### SCIENTIFIC PAYLOADS / 2007 ORBITER INTERFACE REQUIREMENTS DOCUMENT

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<td>29-Jan-02</td>
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**TITLE:**
SCIENTIFIC PAYLOADS / 2007 ORBITER INTERFACE REQUIREMENTS DOCUMENT

**AUTHOR:** CNES 2007 Orbiter Team.

**ABSTRACT**
This document describes the general interface requirements between the 2007 Orbiter Bus and the scientific payloads.

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C. Preliminary stiffness requirements & Launch loads.
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E. Preliminary EMI/EMC Requirements.
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Acronyms

AIT        Assembly Integration & Tests
CAD        Computer Aided Design
CFE        Customer Furnished Equipment
CoG        Center of Gravity
CNES       Centre National d’Etudes Spatiales
DC         Date Code
DPU        Data Processing Unit
EM         Engineering Model
EGSE       Electrical Ground Support Equipment
FM         Flight Model
GSE        Ground Support Equipment
MCP        Materials, mechanical Components & Processes
MGSE       Mechanical Ground Support Equipment
NASA       National Aeronautics and Space Administration
NCR        Non Conformance Report
NS         Numerical Simulator
OFM        Orbiter Functional Model
PDU        Power Distribution Unit
PFM        Proto-Flight Model
SM         Spare Model
SPL        Science PayLoads
STM        Structural and Thermal Model
STPM       Structural, Thermal & Pyrotechnic Model
TBC        To Be Confirmed
TBD        To Be Defined
TRP        Temperature Reference Point
Applicable documents

AD3 MARS Premier Orbiter Command & Control requirements. MARS-TS-00-025-CNES

AD4 Interface specification between the MARS Premier Orbiter and the Ground System part A : MARS-IF-OO-026-CNES

AD5 Product Assurance Specification for orbiter scientific and technological payloads: MARS-PA-MSRO-027.CNES

AD6 Planetary Protection Requirements. MARS.PA.00.025.CNES (forward contamination only)

AD 8 Mechanical, thermal and electrical design and construction requirements TBD

AD 9 Mechanical and thermal environment requirements TBD

AD 10 EMI / EMC requirements TBD

Reference documents

RD1 2007 Orbiter mission specification: MARS-TS-00-001-CNES

RD2 2007 Orbiter sizing scenarios: TBD

RD3 2007 Orbiter preliminary development Plan: MARS-ON-MSRO-063-CNES
1 INTRODUCTION

This note describes the general interfaces requirements between the 2007 Orbiter and the scientific payloads. An interfaces requirements document will be issued for each payload after scientific payloads selection.

1.1 Conventions

- The **Orbiter Flight System** will be called 2007 Orbiter.
- The **Scientific payloads Flight System** is composed of some scientific instruments with their own data handling and power distribution unit.

1.2 Responsibilities breakdown overview

The science payloads projects are in charge of providing the scientific payloads flight system to CNES Orbiter project.

The CNES Orbiter project is in charge of providing the scientific payloads Flight System to 2007 Orbiter prime contractor.

The 2007 Orbiter is in charge of providing the mounting structure of the scientific payloads Flight System, the harness between the Orbiter and the payloads DPU and PDU, including: the power lines to the PDU, the data interface to the DPU and the pyrotechnic lines until the interconnection bracket(s). In addition some other items to be provided are defined in the following requirements.

1.3 Requirements numbering

The interface requirements will generally be given inside frames. They will also designated by a number with the following format: O/SPL-X-N with:

- O/SPL recall the level of the requirement (O for Orbiter, SPL for Scientific PayLoad, / for interface)
- X is a letter among:
  - R for Requirement,
  - T for Target,
- N is the reference number of the requirement.

The requirements corresponding to the letter R shall be fulfilled and demonstrated.
The requirements corresponding to the letter T are not mandatory to be fulfilled (whatever the reason for this: difficulty to demonstrate, costs risks, state of the art). For these requirements the work and the trade-off performed shall be documented.
2 INTERFACES REQUIREMENTS

2.1 Mission Requirements
The scientific payload mission is described in RD1 and RD2.

2.2 Product Assurance

O/SPL-R-10 PA requirements
AD5 is applicable.
For all modules in interface with the Orbiter, a particularly attention shall be paid to chapter 10 and appendix 7 of AD5. These requirements must be fully followed to prevent any propagation of an electric, thermal, mechanical or dynamic single failure leading to the loss of the Orbiter nominal mission.

O/SPL-R-20 PA conformance.
Each scientific payload shall provide a matrix of conformity with AD5 requirements.

2.3 Planetary Protection.

O/SPL-R-30 planetary protection.
The Flight Models shall respect the Planetary Protection Policy of AD6.
For scientific payloads, implemented on the Orbiter mission bus, these requirements could be limited to: (TBC)
- Flight Model external surfaces bio-cleaned (to prevent cross-contamination),
- Flight Model delivery under double bio-bag.
2.4 Thermo-mechanical Architecture

2.4.1 General description

<table>
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<th>Science payloads implementation. The scientific payloads shall be mounted on the mission stage of the 2007 Orbiter.</th>
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<td>O/SPL-R-50</td>
<td>Mechanical and thermal rules. The mechanical and thermal design rules shall be defined in AD8.</td>
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2.4.2 Mechanical requirements

2.4.2.1 Co-ordinate system

| O/SPL-R-60 | Co-ordinate system. The co-ordinate system to be used by the scientific payloads shall be the one described in appendix A. |

2.4.2.2 Mass, CG and inertia properties

<table>
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<th>Mass budget. The maximum allocated mass for all the scientific payloads shall be 65 kg. - 50 kg for scientific payloads - 15 kg as a global provision for interfaces evolutions. This mass is managed by the CNES Orbiter project. The mass distribution shall be balanced between the reserved volumes.</th>
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<td>Mass margin policy. Each scientific payload shall demonstrate 20 % mass margin at the bidding to the Opportunity or at the beginning of the payload phase A.</td>
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O/SPL-R-90 CoG measurements. The position of the CoG of each scientific payload shall be measured within 5 mm accuracy before delivery to the Orbiter contractor.

2.4.2.3 Mounting points

O/SPL-R-100 Interface mounting points. The 2007 Orbiter shall provide interface mounting points to each scientific payload (including mechanical fixtures and screws).

2.4.2.4 Allowable volumes and fields of view

O/SPL-R-110 Science payloads volumes and fields of view. The reserved volume of scientific payloads and the fields of view shall be the ones defined in Appendix B.

2.4.2.5 Mounting / dismounting

O/SPL-R-120 Science payloads MGSE I/F. During the integration sequence of the scientific payload, the MGSE shall not need any mechanical interface with the Orbiter structure.

O/SPL-R-130 Planetary protection in AIT. The integration sequence shall take into account planetary protection requirements (see AD6).

O/SPL-R-140 Science payloads MGSE. The specific tools necessary for scientific payloads mounting / dismounting shall be mutually defined and provided by the scientific payloads projects.

O/SPL-R-150 Min. mounting/dismounting sequences. A minimum of 15 mounting / dismounting sequences of the scientific payloads Modules shall be possible.
2.4.2.6 Stiffness requirements

O/SPL-R-180 Stiffness.
The minimum frequencies of the dynamic modes of each part of the scientific payloads Flight System hard mounted on an infinitely stiff interface shall be as defined in AD8.
For scientific payloads phase A, preliminary requirements in appendix C.1 shall be applied.

2.4.2.7 Launch loads

The reference launcher for scientific payloads environment is Ariane 5.

O/SPL-R-190 Mechanical launch loads.
Each part of the scientific payloads Flight System shall be compliant with the loads defined in AD9.
For scientific payloads phase A, preliminary requirements in appendix C.1 to C.7 shall be applied.

O/SPL-R-200 Mechanical safety factor.
For scientific payloads phase A, a safety factor for qualification of 1.25 shall be applied to all levels (including quasi static and shocks)

2.4.2.8 Thermoelastic loads

O/SPL-T-210 Thermoelastic loads.
The loads coming from thermoelastic differential deformations between each science payloads modules and the 2007 Orbiter shall be minimised.

2.4.2.9 Deliverable mathematical models
2.4.3 Thermal requirements

O/SPL-R-240 Thermal environment.
Each part of the scientific payloads Flight System shall be compliant with the thermal environment defined in AD9.

Thermal environment shall be defined in phase B.

O/SPL-R-250 heating power.
The heating power for scientific payload has to be taken within the total power allocation.

O/SPL-R-260 Thermal sizing cases.
The sizing cases for thermal analyses of scientific payloads shall be defined with the CNES Orbiter project team and the prime contractor.

O/SPL-R-270 Thermal control.
The scientific payloads shall perform their thermal control autonomously.

O/SPL-R-280 Thermal coupling.
The thermal coupling between 2007 Orbiter and science payloads modules at mechanical interface shall be less than 0.15 W/K (conduction + radiation of each element) and less than 0.25 W/K when including harness and grounding.

O/SPL-R-290 Orbiter radiative I/F
The 2007 Orbiter shall only show diffusive MLI surfaces (to avoid multireflections and hot points) to the scientific payloads (excepted radiators).
O/SPL-R-300 Science payloads radiative I/F
The scientific payloads shall only show diffusive MLI surfaces to the MSRO (excepted radiators).

2.4.3.1 Contact zone temperature

O/SPL-R-310 Temperature reference point.
The temperature Reference Point is defined at the mechanical interface between the 2007 Orbiter and the scientific payloads Modules.

O/SPL-R-320 conductive interface temperature
At the TRP, the contact zone temperature range to be taken into account by scientific payloads for design is defined in AD9.
For scientific payloads phase A, the temperature range to be taken into account is - 50 °C, + 50 °C.

2.4.3.2 Deliverable mathematical thermal model

O/SLP-R-330 Thermal models.
The thermal and radiative models of each part of the scientific payloads Flight System shall be delivered to CNES in the ESATAN and ESARAD format.
2.5 Electrical Architecture

2.5.1 General

O/SPL-R-340 Electrical design rules.
Electrical design rules shall be the ones defined in AD8.
For scientific payloads phase A, preliminary requirements in appendix D.1 to D.6 shall be applied.

O/SPL-R-350 Power lines generalities.
The 2007 Orbiter shall provide to each scientific payload the following power lines (without any cross strapping between nominal and redundant lines):
- Nominal payloads power and heating line,
- Redundant payloads power and heating line,
- Nominal payloads survival heating line,
- Redundant payloads survival heating line,
- Nominal pyrotechnic firing line,
- Redundant pyrotechnic firing line.

Each scientific payload can be connected to the 2007 Orbiter as shown on the following figures:
- For redundant units:

- For non-redundant or internally redundant units

![Diagram of power connection](image)

Figure 2.5.1-1: science payloads main power connection

O/SPL-R-360 Power voltage characteristics.
Characteristics of the power bus provided by the Orbiter will be unregulated 28 V voltage within the following range (22 V; 38 V).
O/SPL-R-370 Power distribution
The power supply coming from the Orbiter shall be provided only to each science payload PDU (Power Distribution Unit), this one is then in charge to distribute it to the other equipment units.

O/SPL-R-380 Science payloads ON/OFF.
Each scientific payload will be fully "switchable" (ON/OFF) by Orbiter directly on the dedicated power bus (nominal and redundant) at PCDU Orbiter level.

2.5.2 Power, heating and pyrotechnic lines definition

O/SPL-R-390 Power lines definition
For each payload, power and nominal heating are dispatched on one redunded line, protected by latch current limiters (LCL). Nominal heating function shall be operated within each scientific payload under scientific payload DPU (Data Processing Unit) control.

O/SPL-R-400 Survival heating lines definition
Survival heating lines shall be connected to external heaters associated with thermostats for a passive thermal control of the payload, when the main power and heating line is OFF (safe mode).

O/SPL-R-410 Pyrotechnic lines definition
The Orbiter supplies pyrotechnic lines to scientific payload under 3 electrical barriers, a firing command and a safe arming plug.

O/SPL-R-420 Pyrotechnic safe arm plug.
All science payloads pyrotechnic elements shall be connected to the Orbiter safe arming plug.

O/SPL-R-430 Science payloads thermistors implementation.
Thermistors shall be implemented on the equipment units of the scientific payloads (internal or externally) for the Orbiter overall thermal measurements.

O/SPL-R-440 Science payloads temperature measurement.
Scientific payloads thermistors shall be passive (no polarization) to ensure measurement capability, including when the payloads will be OFF.

![Diagram of power, heating, and pyrotechnical lines connections](image)

**Figure 2.5.2-1 : power, heating and pyrotechnical lines connections**

### 2.5.3 Budget

**O/SPL-R-450 Power budget.**
The 2007 Orbiter shall provide the following power to scientific payloads:
- 100 W as a maximum for all scientific payloads (including heating power),
- CRUISE: constant 30 W along the cruise phase for the whole science payloads modules,
- MISSION: according to mission profile.

**O/SPL-R-460 Power lines budget.**
The numbers of lines dedicated to scientific payloads are the following:
- Nominal power and heating lines: 3,
- Redundant power and heating lines: 3,
- Survival nominal heating lines: 3,
- Survival redundant heating lines: 3,
- Pyrotechnic nominal firing lines: 6,
- Pyrotechnic redundant firing lines: 6.

2.5.4 EMI/EMC

O/SPL-R-470 EMI/EMC requirements
The scientific payloads modules shall comply with the EMI/EMC requirements defined in AD10.
For scientific payloads phase A, preliminary requirements in appendix E.1 to E.9 shall be applied.

2.5.5 Magnetic cleanliness

O/SPL-R-480 Magnetic cleanliness requirements
The magnetic cleanliness of the overall Orbiter shall less than:
- 2 A.m² for Solar array,
- 2 A.m² for the rest of mission stage.
The scientific payloads modules shall comply with the magnetic cleanliness levels defined in AD10.

2.5.6 Launch safety

O/SPL-R-490 Launch Safety
The scientific payloads shall comply with launch pad safety requirements (safety status and straps to the launch pad safety monitoring ground center).

2.5.7 Harness

O/SPL-R-500 Orbiter harness
The 2007 Orbiter shall provide the harness between the Orbiter and the scientific payloads DPU and PDU until the interconnection brackets:
- power lines,
- data interface lines (1553 buses),
- pyrotechnic lines,
- analog and digital acquisition lines.

O/SPL-R-510 Science payloads harness

The scientific payloads shall provide the harness between their DPU and PDU and any equipment units or scientific instrument.
2.6 Command & Control Requirements

2.6.1 General principle

O/SPL-R-520 Science payloads data handling. Each scientific payload shall have its own data handling system through decentralised calculator (DPU: Data Processing Unit), communicating with the Orbiter Central Calculator by means of 1553 bus.

O/SPL-R-530 Redundant 1553 bus
1553 bus between Orbiter Central computer and scientific DPU shall be redunnded.

O/SPL-R-540 FDIR priority
Monitoring and Failure Detection Isolation/Recovery shall be prioritised as follows:
1) Ground Segment (highest priority)
2) Orbiter Central Computer
3) Scientific payloads Computers (DPU).

O/SPL-R-550 Science payloads DPU
Each scientific payload shall have its own intelligence through decentralised calculator (DPU: Data Processing Unit), communicating with the Orbiter Central Calculator by means of bus 1553.

2.6.2 Commands

O/SPL-R-560 Science payloads command. The payloads shall be commanded using command to be processed and routed to final equipment units by the payload itself. Excepted for:
- General ON/OFF switch of the overall payload,
- Pyrotechnic lines arming and firing.
These commands shall be directly executed from the Orbiter's side.
2.6.3 Telemetry

2.6.3.1 Types of Telemetry

O/SPL-R-570 Science payloads telemetry. The payloads shall have 3 types of telemetry:
- HK1: HouseKeeping data acquired directly by the Orbiter and embedded in the telemetry CCSDS packets generated by the Orbiter. These data shall be mainly surface temperatures of payloads equipment units, currents/voltage monitoring and relay status.
- HK2: HouseKeeping data acquired by the payloads and embedded in the telemetry CCSDS packets generated by the payloads.
- Science Telemetry: Science data in CCSDS packets generated by the payloads.

2.6.4 Time

O/SPL-R-580 Reference time. A reference time (1s-mark+ On-Board Orbiter Time) shall be distributed on the communication bus. The correlation between On-Board Orbiter Time and the UTC (Ground Universal Time) shall be known (at Ground). The accuracy being TBD (On-Board clock stability is $10^{-7}$ TBC).

2.6.5 Philosophy of FDIR (Failure Detection, Isolation & Recovery)

O/SPL-R-590 Science payloads reconfiguration. Scientific payloads automatic reconfiguration is not allowed (baseline).

O/SPL-R-600 Science payload monitoring. The orbiter shall perform only time-critical monitoring of science payload telemetry (over-current, over-temperature). Otherwise, the Ground shall perform the monitoring.

O/SPL-R-610 Science payloads FDIR. When the Orbiter will detect a scientific payload failure:
- The payload shall be switched-off (or survival mode TBD)
- The Orbiter will go into trouble shooting investigations by the Ground.
2.7 Data Handling Interface and Design requirements

2.7.1 Basic principle

The basic principle is to respect a distributed data handling system.

Figure 2.7.1-1: data handling distribution
2.7.2 Communication Bus

O/SPL-R-620 communication bus. The communication bus between the Central Computer of the Orbiter and the DPU of each scientific payload shall be compliant with the MIL-STD-1553B. Each payload shall have its own bus coupler (nominal and redundant if any).

Note: the mass of the bus coupler(s) is within the scientific payloads mass allocation.

2.7.3 Data Handling interfaces Overview

![Data handling interfaces overview](image)

**Figure 2.7.3-1 : Data handling interfaces overview**
2.7.4 Budget

O/SPL-R-630 Data handling Budget

The 2007 Orbiter shall provide the following data handling budget to be shared between all scientific payloads:
- Maximal telecommand volume: 100 kbits daily,
- Telemetry volume: from 400 Mbits daily to 1 Gbits daily (TBC), function of MARS/EARTH distance,
- Maximal communication bus rate (1553): 200 kbits/s.

O/SPL-R-640 Data handling lines

The numbers of lines dedicated to scientific payloads are the following:
- Nominal 1553 addresses: 3,
- Redundant 1553 addresses: 3,
- High Level Command (ON/OFF): 10,
- Status acquisition lines: 10,
- Analog acquisition lines: 30 (including temperature sensors),
2.8 Verification and test

Each payload shall fully tested and qualified (see the test matrix) before delivery to the Orbiter.

<table>
<thead>
<tr>
<th>Interface</th>
<th>Payload responsibility/Test level</th>
<th>Orbiter responsibility/Test level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical measurements</td>
<td>x (1)</td>
<td>X</td>
</tr>
<tr>
<td>Mass</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>C.O.G</td>
<td>x (2)</td>
<td>X</td>
</tr>
<tr>
<td>Inertia</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Vibrations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sine</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Acoustic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Shocks</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Thermal balance</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Thermal cycling in vacuum</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Alignment</td>
<td>x</td>
<td>X (3)</td>
</tr>
<tr>
<td>EMC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Conducted</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>- Radiated</td>
<td>X</td>
<td>X (4)</td>
</tr>
<tr>
<td>- Electrical compatibility</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Pyrotechnic test</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Sign tests (if any)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional and performance tests</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Hardware / software compatibility</td>
<td>x</td>
<td>X</td>
</tr>
<tr>
<td>Ground System compatibility</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

(1) : to avoid any discrepancies all payload/orbiter interface shall be full tested at payload level including command & control expected rate. If the payload EGSE is not full representative of the orbiter I/F, all difference shall be accepted at orbiter level prior to payload acceptance test.

(2) : for each flight configuration

(3) : only main reference point shall be measured at orbiter level.

(4) : EMC radiated test shall be limited to RF compatibility at orbiter level.

Table 2.8-1 : test matrix
2.9 Deliverables & Models Representativity

2.9.1 Deliverables

**O/SPL-R-650 Orbiter deliverable**

The 2007 Orbiter contractor shall provide to CNES a reduced radiative and thermal mathematical model in order for science payload to calculate its external fluxes.\(\text{TBC}\)

**O/SPL-R-660 Science payloads deliverables**

Each science payload shall deliver to the 2007 Orbiter contractor the following:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Item</th>
<th>Number</th>
<th>Delivery Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Science payload ICD</td>
<td>-</td>
<td>PDR - 6 months</td>
</tr>
<tr>
<td>B</td>
<td>Mechanical &amp; thermal models</td>
<td>-</td>
<td>PDR - 6 months</td>
</tr>
<tr>
<td>C</td>
<td>STM (Structural and Thermal Model)</td>
<td>1</td>
<td>09-2004</td>
</tr>
<tr>
<td>C</td>
<td>NS (Numerical Simulator) for OFM and OBSO</td>
<td>2</td>
<td>08-2004</td>
</tr>
<tr>
<td>C</td>
<td>EM (Engineering Model)</td>
<td>1</td>
<td>03-2005</td>
</tr>
<tr>
<td>D</td>
<td>FM (Flight Model)</td>
<td>1</td>
<td>01-2006</td>
</tr>
<tr>
<td>D</td>
<td>SM (Spare Model)</td>
<td>1</td>
<td>as FM</td>
</tr>
</tbody>
</table>

**Table 2.9.1-1 :deliverables**

2.9.2 Models representativeness

**O/SPL-R-670 STM representativeness.**

For the qualification on the 2007 Orbiter Structural and Thermal Model at system level, the Scientific payloads STM models to be delivered shall have to be representative of the flight model for the following parameters:

- Mass,
- CG location,
- Inertia,
- interface (mounting points, local stiffness),
- Dynamic behaviour,
- Conductive coupling/uncoupling to the Orbiter,
- Thermo-optical characteristics (MLI+radiators effects),
- Power dissipation,
- Interface thermal fluxes
O/SPL-R-680 EM representativeness.
The EM shall be representative of the science payloads Modules functions and performances (electrical, EMC, ...). It may use generic items or components but shall be able to exhibit the electrical interfaces, functions & performances required in the unit/subsystem specification and interfaces control documentation.

O/SPL-R-690 NS definition.
The NS shall be a software model allowing simulating the payload behaviour (functional modes, data handling, telemetry and telecommand).

O/SPL-R-700 FM and SM representativeness.
The FM and SM shall be units built from production tooling, with qualified material, parts and processes according to all configuration control and Product Assurance provisions. The FM and SM have to be submitted to all qualification and/or acceptance tests successfully.
APPENDIX

A. Co-ordinate system

B. Allowable volumes and fields of view

C. Preliminary stiffness requirements & Launch loads

D. Preliminary electrical engineering requirements
   (cabling and system grounding)

E. Preliminary EMI/EMC Requirements
Appendix A: co-ordinate system

The Orbiter co-ordinate system origin is at the Orbiter / ARIANE 5 separation plane. The axis are the following ones:

- X axis is ARIANE 5 X axis
- Z axis is the solar panels rotation axis
- Y axis, completes the direct trihedron

The Orbiter second stage co-ordinate system origin is at the 1st stage / 2nd stage separation plane. The axis are the following ones:

- X₂ axis is parallel to X
- Z₂ axis is parallel to Z
- Y₂ axis is parallel to Y

An Orbiter Payload co-ordinate system shall be defined by the Orbiter prime contractor

- XCU axis TBD
- ZCU axis TBD
- YCU axis TBD

Figure A-1 : co-ordinate system
Appendix B: allowable volumes and fields of view

Figure B-1: allowable volumes and fields of view 1
Figure B-2: allowable volumes and fields of view 2
Appendix C: Stiffness requirements & Launch loads

C.1 Stiffness requirement

The structural first natural frequency of each science payloads Module hard mounted to an infinitely stiff interface shall be greater or equal to the following:

<table>
<thead>
<tr>
<th>Science Payloads axis</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X_{cu} &amp; Y_{cu} &amp; Z_{cu}</td>
<td>120</td>
</tr>
</tbody>
</table>

C.2 Quasi static loads (qualification level)

- 20g on each of the 3 axes

C.3 Sine levels (Qualification level)

Sinus level on each of the 3 axes

<table>
<thead>
<tr>
<th>frequency</th>
<th>level</th>
</tr>
</thead>
<tbody>
<tr>
<td>(5 - 21) Hz</td>
<td>11 mm (0 - peak)</td>
</tr>
<tr>
<td>(21 - 60) Hz</td>
<td>20 g (0 - peak)</td>
</tr>
<tr>
<td>(60 - 100) Hz</td>
<td>6 g (0 - peak)</td>
</tr>
</tbody>
</table>

C.4 Random Levels (Qualif Level)

- M being the mass of the element in kg,
  
  20 to 100Hz: +3dB/octave
  
  100 to 300Hz: 0.05*(M+20)/(M+1) g²/Hz
  
  350 to 2000Hz: -5dB/octave

The duration for a protoflight test will be 60 seconds and that for a qualification test will be 120 seconds.

C.5 Shock SRS Constraints

- Shock level (all axes): (Shock Response Spectrum)
  
  100Hz: 20g
  
  100 to 1000Hz: 12dB/octave
  
  1000 to 10000Hz: 2000g

C.6 Shock Loads Induced by Orbiter Internal Pyrotechnic Devices

The shock loads transmitted to scientific payloads by the Orbiter shall be less than those in Section C.5.

C.7 Shock Loads Induced by scientific payloads Internal Pyrotechnic Devices

The shock loads transmitted to Orbiters by the scientific payloads shall be less than those in Section C.5. (TBC)
Appendix D: preliminary electrical engineering
Cabling and System grounding requirements

D.1 General

The return path for all power and signal circuits shall be through conductors in the wiring harness. The spacecraft structure shall not be used as a current carrying conductor. Shields shall not be used for signal returns except in the case of coaxial cables with external shield added.

An overall zero volt and grounding diagram shall be provided for assessing the functional and electromagnetic compatibilities. This diagram shall indicate any AC or DC loop, the type of isolation used and any impedance coupling between zero volt and structure.

D.2 Structural grounding

All structural members of the spacecraft and instrument units chassis and enclosures shall be designed to provide electrical conductivity across all mechanical joints, except where DC isolation is required for maximum electrical reliability. Conductive surface protection coatings such as Iridite, Alodine, or plating shall be used at all joints. The DC resistance across fixed joints shall not exceed 2.5 mOhm.

Redundant bonding straps shall be employed across joints where direct metal-to-metal contact cannot be assured. The DC resistance of these straps shall not exceed 1 Ohm.

D.3 Electrical grounding

a. The exterior case, including connectors and all metallic external covers shall be electrically grounded, directly or indirectly to chassis ground with a resistance of no greater than 2.5 milliohm per bond except for composite components.

b. For composite components, the DC resistance per bond shall be no greater than 100 Ohm.

c. The mounting surface shall be such that it may be electrically grounded to the structure upon which it is to be mounted at installation in the spacecraft.

d. All internal mechanical assemblies shall be electrically grounded directly or indirectly to the base plate.

e. Gimbaled, hinged, or jointed interfaces shall be grounded by means of redundant grounding straps.

D.4 Harness requirements

Circuits having incompatible electromagnetic interference characteristics shall be segregated in cabling and connectors to the maximum extent possible to minimize interference coupling. Separation is necessary for the following circuits categories:

- DC power and command circuits
- Digital signals (0 - 5 V)
- Analog signals (0 - 5 V)
- Electro Explosive Devices
- Radio Frequency lines
- Wires carrying proprietary data
- MIL-STD-1553B bus.

Pyrotechnic lines shall use specific connector.

If two or more circuit categories must share a connector (excepted pyrotechnic), pin assignments shall be made to provide a maximum of isolation in the connector and facilitate separation of the wiring external to the connector. A minimum of two pins separation shall be used.
Power lines (+/-) shall be twisted to reduce magnetic field generation. Pyrotechnic lines shall be constructed using twisted shielded wires. Signal control interface harnesses, in general shall be constructed using twisted shielded wires. Signal return lines shall be shielded. However, some "pulse" commands and relay driver lines will not be shielded in order to save weight on the spacecraft. In this case, EMI analysis shall be performed to ensure EMC/ESD requirement compliance. Neither the structure nor any cable shield shall be used to carry bus power return. This will minimise common mode noise input to the units.

D.5 Isolation

The unit shall provide DC isolation from the primary power to secondary power return of 1 Mohm minimum. Secondary power returns can be grounded to structure only if electrically isolated from primary power. Unit that generates or operates on frequencies equal to or less than 50 Mhz shall have telemetry and command signal and secondary power circuits isolated from the primary power circuits by a minimum DC resistance of 1 Mohm when not connected to the spacecraft harness. Telemetry and command signals that are intended to interface between spacecraft units through the spacecraft harness shall have their return signals isolated from secondary power return by a minimum of 1 MOhm.

D.6 Connectors type and keying

Use of nano-D connectors is not allowed. The instrument units shall employ connector keying, where required, to prevent accidental mismating of connectors. The harness mating connectors shall be configured to properly maintain this keying requirement The harness shall be designed to interface with the mating connectors of the spacecraft electrical units with provision for unit and harness serviceability after assembly. Access shall be provided which supports safe and proper mating and demating of all connectors after spacecraft integration. Electrical connectors shall be electrically bonded to the metallic case in which they are installed to provide electrical resistance of less than 50.0 mOhm (exact resistance data to be supplied for engineering evaluation). Except for cases otherwise approved by systems engineering, the connector housing is bonded to the chassis via a strap with a resistance of less than 1 Ohm.
Appendix E: preliminary EMI / EMC requirements

Electromagnetic Environment

Every instrument unit shall be designed to accommodate for electromagnetic constraints. The requirements specified hereafter are applicable at unit level or group of units when they have a common power converter. The basic requirements to be met by the Instrument Supplier to achieve electromagnetic compatibility of the delivered hardware are defined in terms of grounding, harness/wiring, etc.

Each Instrument Supplier shall provide the electromagnetic compatibility (EMC) test results for his units, to demonstrate their conformance to EMC requirements.

The conducted and radiated emission and susceptibility tests shall be run on one and same model (EM or FM). The need for conducted and radiated emission and susceptibility tests at Flight Model (FM) level shall be investigated in case of non-compliance, changes, and when technology or manufacturer identity are modified from the tested model to the Flight Models.

The documents to be provided by the Instrument Supplier shall include an EMC part. Likewise, the test procedures to be delivered along with the instrument shall include an EMC part, plus the test methods and operating requirements.

E.1 Conducted Emission & Susceptibility Requirements

The requirements hereinafter shall be verified at a power supply voltage of 22 V for conducted emission and 38 V for conducted susceptibility. TBC

A Line Impedance Stabilised Network (LISN) shall be used to simulate impedance of primary power supply. The wound, unshielded test connections shall be with the negative power supply point on LISN input grounded.

E2 Conducted emissions on power lines

The instrument units shall not generate conducted emissions on the unregulated power bus exceeding the following requirements.

a-Frequency domain (Narrowband)

The limits given in figure E.2-1 apply to those units which supply or absorb up to 30 W of power. For higher absorbed or supplied power levels, the limit is increased by 20*log(P/30) up to the maximum reference parameters defined in this figure.
The measurements shall be carried out in differential mode and common mode.

b- time domain:
A limit of 30 mA peak, read in a bandwidth greater than 50 MHz, is defined for really delivered or absorbed power levels less than 30 W. For higher absorbed or supplied power levels, the limit is weighted by a factor P/30, yet without exceeding 1 A peak. This limit is applicable to the frequency domain beyond 60 Hz.
The measurements shall be carried out in differential mode and common mode.

c-Transient signals

- **Turn on transients**
  
  The inrush current shall meet the following requirements:
  
  i) \[ \frac{di}{dt} < 2 \times 10^6 \text{ A/s} \]
  
  ii) \( I_{\text{max}} \cdot t_1 < 400\mu\text{C}, \) with \( I_{\text{max}} < 20 \text{ A} \)
  
  iii) \( I < 2 \cdot I_{\text{nom}} \) for \( t_1 < t < t_2 \) where \( I_{\text{nom}} = \frac{P_{\text{max}} \text{ specified}}{23 \text{ V}} \) subsequently
  
  iv) \( t_2 = 50 \text{ ms} \)

- **Turn off transients**
  
  At instrument switch-off:
  
  The voltage transients superimposed on the power supply voltage shall be measured in both differential and common mode and shall be compliant TBD.
  
  The current transients shall remain within the\([\text{I Nominal, I = 0 A}]\) range.
Operational transients

The current transient on the power bus shall be less than $2 \times 10^4$ A/s.

The instrument units shall preserve nominal performance when the following perturbations occur on the primary power supply lines.

**E.3 Conducted Susceptibility on power lines**

**a- Sine wave signals**

Differential and common-mode signal injection of a sine signal as defined in figure E.3-1. While limits are expressed as voltages, injected current shall nevertheless be measured for each test frequency, and shall by no means exceed 1 A eff., reducing voltage if needed. The test shall comply with methods CS01 and CS02 of MIL-STD-462 with voltage measured between the minus wire and the metallic ground for the common mode.

Sweep rate for the sine signals shall be less than 1 octave/minute.

![Figure E.3-1: Susceptibility to sine conducted emissions](image)

**b-Square wave signals**

Square signals: 1 Vpp from 60 Hz to 500 kHz

The square signal sweep rates shall be less than 1 octave/minute, and the square wave rise time less than 50 ns.

The measurement shall be carried out in differential mode.

**c-Transient signal**

The signal (figure E.3-2) shall be applied for not less than 1 minute by method CS06 of MIL-STD-462, using a positive, then a negative, at a 1 Hz and at a 10 Hz recurrence.

Such signal shall be applied in differential mode and common mode between the minus (-) wire and the metallic ground. The level of injected signal is Vbus in differential mode and 12 V in common mode.

The test shall be performed at Vbus= 22 V and Vbus = 38 V.
The requirement shall be verified with no need for achieving the specified voltage if the limit current value of 3 A peak is measured at the input of the tested unit. Source impedance shall be simulated by the LISN as defined in section E.1.

Figure E.3-2: Conducted susceptibility, transient wave shape

Rise and fall time in all parts < 200 ns
Reference level of the amplitude = 100%

E.4 Susceptibility wrt intermodulation and cross-modulation

The Payload receiver units shall not be perturbed by signal injection as defined hereafter. The instrument receiver units shall be characterised in terms of response to intermodulation and cross-modulation phenomena as well as of rejection w.r.t. spurious signals. Tests shall be run by methods CS03, CS04 and CS05 of MIL-STD-462, and they shall be restricted to the frequency bands utilised by the spacecraft.

E.5 Conducted susceptibility of interface signals

Injection of 70 dBµA signal in 100 kHz to 50 MHz. The measurement shall be carried out in common mode.
E.6 Radiated Emission and Susceptibility Requirements

The requirements hereafter exclusively apply to units. In case of excess emission or susceptibility, the contributions from harness/wiring and the test facilities have to be determined. The measurement shall be carried out up to 1 GHz. For RF equipment, the measurement shall be carried out up to 18 GHz.

E.7 Emissions radiated by E-field

The electric field, measured at 1 m by method RE02 of MIL-STD-462, radiated both by the test equipment and by associated, representative harness/wiring, shall not exceed the limit set in figure E.7-1. The measurement range is 10 kHz to 1 GHz in Narrowband except for RF equipment.

![Figure E.7-1 Radiated emission, E-field, Narrowband.](image)

E.8 Radiated electric susceptibility

The instrument units of the Payload Module shall be free from any misfunctionning or performance degradation when subjected, by method RS03 of MIL-STD-462, to electrically generated electromagnetic radiation within the limits specified in terms of electric fields per figure E.8-1.

In the case of receiver units, this test is not applicable within their receiving band. To that effect, the above field shall be 50 % amplitude-modulated by a sinusoid of a frequency like those frequencies at which the unit was found conduction-susceptible. The carrier-to-modulating frequency ratio shall be more than 5. Susceptibility shall be tested up to 1 GHz. Susceptibility testing of the RF units shall run up to 18 GHz, with functional emission frequencies used as the test frequencies for all units.

Sine wave sweep rate shall not exceed 1 octave/minute, and the sine signal shall be amplitude-modulated by a square signal with a 30% modulation rate in the dedicated (e.g. radar) bands.
Figure E.8-1: Radiated susceptibility, E-field

**E.9 Arc discharge protection**

Surface finish for prevention electrostatic charging, insulating materials or finishes having a resistivity greater than $10^9$ Ohm.cm shall not be used.