EVOLVED EXPENDABLE LAUNCH VEHICLE (EELV)

DEVELOPMENT AND INITIAL LAUNCH SERVICES

REQUEST FOR PROPOSAL

ANNEX 15

EELV STANDARD INTERFACE SPECIFICATION
VERSION 5.0

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This document was produced and is maintained by the Evolved Expendable Launch Vehicle Program Office in conjunction with the Aerospace Corporation. The material in this document was developed largely from information supplied from the two EELV contractors: Lockheed Martin Astronautics and The Boeing Company; with input from the payload programs at the United States Air Force's Space and Missile Systems Center. Please direct any comments or questions to the POCs below:

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1. INTRODUCTION

1.1 Purpose

This document defines the Standard Interface (SI) between the payloads and the Evolved Expendable Launch Vehicle (EELV) system. The SI is being developed to standardize equipment, processes and services among systems and vehicles to standardize payload integration.

This document was developed by the EELV System Program Office (SPO), in collaboration with two competing EELV contractors, with government representatives, and representatives of the payload community in the Standard Interface Working Group (SIWG). It will be more fully developed after the award of the Development agreements.

1.2 Scope

The Standard Interface Specification (SIS) covers those items provided as a standard service to all payloads and is intended to provide guidance for the design of new payloads. Additional payload requirements will be accommodated using mission-unique hardware, processes, or services. This information is also provided as information for potential users of EELV.

Where possible, a common interface characteristic has been defined. However, differences in the Medium Launch Vehicle (MLV) and Heavy Launch Vehicle (HLV) versions of the EELV system necessitate different interface specifications at times, particularly in the area of payload size and environments. In these cases, the interface specification is shown separately for each class of launch vehicle (LV).

1.3 Design Approach

The information provided in this document was developed with two over-arching goals in mind:

1. Reducing the cost of launching space vehicles (SVs) into space.
2. Providing users with a capability as good or better than current launch vehicles.

Therefore, the EELV SIWG philosophy is to provide an equivalent (or better) performance and SV accommodation capability to the SV users while at the same time ensuring that the SV payload environments and launch environments are equivalent to (or less severe) than the LVs currently used to launch military SVs. This “no worse than” policy includes the Delta and Atlas LVs for MLV spacecraft and the Titan IV LV for HLV spacecraft. The accommodations provided by other current launch vehicles were also considered and taken into account wherever possible. The needs of commercial SV busses were also considered, in recognition that military payloads may use commercial busses in the future and that commercial viability is important to the overall cost reduction goal.

The requirements are presented in this document in a singular, independent fashion. It is not the intent of the SIS to impose the maximum limit of all requirements simultaneously when this is not a reasonable representation for a satellite vehicle, payload, or mission. The actual requirements that apply to a particular mission will be documented in the negotiated LV/SV ICD.

The SIWG believes that the capability goals have been accomplished to the greatest extent possible, consistent with the cost reduction goals and the SIWG welcomes user comments to the SIS in order to ensure these goals are achieved.

1.4 Exclusions

The following aspects of the LV to SC interface are excluded from this SIS:

- Payload destruct systems (when required by range safety) are provided by the payload
- Payload adapters, which are also provided by the payload (see Section 0)

1.5 Definitions

Launch Vehicle (LV) - The LV segment consists of the means for transporting the payload from the launch site to the delivery orbit, through completion of the contamination and collision avoidance maneuver (CCAM) and stage disposal. It includes, but is not limited to, production, assembly, propulsion, guidance and control, electrical power, tracking and telemetry, communication, ordnance, flight termination, payload separation initiation, structural elements, payload fairing, software, and appropriate vehicle/ground and vehicle/payload interfaces that are necessary to meet mission requirements. The payload and its unique Airborne Support Equipment (ASE), though transported by the EELV, are not considered as part of the EELV system.

Heavy Launch Vehicle (HLV) - Refers to the version of the EELV that will be used for heavy capability similar to the existing Titan IV launch vehicle.

Medium Launch Vehicle (MLV) - Refers to the version of the EELV that will be used for medium lift capability similar to the existing Atlas, Delta II or Titan II launch vehicles. For some SIS requirements a MLV-S designation is used to indicate conditions experienced by lighter payloads that should be considered during space vehicle design. Unless noted, MLV and MLV-S interface requirements are identical.

Space Vehicle (SV) - The satellite payload (including payload adapter and separation system) provided by the government (or commercial users).

Mission Unique - Items or capabilities that are not part of the Standard Interface but could be provided for a particular mission, usually at an additional cost.

Mission Specific - Items or capabilities that are dependent on the specific mission being flown. Unlike “mission unique” parameters, mission specific items are not considered to be a capability beyond the standard SIS capability.

Concept Specific - Refers to technical parameters that are dependent on the EELV launch vehicle contractor’s specific design. No attempt has been made to define these parameters in the SIS.

Standard Interface Plane (SIP) - The SIP is the plane which defines the interface between the LV-provided and the SV-provided equipment.

Standard Electrical Interface Panel (SEIP) - The structure on which the interfacing LV and SV connectors are supported.

Electromagnetic Interference Safety Margin Event (EMISM) Catagories - EMISM safety margins are categorized in accordance with the worst case potential criticality of the effects of interference induced anomalies. The following categories shall be used:

Category I - Serious injury or loss of life, damage to property, or major loss or delay of mission capability

Category II - Degradation of mission capability, including any loss of autonomous operational capability

Category III - Loss of functions not essential to mission

Grade B Gaseous Nitrogen - Gaseous nitrogen with purity, by volume, of 99.99% minimum. Percent nitrogen includes trace quantities of neon, helium, and small amounts of argon (as defined by MIL-STD-27401P). Maximum total impurities, by volume, are as follows:

Total	100 ppm
Water	11.5 ppm
Total hydrocarbons as methane	5.0 ppm
Oxygen	50 ppm

Grade C Gaseous Nitrogen - Gaseous nitrogen with purity, by volume, of 99.995% minimum. Percent nitrogen includes trace quantities of neon, helium, and small amounts of argon. Maximum total impurities, by volume, are as follows:

Total	50 ppm
Water	5.7 ppm
Total hydrocarbons as methane	5.0 ppm
Oxygen	20 ppm
Hydrogen	0.5 ppm

Class 5000 (air) - Particle concentration no more than $5000(0.5/d)^{2.2}$ particles/ft^3 where d = particle size in micrometers.

Class 100,000 (air) - Particle concentration no more than $100,000(0.5/d)^{2.2}$ particles/ft^3 where d = particle size in micrometers.

1.6 Acronym List

A	Amperes
AGE	Aerospace Ground Equipment
ASTM	American Society For Testing and Materials
AC	Alternating Current
A/C	Air Conditioning
BTU	British Thermal Unit
CCAM	Contamination, Collision Avoidance Maneuver
CDR	Critical Design Review
CG	Center of Gravity
CVCM	Collected Volatile Condensable Material
dB	Decibel
DC	Direct Current
dia.	Diameter
DOP	Dioctyl Phthalate
EED	Electro-Explosive Device
EELV	Evolved Expendable Launch Vehicle
EGSE	Electrical Ground Support Equipment
ELV	Expendable Launch Vehicle
EM	Electromagnetic
EMISM	Electromagnetic Interference Safety Margin
ESD	Electrostatic Discharge
F	Fahrenheit
ft.	Foot
fps	Feet Per Second
GEO	Geosynchronous Earth Orbit
GHe	Gaseous Helium
GHz	Gigahertz
GN_2	Gaseous Nitrogen
GPS	Global Positioning System
GTO	Geosynchronous Transfer Orbit
HEPA	High Efficiency Particulate Air filter
HLV	Heavy Launch Vehicle
hr	Hour
Hz	Hertz (frequency)
ICD	Interface Control Document
I/O	Input/Output
KBPS	Kilobits Per Second
kHz	Kilohertz
kV	Kilovolts
LAN	Longitude of Ascending Node
LEO	Low Earth Orbit
lbs	Pounds
LCU	Liquid Cooling Unit
LSIC	Launch System Integration Contractor
LV	Launch Vehicle

LVC	Launch Vehicle Contractor
MLV	Medium Launch Vehicle
MLV-S	Medium Launch Vehicle (with smaller payload)
m	Meter
mA	Milli-amperes
mg	Milligram
MHz	Megahertz
msec	Millisecond
NASA	National Aeronautics and Space Administration
NEC	National Electrical Code
NMM	AFSPC National Mission Model
NRZL	None Return to Zero Phase L
NSI	NASA Standard Initiator
PDR	Preliminary Design Review
PLA	Payload Adapter
PLF	Payload Fairing
PMP	Parts, Materials and Processes
PSI	Pounds per Square Inch
PSU	Propellant Servicing Unit
RAAN	Right Ascension of Ascending Node
RCS	Reaction Control System
RF	Radio Frequency
RMS	Root Mean Square
SCAPE	Self Contained Atmospheric Protective Ensemble
SCFH	Standard Cubic Feet per Hour
SCFM	Standard Cubic Feet per Minute
SGLS	Space Ground Link Subsystem
SEIP	Standard Electrical Interface Panel
SI	Standard Interface
SIP	Standard Interface Plane
SIS	Standard Interface Specification
SIWG	Standard Interface Working Group
SPRD	System Performance Requirements Document.
SPI	Standard Payload Interface
SPO	System Program Office
SRD	System Requirements Document
SV	Space Vehicle (e.g., payload)
TBD	To Be Determined (By Government)
TBR	To Be Reviewed (jointly by Government and Contractors)
TBS	To Be Supplied (by Contractors)
TML	Total Mass Loss
µSec	Microsecond
V	Volts
VDC	Volts Direct Current
W	Watts

1.7 Reference Documents

1. EWR 127-1, Eastern and Western Range, Range Safety Requirements, 31 Mar 1995.
2. MIL-P-27401C, Propellant Pressurizing Agent, Nitrogen, 20 Jan. 1975.
3. EELV System Performance Requirements Document (SPRD), 18 June 1998.

2. MISSION REQUIREMENTS

2.1 Orbit Requirements

2.1.1 Throw Weight

Requirements are as stated in the System Performance Requirements Document.

2.1.2 Orbit Insertion and Accuracy

Requirements are as stated in the System Performance Requirements Document.

2.1.3 Launch Window

The EELV shall have sufficient capability to deliver the required payload mass (including payload growth, performance margin, and flight performance reserve) to the correct orbit plane when launched any time within a mission dependent window, extending from some time before until a time after the maximum performance launch time as negotiated in the LV/SV ICD.

2.1.4 Attitude Rates and Accuracies

During park orbit or transfer orbit coasts, the EELV shall be capable of providing passive thermal control by orienting the roll axis of the upper stage/payload to passive thermal control attitude and holding attitude to within ± 5 degrees (3 sigma). Also during park orbit or transfer orbit coasts, the EELV shall be capable of providing a commanded roll rate in either direction of between 0.5 and 1.5 degrees per second (MLV configurations) and between 0.5 and 1.0 degrees (HLV configuration) as negotiated by the SV/LV ICD.

Prior to separation, the EELV shall be capable of pointing the upper stage/payload to any desired attitude and either minimizing all rotation rates (3-axis stabilized missions) or providing a spin about the longitudinal axis (spin-stabilized missions). For 3-axis stabilized missions, attitude errors shall be no greater than 1.4 degrees (3 sigma) about each axis and rotation rates shall be less than 0.2 degree/sec (3 sigma) in pitch and yaw and 0.25 degree/sec (3 sigma) in roll. For spin-stabilized missions, the MLV EELV shall have the capability to provide payload spin rates of 5 ± 0.5 (3 sigma) rpm with spin axis orientation accurate to within 1.75 degrees (3 sigma) assuming a maximum 0.5" SV CG offset. For GPS missions, the EELV shall have the capability to provide payload spin rates of 55 + 11/ - 5 (3 sigma) rpm, with spin axis orientation accurate to within 3 degrees (3 sigma) assuming a maximum 0.05" Payload CG (to include adapter) offset.

2.1.5 Separation Requirements

2.1.5.1 Separation Mechanism

The separation mechanism for the SI is to be provided by the SV.

2.1.5.2 Separation Velocity

The SV Separation System shall impart a minimum of 1 ft/sec relative separation velocity between the SV and the LV/PLA at separation.

2.1.5.3 Separation Inhibits

The LV shall be capable of enabling/inhibiting the LV Reaction Control System (RCS) during spacecraft separation operations. As required by specific mission(s), the RCS shall be inhibited up to 1 second before and up to 5 seconds after spacecraft separation.

2.1.5.4 Separation Contingencies

The Launch Vehicle shall have the flexibility to incorporate mission unique nominal and contingency flight sequences. Mission unique flight sequences shall be negotiated and documented in the mission specific LV/SV ICD.

2.1.5.5 Contamination and Collision Avoidance Maneuvers

Contamination, collision avoidance maneuvers (CCAMs) shall be designed to preclude re-contact with the payload and to minimize payload exposure to LV contaminants. Requirements for contamination levels are specified in Section 3.5.

3. PHYSICAL INTERFACES

3.1 Mechanical Interfaces

3.1.1 Interface Definitions

A Cartesian coordinate system shown in Figure 1 will be used for the payload interface reference, placing the origin in the center of the standard interface plane. It is a right-handed coordinate system: the positive “X” is along the centerline of the vehicle and points up to the top of the vehicle. Additionally, the axial axis is defined to be the “X” axis and lateral axes are defined to be the “Y” and “Z” axes. Some items discussed in subsequent sections of this document are shown in Figure 2. This figure shows the relation of the SIP to the SV and SV adapter.

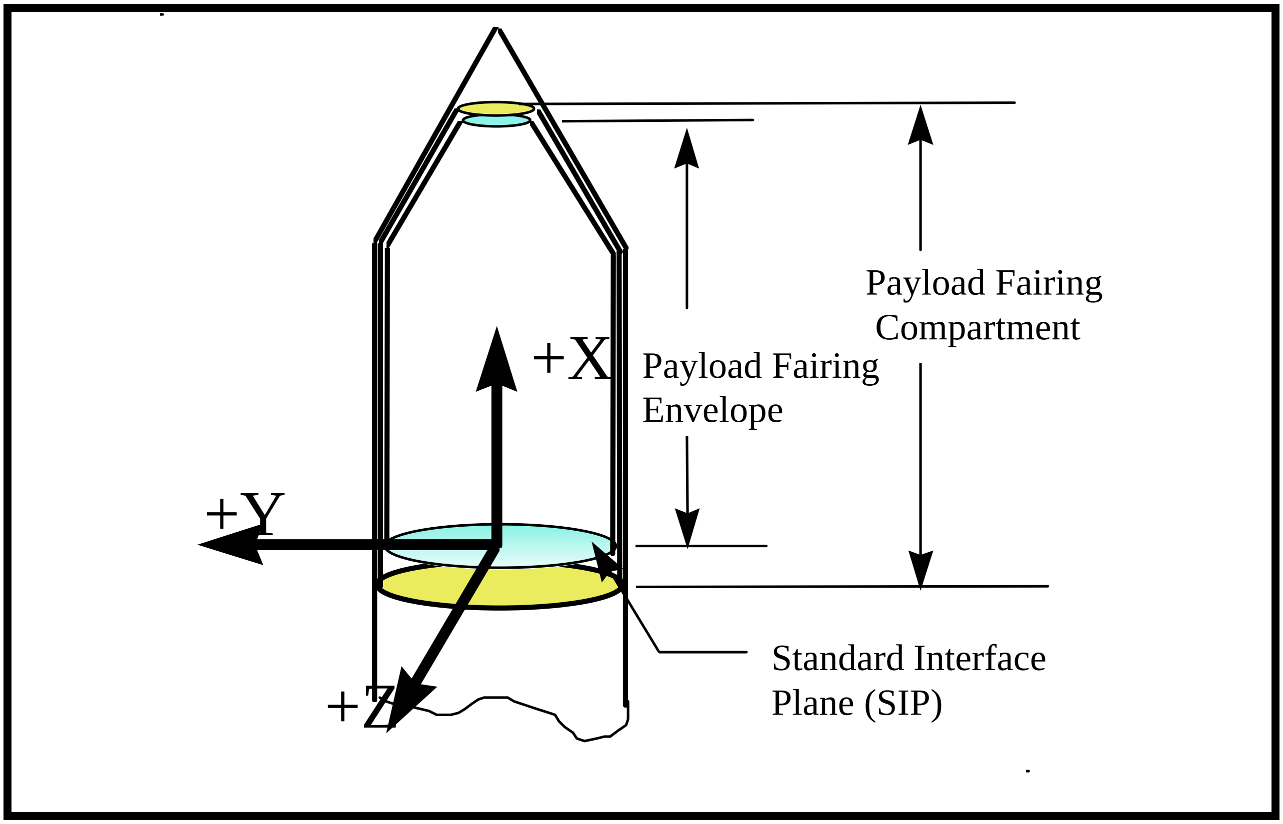

Figure 1 - EELV Standard Interface Coordinate System

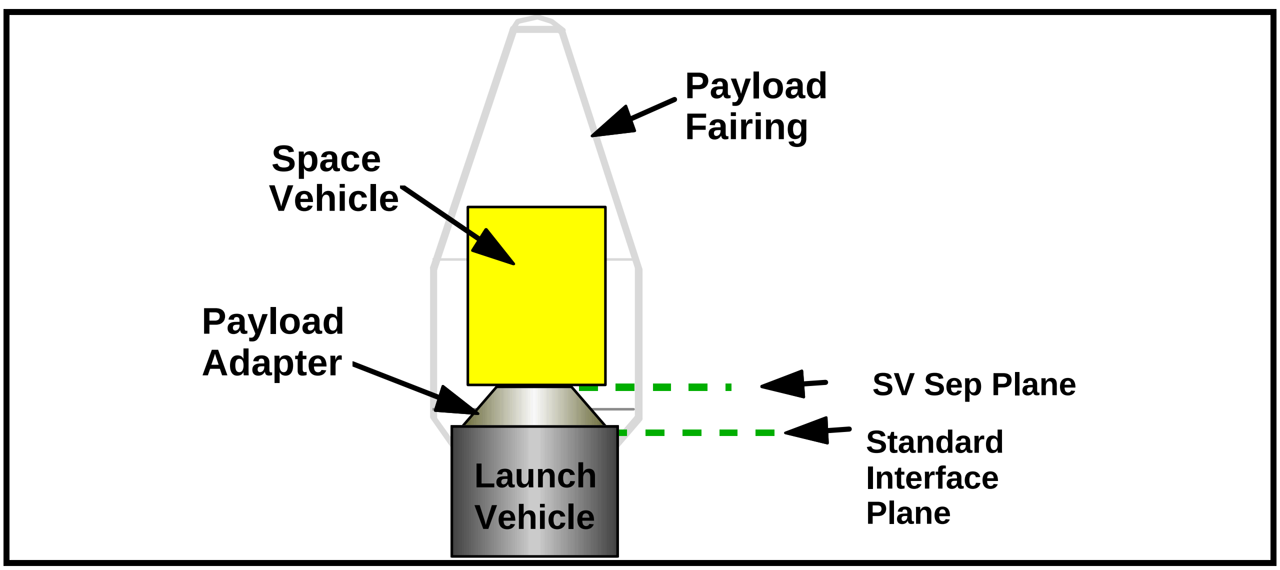

Figure 2 - Standard Interface Plane - Relationship to SV

3.1.2 Mating Surface

3.1.2.1 Bolt Pattern

The LV supplies one of two standard mechanical interfaces (one for the MLV configuration and one for the HLV configuration). This interface joins the LV to the spacecraft or the payload adapter, as provided by the payload user. For the MLV, the bolt pattern has a 62.010” diameter as shown in Figure 3.

The HLV interface has a 173” diameter bolt pattern as shown in Figure 4. This bolt pattern is intended for use with the HLV GEO mission class and is not required to be used with HLV LEO mission class. The interface for the HLV LEO mission class is **TBD**.

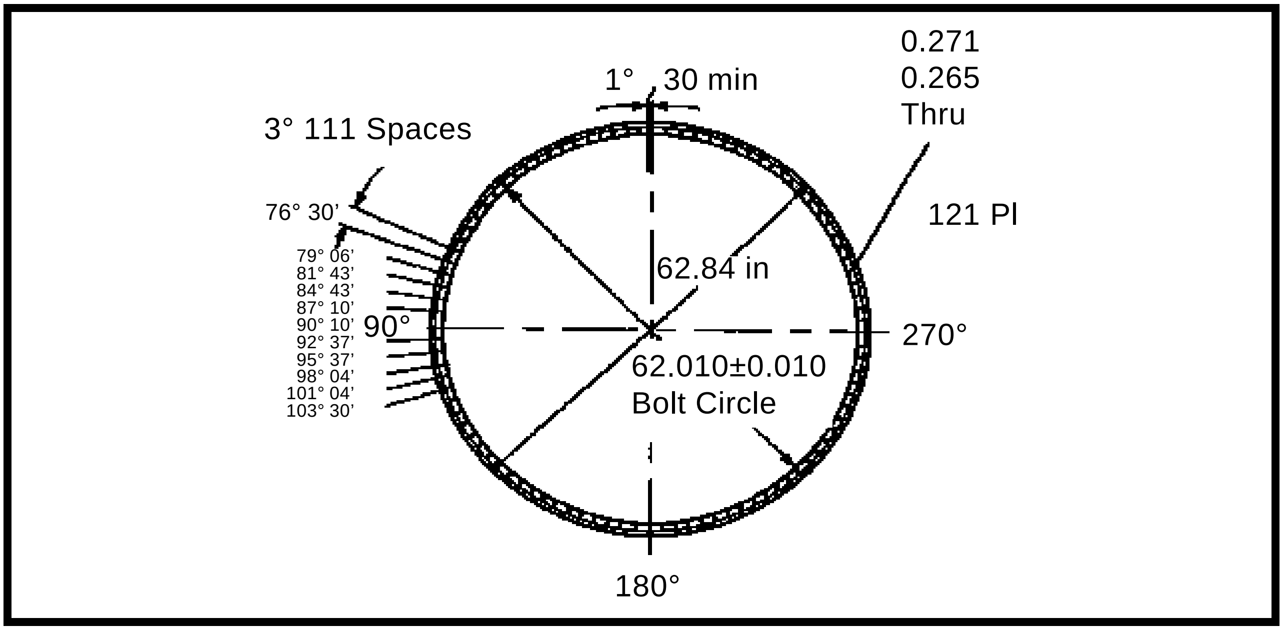

Figure 3 - Small diameter (62.010") payload interface

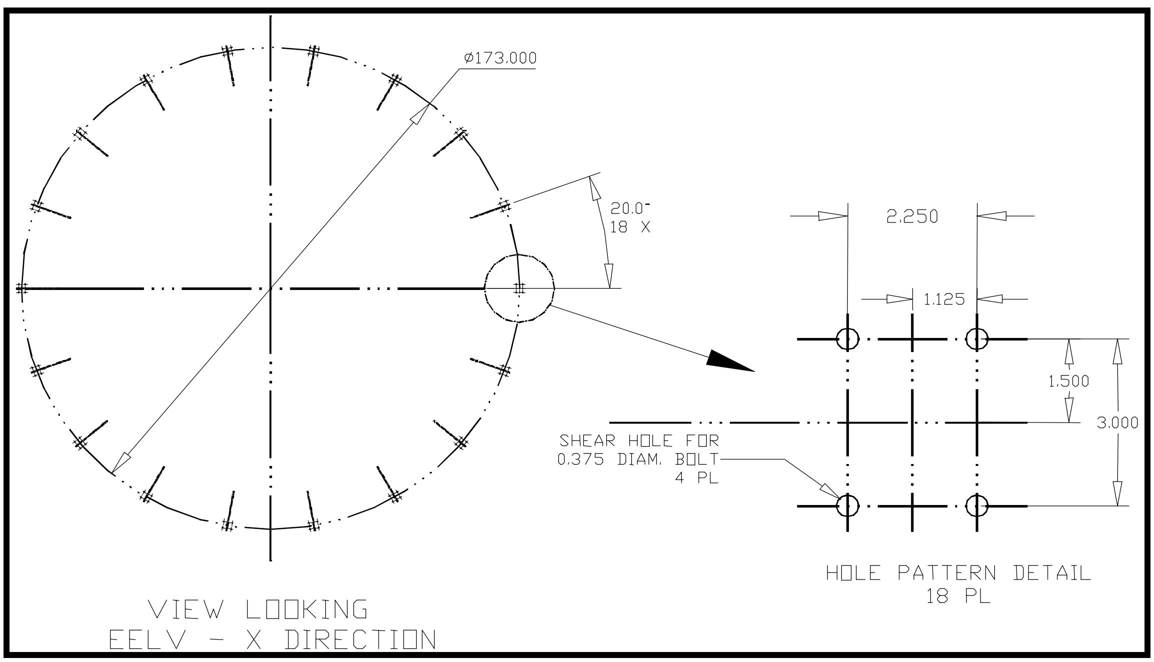

Figure 4 - Large diameter (173") payload interface

3.1.2.2 Flatness

The flatness of EELV mating surfaces at the SIP are defined by a theoretical zone in which any point on the interface must fall within the parallel plane extremities as shown in Figure 5. For MLV, these surfaces shall be flat to within 0.015 inch (15 Mils). For HLV, these surfaces shall be flat to within 0.030 inch (30 Mils).

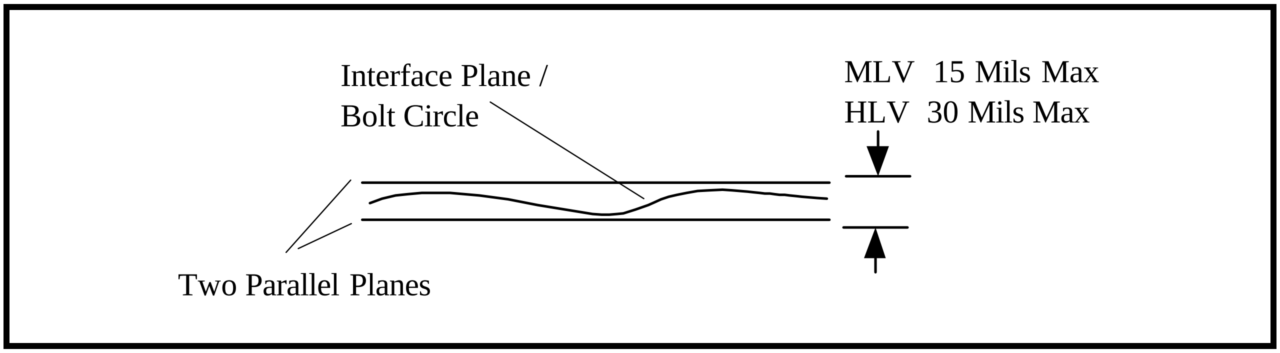

Figure 5 - EELV Flatness Specification

3.1.2.3 Master Gauge

The LV shall provide a master gauge to the SV contractor for interface hole pattern drilling.

3.1.3 Spacecraft Dynamic Envelopes

There are three standard **minimum** sizes for spacecraft dynamic envelopes which are derived from the payload fairing size (actual fairing envelopes may be larger). These envelopes define the useable volume inside the fairing and forward of the SIP as shown in Figure 1. However, there will be some stay-out zones in the fairing envelope which will be negotiated as part of the SV to LV Interface Control Document. Payload fairing envelopes must accommodate existing payloads.

For HLV the payload fairing dynamic envelope is similar in size to that for the Titan IV envelope, as shown in Figure 6. Two sizes of standard fairing envelopes have been defined for MLV, as shown in Figures 7 and 8. The nominal fairing envelope size is as shown in Figure **7**. Where the SV does not require the nominal size, a smaller fairing envelope (similar to Delta II) shown in Figure 8 may be substituted at the option of the LV contractor.

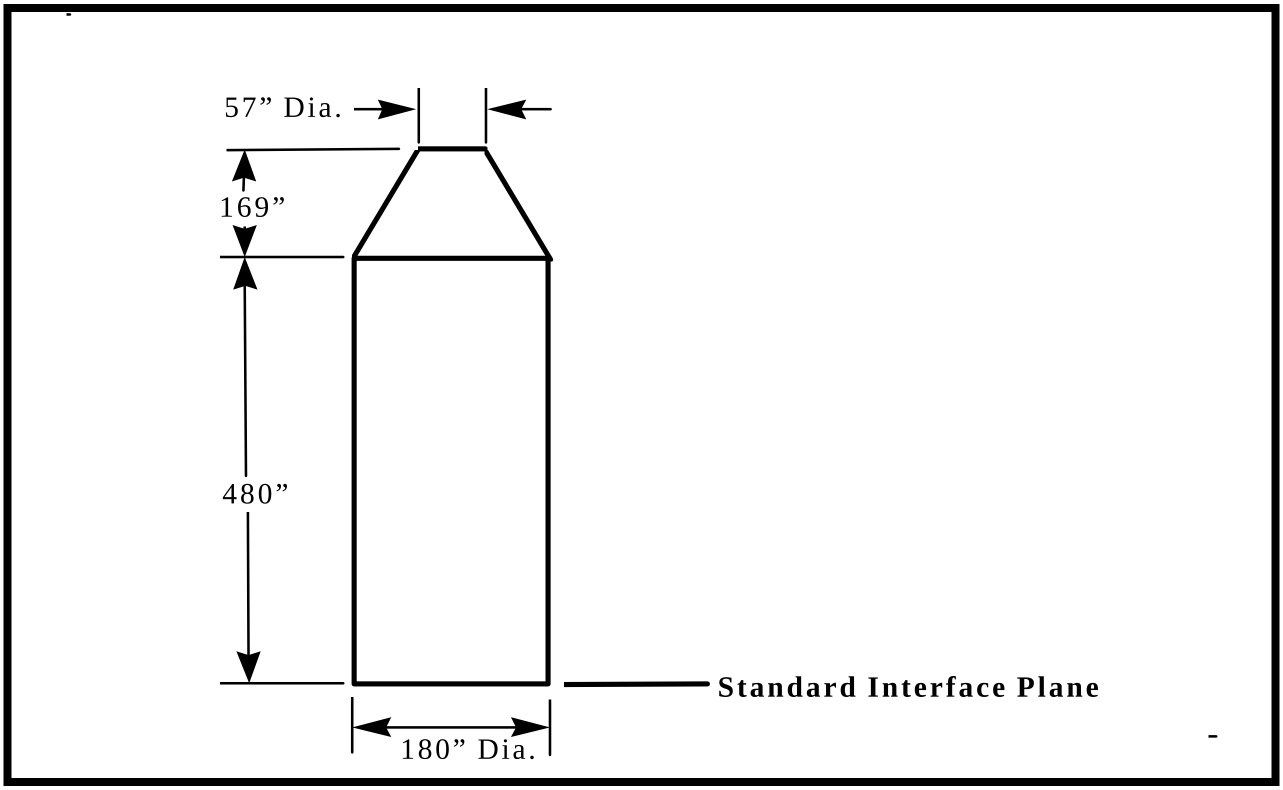

Figure 6 - EELV HLV Spacecraft Dynamic Envelope

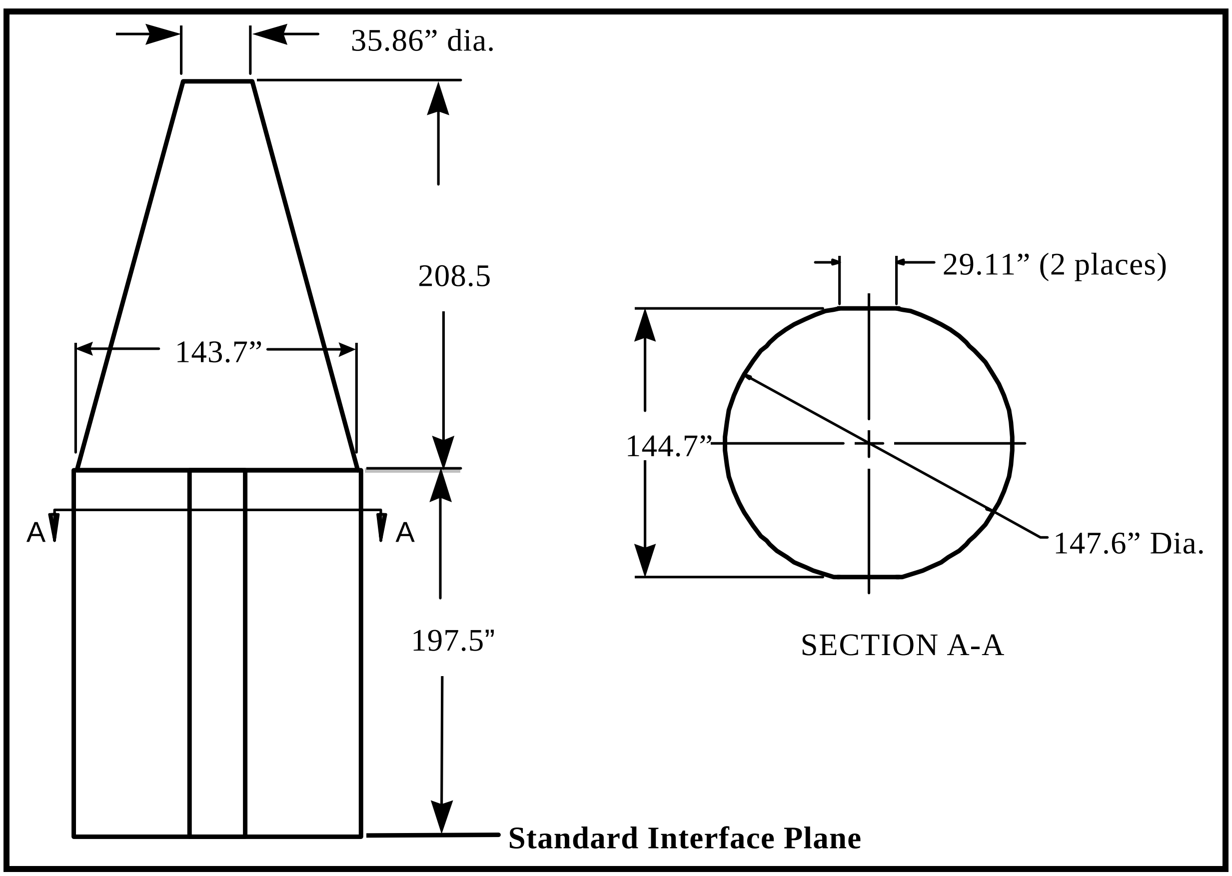

Figure 7 - MLV Spacecraft Dynamic Envelope

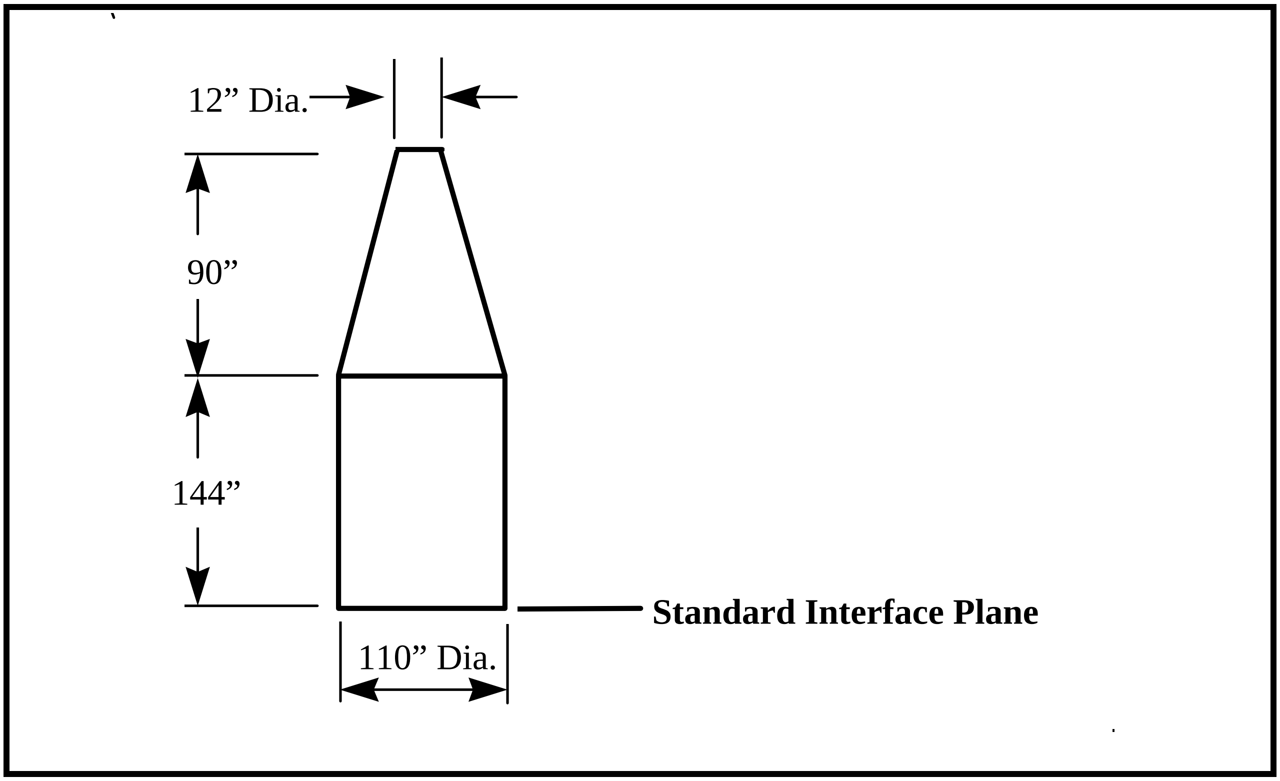

Figure 8 - Smaller (Optional) MLV Spacecraft Dynamic Envelope

3.1.4 PLF Access Doors

3.1.4.1 Routine Access

The LV shall provide two standard doors in the payload fairing for personnel access to the spacecraft. The doors may in general be placed anywhere on the fairing cylindrical section subject to “stay-out zone” restrictions arising from structural, harness routing, and facility access considerations.

Other doors (in addition to the two standard doors) for additional routine access to the spacecraft may be provided on a mission-unique basis.

3.1.4.2 Emergency Access

The EELV shall provide a capability for emergency access to the payload by installing emergency access doors (subject to “stay-out zone” restrictions) or by defining areas of the fairing where emergency access doors can be cut; in either case the doors shall be of a size that allows a person wearing a SCAPE suit to reach in with both hands. These areas are near the bottom of the PLF barrel and are 48 ± 12 inches above the SIP.

3.1.5 Payload Adapters

Payload adapters will interface with the LV at the SIP. All payload adapters are payload provided equipment; adapters to accommodate existing payloads interfaces for use on EELV are the responsibility of those payloads.

3.1.6 Payload Mass Properties

3.1.6.1 Center of Gravity Location

The location of the SV Center of Gravity (CG) in the SI "X" axis, as measured from the SIP, shall be restricted to the acceptable region (to the left or below the lines) shown in Figure 9. The CG in the lateral directions (SI "Y" and "Z" axes directions) shall be limited to less than 5 inches offset from the vehicle centerline for missions in which the LV/SV stack is 3-axis stabilized at separation, within 0.5 inches for low spin rate ($\leq$ 5.5 rpm) missions, and less than 0.05 inches for higher spinning rate missions.

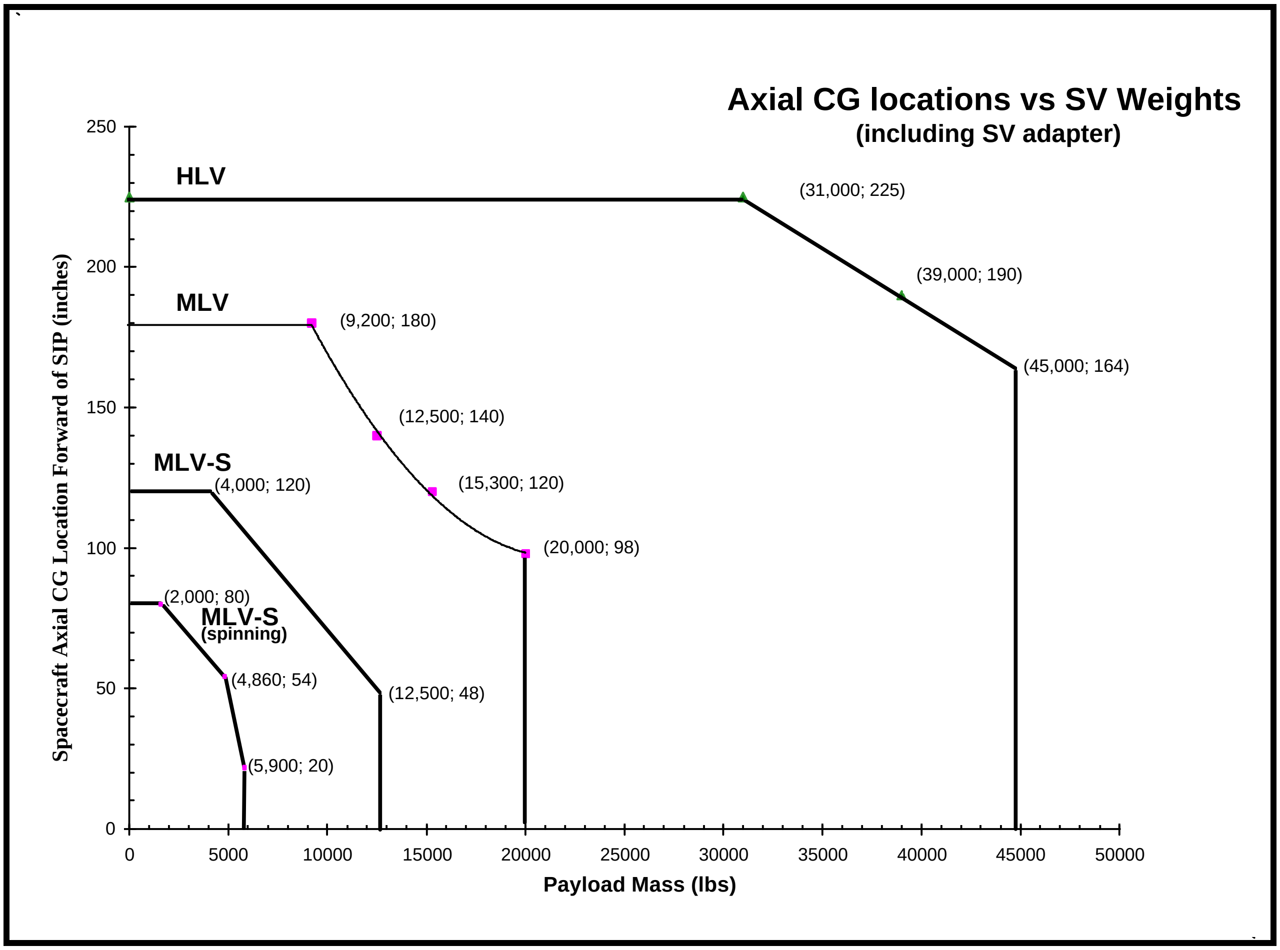

Figure 9 - Allowable CG Location

3.1.6.2 SV Mass Properties

The LV system shall accommodate SVs with the mass properties indicated in Table 1. The mass properties are not intended as absolute limits to SVs, but only as design requirements for the LV system. SVs with exceedances of some of the features specified in these tables may be accommodated as well, as negotiated in the SV/LV ICD. Note that the SV includes the payload, payload adapter, and its separation system. The coordinate axes are as specified in Figure 1.

EELV Mission Class	SV Spin Rate at Separa-tion (rpm)	SV Mass (lbs)	SV cg Location (inches forward of SIP)	Max SV Lateral cg Offset (in.)	SV Moments of Inertia (slug-ft sq)	SV Products of Inertia (slug-ft sq)	Notes
MLV-S	None Required	2000 - 8000	40 - 110	5	I_{xx} = 300 - 4500 I_{yy}= 285 - 8000 I_{zz}= 285 - 8000	I_{xy}= -400 to +400 I_{xz}= -400 to +400 I_{yz}= -400 to +400	1
MLV-S	5	2000 - 4500	40 - 110	0.50	I_{xx}= 300 - 3000 I_{yy}= 285 - 2000 I_{zz}= 285 - 2000	I_{xy}= -50 to +50 I_{xz}= -50 to +50 I_{yz}= -250 to +250	1, 2, 3
MLV-S	55	4700 - 4860	40 - 54	0.05	I_{xx}= 620 - 640 I_{yy}= 535 - 600 I_{zz}= 535 - 600	I_{xy}= -0.5 to +0.5 I_{xz}= -0.5 to +0.5 I_{yz}= -5.0 to +5.0	1, 2, 3
MLV	None Required	2000 - 16,900	40 - 180	5	I_{xx}= 500 - 8000 I_{yy}= 750 - 12,800 I_{zz}= 750 - 12,800	I_{xy}= -670 to +670 I_{xz}= -670 to +670 I_{yz}= -670 to +670	1
MLV	5	5800 - 10,500	40 - 160	0.50	I_{xx}= 1900 - 4000 I_{yy}= 1300 - 5000 I_{zz}= 1300 - 5000	I_{xy}= -50 to +50 I_{xz}= -50 to +50 I_{yz}= -250 to +250	1, 2, 3, 4
HLV LEO	None Required	27,000 - 42,000	150 - 215	5	I_{xx}= 11,000 - 29,500 I_{yy}= 50,000 - 130,000 I_{zz}= 50,000 - 130,000	I_{xy}= -7000 to +7000 I_{xz}= -7000 to +7000 I_{yz}= -7000 to +7000	1
HLV GEO	None Required	5400 - 13,500	85 - 225	5	I_{xx} = 3,000 - 19,500 I_{yy} = 5,000 - 60,000 I_{zz} = 5,000 - 60,000	I_{xy} = -7000 to +7000 I_{xz} = -7000 to +7000 I_{yz} = -7000 to +7000	1

Notes:

1. Values in the table represent the range of capability and the full range for all columns may not be available simultaneously (e.g. mass and cg location combinations are subject to the restrictions shown in Figure 9).
2. These are satellites requiring spin at separation.
3. Pre-PL separation spin up maneuver acceptable; indicated rate not required throughout flight.
4. SV cg location forward of SIP restricted to 100 inches or less for 5800 lbm SV. Linear interpolation from that point to 160 inches forward of SIP for 10,500 lbm SV.

Table 1 - SV Mass Properties

3.1.7 Payload Stiffness

To avoid dynamic coupling between low frequency launch vehicle and space vehicle modes, new SVs should be designed such that the stiffness of the SV structure should produce fundamental frequencies greater than the values shown in Table 2 when cantilevered from the LV interface. Space vehicles with fundamental frequencies less than these values may be accommodated on a mission-unique basis.

EELV Vehicle Class	Fundamental Frequency (Hz) (including adapter)	Axis
MLV-S	12 30	Lateral Axial
MLV	8 15	Lateral Axial
HLV	2.5 15	Lateral Axial

Table 2 - SV Stiffness Requirements

3.2 Electrical/Avionics Interfaces

The EELV system shall provide umbilical electrical interconnection beginning at T-0 umbilical installation. All SV-provided signals and power will be handled as unclassified data.

3.2.1 Electrical Connections at SV/LV Interface

The EELV system shall provide interface airborne electrical interconnection services from the time of payload mate (electrical) to the time of SV separation on orbit. The electrical interface between the SV and the LV will be at the standard electrical interface panel (SEIP) as shown in Figure 10. The SEIP is provided by the LV and is located near the standard interface plane. Wiring harnesses from the SV to the SEIP shall be provided by the SV. The SEIP shall be accessible after SV/LV mate for connection of SV wiring harnesses.

3.2.2 Electrical Connections at EGSE Room

The SVB electrical ground support equipment (EGSE) interface connection will be at the EGSE room interface panel as shown in Figure 10. Space shall be provided in the EGSE room such that the maximum distance between the SV EGSE and the EGSE room interface panel is less than 15 feet.

The EELV shall provide the mating connector halves to the payload to mate to the standard interface panel. This ensures the connectors, pins and sockets are all procured by the same vendor to the same specification minimizing any potential for a mismate.

3.2.3 LV/SV Electrical Connector Separation

At the time SV/LV electrical connectors are to be separated, the current on any line shall be no greater than 10 milliamps. This applies to SV/LV interfaces in the T-0 umbilical and in SV separation connectors.

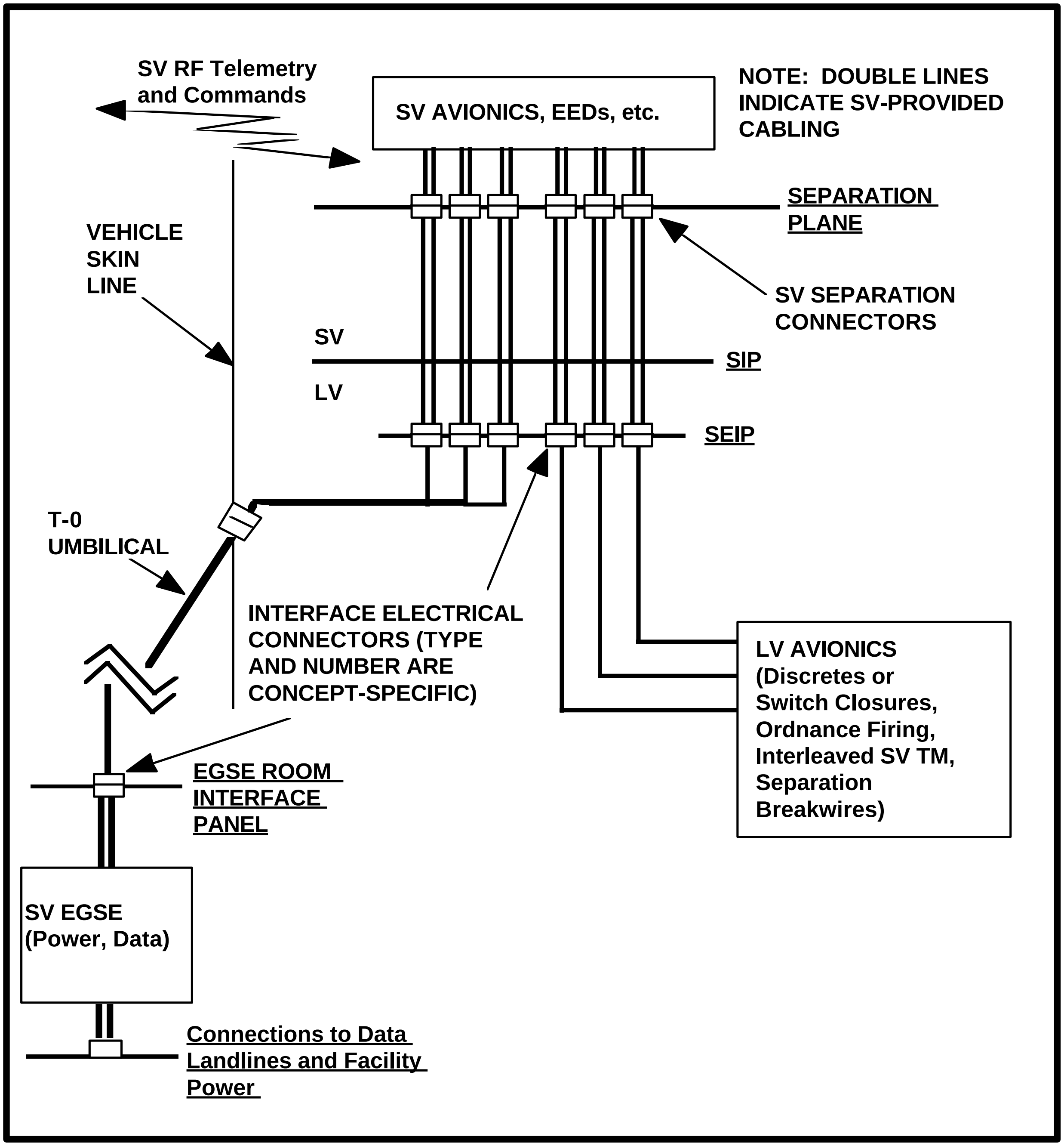

Figure 10 - Interface Wiring Harness Connections

3.2.4 Ground Interfaces

The LV and the EELV ground facility shall provide dedicated "feed-through" cabling from the SEIP, through a LV umbilical, to an EELV-provided EGSE room SV Interface Panel (SVIP) for both power to, and sensor signals from, the SV. Cabling connectivity shall be available from the time the associated LV umbilical is connected until it is disconnected at liftoff.

Each wire of this dedicated cabling shall be isolated from the LV structure by a minimum of one megaohm, measured before any connection to the SV or SV ground equipment.

3.2.4.1 Ground Power

The LV and the EELV ground facility shall provide twelve (12) twisted-pairs for SV power that may include external power, full-power battery charging power, trickle battery charging power, or other power as required by the SV.

When used by the SV, each twisted-pair constitutes part of a complete circuit, with a power source in the EGSE room and a load in the SV, and shall meet the following requirements at the SVIP interface:

Source Voltage:	126 VDC maximum
Current:	11 Amps maximum

The maximum round-trip resistance attributed to this cabling between the SEIP and SVIP for any one pair shall be 1.0 ohms, or less, when shorted at the opposite end.

The power return lines at the SV EGSE power source shall be isolated from earth ground by 1 $\pm$ 0.1 megaohm by the SV contractor, and shall be referenced to a single point ground at the SV structure.

SV power dissipation will be typically be less than 1200 watts (average/steady state) with peak power and duration constrained by the LV cooling capabilities as described in Section 3.3.2.1. Peak power of 2200 watts for one hour, for example, is within the envelope of Section 3.3.2.1.

3.2.4.2 Power Leads and Returns

All primary and secondary power leads shall be routed with an accompanying return lead. Power conductors shall be twisted pairs, unless it is necessary to use heavy gauge which does not lend itself to twisting. In this case the high and return conductors shall be routed along a parallel path, and shall be laced or spot tied together to obtain maximum field cancellation. Connector types will be negotiated as a part of the SV/LV ICD process.

3.2.4.3 Power Isolation

The dedicated feed-through cabling shall be isolated from the LV structure by a minimum of 1 megaohm.

3.2.4.4 Ascent Power

The LV will not provide power to the payload following LV ignition and during boost phase of the flight as a part of the SI. Prior to launch, power is provided by means of facility power provided to the SV ground support equipment which is routed to the SV as described in Sections 3.2.4.1 and 3.2.4.2. This power is available to the SV until the "launch commit" point in the countdown, which occurs shortly before launch. The exact timing of the launch commit point is concept-specific.

3.2.4.5 Ground Support Equipment Power

The EELV shall provide three-phase uninterruptible power to payload ground equipment with the following characteristics:

Voltage:	120/208 volts ± 5%
Frequency:	60 Hz ± 1 Hz
Total Harmonic Distortion (THD) :	shall not exceed 5%
Voltage transients:	shall not exceed 200% nominal rms voltage for more than 20 micro-seconds
Maximum Load:	20 KVA

3.2.4.6 Ground Monitoring

The LV and the EELV ground facility shall provide 60 shielded twisted-pairs for the differential monitoring of power and sensor loads in the SV by the SV ground equipment in the EGSE room. These pairs may be used to monitor SV bus voltage, battery voltage sense, battery temperature, battery pressure or other payload health measurements as required by the SV. These twisted pairs may also be used to provide commands or additional power from the SV ground equipment to the SV.

When used by the SV, each twisted-pair constitutes part of a complete circuit between the SV and SV ground equipment and shall meet the following requirements at both the SEIP and SVIP interfaces:

Source Voltage:	126 VDC maximum
Source Current:	3.0 Amps maximum

The maximum round-trip resistance attributed to this cabling between the SEIP and SVIP for any one pair shall be 5.0 ohms, or less, when shorted at the opposite end.

Some of the ground monitoring lines may be assigned to carry SV power if the SV Contractor so chooses. In this case the power return lines at the SV EGSE power source shall be isolated from earth ground by 1 ± 0.1 megaohm by the SV contractor, and shall be referenced to a single-point ground at the SV structure. All other circuits shall continue to be isolated from earth ground by at least one megaohm.

3.2.5 Flight Command and Telemetry Interfaces

3.2.5.1 Signal Reference

All signals shall have a dedicated signal return line which is referenced at the source.

3.2.5.2 LV to SV Commands

The LV shall provide 8 redundant pairs of SV contractor-definable control commands which can be configured as 28 volt discretes or switch closure functions. The SV contractor will select either all discrete commands or all switch closures.

The LV telemetry shall indicate the state of each command.

The LV shall provide the capability to issue the commands in any sequence with a maximum of ten events per command. An event is defined as the change of state (on or off) of one of the commands.

The capability shall be provided to reference the initiation of commands to Upper Stage guidance events, mission times, and/or selected mission scheduled events.

3.2.5.2.1 Discrete Commands

The LV provided discrete commands shall have the following characteristics at the SEIP:

Voltage:	"On" state +23 VDC minimum to +33 VDC maximum
Current:	500mA maximum per discrete
Pulse Width:	10 sec maximum
	20 msec minimum

The discrete command circuits in the SV shall be isolated from SV structure by a minimum of 1 megaohm.

3.2.5.2.2 Switch Closure Functions

The LV provided switch closure functions shall accommodate the following electrical characteristics at the SEIP:

Voltage:	+22 VDC minimum to +32 VDC maximum
Current:	1 Ampere maximum
Pulse Width:	10 sec maximum
	20 msec minimum
Leakage Current	1 mA

The switch closure circuits in the LV shall be isolated from LV structure by a minimum of 1 megaohm.

3.2.5.3 SV/LV Telemetry Interface

The LV shall provide the capability to accept two channels of serial data from the SV at the SEIP for interleaving into the LV's telemetry stream to the ground. Prior to launch, this LV telemetry will be available for ground operations and space vehicle testing purposes, as specified by the LV/SV ICD.

Each channel shall consist of both a data circuit, using non-return to zero-phase L (NRZL), and a clock circuit. When utilized by the SV, each circuit shall consist of a differential RS-422 line driver pair from the SV and a corresponding differential receiver in the LV. Data shall be sampled by the LV on the false-to-true (logic low to high) transition of the clock.

The LV shall be capable of receiving at least two Kbps of data per channel. The data rate from the SV shall not exceed two Kbps per channel. However, the combined data rate of both channels shall not exceed two Kbps at any one time. Data format and content requirements imposed on the SV will be defined by the SV/LV ICD.

3.2.5.4 SV Radio Frequency Links

EELV shall facilitate the transmission of Space Vehicle RF telemetry, both during ground operations and from liftoff through SV separation. EELV does not provide encryption for SV telemetry or data whether broadcast (RF) or hardline. All telemetry will be handled as unclassified data (both on the ground and in flight). EELV shall facilitate RF uplink commands to the spacecraft during ground operations through liftoff.

3.2.5.5 State Vector Data

There is no provision for furnishing state vector or attitude data directly across the SIP to the SV at spacecraft separation. SVs needing state vector or attitude data will be handled on a mission unique basis.

When required by the SV, the best estimate of state vector and attitude data at the time of separation detection will be provided to the spacecraft operators in as close to real time as possible (with a maximum of 20 minutes) after receipt of data at the LV contractor's facility.

3.2.6 Electromagnetic Compatibility

The requirements for electromagnetic compatibility are outlined in the following sections. These requirements may be tailored for each specific payload. Individual SV circuit susceptibilities will be addressed as part of the negotiated SV/LV ICD process.

3.2.6.1 Radiated Emissions

Unintentional radiated narrowband magnetic field levels produced by subsystems, and components are mission-unique and will be negotiated as part of the SV/LV ICD process.

3.2.6.1.1 SV Radiation Narrowband

The SV intentional and unintentional radiated emissions shall not exceed the maximum allowable emissions curve of Figure 11. Information on the SV emitters and receivers (power, frequency, E-field levels, and sensitivity of receivers) shall be supplied to the EELV contractor. The limit applies at the SIP, and shall account for the increased field level caused by radiating inside the fairing cavity. Payload emitter radiation inside an enclosed fairing will create standing waves and exceed the field levels calculated assuming free-space conditions. Payload fairing RF energy focusing shall be considered when determining the maximum field levels at the SIP.

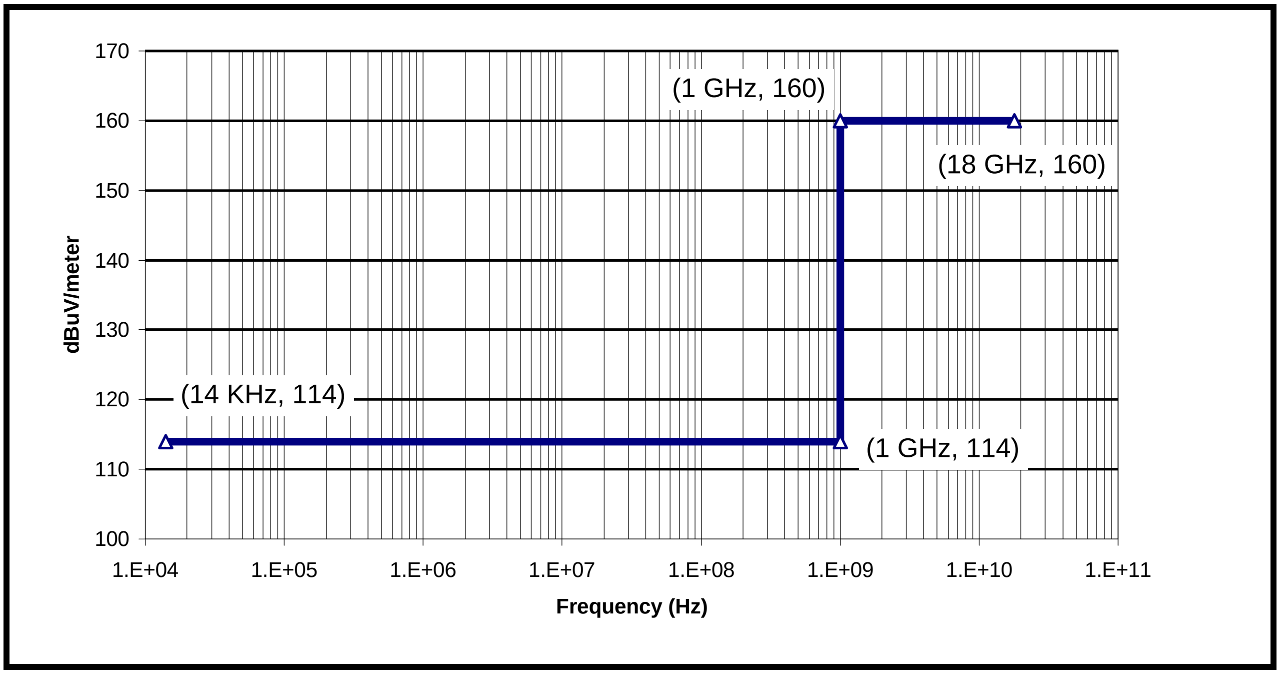

Figure 11 - Maximum Allowable Narrowband SV Radiated E-Fields

3.2.6.1.2 SV Radiation Broadband

The SV unintentional broadband radiated emissions shall not exceed the maximum allowable emissions curve of Figure 12.

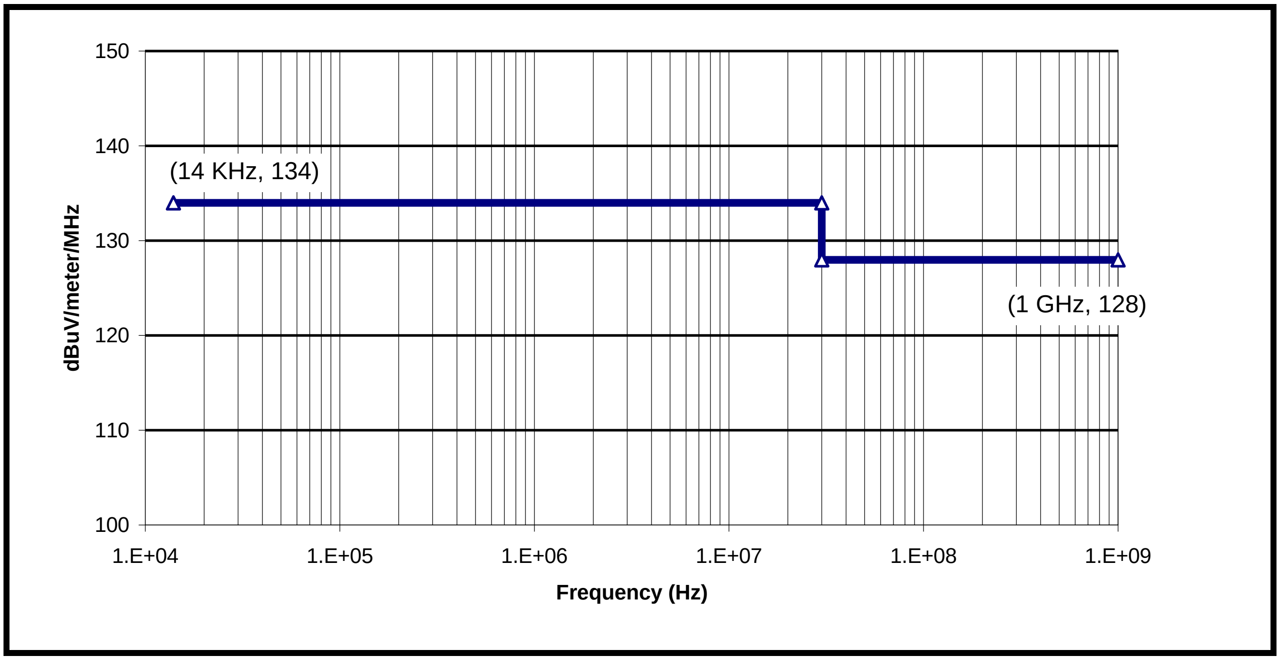

Figure 12 - Maximum Allowable Broadband SV Radiated E-Fields

3.2.6.1.3 LV Radiation Narrowband

The LV narrowband intentional and unintentional radiated emissions at the SIP shall not exceed the maximum allowable emissions curve of Figure 13. Information on the EELV emitters and receivers (power, frequency, E-field levels, and sensitivity of receivers) shall be supplied to the payload contractor. The levels shown in the figure will be notched at frequencies which are dependent the selected EELV configuration.

3.2.6.1.4 LV Radiation Broadband

The LV unintentional broadband radiated emissions shall not exceed the maximum allowable emissions curve of Figure 14 at the standard interface plane.

3.2.6.1.5 Broadband Radiated Emissions Due to Electrostatic Discharge

The LV and SV materials shall be chosen such that the maximum broadband radiated emissions caused by an electrostatic discharge shall not exceed the levels defined in Figure 15 at the standard interface plane.

3.2.6.1.6 PLF Electrostatic Discharge

Electrostatic charge on the PLF shall not be discharged directly to any portion of the SV surface when the SV to PLF distance is equal to or greater than the SV/PLF minimum hardware to hardware clearance as defined in the mission specific ICD.

3.2.6.1.7 PLF Broadband E-Field Limits

Maximum electric fields as derived 1 cm from the PLF internal surface shall not exceed the broadband E-field levels stated in Figure 16.

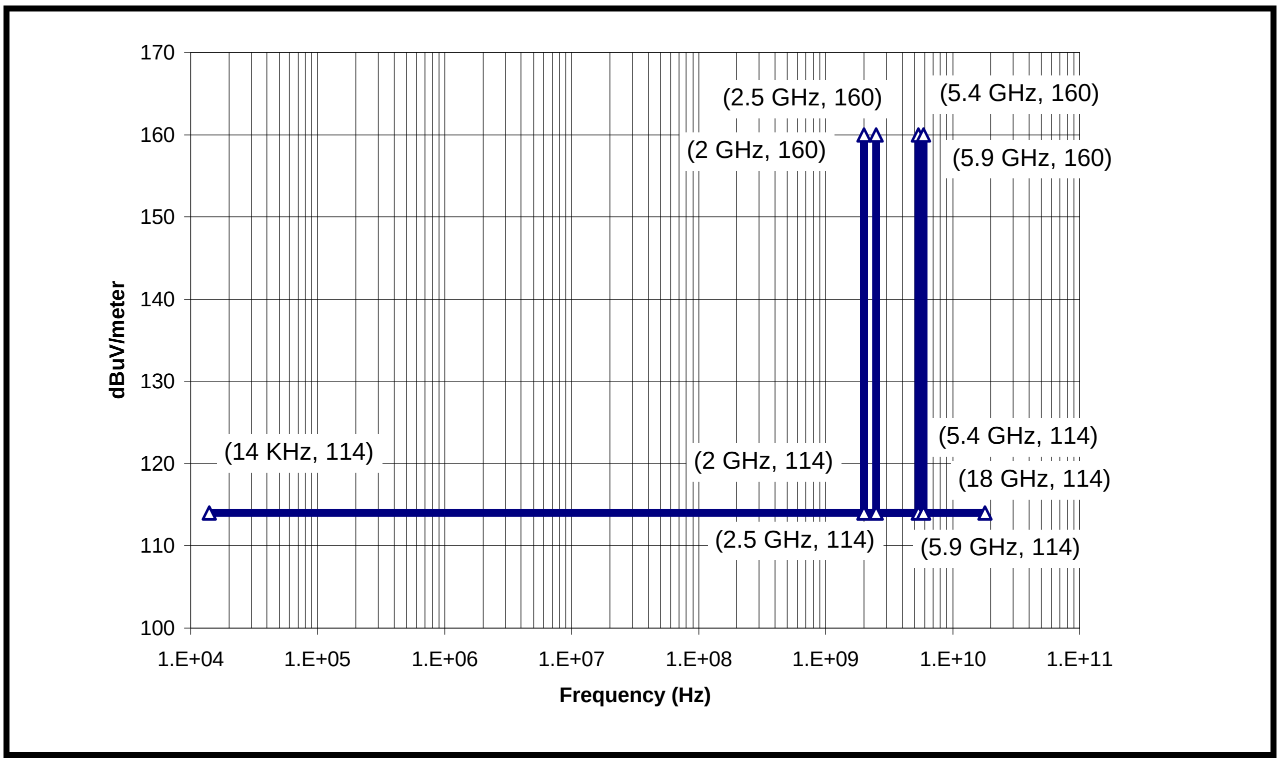

Figure 13 - Maximum Allowable Narrowband LV Radiated E-Fields.

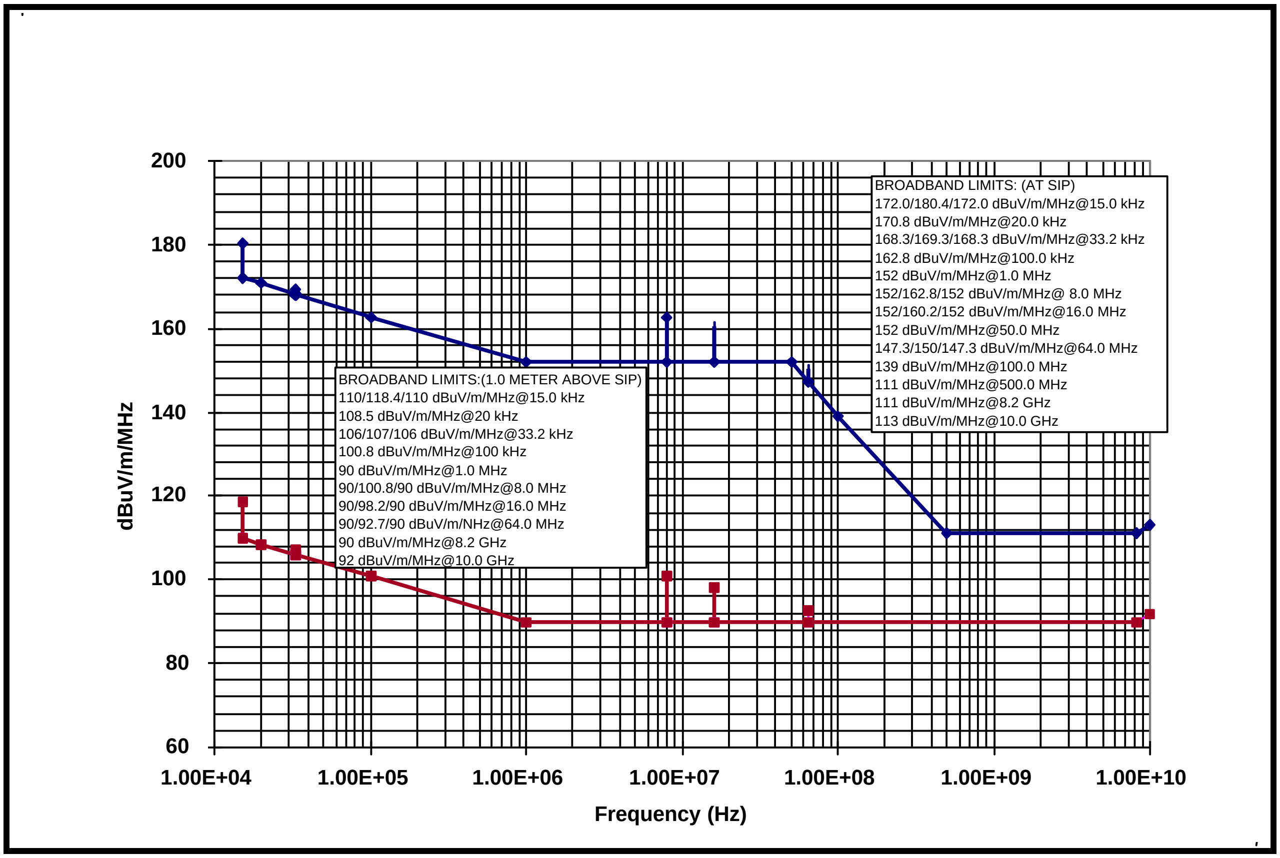

Figure 14 - Maximum LV Radiated Broadband Emissions

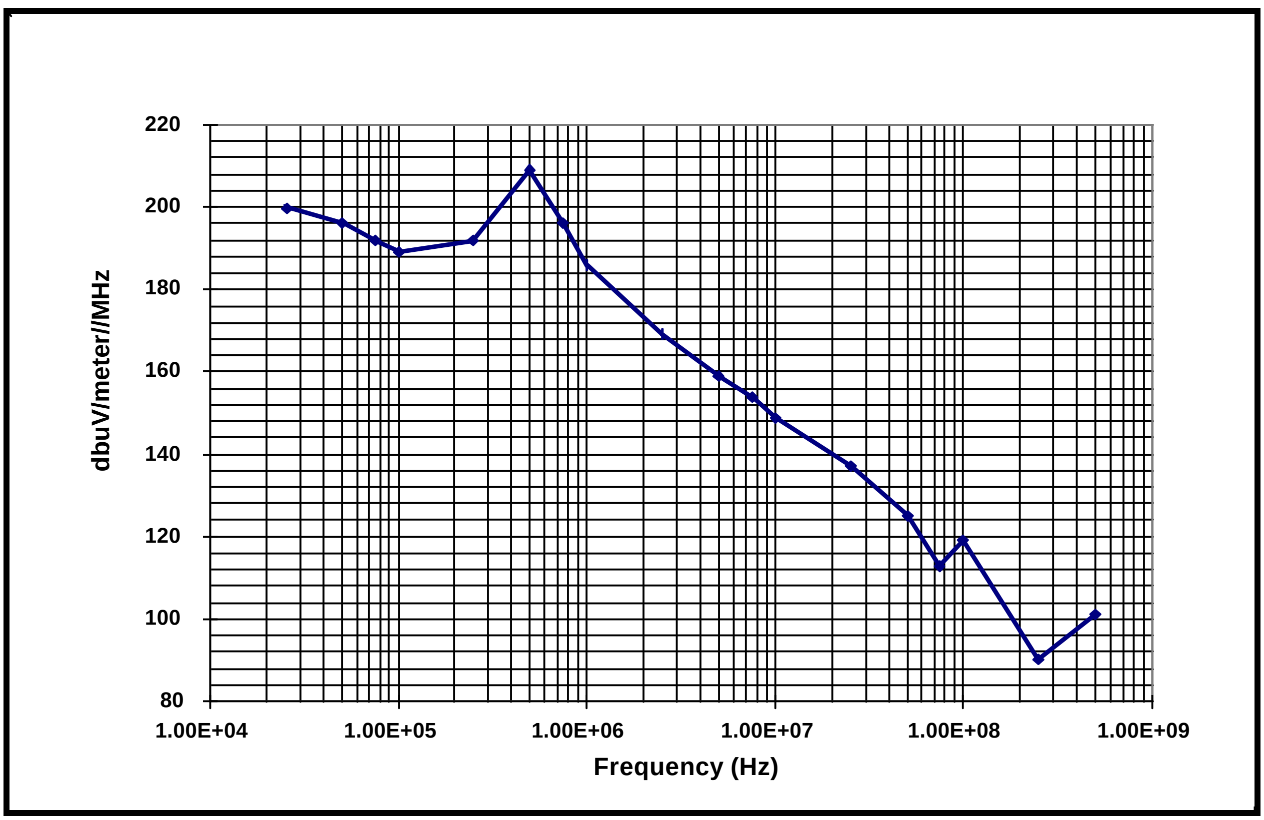

Figure 15 - Maximum Allowable Broadband Radiated E-Fields (ESD Source)

3.2.6.2 Electromagnetic Interference Safety Margin (EMISM)

Electromagnetic Interference Safety Margins (EMISMs) shall be included in the design process to account for variability in system and subsystem components, and for uncertainties involved in verification of system level design requirements. EMISMs of at least 20 dB for Category I interface circuits involving ordnance, and at least 6 dB for Category I non-ordnance and Category II interface circuits are required.

3.2.6.3 Range Compatibility

The flight configured LV/SV shall be compatible with the launch site RF requirements (may include RF mitigation measures coordinated with the launch site). The LV and SV shall each be responsible for the individual system compatibility with the worst case theoretical value.

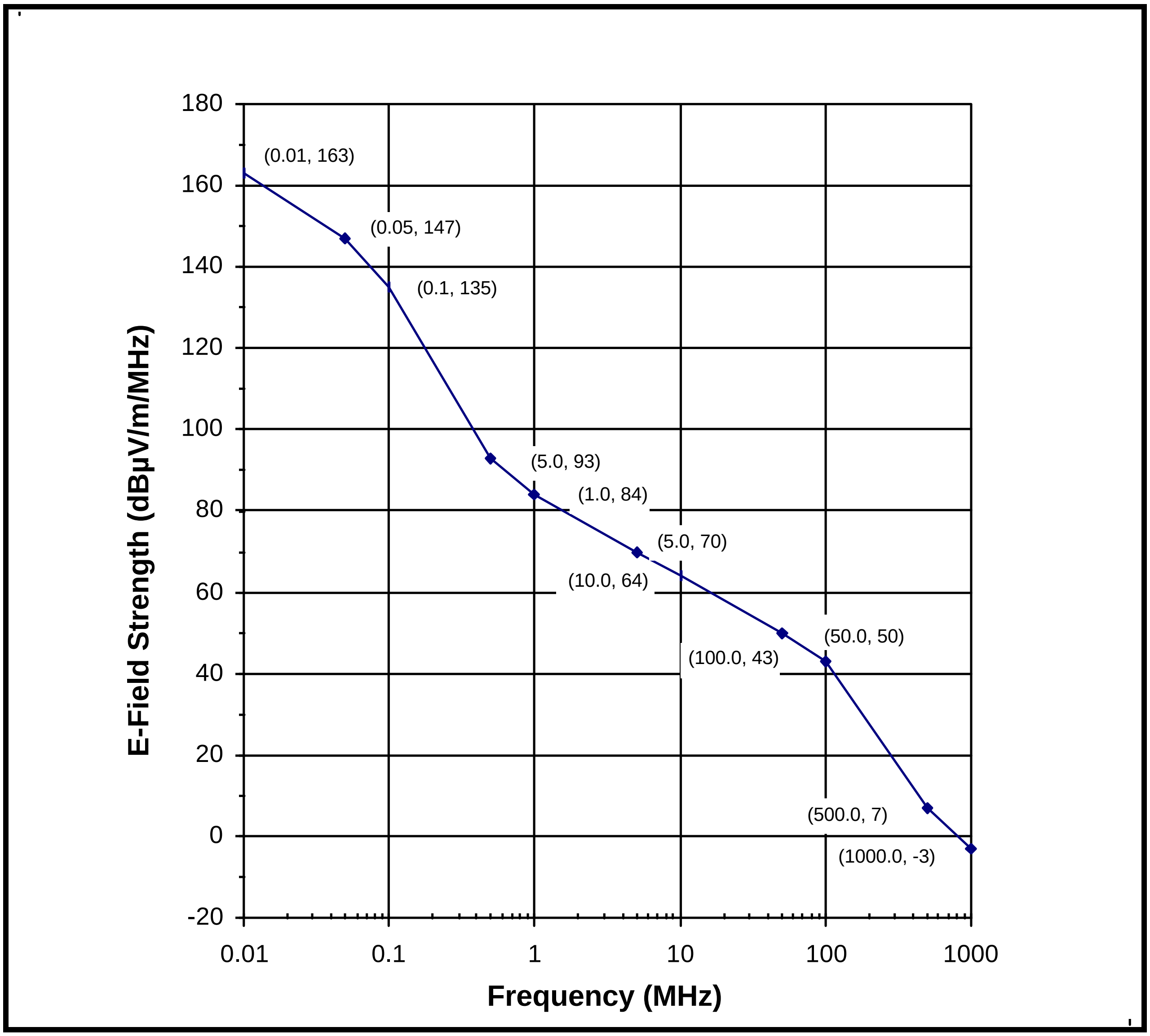

Figure 16 - E-Field Strength Derived Radially 1 cm from PLF Inner Surface

3.2.7 Grounding, Bonding, and Referencing

3.2.7.1 Electrical Bonding

Electrical bonding of mechanical interfaces shall be implemented for management of electrical current paths and control of voltage potentials to ensure required system performance, and to mitigate personnel hazards. Electrical bonding provisions shall be compatible with corrosion control requirements. The launch vehicle/payload interface shall provide a conductive path for electrical bonding of the payload to the launch vehicle. The maximum electrical bonding resistance between the payload and launch vehicle shall be 2.5 milliohms, and shall be verifiable by measurement when they are mated.

3.2.7.2 Interface Connector Bonding

Connector shells shall be bonded to structure. Bonding resistance at these points shall be 2.5 milliohms maximum. The bonding resistance of the cable shield termination path through the mating connector assemblies to the interface shall not exceed 10 milliohms, with no more than 2.5 milliohms across a single joint.

3.2.7.3 Chassis Ground Current

Chassis grounds shall not intentionally be used to conduct power or signal currents.

3.2.7.4 PLF Acoustic and Thermal Blanket Layer Interconnection

Metallized (VDA, VDG, etc.) surfaces and semi-conductive ($\leq 10^9$ ohms per square) layers of thermal (acoustic) insulation blankets shall be designed such that all layers are electrically interconnected. The resistance between any two metallized layers shall be less than or equal to 100 ohms. The resistance between any two semi-conductive layers shall be less than or equal to 10^9 ohms. Existing thermal insulation (acoustic) blanket designs shall be reviewed for acceptance.

3.2.7.5 PLF Acoustic and Thermal Blanket Grounding

Acoustic and thermal insulation blankets shall be connected to the nearest available chassis ground point. The grounding resistance for metallized (VDA, VDG, etc.) layers of the thermal insulated blankets and chassis shall be less than or equal to 100 ohms. The grounding resistance for semi-conductive ($\leq 10^9$ ohms per square) layers of the thermal insulative blankets and chassis shall be less than or equal to 10^9 ohms. There shall be at least one ground point in each square meter of the blanket surface with a minimum of two ground points per blanket. Existing thermal (acoustic) insulation blanket designs shall be reviewed for acceptance.

3.2.8 Separation Ordnance, Power, and Circuits

Separation ordnance power shall be provided by LV to the primary and redundant SV-provided initiators. Each SV separation ordnance circuit (primary and redundant) shall use separate power sources and separation circuits.

The LV ordnance circuits to the SV shall be isolated from the SV structure by a minimum of 1.0 megohms except for the Electrical Static Discharge (ESD) protective devices.

The firing circuit harnesses shall be shielded to provide a 20 dB minimum margin above the EED's firing threshold, as specified in Section 3.2.2.2.

A total of 16 electro-explosive device (EED) firing circuits, 8 primary and 8 redundant, shall be provided by the LV to the SIP for the SV separation from its adapter. EEDs used will be low voltage, 1 ampere/1 watt no-fire designs that have an internal bridge wire with a resistance of approximately 1.0 ohm.

Both primary and redundant separation ordnance firing signals shall be capable of firing one EED at a time or up to the whole group of 8 at the same time.

The total allowable SV resistance for each EED circuit (i.e. from SIP through SV-adapter to SV and return to SIP including EED resistance) shall be in the range of 0.9 to 2.0 ohms.

Firing signals shall be a single pulse with a duration in the range of 40 ±10 milliseconds. The firing signal current for each EED circuit shall be at least 5.0 amperes (*i.e.*, a total of 40 amperes minimum if firing 8 at the same time). The firing current shall also be limited at any time to 18 amperes maximum for each EED circuit.

Primary and redundant firings shall be separated at the SV's discretion by a duration of either less than 5 milliseconds or 80±10 milliseconds of the leading edges of the firing signals as depicted in Figure 17. The SV will specify to the LV the desired firing sequence and firing signal separation choice.

3.2.8.1 Separation Indication

The SV shall provide 2 separation breakwires for sense by EELV in separate interface connectors. These shall be isolated from the SV structure by a minimum of 1 megaohm.
Loopback characteristics of these lines are as follows:

Maximum Resistance: 1.00 ohm
Minimum Resistance after break: 1 Megaohm.

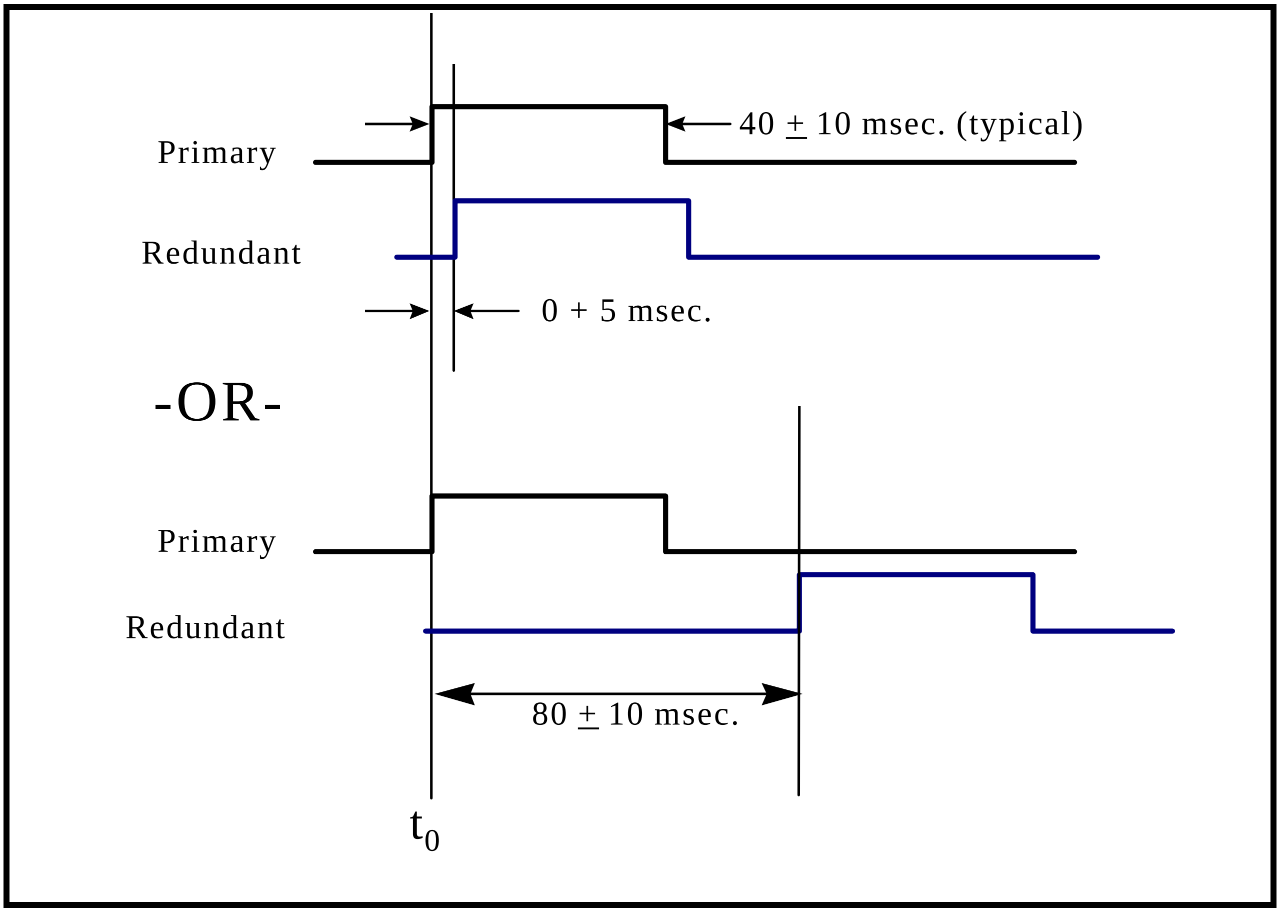

Figure 17 - Ordnance Timing

3.3 Fluid Interfaces and Services

The LV shall provide support for fluid services as specified in the following paragraphs. There are no provisions for fueling spacecraft at LV facilities (including the launch pad) as a standard service. Considerations for SV detanking are covered in Section 4.5.

3.3.1 Coolant

No cooling fluids other than gaseous nitrogen or air are provided to the SV. These are discussed in Section 3.3.2 below. Liquid cooling fluids may be provided on a mission-unique basis.

3.3.2 Air Conditioning

3.3.2.1 Payload Compartment Air Characteristics and Flow

The LV will provide an air conditioning duct located at the top of the standard payload envelope cylinder, directed not to impinge directly on the payload. The standard duct is switchable to provide air or nitrogen flow from a redundant source as determined by the LV and as specified below. In addition, the launch pad air conditioning provisions shall not preclude the routing of a fly-off umbilical fitting located at the base of the payload fairing in addition to the standard duct to the top of the fairing. Air conditioning will be available from SV encapsulation through launch with periods of interruption as negotiated in the LV/SV ICD.

Air. Air flow is provided with the following characteristics:

- Inlet temperature and relative humidity:
  - 50-85°F (controllable to ±5° F) with 20-50% relative humidity

  and

  - 50-70°F (controllable to ±5° F) with 35-50% relative humidity when required for sensitive operations
- Inlet cleanliness: Class 5000 guaranteed (HEPA filters not DOP tested)
- Inlet mass flow rates (air):
  - HLV: 200-300 lb./min. (controllable to ± 12.5 lb/min.)
  - MLV: 80-160 lb./min. (controllable to ± 5 lb/min. after start-up period)
- Flow velocity: The payload air distribution system shall provide a maximum air flow velocity less than 32 fps for MLV in all directions and 35 fps for HLV in all directions. There will be localized areas of higher flow velocity at, near, or associated with the air conditioning duct outlet. Maximum air flow velocities correspond to maximum inlet mass flow rates. Reduced flow velocities are achievable at lower inlet mass flow rates.

The LV shall provide for the capability to divert up to 40% of the air flow to the aft portion of the payload envelope.

N_2. There is no provision for purge of the entire PLF with GN2 prior to launch as a standard spacecraft service. This type of purge is considered a mission-unique service.

3.3.3 SV Instrument Purge (GN_2)

The LV integration facility shall have provisions for both Grade B and high purity Class C GN_2 to supply purges for individual SV instruments. The characteristics of this GN_2 are as follows:

- Inlet dewpoint: Maximum of -35° F
- Inlet cleanliness: Class 5000 guaranteed (HEPA filters not DOP tested)
- Flow rate: 0-500 standard cubic feet per hour (SCFH)

This provision shall not preclude SV-provided carts from being used for higher purity or higher flow rate SV instrument purges.

3.3.4 GHe

There is no provision for providing gaseous Helium to the payload.

3.4 Environmental Conditions

3.4.1 SV Compartment Thermal Environment

The worst case thermal environment in the space vehicle compartment inside the fairing during ascent is defined in Figure 18. The surfaces seen by the SV will generally fall into one of two categories: Surfaces with low emissivity (e ≤ 0.3) and those of higher emissivity (e ≤ 0.9). Maximum temperatures as a function of the time from launch, 300°F for a surface emissivity of 0.3 and 200° for a surface emissivity of 0.9, are shown in the plot. The exact configuration and percentages of each type of surface is both mission specific and LV concept specific. Temperatures may exceed those shown but in no case shall the total integrated thermal energy imparted to the spacecraft exceed the maximum total integrated energy indicated by the temperature profile shown in Figure 18.

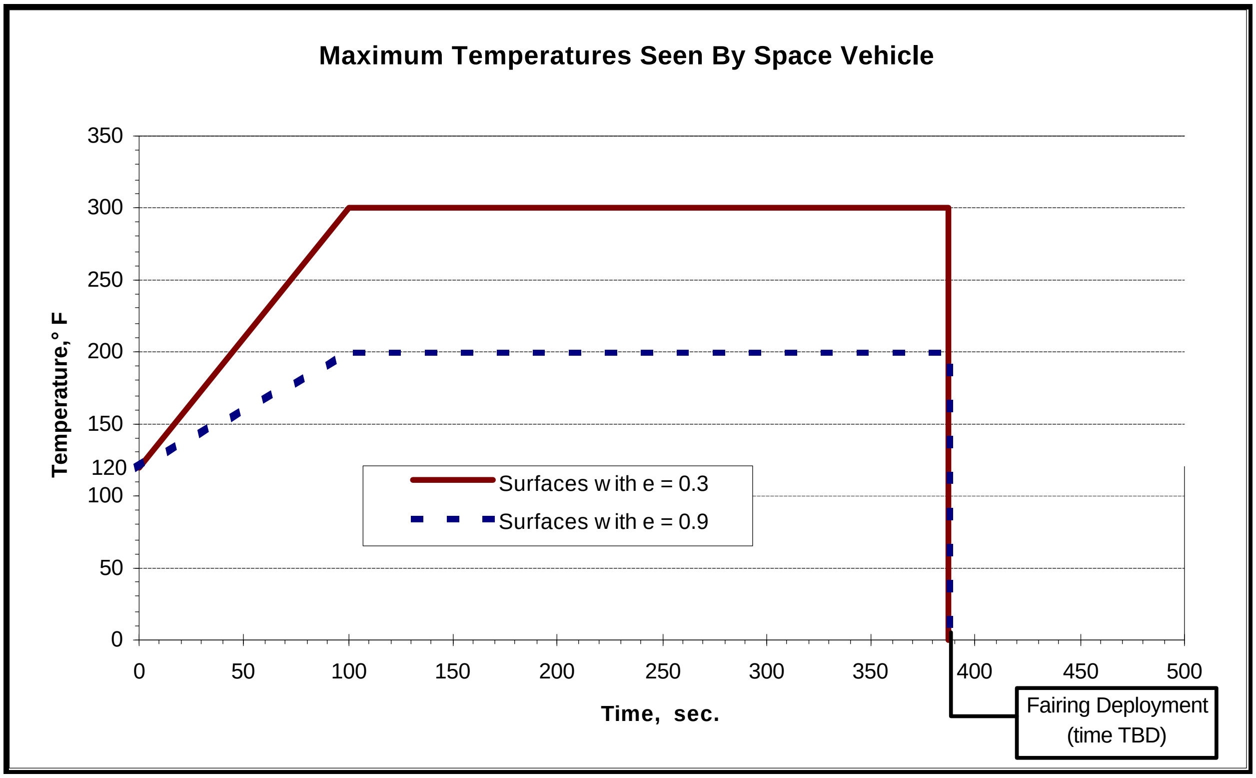

Figure 18 - Maximum PLF Inner Surface Temperatures

3.4.2 Free Molecular Heating

The maximum instantaneous 3-sigma Free Molecular Heating on spacecraft surfaces perpendicular to the velocity vector at the time of fairing separation shall not exceed 320 Btu/hr-ft^2. Lower or higher values may be achieved at the expense of LV performance and will be addressed on a case-by-case basis.

3.5 Contamination Control

3.5.1 Cleanliness

Exposed LV surfaces within the payload fairing shall be cleaned and inspected to be free of visible particles with the unaided eye (except for vision corrected to 20-20), with a 100-125 ft-candle light at a distance of 6 to 18 inches. Non-volatile residue left on the above surfaces shall not exceed 1.0 mg/ft^2.

All payloads (SV, adapter, etc) that have a specific contamination requirement shall, at the time of SV/LV mating, demonstrate a state of cleanliness that is consistent with their contamination requirement.

3.5.2 Impingement

LV plume impingement shall be controlled in accordance with the requirements given in the SPRD.

3.5.3 Windborne Contamination

The Launch Vehicle shall provide protection to the SV from windborne contamination and maintain the cleanliness levels of Section 3.5.1 from payload transport to the launch pad through lift-off.

3.5.4 Flight Contamination

3.5.4.1 Particulate

Particulate contamination levels from the Launch Vehicle shall not exceed 1% surface obscuration from payload encapsulation through CCAM.

3.5.4.2 Molecular

Molecular contamination levels from the Launch Vehicle shall not exceed 150 angstroms from payload encapsulation through CCAM.

3.5.5 Material Selection

3.5.5.1 Non-Metallic Materials

Selection of nonmetallic materials shall include consideration of wear products, shedding and flaking properties in order to reduce particulate contamination. The nonmetallic materials within the PLF volume exposed to thermal vacuum shall not exceed a total mass loss of less than or equal to 1.0% and volatile condensable matter less than or equal to 0.1% when tested per ASTM E-595 or equivalent method. Exceptions for usage on the flight vehicle are below:

Final acceptance of nonmetallic materials shall be determined by analysis of the material outgassing and deposition characteristics. If materials needed for specific applications or used in existing design do not meet these requirements but the sum total determined by analysis meets the flight contamination requirements, a material usage agreement, including rationale for use of the materials shall be issued by the cognizant Parts Materials and Processes (PMP) engineer and provided upon request to the Air Force, satellite contractor or Launch System Integration Contractor (LSIC). Specific criteria for material selection may be dependent upon payload unique requirements. The list for each material requesting a materials usage agreement shall include the following:

1. Manufacturer's trade name of the product or material
2. Manufacturer of the material
3. Thermal and vacuum stability data
4. Rationale for use of non-approved materials including the mass, surface area and location of the material used
5. Contribution of the total outgassing/deposition environment

3.5.5.2 Metallic Materials

The selection of metallic materials shall include consideration of corrosion, wear products shedding and flaking in order to reduce particulate contamination. Dissimilar metals in contact shall be avoided unless adequately protected against galvanic corrosion.

Mercury, compounds containing mercury, zinc plating, cadmium parts and cadmium plated parts shall not be used on flight or LV ground support equipment that comes into direct contact with SV flight hardware.

Pure tin or tin electroplate shall not be used except when refused, re-flowed, or alloyed with lead, antimony or bismuth.

3.6 Acceleration Load Factors

Figures 19, 20 and 21 define SV center-of-gravity acceleration values that when used to calculate LV/SV interface bending moments, axial loads and shear loads will yield maximum loads imposed by the LV on the SV at the SIP. For SV weights other than those given in these figures, adjustments to the axial accelerations should be made according to steady state acceleration vs. weight curves which are concept specific and will be provided during the EMD phase of the program. SV weights are to include any payload adapter which may be required.

Load factors for the preliminary design of the space vehicle structure should be derived for each space vehicle by taking into account the unique design features of the space vehicle and its interaction with the launch vehicle. However, these factors are to be no less than the values in figures 19, 20 and 21 (properly adjusted for spacecraft weight). Following the preliminary design, definition of SV structural loads will be accomplished by means of coupled loads analyses.

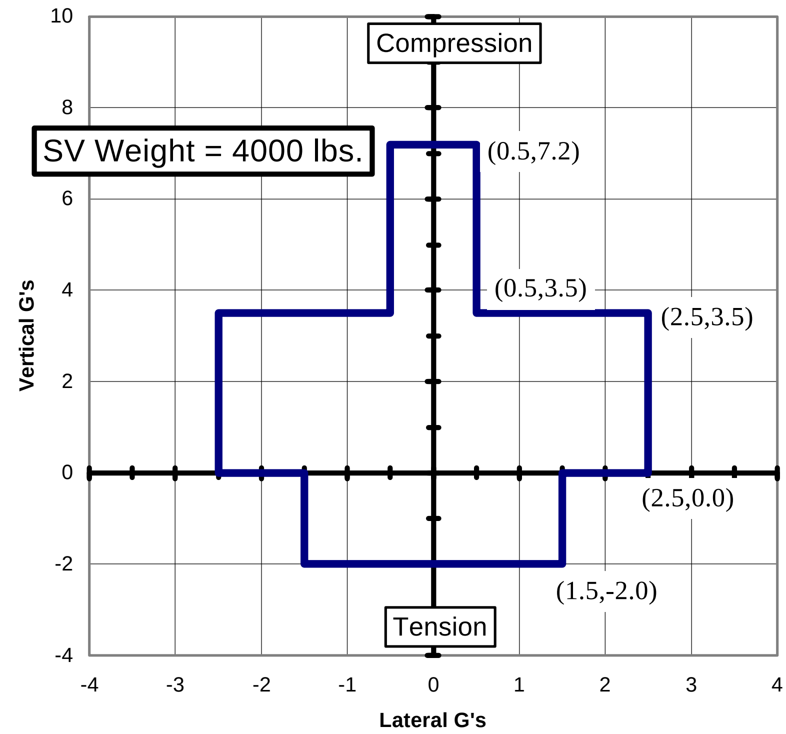

Figure 19 - MLV-S Quasi-Static Load Factors

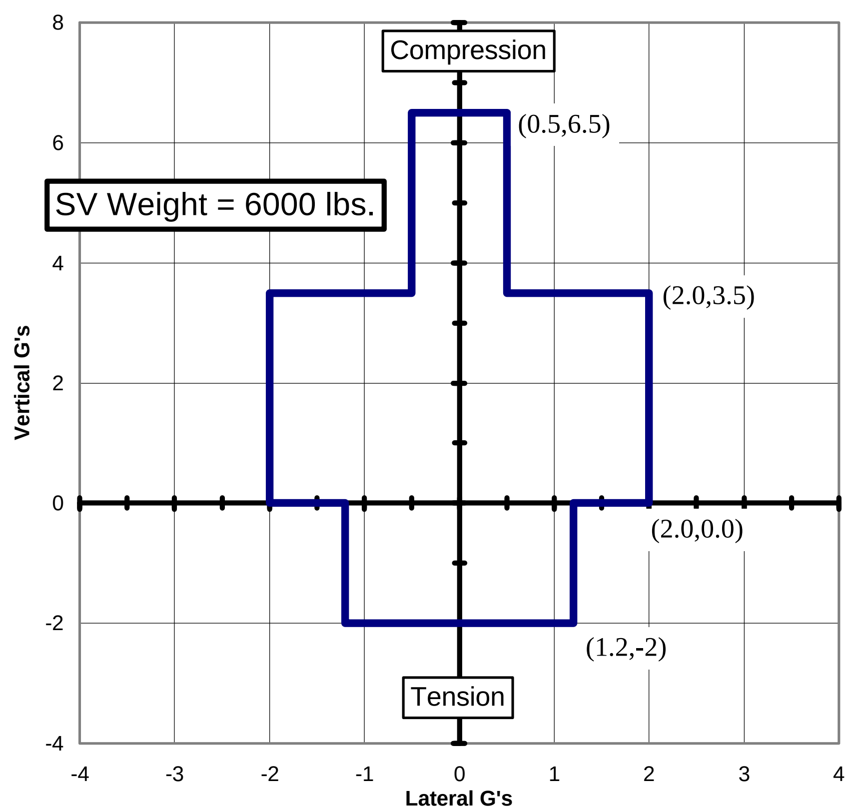

Figure 20 - MLV Quasi-Static Load Factors

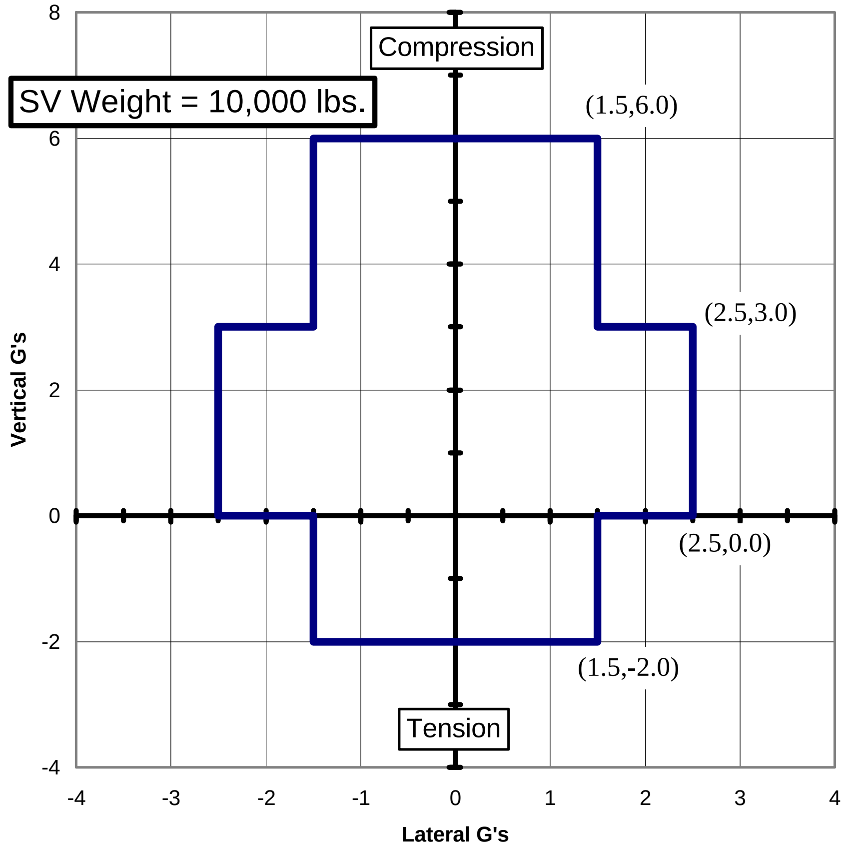

Figure 21 - HLV Quasi-Static Load Factors

3.7 Vibration

The maximum in-flight vibration levels will be provided in the LV to SV ICD, but are not defined in this standard. SV design should be performed using the EELV acoustic data (provided in the next section).

3.8 Acoustics

The SV maximum predicted sound pressure levels (value at 95th percentile with a 50% confidence) from liftoff through payload deployment shall not exceed the values provided in Table 3. The acoustic levels are plotted in Figures 22 and 23 as one-third octave band sound pressure levels versus one-third octave band center frequency for MLV and HLV, respectively. The values shown are for a typical SV with an equivalent cross-section area fill of 60 percent. The defined SV dynamic envelopes (refer to section 3.1.3) were used to calculate the 60 percent cross-section area fill. The provided acoustics levels have been adjusted to represent the equivalent sound pressure levels consistent with the standard acoustic test practice of locating control microphones 508 mm (20 inches) from the SV surface. Space Vehicles with a larger cross-sectional area than 60 percent will incur higher acoustic levels.

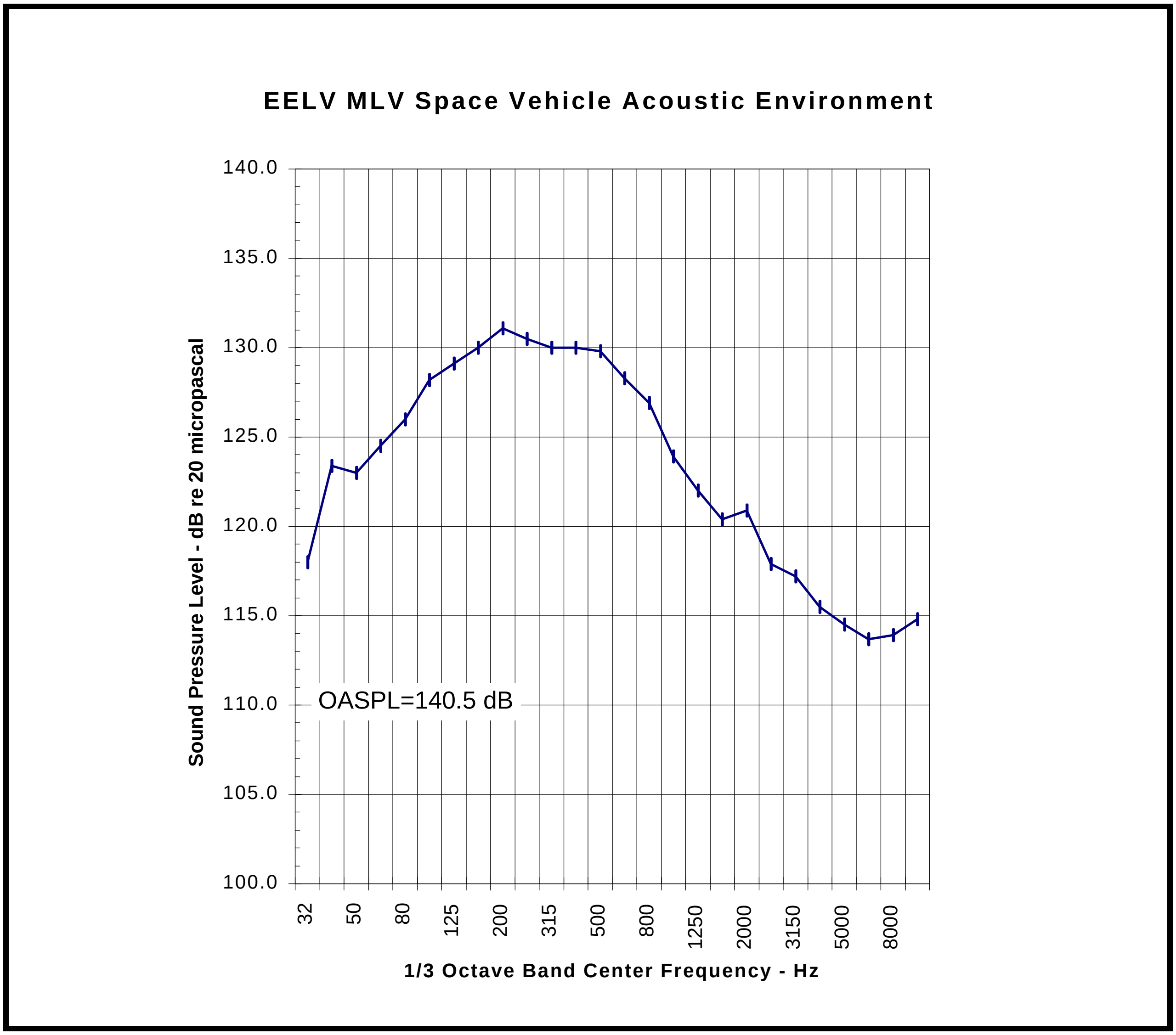

Figure 22 - MLV Acoustic Levels

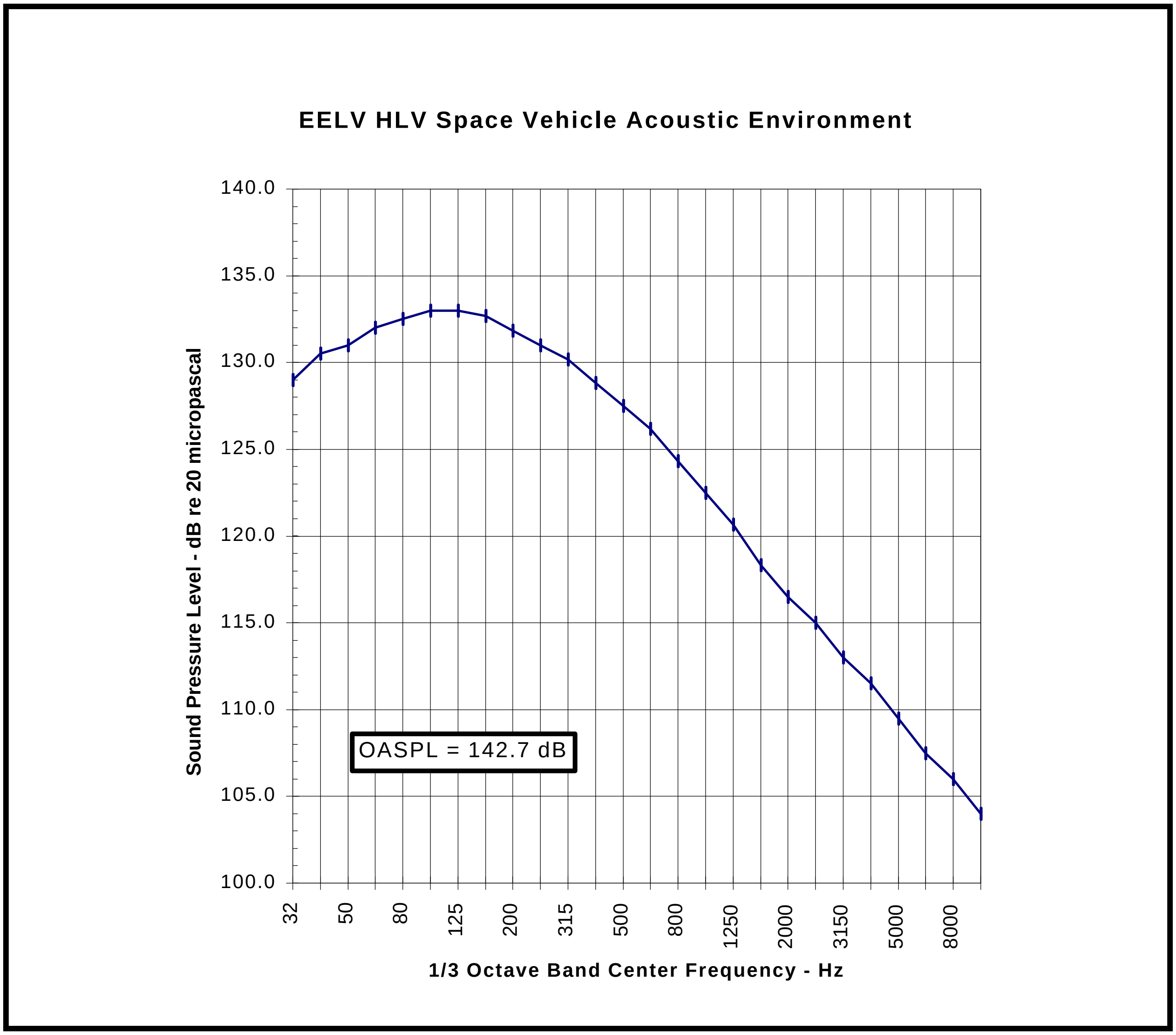

Figure 23 - HLV Acoustic Levels

1/3 Octave Band Center Frequency (Hz)	MLV SV Sound Pressure Level (dB re 20 micropascal)	HLV SV Sound Pressure Level (dB re 20 micropascal)
32	118.0	129.0
40	123.4	130.5
50	123.0	131.0
63	124.5	132.0
80	126.0	132.5
100	128.2	133.0
125	129.1	133.0
160	130.0	132.7
200	131.1	131.8
250	130.5	131.0
315	130.0	130.2
400	130.0	128.8
500	129.8	127.5
630	128.3	126.2
800	126.9	124.3
1000	123.9	122.5
1250	122.0	120.7
1600	120.4	118.3
2000	120.9	116.5
2500	117.9	115.0
3150	117.2	113.0
4000	115.5	111.5
5000	114.5	109.5
6300	113.7	107.5
8000	113.9	106.0
10000	114.8	104.0
OASPL	140.5	142.7

Table 3 - SV Maximum Acoustic Levels

3.9 Shock

The maximum shock spectrum at the SIP (value at 95% probability with 50% confidence; resonant amplification factor, Q=10) shall not exceed the levels shown in Table 4. These levels are shown graphically in Figure 24.

3.10 Ground Processing Load Factors

Ground processing loads will be provided in the LV/SV ICD. They will be less than the flight load factors shown in Section 3.6.

3.11 Payload Fairing Internal Pressure

Payload fairing internal pressure decay rates for HLV shall be limited to 0.4 psi/sec except for a brief transonic spike to 0.6 psi/sec. Decay rates for MLV shall be limited to 0.3 psi/sec except for a brief transonic spike to 0.9 psi/sec.

Shock Spectrum from EELV to SV (G's)			Shock Spectrum from SV to EELV (G's) (due to SV separation)	
Freq-Hz	HLV	MLV	Freq-Hz	HLV & MLV
100	70	40	100	150
125	-	-	125	175
160	-	-	160	220
200	80	-	200	260
250	-	-	250	320
315	-	-	315	400
400	-	-	400	500
500	-	-	500	725
630	-	-	630	1100
800	-	-	800	2000
1600	-	-	1600	5000
2000	3000	-	2000	5000
5000	3000	3000	5000	5000
10000	3000	3000	10000	5000

Refer to graph of Figure 24 for intermediate frequencies

Table 4 - EELV Maximum Shock Levels

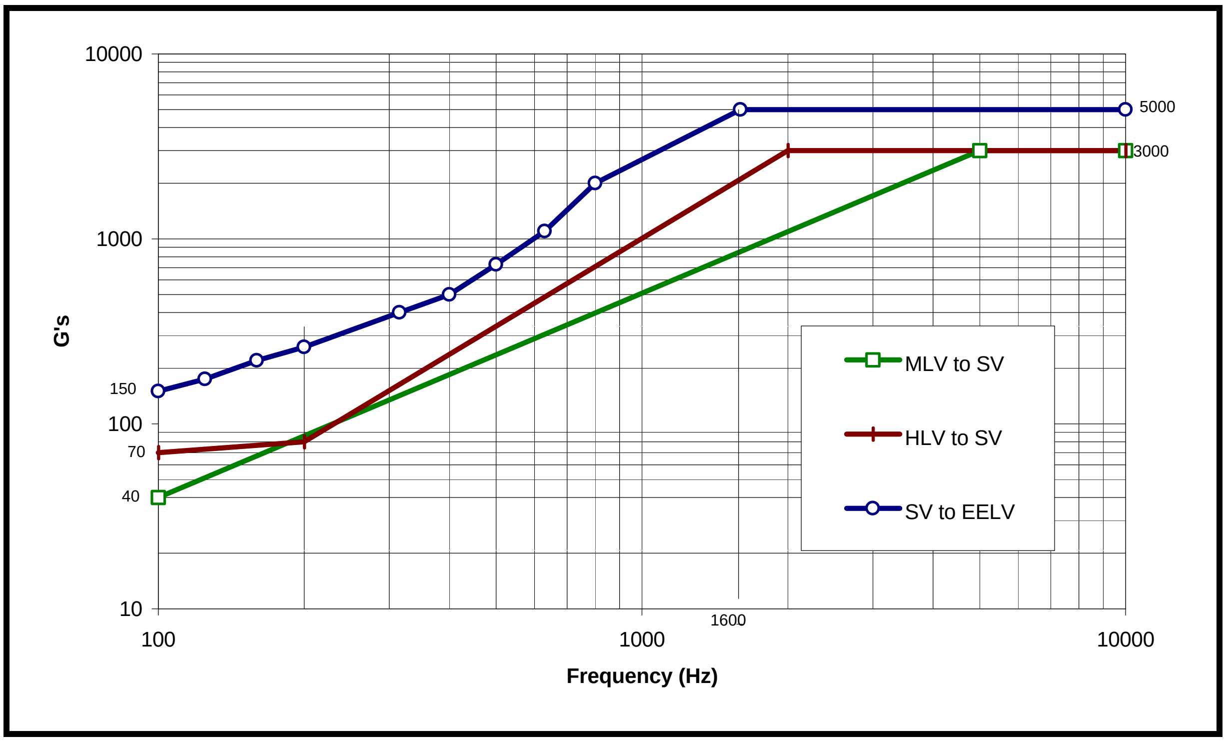

Figure 24 - EELV Maximum Shock Levels

4. FACILITIES AND PROCESSING

4.1 Propellant Services

The SV shall complete propellant loading prior to encapsulation within the EELV payload fairing.

4.2 Access to Payloads - Timeliness

Final access to the SV will occur no later than 24 hours prior to launch. Exact timelines are concept specific and will be provided during the Development phase of the program.

4.3 SV Battery Charging

4.3.1 Full Power Charging

The EELV shall accommodate SV pre-launch battery charging from drained state to full charge state via the T-0 umbilical or via drag-on electrical cables at the appropriate platform level. Ground power shall be in accordance with the requirements of Section 3.2.4. The timing for providing this service will be negotiated in the SV/LV ICD.

4.3.2 Trickle Charging

The EELV shall accommodate SV battery trickle charging to maintain battery charge via the T-0 umbilical power lines. Ground power shall be in accordance with the requirements of Section 3.2.4.

4.4 Hazardous SV Processing

SV hazardous processing, except for tasks which may not be carried out until just prior to movement of the LV to the launch pad (*e.g.* arming of ordnance) shall be completed prior to final close-out of the EELV payload fairing.

4.5 Detanking

If it is required that the SV have the capability for emergency de-tanking at the launch complex, the SV shall use manually connected/disconnected interfaces accessible (as provided in Section 3.2.4) on the -Z axis side without personnel entry into the fairing. Tank drain, vent purge and pressurization (if required) shall be a payload responsibility and shall be accomplished through a payload-provided propellant servicing unit.

The LV will provide measures for personnel protection, collection of hazardous fuels, and storage or disposal of collected fuels.

4.6 Lightning Protection

Lightning protection shall be provided by the LV in accordance with EWR 127-1 Chapter 5. Electrical circuits shall be designed to minimize damage due to lightning strikes.