# AS250 Generic

**Generic Solar Array Technical Specification**

**CI CODE:** T0055566  
**DRL Refs:**

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SUMMARY

This document defines the design need, development, manufacturing, verification, and delivery requirements for the AS250 generic solar array product.

The requirements which are presented in the following pages are generic to all AS250 missions.

It is the status reached for Solar Array CDR2 part 2 review

It is the concatenation of DIV.SP.00057.T.ASTR Issue 03 Rev 00

And

the following Change Requests

-ASTR.CR.00127.ASL
-ASTR.CR.00151.ASL
-ASTR.CR.00157.ASL

No other changes
1. GLOSSARY

BOL  Beginning Of Life
DSAP  Deployable Solar Array Panel
EICD  Electrical Interface Control document
EOL  End Of Life
MICD  Mechanical Interface Control Document
PVA  Photovoltaic assembly
PCDU  Power conditioning and distribution unit
SA  Solar Array
SCA  Solar cell assembly
TICD  Thermal Interface Control Document
2. INTRODUCTION AND SCOPE

2.1 Introduction
The specification defines the design, performance, interfaces and verification requirements for the design, validation and qualification of the photovoltaic Solar Array included in AS250 power subsystem.

The AS250 power subsystem including SA is issued from a new generation of satellites aiming at covering the needs of various Low Earth Orbit missions in terms of power range. The name of this new generation is called AS250

2.2 Scope
The document includes performance, architectural and design requirements, as well as all the interface and environmental requirements specific to the AS250 Solar Array (SA). Generic interface and environmental requirements are contained in an AS250 generic interface requirement document [AD01]. Generic Product Assurance requirements are specified in [AD02], applicable document by default to all AS250 units. Any deviation from these generic requirement documents ([AD01] / [AD02]) are clearly identified in the present document which therefore shall have precedence over the generic documents.

2.3 Guidelines
SA-11 /

The Doors Requirement Number is presented under the following format
SA_xxx/a,b/ for the generic specification and SA_xxx/SA_yyy/a,b/ for mission specific specifications where:

- xxx is a unique number assigned consecutively,
- yyy is the requirement number from original requirement in the AS250 SA specification [AD0] (if any)
- a,b are the intended verification methods

The Intended Verification Method codes are as follows:
- R - Review
- A - Analysis
- I - Inspection
- T - Test
- S - Similarity

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

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

3.1 Applicable documents

The following documents are applicable documents to this specification.

[AD01] DIV-SP-000027-T-ASTR AS250 General design and interface requirement (AS250 GDIR)
[AD02] DIV-SP-00025-T-ASTR AS250 Product Assurance requirements for subcontractors
[AD03] Deleted
[AD04] Deleted
[AD05] General mechanical FEM ADS.E.0787
[AD06] DIV-SP.00056.T.ASTR AS250 Equipment Thermal Model Requirements Specification
[AD07] ADS.E.0925 Transportation escort role definition
[AD08] ECSS-E-ST-33-01C Mechanisms (supersedes ECSS-E-30 part 3A, AD11 of AD01)
[AD09] Stowed and Deployed DSAP generic IRD DT0375955
[AD10] ASTR-TCN-00771-ASL Radiation analysis for S/A power performance calculation

3.2 Reference documents

[RD01] ECSS E20-08 ESA specification for photovoltaic assemblies and components.
4. FUNCTIONAL REQUIREMENTS

4.1 General

SA-25 / R

The Solar Array is made of 3 Deployable Solar Array Panels (DSAP).

SA-26 / R

The 3 DSAPs shall be identical and interchangeable.

SA-27 / R

Once deployed, each Solar Array Panel is fixed with respect to the satellite coordinate system (Osat) as follows:

- One on +Ysat side: Panel Nr 1 located with (Osw1)
- One on -Ysat/+Xsat side: Panel Nr 2 located with (Osw2)
- One on -Ysat/-Xsat side: Panel Nr 3 located with (Osw3)

![Figure 4.1-1: DSAP locations](image-url)

The SA stowed and SA deployed configurations are provided in Section 12. Annex 1.

The satellite attitude in normal mode and in safe mode are provided in Section 13. Annex 2.

SA-28 / R

The 3 DSAPs shall be completely independent and it shall be possible to integrate and remove them separately from the satellite.
SA-29 / R

Each DSAP shall include the following items:

- Panel substrate (1 off)
- Photovoltaic assembly
- Transfer harness with 1 interface connector
- Holddown and release mechanisms (4 off)
- Deployment mechanisms (2 off)
- Stiffening mechanism (stiffener in deployed configuration)
- Thermistor
- Redundant deployment status devices
- Mechanical brackets to the defined interface planes (6 off)
- Thermal and electrical insulation washers and bushings if necessary (6 off)

Solar Array does not include any drive mechanism.

SA-31 / R

Each DSAP shall be fully assembled before delivery to Prime Contractor.

4.2 Electrical functional requirements

4.2.1 Solar Array network

SA-34 / R

The SA network shall be composed of Np strings in parallel; each string composed of Ns photovoltaic cells in series.

Np strings are split into electrical sections

SA-35 / R

The lay-down and stringing arrangement shall be identical for all the DSAPs.

SA-36 / R

There shall be 6 electrical sections per SA, e.g. 2 sections per DSAP.

SA-482 / R

The section 1 shall be the innermost section of each DSAP near to the hinges and section 2 the outermost section.

In case the power demand increases, the section commutation sequence of the PCDU will be the following:

- First, sections 1 in the following sequence => SA1 / SA2 / SA3
- Then, sections 2 in the following sequence => SA1 / SA2 / SA3

In reverse order when the power demand decreases

SA-37 / R

The number of strings in parallel per section shall be identical or very close from one section to another.
The harness layout and stringing shall be optimized to minimize magnetic moment of each DSAP.

4.2.2 Electrical solar array sections management
The SA sections are electrically managed at satellite level by the PCDU (power conditioning and distribution unit). According to satellite power consumption need during sunlight period, each section are either connected to the satellite power bus (operational mode), or switched off (non operational mode with SA section power available on the satellite power bus).

During launch and in-orbit before deployment all DSAP sections are connected to the PCDU in either operational or non operational modes pending sun attitudes and power consumption demands.

In non operational mode, the Solar Array design shall be compatible of two electrical management modes:
• open circuit mode (SA sections are electrically disconnected from the satellite power bus)
• shunt mode (SA sections are short circuited)

4.2.3 Protections
4.2.3.1 Short circuit protection
Each electrical string shall include a blocking diode in serie to protect the Solar Array against multiple short circuits.

4.2.3.2 Shadow protection, reverse bias screening
Every single cell shall be shadow protected by a by-pass diode.

Each cell shall be able to withstand any reverse bias situation possible in orbit condition (due to shadow, to shunt operation in light for the weakest cell etc… and considering the maximum worst case forward voltage of the by-pass diode as low temperature at end of eclipse).

For triple junction cells, a special attention must be carried to the reverse bias situation in light of the weakest cell of a short circuited string: in this case, the weakest of the 3 junctions (generally the top junction) of this cell can be reverse biased by the cumulated voltage of the by pass diode and of the 2 others junctions (middle and bottom)

On each flight cell an acceptance reverse bias screening test shall be done to cover the worst case in orbit situation (not only in dark condition but also in light): the screening test parameters will be justified by the supplier and submitted to prime agreement.

The network components shall be compatible with voltage and current transients resulting from on-ground operations (connector mating and demating, ...) and sections commutation linked to SA sections management as specified in SA-141).

The by-pass diode low leakage current under worst case conditions and stability during long time duration shall be demonstrated by test.
5. PERFORMANCES REQUIREMENTS

5.1 Mechanical performances

5.1.1 Stowed stiffness

SA-52 / T,A

When mounted on an infinitely rigid interface, the Solar Array first eigenfrequency shall be:

Out of plane >= 45 Hz

In plane   >= 70 Hz

5.1.2 Release and deployment

SA-54 / R

Release actuators

The deployment shall be actuated by devices generating no debris and shocks as low as possible (shocks specified in SA-64).

SA-55 / R

Release actuator redundancy

Release actuators shall be redundant.

SA-56 / R

Release sequence

For each DSAP, the 4 hold down points shall be released step by step: for each point, nominal and redundant order shall be sent sequentially, the same sequence will be sent to the next point etc…

The identification of the 4 hold down points of a same DSAP is given on the here under Figure 5.1-1

SA-389 / R

The following informations shall be provided by the SA for Prime review:

• release sequence of each DSAP (order of the released hold points) and associated constraints on time gap between:
  • nominal and redundant order
  • two consecutive hold points release
  • first and last holdpoint release
  • total duration of each DSAP release sequence.

SA-471 / T

The release system shall provide capability for release sequence interruption on both Prime and Redundant thermal knives

SA-485 / T

The release system shall demonstrate capability for redundant thermal knife to release after a single heating interruption of the primary thermal knife

SA-486 / T

The release system shall demonstrate capability for redundant thermal knife to release after a single heating interruption of the redundant thermal knife
SA-487 / T

The release system shall demonstrate capability for redundant thermal knife to release after a single heating interruption of the primary thermal knife followed by a single heating interruption of the redundant thermal knife.

SA-58 / T,A

**Torque margin**

The torque margin throughout the deployment shall comply with [AD01] section 3.2.5.

Other uncertainty factors than those of AD01 could be proposed by Contractor based on its in-house space experience, in that case they shall be submitted to Prime approval.

In all the cases the ratio between motorization loads and the total of all the resistive loads shall be higher than 3 all along the deployment.

SA-59 / A

**Maximum spin rate**

The Solar Array shall be able to be deployed while the spacecraft has an angular rotation rate about any axis of 15°/s.

SA-60 / A

**Loads and environment during release**
The Solar Array shall be able to be released and to deploy under the different loads and environment acting on it at that time:

- spin effect SA-59
- thermo-elastic SA-187
- temperatures SA-194

**SA-61 / A**

**Loads during release sequence**

The Solar Array shall be able to withstand the loads acting during release sequence (see SA-60) when it remains stowed only by 3, 2 or 1 hold points. Purpose of this requirement is to cover the nominal release sequence (with gap time between each point release) and a failure mode if sequence stops for a longer time between two point releases.

**SA-62 / R**

**Deployment kinematics**

During deployment of the solar array, there shall be no risk of impact with spacecraft.

**SA-63 / T,A**

**Backlash**

There shall be no backlash at end of deployment, and no refolding of the solar array DSAPs under in orbit loads.

There shall be no risk of functional interference between anti-backlash device and stiffening mechanism.

**SA-64 / T,A**

**Induced shock**

During release and deployment of the solar array, the induced shock at satellite interface shall not overpass the following SRS (valid for any axis):

- 100 Hz : 20 g
- 400 Hz : 75 g
- 800 Hz : 75 g
- 1000 Hz : 1000 g
- 10000 Hz : 1000 g

**SA-66 / T,A**

**Deployed stiffness**

When mounted on an infinitely rigid interface, the Solar Array first eigenfrequency shall be:
out of plane : ≥ 10 Hz
torsion : ≥ 10 Hz
in plane : ≥ 10 Hz

In that aim, a passive stiffener will be used in deployed configuration; possible solar illumination on stiffener will be also considered.

Eigen modes involving only the stiffener mass are not subject to the here above frequency requirement.

SA-67 / T,A

The behavior of the deployed solar array must be linear under in orbit loads defined in SA-203 and the stiffness must be identical in both directions (deployment and refolding)

5.2 Electrical performances

5.2.1 Electrical Power

SA-70 / A

Power requirement

The Solar Array shall provide at least 1204 W @ 34.2 V at Solar Array interface connector

This figure is considered during sunlit duration in the worst case conditions, computed according to following conditions:

• Sun incidence perpendicular to solar cell plane
• EOL
• Summer solstice, 1321W/m²
• Maximum worst case hot temperature, to be determined by the SA Supplier.
• Including harness and blocking diodes voltage drop till interface connector: this voltage drop shall be lower than 1.6 volts.
• Including power degradation factors as per SA-71
• considering radiation environment as per SA-211

The life time duration and orbit definition are provided in Section 8.1.3

SA-71 / A,R

Power degradation factors and associated computation method are give in Table 5.2-1 for EOL power and BOL maximum current and voltage.
### Table 5.2-1: Power degradation factors for 7 years mission

<table>
<thead>
<tr>
<th>INPUT</th>
<th>POWER @ EOL</th>
<th>Maximum current @ BOL</th>
<th>Maximum voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Current Cell mismatch</td>
<td>0.99</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(b) Possibly better production</td>
<td>1</td>
<td>1.02</td>
<td>1</td>
</tr>
<tr>
<td>(c) Calibration error</td>
<td>0.97</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>(i) Total RSS Calculation (a,b,c)</td>
<td>0.968</td>
<td>1.04</td>
<td>1.03</td>
</tr>
<tr>
<td>(j) Cover Glass gain/loss (to be cancelled when SCA data set will be available)</td>
<td>0.986</td>
<td>1.01</td>
<td>NA</td>
</tr>
<tr>
<td>(d) UV degradation and micrometeorites (total for EOL, 7 years with 0.25% per year)</td>
<td>0.982</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(e) Random failure</td>
<td>At least 1 string upon total number of strings 0.987</td>
<td>1</td>
<td>NA</td>
</tr>
<tr>
<td>(f) Albedo coefficient (on poles)</td>
<td>1</td>
<td>1.04</td>
<td>1</td>
</tr>
<tr>
<td>(g) Misalignment of the SA</td>
<td>2° misalignment = 0.9994</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(h) Arithmetic total (d,e,f,g)</td>
<td>0.968</td>
<td>1.04</td>
<td>1</td>
</tr>
<tr>
<td>(k) Global loss factor (j + RSS(i,h))</td>
<td>0.946</td>
<td>1.064</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Power @ EOL computation in Table 5.2-1 corresponds to Summer Solstice and Maximum current @BOL to Winter Solstice.

**SA-73 / A**

For random failure, at least loss of one string per SA shall be considered or more according to design and according to the reliability figure specified in SA-245.

### 5.2.2 Cells data set

**SA-75 / T**

The complete cells data set including BOL and EOL parameters (open circuit voltage, short circuit current, maximum power point voltage, maximum power point current, efficiency ..), the temperature coefficients and the remaining factors after irradiation, must be provided to Prime.

Reference conditions for cells data set are AM0 1367W/m² and 28°C.

### 5.2.3 Cells performances versus solar flux incidence angle

**SA-77 / T**

Cells performance degradation linked to solar flux incidence angle must fit to a cosinus law within:

- 1% for incidence angle lower than 50°
- % to be provided by SA supplier for angles higher than 50°

### 5.2.4 Magnetic moment

**SA-79 / A,R**

Stringing and harness layout shall minimize the residual magnetic moment.
The residual magnetic moment shall not exceed 1 Am$^2$ per panel: impact of the switching sequence of the different sections shall be analysed.

Analysis shall also give the worst case magnetic moment in case of failure (open circuit, short circuit).
6. DESIGN AND INTERFACE REQUIREMENTS

6.1 Mechanical Design and Interface Requirements

6.1.1 Mass

SA-83 / T,A

The SA total mass in flight configuration (including all margins as defined in [AD01] section 3.2.1.) shall be less than 32 kg, considering 3 complete DSAPs (as per section 4.1) and hold down and hinge interface brackets to Satellite structure.

This shall be verified by mass measurement on the fully assembled wings (accuracy measurement will be better than 0,1 kg for the whole SA)

Mass justification shall be provided according to [AD01] section 3.2.1.

Until final measurement, mass prediction with associated tolerances shall be provided by the Supplier through a mass budget which will be periodically updated.

6.1.2 Centre of Gravity

SA-85 / T,A

DSAP Center of Gravity (CoG) shall be provided for both stowed and deployed configurations (in deployed configuration, misalignments due to deployment and in orbit environmental conditions will be considered).

DSAP Center of Gravity (CoG) shall be determined by analysis based on measurements of mass at the parts and components level and correlating them to the mass model.

Center of Gravity position prediction with associated tolerances shall be provided by the Supplier through a budget which will be periodically updated.

6.1.3 Inertia

SA-87 / A

DSAP inertia shall be provided for both stowed and deployed configurations.

Inertia prediction with associated tolerances shall be provided by the Supplier through a budget which will be periodically updated. After mass measurement, the inertia accuracy will be compliant with [AD01] section 3.2.1.

6.1.4 Mechanical interfaces

SA-89 /

Allocated volume, Mechanical reference frame.

The SA in stowed and deployed configurations shall comply with the allocated volume defined in IRD provided in Section 12. Annex1.

The SA mechanical reference frame (Osw, Xsw, Ysw, Zsw) is indicated on the IRD provided in Section 12. Annex1.

SA-90 / T,A

DSAP alignment

In deployed configuration, the DSAPs shall be in $X_{SW}/Y_{SW}$ plane within ± 2° accuracy.
SA-91 / T,A,I
Attachment interface
The SA supplier shall comply with mechanical interfaces according to IRD [provided in Annex1].
Attachment requirements of [AD01] section 3.2.1 are applicable.
Verification of interface fixation screws non sliding under interface loads (QS, TE, deployment ...) shall be done (for torque / pretension law, the R Sat standard shall be considered). Typical interface screws are M6.

SA-92 / R
MICD
The MICD drawings shall define all mechanical interface data. Typical content is depicted in [AD01] Appendix A

6.1.5 Mounting provisions / SA integration on satellite
SA-94 / R
All the following elements shall be provided by the SA Supplier:
• Adjustment shims (if needed)
• Interface screws and washers for SA integration
• Mechanical interface brackets
• Thermal interface H/W including thermal washers
• Electrical insulation H/W

SA-96 / R
During SA integration on the satellite, hinge interface parts shall be maintained by an MGSE in correct location to not stress the hinges. This MGSE is to be delivered by the SA Supplier.

SA-97 / R
For SA integration, the satellite will be oriented with Z axis horizontal and the wall behind the first DSAP in a vertical plane. After the first DSAP integration, the S/C will be rotated by 120° to integrate the second DSAP in a vertical plane and again for the third DSAP.
Specific MGSE will be provided to handle the DSAPs in the right orientation for integration on S/C, and to perform the DSAP deployment when assembled on the S/C (deployment will be performed DSAP by DSAP, with the same orientation of the S/C as during DSAP integration)

SA-472 / R
The DSAP supplier shall provide or loan any necessary tools including tensionning tool identical to the tools used at supplier premises

6.1.6 Accessibility
SA-99 / R
The unit design shall support easy system integration and shall allow easy access to mounting screws, and easy access to connectors and easy access to exchange the release devices after a functional release.
If needed, the unit Supplier shall provide a kit of tools as part of the unit MGSE, such that the mounting bolts can be tightened from an accessible position.
6.1.7 MGSE interface

SA-101 / R

Each DSAP shall provide interface points for ([AD01] section 3.1.8 is applicable):

• Handling
• Hoisting
• Protective cover

6.1.8 On-ground release and deployment

SA-103 / A,R

The SA shall withstand without degradation 30 manual deployments on ground, as well as 5 releases with flight standard hardware (those numbers cover the whole on-ground life at contractor level and prime level)

6.1.9 Interface template

SA-105 / R

A tooling representative of the pattern and relative position of the fixation holes of the SA on the bus structure (at hold down points level and at root hinge level), will be created. This tool will be used to drill the SA interface fixation holes on the integration benches used by the supplier to assemble the DSAPs. It will also be used to drill or to control the SA interface fixations holes on the flight bus structures.

Such a tool will ensure a correct mating of solar array and bus structure during satellite final integration.

6.1.10 Design factors, safety margin

SA-107 / A,R

Design factors and safety margin applicable for all mechanical analysis are given in [AD01] section 3.2.1. for ground and launch/flight load cases.

6.1.11 General design requirements and interchangeability

SA-109 / R

[AD01] section 3.1.5. is applicable. Interchangeability requirement is applicable to the SA sub assemblies as panels, mechanisms

6.2 Thermal Design and Interface Requirements

6.2.1 Radiative interface

SA-112 / A

The SA will experience thermal radiative coupling with the satellite external surfaces covered with MLI and SSM.

For SA thermal analysis, the satellite external panels will be modelized as covered with 100% MLI decoupled from SC structure, so the temperatures of those external MLI and the coupling between SA and MLI will be directly computed by the SA supplier.

The S/L geometry to be considered is depicted in Figure 6.2-1.

Location of the DSAP’s is given in SA-27
6.2.2 Conductive coupling

SA-115 / R

The conductive coupling at each interface area with the satellite shall be less than 0.15 W/K. This value is to be achieved by the solar array design through the SA / SC attachment (without considering the contact conductance).

SA-419 / A

The maximum heat flux shall be provided by SA supplier and shall remain within the limitations provided per type of connection and per DSAP in Table 6.2-1.
### Heat flux into S/L

<table>
<thead>
<tr>
<th>Connection</th>
<th>Stowed Configuration</th>
<th>Deployed Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total for the 2 hinges</td>
<td>+/- 3 W</td>
<td>+/- 5 W</td>
</tr>
<tr>
<td>Total for the 4 hold-on points</td>
<td>+/- 5 W</td>
<td>+/- 1 W</td>
</tr>
<tr>
<td>Total for all the snubbers</td>
<td>+/- 5 W</td>
<td>+/- 1 W</td>
</tr>
</tbody>
</table>

**Table 6.2-1: Heat flux limitation for each DSAP**

#### 6.2.3 TICD

**SA-117 / R**

The deliverable TICD document shall define all thermal interface data. Typical content is depicted in [AD01] Appendix B.

Mandatory data are alpha (BOL/EOL) /epsilon of front side (Solar cells) and rear side, heat capacity, conductance in panel plane and through the panel thickness, conductance at SA interfaces with the SC. All the data shall be issued from tests on samples of the actual hardware.

#### 6.2.4 Thermal qualification margin rules

**SA-119 / T,A**

Thermal qualification margin rules are given in [AD01] section 3.3.

Qualification margin with respect to predicted in orbit temperature range shall be +10°C for hot case and -10°C for cold case. The analytical uncertainties to be applied to the calculated temperatures are assumed to be +10°C for hot case and -10°C for cold case. This could be revised pending sensitivities analysis results.

#### 6.3 Electrical Design and Interface Requirements

##### 6.3.1 Insulation

**SA-122 / T,R**

Insulation between each electrical circuit (power, thermal sensors, deployment status device, DSAP grounding ..) and between electrical circuits and DSAP structure must be higher than 100 MΩ under 500 Volts for power and 100 volts for others.

##### 6.3.2 Double insulation

**SA-124 / R**

Double insulation shall be implemented by using two different insulating materials, as required in [AD01] Appendix D.

**SA-396 / R**

For SA specific need, some precautions shall be taken to secure insulation:

- Avoid any direct contact between harness and metallic parts by using non conductive pieces.
• Avoid any thermo elastic degradation on harness (no 90° angle in harness path, relaxation loop, no harness in contact with structure corner...)

• Harness through structure hole shall be insulated from structure by dedicated insulated material

### 6.3.3 Grounding

**SA-126 / T,R**

**Metallic part grounding**

All metallic parts, whatever their location and surface, shall be bonded to SA structure.

By deviation from [AD01] GDI-2198, the resistance between metallic parts of the solar array shall be lower than 500 Ohms under 10 mA.

This requirement is not applicable to the SA metallic parts in contact with satellite structure and which cannot be electrically insulated from this structure (example: interface connectors housing grounded to SL structure and isolated from SA structure), because in this case they will short circuit the bleed resistors (see SA-142)

**SA-127 / R**

**Electrically non conductive parts**

Coverglass surface resistivity shall be lower than 2.3 E16 Ohms/square.

Coverglass Bulk resistivity shall be lower than to 1.0 E13 Ohm.m

### 6.3.4 Power & signal interface

**SA-129 / R**

Each DSAP shall be equipped with one connector for power and signal interface. The pins allocated to power interface shall be located in one side of the connector and shall be physically separated from the signal interface pins located on the other side of the connector. The separation between power and signal interfaces shall be performed by pins row not used.

**SA-392 / R**

The pins allocated to power interface for one section (+) and (0V) shall be separated from the pins allocated to the other section (+) and (0V) by the means of a pins row not used. Requirement TBC

**SA-130 / R**

The deliverable EICD document shall define all electrical interface data and shall be compliant with [AD01] Appendix C.

**SA-131 / I,R**

**Connector general requirements**

Refer to [AD01] § 3.5.5.1 & §3.5.5.2

**SA-133 / R**

The pin functions per DSAP connector is listed in Table 6.3-1. The n° of the corresponding pin shall be provided by the SA supplier for Prime review.
Interface connector shall be of type 38999 series 3, reference 340 105 601 B06-19-32-SN-L.

This connector shall be movable connected on flying leads coming from SA (length of flying leads shall be agreed with Prime).

This connector shall be connected and locked to a fix connector located on the satellite.

Master key position and shell elbow orientation are given in figure 6.3-3.

Double insulation of harness against connector backshell is mandatory.

<table>
<thead>
<tr>
<th>PIN</th>
<th>SIGNAL NAME</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>B</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>C</td>
<td>Ground resistor 1</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Thermistor return</td>
<td>No shielded line requested</td>
</tr>
<tr>
<td>E</td>
<td>Thermistor +</td>
<td>No shielded line requested</td>
</tr>
<tr>
<td>F</td>
<td>Microswitch B (Return)</td>
<td>Twisted shielded pair between pins F &amp; G</td>
</tr>
<tr>
<td>G</td>
<td>Microswitch B (+)</td>
<td>Twisted shielded pair between pins F &amp; G</td>
</tr>
<tr>
<td>H</td>
<td>Microswitch A (+)</td>
<td>Twisted shielded pair between pins H &amp; J</td>
</tr>
<tr>
<td>J</td>
<td>Microswitch A (Return)</td>
<td>Twisted shielded pair between pins H &amp; J</td>
</tr>
<tr>
<td>K</td>
<td>Ground resistor 2</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>L</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>M</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>N</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>P</td>
<td>Section 2 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>R</td>
<td>Section 2 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>S</td>
<td>Section 1 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>T</td>
<td>Section 1 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>U</td>
<td>Section 1 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>V</td>
<td>Section 1 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>W</td>
<td>Section 1 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>X</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>Y</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>Z</td>
<td>Unused - unconnected</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>a</td>
<td>Section 2 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>b</td>
<td>Section 2 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>c</td>
<td>Section 2 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>d</td>
<td>Section 2 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>e</td>
<td>Section 1 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>f</td>
<td>Section 1 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>g</td>
<td>Section 1 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>h</td>
<td>Section 2 (0V)</td>
<td>Unused contacts shall not be installed</td>
</tr>
<tr>
<td>j</td>
<td>Section 2 (+)</td>
<td>Unused contacts shall not be installed</td>
</tr>
</tbody>
</table>

Table 6.3-1: pin function of DSAP interface connector
Table 6.3-2: pin location of DSAP interface connector
Table 6.3-3: Master key position and elbow shell orientation

SA-393 / R
Not applicable

SA-433 / R
All exposed power distribution surfaces (including the rear side of connectors) shall be protected from the intrusion of debris likely to cause short circuits.

SA-132 / I,R
Connector savers
Connector savers shall be used on all flight standard connectors. Total number of mate/demate of flight connectors shall be recorded.

6.3.4.1 Power interface
SA-137 / A
The maximum total current at SA interface shall be lower than 48A Amp (that is 8.00A per SA section) even in case of failure (as coupling of an additional string on the section by multiple short circuits on substrate).
Computation shall be done in worst case conditions: short circuit mode, BOL, Winter solstice, 1423W/m², max temperature, pole albedo effect … (see conditions @ BOL in Table 5.2-1)

SA-138 / A
The maximum open voltage of each section must be lower than 100 volts.
Computation shall be done in worst case conditions for this parameter: BOL, minimum temperature … (see conditions @ BOL in Table 5.2-1)

SA-139 / T,A
Worst case electrodynamic capacitance of a SA electrical section shall be lower than 0.25µF/A.

SA-140 / A
Inductance of a SA electrical section shall be lower than 0.25µH/A.

SA-141 / A
Current overshoot:
Solar array electrical sections shall withstand the current overshoot due to the SA equivalent capacity discharge when the section is switched from non operational mode (maximum open circuit voltage or short circuit) to operational mode (operating bus voltage) or the opposite (operational mode to non operational mode)
A system analysis at Prime level will be done including the solar array model coupled to the power subsystem model and interface harness with solar array analytical and measured inputs as capacitance, inductance per SA section provided by the supplier.

SA-142 / T,R
Bleed resistors
In deployed configuration, DSAP structures and satellite structure must be electrically insulated (at root hinges interface level and at stiffener fixations level)
Bleed resistors shall be used to ground each DSAP to the spacecraft structure.
They shall be redundant and mounted in parallel.
Resistance of each bleed resistor shall be such that in case of failure, leakage current shall be lower than 25mA.

6.3.4.2 Signal interface
SA-144 / R
Thermistor
Each DSAP shall be equipped with one thermistor providing interface as specified in [AD01] §3.5.4.9.2 (Thermistor type 2).

SA-145 / R
Deployment status device
Each DSAP shall be equipped with a redundant deployment status device (micro-switches)
The deployment status device shall be a relay status acquisition (RSA) as defined in [AD01] § 3.5.4.11.

SA-146 / R
There shall be no cross strapping of the redundant microswitches harness at SA level
SA-147 / T,R

The switches shall be normally open when DSAP is stowed and normally closed when DSAP is fully deployed.

6.3.5 Release actuator interface

SA-149 / R

Power supply

The deployment actuators shall be compatible with [AD01] § 3.5.4.14.

Independent commands (prime and redundant) will be provided to each holddown point. Commands will be sent sequentially.

The supply voltage will be 19.5V -0.5V/+ 2.0V at actuator interface for a 60 sec -0/+5 sec pulse

The maximum actuator current is limited to 1.5Amps including in-rush current

SA-150 / R

Hold Down Release actuator Connectors

Each holddown mechanism shall be equipped with 2 connectors (1 for nominal actuator, 1 for redundant actuator). Connector type shall be provided by SA contractor for Prime review.

Each connector shall be movable connected on flying leads coming from SA (length of flying leads shall be agreed with Prime).

This connector shall be connected and locked to a fix connector located on the satellite.

6.3.6 Derating

SA-152 / A

Derating analysis must be performed for all the SA electrical components to demonstrate that worst case max current and extreme temperatures (including current flow dissipation) applicable to each of them stay inside manufacturer acceptable values including the derating factor as specified in [AD01] §3.5.9.1.

Some failure cases must be considered in this analysis as the loose of one wire for an electrical section or the coupling of additional strings of another section by short circuit effect to the structure.

6.4 Cleanliness design

SA-447 /

The edges of DSAP shall be closed to prevent debris generation towards the satellite.
7. ENVIRONMENT REQUIREMENTS

7.1 On-ground environment

7.1.1 Integration environment

SA-156 / A

The DSAP’s shall be compatible with the following temperature range:

• Minimum temperature: +16°C
• Maximum temperature: +25°C

SA-157 / A

The DSAP’s shall be compatible with the following relative humidity range:

• Minimum relative humidity: 20%
• Maximum relative humidity: 70%

SA-158 / A

The DSAP’s shall be compatible with Class 100,000 environment conditions

7.1.2 Transportation, ground handling, hoisting and storage

SA-160 / A

Transportation container shall ensure that transportation environment (mechanical, thermal, cleanliness,…) is less constraining than test and launch environment.

Transportation loads are specified in [AD01] section 4.2.1.

SA-161 / A

Transportation container must be compatible with road, rail, ship and air transport. Transport environmental conditions are given in [AD01] section 4.2.1.

SA-162 / A

Relative humidity during transportation will be as follows: 0 to 60% (TBC): refer to [AD01] section 4.1.1.

SA-163 / A

For ground handling and hoisting loads of [AD01] section 3.1.8. are applicable

SA-164 / A

Storage thermal environment will be as follows:

• Minimum temperature: - 40 °C
• Maximum temperature: + 60 °C

SA-434 / A

Transportation Escort requirements provided in [AD07] shall apply.
7.2 LAUNCH AND EARLY OPERATIONS PHASE ENVIRONMENT

7.2.1 Mechanical environment

7.2.1.1 Quasi static loads

SA-168 / A

Applicable quasi static loads to size the hard mounted Solar Array are the following:

15 g spherical qualification level

For Solar Array dimensioning, the design safety factors specified in [AD01] section 3.2.1 shall be added to above qualification levels.

The Supplier shall define the quasi-static qualification and sizing levels of each existing and already qualified component.

SA-169 / A

The Solar Array shall also withstand the minimum qualification level interface loads combinations at each of the 6 interfaces points with the bus structure, as given in the following Table 7.2-1.

<table>
<thead>
<tr>
<th>Interface</th>
<th>FXsw (N)</th>
<th>FYsw (N)</th>
<th>FZsw (N)</th>
<th>MXsw (Nm)</th>
<th>MYsw (Nm)</th>
<th>MZsw (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All HDP’s</td>
<td>900</td>
<td>600</td>
<td>1700</td>
<td>95</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>All hinges</td>
<td>550</td>
<td>450</td>
<td>1650</td>
<td>40</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 7.2-1: Qualification level Interface loads

7.2.1.2 Sine vibrations

SA-173 / T,A

The hard mounted Solar Array shall survive without any degradation the sine loads defined in Table 7.2-2.

SA-174 / A

Notching

Primary notching can be defined at resonance frequencies to not overpass the maxi of quasi-static loads of SA-168 or SA-169 at the sub-assembly interface. Any need for notching shall be notified to Prime Contractor as soon as identified. It shall be justified by a technical note. Prime Contractor reserve the right to reject any notching that is not technically justified or possible.
Table 7.2-2: Sine vibration loads

### 7.2.1.3 Acoustic noise

**SA-178 / T,A**

The hard mounted Solar Array shall survive without any degradation the acoustic loads defined hereafter. These environments are compliant with DNEPR, FALCON 9, PSLV, ROCKOT, SOYOUZ and VEGA launchers.
<table>
<thead>
<tr>
<th>Octave centre frequency (Hz)</th>
<th>Qualification level (dB (Tol –1/+3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.5</td>
<td>131.0</td>
</tr>
<tr>
<td>63</td>
<td>135.0</td>
</tr>
<tr>
<td>125</td>
<td>139.0</td>
</tr>
<tr>
<td>250</td>
<td>140.0</td>
</tr>
<tr>
<td>500</td>
<td>144.0</td>
</tr>
<tr>
<td>1000</td>
<td>139.0</td>
</tr>
<tr>
<td>2000</td>
<td>132.0</td>
</tr>
<tr>
<td>4000</td>
<td>129.0</td>
</tr>
<tr>
<td>8000</td>
<td>126.0</td>
</tr>
<tr>
<td>OASL</td>
<td>147.7</td>
</tr>
<tr>
<td>Duration</td>
<td>3 mn for QM, 2mn for PFM &amp; 1mn for FM</td>
</tr>
</tbody>
</table>

Table 7.2-3: Acoustic noise loads

7.2.1.4 Random vibrations

Not applicable

7.2.1.5 Launcher separation shock

SA-183 / T,A

*The Solar Array shall survive without any degradation the shock loads specified in [AD01] section 4.2.2.*

7.2.1.6 Launcher spin

See requirement SA-59

7.2.2 Thermo-elastic environment

SA-187 / A

*The Solar Array in stowed configuration shall withstand without any degradation the thermo-elastic loads with respect to the satellite.*

*This case is not to be added to the launch quasi static loads. It is to be considered in orbit after launch and before SA deployment.*

*Satellite interface structure characteristics to be used for DSAP FEM modelling are as follows for all the bus structural parts (lateral panels, bottom panel, vertical beams):*

- **minimum temperature** : -10°C
- **maximum temperature** : +50°C
- **material** : aluminium
The Solar Array shall also withstand the minimum qualification level interface loads combinations at each of the 6 interfaces points with the bus structure, as given in the following Table 7.2-4.

Interface points identification is given in Figure 5.1-1.

Those loads are computed with 45°C gradient between SA and satellite.

<table>
<thead>
<tr>
<th>Interface</th>
<th>FXsw (N)</th>
<th>FYsw (N)</th>
<th>FZsw (N)</th>
<th>MXsw (Nm)</th>
<th>MYsw (Nm)</th>
<th>MZsw (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All HDP’s</td>
<td>1000</td>
<td>150</td>
<td>2000</td>
<td>180</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>All hinges</td>
<td>150</td>
<td>150</td>
<td>1200</td>
<td>120</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 7.2-4: Qualification level Thermo elastic Interface loads

7.2.3 Pressure

The Solar Array shall withstand without any degradation the depressurisation rate defined in [AD01] section 4.1.4.

7.2.4 Solar array temperatures

Stowed and deployed solar array worst hot and cold temperatures cases during launch and early orbit phase (before and after solar array deployment) shall be determined by the SA supplier.

Between launch and solar array deployment, hypothesis are as follows:

- launch can be done during night or day
- launcher sequence is about 100 minutes maximum
- deployment sequence start takes place within one minute after injection
- deployment can occur during sunny part of the orbit or during eclipse

After solar array deployment and before reaching the converged ASH described in annex 2, the satellite attitude is undefined and varying during up to 3 orbits.

In order to not exceed the hot qualification temperature of the equipped wing in stowed, the spacecraft attitude shall be limited such as the sun is out of a cone with half angle 25° around a perpendicular axis of the wing or slowly spinned with a minimum of 0.03 rpm without constrains of sun attitude.
7.2.5 Humidity, temperature, thermal flux under fairing and during launch

SA-196 / A

On the launch pad, Solar Array shall be able to stay during one month under fairing with a relative humidity of 5%. Corresponding loads induced by moisture desorption are to be added to launch mechanical loads.

SA-197 / A

On the launch pad, Solar Array shall be able to stay during one month under fairing temperature ranging between 10°C and 30°C (flight level). Corresponding thermoelastic loads are to be added to launch mechanical loads.

SA-198 / A

Thermal control analyses of the solar array shall take into account the thermal flux under fairing and the aerothermal flux after fairing jettison:

- at fairing jettison: linear decrease of aerothermal flux from 1135W/m² to 0W/m² in 20 sec
- Aerothermal flux shall be considered along launcher speed direction axis (Zsat axis).
- Worst case attitude of S/A wrt Solar flux, Earth IR flux and Earth albedo shall be considered at the same time on the SA, they shall be added to the aerothermal flux.
- If protection means are necessary they shall be identified and justified for use on mission specific basis if requested.

7.2.6 Bus structure interfaces

SA-200 / A

For thermoelastic analysis of the SA in stowed configuration, representative boundary conditions of the bus structure stiffness (supplied by prime) will be used.

7.3 In-Orbit Environment

7.3.1 Mechanical environment

SA-203 / A

The Solar Array shall withstand without any degradation following steady state accelerations see Table 7.3-1. These loads are applied at Satellite Centre of Gravity, and are at qualification level.

<table>
<thead>
<tr>
<th></th>
<th>During SA deployment</th>
<th>Safe hold phase</th>
<th>Mission phase</th>
<th>Orbit control phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear acceleration</td>
<td>0 m/s²</td>
<td>0 m/s²</td>
<td>0 m/s²</td>
<td>0.010 m/s² maximum 0.002 m/s² minimum</td>
</tr>
<tr>
<td>Angular acceleration</td>
<td>0 m/s²</td>
<td>0.001 rad/s² maximum</td>
<td>0.20 rad/s² maximum</td>
<td>0.002 rad/s² maximum 0 rad/s² minimum</td>
</tr>
<tr>
<td>Angular rate</td>
<td>15 deg/s</td>
<td>15 deg/s maximum</td>
<td>7 deg/s maximum</td>
<td>0 deg/s constant</td>
</tr>
</tbody>
</table>

Table 7.3-1: Steady State Accelerations
7.3.2 Thermal environment

SA-205 / A

Temperature

The temperature experienced by the SA shall be determined by the SA Supplier.

Thermal radiative coupling with the satellite is specified in SA-112

Orbit characteristics and satellite attitude are defined respectively in SA-240 and in Annex2.

Normal mode (including the effect of the imaging manoeuvres) and Safe mode will be analyzed.

Solar constant, earth albedo and earth emitted radiation are specified in Table 7.3-2, Table 7.3-3 & Table 7.3-4. Earth IR flux and earth albedo flux are not independent and shall be combined in a realistic way to create worst case condition (hot or cold) on the SA. The design temperature shall be assessed with these reference maps. The design temperature shall be assessed with these reference maps.

As part of the sensitivities analysis, the following uncertainty shall be considered.

Albedo +/- 0.05

Earth IR flux +/- 20W/m²

For hot worst case determination, no electrical power generation shall be assumed.

<table>
<thead>
<tr>
<th>DATE</th>
<th>SOLAR IRRADIANCE (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter solstice</td>
<td>1423</td>
</tr>
<tr>
<td>Summer solstice</td>
<td>1321</td>
</tr>
<tr>
<td>Equinox (autumnal)</td>
<td>1357</td>
</tr>
</tbody>
</table>

Table 7.3-2: Solar flux
Table 7.3-3: Monthly average Albedo(%) as a function of latitude, from Gilmore
Table 7.3-4: Monthly average Earthflux as a function of latitude

<table>
<thead>
<tr>
<th>Latitude (deg)</th>
<th>J</th>
<th>E</th>
<th>M</th>
<th>Δ</th>
<th>Δ</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>P</th>
<th>Annual Min</th>
<th>Annual Avg</th>
<th>Annual Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>165</td>
<td>155</td>
<td>146</td>
<td>173</td>
<td>189</td>
<td>207</td>
<td>207</td>
<td>199</td>
<td>178</td>
<td>130</td>
<td>163</td>
<td>177</td>
</tr>
<tr>
<td>80</td>
<td>157</td>
<td>149</td>
<td>154</td>
<td>183</td>
<td>197</td>
<td>211</td>
<td>212</td>
<td>207</td>
<td>186</td>
<td>175</td>
<td>160</td>
<td>156</td>
</tr>
<tr>
<td>70</td>
<td>165</td>
<td>164</td>
<td>170</td>
<td>196</td>
<td>208</td>
<td>222</td>
<td>224</td>
<td>217</td>
<td>198</td>
<td>186</td>
<td>173</td>
<td>167</td>
</tr>
<tr>
<td>60</td>
<td>175</td>
<td>177</td>
<td>188</td>
<td>204</td>
<td>213</td>
<td>222</td>
<td>228</td>
<td>224</td>
<td>211</td>
<td>200</td>
<td>188</td>
<td>182</td>
</tr>
<tr>
<td>50</td>
<td>191</td>
<td>194</td>
<td>203</td>
<td>216</td>
<td>226</td>
<td>235</td>
<td>244</td>
<td>243</td>
<td>232</td>
<td>220</td>
<td>205</td>
<td>198</td>
</tr>
<tr>
<td>40</td>
<td>217</td>
<td>218</td>
<td>224</td>
<td>235</td>
<td>241</td>
<td>254</td>
<td>259</td>
<td>263</td>
<td>253</td>
<td>247</td>
<td>231</td>
<td>222</td>
</tr>
<tr>
<td>30</td>
<td>250</td>
<td>248</td>
<td>251</td>
<td>265</td>
<td>266</td>
<td>268</td>
<td>262</td>
<td>261</td>
<td>261</td>
<td>263</td>
<td>253</td>
<td>251</td>
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<tr>
<td>20</td>
<td>266</td>
<td>264</td>
<td>264</td>
<td>270</td>
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<td>251</td>
<td>259</td>
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<tr>
<td>10</td>
<td>251</td>
<td>251</td>
<td>248</td>
<td>240</td>
<td>232</td>
<td>233</td>
<td>233</td>
<td>235</td>
<td>235</td>
<td>244</td>
<td>243</td>
<td>250</td>
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<tr>
<td>0</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>243</td>
<td>257</td>
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<td>257</td>
<td>253</td>
</tr>
<tr>
<td>-20</td>
<td>261</td>
<td>256</td>
<td>254</td>
<td>263</td>
<td>258</td>
<td>260</td>
<td>260</td>
<td>264</td>
<td>259</td>
<td>258</td>
<td>256</td>
<td>262</td>
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<tr>
<td>-30</td>
<td>253</td>
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<td>187</td>
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<td>208</td>
<td>216</td>
</tr>
<tr>
<td>-60</td>
<td>209</td>
<td>204</td>
<td>193</td>
<td>186</td>
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<td>165</td>
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<td>157</td>
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<tr>
<td>-70</td>
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<td>128</td>
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<td>220</td>
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<tr>
<td>-80</td>
<td>187</td>
<td>171</td>
<td>148</td>
<td>121</td>
<td>105</td>
<td>110</td>
<td>104</td>
<td>94</td>
<td>94</td>
<td>126</td>
<td>160</td>
<td>156</td>
</tr>
</tbody>
</table>

Min | 157 | 149 | 146 | 121 | 105 | 110 | 104 | 94 | 94 | 126 | 160 | 156 | 94 | 135 | 190 |
Avg | 215 | 212 | 209 | 215 | 216 | 219 | 218 | 216 | 211 | 213 | 213 | 218 |
Max | 266 | 264 | 264 | 270 | 270 | 273 | 272 | 276 | 271 | 266 | 257 | 262 |

SA-206 / T.A

The Solar Array shall withstand without any degradation the temperature range experienced in orbit.

SA-207 /

Fatigue

The Solar Array shall withstand without any degradation the fatigue induced by temperature cycling on each orbit.

7.3.3 Thermo-elastic environment

SA-209 / A

The Solar Array in deployed configuration shall withstand without any degradation the thermo-elastic loads with respect to the satellite.

Satellite structural characteristics to be used for DSAP FEM modelling are as follows (valid for lateral panels, bottom panel, vertical beams..)

<table>
<thead>
<tr>
<th>minimum temperature</th>
<th>maximum temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40°C</td>
<td>+50°C</td>
</tr>
</tbody>
</table>

material | aluminium
7.3.4 Radiation environment

SA-211 / A

Refer to [AD10] for power performance analysis

SA-394 / R

The equivalent radiation dose (in e-/cm² of 1 MeV) taken into account to estimate power performances (SA-70) shall be provided by SA supplier for Prime review.

7.3.5 Atomic oxygen environment

SA-213 / A,R

The SA shall withstand without degradation the ATOX environment with the following hypothesis: 10²⁰ atom/cm²/year with a drag perpendicular to velocity vector.

7.3.6 Micro-meteorite environment

SA-215 / A

The SA shall withstand without degradation the micro-meteorite environment. This environment is covered at SA level by a degradation coefficient of 0,25% per year in SA-71.

7.3.7 ESD environment

SA-218 / T,I,R

The SA shall withstand without degradation the ESD environment on the specified orbit: a parallel gap of 2 mm shall be implemented to perform insulation under 50 volts between solar cells belonging to different SA sections.

SA-395 / A

The maximum voltage between two adjacent cells shall be lower than 50Volts worst case.

7.3.8 UV environment

SA-220 / T,A

The SA shall withstand the UV environment on the specified orbit, without degradation larger than considered in the power analysis

7.3.9 Deployment loads

SA-222 / A

The deployment loads at solar array interfaces with the SL structure shall be lower than the values given here after at qualification level within SA axes (X width in stowed SA plane, Y out of SA plane, Z length in stowed SA plane):

At each hinge interface:

• $M_x = 27 \text{ Nm}$

At each upper hold down bracket interface:

• 1000 N along the SA stiffner direction

• $M_x = 30 \text{ Nm}$

• $M_y = 6 \text{ Nm}$

• $M_z = 16 \text{ Nm}$

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8. OPERATIONAL REQUIREMENTS

8.1 mission requirements

8.1.1 Ground Operation Phase

8.1.1.1 Storage

SA-27 / R

The Solar Array shall withstand without any degradation a ground storage duration of 5 years, when SA is assembled on the spacecraft.

Storage constraints (if any) shall be provided by the SA Supplier (on ground environmental conditions are given in Section 7.1).

8.1.1.2 AIT operations at system level

SA-230 / T

The following nominal operations will be applied on the Solar Array at Satellite level:

- Solar Array first delivery to prime site for satellite system tests
- SA integration on Satellite
- SA manual deployment
- SA electrical check
- SA performance reference test
- SA actuation device release and deployment (DSAP after DSAP, hinge line vertical)
- Satellite acoustic and sine test
- Satellite clampband separation test
- SA actuation device release and deployment (DSAP after DSAP, hinge line vertical)
- SA storage till launch campaign

8.1.2 Launch and Early Orbit Phase

8.1.2.1 Launch

SA-233 / T,A

During launch, the Solar Array shall withstand without any performance degradation all the environmental conditions specified in Section 7.2

8.1.2.2 Deployment duration

SA-235 / T,A

Release and deployment time duration will be less than 10 minutes per DSAP.
8.1.3 In-orbit phase

8.1.3.1 Operational lifetime

SA-238 / R

The Solar Array shall be compatible with a life time of 7 years in orbit as specified in [AD01] GDI-137. Environmental conditions are described in Section 7.3.

SA-424 / A

The impact of the design shall be analyzed for a 10 years in-orbit life time as an option.

For a 10 years life time mission:

- a 140% pro rata ratio shall be applied on the radiation total doses (both ionizing and non- ionizing) as defined in the radiation environment [AD01] section 4.4
- UV and micrometeorites degradation factor of 0.975 shall be considered in Table 5.2-1

8.1.3.2 Orbit characteristics

SA-240 / R

The Solar Array shall be designed for the following orbits:

- Altitude : 500 km to 800km
- Orbit inclination angle: from 45° to 98.17°

8.1.4 Life cycle analysis

SA-242 / T,A

A life cycle analysis of all the different ground and in orbit mission steps must be performed at solar array level (including sub system and system activities). From this analysis the environments and the number of operations for each subassemblies will be determined, this will allow to establish and justify their qualification test plan.

8.2 Reliability and availability

8.2.1 Reliability

SA-245 / A

The Solar Array shall be deployed into nominal position with a reliability better than 0.995 (taking into account the safety design factor).

The Solar Array shall provide the required power at EOL with a reliability better than 0.995.

8.2.2 Failure tolerance

8.2.3 Failure propagation

SA-248 / A,R

The SA shall be designed to avoid any failure propagation:

- at external interfaces
- and internally between sections, between strings, between DSAPs.
8.2.4 Single Point Failure (SPF)

SA-250 / A,R

No single failure shall lead to power degradation with respect to the power requirement figure at EOL as specified in SA-70.

SA-251 / A,R

No single failure shall lead to the complete loss of one electrical section.

SA-252 / A,R

No single failure within SA shall lead to a short circuit between:

• positive and return power lines
• positive and panel structure

8.3 Safety

SA-254 / R

The SA shall be designed in order to avoid any safety hazard (personal exposure)

8.4 Pressure and venting

SA-256 / R

Refer to [AD01] § 3.1.4.

8.5 Identification & Marking

SA-258 /

Refer to [AD01] § 3.1.6.

8.6 Delivery configuration

SA-260 /

Refer to [AD01] § 3.1.8
9. VERIFICATION REQUIREMENTS

9.1 Verification matrix

SA-263 / T

Tests shall be performed according to Table 9.1-1 to Table 9.1-5. For Table 9.1-5, all the tests qualification shall be applied on the first equipped DSAP (QUAL) and acceptance on the other 2 DSAPs.

All the tests plans for qualification and acceptance shall be submitted to prime approval. Tests success criteria must be justified.

<table>
<thead>
<tr>
<th>DVT COUPON</th>
<th>QUAL.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full visual inspection (1)</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical health check (1)</td>
<td>Yes</td>
</tr>
<tr>
<td>Performance measurement (1)</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrodynamic Characteristics</td>
<td>Yes</td>
</tr>
<tr>
<td>Temperature cycling life test</td>
<td>Yes</td>
</tr>
<tr>
<td>Thermal vacuum cycling (before and after life test)</td>
<td>5 cycles</td>
</tr>
<tr>
<td>ESD test</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 9.1-1: DVT coupon tests

<table>
<thead>
<tr>
<th>HOLD DOWN &amp; RELEASE MECHANISM</th>
<th>QUAL (2)</th>
<th>ACCEPTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass measurement</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Visual inspection</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Functional dimensions measurement</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Functional performances at ambient</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Functional performances in thermal hot/cold vacuum</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Sine and random vibration test</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Life test</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Ultimate strength test</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Long duration storage in stowed configuration</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Induced shock at hold down interface during release</td>
<td>yes</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

Table 9.1-2: Hold Down and release mechanism tests
### Table 9.1-3: Deployment and stiffening mechanisms tests

<table>
<thead>
<tr>
<th>PVA EQUIPPED PANEL</th>
<th>QUAL</th>
<th>ACCEPTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass measurement</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Dimensional check</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Visual inspection (1)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Electrical health check (1) (continuity, insulation, grounding ..)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Performance measurement (1) (flasher)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Electrodynamic characteristics</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Thermal vacuum cycling</td>
<td>10 cycles</td>
<td>3 cycles or 10 cycles (option to be selected by Customer)</td>
</tr>
<tr>
<td>Thermal cycling at ambient pressure</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Acoustic test</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>DSAP</td>
<td>QUAL</td>
<td>ACCEPTANCE</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>Mass measurement</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>COG</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Dimensional check</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Visual inspection (1)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Electrical health check (1)</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Performance measurement (1): electrical and mechanical</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Release &amp; deployment test</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Motorisation margin test</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Alignment &amp; stiffness</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Sine vibration</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Acoustic test</td>
<td>yes</td>
<td>N.A.</td>
</tr>
<tr>
<td>Shock test</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Thermal Vacuum cycling</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Release &amp; deployment tests</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Release and deployment test (with measurement of induced shock at hold down interface if not performed at subassembly level or not known by similarity)</td>
<td>yes</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

Table 9.1-5: DSAP tests

(1) To be performed before and after each environmental testing

(2) Qualification can be demonstrated by test to be performed, or by similarity with available qualification test results (similarity to be justified).

SA-270 / T

Tests at satellite level after SA first delivery are in SA-230.

SA-271 / T

Static and stiffness tests will be done on panel structures for qualification and acceptance

SA-272 / T

All the resistive torque for deployment (as hinge harness loops) will be characterised at least during qualification, in ambient conditions, extreme temperature and after ageing. If the harness loops are identical to specimen already measured for others programs, those results can be directly used, but similarity shall be justified by Contractor and approved by Prime.
SA-273 / T

Qualification tests, Verification of qualification and acceptance tests on bare cells and Solar Cell Assemblies (SCAs), full PVA, will be done following the rules of [RD01].

Special attention will be attached to perform UV test representative of the in orbit life duration (especially on cover glass anti reflection coating) and to perform accelerated ageing tests (humidity temperature) representative of the on ground life duration.

SA-397 / T,R

The qualification of by-pass diodes shall take into account the recommendations of European working group on diodes referenced DSSA&L R 2006 006 (08/09/06)

9.2 Generic verification requirements

SA-275 /

Refer to [AD01] sections 5.

9.3 Specific verification requirements

SA-277 / T,A

Deployment test

The SA shall be compatible with deployment under gravity (gravity along Zsl direction or along Xsw).

If a deployment rig is needed in that aim, this GSE shall be provided by the SA Supplier.

SA-278 / T

Coupon cycling test

The DVT coupon cycling test shall be performed between extreme qualification temperatures.

54 000 cycles shall be performed (number of eclipses during life time).

The coupon shall be representative of the different panel substrate technologies (including the worst cases inhomogeneous areas and repair technologies) and of all the PVA technologies (including the different repair technologies) : refer to [RD01]

Test plan with definition of the thermal cycles covering in-orbit life with enough margin shall be justified by the Contractor and submitted to Prime approval.

SA-279 / T

Electrical performance measurement (flasher):

Electrical performance measurement (so called flasher test) of each solar array section will be done with a Large Area Sun Simulator: the light source will have an intensity equivalent to solar constant at AMO (1367 W/m²) , uniform on all the solar array section surface and with a wavelength spectrum adapted to the solar cell spectral response.

Before section performance measurement, solar simulator light source intensity shall be calibrated with secondary standard cells (cells of the same type as the solar array cells). For TJ cells, flasher calibration shall be done with 3 isotypes standard cells (each of them representative of the top junction, the middle junction and the bottom junction of the TJ cell) and checked with a complete standard TJ cell. Those secondary standard cells shall have been themselves previously calibrated from a primary standard cell (cell of the same type as the solar array cells whose performances have been measured in actual sun illumination during a balloon flight).

Uniformity of the sun simulator light intensity on the surface of the solar array section will be checked before solar array sections flasher test.
Calibration of the secondary standard cells with respect to the primary standard cell will be checked periodically (typically each year).

Global accuracy of the solar array section performance measurement with sun simulator shall be +/- 2%.

During the test the I / V characteristic of each section will be recorded at room temperature.

The acceptance criteria (I > TBD Amp at V test around the max power point) will be justified in the power analysis, it will correspond to the BOL, room temperature, nominal loss factors, predicted performance of the section at section connector interface.
10. MATHEMATICAL MODEL REQUIREMENTS

10.1 Mechanical model

SA-282 / A

DSAP Finite Element Model shall be provided in both stowed and deployed configuration.

SA-283 / A

Each model shall be a NASTRAN physical model and shall comply with FEM Requirement Specification [AD05].

SA-284 / A

In deployed configuration, effective mass and inertia of each mode shall be provided with phase sign.

10.2 Thermal model

SA-286 / A

The SA Supplier shall use a detailed model in both stowed and deployed configuration for SA thermal analyses.

SA-287 / A

A reduced thermal model in both stowed and deployed configuration shall be delivered. This model shall be a THERMICA/ESATAN model and shall comply with Thermal Model Requirement Specification [AD 06].

10.3 Electrical model

SA-289 / A

The electrical equivalent model of the Solar Array shall be provided; this model consists in providing the inputs necessary to modelize the SA at system level: full cell data set, thermo optical and thermal parameters, capacitance, inductance …
11. PRODUCT ASSURANCE REQUIREMENTS

Refer to [AD02]
12. ANNEX 1 : MECHANICAL INTERFACE REQUIREMENT
Stowed and deployed (DT0375955 Issue 05) given in AD09
13. ANNEX 2: SATELLITE POINTING IN NORMAL MODE AND IN SAFE MODE

The satellite pointing presented in the annex 2 considers a sun synchronous mission. For others mission type, the satellite pointing is specified in SA specific specification.

13.1 Normal mode

The satellite pointing in normal mode is shown in Figure 13.1-1.

- Satellite attitude during day:
  - Sun pointing outside imaging period: SA normal to sun direction with -Z axis towards the sun and with -Y axis towards the Angular Momentum axis (ie normal to orbital plane).
  - Imaging period:
    - Geocentric +Z axis towards the earth and +X axis along the orbital linear speed with de-pointing of SA up to 50° worst case (20° average) with respect to geocentric
    - Imaging period duration: 0 to 32 minutes per orbit between 80°N and 80°S latitudes

- Satellite attitude during eclipse
  - Geocentric: +Z axis towards the earth and +X axis along the orbital linear speed

![Satellite Pointing During Normal Mode](image)
13.2 Acquisition and Safe Hold (ASH) mode

During the first 3 orbits, the satellite pointing is undefined.

The satellite pointing in converged safe mode (ie after the first three orbits) is as follow:

![Diagram showing satellite pointing during safe mode](image)

**Figure 13.2-1: Satellite pointing during safe mode**
### CHANGE LOG

**Note:**

This log is autogenerated from Doors. Special symbols may not be rendered correctly and hence the main body of the document shall always take precedence for requirements. Thus it should only be used as a guide to the modifications in the document and not as a substitute.

**Modified Objects**

In the following table modifications to the Object Text attribute are shown using red line markup. For other attributes the new value and the old value are shown in separate columns.

The codes used in the object type (OT) column are: Rq = Requirement, Inf = Information, Hd = Heading, TC = Table Cell, Ah = Applicability Matrix Heading, Ar = Applicability Matrix Requirement

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<td>Object Text</td>
<td>Rq</td>
<td>Interface connector shall be of type 38999 series 3, reference 340 105 601 B06-19-32-SN-L. This connector shall be movable connected on flying leads coming from SA (length of flying leads shall be agreed with Prime). This connector shall be connected and locked to a fix connector located on the satellite. <strong>Master key position and shell elbow orientation are given in figure 6.3-3.</strong> Double insulation of harness against connector backshell is mandatory.</td>
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<tr>
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<td>OLE</td>
<td>Inf</td>
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<td>Rq</td>
<td>Power supply The deployment actuators shall be compatible with [AD01] § 3.5.4.14. Independent commands (prime and redundant) will be provided to each holddown point. Commands will be sent sequentially. The supply voltage will be 19.5V ±0.5V/+0.5V at power supply/actuator output/interface for a 60 sec -0/+5 sec pulse. The maximum actuator current is limited to 1.5Amps including in-rush current.</td>
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<td>SA-198</td>
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<td>Thermal control analyses of the solar array shall take into account the thermal flux under fairing and the aerothermal flux after fairing jettison: -at fairing jettison: <strong>decreasing linear decrease of</strong> aerothermal flux from 1135W/m² to 0W/m² in 1520 sec from 1150sec to 1850sec after fairing jettison, varying flux up to 600W/m² according to Table hereafter. <strong>Worst case attitude of SA wrt aerothermal</strong> flux shall be considered along <strong>launcher</strong> speed direction axis (Zsat axis). **Worst case attitude of S/A wrt Solar flux, Earth IR flux and Earth albedo shall be considered at the same time on the SA , they shall be added to the aerothermal flux in a realistic way. The necessary If protection means are necessary they shall be identified and justified for use on mission specific basis if requested.</td>
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### Inserted Objects

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### Deleted Objects

SA-500 section 7.2.5 : Information

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