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SPACE SYSTEMS LORAL

3825 Fabian Way
Palo Alto, CA 94303-4604
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Document No. E237665
Revision 6

GENERIC ENVIRONMENTAL REQUIREMENTS SPECIFICATION

The Generic Environmental Requirements Specification E237665 Revision 6 is not export controlled.

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PROGRAM

MULTIPLE PROGRAMS

Following Approvals Controlled By PDM System

Function	Approver Name	Approved
SYS. ENG. ELEC.	Lyon R	12/12/2008
SYS SPACE ENV	Krieg J	12/12/2008
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SYS. ENG. MECH.	Turner S	08/31/2009
SYS SPACE ENV	Watkins B	09/03/2009
SPEC. ENGR.	Shanney R	09/03/2009
SPEC RELEASE	Sobayo L	09/03/2009
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See additional signatures on Page 2.

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PROGRAM MULTIPLE PROGRAMS	
VICE PRESIDENT, PRODUCT ASSURANCE L. Wray	VICE PRESIDENT, MISSION ASSURANCE & CHIEF ENGINEER R. McFarland R. McFarland
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See additional signatures on Page 1.

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CHANGE RECORD

REVISION	AUTHORIZATION	REASON FOR CHANGE	AFFECTED PAGES
1 06/29/03		Initial Release	
2 06/10/02		Incorporated redline updates	Multi
3 09/11/03		Incorporation of E039314, Rev. 9 and E237665, Rev. 2	Multi
4 12/16/04	EC0063552	Incorporated redline updates	Multi
5 04/06/07	EC0080819	1. Replace Figures 4.1-2 Waveguide Flanges with Table 4.1-I Waveguide Flange Dimensions 2. Remove Heritage Radiation (15 year) (text, Figure 3.2-1, and Table 3.2-IX) 3. Update shock requirements including Tables 3.4.3-III. 4. Incorporate Land Launch 5. Include Table 3.4.3-IX Generic Bus Equipment Shock Level Capability 6. Add Plasma induced damage on redundant unit 7. Updated some EMI requirement 8. For dynamic load /environments, added explicit 3-axis requirement, low-level sine survey, functional test and monitoring, and S/C to be in flight like config. 9. Added thermal model requirement 10. Added Compatibility tests in 3.3.8. 11. Remove pulse command signal type (obsolete)	
Rev. 6	EC0105283	Incorporated redline updates Unit Interface Design Requirements and Interface Control Drawing requirements removed and placed into E399000 Thermal Tables (3.5-I) and notes updated (04/03/09) Add Heritage Radiation (18 year) text, Figure 3.2-1, and Table 3.2-IX	

A vertical line in the margin indicates change in this issue.

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1. SCOPE

This document contains the Generic Environmental Requirements for SS/L program components, subsystems, and satellites. The requirements are generic in that they contain the bounded worst case environmental limits. Specific program environmental requirements can be found in the program Environmental Requirement Specification Addendum. This document shall be used in conjunction with the requirements of the Satellite Performance Specification, and the Satellite Program Test Plan, during the design, development, and testing of the equipment.

1.1 General

a. This specification provides the general requirements for the design, development, and performance for units and satellite subsystems. This specification applies to the 1300 series Omega spacecraft.

b. In the event of conflict between the requirements of documents listed in APPLICABLE DOCUMENTS (section 2) and the requirements of this specification, the requirements of this specification shall be considered a superseding requirement.

c. The applicable Product Assurance Requirements for SS/L built equipment is the Mission Assurance Plan E339761.

d. The applicable product assurance requirements for SS/L subcontracted equipment is the Subcontractor Mission Assurance Requirements which is specified by the satellite contract or equipment subcontract statements of work.

1.2 Definitions

Space Systems/LORAL: Where the term "SS/L" is used herein, it shall mean Space Systems/LORAL, Palo Alto, California 94303-4604.

Subcontractor, Vendor, or Supplier: The terms "Subcontractor," "Vendor," or "Supplier" shall mean the industrial organization awarded the procurement agreement of which this specification forms a part.

2. APPLICABLE DOCUMENTS

2.1 US Government Documents

The following documents, of latest issue, form a part of this specification to the extent specified herein.

STANDARDS

MIL-STD-461	Electromagnetic Emission and Susceptibility Requirements for the control of Electromagnetic Interference
MIL-STD-462	Measurement of Electromagnetic Interference Characteristics
MIL-STD-464	Electromagnetic Environmental Effects Requirements for Systems (Ref)
MIL-STD-883E(4)	Test Method, Standard Microcircuits
MIL-STD-889B	Dissimilar Metals
MIL-STD-1541A	Electromagnetic Compatibility Requirements for Space Systems
FED-STD-209	Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones
NASA-HDBK-4002	Avoiding Problems Caused By Spacecraft On-Orbit Internal Charging Effects
NASA TP-2361	Design Guidelines for Assessing and Controlling Spacecraft Charging Effects

2.2 Non-Government Documents

The following documents, of latest issue, form a part of this specification to the extent specified herein.

SPACE SYSTEMS LORAL

SPECIFICATIONS/PLANS

a.	Various	Satellite Performance Specification (Ref)
b.	Various	Satellite Test Plan
c.	Various	Contract Exhibit
d.	Various	Satellite Statement of Work
e.	PP-E191555	EMI/EMC and ESD Design Guideline and Control Plan (SS/L Proprietary) (Ref)

2.2 Non-Government Documents (Continued)

SPECIFICATIONS/PLANS (Continued)

f.	Various	Program EMI/EMC and ESD Control Plan (Ref)
g.	Various	Program Launch Vehicle User's Guide (Atlas, Delta, Ariane, Sea Launch, Long March, H-II, Proton, Land Launch, etc.)
h.	Various	Program Environmental Requirements Specification (ERS) Addendum
i.	Various	Subcontractor Mission Assurance Requirements (see Section 1.1)
j.	PP-E339761	Mission Assurance Plan (SS/L-built equipment)
k.	SH-E399000	Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements
l.	MM-E135793	Serial Interface Adapter (SIA) User Application Specification (Ref)
m.	SE-E038227	Serial Interface Adapter Performance Specification
n.	SH-E023988	Data Requirements Instructions (DRI) for Spacecraft Subcontractors
o.	SH-E124981	Spacecraft Pyroshock Environment and Qualification Requirements
p.	SW-E135840	RF Payload Equipment Statement of Work
q.	Various	Satellite Transportation Plan
r.	SB-128796	Launch Vehicle Induced Shock Levels

PROCEDURES

PD-70	Product Qualification and Testing (for SS/L built equipment only)
QXXX Series	Quality Assurance Quality System (for SS/L built equipment only)

INDUSTRY STANDARDS

EIA RS485	Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems (Ref)

3. ENVIRONMENTAL REQUIREMENTS

3.1 General Requirements

Unless otherwise noted, the equipment shall be designed to meet the requirements of the applicable unit specification prior to exposure, during exposure (where applicable), and after exposure to the environments specified in this document. Environments experienced during equipment transportation and storage shall be controlled to be significantly less severe than the environments specified.

3.1.1 Coordinate System

a. The satellite coordinate system and sign convention that are referenced in this document are shown in Figure 3.1-1. These coordinate axes are defined as a right hand triad fixed in the satellite, with the origin at the center of the satellite separation plane.

b. When the satellite is in the operational configuration in orbit, the roll axis (X-axis) is nominally in the orbital plane in the direction of orbital motion with the positive direction being toward the East. The pitch axis (Y-axis) is nominally perpendicular to the orbit plane with the positive direction being toward the South. The yaw axis (Z-axis) is nominally in the orbit plane and points toward the center of the earth with its positive direction.

c. In the launch configuration, the Z-axis is longitudinal with the positive direction corresponding to the direction of ascent, and the X- and Y-axes are in the lateral directions.

d. For unit level specifications see E399000.

3.2 Radiation and Micrometeoroids

3.2.1 Radiation

The spacecraft and its components shall be designed to survive, with the addition of local shielding (as determined by a shielding analysis), a worst case geosynchronous trapped electron radiation, trapped proton radiation, solar flare proton, and cosmic ray environment for a mission life with margin as specified below. All equipment excluding the optical solar reflectors (OSRs) and the solar array shall be designed using the Radiation Environment defined in Tables 3.2-I to 3.2-VI and Figures 3.2-1 to 3.2-4. The radiation environment is based on the NASA AE8 and AP8 model. The OSRs and the solar array shall be designed using the electron and proton environments as defined in Tables 3.2-VII and 3.2-VIII. OSRs and solar arrays in general shall be designed for the mission lifetime (e.g., 15 years) as a minimum at the actual orbit location particle flux. Heritage equipment requires 18 year design life. Omega-3 and category A equipment require 22.5 year Geosynchronous Equatorial Orbit (GEO) at 160 °W orbit location or 18 year Highly Inclined Elliptical Orbit(HIEO) design life. General design and construction requirements are presented below.

A flowchart of the requirements required for the radiation evaluation is shown in Figure 3.2-5.

a. All materials used in the satellite and in satellite equipment shall be evaluated for radiation acceptability. If the equipment is an internal equipment (i.e., is located inside the satellite structure as defined in paragraph 3.2.1.d.1) or is protected by a supplemental enclosure that provides the same level of shielding as the satellite structure, material hardness evaluation shall be performed using a lifetime total dose of 10 megarads.

1. If all materials in the internal equipment design are insensitive to radiation at a total dose of less than 10 megarads in their equipment-specific application, then documentation of all materials and their associated hardness shall be made, and further materials evaluation is not required. If any material in the internal equipment is sensitive to radiation at a total dose of 10 megarads in its equipment-specific application, a more detailed radiation evaluation, including a shielding analysis, as described in paragraph 3.2.1.d, is required.

3.2.1 Radiation (Continued)

2. All materials used in equipment that are not protected by the satellite structure or a similar structure, i.e., external equipment, require a detail radiation evaluation, including a shielding analysis as described in paragraph 3.2.1.d.

b. Besides basic materials, all active parts in general should meet a minimum radiation hardness of 100 krads (Si). Parts that are softer than 100 krads (Si) may be used for certain applications, but require special approval by SS/L. The minimum allowable shielded radiation susceptibility level for active parts is 15 krads. If a part is sensitive to displacement effect, the degradation due to the displacement effect based on proton or neutron data is required.

c. Circuit designs and the worst case circuit analysis must account for changes in parts parameters caused by total dose effect and displacement damage. Piece part characterization tests are needed to verify the acceptability of the design if:

1. Analysis indicates that the use of a part in a particular application becomes marginal when radiation degradations are applied to the design.
2. There is no previous radiation test data.

Plans for an overall characterization test program and for individual tests must be approved by SS/L. In addition, the list of active piece parts to be used in the design must be reviewed by SS/L to determine if any additional characterization tests are to be required. All radiation testing shall consider bias conditions, temperature, dose rate, rebound effect, and annealing on-a-part by part basis.

3.2.1 Radiation (Continued)

Since the space environment represents a low dose rate environment, parts that are sensitive to low dose rate effects (e.g., bipolar linear integrated circuits) shall be characterized with radiation test data performed at a high dose rate and a low dose rate of 0.05 rads/s or lower to demonstrate the part's hardness in space. This characterization data shall be used to determine effective shielding requirements. Shielding shall be based on the more conservative set of test data; i.e., whichever set of data shows the largest data degradation.

d. The external radiation environment of the spacecraft is defined by the dose-depth curves in Figures 3.2-1 and 3.2-2, together with their tabulations in Tables 3.2-IX and 3.2-X respectively, and does not include shielding.

Equipment shall be designed using the appropriate dose-depth curve as listed above.

The Dose versus Thickness curve in Table 3.2-IX (3.2-X) labeled "SPHERE" represents a 4π solid sphere model, and should be used as the input "kernel" for all computerized ray-tracing evaluations; the curve labeled "GEO-SLAB" represents a 2π single slab model without backscatter, and represents the most optimistic case that cannot usually be achieved in most cases; the curve labeled "GEO AVE" represents a combination of the other two curves, and should be used as the basis for the shielding evaluation when computerized analyses are not available. The "SPHERE" curve should only be used if shielding analyses will be performed using a computerized ray tracing approach. Tables 3.2-IX and 3.2-X identify the data points shown in the Dose versus Thickness curves in Figures 3.2-1 and 3.2-2. Shielding Analysis of the components shall be done based on these curves and the minimum shielding effectiveness of spacecraft structures and piece part cases (i.e., semiconductor packages) as follows:

3.2.1 Radiation, (Continued)

1. All equipment located inside the spacecraft skin shall be analyzed as providing spacecraft shielding equivalent to 0.81 mm (32 mils) of aluminum on the mounting surface and 0.76 mm (30 mils) of aluminum on all other surfaces. In addition to radiation, the equipment chassis and cover thickness shall comply to deep charging requirement as stated in NASA-HDBK-4002.

2. Equipment located outside the spacecraft shall be analyzed as providing shielding equivalent to 1.62 mm (64 mils) of aluminum on the surface facing the spacecraft interior. Other mounting locations, such as the antenna tower, require actual shield thickness in the model.

3. The piece part case (i.e., the semiconductor package) shall be analyzed as providing shielding equivalent to 0.76 mm (30 mils) aluminum in all directions. If more detailed shielding models of specific piece part cases are available, they should be used in the shielding analysis.

4. Other materials may be substituted for aluminum as a wall or cover material; equivalent thickness of other materials can be determined using the equation given below.

$$t_m = t_{eq\_Al} \ (\rho_{Al} / \rho_m)$$

where

t_m = thickness of substitute material

t_{eq_Al} = equivalent thickness of Aluminum

ρ_{Al} = density of Aluminum

ρ_m = density of substitute material

3.2.2 Single Event Effects (SEE)

Single Event Effects includes Single Event Upset (SEU), Single Event Transient (SET), Single Event Latchup (SEL), Single Event Gate Rupture (SEGR), and Single Event Burnout (SEB). SEL, SEGR, and SEB are categorized as permanent damage effect.

3.2.2 Single Event Effects (SEE) (Continued)

The following are the specific requirements:

a. SEU, SET, and SEL shall be considered in the selection of parts and the overall design. All parts potentially susceptible to these effects, including but not limited to digital parts, linear integrated circuits (ICs), and pulse width modulators (PWM), shall be evaluated in their individual circuit applications to ensure compliance with requirements of this specification. Designs utilizing parts susceptible to SEU, SET, or SEL shall incorporate preventative procedures to minimize operational impacts (e.g., voting schemes, re-initialization, hardwired read-only memory (ROM) backups, limiting resistors, filters). Hardware shall be designed to be tolerant of single and multiple upsets. Demonstration of compliance with this requirement shall include a single event effects (SEE) analysis.

b. The following subsection does not apply to heritage items/units where SEE design and analysis has been completed, and the hardware has been flown:

SEE analysis requires the SEE rate be calculated in terms of a worst case cosmic ray environment and during an Anomalously Large (AL) flare. The worst case cosmic ray environment is defined in Figure 3.2-3. Figure 3.2-3 and the accompanying Table 3.2-XI provide a plot and tabulation of the Integral Cosmic Ray Flux (flux) particles/(m^2-ster-s) as a function of Linear Energy Transfer (LET) parameter of the cosmic ray particles. The requirement defined in Figure 3.2-3 is a worst case environment that will only be exceeded 10% of the time (nomenclature M = 3). The plot and table show the number of flux that will have a LET equal to or greater than a given value. The total fluence of particles for a given mission lifetime can be obtained by multiplying the flux in Figure 3.2-3 by the number of seconds of the mission lifetime. The solar flare environment associated with an anomalously large event (average flux in the worst case day) is defined in Figure 3.2-4. This figure defines a plot of the integral particle flux as a function of LET of Solar Flare particles in a large flare day. The plot shows the flux that will have an LET equal to or greater than a given value. The total fluence of particles for a solar flare event can be obtained by multiplying the flux in Figure 3.2-4 by 3.456×10^5 s (the number of seconds in 4 days, a typical duration of a solar flare event). A SEU rate report for an AL solar flare event is required in the SEE analysis report.

3.2.2 Single Event Effects (SEE) (Continued)

c. The SEE analysis shall include calculation of the failure rate due to SEE and the effect of upset/transient on the performance of the unit (each output/function in a unit). The analysis shall be based on heavy ion and proton tests done on unit parts. The calculated unit level upset rate will be flowed up to the system level for satellite upset rate assessment. The total unit level upset/transient rate requirement for the cosmic ray environment is not more than 1 in 300 years, unless the unit is heritage equipment or another value has been assigned in the unit specification. The unit level permanent SEE damage rate requirement is part of the unit's reliability requirement in Failures in Time (FIT). If the unit level upset/transient rate is greater than 1 in 300 years, the unit does not meet the requirement and a waiver request is needed. The waiver shall include the detailed SEE analysis on unit performance and a list of specific actions necessary to return the unit to pre-upset status. SEE rate can be calculated by standard SEE software (e.g., SpaceRad, CREME96, etc.). SEE rate for each output of the unit and the total unit SEE rate shall be performed and documented in the analysis. Updated SEE analysis shall be approved by SS/L Space Environments Engineering through the Subcontract Data Requirements List (SDRL) system.

d. The probability of a mission critical upset during an AL solar flare is important for the satellite. Any unit that is considered mission critical shall have an SEU rate less than 0.1 (i.e., 1 upset/10 flares) in an AL solar flare. Mission critical units shall be defined in the unit level specification.

e. The design must consider the effect of SEB and SEGR on the performance of power Metal Oxide Semiconductor Field Effect Transistors (MOSFETs). Power MOSFETs must be biased in a manner that precludes the possibility of failure due to SEB or SEGR.

3.2.3 Micrometeoroids

All equipment must consider the possible effect of micrometeoroids on the design; however, in most cases, a quick evaluation should indicate that the design is not susceptible to micrometeoroid damage. The following may be expected to have some micrometeoroid impact in the mission life:

- Optical Solar Reflectors (OSRs)
- Solar cells

The environments are defined in Tables 3.2-XII to 3.2-XIV. More recent meteoroid environment such as NASA TM4527 can also be used for analysis. Critical items shall include the probability of success (P_s) due to meteoroids in the reliability P_s allocation calculation.

3.3 EMI/EMC and ESD Requirements.

In addition to the applicable documents listed in Section 2.1, a satellite industry EMI/EMC control standard approved by SS/L Space Environments Department may be used in place of MIL-STD-1541.

3.3.1 Isolation.

At no time shall the spacecraft system impose more than 1.5 volts DC and 0.2 V_{p-p}, from 50 Hz to 150 kHz, between the primary return and secondary ground, or between any equipment secondary signal return and power return. Equipment must work in the presence of these voltage differentials.

1. For units using a Serial Interface Adapter (SIA), the equipment shall provide DC isolation from the primary power return to secondary power return of 10 kohms minimum. For non-SIA units, the isolation shall be 100 kohms minimum.
2. For units using an SIA, when not connected to the spacecraft harness the equipment shall have a minimum DC resistance of 10 kohms between primary power input leads and the equipment case. For non-SIA units, the isolation shall be 100 kohms.

3.3.1 Isolation (Continued)

3. Non-Radio Frequency (NON-RF) equipment that uses an SIA and generates or operates on frequencies equal to or less than 100 MHz shall have telemetry and command signal and secondary power circuits isolated from the primary power circuits by a minimum DC resistance of 10 kohms when not connected to the spacecraft harness. Telemetry and Command signals that are intended to interface between spacecraft equipment through the spacecraft harness shall have their return signals isolated from secondary power return by a minimum of 1.0 kohm.

4. Radio Frequency (RF) equipment that generates or operates on frequencies greater than 30 MHz may have secondary power supply return connected to the equipment case, but shall be isolated from the primary power returns by a minimum DC resistance. Telemetry and command signal returns may be connected to the equipment case with approval by SS/L Systems Engineering, but shall be isolated from the primary power returns by a minimum DC resistance (100 kohms). SIA units shall have a minimum DC resistance of 10 kohms. Non-SIA units shall have a minimum DC resistance of 100 kohms.

5. To meet the EMC requirements, capacitive coupling between primary power input and equipment case is allowed. If capacitive coupling, is used, the value shall be determined by analysis. The capacitor shall be able to tolerate both positive and negative voltage excursions.

6. Isolation between transformer windings shall be greater than one Mohm.

3.3.1.1 Chassis Isolation.

The resistance between the unit primary DC power return and unit external chassis shall be 100 kohms minimum.

3.3.1.2 Interface Isolation.

The resistance between the unit DC power return and any other electrical connection, including unit external chassis (except on-off command) shall be 100 kohms minimum.

3.3.2 Shielding, Bonding and Grounding Requirements

a.In order to insure that the spacecraft meets the on orbit environmental requirements the following shielding, bonding, and grounding design requirements shall be applied. Passive Intermodulation (PIM) requirement shall also be considered in conjunction with this requirement. The Program ERS addendum will specify the unique PIM/bonding/grounding requirement if applicable.

b. Each power bus shall be connected to the spacecraft structure at a single point.

c. The 100V main power bus(es) and 31V low voltage bus(es) shall have their single point ground connected to the spacecraft structure by the Electrical Power Subsystem (EPS) at the location provided within the EPS.

d. All other secondary power busses (e.g., 5V, 9V, etc.) shall:

1. Meet the isolation requirements from the 100V main bus or 31V low voltage bus per section 3.3.1, Isolation.
2. Have a provision in the design for tying secondary outputs to the spacecraft chassis (e.g., spare connector pins, etc.).

e. All DC/DC converter secondary outputs dedicated to individual spacecraft components (e.g., EPC supplying 8V to the LCAMP) shall:

1. Meet the isolation requirements from the 100V main bus or 31V low voltage bus per section 3.3.1, Isolation.
2. Provide for a direct connection and circuit reference to the spacecraft chassis.

3.3.2.1 Structure

a. In order to minimize the effect of the charging environment, the satellite will be constructed as a Faraday cage.

b. All metallic/conductive elements of the structure and Faraday cage shall be electrically interconnected such that the resistance of any member to any other member shall be less than the values specified in Table 3.3-I. The joints of these structural members shall be fastened with conductive screws, bolts, or rivets. Where insulating materials prohibit effective electrical connection at a joint, the insulating material shall be bridged with a copper strap or wire such that the conductance across the joint is assured.

c. Specific satellite and equipment level bonding/grounding requirements are summarized in Table 3.3-I.

3.3.2.1 Structure (Continued)

d. As a general requirement, all harnesses that leave the basic Faraday cage (i.e., that pass outside the basic satellite structure) must either be 1) double shielded (so as to extend the Faraday cage beyond the basic vehicle structure) or 2) must pass through special ESD protection boxes located on the surface of the satellite.

e. All openings in the surface of the satellite (i.g., apertures) must be covered with grounded metal screen or foil to provide adequate ESD isolation. The Faraday cage, including grounded aperture screens and external harness shields, must provide E field shielding equivalent to the following:

Frequency	Minimum E field Shielding
f < 100 MHz	40 dB
100 MHz ≤ f < 1 GHz	30 dB
1 GHz ≤ f < 14 GHz	12 dB

3.3.2.1.1 Continuity Requirements on Panel

The elements of aluminum core structure within the panel shall be tied together as one conductive continuous element. Metallic heat pipes within aluminum panels shall be grounded to the internal surface of the aluminum panel or the honeycomb of the Graphite-Fiber-Reinforced (GFR) panel. Each panel shall be provided with a rivnut identified as the local panel ground (LPG). All rivnuts on non-metallic panels shall be adhesively secured to the GFR panel with conductive epoxy or alternate method approved by System Engineering.

3.3.2.1.2 Equipment Grounding/Bonding

a. All electronic components, whether internal or external to the spacecraft structure, shall be fully enclosed in metallic enclosures that comply with the emission and ESD requirements of this specification. Satellite components shall be directly connected to the spacecraft ground system with a resistance less than that specified in Table 3.3-I. Grounding straps are required for all electronic units with a recommended length to width ratio of five or less. All equipment ICDs shall have a point or area identified as the ground interface. Equipment ground straps shall be indicated on each panel layout drawing and ICD.

3.3.2.1.2 Equipment Grounding/Bonding (Continued)

b. The equipment shall comply with the requirements of the applicable Interface Control Drawing. Each mounting foot shall provide a conductive (as specified in Table 3.3-I Grounding Resistance Requirements) paint free contact surface area as defined in E399000 to permit bonding and grounding of the external equipment chassis to the spacecraft structure.

3.3.2.1.2.1 Cables, Wires, and Harnesses

All floating metal or conducting and semi-conducting parts of cables, wires, and harnesses on the spacecraft of dimension in excess of the requirements of NASA-HDBK-4002 shall have a resistive bleed path to ground for bleeding off accumulated charges deposited by the space environment. This includes parts/items inside units, and cables, wires, and harnesses (center conductors) that can be electrically isolated by the switching of a relay. The resistance value of the bleed path shall not exceed the values listed in Table 3.3-I, Grounding Resistance Requirements, except as allowed by NASA-HDBK-4002. The bleed path shall not affect the unit level performance.

The center conductors of spare or unused cables, wires, or harnesses exist shall be grounded at one end or tied to both ends of an adjacent circuit.

The shields of shielded cables, wires, or harnesses used internal to the spacecraft, shall be grounded at the source end or as approved by Systems Engineering.

The shields of shielded cables, wires, or harnesses external to the spacecraft shall be grounded at both ends in order to extend the satellite Faraday Cage.

The shields of high speed coaxial data links shall be grounded at both ends.

The shields of shielded cables on Electro-Explosive Devices (EEDs) shall be grounded at both ends.

Signal lines of units which are capacitively coupled are considered to be floating at the unit level and the unit level design shall provide a bleed path to ground.

To protect RF electronic units, all RF coax connections (including external test and flight switch in coax) and capacitively coupled connections shall incorporate a DC connection to ground.

3.3.2.1.2.1 Cables, Wires, and Harnesses (Continued)

Cables, wires, and harnesses that are electrically isolated by the switching of a relay must either be discharged immediately before each connection by an active method or be continually discharged by a passive attenuator.

In general, passive RF units are not susceptible to the low energy level ESD that can build up on a coax cable.

Units which cannot meet these requirements may be grounded by adding an Attenuator (or bleed path to ground) which meets this requirement in the circuit path. For implementation, the verification of bleed paths shall be stated in the specification compliance matrix and the Environmental Requirements Specification (ERS) compliance matrix.

3.3.2.1.2.2 Coaxial Cables

See Section 3.3.2.1.2.1.

3.3.2.1.2.3 Propulsion Equipment

The propulsion system shall constitute one electrically continuous metallic assembly. The assembly shall be grounded with a wire attachment to structure at each thruster.

3.3.2.1.2.4 RF Passive Equipment Grounding

Passive RF units such as filters, loads, switches, waveguide, Output Multiplexers (OMUXs), etc., are not required to have an independent ground strap if they are connected with waveguide or coax that provides a ground path through their outer conductor.

Metallic bracket, standoff, or other structural support items for RF units shall be individually grounded.

3.3.2.2 Non-Metallic Surfaces

Non-metallic elements within the spacecraft are capable of charging to very high potentials and these elements may then discharge causing upset or damage to sensitive circuits. NASA HDBK-4002 shall be used as a guide. Conductive path to ground for charge bleed-off shall be considered such as a conductive band, a conductive pad (attached typically with conductive epoxy over a roughened area), or an alternative method. All non-metallic charge bleed-off approaches shall be approved by SS/L's Space Environments Engineering. The bleed-off item (band, pad, or alternative method) shall be connected with a resistance of value specified in Table 3.3-I or less to the LPG (this does not have to be a direct connection but daisy chains of more than 2 items require a ground near each end).

To prevent electrostatic charging, insulating materials or finishes having a resistivity greater than 10^9 ohm-cm shall not be used without SS/L approval.

3.3.2.2.1 Grounding of Feed Aperture Covers

All feed aperture covers shall be grounded. If grounding of the aperture cover is not possible without degrading performance, a waiver analysis is required to justify no grounding or no feed aperture cover. All grounded feed aperture covers require a minimum of two grounding pathways. The two grounding pathways shall originate from two different areas of the cover.

3.3.2.3 Grounding of Isolated Parts

Isolated metal or non-metal conductive (graphite, etc.) parts shall be connected (has charge bleed path) to the nearest LPG. The measured resistance of the part to the LPG shall be less than the value specified in Table 3.3-I.

All conductive material internal to the satellite body shall comply to NASA-HDBK-4002.

3.3.2.4 Grounding Requirements External to the Spacecraft Body

All the grounding requirements of this section apply except that grounds shall be brought into the main faraday cage via an ESD protection box before connection to the nearest LPG. The grounds do not go through the transient protectors but are connected to the grounding point within the ESD box to isolate the ground currents to the cables outside the Spacecraft. All cables shall enter the Spacecraft as close as possible to the ESD box. These cables shall be shielded and physically isolated from internal cables and electronic, propellant, electro-explosive, and ESD sensitive units.

3.3.3 Electrostatic Discharge.

The spacecraft charging phenomenon requires that spacecraft and spacecraft equipment design take into consideration that electrostatic charging potentials in excess of 10 kV may develop on the surface of the satellite. The effect of charge-induced anomalies caused by differential charging and subsequent discharge are the principal concern. Deep or internal charging and the discharge effect shall also be considered in the design. The resulting system effects of the discharge include electrical and material parts damage, circuit upsets in analog and digital electronics, and thermal control material degradation.

3.3.3.1 ESD Test Requirements.

No malfunction or degradation of performance shall occur when spacecraft subsystems or equipment, particularly digital equipment, are subjected to an electrostatic arc discharge having the characteristics described below. The test requirements are based on MIL-STD-1541A, paragraphs 6.5.2 and 6.7.1, but the requirements and method described in this section have been modified from MIL-STD-1541A to incorporate the results from NASA Technical Paper 2361.

a. The equipment under test shall be mounted on a conductive ground plane using the satellite level mount type and attach points. The equipment shall be operated using a flight type electrical harness with flight type shields and shield termination. The unit shall be fully powered during the electrostatic discharge (ESD) test.

b. A pulse discharge, at a pulse rate of 1 per second for a period of 30 seconds, shall be established at a level of 10 kilovolts and a distance of 30 centimeters from each exposed face of the test sample (unit level test only). Exposure shall be close to the middle of each surface. The energy level of the discharge shall be 2.5×10^{-3} to 3.5×10^{-3} joules.

3.3.3.1 ESD Test Requirements (Coninuted)

c. The test shall be repeated using a direct discharge from one test electrode to each face of the unit (corners of the unit are acceptable if the ESD attachment point is convenient). Characteristics of the direct discharge shall be monitored using high frequency current probes and storage oscilloscopes or other similar measurement techniques. The discharge shall exhibit the following characteristics:

1. Peak current: 40 to 60 amperes
(Note: SS/L Space Environments Department can consider lower peak currents if the discharge characteristics, i.e., voltage, energy, etc., are justified).

2. Rise time of current pulse: 5 to 50 nanoseconds

3. Duration of Discharge: not less than 50 nanoseconds

The direct discharge test shall employ a braided ground strap attached to the test point. The maximum length of the ground strap shall be 2 inches and it shall be attached as close as possible to the intended injection location. All signals of the unit under test shall be continuously monitored for any anomaly or damage.

If an anomaly occurs at 10 kilovolts, a failure analysis shall be performed. In the anomaly investigation the voltage level shall be decreased to the point where satisfactory operation is obtained and actual level shall be recorded, and that value shall be reviewed and approved by SS/L’s Systems Engineering and Space Environments Engineering.

If the equipment passed the direct discharge test, the radiated ESD test stated in item b. above can be waived.

3.3.4 Arcing, Corona, Multipactor, and Passive Intermodulation.

a. For units operating during launch, the equipment shall be designed to operate during launch, ascent, and in space without arcing, corona, or multipactor.

b. High power RF equipment systems require power peak handling margins of 6 dB by design and / or 3 dB by test.

c. See also related sections 3.3.3 Electrostatic Discharge, 3.6.3 Critical Pressure, and 3.6.4 Out-gassing.

3.3.4.1 Passive Intermodulation - PIM.

The passive intermodulation (PIM) requirement is part of the system level performance requirement. However PIM control can affect EMI/EMC and ESD control and design. The controls such as material selection and bonding limits for ESD bleed-off shall comply with both EMI/EMC/ESD requirements and PIM requirement. The program ERS addendum will address specific and unique program requirements.

3.3.4.2 Plasma Induced Damage on Redundant Unit.

The following design rules are listed in order of preference for units with voltage of 100V or above:

1. Primary and redundant circuitry shall be housed in separate units
2. When primary and redundant circuitry are housed in one unit (for mass savings or other reasons) a physical barrier shall isolate the primary and redundant circuitry
3. When primary and redundant circuitry is housed in one unit and not isolated by a physical barrier, a method (such as conformal coating) must be employed to ensure that there is no exposed metal for preventing potential plasma propagation between primary and redundant circuitry.

All Printed Wiring Boards (PWBs) shall be conformal coated to prevent contamination and to provide electrical isolation unless this is prohibited by circuit performance requirements such as in RF circuitry.

3.3.5 Radiated Interference and Susceptibility.

3.3.5.1 Radiated Emissions.

All units shall be designed to restrict radiated emissions that include transmitter spurious radiations, receiver oscillator radiation, various other spurious emissions, transients, and broadband interference, but does not include radiation emanating from satellite antennas.

Radiated interference electric fields in excess of the values shown in Figure 3.3-2 and Table 3.3-II shall not radiate from any units, cable (including control, pulse, RF, video, antenna transmission, and power), or interconnecting wiring over the frequency range of 15 kHz to 32 GHz for the spacecraft for broadband impulsive, continuous wave (CW), and pulsed CW interference.

Limits in Figure 3.3-2 are modifications to MIL-STD-461C, RE02. The requirements given in Figure 3.3-2 represent baseline values. However, Table 3.3-II defines additional radiated emissions requirements for payload receive bands.

3.3.5.1.1 RF Equipment - Emissions.

RF equipment is defined as units whose highest operating frequency is in the 1 to 32 GHz range. The radiated emissions limits as specified in MIL-STD-461 and/or modified herein will be verified by testing the RF equipment identified in the referencing equipment specification. Upper frequency ranges shall be:

HIGHEST OPERATING FREQUENCY OF UNIT	REQUIRED UPPER FREQUENCY LIMIT
1 to 32 GHz	To 5^{th} Harmonic or 32 GHz, whichever is lower.

Other such spurious emissions, intermodulation and characteristics of RF equipment operating in its own environment are identified in the referencing equipment specification.

3.3.5.1.2 NON-RF Equipment - Emissions.

NON-RF equipment is defined as units whose highest operating frequency less than 1 GHz. The emission limit, as specified, shall be verified by test. The upper frequency tested shall be:

HIGHEST OPERATING FREQUENCY OF UNIT	REQUIRED UPPER FREQUENCY LIMIT
1 GHz	To 10^{th} Harmonic or 5 GHz, whichever is higher.

3.3.5.1.2 NON-RF Equipment - Emissions (Continued)

NOTE

NOTE 1: The "Highest Operating Frequency" of a unit includes frequency associated with noise generated from switching, slope of the "square" wave (rise time of the pulse), etc. from the unit.

NOTE 2: The bandwidth is $\Delta f = 1/(\pi t)$ where t is the rise time.

NOTE 3: Certain programs require the upper frequency limit to include all payload receive bands. The program Environmental Requirements Specification Addendum will identify these changes, if applicable.

3.3.5.2 Stationary Plasma Thruster Emissions.

The Stationary Plasma Thruster (SPT) will have radiated emission that exceeds Figure 3.3-2. The following is the electric field emission level at the corresponding frequency:

FREQUENCY BAND	RADIATED EMISSION (dB μV/m)
UHF	68
L	73
S	78
C	80
Ku	90

Satellite programs that use SPT require a detailed interference analysis on the SPT emission to ensure satellite antenna operation is within performance specifications with margin. SPT EMI test data may be used for the compatibility analysis.

3.3.5.3 Radiated Field Susceptibility.

No undesirable response, malfunction, or degradation of performance shall be produced in any equipment when it is subjected to the radiated fields (narrow band) shown in Figure 3.3-3. The top portion of Figure 3.3-3 applies to units mounted inside the Faraday cage and the bottom of Figure 3.3-3 applies to units mounted external to the main faraday cage of the spacecraft.

3.3.5.3 Radiated Field Susceptibility. (Continued)

The requirements given in Figure 3.3-3 represent the electromagnetic environment of the satellite (Figure 3.3-3, page 1 of 2), and the launch electromagnetic environments (Figure 3.3-3, page 2 of 2). The requirement requires not only elecromagnetic compatibility with the satellite but also compatibility with the launch vehicle and launch site. High power S-band payload satellite can have high E-field internal to the satellite. The level is 35 V/m at the program payload frequency. The earth sensor and star tracker have EMI requirements shown in Figure 3.3.3. Note besides EMI/EMC/ESD, they shall meet all other environmental requirements. The ERS Addendum will record the requirements if different from above.

3.3.5.3.1 RF Equipment (1-32 GHz) - Susceptibility.

The radiated susceptibility levels specified in MIL-STD-461 and/or modified herein will be verified by testing the RF equipment identified in the referencing equipment specification. Upper frequency ranges shall be:

HIGHEST OPERATING FREQUENCY OF UNIT	REQUIRED UPPER FREQUENCY LIMIT
1 to 32 GHz	To 5^{th} Harmonic or 32 GHz, whichever is lower.

Other such spurious emissions, intermodulation, and characteristics of RF equipment operating in its own environment are identified in the referencing equipment specification.

3.3.5.3.1.1 Shielding Effectiveness.

Some payload equipment items have specific line-item requirements on shielding effectiveness (i.e. RF isolation) in their respective performance specifications. For such equipment, the shielding effectiveness at the RF and direct current (DC) connectors, flying leads, and shell closures shall be evaluated by irradiation of the unit with the specified field intensity of Figure 3.3-3 using MIL-STD-462 method RS03. Units will be measured in their most sensitive normal operating condition. This is at:

UNIT TYPE	OPERATING CONDITION
Receivers	Threshold plus 1 dB
Amplifiers	Minimum Specified Drive
SSPAs	-15 dB from the 2 dB Compression Point

The test shall be sufficient to demonstrate that the specified shielding effectiveness is achieved.

“Sniff” type test can be conducted on low power passive Payload hardware as shielding effectiveness verification. The detailed requirement shall be stated in the unit specification, and approved by SS/L’s Payload Systems Engineering and Space Environments Engineering.

3.3.5.3.2 NON-RF Equipment (<1 GHz) - Susceptibility.

The radiated susceptibility limits, as specified, shall be verified by test. For a unit with a maximum operating frequency below 1 GHz, the upper frequency tested shall be:

UNIT MOUNTING LOCATION	REQUIRED UPPER FREQUENCY LIMIT
Internal to Faraday Cage	5 GHz or to the 10^{th} Harmonic whichever is higher
External to Faraday Cage	21 GHz (Maximum payload transmit frequency)

3.3.6 Conducted Emissions and Susceptibility.

Each unit shall meet or exceed all performance requirements of the referencing specification when supplied with primary or low voltage power with the characteristics defined in this section.

Conducted EMI testing of power and signal lines of active RF units which contain a local oscillator shall have an upper frequency limit equal to the unit’s local oscillator frequency plus 5 MHz.

3.3.6.1 Primary Power.

The primary power bus voltage shall be within the range of 98 to 103 volts. The primary power input voltage to any spacecraft load shall be within the range of 97 to 103 volts. These values are for nominal regulation. The conducted ripple and short term transients described below are on top of the nominal regulation. See also section (and subsections of) 3.4.1 Primary Power Interface.

3.3.6.1.1 NON-Damage Voltage Limits.

Units attached to the primary bus shall withstand, without damage, application of bus voltage between 0 and 110 volts, primary bus for an indefinite period of time.

3.3.6.1.2 Conducted Steady State Interference Limits (Primary Power).

The equipment shall meet all performance requirements when subjected to the following steady state narrowband conducted interference on the primary power bus:

10 Hz to 500 KHz :	2 V_{p-p}
500 KHz to 50 MHz:	Decaying at 20 dB/decade (6 dB/octave)

See Section 3.3.6.2.5, Conducted Emissions and Susceptibility for Signals and Commands, for signal line conducted emissions and susceptibility requirements.

3.3.6.1.3 Conducted Voltage Transients (Primary Power).

Maximum voltage transients on the primary power bus shall not exceed the range of 95 to 105 volts (95 to 105 volts at the load) and shall recover to within 98 to 103 volts (97 to 103 volts at the load) within 3 milliseconds. The conducted steady state interference (i.e., voltage ripple) defined in 3.3.6.1.2, is added on top of this requirement. For compliance testing of units sourced by the primary power bus, a +2 volt transient recovering to within the allowed limits within 3 milliseconds shall be applied on top of the 103 volt maximum steady state input voltage and a -2 volt transient recovering to within the allowed limits within 3 milliseconds shall be applied to the 98 volt minimum steady state input voltage. The maximum rate of change shall be 1 volt per microsecond and at a maximum rate of 16 transients per second.

3.3.6.1.4 Conducted Steady State Current from the Unit's Conducted Emissions Fed Back to Primary Power Bus.

The steady-state narrow band conducted current emissions fed back to the primary power bus shall not exceed the greater of 75 mA_{p-p} or 3.0% of the steady state DC input current from 10 Hz up to 300 kHz, then decreasing at 20 dB/decade from 300 kHz to 10 MHz. The 10 MHz limit applies above that point. The unit shall meet all requirements when measured per method CE01 of MIL-STD-462.

See Section 3.3.6.2.5, Conducted Emissions and Susceptibility for Signals and Commands, for signal line conducted emission and susceptibility requirements.

3.3.6.1.5 Conducted Current In-Rush Transients (In-Rush Current).

During any equipment, except for Traveling Wave Tube Amplifiers (TWTAs)/Solid-State Power Amplifiers (SSPAs), turn-on or operating mode changes, the in-rush current at or subsequent to command ON, shall not exceed 150% (or 300 mA whichever is larger) of the steady-state DC current at 100 volts DC. In-rush transients as defined above shall be limited to 2 per second maximum. The equipment input current shall return to its nominal average value within 50 milliseconds.

3.3.6.1.5.1 High Power Amplifier (TWTA/SSPA) Conducted Current In-Rush Transients.

For TWTA/SSPA turn-on, current transients shall not exceed peak amplitude of 12 amperes where the integrated charge of the transient above the steady state current of the load being switched does not exceed 50 millicoulombs and the maximum rate of change of current does not exceed ±100 mA/microsecond. For dual high-power TWTAs/SSPAs where the peak transient is greater than 12A, either the program ERS Addendum or the individual TWTA/SSPA specification will address the requirement.

Note: 1) The application of bus power to all payload units is "soft," i.e., the +100 volt applied at the unit input connector is slowly ramped up by the spacecraft thus slowly charging the input filter capacitors.
2) This requirement applies at any input RF drive level up to the maximum rated overdrive for the TWTA/SSPA unless otherwise specified.

3.3.6.1.6 DC-DC Converter Design Requirements.

DC-DC converters used in referenced equipment shall meet the minimum design parameters as stated in E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

3.3.6.1.7 Automatic Low Voltage Shutdown

Automatic Voltage shutdown is separated into the following categories as described in subsections to this paragraph. Any additional under-voltage requirements shall be specified in the unit specification.

3.3.6.1.7.1 Automatic Low Voltage Shutdown (Traveling Wave Tube only)

Automatic low voltage shutdown shall be provided to turn OFF the unit in the event of main bus under-voltage. When provided, this automatic low voltage shutdown shall conform to the following constraints:

a. Automatic low voltage shutdown shall occur if the main bus voltage falls below 93V. Automatic low voltage shutdown shall not engage unless main bus voltage falls below 95V. Shutdown shall occur within 50 msec of the main bus voltage falling below 93V.

b. Unit shall not restart following an automatic low voltage shutdown until commanded ON by external command.

c. Any digital ON/OFF telemetry provided for the unit shall accurately reflect the OFF status of the unit after an automatic low voltage shutdown when power is restored to the nominal bus voltage range defined in E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

3.3.6.1.7.2 Automatic Low Voltage Shutdown (Comm units except TWT)

This section shall apply to all RF units used in the Communications (Comm.) payload, except Traveling Wave Tube (TWT), including power supplies designed to operate multiple RF units at once (e.g., Master Converters). This section shall not apply to command (CMD) receivers, telemetry (TLM) transmitters, and any up/down converters that are dedicated to the TC&R Subsystem. Automatic low voltage shutdown shall be provided to turn OFF the unit in the event of main bus under-voltage. When provided, this automatic low voltage shutdown shall conform to the following constraints:

a. Automatic low voltage shutdown shall occur if the main bus voltage falls below 85V. Shutdown shall occur within 50 milliseconds (msec) of the main bus voltage falling below 85V.

b. Automatic low voltage shutdown may occur if the main bus voltage falls between 85V and 95V (except TWT) if required to protect the unit. Automatic low voltage shutdown shall not engage unless main bus voltage falls below 95V.

c. Unit shall not restart following an automatic low voltage shutdown until commanded ON by external command.

d. Any digital ON/OFF telemetry provided for the unit shall accurately reflect the OFF status of the unit after an automatic low voltage shutdown when power is restored to the nominal bus voltage range defined in E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

3.3.6.1.7.3 Automatic Low Voltage Shutdown – TC&R Equipment

This section shall apply to command receivers, TLM transmitters, and any up/down converters that are dedicated to the TC&R Subsystem. Automatic low voltage shutdown may be provided to turn OFF the unit in the event of main bus under-voltage if required to protect the unit. When provided, this automatic low voltage shutdown shall conform to the following constraints:

a. Automatic low voltage shutdown shall not engage unless main bus voltage falls below 85V.

3.3.6.1.7.3 Automatic Low Voltage Shutdown – TC&R Equipment (Continued)

b. Automatic low voltage shutdown shall not be latching. Units operating immediately prior to the low voltage condition shall restart and resume normal operation within 60 milliseconds of main bus voltage exceeding 85V regardless of rate of voltage increase. Units not operating immediately prior to the low voltage condition shall not restart and remain in a non-operating condition.

c. Any digital ON/OFF telemetry provided for the unit shall accurately reflect the ON/OFF status of the unit after an automatic low voltage shutdown when power is restored to the nominal bus voltage range defined in E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

3.3.6.1.7.4 Automatic Low Voltage Shutdown (Bus units)

This section shall apply to all power supplies and converters for bus units that are not directly associated with providing power specifically to payload units (e.g., Data Handling Electronics (DHE), Attitude Control Electronics (ACE), Low Voltage Converters (LVCs), etc.). Automatic low voltage shutdown may be provided to turn OFF the unit in the event of main bus under-voltage only as required to protect the unit. When provided, this automatic low voltage shutdown shall conform to the following constraints:

a. Automatic low voltage shutdown characteristics shall be specified in the unit performance specification after careful evaluation of the specific application of respective unit. Low voltage shutdown or other loss of regulation shall be set to as low a voltage as practical while still protecting the unit. In general, automatic low voltage shutdown or loss of regulation shall not occur unless main bus voltage falls below 85V.

b. Automatic low voltage shutdown shall not be latching. Units operating immediately prior to the low voltage condition shall restart and resume normal operation within 60 milliseconds of main bus voltage exceeding 85V regardless of rate of voltage increase. Units not operating immediately prior to the low voltage condition shall not restart and remain in a non-operating condition.

c. Any digital ON/OFF telemetry provided for the unit shall accurately reflect the ON/OFF status of the unit after an automatic low voltage shutdown when power is restored to the nominal bus voltage range defined in E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

3.3.6.2 Secondary Power.

The spacecraft secondary power (low voltage) bus voltage at the load shall be between 29.5 V and 31.5 V at the output of the power hub distribution unit. These values are for nominal regulation. The conducted ripple and short term transients described below are on the top of the nominal regulation.

3.3.6.2.1 NON-Damage Voltage Limits.

Units attached to the secondary power (low voltage) bus shall withstand, without damage, application of a bus voltage between 0 V and 33.5 V for an indefinite period of time.

3.3.6.2.2 Conducted Steady State Interference Limits (Secondary Power).

The narrowband conducted interface on the secondary power (low voltage) bus shall be equal to or less than the following limits.

10 Hz to 500 KHz :	0.82 V_{p-p}
500 KHz to 50 MHz:	Decaying from 0.82 V_{p-p} at 500 KHz at 6dB/octave

3.3.6.2.3 Conducted Voltage Transients on Secondary Power Bus.

Maximum voltage transmitted on the secondary power (low voltage) bus shall not exceed the range of 29.0 to 33 volts and shall recover to within 29.5 to 31.5 volts within 3 milliseconds. For compliance testing of units using low voltage bus power, a +1 volt transient recovering to within the allowed limits within 3 milliseconds shall be applied on top of the 32 volt steady state input voltage and a -1 volt transient recovering to within the allowed limits within 3 milliseconds shall be applied to the 30 volt steady state input voltage. The maximum rate of change shall be 3.5 volts per millisecond and at a maximum rate of 2 transients per second.

3.3.6.2.4 Conducted Steady State Current Interference Fed Back to Secondary Power Bus.

The steady-state narrow band conducted current emissions fed back to the secondary power (low voltage) bus shall not exceed the greater of 50 mA_{p-p} or 3.0% of the steady state DC input current from 10 Hz up to 300 kHz, then decreasing at 20 dB/decade from 300 kHz to 10 MHz. The 10 MHz limit applies above that point. The unit shall meet all requirements when measured per method CE01 of MIL-STD-462.

3.3.6.2.5 Conducted Emissions and Susceptibility for Signals and Commands.

The unit shall operate without errors in the presence of conducted susceptibility noise less than or equal to that described below over a frequency range from 10 Hz to 500 kHz, decreasing at 6 dB/octave (20 dB/decade) above 500 kHz.

The unit shall not generate conducted emission noise greater than the levels described below over a frequency range from 10 Hz to 150 kHz, decreasing at 6 dB/octave (20 dB/decade) above 150 kHz.

Telemetry Signal Types
- Analog Signals
  - Conducted Susceptibility: 8 µAp-p
  - Conducted Emissions: 20 mVp-p
- Digital Type A Signals
  - Conducted Susceptibility:
    1. "ONE" Level: 20 µAp-p
    2. "ZERO" Level: 20 µAp-p
  - Conducted Emissions:
    1. "ONE" Level: 100 mVp-p
    2. "ZERO" Level: 50 mVp-p
- Digital Type B Signals
  - Conducted Susceptibility:
    1. "ONE" Level: N/A
    2. "ZERO" Level: 20 µAp-p
  - Conducted Interference Emissions:
    1. "ONE" Level: 100 mVp-p
    2. "ZERO" Level: 50 mVp-p

Command Signal Types
- Latching Relay Commands
  - Conducted Susceptibility:
    1. Contacts "Open": 200 mVp-p
    2. Contacts "Closed": 100 mVp-p
  - Conducted Interference:
    1. Contacts "Open": N/A
    2. Contacts "Closed": 100 µAp-p
- Pulse Commands: Omega SCE (are High Side Driver (HSD) pulse commands)
  - Conducted Susceptibility:
    1. “ONE” Level: 2.0 Vp-p
    2. “ZERO” Level: 0.5 Vp-p
  - Conducted Emissions:
    1. “ONE” Level: 3000 µAp-p
    2. “ZERO” Level: 250 µAp-p

3.3.7 Magnetic Fields.

The performance of the unit shall not be affected by the presence of external magnetic fields of any orientation at a level of ±5.0 gauss. The dipole moment generated by the unit shall not exceed 0.05 ampere-meters^2. For TWTAs, the dipole moment shall not exceed 1 ampere-meter^2. SPT-100 (SPT-140) shall not generate a dipole moment greater than 15 (25)ampere-meters^2. Magnetic sensitive equipment shall be distanced from or shielded from magnetic generators like SPTs and magnetic torquers.

3.3.8 Compatibility Tests.

End-to-end self compatibility, launch vehicle compatibility, and ground station compatibility shall be performed to ensure the system will fulfill mission requirements. The mission environment shall be simulated as realistically as possible and sensors shall receive stimuli such as they will receive during the mission. The RF links, ground station operations, and software functions shall be exercised.

3.4 Dynamic (Load) Requirements/Environments.

3.4.1 General.

The satellite shall be capable of sustaining all direct and cumulative static and dynamic load combinations occurring during fabrication, testing, ground handling, transportation, launch, and orbital maneuvers without permanent deformation. Detailed structural design requirements encompass all expected load environments. Included are quasi-static launch loads; sine, random and acoustic vibration loads; separation and deployment shock loads; and frequency requirements. These design requirements are summarized in this section. Applicable loads and frequency requirements are summarized in Table 3.4.1-I.

3.4.1.1 Required Design and Test Levels.

Table 3.4.1-II, Design and Test Factors of Safety, summarizes how the required design and test load levels relate to flight load levels. Limit or acceptance loads correspond to 1.0 times maximum expected flight levels. To provide a performance margin, the satellite and components are to be designed and tested to ultimate or qualification loads equal to the maximum expected flight levels multiplied by the factors of safety given in Table 3.4.1-II. All components shall be capable of sustaining these qualification levels without permanent deformation or, in the case of a friction joint, slippage, and shall satisfy margin of safety requirements specified in the corresponding performance specifications.

3.4.2 Satellite.

Satellite design requirements include quasi-static launch load factors; sine vibration; acoustic vibration; shock levels; frequency requirements; deployment and transfer orbit loads; on-orbit loads; and ground handling and transportation loads.

3.4.2.1 Launch Loads.

Quasi-static limit load factors for all of the candidate launch vehicles are given in Table 3.4.2-I, Launch Vehicle quasi-static limit load factors Seen by Satellite. Also shown are design loads enveloping the maximum longitudinal (compression and tension) and lateral load cases for these launch vehicles. Maximum envelopes are included for both small (<4500 kg) and large satellites (>4500 kg). These Quasi-Static Limit Load Factors are assumed to act uniformly over the height of the satellite. In actuality, the lateral acceleration increases along the height of the satellite. To account for this increase, the rotational load factors listed in Table 3.4.2-II, Additional Satellite Rotational Limit Load Factors have been developed. These rotational load factors, which are primarily of concern for satellites that have extension modules, produce g-loads in the upper elevation of the satellite that are higher than the quasi-static limit load factors listed in Table 3.4.2-I.

The rotational loads given in Table 3.4.2-II apply to the portion of the satellite between stations 100 and 175 inches (Earth deck). A separate maximum Proton/Breeze-M was added to envelope higher lateral responses predicted by an intermediate coupled loads analysis from a heritage program.

Two sets of rotational load factors are given in Table 3.4.2-III for a stand-alone tower and upper module (consisting of a tower, upper comm. Panels, shear webs, and upper deck). The lateral rotational factor for the stand-alone tower is higher than for the upper module.

For the portion of the satellite below 100 inches, including the base bending moment, the quasi-static load factors given in Table 3.4.2-I apply. This is based on assurances from launch vehicle contractors that the base moment during launch will not exceed the value calculated using the quasi-static lateral load factors.

3.4.2.1 Launch Loads (Continued)

To provide a performance margin, the limit load factors given in Tables 3.4.2-I and 3.4.2-II are to be multiplied by a 1.3 qualification factor. The resulting ultimate design loads are to be used for preliminary design and analysis of the satellite primary structure. The tower/upper module design loads in Table 3.4.2-III already include the 1.3 qualification factor. Load Factors given in Tables 3.4.2-I, 3.4.2-II, and 3.4.2-III shall be updated as required based on results of coupled satellite/launch vehicle loads analysis to be performed the launch vehicle contractors using satellite mathematical models provided by SS/L.

3.4.2.2 Sine Vibration Levels.

Sine vibration is used to simulate low frequency dynamic loads that occur during launch. Satellite sinusoidal vibration test inputs for candidate launch vehicles are given in Table 3.4.2-IV, Satellite Sine Vibration Test Levels, along with a combined envelope. Sine vibration is performed in each of three mutually perpendicular axes. To protect the primary structure from unrealistic loads, the vibration input shall be notched at primary structural resonances so that responses do not exceed predicted launch loads. Notching levels shall be based on results of coupled loads analyses and component design loads. The satellite shall be configured in flight-like electrical and mechanical configuration for exposures. A low-level sine survey shall be performed prior to test level exposures. Before and after each test, the satellite shall be examined and functionally tested. During the test, performance shall be monitored.

3.4.2.3 Acoustic Environment.

Acoustic flight environments for the candidate launch vehicles are given in Table 3.4.2-V, Launch Vehicle Acoustic Levels. Satellite acoustic test levels are based on a combined envelope of the candidate launch vehicle acoustic environments (not including Delta-IV H and Long March). These levels are given in Table 3.4.2-VI, Satellite Acoustic Test Levels Envelope. Delta-IV H and Long March were not included since it is unlikely that SS/L satellites will be flown on these launch vehicles in the near future. In addition to the acceptance test levels, Table 3.4.2-VI also gives the corresponding protoflight/qualification levels (acceptance +3 dB). It is recommended that large surface area components (e.g., solar arrays and reflectors) be tested to this envelope in order to qualify them for use on all launch vehicles (except Delta-IV H and Long March). It is also recommended that satellites be tested to this same envelope. However, depending on the contract requirements, spacecraft acoustic tests can be performed to an envelope of levels for the prime and backup launch vehicle(s). Before and after each test, the satellite shall be examined and functionally tested.

3.4.2.4 Shock Environment (Launch Vehicle/Satellite).

a. The satellite shock environment is due both to external launch vehicle shock events and to internal satellite shock sources. Launch vehicle shock events include fairing separation, stage separation, and launch vehicle adapter clampband release. Satellite shock sources include Electro-Explosive Devices (EEDs) and Split Spool Devices (SSDs) used to release deployable components (solar arrays, reflectors, spot antennas, thermal radiators, stationary propulsion thrusters), and propulsion pyrovalves.

b. Shock environments at the separation plane are specified in the various launch vehicle user's manuals. Since measurements taken during flight and ground tests have shown that these user's manual interface shock spectra are generally quite conservative, they are not used to derive the component shock spectra given in this specification. Instead SS/L, in conjunction with the various launch vehicle manufacturers, has defined more realistic interface shock spectra. These interface shock spectra are given in Table 3.4.2-VII and in Figure 3.4.2-1 (Reference E128796, Launch Vehicle Induced Shock Environment). These interface shock spectra were used to develop the launch vehicle induced component shock spectra given in Section 3.4.3.4. Thus, any increases in the launch vehicle interface levels could result in increases in the component shock levels.

c. In addition to launch vehicle induced shock levels, Section 3.4.3.4 also specifies component shock levels for satellite-induced shocks. These satellite-induced shock levels were derived from data measured during SS/L solar array and reflector release tests. Only data for the "modified" holddowns is included. The modified holddowns incorporate crushable core under the holddown rod to reduce the shock imparted into the equipment panels. Data for both EED and SSD release devices are included.

d. The propulsion pyrovalves are not fired during satellite testing, therefore no satellite-level shock data are available. However, limited data are available from component shock tests of pyrovalves. Based on this limited data, it is recommended that the EED shock spectra also be used for pyrovalve shock.

3.4.2.5 Frequency Requirements and Design Goals.

The satellite shall have the required stiffness to maintain structural integrity, to limit deflections, and to minimize dynamic coupling with the launch vehicle. Dynamic loads during launch and ascent depend on the interaction between the launch vehicle and satellite. To minimize launch vehicle induced dynamic loads, Table 3.4.2-IX, Satellite Minimum Frequency Requirements, has been established by the launch vehicle contractors for the satellite in the launch configuration.

3.4.2.6 Deployment and Transfer Orbit Loads.

After launch, the solar arrays and antenna reflectors are released from their stowed positions and deployed to their operational positions. The solar arrays and antenna reflectors and their supporting structures shall be designed to have positive margins of safety for these deployment loads. The deployed solar arrays and, because of contingency, the reflectors shall also be capable of sustaining thrust loads induced by the Main Satellite Thruster (MST) during the orbit raising periods of the mission. Since the MST can also be fired during eclipse, the effect of cold temperatures on the solar array and reflector allowable stress needs to be taken into consideration when analyzing for the thrust loads. The thrust induced by the MST is ~490 Newtons (~110 lbf).

3.4.2.7 On-Orbit Loads.

The satellite shall be designed for loads resulting from on-orbit attitude control thruster firing and for loads generated during attitude control failure and reacquisition. These loads are generally small. However, for satellites with large appendages, reacqisition and maneuvering loads can be of concern and should be evaluated on a program-by-program basis. In orbit, the structure shall also have, and maintain throughout satellite orbital design life, the dimensional stability and alignment relationships required to meet satellite pointing requirements.

3.4.2.8 Ground Handling and Transportation.

The satellite shall be handled and transported on the ground in such a way that the loads will not exceed the launch loads. To ensure this, safe methods for ground handling and transportation, including use of shock-isolated shipping containers, shall be employed. Additional ground handling and transportation environments are defined in specific launch vehicle manuals. The transportation of the satellite shall be per the detailed requirements in the Satellite Transportation Plan.

3.4.3 Components/Units.

Design and test requirements for equipment components have been derived based on the above satellite requirements.

These component design and test requirements include design load factors, sine and random vibration levels, acoustic spectra, shock spectra, and frequency design goals.

3.4.3.1 Qualification Load Factors.

Qualification component design load factors are given in Table 3.4.3-I, Unit Qualification Design Load Factors. These levels are higher than the overall satellite load factors to account for local amplifications that may occur during satellite testing or launch.

3.4.3.2 Sine and Random Vibration Levels.

Required sine and random vibration levels for components are given in Tables 3.4.3-II, Vibration Test Levels. The sine vibration test is intended to exercise the components to worst case responses expected during launch (as predicted by the coupled loads analysis) and during satellite sine vibration testing. Vibration is performed in each of three mutually perpendicular axes. The random vibration test is intended to exercise the components to worst-case response levels occurring during satellite acoustic tests. Specified random vibration test levels are based on measured responses from previous satellite acoustic tests.

The unit shall meet all performance requirements of the applicable unit specification prior to exposure, during exposure (where applicable), and after exposure to the dynamic environments specified in Tables 3.4.3-II, Vibration Test Levels. The applicable unit specification will define which category of Tables 3.4.3-II is applicable. The test levels given in Table 3.4.3-II(a) are intended to apply to the majority of components mounted on the equipment panels.

The test levels in the remaining portions of Table 3.4.3-II specify vibration levels for selected non-panel-mounted components (propellant tanks, pressurant tank, solar array, MST, momentum wheels, feeds, reflectors, subreflectors, etc.) for which the panel mounted component levels are not appropriate. For selected components notching of random or sine input may be performed when specified in Tables 3.4.3-II. For selected components, an acoustic test may be performed instead of a random vibration test. In these cases the mounting configuration shall be simulated as close as possible to the spacecraft configuration.

3.4.3.3 Acoustic Levels.

Acoustic levels for component tests (where required) are the same as the satellite levels given in Table 3.4.2-V, Launch Vehicle Acoustic Test Levels, and Table 3.4.2-VI, Satellite Acoustic Test Levels-Envelope.

3.4.3.4 Shock.

Shock levels from external launch vehicle shock events (stage and fairing separation, clamp band release) are described in E128796 Launch Vehicle Induced Shock Levels. Shock levels from internal satellite shock events (e.g., solar array and antenna releases, propulsion pyro-valves, etc.) are summarized in numerous satellite pyroshock test reports. Shock levels from these reports were used to derive the component shock specifications given in Table 3.4.3-III(a). This table shows numerically labeled shock specifications, with Level 4 being the lowest and Level 1 the most extreme. Levels 1, 1.5, and 3 were derived from external launch vehicle shock levels whereas Levels 2 and 4 were derived from internal satellite shock levels.

The figure with Table 3.4.3-III(a) provides a graphical representation of these shock levels. The figure illustrates that shock Level 1 encompasses the remaining four shock levels (i.e., a unit shock qualified to Level 1 would also be shock qualified to Levels 1.5, 2, 3, and 4). It is also apparent that although shock Level 1.5 and Level 2 encompasses Levels 3 and 4, neither one encompasses the other. That is to say, a unit shock qualified to Level 1.5 is also shock qualified to Levels 3 and 4 but not to Level 2. Conversely, a unit shock qualified to Level 2 is also shock qualified to Levels 3 and 4 but not to Level 1.5. Units shock qualified to Level 3 are also shock qualified to Level 4. Units shock qualified to Level 4 are only shock qualified to Level 4.

3.4.3.4 Shock (Continued)

Table 3.4.3-III(b) summarizes the shock requirements for components mounted at the various satellite locations. The levels shown in the second column envelope the shock levels for specific areas at these locations. Category A and B units that are subject to qualification testing should be tested to the enveloping levels. This allows the component to be located anywhere at these locations. If it is determined that a unit cannot be qualified to the enveloping level, a waiver may possibly be granted to test the unit to a lower-allowable shock level provided in the final column of the table. Note, however, that this restricts the specific area that the unit can be located and is thus not recommended. Category C and D units should also be evaluated for the enveloping levels given in the second column of the table. If it is determined that a unit is not qualified for the enveloping level, it is recommended that a delta qualification test be performed to the enveloping level. Alternately, the unit can be moved to a specific area for which it meets the shock level given in the final column of the table. Since this again restricts the location where the unit can be located, it is not recommended.

Table 3.4.3-III(f) Generic Shock Level Requirements summarizes potential locations for generic equipment. If a component can be located at more than one location, it should be tested to the most severe shock requirement for those locations. Also note that some of the equipment has specific shock requirements, as noted by an SPC in the table. These specific shock requirements are given in Table 3.4.3-III(d) Shock Requirements for Specific Units.

3.4.3.5 Frequency Design Goals

The component minimum frequency goals are specified in Table 3.4.3-IV.

3.5 Thermal Requirements.

3.5.1 On-Orbit Temperature Variation.

To assess component thermal stress for analysis (solder joints, adhesive temperature cycling, etc.) and in order to evaluate thermal cycle test requirements for specific components, knowledge of the on-orbit temperature variation is required. The following is a discussion of the general spacecraft temperature environment variation due to seasonal and diurnal spacecraft changes.

A typical (for reference only) seasonal temperature cycle for an equipment panel is shown in Figure 3.5-1. Seasonal temperature cycling in other portions of the spacecraft interior experience the same general trends and levels.

Diurnal temperature variation of internal spacecraft varies with location within the spacecraft main body. North and south equipment panel diurnal temperature variation is approximately 5 to 7 °C. Equipment not located on the north and south equipment heat pipe panels will experience a 15 °C diurnal temperature variation.

A thermal analytical model shall be developed for the satellite, its elements and the mission environment for the purpose of predicting thermal performance.

3.5.2 Required Temperature, Heater And Power Margins.

a. Two types of temperature margin are required for the spacecraft components as shown in Figures 3.5-2(a) & 3.5-2(b).

   1. All interior main body components and components that are thermally coupled to the main body require a ±5 °C margin from design temperature limit to acceptance temperature and a ±10 °C margin from design temperature to qualification/protoflight temperature, as in Figure 3.5-2(a).

   2. Exterior, thermally isolated components require ±5 °C margin from design temperature to acceptance temperature and ±10 °C margin from design temperature to qualification/protoflight temperature. In addition, a ±5 °C analytical uncertainty margin is required between the design temperature limits and the worst case temperature predictions, as in Figure 3.5-2(b).

3.5.2 Required Temperature, Heater And Power Margins. (Continued)

b Heater shall be sized such that when operating at 100% duty cycle, the predicted temperatures shall be at least 5 °C higher than the minimum thermal design temperature or sized to 110% of power required to maintain thermal design temperature at 100% duty cycle, which ever is greater.

3.5.2.1 Thermal Testing.

Unit level testing (qualification, protoflight, acceptance) shall be based on the Satellite Test Plan.

The spacecraft shall be subjected to a thermal vacuum test for 168 hours, minimum, at a vacuum of $\leq 1 \times 10^{-5}$ torr. Figure 3.5-3 shows the thermal vacuum profile including all customer required deviations from the standard thermal vacuum profile. Equipment operations during the thermal vacuum test are defined in the applicable Satellite Test Plan. All customer required deviations from the standard test profile shall be documented in the program ERS addendum.

The test phases, defined in Figure 3.5-3, include but are not limited to the major cases listed below:

a. One initial ambient test phase

b. One transfer-orbit condition (equinox -10 °C with heaters)

c. Two hot and one cold thermal balance conditions. These simulated conditions are equinox Beginning of Life (BOL) (cold), summer solstice End of Life (EOL) and winter solstice EOL (hot). During a hot condition the repeater will be operated with multiple carriers.

d. Three conditions representative of winter, summer, and equinox seasons (equinox seasons with eclipse) with 10 °C margin

e. One final ambient test phase

3.5.2.1 Thermal Testing (Continued)

The spacecraft thermal vacuum test consists of pre-thermal vacuum performance testing, thermal balance and thermal vacuum performance testing, and post-thermal vacuum testing. The test chamber, test fixture, spacecraft configurations, and test methods are the same for all spacecraft. Thermal balance tests are performed for conditions simulating summer solstice EOL, equinox BOL, and winter solstice EOL in order to verify the proper implementation of the thermal control subsystem. Performance testing is performed at the applicable temperature margin.

3.5.3 Dissipation/Heat Flux Density.

The maximum allowed dissipation/heat flux density through the unit baseplate to the spacecraft interface is 1 watt/in^2 (0.155 watt/cm^2) for unrestricted mounting on the spacecraft. Dissipation densities of greater than 1 watt/in^2 require SS/L Thermal Engineering review and approval. In general, dissipation densities of greater than 1 watt/in^2 must be located directly above a heat pipe.

Dissipation/heat flux densities of greater than 12 watts/in^2 (1.86 watts/cm^2) over a heat pipe require additional SS/L Thermal Engineering review and approval. Restrictions on the proximity of unit mounting hole location with respect to heat pipe location and heat pipe dimensions are provided in E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

Units are divided into two categories based on their unit dissipation densities:

a. Case A - Units with dissipation/heat flux densities less than or equal to 1 watt/in^2 (0.155 watt/cm^2).

b. Case B - Units with dissipation/heat flux densities greater than 1 watt/in^2 (0.155 watt/cm^2).

3.5.4 Unit Thermal Environment.

The unit shall meet all performance requirements within the operating range and survive within the non-operating or survival temperature range specified in the applicable specification.

Tables 3.5-I provide the non-operating and operating qualification, protoflight, and acceptance temperature limits for each component. The temperature description column of Table 3.5-I must be used to interpret the temperature limits. Reference the program Environmental Requirements Specification Addendum for the component temperature limits specific to the program.

The standard power handling margin is 1 dB by test for high power testing of payload components to preclude the risk of thermal breakdown.

3.5.4.1 Thermal Interface

3.5.4.1.1 Cooling

Cooling of components shall utilize thermal conduction to the mounting interface unless otherwise stipulated in the unit specification.

3.5.4.1.2 Finish

The unit enclosure exterior hemispherical emissivity shall be greater than 0.80 or as specified in the unit's specification. The mounting finish shall be approved by SS/L.

3.5.4.1.3 Mounting

See E399000 for unit mounting design requirements.

3.5.4.1.4 Temperatures

a. Thermal interface temperature requirements shall be defined using the process flowchart attached in Figure 3.5-6. The vendor shall provide component thermal interface details, including mounting contact area, dissipation, and any high dissipation/heat flux regions greater than 1 watt/in^2). If dissipation/heat flux densities exceed 1 watt/in^2, then the vendor shall also provide dissipation/heat flux density maps, heat pipe locations, and component baseplate details (e.g., size, thickness, material, thermal conductivity). If dissipation/heat flux densities exceed 1 watt/in^2 over a non-heat pipe region or 12 watts/in^2 over a heat pipe, then SS/L Thermal Engineering will provide a temperature map to the vendor in order to perform updated thermal analysis. The vendor and SS/L Thermal Engineering shall exchange heat flux and temperature maps from their respective thermal analyses until the temperatures converge. The interface temperature shall be defined on the unit baseplate as shown in Figure 3.5-5.

b. Components within units that carry high radio frequency (RF) power and have high losses (e.g., output bandpass filters, output isolators, OMUX, switches) may have temperatures which significantly exceed unit baseplate temperatures during operation. RF performance measurements taken on these components when unit baseplate qualification/protoflight/acceptance temperatures are achieved may not represent the actual flight RF levels and duration (i.e., component may not reach the maximum steady state temperature). Therefore, component temperatures within units must be increased in order to properly simulate flight RF levels and durations while at the maximum unit baseplate temperature. This may be accomplished by applying local heat or by elevating the baseplate/environment temperature to cause individual electronic component temperatures within the unit to reach the same value which would be obtained if tested under flight-like conditions. Suppliers shall determine the required local heating or baseplate/environment temperature adjustment and also demonstrate that no overstress condition of the unit or its components will occur.

c. Furthermore, if ambient pressure testing is proposed, then suppliers shall demonstrate that all individual electronic component temperatures will still reach the same value which would be obtained under flight-like vacuum conditions. Otherwise, this may be accomplished by applying local heat or elevating the baseplate/environment temperature to cause individual electronic component temperatures within the unit to reach the same value which would be obtained if tested under flight like vacuum conditions. Suppliers shall determine the required local heating or baseplate/environment temperature adjustment and also demonstrate that no overstress condition of the unit or its components will occur. If this safe operating condition cannot be demonstrated then thermal testing of the unit must be performed under vacuum conditions.

3.6 Static Pressure

3.6.1 Launch Pressure Profile.

During the launch phase of the mission, the spacecraft and its associated equipment will be subjected to a variation in static pressure within the launch vehicle fairing. The pressure profiles for Ariane 4 & 5, Delta IV, Atlas V, Proton, H2A, Long March, Sea Launch, and land launch are shown in Figures 3.6-1(a) to (i).

3.6.2 Venting.

a. Provision must be made in all equipment and assemblies for adequate venting to preclude damage due to pressure differentials. The units shall contain vent holes so that the rate of change of barometric pressure of all interior volumes shall be approximately equal to the maximum external pressure rate of change of -6.9 kPa/sec.

b. The vent holes shall be chosen to permit EMC specifications to be met.

c. The vent holes shall be chosen to minimize the entry and exit of particulate contamination.

d. The vent holes shall be chosen to maintain RF isolation of waveguide assemblies. (Venting through the flange rim is acceptable).

e. Membranes that would isolate sections of a waveguide assembly (e.g., Kapton contamination membrane) shall be noted on the Interface Control Drawing (ICD).

f. All vent locations, venting areas (e.g., hole diameter), and vent filter (if used) characteristics are to be identified on the ICD. All weight relief cavities on unit base plates must be vented directly to the exterior of the unit if the cavity could trap air when thermally mounted to the panel. Vent holes should be as high as possible to preclude blockage by adhesive during installation. Weight relief cavities at the panel mounting interface shall not incorporate any through holes into the interior of the unit that could permit intrusion of thermal compound into the interior.

g. Vent holes are not required if the equipment is hermetically sealed. Hermetically sealed Hybrid microcircuit devices shall meet fine and gross leak seal test requirements of MIL-STD-883, Method 1014, sealed with a minimum of 10% helium tracer gas. The design and construction of the unit shall result in an internal atmosphere that is consistent with reliability and design life requirements, and shall not cause a performance malfunction or unexpected degradation of semiconductor parts.

3.6.3 Critical Pressure

As venting occurs through launch ascent and the transfer orbit, the pressure inside the satellite decreases through a critical pressure region. Electrical breakdown can occur under the Paschen's law in the launch pressure environment if equipment is powered. All TC&R equipment must be designed to survive the critical pressure region without damage or permanent degradation in performance. Analysis shall be performed at the satellite level with potential launch vehicles to determine the expected pressure region for all TC&R equipment. Either analysis or test may be performed to show compliance of TC&R equipment.

3.6.4 Out-Gassing

Some materials continue to out-gas beyond the early launch phase. These materials in the satellite must be properly vented to prevent a critical pressure environment created by out-gassing, which may cause voltage breakdown in equipment.

Material out-gassing requirement is specified in an individual Parts and Material Specification, and controlled under the Commercial Program Product Assurance Plan.

3.7 Storage Environments

The spacecraft may be stored on ground for a period of up to five years. The environmental condition of this storage is specified as:

a. Temperature Range: 18.3 to 25.7 °C.

b. Humidity Range: 25% to 60%.

c. Particulate Requirement: Class M6.5 (100,000) per FED-STD-209

4. UNIT DESIGN AND INTERFACE REQUIREMENTS

The Unit Interface Design Requirements shall comply to E399000 Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

5. RELIABILITY AND PRODUCT ASSURANCE

5.1 Reliability Requirements

a. For subcontracted units: The equipment design and construction shall be consistent with the reliability and design life requirements in the following subparagraphs. The reliability analyses that are required are called out in the Statement of Work, SW-E135840. Analysis methods and documentation requirements are specified in the Subcontractor Mission Assurance Requirements document (see Section 1.1), and the Data Requirements Instructions (DRI) for Spacecraft Subcontractors, SH-E023988.

b. For SS/L in-house built units: The equipment design and construction shall be consistent with the reliability and design life requirements in the following subparagraphs. The reliability analyses that are required are called out in the Mission Assurance Plan, PP-E339761. Analysis methods and documentation requirements are specified in the Mission Assurance Plan, PP-E339761, and the Product Qualification procedure, PD-70.

5.1.1 Life Requirements

All elements of the satellite shall be designed with adequate and sufficient life margins. These design life requirements include:

a. Electronic assemblies shall be designed and electronic piece parts applied such that all performance requirements are satisfied for a period of at least 18 years under worst case total environment conditions of temperature, radiation exposure, and aging.

b. Items such as TWTs, moving mechanical items, materials, or other items which may be subject to wear-out or depletion shall be designed such that all performance requirements are satisfied for at least 18 years.

c. Items subject to power on/off cycling or other forms of cyclic operation shall be designed to satisfy all performance requirements following 1.5 times the worst case anticipated number of cycles for a 15 year mission, including testing.

5.1.2 Storage Requirements

See section 3.7 for Storage Environments/Requirements.

5.1.3 Failure Safety/Isolation

The failure safety/isolation shall be consistent with the following single point failure and failure propagation requirements. All circuits shall be designed to preclude failure propagation. Design shall also minimize propagation of failures between subsystems including those that are redundant.

5.1.3.1 Single Point Failure

Single point failure modes shall be eliminated or the effects minimized.

5.1.3.2 Failure Propagation

Failure propagation within a unit (e.g., redundant path) or to another unit or subsystem shall be minimized.

5.1.3.3 Isolation

Primary and redundant functions are to be electrically separated. Layout of components will preclude any overlapping interference.

5.2 Product Assurance

5.2.1 Product Assurance Program

a. For subcontracted units: The manufacturer shall be responsible for verifying all the requirements of the unit performance specification in accordance with their controlled and released test plan, and procedures. The manufacturer shall also be responsible for meeting all the requirements of the Subcontractor Mission Assurance Requirements (see Section 1.1).

b. For SS/L built units: The responsible engineer shall be responsible for verifying all the requirements of the unit specifications in accordance with their controlled and released test plan, procedure PD-70, and E339761.

6. TEST CONDITIONS AND TEST REQUIREMENTS

System level testing shall be accomplished in accordance with the test methods specified in and required by the individual Satellite Test Plan. Unit specifications list the unique set of tests required for each unit. Environmental requirements that shall be verified during test are contained herein (see summary Table 6-I).

6.1 General Test Conditions

All tests shall be accomplished in accordance with test procedures which have been approved by Space Systems/LORAL (SS/L). Test data, when demonstrated to be applicable, may be used to satisfy more than one type of test. Records of all tests on the equipment shall be made in accordance with the requirements of approved test procedures. Records shall be maintained in permanent files. The records shall include all pertinent test data, equipment used, test procedures, and any failures or irregularities observed and noted during testing of equipment. Surveillance of tests shall be performed by the manufacturer's Product Assurance (PA) organization.

Controls for test configuration and documentation, nonconformance and failure reporting, and inspection and test surveillance, shall be as specified in the Subcontractor Mission Assurance Requirements (SS/L sub-contracted equipment, see Section 1.1), or the Mission Assurance Plan E339761 (SS/L built equipment).

6.1.1 Ambient Conditions.

Prior to conducting environmental tests, the equipment shall be instrumented and tested for satisfactory performance under room ambient conditions. This performance test shall be made in accordance with the approved test procedures. A record shall be made of all data necessary to determine complete operational performance characteristics.

These tests shall be performed with conditions specified in Table 6-I, Test Environmental Requirements Summary.

An alternative to complying with the minimum humidity requirement for ESD sensitive devices is to incorporate an automated system to control ESD.

6.1.2 Tolerance

The maximum allowable tolerances on test conditions during environmental testing shall be as shown in Table 6.1-I unless otherwise specified.

6.1.3 Test Equipment Accuracy

The accuracy of the instruments and test equipment shall be verified periodically by calibration procedures traceable to SS/L approved reliability standards. Measurement accuracies to be considered in the selection of test equipment shall be specified in test plans and procedures by the manufacturer. Measurement methods are for guidelines only.

RF Power Levels:		<±0.1 dB
Return Loss:	>20 dB:	±1.0 dB
	≤20 dB:	±0.5 dB
Spurious Level:	0 to -20 dBc	±0.5 dB
	<-20 to -80 dBc	<±1.0 dB
Frequencies:	<20 kHz:	10 ppm
	20 kHz to 10 MHz:	1 ppm
	Above 10 MHz:	0.01 ppm
	Stability, drift:	0.1 ppm
Voltages:	<5 volts:	≤0.2%
	5 to 50 volts:	≤0.5%
	>50 volts:	≤0.5%
Currents:	<1 ampere:	≤0.5%
	>1 ampere:	≤1.0%
	DC Power:	≤1.0%

6.1.3.1 RF Tests

All RF test requirements shall be specified in the unit specification.

6.1.4 Telemetry and Command Functional

Tests shall be conducted to assure that all command and telemetry circuits are functioning properly. Measure and record all telemetry voltages and status indicators.

Full range calibration curves are to be provided for all units producing analog telemetry outputs. These curves are to be derived from measured data (at lower assembly level if necessary) for each individual unit at cold, ambient, and hot temperature dwells.

6.1.5 Overdrive

All units with microwave semiconductors and an RF input shall be tested for overdrive in their most sensitive active operational mode and with the unit off.

6.2 Unit Test Requirements

6.2.1 General

Testing shall be accomplished in accordance with the requirements specified below. A typical unit qualification, protoflight, or acceptance test sequence is shown in Figure 6.2-1.

6.2.2 Classification of Tests

Testing shall be classified as follows:

a. Development Tests

b. Engineering Qualification Model (EQM)/Qualification Tests

c. Protoflight Test

d. Acceptance Tests

e. Life Tests

6.2.3 Development Tests

Development tests shall be conducted to identify specific problem areas early in the design development cycle in order that design or interfacing requirements may be altered to achieve the overall system requirements. It is particularly important to identify problem areas early in order that corrective measures can be taken to achieve the required performance. The development testing shall include the tests at qualification levels plus the verification of the EMC requirements.

6.2.4 EQM/Qualification Tests

EQM/Qualification testing shall be performed on a flight configuration unit in accordance with the test matrix and test sequence shown in the applicable unit specification test matrix.

For units with internal redundancy, all operating cycles must be performed on both primary and redundant items/modules.

All units are to have the applicable voltage present during pumpdown for Thermal Vacuum Chamber (TVAC) testing (e.g., 100 volts present at input of a 100 volt unit).

6.2.4.1 Reference Functional Test

With the equipment at ambient temperature and pressure, measure the parameters shown in the applicable unit specification test matrix.

6.2.4.2 Dynamic Tests

6.2.4.2.1 Sine Vibration

The following conditions shall apply:

a. A vibration survey shall be conducted prior to performing the tests specified in 6.2.4.2.1(b). Successful completion of this survey shall be a requirement for qualification testing. The transmissibility and crosstalk of the test fixture, with the unit mounted to the fixture through the normal mounting points, shall be determined by swept sinusoid or low level random vibration applied in each of the three orthogonal axes. Transmissibility between component mounting feet shall not exceed a factor of +3 dB. crosstalk shall not exceed input.

b. The unit shall be vibrated at the qualification level and sweep rate shown in Tables 3.4.3-II. Vibration shall be applied consecutively in each of the three orthogonal axes. The parameters shown in the applicable unit specification test matrix shall be measured and the equipment shall operate without failure, malfunction, or out-of-tolerance performance during the vibration test and post-dynamic functional testing.

6.2.4.2.2 Random Vibration

The following conditions shall apply:

a. The conditions of 6.2.4.2.1(a) shall apply. If sine vibration in the same axis is performed immediately before or after random vibration, with no change being made to the test setup, the vibration survey need not be repeated. However, the requirements of 6.2.4.2.1(a) shall be conducted immediately prior to random vibration under all other circumstances.

b. The equipment shall be vibrated at the qualification level and duration shown in Tables 3.4.3-II. Vibration shall be applied consecutively in each of the three orthogonal axes. The parameters shown in the applicable unit specification test matrix shall be measured and the equipment shall operate without failure, malfunction, or out-of-tolerance performance during the vibration test and post-dynamic functional testing.

6.2.4.2.3 Shock Response

The specified shock responses spectra shall be applied a minimum of three times in each axis for Qualification testing. In the case where the shock test excitation is primarily in a single axis (e.g., a Mechanical Impact Pryoshock Simulation (MIPS) or a shaker test), a minimum of nine pyrotechnic shock tests are required – three in each of three orthogonal axes.

If the shock test produces high responses in more than one axis (e.g., a test on a plate excited by primicord attached to the plate), the shock requirement may be satisfied with less than nine tests. If a single shock test produces the required shock response spectra in all three axes, the requirement for testing the unit one time in each of the three axes is satisfied. In this case, the requirement of applying the specified shock spectrum three times in each axis can be satisfied by performing this test three times.

If a single pyrotechnic shock test produces the specified shock response spectra in two axes, but under tests the third axis, performing this test three times satisfies the requirement of three shocks in these two axes. However, three additional shock tests in the under-tested axis are required to satisfy the three-shock requirement for this axis.

All units must demonstrate appropriate shock input to the entire mounting footprint of the unit. This allows the use of the unit in any orientation with respect to the shock source.

In all cases, electronic spreadsheet data for each axis shall be provided for each shock test to verify that the shock requirement in that axis is satisfied. In addition to the Shock Response Spectrum (SRS) plots, acceleration vs. frequency data shall be provided electronically in spreadsheet or text format. SRS computations shall be made at a minimum of 1/12 octave intervals up to 10,000 Hz minimum.

Although not a requirement, it is recommended that a mass mockup of the actual test item be used to set-up the test levels prior to performing the test on the qualification unit. The mass mock-up and test unit shall be mounted in the same manner as on the spacecraft.

6.2.4.2.4 Post Dynamic Functional Test

With the equipment at ambient temperature and pressure, measure the parameters shown in the applicable unit specification test matrix. See Figure 6.2-1 Typical Unit Test Sequence.

6.2.4.3 Temperature Cycling/Thermal Vacuum Test

A thermal vacuum test shall be performed at the temperature limits and test parameters listed in the applicable unit specification.

a. The equipment shall be mounted within the environmental chamber on a conductive isothermal heat sink in a manner which simulates the type of mounting provisions to be used in the spacecraft (see Section 3.5.4 Unit Thermal Environment).

b. The chamber radiation environmental temperature shall be controlled to the same temperature as the isothermal mounting heat sink. Alternately, an adiabatic cover (blanket) may be used. For all units, temperature instrumentation should be located at both the unit baseplate and isothermal mounting heat sink (see Figure 3.5-5) and temperatures reported.

c. The unit baseplate and radiation shroud temperature shall be stabilized. Temperature stabilization has been reached when three consecutive temperature readings taken five minutes apart are within the specified 3 °C temperature tolerance range.

d. Transition from minimum to maximum temperatures shall attempt to achieve a nominal transition rate between 3 to 5 °C per minute, with a transition rate of not less than 1 °C per minute.

e. The unit shall dwell at the specified high and low temperature after temperature stabilization has been achieved. [The dwell time shall be one hour or for all parts to be within 1 °C of the projected steady state temperature.] Stability shall be achieved prior to initiating temperature transitions or prior to conducting any testing (turn-on, turn-off, performance, etc.).

f. The equipment shall be turned on, if required, and subjected to depressurization at ambient temperature to a chamber pressure of 1×10^{-5} torr or less. The chamber pressure shall remain at 1×10^{-5} torr or less for the remainder of the test.

g. The equipment shall be subjected to the steps and cycles of the unit thermal vacuum test profile shown in Figure 6.2-2. Any variations from the test profile of Figure 6.2-2 are to be submitted to SS/L for review and approval, and shall be documented in a program ERS addendum to this specification.

h. The temperature shall be controlled during each phase of the test indicated in Figure 6.2-2 per the specifications in Table 3.5-I.

6.2.4.3 Temperature Cycling/Thermal Vacuum Test (Continued)

i. Turn-on capability shall be demonstrated at temperature extremes as indicated in the thermal vacuum profile of Figure 6.2-2.

j. Thermal vacuum cycles and performance tests shall be conducted as indicated in Figure 6.2-2. Tests shall be performed in accordance with the applicable unit specification test matrix within specification requirements.

k. For units with internal redundancy, all operating cycles must be performed on both primary and redundant items/modules.

l. All units are to have the applicable voltage present during pumpdown for TVAC testing (e.g., 100 volts present at input of a 100 volt unit).

m. Temperature data, including temperature levels, soak times, and transition rates, shall be recorded and included in the test data package.

6.2.4.4 Final Functional Test

With the equipment at ambient temperature and pressure, measure the parameters shown in the applicable unit specification test matrix.

6.2.4.5 ESD Test Requirements for Units

For each unit (electrical/electronics box), no malfunction or degradation of performance shall occur when the equipment is subjected to an electrostatic arc discharge as defined in Section 3.3.3.

6.2.4.6 ESD Requirements for Evaluation of Currents Induced in Harnesses

All units shall be verified that they are not damaged or upset by ESD currents that are induced in the harness wires or cables (except RF) leading into or out of the unit. Unit level verification can be tested for ESD susceptibility using all harness and cables (except RF) going to or from the unit as part of the qualification test. Cables shall be flight or flight-like. Cables shall be tested by the coupled method using a wire adjacent to the harness. The pulse shall be monitored during the test. The circuit used and the test configuration shall be fully described in the ESD test procedure. ESD pulse characteristics are defined in Section 3.3.3.

The pulse shall be discharged through a test cable that is at least 0.2 meters long for the section that is adjacent to the cable under test and as close as practical to the device under test. The pulse test return/supply wires shall be at least 0.1 meter from the cable under test and parallel to it. For heritage equipment, this harness ESD test can be waived.

6.2.5 Protoflight Tests

Protoflight testing shall be performed on a flight configuration unit in accordance with 6.2.4.1 through 6.2.4.4 and the unit specification.

For units with internal redundancy, all operating cycles must be performed on both primary and redundant items/modules.

6.2.6 Acceptance Tests

Acceptance testing shall be performed on a flight configuration unit in accordance with 6.2.4.1 through 6.2.4.4 and the unit specification.

For units with internal redundancy, all operating cycles must be performed on both primary and redundant items/modules.

All units are to have the applicable voltage present during pumpdown for TVAC testing (e.g., 100 volts present at input of a 100 volt unit).

6.3 Recording of Data

Data recorded during test shall include accumulated operating hours and connector mate/demate cycles. This information shall be included in the test data package.

6.4 Test Failures

a. For subcontracted units: If a failure occurs during or after a qualification, protoflight or acceptance test, SS/L shall be notified in accordance with the requirements of the Subcontractor Mission Assurance Requirements (see Section 1.1). A complete record of all failures shall be maintained for each unit and submitted to SS/L with the unit test data package.

b. For SS/L built units: If a failure occurs during or after qualification, protoflight, or acceptance test, a nonconformance report shall be generated in accordance with the Quality Assurance Quality System. A complete record of all failures shall be maintained for each unit and included with the appropriate unit test data package.

7. ABBREVIATIONS

ACE	Attitude Control Electronics
AL	Anomalously Large
AMF	Apogee Maneuver Firing
AU	Astronomical Unit
BOL	Beginning of Life
CAGE	Contractor and Government Entity
COMM or Comm.	Communications
CW	Continuous Wave
DC	Direct Current
DHE	Data Handling Electronics
DLF	Design Load Factor
EED	Electro-Explosive Device
EMI	Electromagnetic Interference
EMC	Electromagnetic Compatibility
EOL	End of Life
EQM	Engineering Qualification Model
ERS	Environmental Requirements Specification
ESD	Electrostatic Discharge
FIT	Failures in Test
GEO	Geosynchronous Equatorial Orbit
GFR	Graphite-Fiber-Reinforced
HIEO	Highly Inclined Elliptical Orbit
HSD	High-Side Driver
IC	Integrated Circuit
ICD	Interface Control Drawing
LET	Linear Energy Transfer
LPG	Local Panel Ground
LV	Launch Vechile
LVC	Low Voltage Converter
MIPS	Mechanical Impact Pryoshock Simulation
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
MSEC	Millisecond
MS-QSA	Mini-Specification Qualification Status Analysis
MST	Main Satellite Thruster

7 Abbreviations (Continued)

OMUX	Output Multiplexer
OSR	Optical Solar Reflector
PIM	Passive Intermodulation
PWB	Printed Wiring Board
RAD	Radiation Absorbed Dose
RF	Radio Frequency
RFI	Radio Frequency Interference
ROM	Read-Only Memory
SADA	Solar Array Drive Assembly
S/C	Spacecraft
SCD	Source Control Drawing
SCE	Spacecraft Control Electronics
SDRL	Subcontract Data Requirements List
SEB	Single Event Burnout
SEE	Single Event Effects
SEGR	Single Event Gate Rupture
SEL	Single Event Latchup
SET	Single Event Transient
SEU	Single Event Upset
SIA	Serial Interface Adapter
SMA	Subminiature Assembly
SPT	Stationary Plasma Thruster
SRS	Shock Response Spectrum
SSD	Split Spool Device
SSPA	Solid-State Power Amplifier
SS/L	Space Systems/LORAL
T&F	Tables and Figures
TC&R	Telemt
TNC	Terminal Network Controller
TTL	Transistor-Transistor Logic
TVAC	Thermal Vacuum Chamber
TWT	Traveling Wave Tube
TWTA	Traveling Wave Tube Amplifier
UNF	Unified Fine Thread

8. T&F - TABLES AND FIGURES

This section contains the tables and figures for the document. The tables and figures are sectioned according to the text sections.

8.1 T&F - Scope

There are no tables and figures for Scope section.

8.2 T&F - Applicable Documents

There are no tables and figures for Applicable Documents section.

8.3 T&F - Environmental Requirements

Tables and figures for Environmental Requirements are in the stated sub-sections.

8.3.1 T&F - General Requirements

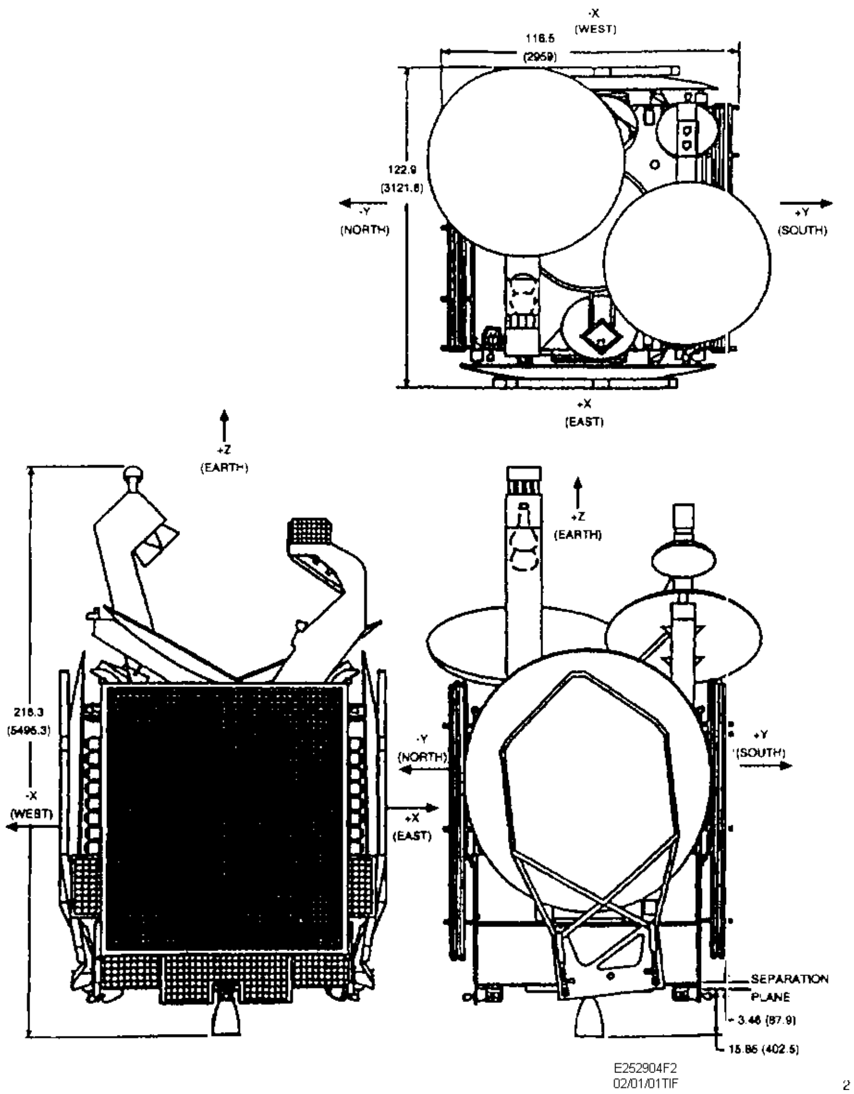


Figure 3.1-1. Stowed Configuration Typical SS/L Satellite

8.3.2 T&F - Radiation and Micrometeoroids

Table 3.2-I. Electron Flux Design Requirements for Various GEO Orbit Locations

1. Electronics shall be evaluated with 160°W orbit location.
2. Solar Array and OSR's shall use program orbit location.

Electron Flux electrons/(cm^2-s^1) ≥ E

Energy (MeV)	0 °E	20 °E	40 °E	60 °E	80 °E	100 °E	120 °E	140 °E	160 °E	180 °E	160 °W	140 °W	120 °W	100 °W	80 °W	60 °W	40 °W	20 °W
	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340
4.00E-02	4.39E+07	4.45E+07	4.42E+07	4.33E+07	4.23E+07	4.16E+07	4.18E+07	4.28E+07	4.45E+07	4.60E+07	4.64E+07	4.53E+07	4.27E+07	4.00E+07	3.84E+07	3.86E+07	4.02E+07	4.23E+07
1.00E-01	2.96E+07	3.01E+07	2.99E+07	2.91E+07	2.83E+07	2.77E+07	2.79E+07	2.88E+07	3.03E+07	3.16E+07	3.19E+07	3.09E+07	2.86E+07	2.61E+07	2.47E+07	2.49E+07	2.63E+07	2.81E+07
2.50E-01	1.01E+07	1.04E+07	1.03E+07	9.97E+06	9.61E+06	9.39E+06	9.45E+06	9.85E+06	1.05E+07	1.11E+07	1.12E+07	1.07E+07	9.72E+06	8.68E+06	8.09E+06	8.15E+06	8.73E+06	9.51E+06
5.00E-01	2.61E+06	2.69E+06	2.67E+06	2.57E+06	2.46E+06	2.39E+06	2.41E+06	2.54E+06	2.74E+06	2.93E+06	2.97E+06	2.81E+06	2.49E+06	2.17E+06	1.99E+06	2.00E+06	2.18E+06	2.42E+06
7.50E-01	9.78E+05	1.03E+06	1.01E+06	9.62E+05	9.04E+05	8.69E+05	8.80E+05	9.49E+05	1.06E+06	1.16E+06	1.18E+06	1.10E+06	9.15E+05	7.43E+05	6.53E+05	6.59E+05	7.47E+05	8.72E+05
1.00E+00	4.16E+05	4.34E+05	4.29E+05	4.10E+05	3.87E+05	3.74E+05	3.78E+05	4.04E+05	4.47E+05	4.86E+05	4.94E+05	4.61E+05	3.92E+05	3.26E+05	2.91E+05	2.93E+05	3.28E+05	3.76E+05
1.50E+00	1.02E+05	1.07E+05	1.06E+05	1.00E+05	9.41E+04	9.04E+04	9.16E+04	9.88E+04	1.11E+05	1.22E+05	1.24E+05	1.15E+05	9.53E+04	7.72E+04	6.76E+04	6.83E+04	7.75E+04	9.07E+04
2.00E+00	3.28E+04	3.48E+04	3.43E+04	3.23E+04	2.99E+04	2.86E+04	2.90E+04	3.18E+04	3.64E+04	4.06E+04	4.15E+04	3.79E+04	3.04E+04	2.36E+04	2.02E+04	2.04E+04	2.37E+04	2.86E+04
2.50E+00	8.40E+03	8.96E+03	8.83E+03	8.25E+03	7.60E+03	7.22E+03	7.35E+03	8.13E+03	9.47E+03	1.07E+04	1.09E+04	9.88E+03	7.71E+03	5.82E+03	4.88E+03	4.94E+03	5.84E+03	7.19E+03
3.00E+00	3.02E+03	3.21E+03	3.16E+03	2.97E+03	2.76E+03	2.63E+03	2.67E+03	2.93E+03	3.36E+03	3.77E+03	3.86E+03	3.50E+03	2.79E+03	2.16E+03	1.85E+03	1.87E+03	2.17E+03	2.63E+03
3.50E+00	1.26E+03	1.34E+03	1.32E+03	1.24E+03	1.15E+03	1.10E+03	1.11E+03	1.22E+03	1.41E+03	1.57E+03	1.60E+03	1.47E+03	1.17E+03	9.00E+02	7.65E+02	7.74E+02	9.03E+02	1.09E+03
4.00E+00	3.80E+02	3.97E+02	3.92E+02	3.74E+02	3.53E+02	3.41E+02	3.45E+02	3.69E+02	4.09E+02	4.46E+02	4.55E+02	4.22E+02	3.58E+02	2.96E+02	2.64E+02	2.66E+02	2.98E+02	3.43E+02
4.50E+00	1.00E+02	1.05E+02	1.03E+02	9.89E+01	9.36E+01	9.05E+01	9.15E+01	9.75E+01	1.07E+02	1.17E+02	1.19E+02	1.11E+02	9.48E+01	7.94E+01	7.12E+01	7.18E+01	7.99E+01	9.11E+01
5.00E+00	3.35E+00	3.60E+00	3.54E+00	3.28E+00	2.99E+00	2.82E+00	2.88E+00	3.23E+00	3.83E+00	4.41E+00	4.53E+00	4.02E+00	3.04E+00	2.21E+00	1.81E+00	1.84E+00	2.22E+00	2.81E+00

Table 3.2-II. Proton Flux (Including Solar Flares) and Alpha Particles for Design of All Spacecraft Items

ENERGY E MeV	PROTON FLUX proton/(cm^2-s^1) ≥ E	ALPHA FLUX alpha/(cm^2-s^1) ≥ E
0.01	2.88×10^7	-----
0.03	2.14×10^7	-----
0.05	1.59×10^7	-----
0.10	7.60×10^6	-----
0.50	1.10×10^5	-----
1.00	2.95×10^3	1.48×10^2
4.00	5.28×10^2	2.64×10^1
10.00	2.31×10^2	1.16×10^1
30.00	8.50×10^1	4.25×10^0
60.00	2.66×10^1	1.33×10^0
100.00	5.95×10^0	2.98×10^{-1}

Table 3.2-III. Cosmic Ray Spectrum

GALACTIC COSMIC RAYS REPRESENTATIVE FLUX	
CHARGE (ELEMENT)	FLUX particles/(cm^2-s^1) ≥ E
1 (Hydrogen)	4.00
2 (Helium)	0.500
8 (Oxygen)	0.030
14 (Silicon)	0.007
26 (Iron)	0.003
ABUNDANCE BY CHARGE GROUPS COMPARED TO He GIVEN ABOVE	
3 < z < 5	1/48
6 < z < 9	1/16
10 < z < 14	1/75
15 < z < 19	1/600
20 < z < 30	1/200
30 < z	1/800000

Z = Atomic Number

Table 3.2-IV. Seasonal Variations in Solar Energy

SEASONAL VARIATIONS IN SOLAR ENERGY	
SEASON	RELATIVE SOLAR INTENSITY
Summer Solstice	0.968
Vernal Equinox	1.008
Winter Solstice	1.035
Autumnal Equinox	0.993

Table 3.2-V. Ultraviolet Radiation

WAVELENGTH Å	FRACTION OF TOTAL ENERGY BELOW WAVELENGTH hc/λ	ENERGY ergs/(cm^2-year)
1	1.0×10^{-11}	1×10^{2} to 1×10^{3}
10	1.0×10^{-8}	1×10^{5} to 1×10^{6}
100	1.0×10^{-7}	1×10^{7} to 1×10^{8}
500	1.0×10^{-6}	1.0×10^{8}
1000	1.0×10^{-5}	4.0×10^{8}
1500	6.0×10^{-5}	2.5×10^{9}
2000	1.5×10^{-4}	6.0×10^{9}
2500	2.1×10^{-3}	9.0×10^{10}
3000	1.2×10^{-2}	5.0×10^{11}
4000	9.0×10^{-2}	4×10^{12}
5000	2.4×10^{-1}	1.1×10^{13}

Note: Values are determined from a solar constant of 1400 W/m^2 at 1 Astronomical Unit (AU).

Table 3.2-VI. Solar Spectral Irradiance

λ	E_λ	$D_{o-\lambda}$	λ	E_λ	$D_{o-\lambda}$	λ	E_λ	$D_{o-\lambda}$
0.12	0.1	$4x10^{-4}$	0.43	1639	12.47	0.90	891	63.37
0.14	0.03	$5x10^{-4}$	0.44	1810	13.73	1.00	748	69.49
0.16	0.23	$7x10^{-4}$	0.45	2006	15.14	1.2	485	78.40
0.18	1.25	$1.7x10^{-3}$	0.46	2066	16.56	1.4	337	84.33
0.20	10.7	$8.1x10^{-3}$	0.47	2033	18.17	1.6	245	88.61
0.22	57.5	0.05	0.48	2074	19.68	1.8	159	91.59
0.23	66.7	0.10	0.49	1950	21.15	2.0	103	93.49
0.24	63.0	0.14	0.50	1942	22.60	2.2	79	94.83
0.25	70.9	0.19	0.51	1882	24.01	2.4	62	95.86
0.26	130	0.27	0.52	1833	25.38	2.6	48	96.67
0.27	232	0.41	0.53	1842	26.74	2.8	39	97.31
0.28	222	0.56	0.54	1783	28.08	3.0	31	97.83
0.29	482	0.81	0.55	1725	29.38	3.2	22.6	98.22
0.30	514	1.21	0.56	1695	30.65	3.4	16.6	98.50
0.31	689	1.66	0.57	1712	31.91	3.6	13.5	98.72
0.32	830	2.22	0.58	1715	33.18	3.8	11.1	98.91
0.33	1059	2.93	0.59	1700	34.44	4.0	9.5	99.06
0.34	1074	3.72	0.60	1666	35.68	4.5	5.9	99.34
0.35	1093	4.52	0.62	1602	38.10	5.0	3.8	99.51
0.36	1068	5.32	0.64	1544	40.42	6.0	1.8	99.72
0.37	1181	6.15	0.66	1486	42.66	7.0	1.0	99.82
0.38	1120	7.00	0.68	1427	44.81	8.0	0.6	99.89
0.39	1098	7.82	0.70	1369	46.88	10.0	0.25	99.94
0.41	1429	8.73	0.72	1314	48.86	15.0	$4.9x10^{-2}$	99.98
0.41	1751	9.92	0.75	1235	51.69	20.0	$1.6x10^{-2}$	99.99
0.42	1747	11.22	0.80	1109	56.02	50.0	$3.8x10^{-4}$	100.00

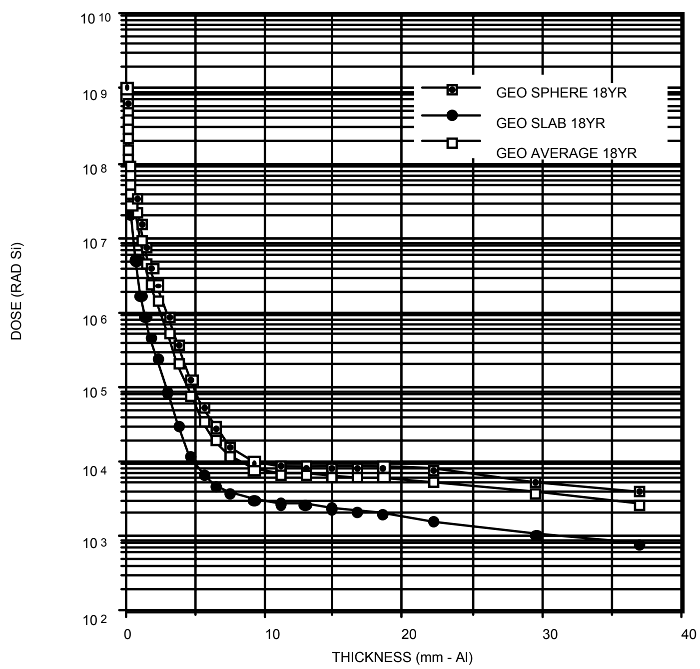
λ	Wavelength (μm)
E_λ	Solar spectral irradiance averaged over small bandwidth centered at λ in W x m^{-2} x μm^{-1}.
$D_{o-\lambda}$	Percentage of the solar constant associated with wavelengths shorter than λ.
Solar Constant	= 1353 W x m^{-2}

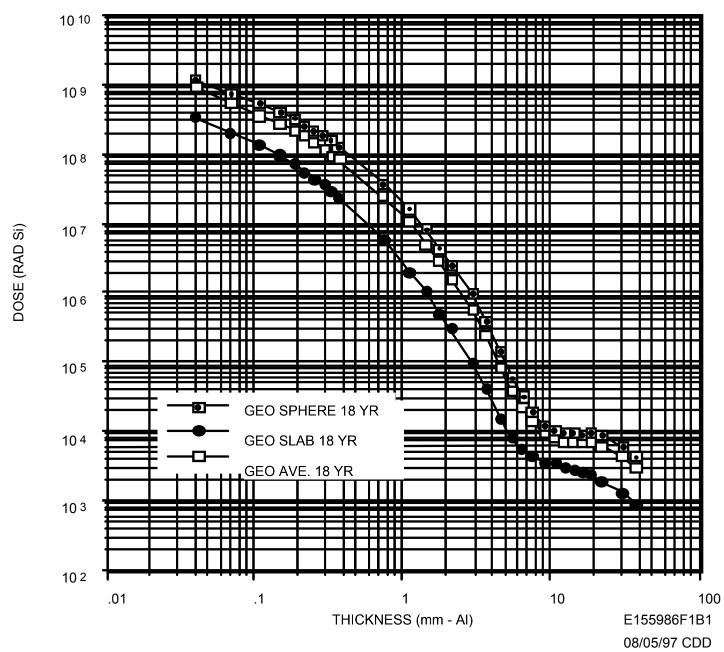
Table 3.2-VII. Electron Flux Model for Solar Cell Design for Specific Orbital Location and Lifetime

Deleted – use Table 3.2-I Electron Flux Design Requirements

Table 3.2-VIII. Solar Flare Proton Model for Solar Cell Design for Specific Orbital Location and Lifetime

Deleted – use Table 3.2-II Proton Flux (Including Solar Flares) and Alpha Particles for Design of All Spacecraft Items





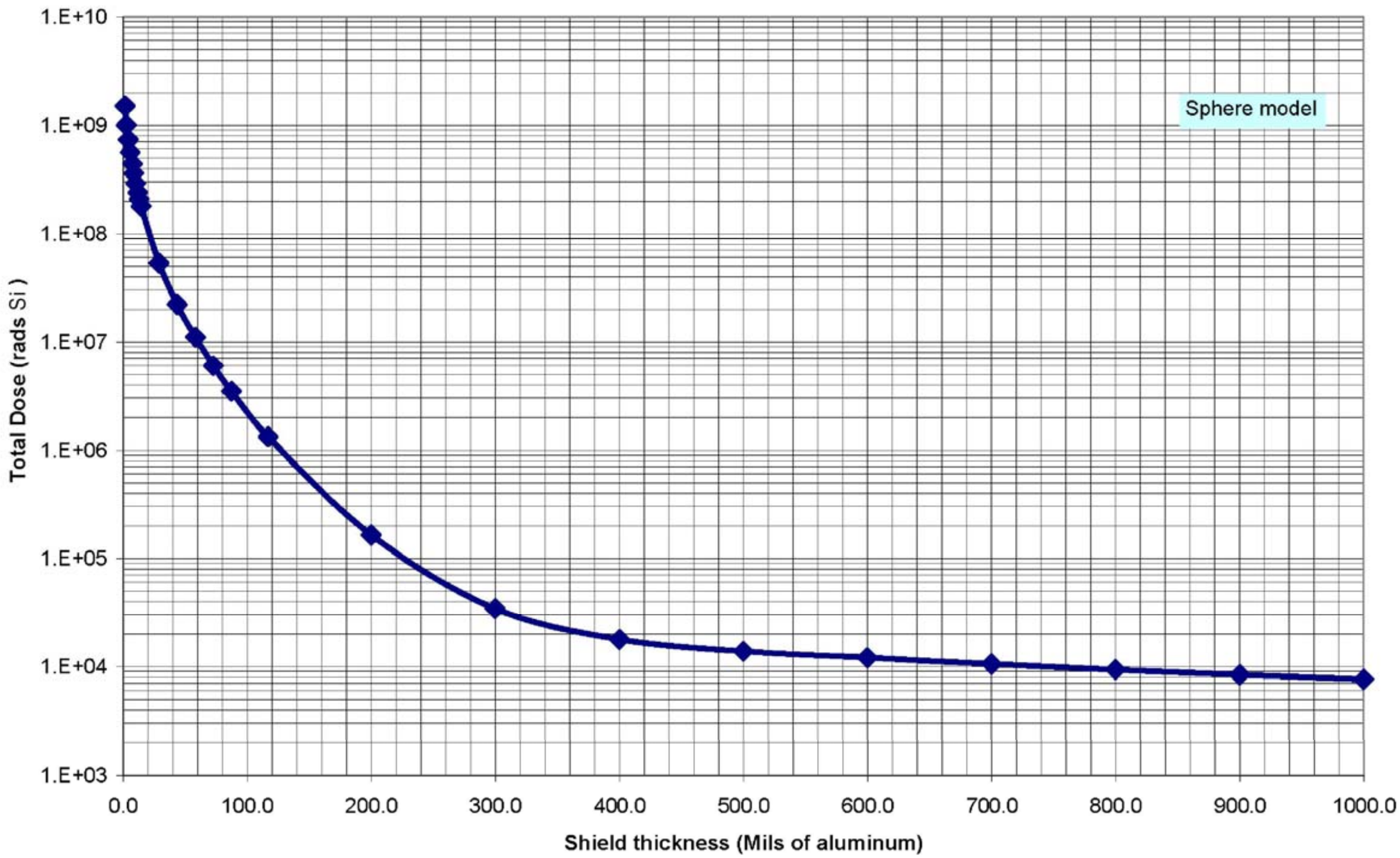
(See Table 3.2-IX)

Figure 3.2-1. Heritage Equipment Dose Versus Thickness Curves
(18 years at 160 °W GEO)

Table 3.2-IX. Heritage Equipment Dose Versus Thickness Table
(18 YEARS AT 160 °W GEO)

(See Figure 3.2-1)

THICKNESS	SPHERE	GEO SLAB	GEO AVE
(mm-Al)	Dose (Rads-Si)	Dose (Rads-Si)	Dose (Rads-Si)
0.04	1215600000	365400000	973200000
0.07	810600000	210840000	616200000
0.11	587760000	140280000	434040000
0.15	449400000	100320000	326400000
0.19	354240000	75084000	252240000
0.22	285000000	58080000	200640000
0.26	234960000	46020000	162600000
0.30	195840000	37236000	135120000
0.33	165120000	30600000	113184000
0.37	140520000	25500000	95760000
0.74	42000000	6547200	27552000
1.11	17856000	2053200	11409600
1.48	8791200	1123800	5520000
1.85	4779600	569400	2959200
2.22	2782800	309600	1700400
2.96	1065840	103980	636600
3.70	428040	39780	253800
4.63	151800	15576	91476
5.56	65376	8340	41040
6.48	35136	5660	23232
7.41	19236	4578	14184
9.26	12024	3844	9864
11.11	10734	3490	8856
12.96	10182	3198	8290
14.81	9880	2940	7880
16.67	9766	2694	7578
18.52	9652	2443	7269
22.22	9208	1930	6534
29.63	6270	1294	4428
37.04	4666	933	3268



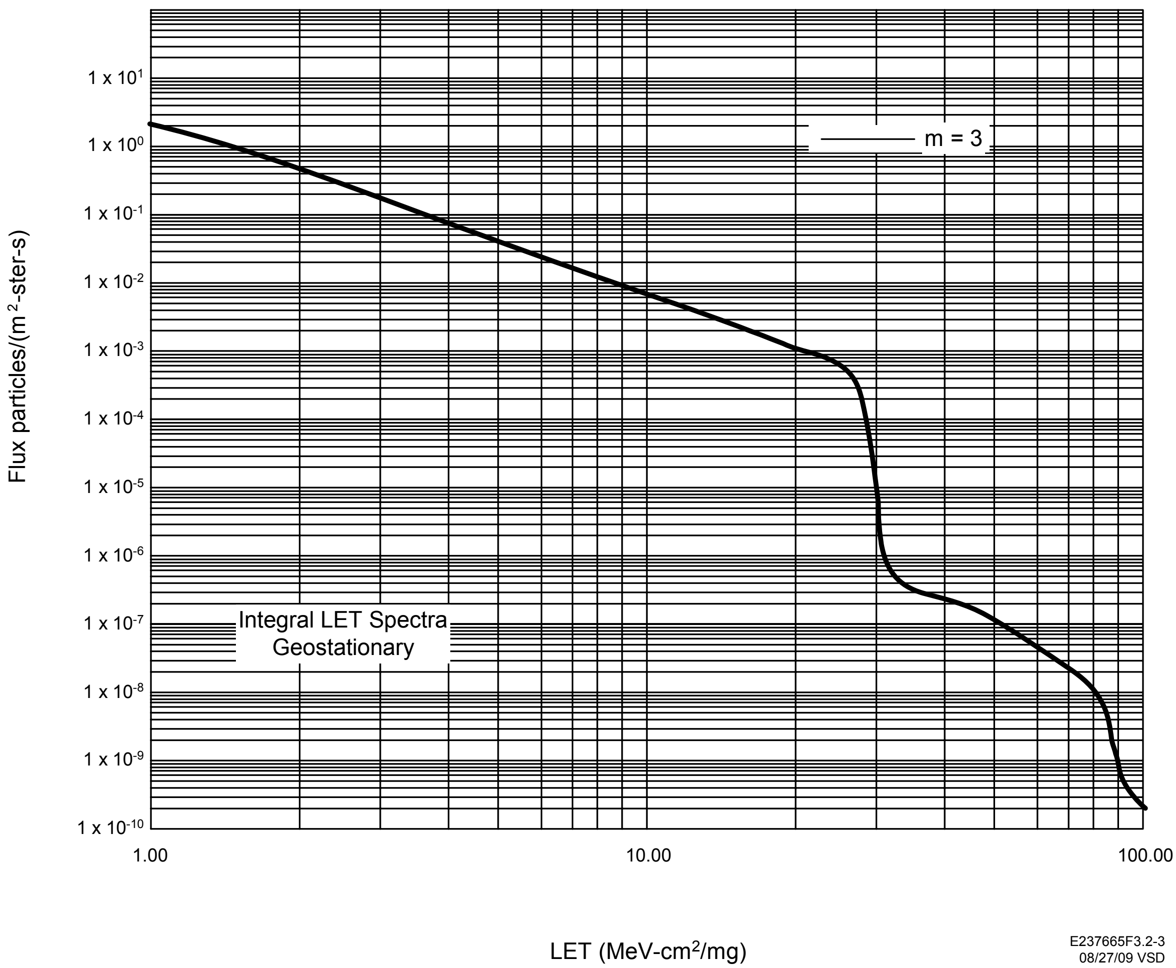
(See Table 3.2-X)

Figure 3.2-2. Dose Versus Thickness for a Worst-Case 22.5-Year GEO or 18-Year HIEO Radiation Lifetime (Sphere Model)

Table 3.2-X. Dose Versus Thickness for a Worst-Case 22.5-Year GEO or 18-Year HIEO Radiation Lifetime (Sphere Model)

(See Figure 3.2-2)

THICKNESS		**DOSE (Sphere Model)**
(mm-Al)	**(mils-Al)**	**(rads-Si)**
0.04064	1.6	1.50E+09
0.07112	2.8	1.00E+09
0.10922	4.3	7.30E+08
0.14986	5.9	5.60E+08
0.1905	7.5	4.40E+08
0.22098	8.7	3.60E+08
0.25908	10.2	2.90E+08
0.29972	11.8	2.40E+08
0.3302	13	2.10E+08
0.37084	14.6	1.80E+08
0.73914	29.1	5.30E+07
1.10998	43.7	2.20E+07
1.48082	58.3	1.10E+07
1.84912	72.8	5.97E+06
2.21996	87.4	3.48E+06
2.9718	117	1.33E+06
5.08	200	1.64E+05
7.62	300	3.42E+04
10.16	400	1.78E+04
12.7	500	1.38E+04
15.24	600	1.20E+04
17.78	700	1.05E+04
20.32	800	9.33E+03
22.86	900	8.40E+03
25.4	1000	7.63E+03



(See Table 3.2-XI)

Figure 3.2-3. Integral LET Spectra for Geostationary Orbit, M=3

Table 3.2-XI. Integral LET Spectra for Geostationary Orbit, M=3

(See Figure 3.2-3)

Integral LET Spectra m = 3		Integral LET Spectra m = 3 (cont'd)	
LET Mev cm^2/mg	Flux Particles/(m^2 -ster- s)	LET Mev cm^2/mg	Flux Particles/(m^2 -ster- s)
0.95	2.49	10.27	8.29×10^{-3}
1.00	2.33	10.90	7.07×10^{-3}
1.07	2.18	11.57	5.99×10^{-3}
1.13	2.04	12.28	4.99×10^{-3}
1.20	1.59	13.03	4.22×10^{-3}
1.28	1.32	13.83	3.51×10^{-3}
1.35	1.10	14.68	2.92×10^{-3}
1.44	9.41×10^{-1}	15.58	2.47×10^{-3}
1.53	8.12×10^{-1}	16.54	2.05×10^{-3}
1.62	7.03×10^{-1}	17.55	1.73×10^{-3}
1.72	6.12×10^{-1}	18.63	1.43×10^{-3}
1.82	5.32×10^{-1}	19.78	1.17×10^{-3}
1.94	4.61×10^{-1}	20.99	9.37×10^{-4}
2.05	4.00×10^{-1}	22.28	7.29×10^{-4}
2.18	3.47×10^{-1}	23.65	5.40×10^{-4}
2.31	3.01×10^{-1}	25.10	3.82×10^{-4}
2.46	2.62×10^{-1}	26.64	2.31×10^{-4}
2.61	2.27×10^{-1}	28.28	4.81×10^{-5}
2.77	1.98×10^{-1}	30.01	8.30×10^{-6}
2.94	1.72×10^{-1}	31.86	9.97×10^{-7}
3.12	1.50×10^{-1}	33.81	6.01×10^{-7}
3.31	1.30×10^{-1}	35.89	4.69×10^{-7}
3.51	1.13×10^{-1}	38.09	3.73×10^{-7}
3.73	9.81×10^{-2}	40.43	2.99×10^{-7}
3.96	8.53×10^{-2}	42.91	2.35×10^{-7}
4.20	7.41×10^{-2}	45.55	1.88×10^{-7}
4.46	6.44×10^{-2}	48.35	1.51×10^{-7}
4.73	5.60×10^{-2}	51.32	1.18×10^{-7}
5.02	4.85×10^{-2}	54.47	9.17×10^{-8}
5.33	4.20×10^{-2}	57.81	6.81×10^{-8}
5.66	3.65×10^{-2}	61.36	4.97×10^{-8}
6.01	3.17×10^{-2}	65.13	3.59×10^{-8}
6.37	2.74×10^{-2}	69.13	2.69×10^{-8}
6.77	2.37×10^{-2}	73.37	1.95×10^{-8}
7.18	2.04×10^{-2}	77.88	1.34×10^{-8}
7.62	1.75×10^{-2}	82.66	8.15×10^{-9}
8.09	1.52×10^{-2}	87.73	3.63×10^{-9}
8.59	1.31×10^{-2}	93.12	4.11×10^{-10}
9.11	1.13×10^{-2}	98.84	2.12×10^{-10}

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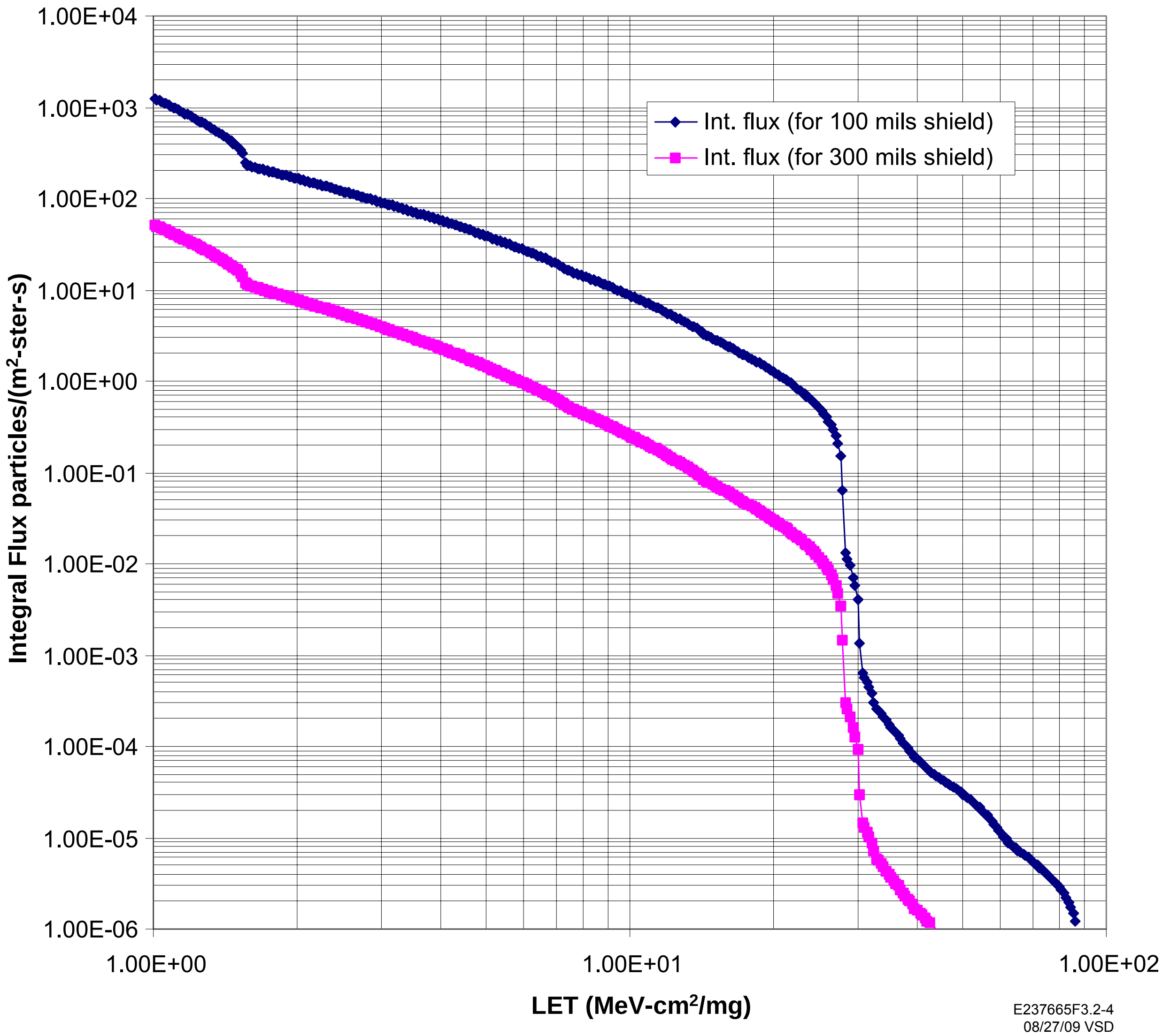


Figure 3.2-4. Integral LET Spectra (Flux) for an Anomalously Large Solar Flare Event Calculation

Refer to radiation related sections in Section 3.2

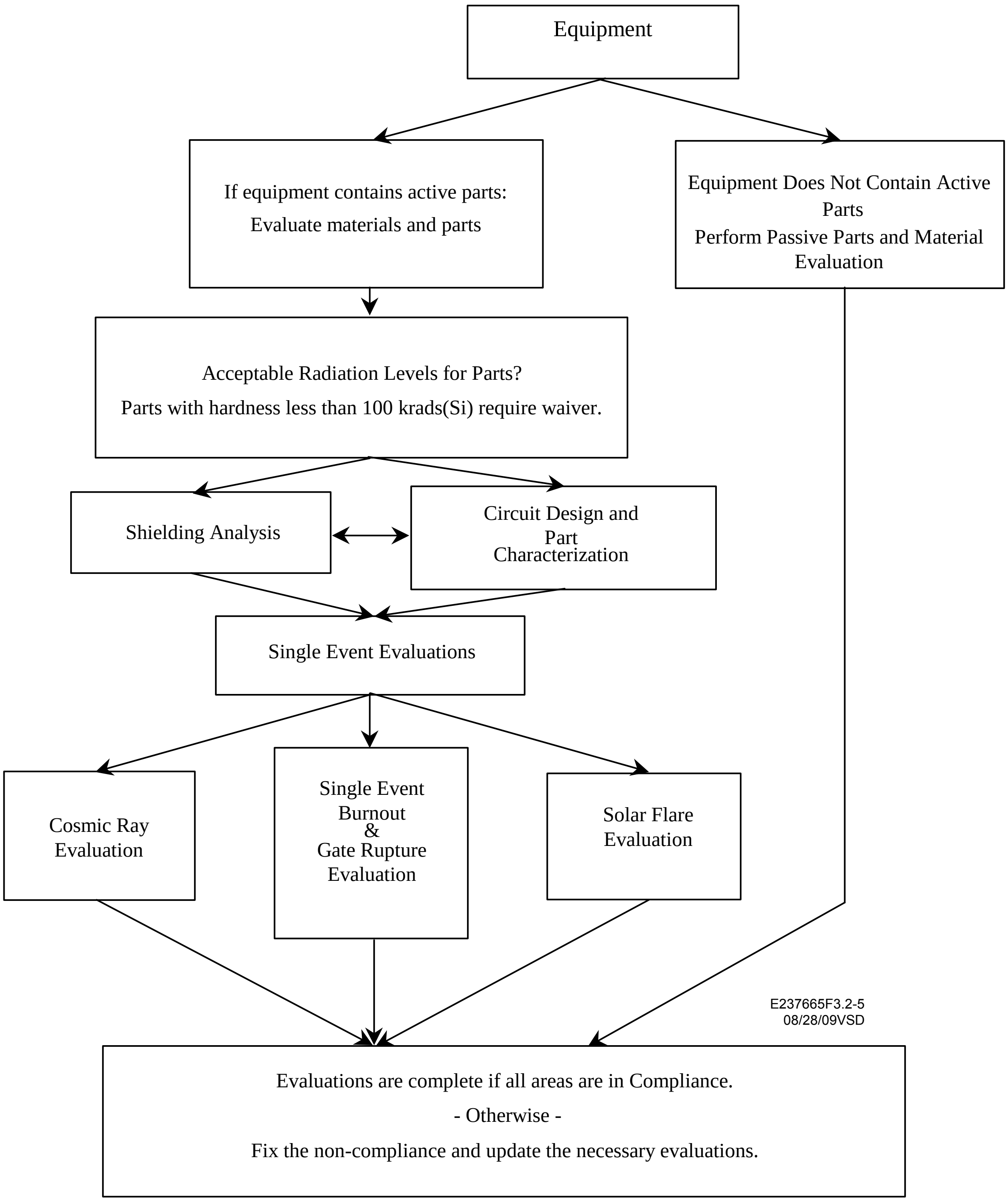


Figure 3.2-5. Steps Required for Radiation Analysis

Table 3.2-XII. Meteoroid Flux Model by Mass

NASA SP 8013, dated March 1969

Mass M (g)	Meteoroid Flux events/(m^2-day) ≥ M
1×10^{-12}	1.9×10^{0}
1×10^{-11}	1.3×10^{0}
1×10^{-10}	7.1×10^{-1}
1×10^{-9}	3.3×10^{-1}
1×10^{-8}	9.3×10^{-2}
1×10^{-7}	2.0×10^{-2}
1×10^{-6}	3.8×10^{-3}
1×10^{-5}	2.3×10^{-4}
1×10^{-4}	1.5×10^{-5}
1×10^{-3}	8.8×10^{-7}
1×10^{-2}	5.5×10^{-8}
1×10^{-1}	3.3×10^{-9}
1	2.3×10^{-10}

Table 3.2-XIII. Meteoroid Velocity Distribution

NASA SP 8013, dated March 1969

VELOCITY km/s	PERCENT OF TOTAL
0 to 9	0.0
9 to 12	4.6
12 to 15	25.4
15 to 18	25.7
18 to 21	14.0 (Mean: 20 km/s)
21 to 24	9.3
24 to 27	5.6
27 to 30	4.7
30 to 33	3.0
33 to 36	1.9
36 to 39	1.2
39 to 42	1.0
42 to 75	3.6
75 and up	0.0

Table 3.2-XIV. Meteoroid Penetration Thickness and Crater Diameter

Penetration Thickness In Aluminum (cm)	Crater Diameter In Aluminum (cm)	Meteoroid Flux events/(m^2-day) ≥ M
0.001	0.005	7.0×10^{-1}
0.004	0.020	3.5×10^{-1}
0.010	0.050	1.0×10^{-1}
0.040	0.200	7.0×10^{-3}
0.100	0.500	6.0×10^{-4}
0.400	2.000	1.0×10^{-5}
1.000	5.000	5.0×10^{-7}
4.000	20.000	4.5×10^{-9}

8.3.3 T&F - EMI/EMC and ESD

Table 3.3-I. Grounding Resistance Requirements

Configuration Item		Max. D.C. Resistance (ohms)	Comments
All Electrical and Electronic Units to LPG (includes RF units)		0.1	For EMC control;
Harness Shields to LPG		0.1	For EMC control
Sensor/Optical Head Housing to LPG		0.1	For EMC control
Radio Frequency Interference (RFI) Shields to LPG		0.1	For EMC control
Between adjacent panels of main Faraday Cage		0.1	For Faraday Cage integrity; for EMC control
Heat Pipes to LPG		0.1	
Between front and back of panel facesheets: for Al facesheets for graphite facesheets		 1.0 10.0	For EMC control
Longeron-to-longeron, longeron-to-panel		0.1	For EMC control
Panel LPG to SGP		0.1	For EMC control
Mechanical equipment ground to LPG		1.0	Including rotating axis mechanisms (SADA, APM, DAPM); for charge bleed-off
Passive RF/units to LPG		1.0	Includes all waveguides; for charge bleed-off; note 3
Equipment mounting brackets, graphite struts		10.0	For charge bleed-off
Across Hinges (antennas, deployed booms)		1.0	For charge bleed-off
Between front and back facesheets of reflectors and sub-reflectors		10.0	For charge bleed-off
Thermal blankets ground to LPG		10.0	For charge bleed-off
Thermal Shields to structure		10.0	For charge bleed-off
Graphite Arm (end to end)		10.0	For charge bleed-off
Solar Array Yoke		100	For charge bleed-off
Isolated Metal or non-Metal conductive part		1,000,000 500 to 1M	Includes specific dead metal or graphite parts (note 6)
Battery Assembly to LPG	Through fuse	0.2	Through paralleled fuse-10kΩ resister
	Fuse blown	10,000	
Coax Center Conductor, Cables, Wires, Harnesses		10,000,000	For charge bleed-off: note 7

LPG = Local Panel Ground - Each panel shall be provided with a sufficient number of grounding studs or inserts for ground straps to be connected between that panel and adjacent panels and other equipment.

SGP = Spacecraft Ground Point – where the negative terminal of one of the PCUs connects to the satellite structure. Electronic Units = Units with semiconductors in them

NOTE 1: A separate ground return from chassis is required for any powered application.

NOTE 2: For EMI/EMC and ESD Design Guideline and Control Plans, refer to E191555.

NOTE 3: For Passive RF Units: measurement shall be recorded after unit installation and before RF hook-up. The value will depend on installation method. After RF hook-up the value shall be $\leq 1\Omega$.

NOTE 4: Battery cells are isolated from satellite ground before connections with PCU/BSU.

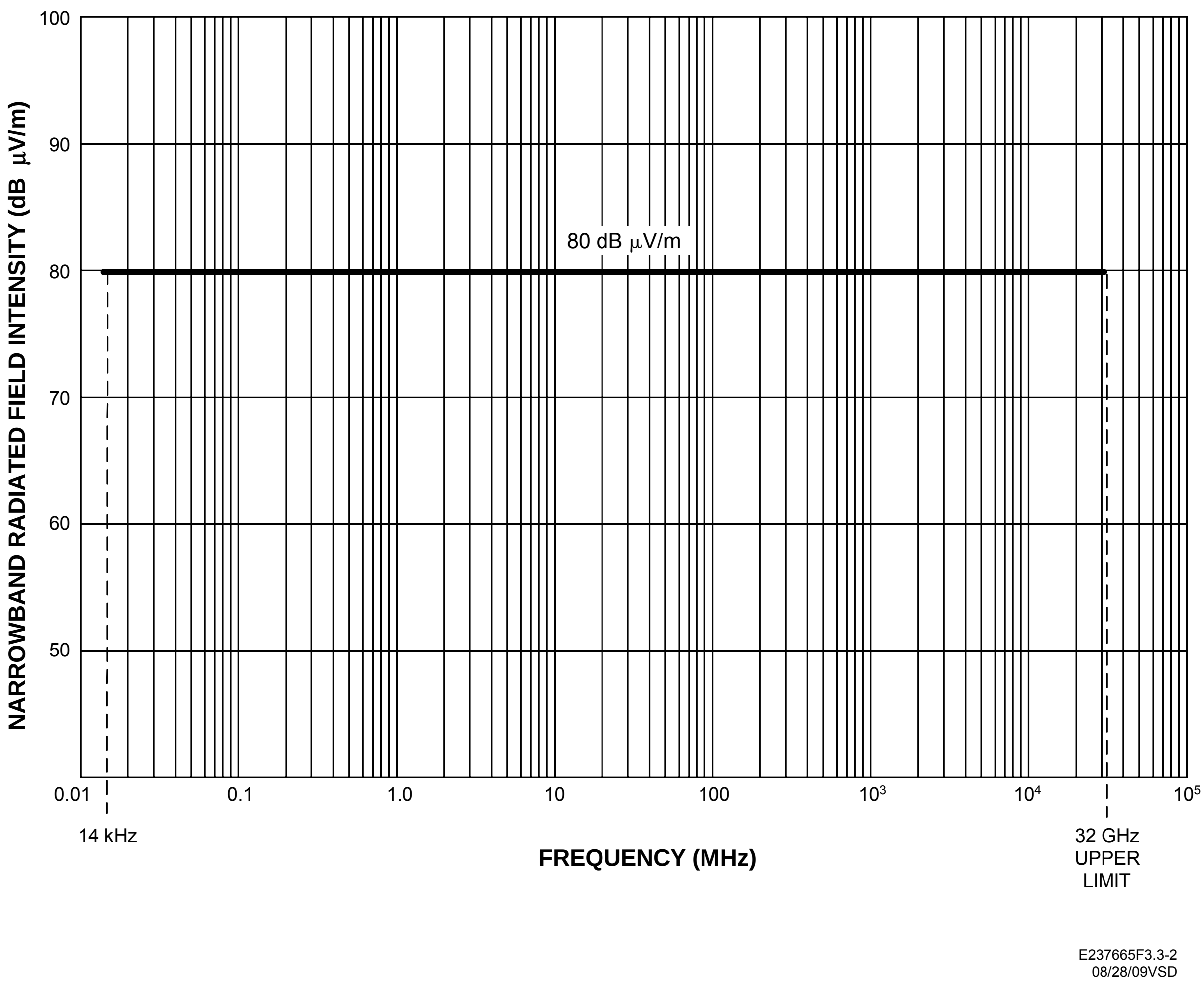
NOTE 5: All electrical and electronics units that is mounted with an insulating pad are allowed to have resistance value of 0.2 ohm maximum.

NOTE 6: Bonding resistance shall be as low as possible, but it can be 1Megohms if charging analysis indicates acceptability. Deep charging analysis based on NASA-HDBK-4002 will determine the bonding and charge bleed off requirement if standard bonding requirement can not be met.

NOTE 7: Applies to electrically isolated items. See 3.3.2.1.2.1 Cables, Wires, and Harnesses.

See section 3.3.2 Shielding, Bonding and Grounding Requirements.

Figure 3.3-1. DELETED Overview of Spacecraft Electrical Grounding



See also Table 3.3-II

Figure 3.3-2. Radiated Emissions (Narrowband)

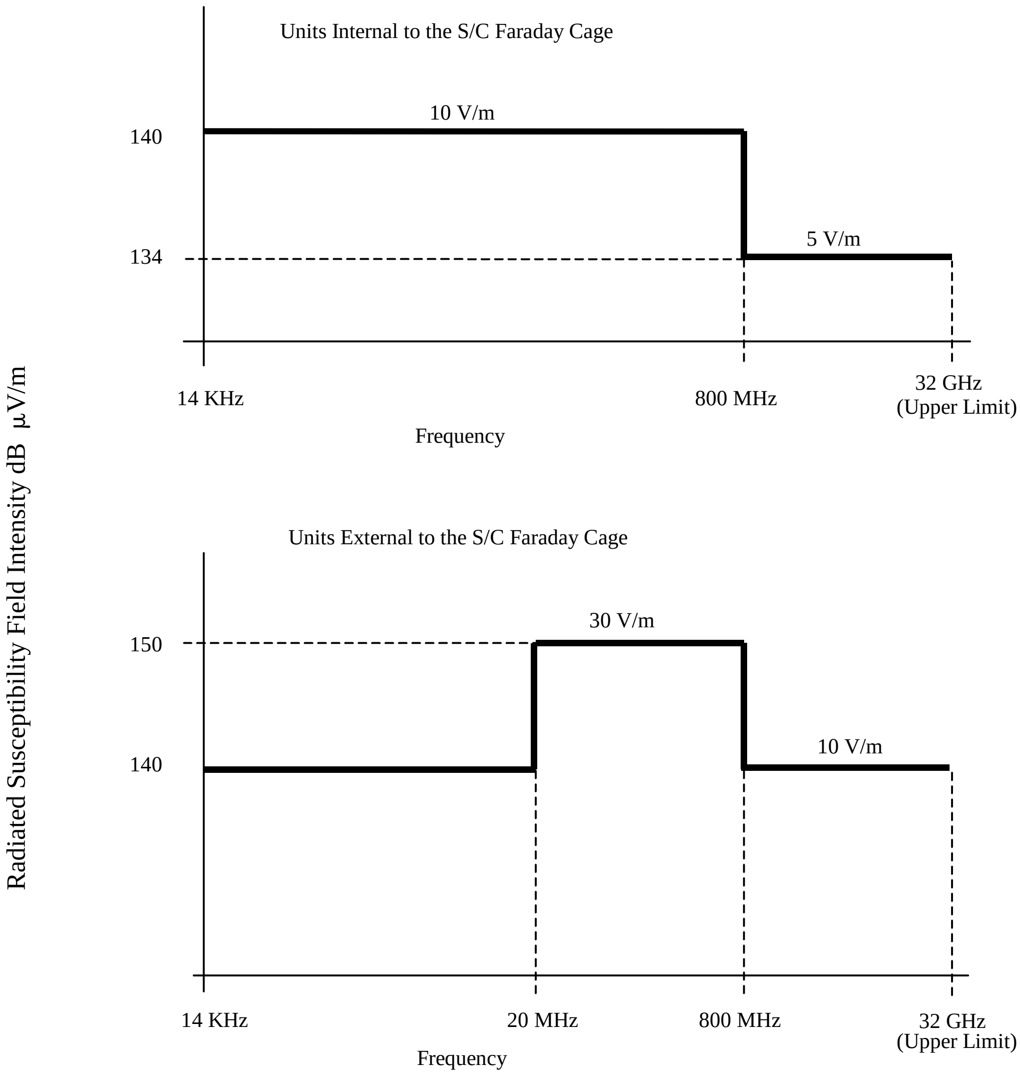
Table 3.3-II. Additional Radiated Emissions Restrictions for Antenna Receive Bands

(See also Figure 3.3-2)

Frequency		Radiated Emissions
Minimum	Maximum	
290 MHz	320 MHz	30 dB μV/m
400 MHz	500 MHz	30 dB μV/m
762 MHz	776 MHz	30 dB μV/m
1.57 GHz	1.661 GHz	30 dB μV/m
1.98 GHz	2.12 GHz	30 dB μV/m
5.725 GHz	7.1 GHz	30 dB μV/m
7.9 GHz	8.4 GHz	30 dB μV/m
12.75 GHz	13.25 GHz	30 dB μV/m
13.75 GHz	14.80 GHz	30 dB μV/m
17.3 GHz	18.1 GHz	30 dB μV/m
27.0 GHz	31.0 GHz	30 dB μV/m

Notes:

1. All non-RF units located inside the spacecraft Faraday Cage shall have a limit of 50 dB μV/m at the above frequency bands.
2. For TWTA, the radiated emission maximum level at the TWTA/Payload frequency is 90 dB μV/m. The rest of the narrowband radiated field intensity frequencies remain at 80 dB μV/m.
3. See the program ERS addendum for deviations.



Notes:
1) Launch Vehicle and Launch Site Electromagnetic Environments are shown in Figure 3.3-3, page 2 of 2 (only Ariane 5, Proton, Delta, Atlas, Sea Launch and Land Launch).

2) Program payload transmit frequency band has 20 V/m radiated susceptibility level for external units. 20 V/m level assumed the external unit has certain amount of RF shielding such as MLI blankets to attenuate the surrounding payload E-field.

3) The Earth Sensor has a 50 V/m test requirement. Actual E-field level can vary depending on the payload and direction of the field.

4) Payload, TC&R, and RFAT receive bands shall have 30 mV/m (90 dBµV/m).

5) High power S-band satellites can have E-field levels as high as 35 V/m internal to the spacecraft

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Figure 3.3-3. Radiated Field Susceptibility Limits (page 1 of 2) (Spacecraft Unit Compatibility)

LV Emission *		LV	LV Susceptibility*	
Frequency (GHz)	E-field (dB µV/m)		Frequency	E-field (dB µV/m)
1.0 to 1.5 2.20 to 2.29 2.90 to 3.40 5.40 to 5.90	145 145 145 145	Ariane 5	420 to 480 MHz 5.45 to 5.825 GHz	35 70
1.005 to 1.025 3.37 to 3.45	135 125	Proton M & K	765 to 771 MHz 1.57 to 1.62 GHz 1.72 to 2.73 GHz 5.7 to 5.8 GHz	36 45 60 30
2.0 to 2.5 5.4 to 5.9	144 149	Delta IV	408 to 426 MHz 5.6 to 5.8 GHz	32 40
2.2 to 2.5 5.6 to 5.8	157 161.4	Atlas	410 to 430 MHz 5.66 to 5.72 GHz	114 114
1.0105 1.6265 to 1.6465 2.211 2.2725 6.24 to 6.286	127 131 134 134 111	Sea Launch	762 to 776 MHz	20
230 to 248.6 MHz 1.0092 to 1.0193 GHz 1.0255 to 1.0355 GHz All other	150.9 149.6 145 70	Land Launch[4]	1.570 to 1.630 GHz	30

*Note:

1) Due to potential changes on launch vehicle and launch site environments in the specifications, one shall use the latest Launch Vehicle User's Guide/Manual information for design and analysis.

2) The Launch Vehicle emissions listed are the emitters that have frequency greater than 1 GHz with field level greater than 120 dB µV/m.

3) See ERS Addendum for specific program potential launch vehicles and possible updates on frequencies and levels.

4) Land Launch User's Guide Rev. Initial Release Section 4:
Includes Zenit-2SLB and Zenit-3SLB. The values are TBS since these values do not include fairing attenuation which is TBD.

Figure 3.3-3. Radiated Field Susceptibility Limits
(page 2 of 2) (Launch System and Satellite {TC&R} Compatibility)

8.3.4 T&F - Dynamic (Load) Requirements

Table 3.4.1-I. Applicable Load and Frequency Requirements

Structure Type	Frequency Requirements	Loading Environment Requirements				
		Quasi-Static	Sine	Acoustic	Random	Shock
Assembled Satellite	Para 3.4.2.5 Table 3.4.2-IX	Para 3.4.2.1 Table 3.4.2-I	Para 3.4.2.2 Table 3.4.2-IV	Para 3.4.2.3 Table 3.4.2-V, 3.4.2-VI	N/A	Para 3.4.2.4 Table 3.4.2-VIII
Components	Para 3.4.3.5 Table 3.4.3-IV	Para 3.4.3.1 Table 3.4.3-I	Para 3.4.3.2 Tables 3.4.3-II	Para 3.4.3.3 Table 3.4.2-V, 3.4.2-VI	Para 3.4.3.2 Table 3.4.3-II	Para 3.4.3.4 Tables 3.4.3-III

Table 3.4.1-II. Design and Test Factors of Safety

Load Type and Level		Static	Sine 2/	Acoustic	Random	Shock
Design Loads	Qualification (Ultimate)	1.3 x Flight	1.3 x Flight	Flight +3 dB	Flight +3 dB	Flight +3 dB
	Limit	Flight	Flight	Flight	Flight	Flight
Test Load	Qualification	1.3 x Flight	1.3 x Flight (2 oct/min)	Flight +3 dB (180 seconds)	Flight +3 dB (180 sec/axis) 4/	Flight +3 dB (3 events per axis)
	Protoflight	1.3 x Flight	1.3 x Flight (4 oct/min)	Flight +3 dB (60 seconds)	Flight +3 dB (60 sec/axis)	Flight +3 dB (1 event per axis) 3/
	Acceptance	1.0 x Flight 1/	1.0 x Flight (4 oct/min)	Flight (60 seconds)	Flight (60 sec/axis)	None

Notes:

1/ Static load acceptance tests of composite and low-ductibility structures shall be performed to 1.3 x flight.

2/ Sine flight levels are launch vehicle specified input levels notched to coupled loads analysis results.

3/ A protoflight shock test is not required simply because it is a protoflight unit. Protoflight shock test is only required on a protoflight unit when delta-qualification is required and the delta-qualification test will not be performed on an equivalent qualification or engineering unit.

4/ Additionally existing heritage components previously qualified to 120 sec/axis (previous standard) remain fully qualified. If delta-qualification will be performed on a non-flight QM or EQM, then the new 180 sec/axis requirement will be used.

Table 3.4.2-I. Launch Vehicle Quasi-Static Limit Load Factors seen by Satellite

(1 of 3)

Launch Vehicle	Flight Event [4]	Quasi-Static Limit Load Factors (g) [1, 8]						
		Longitudinal (Z) [2, 5]				Lateral (X,Y)[3]	Overflux[6]	
		Steady State	Dynamic	Total (Compression)	Total (Tension)	Total	N/mm	(lb/in)
Ariane 5	Lift-off	-1.7	±1.5	-3.2		±2.0	10	(57)
	Maximum dynamic pressure	-2.7	±0.5	-3.2		±2.0	14	(80)
	SRB end of flight	-4.55	±1.5	-6.0		±1.0	20	(114)
	Main core thrust tail-off	-0.2	±1.4	-1.6	+1.2	±0.3	0	(0)
	Max. tension case SRB jettisoning	0.0	±2.5	-2.5	+2.5	±0.9	0	(0)
Atlas V	Launch	-1.2	±0.5	-1.7		±1.0		
40 Z	Flight Winds	-2.8 to -1.0	±0.5	-3.3		±2.0		
50 Z	BECOBETO (Max Axial)	-5.5	±0.5	-6.0		±0.5		
	BECO/BETO (Max Lateral)	-3.0 to 0.0	±1.0	-4.0	+1.0	±1.5		
	MECO/CLE (Max Axial)	-4.5 to 0.0	±1.0	-5.5	+1.0	±0.3		
	MECO/CLE (Max Lateral)	0.0	±2.0	-2.0	+2.0	±0.6		
Atlas V	Launch	-1.5	±1.5	-3.0	0.0	±2.0		
4 YZ,	Flight Winds	-2.8 to -1.0	±0.5	-3.3		±2.0		
5 YZ	Strap-On Separation	-3.3	±0.5	-3.8		±0.5		
	BECOBETO (Max Axial)	-5.5	±0.5	-6.0		±0.5		
	BECO/BETO (Max Lateral)	-3.0 to 0.0	±1.0	-4.0	+1.0	±1.5		
	MECO/CLE (Max Axial)	-4.5 to 0.0	±1.0	-5.5	+1.0	±0.3		
	MECO/CLE (Max Lateral)	0.0	±2.0	-2.0	+2.0	±0.6		
Delta IV	Maximum longitudinal (compression)			-6.5		±0.5		
Medium	Maximum longitudinal (tension)				+1.0	±0.5		
Medium plus (4 , 2)	Maximum lateral			-2.5	+0.2	±2.0		
Delta IV	Maximum longitudinal (compression)			-6.0		±0.5		
Medium plus (5, 2)	Maximum longitudinal (tension)				+1.0	±1.0		
Medium plus (5, 4)	Maximum lateral			-2.3	+0.0	±2.0		
Delta IV	Maximum longitudinal (compression)			-6.0		±0.5		
Heavy	Maximum longitudinal (tension)				+1.0	±1.0		
	Maximum lateral			-2.3	+0.0	±2.0		
H-IIA	Lift-off	-1.6	±1.7	-3.2	+0.1	±1.8		
	Immediately before MECO			-4.0		±0.5		
	MECO Transit				+1.0	±1.0		

See notes on Table 3.4.2-I (3 of 3)

Table 3.4.2-I. Launch Vehicle Quasi-Static Limit Load Factors seen by Satellite (2 of 3)

Launch Vehicle	Flight Event [4]	Quasi-Static Limit Load Factors (g) [1, 8]: Longitudinal (Z) [2, 5]: Steady State	Longitudinal (Z): Dynamic	Longitudinal (Z): Total (Compression)	Longitudinal (Z): Total (Tension)	Lateral (X,Y)[3]: Total	Overflux[6]: N/mm (lb/in)
Land Launch (Zenit 3SLB)	Maximum Longitudinal (compression)			-4.5		±0.7	
	Maximum Longitudinal (tension)				+2.0	±1.0	
	Maximum Lateral			-2.0	0.0	±2.0	
Long March 3B	Transonic phase and MDP	-2.2	±0.8	-3.0		±1.5	
	Prior to booster separation	-5.3	-0.8/+3.6	-6.1		±1.0	
	After 1st/2nd stage separation	-1.0	-2.7/+3.6	-3.7	+2.6	±1.0	
Proton M/ Breeze M (S/C 3300-4500 Kg	Lift-off			-2.7		±2.0	
	Maximum Dynamic Pressure (Qmax)			-2.2		±1.2	
	1st/2nd stages separation (max. comp.)			-4.65		±1.2	
	1st/2nd stages separation (max. tens.)				+3.2	±1.2	
	2nd/3rd stages separation			-3.0		±0.3	
	3rd/4th Breeze-M separation			-2.8		±0.3	
Proton M/ Breeze M (S/C 4500-5700Kg	Lift-off	-1.35	+1.25	-2.6		±1.7	
	Lift-off (112% Thrust Engine)			-2.9	0.1	±1.5	
	Maximum Dynamic Pressure (Qmax)			-2.2		±1.2	
	1st/2nd stages separation (max. comp.)			-5.1		±1.0	
	1st/2nd stages separation (max. tens.)				+3.7	±1.0	
	2nd/3rd stages separation			-3.0		±0.3	
	3rd/Breeze-M separation			-2.8		±0.3	
Sea Launch (Zenit 3SL)	Maximum longitudinal (compression)			-4.5		±0.7	
	Maximum longitudinal (tension)				+2.0	±1.0	
	Maximum lateral			-2.5	+0.0	±2.0	
Design Loads (S/C 3300 4500Kg)	Maximum longitudinal (compression)			-6.0 [7]		±1.0	
	Maximum longitudinal (tension)				+3.2	±1.2	
	Maximum lateral (compression)			-3.3		±2.0	
	Maximum lateral (tension)				+0.2	±2.0	
Design Loads (S/C > 4500 Kg)	Maximum longitudinal (compression)			-6.0 [7]		±1.0	
	Maximum longitudinal (tension)				+3.7	±1.0	
	Maximum lateral (compression)			-3.3		±2.0	
	Maximum lateral (tension)				+0.2	±2.0	

See Notes on Table 3.4.2-I (3 of 3)

Table 3.4.2-I. Launch Vehicle Quasi-Static Limit Load Factors seen by Satellite (3 of 3)

Notes:

1. Load factors are equivalent values at satellite center of gravity.
2. Negative longitudinal load factor represents compression.
3. Lateral load factors may act in any direction.
4. Load factors for each flight event are assumed to act simultaneously.
5. Gravity load is included.
6. Additional line load to be added at the spacecraft separation interface, due to non-uniform transmission of thrust.
7. Does not include -6.5g (Delta IV medium, medium plus (4, 2) and -6.1g (Long March 3B). If these launch vehicles are to be included, need to increase axial compression design load or negotiate for reduced level with launch vehicle contractor.
8. To obtain ultimate (qualification) load factors, multiply above limit load factors by 1.3.

Table 3.4.2-II. Additional Satellite Limit Load Factors

Component	Load Case	Limit Load Factor (g) 1/, 2/,	
		Lateral (X or Y)	Longitudinal (Z)
Upper Cylinder &	Maximum Longitudinal (compression)	0.58g + 0.0092 g/in	-6.0
Extension Module	Maximum Longitudinal (tension)	0.58g + 0.0092 g/in	3.0
Design Loads	Maximum Lateral	0.77g + 0.0123 g/in	-3.6/+0.4
Z = 100” to Earth Deck	Maximum Proton/Breeze-M Lateral	0.77g + 0.0137 g/in	-3.6/+0.4

1/ Lateral (X & Y) and axial (Z) load factors for each load case are assumed to act simultaneously unless otherwise indicated. Loads may occur in either + or - direction unless otherwise specified.

2/ To obtain ultimate (qualification) load factor, multiply limit load factor by 1.3

Table 3.4.2-III. Tower/Upper Module Qualification Design Load Factors

Component / Load Case	Qualification Load Factor (g) 1/	
	Lateral (X or Y)	Longitudinal (Z)
Tower Structure 2/		
Maximum Lateral Case	4.0 at earth deck + 0.10 g/in	-5.2/ +1.3
Maximum Longitudinal Case	2.0 at earth deck + 0.05 g/in	-10.4/ +4.8
Upper Module 2/		
Maximum Lateral Case	4.0 at earth deck + 0.064 g/in	-4.0 / +1.3
Maximum Longitudinal Case	2.0 at earth deck + 0.032 g/in	-8.0 / +4.8

1/ Lateral (X & Y) and axial (Z) load factors for each load case are assumed to act simultaneously unless otherwise indicated. Loads may occur in either + or - direction unless otherwise specified.

2/ Overall tower or upper module structure shall be designed for this loading. Tower components support structure shall be designed to individual component load factors.

Table 3.4.2-IV. Satellite Sine Vibration Test Levels

Launch Vehicle	Test	Lateral (X, Y) Frequency (Hz)	Lateral (X, Y) Amplitude (0-peak)	Longitudinal (Z) Frequency (Hz)	Longitudinal (Z) Amplitude (0-peak)	Sweep Rate
Ariane 5	Acceptance	5 **to** 25	0.8 g	5 **to** 100	1.0 g	4 oct/min
		25 **to** 100	0.6 g			
Atlas V 4YZ/5YZ	Acceptance	5 **to** 25	0.8 g	5 **to** 100	1.0 g	4 oct/min
		25 **to** 100	0.7 g			
Atlas V 40Z	Acceptance	5 **to** 65	0.4 g	5 **to** 20	0.6 g	4 oct/min
		65 **to** 80	0.5 g	20 **to** 30	0.8 g	
		80 **to** 85	0.55 g	30 **to** 75	0.6 g	
		85 **to** 100	0.6 g	75 **to** 80	0.7 g	
				80 **to** 100	0.9 g	
Delta IV	Acceptance	5 **to** 100	0.7 g	5 **to** 100	1.0 g	4 oct/min
H-IIA	Acceptance	5 **to** 18	0.7 g	5 **to** 30	1.0 g	4 oct/min
		18 **to** 100	0.6 g	30 **to** 100	0.8 g	
Land Launch (Zenit 3SLB)	Acceptance	5 **to** 100	0.7 g	5 **to** 100	0.7 g	4 oct/min
Long March 3B	Acceptance	5 **to** 100	0.6 g	5 **to** 100	0.8 g	4 oct/min
Proton M/ Breeze M	Acceptance	5 **to** 10	0.3 g			4 oct/min
		10 **to** 20	0.4 g	5 **to** 20	1.4 g 1/	
		20 **to** 100	0.6 g	20 **to** 100	0.6 g	
Sea Launch (Zenit 3SL)	Acceptance	5 **to** 100	0.6 g	5 **to** 100	0.6 g	4 oct/min
Combined 2/ Envelope	Acceptance	5 **to** 25	0.8 g	5 **to** 100	1.0 g	4 oct/min
		25 **to** 100	0.7 g			
	Protoflight	5 **to** 25	1.04 g	5 **to** 100	1.3 g	4 oct/min
		25 **to** 100	0.91 g			
	Qualification	5 **to** 25	1.04 g	5 **to** 100	1.3 g	2 oct/min
		25 **to** 100	0.91 g			

1/ Testing below 20Hz can be eliminated (longitudinal axis only) if there are no secondary structure resonances below 20Hz and peak responses of primary and secondary structure can be attained above 20Hz. However, recommended that testing from 5 Hz to 20 Hz at a level of at least 1.0g be performed to provide workmanship quality demonstration.

2/ Input levels may be notched, as required, so that responses do not exceed predicted launch load levels times appropriate environmental test factor:

Acceptance:	1.0
Protoflight:	1.3
Qualification:	1.3

Table 3.4.2-V. Launch Vehicle Acoustic Test Levels

ACOUSTIC TEST LEVELS — Envelope of: Ariane5 ECA/GS, Atlas-V(400, 500), Delta-IV(M/M+, M+), H-IIA-212, Proton M-Breeze-M, Sea Launch Zenit-3SL, Land Launch Zenit-3SLB.

•Note: To add/remove a particular Launch Vehicle (LV) from the enveloping calcs ==> Click the "Include" checkbox below LV Name.

•Last updated Jun-2009 (updated SPLs: SeaLaunch, LandLaunch; updated all LV User Manual ref's)

Sound Pressure Level, dB [1] (Reference: 0.00002 N/m^2) — Acceptance

Center Frequency (Hz)		**Ariane5** ECA/GS **5.0**m fairing Ref.[3] ☑ Include		**Atlas-V** 400 4.2m fairing Ref.[4a] ☑ Include		**Atlas-V** 500 **5.4**m fairing Ref.[4b] ☑ Include		**Delta-IV** M/M+ 4.1m fairing Ref.[5] ☑ Include		**Delta-IV** M+ **5.1**m fairing Ref.[5] ☑ Include		**Delta-IV** H **5.1**m Gr/Ep Ref.[5] ☐ Include		H-IIA H-IIA-212 **5.1**m fairing Ref.[6] ☑ Include		LongMarch LM-3B 4.0m fairing Ref.[7] ☐ Include		**Proton** M-Breeze-M 4.3m fairing Ref.[8] ☑ Include		**Sea Launch** Zenit-3SL 4.2m fairing Ref.[9] ☑ Include		Land Launch Zenit-3SLB 4.2m fairing Ref.[10] ☑ Include		Envelope[1] of Flagged Launch Vehicles #LVs= 9		Toler-ance
1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	1/3 Octave Band	Full Octave Band	[2] (dB)
25		120.6		114.0										122.7		113.4		117.0						122.7		
31.5	31.5	123.0	128.0	121.0	129.1	124.6	129.0	119.5	124.3	123.0	127.8	123.5	129.0	123.2	128.0	115.0	120.0	123.0	128.8	123.0	126.0	119.0	123.1	124.6	130.6	-2/+2
40		125.0		128.2		127.0		122.5		126.0		127.5		123.7		116.7		127.0		123.0		121.0		128.2		
50		124.7		122.5		128.5		125.2		128.0		130.0		124.2		118.8		126.5		124.0		123.0		128.5		
63	63	125.9	131.0	124.0	128.5	129.5	134.1	126.3	131.4	130.0	134.4	131.5	136.2	124.6	129.5	121.0	126.0	127.8	134.0	125.0	130.3	127.5	133.1	130.0	135.0	-1/+1
80		127.6		124.5		130.0		128.0		130.5		132.5		125.3		122.9		131.6		127.0		131.0		131.6		
100		130.6		126.0		130.5		129.0		130.5		133.0		126.6		125.0		132.4		129.0		129.0		132.4		
125	125	131.6	136.0	126.0	131.2	130.5	135.2	130.0	134.5	130.5	135.3	133.0	137.8	129.3	134.0	126.9	132.0	131.3	136.7	130.0	134.8	130.0	134.8	131.6	136.8	-1/+1
160		131.4		127.2		130.3		130.0		130.5		133.0		130.8		128.9		132.1		131.0		131.0		132.1		
200		129.5		127.0		129.5		130.0		130.5		133.0		131.5		130.6		132.1		133.0		131.0		133.0		
250	250	127.9	133.0	126.5	131.3	128.8	133.6	130.0	134.8	130.5	135.2	133.0	137.8	131.5	136.0	131.5	136.0	132.1	136.3	134.0	138.1	131.0	135.8	134.0	138.1	-1/+1
315		126.9		126.0		128.0		130.0		130.2		133.0		130.6		131.5		129.9		133.0		131.0		133.0		
400		125.8		126.0		126.8		129.5		128.0		131.0		128.1		131.0		129.0		131.0		130.0		131.0		
500	500	124.0	129.0	124.5	129.2	125.5	130.5	128.0	132.6	125.5	130.7	129.0	134.0	126.3	131.5	130.2	135.0	127.0	131.9	129.0	134.1	129.0	133.6	129.0	134.1	-1/+1
630		122.2		122.0		124.5		125.0		123.0		126.5		125.3		129.3		124.0		127.0		127.0		127.0		
800		120.2		119.5		123.0		123.0		121.0		124.5		124.4		128.3		121.0		125.0		122.0		125.0		
1000	1000	117.8	123.0	116.5	122.0	121.5	126.4	121.0	126.2	119.5	124.4	122.5	127.6	123.2	128.0	127.3	132.0	119.0	124.1	122.0	127.8	120.0	125.3	123.2	128.3	-1/+2
1250		115.3		114.0		120.0		119.5		118.0		120.7		121.7		125.7		117.0		121.0		119.0		121.7		
1600		113.1		112.0		118.0		118.0		116.5		118.3		119.8		123.7		114.5		120.0		117.0		120.0		
2000	2000	110.8	116.0	114.0	117.3	116.5	121.4	116.5	121.4	115.0	119.9	116.5	121.6	118.0	123.0	121.9	127.0	112.5	117.7	119.0	123.8	116.0	120.8	119.0	123.8	-1/+3
2500		108.6		111.0		115.0		115.0		113.5		115.0		116.2		120.5		111.0		118.0		115.0		118.0		
3150				110.0		113.0		113.5		112.0		113.0		114.4		119.5		109.0		117.0				117.0		
4000	4000			109.0	114.0	111.5	116.3	112.0	116.9	110.0	115.2	111.5	116.3	113.0	118.0	118.3	123.0	108.0	112.8	115.0	120.3			115.0	120.3	-4/+4
5000				108.5		109.5		110.5		108.5		109.5		111.9		116.3		107.0		114.0				114.0		
6300				108.0		107.5		109.0		106.5		107.5		111.4		113.5		105.5		113.0				113.0		
8000	8000			109.5	114.2	106.0	110.8	107.5	112.4	105.0	109.8	106.0	110.8	111.2	116.0	110.7	116.0	104.0	109.2	111.0	116.3			111.2	116.6	-4/+4
10000				110.5		104.0		106.0		103.0		104.0		111.1		107.6		103.5		110.0				111.1		
Overall		139.5	139.5	137.2	137.2	140.3	140.3	140.0	140.0	140.6	140.7	143.1	143.1	140.1	140.2	140.6	140.6	141.5	141.5	141.6	141.6	140.7	140.7	142.8	142.8	-1/+1
PT/QT Margin		+3 dB		+3 dB		+3 dB		+3 dB		+3 dB		+3 dB		+3 dB		**+4 dB**		+3 dB		+3 dB		+3 dB				
Duration		60 Seconds for Acceptance & Protoflight; 120 Seconds for Qualification (Launch Vehicle Requirement; SS/L requires 180 seconds for Qualification)																								-0/+5%

[1] Envelope of: Ariane5 ECA/GS, Atlas-V(400, 500), Delta-IV(M/M+, M+), H-IIA-212, Proton M-Breeze-M, Sea Launch Zenit-3SL, Land Launch Zenit-3SLB

[2] Upper test tolerances may be increased at the discretion of the responsible engineer in the event that test chamber levels cannot be maintained within the above tolerances. In this case, the upper tolerance may be increased to +4 dB from 25-40 Hz and to +3 dB from 50-2500 Hz. The overall test tolerance of ±1 dB shall be maintained.

[3] Ariane 5 full-octave levels per Ariane 5 User's Manual, Issue 5, Rev 0, Tbl.3.2.5.2a, July-2008; (1/3-oct levels extrap from full-oct).

[4a] Atlas-V 400 Series (worst case 43z) with 4-m Payload Fairings (with blankets), 50-75% Fill Fraction, ref: Atlas Launch System Mission Planner's Guide , Rev 10a, Jan-2007, Figure 3.2.2-1.

[4b] Atlas-V 500 Series (worst case 55z) with 5-m Payload Fairings, 40-50% Fill Fraction, ref: Atlas Launch System Mission Planner's Guide , Rev 10a, Jan-2007, Figure 3.2.2-2.

[5] Delta-IV Payload Planners Guide, Doc No. 06H0233, dated Sep-2007, Tbl 4-43.

[6] H-IIA User's Manual 2nd Ed./Rev.A (prelim) Dec-97, Fig 3.2.3 for H2A212 5m fairing with acoustic blanket; (1/3-oct levels extrap from full-oct).

[7] LM-3B User's Manual, Issue 1999, Fig 6-12. (1/3 oct levels extrap from full-oct)

[8] Proton Launch System Mission Planners Guide, LKEB-9812-1990, Rev 6, dated Dec-04, Fig. 3.4.3-1

[9] Sea Launch Users Guide, Rev. D, Tbl.5-3, Feb-2008.

[10] Ref.: Telstar-11N/LandLaunch ICD, Doc No. HPD-19012, Rev.C, Tbl 3.3.3-1

[11] LV user manuals available at: SSL Launch Systems Group or: Embedded snapshots of acoustic specs from above-listed LV user manuals -- on worksheet "LV-docs"

Table 3.4.2-VI. Satellite Acoustic Test Levels – Envelope

Acoustic Levels for component tests are the same as the satellite levels (see section 3.4.3.3 Acoustic Test Levels)

Center Frequency (Hz)		Sound Pressure Level, dB [1] (Reference: 0.00002 N/m^2)				Test Tolerance
		Acceptance		Qualification/Protoflight [2]		
1/3 Octave Band	Octave Band	1/3 Octave Band [5]	Octave Band	1/3 Octave Band [5]	Octave Band	[4] (dB)
25		122.7		125.7		
31.5	31.5	124.7	130.6	127.7	133.6	-2/+2
40		128.3		131.3		
50		128.5		131.5		
63	63	130.0	135.0	133.0	138.0	-1/+1
80		131.6		134.6		
100		132.4		135.4		
125	125	131.6	136.8	134.6	139.8	-1/+1
160		132.1		135.1		
200		133.0		136.0		
250	250	134.0	138.1	137.0	141.1	-1/+1
315		133.0		136.0		
400		131.0		134.0		
500	500	129.0	134.1	132.0	137.1	-1/+1
630		127.0		130.0		
800		125.0		128.0		
1000	1000	123.2	128.3	126.2	131.3	-1/+2
1250		121.7		124.7		
1600		120.0		123.0		
2000	2000	119.0	123.8	122.0	126.8	-1/+3
2500		118.0		121.0		
3150		117.0		120.0		
4000	4000	115.0	120.3	118.0	123.3	-4/+4
5000		114.0		117.0		
6300		113.0		116.0		
8000	8000	111.2	116.6	114.2	119.6	-4/+4
10000		111.1		114.1		
Overall		142.8	142.8	145.8	145.8	-1/+1
Duration		60 Seconds		180 Seconds [3]		-0/+5%

[1] Envelope of Ariane 5 ECA/GS, Atlas-V 400, Atlas-V 500, Delta-IV M/M+ 4.1 m fairing, Delta-IV M+ 5.1 m fairing, H-IIA-212, Proton-M/Breeze-M, Sea Launch, Land Launch. (Delta-IV H and Long March not included.)

[2] Qual/Proto margin: Acceptance +3dB

[3] Protoflight duration is 60 seconds.

[4] Upper test tolerances may be increased at the discretion of the responsible engineer in the event that test chamber levels cannot be maintained within the above tolerances. In this case, the upper tolerance may be increased to +4 dB from 25 to 40 Hz and to +3 dB from 50 to 2500 Hz. The overall test tolerance of ±1 dB shall be maintained.

[5] 1/3-octave levels derived from specified full-octave levels for Ariane 5. (Others specify 1/3-oct levels.)

Table 3.4.2-VII(a). Shock Spectra at Separation Plane, Clampband Average

(See Figure 3.4.2-1)

Frequency (Hz)	SRS - Acceleration (g)	
	Longtiudinal	Radial
100	5	20
1330		2000
2200	1000	2000
10000	2000	2000

Note: Shock Spectra in Table 3.4.2-VII(a) to (c) do not meet mission planner's guide specifications. ERS Shock Spectra shown are based on prior program negotiated agreements and are not necessarily applicable to future programs. Recommend securing launch vehicle provider concurrence to these reduced levels at program start or sooner.

Table 3.4.2-VII(b). Shock Spectra at Separation Plane, Sea Launch Vehicle Fairing and Stage Separation

(See Figure 3.4.2-1)

Frequency (Hz)	SRS - Acceleration (g)	
	Longtiudinal	Radial
100	10	20
1000	500	900
2000	1000	2000
10000	1000	2000

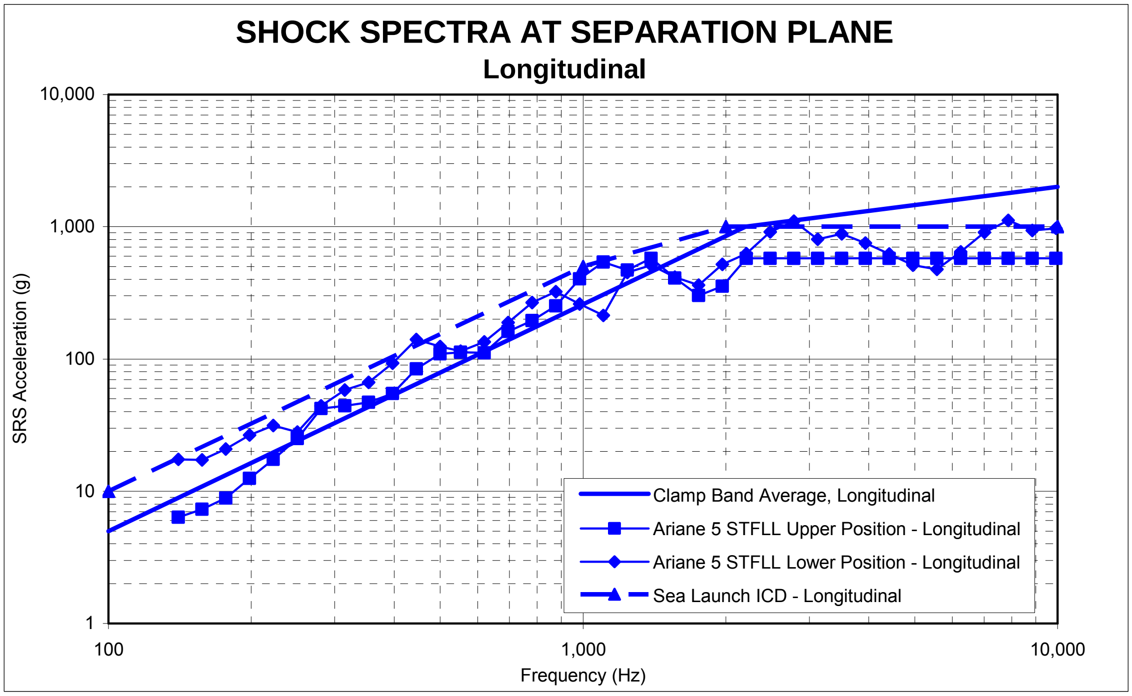
Note: Shock Spectra in Table 3.4.2-VII(a) to (c) do not meet mission planner's guide specifications. ERS Shock Spectra shown are based on prior program negotiated agreements and are not necessarily applicable to future programs. Recommend securing launch vehicle provider concurrence to these reduced levels at program start or sooner.

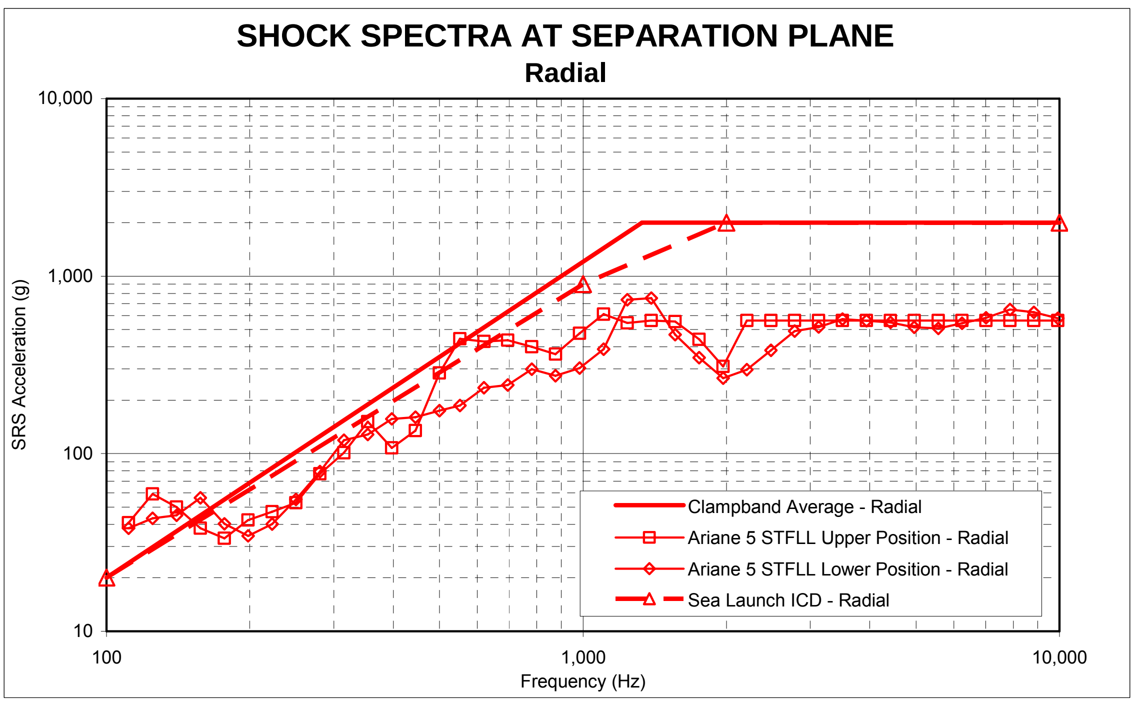
Table 3.4.2-VII(c). Shock Spectra at Separation Plane, Ariane Launch Vehicle Fairing and Stage Separation

(See Figure 3.4.2-1)

Frequency, Hz	Shock Response Spectra - Acceleration, g			
	Ariane 5 Short-Term Flight Limit Levels (STFLL) - January 2004 Spec			
	Upper Position		Lower Position	
	Longitudinal	Radial	Longitudinal	Radial
111		41		38
125		59		43
140	6	50	17	45
157	7	38	17	56
177	9	33	21	40
198	12	42	27	34
223	17	47	31	40
250	25	53	28	55
281	42	77	44	79
315	44	101	58	119
354	47	152	67	129
397	55	108	93	157
445	84	135	141	160
500	109	285	124	175
552	113	444	114	187
620	111	428	135	236
696	161	436	189	244
781	195	401	267	299
876	252	364	323	275
984	404	476	260	304
1104	539	611	214	388
1239	470	545	450	737
1391	576	563	513	753
1562	409	554	416	469
1753	302	441	362	348
1968	355	310	520	267
2209	576	563	625	297
2479	576	563	915	382
2783	576	563	1101	489
3124	576	563	806	517
3506	576	563	886	573
3936	576	563	754	561
4418	576	563	622	549
4959	576	563	511	515
5566	576	563	477	507
6248	576	563	646	544
7013	576	563	905	583
7872	576	563	1116	647
8836	576	563	939	626
9918	576	563	975	579

Note: Shock Spectra in Tables 3.4.2-VII(a) to (c) do not meet mission planner's guide specifications. ERS Shock Spectra shown are based on prior program negotiated agreements and are not necessarily applicable to future programs. Programs should verify that the launch vehicle provider concurs with these reduced levels





(See Table 3.4.2-VII)

Figure 3.4.2-1. Shock Spectra at Separation Plane

Table 3.4.2-VIII. Satellite Induced Shock Levels

Replaced by 3.4.3-III(c) and 3.4.3-III(d)

Table 3.4.2-IX.   Satellite Minimum Frequency Requirements

Satellite, Fixed Base (Launch Configuration)	Lateral (X, Y)	Longitudinal (Z)
Ariane 5	10 Hz (S/C mass < 4500 kg) 8 Hz (4500 $\leq$ S/C $\leq$ 6500 kg) 7.5 Hz (S/C mass > 6500 kg)	31 Hz (S/C mass < 4500 kg) 27 Hz (S/C mass $\geq$ 4500 kg)
Atlas	8 Hz	15 Hz
Delta IV Medium	10 Hz	27 Hz
Delta IV Heavy (Reference only)	8 Hz	30 Hz
H-IIA	10 Hz	30 Hz
Land Launch	8 Hz	20 Hz
Long March 3B (Reference only)	10 Hz	30 Hz
Proton-M/Breeze-M	8.5 Hz	25 Hz
Sea Launch	8 Hz	20 Hz
Design Envelope (S/C ≤ 4500 kg) [1/]	10 Hz	31 Hz
Design Envelope (S/C > 4500 kg) [2/]	8.5 Hz	27 Hz

1/ Design envelope for S/C mass < 4500 kg (SS/L 1300LL satellite) envelopes requirements for Ariane 5 (S/C < 4500 kg), Atlas, Delta IV Medium, H-IIA, Land Launch, H-IIA, Proton-M/Breeze-M, and Sea Launch launch vehicles.

2/ Design envelope for S/C mass > 4500 kg envelopes Ariane 5 (S/C > 4500 kg), Atlas, Proton-M/Breeze-M and Sea Launch. This design envelope is below minimum frequency requirement for Delta IV Medium, Delta-IV Heavy, H-IIA, and Long March 3B. If any of these are included in candidate launch vehicles, either need to increase minimum frequency requirements, or request waiver from launch vehicle provider.

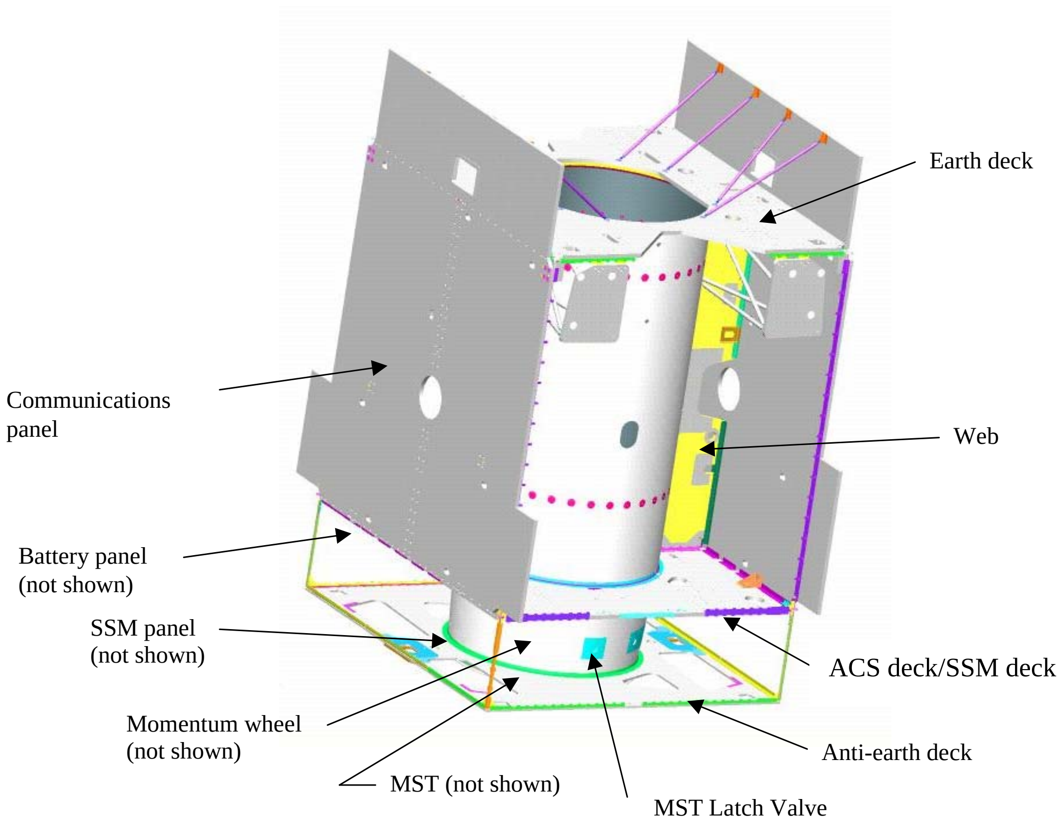
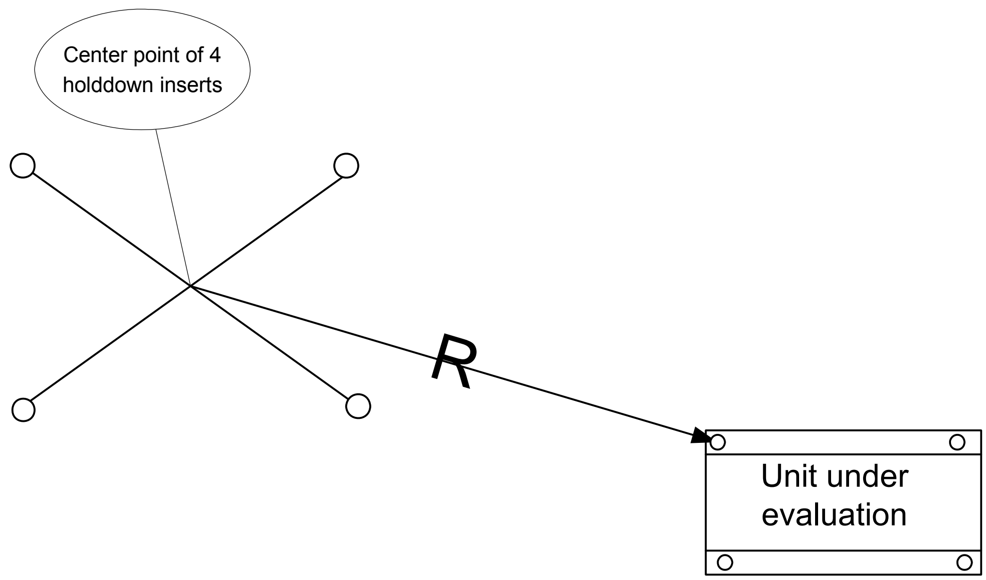


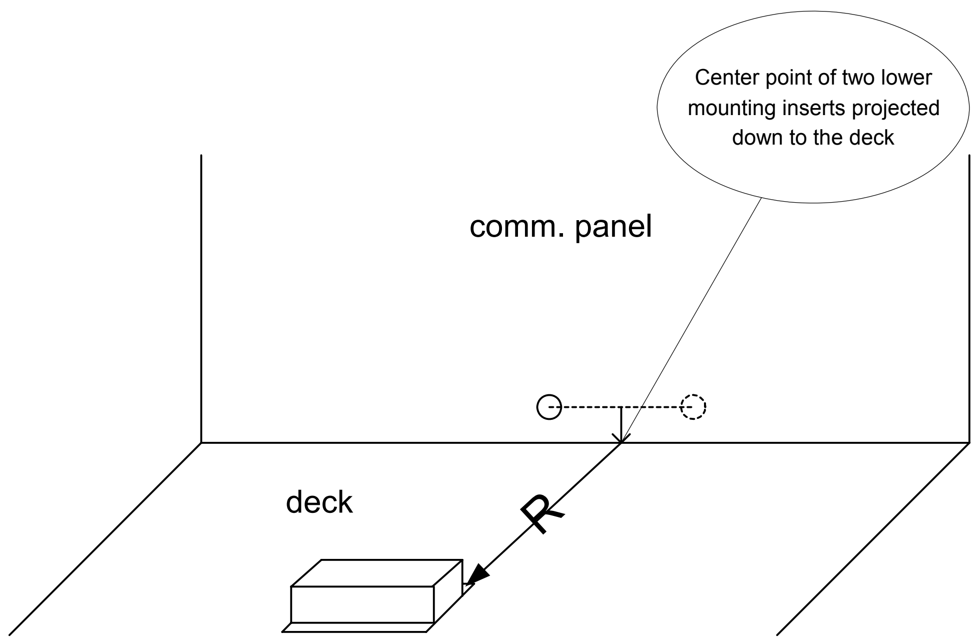
Figure 3.4.3-1. Typical Satellite Configuration to Be Used as a Guide for Shock Level Locations



Components mounted on the same panel as the EED holddown insert footprint- A component is within R inches of an EED holddown, where R is measured along the panel surface, when the component's closest mounting foot is within R inches from the center of the EED holddown mounting footprint.

Credit shall not be taken for panel thickness in calculating R.

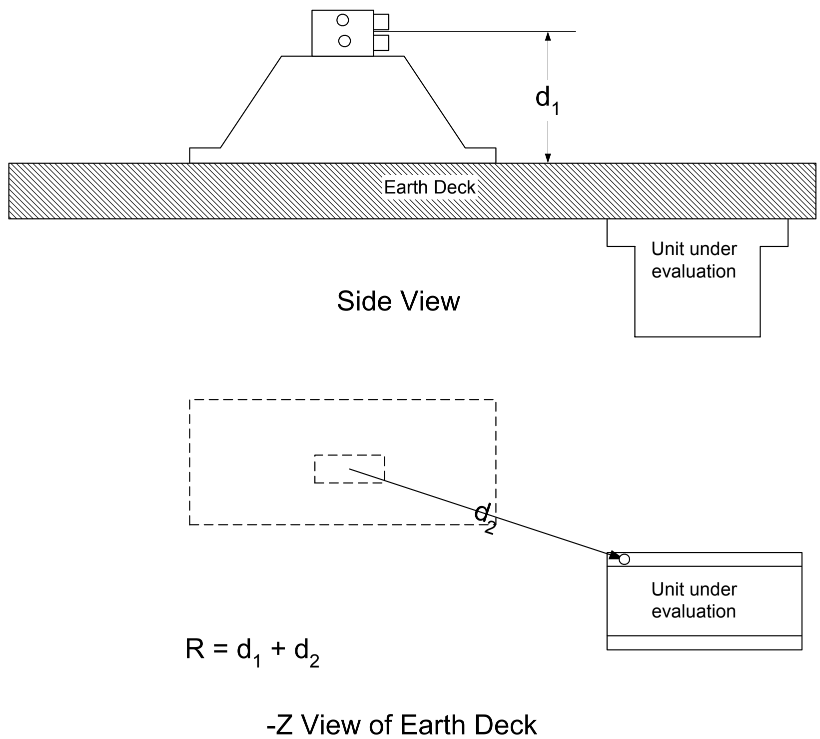
Figure 3.4.3-2(a). Distance R for a Unit Mounted on the Same Panel.



Components not mounted to the same panel as the EED holddown insert footprint- A component is within R inches of an EED holddown, where R is measured along the panel surfaces, when the component's closest mounting foot is within R inches from the center of the two inserts of the EED holddown mounting footprint (projected down to the deck) closest to the adjacent panel upon which the component is mounted.

Credit shall not be taken for panel thickness in calculating R.

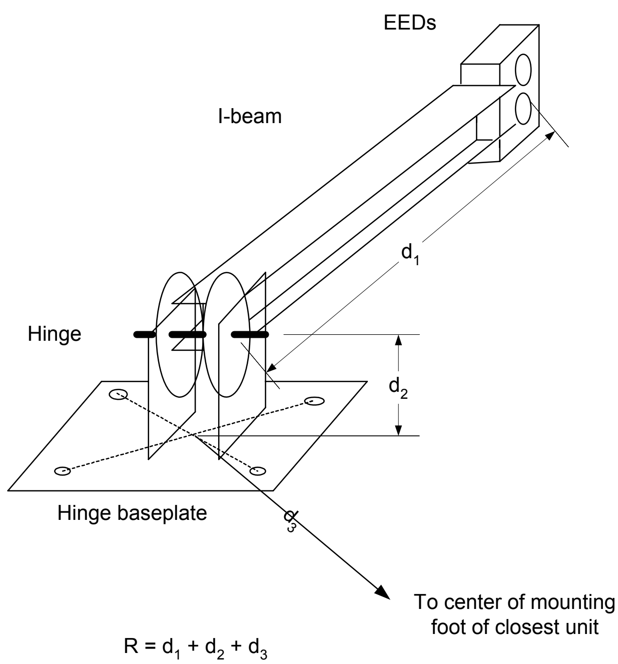
Figure 3.4.3-2(b). Distance R for a Unit Mounted On Adjacent Panel.



Components mounted near an antenna mechanism EED release device - A component is within R inches of an EED holddown, where R is measured from the center of the EED cutter block. Credit can be taken for the height of support brackets.

Credit shall not be taken for panel thickness in calculating R.

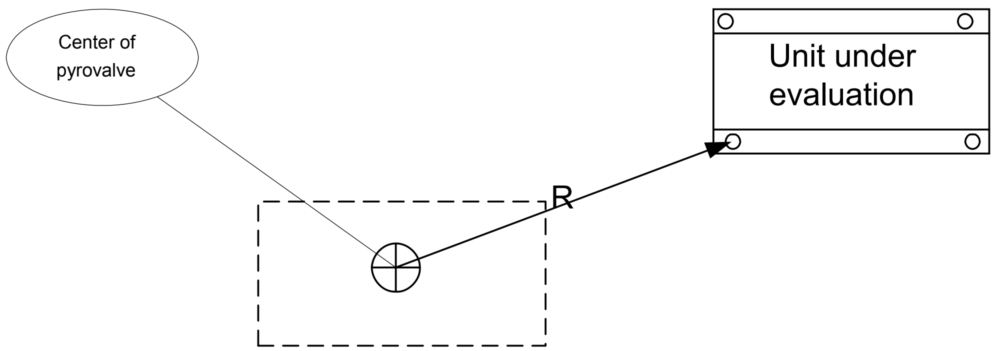
Figure 3.4.3-2(c). Distance R for a Unit Mounted Under an Earth Deck Holddown.



Components mounted near an antenna mechanism EED release device - A component is within R inches of an EED holddown, where R is measured from the center of the EED cutter block. Credit can be taken for the height of support brackets.

Credit shall not be taken for panel thickness in calculating R.

Figure 3.4.3-2(d). Distance R for an I-Strut or A-Frame Reflector Holddown.



Components mounted on the same panel as the propulsion pyrovalve bracket insert footprint- A component is within R inches of a pyrovalve, where R is measured along the panel surface, when the component's closest mounting foot is within R inches from the center of the propulsion pyrovalve bracket mounting footprint.

Credit shall not be taken for panel thickness in calculating R.

Figure 3.4.3-2(e). Distance R from a Unit Mounted Under a Propulsion Pyrovalve.

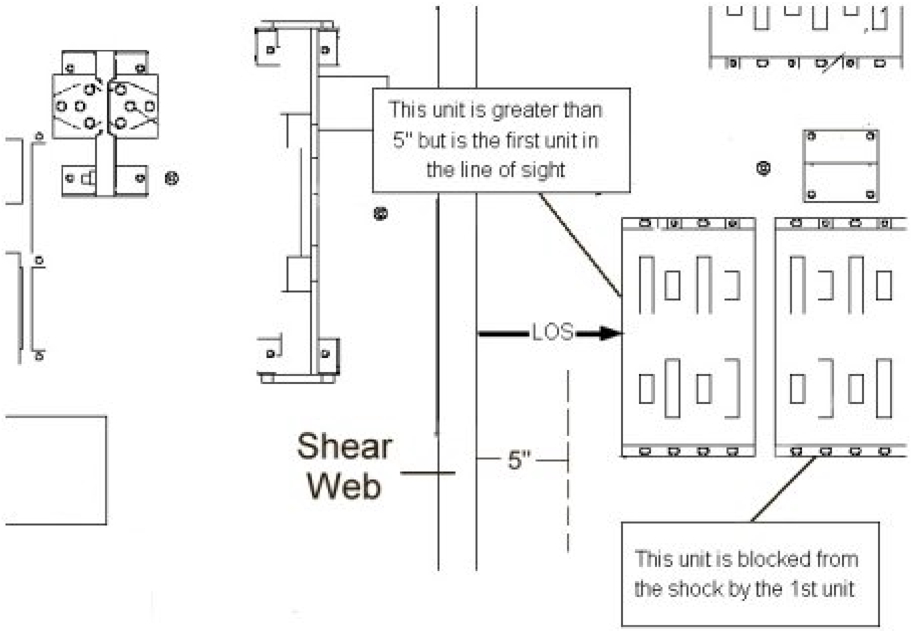


Figure 3.4.3-2(f). Line of sight from Shear Web

There is no distance limit on the line of sight.

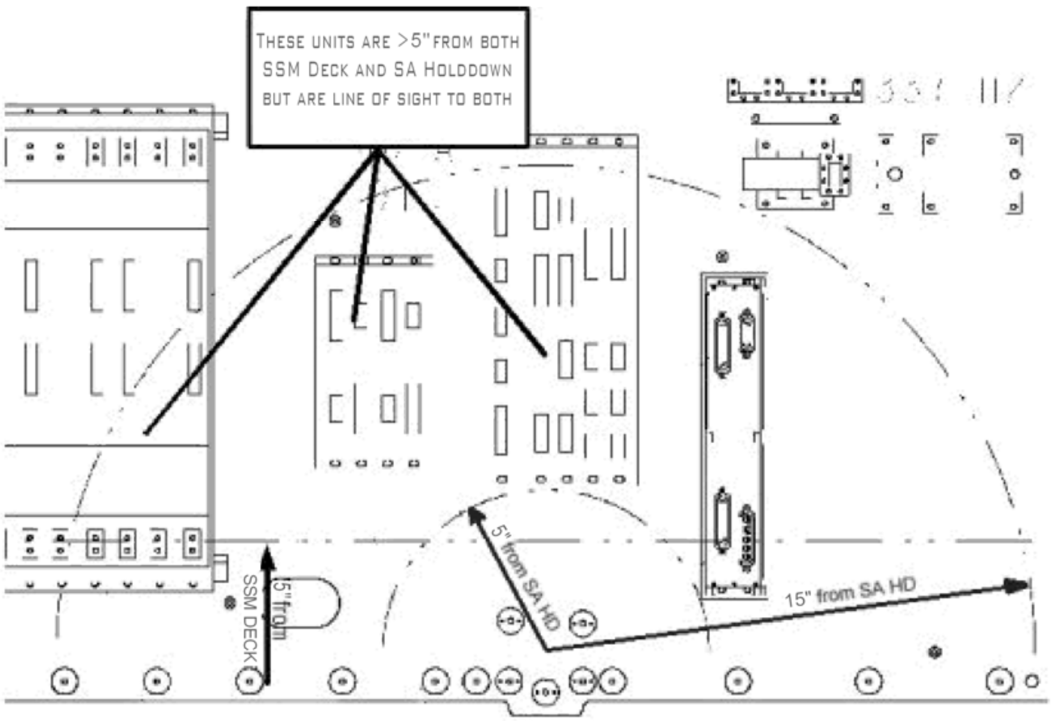


Figure 3.4.3-2(g). Line of Sight from SSM Deck and Solar Array Holddown

There is no distance limit on the line of sight.

Table 3.4.3-I. Unit Qualification Design Load Factors
(1 of 3)

Component	Qualification Load Factor (g) 1/, 2/	
	Lateral X or Y	Longitudinal Z
Solar Array		
Launch Load Case		
Maximum Lateral Case	5.2	6.5
Maximum Longitudinal Case	2.6	8.5
Maximum Out-of-Plane Modal Response	20.8 (<40 Hz)	-
	25 (40 to 50 Hz)	-
	30 (>50 Hz)	-
Deployed Load Case (Transfer orbit)	-	0.045 or 0.066 (note 5/)
OMUX Panels (Supported off Cylinder)		
Maximum Lateral Case	6.5	5.2
Maximum Longitudinal Case	3.0	10.4
Max Out-of-Plane Modal Response - Main Panel	13.0	-
Max Out-of-Plane Modal Response - Wing Panels	20.0	-
Feed Array Assembly (Upper Module)		
Maximum Lateral Case	4.0 g + 0.064 g/in lateral rotational acceleration 3/	4.0/-2.0
Maximum Longitudinal Case	2.0 g + 0.032 g/in lateral rotational acceleration 3/	8.0/-4.0
Maximum Out-of-Phase Modal Response	15.0	-
Selectable Sub-Reflector (SRR)	10.4 g + 0.1 g/in rotational acceleration 4/	15.0
SPT DAPM Module		
Max Lateral Case	8.0	5.2
Max Longitudinal Case	3.0	10.4
Max Modal Response of SPT Thruster	13.0	13.0
Deployed Load Case	-	0.066 g
Communication and SSM Equipment Panels		
Maximum Lateral Case	5.2	6.5
Maximum Longitudinal Case	2.6	8.5
Maximum Out-of-Plane Modal Response	13.0	-
Battery Panels		
Maximum Lateral Case	5.2	6.5
Maximum Longitudinal Case	2.6	8.5
Maximum Out-of-Plane Modal Response	10.4	-

See notes on Table 3.4.3-I (3 of 3)

Table 3.4.3-I. Unit Qualification Design Load Factors
(2 of 3)

Component	Qualification Load Factor (g) 1/, 2/ Lateral X or Y	Longitudinal Z
Main Body Mounted Reflectors		
Launch Load Case		
Maximum Lateral Case	6.5	5.2
Maximum In-Plane Lateral (Rotational)	Program specific	Program specific
Maximum Longitudinal Case	2.6	10.4
Maximum Out-of-Plane Modal Response	30 (<40 Hz)	-
	45 (40 to 60 Hz)	-
	60 (>60 Hz)	-
Deployed Load Case (Transfer orbit)	-	0.045 or 0.066 (note 5/)
Unsupported Ground Deployment (if required)		
Hinge Supported Reflectors (Special Load Case)	Side load in ±Y direction of at least 2.0 g x the reflector mass applied at hold down and hinge line locations	
Unfurlable Reflectors		
Launch Load Case		
Maximum Lateral Case	6.5	5.2
Maximum Longitudinal Case	2.6	9.5
Deployed Loads	Program Specific	Program Specific
Tower Mounted Reflectors		
Launch Load Case		
Maximum Lateral Case	8.0	5.2
Maximum Longitudinal Case	3.0	10.4
Maximum Out-of-Plane Modal Response	-	25.0
Main Body Mounted Feeds		
Maximum Lateral Case	8.0	5.2
Maximum Longitudinal Case	3.0	10.4
Lower Tower Mounted Feeds and Feed Arrays		
Maximum Lateral Case	15.0	5.2
Maximum Longitudinal Case	7.5	10.4
Upper Tower Mounted Components (Feeds, Feed Arrays, Subreflectors, Splashplates)		
Maximum Lateral Case	20.0	5.2
Maximum Longitudinal Case	10.0	10.4
Subreflector and Splashplate	-	60.0
Maximum Edge Out-of-Plane Response		

See notes on Table 3.4.3-I (3 of 3)

Table 3.4.3-I. Unit Qualification Design Load Factors (3 of 3)

Component	Qualification Load Factor (g) 1/, 2/ Lateral X or Y	Qualification Load Factor (g) 1/, 2/ Longitudinal Z
Propellant Tank (Loaded)		
Maximum Lateral Case	3.0	+0.50/-4.6
Maximum Longitudinal Case	1.3	3.25/-7.8
Xenon Tank Structure Assembly		
Maximum Lateral Case	4.0	4.6
Maximum Longitudinal Case	1.3	8.0
Main Satellite Thruster (MST)	7.0	10.0
Momentum/Reaction Wheel	8.0 (in each axis separately)	
Battery	10.4 (in each axis separately)	
Equipment Panel & Bracket Mounted Units	13.0 (in each axis separately)	
Pressurant/Xenon Tank	13.0 (in each axis separately)	
22N (5 lbf) Thruster	13.0 (in each axis separately)	
Ring Laser Gyro (RLG)	13.0 (in each axis separately)	
Solar Array Drive Assembly (SADA)	13.0 (in each axis separately)	
Sensors (CASS, ECASS)	16.0 (in each axis separately)	
Sensors (DSS, DSSE)	12.5 (in each axis separately)	
Earth Sensor Module Assembly	18.0 (in each axis separately)	
TC&R Antennas	25.0 (in each axis separately)	
Waveguide and Bracket Assembly	50.0 (in each axis separately)	
Star Tracker	20.0 (in each axis separately)	

NOTES:

1/ Load factors are equivalent values at component center of gravity. Loads are in spacecraft coordinates unless otherwise indicated.
2/ Lateral (X & Y) and axial (Z) load factors for each flight event are assumed to act simultaneously unless otherwise indicated. Loads may occur in either + or - direction unless otherwise specified.
3/ A rotational g load is applied to the feed array assembly. The orientation of the rotation axes will be determined so that the lateral loads are applied in the X or Y directions. The origin of the rotation axes will be determined such that the constant lateral acceleration is applied at the earth deck.
4/ Overall SSR shall be designed for a rotational g load. The rotation axis can be in any direction. The origin of the rotation axis is about the point where the DAPM axes intersect.
5/ Maximum deployed acceleration during transfer orbit is equal to:
[(110 lb MST thrust)/(S/C BOL dry mass)] x 2.0 DLF x 1.3 Qual factor.
If the resulting acceleration is ≤ 0.045g then design to 0.045g.
If the resulting acceleration is > 0.045g and < 0.066g then design to 0.066g.

Table 3.4.3-II(a). Vibration Test Levels, Equipment Panel Mounted Units

Component 16/	Test	Axis 7/	Frequency (Hz)	Acceptance	Qualification & Protoflight
Equipment Panel Mounted Units	Sine 1/, 2/, 3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 4.0 g	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.1 g^2 Hz -4.5 dB/oct 10.5 g_{rms}	6 dB/oct 0.2 g^2/Hz –4.5 dB/oct 14.9 g_{rms}
		Parallel to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.04 g^2/Hz -4.5 dB/oct 6.7 g_{rms}	6 dB/oct 0.08 g^2/Hz –4.5 dB/oct 9.4 g_{rms}
Bracket Mounted Units (Tested without brackets)	Sine 1/, 2/, 3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 7.7 g	0.25 in 13.0 g 10.0g
	Random 4/, 5/	All 3 Axes	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.25 g^2/Hz -4.5 dB/oct 16.6 g_{rms}	6 dB/oct 0.5 g^2/Hz -4.5 dB/oct 23.6 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(b). Vibration Test Levels, Reflectors, Subreflectors, and Splashplates

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
Main Body Mounted Reflectors	Sine 1/, 2/, 3/, 6/, 11/	Z	5 to 20.2 20.2 to 50 50 to 100	0.19 in 8.0 g 1.5 g	0.25 in 10.4 g 2.0 g
		X and Y	5 to 16 16 to 50 50 to 100	0.19 in 5.0 g 1.5 g	0.25 in 6.5 g 2.0 g
	Random		Not Required. Perform Acoustic Test per Table 3.4.2-VI.		
Tower Mounted Antenna Reflectors	Sine 1/, 2/, 3/ 6/, 11/	Z	5 to 20.2 20.2 to 50 50 to 100	0.19 in 8.0 g 1.5 g	0.25 in 10.4 g 2.0 g
		X and Y	5 to 17.7 17.7 to 50 50 to 100	0.19 in 6.2 g 1.5 g	0.25 in 8.0 g 2.0 g
	Random		Not Required. Perform Acoustic Test per Table 3.4.2-VI.		
Subreflectors and Splashplates Mounted Low on Tower	Sine 1/, 2/, 3/ 6/, 11/	Z	5 to 24.2 24.2 to 50 50 to 100	0.19 in 11.5 g 2.3 g	0.25 in 15.0 g 3.0 g
		X and Y	5 to 20.2 20.2 to 50 50 to 100	0.19 in 8.0 g 1.5 g	0.25 in 10.4 g 2.0 g
	Random		Not Required. Perform Acoustic Test per Table 3.4.2-VI.		
Subreflectors and Splashplates Mounted High on Tower	Sine 1/, 2/, 3/ 6/, 11/	Z	5 to 24.2 24.2 to 50 50 to 100	0.19 in 11.5 g 2.3 g	0.25 in 15.0 g 3.0 g
		X and Y	5 to 28 28 to 50 50 to 100	0.19 in 15.4 g 3.1 g	0.25 in 20.0 g 4.0 g
	Random		Not Required. Perform Acoustic Test per Table 3.4.2-VI.		

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(c). Vibration Test Levels, Feeds and Feed Arrays

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
Feeds (Main Body)	Sine 1/, 2/, 3/, 13/	Z	5 to 20.2 20.2 to 50 50 to 100	0.19 in 8.0 g 2.3 g	0.25 in 10.4 g 3.0 g
		X and Y	5 to 17.7 17.7 to 50 50 to 100	0.19 in 6.2 g 2.3 g	0.25 in 8.0 g 3.0 g
Feeds and Feed Arrays (Lower Tower)	Sine 1/, 2/, 3/, 13/	Z	5 to 20.2 20.2 to 50 50 to 100	0.19 in 8.0 g 2.3 g	0.25 in 10.4 g 3.0 g
		X and Y	5 to 24.2 24.2 to 50 50 to 100	0.19 in 11.5 g 2.3 g	0.25 in 15.0 g 3.0 g
Feeds and Feed Arrays (Upper Tower)	Sine 1/, 2/, 3/, 13/	Z	5 to 20.2 20.2 to 50 50 to 100	0.19 in 8.0 g 2.3 g	0.25 in 10.4 g 3.0 g
		X and Y	5 to 28 28 to 50 50 to 100	0.19 in 15.4 g 3.1 g	0.25 in 20.0 g 4.0 g
Feeds (Main Body, Lower Tower, Upper Tower)	Random 4/, 5/, 13/, 14/	Normal to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.133 g^2/Hz -4.5 dB/oct 12.2 g_{rms}	6 dB/oct 0.266 g^2/Hz -4.5 dB/oct 17.2 g_{rms}
		Parallel to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.05 g^2/Hz -4.5 dB/oct 7.5 g_{rms}	6 dB/oct 0.10 g^2/Hz -4.5 dB/oct 10.5 g_{rms}
Feed Arrays (Lower Tower, Upper Tower)	Random 4/, 5/, 13/, 14/	Normal to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.075 g^2/Hz -4.5 dB/oct 9.1 g_{rms}	6 dB/oct 0.15 g^2/Hz -4.5 dB/oct 12.9 g_{rms}
		Parallel to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.05 g^2/Hz -4.5 dB/oct 7.5 g_{rms}	6 dB/oct 0.10 g^2/Hz -4.5 dB/oct 10.5 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(d). Vibration Test Levels, Solar Array

Component	Test	Axis 7/	Frequency, Hz	Acceptance 12/	Protoflight & Qualification
Solar Array (Including Yoke)	Sine 1/, 2/, 3/, 6/, 11/	Z	5 to 18.2 18.2 to 50 50 to 100	0.19 in 6.5 g 1.5 g	0.25 in 8.5 g 2.0 g
		X and Y	5 to 14.3 14.3 to 25 25 to 50 50 to 100	0.19 in 4.0 g 3.0 g 2.0 g	0.25 in 5.2 g 3.9 g 2.6 g
	Random		Not Required. Perform Acoustic Test Per Table 3.4.2-VI.		

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(e). Vibration Test Levels, TC&R Antenna

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
TC&R Antenna	Sine 1/, 2/, 3/ ,15/	All 3 axes	5 to 31.3 31.3 to 50 50 to 100	0.19 in 19.2 g 3.8 g	0.25 in 25 g 5.0 g
	Random 4/, 5/ ,15/	All 3 axes	20 to 50 50 to 600 600 to 2000	6 dB/oct 0.15 g^2/Hz -4.5 dB/oct 12.9 g_{rms}	6 dB/oct 0.30 g^2/Hz -4.5 dB/oct 18.2 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(f). Vibration Test Levels, Earth Sensor

Component 8/	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
Earth Sensor Module Assembly (Tower Mounted)	Sine 1/, 2/, 3/	All 3 axes	5 to 26.5 26.5 to 50 50 to 100	0.19 in 13.8 g 3.1 g	0.25 in 18.0 g 4.0 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 100 100 to 300 300 to 2000 Overall	9 dB/oct 0.10 g^2/Hz -6 dB/oct 6.9 g_{rms}	9 dB/oct 0.20 g^2/Hz -6 dB/oct 9.8 g_{rms}
		Parallel to Mounting Surface	20 to 100 100 to 300 300 to 2000 Overall	6 dB/oct 0.25g^2/Hz -6 dB/oct 11.0$_{grms}$	6 dB/oct 0.50 g^2/Hz -6 dB/oct 15.6 g_{rms}
Earth Sensor	Sine 1/, 2/, 3/	All 3 axes	5 to 26.5 26.5 to 50 50 to 100	0.19 in 13.8 g 4.1 g	0.25 in 18.0 g 5.3 g
	Random 4/, 5/	Z Axis Normal to ESA Mounting Surface	20 to 130 130 to 240 240 to 250 250 to 372 372 to 650 650 to 2000 Overall	9 dB/octave 0.175 g^2/Hz 51 dB/oct 0.35 g^2/Hz -15 dB/oct -6 dB/oct 10.4 g_{rms}	9 dB/octave 0.35 g^2/Hz 51 dB/oct 0.7 g^2/Hz -15 dB/oct -6 dB/oct 14.7 g_{rms}
		X Axis Parallel to ESA Mounting Surface	20 to 190 190 to 270 270 to 2000 Overall	7 dB/octave 0.5 g^2/Hz -7 dB/oct 12.8 g_{rms}	7 dB/octave 1.0 g^2/Hz -7 dB/oct 18.0 g_{rms}
		Y Axis Parallel to ESA Mounting Surface	20 to 115 115 to 190 190 to 200 200 to 300 300 to 2000 Overall	9 dB/octave 0.5 g^2/Hz -40.5 dB/oct 0.25 g^2/Hz -6 dB/octave 12.0 g_{rms}	9 dB/octave 1.0 g^2/Hz -40.5 dB/oct 0.5 g^2/Hz -6 dB/octave 16.97 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(g). Vibration Test Levels, Sensors

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
CASS and ECASS	Sine 1/, 2/, 3/	All 3 axes	5 to 25 25 to 50 50 to 100	0.19 in 12.3 g 3.8 g	0.25in 16 g 5.0 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 50 50 to 1000 1000 to 2000	6 dB/oct 0.133 g^2/Hz -6.0 dB/oct 14.0 g_{rms}	6 dB/oct 0.266 g^2/Hz -6 dB/oct 19.7 g_{rms}
		Parallel to Mounting Surface	20 to 50 50 to 1000 1000 to 2000	6 dB/oct 0.044 g^2/Hz -6 dB/oct 8.1 g_{rms}	6 dB/oct 0.089 g^2/Hz -6 dB/oct 11.4 g_{rms}
DSS DSSE	Sine 1/, 2/, 3/	All 3 axes	5 to 22 22 to 50 50 to 100	0.19 in 9.6 g 3.8 g	0.25in 12.5 g 5.0 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 50 50 to 1000 1000 to 2000 Overall	6 dB/oct 0.133 g^2/Hz -6 dB/oct 14.0 g_{rms}	6 dB/oct 0.266 g^2/Hz -6 dB/oct 19.7 g_{rms}
		Parallel to Mounting Surface	20 to 50 50 to 1000 1000 to 2000 Overall	6 dB/oct 0.044 g^2/Hz -6 dB/oct 8.1 g_{rms}	6 dB/oct 0.089 g^2/Hz -6 dB/oct 11.4 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(h). Vibration Test Levels, Ring Laser Gyro (RLG)

Component	Test	Axes 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
RLG	Sine 1/,2/,3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 4.0 g	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	All 3 Axes	20 to 50 50 to 600 600 to 2000	6 dB/octave 0.1 g^2/Hz –4.5 dB/oct	6 dB/octave 0.2 g^2/Hz –4.5 dB/oct
			Overall	10.5 g_{rms}	14.9 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(i). Vibration Test Levels, SIRU

	Test	Axes 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
SIRU	Sine 1/, 2/, 3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 4.0 g	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 80 80 to 600 600 to 2000 Overall	6 dB/octave 0.1 g^2/Hz -4.5 dB/oct 10.4 g_{rms}	6 dB/octave 0.2 g^2/Hz -4.5 dB/oct 14.8 g_{rms}
		Parallel to Mounting Surface	20 to 60 60 to 700 700 to 2000 Overall	6 dB/oct 0.04 g^2/Hz -6 dB/oct 6.7 g_{rms}	6 dB/oct 0.08 g^2/Hz -6 dB/oct 9.4 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(j). Vibration Test Levels, Propellant Tank
1 of 2

A. Loaded Tank-Qualification (Trichlorotrifluorethane) - Reference Only

Test	Axis 7/	Frequency (Hz)	Acceleration (g, 0-Peak)	Limit Acceleration (g)
Sine Qualification 1/, 2/, 3/ 6/, 10/	Lateral (X and Y)	5.0 to 10.8 10.8 to 45 45 to 100	0.25 in. 3.0 2.0	3.0 3.0 3.0
	Axial (Z)	5.0 to 18.2 18.2 to 20 20 to 22 22 to 50 50 to 52 52 to 100	0.20 in. 6.8 9/ Ramp Down 2.6 Ramp Down 1.3	6.8 9/ 6.8 9/ 6.8 9/ 4.5 4.5 2.6

B. Loaded Tank-Protoflight (Water)

Test	Axis 7/	Frequency (Hz)	Acceleration (g, 0-Peak)	Limit Acceleration (g)
Sine Protoflight 1/, 2/, 3/ 6/, 10/	Lateral (X or Y)	5 to 13 13 to 17 17 to 45 45 to 100	0.25 in 4.3 3.0 2.0	5.0 5.0 3.0 3.0
	Axial (Z)	5 to 22.3 22.3 to 24 24 to 26 26 to 50 50 to 52 52 to 100	0.20 in 10.2 9/ Ramp Down 2.6 Ramp Down 1.3	10.2 9/ 10.2 9/ 10.2 9/ 4.5 4.5 2.6

C. Loaded Tank-Acceptance (Water)

Test	Axis 7/	Frequency (Hz)	Acceleration (g, 0-Peak)	Limit Acceleration (g)
Sine Acceptance 1/, 2/, 3/ 6/, 10/	Lateral (X or Y)	5 to 13 13 to 17 17 - 45 45 – 100	0.19 in 3.3 2.31 1.54	3.86 3.86 2.31 2.31
	Axial (Z)	5.0 to 22.3 22.3 to 24 24 to 26 26 to 50 50 to 52 52 to 100	0.15 in 7.6 9/ Ramp Down 2.0 Ramp Down 1.0	7.6 9/ 7.6 9/ 7.6 9/ 3.46 3.46 2.0

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(j). Vibration Test Levels, Propellant Tank
2 of 2

D. Unloaded Tank-Qualification (for Shipping and Handling)

Test	Axis 7/	Frequency (Hz)	Acceleration (g, 0-Peak)	Limit Acceleration (g)
Sine Qualification 1/, 2/, 3/, 10/	All 3 Axes	5.0 to 10.8 10.8 to 20 20 to 100 100 to 400	0.25 in. 3.0 1.5 1.0	Not Applicable

E. Loaded Tank (Trichlorotrifluorethane) - Random, Reference Only

Test	Axis 7/	Frequency (Hz)	Acceptance (Reference only - test not required)	Protoflight & Qualification
Random 4/, 5/	All 3 axes	90 to 100 100 to 800 800 to 2000 Overall	30 dB/oct 0.027 g^2/Hz -3 dB/oct 6.2 g_{rms}	30 dB/oct 0.054 g^2/Hz -3 dB/oct 8.7 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(k). Vibration Test Levels, Pressurant/Xenon Tank

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
Pressurant Tank	Sine 1/, 2/, 3/	Tank Axial and One Orthogonal Axis	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 4.0 g	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	Tank Axial and One Orthogonal Axis	20 to 50 50 to 300 300 to 2000 Overall	9 dB/oct 0.020 g^2/Hz -6 dB/oct 3.2 g_{rms}	9 dB/oct 0.040 g^2/Hz -6 dB/oct 4.6 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(l). Vibration Test Levels, 22N (5 lbf) Bi-Propellant Thruster

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
22N (5 lbf) Bi-Propellant Thruster	Sine 1/, 2/, 3/	All	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 4.0 g	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	All	20 to 125 125 to 252 252 to 300 300 to 900 900 to 2000 Overall	9 dB/oct 0.130 g^2/Hz -12 dB/oct 0.065 g^2/Hz -9 dB/oct 9.3 g_{rms}	9 dB/oct 0.260 g^2/Hz -12 dB/oct 0.130 g^2/Hz -9 dB/oct 13.2 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(m). Vibration Test Levels, 490N (110 lbf) Main Satellite Thruster

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Qualification & Protoflight
Main Satellite Thruster	Sine 1/, 2/, 3/	Axial	10 to 19.7 19.7 to 50 50 to 60 60 to 100	0.19 in 7.7 9 Ramp Down 2.0 g	0.25 in 10.0 g Ramp Down 2.6 g
		Lateral	10 to 16.5 16.5 to 50 50 to 60 60 to 100	0.19 in 5.4 g Ramp Down 0.9 g	0.25 in 7.0 g Ramp Down 1.2 g
	Random 4/, 5/	All Axes	20 to 35.4 35.4 to 150 150 to 212 212 to 600 600 to 2000 Overall	6.0 dB/oct 0.02 g^2/Hz 6.0 dB/oct 0.04 g^2/Hz -4.5 dB/oct 6.4 g_{rms}	6.0 dB/oct 0.04 g^2/Hz 6.0 dB/oct 0.08 g^2/Hz -4.5 dB/oct 9.1 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(n). Vibration Test Levels, Battery

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
Battery Units (Nickel-Hydrogen; Lithium-Ion)	Sine 1/, 2/, 3/	All 3 Axes	5 to 20.2	0.19 in	0.25 in
			20.2 to 50	8.0 g	10.4 g
			50 to 100	4.0 g	5.2 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 50	6.0 dB/oct	6.0 db/oct
			50 to 600	0.03 g^2/Hz	0.06 g^2/Hz
			600 to 2000	-6.0 db/oct	-6.0 db/oct
			Overall	5.4 g_{rms}	7.7 g_{rms}
		Parallel to Mounting Surface	20 to 50	6.0 db/oct	6.0 db/oct
			50 to 600	0.02 g^2/Hz	0.04 g^2/Hz
			600 to 2000	-6.0 db/oct	-6.0 db/oct
			Overall	4.4 g_{rms}	6.3 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(o). Vibration Test Levels, Reaction Wheel

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
Reaction Wheel (all wheels except for Honeywell Constellation Series)	Sine 1/, 2/, 3/,11/	2 Axes: 1 axial 1 radial	5 to 17.7 17.7 to 50 50 to 100	0.19 in 6.2 g 4.0 g	0.25 in 8.0 g 5.2g
	Random 4/, 5/	All 3 Axes	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.04 g^2/Hz -4.5 dB/oct 6.6 g_{rms}	6 dB/oct 0.08 g^2/Hz -4.5 dB/oct 9.4 g_{rms}
Reaction Wheel (Honeywell Constellation Series CS RW83, CS RW57)	Sine 1/, 2/, 3/, 11/	All 3 Axes	5 to 17.7 17.7 to 50 50 to 80 80 to 100	0.19 in 6.2 g 4.0 g 1.5 g	0.25 in 8.0 g 5.2 g 2.0 g
	Random 4/, 5/	All 3 Axes	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.04 g^2/Hz -4.5 dB/oct 6.6 g_{rms}	6 dB/oct 0.08 g^2/Hz -4.5 dB/oct 9.4 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(p). Vibration Test Levels, SADA

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
SADA	Sine 1/, 2/, 3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 4.0 g	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	All 3 Axes	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.05 g^2/Hz -4.5 dB/oct 7.4 g_{rms}	6 dB/oct 0.1 g^2/Hz -4.5 dB/oct 10.5 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(q). Vibration Test Levels, Propulsion Equipment Mounted on the ACS Deck (SSM Deck for LS1300S)

Component	Test	Axis 7/	Frequency, Hz	Acceptance	Protoflight & Qualification
Propulsion Equipment Mounted on ACS Deck	Sine 1/, 2/, 3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	0.19 in 10.0 g 4.0 g	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	All 3 Axes	20 to 50 50 to 600 600 to 2000 Overall	+6 dB/oct 0.1 g^2/Hz -4.5 dB/oct 10.5 g_{rms}	+6 dB/oct 0.2 g^2/Hz -4.5 dB/oct 14.9 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(r). Vibration Test Levels, OMUX Panel Subassembly

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
OMUX Panel Assembly Main Panel Mounted Units	Sine 1/,2/,3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	Not required	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 db/oct 0.1 g^2/Hz -4.5 dB/oct 10.5 g_{rms}	6 db/oct 0.2g^2/Hz -4.5 dB/oct 14.9 g_{rms}
		Parallel to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 db/oct 0.04g^2/Hz -4.5 dB/oct 6.7 g_{rms}	6 db/oct 0.08 g^2/Hz -4.5 dB/oct 9.4 g_{rms}
OMUX Panel Assembly Wing Panel Mounted Units (switches)	Sine 1/,2/,3/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	Not required	0.25 in 13.0 g 5.2 g
	Random 4/, 5/	All 3 Axes	20 to 50 50 to 600 600 to 2000 Overall	6 db/oct 0.25 g^2/Hz -4.5 dB/oct 16.7 g_{rms}	6 db/oct 0.50 g^2/Hz -4.5 dB/oct 23.6 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(s). Vibration Test Levels, Stationary Plasma Thruster (SPT)

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
Stationary Plasma Thruster (SPT)	Sine 1/,2/,3/	All 3 Axes	5 to 25.4 25.4 to 50 50 to 100	0.15 in 10.0 g 4.0 g	0.20 in 13.0 g 5.2 g
	Random 4/, 5/	All 3 Axes	20 to 125 125 to 252 252 to 300 300 to 900 900 to 2000 Overall	9 dB/oct 0.13 g^2/Hz −12.0 dB/oct 0.065 g^2/Hz -9 dB/oct 9.4 g_{rms}	9 dB/oct 0.26 g^2/Hz −12.0 dB/oct 0.13 g^2/Hz -9 dB/oct 13.2 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(t). Vibration Test Levels, Deployment and Positioning Mechanism (DAPM) Rotary Actuator

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
DAPM Rotary Actuator 19/	Sine 1/,2/,3/	All Axes	5 to 24.2 24.2 to 50 50 to 100	0.19 in 11.5 g 2.3 g	0.25 in 15.0 g 3.0 g
	Random 4/, 5/	All Axes	20 to 50 50 to 600 600 to 2000	6 dB/oct 0.1 g^2/Hz -4.5 dB/oct 10.5 g_{rms}	6 dB/oct 0.2 g^2/Hz -4.5 dB/oct 14.9 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(u). Vibration Test Levels, Enhanced Deployment and Positioning Mechanism (EDAPM) Rotary Actuator

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
EDAPM Rotary Actuator 19/	Sine 1/,2/,3/	All Axes	5 to 24.2 24.2 to 50 50 to 100	0.19 in 11.5 g 2.3 g	0.25 in 15.0 g 3.0 g
	Random 4/, 5/	All Axes	20 to 50 50 to 600 600 to 2000	6 dB/oct 0.1 g^2/Hz -4.5 dB/oct 10.5 g_{rms}	6 dB/oct 0.2 g^2/Hz -4.5 dB/oct 14.9 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(v). Vibration Test Levels, APM

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
APM (with simulated sub-reflector)	Sine 1/,2/,3/	Z	5 to 22.6 22.6 to 100	0.19 in 10.0 g	0.25 in 13.0 g
		X and Y	5 to 24.2 24.2 to 60 60 to 100	0.19 in 11.5 g 6.5 g	0.25 in 15.0 g 8.0 g
	Random 4/, 5/	Normal to Mounting Surface	20 to 40 40 to 140 140 to 200 200 to 400 400 to 2000	6 dB/oct 0.050 g^2/Hz 5.83 dB/oct 0.100 g^2/Hz -6 dB/oct 7.87 g_{rms}	6 dB/oct 0.100 g^2/Hz 5.83 dB/oct 0.200 g^2/Hz -6 dB/oct 11.14 g_{rms}
		Parallel to Mounting Surface	20 to 200 200 to 400 400 to 2000	3 dB/oct 0.020 g^2/Hz −3 dB/oct 4.34 g_{rms}	3 dB/oct 0.040 g^2/Hz −3 dB/oct 6.14 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(w). Vibration Test Levels, Stationary Plasma Thruster (SPT) DAPM Module

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
Stationary Plasma Thruster (SPT)DAPM Module	Sine 1/,2/,3/, 6/, 11/	Z	5 to 20.2 20.2 to 50 50 to 100	0.19 in 8.0 g 1.5 g	0.25 in 10.4 g 2.0 g
		X and Y	5 to 17.7 17.7 to 50 50 to 100	0.19 in 6.2 g 1.5 g	0.25 in 8.0 g 2.0 g
	Random 4/, 5/, 18/	Normal to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.03 g^2/Hz -6.0 dB/oct 5.4 g_{rms}	6 dB/oct 0.06 g^2/Hz -6.0 dB/oct 7.7 g_{rms}
		Parallel to Mounting Surface	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.02 g^2/Hz -6.0 dB/oct 4.4 g_{rms}	6 dB/oct 0.04 g^2/Hz -6.0 dB/oct 6.3 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(x). Vibration Test Levels, Unfurlable Reflector

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
Unfurlable Reflectors	Sine 1/,2/,3/, 6/, 11/	Z	5 to 18.2	0.19 in	0.25 in
			18.2 to 50	6.5 g	8.5 g
			50 to 100	1.5 g	2.0 g
		X and Y	5 to 16	0.19 in	0.25 in
9-meter			16 to 50	5.0 g	6.5 g
12-meter			50 to 100	1.5 g	2.0 g
18-meter	Random 4/, 5/, 17/	All 3 axes	20 to 100	12 dB/oct	12 dB/oct
			100 to 300	0.02 g^2/Hz	0.04 g^2/Hz
			300 to 500	-6 dB/oct	-6 dB/oct
			Overall	2.61 g_{rms}	3.69 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(y). Vibration Test Levels, Feed Array

<table>
<tr><th>Component</th><th>Test</th><th>Axis 7/</th><th>Frequency (Hz)</th><th>Acceptance</th><th>Protoflight & Qualification</th></tr>
<tr><td rowspan="3">Feed Array</td><td rowspan="2">Sine 1/,2/,3/, 6/, 11/</td><td>$Z_{S/C}$</td><td>5 to 17.7
17.7 to 50
50 to 100</td><td>0.19 in
6.5 g
1.5 g</td><td>0.25 in
8.0 g
2.0 g</td></tr>
<tr><td>$X_{S/C}$ and $Y_{S/C}$</td><td>5 to 16
16 to 50
50 to 100</td><td>0.19 in
5.0 g
1.5 g</td><td>0.25 in
6.5 g
2.0 g</td></tr>
<tr><td>Random 4/, 5/</td><td></td><td colspan="3">Not Required
Perform Acoustic Test per Table 3.4.2-VI, Satellite Acoustic Test Levels - Envelope</td></tr>
</table>

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(z). Vibration Test Levels, Bracket Mounted Ku IMUX

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
Bracket Mounted Ku IMUX	Sine (Tested without brackets) 1/,2/,3/, 6/, 11/	All 3 Axes	5 to 22.6 22.6 to 50 50 to 100	Not Required since the Ku-IMUX and bracket assembly fundamental frequency ≥ 100 Hz.	0.25 in 13.0 g 10.0 g
	Random (Tested without brackets) 4/, 5/	Normal To Mounting Panel	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.25 g^2/Hz -4.5 dB/oct 16.7 g_{rms}	6 dB/oct 0.5 g^2/Hz -4.5 dB/oct 23.6 g_{rms}
		Parallel To Mounting Panel	20 to 50 50 to 600 600 to 2000 Overall	6 dB/oct 0.25 g2/Hz -10 dB/oct 14.2 g_{rms}	6 dB/oct 0.5 g2/Hz -10 dB/oct 20.1 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II(aa). Vibration Test Levels, Star Tracker

Component	Test	Axis 7/	Frequency (Hz)	Acceptance	Protoflight & Qualification
Star Tracker	Sine 1/,2/,3/	All Axes	5 to 28 28 to 50 50 to 100	0.19 in 15.4 g 7.7 g	0.25 in 20.0 g 10.0 g
	Random 4/,5/	All Axes	20 to 50 50 to 600 600 to 1000	6 dB/oct 0.25 g^2/Hz -4.5 dB/oct 16.6 g_{rms}	--
			20 to 50 50 to 247 247 to 400 400 to 1000 1000 to 2000	--	6 dB/oct 0.6 g^2/Hz -6 dB/oct 0.23 g^2/Hz -8 dB/oct 20.4 g_{rms}

See notes, Table 3.4.3-II (notes)

Table 3.4.3-II (notes). Notes, Vibration Test Levels

1/ Sine Vibration displacements are specified as "Single Amplitude" (0 to peak)

2/ Sine Vibration Test Sweep Rates:

	4 octaves/minute	(acceptance)
	4 octaves/minute	(protoflight)
	2 octaves/minute	(qualification)

3/ Sine vibration is not required for acceptance testing for components whose minimum resonant frequency is greater than 100 Hz.

4/ Random Vibration Test durations:

	60 seconds/axis	(acceptance)
	60 seconds/axis	(protoflight)
	180 seconds/axis	(qualification)

5/ The qualification duration for random vibration tests has increased from 120 seconds/axis to 180 seconds/axis. Existing heritage components qualified to the previous standard of 120 seconds/axis remain fully qualified. If delta-qualification will be performed for previously qualified hardware on a non-flight QM/EQM, then the new 180 seconds/axis requirement will be used.

6/ Notching of input, or other appropriate force limiting methods, is permitted on equipment assigned this note such that responses do not exceed appropriate levels determined from structural analysis. Maximum modal responses for reflectors are contained in other tables of this document or the program ERS addendum. All other equipment maximum response levels shall be approved in appropriate design specifications or technical memorandums.

7/ Vibration coordinate axes are referenced to the satellite coordinate system, unless otherwise indicated. Permissible to test component in local axes, provided maximum level is enveloped.

8/ The Earth Sensor is procured and tested at the unit level. The Earth Sensor is then mounted in a bracket assembly at the spacecraft level, which is called the Earth Sensor Module Assembly (ESMA). The specifications defined for the ESMA correspond to the levels derived from spacecraft structural analysis. The levels for the Earth Sensor are derived from test results of an ESMA at the spacecraft required levels. These derived specifications for the Earth Sensor are then used for unit level tests at the supplier.

9/ Allowance made for 1g gravitational field.

10/ Qualification tests shall be performed in all three axes. Protoflight and acceptance tests shall be performed in the axial and one lateral direction only.

11/ Notching of input is permitted such that responses do not exceed qualification design load factors in Table 3.4.3-I, Unit Qualification Design Load Factors. For acceptance tests, limiting levels are scaled by 1/1.3 respectively.

12/ Acceptance sine vibration test is not required for solar array performed at satellite level.

13/ Notching of input is permitted such that responses do not exceed:

	Acceptance	Protoflight & Qualification
Sine Vibration	19.2 g	25 g (any location)
Random Vibration	5 g^2/Hz	10 g^2/Hz (feed tip)
	10 g^2/Hz	20 g^2/Hz (any other location)

14/ Acoustic test may be substituted for random vibration test. If acoustic test is performed, feed shall be mounted on a fixture representative of satellite support configuration.

15/ Notching of input is permitted such that responses do not exceed:

	Acceptance	Protoflight & Qualification
Sine Vibration	19.2 g	25 g (any location)
Random Vibration	10 g^2/Hz	20 g^2/Hz (any location)

16/ Applies to equipment mounted to communications, SSM, Earth, Anti-Earth, and ACS Panels, unless shown in subsequent tables. e.g., Battery, Momentum Wheels, etc.

17/ Notching of input is permitted such that 3-sigma interface loads do not exceed loads corresponding to quasi-static loads specified in Table 3.4.3-I. For acceptance tests, the limiting interface loads are scaled by 1/1.3.

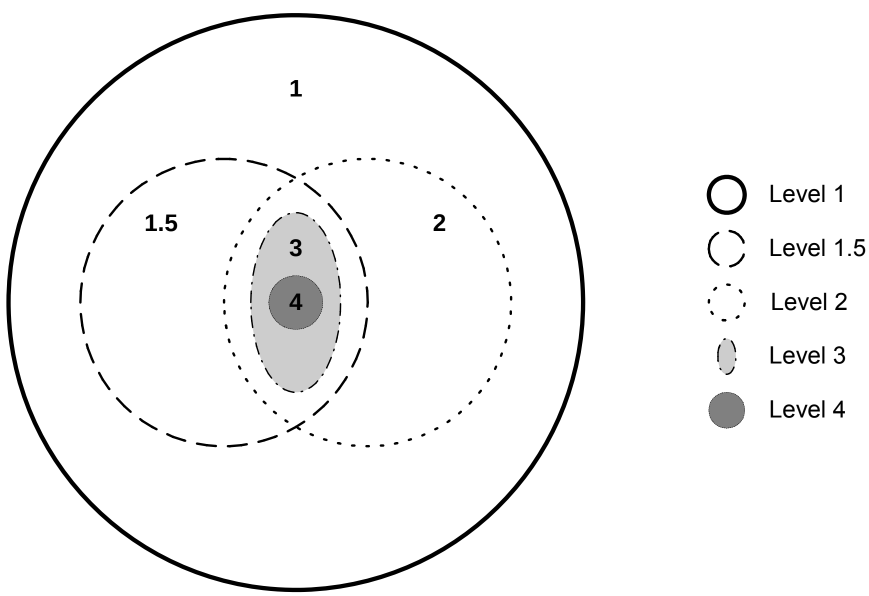
18/ Notching is permitted such that the responses on the thrusters, or the DAPM, do not exceed 0.13g^2/Hz for proto/qual, or 0.065 g^2/Hz for acceptance testing.

19/ Levels apply to both main body and tower mounted DAPM and EDAPM. Vibration levels apply to testing at the rotary actuator level. Input levels are applied at the inboard interface. No vibration tests are performed on the DAPM or EDAPM gimbal level (gimbal level is two actuators that are mounted orthogonally onto the central bracket).

Table 3.4.3-III(a). Generic Shock Levels

Component Shock Level	Frequency (Hz)	SRS Acceleration, g (Q=10)	
		Flight	Protoflight & Qualification
1	200	100	140
	4000	3000	4200
1.5	200	100	140
	1400	600	840
	4000	1332	1865
2	200	37	52
	4000	3000	4200
3	200	37	52
	1400	600	840
	4000	1332	1865
4	200	25	35
	4000	1332	1865
Test Exposures		None 6/	1 per axis (Protoflight) 3 per axis (Qualification)

See notes, Table 3.4.3-III (notes)



Graphical Representation of Generic Shock Levels

Note Level 2 is NOT a subset of Level 1.5

Table 3.4.3-III(b). Induced Shock Levels

NOTE: Table 3.4.3-III(b) Induced Shock Levels consolidates and replaces E237665 Revision 5 Table 3.4.3-III(b) Launch Vehicle Induced Shock Levels and Table 3.4.3-III (c) Satellite Induced Shock Levels.

General Location	Shock Requirement				Heritage Locations	Heritage Shock Levels
	Level	Frequency, Hz	SRS Acceleration, g (Q = 10)			
			Flight	Protoflight & Qualification		
Tower	2	200 4000	37 3000	52 4200	<5" from or in LOS to SSD or pyrodevice	2
					>5" from SSD or pyrodevice	4
Earth Deck	2	200 4000	37 3000	52 4200	<5" from or in LOS to SSD or pyrodevice	2
					>5" from SSD or pyrodevice	4
COMM Panel	2	200 4000	37 3000	52 4200	<5" from or in LOS to SSD or pyrodevice	2
					<5" from or in LOS to SSM Deck or Shear Web	3
					>5" from SSD or pyrodevice	4
					>5" from and not in LOS to SSM deck or Shear Web	4
Shear Web	1	200 4000	100 3000	140 4200	<5" from or in LOS to SSD or pyrodevice	1.5 or 2
					>5" from SSD or pyrodevice	1.5
Upper COMM Module[14]	2	200 4000	37 3000	52 4200	<5" from or in LOS to SSD or pyrodevice	2
					>5" from SSD or pyrodevice	4
OMUX Panel	4	200 4000	25 1332	35 1865	panel or strut mounted	4
SSM Deck/Anti-Earth Deck	1	200 4000	100 3000	140 4200	<10" from cylinder or in radial LOS of cylinder	1
					<5" from or in LOS to SSD or pyrodevice	2
					>10" from cylinder (not in radial LOS of cylinder)	3
Battery Panel	3	200 1400 4000	37 600 1332	52 840 1865	east/west lithium ion	3

See notes, Table 3.4.3-III (notes)

Table 3.4.3-III(c). Satellite Induced Shock Levels

Satellite induced Shock Levels are incorporated into Table 3.4.3-III(b) Induced shock Levels.

Table 3.4.3-III(d). Shock Requirements for Specific Units

Component		Frequency (Hz)	SRS Acceleration (g) Flight	SRS Acceleration (g) Protoflight & Qualification	Comments
MST (Radial)		200	37	52	
		850	500	700	
		4000	1500	2100	
MST (Axial)		200	71	100	
		850	1000	1400	
		4000	1000	1400	
MST Latch Valve (Radial)		200	100	140	
		1000	2000	2800	
		4000	2000	2800	
MST Latch Valve (Axial)		200	250	350	
		1000	1500	2100	
		4000	1500	2100	
Reaction Wheel (Radial)		200	130	180	
		850	700	980	
		4000	1770	2500	
Reaction Wheel (axial)		200	150	210	
		450	450	630	
		4000	750	1050	
Honeywell MW		200	121	170	
MW Radial and axial directions		2000	1500	2100	
		4000	1500	2100	
Teldix MW Radial		200	71	100	
MW Radial direction		2000	1429	2000	
		4000	1429	2000	
Teldix MW Axial		200	50	70	
MW Axial direction		2000	1429	2000	
		4000	1429	2000	
Solar Array Panel Components		1000	2350	3300	Shock levels adjacent to
		10000	27000	38000	solar array holddowns
Thales Velizey	Gun	200	25	35	See STIRS E895-ST-0070
conduction-	Assembly	4000	1332	1865	for derivation of shock levels
cooled TWTs	Collector/	200	37	52	
	Body	4000	3000	4200	
Solar Array Drive Assembly (SADA)		200	37	52	
		1400	600	840	
		4000	1332	1865	
Star Tracker		200	37	140	
		1400	600	840	
		4000	1332	1865	
Test Exposures			None 10/	3 per axis (Qualification)	

See notes, Table 3.4.3-III (notes)

Table 3.4.3-III(e). DELETED Shock Requirements for Category A and B Units

Table 3.4.3-III(f). Generic Equipment Shock Level Requirements

Subsystem	Part Description	Potential Locations									Shock Level Req[13]	Mounting Provision Notes
		Earth Deck	COMM Panel	Shear Web	Upper COMM Module[14]	OMUX Panel	SSM Deck	Battery Panel	Anti-Earth Deck	Other		
ACS	Digital sun sensor (DSS)								X		1	
ACS	DSS electronics						X				1	
ACS	ES, two-axis infrared									X	2	Tower
ACS	Enhanced coarse analog sun sensor (ECASS)								X		1	
ACS	Reaction wheel assembly (RWA)									X	Special[12]	Cylinder
ACS	Ring laser gyro (RLG)						X				1	
ACS	Space inertial reference unit (SIRU)						X				1	
ACS	Wheel drive electronics (WDE)						X				1	
DHS	Attitude control electronics (ACE)		X				X				1	
DHS	Current monitor assembly	X					X				1	
DHS	Data handling electronics (DHE)		X								2	
DHS	Data translation unit (DTU), north/south		X								2	
DHS	DTU, SSM						X				1	
DHS	Enhanced serial interface adapter module (ESIAM)		X				X				1	
DHS	Expanded ESIAM (EESIAM)		X								2	
DHS	Latching relay unit		X	X							1	
DHS	Router hub		X								2	
DHS	Super hub		X								2	
EPS	ACE power distribution unit (ACE PDU)	X	X	X			X		X		1	
EPS	Battery control electronics (BCE)		X								2	
EPS	Battery switch tray (BST)							X			3	
EPS	Diode box assembly						X				1	
EPS	Electrostatic discharge unit (ESDU)	X	X	X			X		X		1	
EPS	Enhanced heater control (EHC) unit		X								2	

See Notes, Table 3.4.3-III(notes)

Table 3.4.3-III(f). Generic Equipment Shock Level Requirements (Continued)

Subsystem	Part Description	Potential Locations									Shock Level Req[13]	Mounting Provision Notes
		Earth Deck	COMM Panel	Shear Web	Upper COMM Module[14]	OMUX Panel	SSM Deck	Battery Panel	Anti-Earth Deck	Other		
EPS	Low voltage direct current converter (LVDC)		X								2	
EPS	Power control unit (PCU)		X								2	
EPS	Power hub unit (PHU)		X								2	
EPS	Power processing unit (PPU)		X								2	
EPS	Quad-voltage fuse unit (QVFU)		X								2	
EPS	Single-voltage fuse unit (SVFU)		X	X							1	
MEC	DAPM actuator									X	1	Support structure
MEC	Enhanced DAPM (EDAPM)									X	1	Support structure
MEC	Holddowns, A-frame	X									n/a	
MEC	Holddowns, DAPM									X	n/a	Support structure
MEC	Holddowns, fixed (spot)									X	n/a	Support structure
MEC	Holddowns, I-beam	X									n/a	
MEC	Main reflector hinges									X	n/a	Support structure
MEC	Pyrotechnic initiator									X	n/a	Mechanism
MEC	Solar array drive assembly (SADA)		X								Special[12]	
MEC	Stationary plasma thruster (SPT) actuator		X								2	
MEC	Subreflector actuator mechanism (SAM)									X	1	Support structure

See Notes, Table 3.4.3-III(notes)

Table 3.4.3-III(f). Generic Equipment Shock Level Requirements (Continued)

Subsystem	Part Description	Potential Locations									Shock Level Req[13]	Mounting Provision Notes
		Earth Deck	COMM Panel	Shear Web	Upper COMM Module[14]	OMUX Panel	SSM Deck	Battery Panel	Anti-Earth Deck	Other		
PAY	Adapter, waveguide (WG) to co-axial (COAX)	X	X	X	X	X	X				1	
PAY	Autotrack tracking receiver		X		X						2	
PAY	C-band output multiplexer (OMUX)		X								2	
PAY	Channel filter	X	X	X	X						1	
PAY	Circulator	X	X		X						2	
PAY	Command receiver		X		X						2	
PAY	DC/DC converter		X		X						2	
PAY	Diplexer		X		X	X					2	
PAY	Directional coupler	X	X	X	X						1	
PAY	Directional filter, input	X	X	X	X						1	
PAY	Downconverter		X		X						2	
PAY	Ferrite switch	X	X	X	X						1	
PAY	Filter, output	X	X	X	X						1	
PAY	Harmonic filter		X		X	X					2	
PAY	High-power output assembly (HPOA)		X		X						2	
PAY	Hybrid, COAX	X	X	X	X						1	
PAY	Hybrid, WG	X	X	X	X						1	
PAY	Input multiplexer (IMUX)		X	X							1	
PAY	Isolator	X	X	X	X						1	
PAY	Ku-band OMUX		X		X	X					2	
PAY	Linearized channel amplifier (LCAMP)		X		X						2	
PAY	Low-noise amplifier (LNA)	X	X		X						1	
PAY	Load, COAX		X		X						2	
PAY	Load, WG		X		X						2	
PAY	Low pass filter	X	X	X	X						1	

See Notes, Table 3.4.3-III(notes)

Table 3.4.3-III(f). Generic Equipment Shock Level Requirements (Continued)

Subsystem	Part Description	Potential Locations: Earth Deck	COMM Panel	Shear Web	Upper COMM Module[14]	OMUX Panel	SSM Deck	Battery Panel	Anti-Earth Deck	Other	Shock Level Req[13]	Mounting Provision Notes
PAY	Master local oscillator		X		X						2	
PAY	Master reference oscillator		X		X						2	
PAY	Mini master DC/DC converter (MMDC)		X		X						2	
PAY	Phase shifter, commandable		X		X						2	
PAY	Power combiner, coax	X	X	X	X						1	
PAY	Power detector, S-band		X		X						2	
PAY	Power divider, coax	X	X	X	X						1	
PAY	Preselect filter	X	X	X	X						1	
PAY	Pseudo monopulse		X		X						2	
PAY	Receiver	X	X		X						1	
PAY	Spur filter, input	X	X	X	X						1	
PAY	Switch, COAX	X	X	X	X						1	
PAY	Switch, WG	X	X	X	X	X					1	
PAY	Telemetry transmitter	X	X		X						1	
PAY	Test coupler	X	X	X	X						1	
PAY	Traveling wave tube (TWT)		X		X						2	Including electronic power conditioner
PAY	Upconverter	X	X		X						2	

See Notes, Table 3.4.3-III(notes)

Table 3.4.3-III(f). Generic Equipment Shock Level Requirements (Continued)

Subsystem	Part Description	Potential Locations: Earth Deck	COMM Panel	Shear Web	Upper COMM Module[14]	OMUX Panel	SSM Deck	Battery Panel	Anti-Earth Deck	Other	Shock Level Req[13]	Mounting Provision Notes
PRP	Attitude control thruster (22N)	X							X		1	
PRP	Check valve						X			X	1	Cylinder
PRP	Fill & drain valve								X		1	
PRP	Filter						X				1	
PRP	Latch valve, bipropellant						X				1	
PRP	Latch valve, main satellite thruster (MST)									X	Special[12]	Cylinder
PRP	MST									X	Special[12]	Cylinder
PRP	Pressurant tank									X	1	Cylinder
PRP	Pressure transducer						X				1	
PRP	Propellant tank									X	n/a	Cylinder
PRP	Pyrotechnic valve						X			X	1	Cylinder
PRP	Regulator, series redundant						X				1	
SPT	Pyrotechnic initiator						X			X	1	Cylinder
SPT	Pyrotechnic valve						X			X	1	Cylinder
SPT	SPT						X				1	
SPT	SPT ESDU						X				1	
SPT	SPT PPU						X				1	
SPT	Xenon flow controller (XFC)									X	1	Propulsion web

See Notes, Table 3.4.3-III(notes)

Table 3.4.3-III(notes). Notes, Shock Levels and Requirements

Notes 1-9 apply to all tables.

(Shock Testing Requirements Version 1 final 12-Mar-09)

1. Shock response spectrum (SRS) computations shall be made with the absolute acceleration time history using the maxi-max technique and a *Q* of 10. Space Systems/Loral (SS/L) recommends using the Smallwood algorithm for SRS computations. If an alternate algorithm is used, the name of the algorithm shall be provided.
    a. SRS computations shall be made at 1/12 octave intervals.
    b. SRS specifications are defined by a straight line on a log-log plot.
    c. The *analysis band* is defined as the frequency spectrum of interest.
2. Testing levels shall be within tolerance bands as follows:
    a. A minimum of 50% of the SRS response shall meet or exceed the nominal test specification.
    b. A minimum of 80% of the SRS response shall be contained between -3 dB and +6 dB of the nominal test specification.
    c. 100% of the SRS response shall be contained between -6 dB and +9 dB of the nominal test specification.

   Note: SS/L assumes no responsibility for damaged units if the upper tolerance levels are exceeded without prior SS/L consent.
3. The amplitude of the highest absolute peak in the shock acceleration time history shall be equal to or lower than 10% of the initial highest peak value within 15 milliseconds (ms).
4. The measured acceleration time history shall be integrated to calculate the corresponding velocity.
    a. The calculated velocity plots shall decay within 50 milliseconds to a net stabilized velocity change of zero, ±10% of the initial highest peak value.
    b. If the planned shock test includes a net displacement, the calculated velocity plots shall decay within 50 milliseconds to a net stabilization about the expected real velocity, ±10% of the initial highest peak value.

   Note: SS/L must review and approve any net displacement shock testing technique.

Table 3.4.3-III(notes). Notes, Shock Levels and Requirements (Continued)

5. The shock level shall be monitored for each of the three orthogonal axes for each shock event, even if only a single axis is being tested. When only one principal axis is being tested, the SRS for each cross-axis shall not exceed the nominal test specification for that axis at any frequency.
6. The SRS shall be computed and plotted to 10,000 Hz minimum. Acceleration as a function of frequency data (i.e., SRS in units of Gs and frequency in units of Hz) shall be provided electronically in spreadsheet or text column format in addition to the SRS plots. Acceleration as a function of time and velocity as a function of time shall be provided electronically in spreadsheet or text format in addition to being plotted.
7. The measurement system noise level with no excitation present shall be less than 0.1% of full scale.
8. Signal Processing Requirements:
   a. An analog filter shall be used at the input of the measurement subsystem that provides a minimum rejection of aliased responses in the analysis band of 60 dB (0.1%).

   Note: This includes all effects due to analog filter attenuation characteristics and analog-to-digital (A/D) conversion sampling rate.

   b. A measurement (plot) of the analysis band frequency response of the signal processing/data collection subsystem shall be provided.
      i. Analysis band limits for a Mechanical Impact Pyroshock Simulator (MIPS) or pyrotechnic source shall extend from 100 Hz to 10 kHz.
      ii. Analysis band flatness shall be within ±0.5 dB (10%) over the analysis band limits.
      iii. The phase response shall be linear over the analysis band.

      Note: This includes the effects of the analog filtering preceding the A/D converter as well as any digital filtering.

   c. The dynamic range of the measurement system shall be adequate to prevent clipping of the transducer signal.
9. Transducer Requirements
   a. The transducer shall have a linear dynamic range greater than the applied shock waveform amplitude and be linear within 5% over the range of 5% to 100% of the applied shock waveform amplitude. This shall be confirmed by examining the time history.
   b. The transducer frequency response shall be compatible with item 8b(i).
   c. Transducers assigned to multiple channels shall be matched within 10%.

Table 3.4.3-III(notes). Notes, Shock Levels and Requirements (Continued)

10. Shock tests are not required for flight units.

11. Figures 3.4.3-2(a) through 3.4.2-2(e) define how to determine the distance from the shock source. Figures 3.4.3-2(f) and 3.4.3-2(g) give line of site examples.

12. Unit specific shock requirements. See Table 3.4.3-III(d) Shock Requirements for Specific Units.

13. The shock level listed is based on potential location and is the highest level listed from Table 3.4.3-III(b)

14. Includes upper comm module's adjoining closeout panels closeout panels & shear web.

Table 3.4.3-IV. Component Minimum Frequency Design Goals
(1 of 2)

(a) Launch Stowed Configuration

Component	Design Goal (Hz)	
	Lateral 1/	Axial 1/
Equipment Panels		
Vertical Panels (Out-of-Plane Symmetric Mode)	18	-
Horizontal Panels (Out-of-Plane)	-	50
Antenna Tower Module (Fixed Base)	35	50
OMUX Panel Assembly (Fixed Base)		
Cylinder Mounted	30	50
Comm Panel Mounted (including support brackets)	120	120
Solar Arrays	25	50
Propulsion Tanks	50	50
Reflectors/Subreflectors 2/		
Main Body Reflector (Fixed Base with DOFs simulating hold-downs and hinges or DAPM)	35 (in-plane) 30 (out-of-plane)	50
Main Body Reflector Subassembly (includes reflector, holddowns, and hinges or DAPM)	30	40
Main Body Reflector Assembly (includes reflector subassembly and S/C structure)	25	35
Tower Mounted Reflectors (Fixed Base)	50	50
Subreflectors (Fixed Base)	75 3/	75 3/
Unfurlable Reflectors		
Reflector Assembly (Fixed-Base) 2/	25 7/	30 7/
Main Body Reflector Assembly	22.5	27
Feeds		
Feeds (Fixed -Base)	120	120
Feed Assembly (includes support structure)	75	75
Feed Array (Fixed Base)	70	70
TT&C Antenna (Fixed Base)	120	120
Earth Sensor Module Assembly (Fixed Base)	120	120
Sensors (CASS, ECASS, DSS)	120	120
Unit Components		
Panel Mounted	100	100
Bracket Mounted (fixed at base of support bracket)	100	100
Waveguide (unsupported section)	100	100

See Notes on Table 3.4.3-IV (2 of 2)

Table 3.4.3-IV. Component Minimum Frequency Design Goals
(2 of 2)

(a) Launch Stowed Configuration (Continued)

Component	Design Goal (Hz)	
	Lateral 1/	Axial 1/
Xenon Tank Structure Assembly	50	50
SPT Structure Assembly	50	50
Selectable Sub-Reflector (SRR)		
SRR (Fixed Base)	75	75
SRR Subassembly (includes subreflectors, Holddowns, DAPM, Tower Support Structure)	45	60
SPT DAPM Module (Fixed Base)	50	50

(b) On-Orbit (Deployed) Configuration

Assembly 4/	Design Goal (Hz)
Solar Array	
First Bending Mode 5/	> 0.06
First Torsional Mode (3/4 panel solar array)	0.06 <f < 1.5
First Torsional Mode (5/6 panel solar array)	> 0.35
Reflectors	
Hinge Supported	> 3
DAPM Supported	> 2
Subreflectors	> 3
SPT DAPM Module 6/	> 2.0

1/ Design goals are referenced to satellite coordinate system, unless otherwise indicated.
2/ Boundary conditions simulate satellite launch configuration.
3/ Finite element model required if stowed frequency is less than 100 Hz.
4/ Design goals apply to the complete satellite.
5/ Solar array bending frequency may be less than 0.06 Hz with approval of controls personnel.
6/ Includes flexibility of main body support structure.
7/ Local modes may have lower frequencies if the sum of the effective mass in each of the X, Y, and Z directions for the three modes is less than 10% of the total mass.

8.3.5 T&F - Thermal Requirements

Table 3.5-I(a1). Generic Electrical Power Subsystem Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERIC ELECTRICAL POWER											
E093700-02	Battery, NiH2, 34 Cells, 149 A-hr	NA / -25 / -30	NA / 45 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-25 / -25 /NA	33 / 45 /NA	-25 / -25 /NA	28 / 40 /NA	RT,BT1 /RT,BT2 RT,BT5,REF1
E135500-01	Battery, NiH2, 32 Cells, 149 A-hr	NA / -25 / -30	NA / 45 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-25 / -25 /NA	33 / 45 /NA	-25 / -25 /NA	28 / 40 /NA	RT,BT1 /RT,BT2 RT,BT5,REF1
E242510-12	Battery, NiH2, 34 Cells, 178 A-hr	NA / -25 / -30	NA / 45 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-25 / -25 /NA	33 / 45 /NA	-25 / -25 /NA	28 / 40 /NA	RT,BT1 /RT,BT2 RT,BT5,REF1
E252510-38	Battery, NiH2, 38 Cells, 178 A-hr	NA / -25 / -30	NA / 45 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-25 / -25 /NA	28 / 45 /NA	-25 / -25 /NA	23 / 40 /NA	RT,BT1 /RT,BT2 RT,BT5,REF1
E252510-40	Battery, NiH2, 40 Cells, 178 A-hr	NA / -25 / -30	NA / 45 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-25 / -25 /NA	28 / 45 /NA	-25 / -25 /NA	23 / 40 /NA	RT,BT1 /RT,BT2 RT,BT5,REF1
E300430-32	Battery, NiH2, 32 Cells, 178 A-hr	NA / -25 / -30	NA / 40 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-25 / -25 /NA	28 / 45 /NA	-25 / -25 /NA	23 / 40 /NA	RT,BT1 /RT,BT2 RT,BT5,REF1
E300430-34	Battery, NiH2, 34 Cells, 178 A-hr	NA / -25 / -30	NA / 40 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-25 / -25 /NA	28 / 45 /NA	-25 / -25 /NA	23 / 40 /NA	RT,BT1 /RT,BT2 RT,BT5,REF1
E170000-02, -03	Battery Switch Unit (BSU)	-30	75	NA	-30	65	-25	65	-20	60	HS, MC1
E104100-03	Power Control Unit (PCU)	-30 / -30	76 / 76	NA /NA	-30 / -30	76 / 76	-25 / -25	71 / 60	-20 / -20	66 / 55	BT3, HS, MC1 /BT4, HS, MC1
E156100-03	Power Control Unit (PCU)	-30 / -30	75 / 75	NA /NA	-30 / -30	70 / 70	-25 / -25	70 / 70	-20 / -20	65 / 65	BT3, HS, MC1 /BT4, HS, MC1
E104170-03	Power Distribution Unit	-30	70	NA	-30	70	-25	65	-20	60	B
E169379-21, -22	Fuse Tray, Quad Voltage	-30	75	NA	-30	75	-25	70	-20	65	B
E169386-02	Fuse Tray, Single Voltage	-30	75	NA	-30	70	-25	70	-20	65	B
E245670-01	Power Hub Unit Assy, (PHU)	-30	75	NA	-30	70	-25	70	-20	65	HS, MC1
E252150-01	Auxiliary Power Unit, (APU)	-40	72	NA	-40	67	-25	67	-20	62	B
E262170-01	Master DC/DC Converter	-35	72	NA	-35	67	-15	67	-10	62	B
595375-01 -- -04	Power Integration Unit, (PIU)	-40	65	NA	-40	65	-25	60	-20	55	B
E354325-01	Shunt Unit Assy, Standalone	-40	75	NA	-40	70	-30	70	-25	65	BT3,HS,MC1

See notes, Table 3.5-I (Notes)

Table 3.5-I(a2). Generic Super Power Subsystem Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
SUPER POWER											
E144020-01, -02	Power Hub Unit Assy, (PHU)	-30	75	NA	-30	75	-25	70	-20	65	HS,MC1
E201200-05, -06	Battery Control Electronics (BCE), SPS	-40	75	NA	-40	65	-30	65	-25	60	B
E201405-01	Power Control Unit (PCU), SPS	-40 / -40	75 / 75	NA /NA	-40 / -40	70 / 60	-30 / -30	70 / 60	-25 / -25	65 / 55	BT3,HS,MC1 /BT4,HS,MC1
E201460-01	Low Voltage DC Converter Tray, SPS	-40	75	NA	-40	70	-30	70	-25	65	HS,MC1
E201464-01	Diode Box Assy, SPS	-40	65	NA	NA	NA	-40	65	-40	65	B
E201600-124	Battery, Li-Ion	-10 / -20	45 /NA	NA /NA	NA /NA	NA /NA	-10 /NA	45 /NA	-5 /NA	40 /NA	RT /BT5,REF1
E201600-222	Battery, Li-Ion	-10 / -20	45 /NA	NA /NA	NA /NA	NA /NA	-10 /NA	45 /NA	-5 /NA	40 /NA	RT /BT5,REF1
E201600-224	Battery, Li-Ion	-10 / -20	45 /NA	NA /NA	NA /NA	NA /NA	-10 /NA	45 /NA	-5 /NA	40 /NA	RT /BT5,REF1
E201620-02	Battery Switch Tray (BST), SPS	-30	75	NA	-30	55	-25	55	-20	50	HS, MC1
E333350-01	Battery Control Electronics (BCE)	-40	75	NA	-40	65	-30	65	-25	60	B
E201405-02	Power Control Unit (PCU), SPS	-40 / -40	75 / 75	NA /NA	-40 / -40	70 / 60	-30 / -30	70 / 60	-25 / -25	65 / 55	BT3,HS,MC1 /BT4,HS,MC1
E201405-04	Power Control Unit (PCU), SPS	-40 / -40	75 / 75	NA /NA	-40 / -40	70 / 60	-30 / -30	70 / 60	-25 / -25	65 / 55	BT3,HS,MC1 /BT4,HS,MC1

See notes, Table 3.5-I (Notes)

Table 3.5-I(b). Generic Solar Array Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1) Min [°C]	Non-Op QT, PFM, AT (1) Max [°C]	Power Handling QT (2) Max [°C]	Turn ON QT (3) Min [°C]	Turn ON QT (3) Max [°C]	Operating QT (4) Min [°C]	Operating QT (4) Max [°C]	Operating AT (4) Min [°C]	Operating AT (4) Max [°C]	Temperature Description (5)
GENERIC SOLAR ARRAY											
STD-SA-E095300_01	Four Panel Solar Array (SADA Hinge)	-50 / -130 /NA	75 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -73 / -53	85 / 66 / 53	-175 / -68 / -48	80 / 61 / 48	SA1 /SA2 /SA3
STD-SA-E095300_02	Four Panel Solar Array (Damper)	-50 /NA /NA	75 /NA /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-90 / -25 / -25	110 / 55 / 55	-85 / -20 / -20	105 / 50 / 50	SA1 /SA2 /SA3
STD-SA-E095300_03	Four Panel Solar Array (Yoke)	-140 / -130 /NA	85 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -137 / -53	85 / 88 / 41	-175 / -132 / -48	80 / 83 / 36	SA1 /SA2 /SA3
STD-SA-E095300_04	Four Panel Solar Array (Panel1)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -97 / -23	85 / 93 / 44	-175 / -92 / -18	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E095300_05	Four Panel Solar Array (Panel2)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -124 / -15	85 / 93 / 44	-175 / -119 / -10	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E095300_06	Four Panel Solar Array (Panel3)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -125 / -20	85 / 95 / 44	-175 / -120 / -15	80 / 90 / 39	SA1 /SA2 /SA3
STD-SA-E095300_07	Four Panel Solar Array (Panel4)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -106 / -13	85 / 102 / 64	-175 / -101 / -8	80 / 97 / 59	SA1 /SA2 /SA3
STD-SA-E095300_08	Four Panel Solar Array (Yoke/Panel1 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -130 / -84	85 / 105 / 85	-175 / -125 / -79	80 / 100 / 80	SA1 /SA2 /SA3
STD-SA-E095300_09	Four Panel Solar Array (Panel1/Panel2 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -125 / -80	85 / 106 / 81	-175 / -120 / -75	80 / 101 / 76	SA1 /SA2 /SA3
STD-SA-E095300_10	Four Panel Solar Array (Panel2/Panel3 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -142 / -90	85 / 110 / 84	-175 / -137 / -85	80 / 105 / 79	SA1 /SA2 /SA3
STD-SA-E095300_11	Four Panel Solar Array (Panel3/Panel4 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -126 / -82	85 / 115 / 89	-175 / -121 / -77	80 / 110 / 84	SA1 /SA2 /SA3
STD-SA-E095300_12	Four Panel Solar Array (Pyro Cutter)	-180 /NA	120 /NA	NA /NA	NA /NA	NA /NA	NA / -160	NA / 110	NA / -155	NA / 105	SA1 /SA2
STD-SA-E095300_13	Four Panel Solar Array (Holddowns)	-140	140	NA	NA	NA	NA	NA	NA	NA	SA1
STD-SA-E177400_01	Five Panel Solar Array (SADA Hinge)	-50 / -130 /NA	75 / 60 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -73 / -53	85 / 66 / 53	-175 / -68 / -48	80 / 61 / 48	SA1 /SA2 /SA3
STD-SA-E177400_02	Five Panel Solar Array (Damper)	-50 /NA /NA	75 /NA /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-90 / -10 / -10	110 / 35 / 35	-85 / -5 / -5	105 / 30 / 30	SA1 /SA2 /SA3
STD-SA-E177400_03	Five Panel Solar Array (Yoke)	-44 / -130 /NA	49 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -103 / -50	85 / 88 / 41	-175 / -98 / -45	80 / 83 / 36	SA1 /SA2 /SA3
STD-SA-E177400_04	Five Panel Solar Array (Panel1)	-59 / -180 /NA	75 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -85 / -31	85 / 93 / 44	-175 / -80 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E177400_05	Five Panel Solar Array (Panel2)	-72 / -180 /NA	87 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -99 / -31	85 / 93 / 44	-175 / -94 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E177400_06	Five Panel Solar Array (Panel3)	-139 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -90 / -34	85 / 93 / 44	-175 / -85 / -29	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E177400_07	Five Panel Solar Array (Panel4)	-92 / -180 /NA	109 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -85 / -31	85 / 93 / 44	-175 / -80 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E177400_08	Five Panel Solar Array (Panel5)	-92 / -180 /NA	109 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -81 / -31	85 / 93 / 44	-175 / -76 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E177400_09	Five Panel Solar Array (Yoke/Panel1 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -130 / -84	85 / 105 / 81	-175 / -125 / -79	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E177400_10	Five Panel Solar Array (Panel1/Panel2 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E177400_11	Five Panel Solar Array (Panel2/Panel3 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -112 / -62	85 / 105 / 81	-175 / -107 / -57	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E177400_12	Five Panel Solar Array (Panel2/Panel4 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3

See notes, Table 3.5-I (Notes)

Table 3.5-I(b). Generic Solar Array Component Temperature Requirements (continued)

Part Number	Part Description	Non-Op QT, PFM, AT (1) Min [°C]	Non-Op QT, PFM, AT (1) Max [°C]	Power Handling QT (2) Max [°C]	Turn ON QT (3) Min [°C]	Turn ON QT (3) Max [°C]	Operating QT (4) Min [°C]	Operating QT (4) Max [°C]	Operating AT (4) Min [°C]	Operating AT (4) Max [°C]	Temperature Description (5)
GENERIC SOLAR ARRAY											
STD-SA-E177400_13	Five Panel Solar Array (Panel2/Panel5 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E177400_14	Five Panel Solar Array (Pyro Cutter)	-180 /NA	120 /NA	NA /NA	NA /NA	NA /NA	NA / -160	NA / 110	NA / -155	NA / 105	SA1 /SA2
STD-SA-E177400_15	Five Panel Solar Array (Holddowns)	-140 /NA	140 /NA	NA /NA	NA /NA	NA /NA	NA / -100	NA / 60	NA / -95	NA / 55	SA1 /SA2
STD-SA-E170275_01	Six Panel Solar Array, Cross at 2 (SADA Hinge)	-50 / -130 /NA	75 / 60 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -73 / -53	85 / 66 / 53	-175 / -68 / -48	80 / 61 / 48	SA1 /SA2 /SA3
STD-SA-E170275_02	Six Panel Solar Array, Cross at 2 (Damper)	-50 /NA /NA	75 /NA /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-90 / -10 / -10	110 / 35 / 35	-85 / -5 / -5	105 / 30 / 30	SA1 /SA2 /SA3
STD-SA-E170275_03	Six Panel Solar Array, Cross at 2 (Yoke)	-25 / -130 /NA	36 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -23 / -23	85 / 21 / 21	-175 / -18 / -18	80 / 16 / 16	SA1 /SA2 /SA3
STD-SA-E170275_04	Six Panel Solar Array, Cross at 2 (Panel1)	-40 / -180 /NA	107 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -36 / -36	85 / 85 / 85	-175 / -31 / -31	80 / 80 / 80	SA1 /SA2 /SA3
STD-SA-E170275_05	Six Panel Solar Array, Cross at 2 (Panel2)	-91 / -180 /NA	118 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -99 / -31	85 / 93 / 44	-175 / -94 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E170275_06	Six Panel Solar Array, Cross at 2 (Panel3)	-111 / -180 /NA	121 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -90 / -34	85 / 93 / 44	-175 / -85 / -29	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E170275_07	Six Panel Solar Array, Cross at 2 (Panel4)	-146 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -90 / -34	85 / 93 / 44	-175 / -85 / -29	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E170275_08	Six Panel Solar Array, Cross at 2 (Panel5)	-65 / -180 /NA	114 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -85 / -31	85 / 93 / 44	-175 / -80 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E170275_09	Six Panel Solar Array, Cross at 2 (Panel6)	-53 / -180 /NA	110 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -85 / -31	85 / 93 / 44	-175 / -80 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E170275_10	Six Panel Solar Array, Cross at 2 (Yoke/Panel1 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -36 / -36	85 / 105 / 81	-175 / -31 / -31	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E170275_11	Six Panel Solar Array, Cross at 2 (Panel1/Panel2 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E170275_12	Six Panel Solar Array, Cross at 2 (Panel2/Panel3 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -112 / -62	85 / 105 / 81	-175 / -107 / -57	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E170275_13	Six Panel Solar Array, Cross at 2 (Panel3/Panel4 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -126 / -82	85 / 105 / 89	-175 / -121 / -77	80 / 100 / 84	SA1 /SA2 /SA3
STD-SA-E170275_14	Six Panel Solar Array, Cross at 2 (Panel2/Panel5 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E170275_15	Six Panel Solar Array, Cross at 2 (Panel2/Panel6 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E170275_16	Six Panel Solar Array, Cross at 2 (Panel2/Panel5 Damper)	-15 / -180 /NA	45 / 20 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-85 / -15 / -15	85 / 45 / 45	-80 / -10 / -10	80 / 40 / 40	SA1 /SA2 /SA3
STD-SA-E170275_17	Six Panel Solar Array, Cross at 2 (SSD)	-135 /NA	135 /NA	NA /NA	NA /NA	NA /NA	NA / -90	NA / 110	NA / -85	NA / 105	SA1 /SA2
STD-SA-E333998_01	Six Panel Solar Array, Cross at 3 (SADA Hinge)	-50 / -130 /NA	75 / 60 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -73 / -53	85 / 66 / 53	-175 / -68 / -48	80 / 61 / 48	SA1 /SA2 /SA3
STD-SA-E333998_02	Six Panel Solar Array, Cross at 3 (Damper)	-50 /NA /NA	75 /NA /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-90 / -10 / -10	110 / 35 / 35	-85 / -5 / -5	105 / 30 / 30	SA1 /SA2 /SA3
STD-SA-E333998_03	Six Panel Solar Array, Cross at 3 (Yoke)	-34 / -130 /NA	52 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -23 / -23	85 / 21 / 21	-175 / -18 / -18	80 / 16 / 16	SA1 /SA2 /SA3
STD-SA-E333998_04	Six Panel Solar Array, Cross at 3 (Panel1)	-44 / -180 /NA	68 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -36 / -36	85 / 85 / 85	-175 / -31 / -31	80 / 80 / 80	SA1 /SA2 /SA3
STD-SA-E333998_05	Six Panel Solar Array, Cross at 3 (Panel2)	-57 / -180 /NA	80 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -99 / -31	85 / 93 / 44	-175 / -94 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E333998_06	Six Panel Solar Array, Cross at 3 (Panel3)	-72 / -180 /NA	92 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -90 / -34	85 / 93 / 44	-175 / -85 / -29	80 / 88 / 39	SA1 /SA2 /SA3

See notes, Table 3.5-I (Notes)

Table 3.5-I(b). Generic Solar Array Component Temperature Requirements (continued)

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERIC SOLAR ARRAY											
STD-SA-E333998_07	Six Panel Solar Array, Cross at 3 (Panel4)	-141 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -90 / -34	85 / 93 / 44	-175 / -85 / -29	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E333998_08	Six Panel Solar Array, Cross at 3 (Panel5)	-109 / -180 /NA	115 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -85 / -31	85 / 93 / 44	-175 / -80 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E333998_09	Six Panel Solar Array, Cross at 3 (Panel6)	-88 / -180 /NA	103 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -85 / -31	85 / 93 / 44	-175 / -80 / -26	80 / 88 / 39	SA1 /SA2 /SA3
STD-SA-E333998_10	Six Panel Solar Array, Cross at 3 (Yoke/Panel1 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -36 / -36	85 / 105 / 81	-175 / -31 / -31	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E333998_11	Six Panel Solar Array, Cross at 3 (Panel1/Panel2 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E333998_12	Six Panel Solar Array, Cross at 3 (Panel2/Panel3 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -112 / -62	85 / 105 / 81	-175 / -107 / -57	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E333998_13	Six Panel Solar Array, Cross at 3 (Panel3/Panel4 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -126 / -82	85 / 105 / 89	-175 / -121 / -77	80 / 100 / 84	SA1 /SA2 /SA3
STD-SA-E333998_14	Six Panel Solar Array, Cross at 3 (Panel2/Panel5 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E333998_15	Six Panel Solar Array, Cross at 3 (Panel2/Panel6 Hinges)	-140 / -180 /NA	125 / 85 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-180 / -93 / -42	85 / 105 / 81	-175 / -88 / -37	80 / 100 / 76	SA1 /SA2 /SA3
STD-SA-E333998_16	Six Panel Solar Array, Cross at 3 (Panel2/Panel5 Damper)	-15 / -180 /NA	45 / 20 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-85 / -15 / -15	85 / 45 / 45	-80 / -10 / -10	80 / 40 / 40	SA1 /SA2 /SA3
STD-SA-E333998_17	Six Panel Solar Array, Cross at 3 (SSD)	-135 /NA	135 /NA	NA /NA	NA /NA	NA /NA	NA / -90	NA / 110	NA / -85	NA / 105	SA1 /SA2

See notes, Table 3.5-I (Notes)

Table 3.5-I(c). Telemetry, Command, and Ranging (TC&R) Subsystem Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
See ERS Addendum											

See notes, Table 3.5-I (Notes)

Table 3.5-I(d). Communications Subsystem Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
See ERS Addendum											

See notes, Table 3.5-I (Notes))

Table 3.5-I(e). Generic Miscellaneous Components, Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERIC MISCELLANEOUS COMPONENTS											
STD-HP-1	Heat Pipe, Ammonia	-70	127	NA	NA	NA	-20	60	-20	60	B
STD-HP-2	Heat Pipe, Toluene	-40	170	NA	NA	NA	-45	135	-45	135	B
STD-XHP-1	Crossing Heat Pipes	-70	70	NA	NA	NA	-20	60	-20	60	B
STD-MLHP-1	Mini Loop Heat Pipe (MLHP)	-65	125	NA	NA	NA	10	75	10	75	B
STD-COAX-1	Coaxial Cables, Mainbody	-40	150	NA	NA	NA	-40	150	-35	145	B
STD-COAX-2	Coaxial Cables, External	-155	150	NA	NA	NA	-155	150	-150	145	B
STD-COAX-3	Coaxial Cables, Low Power	-40	85	NA	NA	NA	-30	85	-25	80	B
STD-WG-1	W/G, Mainbody	-70	120	NA	NA	NA	-70	120	-65	115	B
STD-WG-2	W/G, Tower	-120	120	NA	NA	NA	-120	120	-115	115	B
STD-WG-3	W/G, Post Ku-Omux	-70	180	NA	NA	NA	-70	180	-65	175	B
STD-STR-2	Primary Tower Structure (High Temp Range)	-110	110	NA	NA	NA	-110	110	-110	110	B
STD-STR-4	Graphite Slide Plates	-125	140	NA	NA	NA	-125	140	-125	140	B

See notes, Table 3.5-I (Notes)

Table 3.5-I(f). Generic Attitude Determination and Control Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERAL ATTITUDE DETERMINATION AND CONTROL											
E002091-04	Digital Sun Sensor, Electronics	-25	65	NA	-25	65	-20	60	-20	60	B
E002092-05, -06	Digital Sun Sensor (DSS)	-45	89	NA	-45	89	-40	84	-35	79	B
E002093-07	Sun Sensor (CASS Assembly)	-40	71	NA	-40	71	-40	71	-40	71	B
E164600-02	Sun Sensor (ECASS Assembly)	-45	76	NA	-40	71	-40	71	-40	71	B
E124313-04, -05	Earth Sensor (ES)	-35	65	NA	-35	65	-30	60	-25	55	B
E002098-01, -03	DIRA Gyro Unit	-40	65	NA	-30	65	-25	60	-20	55	HS, MC1
E002099-01, -03	DIRA Electronics Unit	-40	65	NA	-30	65	-25	60	-20	55	HS, MC1
E064999-01	Space Inertial Reference Unit (SIRU)	-40	75	NA	-35	75	-35	70	-29	65	HS,MC1
E124334-03	Ring Laser Gyro Assembly (RLGA)	-34	75	NA	-30	70	-30	70	-30	65	HS,MC1
E128049-57	Reaction Wheel / Wheel Drive Electronics (WDE) Assembly	-15 / -40	70 / 70	NA /NA	-15 / -40	65 / 65	-15 / -25	65 / 65	-10 / -20	60 / 60	RW1 /RW2
E112811-01 -- -03	Reaction Wheel / Wheel Drive Electronics (WDE) Assembly	-15 / -40	70 / 70	NA /NA	-15 / -40	70 / 70	-15 / -25	65 / 65	-10 / -20	60 / 60	RW1 /RW2
E128049-01	Reaction Wheel / Wheel Drive Electronics (WDE) Assembly	-15 / -40	70 / 70	NA /NA	-15 / -40	65 / 65	-15 / -25	65 / 65	-10 / -20	60 / 60	RW1 /RW2

See notes, Table 3.5-I (Notes)

Table 3.5-I(g1). Generic Data Handling Subsystems and Spacecraft Control Electronics Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERIC DATA HANDLING SYSTEMS											
E002690-06 -- -08	Protection Unit, ESD	-40	75	NA	-40	70	-25	70	-20	65	B
E033781-01	Pyro Tray	-40	70	NA	-40	70	-25	70	-20	65	HS, MC1
E066784-02	Electrostatic Discharge Unit	-40	75	NA	-40	70	-25	70	-20	65	B
E142010-03, -05, -08, -10	ACE Power Distribution Unit, (ACE PDU)	-40	70	NA	-40	65	-25	65	-20	60	B
E142010-20	ACE Power Distribution Unit, (ACE PDU)	-40	70	NA	-40	65	-25	65	-20	60	B
E142050-01	Current Monitor	-40	75	NA	-40	70	-25	70	-20	65	B
E029191-02	Connector Assy, Bus Terminator	-40	66	NA	-40	66	-40	66	-35	61	B
E169365-01	Tray Assy, RS485 Router	-40	70	NA	-40	65	-25	65	-20	60	B
E169370-01	Tray Assy, Relay Matrix And On/Off	-40	70	NA	-40	65	-25	65	-20	60	B
E169379-23	Fuse Tray, Quad Voltage	-30	75	NA	-30	70	-25	70	-20	65	B
E169357-01	RS485 Router & Relay Matrix/On-Off	-40	70	NA	-40	70	-25	65	-20	60	B
E246560-02,-05,-06	Enhanced Heater Control Tray (EHCT)	-40	85	NA	-40	65	-25	65	-20	60	B
E252086-01	HUB RS485 Router & Relay Matrix/On-Off	-40	70	NA	-40	60	-25	65	-20	60	B
E201250-05, -06	ESIAM, ESIAM-T, ESIAM-A	-40	80	NA	-40	75	-25	75	-20	70	B
E201252-01, -11	ESIAM, ESIAM-T, ESIAM-A	-40	80	NA	-40	75	-25	75	-20	70	B
E207550-03, -07	ESIAM, ESIAM-T, ESIAM-A	-40	80	NA	-40	75	-25	75	-20	70	B
E207550-10, -25	ESIAM, ESIAM-T, ESIAM-A	-40	80	NA	-40	75	-25	75	-20	70	B
E253024-01	ESIAM, ESIAM-T, ESIAM-A	-40	80	NA	-40	75	-25	75	-20	70	B
E245885-04	ESIAM-T	-40	80	NA	-40	75	-25	75	-20	70	B
E245885-05	ESIAM-A	-40	80	NA	-40	75	-25	75	-20	70	B
E245885-25	ESIAM-A	-40	80	NA	-40	75	-25	75	-20	70	B
E339242-01	Unit Assy, Expanded Enhanced Serial Interface Adapter Module	-40	80	NA	-40	75	-25	75	-20	70	B

See notes, Table 3.5-I (Notes)

Table 3.5-I(g1). Generic Data Handling Subsystems and Spacecraft Control Electronics Component Temperature Requirements (Continued)

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERIC DATA HANDLING SYSTEMS											
E207560-02	Attitude Control Electronics (ACE)	-40	70	NA	-40	65	-25	65	-20	60	B
E246570-06	Attitude Control Electronics (ACE)	-40	70	NA	-40	65	-25	65	-20	60	B
E207570-17, -18	Data Handling Electronics (DHE)	-40	70	NA	-40	65	-25	65	-20	60	B
E246552-01	Data Handling Electronics (DHE)	-40	70	NA	-40	65	-25	65	-20	60	B
E210150-03, -04	Processor Assembly	-40	70	NA	-40	70	-25	65	-20	60	B
E246850-01	Data Translation Unit (DTU)	-40	81	NA	-40	76	-25	76	-20	71	B
E246554-02	Data Translation Unit (DTU)	-40	81	NA	-40	76	-25	76	-20	71	B
E248086-01	Data Translation Unit (DTU) (SSM)	-40	81	NA	-40	76	-25	76	-20	71	B
E252082-01	Super Hub	-40	70	NA	-40	65	-25	65	-20	60	B
E253015-01	Hardline Command Receiver	-40	70	NA	-40	65	-25	65	-20	60	B

See notes, Table 3.5-I (Notes)

Table 3.5-I(g2). Generic RF Autotrack Subsystem Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
See ERS Addendum											

See notes, Table 3.5-I (Notes)

Table 3.5-I(h1). Generic Propulsion Subsystems Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1) Min [°C]	Non-Op QT, PFM, AT (1) Max [°C]	Power Handling QT (2) Max [°C]	Turn ON QT (3) Min [°C]	Turn ON QT (3) Max [°C]	Operating QT (4) Min [°C]	Operating QT (4) Max [°C]	Operating AT (4) Min [°C]	Operating AT (4) Max [°C]	Temperature Description (5)
GENERIC PROPULSION											
E001010-01	Filter (Ox, Fuel)	-7 / -7	60 / 60	NA /NA	NA /NA	NA /NA	-7 /NA	60 /NA	-7 /NA	55 /NA	B,P1 /B,P4
E054910-01	Filter (He)	-7 / -7	60 / 60	NA /NA	NA /NA	NA /NA	-7 /NA	60 /NA	-7 /NA	55 /NA	B, P2 /B, P4
E299169-01	Filter, Inline	-7 / -7 / -7	60 / 60 / 70	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 / -7	60 / 60 / 70	-7 / -7 / -7	60 / 60 / 70	B,P1 /B,P2 /B,P4
E001012-01, -03	Pressure Transducer (High/Low)	-7 / -7 / -7	71 / 71 / 71	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 /NA	65 / 65 /NA	-7 / -7 /NA	60 / 60 /NA	B,P1 /B,P2 /B,P4
E001013-02	Check Valve (He)	-7 / -30	65 / 65	NA /NA	NA /NA	NA /NA	-7 /NA	49 /NA	-7 /NA	44 /NA	B, P2 /B, P4
E001209-01	Latch Valve, (Ox, Fuel, He)	-7 / -40 / -40	65 / 65 / 65	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 / -7	60 / 60 / 60	-2 / -2 / -2	55 / 55 / 55	B, P1 /B, P2 /B,P4
E001030-01	Pyro Valve (Ox, Fuel, He)	-7 / -7 / -7	60 / 60 / 60	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 / -7	60 / 60 / 60	-7 / -7 / -7	55 / 55 / 55	B,P1 /B,P2 /B,P4
E001030-02	Pyro Valve (Ox, Fuel, He)	-7 / -34 / -34	71 / 71 / 71	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -34 / -34	71 / 71 / 71	-7 / -24 / -24	61 / 61 / 61	B,P1 /B, P2 /B,P4
E124999-01	Propellant Tank (Fuel, Oxidizer)	-7 / -7 / -40	55 / 55 / 66	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 /NA	55 / 55 /NA	-7 / -7 /NA	50 / 50 /NA	B,P1 /B, P2 /B,P4
E134999-01	Propellant Tank (Fuel, Oxidizer)	-7 / -7 / -40	55 / 55 / 66	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 /NA	55 / 55 /NA	-7 / -7 /NA	50 / 50 /NA	B,P1 /B,P2 /B,P4
E033674-01	Regulator (He)	-7 / -7 / -7	60 / 60 / 60	NA /NA /NA	NA /NA /NA	NA /NA /NA	-50 /NA / -7	49 /NA / 49	-50 /NA / -7	49 /NA / 49	B,P2,REF2 /B,P4 /R1
E033675-01	Pressurant Tank (He)	-7 / -7	60 / 60	NA /NA	NA /NA	NA /NA	-79 /NA	71 /NA	-74 /NA	66 /NA	B,P2 /B,P4
E033676-01	Fill & Drain Valve (Ox)	-7 / -40	60 / 60	NA /NA	NA /NA	NA /NA	-7 / -7	60 / 60	-7 / -7	55 / 55	B,P1 /B,P4
E033676-02, -03	Fill & Drain Valve (Fuel, He)	-40 / -40	60 / 60	NA /NA	NA /NA	NA /NA	-7 / -7	60 / 60	-7 / -7	55 / 55	B,P2 /B, P4
E038834-01	Thruster Drive Filter Assembly	-40	65	NA	NA	NA	-25	60	-20	55	B
E001020-02, -04	Main Satellite Thruster (MST)	-7 /NA / -7	121 / 121 / 260	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 /NA / -7	121 /NA / 260	-7 /NA / -7	121 /NA / 260	TV1, P1, P2, P4, REF2 /TV2, P1, P2, P4 /TI, P1, P2, P4, REF3
E136325-04	High Performance (HiPAT) Main Satellite Thruster (MST)	-7 /NA / -7	121 / 121 / 260	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 /NA / -7	121 /NA / 260	-7 /NA / -7	121 /NA / 260	TV1,P1,P2,P4,REF2 /TV2,P1,P2,P4 /TI,P1,P2,P4,REF3
E136360-01	22N Bi-Prop Thruster Assy	-7 /NA / -7	70 / 120 / 700	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 /NA / -7	120 /NA / 700	-7 /NA / -7	115 /NA / 700	TV1, P1, P2, P4, REF2 /TV2, P1, P2, P4 /TI,P1,P2,P4,REF3
E344697-01, -03	22N Bi-Prop Thruster Assy PT/RH	-7 /NA / -7	70 / 120 / 275	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 /NA / -7	120 /NA / 275	-7 /NA / -7	115 /NA / 275	TV1,P1,P2,P4,REF2 /TV2,P1,P2,P4 /TI,P1,P2,P4,REF3
E136384-02	Main Satellite Thruster (MST) Isolation Latch Valve	-7 / -7 / -7	70 / 70 / 70	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 / -7	47 / 47 / 47	-7 / -7 / -7	42 / 42 / 42	B, P1 /B, P2 /B,P4
E136384-03	Main Satellite Thruster (MST) Isolation Latch Valve	-7 / -7 / -7	70 / 70 / 70	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 / -7	47 / 47 / 47	-7 / -7 / -7	42 / 42 / 42	B,P1 /B,P2 /B,P4
E136385-02	Bi-Prop Latch Valve	-7 / -7 / -7	65 / 65 / 65	NA /NA /NA	NA /NA /NA	NA /NA /NA	-7 / -7 / -7	40 / 40 / 40	-7 / -7 / -7	35 / 35 / 35	B, P1 /B, P2 /B,P4
E137830-01	Pressurant Tank (He)	-7 / -7	60 / 60	NA /NA	NA /NA	NA /NA	-79 /NA	71 /NA	-74 /NA	66 /NA	B,P2 /B,P4
STD-BIPROP-1	Fuel Lines	-7 / -7	60 / 90	NA /NA	NA /NA	NA /NA	-7 /NA	60 /NA	-7 /NA	55 /NA	W, P2 /W, P4
STD-BIPROP-2	Oxidizer Lines	-7 / -7	60 / 90	NA /NA	NA /NA	NA /NA	-7 /NA	60 /NA	-7 /NA	55 /NA	W, P1 /W, P4
E127971-01	Pressure Regulator, Series Redundant	-70	81	NA	NA	NA	-54	77	-54	77	B

See notes, Table 3.5-I (Notes)

Table 3.5-I(h2). Generic Electric Propulsion Subsystem Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERIC ELECTRICAL PROPULSION											
E170990-02, -03, -04	Fill and Drain Valve (Xe)	0 / -34	60 / 71	NA /NA	NA /NA	NA /NA	17 /NA	60 /NA	22 /NA	55 /NA	B,P3 /B,P4
E038578-02	Propellant Management Assy (PMA)	0 / -34	60 / 71	NA /NA	NA /NA	NA /NA	17 /NA	60 /NA	22 /NA	55 /NA	B, P3 /B,P4
E066700-04, -05	Power Processing Unit (PPU), SPT-100	-40	70	NA	-40	70	-30	70	-25	65	B
E137830-02, -04	Xenon Tank	0 / 0	60 / 60	NA /NA	NA /NA	NA /NA	17 /NA	60 /NA	22 /NA	55 /NA	B,P3 /B,P4
E138905-01	Xenon Flow Controller (XFC), SPT-100	-15 / -15	95 / 89	NA /NA	-15 / -15	90 / 84	-15 / -15	95 / 89	-10 / -10	90 / 84	B, P3 /RT, P3
E138910-01	Stationary Plasma Thruster (SPT), SPT-100	-48 / -48	200 / 200	NA /NA	-48 /NA	NA /NA	-48 /NA	200 /NA	-43 /NA	195 /NA	RT, P3 /RT, P4
E176300-01	Gimbal Assy, SPT	-65 / -60	105 / 80	NA /NA	NA /NA	NA /NA	-45 /NA	100 /NA	-40 /NA	95 /NA	B, D1 /B, D2
STD-EPROP-1	Low-Pressure Xenon Lines	-150 / -60 / -60	300 / 125 / 125	NA /NA	NA /NA	NA /NA	-150 / -60 /NA	300 / 125 /NA	-145 / -55 /NA	295 / 120 /NA	W,P3 /P6,P3 /W,P4
STD-EPROP-2	High-Pressure Xenon Lines	17 / -29	60 / 66	NA /NA	NA /NA	NA /NA	17 /NA	60 /NA	22 /NA	55 /NA	W, P3 /W, P4
STD-EPROP-3	Low-Temperature Harness	-150 / -20 /NA	150 / 68 /NA	NA /NA /NA	NA /NA /NA	NA /NA /NA	-150 / -32 / 0	150 / 78 /NA	-145 / -32 / 0	145 / 78 /NA	B /P6 /P7

See notes, Table 3.5-I (Notes)

Table 3.5-I(i). Communications Antennas Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
See ERS Addendum											

See notes, Table 3.5-I (Notes)

Table 3.5-I(j). Generic Mechanisms Component Temperature Requirements

Part Number	Part Description	Non-Op QT, PFM, AT (1)		Power Handling QT (2)	Turn ON QT (3)		Operating QT (4)		Operating AT (4)		Temperature Description (5)
		Min [°C]	Max [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	Min [°C]	Max [°C]	
GENERIC MECHANISMS											
E001845-01	Viscous Damper	-90 / -50	110 / 75	NA /NA	NA /NA	NA /NA	-25 /NA	55 /NA	-20 /NA	50 /NA	DM,D1 /DM,D2
E023290-02	Antenna Positioner Mechansim (APM)	-100 / -100 / -100	100 / 100 / 150	NA /NA /NA	-100 / -85 / -85	90 / 90 / 140	-70 / -70 /NA	90 / 90 / 140	-65 / -65 /NA	85 / 85 / 140	B /MH, RT /MH, RT, REF3
E033750-10	Reflector Hinge Assembly (E001845-XX Damper)	-135 / -90 / -50	110 / 110 / 75	NA /NA /NA	NA /NA /NA	NA /NA /NA	-125 / -25 /NA	95 / 55 /NA	-120 / -20 /NA	90 / 50 /NA	RH /DM, D1 /DM, D2
E028600-99	Holddown Assembly (Axial/lateral)	-165 / -180	135 / 120	NA /NA	NA /NA	NA /NA	-95 / -160	125 / 110	-90 / -155	120 / 105	HD /CT
E094021-99	Holddown Assembly (Axial/lateral)	-165 / -180	135 / 120	NA /NA	NA /NA	NA /NA	-95 / -160	125 / 110	-90 / -155	120 / 105	HD / CT
E210310-99	Holddown Assembly, Main Reflector 3rd	-165 / -180	135 / 120	NA /NA	NA /NA	NA /NA	-95 / -160	125 / 110	-90 / -155	120 / 105	HD / CT
E201091-13 -- -15	Split Spool Device	-135 / -135	135 / 135	NA /NA	NA /NA	NA /NA	-90 / -90	110 / 110	-85 / -85	105 / 105	B /R1
E113410-02, -03	Solar Array Drive Assembly (SADA)	-40 / -70	85 / 80	NA /NA	-40 / -70	75 / 70	-20 / -60	75 / 70	-15 / -55	70 / 65	SD1 /SD2
E200008-02 -- -06	Deployment And Positioning Mechanism (DAPM)	-60	115	NA	-50	105	-50	105	-45	100	MH,RT
E200008-PH	Deployment And Positioning Mechanism (DAPM)	-60	115	NA	-50	105	-50	105	-45	100	MH,RT
567746-01 -- -06	Pyro Cutter Assembly	-180	120	NA	NA	NA	-160	110	-155	105	B

See notes, Table 3.5-I (Notes)

Table 3.5-I(Notes). Notes for Component Temperature Requirements

Note 1:	Unless otherwise noted, the definition of Non-Operating is defined as follows: Generic Electrical Units: No electrical power (off) For RF passive components, RF Loads: No RF power RF Switches: No RF power and no switch actuation NiH2 and Li Ion Batteries: Not discharging or charging (survival testing) Bi-Prop and plasma thrusters and valves: No thruster firing Bi-Propellant and Electrical Propulsion System Valves: No valve actuation Propulsion Tanks, Regulator, Check Valve, XFC: Not flowing pressurant/propellant Deployment and Adjustment Mechanisms/Cutters: No deployment, movement, or cutting Solar Array Wings: Stowed and MST firing as applicable
Note 2:	The power handling qualification test, applicable only to passive RF components and RF switches (no actuation), demonstrates unit performance at or above the unit-level design RF power. The RF power level for this test is defined by the RF Power Handling as applicable. The unit and environmental temperature requirements, however, are derived from the unit-level design RF power level as defined by the Operating RF Power. For units with a spacecraft over-temperature monitor, the power handling temperatures specified are the worst-case temperatures possible before the monitor is tripped and RF power removed.
Note 3:	Unless otherwise noted, the definition of Turn-On is defined as follows: Generic Electrical Units: Unit is powered on, but spec performance is not required All other units: Not applicable Turn-On PFM temperatures should be set at Turn-On QT temperatures. Turn-ON AT temperatures should be set at Turn-On QT Min and Op AT Max temperatures.
Note 4:	Unless otherwise noted, the definition of Operating is defined as follows: Generic Electrical Units: Unit is powered on, spec performance is required For RF passive components: Defined by Operating RF Power as applicable RF Switches: Switch actuation and no RF power NiH2 Batteries: Geosynchronous on-orbit or launch/test operation as applicable Bi-Prop and plasma thrusters and valves: Thruster firing Bi-Propellant and Electric Propulsion System Valves: Valve actuation Propulsion Tanks, Regulator, Check Valve, XFC: Flowing pressurant/propellant Deployment and Adjustment Mechanisms/Cutters: Deploying or moving/cutting Solar Array Wings: Deployment and on-orbit operation as applicable Operating PFM temperatures should be set at Operating QT temperatures.
Note 5:	The Temperature Description is used to define the approximate location of the specified temperature, as well as to define the meaning of multiple temperatures when they are needed for Non-Operating, Survival, Operating, and Acceptance Temperatures. The following description codes are defined:
	B - Unit baseplate if present, or unit body temperature if no baseplate is present
	W - Worst-Case temperature location
	C - Case temperature (Filters, Couplers, etc.)
	RT - Flight thermistor temperature
	HS - Isothermal heat sink temperature
	HP - Heat pipe temperature. Heat pipes are 1in wide. If an isothermal heat sink is used for unit testing, the sink temperature should be increased as dictated by unit-level analysis to provide an equivalent environment.
	R_ - Radiation environment temperature
	R1 - Unit radiation environment temperature (thermal shroud)
	R2 - DRC TWT fin radiation environment temperature
	R3 - Inboard side of OMUX subpanel
	R4 - Outboard side of OMUX subpanel
	REF_ - Associated temperature is provided for reference only and is not used as an imposed or controlled condition during unit level testing
	REF1 - Associated non-operating temperature shown is for reference only.
	REF2 - Associated operating temperature is for reference only
	REF3 - Associated non-operating and operating temperatures are both for reference only
	TW - TWT temperature (TWTA Assemblies Only)
	EP - EPC temperature (TWTA Assemblies Only)
	MC_ - Thermal mounting interface between unit and heatsink
	MC1 - 1275 W/C/m2
	MC2 - 2170 W/C/m2

Table 3.5-I. (Notes) Notes for Component Temperature Requirements (Continued)

	BT - Battery operation description
	BT1 - NiH2 Battery Nominal Geosynchronous On-Orbit Operations (ABM control)
	BT2 - NiH2 Battery Launch, Test, and Survival Operations (No capacity requirements)
	BT3 - Solstice Operations (No Battery Discharge)
	BT4 - Eclipse Operations (Battery Discharge)
	BT5 - Battery Cold Storage Temperature
	TI - Bi-Propellant thruster injector temperature
	TV_ - Bi-Propellant thruster valve temperature
	TV1 - Non-Operating: Pre-Firing. Operating: Firing.
	TV2 - Max Non-Operating: Soakback. Min Non-Operating and Min/Max Operating: Not Applicable.
	P_ - Bi-Propellant or Electric Propulsion System unit temperature
	P1 - Oxidizer (N2O4) present
	P2 - Fuel (MMH) and/or pressurant (He) present
	P3 - Xenon present
	P4 - No fuel, oxidizer, or pressurized Xenon present (manufacturing/test setup)
	P5 - Internal Magnet Winding location
	P6 - DAPM location with no qualification margin. Non-Operating: Stowed. Operating: Deployed.
	P7 - DAPM location with no qualification margin. Non-Operating: Not Applicable. Operating: Deployment.
	SA_ - Solar array wing temperature
	SA1 - Non-Operating: Stowed. Operating: Deployed.
	SA2 - Non-Operating: MST firing deployed. Operating: At Pyro Event, deployment.
	SA3 - Non-Operating: Not applicable. Operating: Latch-up, deployment.
	SD - SADA temperature
	SD1 - SADA spacecraft mounting surface (housing)
	SD2 - SADA solar array mounting surface (shaft)
	SD3 - SADA bearing temperature
	SNA - See Next Assembly, either higher or lower level assembly for actual temperature requirements (i.e., component is not temperature tested at this level)
	MH - Motor housing temperature
	HD - Holddown assembly temperature
	CT - Pyro cutter assembly temperature
	D_ - Pre- or Post- Deployment definition for deployable products
	D1 - Non-Operating: Post-Deployment. Operating: Deployment.
	D2 - Non-Operating: Pre-Deployment. Operating: Not Applicable.
	RH - Reflector hinge body temperature
	DM - Viscous damper temperature
	RF_ - Reflector and backup structure temperature. Minimum temperature limit may be raised to -175C due to test facility constraints
	provided that reflectors are manufactured and qualified with heritage materials and heritage processes.
	RF1 - Reflector shell
	RF2 - Reflector backup structure
	RW_ - Reaction/Momentum wheel temperatures
	RW1 - Wheel baseplate temperature
	RW2 - Wheel Drive Electronics (WDE) baseplate temperature
Note 6:	The RF Power Description is used to define the RF power for two cases: Power Handling and Operating. Power Handling is typically 120% of Operating Power. When a number is specified, it represents the total RF power in Watts for all applicable pathways in the forward and reverse direction as applicable. This power level should be considered as reference only. Note that systems level design is based upon Operating Power and Operating Temperatures, not Power Handling requirements. For both cases, the following description codes are defined:
	N - No RF power
	L - Low RF power (Less than 1 Watt, Input RF component)
	F - Forward in-band frequency power as specified
	R - Forward and reverse in-band frequency power in all applicable pathways as specified
	BE - Forward power as specified for both center frequency case and Band-Edge frequency case (maximum filter dissipation)
Note 7:	If low power testing is used in place of the operating RF power as described, the test temperatures must be increased as necessary to approximate the temperatures resulting from RF drive as applicable.

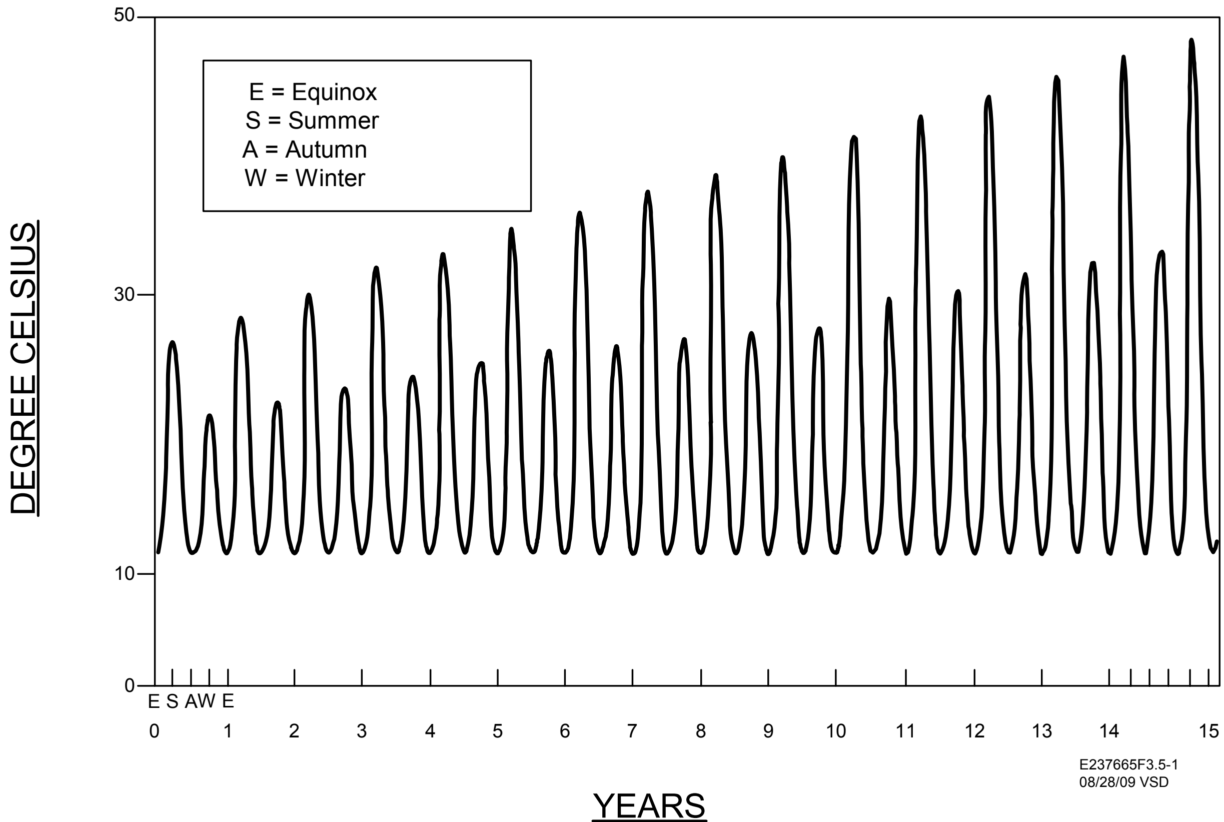


Figure 3.5-1. Typical Predicted Panel Temperature Over Life

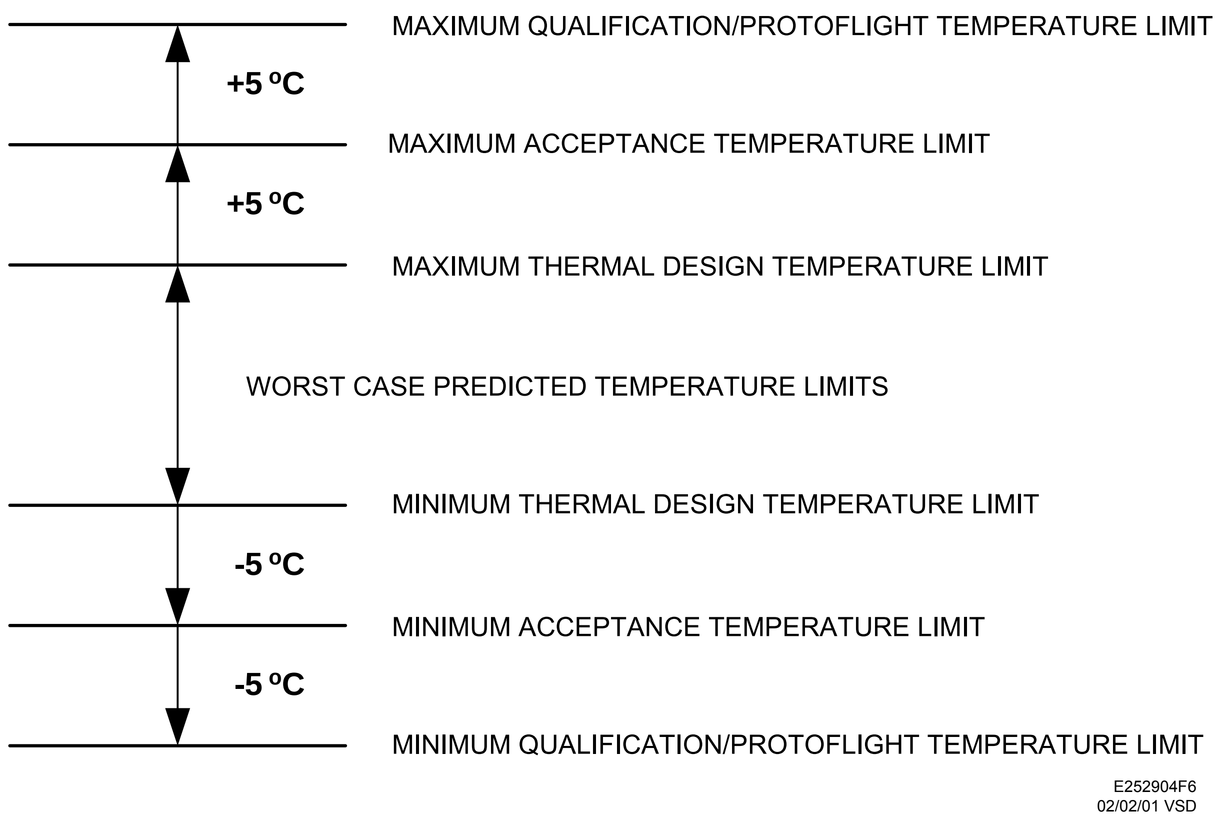


Figure 3.5-2(a). Temperature Margins for Internal Mainbody and Thermally Coupled External Equipment

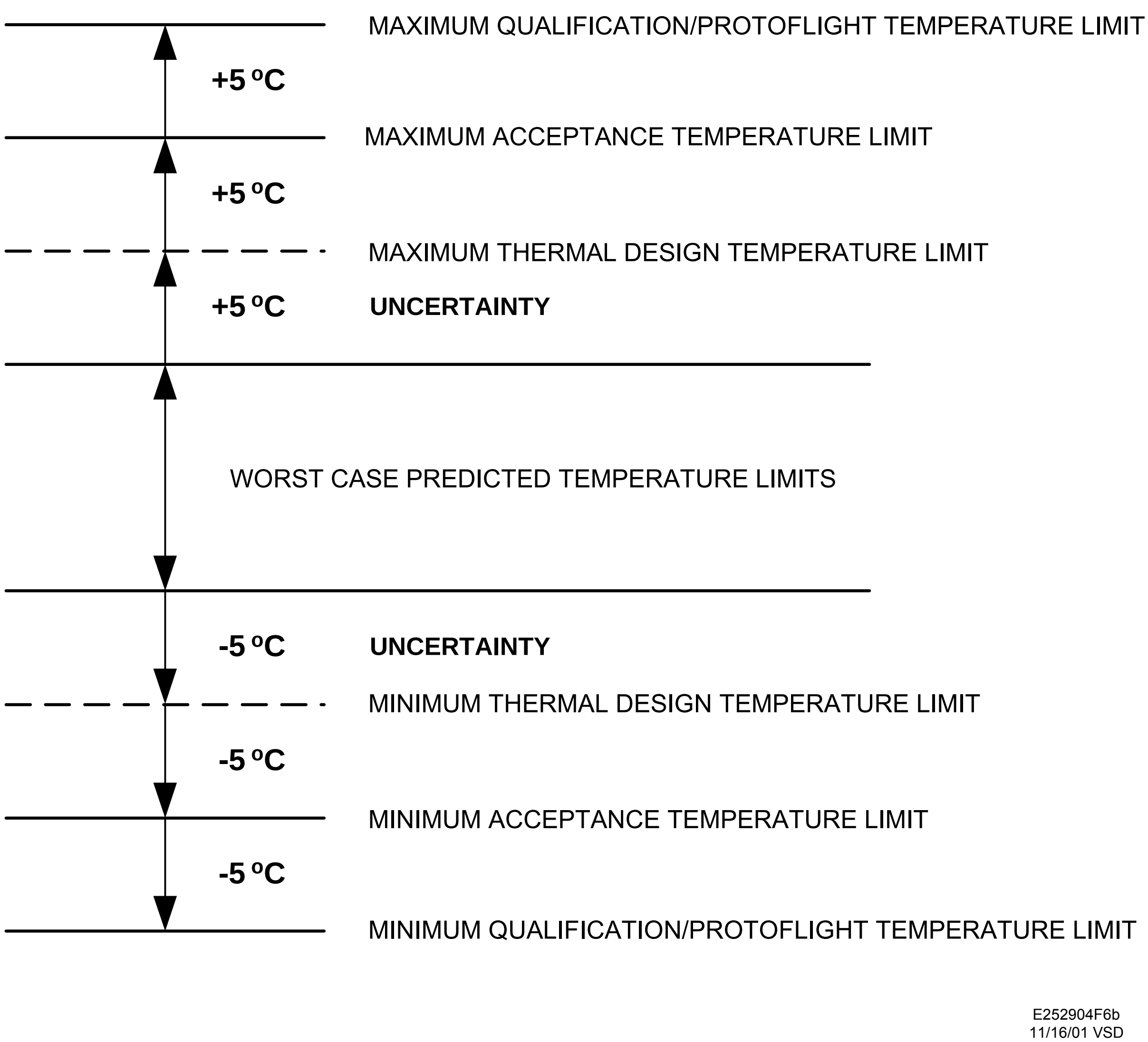
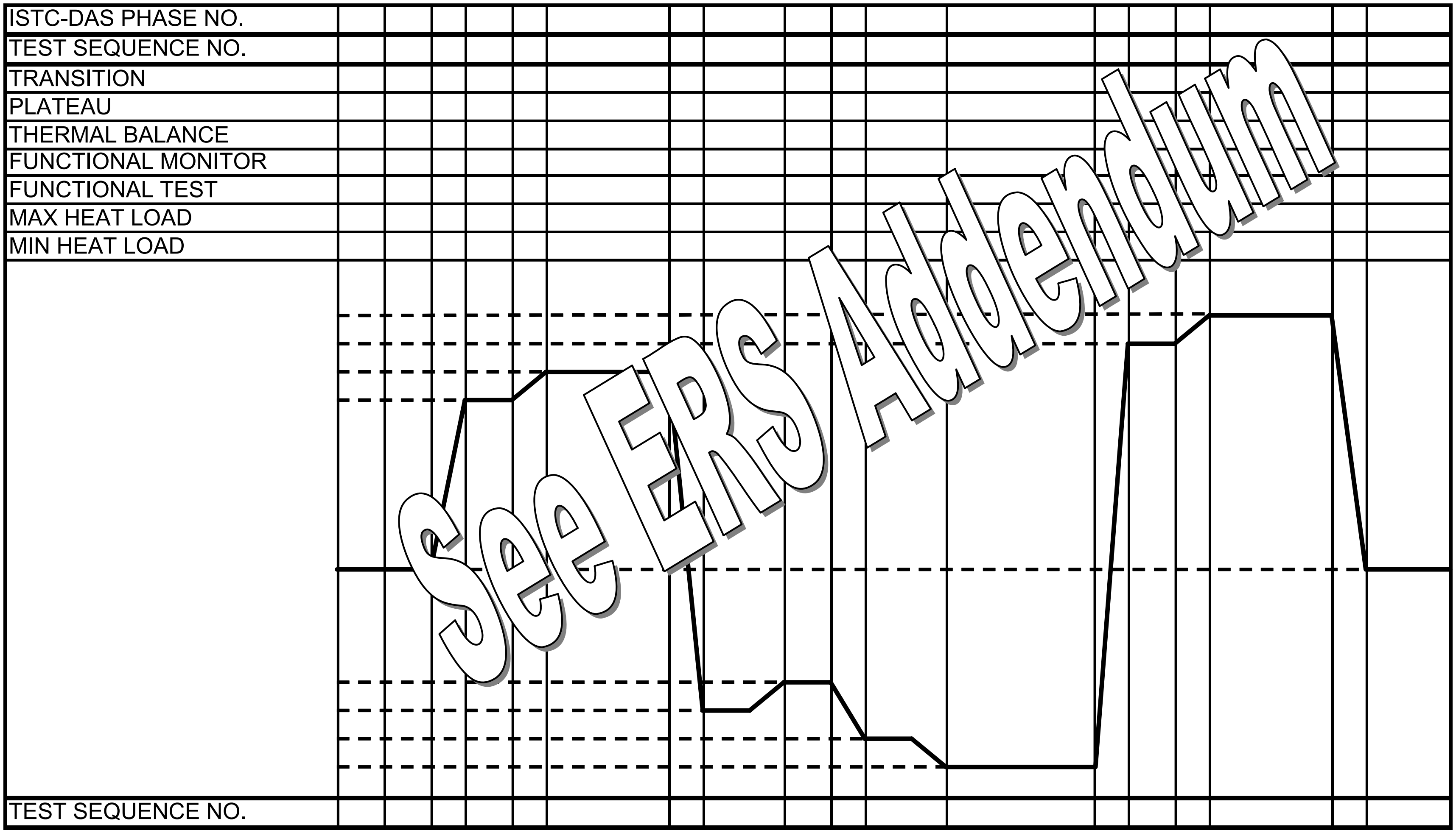


Figure 3.5-2(b). Temperature Margins for External Thermally Isolated Equipment



Note: Table values to be determined by specific program and listed in the addendum.

Figure 3.5-3. Spacecraft Thermal Vacuum Profile

See E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements

Figure 3.5-4. DELETED Unit to Spacecraft Communications Panel Mechanical and Thermal Interface

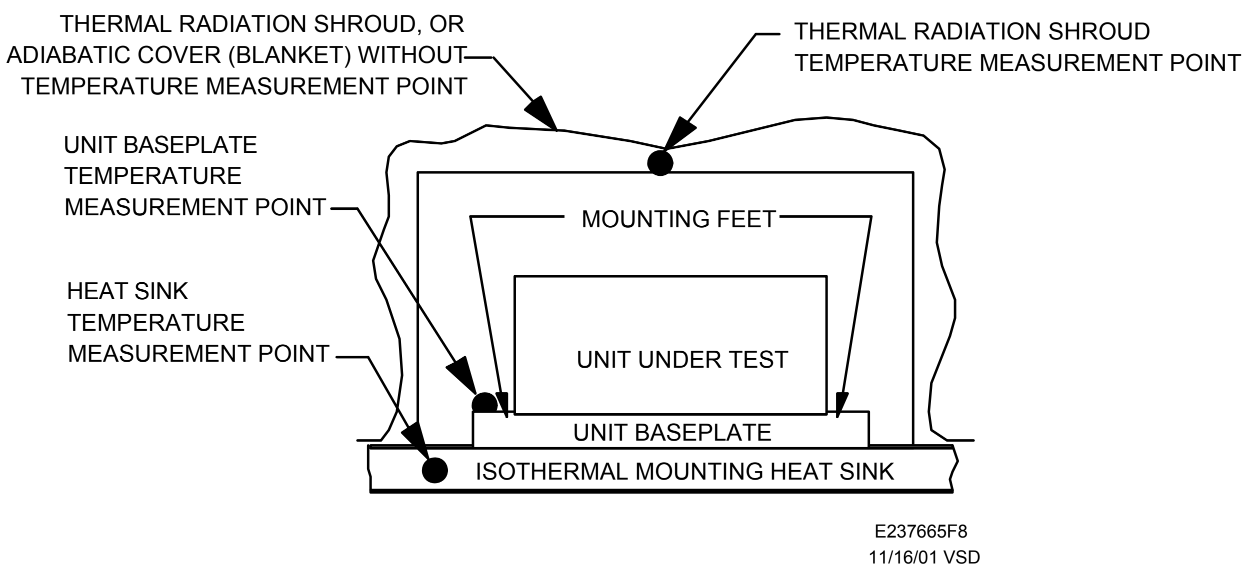
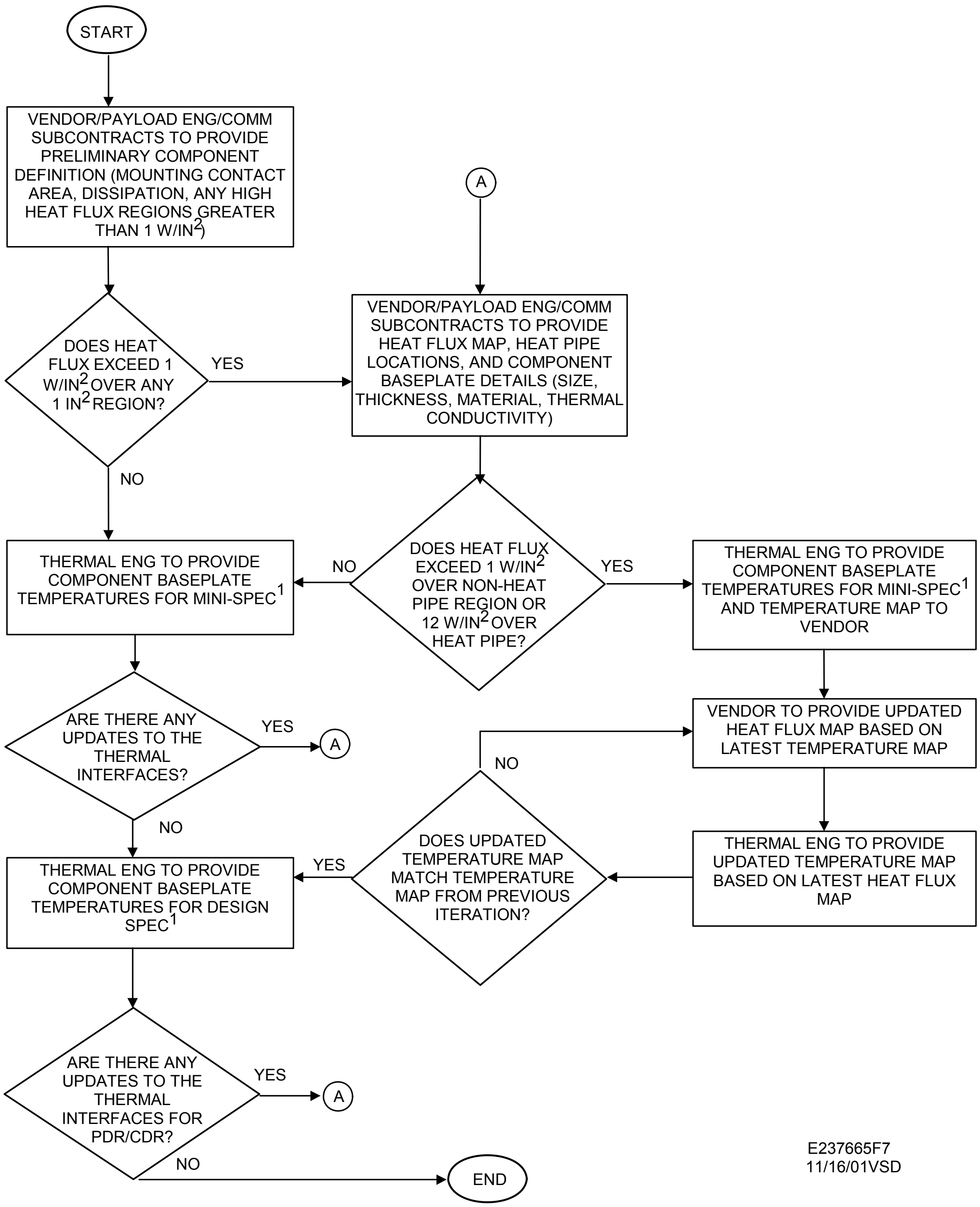


Figure 3.5-5. Temperature Sensor Locations



Note: 1. If required, Thermal Eng to identify baseplate temperature offset between flight analysis with heat pipe and test analysis with isothermal test platen.

Figure 3.5-6. Thermal Interface Temperature Process Flowchart

8.3.6 T&F - Static Pressure

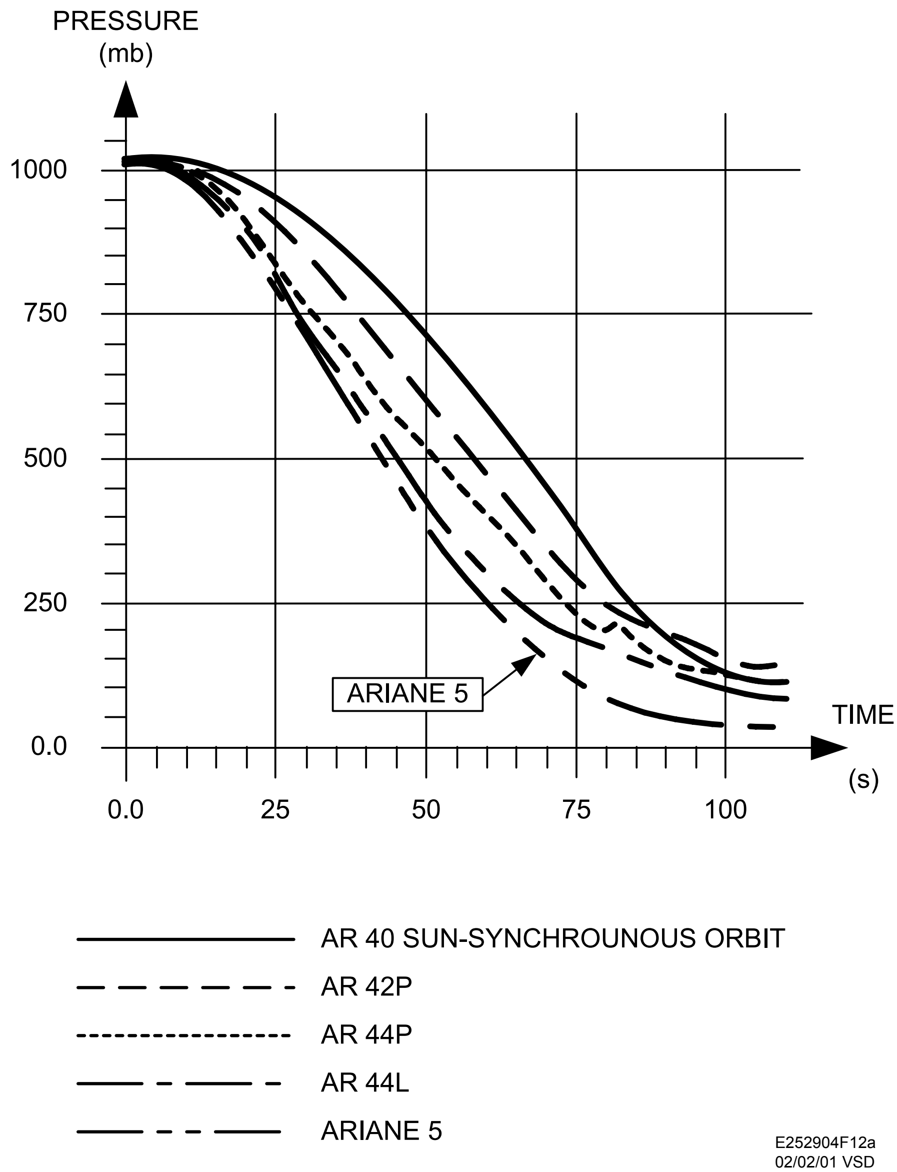


Figure 3.6-1(a). Variation of Static Pressure Within Fairing - Ariane 4 and 5

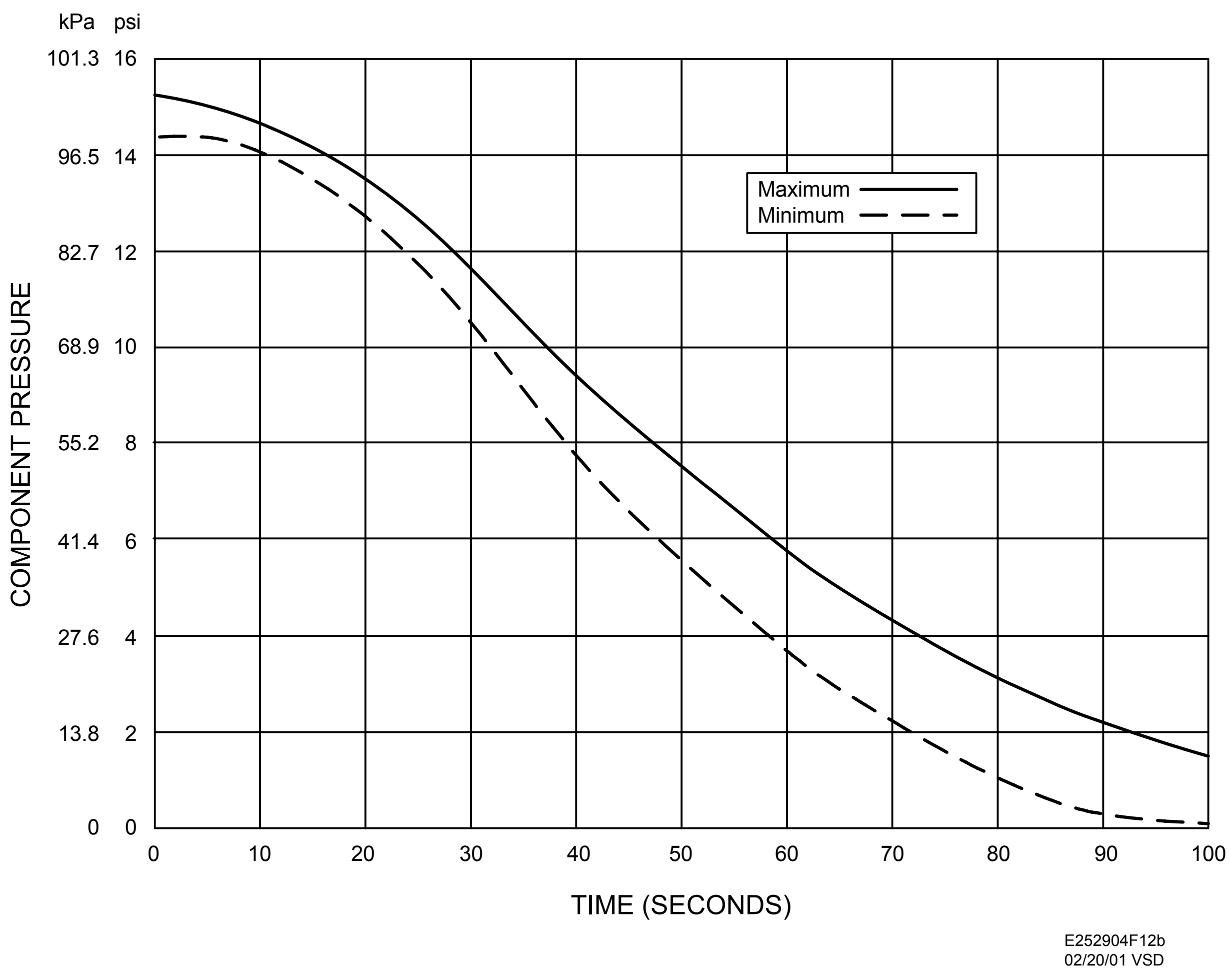
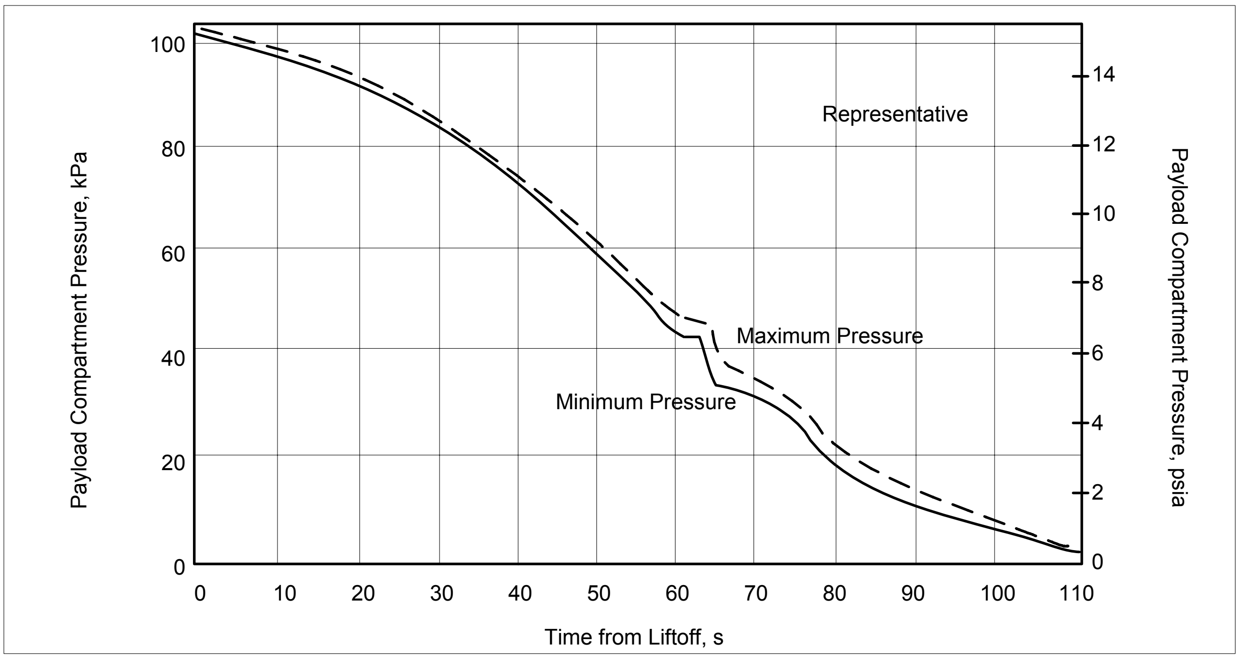
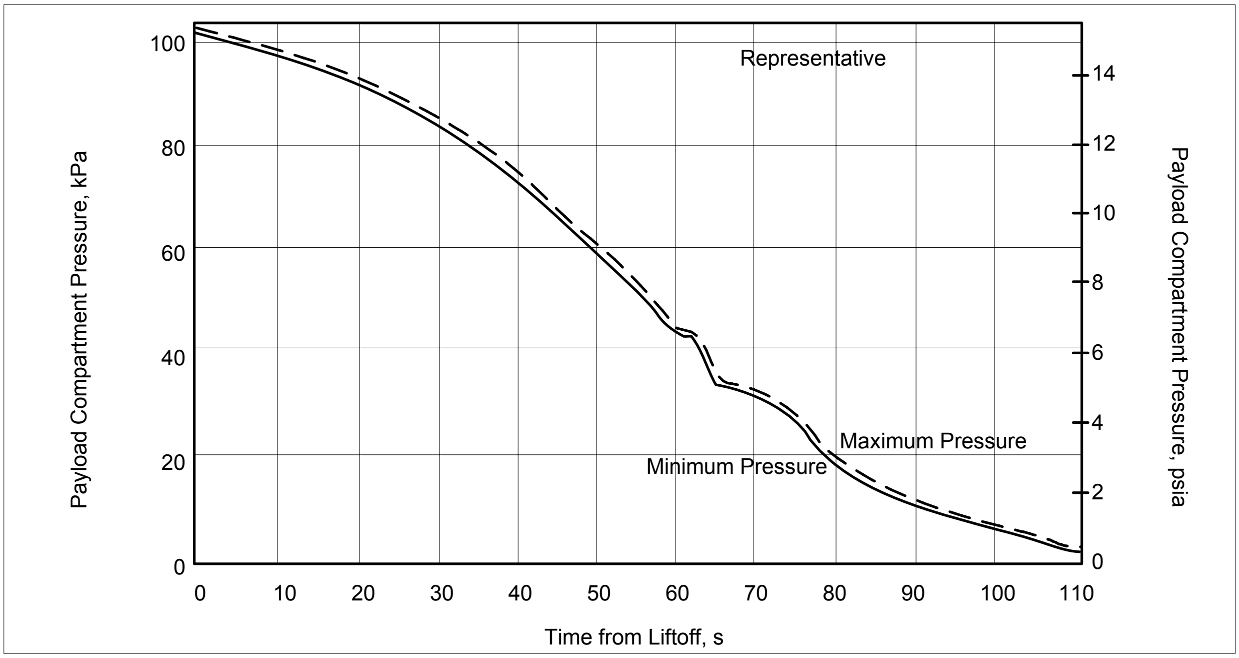


Figure 3.6-1(b). Variation of Static Pressure Within Fairing - Delta IV Medium-Plus (4,2)



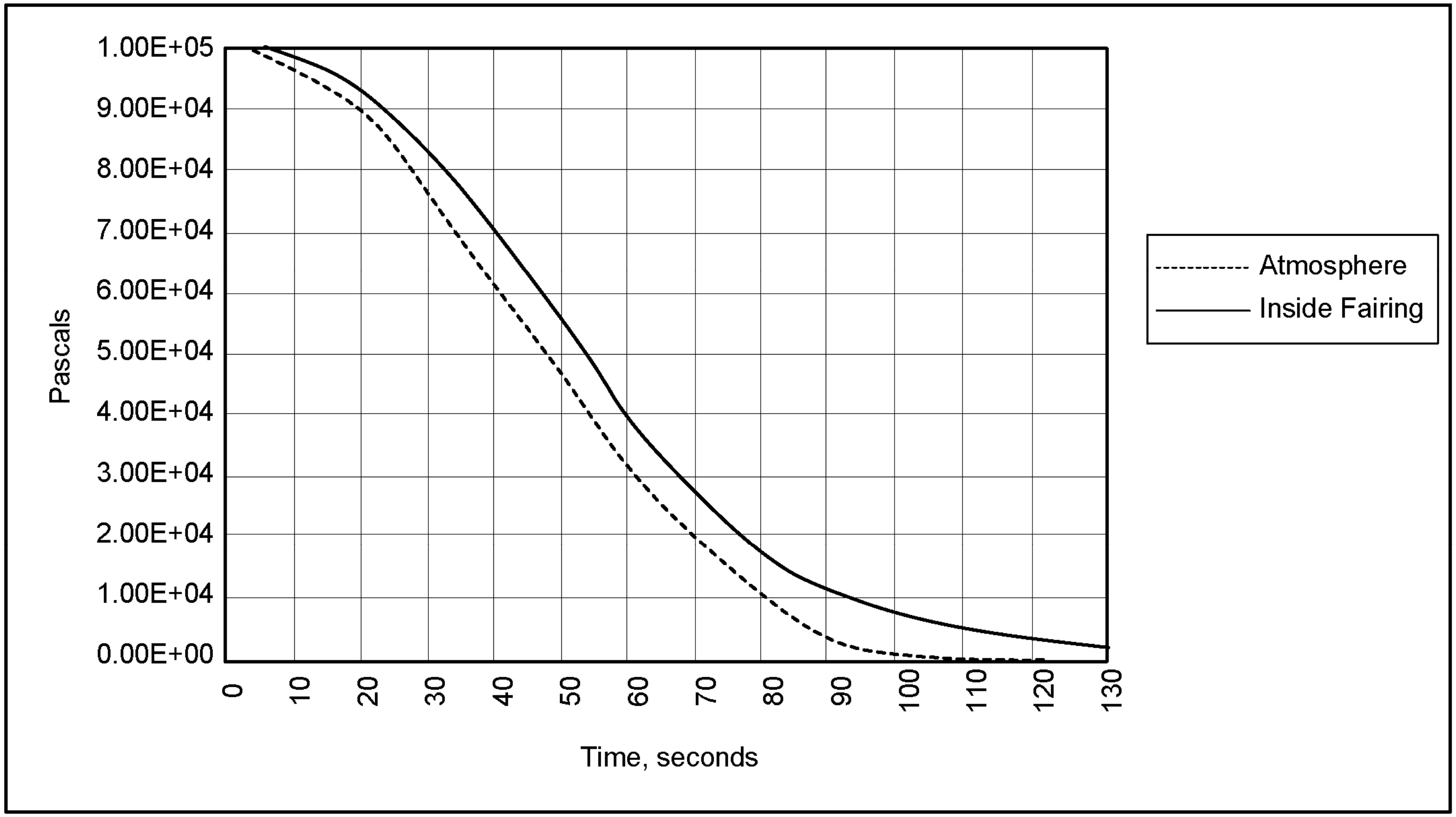
(Reference Rev. 7)

Figure 3.6-1(c). Variation of Static Pressure Within Fairing - Atlas V Medium Payload Fairing



(Reference Rev. 7)

Figure 3.6-1(d). Variation of Static Pressure Within Fairing - Atlas V Large and Extended-Length Large Payload Fairing



(Reference Issue I, Rev.4, March 1, 1999)

Figure 3.6-1(e). Variation of Static Pressure Within Fairing – Proton

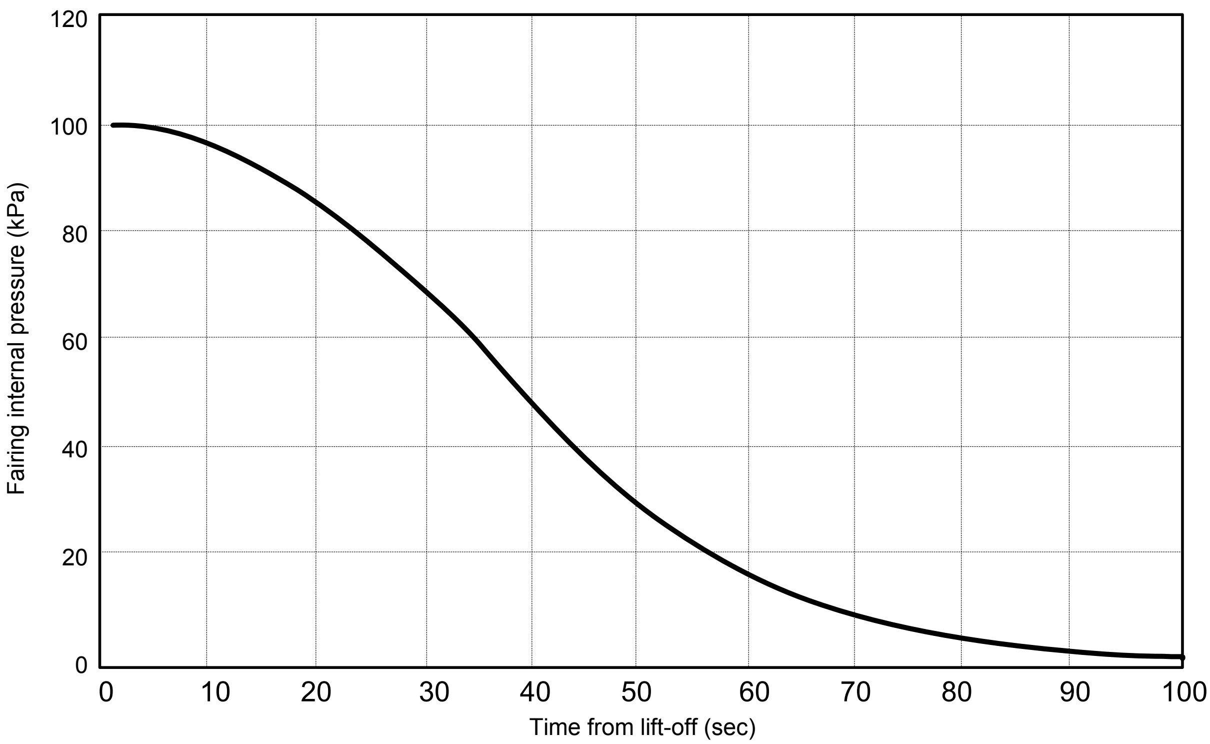
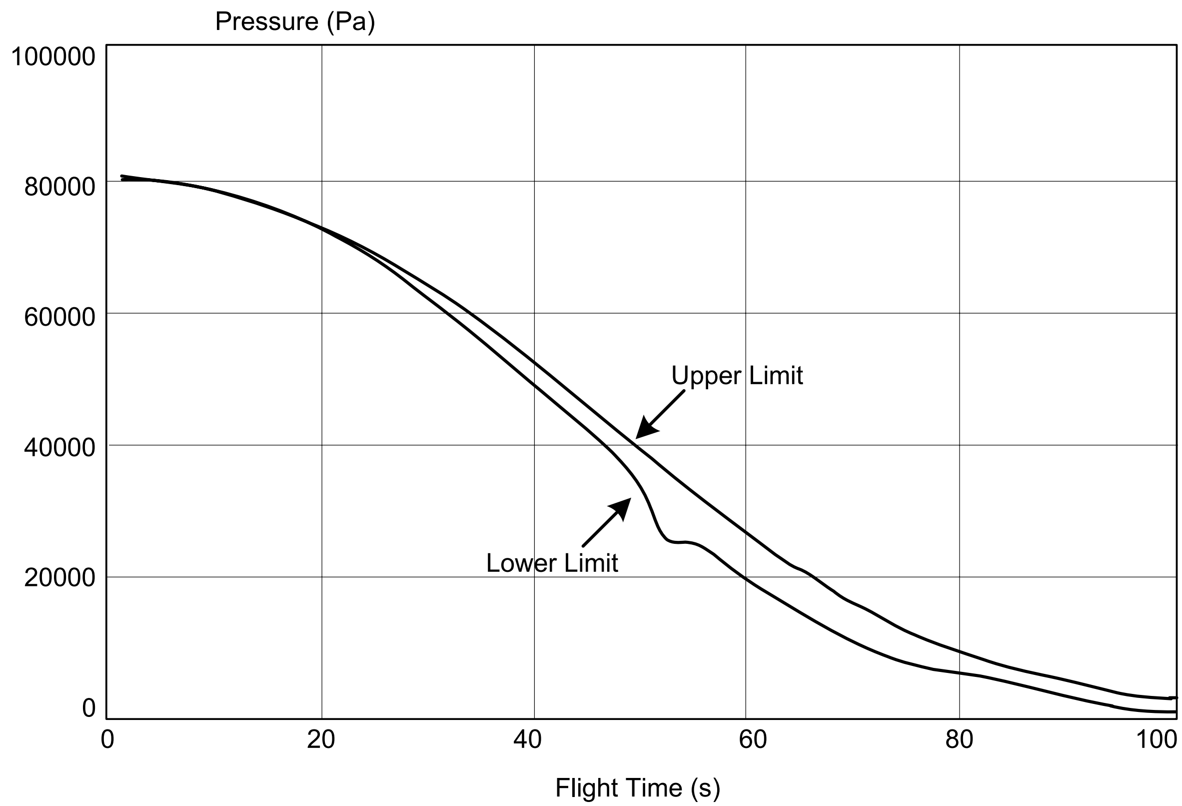


Figure 3.6-1(f). Variation of Static Pressure Within Fairing - H2A 4s Fairing



(Reference Issue 1999)

Figure 3.6-1(g). Variation of Static Pressure Within Fairing - Long March

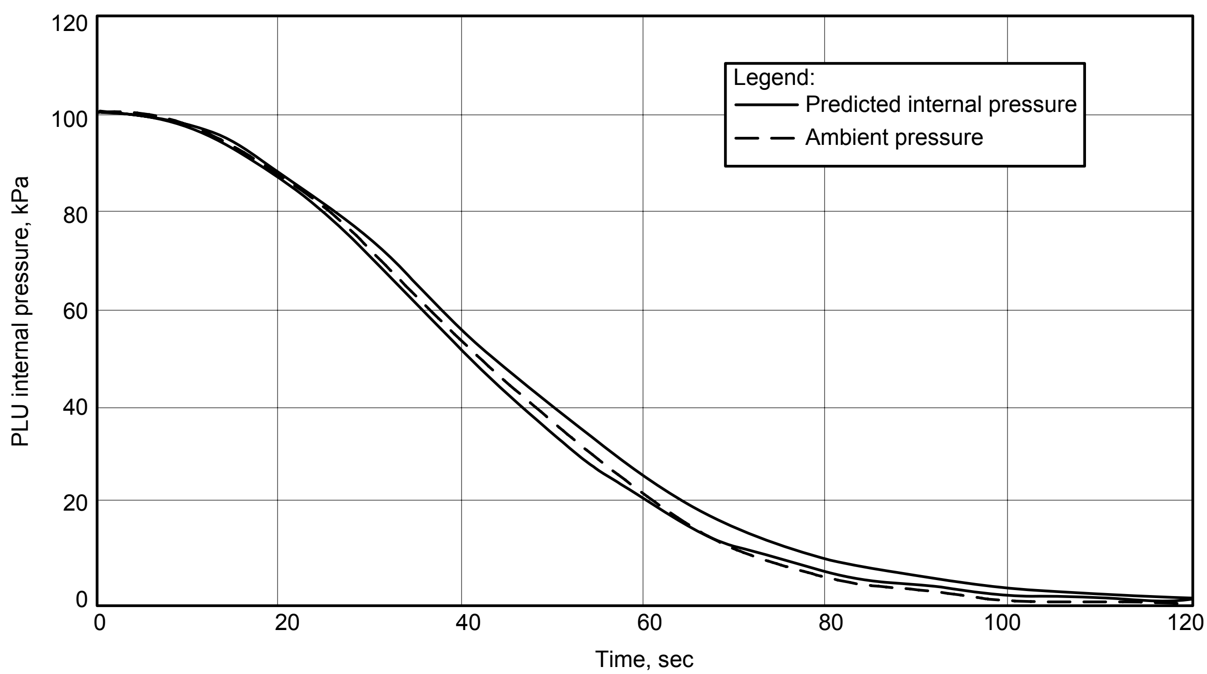
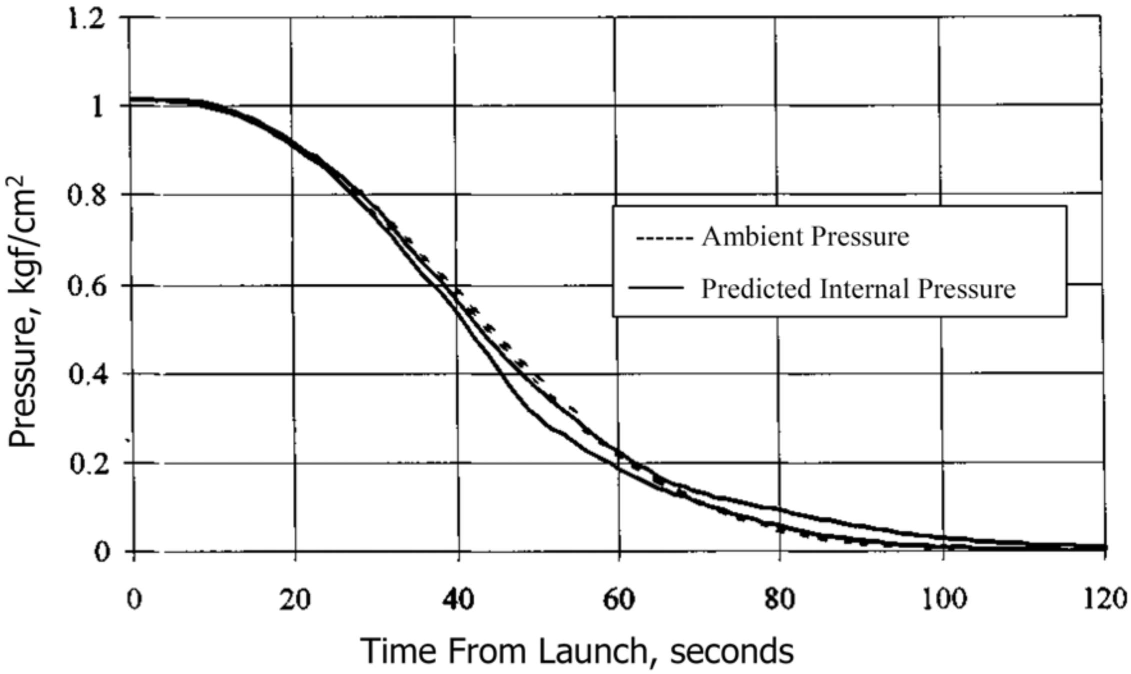


Figure 3.6-1(h). Variation of Static Pressure Within Fairing - Sea Launch



From Land Launch User's Guide Rev. Initial Release Section 4:

Typical Zenit-2SLB fairing internal pressure profile during ascent (Zenit-3SLB TBD)

Figure 3.6-1(i). Variation of Static Pressure Within Fairing - Land Launch

8.4 T&F - Design and Interface

See E399000, Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.

8.5 T&F - Reliability and Product Assurance

There are no tables and figures for Reliability and Product Assurance section.

8.5.1 T&F - Reliability

There are no tables and figures for Reliability section.

8.5.2 T&F - Product Assurance

There are no tables and figures for Product Assurance section.

8.6 T&F - Test Conditions and Requirements

There are no tables and figures for Test Conditions and Requirements section.

8.6.1 T&F - General Test Conditions

There are no tables and figures for the General Test Conditions section.

8.6.2 T&F - Test Requirements

Table 6-I. Test Environmental Requirements Summary

Parameter	Minimum	Maximum
Relative Humidity (ambient)	30%	60%
Barometric Pressure Steady-State (ambient)	710 mmHg	815 mmHg
Pressure – Venting	Section 3.6.2	
Random Vibration	Section 3.4.3.2, Table 3.4.3-II(a)	
Sine Vibration	Section 3.4.3.2, Table 3.4.3-II(a)	
Shock Response	Section 3.4.3.4, Tables 3.4.3-III	
Radiated Emissions	Section 3.3, Figures 3.3-2, 3.3-3, Table 3.3-II	
Radiated Field Susceptibility		
Conducted Susceptibility		
Conducted Emissions		
Temperature	See program ERS Addendum and Unit Specification	

1. Storage requirements in section 3.7 and test conditions and test requirements in 6.1.1 have different humidity limits. Flight hardware should be tested under most stringent ambient conditions.
2. 1 torr = 1 mm Hg = 133.322 Pa
3. Minor changes of the above limits are allowed if the test plan/procedure has been approved by SS/L.
4. Ambient temperature is 18.3° C to 25.7° C.
5. Test in vacuum then the pressure level is 1×10^{-5} mmHg or less.
6. If non-flight units are in the test environment the humidity may be from 25% to 70%.

Table 6.1-I. Test Tolerances

Test Temperature: Hot: Cold:	 +3, -0 C +0, -3 C
Test Pressure: ≥0.1 torr <0.1 torr	 ±5% ±50%
Test Duration:	+5/-0%
Acceleration (Centrifuge Load):	±5%
Sinusoidal Vibration Amplitude Amplitude Input: Frequency Input < 20 Hz > 20 Hz	 ±10% ±0.5 Hz ±2%
Random Vibration Acceleration Power Spectral Density, 20-300 Hz (g^2/Hz): Power Spectral Density, 300-2000 (g^2/Hz): Random Overall (g_{rms}):	 ±1.5 dB ±3.0 dB ±1.0 dB
Pyroshock Shock Response Spectrum (Q=10)	a) 50% of the overall frequency bandwidth test levels shall meet or exceed the nominal test specification b) 80% of the overall frequency bandwidth shall be contained between -3 dB and +6 dB of the nominal test specification c) 100% of the overall frequency bandwidth shall be contained between -6 dB and +9 dB of the nominal test specification
Static Load	+5/-0%

1. For qualification tests on non-flight units, test levels may exceed the upper tolerance (at the risk of the manufacturer).

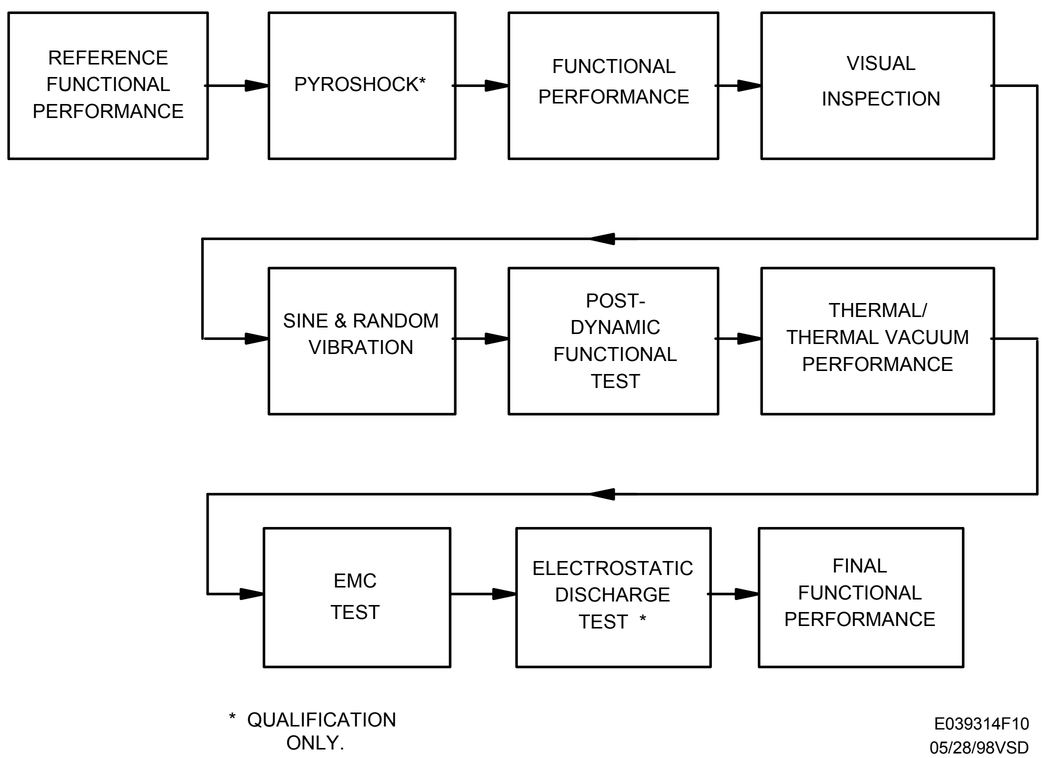
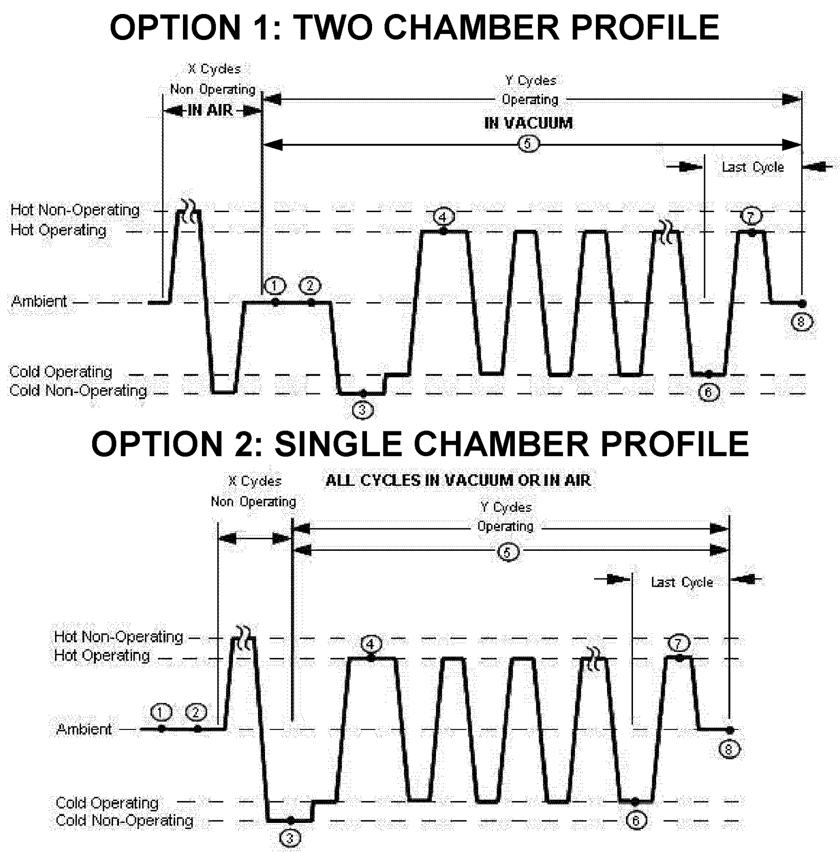


Figure 6.2-1. Typical Unit Test Sequence



1. Chamber Pump Down, TVAC Only
2. Initial Ambient Performance Test TVAC Only, Turn off after test
3. Turn On at cold non-operating Temperature. Soak for 1 hr at cold operating temperature. Turn Off after soak.
4. Soak for 1 hour minimum. Then turn on. For qual, Hot Performance Test is recommended.
5. Continuous monitoring & Functional Verification
6. Cold Performance Test
7. Hot Performance Test
8. Final Ambient Performance Tests

Soak Time: 1 hour min, non-operating

Transition Rate: 3°C to 5°C per minute nominal and 1 °C per minute minimum.

Non-Operating Cycles, "X"	Operating Cycles, "Y"
2 Cycles (EQM, Qual, PFM)	10 Cycles (EQM, Qual, PFM)
1 Cycle (AT)	8 Cycles (AT)

a) For units with internal redundancy, all operating cycles must be performed on both primary and redundant items/modules.

b) All units are to have the applicable voltage present during pumpdown for TVAC testing (ex: 100 present at input of a 100 volt unit).

c) Non-operating/operating cycles can be increased or reduced if they are shown not to have value-added because of the application of the unit- for example, the unit is always operating.

Figure 6.2-2. Unit Thermal/Thermal Vacuum Profile

8.6.3 T&F - Recording of Data

There are no tables and figures for Recording of Data section.

8.6.4 T&F - Test Failures

There are no tables and figures for Test Failures section.

Appendix I Applicability Table

Environmental Requirements Specification (ERS) Applicability Table

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
1.	**SCOPE**	ALL		
1.1	**General**			
1.1 a		ALL		
1.1 b		ALL		
1.1 c		SUB – SUBCONTRACTED UNITS		Refers to E032894 or E447271
1.2	**Definitions**	ALL		
2	**APPLICABLE DOCUMENTS**			
2.1	**US Government Documents**	ALL		
	STANDARDS	ALL		
	MIL-STD-461	ALL		
	MIL-STD-462	ALL		
	MIL-STD-464	ALL		
	MIL-STD-883E(4)	ALL		
	MIL-STD-1541A	ALL		
	FED-STD-209	ALL		
	NASA-HDBK-4002	ALL		In addition to radiation, the equipment chassis and cover thickness shall comply to deep charging requirement as stated in NASA-HDBK-4002.
2.2	**Non-Government Documents**	ALL		
	SPACE SYSTEMS LORAL			
	SPECIFICATIONS/PLANS			
a	Various Satellite Performance Specification (Ref)	ALL		
b	Various Contract Exhibit	ALL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
c	PP-E191555	SS/L - LORAL INTERNAL BUILD		Reference means no explicit requirements come from this document. The significance to list it here is for SS/L internal designer only!
d	Various Program EMI/EMC and ESD Control Plan (Ref)	ALL		Reference means no explicit requirements come from this document. This is listed in case some programs has an unique EMI/EMC control imposed from the customer.
e	Various Program Launch Vehicle User's Guide (Atlas, Delta, Ariane, Sea Launch, Long March, H-II, Proton, etc.)	SS/L - LORAL INTERNAL BUILD		SSL envelopes all the curves and defines the environment based on these documents.
f	Various Program Environmental Requirements Specification (ERS) Addendum	ALL		The Addendum plus the Generic form the complete environmental document for each program.
g	SH-E032894	SUB – SUBCONTRACTED UNITS		Non-SES programs
h	SH-E447271	SUB – SUBCONTRACTED UNITS		SES programs
i	SH-E339761	SS/L - LORAL INTERNALBUILD		
j	MM-E135793	ALL		All with a SIA interface. This will be part of the Interface Requirement document.
k	SE-E038227	ALL		All with SIA interface. This will be part of the Interface Requirement document.
l	SH-E023988	SUB – SUBCONTRACTED UNITS		
m	PP-E038152	SS/L - LORAL INTERNAL BUILD		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
n	E124981	ALL		ALL but this is imbedded in shock requirements
	STANDARDS	ALL		
	PROCEDURES	SS/L - LORAL INTERNAL BUILD		
	OTHER			
	SW-E135840	AP – ACTIVE PAYLOAD, PP - PASSIVE PAYLOAD		
	Industry Standards			
a	EIA RS485	AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		
b	NASA 2361	ALL		
3	**ENVIRONMENTAL REQUIREMENTS**			
3.1	**General Requirements**	ALL		
3.1.1	**Coordinate System.**			
3.1.1 a		ALL	**Figure 3.1-1**	
3.1.1 b		SS/L - LORAL INTERNAL BUILD		
3.1.1 c		SS/L - LORAL INTERNAL BUILD		
3.1.1 d		ALL		
3.2	**Radiation and Micrometeoroids**			
3.2.1	**Radiation**	ALL	Figures 3.2-1 to 3.2-4 Tables 3.2-I to 3.2-VII	Individual item spec. might have tailored requirement such as certain function has shorter lifetime requirement (e.g.used during deployment.only)
3.2.1 a		ALL		INT v. EXT criterion 10 Megarad cutoff criterion

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.2.1 a (1)		ALL INT – INTERNAL TO FARADAY CAGE/MAIN BODY		10 Megarad cutoff criterion
3.2.1 a (2)		ALL EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G. TOWER)		Unless protected by a supplemental enclosure that provides the same level of shielding as the satellite structure.
3.2.1 b		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		Active Parts 100 krad - criterion 15 krad - min Displacement effect - criterion
3.2.1 c		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		Implicit assumption of active designs
3.2.1 c (1)		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		
3.2.1 c (2)		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		Dose rate based on Mil-std. 883, Test method 1019. Low dose rate is .1 to .01 rads/sec. and SS/L defines it at the mid-point (0.05).
3.2.1 d		ALL	**Figure 3.2-2** **Table 3.2-X**	
3.2.1 d (1)		INT – INTERNAL TO FARADAY CAGE/MAIN BODY		INT and EXT criterion NASA requirement
3.2.1 d (2)		EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G. TOWER)		
3.2.1 d (3)		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.2.1 d (4)		ALL		
3.2.2	**Single Event Effects (SEE)**	AB – ACTIVE BUS, AP – ACTIVE PAYLOAD	**Figure 3.2-3 and 3.2-4 Table 3.2-XI**	list specific part categories?
3.2.2 a		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		
3.2.2 b		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		
3.2.2 c		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		
3.2.2 d		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		
3.2.2 e		AB – ACTIVE BUS, AP – ACTIVE PAYLOAD		Power MOSFET
3.2.3	**Micrometeoroids**	ALL EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G. TOWER), critical INT – INTERNAL TO FARADAY CAGE/MAIN BODY		
3.3	**EMC and ESD Requirements**			
3.3.1	**Isolation**			Note, AB and AP are included in AE
3.3.1 (1)		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		SIA/non-SIA condition
3.3.1 (2)		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		SIA/non-SIA condition
3.3.1 (3)		AB – ACTIVE BUS		SIA, NON-RF (AP)
3.3.1 (4)		AP – ACTIVE PAYLOAD		SIA, NON-RF (AP)

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.1 (5)		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.1 (6)		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.1.1	**Chassis Isolation.**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.1.2	**Interface Isolation.**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.2	**Shielding, Bonding and Grounding Requirements**			
3.3.2.a		SS/L - LORAL INTERNAL BUILD		
3.3.2.b		SS/L - LORAL INTERNAL BUILD		
3.3.2.c		SS/L - LORAL INTERNAL BUILD		
3.3.2.d.1		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.2.d.2		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.2.e.1		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.2.e.2		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.2.1	**Structure**			
3.3.2.1 a		SS/L - LORAL INTERNAL BUILD		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.2.1 b		ALL	Table 3.3-I	
3.3.2.1 c		ALL	Table 3.3-I	
3.3.2.1 d		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD) EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G. TOWER)		Vendor unit that interfaces with external unit will have ESD requirement imposed on the interfaces.
3.3.2.1 e		SS/L - LORAL INTERNAL BUILD		Requirement can be flowed down to the vendor from SS/L if the contract calls out the shielding on the vendor part used as part of the Faraday Cage.
3.3.2.1.1	**Continuity Requirements on Panels**	SS/L - LORAL INTERNAL BUILD		Requirement will be flowed down to vendor if needed.
3.3.2.1.2	**Equipment Grounding/Bonding**			
3.3.2.1.2 a		ALL	Table 3.3-I	
3.3.2.1.2 b		ALL		
3.3.2.1.2 c		SS/L - LORAL INTERNAL BUILD	**Figure 3.3-1**	Updated figure is presented in ERS Addendum

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.2.1.2.1	**Cables, Wires, and Harnesses**	ALL		Spacecraft charging
3.3.2.1.2.2	**Coaxial Cables** See Section 3.3.2.1.2.1.	ALL, PP - PASSIVE PAYLOAD	Table 3.3-I	
3.3.2.1.2.3	**Propulsion Equipment**	AB – ACTIVE BUS, PB - PASSIVE BUS		
3.3.2.1.2.4	**RF Passive Equipment Grounding**	PP - PASSIVE PAYLOAD		grounding
3.3.2.2	**Non-Metallic Surfaces**	ALL		
3.3.2.2.1	**Grounding of Feed Aperture Covers**	EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G., TOWER) (feed)		See detailed analysis in a separate requirement source folder.
3.3.2.3	**Grounding of Isolated Parts**	ALL	Table 3.3-I	Mainly SSL. Any vendor attach units to panels would also need this – e.g., deliver a sub-panel.
3.3.2.4	**Grounding Requirements External to the Spacecraft Body**	SS/L - LORAL INTERNAL BUILD		Any vendor attach units to panels would also need this – e.g., deliver a sub-panel.
3.3.3	**Electrostatic Discharge**	ALL		
3.3.3.1	**ESD Test Requirements**	ALL		
3.3.4	**Arcing, Corona, Multipactor, and Passive Intermodulation.**			
3.3.4 a		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.4 b		AP – ACTIVE PAYLOAD		
3.3.4 c		ALL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.4.1	**Passive Intermodulation – PIM**	ALL		This requirement will be flowed down to proper sub-level specifications.
3.3.4.2	**Plasma Induced Damage on Redundant Unit**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		100V criterion (SS/L primary bus is 100v)
3.3.5	**Radiated Interference and Susceptibility**			
3.3.5.1	**Radiated Emissions**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.5.1.1	**RF Equipment - Emissions**	AP – ACTIVE PAYLOAD		Flight heritage indicated 5^{th} harmonic is sufficient in order to reduce test time and cost to 32GHz.. In some RE test, this does not impact the test time much.
3.3.5.1.2	**Non-RF Equipment - Emissions.**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		Some payload components have non-RF circuitry.
3.3.5.2	**Stationary Plasma Thruster Emissions.**	SS/L - LORAL INTERNAL BUILD and PB - PASSIVE BUS (SPT)	2	SS/L Payload engineering needs to design to the expected environment. The SPT design shall not be changed to ensure the specified levels will not be exceeded. (Imbedded requirement - requirement will be flowed down to vendor in unit spec if needed)

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.5.3	**Radiated Field Susceptibility.**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)	**Figure 3.3-3**	
3.3.5.3.1	**RF Equipment (1-32 GHz) - Susceptibility.**	AP – ACTIVE PAYLOAD		
3.3.5.3.1.1	**Shielding Effectiveness**			
3.3.5.3.2	**Non-RF Equipment (<1GHz) – Susceptibility**	AB – ACTIVE BUS		
3.3.6	**Conducted Interference Emissions and Susceptibility.**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.1	**Primary Power**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.1.1	**Non-Damage Voltage Limits**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		Attached to primary bus criterion
3.3.6.1.2	**Conducted Steady State Interference Limits (Primary Power)**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		Attached to primary bus criterion
3.3.6.1.3	**Conducted Voltage Transients (Primary Power)**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.1.4	**Conducted Steady State Current from the Unit's Conducted Emissions Fed Back to Primary Power Bus.**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.6.1.5	**Conducted Current In-Rush Transients (In-Rush Current)**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD) except TWTA/SSPA		Except TWTA/SSPA
3.3.6.1.5.1	**High Power Amplifier (TWTA/SSPA) Conducted Current In-Rush Transients**	TWTA/SSPA		
3.3.6.1.6	**DC-DC Converter Design Requirements**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD) (REF – REFERENCE)		Specific component DC-DC converter requirement listed in a different section
3.3.6.1.7	**Automatic Low Voltage Shutdown**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.1.7.1	**Automatic Low Voltage Shutdown (TWT only)**	TWT		
3.3.6.1.7.2	**Automatic Low Voltage Shutdown (Comm units except TWT)**	AP – ACTIVE PAYLOAD		Non-TWT
3.3.6.1.7.3	**Automatic Low Voltage Shutdown – TC&R Equipment**	AP – ACTIVE PAYLOAD (TC&R)		
3.3.6.1.7.4	**Automatic Low Voltage Shutdown (Bus units)**	AB – ACTIVE BUS		
3.3.6.2	**Secondary Power**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.2.1	**Non-Damage Voltage Limits**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.2.2	**Conducted Steady State Interference Limits (Secondary Power)**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.6.2.3	**Conducted Voltage Transients on Secondary Power Bus**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.2.4	**Conducted Steady State Current Interference Fed Back to Secondary Power Bus**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.3.6.2.5	**Conducted Emissions and Susceptibility for Signals and Commands.**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.3.7	**Magnetic Fields**	ALL		
3.3.8	**Compatibility Tests**	SS/L - LORAL INTERNAL BUILD		Doesn't apply directly to a unit vendor. As a general statement may not need to be in applicability matrix
3.4	**Dynamic (Load) Requirements/Environments**			
3.4.1	**General**	ALL	Table 3.4.1-I	As a general statement may not need to be in applicability matrix
3.4.1.1	**Required Design and Test Levels**	ALL	Table 3.4.1-II	
3.4.2	**Satellite**	ALL (top level, and it will be flowed down at lower level)		Imbedded requirements for ALL
3.4.2.1	**Launch Loads**	ALL	Table 3.4.2-I Table 3.4.2-II Table 3.4.2-III	Imbedded requirements for ALL
3.4.2.2	**Sine Vibration Levels**	ALL	Table 3.4.2-IV	Imbedded requirements for ALL
3.4.2.3	**Acoustic Environment**	SS/L - LORAL INTERNAL BUILD	Table 3.4.2-V Table 3.4.2-VI	Imbedded requirements for ALL
3.4.2.4	**Shock Environment (Launch Vehicle/Satellite).**			
3.4.2.4 a		SS/L - LORAL INTERNAL BUILD		Imbedded requirements for ALL Some equipment will be located near the EEDs – to be described elsewhere.
3.4.2.4 b		ALL		Imbedded requirements for ALL

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.4.2.4 c		ALL		Imbedded requirements for ALL
3.4.2.4 d		ALL		Imbedded requirements for ALL
3.4.2.4 e		ALL		Imbedded requirements for ALL
3.4.2.5	**Frequency Requirements and Design Goals.**	SS/L - LORAL INTERNAL BUILD	Table 3.4.2-IX	Imbedded requirements for ALL
3.4.2.6	**Deployment and Transfer Orbit Loads**	SS/L - LORAL INTERNAL BUILD		Imbedded requirements for ALL
3.4.2.7	**On-Orbit Loads**	SS/L - LORAL INTERNAL BUILD		Imbedded requirements for ALL
3.4.2.8	**Ground Handling and Transportation**	SS/L - LORAL INTERNAL BUILD, ALL		Imbedded requirements for ALL
3.4.3	**Components/Units**	ALL		Imbedded requirements for ALL
3.4.3.1	**Qualification Load Factors**	ALL	Table 3.4.3-I	
3.4.3.2	**Sine and Random Vibration Levels**	ALL	Table 3.4.3-II	Location specific, Separate out specific units to be able to put into matrix
3.4.3.3	**Acoustic Levels**	ALL (applicable only when unit/component spec. states applicability	Table 3.4.2-V Table 3.4.2-VI,	
3.4.3.4	**Shock**			
3.4.3.4 a				
3.4.3.4 a (1)		BUS		
3.4.3.4 a (2)		PAY		
3.4.3.4 a (3)		PAY		
3.4.3.4 a (4)		PAY		
3.4.3.4 b		PAY		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.4.3.4 c		ALL	**Tables 3.4.3-III(b)-(e)**	
3.4.3.4 d		ALL	**Table 3.4.3-III(f)**	
3.4.3.5	**Frequency Design Goals**	ALL	**Table 3.4.3-IV**	
3.5	**Thermal Requirements.**			
3.5.1	**On-Orbit Temperature Variation.**	ALL	**Figure 3.5-1**	Imbedded requirements
3.5.2	**Required Temperature, Heater And Power Margins.**			
3.5.2 a		ALL	**Figure 3.5-2(a)-(b)**	Imbedded requirements
3.5.2 a (1)		INT – INTERNAL TO FARADAY CAGE/MAIN BODY	**Figure 3.5-2(a)**	
3.5.2 a (2)		EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G., TOWER)	**Figure 3.5-2(b)**	
3.5.2 b		ALL		Imbedded requirements
3.5.2.1	**Thermal Testing.**	ALL	**Figure 3.5-3**	Imbedded requirements Imbedded requirements Matrix to have a check mark for “customer required deviations”
3.5.3	**Dissipation/Heat Flux Density.**	ALL	**Tables 3.5-I ERS Addendum**	“in general” 0-1 W/in2, 1-12 W/in2, and >12W/in2 will still need to be reviewed by Thermal. Forces a S/C location requirement. Separate the numberical values in the paragraph.

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.5.4	**Unit Thermal Environment**	ALL		
3.5.4.1	**Thermal Interface**			
3.5.4.1.1	**Cooling**	ALL		
3.5.4.1.2	**Finish**	ALL		
3.5.4.1.3	**Mounting**	ALL		See E399000
3.5.4.1.4	**Temperatures**			
3.5.4.1.4 a		ALL	**Figure 3.5-5**	
3.5.4.1.4 b		AP – ACTIVE PAYLOAD		
3.5.4.1.4 c		AP – ACTIVE PAYLOAD		…if ambient pressure testing is proposed.
3.6	**Static Pressure**			
3.6.1	**Launch Pressure Profile**	SS/L - LORAL INTERNAL BUILD	Section 3.6.2	Indirect requirement – see section 3.6.2.
3.6.2	**Venting**			
3.6.2 a		ALL		
3.6.2 b				
3.6.2 c				
3.6.2 d				
3.6.2 e		PP - PASSIVE PAYLOAD		
3.6.2 f		ALL		
3.6.2 g		ALL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
3.6.3	**Critical Pressure**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
3.6.4	**Out-Gassing**	ALL (REF – REFERENCE)	PAPL	Commercial Program Product Assurance Plan should be defined
3.7	**Storage Environments**	ALL		
4	**UNIT DESIGN AND INTERFACE REQUIREMENTS**	Refer to E399000 Unit Interface Design Requirements and Interface Control Drawing (ICD) Requirements.		
5	**RELIABILITY AND PRODUCT ASSURANCE**			
5.1	**Reliability Requirements**			
5.1 a		SUB – SUBCONTRACTED UNITS		
5.1.b		SS/L - LORAL INTERNAL BUILD		
5.1.1	**Life Requirements**	ALL		
5.1.1 a		AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
5.1.1 b		ALL		TWTs, moving mechanical items, materials or other items which may be subject to wear-out or depletion
5.1.1 c		ALL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
5.1.2	**Storage Requirements**	ALL		
5.1.3	**Failure Safety/Isolation**	ALL		
5.1.3.1	**Single Point Failure**	ALL		
5.1.3.2	**Failure Propagation**	ALL		
5.1.3.3	**Isolation**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
5.2	**Product Assurance**			
5.2.1	**Product Assurance Program**			
5.2.1 a		SUB – SUBCONTRACTED UNITS		
5.2.1 b		SS/L - LORAL INTERNAL BUILD		
6	**TEST CONDITIONS AND TEST REQUIREMENTS**	ALL	Table 6-I	
6.1	**General Test Conditions**	ALL		
6.1.1	**Ambient Conditions**	ALL	Table 6-I	
6.1.2	**Tolerance**	ALL		
6.1.3	**Test Equipment Accuracy**	ALL		
6.1.3.1	**RF Tests**	AP – ACTIVE PAYLOAD		
6.1.4	**Telemetry and Command Functional**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
6.1.5	**Overdrive**			
	All units with microwave semiconductors and an RF input shall be tested for overdrive in their most sensitive active operational mode and with the unit off.	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
6.2	**Unit Test Requirements**			
6.2.1	**General**	ALL	**Figure 6.2-1**	
6.2.2	**Classification of Tests**	ALL		
6.2.3	**Development Tests**	ALL		
6.2.4	**EQM/Qualification Tests**	ALL		
6.2.4.1	**Reference Functional Test**	ALL		
6.2.4.2	**Dynamic Tests**			
6.2.4.2.1	**Sine Vibration**	ALL		
6.2.4.2.2	**Random Vibration**	ALL		
6.2.4.2.3	**Shock Response**	ALL		
6.2.4.2.4	**Post Dynamic Functional Test**	ALL		
6.2.4.3	**Temperature Cycling/Thermal Vacuum Test**	ALL		
6.2.4.4	**Final Functional Test**	ALL		
6.2.4.5	**ESD Test Requirements for Units**	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
6.2.4.6	**ESD Requirements for Evaluation of Currents Induced in Harnesses**	ALL		
6.2.5	**Protoflight Tests**	ALL		
6.2.6	**Acceptance Tests**	ALL		
6.3	**Recording of Data**	ALL		
6.4	**Test Failures**			
6.4 a		NON-SS/L		State documents referenced
6.4 b		SS/L – LORAL INTERNAL BUILD		State documents referenced

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements Paragraph No.	Technical Requirements	Applicability	Reference	Comments
7	**ABBREVIATIONS**	Abbreviations are INFO only		
8.	**T&F - TABLES AND FIGURES**			
8.1	**T&F - Scope**			
8.2	**T&F - Applicable Documents**			
8.3	**T&F - Environmental Requirements**			

Paragraphs 8.3.1 through 8.64 follow with their corresponding art and tables.

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
Figure 3.1-1.	Stowed Configuration Typical SS/L Satellite	ALL		
Table 3.2-I.	Electron Flux Design Requirements	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Table 3.2-II.	Proton Flux (Including Solar Flares) and Alpha Particles for Design of All Spacecraft Items	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Table 3.2-III.	Cosmic Ray Spectrum	SS/L – LORAL INTERNAL BUILD		
Table 3.2-IV.	Seasonal Variations in Solar Energy	SS/L – LORAL INTERNAL BUILD		
Table 3.2-V.	Ultraviolet Radiation	SS/L – LORAL INTERNAL BUILD		
Table 3.2-VI.	Solar Spectral Irradiance	SS/L – LORAL INTERNAL BUILD		
Table 3.2-VII.	Electron Flux Model for Solar Cell Design for Specific Orbital Location and Lifetime	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Table 3.2-VIII.	Solar Flare Proton Model for Solar Cell Design for Specific Orbital Location and Lifetime	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Table 3.2-IX.	Heritage Equipment Dose Versus Thickness Table (18 YEARS AT 160 °W GEO)			
Table 3.2-X.	Dose Versus Thickness for a Worst-Case 22.5-Year GEO or18-Year HIEO Radiation Lifetime (Sphere Model)	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
Table 3.2-XI.	Integral LET Spectra for Geostationary Orbit, M=3	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Table 3.2-XII.	Meteoroid Flux Model by Mass	EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G., TOWER) & CI – CRITICAL UNIT/ITEM FOR SYSTEM		
Table 3.2-XIII.	Meteoroid Velocity Distribution	EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G., TOWER) & CI – CRITICAL UNIT/ITEM FOR SYSTEM		
Table 3.2-XIV.	Meteoroid Penetration Thickness and Crater Diameter	EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G., TOWER) & CI – CRITICAL UNIT/ITEM FOR SYSTEM		
Figure 3.2-1.	Heritage Equipment Dose Versus Thickness Graph (18 years at 160 °W GEO)			
Figure 3.2-2.	Dose Versus Thickness for a Worst-Case 22.5-Year GEO or 18-Year HIEO Radiation Lifetime (Sphere Model)	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Figure 3.2-3.	Integral LET Spectra for Geostationary Orbit, M=3	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Figure 3.2-4.	Integral LET Spectra (Flux) for an Anomalously Large Solar Flare Event Calculation	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
		BUS AND PAYLOAD)		
Figure 3.2-5.	Steps Required for Radiation Analysis	ALL		
Table 3.3-I.	Grounding Resistance Requirements	ALL		
Table 3.3-II.	Additional Radiated Emissions Restrictions for Antenna Receive Bands	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Figure 3.3-1.	DELETED -Overview of Spacecraft Electrical Grounding			See Section 3.3.2
Figure 3.3-2.	Radiated Emissions (Narrowband)	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Figure 3.3-3.	Radiated Field Susceptibility Limits	AE – ALL ELECTRICAL UNIT/COMPONENT (INCLUDES ACTIVE BUS AND PAYLOAD)		
Table 3.4.1-I.	Applicable Load and Frequency Requirements	ALL		
Table 3.4.1-II.	Design and Test Factors of Safety	ALL		
Table 3.4.2-I.	Launch Vehicle Quasi-Static Limit Load Factors seen by Satellite	SS/L – LORAL INTERNAL BUILD		
Table 3.4.2-II.	Additional Satellite Limit Load Factors	SS/L – LORAL INTERNAL BUILD		
Table 3.4.2-III.	Tower/Upper Module Qualification Design Load Factors	SS/L – LORAL INTERNAL BUILD		
Table 3.4.2-IV.	Satellite Sine Vibration Test Levels	SS/L – LORAL INTERNAL BUILD		
Table 3.4.2-V.	Launch Vehicle Acoustic Test Levels	SS/L – LORAL INTERNAL BUILD		
Table 3.4.2-VI.	Satellite Acoustic Test Levels - Envelope	ALL		
Table 3.4.2-VII(a).	Shock Spectra at Separation Plane, Clampband Average	SS/L – LORAL INTERNAL BUILD		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
Table 3.4.2-VII(b).	Shock Spectra at Separation Plane, Sea Launch Vehicle Fairing and Stage Separation	SS/L – LORAL INTERNAL BUILD		
Table 3.4.2-VII(c).	Shock Spectra at Separation Plane, Ariane Launch Vehicle Fairing and Stage Separation	SS/L – LORAL INTERNAL BUILD		
Table 3.4.2-VIII.	Satellite Induced Shock Levels	--		REPLACED BY 3.4.3-III(C)&(D)
Table 3.4.2-IX.	Satellite Minimum Frequency Requirements	ALL		
Table 3.4.3-I.	Unit Qualification Design Load Factors	ALL		
Table 3.4.3-II(a).	Vibration Test Levels, Equipment Panel Mounted Units	ALL		
Table 3.4.3-II(b).	Vibration Test Levels, Reflectors and Subreflectors	ALL		
Table 3.4.3-II(c).	Vibration Test Levels, Feeds	ALL		
Table 3.4.3-II(d).	Vibration Test Levels, Solar Array	ALL		
Table 3.4.3-II(e).	Vibration Test Levels, TC&R Antenna	ALL		
Table 3.4.3-II(f).	Vibration Test Levels, Earth Sensor	ALL		
Table 3.4.3-II(g).	Vibration Test Levels, Sensors	ALL		
Table 3.4.3-II(h).	Vibration Test Levels, Ring Laser Gyro (RLG)	ALL		
Table 3.4.3-II(i).	Vibration Test Levels, SIRU	ALL		
Table 3.4.3-II(j).	Vibration Test Levels, Propellant Tank	ALL		
Table 3.4.3-II(k).	Vibration Test Levels, Pressurant Tank	ALL		
Table 3.4.3-II(l).	Vibration Test Levels, 22N (5 lbf) Bi-Propellant Thruster	ALL		
Table 3.4.3-II(m).	Vibration Test Levels, 490N (110 lbf) Main Satellite Thruster	ALL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
Table 3.4.3-II(n).	Vibration Test Levels, Battery	ALL		
Table 3.4.3-II(o).	Vibration Test Levels, Reaction Wheel	ALL		
Table 3.4.3-II(p).	Vibration Test Levels, SADA	ALL		
Table 3.4.3-II(q).	Vibration Test Levels, Propulsion Equipment Mounted on the ACS Deck (SSM Deck for LS1300S)	ALL		
Table 3.4.3-II(r).	Vibration Test Levels, OMUX Panel Subassembly	ALL		
Table 3.4.3-II(s).	Vibration Test Levels, Stationary Plasma Thruster (SPT)	ALL		
Table 3.4.3-II(t).	Vibration Test Levels, Deployment and Positioning Mechanism (DAPM)	ALL		
Table 3.4.3-II(u).	Vibration Test Levels, APM	ALL		
Table 3.4.3-II(v).	Vibration Test Levels, Stationary Plasma Thruster (SPT) DAPM Module	ALL		
Table 3.4.3-II(w).	Vibration Test Levels, Unfurlable Reflectors	ALL		
Table 3.4.3-II(x).	Vibration Test Levels, Feed Array	ALL		
Table 3.4.3-II (notes)	Notes, Vibration Test Levels	ALL		
Table 3.4.3-III(a).	Generic Shock Levels	ALL		
Table 3.4.3-III(b).	Launch Vehicle Induced Shock Levels	SS/L – LORAL INTERNAL BUILD		
Table 3.4.3-III(c).	Satellite Induced Shock Levels	ALL		
Table 3.4.3-III(d).	Shock Requirements for Specific Units	ALL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
Table 3.4.3-III(e).	Shock Requirements for Category A and B Units	ALL		
Table 3.4.3-III(f).	Generic Bus Equipment Shock Level Capability	ALL		
Table 3.4.3-III (notes)	Notes, Shock Levels and Requirements	ALL		
Table 3.4.3-IV.	Component Minimum Frequency Design Goals	ALL		
Figure 3.4.2-1	Shock Spectra at Separation Plane	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-1.	Typical Satellite Configuration to Be Used as a Guide for Shock Level Locations	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-2(a).	Distance R for a Unit Mounted on the Same Panel.	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-2(b).	Distance R for a Unit Mounted on Adjacent Panel.	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-2(c).	Distance R for a Unit Mounted under an Earth Deck Holddown.	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-2(d).	Distance R for an I-strut or A-frame Reflector Holddown.	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-2(e).	Distance R from a Unit Mounted Under a Propulsion Pyrovalve.	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-2(f)	Line of Sight from Shear Web	SS/L – LORAL INTERNAL BUILD		
Figure 3.4.3-2(g)	Line of Sight from ACS Deck and Solar Array Holddown	SS/L – LORAL INTERNAL BUILD		
Table 3.5-I(a1).	Generic Electrical Power Subsystem Component Temperature Requirements	ALL		
Table 3.5-I(a2)	Generic Super Power subsystem Component Temperature Requirements	ALL		
Table 3.5-I(b).	Generic Solar Array Component Temperature Requirements	ALL		
Table 3.5-I(c).	Telemetry, Command, and Ranging (TC&R) Subsystem Component	ALL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
	Temperature Requirements			
Table 3.5-I(d).	Communications Subsystem Component Temperature Requirements	ALL		
Table 3.5-I(e).	Generic Miscellaneous Components Component Temperature Requirements	ALL		
Table 3.5-I(f).	Generic Attitude Determination and Control Component Temperature Requirements	ALL		
Table 3.5-I(g1).	Generic Data Handling Subsystems and Spacecraft Control Electronics Component Temperature Requirements	ALL		
Table 3.5-I(g2)	Generic RF Autotrack Subsystem Component Temperature Requirements	ALL		
Table 3.5-I(h1).	Generic Propulsion Subsystems Component Temperature Requirements	ALL		
Table 3.5-I(h2)	Generic Electrical Propulsion Subsystem Component Temperature Requirements	ALL		
Table 3.5-I(i).	Communications Antennas Component Temperature Requirements	ALL		
Table 3.5-I(j).	Generic Mechanisms Component Temperature Requirements	ALL		
Table 3.5-I (notes)	Notes for Component Temperature Requirements	ALL		
Figure 3.5-1.	Typical Predicted Panel Temperature Over Life	SS/L – LORAL INTERNAL BUILD		
Figure 3.5-2(a).	Temperature Margins for Internal Mainbody and Thermally Coupled External Equipment	ALL		
Figure 3.5-2(b).	Temperature Margins for External Thermally Isolated Equipment	EXT – EXTERNAL TO FARADAY CAGE/MAIN BODY (E.G. TOWER)		
Figure 3.5-3.	Spacecraft Thermal Vacuum Profile			
Figure 3.5-5.	Temperature Sensor Locations	ALL		
Figure 3.5-6.	Thermal Interface Temperature Process Flowchart	ALL		
Figure 3.6-1(a).	Variation of Static Pressure Within Fairing - Ariane 4 and 5	SS/L – LORAL INTERNAL BUILD		
Figure 3.6-1(b).	Variation of Static Pressure Within Fairing - Delta IV Medium-Plus	SS/L – LORAL		

Environmental Requirements Specification (ERS) Applicability Table (Continued)

Requirements TABLE/FIGURE	Technical Requirements	Applicability	Source	Comments
	(4,2)	INTERNAL BUILD		
Figure 3.6-1(c).	Variation of Static Pressure Within Fairing – Atlas V Medium Payload Fairing	SS/L – LORAL INTERNAL BUILD		
Figure 3.6-1(d).	Variation of Static Pressure Within Fairing – Atlas V Large and Extended-Length Large Payload Fairing	SS/L – LORAL INTERNAL BUILD		
Figure 3.6-1(e).	Variation of Static Pressure Within Fairing – Proton	SS/L – LORAL INTERNAL BUILD		
Figure 3.6-1(f).	Variation of Static Pressure Within Fairing – H2A 4s Fairing	SS/L – LORAL INTERNAL BUILD		
Figure 3.6-1(g).	Variation of Static Pressure Within Fairing – Long March	SS/L – LORAL INTERNAL BUILD		
Figure 3.6-1(h).	Variation of Static Pressure Within Fairing – Sea Launch	SS/L – LORAL INTERNAL BUILD		
Figure 3.6-1(i).	Variation of Static Pressure Within Fairing – Land Launch	SS/L – LORAL INTERNAL BUILD		
Table 6-I.	Test Environmental Requirements Summary	ALL		
Table 6.1-I.	Test Tolerances	ALL		
Figure 6.2-1.	Typical Unit Test Sequence	ALL		
Figure 6.2-2.	Unit Thermal/Thermal Vacuum Profile	ALL		