

Harness Requirement Specification

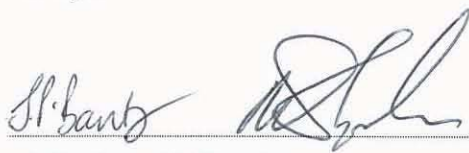
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1 SCOPE AND INTRODUCTION

1.1 Scope

This Specification defines all relevant standard technical requirements and constraints to be respected for the design definition, manufacturing and testing of the Sentinel 5 Precursor Harness. [3]

1.2 Introduction

This document contains the standard technical requirements for the harness. This includes: [6]

- the standard performance and equipment specific design and interface requirements [7]
- the standard equipment specific testing and verification requirements (if any) [8]
- the standard general design and interface requirements [9]

Each requirement contained in this document is identified by a unique Requirement Number **HAR-xyz / Verification / Applicability** , with xyz denoting a three digit number, and by the Verification Method (T= Test, A = Analysis, I = Inspection, R = Review of Design) and the applicability code (AR, DO MA) as defined below. [10]

The requirements of this document have also an applicability code : [12]

AR is for electrical Architect [13]

DO is for the harness designer [14]

MA is for the harness manufacturer [15]

HAR-1324 / / MA

Only requirements that include MA in the Applicability field shall be addressed by the Harness Supplier

The roles of the actors is defined here below : [16]

Architect :

 [17]

The electrical architect defines the avionics or satellite EICD [AD 04] a link list inputs document [AD 08] based on units EICDs, which includes the following elements : [18]

- Unit List [19]
- Connector List [20]
- Link List [21]
- Pin Out List [22]

Harness Designer

 [23]

The Designer defines the Harness Manufacturing Files (HMF), the routing and the implementation on the satellite . The manufacturing Files contents and format are defined in RD[X] [24]

The harness designer defines the list of components. [25]

The harness designer is also responsible for the integration of the harness on the satellite. [26]

Harness Manufacturer

 [27]

The Harness manufacturer is in charge of delivering a validated and tested hardware including all accessories compliant to manufacturing files defined by the designer. [28]

Harness manufacturer may also be in charge of the installation of the harness on the satellite. [29]

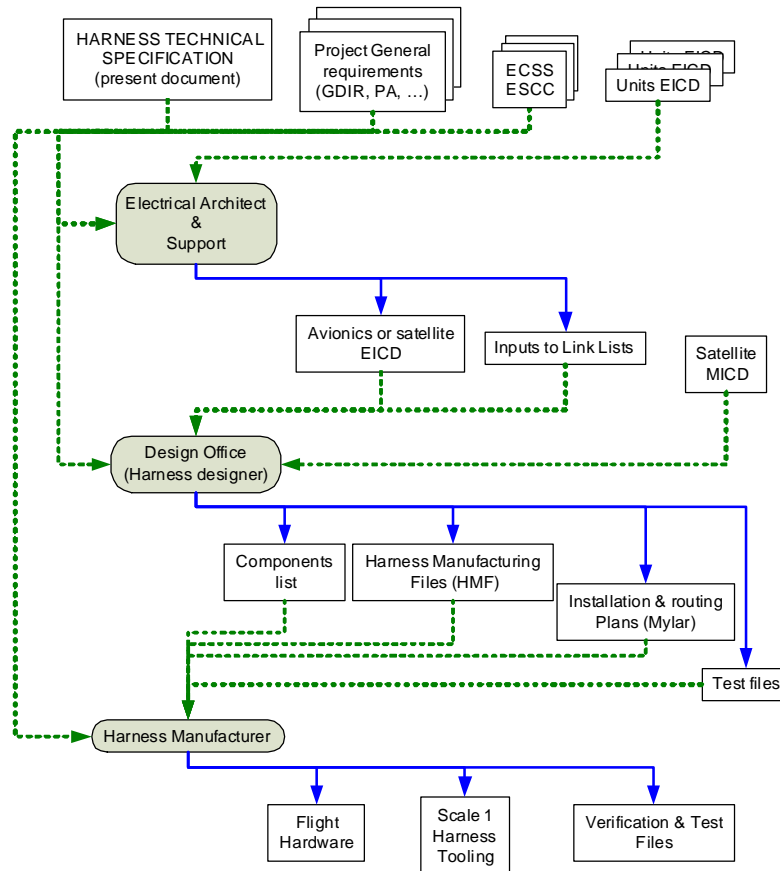


Figure 1.2-1: Harness process principle (simplified)

1.3 Handling of non-conformances and Deviations

Statement of compliance

At submission of the proposal, the Statement of Compliance (SOC) shall just contain the statements “compliant” and/or “not compliant”. Neither “partially compliant” nor exception clauses shall be formulated. Any non-compliance shall be explained and a way forward shall be given to achieve compliance. This way forward may contain a proposed relaxation or omission of the requirement by prime.

Electrical Interface Control Document

Any deviation of the EICD [AD 04] to the requirements given in the present document shall be adverted to prime for approval. This procedure shall be followed informal, i.e. it is no subject for submission of a RFD (Request for Deviation) or CCN (Contractual Change Note) as long as no ECO (Engineering Change Order) has been released by prime.

1.4 General Description

The purpose of the Harness is to establish required electrical interconnections between all electrical and electronic equipment in the AstroSat 250 generic platform.

It shall provide adequate distribution and separation of all power supplies, signals, commands, instrument data, and all connections to the umbilical and test connectors.

The Astrosat 250 avionics includes the following elements :

Power SubSystem

- PCDU
- Battery

- Solar Generator [44]

Payload Data Management (PDM) [45]

- X-Band Modulator [46]
- X-Band SSPA [47]
- PDHU (Payload Data Handling Unit) [48]
- ICU (Instrument Control Unit) [1326]

DHS : [50]

- OBC [51]
- RIU [52]
- MIL-STD-1553 bus [53]

TTC [54]

- S Band Transponder [55]

AOCS [56]

- STR (Star Tracker) [57]
- GPS Receiver [60]
- RW (Reaction Wheel) [61]
- MAG (Magnetometer) [62]
- MTQ (Magneto-torquer) [63]
- CSS (Coarse Sun Sensor) [64]
- PM (Propulsion Module) [65]

2 DOCUMENTS

2.1 Applicable Documents

The latest versions of the following documents are applicable to their full extent to this Standard Equipment Specification:

[68]

AD 01	DIV.SP.00027.T.ASTR	General Design and Interface Requirements
AD 02	S5P.SP.ASU.SY.00010	Product Assurance Requirements for Subcontractors
AD 05*	DIV.SP.00092.T.ASTR	Manufacturing Specification for Harness
AD 07	S5P.ICD.ASU.SC.00012	<Satellite Mechanical ICD>
AD 08	<TBD>	Inputs to Link list
AD 09	<TBD>	Satellite Thermal ICD
AD 10	ECSS-Q-ST-70-08	Manual Soldering of high-reliability electrical connections
AD 11	ECSS-Q-ST-70-26	Crimping of high-reliability electrical connections
AD 12	ECSS-Q-ST-70-30	Wire wrapping of high-reliability electrical connections
AD 13	ECSS-Q-ST-30-11C	Derating requirements and application rules for electronic equipment
AD 14	MIL-STD-1553B + Notice 3 STD	MIL-1553B Harness bus requirement specification
AD 15	ESA/SCC 3401	Generic Specification for Connectors Electrical Non-Filtered Circular and Rectangular
AD 16	ESA/SCC 3401/002	Connectors Electrical Rectangular Removable Crimp Contacts, based on type D*MA
AD 17	ESA/SCC 3401/056	Connectors Electrical Triple-Start Self Locking Coupling Scoop Proof Removable Crimp Contacts, based on MIL-C-38999 Series III
AD 18	ESA/SCC 3401/005	Contacts, electrical, crimp for 3401/002 connectors
AD 19	ESA/SCC 3401/052	Connectors, electrical, circular, bayonet coupling, scoop-proof, removable crimp contacts, based on MIL-C-38999 Series 1
AD 20	ESA/SCC 3402/001-003	RF Coaxial connectors Type SMA
AD 21	ESA/SCC 3402/008-010	RF Coaxial connectors Type TNC
AD 22	ESA/SCC 3901/019	Polyimide insulated wires and cables (based on type SPL)
AD 23	ESA/SCC 3901/021	Polyimide insulated wires and cables with drain wire
AD 24	ESA/SCC 3902/001	Coaxial, double shielded coaxial, shielded and jacketed coaxial cables, Flexible 50 Ohms, miniature, PTFE dielectric
AD 25	ESA/SCC 3902/002	Coaxial, triaxial and symmetric cables
AD 26	ESA/SCC 3903/003	Cable, SpaceWire, round, quad using symmetric cables
AD 28	<TBD>	<Satellite to Launcher Interface Requirements Document>

* AD1,3,4 of AD5 will not be provided

2.2 Reference Documents

The latest versions of the following documents are to be used as reference to this Standard Equipment Specification:

[199]

RD 01	<TBD>	Electrical Ground-Spacecraft Interface Document
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2.3 Nomenclature

In the present document, the following terminology is used.

[206]

Functional chain	Amount of units representing a top level function
Unit	A unit provides at least one dedicated function. A unit can consist of several items e.g. Star tracker: Items: Sensor heads 1,2 and 3, electronics
Item	An item is a physically enclosed equipment, e.g. star tracker electronics
Module	A module consists of components and parts and represents one function
EEE Component	Electrical Part on circuit level (e.g. transistors, diodes)

Functional chain	Amount of units representing a top level function
Equipment	Equipment is a general term which can summarize units and items without further functional correlation. Equipment is the wording equivalent to both item and unit.
Location	Location is defined as mechanical position on which items are assembled on, e.g. platform panel -X.

[220]

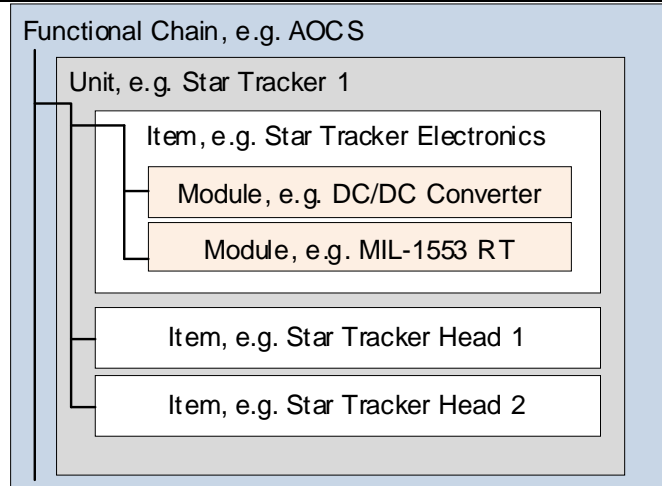


Figure 2.3-1: Hierarchy of physical elements on equipment level

[221]

EEE Component	Electrical Part on circuit level (e.g. transistors, diodes)
Equipment	Equipment is a general term which can summarize units and items without further functional correlation. Equipment is the wording equivalent to both item and unit.
Location	Location is defined as mechanical position on which items are assembled on, e.g. platform panel -X.
Functional Interface (L1)	The Functional Interface specifies the purpose of the connection (e.g. <<unit>> temperature acquisition) as well as the signal flow direction One functional interface can be realised with one or several Functional Channels, e.g. Functional Interface: MMFU_Temperature
Functional Channel (L2)	Each functional channel is routed from one item to another and is described by <ul style="list-style-type: none"> •the unique functional channel designation, e.g. MMFU_Temperature_N •the Signal Type (e.g. TH1, ANY, STM) incl. voltages, rise and fall times etc. •the source and target destinations expressed down to connector level, e.g. MMFU J01 (source) and OBC J61 (target)
Signal type	A Signal type is the electrical definition of an electrical circuit, e.g. TH3 specifies thermistor acquisition for Betatherm 4K3A354 or equivalent Each signal type is assigned with a link to a specification section and an I/F circuit data sheet stored in the project GDIR with the following information: Electrical parameter as relevant: current, voltage levels, rise/fall times, timing constraints, impedance etc. EMC class Wire types incl. shielding, twisting, Wires naming rules (e.g. SIG/RTN). Connection of shields (if applicable) Beside the signal code (e.g. AN1) a signal name is defined (e.g. Analogue signal)

EEE Component	Electrical Part on circuit level (e.g. transistors, diodes)
Interface Circuit type	<p>Specific record for the definition of the circuitry of drivers or receivers; to be defined & maintained in the GDIR.</p> <p>The unit suppliers use these interface circuit types in order to define the allowed unit' interfaces. Thereof, the supplier selects the circuits available at their unit and specifies the external implementation down to connector and pin level on the connectors and the internal implementation to drivers & receivers.</p> <p>During pin allocation both sides of a functional channel, namely a driver and a receiver circuit of the same interface circuit type have to be connected by the harness engineer.</p>
Driver / Receiver	Driver is the source of data or power, while the receiver is the dedicated data or power sink (from a functional point of view).
Interface Data Sheet	A summary datasheet of all electrical data relevant for the given I/F, which is defining a signal type and maintained in the GDIR as part of the interface circuit type definition.
Harness	The harness specifies the amount of all wires, cables, bundles, connectors, backshells and mechanical parts required for the hardware implementation of all functional electrical interfaces.
Corridor	The corridor represents the virtual geometrical envelope reserved for harness routing. Equivalent to "Space Reservations" in CATIA
Bundle	A bundle consists of more than one cable. It can be furnished with overall wrap for shielding (using braid or aluminium foil) or insulation (Kapton).
Cable (L3)	A cable consists of at least one wire including the shielding, if shielding is applied.
Wire (L3)	The wire is the electrically isolated metallic conductor (core + insulation) interconnecting two or more pins (e.g. for daisy chains or cross-strapping).
Core	A core is the metallic conductor without isolation.
Splice	A splice (soldered or crimped) connects at least two wires in order to either or both perform a n-to-n connection and or to change the wire gauge. Splices are defined by electrical harness engineering as part of the functional electrical harness definition.
Branch point	A branch point is the point where one bundle is separated in two or more. Branch points are defined by the mechanical harness engineering in order to perform harness routing.
Harness connector (P..)	Connectors assembled on the harness, i.e. the loose part
Item connector (J..)	Connector fix mounted onto an item or a connector bracket
Connector naming	<p>Coax connectors = male, female</p> <p>Circular connectors = plug, receptable</p> <p>D-sub connectors = mating half, fixed half</p>
Backshell	Mechanical part of a connector for strain relief of the cables, fixation of the connector to its counterpart, shield connection and shielding the wires connected to the connector.
Pin / Socket	The pin is this mechanical part of a male J- or P-connector the wire physically is connected with. The socket is the respective part on a female J- or P-connector.
Connector bracket	Mechanical interface for harness interconnection in order to ease AIT. Wiring is 1 to1 from P-Connector to the J-Connector
Skin Bracket	Mechanical interface for harness connected to external applications, e.g EGSE, SCOE or for application of arming/inhibition devices (e.g. pyro, battery). Two types of skin brackets exist. Signal ends at the J-Connector Signal comes from J-Connector is bridged in the P-Connector and continues out to the J-Connector
Umbilical	Electrical interface between spacecraft and launch vehicle is called umbilical: Wiring is 1 to 1 from Launcher P-Connector to the Spacecraft J-Connector

EEE Component	Electrical Part on circuit level (e.g. transistors, diodes)
Electrical top level architecture (Level 0)	The electrical top level architectures shows all units and the preliminary design of the concepts for command and control, power supply and payload data handling.
Electrical architecture	The electrical architecture shows all major items and the major functional interfaces without displaying the functional interface names.
Interface Diagram (Level 1)	The interface diagram shows all functional channels connected to the destinations' unit connectors.
Wiring Diagram (Level 2)	The wiring diagram shows the implementation level of the harness by representing the pin-to-pin definition and routing via brackets. All details of electrical harness definition are represented here, e.g. connector and cable types, signal types, wire names, grounding and shielding of cables

Other Definitions

As these terms can have broad interpretation, they are not used for the purpose of this document.

[311]

[312]

Block Diagram	A block diagram is a simplified view of a unit, facility, network or system. The several system components (e.g. Units or Functional Chains) become represented by standardised graphical symbols. Interconnections and data/energy flows are symbolised with lines and arrows.
Interface	An interface can be a dedicated interface for one special purpose (e.g. functional channel) or a generic term for all electrical, mechanical or thermal interfaces between two parts or items.
Connection	A connection can be physical and or logical. All kinds of connections e.g. mechanical or thermal can be summarised to the interface.
Function	Functions should have a single definite purpose. Function names should have a declarative structure (e.g. "Validate Telecommands"), and say "what" is to be done rather than "how". A function is up to functional analysis, but not for the purpose of interface and harness engineering. Interfaces and harness can be linked to a top level function defined on system level, e.g. distribute power.

3 FUNCTIONAL REQUIREMENTS

3.1 Failure tolerance

3.1.1 Failure Catalogue to be considered

HAR-329 / R / AR,DO

For the Failure analysis, the following failures shall be considered:

- Loss of an electrical contact
- Detachment of a soldered splice or a solder
- Loss of a grounding insert (electrically speaking), if this failure can cause a thermal hot spot.

Note: Failures not to be considered:

- Loss of a mechanical contact
- Loss of a wire
- Loss of a crimp

[330]

[331]

[332]

[333]

3.1.2 Failure Tolerance implementation

HAR-335 / R / DO

As far as practicable, wiring of redundant systems, subsystems or elements of subsystems shall be routed through separate connectors and wire bundles.

Note: In case of triple redundancy like for unit thermistors, it is sufficient that the three interfaces are routed via two (2) different connectors or bundles.

HAR-336 / R / DO

As far as possible, the design shall not provide a main and redundant circuit on the same bundle.

HAR-337 / R / DO

As a goal, redundant and nominal bundles shall be routed separately as far as pragmatically possible. This means, if possible a distance of less than 5cm shall be avoided.

Note: For mouse holes, in front of the unit connectors or others restricting areas, where keeping this goal is simply not possible, this goal does not apply.

HAR-338 / R / DO

For power harness, the sizing of the wires shall take into account one failure of one contact.

3.2 Performance requirements

3.2.1 General

HAR-341 / R / DO

The electrical harness design shall be designed in accordance with the functional definition given in [AD 08] and the generic interface definition as specified by [AD 01].

HAR-342 / R / DO

The cables gauge and the number of shielded cables shall be minimised as far as the electrical considerations will allow. This requirement is considered as a design 'goal' dependent upon electrical considerations and input provided in [AD 08].

3.2.2 Specific constraints**3.2.2.1 Voltage drop constraints****HAR-347 / A,R / DO**

The voltage drop requirement shall take into account all elements of harness as detailed in paragraph 8.1.2 :

Max current as defined in AD[08]

Hot and return wires, contacts, crimps, splices, brackets ...

HAR-348 / T,A / DO,MA

The voltage drop in power harness linking the Solar Array and the PCDU shall be less than 400mV

HAR-349 / T,A / DO,MA

The voltage drop in power harness linking the Battery and the PCDU shall be less than 250mV

HAR-350 / T,A / DO,MA

The voltage drop in power_AIT_BAT harness linking Umbilical bracket (SD_UMB) and the PCDU shall be less than 500mV

HAR-351 / T,A / DO,MA

The voltage drop in power_AIT_BUS harness linking Umbilical bracket (SD_UMB) and the PCDU shall be less than 500mV

HAR-352 / T,A / DO,MA

The voltage drop in power harness linking PCDU and units power supplied by LCL or FCL shall be less than 500mV

HAR-353 / T,A / DO,MA

Voltage drop in power supply harness linking PCDU and RIU PROPU shall be less than 200mV

HAR-354 / T,A / DO,MA

Voltage drop in TC FCV harness linking RIU and Propulsion Module interface bracket (SD PROPU) shall be less than 300mV

HAR-355 / T,A / DO,MA

Voltage drop in TC LV harness linking RIU and Propulsion Module interface bracket (SD PROPU) shall be less than 500mV

HAR-356 / T,A / DO,MA

Voltage drop in TC Battery relay harness linking Umbilical and PCDU shall be less than 500mV

HAR-357 / T,A / DO,MA

Voltage drop in CBH harness linking RIU and Propulsion Module interface bracket shall be less than 300mV

HAR-358 / T,A / DO,MA

Voltage drop in power harness linking RIU and MTQ shall be less than 500mV

HAR-359 / T,A / DO,MA

Voltage drop in power harness linking RIU and MAG shall be less than 300mV

S5p-HAR-360 / T,A / DO,MA

Voltage drop in TC RF Switch harness linking RIU and RF Switch shall be less than 3V

3.2.2.2 Specific constraints on power harness**HAR-362 / R / DO**

The cable length between Solar Array sections and the PCDU shall be as short as possible.

HAR-364 / A,R / DO

The cable length between Battery and the PCDU shall be as short as possible

HAR-366 / T,A / DO,MA

The difference between

- *total resistance (Plus and return) of the power harness linking PCDU and Battery Module 1 on one hand,*
- *and total resistance (Plus and return) of the power harness linking PCDU and Battery Module 2 on the other hand*

shall be less than 1% of the total resistance value.

HAR-367 / A,R / DO,MA

The distance between the power Plus wires and the return wires of the battery modules shall be minimized in order to reduce the magnetic moment.

3.2.2.3 Specific constraints on AOCS harness**HAR-377 / A,R / AR,DO**

The cable linking RIU and SD AOCS for TACHO signal shall present a differential capacitance (line vs return) less than 120pF

HAR-378 / A,R / AR,DO

The cable linking RIU and SD AOCS for TACHO signal shall present a resistance (line and return) less than 0.3 Ohm

HAR-379 / A,R / AR,DO

The cable linking RIU and CSS shall present a resistance (line and return) less than 2 Ohm

3.2.2.4 Kevlar cutter and pyrotechnic harness**HAR-381 / R / AR**

Connections to all pyrotechnic devices shall be capable of being mechanically interrupted during ground handling by a safe/arm connector.

HAR-382 / R / AR

The safe/arm connector shall connect power lines as well as power return lines.

HAR-383 / R / DO,MA

The backshell of the safe/arm connector shall be metal and of blanking caps configuration (EMC tight).

HAR-384 / R / AR

The pyro safety plug must present a short connected to ground on the initiator side and an open circuit on the power supply circuit side..

HAR-385 / T,R / AR,DO

Pyro safe/arm connector shall be located in accessible positions external to the spacecraft

HAR-386 / R / AR

A separation strap shall be included in arm connectors to be monitored by data handling.

HAR-387 / R / MA

There shall be no gaps or discontinuities in the shielding, including the termination at the back faces of the connectors, nor aperture in any container which houses elements of the firing circuit.

HAR-388 / R / DO,MA

Multiple grounding points of shields for pyro or Kevlar cutter lines are recommended, and shall be done at least at both ends.

HAR-389 / R / AR,DO,MA

All electro explosive devices and safe and arm devices shall have EMC shielding caps attached during storage, handling and installation.

HAR-390 / R / MA

Shielding caps shall have a solid metal outer shell which makes electrical contact with the EED case in the same manner as the mating connector for EED.

HAR-391 / R / AR,DO

The interceptions on the Pyro line shall be minimised.

HAR-392 / R / AR

Structure return shall not be used for pyro circuitries.

HAR-393 / R / AR,DO

For EED (Pyro) lines, one wire per pin shall be used.

HAR-394 / R / AR,DO

Redundant and nominal pyro lines shall be routed separately as far as pragmatically possible. This means, a distance of less than 2 cm shall be avoided.

3.2.3 MIL-STD-1553B Bus Harness**3.2.3.1 MIL-STD-1553B Bus General information and requirements**

The MIL-STD-1553B Data bus is dedicated to link all the units of the satellite managed by the DATA HANDLING Subsystem using one Prime Data Bus and one redundant Data Bus. [397]

The bus is divided in two sections: [398]

- Avionics bus [399]
- Payload bus [400]

Each section includes: [401]

- Main transmission cables (Nominal and Redundant) [402]
- Cables stub for each Remote Terminal and Bus Controller [403]
- Single or double in-line transformer couplers [404]
- Bus terminator loads [405]
- RT or BC connectors and the relevant back-shell at the end of each long stub cable. [406]

Main Bus and redundant Bus stub terminations may be on the same connector of a Remote Terminal or Bus Controller. [407]

HAR-408 / R / AR,DO,MA

The MIL-STD-1553B bus harness shall comply with [AD 14].

HAR-409 / R / AR,DO,MA

Main and redundant Busses shall use separated cables

HAR-410 / R / AR,DO

The harness design shall ensure external accessibility to the MIL-STD-1553B Bus by Remote terminal, MIL-Bus extension; Remote terminal and MIL-Bus extension; test stub output via a skin bracket.

HAR-411 / R / AR

The MIL-STD-1553B Bus interfaces to the RT and BC shall be designed with an isolation transformer and therefore shall be Long Stub coupled

HAR-412 / R / AR,MA

To avoid μ cuts due to connector's pins behaviour, each bus line shall use two contacts in interception connectors or bus terminator plugs.

HAR-413 / R / AR

The Data Bus shall be operating during launch with full performances.

3.2.3.2 MIL-STD-1553B Bus Transmission lines characteristics**HAR-415 / R / AR,DO,MA**

Main transmission cable and long stub cable shall use the same type of cable.

HAR-416 / R / MA

*The wire polarity shall be identified in a non ambiguous manner at the **long stub termination connections** and at level of each **main transmission cable terminations**.*

HAR-417 / R / MA

The type of cable shall be : TWINAX 40 AWG 24, P512296.

HAR-418 / R / AR,MA

All main transmission cable and long stub cable shall be considered as internal to the Spacecraft.

HAR-419 / R / MA

The manufacturing contractor shall justify all sizing, electrical and mechanical characteristics of the cable, including for the materials used (see AD-01).

HAR-420 / R / MA

All these characteristics shall be compatible with the environment described in the AD-01 (GDIR).

HAR-421 / R / MA

The cable used shall be compliant with the environmental requirements of the AD-01, the Product Assurance requirements of the AD-02 and the functional requirements of the [AD 14].

3.2.3.3 MIL-STD-1553B Bus Microcoupler for bus**HAR-423 / R / MA**

The in line transformer coupler design shall be in accordance with the [AD 14] and compliant with the environment requirements of the AD-01 and the Product Assurance requirements of the AD-02

HAR-424 / R / MA

The in line transformer couplers shall not be removable.

HAR-425 / R / MA

The manufacturing contractor shall justify all sizing, mechanical and electrical characteristics of the in line transformer coupler, including its different elements (transformer performances, isolation ...).

HAR-426 / R / MA

All the in line transformer couplers characteristics shall be compatible with the environment describe in the AD-01.

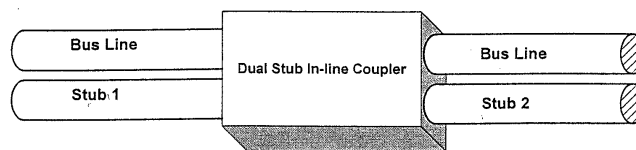
HAR-427 / R / MA

Each in line transformer coupler shall be marked in order to identify the in/out main transmission cable and the in/out stub user

HAR-428 / R / MA

The following type of microcoupler shall be used : **AMB/S-Cx-40** :

AMB/S-C2-40 bus lines on opposite sides of the microcoupler and two stubs (S: Spatial version) are generally recommended.



[429]

Figure 3.2-1: Principle outlining of the Dual Stub In-line Coupler

[430]

3.2.3.4 MIL-STD-1553B Bus Line termination loads

HAR-432 / T,R / MA

Each nominal and redundant bus shall be closed at each end by a 77 Ohm +/- 1% resistor termination load in order to insure the line adaptation.

- One side shall be an in line bus terminator which reference shall be AMB/S-I-40.
- The other side terminal loads connected on a connector shall be realized by a brazing with potting and backshell providing mechanical and EMC protection. The technologies used for the making of these backshells will be submitted to the approbation of EADS ASTRIUM

3.2.3.5 MIL-STD-1553B Bus sections characteristics

HAR-434 / R / MA

The dimensional characteristics of the bus sections and the connectors' localisation are <TBD>

HAR-435 / R / AR,DO,MA

The length of long stub shall not exceed 6m

HAR-436 / R / AR,MA

The screw lock shall be female screw locks for the fixed connectors (with J)

The screw lock shall be male screw locks for the mobile connectors (with P).

HAR-437 / R / MA

The main lines of the MIL-STD-1553B Bus (Nominal and redundant) shall be coloured in blue.

HAR-438 / R / MA

The Stub lines of the MIL-STD-1553B Bus (Nominal and redundant) shall be coloured in white.

HAR-439 / R / MA

All the connectors shall be filled with contacts at 100%.

HAR-440 / R / MA

The lengths are described from the middle of the stub to the middle of another stub and from the middle of the stub to the front face of a connector. The tolerance will be of 0/+10 mm for the lengths < to 2000 mm and of 0/+20 for the lengths > to 2000mm.

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HAR-441 / R / MA

The backshells in the rear side of the connectors shall be straight threaded backshells (except for EFOG) <TBC>

3.2.3.6 MIL-STD-1553B Bus grounding

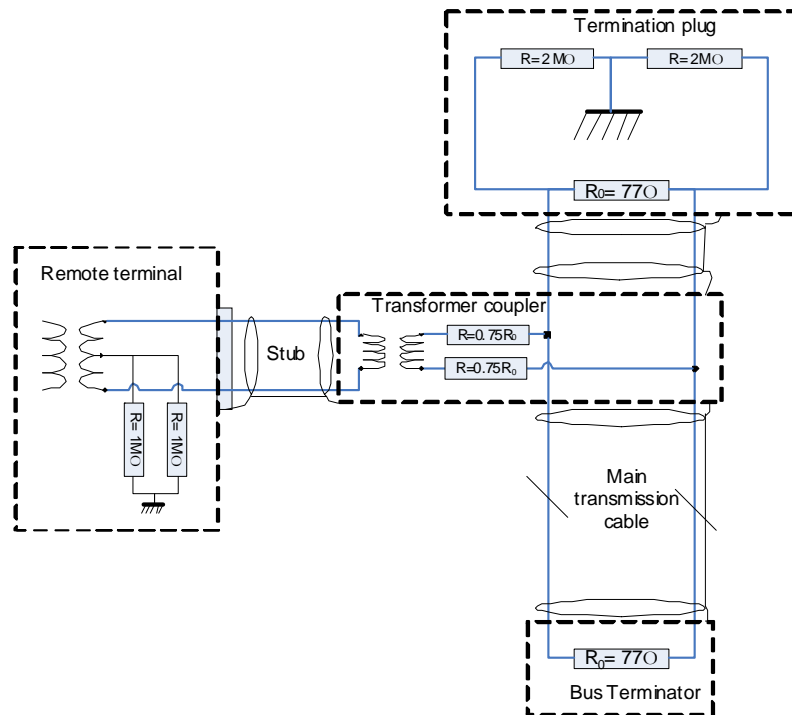
HAR-444 / T,R / MA

The terminal load at the plug side shall be connected to the mechanical ground via two resistors of 2 MOhms. Mechanical grounding corresponds to cable shielding.

Note : Each stub (long stub) shall be connected to ground inside the remote terminal or the bus controller by a redundant resistor of 1 M Ohms.

HAR-446 / R / AR

Cables shieldings shall be connected to the connector or to the backshell at unit level (controller bus or remote terminal).



[447]

Figure 3.2-2: Principle outlining the Bus grounding principle

[448]

3.2.3.7 MIL-STD-1553B Bus specific Process

HAR-450 / R / MA

Cable shieldings shall be connected on the entire circumference at terminations level. This means that the backshells shall be used at the rear face of Sub-D type connectors.

HAR-451 / R / MA

The backshells shall preferentially be made of nickered aluminium or passived Inox (or with gold layer).

HAR-452 / R / MA

Connectors' male fixations, compliant with standard 4.40 UNC, shall be provided if the thickness to tighten exceeds the usual dimensions (incompatible with standard screw tools in C&K catalogue). In this case, the screws shall be made of Inox and unlosable

HAR-454 / R / MA

Cabled contacts will be fitted out with transparent shrink sleeves covers in the crimping zone.

HAR-455 / R / MA

Delivered products will be submitted to:

- *Controls during the manufacturing*
- *Inspections and controls on final products.*

The wiring process will be qualified standard space process agreed by EADS Astrium.

The working environment will be rooms with a class od 100,000 particles per m² or better.

4 DESIGN REQUIREMENTS

4.1 General

S5p-HAR-458 / R / AR,DO,MA

The harness shall comprise:

Elements of flight configuration

the connectors and connector backshells,

- *contacts,*
- *cables and wires,*
- *harness shielding,*
- *harness fixation,*
- *connector and cable labels,*
- *connector brackets,*
- *ESD protection components as anti-static resistors (in case of pyro lines) and transzorb diodes (in case of signals from solar arrays)*
- *accessories (e.g. shrinkable sleeves, splices, connector, fixation material ...)*
- *arm plugs, umbilical connectors, skin connectors and associated EMC flight plug*
- *Elements of test and ground handling configuration*
- *connector savers for skin connectors,*
- *dust caps,*
- *safe plugs*
- *an adequate quantity of test adapters and test cables for all different kind of used harness connectors*

HAR-460 / R / AR

Inclusion of components in the harness, such as resistors, diodes, capacitors, fuses, or other similar devices is not allowed except with prime contractor approval or when included within dedicated devices (plugs...).

HAR-461 / R / AR,DO

Harness design shall not prevent unit mounting/dismounting.

4.2 Electrical design requirements

HAR-463 / A,R / AR,DO

Unless specified by unit design, characteristics of wires shall be maintained through bracket connectors along a functional channel.

HAR-464 / R / AR,DO

Connectors supplying power to other units shall have for the fixed part socket contacts for D-Sub connectors and pin contacts for Micro-D connectors.

HAR-465 / R / AR,DO

The termination of wires to their relevant connection points shall be by crimp. Termination by soldering shall be submitted to prime contractor approval.

HAR-466 / R / AR,DO

Solder contacts shall not be used except on filter connectors or in line termination connectors with electrical devices fitted to them. This shall be approved by prime on case by case basis.

HAR-467 / R / AR,DO

Splices on cables shall be minimised - unless explicitly required in [AD 08] - as far as the electrical considerations will allow

HAR-468 / I,R / AR

Test connectors shall be designed with socket-contacts.

HAR-469 / I,R / AR,DO,MA

Single lines in area of 20-40mm behind connector contact shall be not crossed to permit proper insertion / extraction tooling.

HAR-470 / A,R / AR

The following types of cables shall be used :

Link type	Wire Type	Wire type	Wire Gauge	Specific Requirement
ULCL/UFCL	TP	21	SAS	
POWER_STRAP	M	11	SAS	
POW_BAT	TP	21	12	
POW_SA	TP	21	20	
POW_SEC	TP	21	SAS	
PCDU_HEATER	TP	21	SAS	
IVU_HEATER	TP	21	SAS	
LNTHD	COAX			Coaxial Gore Type 27
VIDEO NAOMI	COAX			COAX CIS 50
AN1	TSP	23	28	
AN2	TSP	23	28	
AN3	TSP	23	28	
ANF	TP	21	28	
ANP	TP	23	28	
ANY	TP	21	28	
SHF	TP	21	26	
EHP	TP	21	SAS	
SLP	TP	21	SAS	
FCV/CBH	TP	21	24	
RSA	TP	21	26	
BLD	TSP	23	26	
LVDS	TSP	23	28	Zc = 100 ?
SBDL	TSP	23	26	Zc = 120 ?
SPW	TSP	23	28	Zc = 100 ?
THERMAL CUTTER	TSP	23	SAS	

[471]

The link types are defined in AD1

[472]

Nota : SAS mean "to be optimised by Design Office vs Vdrop requirement"

[473]

HAR-474 / I,R / MA

Transparent shrink sleeves on pins and sockets to harness connection shall be used.

Note: MIL-Series circular connectors are excluded from that requirement.

Note: Non-transparent shrink sleeves (e.g. Viton) shall be limited as far as possible and submitted to prime for approval.

HAR-475 / I,R / AR

Hot and Return lines (for instance positive and negative of a power line or signal and return line of a telemetry line) shall be located as close to each other as possible to facilitate cable twisting and shielding.

Note: This requirement does only concern connectors under definition by the harness subcontractor. Unit connectors defined in [AD 08] shall be used as is.

HAR-476 / I,R / AR,DO

Impedance controlled cables shall not be spliced

HAR-477 / R / AR

In no case the pyro power Hot and Return lines shall be spliced.

4.2.1 Connectors**HAR-480 / R / DO**

The bundle diameter entering the backshell (if any) shall be less than the maximum cable entrance to place protection in between cable and outlet border.

HAR-481 / R / DO

Interface connector brackets with several connector rows in parallel shall be designed with connectors in alternating orientation and half width space of biggest neighbourhood backshell/connector in between. Lowest row shall be high enough to allow harness routing in front of the bracket.

HAR-482 / R / MA

*For rectangular connectors based on type D*MA, removable crimp contacts shall be used as defined in [AD 15] and [AD 16].*

HAR-483 / R / AR,DO,MA

For circular connectors based on MIL-C-38999 Series III as specified in [AD 15] and [AD 17] key-way coding shall be used to minimize the possibility of mismatch of connectors with different contacts.

HAR-485 / R / AR,DO

Selection of crimp contacts shall be selected according to SCC specifications and S/C requirements and compliance between wire/contacts combinations.

HAR-486 / I,R / AR

When coaxial connectors are used, the female centre contact shall be located in the unit connector (J connector).

4.2.1.1 Backshell**HAR-488 / R / AR**

EMC metallic Back shell with a 360° shield termination shall be fitted on each connector for pyro and any data bus, e.g. MIL-1553.

4.2.1.2 Connector contact assembly**HAR-490 / I,R / MA**

All connectors shall be populated with all pins and sockets, also for unused contacts, to prevent inverse mating and to improve mechanical stability.

Note : this requirement can be relaxed under prime contractor approval. HAR-491 and HAR-492 are then applicable

HAR-491 / I,R / MA

All wired contacts as well as population pins (see HAR-492) have to be inserted.

HAR-492 / I,R / DO

In order to guarantee good mechanical characteristics during the mating/demating and the launch, all harness connectors shall be populated with pins as described on the scheme given hereafter for D-Sub connectors.

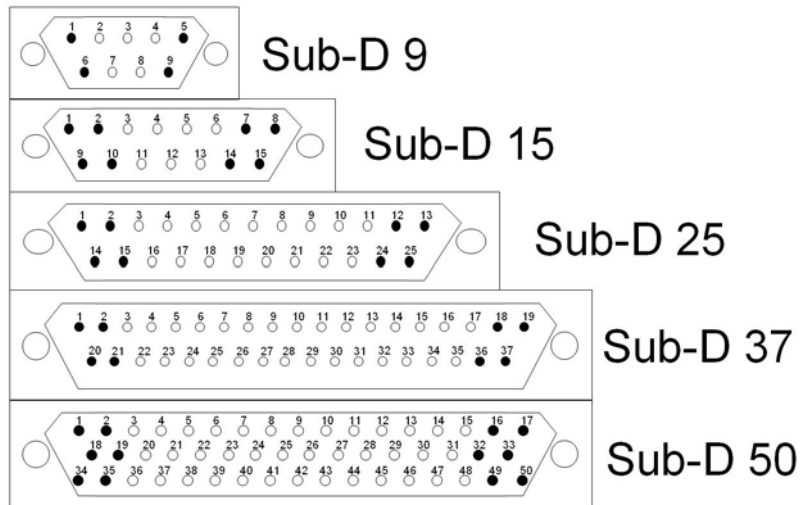


Figure 4.2-1: D-Sub standard contact arrangement

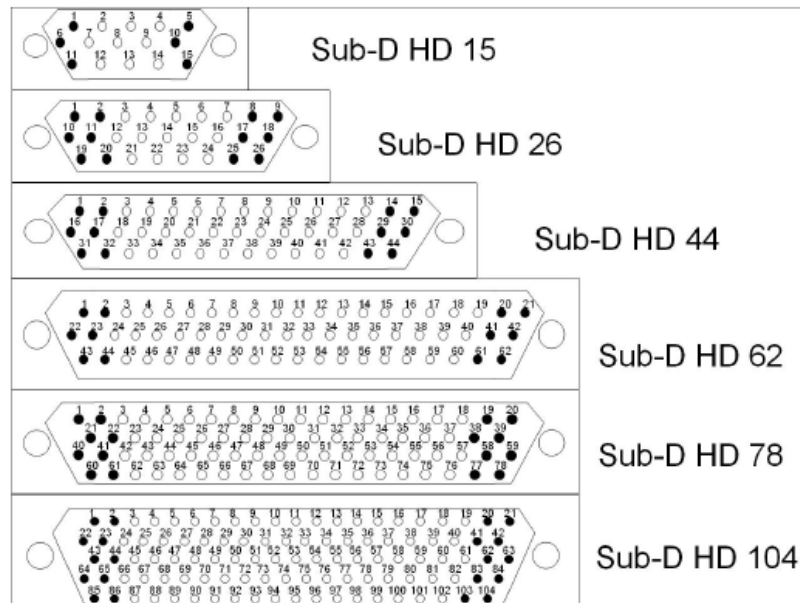


Figure 4.2-2: D-Sub High density contact arrangement

Note: Black coloured contacts are those that shall be mandatorily equipped with pins or sockets. (functional or population pins or sockets)

For Circular connectors : TBD

HAR-499 / I,R / AR

For Spacecraft external connectors, the populating pins shall be grounded. The value of the grounding resistance shall not exceed 100 kΩ.

Note: Population pins are those pins which are not wired.

HAR-500 / R / AR

On interface brackets, connector spare contacts shall be designed in accordance with the following Table.

	Connector Contact Quantity	<9 contacts	<15 contacts	<25 contacts	<37 contacts	<50 contacts	<78 contacts	<100 contacts
Until CDR	Spare contacts	2	2	4	4	6	8	10
After CDR	Spare contacts	2	2	2	2	2	4	4

[501]

Table 4.2-1: Connector spare contacts

[502]

Note: Pyro and filter connectors shall be excluded from this spare contact design.

[503]

4.2.2 Derating

HAR-505 / R / AR,DO

For derating assessment, [AD 13] shall be used.

HAR-506 / A,R / AR,DO

All cables subject to prolonged high current shall be bundled and routed so as to dissipate heat as efficiently as possible. To achieve this need :

- *bundles shall be split down to small sizes and routed on aluminium surfaces*
- *bundles shall be minimised in length*
- *to improve emissivity, Kapton tape can be wrapped around the bundle (Note: In case bundle are overall shielded, Kapton tape to be applied around overall bundle shielding)*

HAR-507 / R / AR,DO

Derating for connectors shall follow section 6.11 of [AD 13].

HAR-508 / R / AR,DO

Derating for RF connectors shall follow section 6.12 of [AD 13].

HAR-509 / R / AR,DO

Derating for cables shall follow the table here below.

Note the table is derived from section 6.32 of [AD 13], but columns “Wires AWG 0 to AWG 12” and “Wires AWG 14 to AWG 32” are changed and switched into :

“Wires AWG 12 to AWG 32” and “Wires AWG 0 to AWG10”

Parameters	Load ratio or limit														
Voltage	50 %														
Wire size (AWG)	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4
Maximum current Cu (I) (A) ^{a b}	1,2	1,3	1,5	2,5	3,5	5	7,5	10	13	17	25	32	45	60	81
Maximum current Al (I) (A) ^{a b}						4	6	8	10,4	13,6	18,4	25,6	36		
Wire surface temperature	Manufacturer's maximum rating – 40 °C or 120 °C, whichever is lower.														
^a Maximum applied current according to the wire size (AWG) resulting in a maximum temperature of 120 °C.															
^b The derating on current for bundles with N wires is calculated as follows $I_{BW} = I_{SW} \times K$	Wires AWG 12 to AWG 32							Wires AWG 0 to AWG 10							
	Number of wires (N)			K				Number of wires (N)				K			
	1 < N ≤ 3			1,1 – (0,1 × N)				1 < N ≤ 3				1,1 – (0,1 × N)			
	3 < N ≤ 7			1,01 – (0,07 × N)				3 < N ≤ 7				1,01 – (0,07 × N)			
	7 < N ≤ 19			0,81 – [0,15 × ln(N)]				7 < N ≤ 52				0,81 – [0,15 × ln(N)]			
	19 < N ≤ 331			0,59 – [0,076 × ln(N)]				52 < N ≤ 331				0,467 – [0,0632 × ln(N)]			
I _{BW} : maximum current for an individual wire in a bundle. I _{SW} : maximum current for a single wire as given in the derating table above. ln: Natural log.															

HAR-511 / R / AR,DO

Derating for fibre optic cables shall follow section 6.35 of [AD 13].

HAR-512 / R / AR,DO

In case passive components like resistors, filters, diodes are implemented within the harness, they shall follow the appropriate section of [AD 13].

HAR-513 / R / AR,DO

Connector contacts current rating shall be in accordance with derating requirements of [AD 13].

4.3 Mechanical design requirements

HAR-515 / R / AR,DO

The harness shall be designed according to the Mechanical Interface Control Document [AD 07].

HAR-517 / I,R / AR,DO

AWG30 or smaller shall not be used.

HAR-518 / I,R / AR,DO

The harness connectors shall be easily accessible, attachable and removable from the corresponding unit connectors; the removal of units or disconnection of adjacent connectors shall not be necessary. Spacing shall permit standard tooling.

Note: Problems concerning accessibility caused by definition derived from [AD 07] shall be communicated to the prime.

HAR-519 / R / MA

Screw locks shall be in accordance with the interface fasteners alloy (gold-plated brass for connectors or stainless steel i.a.w ESA SCC specification).

HAR-520 / R / DO,MA

Harness flange-mounted circular connector receptacles and all harness mechanical items such as junction blocks ('DA') and connector brackets, shall be fixed using approved fasteners.

HAR-521 / I,R / DO,MA

Special care shall be taken to ensure that fragile cables (semi-rigid, co-axial, tri-axial) are held firmly yet protected from possibility of dielectric/insulation crushing due to over clamping or over flexing during handling/launch environments.

HAR-522 / T,R / DO

The integrated harness shall be designed to withstand the required mechanical (test) loads as given in [AD 18].

Note: Mechanical and thermal qualification will be done on system level.

Note: As a design guideline, load factors shall be taken into account, considering safety factors of 1.5 against ultimate and 1.25 against yield for any I/F CB and harness attachments to structure.

4.3.1 Mass and mechanical properties

HAR-524 / T,R / MA

The harness mass in flight configuration shall be less than 75 kg (TBC)

Note:

This figure shall comprise all elements listed in HAR-458 for flight configuration.

HAR-525 / R / MA

The mass of the harness, including all contingencies, are to be considered as contributors to the Spacecraft mass and CoG. Detailed breakdowns shall be included in the harness mass budget. The required accuracy shall be as defined in Table 4.3-1.

Category	Design Maturity	Margins
A	Existing Hardware	+/-5%
B	Design based on existing hardware requiring minor modification	+/-10%
C	Detailed Design / Design based on existing H/W requiring major modification	+/-15%
D	Preliminary Design/Equipment not yet developed	+/-20%

[526]

Table 4.3-1: Mass Budget Consolidation Margins

[527]

HAR-528 / A / DO

The centre of gravity of the harness must be determined by analysis or by test to an accuracy of:

- +/- 2cm out of plane (TBC)
- +/- 5cm in the plane (TBC)

4.3.2 Mechanical routing requirements

HAR-530 / I,R / DO,MA

Cable routing shall be such to allow adequate clearance for unit mounting and dismounting. It shall also provide a dynamic clearance of a minimum of 5mm around unit edges or at sharp interfaces. A layer of kapton wrap or Permacel P213 glass fibre tape shall be put around the bundle to guard against possible damage at that places. Non-sticky protection shall be used to avoid damage.

HAR-531 / I,R / DO,MA

The minimum bending radius of bundles shall be limited in order to avoid cable stress. Table hereafter is applicable:

- A cable (EMC class 4, RF): $R \geq 10 d$ (d: diameter of cable)
- A bus twisted shielded pair as bus 1553: $R \geq 5 d$ (d: diameter of cable)
- A bundle without Bus and without Co-axial: $R \geq 2 d$ (d: diameter of bundle)
- A bundle with Bus or Co-axial: $R \geq \max(35+d/2, 2d)$ (d: diameter of bundle)
- If not covered by above take $R = 5d$ for a bundle.

Note: Any of the above given requirements shall be checked versus the cable manufacturer's specific requirements. Supplier specific requirements being more severe to the requirements given above shall be used and submitted to prime for approval.

HAR-532 / R / DO

The harness shall be as far as possible routed along the shortest possible way.

HAR-533 / R / DO

Mechanical stay-out areas shall be taken into account for the harness routing as defined in [AD 07].

HAR-534 / R / DO

Wires and cable bundles routed in same direction shall be in parallel and not mixed-up.

HAR-535 / R / MA

Flying leads (e.g. thrusters, latch valves, heaters, thermistors) shall be secured to the mounting planes, as the harness is.

HAR-536 / R / DO

To facilitate bending of large harness bundles, splitting of the bundle into smaller sub-bundles with a maximum diameter of 45 mm shall be implemented.

4.3.2.1 Harness fixation**HAR-538 / R / DO,MA**

The harness shall be attached rigidly to the structure.

HAR-539 / R / DO,MA

Cables routed to unit interfaces greater than 150mm (TBC) above the unit mounting plane are to be secured using suitable fixations to the unit bodies.

HAR-540 / R / DO,MA

The harness fixation shall be done using fasteners « Tie-Wrap », ensuring both assembly of wires and cables to bundles and fixation of them onto the structure.

HAR-541 / I,R / DO,MA

Cable bundles shall be fixed to the structure. This shall be performed by means of tie bases spaced at least 120 mm to 180 mm (TBC) from each other according to bundle size. The smaller distance being used for bundles greater than 20mm diameter. Where interface connectors are used within the harness, they shall be fixed to brackets which are mechanically fixed to the structure.

HAR-542 / R / DO,MA

All tie-wraps shall be accessible on structure in order to pass tie-wrap tool type GS2B (TBC).

HAR-543 / R / MA

The tying method utilising spot ties shall consist of at least two complete turns of lacing cord around all the conductors being tied.

HAR-544 / R / MA

Wires and cables shall be clamped or tied without deformation and stress.

HAR-545 / R / DO

If tie-bases are glued on nominal and redundant equipment, positioning of tie-bases shall be both identical to easily invert them.

HAR-546 / R / MA

If no over-shield is foreseen, the lacing cord shall be secured with a non-slip knot to prevent movement of the tie during handling of the unit harness assembly and shall be secured by adequate bonding material.

HAR-547 / R / MA

The spacing between the spot ties shall not exceed 60 mm, with respect to the overall-shielding wrapping.

4.3.2.2 Harness routing from fixed panels to mobile walls (rotatable)**HAR-549 / R / DO,MA**

Bundles between fixed panels and mobile walls shall be designed to tolerate 90° (TBC) rotation (closed/opened position).

HAR-550 / R / DO,MA

Bundles between fixed panels and mobile walls shall be individually protected by a helicoidally PTFE sleeve (e.g. SPIRAFLEX or HELLERMANN).

HAR-553 / R / DO

Bundles fixation on structure shall be at least each 120 mm for tall tie-bases e.g. TY8G1 (large one) and 80 mm for small tie-bases e.g. TY3G1.

Note: This requirement supersedes HAR-547 above for the affected bundles of this chapter.

HAR-554 / R / DO

Tie-bases can be glued on equipment face if top connector plane and unit height is higher than 50 mm. In this case, harness design Responsible shall furnish exact positioning of tie-bases on equipment.

4.3.2.3 Harness routing outside of spacecraft structure

The harness shall be considered as outside of spacecraft structure when not installed inside the enclosure made by the structural walls. In this case the harness is protected from outer space by thermal blankets and possibly by ESD screen made of Aluminium sheets or conductive mesh.

[556]

HAR-557 / R / AR,DO

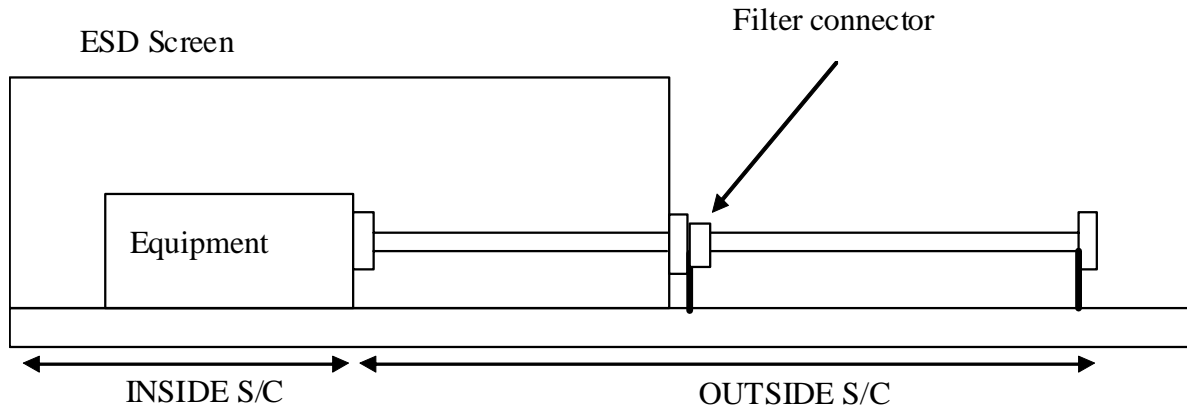
For critical signals, the filter connector shall be fitted at skin connector's level or entry level of the Faraday Cage constituted by the spacecraft structure panels and ESD screen. Identification of critical signals shall be submitted for prime approval.

HAR-559 / R / AR,DO

Any filter connector should be located outside the spacecraft structure or at S/C interface.

HAR-560 / R / AR,DO

A shielding shall be used outside the spacecraft for wire protection up to the filter connector in the bracket.



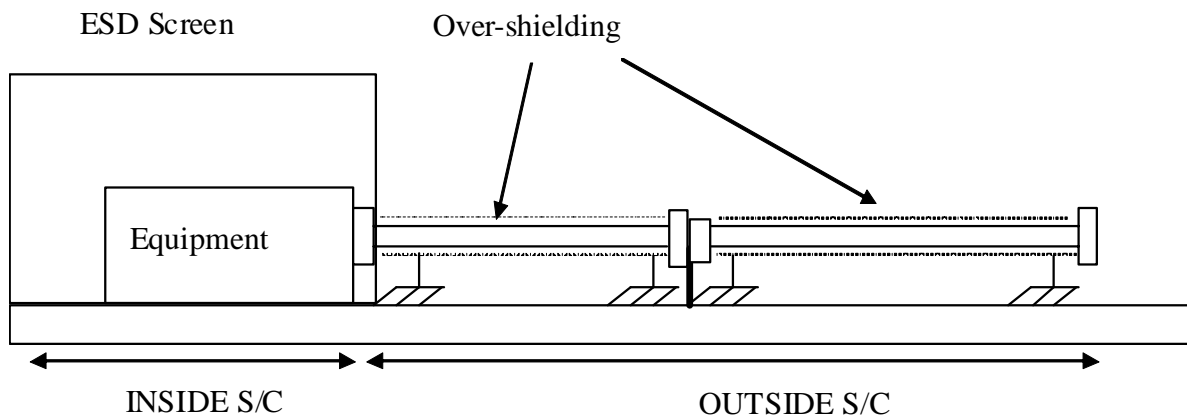
[561]

Figure 4.3-1: External harness routing with filter connector

[562]

HAR-563 / R / AR,DO

An over shielding on the total length of the wire shall be used if the wire outside the spacecraft is not routed through a filter connector (see figure below). It shall be grounded at both cable ends (length of grounding wires < 5cm).



[564]

Figure 4.3-2: External harness routing without filter connector

[565]

HAR-566 / R / AR,DO

The list of filter connectors shall be submitted to prime approval at CDR.

4.3.2.4 Solar Array harness (only applicable for S/A without SADM)

HAR-568 / R / AR,DO

Solar array harness shall be installed on brackets for eased installation.

HAR-569 / R / AR,DO

Mouse holes or skin brackets shall be considered for solar array harness routing and connection with platform harness. This is subject to prime approval during harness design phase.

4.3.3 Connector mounting

HAR-571 / R / DO

All harness connectors at interface connector brackets shall be selected as rear-panel or back panel mounted square-flange connectors.

Note: This requirement may be overruled by prime input in [AD 08].

HAR-572 / R / DO

For rectangular D-sub connectors the wall thickness shall be reduced with regard to the female fixation bolt length.

Note: Best practise shows that reduction is down to 1.5mm - 1.6mm. Reduction shall be submitted to prime for approval.

HAR-573 / R / DO

The D-sub connector female-fixation bolt head surface and the connector front-end shall be in same shape

HAR-574 / R / DO

All connector fixation nuts shall be secured by approved adhesive.

HAR-575 / R / DO

Surface scratching split- and star washer shall not be used for locking.

HAR-576 / R / DO

Circular connector-receptacles shall be fixed with counter-sink (not winged) bolts of LN-standard.

4.3.4 Backshells

The following requirements are applicable only when backshells are required in AD08

[578]

HAR-579 / R / DO,MA

*For circular-connectors EMI/RFI Non Environmental Backshell Series 380*007 MIL-C-85049 shall be used, and shall comply with the shielding requirements as defined in in section 4.4.3 of the present document*

HAR-580 / R / DO,MA

For rectangular connectors, non-magnetic EMI/RFI backshells with deep straight clamp and with inner electrical conductive surface types shall be used, and shall comply with the shielding requirements as defined in section 4.4.3 of the present document.

HAR-581 / R / DO,MA

For D-Sub connectors, non-magnetic EMI/RFI backshells compliant to ESA SCC 3401/072 shall be used.

4.3.5 Brackets**4.3.5.1 Skin brackets**

Skin brackets are used for external access to the spacecraft, when the spacecraft is already fully mated.

[584]

HAR-585 / R / AR,DO

Skin brackets hosting test points for data handling units (e.g. OBC, RIU) shall be close to these units.

HAR-586 / R / AR,DO

Skin connectors shall not be covered by the solar array. Skin connectors on panels on which the solar arrays are mounted, shall be avoided as far as possible as accessibility to all skin connectors has to be granted even after solar array integration.

HAR-587 / R / AR,DO

Harness plugs (e.g. bus termination) including arming function (e.g. pyro or other release initiation) shall be accessible without mating / demating thermal blankets or structure elements.

HAR-588 / R / AR

No pin of harness skin connector shall be connected to the ground reference (see HAR-638).

HAR-589 / I,R / AR,DO

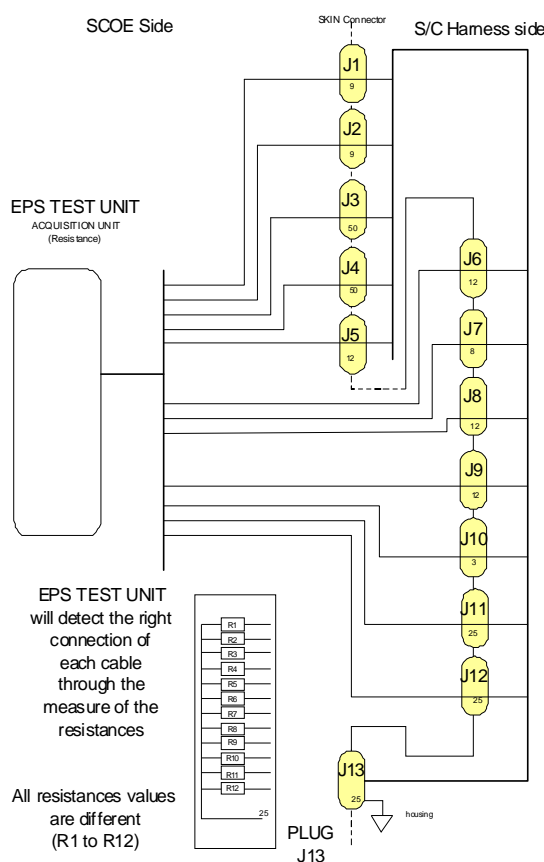
The harness design shall provide access to test adapter interconnection at satellite level without removal of thermal equipment or removal of any other equipment with exception of the respective EMC cover.

HAR-590 / R / AR

Spacecraft skin connectors' pin function definition shall comply with Fool Proofing (also named as Error Proofing) in order to avoid catastrophic effects in case of wrong connections.

An example of fool Proofing Technique is given hereafter:

A special device shall be implemented to detect the right connection of each cable through the measure of the resistances implemented for each connector, as described here under



[591]

Figure 4.3-3: Exemplary fool proofing configuration

[592]

4.3.5.2 Umbilical bracket

The umbilical bracket is used as interface between the spacecraft and the launch vehicle.

[594]

HAR-597 / R / AR

For the interface between platform and launcher, circular connectors in accordance with ESCC 3401/008/801 (DBAS) or MIL-C-81703 shall be used.

Note: Typically the umbilical is a customer furnished item and not to be defined by the harness subcontractor.

4.3.5.3 Connector Brackets

Connector brackets (also called interface brackets) are used for harness segregation e.g. for AIT purpose.

[599]

HAR-600 / R / DO

Connector brackets shall be designed in accordance with [AD 07] and [AD 08].

HAR-601 / R / DO

The connector spacing shall be defined in accordance with the electrical constraints, harness bundle sizes, connector backshell and strain-relief clamp sizes and test adapter accessibility. The harness connector backshell end-entry diameters and the overall width of rectangular shrinkable-boots shall also be considered.

HAR-602 / R / DO

Wrong connector mating shall be prevented by use of connector keying, alternation of connector sizes and connector rotations of 90 to 180 deg.

4.4 EMC requirements

According to the signal characteristics and the circuit parameters, electrical circuits within the spacecraft are classified in standard groups for EMC purpose, according to [AD 01].

[604]

HAR-606 / R / DO

The harness shall be designed in accordance with the signal types defined in [AD 01] and the herein defined allocation of EMC classes to the signal types.

Colour / EMC code	EMC type	Signal type
1	DC Power (primary /secondary)	- Solar Array - PCDU link (double insulation) - Battery - PCDU link (double insulation) - PCDU - All other units => Power supplies - PCDU - Heaters => Heating lines - Secondary power between units => possible segregation between secondary lines and primary lines on a case by case basis.
2-1	Digital signals High level (non sensitive) analogue signals (except RF)	- TCs: SHP (Standard High Power), EHP (Extended High Power), SLP (standard low power) - RSA (Relay Status Acquisition) - BLD (bi-level digital) - commands LV, FCV, CBH (can be routed with EMC class 1 as it is primary power on AT) - SBDL (RS422) standard balanced digital line - Temperature TMs (ANY, ANF, ANP) - LNTHD (COAX) - LVDS - 1553
2-2	Bus 1553	1553 (can be routed with EMC2-1)
3	Pyrotechnics	4- Thermal knives lines
4	Low level (sensitive) analogue signals	- Analog TM (AN1, ANA2, AN3) - CSS signals (coarse sun sensor) - Propulsion module pressure transducer (PTA) - Videos Instrument (coaxial) SURBLINDE **
5	RF signals (via coaxial lines, waveguides, microwave)	Coaxial links for GPS, TRSP
	Test or removable	this color is used to specify the removable or test harness
	Grounding	

HAR-608 / / AR,DO

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

Note: The according cable type per signal type is given in [AD 08].

HAR-609 / R / AR,DO

Skin/test connectors which need straps in flight configuration shall be covered with conductive EMC tight connectors used as caps, bolted to their fixation assembly. Connectors without the need of straps shall be covered with conductive caps, bolted to the skin bracket connector fixation assemblies.

4.4.1 EMC, Overshielding & Ferrites

S5p-HAR-1260 / I,R / DO,MA

OBC: Bundles exiting from connectors J21, & J31 shall have backshell & overshield only for the full defined length.

All remaining harness bundles on the OBC shall have backshell & overshield for the defined length and ferrites fitted at the ends.

S5p-HAR-1262 / I,R / AR,MA

LVDS lines (SpW lines) between ICU and PDHU (mass memory) shall have backshell & overshield over the full defined length, no ferrites.

S5p-HAR-1263 / I,R / DO,MA

LVDS lines between the PDHU (mass memory) and the X band Modulators shall have backshell & overshield over the full defined length, no ferrites.

4.4.2 EMC segregation rules

Classifications: Power and signal lines shall be gathered into the following EMC classes:

[611]

HAR-612 / A,R / AR

When lines with different EMC classes on same connectors cannot be avoided, these lines shall be separated by a grounded row of pins. The respective solutions shall be approved by prime, who will perform the necessary analyses.

Note: If defined in [AD 08], e.g. power and TMTC on AOCS off-the-shelf equipment, the subcontractor shall use the connector definition as is.

HAR-613 / I,R / DO,MA

Bundles of different EMC classes (e.g. 2 lines EMC class 1 power and 4 lines EMC class 2 TMTC) shall be separated in the backshell. All cables of each EMC shall be wrapped to bundles and leave the backshell as bundles apart.

HAR-614 / A,R / DO

Wires falling into one EMC category shall be assembled into one bundle taking into account that as far as possible, nominal and redundant lines of the same function shall not be routed in the same bundle.

HAR-615 / R / DO

The minimum distance between the bundles of different EMC classes shall be greater than

- 5 cm from the middle to middles of bundles
- 2cm from edge to edge of bundles

In case of deviation, The contractor shall identify length and bundle composition for acceptance.

Note: It is however allowed that locally, due to structure constraints (holes for instance) or at equipment level, bundles may be grouped together. In this case, routing acceptability shall be submitted to prime approval.

HAR-616 / A,R / DO

In case of fitting out problem in segregation application rules, , recommended associations of bundles are as follows :

EMC type [3,4 et 5] shall be routed together if necessary

EMC type [5] shall separated from LVDS and LNTHD

For specific area EMC type [2 et 4] can be routed together in parallel only if LVDS links are not part of the EMC 2 bundle and only if Videos lines are not part of EMC 4

HAR-617 / A,R / DO

If cable spacing according to the above requirement HAR-615 cannot be maintained and if deemed not acceptable by prime contractor, then separation of different cable categories shall be performed by metallic separation using overall bundle shielding.

HAR-618 / R / DO

Bundles of EMC classes to be segregated can cross one another. The crossing angle shall be $90^\circ \pm 20^\circ$ to limit capacitive and inductive coupling.

HAR-619 / R / DO

Bundles shall be routed as close as possible to the structure to avoid coupling on the signals and minimize spacecraft magnetic momentum.

Recommended values : $h < 10\text{mm}$

Near hinge and to avoid flexibility of bundle, 40mm height is tolerated.

4.4.3 Harness twisting**HAR-621 / R / DO,MA**

Twisted wires shall be used to reduce magnetic pick-up and emission. When several lines share a return line, the whole bundle shall be twisted with its return wire.

HAR-622 / R / MA

For all cables specified in [AD 08] of being not covered by ESA SCC, the twisting pitch is to be 20 times the combined cables diameter, i.e. if a twisted pair cable was to have a combined diameter of 2mm, then the twisting pitch would be 40mm.

Note: Typically all twisted cables or twisted shielded cables are subject to ESA SCC compliance.

4.4.4 Shielding**HAR-624 / R / DO,MA**

Cable shield with at least 85% coverage shall be used, except on critical signal lines (either outside spacecraft structure or sensitive links to be identified), where a shield with at least 98% coverage shall be used.

HAR-625 / I,R / DO,MA

The unshielded part of any single cable, which is determined by its signal type to be shielded, shall not exceed 2.5 cm at each connector interface

HAR-626 / T / DO,MA

The DC resistance between any harness shield and its ground reference or connector termination shall be less than 5 m Ω .

HAR-628 / R / MA

The connection from harness shield to structure shall be made directly through the connector shell. The connection inductance between shield and connector must be as low as possible (less than 5 cm length). When backshells are used, the shield shall be directly terminated to the internal part of the backshell housing.

HAR-629 / R / AR

Cable shields shall not be used as intentional return conductors, except for specific requirements for example coax cabling.

4.4.4.1 Overall bundle shielding**S5p-HAR-631 / R / MA**

All lacing cords shall be removed during the wrapping so that no lacing cord remains underneath. The top layer shall end at the connector end to support possible harness branch repair. Only applicable for harness outside the S/C

S5p-HAR-632 / R / MA

The overall harness shields shall be grounded to the connector housing or the connector backshells. Only applicable for harness outside the S/C

4.4.4.2 Shield termination**HAR-634 / R / DO,MA**

Cable shields external to the spacecraft structure shall be grounded at the spacecraft skin bracket to minimise possibility of carrying noise through the bracket into the spacecraft.

HAR-635 / R / AR,DO,MA

For bracket connectors the cable shield shall be grounded at the connector body level.

HAR-636 / R / MA

Shields shall be individually grounded. Daisy chaining shall be avoided as far as possible and to be submitted to prime for approval.

HAR-637 / I,R / DO,MA

The cable shields shall be electrically connected to the connector housing/backshell by using the haloring

HAR-638 / R / MA

In case of interface connector, it shall be avoided to connect the shielding through any connector pin; the shield shall also be grounded at interface connector body level to the structure e.g. with haloring techniques.

Note: It is forbidden to solder combs on the connector's body, if the connector is delivered without any soldered combs.

HAR-639 / R / MA

The harness overall bundle shielding shall be grounded to the structure by a proven technique with a wire length lower than 5 cm

HAR-640 / R / MA

Over-shielding shall be grounded to the structure at both ends in the cases where multiple shields are used with over-shielding

4.4.5 Bonding of electrical and electronic units

This paragraph is applicable only when the bonding of electrical and electronic units is in the perimeter of the harness designer and manufacturer.

[642]

HAR-643 / R / AR,DO,MA

All units shall also have a bonding lug for a strap provided by harness with length to width ratio of less than 5 to 1 with a contact area of more than 1 cm².

Note: If the length to width ratio cannot be kept, extension to 10 to 1 is possible and shall be submitted to prime for approval.

HAR-644 / R / AR,DO,MA

The bond shall be proven corrosion resistant over its lifetime in its environment with a resistance as per [AD 01]

HAR-645 / T / MA

The resistance of the bond strap shall be measured with both directions of voltage polarisation at minimum of 1A.

HAR-646 / T / AR,DO,MA

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

HAR-647 / T / MA

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 5mOhm.

HAR-648 / / AR,DO,MA

For units bonding to panel's structure (or ground reference rail), two grounding straps per unit shall be foreseen

HAR-649 / R / MA

Bonding straps shall be made of plain material (e.g. aluminium tape type A5 or equivalent) with a thickness of 0.250 or 0.500mm (tbc) and width of 12, 25 or 50mm (tbc).

4.5 Isolation

HAR-651 / T,R / MA

The isolation resistance shall be $\geq 100 M\Omega$ at 500V; isolation resistance of MIL-1553B shall be $\geq 10 M\Omega$ at 50V. In case the cable supplier specifies lower values for its assembly, these shall be submitted to prime for approval.

HAR-652 / R / MA

The cable carrying primary power (from Solar Array to PCDU and from Battery to PCDU) shall be as per Figure 4.5-1 for protection of main bus circuit due to possible shorts.

Note: Cables in accordance with ESA SCC 3901/002 do cover this requirement.

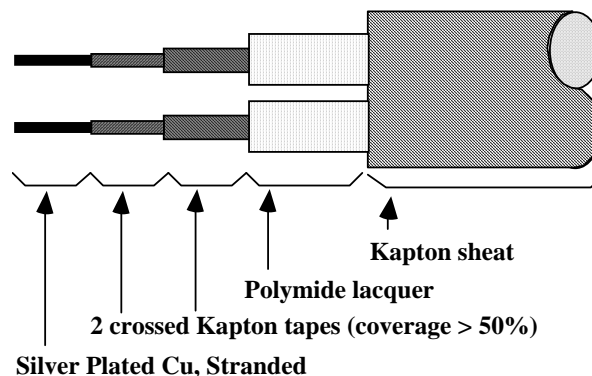


Figure 4.5-1: Primary power cable type

4.5.1 Double insulation

Double insulation shall be applied on all cables resulting in mission loss or degradation in case of loss of insulation.

HAR-658 / R / AR,DO

The following lines shall have double insulation:

- Power harness between the PCDU and the batteries
- Harness monitoring lines (V cell lines) between PCDU and battery

- Power harness between the PCDU and the SA/SADM
- Power harness between the PCDU and the umbilical
- Power harness between the PCDU and the OVP heaters
- TBD others

HAR-659 / R / AR,DO,MA

The double insulation shall be made using adhesive kapton tape with a thickness <50µm to avoid kapton bulk charging. The tape may be applied to the structure under the cable bundle (preferred) or by wrapping around the bundle.

HAR-660 / R / DO,MA

If part of a bundle comes into contact with a unit, MLI or any other element connected to the structure, wrapping using adhesive kapton tape of this bundle shall be applied

4.6 ESD requirements

The intention of this section is to make sure that the spacecraft is capable of operating in a space plasma charging environment without degradation of the specified space vehicle capability.

[663]

HAR-664 / T,R / AR,DO

The differential charging potential of the spacecraft surfaces exposed to the space plasma environment shall be limited. To achieve this, the design requirements as detailed in [AD 01] shall be followed.

HAR-665 / R / DO,MA

Bundle bending radii shall be designed and manufactured such that they cannot create enclosed conductive layers.

4.6.1 Bulk charging

The choice of the dielectric insulator is of great importance to limit bulk charging at orbits with high flux of energetic electrons.

[668]

HAR-669 / R / MA

Harness subcontractor shall provide for each type of cable dielectric material, the surface resistivity, the bulk resistivity, and the variation of resistivity induced by radiation.

HAR-670 / R / AR,DO,MA

*All external surfaces above 5cm² shall be electro-statically conductive and grounded to the structure; the surface resistivity shall be less than **1E+9 Ω/square** or the bulk resistivity shall be less than **1E+13Ωm** (including irradiation effects)*

HAR-671 / R / AR,DO,MA

The use of standard Teflon (FEP, PTFE, FLPO, TEFZEL) shall be avoided or submitted to Prime for approval as this is an ESD occurrence risk (conductivity decreases under irradiation). For approval the subcontractor shall provide test data from the parts supplier, showing compliance with the requirements HAR-669.

HAR-672 / R / AR,DO,MA

To mechanically secure and insulate the bundles at sharp edges, either Kapton tape or P213 fibre glass tape shall be used.

HAR-673 / R / AR,DO,MA

All the metallic parts of the harness, whatever the size, location and surface is, should be grounded to the structure by DC resistance less than 100kΩ.

As a consequence, it is required:

- No floating cable shall be left for flight including test harness.
- No floating metallic labels (e.g. on brackets, plugs) shall be used.
- For populating pins, see HAR-491 & HAR-492

If compliance with the above requirements cannot be achieved due to conflicting design requirements then tests shall be performed on a representative sample of the concerned surface material. Details of the procedure and the test results shall be submitted to Prime for approval.

4.7 Magnetic cleanliness

HAR-675 / R / DO,MA

Non-magnetic materials shall be used; especially non-magnetic harness backshells and shells including their screws shall be used.

HAR-676 / R / AR,DO,MA

No permanent magnets are allowed.

HAR-677 / R / AR

To aid in the minimising of the spacecraft magnetic moment, signal and corresponding return shall be as far as possible be located on adjacent pins.

4.8 Thermal requirements

HAR-679 / A / AR,DO,MA

In order to ensure compatibility of harness design with spacecraft and payload thermal control, the harness shall be designed according to the requirements specified below:

- To survive the thermal environment as specified in [AD 09]
- According to the operating, non-operating, and qualification level temperatures as defined in [AD 01]

4.8.1 Qualification temperatures

HAR-681 / A / MA

The required values for non-operating and operating temperature limits are given in the table below:

	OPERATIONAL				NON-OPERATIONAL			
	ACCEPTANCE		QUALIFICATION		ACCEPTANCE		QUALIFICATION	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
INSIDE S/C	-45	75	-50	80	-45	75	-50	80
OUTSIDE S/C	-125	125	-130	130	-125	125	-130	130

[682]

Table 4.8-1: Harness temperature limits

[683]

HAR-684 / A / AR,DO,MA

Harness, connectors and supports (as part level) shall be designed to sustain in radiative exchange the following environmental temperature ranges.

These temperatures are in radiative environment only. Bundles shall be designed to withstand these levels. Especially, emissivity shall be adequate. High emissivity is recommended for power distribution harness.

Qualification:	-60°C to +90°C
Acceptance :	-55°C to +85°C
Operating :	-50°C to +80°C
Extreme temperatures (apart appendages listed hereunder) :	-60°C to +145°C

Qualification:	-60°C to +90°C
Extreme temperatures (when applicable)*:	-211°C to +200°C

[701]

Table 4.8-2: Harness parts' temperature limits

* These extreme temperatures are applicable to harness routed along external appendages like solar array, antenna.

[702]

4.8.1.1 Operating qualification temperatures

HAR-704 / T,R / AR,MA

The qualification or proto-flight model shall demonstrate during thermal vacuum testing compliance with performance requirements over operating qualification temperature range when the harness is in operating mode.

Note: This test will be done at system level TVAC (TBC).

4.8.1.2 Non-operating qualification temperatures

HAR-706 / T,R / AR

The qualification or proto-flight model shall demonstrate during thermal vacuum testing compliance with performance requirements over non-operating qualification temperature range when the harness is non-operating and that does not lead to degradation of operating performance requirements.

Note: This test will be done at system level TVAC (TBC).

4.8.2 Storage temperature limits

HAR-708 / A / MA

The harness shall comply with storage temperature limits defined in [AD 01].

Note: Storage temperature limits are defined on the basis of the maximum and minimum expected manufacturing, storage, transport, integration and handling temperature to be experienced by the harness, plus a margin, and refer to the un-powered or non-operational state.

4.9 Operating & Life requirements

The Platform harness shall be designed to ensure it meets requirements for storage and operating life as defined in [AD 01].

[710]

HAR-711 / A,R / DO

The harness shall be designed to meet a minimum on-ground life time of 4 years including, and additional 10 years of in-orbit lifetime.

5 PRODUCT ASSURANCE

5.1 Safety

HAR-714 / R / AR,DO,MA

The harness subsystem shall comply with the requirements specified in [AD 02].

HAR-715 / R / AR,DO,MA

The safety factors as specified in [AD 01] in terms of mechanical, electrical & thermal requirements shall be applied to the harness Subsystem.

HAR-716 / R / AR

As a principle, the harness subsystem shall present no single failure point. Any single failure point resulting from recurring architecture/hardware, if proposed to stay « as is », shall be submitted to prime approval through Request For Deviation (RFD).

5.2 Cleanliness

HAR-718 / R / MA

Cleanliness requirements of [AD 02] shall be observed during all of the build and installation activities applicable to the harness.

HAR-719 / I,R / MA

All harness manufacturing, storage and testing shall be performed in a clean area, class 100,000 or better

HAR-720 / R / MA

All parts and materials shall be packed and stored in a controlled area. They shall be touched with clean gloves only.

HAR-721 / R / MA

Cleaning and outgassing of the harness models has to be performed before delivery.

5.3 Reliability

HAR-723 / R / AR,DO,MA

The harness subsystem shall comply with the requirements specified in [AD 02].

5.4 Parts, Materials & Processes

HAR-725 / R / AR,DO,MA

The selection of parts, materials and processes is given in [AD 02].

HAR-726 / R / MA

Shrink shells shall not be used

5.4.1 Connectors

HAR-728 / R / AR,DO,MA

All connectors for power and signal applications shall be ESA SCC types.

HAR-729 / R / AR,DO,MA

Pyro connectors, shall be ESA SCC types series 3401-008 (DBAS Push-Pull) or series 951 (MIL-C-26482 series 2), e.g. from Company Deutsch.*

HAR-730 / R / AR,DO,MA

Umbilical connectors shall be procured from company Deutsch, type to be agreed with Prime.

5.4.2 Cables

HAR-733 / A,R / DO

All wires and cables for power, release actuators and signal applications shall be ESA SCC types.

Note:

The preferred cables are those ones based on 3901-002 and 3901-019 series.

Note:

The cable types to be selected have to be analysed with respect to survivability with spacecraft environment as defined per [AD 01] which might have implications on the usability of Teflon jacketed cables.

5.4.2.1 Co-axial, Tri-axial and Symmetric cables

HAR-735 / R / AR,DO,MA

Co-axial, Tri-axial and Symmetric cables shall be procured with connectors and shall be tested and qualified by the manufacturer.

HAR-736 / R / AR,DO

Minimized quantity of connector-brackets shall be designed, to reduce insertion loss for lines which are realised with co-axial, tri-axial or symmetrical cables.

HAR-737 / R / DO

Co-axial, Tri-axial and Symmetric cables shall be routed in separate bundles (where possible).

5.4.3 Mechanical construction items

Mechanical construction items are subject to design of the harness subcontractor (e.g. brackets, stand-offs, bridges) but no standard parts (e.g. backshells, tie-bases).

[739]

HAR-740 / R / MA

Brackets must be made of aluminium alloy, e.g. 2024 T351 or equivalent and 5086 H111 if soldering technology is applied.

HAR-741 / R / DO

All brackets shall be designed with one bonding studs on each flange, i.e. hole thickness of 4.5mm must be added.

HAR-742 / R / MA

Brackets must be protected by Alodine 1200 treatment.

5.4.4 Accessories

HAR-744 / R / MA

Red colored tie-wraps shall be used for primary power harness, e.g. HALAR Cable Ties.

Primary power harness include the harness linking :

- Solar Generator/SADM to PCDU
- Battery to PCDU
- Umbilical to PCDU

6 INTERFACES REQUIREMENTS

6.1 Environmental requirements

HAR-747 / R / DO

The harness shall comply with the requirements specified in [AD 01].

HAR-748 / A,R / DO

Cables shall keep insulation integrity when subjected to a radiation environment as given below

- Internal to spacecraft: TBD Mrads*
- External to spacecraft: TBD Mrads.*

6.2 Electrical interfaces

HAR-750 / R / DO

All electrical interfaces to spacecraft equipments, skin & test connectors and module interface connectors shall be realised as specified in [AD 08].

6.3 Mechanical interfaces

HAR-752 / R / DO

The installation of the harness sub-assemblies in the spacecraft structure shall comply with the relevant interface drawings as defined in [AD 07].

6.4 Thermal interfaces

HAR-755 / R / DO

The harness shall comply with the requirements specified in [AD 09].

6.5 Ground Support Equipment (GSE) Interfaces

HAR-758 / A,R / DO

The spacecraft harness subsystem shall interface with the spacecraft EGSE, through dedicated skin and test connectors as identified in [AD 08].

HAR-759 / A,R / DO

The interfaces from the spacecraft harness with the EGSE harness shall be defined in a way such that incorrect connection to flight equipment is not possible.

7 MANUFACTURING**HAR-761 / I,R / MA**

Harness cable cutting length shall provide excess lengths for harness relief and rework.

As rule of thumb each cable shall be extended by

- 100mm for cable length of less than 1m
- 300mm for cable length of 1m to 3m
- 400mm for cable length of 3m to 5m
- 500mm for cable length of more than 5m.

HAR-762 / I,R / MA

For the design, manufacturing and assembly of the cable-harness the following standards shall be maintained:

- Crimping: ECSS-Q-ST-70-28; [AD 11]
- Soldering: ECSS-Q-ST-70-08; [AD 10]

HAR-763 / R / MA

The proper installation of shrink sleeves shall be verified by double check.

7.1 Connectors**HAR-765 / I,R / DO,MA**

Connector screw lock torque shall be as follows:

- Male screw locks: 0.34Nm
- Female screw locks: 0.55Nm.

HAR-766 / I,R / DO,MA

At final torque activities or where further build of the spacecraft will hide connectors, a visible adhesive is to be applied to the screw head in the case of male screw lock or to the nut at the rear of females.

7.2 Splices**HAR-768 / R / DO**

Harness splices shall be avoided as far as possible.

S5p-HAR-769 / I,R / DO

Soldered power wire splices within the harness shall not be permitted. In all cases crimped wire splices shall be used to support the cleanliness and to keep the harness flexibility.

7.3 Harness tooling**HAR-771 / R / DO,MA**

Harness tools or manufacturing supports shall be made of non out-gassing materials, such as stainless steel, Aluminum alloy, Pure Wood type oak (resinous woods are forbidden).

Note: Wood must be coated by two polyurethane varnish layers.

HAR-772 / R / DO,MA

All angles on steel and aluminum alloy must be rounded.

HAR-773 / R / DO,MA

Harness tools must be cleaned before using to prevent any pollution of flight wires.

HAR-774 / A,R / DO,MA

The design of the manufacturing support (i.e. a mock-up wall for instance) shall consider the total mass multiplied by 3 to ensure margins.

Note: The total mass considers the wall mass added with harness and equipment tooling mass.

HAR-775 / A,R / DO,MA

Rotatable panels of the spacecraft structure as specified in [AD 07] shall be reflected in the harness manufacturing mock-up. Walls on harness manufacturing supports shall be then also able to rotate of 90 ° with axis of rotation compliant with MICD at +/- 1 mm

HAR-776 / R / DO,MA

Tools made of oak wood shall be designed with overall dimensions of the Interface Control Drawing of the equipment.

- *Blocks under Tie-bases must be made of wood at the correct height +/- 1 mm.*
- *Tie-bases can be either screwed or glued with adhesive film on harness tooling.*
- *Position of different walls and panels must be compliant with nominal dimension at +/- 4 mm*
- *Position of different Equipments and brackets on each wall or panel must be compliant with nominal dimension at +/- 2 mm*
- *Position of different connector on equipments and brackets must be compliant with nominal equipment interface drawing dimension at +/- 2 mm. The position of connector is defined as the centre and the external plan for D-Sub connector (top of screw-locks interface plan).*
- *Dimensions between screw-locks on equipment tooling must require the following board on Sub-D connectors:*

Connector reference	Dimensions between Screw-locks
<i>DEM-9* or DEMA-9* from CANNON</i>	<i>25 +/- 0.1 mm</i>
<i>DAM-15* or DAMA-15* from CANNON</i>	<i>33.4 +/- 0.1 mm</i>
<i>DBM-25* or DBMA-25* from CANNON</i>	<i>47.1 +/- 0.1 mm</i>
<i>DCM-37* or DCMA-37* from CANNON</i>	<i>63.5 +/- 0.1 mm</i>
<i>DDM-50* or DDMA-50* from CANNON</i>	<i>61.1 +/- 0.1 mm</i>

**: S or P*

Dimensions of circular receptacle on equipment must be interchangeable with the harness plug according to DBAS catalogue for DBAS connector type

- *Female interfaces screw-locks (D-Sub interfaces) on equipment or bracket of the jig shall be of stainless a-magnetic steel (CANNON spatial references are allowed for example).*
- *Military Circular interfaces connectors can be used on the jig if material and treatment are equivalent (electro-less nickel on aluminum alloy for example).*
- *Position of Tie-bases on equipment must be compliant with nominal dimension at +/- 2 mm*
- *Position of Tie-bases on panels and walls must be compliant with nominal layouts dimension at +/- 2 mm*

7.4 Templates

Templates are the paper made mask to be put on the structure showing the place on which harness elements, for instance tie bases, have to be glued on.

[778]

HAR-779 / R / MA

The harness supplier shall produce harness section template sets as specified in [AD 05], where the location of all harness fixations as tie-bases, P-clamps, Saddle-clamps, stand-offs are shown and the contours of these items are cut out.

HAR-780 / R / MA

The cut -out shall be 2 mm bigger to all sides as the real hardware.

HAR-781 / R / MA

The foil shall be 0.3 mm thick, handy and sectioned with reference marks for proper fitting in the satellite structure.

8 VERIFICATION & TEST

HAR-783 / R / MA

For the purpose of the TRR, all test configurations have to be described and to be submitted to prime for approval.

HAR-784 / R / MA

All data of any test shall be logged and delivered at DRB.

HAR-785 / R / MA

All ground tests, except for temperature cycling and vacuum temperature cycling shall be conducted at standard ambient conditions:

- Temperature: 21°C ± 2°C
- Relative humidity: 40% RH min / 60% RH max
- Ambient pressure: 750 hPa to 1 060 hPa

HAR-786 / R / MA

All measurements shall be performed with accuracy better than +/-5%.

HAR-787 / R / MA

All specific support test equipment must be compliant with the intended purpose, within its useful life and calibration

HAR-788 / R / MA

The test tolerances quoted in this specification shall be applied to the nominal test values specified. The tolerance of test parameters specifies the maximum allowable range within which the specified test level (input level).

HAR-789 / R / MA

All instruments and test equipment used in conducting the tests shall have an accuracy of better than one third of the tolerance for the variable to be measured unless otherwise specified.

Note: This is not applicable for pass/fail tests.

8.1 Analysis

8.1.1 Thermal analysis

HAR-792 / A,R / DO

The rating and temperatures limits of wires and cables into common bundles shall be computed, special care shall be taken for shielded bundles.

8.1.2 Voltage drop

HAR-794 / A,R / DO

The wire voltage drop shall be computed for the following conditions:

- Maximum Resistance (tolerance)
- Temperature
- Max current as indicated in AD08

8.2 Functional verification

HAR-796 / R / MA

The harness test procedures shall be approved by the customer and shall cover as a minimum the following measurements:

For EM and PFM each harness conductor shall be measured for continuity and resistance.

For EM and PFM each harness conductor shall be measured for isolation.

For EM and PFM each harness conductor shall be measured for bonding.

The EM and PFM harness length shall be measured for each harness section.

The SM, EM, and PFM harness mass shall be measured.

All tests shall be done with equipment, which is calibrated adequately.

In all cases a description of the test set-up shall be given in the test procedure.

8.2.1 Isolation test

HAR-798 / R / MA

Prior and after each test session, the used test adapters used during this test session shall be verified by continuity and isolation test in order to verify that no damage of test adapters is present.

HAR-799 / R / MA

The proper function of the high voltage generator inside the harness tester throughout the whole test shall be verified. This may be facilitated by connecting a varistor in addition to the test harness to the harness tester and verifying the break-through of the varistor.

HAR-800 / R / MA

During isolation test, no test time reduction shall be activated

HAR-801 / R / MA

A high potential test at 500V (except for filter connector at 100V or if cable supplier specifies lower values for its assembly, e.g. MIL-Bus 1553B) shall be performed on the harness between each conductor and every other conductor; between each conductor and all shields and between each conductor and connector shell.

HAR-802 / R / MA

The insulation value shall be more than 100 MΩ.

HAR-803 / T / MA

In the case of harness rework during the spacecraft integration, the value of the insulation and of the voltage for the tests after modifications should be determined taking into account the integration phase on going.

- 500V (or 100V for the filter connectors) is required if there are no unit fitted on the structure.
 - Success criteria: >100MΩ
- 100V is required if there are no unit connected to the harness.
 - Success criteria: >100MΩ
- Digital Voltmeter (DVM) (5V) is required if there are some unit fitted on the structure connected to harness.
 - Success criteria: shall display OL (open loop)

HAR-804 / R / MA

Where devices, e.g. thermistors are fitted to termination / protection connectors, these are to be tested for insulation and continuity and the measured value of the device fitted shall be documented.

HAR-805 / T / MA

Insulation under 100V shall be tested in between pins carrying components. Insulation under 500V shall be tested between free pins and pins carrying components on one hand and connector shell on the other. Current shall be limited to 10 mA maximum, even transiently.

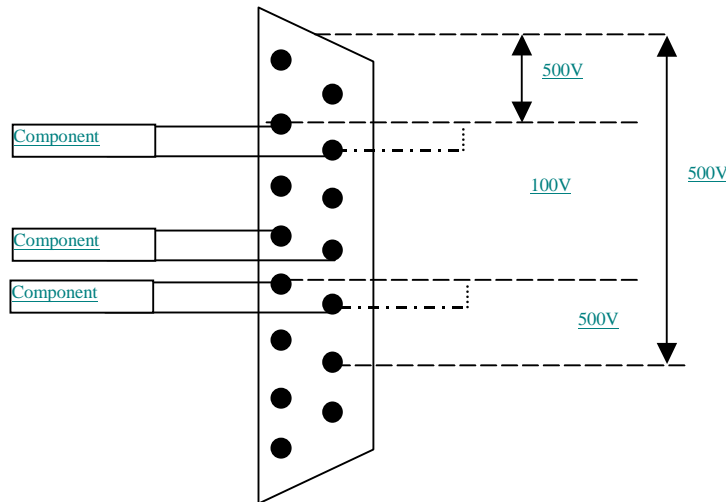


Figure 8.2-1: Device insulation test

HAR-809 / R / MA

Resistors shall be measured using a test current of a maximum 0.1A. The resistor power rating shall NOT be exceeded at any time during the test.

8.2.2 Continuity test

HAR-811 / T / MA

A circuit continuity test shall be performed on each conductor and on each shield and the measurement result given in the test report.

HAR-812 / R / MA

Maximum current for test shall be 100mA.
The acceptance limit value shall be agreed at the TRR.
This test shall be conducted as a flight acceptance test.

8.2.3 Resistance test

After manufacturing the measurement data will be compared with computed voltage drop values and shall be checked with the specification values.

HAR-815 / T / MA

DC resistance shall be measured for power and pyro lines using the <<4 wire>> method.
The actual required lines to be measured shall be defined in [AD 08].

HAR-816 / T / MA

Harness Voltage drop and resistance shall be performed on all interfaces for which a controlled drop is required.

HAR-817 / R / MA

Voltage drop criteria for all tested interfaces will be delivered with Harness manufacturing files.

HAR-818 / R / MA

The measurement current shall be indicated at the TRR.

HAR-819 / T / MA

Accuracy of voltage drop measurement shall be within +-5%. The measure shall appear in the test report with the compliance status to the specified requirement and compared (delta (percentage) shall be indicated) to the expected value (determined by analysis).

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[807]

[814]

HAR-820 / T,R / MA

All the « shunts » shall be measured before harness soldering and the values included in the voltage drop test report.

HAR-821 / T,R / MA

All the plug values shall be included in the voltage drop test report when it's necessary.

8.2.4 Capacitance test

HAR-823 / T / MA

Specific capacitance test shall be carried out on lines defined in [AD 08].

8.2.5 Shielding and grounding measurement

HAR-825 / R / MA

The resistance shall be measured by the harness manufacturing subcontractor on representative samples in order to validate the grounding process.

HAR-826 / T / MA

Between shielding or data bus (e.g. MIL-1553B) EMC over shielding both ends the resistance shall be <135 mΩ (before shielding connection to structure).

HAR-827 / T / MA

For 1328 wire (shielded mono AWG28 wire), the resistance between shielding or data bus EMC over shielding both ends < 160 mΩ.

HAR-828 / T / MA

The resistance between shielding and spacecraft 0V structure shall be < 20 mΩ (after shielding connection to structure)

10 mΩ between bracket and spacecraft 0V structure to be checked by structure manufacturer.

10 mΩ between shielding and connector chassis to be measured on representative samples of wire type and batch number, by harness manufacturer (4 points measurement under 1A). Harness manufacturer shall also ensure a repeatable process for shielding grounding

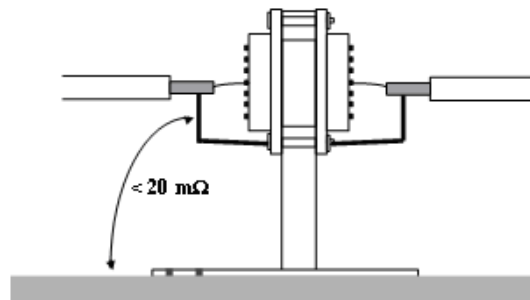


Figure 8.2-2: Resistance between shielding and spacecraft 0V structure

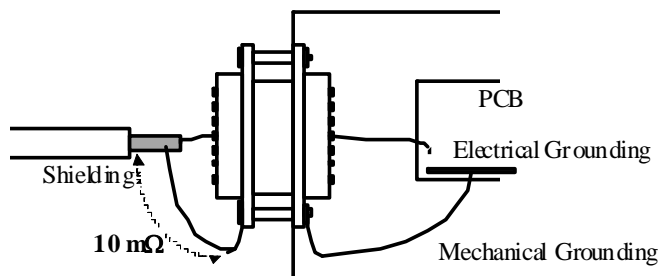


Figure 8.2-3: Resistance between shielding and connector chassis

[832]

8.2.6 Thermal hardware test

HAR-834 / T / MA

All heater circuits shall be tested with a DVM (Digital Voltmeter). The tolerance for these circuits measurement is +/-10%. Criteria: value shall be agreed during TRR.

HAR-835 / T / MA

Insulation of thermal hardware shall be checked: under 500V (TBC) for thermostats, heaters and thermistors and under 250V (TBC) for thermo-coaxes.

Success criteria:

- > 100 MΩ for thermostats, heaters and thermistors*
- > 0.1 MΩ for thermo-coaxes*

HAR-836 / I,R / MA

Insulation of thermal hardware shall be performed before and after connection

HAR-837 / R / MA

Resistance measurement of thermal hardware shall be performed before and after connection.

For all thermistors, a finger test shall be performed after connection (increase or decrease of resistance)

Criteria: value shall be agreed during TRR.

8.3 Random vibration

HAR-839 / R / DO

The harness, connectors and support shall be designed to sustain the input spectrum as defined in the GDIR.

[840]

8.4 Connector contact retention test

HAR-843 / R / MA

A contact retention test shall be performed on all pins according to the following table.

This test shall be conducted as a flight acceptance test:

CONNECTOR/CONTACT TYPE	APPLICABLE VALUE
Sub-D size 22	20N
Sub-D size 20	20N
Sub-D size 8	65N
Deutsch DBAS size 22	22N
Deutsch DBAS size 20	34N
Deutsch DBAS size 16	57N
Deutsch DBAS size 12	57N
NBS size 20	20N
MIL-C-38999 size 22	22N
MIL-C-38999 size 20	33N
MIL-C-38999 size 16	55N
MIL-C-38999 size 12	55N
MIL-C-38999 size 8	75N

Table 8.4-1: Connector contact retention test - applicable force per contact type

[887]

9 OPERATIONS & DELIVERY**HAR-889 / R / DO**

The design shall be such as to permit the replacement of malfunctioning components with minimum readjustment, de-integration and calibration to previously tested hardware.

HAR-890 / A / MA

During performance of the testing, care shall be taken to minimise the number of mating/demating cycles performed to the functional connectors. These shall be recorded in the mating/demating log.

HAR-891 / R / MA

Connector savers on brackets shall be used on all hi-rel and golden plated connectors to minimise the number of mate and de-mate cycles seen by connectors during test and integration.

HAR-892 / R / DO,MA

The manufacturing personnel shall wear gloves during harness manufacturing and handling

HAR-893 / R / DO,MA

Before start harness of manufacturing the mock-up shall be released by configuration control.

9.1 Mock-up (Scale 1 tooling)**HAR-895 / R / MA**

The harness shall be pre-manufactured on an adequate GSE, e.g. a satellite scale 1 mock-up, and finally all harness shall be installed on the Satellite Structure during the corresponding satellite integration phases.

HAR-896 / R / MA

The harness supplier shall provide a 3-D harness manufacturing mock-up scale 1:1.

HAR-897 / R / MA

All obstacles, which influence the harness design, shall be modelled. The connector positions of the units shall be modelled.

HAR-898 / R / MA

The mock-up shall be suitable for cleanliness 100,000.

HAR-899 / R / MA

If the mock-up is foreseen for transport/delivery it shall have lifting / hoisting supports.

HAR-900 / R / MA

The mock-up shall comprise all units, boxes, stay-out areas, harness bracketry, Interface-brackets and stand-off's in scale 1:1 with representative outer envelopes and correct connector interfaces.

HAR-901 / R / MA

For manufactory of dummy units, simplified or unit ICD drawings shall be used to get the latest data of subject unit.

HAR-902 / R / MA

The connector allocation shall be in same position as on the original unit.

HAR-903 / R / MA

The connector or dummy shell finish shall be electroless nickel for circular connectors and gold-plated for rectangular connectors, cadmium plated finishes are not permitted, due to PFM harness manufacturing and overall cleanliness requirements.

HAR-904 / R / MA

Harness fixation on the unit shelf shall be allocated in the same locations as on the original unit for proper harness configuration.

HAR-905 / R / MA

Harness routing drawing with reference points shall be fixed to the manufacturing mock-up to guarantee proper harness routing and configuration between the SM, EM and PFM models and the transfer of harness fixation to the original satellite structure.

HAR-906 / R / MA

Connector brackets and harness fixation brackets shall be rigid such, that no deformation or bending occurs when the harness is mated or fixed to it.

HAR-907 / R / MA

The finish of mechanical brackets shall be non-contaminating.

HAR-908 / R / MA

All sharp metallic bracket corners shall be broken and designed satellite corner protections as simulations in same shapes of the mock-up.

HAR-909 / R / MA

The mechanical stay-out areas and structural cut-outs shall be marked. If possible/available the dummy hardware shall be mounted to the manufacturing mock-up.

9.2 Transport, preservation and packing**HAR-911 / R / MA**

The harness shall be prepared for delivery, preserved, packaged and stored in accordance with [AD 02] which will provide protection against corrosion, deterioration and damage from supply source until its requirement for use.

HAR-912 / R / MA

In particular the harness subsystem shall be handled in its container from the contractor to the Prime contractor. This applies also to the spare equipments which will be delivered in individual container.

HAR-913 / R / MA

The wire insulators shall be protected against abrasion.

HAR-914 / R / MA

Each connector shall be packaged into an individual antistatic bag.

HAR-915 / R / MA

Connector pins shall be protected by caps.

HAR-916 / R / MA

Fragile harness parts shall be stored on their manufacturing jig.

HAR-917 / R / MA

Any exposed conductor (e.g. flying leads to thermistor ...) shall be protected against short circuit by insulation tape or PVDF (e.g. Kynar) sleeves until their final connection to the designated component.

HAR-918 / R / MA

The entire harness shall be packed into two plastic bags with desiccant in between bags.

9.2.1 Labelling**HAR-920 / I,R / MA**

The harness hardware shall be marked by labels in order to achieve configuration traceability. The identification shall be made by a label containing the following information:

- PT Item Code: TBD
- Part - Number: TBD
- FM Number: TBC (if applicable)

HAR-921 / R / MA

Nameplates provided for component identification shall contain the following information:

- Manufacturer source
- Part number
- Serial number (where applicable)
- Configuration item (CI) number
- Nomenclature of the item
- Contact number (where applicable)

Note: Nameplates are required for all mechanical construction parts, e.g. brackets, stand-offs, bridges.

HAR-922 / R / MA

The nameplate shall be visible when installed and its location shall be defined on the assembly drawing

HAR-923 / R / MA

Ink type must be qualified in accordance with TBD standard and to comply with environmental requirements.

HAR-924 / R / MA

All connectors (including interface connectors) shall have a unique harness label corresponding to the wiring list.

HAR-925 / R / MA

All cables and wires shall have a label corresponding to the wiring list. Note: Each wire has a unique identification

HAR-926 / R / MA

The identification marking has to be done using the following items according "system TMS 90", which is:

- Line 1: XXX-J/PYY
 - XXX - Equipment name - abbreviated
 - J/P - Jacket or Plug
 - YY - Number of the connector
- Line 2: WXYZA
 - X= EMC Classification number [1-5]
 - Y=
 - AO for AOCS subsystem

- DH for DHS subsystem
- EP for EPS subsystem
- TM for TMCU subsystem
- IN for INSTRUMENT
- TH for THERMAL
- PR for PROPULSION

- Z=
 - TM for telemetry
 - TC for telecommands
 - VI for video links
 - HP for high power
 - MP for main power
 - BU for bus links

Note: All data shall be used i.a.w. [AD 08].

9.3 Interchangeability

HAR-928 / R / DO

Where multiple models are required for specific projects, the deliverable models (PFM, FM2 etc.) shall be directly interchangeable in form, fit and function.

9.4 Maintainability & repair

HAR-930 / I,R / DO,MA

Routing and layout shall be such as to enable replacements on parts level

HAR-931 / R / DO,MA

The design of harness shall be such that any addition/deletion of cables, pin function modification, local routing modification can be easily introduced.

Note: Any above named repair activity shall not cause delay of more than TBD hours/days.

10 ANNEX**10.1 Double Insulation Principle**

The double insulation requirements depend on the accurate identification of:

- The way insulation is performed (thickness, gap, and materials) between two electrically conductive elements at different potentials
- The conceivable variations of the thickness / gap
- The possibility of insulation loss due to external pollution (metallic particles, ...)

Terminology:

- Invariable gap
 - When the physical distance between two electrically conductive elements is not subject to significant variations or changes, whatever the constraints applied to the unit or part of the unit.
- Variable gap
 - When the physical distance between two electrically conductive elements can be subject to variations or changes, according to the constraints applied to the unit or part of the unit (environmental tests, AIT operations, changes with time, use of insulation materials...).
- Rigid insulating material
 - Strong, mechanically resistant, non-porous
- Non Rigid insulating material
 - Flexible, thinness (kapton, choterm, glue, varnish, etc.)
- Case A : Invariable gap, and gap > 1mm
 - The double insulation requirements ask for at least one insulating material (rigid or not); the selection of a non rigid insulating material is authorized if it is resistant whatever the constraints undergone during lifetime (manufacturing processes, AIT operations, environmental tests, launch and in-orbit environment operation). In this case of invariable gap, the minimum physical distance between two electrically conductive elements shall be greater than 1mm.
- Case B : Variable gap, or gap < 1mm
 - In case of Variable gap, or when the physical distance between two electrically conductive elements is less than 1mm, the double insulation requirements ask for two insulating materials including one rigid insulating material. The non rigid insulating material shall be resistant whatever the constraints undergone during lifetime (manufacturing processes, AIT operations, environmental tests, launch and in-orbit environment operation).

Examples of double insulation implementation (as guidelines):

- Pins inside connectors: case A (except for MDM connector)
 - Invariable gap due to insulator gives double insulation.
- Connector connections: case B
- Double insulation requested between pins (at the rear of enlarged barrel and power contacts)
 - Variable gap due to flexible wires
- Splice connections: case B
- Two shrink sleeves at splice level

11 LIST OF ABBREVIATIONS

AIVT	Assembly, Integration, Verification and Test
ATOX	Atomic Oxygen
AWG	American Wire Gauge
CDR	Critical Design Review
CE	Conducted Emissions
CFI	Customer Furnished Item
CFRP	Carbon Fibre Reinforced Plastics
CoG	Center of Gravity
CS	Conducted Susceptibilities
CVM	Converter Module
DC	Direct Current
DID	Design and Interface Document
DPA	Destructive Physical Analysis
DSPG	Distributed Star-Point Grounding
DVM	Digital Voltmeter
EB	Elegant Bread-Board
ECSS	European Committee on Space Standardisation
EED	Electro Explosive Device
EEE	Electromechanic, Electric and Electronic
EGRP	Earth Grounding Reference Point
EGSE	Electric Ground Support Equipment
EICD	Electrical Interface Control Document
EIDP	End Item Data Package
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FDIR	Fault Detection, Isolation and Recovery
FM	Flight Model
FMECA	Failure Mode Effects and Criticality Analysis
GDIR	Generic Design & Interface Requirements
HPC	High Priority Command
HK	Housekeeping
H/W	Hardware
ICD	Interface Control Document/Drawing
I/F	Interface
I/O	Input/Output
Mbps	MegaBit per Second
MLI	Multi-Layer Insulation
MMFU	Mass Memory & Formatting Unit
NCR	Non-Conformance Report
OBC	On-Board Computer
OBDH	On-Board Data Handling
OS	Operating System
PA	Product Assurance
PCDU	Power Conditioning and Distribution Unit
PDHU	Payload Data Handling Unit
PFM	Protoflight Model
PFR	Problem/Failure Reporting
PM	Processor Module
PTFE	Poly Tetra Fluor Ethylene
PDVF	Polyvinylidene fluoride
QA	Quality Assurance

AIVT	Assembly, Integration, Verification and Test
QPL	Qualified Parts List
RCS	Reference Coordinate System
RCS	Reaction Control System
RD	Reference Document
RE	Radiated Emissions
RF	Radio Frequency
RFEA	Radio Frequency Equipment Assembly
RFI	Radio Frequency Interference
RfW	Request for Waiver
RH	Relative Humidity
RIU	Remote Interface Unit
rms	root mean square
RS	Radiated Susceptibilities
RTS	Request to Send
SADM	Solar Array Drive Mechanism
SCC	Space Component Coordination
SCOE	System or Special Check-Out Equipment
SEE	Single Event Effect
SEB	Single Event Burn-Out
SEGR	Single-Event Gate Rupture
SEL	Single Event Latch-Up
SEU	Single Event Upset
SOC	Statement of Compliance
S/C	Spacecraft
S/W	Software
TB	Thermal Balance
TBC	To be confirmed
TBD	To be defined
TM	Telemetry Encoder
TP	Twisted Pair
TRP	Temperature Reference Point
TSP	Twisted Shielded Pair
TT&C	Telemetry/Telecmd, Tracking and Control
Tx	Transmitter
TV	Thermal Vacuum

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