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Space systems — Spacecraft-to-launch-vehicle interface control document

Systèmes spatiaux — Document de contrôle des interfaces entre le véhicule spatial et le lanceur spatial

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15863 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard defines the basic rules for writing an interface control document (ICD) between spacecraft (SC) and launch vehicle (LV) organizations. The necessity of writing this International Standard was expressed by the communication spacecraft community, which is faced with an increasing number of launch vehicle agencies, with the objective of reducing workload and costs.

The application of this International Standard will permit to control the compatibility of SC with various LV systems reducing thereby the risk of discovering incompatibilities late in the launch-preparation process.

LV and SC organizations may include additional topics if required. Some sections of this International Standard may refer to elements that are not applicable to the LV, SC or launch range characteristics, in which case they should be ignored. For most items, except when specified, the information can be provided in SC or LV drawings and in tabular or narrative format with figures.

Space systems — Spacecraft-to-launch-vehicle interface control document

1 Scope

The purpose of this International Standard is to provide spacecraft (SC) and launch vehicle (LV) organizations with the general format for presenting the interface control document (ICD) that verifies and controls the compatibility between SC and LV for a dedicated mission. This International Standard addresses the definition of the mission, the compatibility of the SC with the LV environment, including all mechanical, electrical, radio frequency, and electromagnetic aspects related to SC to LV and SC to launch range interfaces, verification analyses and tests for the induced environment, and the necessary facilities and support for launch range operations.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14303, *Space systems — Launch-vehicle-to-spacecraft interfaces*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14303 apply.

3.2 Abbreviated terms

EMC electromagnetic compatibility

EIRP effective isotropically radiated power

ICD interface control document

LV launch vehicle

RF radio frequency

SC spacecraft

4 Applicable and reference documentation

4.1 Applicable documents

The list of documents that are contractually binding and require a waiver or a formal agreement for any modification shall be provided. This list shall include the applicable LV user's manual.

4.2 Reference documents

The list of documents that form the necessary database for the LV and the SC contractors in the course of the launch preparation shall be provided. Typically, the list shall include the documentation related to the various analyses and test programs specific to the mission.

4.3 Safety submission sheets

The list of safety submission sheets and corresponding current status shall be provided.

4.4 Waivers

The list of applicable waivers and corresponding current status shall be provided.

In case of conflict between the above-listed documentation and the ICD, the latter shall take precedence.

5 Spacecraft mission characteristics

5.1 General

This chapter of the ICD is optional. It is for reference and information only and does not establish interface definitions or requirements.

5.2 Mission description

The purpose of the SC mission and its orbital characteristics shall be described. An in-orbit view of the SC should be included. General aspects of the mission such as ground network, coverage zones and lifetime may be addressed.

5.3 Spacecraft description

5.3.1 Spacecraft bus description

The general characteristics of the SC bus including appendages shall be described. The following items may be addressed:

— platform type and heritage (if applicable);

— overall structure;

— fixed and deployable appendages;

— attitude and orbit control system.

5.3.2 Spacecraft payload description

The payload equipment and its purpose shall be described. The following items may be addressed:

— antennas and associated frequency bands;

— transmission characteristics;

— transponder type and number;

— electrical power.

6 Mechanical interfaces

6.1 General

This chapter of the ICD shall provide the specific characteristics and parameters that establish the mechanical interface between the SC and the LV. The information can be provided in SC or LV drawings and in tabular or narrative format with figures.

6.2 Mechanical configuration

The LV and SC reference axes and relative rotational orientation shall be described. Drawings of the SC and adapter assembly within the payload compartment, which show and define the location of all interface components, shall be provided.

6.3 Spacecraft fundamental frequencies

The minimum allowable SC fundamental frequencies in axial and lateral directions shall be specified.

6.4 Usable volume

Drawings that show the allowable usable volume within the payload compartment shall be provided. The usable volume is determined by the physical clearances that are based on the static clearances and dynamic deflections of the fairing and SC. Critical clearance information including detailed views of protrusion areas with associated dimensions shall be provided.

6.5 SC–LV adapter interface

6.5.1 General

All of the characteristics of the physical and geometric interface for both the SC and the LV shall be described.

6.5.2 Payload adapter description (optional)

The following general characteristics of the payload adapter shall be described:

- type;
- material;
- geometrical shape;
- diameter of upper and lower interface rings;
- mass properties of equipped adapter.

6.5.3 Interface ring characteristics

Drawings showing side sections of the LV and SC interface rings with detailed dimensions and tolerances shall be provided. The following characteristics shall be specified:

a) material;

b) Young's modulus;

c) coating:

— surfaces in contact,

— other surfaces;

d) roughness;

e) flatness/perpendicularity;

f) stiffness:

— applicable length,

— section area,

— inertia.

These requirements are also applicable to a bolted interface between the LV and the SC adapter when the SC provides the adapter.

6.5.4 Separation system characteristics

Drawings showing the separation-system actuator mechanism shall be provided. The following characteristics shall be specified:

— number;

— location;

— nominal stroke;

— reduced stroke;

— maximum force;

— energy per unit.

6.5.5 SC mating system description

6.5.5.1 General

The SC mating and release system shall be described, including system characteristics and material properties as listed below. When the SC contractor provides the adapter, the corresponding separation shock spectrum at the LV-SC interface plane shall be shown (see 10.2.7).

6.5.5.2 Clampband system

The following characteristics shall be specified:

a) coating:

— surface in contact with adapter and SC,

— other surfaces;

b) roughness;

c) tension:

   — ground or test configuration,

   — flight configuration.

6.5.5.3 Pyrotechnic bolts

The following characteristics shall be specified:

— number;

— location;

— diameter;

— length;

— mass (of separated hardware);

— pre-load.

6.5.6 Mating-system installation

The orientation of the mating system with respect to the adapter frame shall be defined.

6.6 Connectors and microswitches

The connector interface shall be defined. The following characteristics shall be considered:

a) supplier and part number;

b) quantity;

c) location and mechanical interface:

   — angular position,

   — radial position,

   — height from separation plane;

d) push-on and push-off loads;

e) energy released;

f) separation force;

g) keying index.

6.7 Purges and fluid-connection interface

The SC purge and fluid-connection interface shall be defined. The following characteristics shall be considered:

a) location and mechanical interface:

   — angular position,

   — radial position,

   — height from separation plane;

b) push-on and push-off loads;

c) energy released;

d) separation force.

6.8 Encapsulated SC access

6.8.1 SC-access requirements

SC items to be accessed and purpose of access needed shall be listed and referenced to the SC coordinate system.

6.8.2 Access configuration

Information that shows the location and configuration of the required SC physical access openings in the payload compartment shall be provided, including the following indications:

— payload compartment relevant dimensions;

— location of centre of door (s) referenced to the LV axes;

— dimensions of door(s).

7 Electrical interface

7.1 Umbilical wiring diagram

Detailed drawings of the SC-to-LV and SC-to-ground facilities wiring diagram shall be provided.

7.2 Umbilical connectors

Organizations responsible for providing connector elements shall be identified.

Umbilical connectors shall be described for both the LV and the SC sides. The distinction shall be made between SC servicing and SC pyrotechnic functions that are maintained on separate LV-SC connectors. Example figures of connectors shall be included.

Connector characteristics shall be defined as follows:

— supplier;

— part number;

— number of pins available to user;

— polarizing key orientation;

— insert clocking;

— location (see also 6.6);

— backshell shielding requirement;

— harness shielding requirement.

7.3 Umbilical wiring links

Umbilical links between the SC and the LV and between the SC and the electrical checkout equipment plugs shall be described with the following characteristic, for each connector and each connector pin:

- pin number;
- function(s);
- wire type;
- twisting and shielding;
- maximum voltage (in volts);
- maximum current (in amperes);
- end-to-end resistance (in ohms);
- line start;
- line end;
- maximum voltage at separation (if applicable);
- maximum current at separation (if applicable);
- signal type;
- signal frequency.

The LV contractor shall define and conduct verification tests of the end-to-end, line-to-ground and line-to-line isolation resistance.

7.4 Electrical commands dedicated to spacecraft

7.4.1 Pyrotechnic commands

The SC contractor shall provide a schematic of the SC electrical circuits related to pyrotechnic commands. Pyrotechnic commands shall be described with the following characteristics:

- command identification;
- number of redundant commands;
- time of command initiation;
- minimum time interval between commands (in milliseconds);
- pulse width (in milliseconds);
- voltage (in volts);
- minimum all-fire current (in amperes);
- maximum no-fire current (in amperes);

— output isolation (in ohms);
— wire gage;
— wire type;
— wire length from LV-SC interface;
— circuit connectors to pyrotechnic devices;
— initiator characteristics.

The LV contractor shall indicate possible constraints applicable to the SC circuitry, in particular:

a) SC wiring-isolation requirements;

b) safety-plug definition.

7.4.2 Dry-loop commands

Dry-loop commands shall be described with the following characteristics:

— command identification;
— number of redundant commands;
— time of command initiation (on ground or in flight);
— resistance ON/OFF (in ohms);
— maximum, minimum and nominal voltage (in volts);
— maximum current (in amperes);
— on-board circuit isolation;
— grounding requirements;
— LV and SC circuit configuration.

The LV contractor shall indicate possible constraints applicable to the SC circuitry, in particular:

a) SC circuit-protection requirements;

b) safety-plug definition.

7.4.3 Electrical commands

Electrical commands generated by the LV for the SC shall be described with the following characteristics:

— command identification;
— number of redundant commands;
— time of command initiation (on ground or in flight);
— minimum time interval between commands (in milliseconds);

- maximum, minimum and nominal output voltage (in volts);
- maximum current (in amperes);
- current profile characteristics;
- command duration;
- grounding requirements;
- circuit configuration.

The LV contractor shall indicate possible constraints applicable to the SC circuitry, in particular:

a) SC circuit-protection requirements;

b) SC wiring-isolation requirements;

c) safety-plug definition;

d) electromagnetic-compatibility requirements.

7.5 Separation-status transmission

The measurement used to confirm SC separation shall be specified.

7.6 In-flight telemetry

SC measurements transmitted via the LV telemetry system shall be characterized as follows:

- number of channels;
- type of measurement;
- transducer range;
- signal voltage;
- sampling rate;
- encoding format;
- source impedance (in ohms).

7.7 Power supply

The specification for electrical power provided by the LV to the SC, if required for pre-launch or flight phases, shall be defined as follows:

- voltage (in volts);
- current (in amperes);
- time of transfer;
- frequency;
- ripple noise.

The LV contractor shall indicate possible constraints applicable to the SC circuitry such as:

a) SC circuit-protection requirements;

b) SC wiring-isolation requirements;

c) electromagnetic-compatibility requirements.

7.8 Earth-potential continuity

The SC requirements in terms of electrical continuity with respect to the Earth potential shall be expressed as follows:

— location of reference point on SC;

— maximum resistance (in ohms) allowed between SC metallic elements and reference point;

— maximum resistance (in ohms) allowed for SC interface plane.

8 RF and electromagnetic interfaces

8.1 Characteristics of radio-electrical systems

8.1.1 LV radio-frequency characteristics

The description of the LV transmitter and receiver characteristics and of the ground-radar transponders shall include the following information for each unit:

a) unit designation;

b) function of unit;

c) frequency band;

d) carrier frequency;

e) bandwidth corresponding to attenuations of –3 dB and –60 dB;

f) carrier modulation:

  — type,

  — index;

g) carrier polarization;

h) transmitter power (EIRP): maximum value;

i) field strength of receiver antenna: maximum value;

j) antenna description:

  — location;

  — pattern and gain.

8.1.2 SC radio frequency characteristics

The description of the SC transmitter and receiver characteristics shall include the following information for each unit:

a) unit designation;

b) function of unit;

c) frequency band;

d) carrier frequency;

e) bandwidth corresponding to attenuations of –3 dB and –60 dB;

f) carrier modulation:

- type,
- index,
- bit rate,
- sub-carrier frequency;

g) carrier polarization;

h) receiver frequencies:

- local oscillator,
- first intermediate,
- second intermediate (if applicable);

i) transmitter power (EIRP): nominal and maximum values;

j) field strength of receiver antenna: minimum, nominal and maximum values;

k) antenna description:

- location (with reference to SC drawings);
- pattern and gain.

8.1.3 SC transmission plan

The SC contractor shall provide the SC transmission plan. The status (ON/OFF) of each unit described in 8.1.2 shall be defined for the following typical phases:

- before count-down sequence (number of hours to be determined);
- from the time of start of count-down sequence to a given time after SC separation, (number of seconds to be determined);
- in transfer orbit;
- on station.

The LV contractor shall provide the list of events to be considered and the corresponding timetable.

8.2 RF telemetry and command link

8.2.1 SC RF-link definition

The SC RF-link requirements shall be defined by the SC contractor with the following indications:

- number of sources and corresponding frequency bands;
- type of link requested (if several options are available);
- purpose of link;
- link destinations;
- events corresponding to link activation and timetable.

8.2.2 SC antenna coordinates

The location of SC antennae shall be described with the following indications for each antenna:

- identification;
- coordinates in the SC reference frame;
- field of view.

8.2.3 RF-link implementation

If RF links are assured via an RF-transparent window, the location of the window in the corresponding payload compartment shall be described by the following information:

- relative position of SC RF components;
- reference axes of SC and of LV payload compartment with relative angular position;
- location of LV RF window and corresponding coordinates;
- dimensions of LV RF window.

If RF links are assured via a passive standard repeater system, the location of the repeater in the corresponding payload compartment shall be described by the following information:

a) relative position of SC RF components;

b) reference axes of SC and of LV payload compartment with relative angular position;

c) location of LV repeater and corresponding coordinates.

8.2.4 RF-link budget

For SC data transmission using RF links during ground operations, the following link budget information shall be provided.

a) Telecommand:

   1) at SC test equipment output:

      - frequency of signal,
      - bandwidth,

   — output power (maximal, nominal, minimal),
   — modulation;

2) at SC omni antenna:
   — frequency of signal,
   — power density (maximal, nominal, minimal);

b) Telemetry:

1) at SC omni antenna:
   — frequency of signal,
   — bandwidth,
   — output power: EIRP (maximal, nominal, minimal);

2) at SC test equipment input:
   — frequency of signal,
   — power density (maximal, nominal, minimal).

8.2.5 Base-band signal characteristics

For SC data transmission using base-band links during ground operations, the following base-band signal characteristics shall be provided for the range system and the SC system:

a) Telecommand:

1) number of channels;

2) digital:
   — code,
   — bit rate;

3) analog:
   — modulation,
   — frequency;

4) acceptable input from electrical support equipment (level and offset);

5) adjustable output to SC (level and offset).

b) Telemetry:

1) number of channels;

2) digital:
   — code,
   — bit rate;

3) analog:

— modulation,

— frequency;

4) acceptable input from SC (level and offset);

5) adjustable output to electrical support equipment (level and offset).

9 Launch vehicle and spacecraft mission characteristics

9.1 SC input data for mission analyses

9.1.1 General

The SC contractor shall provide the input data defined in 9.1.2 to 9.1.5 for all SC configurations associated with operations conducted by the LV contractor.

9.1.2 Reference axes

The LV and SC reference axes used for mission analysis studies shall be consistent with the mechanical configuration described in 6.2.

9.1.3 Mass and inertia characteristics

If the SC configuration changes before it is separated from the LV (deployment of antenna for instance), the following data shall also be given for the alternative configuration.

— The mass of the SC with related tolerances shall be provided.

— The centre of gravity coordinates and related tolerances shall be given in a reference frame parallel to the SC reference frame with the origin located in the SC separation plane.

— Moments and products of inertia and related tolerances shall be provided with respect to a reference frame parallel to the SC reference frame with the origin located at the SC centre of gravity. Inertia ratios between the transverse moments of inertia and the longitudinal moment of inertia shall be indicated.

The products of inertia (P_{xy}, P_{yz}, P_{zx}) are defined as follows:

$$P_{xy} = \int_m xy \, \mathrm{d}m = -I_{xy}$$

$$P_{yz} = \int_m yz \, \mathrm{d}m = -I_{yz}$$

$$P_{xz} = \int_m xz \, \mathrm{d}m = -I_{xz}$$

where

x, y, z are the coordinates of the SC mass element expressed in the SC reference frame (translated at the SC centre of gravity);

dm is the SC mass element;

I_{xy}, I_{yz}, I_{xz} are the off-diagonal elements of the SC inertia matrix.

— The SC static and dynamic imbalances and resulting tolerances compared with the LV specifications shall be provided.

9.1.4 Sloshing masses

Sloshing fluid masses shall be described for each tank by means of the following parameters:

- type of tank (bladder, material, etc.);
- type of propellant;
- maximum volume of tank;
- filled volume with fluid-fill factor;
- mass of liquid;
- centre of gravity of wet tank in SC reference frame.

If the mass of propellants is a significant fraction of the total SC mass, the LV contractor may require a pendulum model of the sloshing masses for attitude-control analysis purposes.

For each tank, the pendulum model shall be defined for a 1-g and a low-g gravity environment as follows:

a) mass (corresponding to sloshing fraction);

b) length;

c) location of attachment point with respect to the tank;

d) first sloshing frequency (1-g model).

9.1.5 SC-mission constraints

All SC-mission characteristics that can affect the LV trajectory, the LV attitude or the sequence of flight events shall be indicated by the SC contractor, including but not limited to the following:

- maximum allowable aerothermal flux at fairing jettisoning;
- solar-aspect-angle constraint after fairing jettisoning;
- telemetry-data acquisition;
- limitations on angular accelerations or velocities;
- deployment of appendages before SC separation with related time sequence;
- use of inertial units before SC separation.

9.2 Trajectory and performance analysis

9.2.1 Sequence of flight events (optional)

The LV contractor shall describe the various key flight events and corresponding times. Flight events include flight-related LV commands before lift-off, the flight and separation of the various LV stages, and the payload(s) orientation and separation.

These data shall be derived and updated from the mission-analysis studies (see 9.2.2, 9.2.3 and 9.4.3).

9.2.2 Orbit

The target orbit derived from the mission-analysis studies shall be described with the following set of typical parameters:

— epoch: time of injection of the SC into target orbit;

— inclination, i, in degrees;

— altitude of perigee, H_p, in kilometres;

— altitude of apogee, H_a, in kilometres;

— argument of perigee, ω, in degrees;

— target longitude of descending node, Ω, with respect to the Greenwich meridian in degrees;

— target true anomaly, v, in degrees.

The above set of parameters is standard for elliptical orbits.

For circular orbits, the semi-major axis, a, and the eccentricity, e, are generally used as alternatives to perigee and apogee altitudes.

For escape orbits, the apogee altitude parameter, H_a, is replaced by the hyperbolic excess velocity squared, C_3, and the inclination by the declination of the departure asymptote.

For geostationary-transfer orbit or similar type of orbit, the equivalent true altitude at first apogee passage shall be indicated.

Any alternative set of orbit parameters can be provided upon agreement between the SC and LV contractors.

9.2.3 Injection accuracy

The LV injection accuracy resulting from the final mission-analysis studies shall be defined in terms of the orbital parameters as described in 9.2.2.

As minimal information, the standard deviations (1σ) of the orbital parameters shall be given as listed below. As an option, a covariance matrix of the same parameters may be provided:

— Δi, in degrees;

— ΔH_p, in kilometres;

— ΔH_a, in kilometres;

— $\Delta \omega$, in degrees;

— $\Delta \Omega$, in degrees.

The above set of parameters is standard for elliptical orbits.

For circular orbits, the semi-major axis, a, and the eccentricity, e, are generally used as an alternative to perigee and apogee altitudes as follows:

a) Δa, in kilometres;

b) $\Delta(e\sin\omega)$;

c) $\Delta(e\cos\omega)$.

For escape orbits, the apogee altitude parameter, H_a, is replaced by the hyperbolic excess velocity squared, C_3.

9.3 Launch windows

9.3.1 General

Launch windows shall be presented in tabular or graphical form in UT hours (universal time).

9.3.2 SC reference launch window (for multiple SC launches only)

The SC reference launch window shall be calculated by the SC contractor from the SC constraints (see 9.3.5) on the basis of a reference orbit associated with the standard dual launch window provided by the LV contractor.

The reference launch window shall be expressed in terms of a reference time and cover a period of one year.

NOTE The reference time is related to an orbital event such as the first perigee passage, for instance.

The LV contractor shall present the superimposition of the SC reference window and the LV standard window.

9.3.3 SC final launch window

The SC final daily launch window shall be calculated by the SC contractor on the basis of the SC constraints (see 9.3.5) with the actual orbit parameters (see 9.2.2). The final launch window is expressed in terms of lift-off time and covers the foreseen launch period.

9.3.4 Combined launch window (for multiple SC launches only)

The LV contractor shall present the superimposition of the SC contractor final launch window and the copassenger launch window.

9.3.5 Launch-window operational constraints (for multiple launches only)

The SC contractor shall describe the various sub-systems and operational constraints that are taken into account in the calculation of the SC launch window, including but not limited to the following:

a) solar aspect angle (SAA) with respect to one or two SC reference axes:

 — in the separation attitude,

 — in the apogee boost motor (ABM) firing attitude;

b) SAA with respect to sun sensors during Earth-acquisition manœuvres and ABM firing;

c) sun-eclipse duration in transfer orbit;

d) moon-eclipse or interference of the moon with Earth sensors;

e) ground-station visibility and aspect angle (when the trajectory ground track depends on the launch time).

9.3.6 LV launch window

The LV shall specify the maximum LV launch window duration.

9.4 SC pointing and separation

9.4.1 Spin velocity

For a spinning SC, the spin requirement shall be defined as follows:

— spin velocity (revolutions per minute) and tolerance;

— spin axis with respect to the SC reference frame;

— spin direction (to be clearly shown in a figure).

9.4.2 SC attitude at separation

The LV contractor shall define an orbital reference frame so that required SC orientations at separation can be specified. The orbital frame orientation may be fixed with respect to the orbit plane or linked to the SC orbital position.

The SC contractor shall define the SC orientation just prior to separation in the following terms;

a) spinning SC:

- components of the SC spin axis in the orbital reference frame;
- acceptable tolerance on the SC spin axis orientation;

b) triaxially stabilized SC:

- components of the SC axes in the orbital reference frame;
- acceptable tolerances on the orientation of the SC axes;
- acceptable tolerances on the residual transverse velocities.

When the SC separation attitude depends on the solar aspect, the corresponding constraints shall be expressed in the SC reference frame in such a way that the required attitude can be determined without ambiguity in the orbital reference frame as a function of the solar direction components.

The LV contractor shall indicate possible restrictions to the above requirements due to the LV attitude control system characteristics.

9.4.3 Orientation performance

The SC kinematic conditions immediately after separation resulting from the final pointing, separation and spacing analyses shall be indicated and compared with the LV specifications by the LV contractor in terms of mean value and standard deviation of the following parameters:

a) spinning SC:

- spin velocity;
- transverse angular velocities;
- depointing of the SC angular momentum vector;
- relative separation velocity between SC and LV;

b) triaxially stabilized SC:

- transverse angular velocities;
- depointing of all 3 SC axes;
- relative separation velocity between SC and LV.

10 Verification analyses for induced environment

10.1 General

The results of the analyses of the final verification shall be stated either explicitly, or by reference to applicable documents, in order to assess the compatibility between the LV and the SC for the induced environment. A verification matrix may be used for this purpose.

10.2 Mechanical environment

10.2.1 Static acceleration

The static acceleration profile related to the LV flight shall be obtained from the trajectory analysis as described in 9.2.

10.2.2 Quasi-static loads

A synthesis of static and dynamic flight loads calculated at the SC centre of gravity shall be provided on the basis of the dynamic coupled load analysis (processed with a test-verified SC model).

10.2.3 Low-frequency longitudinal vibration

The envelope of all longitudinal sine and transient vibrations at the SC base shall be provided in terms of equivalent longitudinal sinusoidal vibrations over the frequency range of interest.

10.2.4 Low-frequency lateral vibration

The envelope of all lateral sine and transient vibrations at the SC base shall be provided in terms of equivalent lateral sinusoidal vibrations over the frequency range of interest.

10.2.5 Random vibrations

The envelope spectrum of the flight-level random vibrations in the longitudinal and lateral directions shall be provided.

10.2.6 Acoustic noise

The flight-level noise spectrum under the payload compartment shall be provided in terms of octaves or third of octaves.

10.2.7 Shock

The envelope shock spectrum generated by the LV at the LV-SC interface plane shall be provided.

When the SC provides the adapter, the SC contractor shall provide the envelope shock spectrum generated by the SC separation system at the LV-SC interface plane.

10.2.8 Critical clearances

If applicable, the results of the dynamic-clearance analysis of the SC critical points protruding outside the payload usable volume (see 6.4) shall be provided.

10.3 Thermal environment

10.3.1 General

The detailed SC thermal environment related to the ground and flight phases shall be described in the LV-SC final verification coupled thermal analysis.

10.3.2 Air conditioning

A drawing showing the SC inside the payload compartment with a representation of the airflow path may be provided. The following payload-compartment air-conditioning parameters shall be indicated for the various operation phases:

- inlet temperature;
- outlet temperature (optional);
- relative humidity;
- filtration;
- air flow rate;
- air velocity;
- cleanliness.

10.3.3 Aerothermal flux

The maximum aerothermal flux value shall be provided for the fairing-jettisoning event and, if applicable, for any other high-flux flight event, with the corresponding phase duration.

10.4 Static pressure

The time history of the static pressure inside the payload compartment during the flight shall be provided.

10.5 Contamination and cleanliness

If applicable, the results of the contamination and cleanliness analysis conducted by the LV contractor shall be provided.

The SC contractor shall provide a list of the SC materials outgassing characteristics.

10.6 RF and electromagnetic environment

10.6.1 LV-generated radiation

The LV contractor shall describe the radiation emitted at a specified LV station by the LV transmitters in terms of electrical field as a function of radio-frequency bands.

10.6.2 SC-generated radiation

The SC contractor shall describe the radiation emitted at a specified SC station by the SC transmitters in terms of electrical field as a function of radio-frequency bands.

10.6.3 Range-generated radiation

The LV contractor shall describe the range electromagnetic environment including telemetry, telecommand and radar transponders.

10.7 Overall compatibility

A conclusion on the compatibility between the LV and the SC with respect to the induced environment shall be formulated on the basis of the results presented in 10.1 to 10.6.

11 Verification tests

11.1 General

Concise information showing the compliance of the SC test results with the corresponding LV requirements shall be provided either explicitly or by reference to applicable documents. A verification matrix may be used for this purpose.

11.2 SC mechanical-environment qualification and acceptance tests

11.2.1 General

The SC contractor shall briefly describe the test philosophy adopted in order to verify the compliance of the SC design with the LV environment requirements as defined in the LV user's manual.

The distinction shall be made between structural model (SM) used for qualification purpose, protoflight model (PFM) used for qualification and flight, and flight model (FM) submitted to acceptance tests only.

The list of tests applicable to the SC shall be indicated considering the following series of possible tests:

- static load;
- modal survey;
- sinusoidal vibration;
- acoustic noise;
- random vibration;
- separation shock.

For each type of test in 11.2.2 to 11.2.7, the test article and the test configuration shall be described briefly, with the distinction between flight, flight-type and simulated hardware. The time and place of test, the test requirements and related conclusions shall be indicated.

11.2.2 Static load test

The maximum longitudinal and lateral loads shall be provided for the envelope test cases in comparison with the quasi-static loads of the LV user's manual.

11.2.3 Modal survey test

The test results for the major SC structural modes shall be compared with the SC dynamic model data.

11.2.4 Sinusoidal vibration test

The SC unnotched base input profile shall be described and compared with the LV-required levels. Preliminary notch parameters shall be agreed between the LV and the SC contractors on the basis of the SC design loads and LV-SC dynamic-coupled load-analysis results. Final notch parameters shall be established during testing.

11.2.5 Acoustic noise

The SC acoustic input levels shall be described and compared with the LV-required levels.

11.2.6 Random vibrations

The SC random vibration input levels shall be described and compared with the LV-required levels.

11.2.7 Separation shock test

The type of test and corresponding input spectrum shall be described and compared with the LV requirements.

11.3 LV-SC compatibility tests

The list of tests applicable to the SC shall be indicated considering the following series of possible tests:

— match-mate;

— separation;

— umbilical connector pull-out;

— clearance measurement;

— EMC;

— end-to-end electrical;

— RF link.

12 Launch range operations — Facilities and support

12.1 Range capabilities

12.1.1 General

The LV contractor shall provide to the SC contractor a detailed documentation describing the overall facilities and support available for launch range operations. Only items specific to the SC launch campaign shall be mentioned in this section of the ICD.

12.1.2 SC preparation facility

The LV contractor shall describe the facilities and equipment provided for processing the SC, including specific additional requirements from the SC contractor.