432 / / T

After refurbishment the ground test HDRMs shall meet all the performance requirements of its procurement specification.

RV-GDIR-5433 / / R

Refurbished HDRMs shall undergo a reduced acceptance test that is a subset of the initial delivery acceptance test.

Note: The reduced acceptance test shall be agreed between the contractor and the customer.

RV-GDIR-5422 / / R

Ground test and flight HDRMs shall be procured against the same requirements specification and be interchangeable in terms of form, fit and function.

RV-GDIR-5423 / / I,R

Ground test and flight HDRMs shall have different part numbers.

3.2.5.3 Mechanism Testing

RV-GDIR-5400 / MS-METH-REQ-1130 / R

All flight mechanisms shall be designed to allow ground verification testing.

Notes:

1) The contractor shall specify if an offload system is to be used, as it will not always be possible to use Mars equivalent masses. If a full mass assembly is used and an offload system is not used then...
the Actuation factor requirements of Tailored ECSS-E-33-01C [NR 05] need not be observed but the mechanism must function without degradation.

2) If an offload system is required for ground operations with the flight payload then the contractor shall supply the offload system as part of any deliverable GSE.

RV-GDIR-491 / / A
The mechanism design shall be compatible with operation in ambient and thermal vacuum conditions and gravity in any orientation

RV-GDIR-5401 / / R
Mass dummies fitted during the all earth based ground tests may be adjusted to simulate reduced Martian gravity.

RV-GDIR-5402 / / R
Mass dummies fitted during all earth based ground tests shall have similar inertia properties to the flight hardware.

RV-GDIR-5405 / / R
Representative harness/fibre optic cables shall be fitted during all earth based ground tests.

RV-GDIR-502 / / T,A
The lifetime of a mechanism shall be demonstrated by test in the appropriate environment.

Note: The requirements of Tailored ECSS-E-33-01C [NR 05] are applicable. The adequacy of the lifetime of Commercial Off the Shelf (COTS) items with respect to this requirement must be demonstrated.

3.3 Thermal Design and Interface Requirements

Note: Astrium will perform the thermal control and analysis of the overall Rover Vehicle. The contractor shall be responsible for thermal analysis and qualification of the equipment.

Note: Any special requirements for temperature stability, gradients and differentials on particular equipment (if any) shall be agreed between the contractor and Astrium and shall be identified in the appropriate ICD or specification.

RV-GDIR-5195 / / T,R
The thermal design and qualification for the unit shall be performed in accordance with ECSS Thermal Control [NR 11].

Table 3-6 contains definitions of standard thermal design terminology that will be used.

<table>
<thead>
<tr>
<th>Environmental Radiative Temperature</th>
<th>This is the radiative interface temperature experienced by the units.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Air Temperature</td>
<td>This is the atmospheric interface temperature experienced by the units.</td>
</tr>
<tr>
<td>Operating Temperature (TFO)</td>
<td>This temperature shall be maintained at the TRP by Rover thermal control whilst the unit is operating. This temperature shall be independent of unit operating modes</td>
</tr>
<tr>
<td>Non-Operating Temperature (TNF)</td>
<td>This temperature shall be maintained at the TRP by Rover thermal control when the unit is not operating</td>
</tr>
<tr>
<td>Unit Switch-on Temperature (TSU)</td>
<td>The contractor 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</td>
</tr>
</tbody>
</table>
### General Design and Interface Requirements

**Environmental Radiative Temperature**
This is the radiative interface temperature experienced by the units.

**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 subtraction 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).

### 3.3.1 Thermal Design Requirements

**RV-GDIR-5182 / MS-METH-REQ-2550 / T,A**

*The internal thermal design of the unit shall be capable of dissipating all internal power at expected worst-case interface temperatures, for all modes of operation, by either:*

- Conduction through the baseplate (or mechanical mounting path)
- Radiation and convection (when on Mars) from the whole exterior area

*Note: As a rule equipment mounted inside the Rover should use a conductive design and equipment mounted outside the Rover should use a radiative design. Please refer to Astrium for clarification if necessary.*

**RV-GDIR-5180 / MS-METH-REQ-2100 / R**

*The margin philosophy for the unit shall be in accordance with Figure 3-2.*
General Design and Interface Requirements

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Figure 3-2: Temperature Design, Acceptance and Qualification Levels

RV-GDIR-5436 / RV-SYS-203, RV-SYS-204, MS-METH-REQ-0270 / T,A

The thermal performance of the units shall be maintained in the event of:

• Dust deposition of TBD% on horizontal surfaces
• Dust deposition of TBD% on vertical surfaces
• TBD ìm of CO2 ice formation on external surfaces

RV-GDIR-581 / MS-METH-REQ-2120, MS-METH-REQ-2130, MS-METH-REQ-2140, MS-METH-REQ-2150, MS-METH-REQ-2170 / T,A

The unit shall include a TRP that represents the temperature of the unit for system level thermal control.

Notes:

1) A Temperature Reference Point (TRP) shall be selected on the unit external surface, preferably close to a mounting bolt, in an area where temperature is the most representative of the average unit housing temperature i.e. not a hot or cold spot. Evidence that the position of the TRP will monitor the general thermal status of the unit and the critical unit components is to be provided.

2) The TRP is to be identified by the contractor and agreed with Astrium. It should be identified on Interface Control Drawings.

3) The TRP shall be used as the unit reference for the thermal acceptance and qualification tests.

4) The TRP will be maintained within the specified temperature limits by the Rover Vehicle Thermal Control System during flight.

RV-GDIR-583 / MS-METH-REQ-2160 / R

The contractor shall provide any internal temperature sensors to monitor the critical components (if any), according to the unit specification.

Notes:
1) Temperature monitoring of critical components shall be provided to cover the following cases:
   - Unit operational health and safety monitoring
   - Unit operational temperature and performance monitoring

2) The location, type and electrical interface of all devices used for unit temperature measurement will be defined in the ICD.

RV-GDIR-5192 / T,A

Maximum local instantaneous peak harness wire or insulation temperature shall never exceed 420K when both ends are maintained at 300K during any ground or flight use.

RV-GDIR-577 / MS-METH-REQ-3110 / R

The unit thermal control must be testable on ground.

RV-GDIR-578 / R

If special equipment is delivered by the unit subcontractor to evacuate the heat during the spacecraft functional tests under ambient environment it shall be compatible with the PP & cleanliness requirements.

3.3.2 Thermal Interface Requirements

3.3.2.1 Conductive Interface

RV-GDIR-5185 / MS-METH-REQ-2610 / R

The baseplate contact area shall be sized in order to comply with the max allowable heat flux conducted through it:
   - Max. allowable base contact heat flux: <0.25 W/cm² (contact area <100 cm²)
   - Max. allowable base contact heat flux: <0.15 W/cm² (contact area >100 cm²)
   - Max. allowable base contact heat flux: <1.6 W/cm² (TWT, Solid State Amplifiers or other highly dissipative unit)

3.3.2.2 Radiative Interface

RV-GDIR-528 / MS-METH-REQ-2520, MS-METH-REQ-2590, MS-METH-REQ-2610 / I

The unit surface emissivity shall be less than 0.05 (unless otherwise stated).

Note: The contractor is responsible for the application of a coating compliant with the thermal requirements. Effects of aging and radiation must be taken into account when selecting and estimating thermo-optical characteristics.

3.3.2.3 Thermal Interface Control Documents

RV-GDIR-588 / MS-METH-REQ-2580 / I

A Thermal ICD shall be provided for the unit in accordance with Appendix B.

Notes:
1) As a minimum the contractor shall define the following:
   - Thermo-optical and thermal properties
   - Geometrical features and contact area
3.3.3 Thermal Mathematical Model Requirements

RV-GDIR-5184 / MS-METH-REQ-2570, MS-METH-REQ-3000, MS-METH-REQ-3100 /

The contractor shall carry out a thermal analysis of the unit internal temperature distribution and hot points in sufficient detail to demonstrate that temperature requirements for all thermally critical components are met even under single failure conditions.

Notes:

1) The objective of the unit thermal analysis is to demonstrate that internal components have acceptable temperatures when the unit TRP is at its operating temperature limits, with a reasonably representative distribution of the heat flow to the external environment.

2) 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 [NR 11].

3) Delivery of any TMM models must include an analysis case description and results for this case. Rationale: To be used for verification of correct model transfer.

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

5) A sensitivity analysis shall be performed to determine the analytical uncertainty in the unit model.

6) The contractor shall perform unit level thermal analysis for the unit, covering the thermal worst cases and operational modes (including transient cases where relevant) with the objective to demonstrate that temperature of internal components and heat fluxes density are compliant with the specification, when the equipment is at its operating design temperature limits.

7) The contractor shall perform unit level thermal analysis for the unit, covering the thermal worst cases and operational modes (including transient cases where relevant) with the objective to demonstrate that temperature of internal components are lower (with a non-negligible margin) than relevant rated temperature limits when the average temperature of the equipment interface (baseplate or external case) is at its maximum qualification temperature limits.

RV-GDIR-592 / MS-METH-REQ-2210, MS-METH-REQ-2220 /

The contractor shall provide a reduced thermal model as part of the thermal data in the case of non-isothermal units.

Note: The delivered model shall be compatible with ESARAD and ESATAN. Correlation of the reduced model with the detailed model shall also be supplied.
3.4 Optical Design and Interface Requirements

3.4.1 Optical Design Requirements

RV-GDIR-596 / / R

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

3.4.1.1 Materials

RV-GDIR-598 / / R

Glass types and material quality shall be selected to comply with the performance requirement in terms of spectral transmittance and spatial environment.

Note: 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 should be avoided.

RV-GDIR-600 / / R

The use of optical cements shall be avoided as far as possible.

Note: If their use is nevertheless necessary, the contractor shall demonstrate their qualification to the project requirements (ageing, thermal cycles, radiation dose, etc…). Reference to their use for other space programmes should also be mentioned.

3.4.1.2 Coatings

RV-GDIR-602 / / T,R

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

Notes:

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

2) Thermo-optical properties of the coatings must be compatible with the thermal control design requirements.

3) Particular attention should be paid to the selection of the materials and processes to avoid sensitivity of these coatings to water desorption in vacuum environment, especially for the multi layer coatings, if any.

4) The Martian dust environment must be considered when defining external coatings.

RV-GDIR-603 / / R

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

RV-GDIR-606 / / R

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

RV-GDIR-609 / / T

The optical performance of the unit shall be verifiable on ground under ambient pressure and Earth gravity conditions otherwise explicitly specified in the relevant unit specification.

RV-GDIR-610 / / T

Alignment and interface with regard to other optical units shall be maintained between clean room conditions and space environment.

Note: 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 must not affect performed alignment nor measured performance.

3.4.2 Optical Interface Requirements

RV-GDIR-612 / /

The contractor shall provide an Optical Interface Control Document

RV-GDIR-613 / / R

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.

Notes:
1) The minimum clear aperture is determined according to the input beam characteristics, specified FOV, pupil (dimensions, location and decentering if any), alignment and long term stability.
2) Units must be designed to minimise internal stray light.

3.4.3 Optical Mathematical Model Requirements

RV-GDIR-616 / /

The contractor shall use an optical model for numerical simulation of the unit.

Notes:
1) This model will be established using the complete set of latest specifications and tolerances that are available about the unit. The model will include not only the actual optical elements but also intermediate image planes, intermediate pupil imaging planes wherever applicable.
2) The numerical model shall be developed on Code V ® or ZEEMAX ® or using a software providing a simple export capability into one of these two software packages.
3) The numerical model shall be used for the evaluation of the unit’s optical performance. Actual glass characteristics as measured by the glass supplier must be included. Performance analyses must take into account the diffraction effects, misalignments and manufacturing tolerances.

3.5 Electrical Design and Interface Requirements

3.5.1 General Electrical Requirements

All electrical performances are specified under Worst-Case End-Of-Life conditions, unless otherwise explicitly notified.
The electrical, electronic, electromagnetic and microwave equipment design shall be performed in compliance with [NR 10].

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

All interfaces are referenced by a specific Interface Code. Table 3-7 below lists all the standard interfaces:

<table>
<thead>
<tr>
<th>Interface Code</th>
<th>Interface Designation</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULCL</td>
<td>Unregulated Latching Current Limiter</td>
<td></td>
</tr>
<tr>
<td>UFC</td>
<td>Unregulated Foldback Current</td>
<td></td>
</tr>
<tr>
<td>LCA (LCL)</td>
<td>Regulated Latching Current Limiter Power Class 1:</td>
<td>1A</td>
</tr>
<tr>
<td>LCB (LCL)</td>
<td>Regulated Latching Current Limiter Power Class 2.5:</td>
<td>2.5A</td>
</tr>
<tr>
<td>LCC (LCL)</td>
<td>Regulated Latching Current Limiter Power Class 3:</td>
<td>3A</td>
</tr>
<tr>
<td>LCD (LCL)</td>
<td>Regulated Latching Current Limiter Power Class 5:</td>
<td>5A</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 (TBC)</td>
<td></td>
</tr>
<tr>
<td>PPS</td>
<td>Pulse Per Second Interface (TBC)</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</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 (TBC)</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 (TBC)</td>
<td></td>
</tr>
<tr>
<td>SLP</td>
<td>Standard Low Power On/Off Command</td>
<td></td>
</tr>
<tr>
<td>RSA</td>
<td>Relay Status Acquisition</td>
<td></td>
</tr>
<tr>
<td>BLD</td>
<td>Digital Bi-Level TM Acquisition (TBC)</td>
<td></td>
</tr>
<tr>
<td>XTC</td>
<td>X-Band Digital TC Channel IF (DHS Only)</td>
<td></td>
</tr>
<tr>
<td>RLS</td>
<td>Receiver Lock Status IF (DHS Only)</td>
<td></td>
</tr>
<tr>
<td>XTM</td>
<td>X-Band Digital TM Channel IF (DHS Only)</td>
<td></td>
</tr>
<tr>
<td>PYR</td>
<td>Pyro Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>SMD</td>
<td>Shape Memory Device Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>MDD</td>
<td>Motor Actuator Device Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>LVC</td>
<td>Latch Valve Command Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>LVS</td>
<td>Latch Valve Status Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>FCVC</td>
<td>Flow Control Valve Command Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>MEC</td>
<td>Main Engine Flow Control Valve Command Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>PTS</td>
<td>Pressure Transducer Supply Interface (TBC)</td>
<td></td>
</tr>
<tr>
<td>PTA</td>
<td>Pressure Transducer Acquisition Interface (TBC)</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 Requirements

All primary power bus protection is centralised, through the use of a latching current limiters LCL which are commanded and monitored in the PCDE (Power Control and Distribution Electronics). Each primary and redundant part of a unit will be assigned to an LCL as appropriate.

The Rover Vehicle PCDE will supply the following power lines:

- +28V, nominally regulated ±1%, at 5A maximum
- 18V to 25.2V unregulated, at 5A maximum (Heaters & Frangibolts only)
- +15V regulated ±1%, at 2.5A maximum (Payload only)
- +5V regulated ±1%, at 1A maximum (Payload only)

Note: The voltage limits given apply to the voltages within the PCDE not at the User input terminals.

The EGSE that will be used during AIT and Launch Site Activities will be connected to the primary power bus via the Power Bus conditioning line. This allows operation of the PCDE and the Rover on ground without a flight battery.

3.5.2.1 Primary Power Bus

3.5.2.1.1 +28V Regulated Power Bus Requirements

RV-GDIR-806 / / T,R

If undervoltage protection is implemented by the load, the load shall not switch off its DC/DC converter for voltages in the specified operating range: V > minimum specified operating Voltage - 1V

Rationale: To ensure undervoltage protection does not interact with the main bus undervoltage protection.

RV-GDIR-8393 / / T,R

If undervoltage protection is implemented by the load, appropriate Hysteresis shall be implemented between switch on / switch off.

Note: Detailed timing of automatic switch-on after under voltage switch-off if implemented shall be defined and agreed via unit Interface Control Document.

RV-GDIR-4998 / / T,R

The power source voltage ripple shall be less than ±500mV peak-to-peak.

RV-GDIR-807 / / T,A

In case of an inductive load, when considering the bus impedance mask, the maximum over voltage emission shall not exceed 0.5 Volts above the maximum defined DC bus voltage.

RV-GDIR-8395 / / R

The load shall not be irreversibly degraded for any standing or fluctuating voltage as defined in RV-GDIR-8143-18.

RV-GDIR-809 / / R

No fuse protection shall be implemented.

RV-GDIR-810 / / R

Primary current protection shall not be implemented on the DC/DC converter of a load, which is connected to an Latching Current Limiter (LCL) output.
Note: Input filters shall be properly designed according to the capability of the LCL.

RV-GDIR-8143 / / T,R

All units connected to the 28V regulated bus shall ensure full performance for a power bus voltage at the unit power input as specified in Table 3-8.

Table 3-8: 28V Regulated LCL Power Interface Characteristics

<table>
<thead>
<tr>
<th>Req.</th>
<th>Source Circuit Specification</th>
<th>I/F Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Bus voltage:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nominal: 28V ±0.28V at the PCDE main regulation point</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anomaly: 34V and 18V at the PCDE main regulation point</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>LCL current (I_{max}): (1)</td>
<td>LCL class A (LCA): 1A</td>
</tr>
<tr>
<td></td>
<td>LCL class B (LCB): 2.5A</td>
<td>LCL class C (LCC): 3A</td>
</tr>
<tr>
<td></td>
<td>LCL class D (LCD): 5A</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Overcurrent limitation (I_{L}):</td>
<td>I_{max} * 1.25 (±5%)</td>
</tr>
<tr>
<td>-4</td>
<td>Current limitation response time:</td>
<td>3 to 5μs (no active current limitation)</td>
</tr>
<tr>
<td>-5</td>
<td>Trip-Off time:</td>
<td>In case the load does exceed its LCL class trip-off point, the latch current limiter will limit the current to its I_{L} value and switch-off after a delay time of 8ms ≤ t ≤ 15ms (fixed value)</td>
</tr>
<tr>
<td>-6</td>
<td>Response to bus undervoltage:</td>
<td>All Regulated Bus LCLs supplying Non-essential loads shall switch off automatically in the event of an undervoltage condition when the bus voltage, at the regulation point, is less than 25V ± 0.25V/-0.0V for a duration exceeding 50ms + 5ms / -0.0ms.</td>
</tr>
<tr>
<td></td>
<td>All Regulated Bus LCLs supplying Essential loads shall switch off automatically in the event of an undervoltage condition when the bus voltage, at the regulation point, is less than 20V ± 0.2V/-0.0V for a duration exceeding 100ms + 10ms / -0.0ms.</td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Voltage drop from main regulation point to PCDE output:</td>
<td>≤ 0.5V for LCL Outputs</td>
</tr>
<tr>
<td></td>
<td>≤ 0.8V for LCL Outputs via Switch Network (shared LCL output)</td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Stability:</td>
<td>The LCL shall be unconditionally stable into any capacitive load and inductive loads of at least 200μH</td>
</tr>
<tr>
<td>-9</td>
<td>Fault voltage emission:</td>
<td>0V to 34V</td>
</tr>
<tr>
<td>-10</td>
<td>Fault voltage tolerance:</td>
<td>0V to 35V</td>
</tr>
<tr>
<td>-11</td>
<td>Output current rate rise:</td>
<td>≤ 1A/μs, limited by the LCL during LCL switch ON/OFF commanding</td>
</tr>
</tbody>
</table>

Load Circuit Specification

-12a Bus voltage (nominal): Non-essential loads shall provide full performance for primary input voltages within the range 25V to 28.28V (including harness losses). Essential loads shall provide full performance for primary input voltages within the range 20V to 28.28V (including harness losses), as a minimum.

-12b Bus voltage (undervoltage):
### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Item</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>-12c</td>
<td>Bus voltage (anomaly): 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>
</tr>
<tr>
<td>-13a</td>
<td>Input characteristic of load input filter: Input filter shall be designed in accordance to the (Current*time) capability of the LCL and EMC performance and shall ensure dI/dt requirement of RV-GDIR-8143-11 is not exceeded.</td>
</tr>
<tr>
<td>-13b</td>
<td>The effective input inductance shall not exceed 150μH</td>
</tr>
<tr>
<td>-14</td>
<td>Input current settling time: Note: Following switch ON, if the user current exceeds the LCL overcurrent limit the LCL will enter its current limiting mode and start charging the users input filter with a current Ic [1.25 (±10%) * Imax]. The user shall ensure that under this condition, its input filter reaches the nominal steady state within t &lt; 5ms.</td>
</tr>
</tbody>
</table>
| -15 | Maximum current allowed for user: Beside the switch-on peak duration performances listed above (Input current settling time) the maximum current loads over the nominal input voltage range shall be  
  - Steady State: 0.90 * Imax  
  - Peak: 1.05 * Imax  
  Where peak duration is less than the minimum limiting time of the LCL. |
| -16 | Current limiter: No active control loop within the load shall limit the load current when the LCL is in its current limiting mode. |
| -17 | Fault voltage emission: 0.5V above maximum specified DC bus voltage. |
| -18 | Fault voltage tolerance: 0V to 35V |

### Harness Specification

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-19</td>
<td>Wiring Type: Twisted pair (TP)</td>
</tr>
</tbody>
</table>
| -20 | Voltage Drop (harness):  
  - ≤ 1.0V at Imax for 'Bathtub' External Loads (supply and return Lines)  
  - ≤ 0.5V at Imax 'Bathtub' Internal Loads (supply and return Lines) |

Notes: (1) Steady-state, excluding switch-on transients  
Fault voltages shall be verified by Worst Case Analysis

**RV-GDIR-812 / / T,R**  
*All electronic logic circuits shall assume a defined and safe configuration upon application of primary power.*

**RV-GDIR-813 / / T**  
*All power converters shall work in free-running mode.  
Note: The as designed free-running frequency and frequency variations shall be reported in the unit Interface Control Document.*

**RV-GDIR-814 / / T**  
The free-running frequency shall be limited to ± 10% of the nominal unit design frequency.

**RV-GDIR-8398 / / A**  
*Equipments shall be designed taking into account the source impedance defined in Figure 3-3 for primary power lines.*
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 3-3.

![Figure 3-3: Regulated Primary Bus Source Impedance (at the Main Regulation Point)](image)

3.5.2.1.2 18 to 25.2V Unregulated Power Bus Requirements
To be written. (applicable to heater circuits & Frangibolt circuits only).

3.5.2.1.3 ±15V Regulated Power Bus Requirements
To be written. (applicable to payloads only).

3.5.2.1.4 ±5V Regulated Power Bus Requirements
To be written. (applicable to payloads only).

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

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

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

RV-GDIR-8390 / / A
A power consumption test shall be required at temperature extremes during environmental testing on flight equipment with the unit running in a operationally representative state.
RV-GDIR-5364 / / R

The Power Predicted (Pp) of each unit/equipment shall be calculated as the sum of the Power best engineering estimate (Pbee) and the Power maturity margin (Pmm).

\[ Pp = Pbee + Pmm \]

RV-GDIR-5365 / / R

At unit/equipment level, the following Pmm shall be applied:

- 5% of the Pee for OTS equipment ([NR 08] category A/B) or unit/equipment passed the CDR
- 10% of the Pee for OTS with minor modification ([NR 08] category C) or unit equipment passed PDR
- 20% of the Pee for new design/developed unit/equipment, or items requiring major modification

3.5.2.3 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.

RV-GDIR-928 / / T

It shall be possible to switch on the source unit without having to connect an external load to its power outputs.

Note: In this case the output voltages will correspond to their nominal values under these conditions.

RV-GDIR-929 / / T

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

RV-GDIR-4485 / / R

Overvoltage protections shall be implemented on unit DC/DC converter secondary sides within units such that no single failure shall cause any external interface to exceed the fault emission requirement as specified within the interface definition.

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 3-4).

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 3-4).
Figure 3-4: Typical Link Definition

RV-GDIR-936 / / R

Specified driver (or source) characteristics shall be considered at the output of the driver (or source), with the specified load.

RV-GDIR-937 / / T,A

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

RV-GDIR-938 / / T,A

The unit shall tolerate active signal interfaces when unpowered without any degradation.

RV-GDIR-939 / / T,R

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’.

RV-GDIR-940 / / R

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

RV-GDIR-941 / / A

Signal interfaces shall withstand without damage positive or negative voltages that are accessible on the same connector.

Note: EGSE which connects to Flight Equipment shall incorporate interface protection such that the Flight Equipment is protected against damaging voltage or current levels. The protection shall ensure that the interface characteristics given in this specification are not exceeded after any single credible failure of the EGSE.

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.
**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 3-6.

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

![Figure 3-5: Definition of Signal Pulse Width Td](image)

![Figure 3-6: Definition of Signal Rise Time Tr and Fall Time Tf](image)

### 3.5.3.2 Harness Capacitance

**RV-GDIR-950 / / R**

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 3-7 for a Twisted Shielded Pair.
3.5.4 Standard Interfaces

3.5.4.1 CAN Bus Interfaces

The Rover Vehicle CAN Bus architecture features 2 (TBC) different CAN Buses, one Prime and one Redundant. Only one bus is active at any time. All units or PCBs connect to the bus as nodes. The Rover Vehicle CAN Bus Interface Control Document [IR 06] describes the implementation of the CAN Bus for the Rover Vehicle equipments.

3.5.4.2 Standard Balanced Digital link (SBDL)

The SBDL link interface is dedicated to serial digital links or synchronisation signals. This link is based on the RS-422 standard. The SBDL Link interface is shown in Figure 3-8.

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.

\[ V_{\text{diff}} = V_{\text{true}} - V_{\text{comp}} \]

The status \( V_{\text{diff}} = V_{\text{true}} - V_{\text{comp}} \) of the signal is defined High (Logic “1”) when the true line has a positive \( \pm 1 \) level w.r.t the ground and the complementary line has a \( \pm 0 \) level versus the ground.

Note: \( C_1 = 100 \) pF/m for MIL-STD-1553B cable

Figure 3-7: Harness Capacitance

Figure 3-8: SBDL Link
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.

RV-GDIR-1190 / / T,R

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 3-9.

Table 3-9: SBDL Specification

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>IF-Code:</th>
<th>SBDL</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 V ≤ V_{od} ≤ -1.75 V (with load 6kOhm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Diff. output volt. Logic &quot;1&quot; (1): +1.75 V ≤ V_{od} ≤ +5.5 V (with load 6kOhm)</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 ≤ 20 ns for Tb &gt;200ns, otherwise 0.1xT_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; 3V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Common mode output: 0 V to +7 V</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>-10</td>
<td>Fault voltage emission (3): -0.5 V to +7 V (through 1 KOhm)</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance: OFF transmitter shall withstand an ON receiver even with failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>OFF state tolerance: ON transmitter shall withstand an OFF receiver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>ON state tolerance: Receiver shall detect a static logic “1” level when inputs are in open circuit condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Circuit type: Differential CMOS RS422 line receiver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Recommendation: HS-26C/CT/CLV32 RH ESD class 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>Input impedance (4): DC: ≥ 6 KOhm incl. input series resistors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>AC: 120 Ohm in series with 50 pF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>Diff. input level Logic &quot;0&quot;: -10 V ≤ V_{id} ≤ -0.6 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-19</td>
<td>Diff. input level Logic &quot;1&quot;: +0.6 V ≤ V_{diff} ≤ +10V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-20</td>
<td>Common mode range: -4V ≤ V ≤ +7V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-21</td>
<td>Fault voltage emission (3): -0.5V to +7V (through 1 KOhm)</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>-22</td>
<td>Fault voltage tolerance: OFF receiver shall withstand an ON transmitter even with failure</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>-23</td>
<td>OFF-state tolerance: Receiver shall withstand an OFF transmitter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-24</td>
<td>Wiring Type (5): Twisted Shielded Pair (TSP)</td>
<td></td>
<td>R</td>
</tr>
<tr>
<td>-25</td>
<td>Shielding: Shield at backshell on driver and receiver side</td>
<td></td>
<td>R</td>
</tr>
</tbody>
</table>

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 ± 1%
(5) or TwinAx (TCX) (120 Ohm balanced shielded lines acc. ESA/SCC 3902/002)

Fault Voltages shall be verified by Worst Case Analysis.

### 3.5.4.3 Low Voltage Differential Signalling (LVDS)

#### 3.5.4.3.1 Point-to-Point LVDS Link

**RV-GDIR-1226 / / T,R**

Low-Voltage Differential Signalling (LVDS) link shown on Figure 3-9 shall comply with the 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.

**RV-GDIR-1227 / / T,R**

With reference to Figure 3-9:

- The A terminal of the generator shall be negative with respect to the B terminal for binary 1.
- The B terminal of the generator shall be negative with respect to the A terminal for binary 0.

![Figure 3-9: LVDS Link](image)

**RV-GDIR-5368 / / T,R**

The contractor shall design his side of the Low Voltage Differential Signal (LVDS) interface to be compliant to the characteristics as defined in Interface Datasheet "LVDS", RV-GDIR-5368.

**Table 3-10: LVDS Driver Specification**

<table>
<thead>
<tr>
<th>Req</th>
<th>Driver Circuit Specification</th>
<th>Low Voltage Differential Signal</th>
<th>IF-Code: LVDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Transmission Type:</td>
<td>Differential</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Diff. output voltage (V&lt;sub&gt;T&lt;/sub&gt;): 250mV ≤ V&lt;sub&gt;od&lt;/sub&gt; ≤ 450mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Diff. output voltage variation (D&lt;sub&gt;Vt&lt;/sub&gt;): 0.2 V&lt;sub&gt;ss&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Offset output voltage (V&lt;sub&gt;o&lt;/sub&gt;): 1.125V ≤ V&lt;sub&gt;os&lt;/sub&gt; ≤ 1.375V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Source impedance: 100 Ohm ±1% incl. driver source impedance and series resistors (for 100 Ohm line adaptation)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

General Design and Interface Requirements

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### INTERFACE DATA SHEET

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>Rise and Fall time (1):</td>
<td>tr, tf ≤ TBDns for Tb &gt; TBDns, otherwise 0.1xTb</td>
</tr>
<tr>
<td>-7</td>
<td>Short circuit current (I_{SA}, I_{SB}):</td>
<td>Short circuit proof, max: 24mA (each terminal to ground)</td>
</tr>
<tr>
<td>-8</td>
<td>Short circuit current (I_{SAB}):</td>
<td>Short circuit proof, max: 12mA (terminals shorted to each other)</td>
</tr>
<tr>
<td>-9</td>
<td>Common mode output:</td>
<td>0.2 to 0.8 of V_{SS}</td>
</tr>
<tr>
<td>-10</td>
<td>Fault voltage emission (2):</td>
<td>0V to +3.6V</td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance:</td>
<td>0V to +3.6V (through 1KOhm)</td>
</tr>
<tr>
<td>-12</td>
<td>OFF state tolerance:</td>
<td>OFF transmitter shall withstand an ON receiver even with failure</td>
</tr>
<tr>
<td>-13</td>
<td>ON state tolerance:</td>
<td>ON transmitter shall withstand an OFF receiver</td>
</tr>
</tbody>
</table>

#### Receiver Circuit Specification

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-14</td>
<td>Fail-safe:</td>
</tr>
<tr>
<td>-15</td>
<td>Input impedance (4):</td>
</tr>
<tr>
<td>-16</td>
<td>Input voltage (Circuit Common):</td>
</tr>
<tr>
<td>-17</td>
<td>Diff. input voltage:</td>
</tr>
<tr>
<td>-18</td>
<td>Input Voltage Threshold (VTH):</td>
</tr>
<tr>
<td>-19</td>
<td>Common mode range:</td>
</tr>
<tr>
<td>-20</td>
<td>Fault voltage emission (2):</td>
</tr>
<tr>
<td>-21</td>
<td>Fault voltage tolerance:</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>-22</td>
<td>OFF-state tolerance:</td>
</tr>
<tr>
<td>-23</td>
<td>ON-state tolerance:</td>
</tr>
</tbody>
</table>

#### Harness Specification

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-24</td>
<td>Wiring Type (5):</td>
</tr>
<tr>
<td>-25</td>
<td>Shielding:</td>
</tr>
</tbody>
</table>

**Notes:**

1. With load 100 Ohm.
2. Special attention has to be paid to failure modes of the interface circuit power supply.
3. Proposed input series resistors (Ris): 1 KOhm ± 1%
4. or TwinAx (TCX) (120 Ohm balanced shielded lines acc. ESA/SCC 3902/002)

Fault Voltages shall be verified by Worst Case Analysis.

**RV-GDIR-1247 / / T,R**

The LVDS link signal waveform shall comply with that shown in Figure 3-10.
3.5.4.3.2 Multi-drop LVDS Configuration

RV-GDIR-1250 / R

No LVDS configuration involving more than one LVDS driver should be implemented.

Note: In case this is demonstrated as an inevitable implementation, it should be done as shown on Figure 3-11.

Figure 3-11: Driver Configuration

3.5.4.4 UART RS-422 Serial Link (USL)

UART's are used for digital transfer between units through a serial link (see Figure 3-12).

RV-GDIR-1254 / R

The UART serial link shall be composed of two signals: One Transmit Data Line (TD) and one Receive Data Line (RD) as seen from the OBC (see Figure 3-12).
General Design and Interface Requirements

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RV-GDIR-1256 / / R

The UART RS-422 Serial Link Interface shall be implemented using Standard Balanced Link (SBDL) interface.

Note: The contractor shall design his part of the interface to be compliant to the characteristics as given by the Interface Data Sheet "SBDL".

RV-GDIR-1257 / / R

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 RS-232 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 in the range 2k to 2.2M Bauds

Figure 3-13 shows an example for data transmission via the UART Serial Link (AB hex).

RV-GDIR-1258 / / R

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

RV-GDIR-5335 / / R

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 3-13: Example Data Transmission (Input/Output of RS-422)

Note: Figure 3-13 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.

RV-GDIR-1261 / / T

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

RV-GDIR-1262 / / T

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

RV-GDIR-1263 / / T

Command messages 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.

3.5.4.5 Timing Pulses

3.5.4.5.1 On-Board Time Synchronisation or Datation Pulses (PPS)

These signals are used for on-board time synchronisation or datation purposes.

RV-GDIR-1267 / / R

The Pulse Per Second (PPS) Interface shall be implemented using Standard Balanced Link (SBDL) interface.

RV-GDIR-5338 / / R

The contractor shall design his part of the interface to be compliant to the characteristics defined in Table 3-11 (Interface Data Sheet "PPS"):

<table>
<thead>
<tr>
<th>Table 3-11: Pulse Per Second Interface Data Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERFACE DATA SHEET</td>
</tr>
<tr>
<td>I/F Designation: Pulse Per Second Interface</td>
</tr>
<tr>
<td>Req.</td>
</tr>
<tr>
<td>-1</td>
</tr>
<tr>
<td>-2</td>
</tr>
<tr>
<td>-3</td>
</tr>
<tr>
<td>-4</td>
</tr>
<tr>
<td>-5</td>
</tr>
<tr>
<td>Harness Specification</td>
</tr>
</tbody>
</table>
INTERFACE DATA SHEET

-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)

RV-GDIR-1272 / / R

The synchronisation edge shall be the rising edge, i.e. the leading edge of the PPS signal shall match to the time data with the accuracy/parameters as given in the Interface Data Sheet "PPS". This point of time defines the time stamp.

RV-GDIR-1273 / / R

The synchronisation interface configuration shall be as described in Section 3.5.7 and shown in Figure 3-21

The synchronisation reference is the leading edge of the SYNC-pulse as defined in Figure 3-14 below.

Note: This point of time defines the time stamp.

![Figure 3-14: SYNC-Pulse Synchronisation Reference](image)

RV-GDIR-1276 / / T,R

The contractor shall design the equipment part of the interface to be compliant to the characteristics as defined in Section 3.5.4.2 (SBDL).

3.5.4.5.2 1 Hz Synchronisation Pulse Interface (1SY)

RV-GDIR-1278 / / R

The active 1SY level shall be High level.

RV-GDIR-1279 / / R

The 1SY 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 Section 1181

The leading edge of the 1SY (OBC Input) shall match to the time data with the accuracy/parameters as follows.

RV-GDIR-1281 / / T,A

The driver circuit frequency shall be 1 Hz ± 1%
RV-GDIR-1282 / T
The driver circuit jitter shall be less than 1μs

RV-GDIR-1283 / T
The driver circuit pulse width (high level) shall be greater than or equal to 0.9μs

3.5.4.6 Housekeeping Analog Acquisitions

Analogue acquisition (AN) interfaces are used for the acquisition of information from users in the form of a voltage varying between two defined limits, whereby these voltage limits may vary between -5V to +5V (AN1), 0V and +5V (AN2), and -10V to +10V (AN3). The voltage is sampled on a regular basis, converted from analogue to digital and coded as an 11 or 12 bit digital information (unipolar or bipolar acquisition).

As a rule, the Most Significant Bit (MSB) will be transmitted first.

Three states are defined for the analogue input:

- During acquisition: the receiver input gate is enabled,
- Outside acquisition: the receiver input gate is disabled,
- Switched off receiver: the receiver input gate is not powered.

RV-GDIR-1286 / R
The interface shall consist of a differential link (single ended emitter, differential receiver) (see Figure 3-15).

![Figure 3-15: Housekeeping Interface (differential link)](image)

3.5.4.6.1 Analogue Telemetry Acquisition [0;+5V] (AN2)

RV-GDIR-1318 / T,R
The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "AN2", Table 3-12.

Table 3-12: Analog Receiver Specification 2

<table>
<thead>
<tr>
<th>INTERFACE DATA SHEET</th>
<th></th>
<th></th>
</tr>
</thead>
</table>

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### 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: 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: ≤ 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 (in both ON and OFF state)</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>

#### Receiver Circuit Specification

-11 Circuit type: Differential receiver with multiplexed input
-12 Transfer: DC coupled
-13 Acquisition range: 0V to +5V
-14 Absolute accuracy (1): ≤ 1 % FSR (including offset, gain, non-linearity and drift errors)
-15 Noise: < 8mV rms
-16 Input differential impedance: During acquisition: ≥ 1 MOhm
-17 Input capacitance: ≤ 1.2µF
-18 Receiver bandwidth: ≤ 500Hz @ 3dB
-19 Acquisition rate: consecutive and different acquisitions every 128 µsec with full performance
-20 Fault voltage emission: -16 V to +16 V (through 1.5 KOhms) | A |
-21 Fault voltage tolerance: -14V to +14V (in both ON and OFF state) | A |
-22 OFF state tolerance: OFF receiver shall withstand an ON driver |      |

#### Harness Specification

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

Notes: (1) Includes offset-, gain-, non-linearity-, drift- errors; FSR: full scale range.

### 3.5.4.7 Temperature Acquisitions (ANY, ANP)

These acquisitions are used for thermal control (control and monitoring) and for unit monitoring.

There are three 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)

**RV-GDIR-1382 / / R**

The signal shall be transmitted via twisted shielded pairs.

*Note: The cable shield is connected at both sides of the interface to chassis ground.*

**RV-GDIR-1383 / / R**

The temperature acquisition interface circuitry, as well as the interconnecting harness, shall be as shown in Figure 3-16.
3.5.4.7.1 Thermistor Type 1: YSI-44907/-44908 (ANY)

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "ANY", Table 3-13.

Table 3-13: Option 1: Receiver Circuit 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>-2</td>
<td>Transfer:</td>
<td>DC coupled</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>Operating temp. range:</td>
<td>-55°C to +70°C</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Fault voltage tolerance:</td>
<td>-16.5V to +16.5V (in both ON and OFF state)</td>
<td>A</td>
</tr>
<tr>
<td>-5</td>
<td>Fault voltage emission:</td>
<td>Not applicable</td>
<td></td>
</tr>
<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>Resolution:</td>
<td>at least 0.2 K / LSB</td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Measurement Range:</td>
<td>-50°C to +70°C (equivalent to 441.3 KOhm to 1990 Ohm)</td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Stability:</td>
<td>±1K (-50°C to +70°C)</td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Measurement current:</td>
<td>≤ 700µA</td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Measurement chain accuracy (uncalibrated channels):</td>
<td>better than ±5 K between -50°C to -5°C, better than ±4 K between -5°C to +70°C</td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Measurement chain accuracy (calibrated channels):</td>
<td>better than ±3 K between -50°C to -5°C, better than ±2 K between -5°C to +70°C</td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Acquisition rate:</td>
<td>Consecutive and different acquisitions every 128 µsec with full performance</td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Receiver bandwidth:</td>
<td>50Hz to 1500Hz @ 3dB</td>
<td></td>
</tr>
</tbody>
</table>

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### INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req.</th>
<th>Driver Circuit Specification</th>
<th>I/F Code:</th>
<th>ANP</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Circuit Type: Thermistor PT1000 (1KOhm @ 0°C), two wire connection</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>Operating temp. range: -160°C to +150°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>Fault voltage tolerance: -16.5V to +16.5V (in both ON and OFF state)</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Fault voltage emission: Not applicable</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

#### Receiver Circuit Specification

<table>
<thead>
<tr>
<th>Req.</th>
<th>Measurement range: -160°C to +140°C (equivalent to 344.6 Ohm to 1542.6 Ohm)</th>
<th>Measurement accuracy: better than ±3K</th>
<th>Measurement current: ≤ 300 µA (permanent)</th>
<th>Acquisition rate: consecutive and different acquisitions every 128 µsec with full performance</th>
<th>Receiver bandwidth: ≤ 350 Hz @ 3dB</th>
<th>Fault voltage tolerance: -14V to +14V (in both ON and OFF state)</th>
<th>Fault voltage emission: -16 V to +16 V (through 1.5 KOhms)</th>
<th>Harness Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-6</td>
<td>Conditioning circuitry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-7</td>
<td>Transfer: DC coupled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Measurement range: -160°C to +140°C (equivalent to 344.6 Ohm to 1542.6 Ohm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Resolution: at least 0.2 K / LSB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Measurement chain accuracy: better than ±3K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Measurement current: ≤ 300 µA (permanent)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Acquisition rate: consecutive and different acquisitions every 128 µsec with full performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Receiver bandwidth: ≤ 350 Hz @ 3dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Fault voltage tolerance: -14V to +14V (in both ON and OFF state)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Fault voltage emission: -16 V to +16 V (through 1.5 KOhms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

### 3.5.4.7.2 Thermistor Type2: PT-1000 (ANP)

**RV-GDIR-1408 / / T,R**

*The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "ANP", Table 3-14.*

**Table 3-14: Option 2: Receiver Circuit Specification**

<table>
<thead>
<tr>
<th>I/F Designation: Temperature Acquisition Type 2: PT-1000</th>
<th>I/F Code:</th>
<th>ANP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-16 Wiring Type: Twisted Shielded Pair (TSP)</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>-17 Shielding: Shield at backshell on driver and receiver side</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

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

### 3.5.4.8 Relay Commands (SHP, EHP, SLP)

The purpose of the High Power On/Off Commands 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.

**RV-GDIR-1472 / / R**

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

**RV-GDIR-1473 / / R**

*The High Power On/Off Command receiver shall be isolated from any user electrical reference.*
RV-GDIR-1474 / / R  
*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.*

RV-GDIR-1475 / / R  
*The High Power On/Off Command source shall be short circuit proof for short circuits to source or receiver signal ground and structure.*

RV-GDIR-1476 / / R  
*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.*

RV-GDIR-1477 / / R  
*Cross-strapping of redundant commands shall be implemented as required in RV-GDIR-2154.*

3.5.4.8.1 Standard High Power On/Off Command: (SHP)

RV-GDIR-1479 / / T,R  
*The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "SHP", Table 3-15.*

**Table 3-15: Standard High Power Command Receiver 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: trise ≤ 500μs tfall ≤ 1000μs when connected to load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-8</td>
<td>Current Drive Capability: ≥ 180mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Short Circuit Output Current: ≤ 400mA during pulse, after that ≤ 100μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Off-State Output Impedance (1): ≥ 100KOhm ±10% (if circuit is powerless or output voltage is off)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11</td>
<td>Fault voltage tolerance: -2V to +35V (in both ON and OFF state)</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>
<tr>
<td></td>
<td>Receiver Circuit Specification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Circuit Type (2): relay or optocoupler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Transfer: DC coupled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Levels: (at unit input terminals) activated at ≤ 18 V and Pulse Width ≤ 30 ms (for max. current of 180 mA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-16</td>
<td>Quiescent level: no activation for ≤ 100 μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-17</td>
<td>Max. Current: &lt; 180mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-18</td>
<td>Filter (2): Pulses up to 10 V, 1 ms shall not activate the switch function</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-19</td>
<td>Fault voltage emission: 0 V to +32 V A</td>
</tr>
<tr>
<td>-20</td>
<td>Fault voltage tolerance: -2 to +35 V (in both ON and OFF state) A</td>
</tr>
</tbody>
</table>

**Harness Specification**

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>-21</td>
<td>Wiring Type: Twisted Shielded Pair (TSP) R</td>
</tr>
<tr>
<td>-22</td>
<td>Shielding: Shield at backshell on driver and receiver side R</td>
</tr>
</tbody>
</table>

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.

Relay commands are used for decentralised power switching or unit configuration purposes. See Figure 3-17.

![Figure 3-17: OBC Relay Command Principle](image)

**3.5.4.8.2 Low Voltage High Power Commands (LV-HPC)**

**RV-GDIR-8414 / I**

The low voltage high power command (LV-HPC) interface shall be designed as specified in section 7.1.2 in ECSS-E-ST-50-14C.

**RV-GDIR-8415 / I**

The low voltage high power command (LV-HPC) electrical characteristics shall be as specified in section 7.1.3 in ECSS-E-ST-50-14C.

**3.5.4.9 Relay Status Acquisitions (RSA)**

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

**RV-GDIR-1562 / I R**

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 3-18 presents the principle of relay status acquisitions.

Figure 3-18: Principle of Relay Status Acquisition

RV-GDIR-1565 / / T,R

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "RSA", Table 3-16.

Table 3-16: Relay Status Acquisition Receiver Specification

<table>
<thead>
<tr>
<th>I/F Designation:</th>
<th>Relay Status Acquisition</th>
<th>I/F Code</th>
<th>RSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Req.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-1</td>
<td>Circuit type:</td>
<td>Relay contact (floating) or optocoupler</td>
<td></td>
</tr>
<tr>
<td>-2</td>
<td>Transfer:</td>
<td>DC coupled</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>
</tr>
<tr>
<td>-4</td>
<td>Open Status:</td>
<td>Resistance ≥ 1 MOhm</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Current capability:</td>
<td>≥ 10 mA</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Fault voltage tolerance:</td>
<td>-16.5 V to +16.5 V (in both On and OFF state)</td>
<td>A</td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission:</td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Receiver Circuit Specification</td>
<td>Single ended with pull-up resistor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Circuit type:</td>
<td>DC coupled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transfer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input voltage threshold (1):</td>
<td>1.4 to 3.3V</td>
<td></td>
</tr>
</tbody>
</table>
INTERFACE DATA SHEET

<table>
<thead>
<tr>
<th>Req.</th>
<th>I/F Designation:</th>
<th>BI-Level TM Acquisition</th>
<th>I/F Code:</th>
<th>BLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>-11</td>
<td>Closed switch resistivity detection:</td>
<td>0 to 50 Ohm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12</td>
<td>Open switch resistivity detection:</td>
<td>&gt; 1 MOhm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-13</td>
<td>Output voltage:</td>
<td>3.7 to 5.5 V via series resistor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14</td>
<td>Output current:</td>
<td>0.5 to 1.0 mA (for switch resistance 0 to 50 Ohm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-15</td>
<td>Fault voltage emission:</td>
<td>-16 V to +16 V (through 1.5 KOhm)</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>-16</td>
<td>Fault voltage tolerance:</td>
<td>-3 V to +14 V</td>
<td></td>
<td>A</td>
</tr>
</tbody>
</table>

Harness Specification

-17 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. The receiver shall detect an open switch for any resistance greater than 1 MOhm.

Fault Voltages shall be verified by Worst Case Analysis.

3.5.4.10 Digital Bi-Level TM Acquisitions (BLD)

RV-GDIR-1586 / R

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

RV-GDIR-1587 / R

When used as an ON/OFF state, "ON" state shall be represented by a logical "1" and "OFF" state by logical "0".

RV-GDIR-1588 / R

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.

RV-GDIR-1589 / T,R

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).

RV-GDIR-1590 / T,R

The contractor shall design his side of the interface to be compliant to the characteristics as defined in Interface Datasheet "BLD", Table 3-17.

Table 3-17: Bi-level Digital Receiver 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>Single ended</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>0 V ≤ VOL ≤ 0.5 V (Logical &quot;0&quot;)</td>
<td></td>
</tr>
<tr>
<td>-4</td>
<td>High Level Output Voltage:</td>
<td>4.5 V ≤ VOH ≤ 5.5 V (Logical &quot;1&quot;)</td>
<td></td>
</tr>
<tr>
<td>-5</td>
<td>Output Impedance:</td>
<td>≤ 7.5 KOhm</td>
<td></td>
</tr>
<tr>
<td>-6</td>
<td>Fault voltage tolerance:</td>
<td>-16.5 V to +16.5 V (in both ON and OFF state)</td>
<td>A</td>
</tr>
<tr>
<td>-7</td>
<td>Fault voltage emission:</td>
<td>-1 V to +12 V</td>
<td>A</td>
</tr>
</tbody>
</table>

General Design and Interface Requirements

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### INTERFACE DATA SHEET

- **-8** Circuit type: Differential receiver
- **-9** Transfer: DC coupled
- **-10** Differential Threshold: 2.5V ±0.5V (<2V is logical “0”; > 3V is logical “1”)
- **-11** Nom. Differential Input Range: 0V to 5V
- **-12** Common Mode Range: 1V to 3.75V
- **-13** Input Impedance:
  - During acquisition: > 100KOhm
  - Outside acquisition: ≥ 20MOhm
  - Switched OFF receiver (unpowered): ≥ 1KOhm
- **-14** Max Fault voltage
  - Emission: -16V to +16V (through 1.5KOhm)
- **-15** Max Fault voltage Tolerance:
  - -15.8V to +15.8V (in both ON and OFF state)
- **-16** Wiring Type: Twisted Pair (TSP)
- **-17** Shielding
  - Shield at backshell on driver and receiver side

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

### 3.5.4.11 COMMS Electrical Interfaces (TT&C)

#### 3.5.4.11.1 Digital TC Channel Interface (XTC)

**RV-GDIR-5306** / /

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

- **Data** (XCD)
- **Clock** (XCC)
- **Data Valid** (XCE) [Enable/Channel Active]

**RV-GDIR-5307** / /

The Digital TC Channel shall be transmitted via Standard Balanced Digital Link Interfaces as defined in Section 3.5.4.2.

For information the relationship between the Data Valid, Clock and Data signals within the XTC channel is as shown in the typical timing diagram shown in Figure 3-19.
3.5.4.11.2 Receiver Lock Status Interface (RLS)

The Receiver Lock Status Signal is issued by the Transceiver and will be acquired by the OBC.

RV-GDIR-5313 / I

_The Receiver Lock Status signal shall be transmitted via Standard Digital Link interface as defined in Section 3.5.4.2._

3.5.4.11.3 Digital TM Channel Interface (XTM)

RV-GDIR-5315 / I

_The Digital TM Channel shall consist of 2 signals. (For these signals the following abbreviations shall be used):_

- _Data (XMD)_

---

**Figure 3-19: Digital TC Timing Diagram**

- **T1** =< 128 bit
- **T2** between 1 bit and 128 bit
- **T3** = 500ms
- **T4** = 100ms
- **Tc** = 500µs ±5% (for a 2kbps 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.
3.5.4.12 SpaceWire

The Rover Vehicle SpaceWire Interface Control Document [IR 07] describes the implementation of SpaceWire for the Rover.

3.5.5 Connectors and Harness General Design Requirements

3.5.5.1 Connector Types

RV-GDIR-2099 / / R

The design of electrical connector interfaces shall comply with ESA standard ECSS-E-20A [NR 10] chapter 4.2.3.

RV-GDIR-2100 / / R

For the Rover Vehicle cable harness the following connector types shall be used:

- Rectangular connectors MDMA in accordance with ESA 3401/077
- Rectangular connectors D-Sub normal or high density in accordance with ESA/SCC 3401/002
- Circular connectors in accordance with ESA/SCC 3401/052, ESASCC 3401/044 or ESA/SCC 3401/056 (Styles similar to MIL-C-38999 series I, II & III.)
- Connectors, which interface with electro-explosive and non-explosive devices that are release initiators shall be in accordance with ESA SCC 3401-008 or MIL-C-26482-2
- Non-magnetic coaxial connectors of the SMA type in accordance with ESA/SCC 3402/001 and 3402/002, or TNC type in accordance with ESA/SCC 3402/008 and 3402/009 for RF cables
- Non-magnetic coaxial connectors of the crimp and solder type per MIL-C-39012
- Non-magnetic SMA coaxial connectors per MIL-C-83517
- All connector contacts shall be as defined in the relevant connector specification and in accordance with the PA requirements

Notes:

1) Where the Harness cables penetrate the Rover Vehicle 'Bathtub' special connectors shall be used to control the heat leakage between the Internal and External Rover Body mounted items.

2) Special connectors, or connectors used for off-the-shelf equipment may deviate from the requirement, but the mating connector counterpart shall be delivered by the manufacturer of the respective unit. The quality level of such connectors shall be agreed with the Prime Contractor prior to supply.

3) Bulkhead connectors for the connection between Internal and External electrical items will be designed as Special Types to meet the Rover Vehicle electrical and thermal requirements.

RV-GDIR-2101 / / R

All connectors mounted on units shall use the following connector types:
ExoMars Rover Vehicle

- MDMA style harness connectors to ESA ESCC 3401/077 and contacts to 3401/078, except for power lines and coaxial links.
- Power line connectors on units shall preferentially be compatible with HDD style harness connectors to ESA ESCC 3401/002 and contacts to 3401/005.
- Coaxial links shall preferentially use SMA type connectors.

Notes:
1) Exception to this requirement may be granted for external units and High voltage connectors.
2) Special connectors, or connectors used for off-the-shelf equipment may deviate from the requirement, but the mating connector counterpart shall be delivered by the manufacturer of the respective unit. The quality level of such connectors shall be agreed with the Prime Contractor prior to supply.
3) Bulkhead connectors for the connection between Internal and External electrical items will be designed as Special Types to meet the Rover Vehicle electrical and thermal requirements.

RV-GDIR-2102 / / R
The number times flight connectors are mated / demated shall not exceed 5, up to unit delivery and shall be designed to cope with a further 50 mating / demating applications.

RV-GDIR-2103 / / R
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
- Class 5 : RF signals (via coaxial lines, waveguides, microwave transmission lines)

RV-GDIR-2104 / / A,R
Signals falling into different EMC classifications shall be assembled to separate connectors and cable bundles.
Note: If not feasible the separation could be achieved by a row of grounded pins.

RV-GDIR-5325 / / A,R
Signal interfaces shall withstand without damage positive or negative nominal voltages that are accessible on the same connector or fault voltages emanating from the EGSE.

RV-GDIR-2105 / / R
Sensitive, "High Quality" secondary power shall not be routed together 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
3.5.5.2 Connector Characteristics

RV-GDIR-2107 / / R

Connectors at interfaces shall be clearly identified in particular in the ICD and GA drawing.

Note: This applies to equipment connectors as well as to interface brackets connectors.

RV-GDIR-2108 / / R

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

Note: Female in this context shall mean a connector with shrouded or covered contacts.

RV-GDIR-2109 / / R

The connector type used for primary power shall not be used for any other signal on the unit

RV-GDIR-2110 / / R

For units or unit assemblies located close to one another, every effort shall be made to minimise the risk of an operator making a wrong connection.

Note: This may be achieved by attaching the cables to the structure or by carefully choosing the position and orientation of each connector, and by using easily readable labels.

RV-GDIR-2111 / / R

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

RV-GDIR-8416 / / I,R

Each active signal line shall have a corresponding dedicated return contact i.e. returns will not be shared between active signal lines.

Note: This requirement may be waived provided sufficient cable accommodation is available within the connector. No more than 3 returns may share a contact.

RV-GDIR-2112 / / I,R

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

RV-GDIR-2113 / / R

Connectors shall be made of Non magnetic material

RV-GDIR-2114 / / R

Nominal and redundant lines shall have separate connectors.

Note: If not feasible, connector pins carrying redundant functions should be physically separated and isolated from each other. Where existing qualified hardware is used that does not comply with the requirement, a Request For Waiver must be issued and will be treated on a case by case basis taking into account failure propagation effects.

Note: Harness bundles will be split as soon as they exit the connector in all cases.
RV-GDIR-2115 / / R

Each connector shall provide one free pin internally connected to the mechanical chassis (ground) of the unit by a resistance lower than 10mOhms.

RV-GDIR-2116 / / R

All connectors (except SpaceWire and CAN Bus) shall have a minimum of 10% spare pins.

3.5.5.3 Connector Mounting

RV-GDIR-2119 / / R

All electrical connectors shall be located to provide a minimum clearance distance of 5mm from the unit mounting plane in order to avoid problems with cable routing and cable harness support fixation. Note: When connectors are located above 50mm from the mounting plane, the contractor shall provide means to support the harness on the unit. These fixations and the associated harness routing shall be iterated with and approved by the customer, and shall be clearly identified in the unit MICD.

RV-GDIR-2120 / / R

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.

RV-GDIR-5326 / / R

The minimum free space around each connector shall be 3mm to allow for the installation of backshells, spacers and covers.

RV-GDIR-470 / / I,R

Mated male and female connectors shall be mechanically locked together.

RV-GDIR-2121 / / I,R

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

RV-GDIR-2122 / / R

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. Note: The unit manufacturer shall provide these savers.

RV-GDIR-2123 / / R

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. Note: The maximum allowable length is 6 cm.

RV-GDIR-2124 / / T,A

The use of a connector saver for ground testing shall not alter the performance of the equipment.
3.5.5.4 Test Connectors

RV-GDIR-2126 / I, R
Test connectors shall have sufficient protection to prevent from any potential hazards to the unit during testing via the unit test set.

Note: The protection may be in the form of current limiting resistors, diodes or protection via the test set when other forms of protection are not practical. The contractor is responsible for the protection provided.

RV-GDIR-2127 / I, R
Test connectors shall be protected by EMC metal covers attached to fixation bolts

RV-GDIR-2128 / R
The metallic protection cover shall be capable of flight operation.

RV-GDIR-2129 / I, R
Signals at spacecraft skin connectors interfacing with EGSE shall follow safety rules documented in IEC 60479:1994 “Effects of current on human beings and livestock” when voltages more than TBD V are involved.

3.5.5.5 Harness

RV-GDIR-2131 / I, R
Cables falling into different EMC classifications shall be assembled to different (separate) cable bundles and connectors.

Note: If this is not feasible and wires of different classifications use the same connector, the separation should be implemented by a row of grounded pins in between.

RV-GDIR-2132 / I, R
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.

RV-GDIR-2133 / I, R
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.

RV-GDIR-2134 / T
The DC resistance between the single cable shield and the shield ground point (at the connector, unit case, PCB or intermediate points) shall be less than 10 mOhms.

3.5.5.6 Cable and Harness Shields

RV-GDIR-2136 / R
Where shielded wires are used, the shield shall be of a braided construction, selected to provide an optical coverage of at least 85%.

RV-GDIR-2137 / I, R
The structure termination of shields shall be made via the connector housing.
Note: When multiple shielding are used, each shield should be grounded separately.

RV-GDIR-2138 / / R
The maximum unshielded length of any shielded wire shall not exceed 2.5cm.

RV-GDIR-5327 / / R
Cable shields shall be grounded at both ends.
Note: Where shielded cable pass through intermediate connectors, the shield must pass through the interface on dedicated pins.

RV-GDIR-2139 / / R
Daisy chaining of shield terminations shall be avoided.
Note: If this is not feasible due to connector limitations, a maximum of three shields of similar electrical interfaces are allowed for daisy chaining.

RV-GDIR-2140 / / R
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.

RV-GDIR-2141 / / R
Overall cable shields shall be made of double wrapped aluminium foil, with an overlap of at least 50%.

RV-GDIR-5328 / / R
Overall shields shall be terminated to the connector backshell.

3.5.5.7 Harness Capacitance

RV-GDIR-2143 / / A
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 3-20 for a Twisted Shielded Pair.

![Figure 3-20: Harness Capacitance](image)

C₁ = 150 pF/m
C₂ = 1.5 nF/m
Core to core cap = C₁ + C₂ = 950 pF
Core to shield cap = C₁ + C₂/C₁+C₂ = 1.75 nF
3.5.6 Use of FPGA and ASIC

RV-GDIR-5439 / / R

Any FPGA or ASIC used shall comply with all the requirements in Appendix E of this document.

RV-GDIR-5440 / / R

For any FPGA firmware, the following margins on the system gates or logic cells shall be maintained:

- At PDR: 50%
- At CDR: 30%
- At acceptance: 20%

3.5.7 Cross Strapping

RV-GDIR-2146 / CELL U-0110 / T,R

All equipments shall implement dual redundant TM/TC interfaces.

Note: For example a unique thermistor for temperature monitoring is not allowed.

RV-GDIR-2148 / / R

For 2 units (UNIT_1 & UNIT_2), which can be used in cold redundancy, the cross strapping of drivers and receivers shall be as defined Figure 3-21.

![Cross Strapping Diagram](image)

Figure 3-21: Cross Strapping Definition

RV-GDIR-2150 / / R

Number of links:
The UNIT_2_A I/F shall be able to receive:
- A signal from the UNIT_1_A I/F through a dedicated link
- A signal from the UNIT_1_B I/F through a dedicated link

The UNIT_2_B I/F shall be able to receive:
- A signal from the UNIT_1_A I/F through a dedicated link
- A signal from the UNIT_1_B I/F through a dedicated link

The UNIT_1_A I/F shall be able to deliver:
- A signal to the UNIT_2_A I/F through a dedicated link
- A signal to the UNIT_2_B I/F through a dedicated link

The UNIT_1_B I/F shall be able to deliver:
- A signal to the UNIT_2_A I/F through a dedicated link
- A signal to the UNIT_2_B I/F through a dedicated link

RV-GDIR-2151 / I/R

IMMUNITY at UNIT_2 level (Receiver = ON linked to Transmitter = OFF of UNIT_1):
In the configuration where UNIT_1 driver is OFF and UNIT_2 receiver is ON, the electrical status at receiver output is stable (due to hysteresis) but possibly unknown (logical "1" or "0"). The information received by this receiver shall not disturb the valid information received by the other receiver (linked to a Transmitter ON)

It is recommended to implement a validation / inhibition stage at the receiver output of UNIT_2.

The validation of the path can be made by a dedicated direct command arriving from UNIT_1, which inhibits the UNIT_2 receiver output unused.

RV-GDIR-2152 / I/R

PROTECTIONS at UNIT_1 Driver level (Transmitter = OFF linked to Receiver = ON of UNIT_2)
Whether powered or not, UNIT_1 Drivers shall withstand any driver characteristics as described in Section 3.5.3.

RV-GDIR-2153 / I/R

PROTECTIONS at UNIT_2 receiver level (Receiver = OFF linked to Transmitter = ON of UNIT_1)
Whether powered or not, UNIT_2 Receivers shall withstand any receiver characteristics as described in Section 3.5.3.

3.5.7.1 Cross-Strapping for Relay Commands

RV-GDIR-2155 / I/R

For non-redundant relay command receivers, which shall be commanded by redundant relay command drivers, the cross strapping principle as given in Figure 3-22 below shall be applied.
Whether powered or not, Relay Command Driver A shall withstand any characteristics of Driver B and vice versa. Failure on Driver A shall not propagate to Driver B and vice versa.

### 3.5.7.2 Cross-Strapping for Relay Status Acquisition

RV-GDIR-2159 / / R

For non-redundant relay status drivers, which shall be acquired by redundant Relay Status Acquisition receivers, the cross strapping principle as given in Figure 3-23 below shall be applied:
Whether powered or not, Relay Status Receiver A shall withstand any characteristics of Receiver B and vice versa. Failure on Receiver A shall not propagate to Receiver B and vice versa.

3.5.8 Electrical Interface Control Document

3.5.9 EMC and ESD Requirements

3.5.9.1 Bonding

Bonding is the method by which adjacent conductive elements are electrically connected in order to minimise any potential differences between them and to direct the flow of electrical fault and noise 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 to reduce the electrochemical potential and prevent corrosion.

Bonds 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 level for an indefinite time.

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

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

For the purpose of electrostatic protection, all equipment without any electrical function shall be bonded to the structure by direct metallic contact with less than 100 kOhms.

Each electrical equipment chassis (case) shall be bonded to structure or GRR by means of a bond strap or direct metal contact.

The bonding interfaces shall be designed not to exceed a chassis to structure bonding resistance of 5 mOhms.
RV-GDIR-5330 / / T

Bondstraps shall have a length to width ratio of 5:1 max.

Rationale: To minimise self inductance and hence reduce the impedance of the bond.

RV-GDIR-2172 / / T

Metallic receptacles of connectors shall be electrically bonded to the equipment case with a DC resistance of 2.5 mOhms or less.

3.5.9.1.1 Ground Reference Rail

RV-GDIR-2174 / / R

Electrical bonding throughout non metallic structures, such as CFRP, shall be achieved by means of a continuous metallic Ground Reference Rail (GRR).

RV-GDIR-2175 / / T

The GRR shall be mechanically attached to structure by fixings that preserve its electrical integrity when it is subjected to the environmental loads, mechanical and thermal, imposed on it and on the structure.

Note: Further mechanical fixings may be required at the ends of the rails.

RV-GDIR-2176 / / T,R

Where it is necessary to form the GRR from separate metallic parts, the resistance across the joint between any adjacent parts of the GRR shall never exceed 2.5 mOhms.

RV-GDIR-2177 / / T,R

The resistance between any two points of the GRR shall be less than 50 mOhms.

3.5.9.1.2 Structure Parts

RV-GDIR-2179 / / T

The DC resistance between two mating metal parts shall be less than 2.5mOhms.

RV-GDIR-2180 / / T

Across movable parts, a bond strap shall be applied to ensure an electrical contact is made between those parts, with a resistance of less than 25 mOhms.

RV-GDIR-2181 / / T,R

Conductive structural components without a shielding function, such as CFRP, shall be bonded to the local GRR with a resistance of less than 100 kOhms.

RV-GDIR-2182 / / T,R

Conductive structural components used for electromagnetic shielding, such as CFRP, shall be bonded to the local GRR with a resistance of less than 2 Ohms.

RV-GDIR-2183 / / T

Metallic structural components without an electrical function that are embedded within insulator, such as aluminium honeycomb, shall be bonded to the structure and GRR with a DC resistance of less than 10 Ohms.
RV-GDIR-2184 / / T

Metal fittings used for the attachment of conductive structural components shall be bonded to the structure and GRR with a DC resistance of less than 100 kOhms.

Note: This may be achieved by bonding the fitting through the conductive component.

RV-GDIR-2185 / / T

The DC resistance between any other conductive component that does not perform an electrical function.

i.e. CFRP, CFK, conductive coatings etc. and the structure shall be less than 100 kOhms

3.5.9.1.3 Mechanical Parts

RV-GDIR-2187 / / T,R

Mechanical Parts without electrical nor shielding function shall show a bonding resistance of less than 100 kOhm between any adjacent parts and the local GRR.

RV-GDIR-2188 / / T,R

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)

3.5.9.2 Grounding, Bonding and Isolation

3.5.9.2.1 General

RV-GDIR-2191 / / I

Each electrical equipment unit shall provide a grounding point, connected to its electrical 0v reference point, which is easily accessible even when all harness connectors have been installed.

RV-GDIR-2192 / / R

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

RV-GDIR-5332 / / R

Grounding rails shall be used as bonding path.

3.5.9.2.2 Insulating Materials

RV-GDIR-2200 / / R

External surface resistivity shall be lower than 1e9 Ohms/square.

3.5.9.2.3 Thermal Parts

RV-GDIR-2210 / / T,R

Internal elements of heaters, thermistors and other discrete thermal components shall be isolated from structure with a resistance of greater than 10 MOhms at 50V.

3.5.9.3 Primary and Secondary Power Lines

Even if the EGRS (Electrical Ground Reference System) 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.
3.5.9.3.1 Primary Power Lines

**Grounding:** Power buses supplied by the Vehicle 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.

**RV-GDIR-2215 / I, T**

The primary power zero volt reference starpoint shall be bonded to the ground reference (structure) by a bonding resistance of less than 2.5 mOhms.

*Note: Applicable for the power control unit of the PSS only.*

**RV-GDIR-2216 / I, T,R**

Within all electrical equipment units the primary power buses shall be isolated.

*Note: There shall be no direct connection between the primary power bus zero volt and the unit’s chassis.*

**RV-GDIR-2217 / A,I,R**

Any conductor located on the live side (upstream) of a protection device and which is set at an electrical potential shall be insulated from the potential reference (either electrical or mechanical) by a double insulation.

*Note: This should be performed by using two different insulating materials. A space greater than 1 mm can be considered as an insulating material. Practical ways to meet this requirement is detailed in Appendix D.*

**RV-GDIR-2218 / I, T,R**

The structure shall not be used intentionally to carry any electrical current.

*Note: In particular, the structure shall not be used as a current return path for primary or secondary power.*

**RV-GDIR-2219 / I, T,R**

All electrical equipment units (except PCDE) shall maintain a galvanic isolation of at least 1MOhm 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).
- Regulated power positive and Unregulated power positive
- Regulated power negative and Unregulated power negative

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.

3.5.9.3.2 Secondary Power Lines

**RV-GDIR-2222 / I,R**

*Grounding: All secondary power supplies, inside a unit, shall be connected to unit structure.*

*Note: For units providing secondary power to other units, requirements RV-GDIR-519 and RV-GDIR-520 apply*
Prior to connection of the unit internal starpoint, the isolation between the secondary power return and unit chassis shall be at least 1MΩhm in parallel with a capacitance of less than or equal to 50nF.

For secondaries distributed between units (1 supplier; 1 receiver) the grounding shall be at ONE point only.

Note: 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)

Secondaries distributed between units (1 supplier; several receivers): The distribution shall be a starpoint system for power line and return.

Note: 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)

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 5 mohms.

Note: To be tested at board level.

Grounding diagram including zero volts interconnection and detailed implementation shall be described in the EICD
  - For each unit
  - For each assembly

The symbols below shall be used in the production of grounding diagram in order to obtain unified drawings.
3.5.9.3.3 Signal Interfaces

RV-GDIR-2231 / / R

Signal circuits interfacing between equipment shall follow the distributed star point grounding concept, Figure 3-24.

RV-GDIR-2232 / / T,R

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).

RV-GDIR-2233 / / R

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.

3.5.9.3.4 EGSE Grounding and Isolation

RV-GDIR-2235 / / R

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 and test harness design.
3.6 Operations and Data Handling Design and Interface Requirements

3.6.1 Bit / Byte Numbering Convention

**RV-GDIR-2252 / / T,R**

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 3-25 below shall apply*

*Note: This excludes the SpaceWire and UART interfaces that use bit 0 as LSB and transmit the LSB first.*

![Bit Numbering Convention](image)

**Figure 3-25: Bit / Byte Numbering Convention**

**RV-GDIR-2255 / T,R**

*The equipment/instrument bit/byte numbering for any parameter submitted or received shall comply to the Big Endian convention as defined in the Rover Vehicle PUS, ECSS PUS ECSS-E-70-41 and CCSDS 102-0-B-5, Packet Telemetry.*

*Any deviation from Big Endian convention (Little Endian) shall be agreed with the customer*  

3.6.2 **Handling of Operational Configuration, Modes and States**

*Note: Mode (Definition from ECSS-E-ST-70-11C) operational state of a spacecraft, subsystem or payload in which certain functions can be performed.*

*Mode transition (Definition from ECSS-E-ST-70-11C) transition between two operational modes.*

**RV-GDIR-2262 / ECSS-E-ST-70-11C / R**

*The equipment contractor shall identify appropriate modes/states and transitions between them for the equipment.*

**RV-GDIR-2263 / ECSS-E-ST-70-11C / T,R**

*The equipment shall at all times be in a clearly defined and identifiable operational mode/state (of both hardware and software) which is unique and exclusive.*

**RV-GDIR-2264 / ECSS-E-ST-70-11C / R**

*The contractor shall identify all internal and external events triggering a mode/state transition.*

**RV-GDIR-2265 / T**

*It shall be possible to transfer the equipment into each of its operation modes/states by means of a single command.*

**RV-GDIR-2266 / ECSS-E-ST-70-11C / T**

*The equipment shall provide sufficient telemetry to allow unambiguous identification of its mode/state and transitions.*

*Note: This applies for ground commanded transitions as well as for autonomous equipment/instrument triggered transitions.*
The contractor shall identify all transition times between modes/states.

Note: 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.

Completion of any equipment mode/state transitions shall be indicated in the telemetry.

Upon switch-on all equipments shall automatically enter a safe and well-defined initial mode/state.

Upon switch-on all equipments shall execute a health check and report the status through telemetry.

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

Commanding to the equipment shall be possible within TBD ms after switch on.

Housekeeping data from the equipment shall be available within TBD ms after switch on.

It shall be possible to command all the equipment switchable elements (e.g. relays) or equipment sub-units individually.

Note: The equipment switchable elements / sub-units are to be identified by the equipment subcontractor and agreed with the customer.

The function of a command shall not change throughout the mission.

The function of a command shall not depend on any previous command history.

Note: 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.
Onboard functions of each equipment shall have well-defined inputs and outputs that are accessible from the ground for work around solutions in case of contingency operations.

Note: The User Manual shall define all commands that are appropriate to each operational mode of the equipment and their sequence.

Nominal and the redundant functions or equipments of a unit shall be commanded by the same quantity, type and format of telecommand.

Changes to onboard data or software/firmware parameters shall be implemented via dedicated equipment telecommands.

Readouts of loaded onboard data or software parameters shall be requested via dedicated telecommands.

A telecommand (e.g. memory dump) in execution shall be capable of being aborted at any time. Note: This excludes High Power Commands.

Commands with variable bit-fields meaning shall not be used.

The equipment design shall avoid any conflict between a command register update by the software and the command acquisition by the equipment. Note: The register update should be possible at any time according to the communication protocol.

The capability shall be provided to perform complete and unambiguous verification of well-defined stages of telecommand execution.

Acknowledgement of commands shall be direct (i.e. not relying on the operation of other equipment/instruments or on the previous commanded state).

Successful execution of a command to the equipment shall be notified to the sender of the command (next higher operational level).

Failures in the acceptance or the execution of commands to the equipment shall be notified to the sender of the command (next higher operational level) stating the nature of the failure.
3.6.3.3 Conflicting Command Handling

RV-GDIR-2314 / / T

The equipment shall provide means to handle conflicting commanding that may arise from:

- Protocol transmission errors
- Commands received while the execution of an ongoing command is not yet finalised
- Incorrect sequencing of commands

Note: Any constraints resulting from conflicting command handling shall be identified by the contractor and documented in its operation manual.

3.6.4 Observability

3.6.4.1 General

Note: Observability (according ECSS-E-70-11A) is the availability to the ground segment and to on-board functions of information on the status, configuration and performance of the space segment.

This means Observability is characterised by the set of telemetry (housekeeping data) that is provided by a system, satellite, instrument, subsystem or equipment, which allows information about its overall status. The correct level of observability allows the next higher operational level (Ground Segment or Application Software) to get the appropriate data for the satellite, instrument, subsystem or equipment for taking any action if required.

RV-GDIR-2319 / / T

The equipment shall provide housekeeping telemetry for all data required for monitoring the operation of the equipment.

Note: The needed acquisition cycle of monitoring telemetry for safely operating the equipment shall be described in the equipment user manual.

Note: Housekeeping telemetry must include as a minimum switch statuses, currents, voltages, temperatures.

RV-GDIR-2321 / / T

The equipment shall allow for cyclic (regular) and on-request housekeeping data acquisition.

RV-GDIR-2322 / ECSS-E-ST-70-11C / T

The equipment shall provide the necessary instrumentation, monitoring and telemetry capability to allow the ground or the next higher operational level to determine at any time the precise and current status of the equipment software and hardware (including redundant units, computer, software parameter where applicable), without knowing the history of telecommands, history of on-board autonomous actions or information in previous histories.

Note: Any specific telemetry data processing required at a higher operational level shall be identified and defined by the equipment contractor and documented in the equipment user manual.

RV-GDIR-2327 / ECSS-E-ST-70-11C / T

Status information in telemetry shall be provided from direct measurements by operating equipment rather than from secondary effects.

Note: This is in particular essential for the status of all on-board relays.
Telemetry measurement sensors shall be designed such that they provide the full performance range with a suitable resolution compatible with the parameter being measured.

Note: This resolution shall be determined taking into account the needs for real-time control and for performances and lifetime evaluation.

Information to indicate all actions taken by onboard equipment autonomous functions shall be visible in the equipment telemetry.

The equipment status telemetry shall be capable of including all commandable parameters such as monitoring and control thresholds, tables and flags.

Telemetry shall always be available to determine the health status of all equipment that manage the generation and routing of (other) telemetry data.

When a key parameter is derived onboard from several inputs, each input shall be available in the telemetry in addition to the parameter itself.

3.6.4.2 Telemetry Acquisition

The value of a monitoring (telemetry) parameter shall be transmitted in contiguous bits within one packet.

The equipment shall provide telemetry to identify the current status of all equipment hardware components.

The TM acquisition process by the data bus shall neither modify the contents of the telemetry hardware register (no status re-initialisation) nor the equipment configuration; i.e. acquisitions with a commanding effect are forbidden.

The equipment design shall avoid any conflict between the acquisition of a telemetry by the software and the updating of telemetry data by the equipment.

TM acquisition shall be possible at any time according to the communication protocol.

TM acquisitions with conditional meaning shall not be used.
Analogue 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.

The calibration curve of an analogue parameter shall be unique i.e. it does not depend on the status of the equipment nor on the value of another parameter.

3.6.4.3 Observability of Hardware Configuration

The configuration of the equipment at elementary function (i.e. converter, bus coupler etc.) level shall be observable and available by telemetry.

Any configuration command register shall be observable by a corresponding telemetry parameter.

The acquisition of the equipment configuration/state shall be possible irrespective of the equipment status when ON.

The acquisition of an ON/OFF status for a relay shall be independent of the equipment status when ON.

If the equipment controls the redundancy configuration or the power of its sub-equipments, 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.

Equipment shall be able to provide sufficient telemetry data to allow discrimination of any fault that occurs.

3.6.5 Safety Critical and Hazardous Functions

Note: ECSS-E-ST-70-11C Definitions:

- Mission-Critical Function: Function that, when executed in the wrong context (e.g. at the wrong time), or wrongly executed, can cause permanent mission degradation.
- Vital Function: Function that is essential to mission success and that can cause permanent mission degradation if not executed when it should be, or wrongly executed, or executed in the wrong context. Note that all vital functions are mission critical.
- Hazardous Function: Functions that could cause loss of mission, mission degradation or damage to instrument, equipment, units, facilities or personnel, when being executed at the incorrect time.
ExoMars Rover
Vehicle

- Critical Commands: Commands which invoke mission critical, vital or hazardous functions and for which inadvertent execution (erroneous or inadvertent command transmission), incorrect execution (aborted command transmission or command transmission in wrong order), or loss of function may cause loss of nominal mission or, during the ground phase, presents hazards for personnel. Example: For instance, critical commands include HDRM firing, propulsion (hydrazine) activation, solar array deployment or other deployment related functions, etc.

RV-GDIR-2366 / ECSS-E-ST-70-11C / A

The execution of any command or command sequence shall not lead to permanent equipment or unit damage.

Note: This applies also for incorrect commands or command sequences.

Note: Exceptions to this requirement will be approved by the Prime Contractor and will be included in a Critical Command List.

RV-GDIR-2367 / ECSS-E-ST-70-11C / R

Commanding of critical functions shall be implemented by at least two separate and independent commands.

Note: The level of implementation shall be approved by the Prime Contractor.

RV-GDIR-2369 / ECSS-E-ST-70-11C / T

Equipments shall provide an unambiguous health status of potentially hazardous functions in a dedicated TM identifier.

3.6.6 Time Synchronisation & Datation

RV-GDIR-2371 / / T

The equipment shall indicate within telemetry, whether the equipment time has been nominally synchronized to the rover onboard master clock.

RV-GDIR-2373 / ECSS-E-ST-70-11C / T

The equipment shall time-stamp all its telemetry packets.

Note: In case the equipment is calculating the time stamping on its own, based on a defined edge of the PPS pulse, additional requirements on deterministic behaviour for the time stamping and failure tolerance for missing PPS signals has to be defined to properly harmonize between equipment and system level timing and datation.

3.6.7 Memory Management

RV-GDIR-2377 / / T

It shall be possible to upload the complete equipment application software image via the equipment specific command interface.

RV-GDIR-2378 / / T

It shall be possible to store the uploaded equipment application software image in a non-volatile memory

RV-GDIR-2379 / / T

It shall be possible to perform memory dumps for any equipment memory type (NVM, RAM, REGISTER)
RV-GDIR-2380 / / T

It shall be possible to perform memory checks for any equipment memory type (PROM, NVM, RAM)

RV-GDIR-2381 / / T

It shall be possible to perform memory patches for all equipment NVM, RAM and REGISTER memory

RV-GDIR-8142 / / I

All PROMs shall be accessible and removable after the unit has been integrated to the Rover without the need to de-integrate the unit from the Rover.

Note: For units in the SVM electronics frames, the units can be de-integrated from Rover to allow access to PROM's.

RV-GDIR-8581 / / A

All PROMs shall be sized with the following margins:

- 50% margin at PDR
- 30% margin at CDR

Note: 50% margin implies the PROM is two thirds full.

RV-GDIR-2382 / / T

Memory patch/dump/check operations shall be possible in at least one stable equipment mode.

Patch/Dump operations have to be possible at least in a mode which can be reached without the need of a proper functioning of the application software itself. Further, it is recommended to provide memory patch/dump/check capabilities for nominal operational modes in order to check/modify parameter settings during nominal operation.

Memory constraints driven by hardware w.r.t. byte boundaries, alignments, etc. shall be supported by the equipment application

3.6.8 Autonomy

RV-GDIR-2385 / / T

The equipment shall be designed for operating autonomously during nominal conditions to serve:

- the overall system autonomy needs
- its designated function
- its mode definitions

RV-GDIR-5442 / / T

During all autonomous operations of the equipment, the equipment shall be commandable and shall include nominal data acquisition and data transmission.

RV-GDIR-2386 / / T

All parameters used for autonomous operations and processes, including FDIR functions, shall be updatable by command and available in telemetry.

RV-GDIR-2387 / / A

Unnecessary equipment reconfigurations shall be avoided, i.e. reconfigurations not necessary to preserve the health of the equipment.
RV-GDIR-2388 / / T

It shall be possible to enable/disable/reset all equipment autonomous functions including equipment FDIR functions by telecommand, parameter by parameter.

Note: Exceptions are allowed for hardware protections intended to prevent rapid fault propagation e.g. under-voltage and over-current protection. Exceptions shall be agreed with the customer.

RV-GDIR-2390 / / T

Initialisation of a equipment mode/state shall include configuration of the necessary internal hardware (e.g. sensors), activation of a default periodic telemetry configuration, and all of the automatic processes (e.g. automatic measurement data acquisition) required to achieve the objective of the mode/state.

RV-GDIR-2391 / / T

Equipment onboard logic shall be available to prevent incorrect commanding of forbidden software based mode transitions (triggered by autonomous commanding as well as by ground commanding).

RV-GDIR-5443 / / T

The allowed and forbidden mode transitions between all possible pairs of equipment modes shall be implemented in software and thus updateable by means of equipment memory patch telecommands.

RV-GDIR-2392 / / T

Telemetry shall be associated to all equipment autonomous functions enabling to provide visibility of all the actions of the equipment autonomous functions and of their enabled/disabled status.

RV-GDIR-2393 / / T

Any input used by the equipment autonomous functions shall be observable in the equipment telemetry.

Note: Exceptions shall be agreed with the customer.

RV-GDIR-2394 / / T

All actions generated by automatic onboard logic (hardware or software) shall be inhibitable, reversible, by command.

Note: Exceptions shall be agreed with the customer.

RV-GDIR-2395 / / T

For all the automatic logic using several criteria in an “OR” configuration inhibition shall be possible individually and independently for each criteria.

RV-GDIR-2396 / / T

The capability to change all onboard logic (hardware and software) thresholds at any time shall be provided.
3.6.9 Fault Management / FDIR

3.6.9.1 Equipment Fault Protection

RV-GDIR-2399 / / T
Any equipment shall be able to withstand interruptions of the cyclic management by the OBSW during TBD minutes, regardless of the configuration it was left, i.e. remain in a safe state, without any requirement on performances, and except in case of equipment failure due to another cause.

RV-GDIR-2400 / / T
Any equipment shall be able to withstand interruptions of the data bus operation during TBD minutes, regardless of the configuration it was left. i.e. remain in a safe state, without any requirement on performances, and except in case of equipment failure due to another cause.

RV-GDIR-2401 / ECSS-E-ST-70-11C / T
It shall be possible to repeat any command several times without disturbing its nominal execution, even in case of timing constraints.
Note: No configuration change, no temporary or permanent degradation of the function performance must result from any command repeatability that would respect data bus constraints.

3.6.9.2 Equipment Self Checks

RV-GDIR-2403 / / T
All equipment that perform regular self-checks shall report the result regularly in a single TM packet.

RV-GDIR-2404 / / T
All equipment that perform self-tests at start-up shall report the result in a single TM packet.

3.6.9.3 Failure Detection, Isolation and Recovery (FDIR) Functions

Note: FDIR functions are those functions, which implement the failure detection, isolation and recovery actions. The FDIR functionality is set up at both equipment/instrument and system levels and is defined within the overall Operations Concept of the 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.

FDIR functions shall be implemented in a hierarchical manner, i.e. failure detection, isolation and recovery shall be implemented to a certain degree on equipment level.

RV-GDIR-2408 / RV-SYS-248 / R
Fault detection, isolation and recovery shall be performed in a hierarchical manner with the aim of isolation and recovering faults as far and as fast as possible.

RV-GDIR-2409 / ECSS-E-ST-70-11C / T
The equipment shall autonomously detect any equipment failure which makes it deviate from its nominal configuration and operating status.
Note: This includes both hardware and software failures.

RV-GDIR-2410 / ECSS-E-ST-70-11C / A
Failures at equipment level 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.
3.6.10 Data Interface Protocol

The data interface protocols used by the Rover Vehicle are defined in the Rover Vehicle CAN Bus Specification [IR 08] and the Rover Vehicle SpaceWire Specification [IR 09]. These specifications are made applicable to equipments by the appropriate equipment requirements specification.
3.6.11 Other Requirements

3.6.11.1 Inputs to Design Justification File

RV-GDIR-2434 / /

The contractor shall provide a design justification for the operations relevant part.

Notes:

1) For each telemetry/telecommand and their parameters a functional description shall be given with the reason for the choice.

2) 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).

3.6.11.2 Inputs to TM/TC Database

RV-GDIR-2436 / /

The equipment contractor shall provide inputs to the Rover TM/TC Database or fill in a customer provided Database. Note: This data shall be provided through a defined and agreed format. 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.

3.6.11.3 Operation Manual

The equipment contractor shall provide an Operations Manual covering all operational aspects (in-flight and on-ground) for the equipment in accordance with the equipment Operations Manual Definition Document.

RV-GDIR-2440 / / R

The definitions in Table 3-18 shall be used for the coding of 2 bit status’s.

<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>
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<tr>
<td>Still</td>
<td>Moving</td>
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<td>Minus</td>
</tr>
<tr>
<td>Disarmed</td>
<td>Armed</td>
</tr>
<tr>
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<td>Active</td>
</tr>
<tr>
<td>Inhibited</td>
<td>Enabled</td>
</tr>
</tbody>
</table>

General Design and Interface Requirements

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3.7 Control Law Design Requirements

3.8 Software Design & Interface Requirements

3.8.1 General Software Requirements

RV-GDIR-8433 / / T

Onboard software shall implement the necessary functions and services to monitor and control the equipments/instruments by the ground in accordance with the operational principles detailed in the PUS standard [IR XX] and the general operational requirement set of the equipment/instrument.

RV-GDIR-8434 / / T

On-board software shall implement the subset identified for the equipment/instrument application in the PUS standard [IR XX]. The implemented subset shall be agreed with the prime contractor.

RV-GDIR-8435 / / R

Standard PUS-service definitions shall be used.

RV-GDIR-8436 / / R

Private PUS service, sub-service and function definitions shall be limited to operational functionalities not covered by the standard service, sub-service and function definitions.

RV-GDIR-8437 / / R

The onboard software should not contain redundant, non reachable or deactivated code.

Note: In case this rule would have to be violated, the relevant code shall be handled according to dedicated PA Requirements for subcontractors [NR 19].

RV-GDIR-8438 / / R

All onboard software running in subsystems shall be developed using the same development environment, except where explicitly exempted under the following conditions:

- Software 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)

RV-GDIR-8439 / / R

All onboard software, including new and reused software shall be delivered to Astrium in source form, including all building scripts necessary to regenerate the onboard image.

Note: All supporting documentation shall also be delivered to Astrium.

RV-GDIR-8440 / / R

All onboard software executed in ASIC, FPGA or other specified circuits (including firmware and development language) shall be delivered to Astrium in source form including all supporting test harness and documentation.

RV-GDIR-8441 / / R

All software licenses for any software used to develop and test the onboard 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.
Note: The freeze point will be established by common agreement.

RV-GDIR-8442 / / R
For any onboard unit embedding software, a software development and maintenance facility shall be maintained that contains all the source codes, executables, test scenarios and results used for software qualification and delivery.

RV-GDIR-8443 / / R
The software development and maintenance facility shall include the patch/modification tools necessary in order to modify and patch the onboard software in flight.

3.8.2 Software Design Requirements

RV-GDIR-8444 / / R
Onboard software shall be designed in accordance with the ESA Software Standards ECSS-E-40 [NR 20] and ECSS-Q-80 [NR 21].

RV-GDIR-8445 / / R
The preferred/selected language, kernel and tools shall be justified and approved by Astrium.
Note: This approval is limited to new software developments, reused or inherited software shall not be affected. No high level programming language, real time kernel or software development tools are imposed on the Contractor.

RV-GDIR-8446 / / R
Functionality implemented by software shall be subjected to a criticality analysis to be performed by the subcontractor in accordance with the PA requirements for sub-contractors [NR 19].
Note: Functions classified as "mission critical" shall be subject to an independent verification and validation.

RV-GDIR-8447 / / R
Onboard software shall be written in a high-level language to be approved by the Astrium, except where explicitly exempted.

RV-GDIR-8448 / / R
Use of a non high-level language code (e.g., assembler) in the onboard software shall be shown to be absolutely necessary to achieve the required performance.
Note: Agreement with the Astrium shall be achieved before implementation.

RV-GDIR-8449 / / R
Onboard software execution shall be deterministic, operationally and functionally predictable.

RV-GDIR-8450 / / T
Onboard software shall support software modification and inspection during flight.
Note: The design of the onboard software shall allow the controlled generation and uplink of small memory areas without requiring all onboard software to be modified.

RV-GDIR-8451 / / T
Onboard software shall support direct patching, including areas where memory management is used.
RV-GDIR-8452 / R
Onboard software shall support the dump to ground of any element of the onboard memory, initiated by telecommands.

RV-GDIR-8453 / R
All software products shall store their version/release number onboard.

RV-GDIR-8454 / R
The onboard software version number shall be retrievable, either in H/K telemetry or table dump.

RV-GDIR-8455 / R
Onboard software shall be modular, minimising the interdependency between software modules in order to allow independent development, testing and modification of software modules.

RV-GDIR-8456 / R
Onboard software shall be implemented with a layered structure separating hardware, software, input/output drivers, basic services, and general mission services.

RV-GDIR-8457 / R
Whenever a condition that forces a processor reset is detected by onboard software, an event report shall be generated and sent to the onboard computer prior to enforcement of the reset.

RV-GDIR-8458 / R
In case of unexpected interruptions or exceptions and before the handler will apply the treatment defined by the FDIR/S requirements, the onboard software handler shall provide (or save) within TM (accessible after error isolation and recovery) any possible detail to identify and locate the error source.

RV-GDIR-8459 / R
The error context information shall include as a minimum the identification of the exception, a time-stamp and the CPU context (i.e. registers and last stack entries) to ease ground investigations.
Note: In case of storage limitations and consecutive errors, the first occurrences shall be saved.

RV-GDIR-8460 / R
Onboard software shall not contain any obsolete code still running in-flight which is needed only for on-ground testing.

RV-GDIR-8461 / R
The onboard software shall be table-driven for ease of operation and modification wherever possible.

RV-GDIR-8462 / R
All onboard software data that are anticipated to be modified or examined by ground shall be organised as tables.

RV-GDIR-8463 / R
Onboard software shall be built using references to the spacecraft central database.
3.8.3 Software Robustness and Error Reporting Requirements

RV-GDIR-8464 / R

The onboard software shall be designed to avoid error propagation throughout the different software layers.

RV-GDIR-8465 / R

Onboard software shall protect itself against infinite loops, computational errors and possible lock-ups resulting from an undetected hardware failure.

RV-GDIR-8466 / T,R

Onboard software shall perform internal error detection and error handling consisting at least:

- Operand elaboration where appropriate only
- Trap handling
- Task surveillance

RV-GDIR-8467 / T

Whenever a processor is running synchronously scheduled tasks, it shall check at the end of each software cycle that all tasks scheduled for that cycle were duly completed.

RV-GDIR-8468 / T

Whenever a processor overload condition is detected, an event report shall be generated.

RV-GDIR-8469 / T

Scheduler overruns shall be detected and reported using high criticality events with information identifying the source/cause of the overrun.

RV-GDIR-8470 / R

Scheduler overruns shall not lead into uncompleted tasks.

RV-GDIR-8471 / T

After a predefined number of consecutive or recurring (of the same task) overruns, a processor module reset shall be triggered.

RV-GDIR-8472 / T

Whenever an unexpected arithmetic overflow condition is detected, an event report shall be generated.

RV-GDIR-8473 / T

Whenever an illegal programme instruction is encountered during execution of a program code, an event report shall be generated.

RV-GDIR-8474 / T

Whenever a data bus error is detected by software, an event report shall be generated.
Whenever a memory corruption is detected by an error detection and correction mechanism, an event report shall be generated.

Whenever a checksum error is detected, an event report shall be generated.

A processor should perform internal consistency checks by comparing its actual status and configuration against a set of allowable status and configuration tables.

Whenever an internal inconsistency is detected, an event report shall be generated.

The event reports that are generated in the case of a failure shall indicate the type of the failure, its location and any additional information needed for failure diagnosis.

Onboard software shall perform a continuous memory scrubbing function of all volatile memory as background activity.

Note: As a minimum each memory cell shall be scrubbed every 30 minutes.

When a single bit error is detected, the memory address shall immediately be scrubbed (read/write-back cycle) to avoid double triggering of the same bit error.

The onboard software developed shall be composed of two stand-alone packages for each hardware unit:

- Initialisation software
- Full mission application software

Note: They shall not run in parallel on the same processor.

The initialisation software shall:

- Execute in PROM and/or RAM
- Perform a check of RAM and processor functions
- Load the mission application software from NVM to RAM

The initialisation software shall support a minimum subset of the standard “Packet Utilization Standard” as defined in the Space to Ground ICD [IR 16]:

- Service 1: Complete
• Service 3: Only a default set of periodic HK packets
• Service 5: Only event reporting subservices
• Service 6: Complete
• Service 9: Time synchronisation (if applicable)
• Service 17: Answering ping from ground or OBC

RV-GDIR-8485 / / T
The equipment/subsystem shall contain a non-volatile memory used to store the initialisation software responsible to start-up the equipment/subsystem.

RV-GDIR-8486 / / T
The non-volatile memory of the initialisation software shall be separate from the mission software and protected against overwriting.

RV-GDIR-8487 / / T
The initialisation software shall support the communication interface between equipment/subsystem and OBC.

RV-GDIR-8488 / / T
The initialisation software shall generate a boot report including all results of all individual tests and sufficient information about which test has been executed after start-up.

RV-GDIR-8489 / / T
The initialisation software shall have the capability to store all test results.

RV-GDIR-8490 / / T
The initialisation software shall have the capability to downlink the boot report on request.

RV-GDIR-8491 / / T
The initialisation software shall have the capability to execute individual (re-)test(s) on request.

RV-GDIR-8492 / / T
The initialisation software shall never reach HALT (e.g. processor HALT) conditions during execution.

RV-GDIR-8493 / / T
A failed test shall not lead to a dead lock of the initialisation software.

3.9 Planetary Protection and Cleanliness Control Requirements

3.9.1 Planetary Protection Requirements

In accordance with COSPAR planetary protection guidelines, the ExoMars mission is classified as Planetary Protection Category IVb, being a mission with life detection instruments and no access to special regions on Mars. To comply with the planetary protection requirements is not only related to mission success of the ExoMars mission itself but aims to limit the biological contamination of the Martian environment to avoid compromising future exobiological investigations.
Bioburden and organic contamination have a crucial impact on the ExoMars mission scientific objectives. It is essential that the requirements of planetary protection are recognised at the earliest stage in the design process.

The importance of Planetary Protection (PP) cannot be over-stated. The following synthesis of PP requirements must be fully understood and addressed and a detailed response to all of the requirements listed below is mandatory. It is essential that these requirements are understood and appropriate Planetary Protection measures are implemented during both design and build phases. The quantitative bioburden status of the hardware is required at delivery, to be determined by assay procedure as per Annex 2 of [NR 01].

Planetary Protection requirements must be addressed at design stage. PP requirements have impact on e.g.; selection of materials and processes, hardware layout and topography, compatibility with cleaning/sterilisation process, compatibility with alcohol wiping processes, and compatibility with bio-assay procedures (alcohol/water swabs).

RV-GDIR-4908 / PPIR-360, MS-CL-0023 / R

To avoid degradation of materials and improve treatment efficiency, materials selection and flight hardware design shall take into account compatibility and suitability with cleaning, sterilization and bioburden assays.

RV-GDIR-5299 / PPIR-310, PPIR-330, PPIR-400 / T,A,R

The function and performance of flight hardware shall not be degraded by the application of the required sterilisation cycles using one of the sterilization methods described below.

Note: The preferred sterilization method for flight hardware (and any delivered GSE) is Dry Heat Microbial Reduction (DHMR) as defined in [NR 01], Annex 3.

Note: Minimum temperature for dry heat microbial sterilization is 110°C.

- D-value to be used for all exposed and mated surfaces is 1 hour at 125°C
- D-value to be used for encapsulated material is 5 hours at 125°C
- Z-value to be used is 21°C.

A 4-log reduction of bioburden is expected depending on pre-sterilization bioburden (based on a 6-log process described by D-values). It is accepted that in practise, there is a real possibility that not all hardware will be compatible with this procedure. Nevertheless, this requirement stands as the primary design driver for ExoMars Rover Vehicle Hardware. Where this requirement cannot be met, the customer must be informed immediately.

Note: A nominal DHMR cycle of 6 hours at 125°C at the specified humidity, plus ramp up and ramp down times and conditions, shall be assumed for compatibility assessment.

Note: Alternative bioburden reduction or sterilisation measures may be applied; these however will be subject to prior approval by the customer and the ESA Planetary Protection Officer (PPO), and will require ratification by assay.

Note: Alternative techniques include hydrogen peroxide gas plasma and gamma irradiation.

RV-GDIR-5300 / / T,A,R

GSE used in common facilities to sterilize flight hardware shall be compatible with one of the sterilization methods described in RV-GDIR-5299.

RV-GDIR-4912 / PPIR-380 / T,A

The flight hardware (and delivered GSE) shall be able to sustain at least three sterilization cycles.

Note:
1) This does not necessarily imply DHMR - if alternative sterilisation methods e.g. Hydrogen Peroxide Plasma or Gamma Irradiation are used, the hardware shall be capable of withstanding three such cycles without impact on performance or reliability.

2) Equipment located inside the Rover body needs to be designed for compatibility but only verified by analysis.

**RV-GDIR-4913 / PPIR-420 / A,R**

Sterilization effects (in particular, thermal expansion and thermal degradation of material properties where DHMR is applied) on different mated components and material combinations shall be taken into consideration.

Note: Sterilization effects on materials like adhesives (particularly structural) shall be analyzed and tests performed (in attachment with the appropriate materials) for retention of bonding strengths, etc by the contractor.

Note: The contractor shall perform appropriate test programmes to substantiate compliance to the above PP requirements. Such test programmes should not be conducted in isolation to e.g. equipment level qualification testing for mission environment - i.e.; DHMR (or any alternative sterilisation procedure if used) need to be considered to be a part of the Total Integrated Mission Environment, and thus shall be included as an additional integral test phase in any Equipment, Assembly or Material Qualification Test Programme. Qualification Test Programmes will be preceded by a Qualification Test Plan and will be subject to approval by the customer prior to commencement of the Test Programme.

**RV-GDIR-4917 / PP-16, PPIR-320 / R**

The flight hardware and appropriate GSE shall be compatible with alcohol wiping.

Note: Alcohol wiping can be used throughout the AIT process to control bioburden. Alcohol wiping is not a sterilisation procedure, it is however an effective bioburden reduction measure if properly performed. The term “alcohol” is restricted in this document to Iso-Propyl Alcohol (Propan-2-ol; IPA) and Ethyl Alcohol (Ethanol) The use of other solvents or cleaning solutions is subject to prior approval by the customer and the ESA PPO.

Caution - specific attention has to be paid regarding compatibility with coatings, surface finishes, and TPS.

Caution - see chapter on electrochemical compatibility in ExoMars Product Assurance Requirements, EXM-MS-RS-ESA-00002.

Note: Any hardware not compatible with alcohol wiping (e.g. sensitive thermal or optical surfaces) shall be identified as early as possible to the Customer.

**RV-GDIR-4919 / PPIR-370 / R**

Surfaces, cavities or discontinuities inaccessible to cleaning shall be avoided as far as possible in the design approach.

**RV-GDIR-4920 / PP-15 / A,R**

All spacecraft hardware shall be compatible with damp swab assays as per “Assay Procedure 1” described in A2.1. of [NR 01]

Caution - see chapter on electrochemical compatibility in ExoMars Product Assurance Requirements, EXM-MS-RS-ESA-00002.

**RV-GDIR-4921 / PPIR-450 / R**

Organic Materials Inventory: a complete list of constituent materials for the equipment/sub-system shall be provided to PP Organization. Material datasheets shall include at least the following features:

- Identifier (e.g.: Trade Mark, MAPTIS code, …)
• Chemical composition
• Rating and references for flammability, off-gassing and fungus growth
• Identification of items and their area which cannot be assayed (as per [NR 01])
• Identification of items and their areas which cannot be cleaned with alcohol
• Temperature tolerance for Dry Heat Microbial Reduction (see Annex 2 of [NR 01], including the list of items that are intolerant
• Organic material list

RV-GDIR-4909 / PA-SY-1940 / R

Materials for hardware where bioburden assessment procedures will be applied (e.g. wet contact by swabbing, wiping) shall be considered as being in a non-controlled (humidity) environment.

RV-GDIR-4922 / I / R

Where bimetallic (galvanic) couples do not fall into Group 0 or Group 1 (ref ECSS-Q-70-71A rev1 (paragraph 5.2.14) or MSFC-SPEC-250 (Protective Finishes for Space Vehicle Structure And Associated Flight Equipment; General Specification for) data.), these locations shall be designated as “non-assayable” and their locations advised to the customer, (risk of galvanic corrosion due to water used during bio-assays).

RV-GDIR-4923 / I / R

Any other locations considered to be non-assayable for whatever reason (e.g.; sensitive optical or thermal control surfaces) shall similarly be identified to the customer as soon as they are identified.

RV-GDIR-4924 / PPIR-080 / I

All flight hardware and appropriate GSE at delivery shall have a certified bioburden level for free surfaces and encapsulated surfaces.

Note: Surface internal to an equipment with free vent paths to the environment are considered as free surfaces. Application of HEPA filters in the vent path allow internal surfaces to be considered encapsulated.

RV-GDIR-4925 / PP-39 / R

An estimate (highest accuracy possible) of the total exposed and encapsulated surface areas on the hardware shall be provided to the customer at PDR, CDR and periodically updated as appropriate.

Note: Estimation of encapsulated/mated hardware bioburden shall be performed using the following values.

Average encapsulated spores density:
- Non-metallic portions of the spacecraft 130 spores/cm³

Source specific encapsulated spore density:
- Electronic piece parts 3-150 spores/cm³
- Other non-metallic materials 1-30 spores/cm³

Source specific enclosed surface spore density:
- Clean room-highly controlled 500-5000 spores/m²
- Clean room-normal control 5000-105 spores/m²
- Uncontrolled manufacturing 105-106 spores/m²
3.9.2 Cleanliness Control Requirements

RV-GDIR-5468 / MS-CL-0022 / I,R

Equipment shall comply with the cleanliness and contamination control requirements of [NR 03].

RV-GDIR-5281 / MS-CL-0022 / A

The following materials are potential contaminants and shall not be used without approval.

- Aromatic hydrocarbons (e.g. benzene, toluene, higher molecular weight aromatics, Polycyclic aromatic hydrocarbons)
- S, N, O heterocyclic aromatics (e.g. furan, pyridine, pyramadine, benzothiopene)
- Carboxylic acids and their salts (e.g. alkyl and aromatic acids, fatty acids)
- Non aromatic hydrocarbons (e.g. alkanes, alkenes, atmospheric methane)
- Nitrogen containing compounds (e.g. Amino acids, amines, amides, purines, pyrimidines, porphyrins)
- Alcohols
- Carbonyl compounds (e.g. esters, ketones, aldehydes)
- Sulfonylic, phosphonic acids (e.g. methanesulfonic acid)
- Lipids and derivatives
- Sugars and derivatives
- Proteins
- Nucleic acids, nucleotides (e.g. DNA fragments)

RV-GDIR-5282 / MS-CL-0009 / A,R

Equipment shall not require purging after delivery for integration to Rover Vehicle.

RV-GDIR-5283 / MS-CL-0015 / R

All non-metallic materials used on flight hardware shall be identified by the following information.

- Commercial identification
  Trade name and number, correct and standard designation. If no trade name exists, then the manufacturer's name plus number are entered.
- Composition
  Chemical composition of the material.
- Use and location
  Indicates in what subsystems, box or item the material is used and whether it acts as a structural element, thermal control, electrical insulation etc. as relevant.
- Cure
  Description of thermal cure parameters, if any
- Temperature
Nominal operating temperature [°C] - average and maximum

- **Size**
  Surface area [cm²] or mass [g] and the indication if the identified non-metallic material is sealed or not

- **Thermal vacuum stability (TVS) values** from identified reference:
  - TML
  - RML
  - CVCM

- **Condensable outgassing rates**
- **Outgassed products and relevant quantities**

Condensable outgassing rates from dynamic outgassing tests such as ESA VBQC-test shall be provided (at material/item operative temperatures).

Relevant condensable outgassing rate at operating temperatures shall be provided taking into account all the processes the item is going to undergo before being delivered to Prime (e.g. DHMR).

Information on outgassed products and relevant quantities shall be provided for all materials.

**RV-GDIR-5284 / MS-CL-0020 / R**

Mechanisms shall not generate and release particulate debris or molecular contaminants as listed in RV-GDIR-5281.

**RV-GDIR-5288 / MS-CL-0025, MS-CL-0026, MS-METH-REQ-1380 / R**

Materials used shall have the following characteristics (as defined in ECSS-Q-70-02A).

- TML < 0.2% (<1% for internal small low-weight internal components)
- RML < 1%
- CVCM < 0.1%.

Note: Silicone-free materials should be used whenever possible.

Note: Bake-out of hardware may be used as a method to achieve the required characteristics.

**RV-GDIR-5290 / MS-CL-0027 / T,R**

Materials and process that could result in particulate contamination through flaking, dust generation or shattering shall not be used.

**RV-GDIR-5293 / MS-CL-0037 / T**

The cleanliness level of hardware at delivery shall be verified to be particulate level Class 300 and molecular level A/10 (i.e.0.1 x 10⁻⁶ g/cm²) as defined in [NR 03].

Note: The particulate levels must be quantitatively measured and certified by e.g. Tape Lift Test per [IR XX] (ECSS-Q-ST-70-01A; section 4.4.1; Cleanliness and contamination control) Molecular levels must be quantified by solvent wipe or solvent rinse method per [NR 03] (section 4.4.2) and [IR YY] ECSS-Q-ST-70-05C Annex “F” - ("Detection of organic contamination of surfaces by infrared spectroscopy").

**RV-GDIR-5286 / MS-CL-0022 / R**

Equipment shall comply with the contamination control requirements of [NR 03]
4 ENVIRONMENT DESIGN REQUIREMENTS

4.1 Atmospheric Conditions

4.1.1 Humidity

RV-GDIR-2455 / I, R
The unit shall be designed to withstand a relative humidity range of 30% to 60% during integration, testing and transport.

4.1.2 Atmosphere

RV-GDIR-4386 / I, T
All externally mounted hardware shall be designed to be compatible with the Martian environment reported in §4 and §5 of [IR 01].

4.2 Mechanical Environment

Mechanical environments for all mission phases are defined in the equipment specification.

4.3 Thermal Environment

RV-GDIR-2987 / I, T,A
For AIV and storage, the unit shall withstand temperature conditions as follows:

- **Storage**: -10°C to +40°C
- **Transportation**: -10°C to +40°C
- **Integration**: +10°C to +30°C
- **Unit testing**: Unit non operational and operational temperature requirement ranges as per RV-GDIR-2991.

RV-GDIR-2989 / I, T,A
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 environment:

- **External temperatures**: -10°C to +40°C

RV-GDIR-4498 / I, A
The definition of the thermal environment at the Martian surface described by [IR 02] shall be used.

4.4 Radiation Environment

The radiation environment induces two types of degradation:

- **Long term degradation**: generated mainly by electrons and protons, following an accumulation of ionising dose deposition in circuits insulators or by atom displacement (protons only).
- **Single Event Effects**: generated by protons and heavy ions coming from solar flare and galactic cosmic rays. In this case, we consider that only one particle (protons or heavy ion) can induce the degradation by striking a sensitive volume in circuits. For heavy ions interaction, the energy deposition is described in term of Linear Energy Transfer (LET).

Note: the level of confidence on the values specified is 95%.
The radiation environment for Mars transfer and in Mars orbit is not as well defined as environments nearer to Earth. However, the radiation environment for all but very lightly shielded components is predominantly energetic (greater than 1MeV) solar protons (and heavy ions) and galactic cosmic rays (GCR) and these are most likely to induce single-event effects (SEE) or degradation/failure due to total ionising dose or displacement damage in electronic components.

The Plasma environment (particles of less than 1MeV) may cause electrostatic discharge and degradation of unshielded or very lightly shielded materials.

4.4.1 Total Ionising Dose

The total ionising dose environment for ExoMars up to Landing is presented in Figure 4-1 and Table 4-1.

Note: The total dose after landing is considered to be negligible in comparison to the dose prior to landing.

![ExoMars - Total Dose vs. Al Shielding](image)

Figure 4-1: Total Dose in Silicon as a Function of Spherical Aluminium Shielding for the Mission up to Landing

<table>
<thead>
<tr>
<th>Aluminium Shielding Thickness [mm]</th>
<th>ExoMars - Integrated Solar Proton Fluence [#/cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.00E-02</td>
<td>1.81E+05</td>
</tr>
<tr>
<td>1.00E-01</td>
<td>8.94E+04</td>
</tr>
<tr>
<td>2.00E-01</td>
<td>4.59E+04</td>
</tr>
<tr>
<td>3.00E-01</td>
<td>3.22E+04</td>
</tr>
<tr>
<td>4.00E-01</td>
<td>2.40E+04</td>
</tr>
<tr>
<td>5.00E-01</td>
<td>1.87E+04</td>
</tr>
<tr>
<td>6.00E-01</td>
<td>1.50E+04</td>
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<tr>
<td>8.00E-01</td>
<td>1.08E+04</td>
</tr>
<tr>
<td>1.00E+00</td>
<td>8.93E+03</td>
</tr>
<tr>
<td>1.50E+00</td>
<td>6.36E+03</td>
</tr>
<tr>
<td>2.00E+00</td>
<td>4.82E+03</td>
</tr>
</tbody>
</table>
Aluminium Shielding Thickness [mm] | ExoMars - Integrated Solar Proton Fluence [#/cm²]
--- | ---
2.50E+00 | 3.85E+03
3.00E+00 | 3.13E+03
4.00E+00 | 2.16E+03
5.00E+00 | 1.62E+03
6.00E+00 | 1.36E+03
7.00E+00 | 1.18E+03
8.00E+00 | 1.04E+03
9.00E+00 | 9.39E+02
1.00E+01 | 8.44E+02
1.20E+01 | 7.06E+02
1.40E+01 | 5.96E+02
1.60E+01 | 5.15E+02
1.80E+01 | 4.54E+02
2.00E+01 | 3.97E+02

RV-GDIR-5081 / MS-EVT-1260 / T,A

All hardware shall meet all performance requirements after exposure to 2 times the fluences given below:

- 3.5 krad (Si) for hardware located internal to the rover body
- 5 krad (Si) for hardware located external to the rover body

Rationale: Assumes a conservative 2mm of equivalent aluminium shielding from the DMC and 1mm of equivalent aluminium shielding from the rover body.

4.4.2 Displacement Damage and Non-ionising Dose

RV-GDIR-3036 / / T,A

All hardware shall meet all performance requirements after exposure to 2 times the proton fluence given in Table 4-2.

Note: This environment is to be used for degradation effects including displacement damage.

Table 4-2: Solar Proton Spectrum for the Mission up to Landing

<table>
<thead>
<tr>
<th>Proton Energy [MeV]</th>
<th>ExoMars - Integrated Solar Proton Fluence [#/cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.85E+11</td>
</tr>
<tr>
<td>2</td>
<td>1.18E+11</td>
</tr>
<tr>
<td>3</td>
<td>8.14E+10</td>
</tr>
<tr>
<td>4</td>
<td>6.14E+10</td>
</tr>
<tr>
<td>5</td>
<td>5.03E+10</td>
</tr>
<tr>
<td>6</td>
<td>4.29E+10</td>
</tr>
<tr>
<td>8</td>
<td>3.18E+10</td>
</tr>
<tr>
<td>10</td>
<td>2.44E+10</td>
</tr>
<tr>
<td>12</td>
<td>2.07E+10</td>
</tr>
<tr>
<td>15</td>
<td>1.63E+10</td>
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<tr>
<td>17</td>
<td>1.48E+10</td>
</tr>
<tr>
<td>20</td>
<td>1.18E+10</td>
</tr>
<tr>
<td>25</td>
<td>8.88E+09</td>
</tr>
<tr>
<td>30</td>
<td>7.03E+09</td>
</tr>
<tr>
<td>35</td>
<td>5.99E+09</td>
</tr>
<tr>
<td>40</td>
<td>5.18E+09</td>
</tr>
<tr>
<td>45</td>
<td>4.51E+09</td>
</tr>
<tr>
<td>50</td>
<td>3.92E+09</td>
</tr>
</tbody>
</table>
4.4.3 Single Event Effects (SEE)

RV-GDIR-5173 / MS-EVT-1280 / T,A

All hardware shall meet all performance requirements while being exposed to the Solar minimum heavy-ion flux described by the CREME96 model.

Note: https://creme96.nrl.navy.mil/

RV-GDIR-5174 / MS-EVT-1280 / T,A

All hardware shall survive and recover from solar particle events described by the CREME96 solar flare environment as the Worst 5 minutes, Worst Day and Worst Week.

Note: Hardware is not required to operate through Worst 5 minutes, Worst Day and Worst Week particle event conditions.

RV-GDIR-5175 / MS-EVT-1280 / T,A

All hardware shall survive and recover from exposure to the proton environment described by the CREME96 solar flare environment as the Worst 5 minutes, Worst Day and Worst Week.

Note: Hardware is not required to operate through Worst 5 minutes, Worst Day and Worst Week proton environment.

4.4.3.1 Destructive Single Event Effects

RV-GDIR-5177 / RM-ROV-2370 / R

Parts that are susceptible to destructive SEE shall not be used.

RV-GDIR-5178 / RM-ROV-2370 / R

MOSFETs that are susceptible to Single Event Gate Rupture (SEGR) and MOSFETs, Field Effect Transistors (FETs), bipolar transistors that are susceptible to Single Event Burnout (SEB) shall be operated with their application voltages in the safe operating region of the devices.

Note: A Linear Energy Transfer (LET) threshold of 20 MeVcm²/mg for SEB and SEGR is considered insensitive.
4.4.3.2 Single Event Upsets (SEU)

RV-GDIR-3043 / RM-ROV-2370 / A,R

Processors, memories and other components shall be evaluated to withstand a LET of 20 MeV/\(cm^2/mg\).

Note: Where this requirement cannot be met, processors and memories must be able to self recover autonomously from a SEU without impacting nominal operation of the unit. When components sensitive to SEU are selected, the design must take care, that solutions to prevent the effects of SEU on the mission are implemented into the equipment in Hardware and/or in Software (e.g. Error Detection & Correction (EDAC) and scrubbing routines). Adequate measures must be applied to avoid the accumulation of SEU’s in storage devices.

RV-GDIR-3044 / RM-ROV-2370 / R

The reset or data corruption occurrence rate due to Single Event Upset (SEU) shall not exceed \(1E^{-4}\) per day.

Figure 4-2 depicts the "Unshielded worst-case instantaneous energy spectra of trapped electrons, trapped protons and solar energetic (geomagnetically shielded) for the mission, for internal charging and sensor interference analysis.

![Instantaneous Worst Case Energy Spectra](image)

Figure 4-2: Unshielded Worst Case Instantaneous Energy Spectra

4.4.3.3 Single Event Latch-Up (SEL)

RV-GDIR-3048 / RM-ROV-2370 / A,R

Microcircuits containing CMOS technologies shall be evaluated to withstand an LET of 60 MeV/cm²/mg without latchup.

Rationale: The requirement is imposed to account for the maximum solar flare activity (Figure 4-3).

RV-GDIR-5179 / RM-ROV-2370 / R

Devices which are known to be susceptible to latch-up’s shall not be used.
4.5 EMC Environment

4.5.1 Conducted Emissions

Note: All conducted requirements are applicable for both regulated and unregulated power unless otherwise noted

4.5.1.1 Inrush Current

RV-GDIR-3077 / T,A

Inrush current at unit switch on shall not exceed the following characteristics:

- \( \frac{dI}{dt} < 2 \text{ A/\(\mu\text{s}\)}, \text{ Maximum 25A} \)
- \( Q < 3\text{ms}^*\text{IL}, \text{ for the input filter setting time of } t < 3\text{ms} (I = \text{LCL Trip-Off Class in [A]}) \)

Note: For unregulated power busses, this requirement shall be tested at maximum and minimum bus voltage.

4.5.1.2 Voltage Transients

RV-GDIR-3079 / T,A

The transient on the primary power bus distribution during switch-ON/OFF of a unit shall stay within the limits of the voltage transient envelope (see Figure 4-4).
Notes:
1. This envelope of voltage transients is applicable between 0 and 50us.
2. 0.5 Unom = 14V

**Figure 4-4: Voltage Transient Envelope**

*RV-GDIR-8559 / / T,A*

*The voltage transient during switching on/off for the regulated bus beyond 50us shall be contained within the envelopes given in Figure 4-5.*

**Figure 4-5: Voltage Transient for Regulated Bus**

*RV-GDIR-8561 / / T,A*

*The voltage transient during switching on/off for the unregulated bus from 1ms shall be contained within the envelopes given in Figure 4-6.*
4.5.1.3 Conducted Emissions on Power Leads, Frequency Domain

RV-GDIR-3083 / MS-EMC-01360, MS-EMC-01361 / T,A

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 4-7.

Note: This requirement shall be applied to each power bus (regulated main bus, unregulated bus and external secondary bus).

RV-GDIR-3085 / MS-EMC-01360 / T

Conducted narrow band current emissions (common mode) in the frequency range 10 kHz - 500 MHz appearing on the unit’s primary power lines shall not exceed the limits of Figure 4-8.

Note: This requirement shall be applied to each power bus (regulated main bus, unregulated bus and external secondary bus).
4.5.1.4 Conducted Emissions on Power Leads, Time Domain

RV-GDIR-3089 / / T,A

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.

Note: The voltage ripple shall be measured with at least 50 MHz bandwidth.

RV-GDIR-3090 / MS-EMC-01361 / T,A

For Primary Power users (regulated power), time domain conducted emissions, differential mode (ripple and spikes) shall be:

- $< 300$ mVpp for the regulated power
- $< 500$ mVpp for the unregulated power

Notes:

1) The voltage ripple shall be measured with at least a 50 MHz bandwidth.

2) This requirement applies during all unit operations including redundancy and mode switching.

RV-GDIR-8563 / MS-EMC-01362 / T,A

The peak to peak input current ripple (including spikes) of any unit shall be less than 60 mApp, normalized to an input nominal current of 1A.

Notes:

1) For loads with higher nominal current, the limit shall be relaxed by $\sqrt{I(A)}$, where $I(A)$ is the load nominal current.

2) The measurement shall be performed with a bandwidth higher or equal to 50 MHz.

3) The spike shall be defined as transitory high frequency oscillations with duration lower than 10 us and without a repetitive period

4) Datafiles including test measurements shall be provided.
4.5.1.5 Conducted Emissions in Case of Failure

RV-GDIR-3093 / / T,A

In the event of a single failure, the amplitude of the spectral signatures on the primary power lines shall not exceed by more than 6dB the limits required for both differential and common mode emissions.

Note: The analysis is limited to a single failure on the main elements of the primary power interface. The contractor shall justify by analysis or by breadboard tests the compliance to the present requirement.

4.5.1.6 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.

4.5.1.6.1 CE for secondary power supply units, Frequency Domain

RV-GDIR-3097 / / T,A

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.

Note: The secondary supplies must be loaded by the representative (R, L, C) loads specified in the unit interface specifications. The load networks must be isolated from ground for these measurements.

4.5.1.6.2 CE for secondary power supply units, Time Domain

RV-GDIR-3099 / / T,A,R

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.

Note: The secondary supplies must be loaded by the representative (R, L, C) loads specified in the unit interface specifications. The load networks must be isolated from ground for these measurements.

4.5.1.7 Conducted Emissions on Signal Bundles, Common Mode

RV-GDIR-3101 / MS-EMC-01365 / T,A,R

Conducted Narrow band conducted emissions (common mode) in the frequency range 10 kHz - 500 MHz as measured on the unit’s signal bundles shall not exceed the limits of Figure 4-9.

Note: This requirement applies also to secondary power bundles.
4.5.2 Conducted Susceptibility on Regulated Power Lines

4.5.2.1 CS Sine Wave, Differential Mode

**RV-GDIR-3105 / MS-EMC-01410 / T,A**

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 - 500 MHz (modified combination of MIL-STD-461C CS01 and CS02 requirements) are developed across the power input terminals (differential mode).

Notes:
1) The applied sine wave shall be amplitude modulated (50% AM) with a modulation frequency of 1 kHz in the frequency range from 50 kHz - 500 MHz.
2) 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.
3) The requirement shall also be considered met when:
   - Frequency range 30 Hz - 50 kHz:
     The specified test voltage levels cannot be generated but the injected current has reached 5 A (rms), and the equipment is still operating nominally:
   - Frequency range 50 kHz - 500 MHz:
     A 1-watt source of 50 Ohms impedance cannot develop the required voltage at the unit’s power input terminals, and the unit is still operating nominally.
4) Anytime a susceptibility is found, the voltage shall be reduced until the unit returns to normal operation. Both the frequency and the minimum voltage to get to normal operational conditions shall be reported.
5) The requirement applies for both regulated and unregulated bus.

4.5.2.2 CS Sine Wave, Common Mode

**RV-GDIR-3107 / / T,A**

Primary power bus powered units shall not exhibit any failure, malfunction or unintended responses when sine wave voltages of 200 mVrms in the frequency range 10 kHz - 500 MHz are injected between the primary power return and structure (common mode).
Notes:

1) The applied sine wave shall be amplitude modulated (50% AM) with a modulation frequency of 1 kHz in the frequency range from 50 kHz - 500 MHz.

2) The frequency sweep rate shall be adjusted based on the characteristics of the units internal frequencies, but not faster than 3min/decade

3) The injected current shall be limited to 1A (rms), if necessary the voltage shall be reduced.

4) Anytime a susceptibility is found, the voltage shall be reduced until the unit returns to normal operation. Both the frequency and the minimum voltage to get to normal operational conditions shall be reported.

5) The requirement is applicable for both regulated and unregulated power bus.

4.5.2.3 CS Transient

RV-GDIR-3109 / MS-EMC-01415, MS-EMC-01420 / T,A

The unit shall not exhibit any failures, malfunctions or unintended responses when the following transient voltages are superimposed on the primary power bus inputs, Figure 4-10

Note: The transient voltages to be applied on units connected on regulated buses (respectively on unregulated buses) should be the one defined in Table 4-3.

![CS Transient Waveform](image)

Figure 4-10: CS Transient Waveform

<table>
<thead>
<tr>
<th>Injection Mode</th>
<th>Regulated</th>
<th>Unregulated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DM</td>
<td>CM</td>
</tr>
<tr>
<td>Max Voltage</td>
<td>Slow</td>
<td>Fast</td>
</tr>
<tr>
<td></td>
<td>±3 Vpp</td>
<td>±28 Vpp</td>
</tr>
<tr>
<td>Duration</td>
<td>700ìs</td>
<td>10ìs</td>
</tr>
</tbody>
</table>

4.5.2.4 Units Linked by Secondary Power Lines

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

RV-GDIR-3159 / T

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.
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.

4.5.2.4.1 CS Sinewave Injection for Secondary Power Supply Units

The conducted susceptibility 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 10 kHz up to 50 MHz in common mode

A margin of at least +6dB shall be demonstrated in frequency domain between the supplier highest emission levels and the supplied unit susceptibility level.

4.5.3 Radiated Emissions (E field)

The unit shall not exceed the radiated electric fields narrow band (NB) in the range 10 kHz - 20GHz in excess of the limit reported in Figure 4-11, Table 4-4 and Table 4-5.

Note: The launcher Radiated Emissions limits Table 4-4 only apply to units that are powered at launch.

![Figure 4-11: Radiated Emissions Electric Field](image)

<table>
<thead>
<tr>
<th>Frequency Band [MHz]</th>
<th>Level [dBμV/m]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>410 to 430</td>
<td>29</td>
<td>Atlas</td>
</tr>
<tr>
<td>1570 to 1640</td>
<td>54</td>
<td>Proton</td>
</tr>
<tr>
<td>2720 to 2730</td>
<td>50</td>
<td>Proton</td>
</tr>
<tr>
<td>5660 to 5760</td>
<td>54</td>
<td>Atlas &amp; Proton</td>
</tr>
</tbody>
</table>

Table 4-5: TT&C & System Notches Electric Field
4.5.4 Radiated Emissions (H field)

RV-GDIR-3227 / MS-EMC-01380 / T,A

The radiated H field generated by units shall not exceed the limits specified in Figure 4-12.

![Figure 4-12: Radiated Emissions Magnetic Field](image)

4.5.5 Radiated Susceptibility (E field)

RV-GDIR-3230 / MS-EMC-01430 / T,A

The unit shall not show any malfunction or deviation from the specified performance when irradiated with the E-fields 10 kHz to 20 GHz: 4 V/m rms.

Note: The injected sinewave signal shall be 30% amplitude modulated by a 1 kHz square wave. Above 30 MHz the requirement shall be met for both horizontally and vertically polarized wave. The test shall be performed following the MIL-STD-461E (RS103) or MIL-STD-462D (RS103).

RV-GDIR-3231 / MS-EMC-01431, MS-EMC-01432 / T,A

The unit shall not show any malfunction or deviation from the specified performance when irradiated with the E-fields as listed in Table 4-6 and Table 4-7.

Note: Table 4-7 applies only to units powered during launch.

<table>
<thead>
<tr>
<th>Frequency Band [MHz]</th>
<th>Level [dBμV/m]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2206 to 2216</td>
<td>156</td>
<td>Atlas</td>
</tr>
<tr>
<td>5660 to 5760</td>
<td>156</td>
<td>Atlas</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency Band [MHz]</th>
<th>Level [dBμV/m]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band UHF - 400 to 450</td>
<td>148</td>
<td>Direct Up Link</td>
</tr>
<tr>
<td>500 to 3000</td>
<td>140</td>
<td>WISDOM Payload</td>
</tr>
</tbody>
</table>
4.5.6 Radiated Susceptibility (H field)

RV-GDIR-3313 / MS-EMC-01440 / T,A

Units shall not show any malfunction or deviation from the specified performance when irradiated with an H-field of 140 dBpT in the frequency range 50 Hz - 50 kHz.

RV-GDIR-3314 / T,A

In the case where a unit uses technologies which are known to be sensitive to AC or DC magnetic fields (e.g. USO's, motors, etc.), this sensitivity shall be reported together with an estimate of the maximum allowed magnetic field.

4.5.7 DC Magnetic Requirements

RV-GDIR-3317 / I,R

The use of ferro-magnetics shall be avoided for parts, components, and equipment structure.

Note: Materials shall be used which are non-magnetic or, if magnetic characteristics cannot be avoided, have the lowest residual field. In particular soft magnetic material shall be avoided whenever possible.

RV-GDIR-3319 / T,I,R

Steel or other magnetic materials shall be avoided for use in the mechanical hardware, and their use shall be minimised in any support equipment. If the use of steel in the mechanical hardware is unavoidable, it shall be stainless steel of proven non-magnetic characteristics.

RV-GDIR-3321 / R

The use of relays shall be limited to the most critical functions, which cannot be handled by solid state switching.

4.5.8 ESD Susceptibility

Note: ESD susceptibility testing is only applicable to Qualification Model, Engineering Model unit builds only. It shall not be performed on Proto Flight or Flight unit builds.

RV-GDIR-3325 / MS-EMC-01460 / T,A

Units shall not be susceptible when submitted to conducted electrostatic discharge with the following characteristics:

- Magnitude/Energy: >10kV/10mJ
- Peak current: 50A typical
- Rise time (10%-90%): <10ns
- Duration (half amplitude): 100ns
- Repetition rate: 10Hz
- Duration: >3 min

RV-GDIR-8558 / MS-EMC-01461 / T,A

Units shall not be susceptible when submitted to radiated electrostatic discharge with the following characteristics:

- Magnitude: >10kV
- Peak current: 50A typical
- Energy: 15mJ
- Distance between source and unit: 30 cm
- Repetition rate: 10Hz
- Duration: >3 min
5  SUBSYSTEM AND EQUIPMENT LEVEL VERIFICATION

5.1  Verification of Requirements

RV-GDIR-5465 / / R

Verification of requirements shall be conducted in accordance with [NR 08]

5.2  Environment Test Requirements

RV-GDIR-5196 / / R

Testing performed at unit level shall be performed in accordance with [NR 09] and with [IR 10], as defined by subsystem and equipment specifications.

Note: Where planned testing is not in accordance to this specification the testing approach will be agreed between the contractor and Astrium prior to the relevant TRR.
6  APPENDIX A : MICD

6.1 Mechanical Interface Datasheet

RV-GDIR-3974 / / R

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

Note: The unit Interface Control Document must describe at least the topics identified in Table 6-1, Table 6-2, Table A-3, Table A-4 and Table A-5. These drawings must detail all co-ordinate systems used and their relationship to each other, together with the principal unit interfaces.

<table>
<thead>
<tr>
<th>Table 6-1: Unit Mechanical Interface Control Document content (1/4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICD reference, issue, revision, date and configuration stamp</td>
</tr>
<tr>
<td>Reference frame axes</td>
</tr>
<tr>
<td>Overall envelope (outline dimensions and relative tolerances)</td>
</tr>
<tr>
<td>Mobile Parts (if any) in the different configurations</td>
</tr>
<tr>
<td>Outline dimensions and relative tolerances</td>
</tr>
<tr>
<td>Type of mobile part, dimensions, location and attachment</td>
</tr>
<tr>
<td>Clearance envelope</td>
</tr>
<tr>
<td>Viewing aperture (location, orientation, FOV dimension and tolerance)</td>
</tr>
<tr>
<td>Alignment reference (location, orientation, FOV dimension and tolerances)</td>
</tr>
<tr>
<td>Mass properties</td>
</tr>
<tr>
<td>Mass</td>
</tr>
<tr>
<td>Centre of mass (nominal location and in different configurations (stowed, deployed… in case of mobile parts)</td>
</tr>
<tr>
<td>Inertia (for unit of mass &gt; 10 kg)</td>
</tr>
</tbody>
</table>
### Table 6-2: Unit Mass - CoG - Inertia Data Sheet

<table>
<thead>
<tr>
<th>Ref</th>
<th>UNIT or ASSEMBLY</th>
<th>Uncert %</th>
<th>Current MASS per UNIT (Kg)</th>
<th>UNIT size (1) Height, Width, Length (m)</th>
<th>UNIT moments of INERTIA through unit CoG (2) (Kg m²)</th>
<th>UNIT moments of INERTIA through unit CoG (2) (Kg m²)</th>
<th>UNIT CoG position wrt unit Mechanical Frame (3) (m)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Y</td>
<td>Z</td>
<td>I_{XX}</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</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>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) : Unit overall size in an axis system parallel to unit mechanical frame O_{unit-mf}, relative dimensions from unit mechanical frame to be provided.

(2) : Unit Inertias in the mechanical frame but with the origin translated to the unit CoG. Moments and products of inertia are defined as follows:

\[ I_{XX} = \int M (Y^2 + Z^2) \, dm \]
\[ I_{YY} = \int M (X^2 + Z^2) \, dm \]
\[ I_{ZZ} = \int M (X^2 + Y^2) \, dm \]
\[ I_{XY} = \int M X Y \, dm \]
\[ I_{XZ} = \int M X Z \, dm \]
\[ I_{YZ} = \int M Y Z \, dm \]

(3) : CoG co-ordinates are given wrt Instrument Mechanical Frame RF (O_{u}, X_{u}, Y_{u}, Z_{u}).
Table 6-3: Unit Mechanical Interface Control Document content (2/4)

<table>
<thead>
<tr>
<th>Attachment bolt type</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tightening torque</td>
<td></td>
</tr>
<tr>
<td>Number of attachment holes</td>
<td></td>
</tr>
<tr>
<td>Reference hole location</td>
<td></td>
</tr>
<tr>
<td>Attachment hole location (w.r.t reference)</td>
<td></td>
</tr>
<tr>
<td>Attachment hole location tolerances</td>
<td></td>
</tr>
<tr>
<td>Holes dimensions and tolerances</td>
<td></td>
</tr>
<tr>
<td>Screw head or washer surface dimension and tolerance</td>
<td></td>
</tr>
<tr>
<td>Attachment point thickness</td>
<td></td>
</tr>
<tr>
<td>Attachment point dimension</td>
<td></td>
</tr>
<tr>
<td>Clearance for mounting hardware</td>
<td></td>
</tr>
<tr>
<td>Contact surface area</td>
<td></td>
</tr>
<tr>
<td>Contact surface flatness</td>
<td></td>
</tr>
<tr>
<td>Contact surface roughness</td>
<td></td>
</tr>
<tr>
<td>Edge radius</td>
<td></td>
</tr>
<tr>
<td>Minimum distance between attachment holes</td>
<td></td>
</tr>
<tr>
<td>Distance between attachment holes and unit side wall</td>
<td></td>
</tr>
<tr>
<td>Angle of attachment hole to attachment surface</td>
<td></td>
</tr>
<tr>
<td>Free width between webs</td>
<td></td>
</tr>
</tbody>
</table>

Table 6-4: Unit Mechanical Interface Control Document content (3/4)

<table>
<thead>
<tr>
<th>Electrical connectors</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification label</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Pin 1 location</td>
<td></td>
</tr>
<tr>
<td>Minimum distance between adjacent connectors</td>
<td></td>
</tr>
<tr>
<td>Number of unit connector face</td>
<td></td>
</tr>
<tr>
<td>Grounding device</td>
<td></td>
</tr>
<tr>
<td>Bonding stud or hole location</td>
<td></td>
</tr>
<tr>
<td>Tightening torque</td>
<td></td>
</tr>
</tbody>
</table>

General Design and Interface Requirements

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### Electrical connectors
- Identification label
- Location
- Pin 1 location

### Harness (where applicable, i.e. for piggy tail harness)
- Output Location
- Length
- Diameter (when greater than 15mm)

<table>
<thead>
<tr>
<th>Table 6-5: Unit Mechanical Interface Control Document content (4/4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonding strap (location, dimensions, tolerances...)</td>
</tr>
<tr>
<td>Thermal blanket attachment points (location, dimensions, tolerances...) if any</td>
</tr>
<tr>
<td>Harness tyrap attachment points (location, dimensions, tolerances...) if any</td>
</tr>
<tr>
<td>Fluid gas connection (type, definition, location, dimensions, tolerances...) if any</td>
</tr>
<tr>
<td>Venting provisions (type, number, location, dimensions...) if any</td>
</tr>
<tr>
<td>MGSE Interface (I/F area characteristics, location, dimension, tolerances...) if any</td>
</tr>
</tbody>
</table>

In addition to the drawing file the MICD shall contain the mechanical data sheets as per table A-6 to table A-12.
### Table 6-6: Unit Mechanical Data Sheet (1/7)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Item (1)</th>
<th>Requirement</th>
<th>Computed</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Frequency (2)</td>
<td>&gt; 140 Hz</td>
<td>1st Frequency (2)</td>
<td>&gt; 140 Hz</td>
<td></td>
</tr>
</tbody>
</table>

### Table 6-7: Unit Mechanical Data Sheet (2/7)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Item (1)</th>
<th>Requirement</th>
<th>Computed</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Frequency (2)</td>
<td>&gt; 140 Hz</td>
<td>1st Frequency (2)</td>
<td>&gt; 140 Hz</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Item (1)</th>
<th>Requirement</th>
<th>Computed</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Frequency (2)</td>
<td>&gt; 140 Hz</td>
<td>1st Frequency (2)</td>
<td>&gt; 140 Hz</td>
<td></td>
</tr>
</tbody>
</table>

### General Design and Interface Requirements

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### GENERAL DESIGN AND INTERFACE REQUIREMENTS

**ESTLTD class:** (4)

<table>
<thead>
<tr>
<th>Items</th>
<th>Requirement</th>
<th>As Design</th>
<th>As Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redundancy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actuation Factor (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No of Cycles (6)</td>
<td>(6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lubrication (7)</td>
<td>(7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>End stops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latching / locking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Release devices (8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-loaded ball bearings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flushing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DESIGN RULES

**QUALIFICATION (before LIFE TEST)**

<table>
<thead>
<tr>
<th>Test</th>
<th>As Requested</th>
<th>As Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly mounting</td>
<td>Representative</td>
<td></td>
</tr>
<tr>
<td>Loads applied</td>
<td>Worst Case</td>
<td></td>
</tr>
<tr>
<td>Test conditions</td>
<td>At ambient</td>
<td></td>
</tr>
<tr>
<td>Test conditions</td>
<td>At Tmin life -20°C</td>
<td></td>
</tr>
<tr>
<td>Test conditions</td>
<td>At Tmax life +20°C</td>
<td></td>
</tr>
<tr>
<td>Test conditions</td>
<td>Worst Tgradient</td>
<td></td>
</tr>
</tbody>
</table>

### ACCEPTANCE

As qualification test, without life test

**LIFE TEST (6)**

Tested as design (see the note, and also GDIR ???)

### INTERFACE INFORMATION

<table>
<thead>
<tr>
<th>Mass</th>
<th>REQUESTED</th>
<th>COMPUTED</th>
<th>MEASURED</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg</td>
<td>+/-</td>
<td>+/-</td>
<td>+/-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Centre of Gravity along Xeq</th>
<th>mm</th>
<th>mm</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre of Gravity along Yeq</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>Centre of Gravity along Zeq</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>Inertia Ixx</td>
<td>kg.m²</td>
<td>+/-</td>
<td>kg.m²</td>
</tr>
<tr>
<td>Inertia Iyy</td>
<td>kg.m²</td>
<td>+/-</td>
<td>kg.m²</td>
</tr>
<tr>
<td>Inertia Izz</td>
<td>kg.m²</td>
<td>+/-</td>
<td>kg.m²</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LENGTH</th>
<th>mm</th>
<th></th>
<th>Number of Bolts:</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIDTH</td>
<td>mm</td>
<td></td>
<td>Remarks:</td>
</tr>
<tr>
<td>HEIGHT</td>
<td>mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6-8: Unit Mechanical Data Sheet (3/7)
### ExoMars Rover Vehicle

Ref: EXM-RM-RQM-ASU-0015  
Issue: 3.1  
Page: 125 of 154

#### General Design and Interface Requirements

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### I.C.D.'s Matrix of Compliance

<table>
<thead>
<tr>
<th>On Text and Tables</th>
<th>Compliance / NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.C.D. Reference Number / Issue</td>
<td></td>
</tr>
<tr>
<td>Identification of the Unit</td>
<td></td>
</tr>
<tr>
<td>Current Mass per Unit</td>
<td></td>
</tr>
<tr>
<td>Mass change per Unit</td>
<td></td>
</tr>
<tr>
<td>Centre of Gravity Location</td>
<td></td>
</tr>
<tr>
<td>Moment of Inertia</td>
<td></td>
</tr>
<tr>
<td>Data Source (computed/measured)</td>
<td></td>
</tr>
<tr>
<td>Tolerance of Data</td>
<td></td>
</tr>
<tr>
<td>Alignment Requirements + Tolerences</td>
<td></td>
</tr>
<tr>
<td>Environmental Stability</td>
<td></td>
</tr>
<tr>
<td>Tolerances between faces of each mirror</td>
<td></td>
</tr>
<tr>
<td>Comments (if any)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>On Drawings</th>
<th>Compliance / NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Dimensioned&quot; views, including footprint</td>
<td></td>
</tr>
<tr>
<td>Foil thickness + washers if any</td>
<td></td>
</tr>
<tr>
<td>IRD in dot lines</td>
<td></td>
</tr>
<tr>
<td>Viewing aperture and field of view</td>
<td></td>
</tr>
<tr>
<td>Unit Size (Length, Width, Height)</td>
<td></td>
</tr>
<tr>
<td>Mounting surface + material + flatness + surface finish</td>
<td></td>
</tr>
<tr>
<td>Surface treatment</td>
<td></td>
</tr>
<tr>
<td>Bolts / washers types and torque</td>
<td></td>
</tr>
<tr>
<td>Shielding thickness</td>
<td></td>
</tr>
<tr>
<td>Connectors type, orientation, positions</td>
<td></td>
</tr>
<tr>
<td>Grounding point(s), positions + necessity of straps</td>
<td></td>
</tr>
<tr>
<td>Positions of the mirror cubes (if any)</td>
<td></td>
</tr>
<tr>
<td>Thermal capacity, dissipation, op/funct temperatures</td>
<td></td>
</tr>
</tbody>
</table>

### Mechanical Design Requirement

#### Mechanical Analysis Report:

#### SAFETY MARGIN

<table>
<thead>
<tr>
<th>Item (1)</th>
<th>Requirement</th>
<th>Computed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield stress of metallic parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultimate stress (except composite)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First ply failure of composite parts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elastic buckling</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 6-9: Unit Mechanical Data Sheet (4/7)
### Qualification / Protoqualification

<table>
<thead>
<tr>
<th>Perpendicular to I/F plane</th>
<th>At I/F plane (Equipment lateral axis)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freq range</strong></td>
<td><strong>Spectral Density</strong></td>
</tr>
<tr>
<td>dB/Oct</td>
<td></td>
</tr>
<tr>
<td><strong>Overall Level gRMS</strong></td>
<td><strong>Overall Level gRMS</strong></td>
</tr>
<tr>
<td>Duration Q 120s</td>
<td>Duration Q 120s</td>
</tr>
<tr>
<td>Duration PQ 60s</td>
<td>Duration PQ 60s</td>
</tr>
<tr>
<td>Unit ON/OFF</td>
<td>Unit tested</td>
</tr>
<tr>
<td><strong>Acceptance</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Freq range</strong></td>
<td><strong>Spectral Density</strong></td>
</tr>
<tr>
<td>dB/Oct</td>
<td></td>
</tr>
<tr>
<td><strong>Overall Level gRMS</strong></td>
<td><strong>Overall Level gRMS</strong></td>
</tr>
<tr>
<td>Duration Q 120s</td>
<td>Duration Q 120s</td>
</tr>
<tr>
<td>Duration PQ 60s</td>
<td>Duration PQ 60s</td>
</tr>
<tr>
<td>Unit ON/OFF</td>
<td>Unit tested</td>
</tr>
</tbody>
</table>

### Acceptance

<table>
<thead>
<tr>
<th>Perpendicular to I/F plane</th>
<th>At I/F plane (Equipment lateral axis)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Freq range</strong></td>
<td><strong>Spectral Density</strong></td>
</tr>
<tr>
<td>dB/Oct</td>
<td></td>
</tr>
<tr>
<td><strong>Overall Level gRMS</strong></td>
<td><strong>Overall Level gRMS</strong></td>
</tr>
<tr>
<td>Duration Q 120s</td>
<td>Duration Q 120s</td>
</tr>
<tr>
<td>Duration PQ 60s</td>
<td>Duration PQ 60s</td>
</tr>
<tr>
<td>Unit ON/OFF</td>
<td>Unit tested</td>
</tr>
</tbody>
</table>

### Commentary:

- **QUALIFICATION / PROTOQUALIFICATION**
  - As requested
  - As tested

- **ACCEPTANCE**
  - As requested
  - As tested

Table 6-10: Unit Mechanical Data Sheet (5/7)
### Qualification / Protoqualification

<table>
<thead>
<tr>
<th>Axis</th>
<th>Acceleration</th>
<th>Axis</th>
<th>Acceleration</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-Axis</td>
<td></td>
<td>X-Axis</td>
<td></td>
</tr>
<tr>
<td>Y-Axis</td>
<td></td>
<td>Y-Axis</td>
<td></td>
</tr>
<tr>
<td>Z-Axis</td>
<td></td>
<td>Z-Axis</td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>60s</td>
<td>Duration</td>
<td>60s</td>
</tr>
</tbody>
</table>

### Acceptance: not applicable (Qualif./ Protoqualification only)

<table>
<thead>
<tr>
<th>Requirement Specification</th>
<th>Test Report</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant Acceleration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 6-11: Unit Mechanical Data Sheet (6/7)**
### Shock

<table>
<thead>
<tr>
<th>Deployable antenna release</th>
<th>Solar array release</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>As requested</strong></td>
<td><strong>As requested</strong></td>
</tr>
<tr>
<td><strong>All three axis</strong></td>
<td><strong>All three axis</strong></td>
</tr>
<tr>
<td><strong>Area</strong> D</td>
<td><strong>Freq</strong></td>
</tr>
<tr>
<td>Unit</td>
<td>Parallel to mounting plate</td>
</tr>
<tr>
<td>Unit tested</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S/C clampband release</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>As requested</strong></td>
<td><strong>As Tested</strong></td>
</tr>
<tr>
<td><strong>All three axis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Freq</strong></td>
<td><strong>SRS acceleration</strong></td>
</tr>
<tr>
<td>Perpendicular to mounting plate</td>
<td>Perpendicular to mounting plate</td>
</tr>
<tr>
<td>Area C</td>
<td>Unit</td>
</tr>
<tr>
<td>Unit tested</td>
<td>Unit tested</td>
</tr>
</tbody>
</table>

**ACCEPTANCE:** not applicable (Qualif./ Protoqualification only)

<table>
<thead>
<tr>
<th>Sinus</th>
<th>Requirement Specification</th>
<th>Test Report</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Acceleration</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Commentary:**

Table 6-12: Unit Mechanical Data Sheet (7/7)
<table>
<thead>
<tr>
<th>Location</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td></td>
</tr>
<tr>
<td>(7)</td>
<td></td>
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<td>(8)</td>
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<td>(9)</td>
<td></td>
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<td>(11)</td>
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<tr>
<td>(21)</td>
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<tr>
<td>(22)</td>
<td></td>
</tr>
<tr>
<td>(23)</td>
<td></td>
</tr>
</tbody>
</table>
7 APPENDIX B : TICD

7.1 Thermal Interface Control Document

RV-GDIR-4108 / / R

All unit thermal interfaces shall be described within a unit thermal interface control document, clearly indicating information of table B-1.

Note: The contractor shall provide a summary of unit thermal characteristics as per Table B-2. The contractor shall prepare and supply Thermal Interface Control Drawings, which shall define the complete thermal interfaces. These drawings and their issue shall be included in the ICD. The interface requirements given below may be defined either in the ICD or in this Thermal Interface Control Drawing. It shall, at least, contain the following data:

- overall layout,
- dimensions - overall size including thickness and their attachment,
- nominal base contact area,
- Temperature Reference Point (TRP),
- internal temperature measurement points (if applicable),
- thermal capacity and tolerance,
- power dissipation and tolerance for each operating mode, including significant transient cases,
- operating and non-operating temperature ranges including minimum start-up temperatures,
- radiator areas,
- external surface optical properties
- apertures (position and size),
- blankets (if applicable),
- blanket performance (if applicable),
- optical properties of box in/outside and protruding parts, apertures, lenses... (BOL, EOL if applicable), and compliance to ESD requirements,
- non operational heater location,
- grounding of MLI (if applicable),
- temperature increment or correction relating locally measured temperatures to average case or baseplate temperature.

### Table 7-1: TICD content

<table>
<thead>
<tr>
<th>Thermal control type (Conduction / Radiation / Mixed)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature reference point (TRP) location</td>
<td></td>
</tr>
<tr>
<td>Temperature distribution for non-isothermal unit (one TRP per node)</td>
<td></td>
</tr>
<tr>
<td>Internal temperature measurement points (if any)</td>
<td></td>
</tr>
<tr>
<td>Thermal capacity and tolerance</td>
<td></td>
</tr>
<tr>
<td>Power dissipation and tolerance, for each operating modes, including significant transient cases and failure cases when necessary</td>
<td></td>
</tr>
<tr>
<td>Operating and non-operating temperature ranges, including minimum start-up temperature</td>
<td></td>
</tr>
<tr>
<td>Temperature increment or correction relating local measured temperatures to average case or baseplate.</td>
<td></td>
</tr>
<tr>
<td>Thermal control type (Conduction / Radiation / Mixed)</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>Finish (material and treatment) including percentage of unit total area for each finish type</td>
<td></td>
</tr>
<tr>
<td>Absorbance (for external unit), BOL &amp; EOL</td>
<td></td>
</tr>
<tr>
<td>Hemispherical emittance, BOL &amp; EOL</td>
<td></td>
</tr>
<tr>
<td>MLI</td>
<td></td>
</tr>
<tr>
<td>Absorbance (for external unit), BOL &amp; EOL</td>
<td></td>
</tr>
<tr>
<td>Hemispherical emittance, BOL &amp; EOL</td>
<td></td>
</tr>
<tr>
<td>Paint free areas (tyrap, heaters...)</td>
<td></td>
</tr>
<tr>
<td>Special thermal provisions</td>
<td></td>
</tr>
<tr>
<td>Alternate finishes (local emittance tape, insulation blanket...)</td>
<td></td>
</tr>
<tr>
<td>Alternate finishes properties</td>
<td></td>
</tr>
<tr>
<td>Thermal interface filler or gaskets</td>
<td></td>
</tr>
<tr>
<td>Low conductance stand off mounts</td>
<td></td>
</tr>
<tr>
<td>Thermistors</td>
<td></td>
</tr>
<tr>
<td>Heaters</td>
<td></td>
</tr>
</tbody>
</table>
## Table 7-2: Unit Thermal Data Sheet

<table>
<thead>
<tr>
<th>Functioning Temperature (°C)</th>
<th>Mission Phase</th>
<th>No of Working Units</th>
<th>Dissipation per working unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFO Min:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFO Max:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFA Min:</td>
<td>Launch:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFA Max:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualification:</td>
<td>In Orbit:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFQ Min:</td>
<td>Sun:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFQ Max:</td>
<td>Eclipse:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Functioning Temperature (°C)</td>
<td></td>
<td>Safe Mode:</td>
<td></td>
</tr>
<tr>
<td>Non Functioning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TNF Min:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TNF Max:</td>
<td>Unit Individual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start up Temperature (°C)</td>
<td>Min:</td>
<td></td>
<td>Remarks: (to precise dissipations in all the existing modes and measured values)</td>
</tr>
<tr>
<td>Ground Storage Temperature (°C)</td>
<td>Min:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Unit wall sizing L(mm)\(^W\)(mm)\(^H\)(mm):**
- **Unit baseplate sizing L(mm)\(^W\)(mm):**
- **Unit contact area (cm\(^2\)):**
- **Unit radiative area (cm\(^2\)):**
- **Unit emittance:**
- **Unit solar absorptivity:**
- **Unit thermal capacitance (J/°C):**

**Comments:**
- Unit individual hot failure dissipation shall be computed for maximum figure.
- Duration shall be given if applicable.
- When applicable, heat dissipation profile shall be provided on a separate sheet.
- Unit dissipation values of the different modes to be provided in addition of Min & Max figures.

**Mission Phase description:**
- Launch: From lift-off to separation from launcher.

---

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APPENDIX C : EICD

8.1 Electrical InterfaceDatasheets (Format)

RV-GDIR-4180 / / R

All unit electrical interfaces shall be described within a unit Electrical Interface Control Document, clearly indicating information described below.

The Electrical Interface data sheets contains 5 type of sheets:

- The Electrical sheet n°1a: " Unit Connector List" which is used for Harness definition (unit-side connectors), see table C-1a. The 'Unit Connector List' shall be provided in the form of the filled MS-Excel spreadsheet (an empty sheet will be given to contractor in electronic form). One copy shall be attached to the Unit EICD in paper form the second copy shall be provided as MS-Excel spreadsheet in electronic form.

- The Electrical sheet n°1b: " Pin Allocation Data Sheet " which is used for Harness definition, see table C-1b. The 'Electrical Interconnection Sheet' shall be provided in the form of the attached and filled MS-Excel spreadsheets (an empty sheet will be given to supplier in electronic form, a paper copy is in the annex). One copy shall be attached to the Unit EICD in paper form the second copy shall be provided as MS-Excel spreadsheet in electronic form. The syntax of the Signal Designation (see table below) will be consolidated at system level. Thereafter the unit EICD shall be updated to implement the changed syntax.

- The Electrical sheet n°2: which provides the List of each Electrical Interface Drawing, see table C-2:

- The ‘Interface Circuit Diagram List’ shall be provided in the form of the filled MS-Excel spreadsheet (an empty sheet will be given to supplier in electronic form). One copy shall be attached to the Unit EICD in paper form the second copy shall be provided as MS-Excel spreadsheet in electronic form.

- The ‘Interface Circuit Diagrams’ itself shall be provided in MS-Visio format (an empty sheet will be given to supplier in electronic form. One copy of each Interface Circuit Diagram shall be attached to the Unit EICD in paper form the second copy shall be provided as MS-Visio shape in electronic form.

- The Electrical sheet n°3: which provides all the internal protections of the unit w.r.t primary power or w.r.t secondary power lines, see table C-3

- The Electrical sheet n°4: which provides the Inrush profile (voltage / current) of the unit primary or secondary supplied, see table C-4.

- The Electrical sheet n°5: which provides the power consumption performances of the unit in terms of Mean and Peak consumption aspects, see table C-5.

Table 8-1: Electrical Data Sheet 1a/5: Unit Connector List

<table>
<thead>
<tr>
<th>Iss/ Rev</th>
<th>Unit-Name</th>
<th>Unit-Con</th>
<th>Connector Function</th>
<th>Connector Type</th>
<th>EMC-Code</th>
<th>Specific Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 8-2: Electrical Data Sheet 1a/5: Pin Allocation Data Sheet

<table>
<thead>
<tr>
<th>PIN</th>
<th>SIGNAL FUNCTION NAME</th>
<th>SOURCE</th>
<th>LOAD</th>
<th>SOURCE</th>
<th>LOAD</th>
<th>FREQ</th>
<th>MIN</th>
<th>MAX</th>
<th>MIN</th>
<th>MAX</th>
<th>SOURCE</th>
<th>LOAD</th>
<th>TOTAL</th>
<th>MODIF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Table 8-3: Electrical Data Sheet 1a/5: Electrical Interface Drawing  
  TBD  
Table 8-4: Electrical Data Sheet 1a/5: Inrush profile  
  TBD (Use LPF format)  
Table 8-5: Electrical Data Sheet 1a/5: Power consumption  
  TBD  
Table 8-6: Electrical Data Sheet 1a/5: Grounding Diagram  
  TBD  
Table 8-7: Electrical Data Sheet 1a/5: Power Distribution Switching  
  TBD  
Table 8-8: Electrical Data Sheet 1a/5: Frequency Plan  
  TBD
9 APPENDIX D : DOUBLE INSULATION TECHNOLOGICAL GUIDELINE

9.1 PRINCIPLE

This appendix is a technological guide to be used by the electrical equipment contractors. It aims at explaining, from a technological point of view, the design rules related to the double insulation requirement.

In a centralised power distribution architecture the protection device is located in the PCDU, so that no single failure downstreams of a protection may lead to a permanent primary power bus degradation, in either ground or flight conditions.

The double insulation requirement is applicable to any section located upstreams of the protection device (LCL, FCL, ...), including the protection device itself.

In addition to the harness itself (including dismountability sections), the double insulation requirement is thus applicable to the following electrical units :
- PCDU
- batteries
- <project must identify all other units to which the double insulation is applicable>

Each contractor shall comply to the requirement RV-GDIR-2217

«Any item located upstream of the protection devices and which is set at an electrical potential shall be insulated from the potential reference (either electrical or mechanical) by a double insulation.

This will be performed by using two different insulating materials. A space greater than 1 mm can be considered as an insulating material.»

However, in some cases where there exists a justified impossibility to comply with the requirement, it will be admitted that such cases be studied in order to state whether they can be accepted or not. A Request For Waiver (RFW) shall be raised in order to trace all non-compliances to the double insulation requirement.

Concerning the particular case of EEE and non-EEE power components concerned by the requirement, compliance to the requirement implies that the internal insulation technology between elements set at a given voltage and the component external case be well known. A risk analysis will allow to conclude whether it is needed or not electrically to insulate the component from the mechanical ground in the case of a single insulation not dealt with through the following rules. EEE components which do not feature double internal protection and the external case of which shall be mandatorily connected to a mechanical or electrical ground (EMI filters, including filter connectors etc.) will be subject to Request For Waivers.

9.2 DESIGN RULES

The use of this guide is based on the following :

- precise identification of the insulation (material, thickness, etc.) between two elements set at different voltages,
- possible variations of the insulation thickness,
- risks of insulation failures linked to an external cause (e.g. pollution).

An insulation will be said to be invariable if the physical distance between two elements set at given potentials will not be subject to any significant variation whatever the constraints applied on any part of the equipment or on the whole equipment.

On the opposite, an insulation will be said to be variable whenever the physical distance between two elements set at given potentials can be subject to modifications as a function of constraints applied to any part of the equipment or on the whole equipment during environmental testing activities, AIT activities, flight operation (e.g. wear-out) or in the case where fragile materials are used.

Depending on the technological configuration of the insulation, the rules in Table 9-1 will have to be respected.
The rules to be observed can be summarised in Table 9-2, as a function of the technology or of the element to be insulated.

The environmental vibration tests shall verify there is no short-circuit of the power supply, which shall be applied in any case, at least up to the first protection device.

Those technological solutions do not prevent from the need for a visual inspection and an electrical test if needed.

<table>
<thead>
<tr>
<th>Element Technology</th>
<th>Insulation Rule</th>
<th>Remark</th>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PCB</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Stiffener</td>
<td>A</td>
<td>E = 0.8mm + surface coating</td>
<td>Figure 9-1</td>
</tr>
<tr>
<td>• Housing Case</td>
<td>C or D, B (N?A)</td>
<td>Opposite insulating material(s)</td>
<td></td>
</tr>
<tr>
<td>• Internal Tracks</td>
<td></td>
<td>Qualified technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remark: caution with implementation</td>
<td></td>
</tr>
<tr>
<td><strong>PCB</strong></td>
<td>A</td>
<td>E := qualified functional rules + surface coating</td>
<td>Figure 9-1</td>
</tr>
<tr>
<td>• External Tracks</td>
<td></td>
<td>(caution with wetability, welding protection, leads etc.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remark: caution with implementation</td>
<td></td>
</tr>
<tr>
<td><strong>Wrapping</strong></td>
<td>A</td>
<td>Difficulty for insulating material implementation. Technology not advised in this field of application</td>
<td></td>
</tr>
<tr>
<td><strong>Bus Bar / Shunt</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Mounting</td>
<td>B</td>
<td>Minimal non-deformable insulating material thickness with respect to structure (bush, washer etc)</td>
<td>Figure 9-2</td>
</tr>
<tr>
<td>• Environment</td>
<td>A, C or D</td>
<td>A: use of coating</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C: opposite insulating materials or Kynar sheath</td>
<td>Figure 9-2</td>
</tr>
</tbody>
</table>

*Cases B and possibly A (air spacing less than 1 mm) are not compliant to the double insulation requirement. In this case, a Request For Waiver shall be raised.

E is the distance between two conducting materials set at a voltage (Case A) or is the minimal insulating material thickness (Case B). An air spacing (vacuum) cannot be considered as an invariable insulation.

E is the distance after deformation or wear-out between two conducting materials set at a voltage.

Non-deformable insulating materials: resistant, non-porous (epoxy, beryllium oxide, etc.). On the opposite, flexible, porous, fragile or very low thickness elements (air, kapton, choterm, glue, etc.) are deformable insulating materials.
<table>
<thead>
<tr>
<th>Element Technology</th>
<th>Insulation Rule</th>
<th>Remark</th>
<th>Figure</th>
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</thead>
<tbody>
<tr>
<td>Power Component</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Mounting</td>
<td>B, A, C or D</td>
<td>Ditto Bus Bar mounting</td>
<td>Figure 9-2</td>
</tr>
<tr>
<td>• Environment</td>
<td></td>
<td>A: use of coating</td>
<td>Figure 9-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C: opposite insulating materials or sheath</td>
<td>Figure 9-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Figure 9-4</td>
</tr>
<tr>
<td>Connector</td>
<td>A</td>
<td>Use of a sheath</td>
<td>Figure 9-5</td>
</tr>
<tr>
<td>External Harness</td>
<td>A, B or D</td>
<td>Use of a sheath</td>
<td>Figure 9-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Figure 9-6</td>
</tr>
<tr>
<td>Wiring</td>
<td>B or D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shield Bonding</td>
<td>D, A, C or D</td>
<td>Use of a sheath</td>
<td>Figure 9-7</td>
</tr>
<tr>
<td>• Conductor Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rigid Flex</td>
<td>A, C or D</td>
<td>Ditto PCB</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 9-1: Printed Circuit Board and Mechanical Case**
General Design and Interface Requirements

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Figure 9-4: Leads/Structure

Figure 9-5: Crimping
General Design and Interface Requirements

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10 APPENDIX E: FPGA / ASIC DESIGN & VALIDATION REQUIREMENTS

This appendix defines the design and validation requirements applicable to units embedding FPGA or ASIC devices.

10.1 Timing Domains

[RULE 4.1.1] All non-clock signals, processes and other functions (such as registers and combinatorial logic) within an ASIC or FPGA (whether internal or visible on its external pins) shall be separated into a number of distinct timing domains.

[RULE 4.1.2] All (internal or external) signals that are synchronised to the same common timing reference (or clock) shall form a single timing domain.

[RULE 4.1.3] Asynchronous inputs (defined as those not synchronised to a timing reference) shall occupy a separate timing domain.

[RULE 4.1.4] Outputs shall be considered to form part to the timing domain in which they are generated.

[RULE 4.1.5] The number of timing domains shall be reduced as far as reasonably possible (e.g. by the adoption of a synchronous design style). Therefore, it is envisaged that for most FPGA applications there will be a single internal timing domain and (optionally) a single asynchronous input timing domain. Where IEEE1149.1 Boundary Scan is used to support board-level testing, there will be an additional timing domain for the entire device.

[RULE 4.1.6] The connection of any input signal to multiple internal timing domains (with the exception of an IEEE1149.1 Boundary Scan timing domain) is strongly discouraged and shall be submitted to prime contractor approval. In such cases, the inputs shall occupy multiple input timing domains.

[RULE 4.1.7] It is permissible for timing domains to straddle the board-device boundary provided they are well controlled (e.g. this might apply to the selection between redundant clocks directly by a control input).

10.2 Clocks

[RULE 4.2.1] Within each timing domain, the ASIC or FPGA shall be designed with a single master clock for the entire domain, which shall be implemented using one clock plane/buffer/tree with controlled skew.

[RULE 4.2.2] An external oscillator should be used rather than internal logic to generate the master clock; any deviation to this requirement shall be submitted to prime contractor approval.

[RULE 4.2.3] Within each timing domain, a synchronous design style shall be used, while using one or both master clock transitions (rising/falling edges).

10.3 Inputs

[RULE 4.3.1] Within each timing domain, all synchronous input signals shall be synchronized by the domain’s master clock in order to control the spread of setup and hold times.

[RULE 4.3.2] Within each timing domain, the synchronization of any input signal shall always be performed using a single storage element (e.g. a D-type flip-flop). (The connection of an input signal to more than one storage element is forbidden).

10.4 Asynchronous Inputs

[RULE 4.4.1] Signals crossing between timing domains (including asynchronous input signals being captured at the input to a synchronous timing domain) shall be protected against metastability. Preference to double-rank synchronisation shall be given, but single-rank synchronisation may be suitable for slow-speed/rare-occurrence applications.

[RULE 4.4.2] An MTBF of >= 100 years due to the misinterpretation of all signals that cross any timing domain(s) within a single device shall be provided. Where a contractor expects to provide many identical devices for use within the same equipment or (sub)system, an MTBF of >= 100 years due to the misinterpretation of all signals that cross any timing domain(s) within (larger of) the equipment or the (sub)system shall be provided.
[Rule 4.4.3] Buses crossing between timing domains shall be synchronised either by an accompanying control signal or by synchronously detecting a change in the value on the bus. In either case, sufficient delay shall be provided for the effects of metastability to flush through the synchronising logic before a reliable value is captured. (Simply sampling an apparently asynchronous bus with an unrelated clock will potentially give the old value of the bus, the new value or any combination of the two).

[Rule 4.4.4] State information crossing between timing domains shall be treated in the same way as buses. Independent re-synchronisation will suffice in the case where only one of the signals representing the state variables can change before they have all been re-synchronised).

10.5 Outputs

[Rule 4.5.1] In order to avoid glitches, all output signals shall be synchronized by the master clock within the associated timing domain.

[Rule 4.5.2] During the ASIC/FPGA power-on ramp, transients can occur on the outputs: outputs for which electrical transients could, might or would (either individually or in combination) lead to unacceptable functional effects (e.g. spurious command generation, digital data bus disruption, shutdown, protection triggering, pyrotechnic activation, etc.). The ASIC/FPGA design shall implement adequate inhibition/protection features to preclude any transient on such outputs.

[Rule 4.5.3] If output glitches are unavoidable and could lead to functional effects, they must be filtered externally to the FPGA/ASIC.

[Rule 4.5.4] Where possible, the direction (i.e. drive state) of all bi-directional pins should be a combinatorial function of some of the device’s input pins. Where the drive state depends on internal flip-flop(s), these shall be affected by reset and cause the bidirectional pin to assume a safe direction (an input is suggested).

[Rule 4.5.5] Where possible, the output enable control signal(s) for all tri-state or bi-directional outputs shall be presented as separate output signals so as to permit board-level debugging. The timing characteristics of such output signal(s) shall be sufficient to adequately control any necessary external bus transceiver(s).

10.6 Reset

[Rule 4.6.1] Within each timing domain, the ASIC or FPGA shall provide a single reset signal, to be implemented on a separate (or spare) clock plane/buffer/tree.

[Rule 4.6.2] The external reset input shall be considered asynchronous in nature, but shall be applied internally as soon as the input is activated.

[Rule 4.6.3] Preference should be given to a circuit design that maintains the internal reset until the clock is established. In all cases, however, if the clock signal can be established before deactivation (end) of the external reset input, then removal of the internal reset shall be synchronized to the active edge of the clock and shall provide sufficient metastability protection.

10.7 Internal Logic Design

[Rule 4.7.1] Upon reset, the ASIC or FPGA shall exhibit deterministic behaviour. At the simplest, it is envisaged that all internal flip-flops will be set to a deterministic state either by the internal reset itself (or if necessary, within a few cycles after removal of reset). It shall be possible to predict the state of all outputs immediately after activation of the external reset input. It shall be permissible for the results of lengthy/complex internal operations to be masked (forced) to a known value until they become valid instead of resetting extensive internal logic that generates them.

[Rule 4.7.2] Proper functional operation of internal combinatorial logic shall not be based on or depend on propagation delay times.

[Rule 4.7.3] In order to prevent glitch-induced errors, the asynchronous set and/or reset inputs of flip-flops shall not be controlled by combinatorial logic functions. Instead, such internal control signals shall be generated in a synchronous manner using the timing domain’s master clock. This requirement shall not apply to flip-flops synchronizing an external reset input.
[Rule 4.7.4] FPGA manufacturer requirements concerning the limited fan-out of FPGA gates shall be met.

[Rule 4.7.5] In the case of counter value comparisons with a fixed value, the comparison shall be performed with a “greater than or equal to” rather than an “equal to” operator.

[Rule 4.7.6] FPGA internal tri-states shall preferably be avoided; if unavoidable, floating nodes shall be prohibited (a buffer shall be added to get a controlled level when all buffers are tri-state). Any manufacturers recommendations regarding contention between the various drivers and/or for guard times between them shall be met.

[Rule 4.7.7] It shall not be possible for unsafe/dangerous/hazardous combinations of output signals (e.g. driving a data bus while generating a read strobe that also causes an external memory to drive the bus) to occur through activation/use of internal test features (e.g. by inadvertent triggering of state machines) once it is located within the target system. (The same considerations as for the power-on ramp apply).

[Rule 4.7.8] Consideration shall be given to the need for sufficient test signals (both inputs and outputs) to support board testing and related activities.

10.8 State Machines and SEU

[Rule 4.8.1] State machines shall not remain improperly locked in any state whatever signal/protocol anomalies occur at the device interface.

[Rule 4.8.2] The FPGA design shall be robust to SEU effects, so that nominal unit performance is maintained in the presence of SEP; in particular state machines shall not remain improperly locked in any state as a result of SEU.

[Rule 4.8.3] State machines shall contain no unused states even after the coding scheme for their implementation has been considered, in order to ensure that they cannot become locked. (For all coding schemes, all 2**n states are still possible as the result of SEU and the logic must eventually map all of them back into the state diagram. “Transitioning through all unused states directly after reset” and “explicit mapping of unused states” are two useful design options.)

10.9 Timing

[Rule 4.9.1] ASIC/FPGA designs shall include timing margins on top of best-case to worst-case timing variations due to temperature, radiation, ageing, and manufacturing processes variations: a 10% margin on the clock frequency, and a 10% margin on all propagation delay times (PSS-01-301), setup times and hold times shall be provided.

[Rule 4.9.2] The ASIC/FPGA design shall be clock skew tolerant (clock skew is the maximum delay from the clock input of one flip-flop to the clock input of another flip-flop within the same timing domain: the use of opposite edge clocking can be a solution to make circuits skew-tolerant). Clock jitter (internal and external) shall be considered a source of clock skew.

[Rule 4.9.3] Variation in the duty cycle of all external clock inputs by at least +10% to -10% beyond their nominal operating range shall be accommodated (e.g. slow variation from a nominal 48-% to 52% duty cycle to 38% and 62% shall be considered).

[Rule 4.9.4] The propagation delay from the active edge of a clock through the output(s) of any flip-flop shall be long enough to respect the hold time from the same active clock edge to the input of any other flip-flop within the same timing domain under all environmental conditions (short path static timing analysis).

[Rule 4.9.5] The propagation delay from the active edge of a clock through the output(s) of any flip-flop shall be short enough to respect the setup time from the next active clock edge to the input of any other flip-flop within the same timing domain under all environmental conditions (long path static timing analysis).

[Rule 4.9.6] It shall not be assumed that all parts of the same device operate under the same environmental conditions. Some variation between input delay chains and their associated clock buffer/plane/tree shall be considered. Where there are multiple internal clock buffers/planes/trees, some variation between them shall be considered.

[Rule 4.9.7] Within each clocked timing domain, the fastest and slowest possible glitch edge propagation delays shall be considered during short path and long path static timing analyses, respectively.

General Design and Interface Requirements

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[Rule 4.9.8] In completely asynchronous timing domains (i.e. those where no internal clock can be used to achieve the desired output timing), internal logic shall be constructed to minimize glitches.

[Rule 4.9.9] During the removal of reset, the local reset signal for each flip-flop shall be removed before arrival of the next active clock edge within the same timing domain.

[Rule 4.9.10] Input signal rise and fall times shall strictly meet the FPGA / ASIC manufacturer requirements. In the case of “slow” input signals, a Schmitt-trigger buffer shall be implemented at the ASIC/FPGA interface. Preference shall be given to the use of an internal Schmitt-trigger buffer, but where this is unavailable, an external fast Schmitt-trigger buffer shall be provided.

[Rule 4.9.11] For input signals that can significantly change the internal logic state (like external oscillator clocks and reset), the external circuitry shall provide a sufficiently low source impedance and sufficiently fast transition times to avoid ground bounce (or perhaps SEU-induced) effects that could otherwise lead to multiple detections or false activation. If necessary, an internal Schmitt-trigger buffer shall be implemented or an external fast Schmitt-trigger buffer shall be provided at the device interface.

[Rule 4.9.12] Device vendor/manufacturer requirements concerning the limited number of simultaneous switching outputs shall be met.

10.10 Sensitive Signals

[Rule 4.10.1] The input pin for sensitive input signals shall not be placed near or in the middle of a group of signals (e.g. a data bus) switching simultaneously (ground bounce). Device vendor/manufacturer requirements concerning sensitive inputs shall be met. Sensitive inputs should normally include all clock, reset and bi-directional control pins as well as any other signals that are not immediately registered.

[Rule 4.10.2] Where output signals are used asynchronously (e.g. where they are used as clock or reset signals for other devices), consideration shall be given to internal and external cross-coupling with nearby groups of signals (e.g. a data bus) to maintain signal integrity. In effect, such signals could be considered sensitive outputs.

10.11 Pin and Size Margin

[Rule 4.11.1] FPGA designs shall provide sufficient pin and size margins to enable designs to be maintained at each stage of their foreseen life-cycle. Pin and size margins shall be re-evaluated (perhaps reduced) at various stages within the design life-cycle. Modification to accommodate future products/designs need not be considered. Working pin and size margins of 10% are suggested once the design is considered stable.

10.12 Design Database

[Rule 4.12.1] An effective design environment for simulation, synthesis, layout, timing analysis and other related tools shall be maintained until the completion of design, equipment or (sub)system acceptance tests. During this time, it shall be possible to investigate design characteristics and make modifications to the design implementation at short notice. The configuration of the associated tools shall be well controlled. Changes between the available releases, revisions, etc. shall also be well controlled (e.g. with changes to later versions normally being made only in support of key stages of the design cycle).

[Rule 4.12.2] An effective design maintenance/revision environment for simulation, synthesis, layout, timing analysis and other related tools shall be maintained from completion of design, equipment or (sub)system acceptance tests until launch. During this time, it is permissible to archive the design database and associated tools but it must be possible to investigate design characteristics or re-work the design implementation using the final design database and the revision of tools used to validate it. Availability of later versions of the same tools is desirable, but may not be preferable.

[Rule 4.12.3] The design database shall be maintained for a sufficient duration after launch to permit the investigation of in-orbit anomalies. Archiving of and/or changes to simulation and timing analysis tools within this time-frame are permissible but it must be possible to investigate design characteristics using the final design database in order to assess any anomaly that is reported. Synthesis and layout tools do not need to be available unless the design can be changed in-orbit (as could be the case for some types of FPGA configured by an on-board computer).
10.13 Manufacturer's / Vendor's Recommendations

[Rule 4.13.1] All FPGA manufacturer's/vendor's design, programming, pin-configuration and test requirements shall be met.

[Rule 4.13.2] Any specific FPGA manufacturer's/vendor's design, programming, pin-configuration and test guidelines should be met.

[Rule 4.13.3] All ASIC manufacturer's/vendor's design, layout, pin-configuration and test requirements shall be met.

[Rule 4.13.4] Any specific FPGA manufacturer's/vendor's design, layout, pin-configuration and test guidelines should be met.

Note: See also rules 4.7.4, 4.7.6, 4.9.10, 4.9.12 and 4.10.1 above

10.14 FPGA / ASIC Validation

[Rule 4.14.1] A statement of compliance and design verification matrix with respect to the FPGA/ASIC design rules shall be generated and documented with appropriate comments indicating why each rule is met, and how it is verified; this document, and associated compliance with FPGA/ASIC manufacturer's/vendor's requirements/recommendations, shall be deliverable and submitted to contractor approval.

[Rule 4.14.2] A Statement of Compliance with respect to the FPGA/ASIC specification shall be generated.

[Rule 4.14.3] Compliance with FPGA/ASIC manufacturer's / vendor's requirements shall be documented.


[Rule 4.14.5] Compliance with any vendor's / manufacturer's pin-programming requirements shall be documented.

[Rule 4.14.6] An issued specification shall be available which shall include all environmental, technology, timing, functional, pin-out, test and associated requirements

[Rule 4.14.7] A definition of the expected timing domains within the device shall be documented.

[Rule 4.14.8] Simulations shall be performed to show proper/expected/specified logic functionality in all specified modes of operation. It shall be shown that all aspects of logic functionality are correct for the final layout. Regression testing against RTL models, pre-layout simulations and/or pre-layout schematics/netlists is recommended (depending on complexity and design flow) if they exist.

[Rule 4.14.9] It shall be shown that serial data patterns are not bit-reversed.

[Rule 4.14.10] It shall be shown that parallel buses (both input and output) are not bit-reversed.

[Rule 4.14.11] The proper operation of interface protocols shall be shown, including tolerance/rejection of and/or graceful degradation due to misuse under such conditions as missing strobes, bad addresses, bad parity, invalid data formats, poor data alignment, etc.

[Rule 4.14.12] Proper operation over the complete range of all pin-programmable and register-programmable parameter values shall be shown.

[Rule 4.14.13] Proper operation over the complete range of dependent/acceptable/unacceptable data values shall be shown.

[Rule 4.14.14] Gate-level post-layout simulations shall be performed with full best case-to-worst case timing variation (derived from the layout and to include voltage, temperature, process, radiation dose, ageing, etc.). There shall be no change in functionality across the entire range of possible timing variations and all environmental conditions shall be considered (not necessarily simulated), not just the corner cases (which must be simulated). Regression testing against RTL models, pre-layout simulations and/or pre-layout schematics/netlists is recommended (depending on complexity and design flow) if they exist. Gate-level post-layout simulations must cover the full range of timing variation on all external interfaces in all operating modes and must also cover the full range of timing of all inter-related signals. Post-layout simulations should also fully prove internal logic functionality. Where post-layout simulations to fully prove
internal logic functionality are not considered practicable (e.g. because back-annotated simulations would take many months to run) then, subject to explicit prime contractor approval, they may be replaced by verification using other methods (such as RTL simulation combined with functional verification and static timing analysis).

[Rule 4.14.15] The set-up and hold times of all synchronous input signals against the relevant clock and their compliance with the specification shall be determined. Preferably, the set-up and hold times of asynchronous inputs being synchronised should also be determined.

[Rule 4.14.16] Where metastability information is not available, calculations for an older/similar technology may be used to determine an upper/approximate limit for the MTBF.

[Rule 4.14.17] The propagation delays of all output signals against the relevant clock and their compliance with the specification shall be determined.

[Rule 4.14.18] Internal reset arrangements shall be verified.

[Rule 4.14.19] It shall be shown that there are no dangling internal inputs.


[Rule 4.14.21] Freedom from internal hold time violations shall be shown for all flip-flops within the design. Static Timing Analysis is heavily preferred since it is otherwise difficult to ensure that the shortest internal timing paths are exercised.

[Rule 4.14.22] Freedom from internal set-up time violations shall be shown for all flip-flops within the design. Static Timing Analysis is heavily preferred since it is otherwise difficult to ensure that the longest internal timing paths are exercised.

[Rule 4.14.23] Libraries used for simulation and/or timing analysis shall be qualified/certified by the FPGA/ASIC vendor/manufacturer. Preferably, tool versions shall be similarly qualified.

[Rule 4.14.24] All vendor’s / manufacturer’s test requirements shall be met.
## APPENDIX F: LIST OF TBD'S

<table>
<thead>
<tr>
<th>TBD</th>
<th>Keywords</th>
<th>Actionee</th>
<th>Due For</th>
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<td>RV-GDIR-5297</td>
<td>Re-pressurisation rate when entering Mars atmosphere.</td>
<td>ESA</td>
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<td>RV-GDIR-5436</td>
<td>Dust deposition on horizontal surfaces</td>
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<td></td>
<td>Dust deposition on vertical surfaces</td>
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<td></td>
<td>Thickness of CO₂ ice formation on external surfaces</td>
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<td>RV-GDIR-5368</td>
<td>Rise and fall time for LVDS driver circuit.</td>
<td>ASU</td>
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<tr>
<td>RV-GDIR-2129</td>
<td>Voltage above which IEC 60479:1994 applies.</td>
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<tr>
<td>RV-GDIR-2273</td>
<td>Mode/State transitions with duration after which transition will be indicated in the telemetry.</td>
<td>ASU</td>
<td></td>
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<tr>
<td>RV-GDIR-2274</td>
<td>Time after switch on that commanding is to be possible.</td>
<td>ASU</td>
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## APPENDIX G: LIST OF TBC'S

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