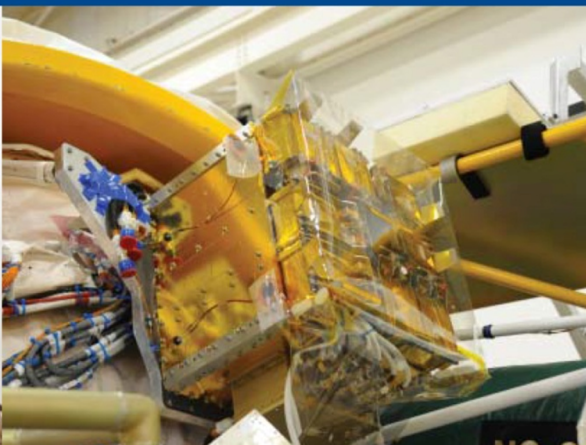
Aft Bulkhead Carrier Auxiliary Payload User's Guide | May 2014



AFT BULKHEAD CARRIER AUXILIARY PAYLOAD USER'S GUIDE

May 2014

Prepared and Maintained by:
United Launch Alliance

The Aft Bulkhead Carrier Auxiliary Payload User's Guide has been cleared for public release by the Chief, Office of Security Review, Department of Defense, as stated in letter 14-S-1400, dated May 05, 2014.

PREFACE

This Aft Bulkhead Carrier Auxiliary Payload User's Guide is issued to the spacecraft user community to provide information about the Aft Bulkhead Carrier (ABC). The ABC is a rideshare capability designed to carry a small payload on an Atlas V launch vehicle. The ABC is a structural plate that is attached to the aft end of the Centaur upper stage, and is capable of supporting and deploying small satellites with a maximum mass of 170 lb. The ABC is an operational capability as the first launch occurred in September 2012.

This document contains current information on the Aft Bulkhead Carrier and includes requirements, anticipated payload environments, mechanical and electrical interface specifications, payload envelopes, payload processing, and other related information of interest to our potential customers.

As new developments to the Aft Bulkhead Carrier program are introduced, ULA will periodically update the information presented in the following pages. To this end, you are urged to visit our website so that you can download updates as they become available.

Recipients are also urged to contact United Launch Alliance with comments, requests for clarification, or requests for supplementary information to this document.

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CONTENTS

GLOSSARY

A, amp	Ampere
ABC	Aft Bulkhead Carrier
ac	Alternating Current
AFSPCMAN	Air Force Space Command Manual
AIP	Aft Instrumentation Panel
AP	Auxiliary Payload
APC	Auxiliary Payload Contractor
APCS	Auxiliary Payload Coordinate System
ASIP	Auxiliary Standard Interface Plane
ASOC	Atlas Spaceflight Operations Center
BH	Bulkhead
BISA	Booster Interstage Adapter
BTU, Btu	British Thermal Units
CAD	Computer Aided Design
CCAFS	Cape Canaveral Air Force Station
CCAM	Collision and Contamination Avoidance Maneuver
CG, cg	Center of Gravity
CISA	Centaur Interstage Adapter
CLA	Coupled Loads Analysis
CNC	Computer Numeric Control
dB	Decibel
dc	Direct Current
deg	Degrees
DoD	Department of Defense
DoT	Department of Transportation
ECS	Environmental Control System

EED	Electroexplosive Devices
EELV	Evolved Expendable Launch Vehicle
EGSE	Electrical Ground Support Equipment
EIRP	Effective Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMISM	EMI Safety Margin
ER	Eastern Range
ESD	Electrostatic Discharge
ET	External Tank
EWR	Eastern and Western Range Regulation
F	Fahrenheit
FAA	Federal Aviation Authority
FAB	Final Assembly Building
FJA	Frangible Joint Assembly
FM	Flight Model
FPA	Flight Plan Approval
Ft	Foot (feet)
FTP	File Transfer Protocol
FTS	Flight Termination System
GC	Generally Clean
GEO	Geosynchronous Earth Orbit
GHz	Gigahertz
GMM	Geometric Mathematical Model
GORR	Ground Operations Readiness Review
GOWG	Ground Operations Working Group
GOX	Gaseous Oxygen

GPI	Ground Payload Interface
GPS	Global Positioning System
GSE	Ground Support Equipment
GTO	Geosynchronous Transfer Orbit
HEPA	High-Efficiency Particulate Air
Hz	Hertz
ICD	Interface Control Document
IFD	In Flight Disconnect
IFR	In-Flight Retargeting
IGES	Initial Graphics Exchange Specification
ILC	Initial Launch Capability
IR	Infrared
ISA	Interstage Adapter
kHz	Kilohertz
KSC	Kennedy Space Center
LAN	Longitude of Ascending Node
LC	Launch Complex
LEO	Low Earth Orbit
LS	Launch System
LV	Launch Vehicle
LVC	Launch Vehicle Contractor
m	Meter(s)
max	Maximum
MEB	Main Engine Burn
MGSE	Mechanical Ground Support Equipment
MIL-STD	Military Standard
MLB	Motorized Lightband

MLP	Mobile Launch Platform
MPDR	Mission Peculiar Design Review
MRS	Minimum Residual Shutdown
MSPSP	Missile System Prelaunch Safety Package
MST	Mobile Service Tower
MTS	Metric Tracking System
NASA	National Aeronautics and Space Administration
NTE	Not to Exceed
OASPL	Overall Sound Pressure Level
ORCA	Ordnance Remote Control Assembly
OSHA	Occupational Safety and Health Administration (US Govt)
OSL	Office of Space Launch
OTM	Output Transformation Matrices
PFM	Protoflight Model
PLCP	Propellant Leak Contingency Plan
PLF	Payload Fairing
PL	Payload
PMRR	President's Mission Readiness Review
PPF	Payload Processing Facility
P-POD	Poly Picosatellite Orbital Deployer
PSC	Planetary Systems Corporation
psi	Pounds per Square Inch
PVAN	Payload Van
P/Y	Pitch/Yaw
RAAN	Right Ascension of Ascending Node
RCS	Reaction Control System
RF	Radio Frequency

RH	Relative Humidity
RPO	Radiation Protection Officer
SC	Spacecraft
sec	Second(s)
SEC	Single Engine Centaur
SEIP	Standard Electrical Interface Panel
SLC	Space Launch Complex
SRB	Solid Rocket Booster
STA	Station
STEP	Standard for the Exchange of Product Model Data
STM	Structural Test Model
SV	Space Vehicle
SVC	Space Vehicle Contractor
SVIP	SV Interface Panel
THD	Total Harmonic Distortion
TLM	Telemetry
TMM	Thermal Mathematical Model
ULA	United Launch Alliance
URCU	Upper Stage Remote Control Unit
V	Volts
VAFB	Vandenberg Air Force Base
VDC	Volts Direct Current
VIF	Vertical Integration Facility

Section 1
INTRODUCTION

1.1 PURPOSE/SCOPE

This User's Guide defines the Launch Vehicle (LV) to Auxiliary Payload (AP) interfaces and worst case launch environments for the Centaur Aft Bulkhead Carrier (ABC) AP component design. The AP that is attached to the ABC is required to conform to these constraints in order to fly on an Atlas V mission. The Centaur ABC design reflects the Atlas V current environments, loads, and envelopes, rather than meeting typical spacecraft standards.

The ABC/AP system will not interfere with the delivery of the primary Space Vehicle (SV) to its orbit. Among other constraints, this means that the ABC/AP system will only be flown on an Atlas V 4X1 or 5X1 Single Engine Centaur Launch Vehicle configuration with sufficient excess performance. The ABC/AP system will not cause violation to the primary LV/SV Interface Control Document (ICD) requirements.

The ABC/AP standard service includes separating the AP or other separable sub-payloads (i.e. CubeSats) after the primary SV separation. APs may be flown on Atlas V launches from either Cape Canaveral Air Force Station (CCAFS) on the East Coast or Vandenberg Air Force Base (VAFB) on the West Coast.

For a given AP, the LV/AP interface requirements will be defined in the LV/AP ICD.

1.2 OVERVIEW

The ABC is a system to support and deploy an AP from the aft end of the Centaur. The baseline ABC design accommodates a single AP on a given Atlas V flight. The ABC's function is to provide the means to deliver an AP to its specified destination orbit without degrading the primary spacecraft delivery and on-orbit performance.

The ABC AP User's Guide will provide the basics of what is included in the ABC/AP Standard Service, but mission unique requirements may be negotiated and added to the mission unique LV/AP ICD.

The ABC/AP mounts to the Atlas V Centaur as shown in Figure 1-1.

The ABC consists of the following major components:

- Separation System
- Structure (plate, struts, and mounting brackets)
- Wiring Harness and Connectors

The ABC/AP system consists of the ABC and the AP.

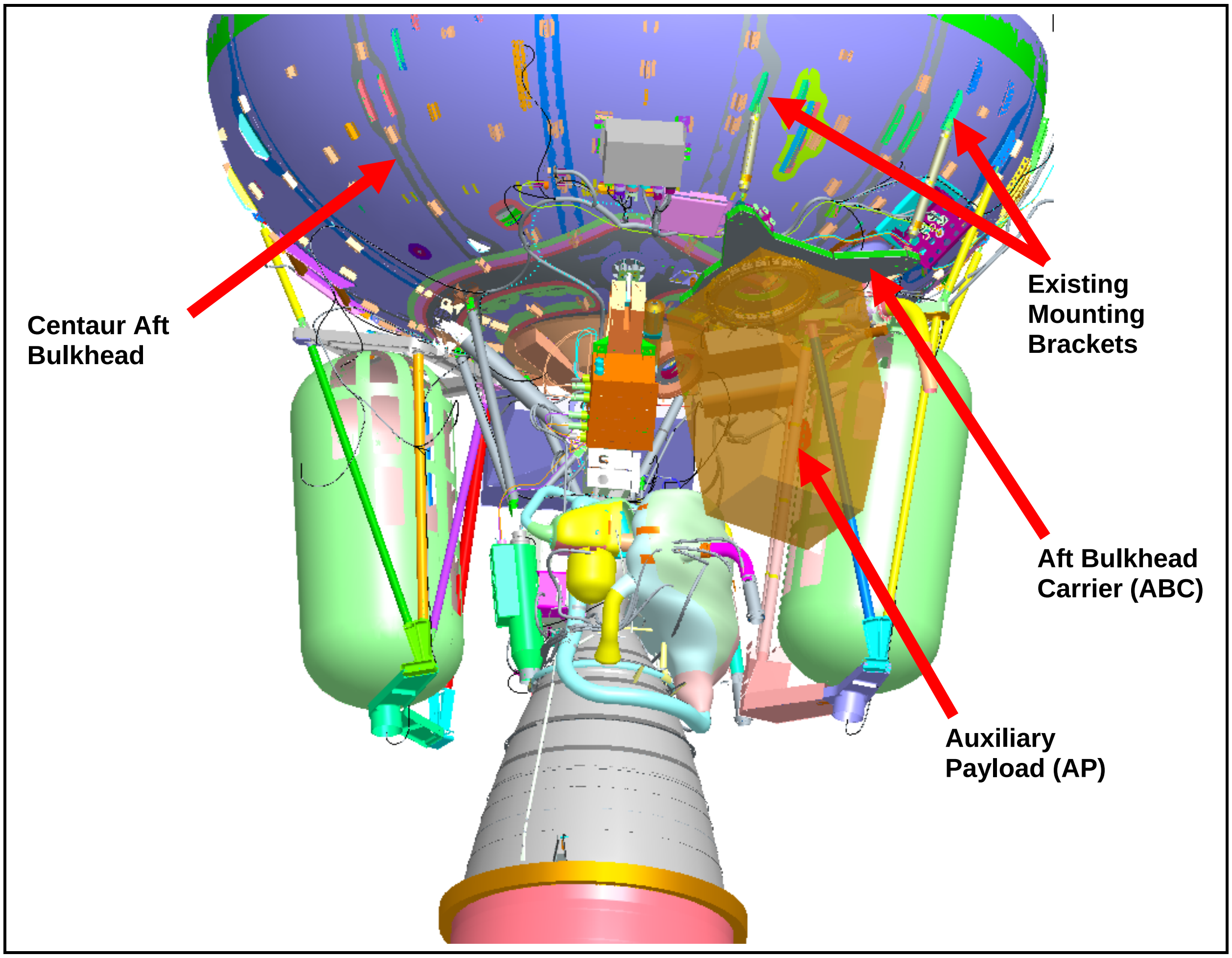


Figure 1-1. Atlas V ABC/AP Installation

1.2.1 Manifesting

Candidate APs must coordinate with United Launch Alliance (ULA) and the primary customer to ensure adequate performance and compatibility between primary and auxiliary payloads. APs must meet ABC AP User's Guide requirements. Further study may be required before an AP can be manifested. Items to be evaluated by ULA include loads, orbit compatibility, umbilicals, discrete commands, mission performance, separation requirements, Payload Van (PVAN) power and space, AP mass and volume size, and RF environments. A leading edge Coupled Loads Analysis (CLA) will be performed by ULA at the earliest opportunity to assess AP impacts to the LV and the primary SV.

The AP integration schedule will conform to the requirements of the primary SV integration schedule.

The ABC/AP standard service does not provide for APs with hazardous commodities. Any requests for hazardous commodities must be negotiated separately on a mission unique basis.

1.2.2 Mass Simulator Requirements

In the event that an APC is unable to meet the integration schedule and/or requirements, a mass simulator may be integrated with the ABC in the place of the AP. The decision to fly a mass simulator must be made on a mission unique basis to ensure no impact to integrated analyses and ultimately to the mission schedule. In this case, ULA will provide a mass simulator with sufficiently high fundamental frequency to be considered a stiff mass for coupled loads analyses. ULA will perform parallel loads analyses using the AP and mass simulator models to ensure the ability to fly a system that has been analyzed.

In the case of an AP that deploys smaller components (CubeSats, etc) and one or more of the components do not meet the schedule or requirements, then the AP will be responsible for providing either an acceptable substitute component or mass simulator such that the overall properties of the AP are consistent with that provided to and analyzed by ULA.

1.2.3 Summary of ULA Provided ABC/AP Standard Service

The ABC/AP Standard Service consists of a standardized launch service provided by ULA.

This User's Guide provides a description of the standard service ULA will provide for an AP mission. The description of environments encompasses worst-case flight environments which are dependent upon launch trajectory. The ABC/AP standard service does not provide for APs with hazardous commodities, however, non-standard services can be provided on a mission unique basis at an additional cost to the AP customer. ULA encourages AP users to identify and discuss non-standard requirements as early as possible so appropriate contractual and technical provisions can be made.

ABC/AP standard service consists of a 24 month integration that begins after the AP evaluation is complete and the AP is manifested on a mission. The standard service schedule will be adjusted as necessary to maintain compatibility with the primary SV integration schedule. Standard service includes the required AP launch services, to include program and mission management, AP-to-ABC integration, and AP processing services. Details regarding typical AP integration meetings and milestones associated with ABC/AP standard service are given in the following subsections and in Figure 1-2. Additional details regarding AP deliverables are provided in Appendix A.

Meeting/Review	Typical Time	Participation	Description
Kick-off Meeting	ATP +30 days	APC, ULA, LV procuring agency	Share overall launch integration process information
AP/ABC Telecon	Bi-weekly	APC, ULA, LV procuring agency	Periodic communication
Management Working Groups	As Needed Relative to AP Involvement	APC, ULA, LV procuring agency (Project Managers)	Cost, Schedule, and Issues Discussions
Compliance/ICD Review	L-18 months	APC, ULA, LV procuring agency	Review ICD and AP ability to proceed.
Ground Operations Working Group (GOWG)	L-14 months (if required)	APC, ULA, LV procuring agency	Review processing/mate and launch procedures
Compliance Review	L-12 months	APC, ULA, LV procuring agency	Review AP final design and configuration acceptability
Compliance/Mission Peculiar Design Review (MPDR)	L-6 months	APC, ULA, LV procuring agency	Complete payload design review
Ground Operations Readiness Review (GORR)	L-3 months	APC, ULA, LV procuring agency	Readiness Review for AP mate to Centaur
Systems Review	L-2 months	APC, ULA, LV procuring agency	LV/Mission compatibility and readiness review
President's Mission Readiness Review (PMRR)	L-10 days	APC, ULA, LV procuring agency	Review AP readiness

Figure 1-2. AP Meetings and Reviews

1.2.4 ICD Process and Verification

To ensure clear concise communication of requirements, an ICD will be jointly developed with the ULA and AP team. The ICD will be controlled and maintained by ULA.

The purpose of the ICD is to provide detailed technical requirements for performance, physical, functional, environmental, and ground operation interfaces.

Requirements to be formally verified are identified in the ICD, assigned a Requirements Traceability Number (RTN), and tracked in a Verification Matrix that is part of the ICD. Participating parties are each responsible for tracking and verifying compliance for each requirement that applies to their respective side of the interface. To ensure requirements have been properly interpreted and implemented, verification evidence is made available to all other ICD signatory parties for approval.

1.3 DEFINITIONS

Auxiliary Payload (AP) – The spacecraft or payload which is attached to the Centaur Aft Bulkhead Carrier.

AP Contractor (APC) – The contractor which provides the AP and/or the agency procuring the AP (the AP customer).

Space Vehicle (SV) – The primary spacecraft which is attached to the forward end of the Centaur.

Space Vehicle Contractor (SVC) – The contractor that provides the primary SV and/or the agency procuring the SV (the SV customer).

Atlas V Launch Vehicle (LV) – The Atlas V Launch Vehicle includes the Atlas Common Core Booster, Centaur, Payload Fairing (PLF), umbilical cable links, and the mission peculiar guidance and sequencing required to place the SV and AP into the designated orbit and provide for SV separation, AP separation, and Centaur Collision and Contamination Avoidance Maneuver (CCAM). The launch vehicle for the ABC mission consists of the Atlas V 400 or 500 launch vehicle system with the 4-m or 5-m diameter PLF, respectively. A three digit naming convention (XYZ) was developed for the Atlas V launch vehicle system to identify its multiple configuration possibilities, and is indicated as follows: First digit (X) identifies the diameter class (in meters) of the PLF (4 or 5); Second digit (Y) indicates the number of Solid Rocket Boosters (SRB) used (0-3 for Atlas V 400 Series, 0-5 for Atlas V 500 Series); Third digit (Z) represents the number of Centaur engines (1 or 2). Therefore, an Atlas V 401 configuration mission includes a 4-m PLF, zero SRBs, and a single engine Centaur.

Launch Vehicle Contractor (LVC) – ULA Atlas V program and all launch services provided by its subcontractors.

Atlas V Launch System (LS) – The Atlas V Launch System includes the LV and all LVC provided airborne and ground support equipment, and facilities necessary to process, launch, and monitor activities through SV separation, AP separation, and CCAM.

Separation Plane – The plane where the AP or SV is separated during flight.

Auxiliary Standard Interface Plane (ASIP) – The AP/LV Interface Plane which is located at the aft surface of the ABC plate.

AP Electrical Interface – The electrical interface between the AP and the LV is at the payload In-Flight Disconnects (IFDs) as shown in Figure 4-14 and with clocking to be defined in the mission unique LV/AP ICD.

1.4 REFERENCE DOCUMENTS

Figure 1-3 identifies documents referenced in this User's Guide.

Document Number	Document Title
AFSPCMAN 91-710	Range Safety User Requirements (as tailored for the AP)
N/A	Atlas V Launch Services User's Guide
Department of the Air Force Memorandum dated 04 May 2005	Joint 45 SW/SE and 30 SW/SE Interim Policy Regarding EWR 127-1 Requirements for System Safety for Flight and Aerospace Ground Equipment Lithium-Ion Batteries
JSC-20793, Revision A	Crewed Space Vehicle Battery Safety Requirements
MIL-STD-1541	Electromagnetic Compatibility Requirements for Space Systems
MIL-STD-1576	Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems
MIL-STD-461C/462	Requirements and Test Methods RE01 (B-Field emissions) and RE02 (E-Field emissions)

Figure 1-3. Reference Documents

Section 2
MISSION REQUIREMENTS

2.1 ORBIT INSERTION AND ACCURACY

The accuracy at the final orbit injection point for each AP is defined by the following seven parameters: apogee, perigee, inclination, eccentricity, argument of perigee, Longitude of Ascending Node (LAN) and Right Ascension of Ascending Node (RAAN). The accuracies for each parameter are presented in Figure 2-1, if applicable, and are representative of the three-sigma accuracy for a guidance-commanded shutdown for each orbit type. This data represents typically achievable accuracies for the stated reference missions using typical mission designs. The accuracies do not include the accuracy impacts of performance-enhancing mission design options such as Minimum Residual Shutdown (MRS) and In-Flight Retargeting (IFR). The mission unique orbit and accuracy requirements will be defined in the LV/SV ICD.

Reference Missions	Apogee Altitude (nmi)	Perigee Altitude (nmi)	Inclination (deg)	Eccen-tricity (nd)	Arg of Perigee (deg)	LAN (deg)	RAAN (deg)
LEO	±12	±5	±0.15	±0.01	n/a	n/a	±0.2
Polar 1	±9	±7	±0.1	n/a	n/a	n/a	n/a
Polar 2	±12	±5	±0.1	±0.01	n/a	n/a	±0.2
Semi-Synch Direct Inject	±210	n/a	±1.0	±0.02	n/a	±2.0	n/a
Semi-Synch Transfer	±210	±4	±0.4	n/a	n/a	n/a	±0.2
GTO	±70	±4	±0.1	n/a	±0.3	±0.5	±0.75
Molniya	±60	±5	±0.1	n/a	±0.1	n/a	±0.1
GEO	±80	±80	±0.1	n/a	n/a	n/a	n/a

Figure 2-1. Orbital Parameter Accuracies

2.2 LAUNCH WINDOW

The AP will support a launch at any time within a primary SV mission-defined launch window.

2.3 AP SEPARATION CONTROL

2.3.1 Control System Capabilities

Centaur will be capable of providing pre-separation characteristics as defined in Figure 2-2.

Separation Parameters at AP Separation Command			
Centaur Body Axis Rates			
About X	0.0 ± 0.2	(3 sigma)	deg/sec
About Y	0.0 ± 0.2	(3 sigma)	deg/sec
About Z	0.0 ± 0.25	(3 sigma)	deg/sec
Centaur Body Axis Attitude Pointing Errors (per axis)	< 1.40	(3 sigma)	deg

Figure 2-2. Control System Capabilities (3-Axis Stabilized Attitude Hold)

All requests for attitude rates and pointing errors at AP separation more restrictive than those listed in Figure 2-2 require LVC approval (See Appendix B).

2.3.2 AP Mass Property Range

The Atlas V Centaur flight control systems can accommodate AP(s) that fall within the range of AP mass properties, correlated with specific vehicle maneuvers, as identified in Figure 2-3. The AP mass properties identified in this figure include the AP(s), any AP adapters and/or separation system hardware that remains attached to the AP after the separation event, and associated 3-sigma uncertainties.

AP(s) that fall outside of these generic design ranges may be accommodated on a mission-peculiar basis (See Appendix B). A mission specific CLA is required for all AP(s) to assess potential impacts to the LV and primary SV. A mission specific separation analysis is required for all APs to verify acceptability of mission specific configurations.

Atlas V Config.	**Pre-AP Separation Maneuver**	**AP Mass, kg (lb)**	**AP Z cg Location, mm (in.)**	**AP X & Y cg Offsets, mm (in.)**
SEC	3-Axis Stabilized Attitude Hold	65.8 ± 11.3 (145 ± 25)	243.84 ± 190.5 (9.6 ± 7.5)	0 ± 12 (0 ± 0.5)
AP coordinate system is defined in section 4.1.1.				

Figure 2-3. Design Range of AP Mass Properties

2.3.3 Separation Velocity and Angular Rates After Separation

The relative separation velocity (between the AP and the Centaur) as well as the AP angular rates after separation are a strong function of the mass properties of the separated AP and the separation mechanism. The ABC separation system is designed to preclude re-contact between the AP and Centaur and provide adequate separation for collision and contamination avoidance. Angular rates after separation are characterized by mission unique separation analyses. If the AP is sensitive to the angular rates after separation, it is recommended that a separation analysis be performed as early as possible during the integration cycle to facilitate separation requirements definition (See Appendix B).

2.3.4 Separation Contingencies

The Launch Vehicle has the flexibility to incorporate mission-unique nominal and contingency flight sequences. Mission-unique flight sequence requirements will be negotiated and documented in the applicable ICD.

2.3.5 Collision and Contamination Avoidance Maneuvers

Collision and Contamination Avoidance Maneuvers (CCAMs) are designed to preclude recontact of the AP with the Centaur and primary SV and to minimize AP exposure to LV contaminants.

2.4 SEPARATION REQUIREMENTS

2.4.1 Separation Mechanism

For separating APs, the LVC will provide the AP separation mechanism to separate the AP from the ABC.

On a mission unique basis, the APC may provide its own separation system, but it must be compatible with the LV separation command capability and must also be compatible with the Separating AP envelope (i.e. be proven by separation analysis to provide acceptable clearances). See Appendix B for additional information.

Section 3
ENVIRONMENTS

3.1 PRELAUNCH ENVIRONMENTS

3.1.1 Thermal

3.1.1.1 Processing. The ABC and the AP will be installed in the ASOC (East Coast)/ Building 7525 (West Coast). The ASOC is an air-conditioned space with a temperature range of approximately 50 to 95 ^{o}F. Building 7525 has heating capability only with a temperature varying anywhere between approximately 50 and 100 ^{o}F. Relative Humidity (RH) is not tightly controlled and reflects launch site ambient (0% to 100% RH). The AP must be capable of withstanding these environments while in these facilities.

3.1.1.2 Transport and Erection/Mate. The ABC and AP are transported from the ASOC/Building 7525 to the VIF/pad while installed on the Centaur. During this period it will be exposed directly to launch site ambient conditions. All exposed equipment and facilities will be designed for a maximum relative humidity of 100% and for exposure to a salt atmosphere as found in a coastal location. The AP must be capable of withstanding this environment including blowing rain, fog, salt fog, sand, dust, fungus and/or other weather conditions.

- Ambient Temperature: 35 ^{o}F to 100 ^{o}F
- Relative Humidity: 0% to 100%

3.1.1.3 Prelaunch. Prior to final close-out of the vehicle, the ABC and the AP will be exposed directly to the VIF/MST environment, purged with the facility Environmental Control System (ECS) or purged with a drag-on blower/HEPA filter. The AP must be capable of withstanding this environment.

Pre-Close-out:

- Ambient Gas Temperature: 35 ^{o}F to 100 ^{o}F
- Relative Humidity: 0% to 100%
- Heat Transfer Coefficient: See Figure 3-16
- Direct inflow of unfiltered/unconditioned air is possible

After final close-out of the vehicle, the ABC and AP will be exposed to an air, nitrogen or helium purge. The purge temperature and resulting compartment ambient temperature vary considerably during prelaunch operations. The AP must be capable of withstanding these environments.

Post-Close-out to Launch (including abort):

- Vehicle located in the VIF/MST and exposed to outside ambient conditions on the launch pad
- Purged with filtered facility air, Nitrogen or Helium

- Ambient Gas Temperature: 50 ^{o}F to the recovery temperatures for the prelaunch ECS values listed in Figure 3-16.
- Relative Humidity: 0% to 60%
- Heat Transfer Coefficient: See Figure 3-16

3.1.2 Electromagnetic Compatibility

The LVC performs an Electromagnetic Interference Safety Margins (EMISM) analysis relative to known RF environments generated by the AP, SV, LV and Western Range RF sources to establish compatibility, for the LV only. The APC will provide the LVC with their analyses for their respect hardware (avionics and RF transmitters/receivers) to support their EMISM evaluation to the RF environments defined above, which will be reviewed by the LVC. The LVC will review the AP margin analyses results in conjunction with the SVC provided SV margin analyses and identify any potential impacts on the AP, SV and LV.

a. Electromagnetic Interference (EMI) emissions and susceptibility of the AP, SV and LV are to be individually controlled to ensure Electromagnetic Compatibility (EMC) of the fully integrated system.
b. EMI control, in the form of wire twisting and shielding, will be implemented in the electrical design.

3.1.2.1 Electromagnetic Interference Safety Margin. The integrated AP/SV/LV system design will provide EMC with a minimum of 20 dB EMISM (vs. dc no-fire thresholds) for ordnance circuits and a minimum of 6 dB EMISM for all other non-ordnance circuits (Category I and II) which are deemed safety or mission critical.

3.1.2.1.1 Payload RF Susceptibility. The AP RF Susceptibility criteria, including a 6 dB EMISM, in the frequency range from 14 kHz to 18.0 GHz will be defined in the LV/AP ICD. The AP will be capable of withstanding RF environments generated by the primary SV and will be evaluated as part of the manifesting process.

3.1.2.2 Launch Vehicle Intentional Narrowband Emissions. The AP will be compatible with the LV worst case intentional narrowband radiated emissions (E-Fields) as shown in Figure 3-1 and Figure 3-2. Figure 3-1 is a composite of the worst case RF environment that would be expected from an Atlas V 400 or 500 series LV.

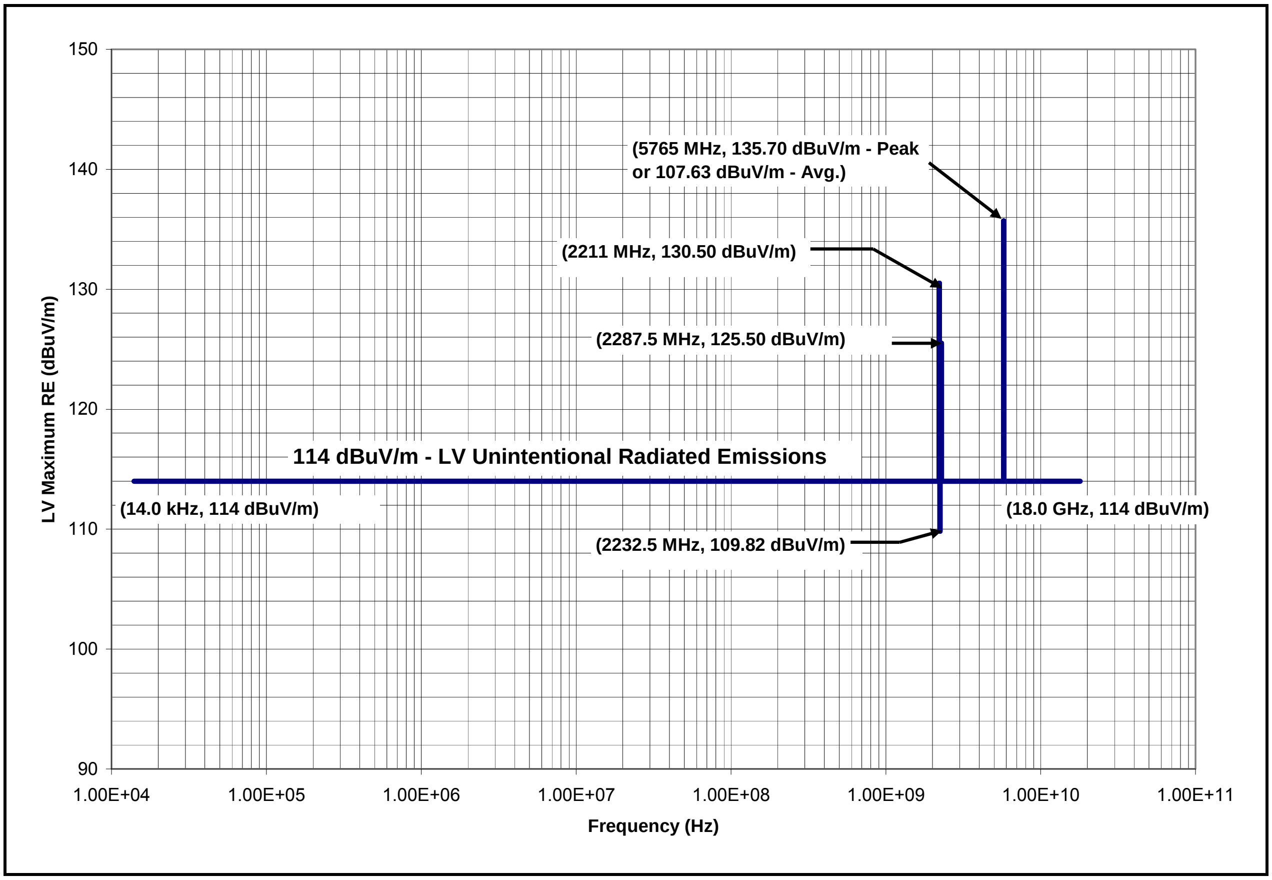


Figure 3-1. Maximum LV Intentional Narrowband Radiated Emissions

	Operational Frequency (MHz)	400 LV Worst Case (dBuV/m) / (V/m)	500 LV Worst Case (dBuV/m) / (V/m)
Centaur C-Band (Omni)	5765	135.7023 (6.097)	134.3017 (5.189)
Centaur S-Band (Omni)	2211	121.9936 (1.258)	122.5421 (1.340)
Centaur S-Band (Single)	2211	124.8309 (1.744)	124.8459 (1.747)
Centaur S-Band BISA (Omni)	2211	N/A	130.4983 (3.349)
Booster S-Band (Omni)	2232.5	109.8272 (0.310)	109.8272 (0.310)
Centaur Video (Single)	2255.5 & 2272.5	120.5877 (1.070)	120.8041 (1.097)
Booster Video (Omni)	2272.5	108.9741 (0.281)	108.9741 (0.281)
GPS Metric Tracking System	2287.5	125.4647 (1.876)	124.6548 (1.709)
Note: (1) Look Angle to the ABC Payload - 2 Degree			

Figure 3-2. Maximum LV Intentional Narrowband Radiated Emissions

3.1.2.3 Launch Vehicle Unintentional RF Emissions. Unintentional narrowband radiated emissions from Centaur equipment/avionics/RF transmitters and receivers will not exceed 114 dBμV/m in the frequency range from 14 kHz to 18 GHz, as displayed in Figure 3-3, at the AP static envelope.

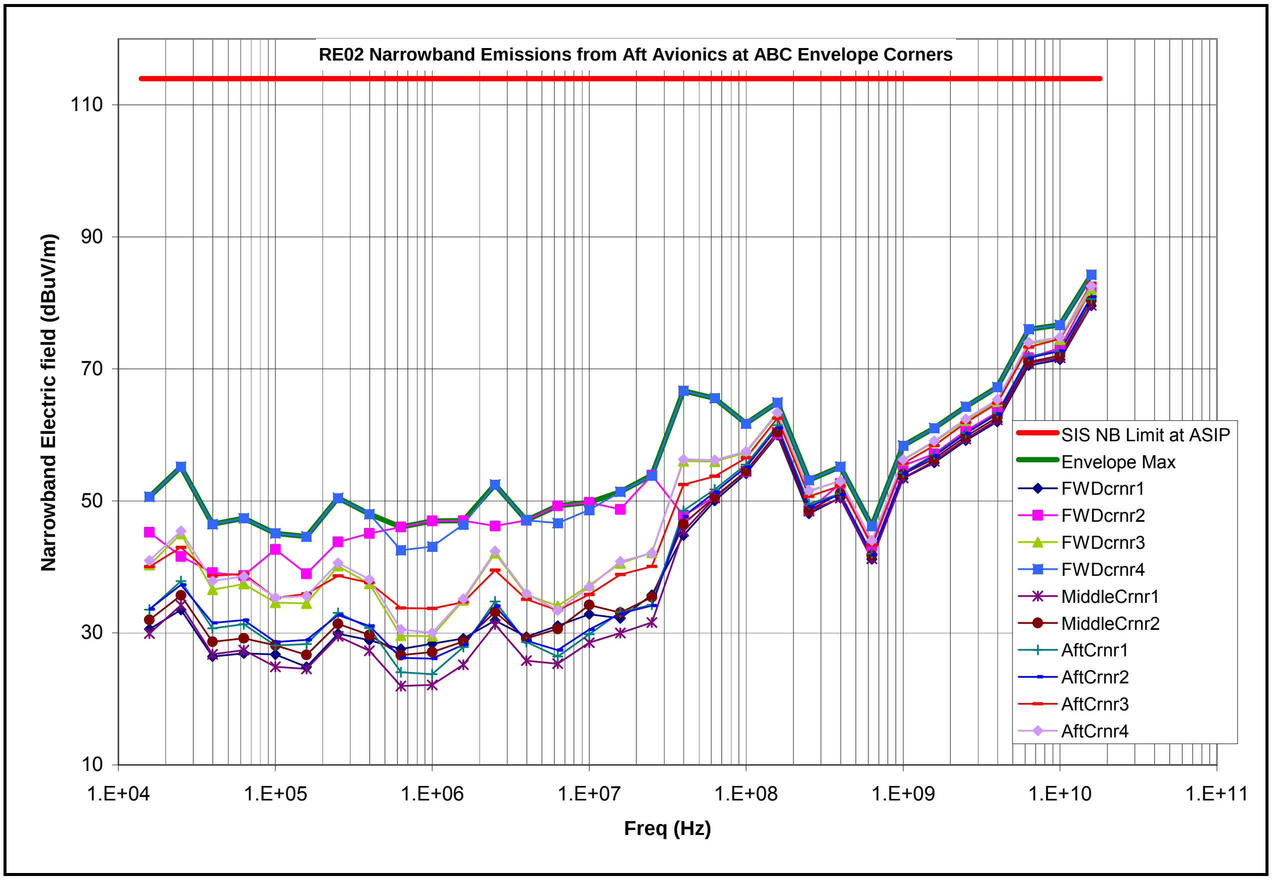


Figure 3-3. Bulkhead Narrowband Emissions Observed at the ABC Payload Envelope

3.1.2.4 Launch Complex Electromagnetic Environment. The flight configured AP/SV/LV integrated system will be compatible with the Eastern or Western Range RF sources located near VIF/LC-41 or SLC-3E, respectively. Figures 3-4 and 3-5 summarize the known range controlled RF environments at the time of release of this User's Guide. E-field levels and RF sources will be updated as required for the mission. Consult with ULA for the latest environments.

a. The AP will address individual system compatibility with the known RF environments defined in Figures 3-4 and 3-5.

b. The LVC coordinates masking or attenuation of Range controlled RF sources during encapsulated transport and at the launch complex (VIF/LC-41 or SLC-3E).

Emitter Name	Frequency (MHz) (1)	Theoretical and/or Measured Peak Intensity (V/m) (1) (3)		Duty Cycle (1) (2)	Mitigation (1)	
CSAS Orbit	406.5 / 416.5 / 421.0	*0.24*		*1.0*	None	
Radar ARSR-4	1244.06, 1326.92	*1.28*		*0.0432*	None	
GPS Grnd Antenna	1783.74	*2.37*		*1.0*	None	
NASA STDN	2041 & 2106	*0.96*		*1.0*	None	
Miscellaneous #1	2710 & 2720	*4.47*		*0.0012*	None	
Miscellaneous #2	2800	*1.06*		*0.0008*	None	
Miscellaneous #3	2750 – 2840	*5.27*	*(2.18)(6)*	*0.0008*	None	Measured
WSR-88D (NEXRAD)	2865	*12.83*	*(0.10)(6)*	*0.006*	See Note 10	Measured
SRB Retrieval Ship (S-Band)	3049.4	*3.79*		*0.00072*	None	
SRB Retrieval Ship (S-Band)(9) (North Dock)	3049.4	*16.91*		*0.00072*	See Note 10	
Miscellaneous #4	3050	*1.64*		*0.00072*	None	
SLF Avian Radar (North)	2900-3100	*0.13*		*0.11765*	None	
SLF Avian Radar (South)	2900-3100	*0.19*		*0.11765*	None	
Channel 35 Weather	5470	*17.43*		*0.010*	See Note 10	
Channel 9 Weather	5555	*9.94*		*0.010*	See Note 10	
Channel 2 Weather	5570	*4.66*		*0.0032*	None	
WSR-74C	5625	*10.75*	*(0.07)(6)*	*0.0064*	See Note 10	Measured
TDR 43-250	5625	*10.48*		*0.0030*	See Note 10	
TDWR	5640	**10.00**		**0.010**	Topography(5)	
Radar 0.134	5690	**83.90(4)**		**0.0016**	Procedure Mask	
Radar 1.16	5690	**55.35(4)**		**0.00064**	Procedure Mask	
Radar 19.39	5710	**30.77(4)**		**0.005**	Procedure Mask	
Radar 19.14	5690	**109.50(4)**		**0.0016**	Procedure Mask	
Radar 19.17	5690	**55.05(4)**		**0.0008**	Procedure Mask	
Radar 28.14	5690	**15.53**		**0.0016**	Topography(5)	
NDR (MCR) C-Band Pulse Doppler	5525	**172.98(4)**		**0.004**	Ops Min 5 degrees Elevation(5)	
SRB Retrieval Ship (X-Band)	9413.6	*0.91*		*0.00072*	None	
SRB Retrieval Ship (X-Band)(9) (North Dock)	9413.6	*4.08*		*0.00072*	See Note 10	
Miscellaneous #5	9410	*2.51*		*0.00072*	None	
ET Barge Tug	9340	*4.17(8)*		*0.0012*	See Note 10	
Miscellaneous #6	9407	**41.93**	*(0.13)(6)*	**0.00072**	See Note 10	Measured
Miscellaneous #7	9410	*2.01*		*0.00072*	None	
Miscellaneous #8	9410	*2.44*		*0.0024*	None	
Miscellaneous #9	9410	***24.31***		**0.0024**	See Note 10	
Cruise Ships	9410	*2.26*		*0.0012*	None	
NASA Avian Detector	9410	2.41		0.0005	Ops Min 25.5 deg Elevation(5)	

Figure 3-4. RF Environment at LC-41/VIF

Emitter Name	**Frequency (MHz)** (1)	**Theoretical and/or Measured Peak Intensity (V/m)** (1) (3)	**Duty Cycle** (1) (2)	**Mitigation** (1)
Radar Test Bed (7)	5690	*25.90*	*0.0016*	OR Restrict to ≤20 V/m(7)
NASA X-Band CW Hangar (Liberty)	10490 & 10499	**4.39**	**1.0**	Ops Min 5 degrees Elevation
NASA X-Band CW (LCU)	10490 & 10499	*1.75*	*1.0*	None
NASA X-Band CW (Haulover Canal)	10490 & 10499	*1.64*	*1.0*	None
NASA X-Band CW (Channel Closest)	10490 & 10499	**5.43**	*1.0*	None
Aircraft	2000 – 4000, 7000 – 12000	*4.0*	*0.01*	None

Notes:

(1) RF E-field Environments taken from Cape Canaveral Radio Frequency Environment: Eastern Range, Aerospace Report No. TOR-2009(1663)-1 dated 30 December 2009.
(2) Avg. V/m = PkV/m*sqrt(Duty Cycle).
(3) Bold sources in shaded cells indicate masking or blanking that prevents emissions in direction of site: Non shaded bold sources indicate site below beam (topography) or blocked by emitter horizon; Italicized sources indicate no masking or topography controls.
(4) In-flight tracking levels for Tracking Radars (0.134, 1.16, 19.39, 19.14, 19.17 and NASA C-Band) are typically 20 V/m.
(5) E-field levels are above the VIF/MLP – E-fields will be seen after launch.
(6) Measured E-fields indicated by ( ) - in VIF at Level 6 – Test Report, BOEING-KSC-N120-53434-05 dated 9 February 2005.
(7) Radar Test Bed is pointing up when not in use.
(8) Results based on closest approach during ET Barge transit. If radar is on south of Causeway Bridge, field level only reaches 1.19 V/m.
(9) Results based on SRB Retrieval Ship being used as ET Barge tug vessel. SRB Retrieval Ships only venture north of Cause way Bridge during KSC open house.
(10) AP will comply with paragraph 3.1.2.1.

Figure 3-4. RF Environment at LC-41/VIF (cont)

Emitter Name	**Frequency (MHz) (1)**	**Theoretical Intensity (1) (V/m)**		**Duty Cycle (1) (2)**	**Mitigation (1) (3)**	
CT-1	416.5 / 421.0	*0.50*		*1.0*	NC	
CT-5	416.5 / 421.0	*3.08*		*1.0*	NC	
CT-3	416.5 / 421.0	*1.71*		*1.0*	NC	
ATCBI-6	1030	*0.04*		*1.0*	NC	
AN/FRN-45	1146	*0.05*		*0.0252*	NC	
Unknown Source	1249	*9.2*		*unknown*	NC	Measured Roof
ARSR-4	1262 & 1345	*18.27*	*(5.91)*	*0.02592*	NC(6)	Measured Roof
SGLS-46	1750-1850	*2.15*		*1.0*	NC	
ASR-11	2750 & 2845	*1.32*		*0.050018*	NC	
NEXRAD	2890	*25.77*	*(32.06)*	*0.006149*	NC(6)	Measured Roof
Unknown Source	2956	*22.3*		*unknown*	NC	
FPS-16-1	5725	*94.57*		*0.00064*	See Note 8	
HAIR	5400-5900	*254.93*		*0.002*	See Note 8	
TPQ-18	5840	*1014.90*		0.000384	See Note 8	
PULSTAR	9245 & 9392	*33.05*	*(23.43)*	*0.010*	See Note 8	Measured Roof
Miscel. Radars	9410	*3.73*		*0.00072*	Procedure Masked – Sector Controlled	
Marine (South)(9)	3040-3060 / 9410	*5.92*		*0.0012*	NC	
Marine (Central)(9)	3040-3060 / 9410	*13.82*		*0.0012*	NC	
Marine (North)(9)	3040-3060 / 9410	*4.30*		*0.0012*	NC	

Notes:

(1) RF E-field Environments taken from Vandenberg Air Force Base Radio Frequency Environment, Aerospace Report No. TOR-2009(3908)-9178 dated 30 June 2009.

(2) Avg. V/m = PkV/m*sqrt(Duty Cycle).

(3) NC = Not Controlled.

(4) Bold sources in shaded cells indicates masking or blanking that prevents emissions in direction of site; Non-shaded bold sources indicate site below beam (topography) or blocked by emitter horizon; italicized sources indicate no masking or topography controls.

(5) In-flight tracking levels for Tracking Radars (FPS-16-1, HAIR, TPQ-18 and PULSTAR) are typically 20 V/m.

(6) E-field levels are above the SLC-3E – E-fields will be seen after launch.

(7) Measured E-fields indicated by ( ).

(8) AP will comply with paragraph 3.1.2.1.

(9) Low Probability of occurrence.

Figure 3-5. Western Range RF Environment at SLC-3E

3.1.2.4.1 Transport Electromagnetic Environment. The transport RF environment at CCAFS is presented in Figure 3-6 and the transport RF environment at VAFB is presented in Figure 3-7 (at the time of release of this User's Guide). E-field levels and RF sources will be updated as required for the mission.

Emitter Name	Frequency (MHz) (1)	Theoretical and/or Measured Pea Intensity (V/m) (1) (3)	Duty Cycle (1) (2)	Mitigation (1)
CSAS Orbit	406.5 / 416.5 / 421.0	*0.44*	*1.0*	None
Radar ARSR-4	1244.06, 1326.92	*1.42*	*0.0432*	None
GPS Grnd Antenna	1783.74	*4.94*	*1.0*	None
NASA STDN	2041 & 2106	*1.34*	*1.0*	None
Miscellaneous #1	2710 & 2720	*4.64*	*0.0012*	None
Miscellaneous #2	2800	*1.04*	*0.0008*	None
Miscellaneous #3	2750 - 2840	*6.26*	*0.0008*	None
WSR-88D (NEXRAD)	2865	*14.54*	*0.006*	See Note 6
SRB Retrieval Ship (S-Band)	3049.4	*9.94*	*0.00072*	See Note 6
SRB Retrieval Ship (S-Band)(5) (North Dock)	3049.4	*6.19*	*0.00072*	None
Miscellaneous #4	3050	*2.45*	*0.00072*	None
SLF Avian Radar (North)	2900-3100	*0.13*	*0.11765*	None
SLF Avian Radar (South)	2900-3100	*0.19*	*0.11765*	None
Channel 35 Weather	5470	*17.78*	*0.010*	See Note 6
Channel 9 Weather	5555	*10.07*	*0.010*	See Note 6
Channel 2 Weather	5570	*4.71*	*0.0032*	None
WSR-74C	5625	*12.94*	*0.0064*	See Note 6
TDR 43-250	5625	*11.57*	*0.0030*	See Note 6
TDWR	5640	*10.42*	*0.010*	See Note 6
Radar 0.134	5690	**99.26**	**0.0016**	Procedure Mask
Radar 1.16	5690	*116.02*	*0.00064*	See Note 6
Radar 19.39	5710	*48.23*	*0.005*	See Note 6
Radar 19.14	5690	*160.59*	*0.0016*	See Note 6
Radar 19.17	5690	*53.98*	*0.0008*	See Note 6
Radar 28.14	5690	**16.00**	**0.0016**	Topography
NDR (MCR) C-Band Pulse Doppler	5525	**170.57**	**0.004**	See Note 6
SRB Retrieval Ship (X-Band)	9413.6	*2.28*	*0.00072*	None
SRB Retrieval Ship (X-Band)(5) (North Dock)	9413.6	**1.49**	*0.00072*	See Note 6

Figure 3-6. RF Environment During Transport from ASOC to LC-41

Emitter Name	Frequency (MHz) (1)	Theoretical and/or Measured Peak Intensity (V/m) (1) (3)	Duty Cycle (1) (2)	Mitigation (1)
Miscellaneous #5	9410	*3.75*	*0.00072*	None
ET Barge Tug	9340	*4.15*	*0.0012*	See Note 6
Miscellaneous #6	9407	**24.52**	**0.00072**	See Note 6
Miscellaneous #7	9410	*3.11*	*0.00072*	None
Miscellaneous #8	9410	*2.30*	*0.0024*	None
Miscellaneous #9	9410	*14.17*	*0.0024*	See Note 6
Cruise Ships	9410	*3.32*	*0.0012*	None
NASA Avian Detector	9410	**2.24**	**0.0005**	None
Radar Test Bed (4)	5690	30.68	0.0016	None
NASA X-Band CW Hangar (Liberty)	10490 & 10499	**10.93**	***1.0***	None
NASA X-Band CW (LCU)	10490 & 10499	*1.94*	*1.0*	None
NASA X-Band CW (Haulover Canal)	10490 & 10499	*1.94*	*1.0*	None
Aircraft	2000 – 4000, 7000 – 12000	*4.0*	*0.01*	None

Notes:
(1) RF E-field Environments taken from Cape Canaveral Radio Frequency Environment: Eastern Range, Aero-space Report No. TOR-2009(1663)-1 dated 30 December 2009.
(2) Avg. V/m = PkV/m*sqrt(Duty Cycle).
(3) Bold sources in shaded cells indicate masking or blanking that prevents emissions in direction of site; Non shaded bold sources indicate site below beam (topography) or blocked by emitter horizon; Italicized sources indicate no masking or topography controls.
(4) Radar Test Bed is pointing up when not in use.
(5) Results based on SRB Retrieval Ship being used as ET Barge tug vessel.
(6) AP will comply with paragraph 3.1.2.1.

Figure 3-6. RF Environment During Transport from ASOC to LC-41 (cont)

Emitter Name	Frequency (MHz) (1)	Theoretical Intensity (1) (V/m)	Duty Cycle (1) (2)	Mitigation (1)(3)
CT-1	416.5 / 421.0	*1.34*	*1.0*	NC
CT-5	416.5 / 421.0	*17.44*	*1.0*	NC
CT-3	416.5 / 421.0	*1.71*	*1.0*	NC
ATCBI-6	1030	*0.04*	*1.0*	NC
AN/FRN-45	1146	*0.12*	*0.0252*	NC
ARSR-4	1262 & 1345	*18.24*	*0.02592*	NC
SGLS-46	1750 - 1850	*3.94*	*1.0*	NC
ASR-11	2750 & 2845	*1.96*	*0.050018*	NC
NEXRAD	2890	*38.54*	*0.006149*	NC
FPS-16-1	5725	*94.41*	0.00064	See Note 5
HAIR	5400 - 5900	*383.79*	0.002	See Note 5
TPQ-18	5840	*3604.36*	0.000384	See Note 5
PULSTAR	9245 & 9392	*86.28*	*0.010*	See Note 5
Miscel. Radars	9410	*3.73*	0.00072	Procedure Masked – Sector Controlled
Marine (South)(6)	3040-3060 / 9410	*5.92*	*0.0012*	NC
Marine (Central)(6)	3040-3060 / 9410	*41.04*	*0.0012*	NC
Marine (North)(6)	3040-3060 / 9410	*5.76*	*0.0012*	NC

Notes:

(1) RF E-field Environments taken from Vandenberg Air Force Base Radio Frequency Environment, Aerospace Report No. TOR-2009(3908)-9178 dated 30 June 2009.

(2) Avg. V/m = PkV/m*sqrt(Duty Cycle).

(3) NC = Not Controlled.

(4) Bold sources in shaded cells indicates masking or blanking that prevents emissions in direction of site; Non-shaded bold sources indicate site below beam (topography) or blocked by emitter horizon; italicized sources indicate no masking or topography controls.

(5) AP will comply with paragraph 3.1.2.1.

(6) Low probability of occurrence.

Figure 3-7. Western Range RF Environment During Transport from Bldg. 7525 to SLC-3E

3.1.2.5 AP Generated EMC Environment Limitation.

a. AP Radiated Emissions Measurements

Nominally, the AP is powered off and will not create EMI. The AP will provide the radiated emission measurements performed in accordance with MIL-STD-461C/462, Requirements and Test Methods RE01 (B-Field emissions) and RE02 (E-Field emissions) to the LVC. The RE02 measurements will be employed to verify compliance with the limits outlined in Figure 3-8. RE01 measurements will be employed to address any Primary SV magnetic field limits imposed via the LV/SV ICD. For receivers, Figure 3-8 is applicable at Centaur Station 106.9. For LV avionics, Figure 3-8 is applicable at the AP/LV separation plane.

b. Conducted Emissions Controls

Coupled conducted emissions between the AP and Atlas V Centaur harnesses will be controlled with the implementation of double shields on the AP dedicated harnesses from the T-0 interface to the AP separation interface on the aft end of the Atlas V Centaur.

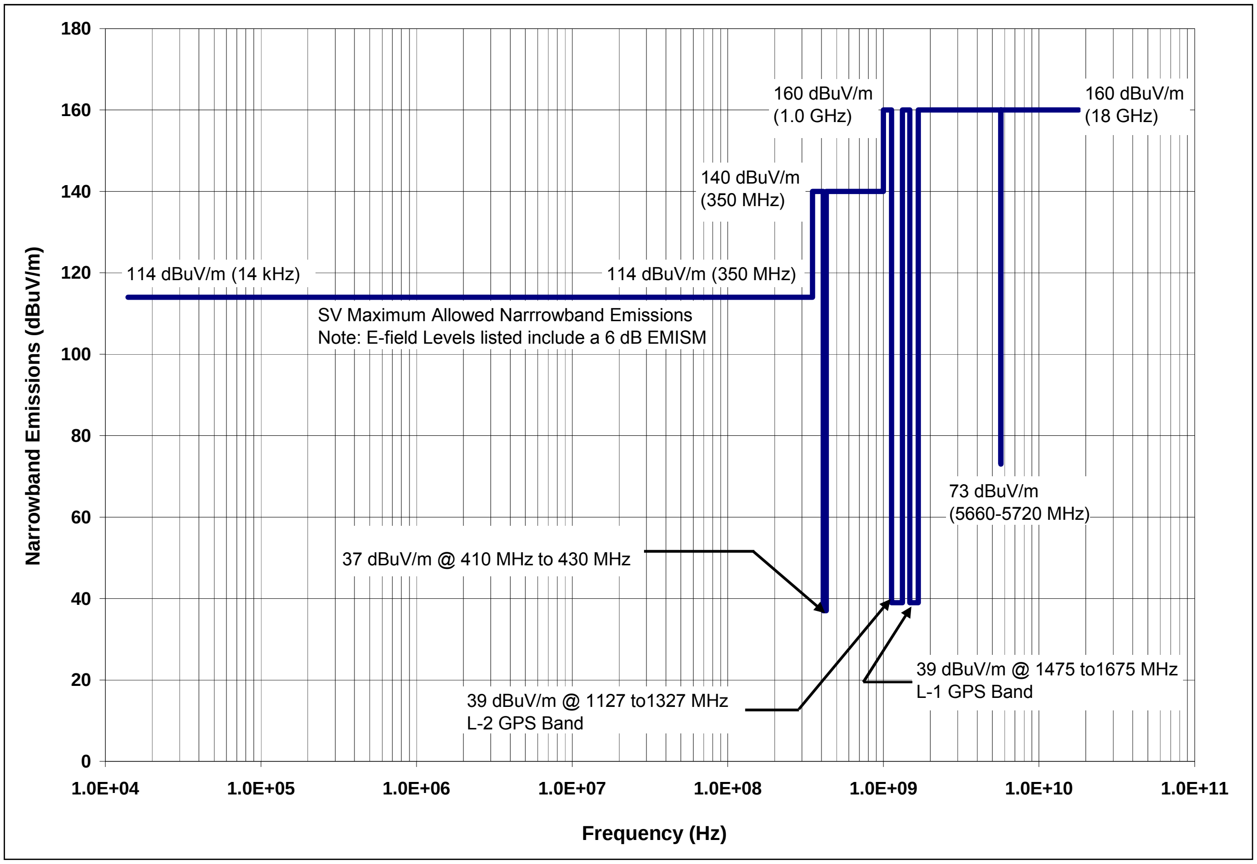


Figure 3-8. AP Maximum Narrowband Emissions (Unintentional & Intentional) Limits

3.1.2.5.1 Payload Maximum EIRP – Intentional Radiated Emissions. The AP will not activate transmitting antenna(s) (frequency range from 14 kHz to 18 GHz) having an EIRP equal to or less than 39 dBm (7.94 Watts), closer than 30.5 meters (100 feet) from the Atlas V Centaur or the Primary SV. The AP will not activate transmitting antenna(s) (frequencies ≥ 350 MHz and ≤ 18.0 GHz) having an EIRP greater than 39 dBm (7.94 Watts) and less than or equal to 43.8 dBm (24 Watts) closer than 2.7 meters (8.85 feet) from the Atlas V Centaur or the Primary SV. EIRPs greater than 43.8 dBm (24 Watts) or APs with transmitting frequencies below 350 MHz will be evaluated by the Atlas V EMC group for impacts on the Atlas V Centaur and the Primary SV. (Note: It is assumed that the primary SV has been tested to a 20 V/m RF susceptibility level above 350 MHz).

3.1.2.5.2 ABC Auxiliary Payload LV Provided Power. Mission unique deviations from paragraph 4.2.4.2, Ascent Power, will require additional conducted emissions testing in accordance with MIL-STD-461C/462 test methods (CE01, CE03, CE07, etc.) to evaluate the impact to LV avionics components, i.e., URCU and/or ORCA.

3.1.2.5.3 AP Static Magnetic Field Limitations. Static magnetic fields due to intentional AP magnetic materials, if any, must be less than 0.5 gauss at the AP envelope. AP static magnetic fields at the SV must be evaluated as part of the manifesting process.

3.1.2.6 Centaur Thermal Blankets. The Centaur vehicle can transition through parts of the Van Allen Radiation belts (depending on the trajectory employed to deliver the SV to orbit), which may result in possible charging/discharging of the Centaur thermal blankets.

a. An evaluation of the trajectory will be performed to determine passage of AP/SV/Centaur through the space radiation region prior to AP separation.
b. The LV broadband radiated emission peak levels caused by an electrostatic discharge from the Centaur/AP passage through the space radiation regions (defined as an Earth magnetic L-shell > 5.5) are defined in Figure 3-9. The AP will be compatible with the LV broadband radiated emissions shown in Figure 3-9.

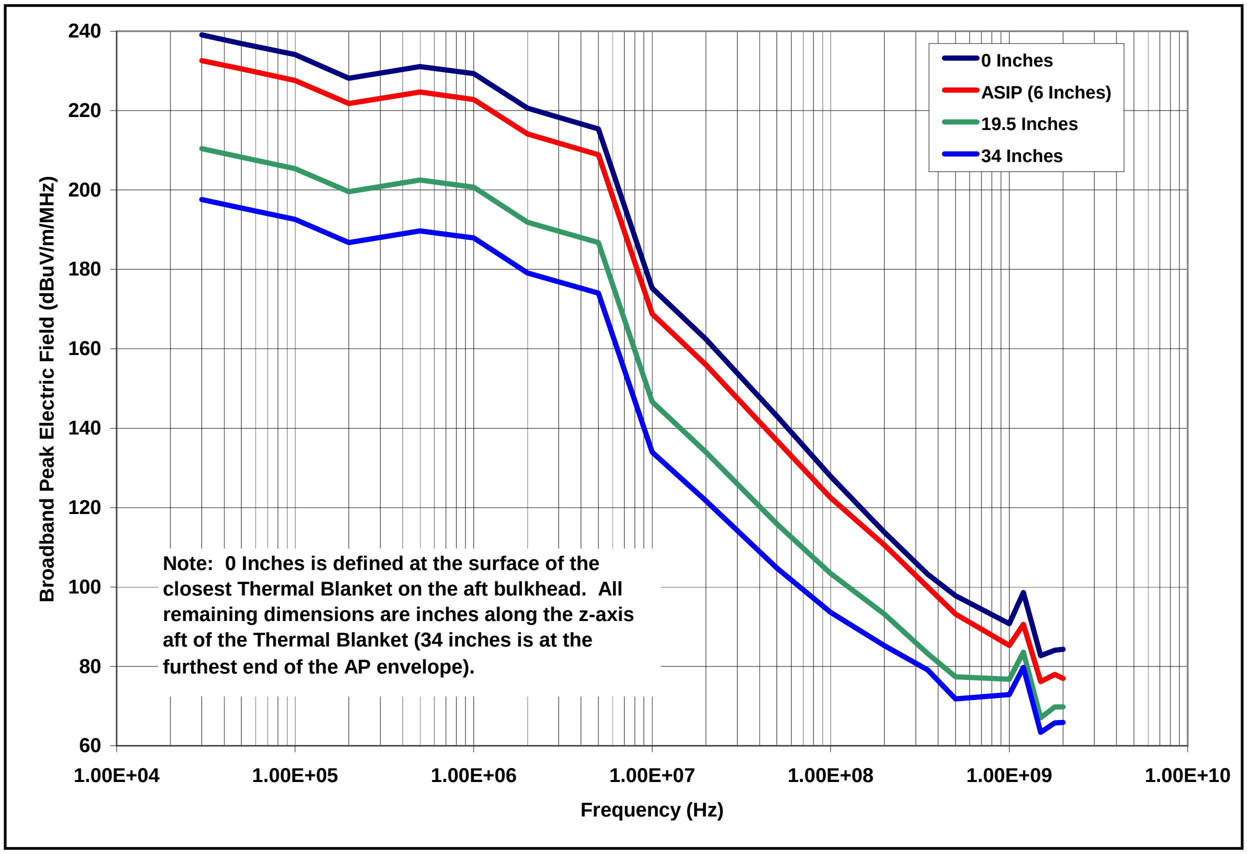


Figure 3-9. Centaur Thermal Blanket ESD Environment

3.1.2.7 Lightning Mitigation. Lightning mitigation is provided by the air terminal systems employed at the VIF/LC-41 (Eastern Range) and MST/SLC-3E (Western Range) along with the umbilical harnesses shields. Augmentation of the standard provisions for any necessary individual circuit protection is the responsibility of the AP.

3.1.2.8 Handheld Portable Devices. The AP may use the information present in Figure 3-10 to define the applicable keep-out distance for handheld portable devices required to maintain a 6 dB EMISM relative to RF susceptibility criteria identified in paragraph 3.1.2.1.1. Updates to the handheld portable device parameters presented in Figure 3-10 will be provided as required.

Portable Unit	RF Band	Frequency (Hz)	Near to Far-Field Transition (meters)	Power (Watts)	Power (dBm)	Gain (dB)	Losses (dB)	EIRP (dBm)
Walkie-Talkies (151.865 MHz) Motorola CP200 (AAH50KDC9AA1(2)AN) - **Retuned to 1 Watt (all chnls) - SLC-3E**	VHF	1.519E+08	3.14E-01	**1**	30.0000	3	0	33.0000
Walkie-Talkies (380-399 MHz) - Carried by Security Forces at VAFB	UHF	3.800E+08	1.26E-01	**4**	36.0206	3	0	39.0206
Ron Load Cell 2501 S-20	UHF	4.339E+08	1.10E-01	0.01	10.0000	3	0	13.0000
Two-Way Pagers - Lower Band	UHF	4.580E+08	1.04E-01	2	33.0103	3	0	36.0103
Walkie-Talkies (462.2(ch2) to 462.45(ch4) MHz - Analog) CP150 & CP200 - **L Ops Specially Tuned to 0.1 Watt - LC-41**	UHF	4.620E+08	1.03E-01	**0.1**	20.0000	3	0	23.0000
Walkie-Talkies (462.2(ch2) to 462.45(ch4) MHz - Analog) CP150, CT250 & CP200 - **L Ops Tuned to less than or equal to 2 Watt - LC-41**	UHF	4.620E+08	1.03E-01	**2**	33.0103	3	0	36.0103
Remote Keyless Entry	UHF	8.000E+08	5.97E-02	0.1	20.0000	3	0	23.0000
Cell Phone	UHF	8.240E+08	5.79E-02	2	33.0103	3	0	36.0103
Cell Phone	UHF	8.490E+08	5.62E-02	2	33.0103	3	0	36.0103
Sprint AirCard 597E, Verizon Air Card 595 (Cell Operations 824 to 849 MHz, 1.25 MHz Channel Spacing)	UHF	8.240E+08	5.79E-02	0.2	23.0103	5.55	0	28.5603
Sprint AirCard 597E, Verizon Air Card 595 (Cell Operations 824 to 849 MHz, 1.25 MHz Channel Spacing)	UHF	8.490E+08	5.62E-02	0.2	23.0103	5.55	0	28.5603
BlackBerry (850/ 950 MHz), 2G iPhone (850/900 MHz), 3G iPhone (850 MHz) other Smart Phones (Protocals GSM/EDGE/UMTS/HSDPA)	UHF	8.240E+08	5.79E-02	2	33.0103	3	0	36.0103
BlackBerry (850/ 950 MHz), 2G iPhone (850/900 MHz), 3G iPhone (850 MHz) other Smart Phones (Protocals GSM/EDGE/UMTS/HSDPA)	UHF	8.490E+08	5.62E-02	2	33.0103	3	0	36.0103
Two-Way Pagers - Upper Band	UHF	9.000E+08	5.31E-02	2	33.0103	3	0	36.0103
Cell Phone	S-Band	1.710E+09	2.79E-02	2	33.0103	3	0	36.0103
Cell Phone	S-Band	1.755E+09	2.72E-02	2	33.0103	3	0	36.0103
BlackBerry (1800/1900 MHz), 2G iPhone (1800/1900 MHz), 3G iPhone (1900 MHz) other Smart Phones (Protocals GSM/EDGE/UMTS/HSDPA)	S-Band	1.850E+09	2.58E-02	2	33.0103	3	0	36.0103
BlackBerry (1800/1900 MHz), 2G iPhone (1800/1900 MHz), 3G iPhone (1900 MHz) other Smart Phones (Protocals GSM/EDGE/UMTS/HSDPA)	S-Band	1.910E+09	2.50E-02	2	33.0103	3	0	36.0103
Sprint AirCard 597E, Verizon Air Card 595 (CDMA Operations 1805 to 1870 MHz, 1.25 MHz Channel Spacing)	S-Band	1.805E+09	2.65E-02	0.2	23.0103	4.95	0	27.9603
Sprint AirCard 597E, Verizon Air Card 595 (CDMA Operations 1805 to 1870 MHz, 1.25 MHz Channel Spacing)	S-Band	1.870E+09	2.55E-02	0.2	23.0103	4.95	0	27.9603
Cell Phone	S-Band	1.850E+09	2.58E-02	2	33.0103	3	0	36.0103
Cell Phone	S-Band	1.910E+09	2.50E-02	2	33.0103	3	0	36.0103
ScanSmart Bar Code Reader	S-Band	2.000E+09	2.39E-02	0.6	27.7815	10	0	37.7815
World Phone	S-Band	2.100E+09	2.27E-02	2	33.0103	3	0	36.0103
Wireless LAN (802.11 n - 2.402 to 2.485 GHz)	S-Band	2.402E+09	1.99E-02	0.07943	18.9998	2.2	0	21.1998
Wireless LAN Base Station - ASOC	S-Band	2.440E+09	1.96E-02	0.05	16.9897	2.2	-6.8	12.3897
Wireless LAN Base Station - VIF	S-Band	2.440E+09	1.96E-02	0.05	16.9897	2.2	-6.8	12.3897
Wireless LAN Base Station - PAD	S-Band	2.440E+09	1.96E-02	0.05	16.9897	12	-6.8	22.1897
PDA	S-Band	2.440E+09	1.96E-02	0.6	27.7815	3	0	30.7815
Wireless LAN - Toshiba Tablets	S-Band	2.483E+09	1.92E-02	0.032	15.0515	3	0	18.0515
Wireless LAN - Computer PC Cardbus (802.11 b/g - 2412 to 2484 MHz)	S-Band	2.484E+09	1.92E-02	0.1	20.0000	3	0	23.0000
Wireless LAN Base Station - MST/Level 12	S-Band	2.483E+09	1.92E-02	0.0324	15.1055	3	0	18.1055
Wireless LAN Base Station - MST/Level 7	S-Band	2.483E+09	1.92E-02	0.0213	13.2838	3	0	16.2838
Wireless LAN Base Station - MST/Level 2	S-Band	2.483E+09	1.92E-02	0.0213	13.2838	3	0	16.2838
SLC-3E Fuel Farms (4 Antennas)	S-Band	2.483E+09	1.92E-02	0.0535	17.2835	3	0	20.2835
Dillion Load Cell EDx-50k - Bluetooth	S-Band	2.478E+09	1.93E-02	0.01	10.0000	3	0	13.0000
Bluetooth (Class 1)	S-Band	2.484E+09	1.92E-02	0.1	20.0000	3	0	23.0000
Wireless LAN (802.11 n - 5.15 to 5.25 GHz, 5.25 to 5.35 GHz, 5.47 to 5.75 GHz, 5.75 to 5.85 GHz)	C-Band	5.150E+09	9.27E-03	0.05	16.9897	3	0	19.9897
Wireless LAN - Computer PC Cardbus (802.11 a - 5170 to 5805 MHz)	C-Band	5.805E+09	8.23E-03	0.04	16.0206	3	0	19.0206
Digital Phone - Spread Spectrum	C-Band	5.800E+09	8.23E-03	1	30.0000	3	0	33.0000

Figure 3-10. Handheld Portable Device Operational Parameters

3.1.2.9 AP Transmitter/Receiver RF Parameters. The AP will provide information on their intentional transmitters and receivers. Those parameters will include at a minimum the antenna(s) gain (dBi), transmitter maximum power at the antenna (dBm), receiver bandwidths (3 dB and 60 dB), receiver thresholds and receiver damage levels. The AP also needs to demonstrate for their intentional RF transmitter(s) the required three independent inhibits as defined in AFSPCMAN 91-710.

The AP will be capable of withstanding the RF environment generated by the Primary SV. This will be evaluated as part of the manifesting process.

3.1.2.10 LVC Ordnance Installation/Mating Operations. The AP must be capable of being completely powered down at selected times during LV processing. The AP will be required to power down when the LVC performs ordnance installation and mating operations at the associated launch complex (VIF/LC-41 or SLC-3E). Any exceptions must be evaluated by Range Safety.

3.1.2.11 Primary SV and AP Compatibility. The AP will demonstrate EMC with the Primary SV during leading edge compatibility evaluations. RF environments to be considered by the APC are Primary SV unintentional and intentional radiated emissions and RF resonant environments resulting from the operations of a re-radiation antenna system within the interior of a 5.4 meter Payload Fairing.

The Primary SV must also address EMC relative to AP unintentional radiated emissions impacts on EEDs, avionics, and receivers during the leading edge evaluation. In addition, AP mission unique intentional and unintentional radiated emissions must not violate the Primary SV RF susceptibility criteria at the LV/SV separation plane.

3.1.3 Contamination Control and Cleanliness

3.1.3.1 Aft Bulkhead Contamination Environment. The Aft Bulkhead and attached hardware will be maintained at a Generally Clean (GC) level through launch.

During Centaur hoist and mate with the booster, the aft end of the Centaur is exposed to the ambient environment without protection. At the launch pad, there is a potential for rain mist to enter the ISA compartment.

After Centaur mate to the booster, the ISA compartment environment is continuously purged with Class 5000, High-Efficiency Particulate Air (HEPA) filtered air.

3.1.3.2 Aft Bulkhead Helium Environment in Prelaunch Operations. The Aft Bulkhead helium environment for the 4XX and 5XX series ABC configuration, assuming 4 launch aborts, is 3000 Torr-hours.

3.1.4 Centaur Transport and Hoist Loads

The Centaur is shipped on its side mounted to the transport fixture. The usual Centaur shock recorder axes are as follows: X = fore/aft (in the direction of transport); Y = side to side; Z = up and down as shipped.

Centaur transport and hoist maximum allowable accelerations with 25 Hz low-pass filter applied are:

X = +/- 1.5 g's (fore and aft)
Y = +/- 1.0 g's (lateral side to side)
Z = +/- 1.5 g's (vertical up and down)

Note: In this configuration, +/- X corresponds to the Centaur Longitudinal axis, +/- Y corresponds to 120° & 300°, and +/- Z corresponds to 30° & 210°.

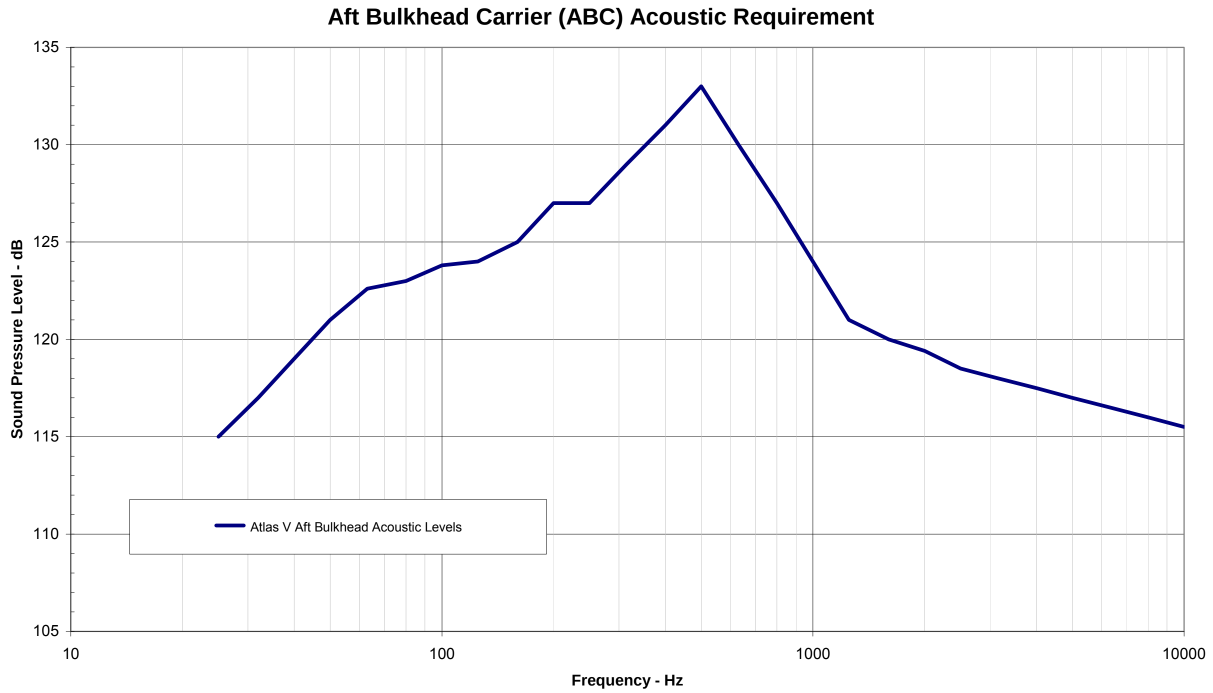
3.2 LAUNCH AND FLIGHT ENVIRONMENTS

3.2.1 Spacecraft Design Load Factors

The AP will be capable of withstanding the following maximum predicted environment. Acceleration limit load factors (not including factors of safety) are 7 g's Z_{AP} and 5 g's X_{AP} and Y_{AP} applied simultaneously. These loads should be applied at the CG of the AP in the AP coordinate system as defined in Section 4.1.1.

3.2.2 Acoustics

The AP will be capable of withstanding the maximum predicted environment as shown in Figure 3-11.

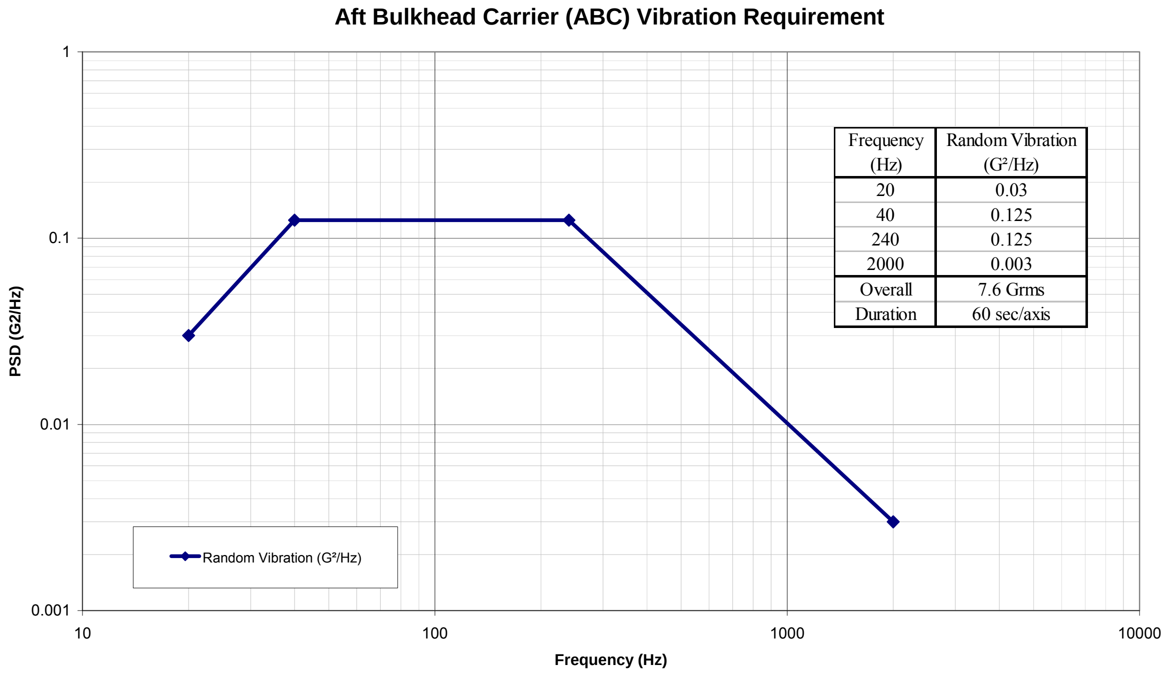


1/3 OB Center Frequency (Hz)	Sound Pressure Level (dB)	1/3 OB Center Frequency (Hz)	Sound Pressure Level (dB)
32	117	630	130
40	119	800	127
50	121	1000	124
63	122.6	1250	121
80	123	1600	120
100	123.8	2000	119.4
125	124	2500	118.5
160	125	3150	118
200	127	4000	117.5
250	127	5000	117
315	129	6300	116.5
400	131	8000	116
500	133	10000	115.5
OASPL = 139.5 dB			

Figure 3-11. Atlas V Maximum Predicted Acoustic Levels

3.2.3 Vibration

The AP will be capable of withstanding the maximum predicted environment as shown in Figure 3-12.

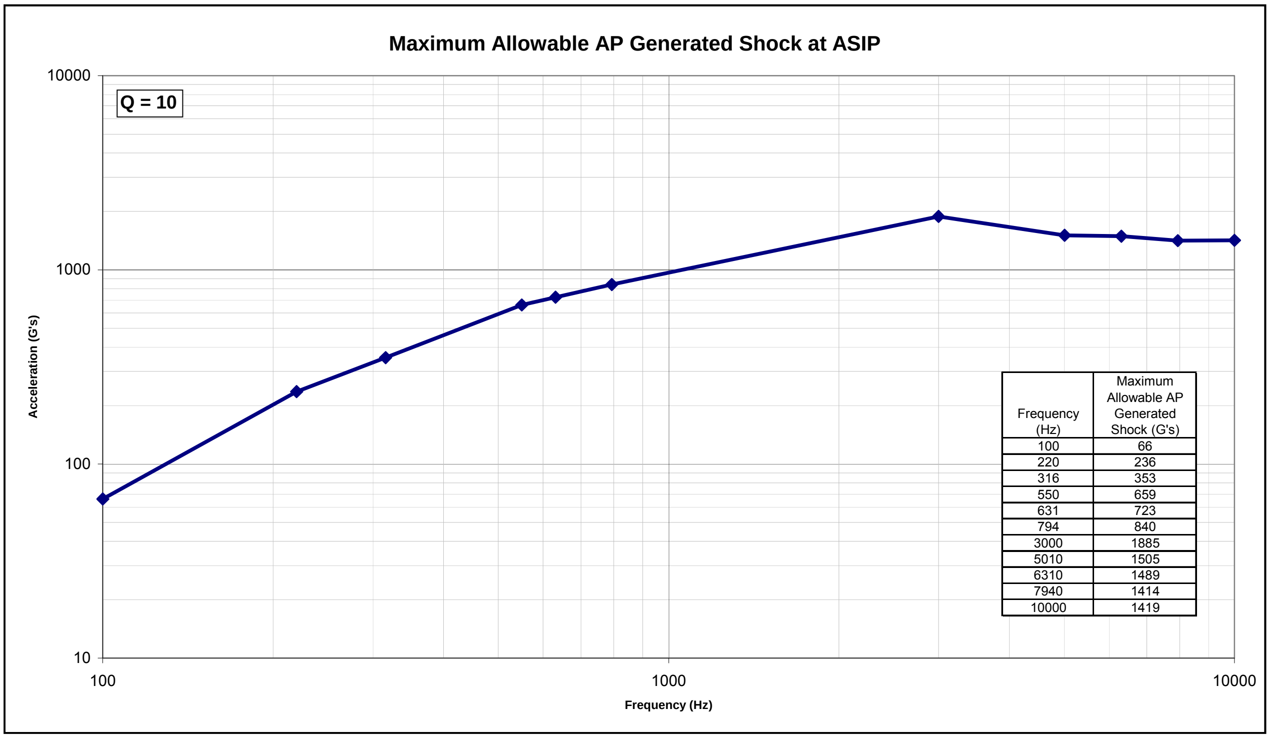


Frequency (Hz)	Random Vibration (G²/Hz)
20	0.03
40	0.125
240	0.125
2000	0.003
Overall	7.6 Grms
Duration	60 sec/axis

Figure 3-12. Maximum Random Vibration Environment at the ASIP

3.2.4 Shock

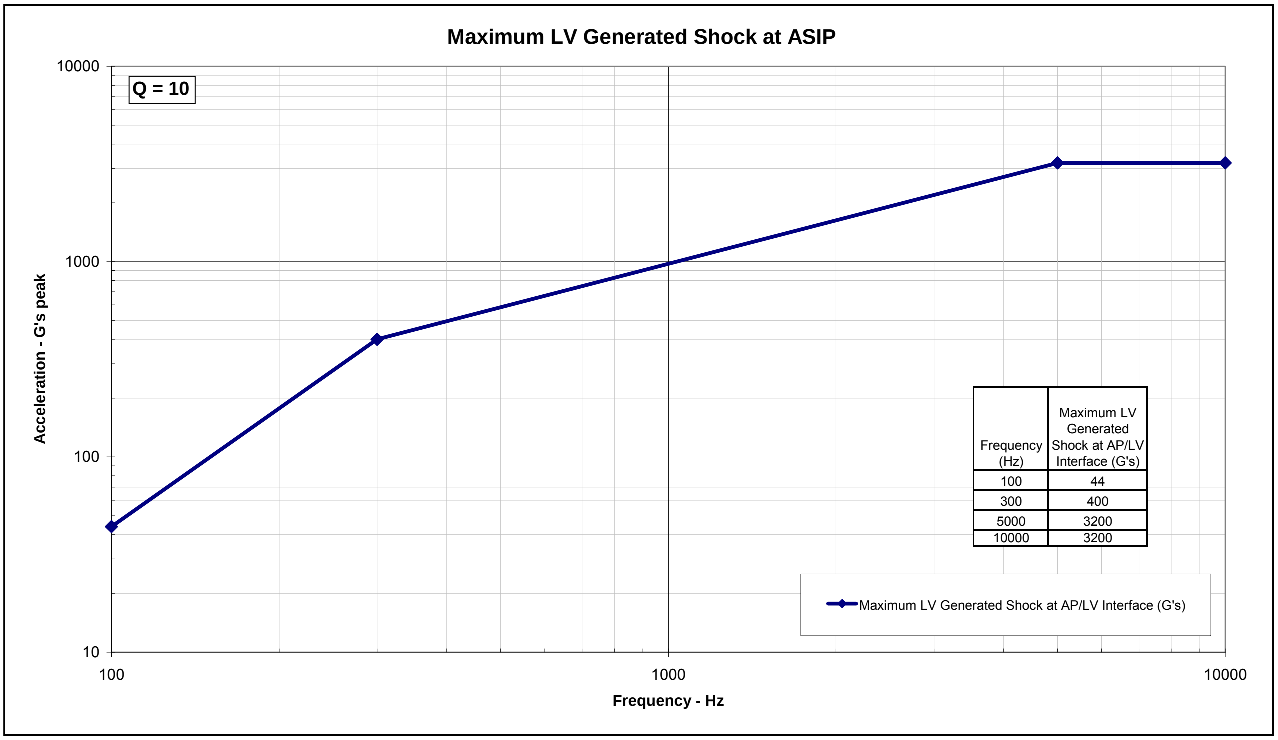
3.2.4.1 AP Generated Shock. Any AP generated shock levels at the ASIP, based on a statistical significance of 95 percent probability and 50 percent confidence, will be less than or equal to the spectrum shown in Figure 3-13.



Frequency (Hz)	Maximum Allowable AP Generated Shock (G's)
100	66
220	236
316	353
550	659
631	723
794	840
3000	1885
5010	1505
6310	1489
7940	1414
10000	1419

Figure 3-13. Maximum Allowable AP Generated Shock Levels at the ASIP

3.2.4.2 LV Generated Shock. The AP will be capable of withstanding the maximum predicted dynamic flight environment shown in Figure 3-14. The levels in Figure 3-14 are preliminary predictions for the Motorized Lightband (MLB) and have not been validated through Qualification testing.



Frequency (Hz)	Maximum LV Generated Shock at AP/LV Interface (G's)
100	44
300	400
5000	3200
10000	3200

Figure 3-14. Maximum LV Generated Shock Levels at the ASIP

3.2.5 Thermal

3.2.5.1 Ambient Temperature and Convection. For minimum heating analysis, the ambient gas temperature around the ABC and AP is assumed to be 50 ^{o}F at T-0 and ramps linearly to -50 ^{o}F at T+120 seconds. For maximum heating analysis, the temperature of the ambient gas around the ABC and AP is assumed to remain constant at the recovery temperatures for the prelaunch ECS values listed in Figure 3-15 from T-0 to T+120 seconds. For both cases, the convection coefficient from ABC and AP surfaces to the ambient gas ramps linearly from the prelaunch ECS heat transfer coefficient value specified in Figure 3-15 at T-0 seconds to 0 at T+120 seconds.

3.2.5.2 Orbital Heating Environment. Following Booster/Centaur Separation, the ABC and AP will withstand exposure to orbital heating environments. The on-orbit solar environment falls between a minimum of 404 Btu/hr-ft2 (cold case) and a maximum of 450 Btu/hr-ft2 (hot case). Earth emitted and reflected IR falls between a minimum of 70 Btu/hr-ft2 (cold case) and a maximum of 77 Btu/hr-ft2 (hot case). The dispersed Earth albedo constant falls between a minimum of 0.25 and a maximum of 0.35. Free Molecular Heating is a function of the mission trajectory and will be determined for each mission. Figure 3-15 contains orbital parameters likely to bound minimum and maximum heating for most ABC missions.

Parameters	**Maximum Heating**	**Minimum Heating**
Orbit	90 x 10,985 nmi	100 x 11,000 nmi
Beta Angle	30°	25°
Orientation	Broadside to Sun	Broadside to Sun
Roll Rate	5 rev/hr	5 rev/hr
Roll During Burns	No	NO
Shadow	No	1,800 seconds
Transfer Orbit Coast (Roll)	10,800 seconds	10,800 seconds
Total Centaur Mission Time	18,282 seconds	18,282 seconds

Figure 3-15. Orbital Heating Parameters for Max/Min Heating

3.2.5.3 Plume Impingement Environments. The AP will be compatible with the impingement environments shown in Figure 3-16 and Figure 3-17**.** The zones for RCS impingement environments are shown in Figure 3-18.

		RCS						
	RL-10	**Zone 1**	**Zone 2**	**Zone 3**	**Retro Rockets**	**GOX**	**ECS – AP Outboard Surface Below Z_{AP} +16.2”**	**ECS – Remainder of AP**
Impingement Pressure (psf)	0.01	0.014	0.007	0.001	3.75	14.2	1.44*	1.44*
Heating Rate (BTU/ft^2-hr)	75	220	100	25	10310	N/A	N/A	N/A
Heat Transfer Coefficient (BTU/ft^2-hr-°R)	N/A	N/A	N/A	N/A	N/A	217	15.5	4.5
Recovery Temperature (°R)	N/A	N/A	N/A	N/A	N/A	178	585	575
Mass Flux (lbm/ft^2-hr)	0.032	0.34	0.12	0.05	37.8	1110	N/A	N/A
Maximum Continuous Duration (sec)	920	1500	1500	1500	3.0	40	N/A	N/A
Maximum Number of Events	1	4	4	4	1	2	N/A	N/A
*Note: The maximum ECS impingement pressure corresponds to a maximum velocity of 35 ft/s								

Figure 3-16. Worst-Case AP Pre-Separation Impingement Environment

	RCS*
Impingement Pressure (psf)	5E-4
Heating Rate (BTU/ft^2-hr)	9.0
Mass Flux (lbm/ft^2-hr)	6E-3
Duration (sec)	5
*These impingement environments were based on the following assumptions: • A complete settling thruster inhibit during the separation event • A 3 second P/Y thruster inhibit following the separation event • An AP separation velocity of 1.6 m/s (5 ft/s)	

Figure 3-17. AP Post-Separation Impingement Environments

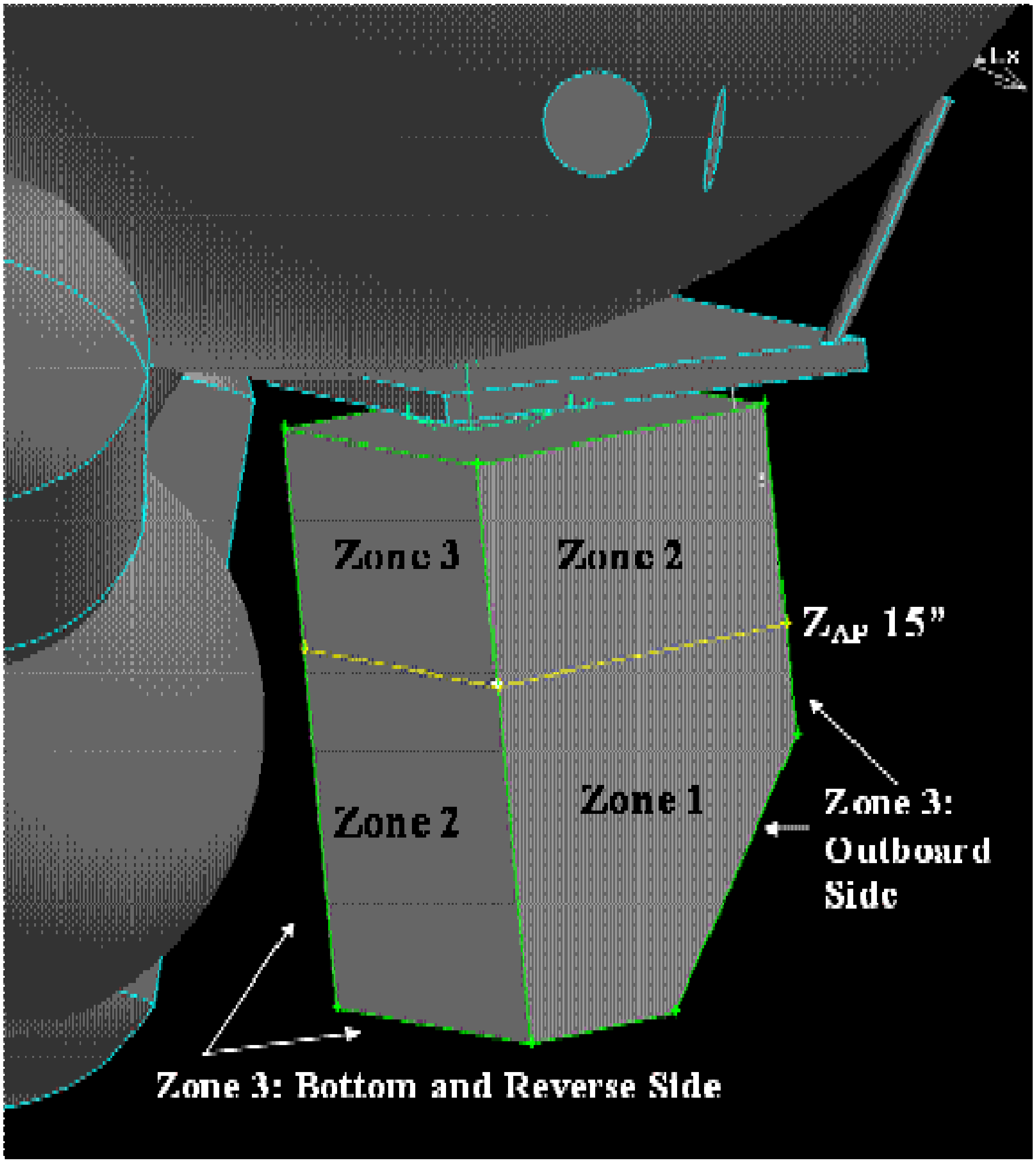
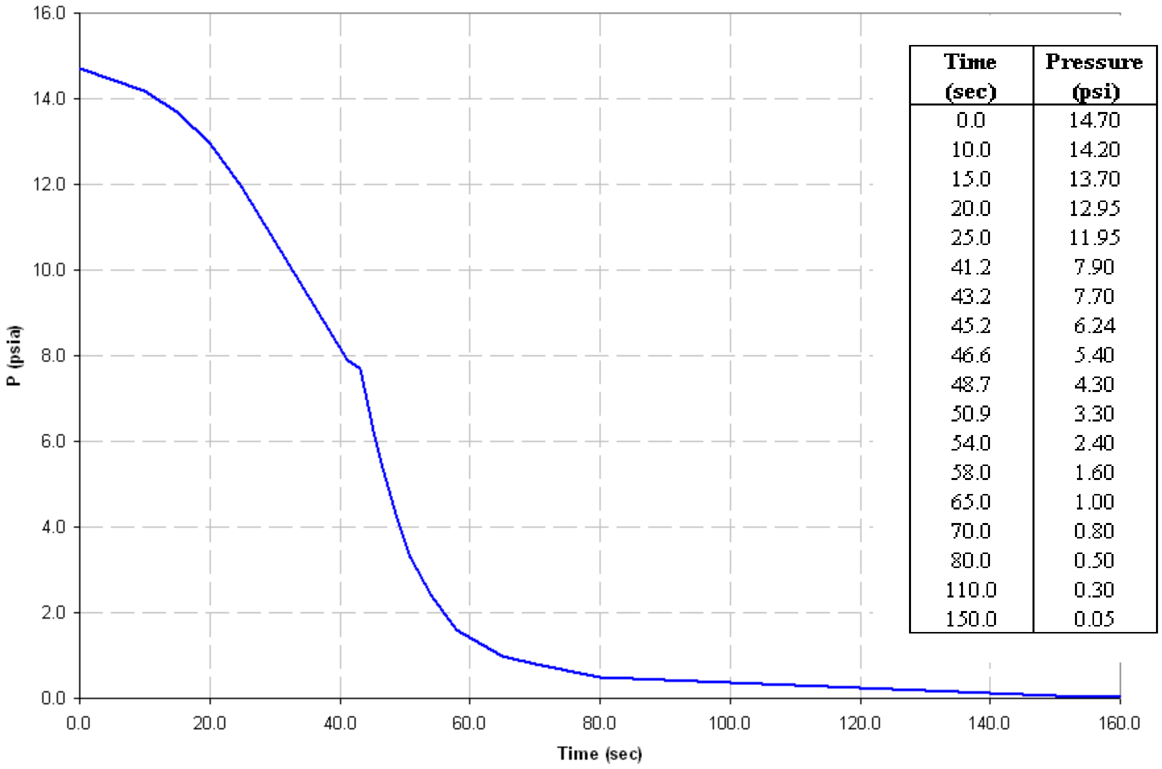


Figure 3-18. RCS Impingement Zones

3.2.5.4 Centaur Component Thermal Radiation. Various pieces of Centaur hardware will radiate heat to the ABC and AP. Analysis will be conducted on a mission by mission basis to calculate this heating. The primary source of radiation from the Centaur to the ABC and AP is the Centaur main engine. During Centaur Main Engine Burns (MEBs), the nozzle extension operating temperature is 1900°F. The nozzle extension has an emissivity of 0.85. The view factor from the ABC and AP to the nozzle extension is 0.5. The maximum total Centaur main engine burn duration is 920 seconds.

3.2.6 ISA Static Pressure

The AP will be capable of withstanding the pressure environment defined in Figure 3-19.



Time (sec)	Pressure (psi)
0.0	14.70
10.0	14.20
15.0	13.70
20.0	12.95
25.0	11.95
41.2	7.90
43.2	7.70
45.2	6.24
46.6	5.40
48.7	4.30
50.9	3.30
54.0	2.40
58.0	1.60
65.0	1.00
70.0	0.80
80.0	0.50
110.0	0.30
150.0	0.05

Figure 3-19. ISA Worst-Case Compartment Pressure Profiles

3.2.7 Contamination Control

Launch system ground contamination sources were addressed in paragraph 3.1.3. Launch system ascent contamination sources are discussed below.

The AP will be capable of withstanding the environments defined in 3.2.7.1 and 3.2.7.2.

Note: The molecular and particulate requirements are based on conservative assumptions. A refinement to these assumptions is available based on mission parameters.

3.2.7.1 Molecular Contamination. Molecular deposition on the AP from all launch system sources from the time of LV/AP mate through deployment will be no greater than the values shown in Figure 3-20.

	4m PLF	5m PLF
Using Aerojet Retrorockets	52 mg/ft^2	8 mg/ft^2
Using ATK Retrorockets	26 mg/ft^2	8 mg/ft^2

Figure 3-20. Maximum Molecular Deposition

Molecular contamination that deposits on the AP transfers from the following Atlas launch vehicle sources:

Retrorockets: The booster retrorockets are fired when the booster separates from the Centaur upper stage. Unlike the 5XX series, the 4XX series does not have a boat-tail in place to deflect the retrorocket plume, which accounts for the increased molecular deposition.

Molecular Outgassing: Nonmetallic materials outgas molecules that can deposit on spacecraft surfaces. In the ISA compartment, materials that outgas are not controlled or quantified as they are in the primary SV compartment.

Nonvolatile Residue Transfer: Surfaces in the ISA volume including the RL10 engine assembly, will have adsorbed molecules that desorb when these surfaces are warmed and the pressure in the compartment decreases. They can deposit on spacecraft surfaces that are cooler than the condensation temperature of these molecules.

Reaction Control System (RCS) Thruster Plume Impingement: The Atlas RCS operates throughout the Centaur phase of flight.

3.2.7.2 Particulate Contamination. Particulate deposition on the AP from all launch system sources from the time of LV/AP mate through deployment will be no greater than the values shown in Figure 3-21.

	4m PLF	5m PLF
Using Aerojet Retrorockets	14%	0.3%
Using ATK Retrorockets	42%	0.3%

Figure 3-21. Maximum Particulate Deposition

Particulate contamination that deposits on the AP transfers from the following Atlas launch vehicle sources:

Retrorockets: The booster retrorockets are fired when the booster separates from the Centaur upper stage. Unlike the 5XX series, the 4XX series does not have a boat-tail in place to deflect the retrorocket plume, which accounts for the increased particulate deposition.

Prelaunch: Existing particles on the aft end of the Centaur quantified by taking tapelifts of AV-014 engine cover. Particle sources the ABC will be exposed to prior to launch include processing at the ASOC, transport and hoist, and ECS (HEPA filtered) at the VIF and pad.

Wind Ingestion: (4XX series only) When the LV rolls to the pad there is a possibility that ambient air will be ingested into the ISA when wind speeds are sufficiently high. The analysis is based on a worst case assumption of 60 knot winds for a period of 24 hours.

Particle Redistribution: Particles on surfaces within the ISA volume can shake loose and redistribute to the AP surfaces during launch and flight.

Booster Separation: The Frangible Joint Assembly (FJA) shears allowing the booster to separate from the Centaur.

3.2.7.3 Debris. Debris from all AP sources will not impinge on any surface of the launch vehicle with sufficient energy to penetrate, nick, scratch, indent, fracture, or otherwise harm the launch vehicle. Systems that may potentially produce high velocity debris or particles, including separation systems and reaction control systems, will contain all debris and particles or be designed to direct the debris and particles away from the launch vehicle.

3.2.8 Radiation and EMC

The description of EMC environments in Section 3.1.2 encompasses EMC flight environments with some individual exceptions, which are dependent upon launch trajectory. Any individual exceedances will be addressed for specific launches.

3.3 AP COMPATIBILITY TEST REQUIREMENTS

3.3.1 AP Dynamic Compatibility Requirements

The AP is subjected to a wide range of dynamic excitation during launch. The general nature of the flight environment cannot be defined by any one characterization. For this reason, the maximum expected flight dynamic environments are defined by the following categories: 1) low frequency, 2) mid-frequency, and 3) high frequency. The low frequency environment constitutes the 0-50 Hertz range, and is defined by the mission specific coupled loads analysis. The high frequency range is characterized by two environments: 1) acoustic and 2) shock. The acoustic environment is defined from 25 to 10,000 Hertz, while the shock ranges from 100 to 10,000 Hertz. The transition zone between the low and high frequency is the mid-frequency range (approximately 50-100 Hz).

The LVC requires that all APs be capable of experiencing maximum expected flight environments multiplied by appropriate margins to preclude impact to mission success. The AP structural designs and qualification programs will verify that the AP systems are compatible with all maximum expected flight environments. Compatibility is demonstrated by design margin, test, analysis, or a combination thereof. Particular attention should be paid to structure in the mid-frequency transition zone (50-100 Hz) between low frequency (CLA) and high frequency (acoustic) regions.

Coordination must take place with the LVC as early as possible in the planning stage to mitigate schedule, cost, and mission risk. A qualification plan must be supplied to the LVC which outlines the methods to be used to demonstrate AP compatibility to each of the above dynamic environments, in addition to plans for validation of the dynamic model used in the coupled loads analysis. A summary report must also be supplied at the end of the qualification program to summarize compliance to all dynamic environments.

3.3.2 Thermal Test Requirements

ULA suggests that the APC demonstrate the AP capability to withstand thermal environments from an AP mission success perspective. The APC will demonstrate that the AP will not structurally fail or separate prematurely given the thermal environments.

3.3.3 EMI/EMC Test Requirements

ULA suggests that the APC demonstrate the AP capability to withstand EMI/EMC environments (from an AP mission success perspective) as defined in section 3.1.2 and applicable subsections. The APC will demonstrate that the AP will not inadvertently initiate AP functions or separate prematurely given the EMI/EMC environments.

Section 4
ABC AUXILIARY PAYLOAD INTERFACE

4.1 SPACECRAFT-TO-LAUNCH VEHICLE INTERFACES

The ABC is a structure providing one slot for deployment of an Auxiliary Payload. The ABC structure is depicted below in Figure 4-1.

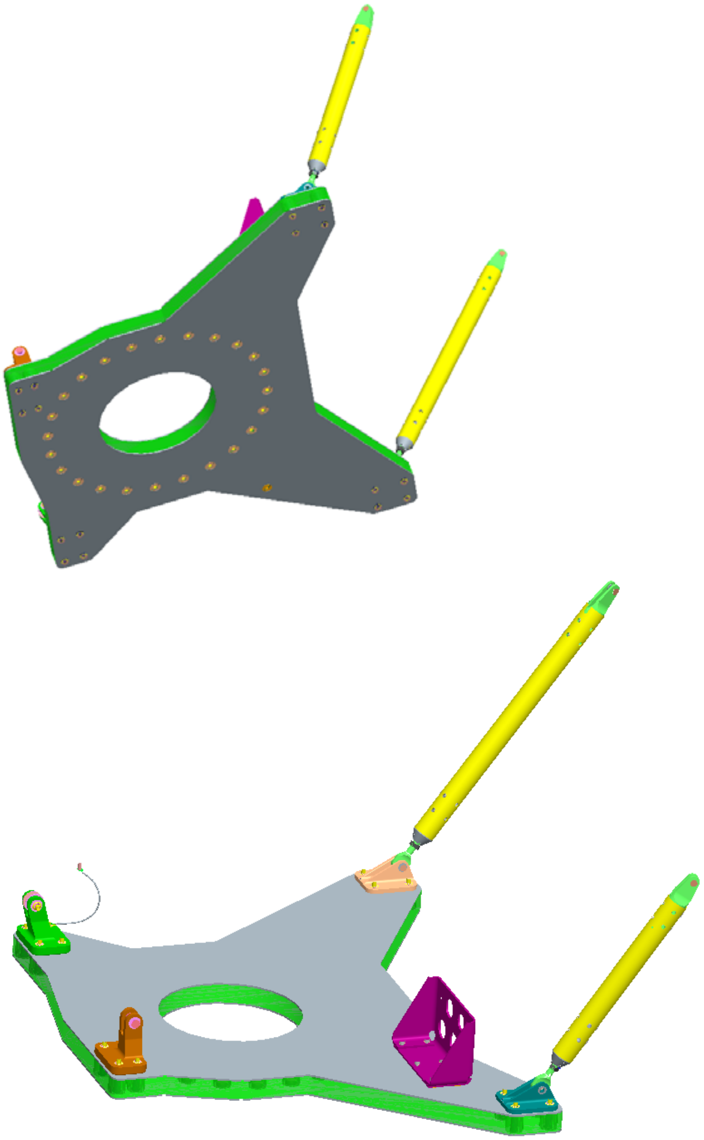


Figure 4-1. ABC Structure

4.1.1 Auxiliary Payload Coordinate System

The coordinate system that will be used by the AP is a right-handed coordinate system with the origin located on the Auxiliary Standard Interface Plane (ASIP) (the aft surface of the ABC plate) at the center of the bolt hole circular pattern. The AP local coordinate system is depicted in Figure 4-2, referenced with respect to the ASIP. The axial ($+Z_{AP}$) direction of the AP is normal to the ASIP with the positive direction starting from the ASIP and pointing normal to the ABC plate (away from the Centaur bulkhead). This direction will be referred to as the $+Z_{AP}$, where the subscript "AP" refers to the Auxiliary Payload. The $+X_{AP}$ axis corresponds to the axis created by the mounting bracket clevis holes to the Centaur Aft Bulkhead Thrust ring. The $+Y_{AP}$ axis finishes the right-handed coordinate system and is perpendicular to the plane of the $+X_{AP}$ and $+Z_{AP}$.

It may be required that the AP provides an alignment mark to ensure proper clocking during the AP to ABC/MLB mate. If required, the location will be specified in the mission specific ICD.

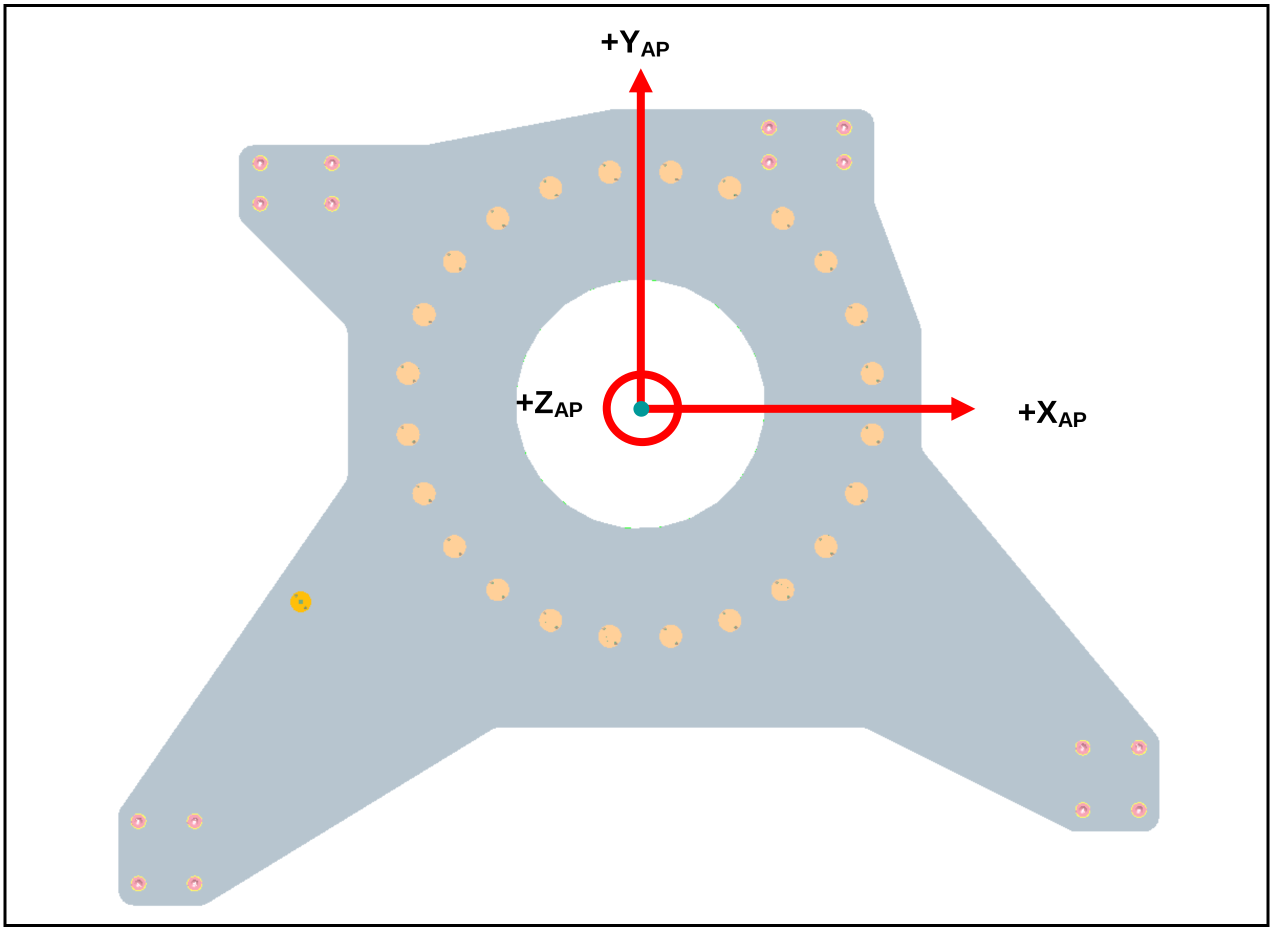


Figure 4-2. ABC Auxiliary Payload Coordinate System

The Centaur vehicle coordinate system is shown in Figures 4-3 and 4-4. The +Z-axis corresponds to the centerline of the vehicle pointed toward the aft end of the LV. The +X-axis points to the 90 degree azimuth and the +Y-axis points to the 0/360 degree azimuth. For reference, the aft surface of the Centaur aft ring is located at Station 412.72, corresponding to Z = 412.72 inches.

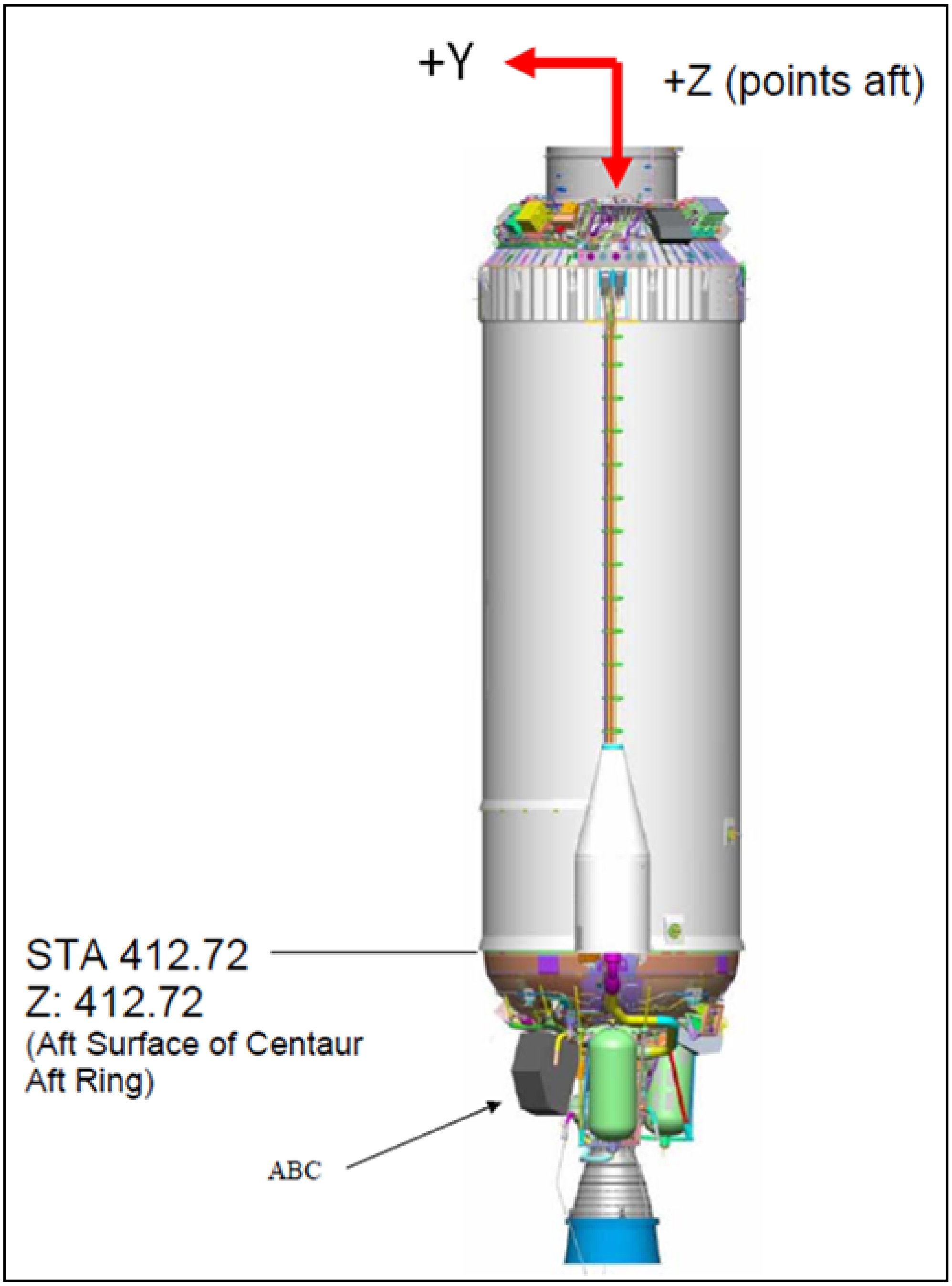


Figure 4-3. Centaur Vehicle Coordinate System (Side View)

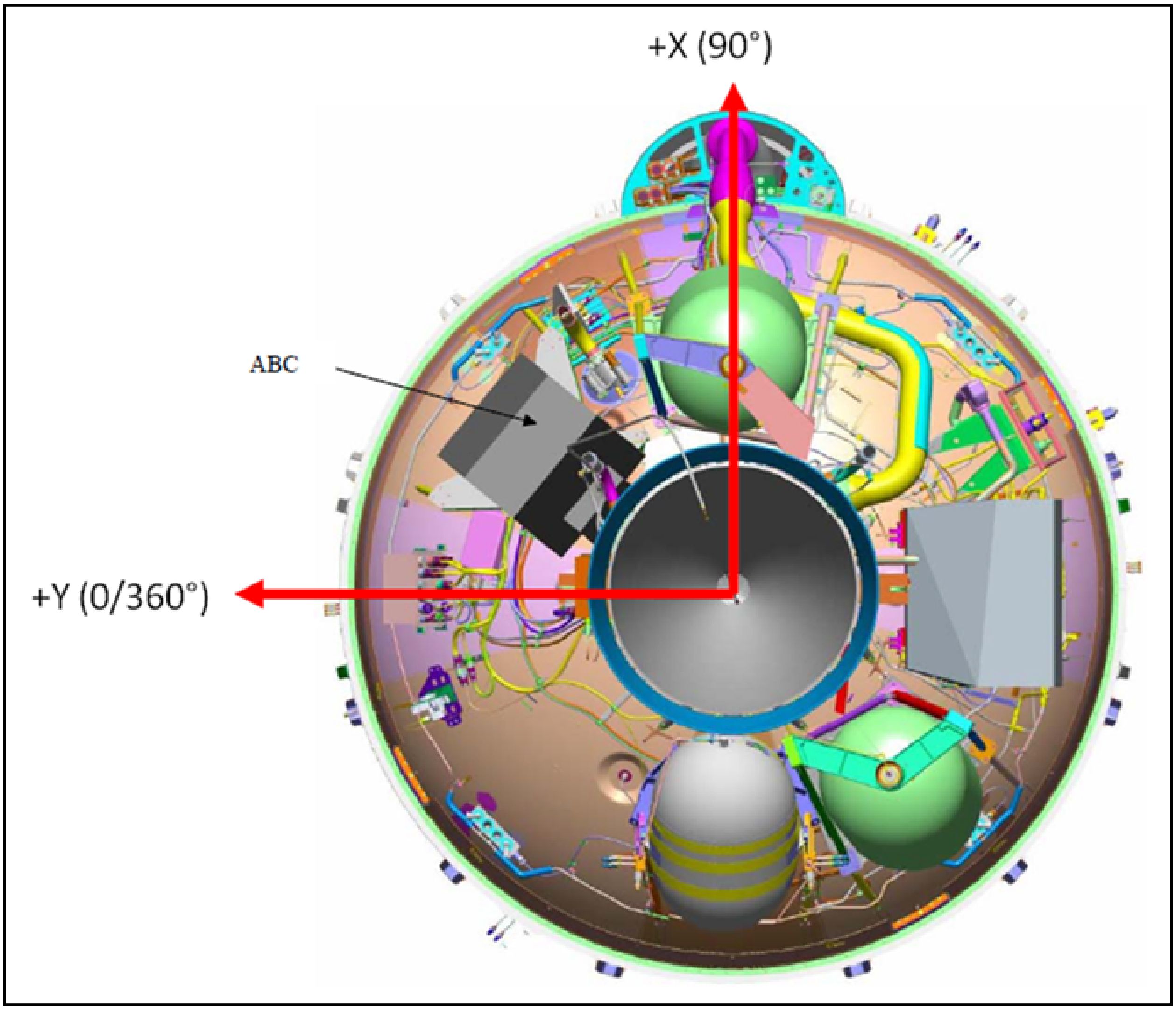


Figure 4-4. Centaur Vehicle Coordinate System (Bottom View)

The origin of the Auxiliary Payload Coordinate System (APCS) is located at the (18.9, 27.7, 451.8) coordinate of the Centaur Vehicle Coordinate System.

4.1.2 Auxiliary Payload Volume

The separating AP envelope consists of 34 inches (plus mated separation system height, which is 2.1 inches for Lightband Assembly) along the $+Z_{AP}$, 20 inches along the X_{AP} axis centered about the origin, and 20 inches along the Y_{AP} centered about the origin as shown in Figure 4-5. Minor local excursions to this envelope may be permissible upon approval by ULA. Excursions forward of the ASIP, i.e. into the ABC separation system internal volume, must be coordinated and approved by ULA.

The total envelope allocated to a separating AP is shown in Figure 4-5. This total envelope does not include the separation system. The total envelope allocated to a non-separating AP (Pre-CubeSat Separation) is shown in Figure 4-6. The total envelope allocated to a non-separating AP (Post-CubeSat Separation) is shown in Figure 4-7.

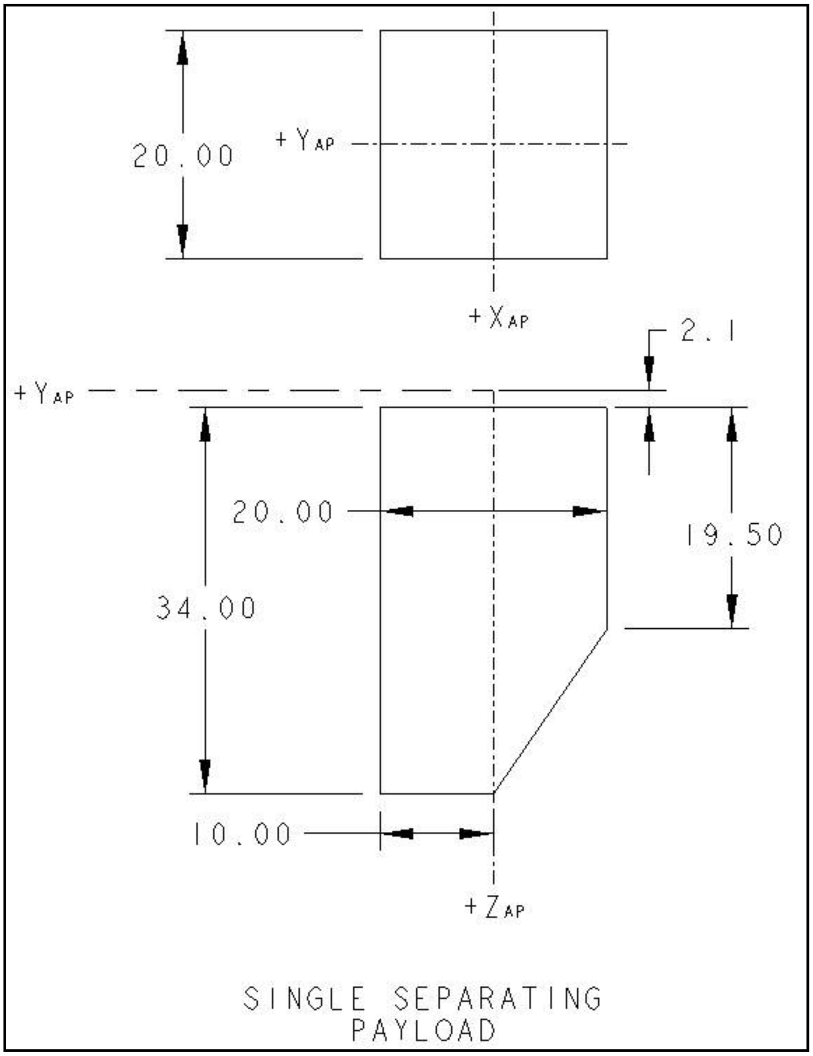


Figure 4-5. Single Separating AP Envelope Definition

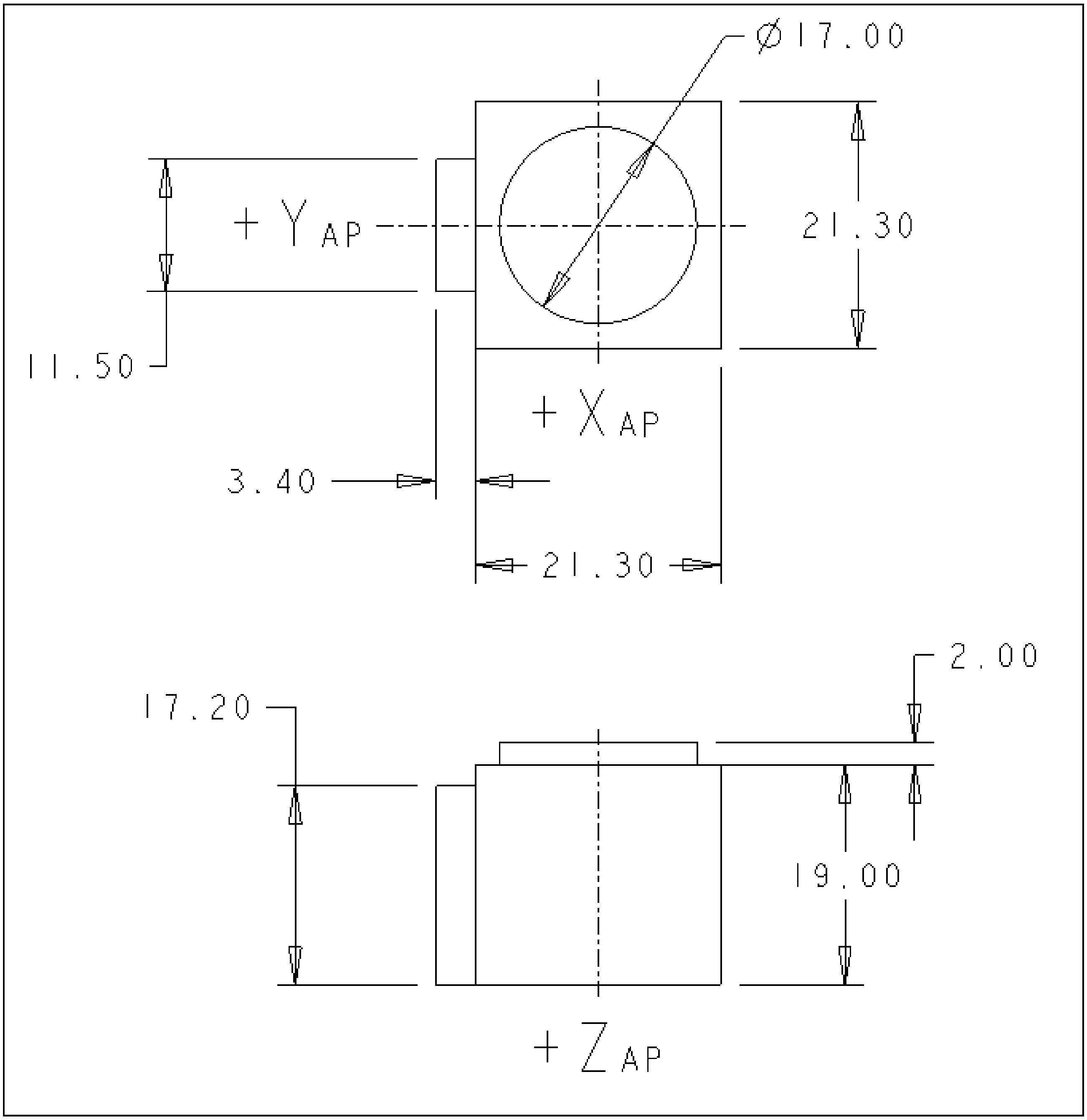


Figure 4-6. Non-Separating AP Envelope Definition (Pre-Cubesat Separation)

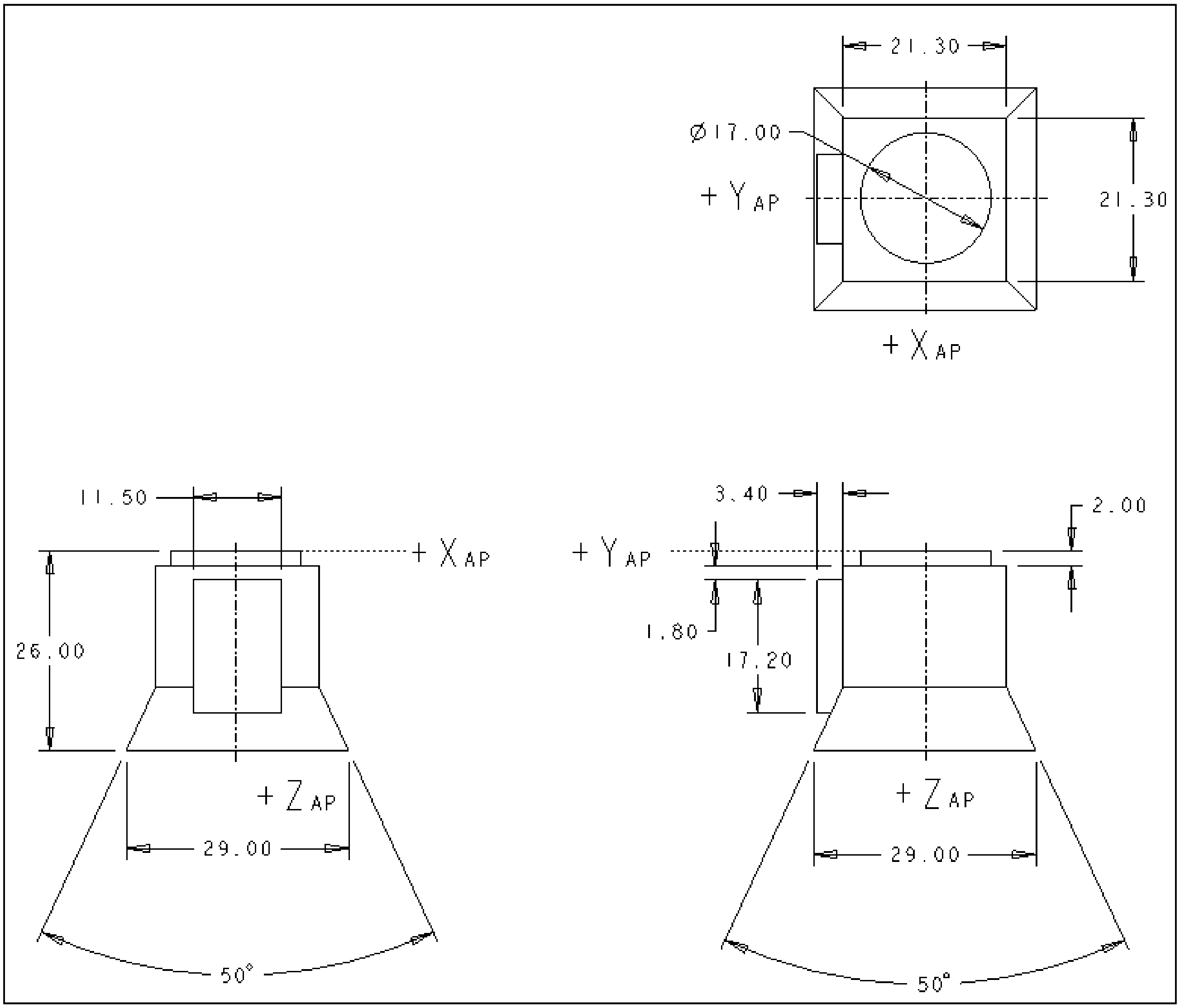


Figure 4-7. Non-Separating AP Envelope Definition (Post-Cubesat Separation)

4.1.3 Mechanical Interface

Each AP must match the standard interface to the ABC, either directly or through an AP provided adapter. A Computer Numeric Control (CNC) build is allowable, though an ABC drill template is also available. A detailed view of the Auxiliary Standard Interface Plane (ASIP) is shown in Figure 4-8. The insert pattern has a diameter of 15 inches between bolt-hole centers. The bolt pattern consists of (24) .2500-28UNJF inserts and are spaced every 15 degrees around the ring. The zero degree point of the ring lies along the $+Y_{AP}$ direction in the AP coordinate system.

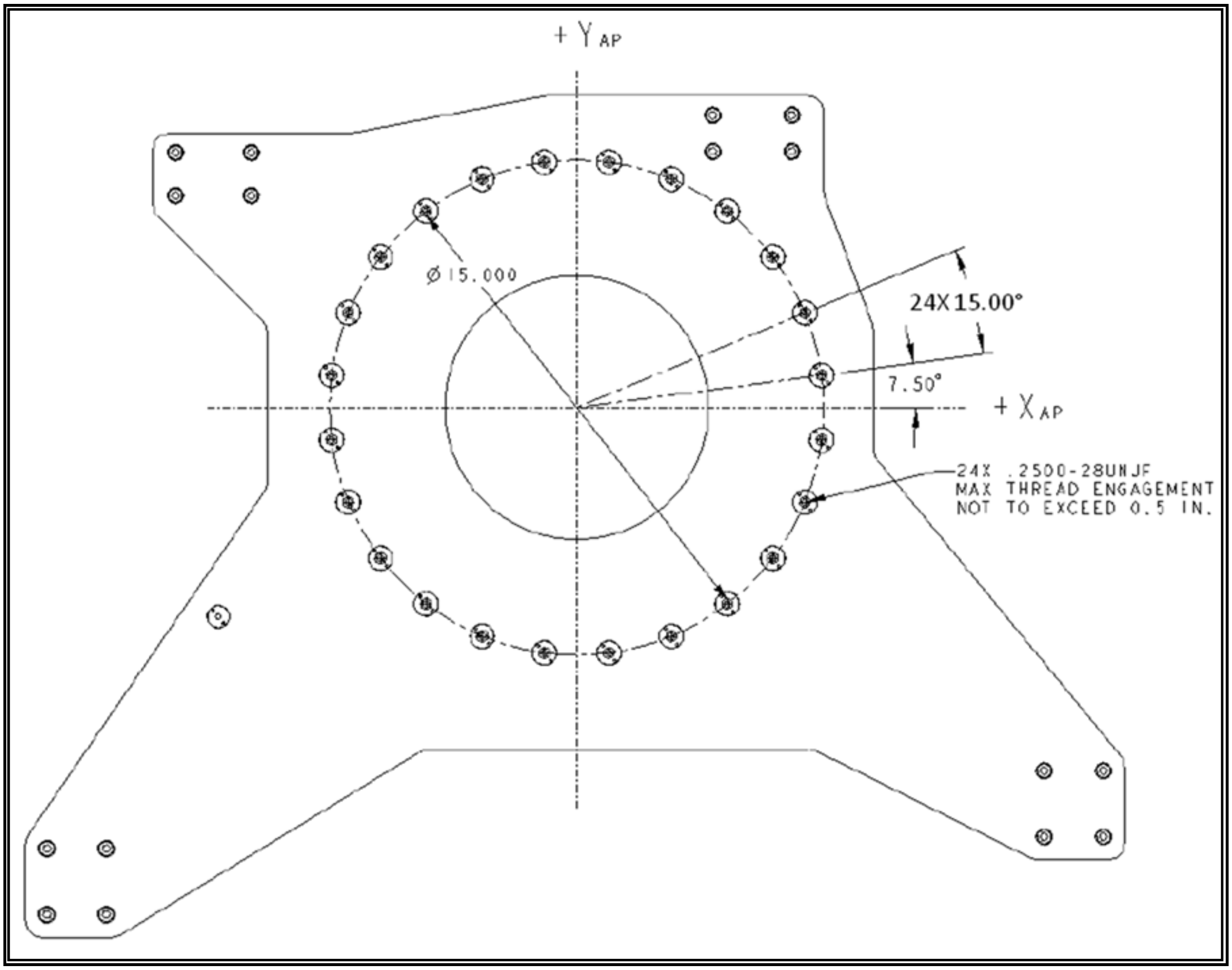


Figure 4-8. ABC Auxiliary Standard Interface Plane

4.1.3.1 Separation Mechanism. ULA can provide the separation mechanism as required to separate the AP from the ABC as shown in Figures 4.1.3.1-1 and 4.1.3.1-2. The separation mechanism is the Planetary Systems Corporation Mark II 15 inch Lightband Separation System as shown in Figure 4-9. The Lightband's ring which attaches to the AP is known as the "Upper Ring" and the ring which attaches to the ABC structure is known as the "Lower Ring" (see Figure 4-10). The upper ring has a 24 hole, 15 inch diameter bolt circle identical to that shown in Figure 4-8. The Lightband separation system can accommodate a maximum of 24 separation springs but for ABC/AP Standard Service the number of springs will be configured as discussed in Section 2.3.3. The upper ring, electrical connectors, separation switches, and fasteners have a combined weight of approximately 2.5lb and are provided by the ULA as part of the separation system but are considered AP mass. The fasteners required are ¼ inch fasteners (24 each) for bolting the upper ring to the AP. It is recommended that the AP provide threaded holes for interfacing with these fasteners as opposed to a through hole requiring a nut and bolt. Obtaining access to tighten nuts on the AP interface structure can be difficult. More detailed information about the separation system can be found in Planetary Systems Corporation (PSC) Mark II 15 inch Lightband Separation System Users Manual 2000785 Rev B.

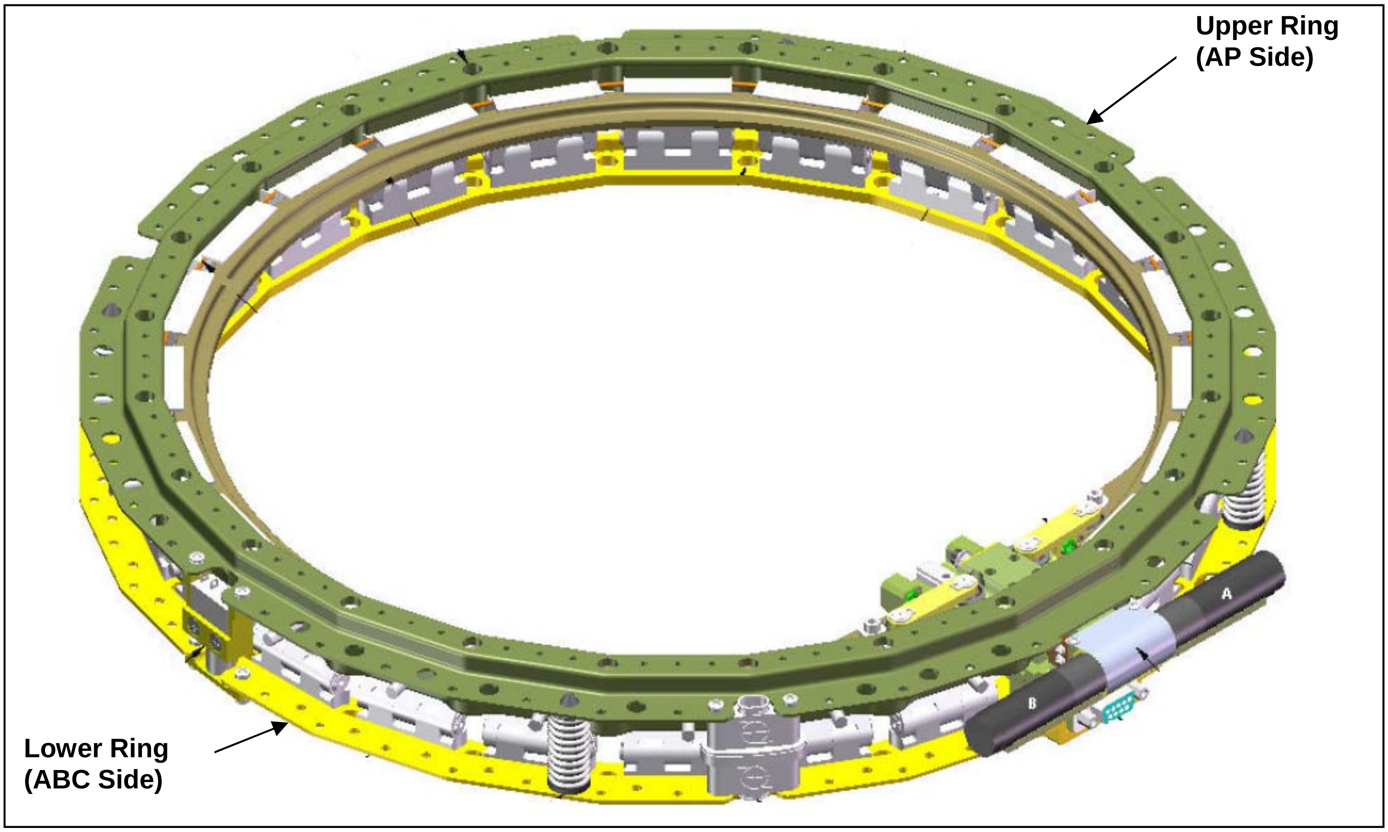


Figure 4-9. Generic Illustration of PSC 15 inch Lightband Separation System Stowed

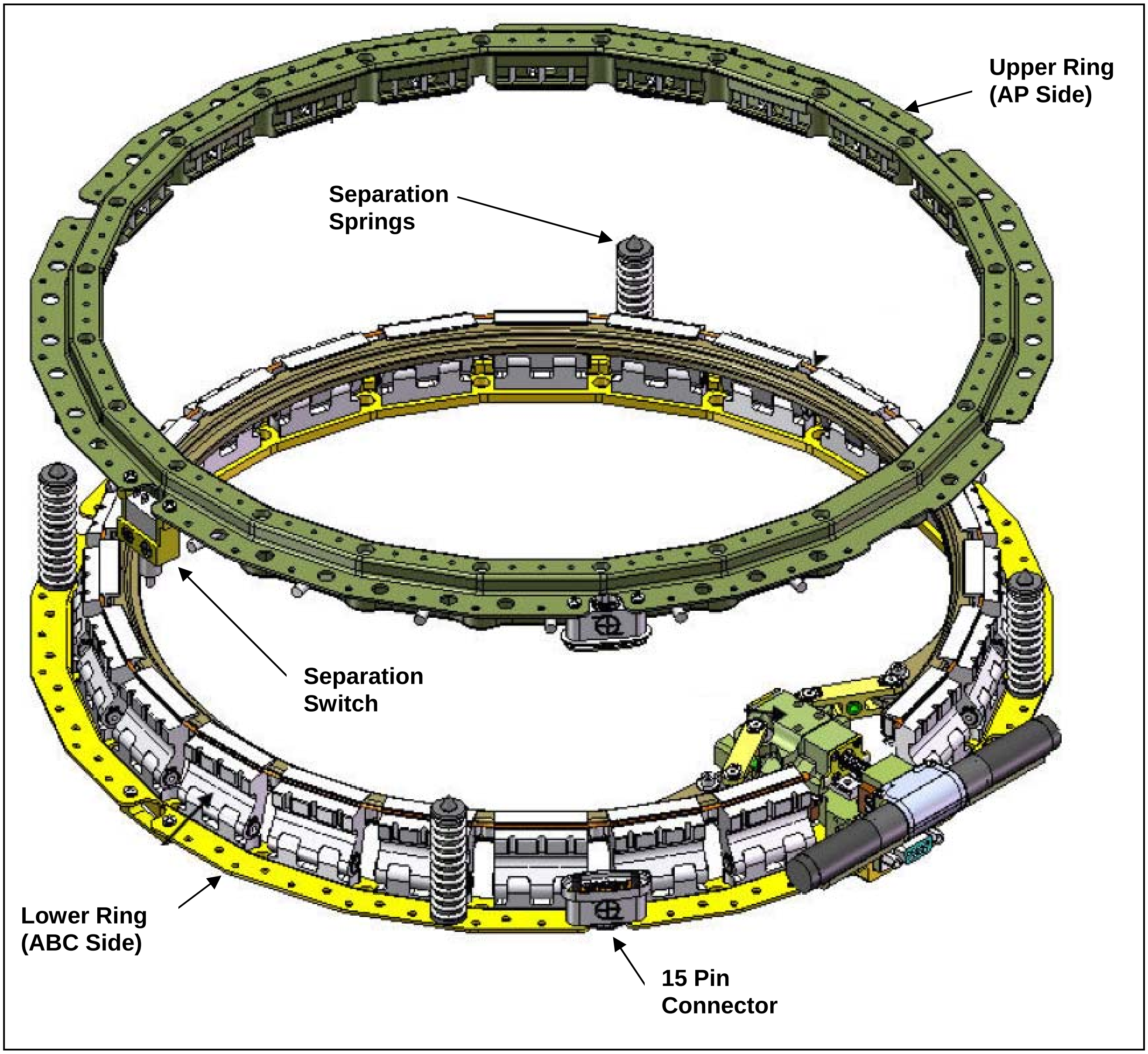


Figure 4-10. Generic Illustration of PSC 15 inch Lightband Separation System Deployed

Note: Lightband illustrations are for representative purposes only. Actual configuration for ABC/AP Standard Service number of springs and connectors is subject to change.

4.1.3.2 Separation Mechanism Clocking. The 15 pin electrical connectors and the separation indicator switches can be clocked and located as required.

Figure 4-11 illustrates a representative example of a Lightband Separation System mounted to the ABC plate. In this example, the Lightband Motor Bracket Assembly is oriented along the $+Y_{AP}$ coordinate.

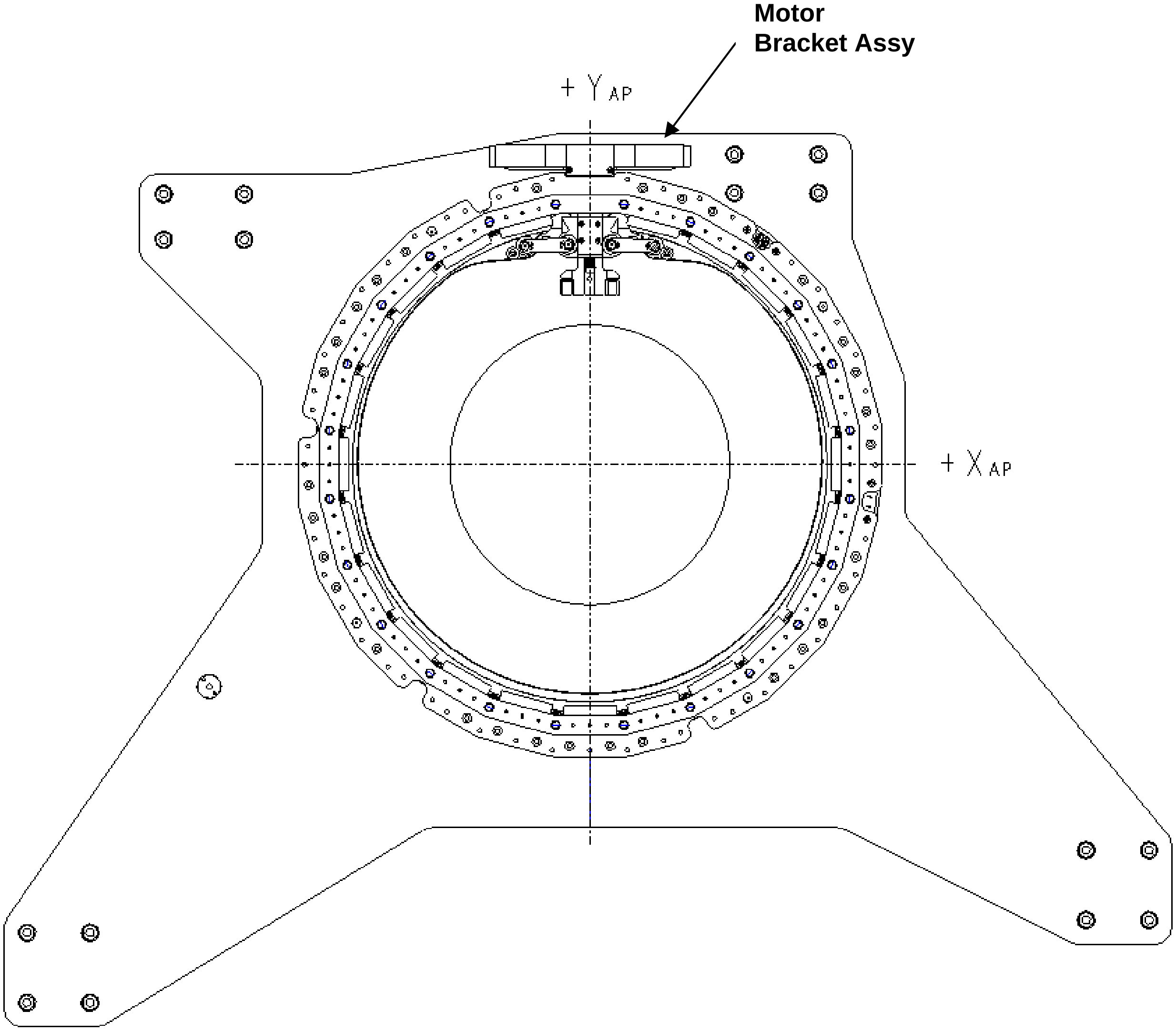


Figure 4-11. Separation Mechanism Clocking

4.1.3.3 AP Stiffness. The AP stiffness/fundamental frequency will be greater than 35 Hz when mounted to a rigid interface.

4.1.3.4 Interface Electrical Bonding. Electrical bonding across the AP/LV separation plane will not exceed 2.5 milli-ohms.

4.1.3.5 Flatness of AP Surface Adjoining the Lightband Separation System. For Separating APs, the AP structure surface adjoining the Lightband Separation System will be flat to 0.0040 inches, peak to peak.

4.1.3.6 Flatness of AP Surface Interfacing the ABC Structure. For Non-Separating APs, the AP structure interfacing the ABC Structure will be flat to 0.010 inches, peak to peak.

4.2 ELECTRICAL/AVIONICS INTERFACES

For Separating APs, the LV provides an umbilical electrical interconnection from the time of T-0 umbilical installation until launch. Motorized Lightband (MLB) separation detection switches are provided for AP use to detect separation. All payload provided signals and power are handled as unclassified data. Separating APs will have removable separation switch interface harnesses and removable 15-Pin interface harnesses to facilitate AP mating operation. Figure 4-12 shows a block diagram of the standard electrical interfaces for a Separating AP.

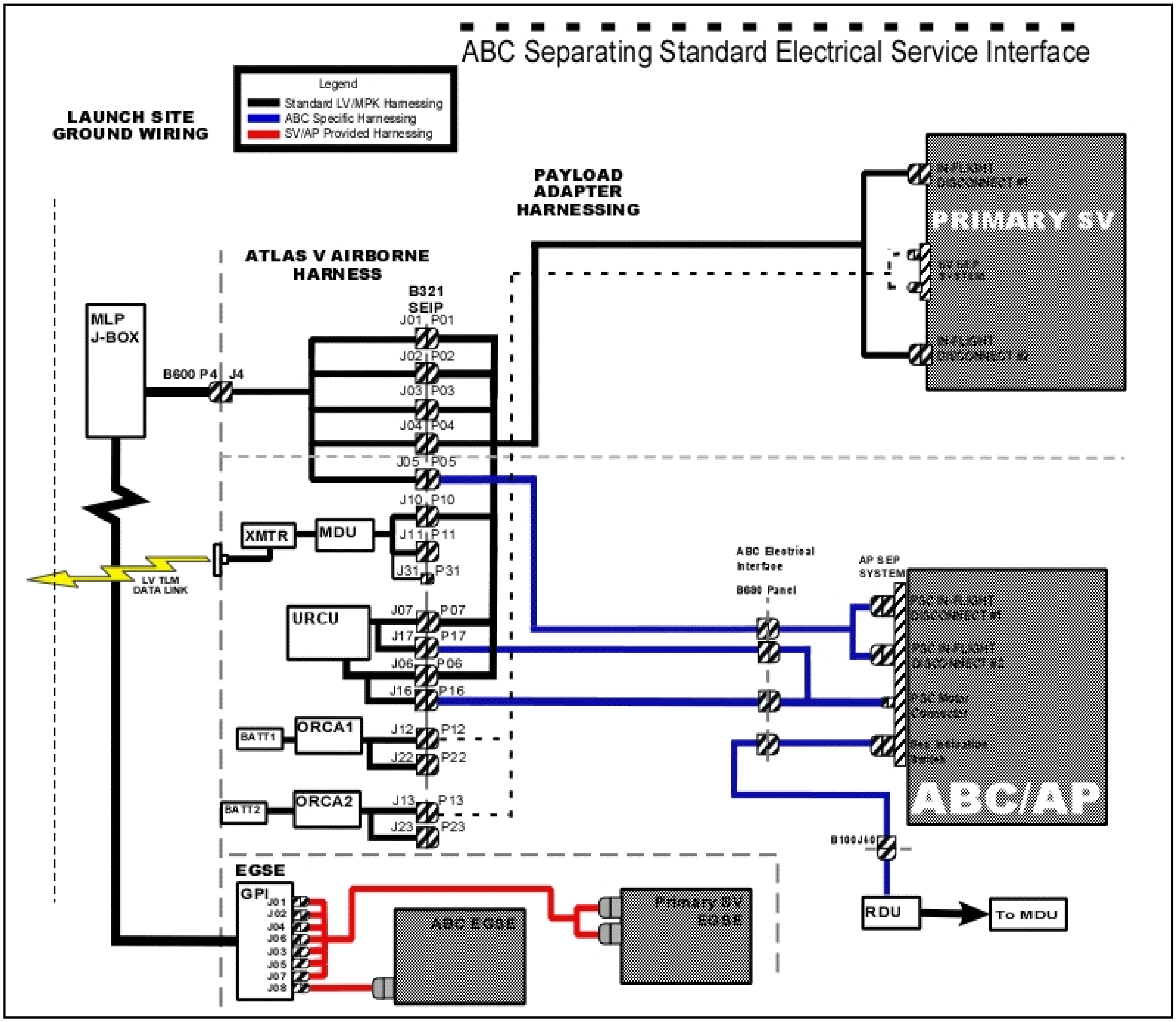


Figure 4-12. Separating AP Standard Electrical Service Interface

For Non-separating APs, the LV provides an airborne electrical interconnection from the time of LV power on until mission completion. All payload provided signals and power are handled as unclassified data. Figure 4-13 shows a block diagram of the standard electrical interfaces for a Non-separating AP.

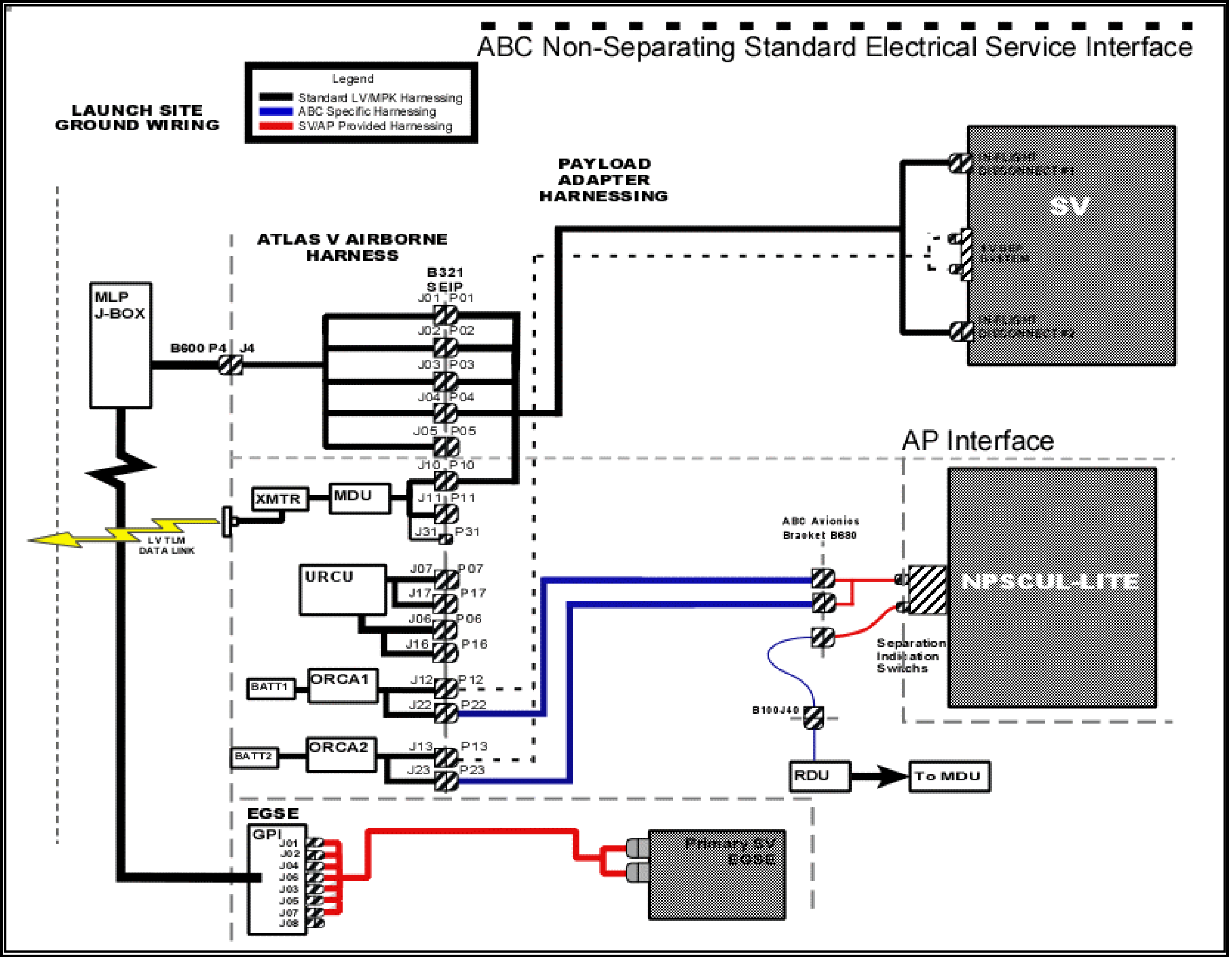


Figure 4-13. Non-Separating AP Standard Electrical Service Interface

4.2.1 Electrical Connections at LV/AP Interface

For Separating APs, the LV provides umbilical electrical interconnection services from the time of umbilical mate to the Centaur until launch. The electrical interface between the AP and the LV is limited to two 15-pin In-Flight Disconnect (IFD) separation connectors shown in Figure 4-14 and with clocking to be defined in the mission unique LV/AP ICD.

The LVC will provide the mating connector halves to the APC to mate to matching connectors at the separation interface. This ensures the connectors, pins, and sockets are all procured from the same vendor to the same specifications, minimizing any potential for mis-mate.

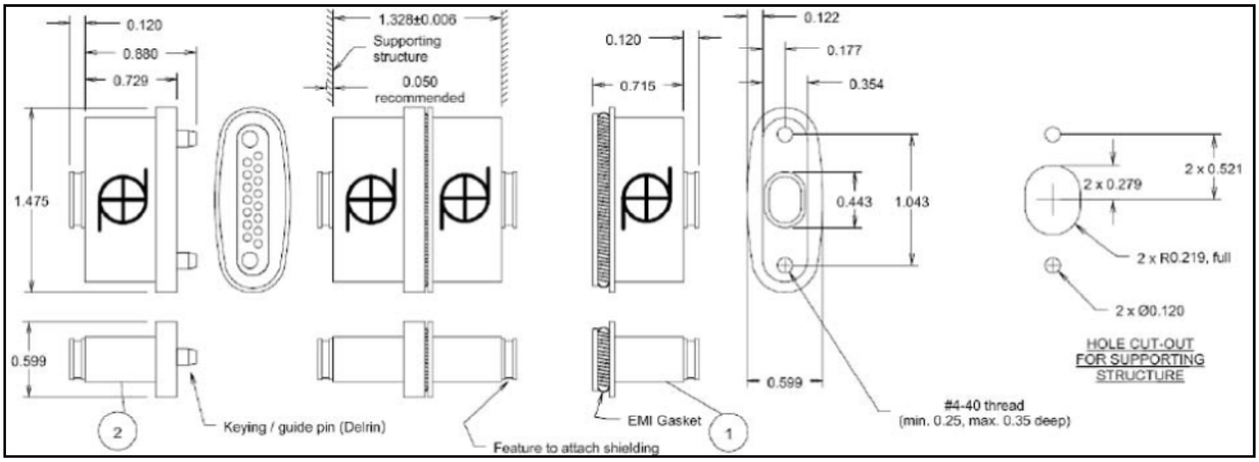


Figure 4-14. Payload In-Flight Disconnects

For Non-separating APs, the LV provides airborne electrical interconnection services from the time of LV power on for telemetry monitoring and from the time of primary SV separation for power commands until mission completion. The electrical interface between the AP and the LV will be at the B630 ABC Avionics Bracket. The LVC will provide the mating connector halves to the APC to mate to matching connectors at the interface. This ensures the connectors, pins, and sockets are all procured from the same vendor to the same specifications, minimizing any potential for mis-mate.

4.2.2 LV/AP Electrical Connector Separation

At the time LV/AP electrical connectors are to be separated, the current on any line will be no greater than 10 milliamps. This applies to LV/AP ground interfaces at LV liftoff and AP/LV Separation.

4.2.3 Ground Interfaces

The AP and associated ground operations will be compatible with standard Primary SV ground operations.

The LV and EELV ground facility provides dedicated "feed-through" cabling from the 15-pin IFDs, through an LV umbilical, to an LVC-provided EGSE room Ground Payload Interface (GPI) for both power to, and sensor signals from, the AP. Cabling connectivity will be available from the time the T-0 umbilical is connected until it is disconnected at liftoff. Use of the EGSE room for AP GSE, along with all resources associated with it, must be pre-approved and shared by the primary SVC. Space in the EGSE room is such that the maximum distance between the payload EGSE and the EGSE room interface panel is less than 30 feet.

The LVC will provide the mating connector halves to the APC to mate to the GPI panel interface. This ensures the connectors, pins and sockets are all procured from the same vendor to the same specifications, minimizing any potential for mis-mate.

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

4.2.3.1 Ground Monitoring. The LV and the EELV ground facility will provide 12 shielded twisted-pairs for the differential monitoring of power and sensor loads in the AP by the AP ground equipment in the EGSE room. These pairs may be used to monitor AP bus voltage, battery voltage sense, battery temperature, battery pressure, or other payload health measurements as required by the APC. These twisted pairs may also be used to provide commands or power from the AP ground equipment to the AP.

When used by the AP, each twisted-pair constitutes part of a complete circuit between the AP and AP ground equipment and will meet the following requirements at both the IFD and GPI interfaces:

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

The maximum round-trip resistance attributed to this cabling between the IFDs and GPI for any one pair will be 8.0 ohms, or less, when shorted at the opposite end.

Some of the ground monitoring lines may be assigned to carry payload power if the APC so chooses. In this case the power return lines at the payload EGSE power source will be reference to a single-point ground at the AP structure. All other circuits will continue to be isolated from earth ground by at least one megohm.

4.2.3.2 Ascent Power. The LV does not provide power to the single separating AP during flight as part of ABC/AP standard service.

The LV will provide power commands to the non-Separating AP during flight following Primary payload separation as a part of the standard service.

The AP will be in a "powered-off" state throughout the launch until after primary SV Separation.

4.2.3.3 Ground Support Equipment Power. The EELV ground facility provides 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): Will not exceed 5%
- Voltage transients: Will not exceed 200% nominal rms voltage for more than 20 micro-seconds
- Maximum Load for all primary SV and AP EGSE: 20 kVA

4.2.4 Flight Command and Telemetry Interfaces

The LV provides non-separating APs door switch telemetry interfaces from the time of LV power on until mission completion. The electrical interface between the AP and the LV will be at the B630 ABC Avionics Bracket. The LVC will provide the mating connector halves to the APC to mate to matching connectors at the interface. This ensures the connectors, pins, and sockets are all procured from the same vendor to the same specifications, minimizing any potential for mis-mate.

4.2.4.1 Signal Reference. All signals have a dedicated signal return line which is referenced at the source.

4.2.4.2 LV to AP Discrete Commands. No discrete commands will be provided to the AP as ABC/AP standard service.

4.2.4.3 LV/AP Telemetry Interface. Interleaved AP telemetry is not provided as ABC/AP standard service.

4.2.4.4 SV Radio Frequency Links. The AP will not have RF telemetry available during ground operations or during ascent through AP/LV Separation.

4.2.4.5 State Vector Data. There is no provision for furnishing state vector or attitude data directly across the IFDs to the AP at AP/LV Separation.

4.2.5 Separation Indication

For separating payloads, the APC will provide 1 separation breakwire, for sense by the LV, in each IFD. These lines will be isolated from AP structure by a minimum of 1 megohm. Loopback characteristics of these lines are as follows:

- Maximum Resistance: 1.00 ohm
- Minimum Resistance after break: 1 Megohm

For Separating APs, the LV will transmit telemetry verification of AP/LV Separation.

For Non-separating APs with CubeSats, the AP will provide separation indications from the P-POD door switches that go to the RDU. These are for use by the LV to indicate the opening of each P-POD door. The LVC will provide separation indication monitoring circuits to monitor the AP P-POD door switches.

For Non-separating APs with CubeSats, the LV will transmit telemetry verification of each AP P-POD door opening event.

4.2.6 Separation Initiation Signals

For Non-separating APs with CubeSats, the LV will provide 8 separation signals to the AP to initiate separation of the CubeSats by commanding eight 9102G Non-Explosive Actuators, which open the P-POD doors.

4.3 RANGE AND SYSTEM SAFETY INTERFACES

4.3.1 Requirements and Applicability

ABC APs will comply with the applicable programmatic, design and operating/operational requirements of Air Force Space Command Manual (AFSPCMAN) 91–710, Volumes 1, 3, and 6, as a minimum. An appropriate ABC AP-sponsoring organization will demonstrate compliance with the aforementioned applicable requirements by the generation and submittal to Range Safety and ULA of an acceptable Missile System Prelaunch Safety Package (MSPSP) consistent with the requirements of AFSPCMAN 91–710, Volume 3, Attachment 1, as a minimum. Consistent with the Safety Integration process addressed and illustrated in the Atlas V Launch Services User's Guide (Section 4.3), additional requirements may be imposed, or requirements may be relaxed, as part of the Mission Orientation activity.

The AP is initially an unknown entity to the primary SV, launch vehicle, and Range (Safety) review authorities. Until demonstrated otherwise, the AP is assumed to present any number of inadequately controlled potential hazards to launch base personnel, the general public, other payload and launch vehicle flight and ground hardware, facilities, and/or the environment. The primary vehicle for demonstrating otherwise is an adequate MSPSP. An adequate/compliant AP MSPSP (and supporting documentation, as requested) is the primary means to prove otherwise.

An adequate MSPSP:

- Identifies the hazards inherent in the ABC APs hardware and operations,
- Identifies and describes the ABC AP design features and procedural precautions that preclude, prevent, control, mitigate, or ameliorate these hazards not only during nominal/planned operating/operational conditions but also during credible fault/failure conditions,
- Summarizes how the effectiveness of the hazard controls or procedural precautions will be verified (by test, analysis, inspection, or some combination thereof), and
- Provides the applicable data required by AFSPCMAN 91–710, Volume 3, Attachment 1.

APs are required to provide documentation in a timely manner and safety documentation must meet Range standards for approval. Adequate, well-reasoned and compelling technical rationale for departures from "letter-of-the-law" compliance may be considered on a case-by-case basis, if the alternate approach being proposed provides "an equivalent level of safety."

ABC APs should assume that their inherent hazards are potentially catastrophic with respect to ride-sharing and/or co-located organization personnel, equipment, or facilities, unless and until they can demonstrate otherwise. Until that time, for "functional failure" hazards, the ABC AP should incorporate two-fault tolerance features (also known as "three independent inhibits") into their design. "Functional failure" hazards may include, but are not limited to:

- Premature/Inadvertent/Unintentional Appendage (Mechanism, Moving Mechanical Assembly) Release/Deployment
- Premature/Inadvertent/Unintentional Non-ionizing (radio frequency, laser, high-intensity infrared/visible/ultraviolet) Radiation
- Premature/Inadvertent/Unintentional (Hazardous) Commodity/Fluid Release/Leakage
- Premature/Inadvertent/Unintentional Propulsion System Activation/Operation (for those ABC APs which may contain such)

Figure 1 of MIL–STD–1576, "Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems," is recommended as a guide for the design/implementation of "inhibited" systems controlling the hazards noted above. In the example cited, the actual inhibits are the breaks/interruptions in the path/circuitry provided by the open relay contacts between the power source on the left and the hazardous end function (an ordnance device firing) on the right. APs may mechanize their inhibits via <u>any</u> device (see AFSPCMAN 91–710, Volume 3, Chapter 3, paragraph 3.2.7) that functions like an <u>OPEN</u> switch; the use of relays is only one of a number of potential design/implementation options for use at the APs discretion.

Conversely, in a hazardous fluid system the operative, mechanical, inhibits are more likely to be <u>CLOSED</u> valves (actually, valve seats) against leakage internal to the plumbing. Adequate fault-tolerance (at a system level) must also exist in the (electrical inhibit) circuitry, which may drive/control the opening of the valves. Leakage across the "structural" elements (such as tank/tube walls or component bodies) is to be controlled by the use of adequate safety factors with positive structural margins (i.e., "design for minimum risk"). At or across "mechanical joints," such as bolted flanges, flared fittings, or at fill/drain/vent valves, an appropriate number of "'barriers' against leakage," such as o-rings, metal-to-metal seals, or similar are to be used. Again, the actual device selected is immaterial and at the discretion of the AP; the function (and corresponding fault tolerance) is what is important.

In other systems, the inhibits employed may be either OPENs or CLOSEDs.

In a potentially hazardous non-ionizing radiation system, emitting radio-frequency (RF) energy for example, the "inhibits" may function, or be implemented, as either OPEN switches or CLOSED valves, depending upon the design of the system. Switches may control the operation of the local oscillator, may direct generated RF into a dummy load, or control the operation of the final amplifier (which may otherwise act as a valve to block RF out when not operating). "Folded" wave guides, in those systems that use them, may also block RF-out through an undeployed, mechanism-driven antenna. As an actual "inhibit" may be difficult to identify, it may be more appropriate to address the "fault-tolerance" that precludes input power from becoming RF-out.

Similarly, in a potentially hazardous laser system, electrical inhibits may control operation of the lasing medium, an amplification device, or a beam director. The system may employ an independently inhibited, mechanical and/or electrical shutter or deployable beam stop. As for an RF system, it may be more appropriate to address system-level "fault-tolerance" that precludes input power from becoming laser light-out.

To meet fault-tolerance requirements, not only must an AP provide the requisite number of inhibits, the AP must also demonstrate that those inhibits are "independent" (see AFSPCMAN 91–710, Volume 3, Chapter 3, paragraph 3.2.6). Inhibits are independent if it can be shown that no single, credible, environmental exposure, inadvertent or out-of-sequence event, inhibit component failure, controlling signal/circuitry component failure, operator error, or similar, may defeat more than one inhibit. Computer software, whether inhibited from execution or not, may drive the circuitry that, in turn, controls the state of an inhibit; however, software itself may not be considered an inhibit (see AFSPCMAN 91–710, Volume 3, Chapter 3, paragraph 3.2.7 – hardware only). Likewise, operator intervention is also not to be considered an inhibit (see AFSPCMAN 91–710, Volume 3, Chapter 3, paragraph 3.2.8).

From a launch vehicle and Range Safety perspective, the ABC AP must also be able to demonstrate that it will present no inadequately controlled hazards (i.e., it will remain "safe") when exposed to the worst-case, predicted, environmental conditions, such as loads/stresses, shock, vibration, electromagnetic interference, and temperature extremes, at least from arrival at the launch base through liftoff. Appropriate safety factors, and positive margins must be demonstrated for these, and other, "design for minimum risk" -types of hazards. AP "safety" prior to launch base arrival is outside the purview of Range and LV Safety, but may be subject to Occupational Safety and Health Administration (OSHA), Department of Transportation (DoT), or other regulatory agency requirements. After liftoff, a lower level of AP fault-tolerance during ascent-to-orbit and on-orbit may be acceptable. The LV Flight Termination System (FTS) is expected to control hazards during that time. AP "contributions" to these hazards are therefore more likely to be "threats" to overall mission success and should be negotiated during the mission integration process.

Leakage or rupture of ABC AP batteries warrants special consideration as multiple hazards may result: fire, explosion, release of corrosive electrolyte constituents, decomposition of the electrolyte and the resulting production and/or release of other potentially hazardous chemical species, for example. Battery chemistries, aqueous or non-aqueous electrolytes, (dis)charge/(dis)charging approaches/circuit(s/ry) nominal and fault conditions, cell construction features/techniques, higher-level assembly/packaging and even "ancillary" system (such as thermal control heaters/coolers) faults may have an impact on battery safety. JSC–20793, Revision A, "Crewed Space Vehicle Battery Safety Requirements" is recommended as a guide for designing battery systems to be used in the vicinity of personnel. In addition to applicable AFSPCMAN 91–710, Volume 3, Chapter 14, and Volume 6, Chapter 14 requirements, lithium-ion chemistry batteries are also required to comply with the "Joint 45 SW/SE and 30 SW/SE Interim Policy Regarding EWR 127–1 Requirements For System Safety for Flight and Aerospace Ground Equipment Lithium-Ion Batteries" (Memorandum, dated 04 May 2005).

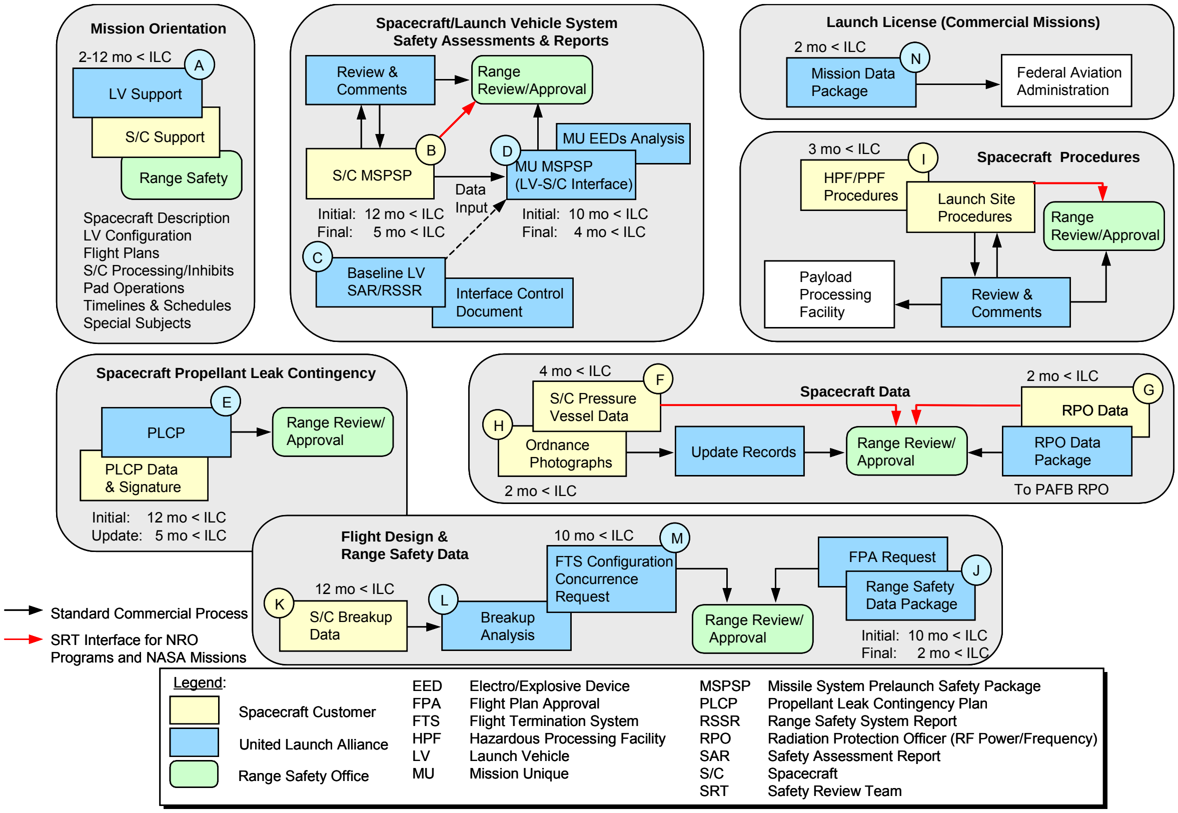
To support LV ordnance installation and hook-up operations, the AP and its affiliated Ground Support Equipment (GSE) must be capable of being completely turned OFF during those operations. Circuits which may otherwise switch ON or OFF without operator intervention, such as those associated with thermostatically controlled heaters or "on-demand" battery trickle/topping/taper charging, must be identified and will warrant analysis by the LV electromagnetic interference (EMI) group to assure that they present no inadequately controlled hazards during conduct of the LV ordnance operations.

4.3.2 Safety Integration Process

The process used by ULA to facilitate Range and System Safety coordination and receive Range approval and/or permission to launch is shown in Figure 4-15. This figure identifies responsibilities of the APC, ULA, and the Range. Timelines identified in this process are typical and may vary to accommodate mission specific requirements.

For each mission integration effort, ULA will provide qualified engineers to assist the APC during the Range review and approval process. ULA will monitor, coordinate, and/or obtain Range Safety and ULA System Safety approvals per contractual provisions. The following paragraphs summarize our safety integration process and define safety data to be developed by the AP customer during implementation of this process. Refer to section 4.3.3 for additional information on AP data requirements.

Mission Orientation – Soon after contract award, ULA and the APC will introduce a new system or mission to the Range during a mission orientation meeting with Range Safety. Figure 4-15. Block A, shows basic elements of this orientation. The orientation provides a general overview of the mission and provides a forum for initial coordination of mission specific requirements, schedules, and data submittals. Mission specific designs and operational issues are reviewed so agreements can be established during the early phase of mission integration. Range Safety requirements that will be imposed on AP designs and ground processing operations are identified.



*Timelines Typical Mission Specific Adjustments as Required

Figure 4-15. Atlas V Safety Integration Process*

For follow-on or reflight missions, a formal meeting may not be necessary. ULA will develop and submit a mission orientation letter to coordinate mission specific requirements, schedules, and data submittals. The APC may be asked to provide inputs to the mission orientation letter.

AP and Launch Vehicle Safety Assessments – Mission-specific AP designs and ground processing operations will be documented in an APC-developed and APC-provided Missile System Prelaunch Safety Package (MSPSP) (Figure 4-15, Block B). The APC will develop the AP MSPSP to describe the AP, document potential hazards associated with ground processing operations at the Range (e.g., pressure systems, ordnance control systems, toxic materials, AP access requirements, RF testing, etc.), and define the means by which each hazard is to be eliminated or controlled to an acceptable level. Range Safety regulations provide details on the format and contents of the MSPSP.

An initial AP MSPSP is typically submitted to ULA and/or Range Safety approximately 12 months before Initial Launch Capability (ILC). Earlier drafts are recommended. ULA will review the document, provide comments if necessary, and forward the document with comments to the Range for formal review and comment. ULA will then forward the AP MSPSP review comments to the APC for incorporation into the final submittal of the MSPSP. The final AP MSPSP is typically submitted to ULA about 5 months before scheduled ILC.

ULA will combine data from the AP MSPSP with data from existing baseline Atlas V launch vehicle safety reports (Figure 4-15, Block C) and the mission-specific ICD to perform and document a safety assessment of the launch vehicle to AP interface. Results of this assessment will be delivered to the Range as the mission unique launch vehicle MSPSP (Figure 4-15, Block D).

For Western Range programs, ULA will develop and submit a Missile System Ground Safety Approval (MSGSA) request. Formal ground safety approval from the 30th Space Wing is typically received approximately two weeks prior to ILC.

AP Propellant Leak Contingency – The ABC/AP standard service does not provide for APs with hazardous commodities. Any AP requirement for hazardous commodities would be a significant mission unique impact and would need to be investigated and negotiated on a mission unique basis.

AP Data – The APC will provide pressure vessel qualification and acceptance test data to the Range (through ULA) for review and acceptance. These data are shown in Figure 4-15, Block F. For follow-on or reflight missions, if the pressure vessel remains unchanged, only acceptance data is required.

The APC will also submit data specifying the type and intensity of RF radiation that the AP could or will transmit during ground testing, processing, and launch at the Range. ULA will forward these data to the Radiation Protection Officer (RPO) for review and approval of RF related operations to be performed at the launch site. RPO data are shown in Figure 4-15, Block G. The required RPO data includes descriptions of the equipment involved, the procedures that will be used, and information on the personnel who will be running the procedures. Permission must be received from the RPO before intentional spacecraft RF emissions will be allowed at the launch complex. The APC will be required to complete the appropriate RPO forms.

The Range requires photographs showing locations of ordnance items, if any, as installed on the AP. These data are shown in Figure 4-15, Block H. AP ordnance photographs may be submitted to the Range through ULA, or the APC may submit ordnance photographs directly to the Range Safety Office. Images may be hard copy or digital media. If the APC selects the direct submittal option, ULA requires notification that photographs have been delivered. A follow-up meeting between the Range and the APC may be required to review ordnance data.

AP Procedures – Through ULA, the APC will submit onsite processing procedures (Payload Processing Facility (PPF) procedures and launch pad procedures) (Figure 4-15, Block I) to the operator of the PPF (e.g., Astrotech SSI, NASA, or Air Force) and the Range for review and approval. As indicated in Section 4.3.1, PPF procedures must comply with the applicable processing facility's safety policy. Procedures to be implemented at the launch pad will comply with applicable ULA and Range Safety regulations. For first time missions, the Range requires submittal of all AP procedures. For follow-on missions, only hazardous procedures must be submitted.

Flight Design and Range Safety Data – ULA's flight design group will develop a Range Safety data package (Figure 4-15, Block J) that describes the basic AP configuration, the preliminary flight profile, and the time of launch. ULA will submit the preliminary (initial) package to the Range approximately 10 months before ILC. The initial data package will include a Flight Plan Approval (FPA) request to receive preliminary approval to fly the mission on the Range, as designed. Approximately 2 months before ILC, ULA will submit the final Range Safety data package with a request for final FPA. Final FPA is usually received from the Range approximately 7 days before ILC.

To support development of the Range Safety data package, the APC will provide AP breakup data (Figure 4-15, Block K) to ULA. ULA will use the breakup data to perform a breakup analysis on the AP under expected mission conditions (Figure 4-15, Block L). Refer to paragraph 4.3.3.4 for additional information on AP breakup data and analysis.

Based on results of the breakup analysis, ULA will submit an FTS configuration concurrence request to the Range (Figure 4-15, Block M). The purpose of this concurrence request is to obtain an agreement with the Range regarding requirements for a designated AP destruct capability. Because there are no appreciable and/or additional public safety hazards with typical missions, ULA typically pursues FTS concurrence without a dedicated AP destruct system.

Launch License (Commercial Missions) – For commercial missions, ULA maintains a launch license from the Federal Aviation Authority (FAA). The Atlas launch license requires periodic updates to address each commercial mission. ULA will develop a mission specific addendum to the baseline license for each commercial flight and submit this data package (Figure 4-15, Block N) to the FAA. AP information included in the FAA data package will include MSPSP approval status and overviews of hazardous AP commodities (propellants, pressure systems, batteries, etc).

4.3.3 Safety Data

To launch from Cape Canaveral Air Force Station (CCAFS) on the Eastern Range or Vandenberg Air Force Base (VAFB) on the Western Range, spacecraft design and ground operations must meet the applicable launch-site safety regulations. Refer to Section 4.3.1 for a listing of these regulations. Mission-specific schedules for development and submittal of the spacecraft safety data will be coordinated in safety working group meetings during the safety integration process. Refer to Section 4.3.2 for additional information on this process.

4.3.3.1 Missile System Prelaunch Safety Package. The Missile System Prelaunch Safety Package (MSPSP) is the data package that describes in detail the hazardous and safety-critical spacecraft systems/subsystems, their interfaces, and the associated Ground Support Equipment (GSE). In addition, the Spacecraft MSPSP provides verification of compliance with the applicable Range Safety requirements. The spacecraft MSPSP must be approved by Range Safety before the arrival of spacecraft elements at the launch site.

4.3.3.2 Spacecraft Launch Site Procedures. Before any procedures are performed at the launch site, hazardous spacecraft procedures must be approved by the Range Safety Office and/or the safety organization at the appropriate spacecraft processing facility (e.g., Astrotech, NASA, DoD). Since the approving authority must also concur with the nonhazardous designation of procedures, all spacecraft launch-site procedures must be submitted for review. ULA's System Safety group is the point of contact for submittal/coordination of all spacecraft data (refer to Section 4.3.2).

4.3.3.3 Radiation Protection Officer Data. Permission must be received from the Range Radiation Protection Officer (RPO) before spacecraft Radio Frequency (RF) emissions are allowed at the launch complex. The required RPO data includes descriptions of the equipment involved, the procedures that will be used, and information on the personnel who will be running the procedures.

4.3.3.4 Spacecraft Breakup Data Requirements. The spacecraft data described in the following three subsections is required for the Atlas V program to complete mission-specific analyses that satisfy 45th Space Wing/SEOE and 30th Space Wing/SESE requirements for submitting a request for Range Safety Flight Plan Approval (FPA).

4.3.3.4.1 Inadvertent Spacecraft Separation and Propulsion Hazard Analysis. This data set is related to inadvertent separation of the spacecraft during early ascent and the potential for launch area hazards that could exist in the event spacecraft engine(s) fire. Typical spacecraft propulsion system data provided by the customer include the maximum tanked weight, maximum loaded propellant weight, maximum axial thrust (all motors), and maximum resultant specific impulse.

4.3.3.4.2 Intact Impact Analysis. This data set is related to the ground impact of the spacecraft. The intact impact analysis assumes ground impact of a fully loaded, fueled, intact spacecraft. It also assumes propellants will combine and explode. Typical spacecraft data provided by the customer include the types and weights of explosive propellants; estimates of the number of pieces of the spacecraft that could break off in an explosion; and the location, size, weight, and shape of each piece.

4.3.3.4.3 Destruct Action Analysis. This data set is related to the Flight Termination System (FTS) destruction of the launch vehicle. The destruct action analysis assumes in-flight destruction of the launch vehicle by detonation of the Range Safety charge. Typical spacecraft data provided by the customer include an estimate of the number of spacecraft pieces that could break off because of commanded vehicle destruction and estimates of their size, weight, shape, and location on the spacecraft.

4.4 FACILITIES AND PROCESSING

The AP system operations will be compatible with Centaur operations and access requirements. The AP is responsible for its own processing and process facility (as required). The AP will be presented at the ASOC/Building 7525 in mate ready configuration to support Centaur processing launch flow. Nominally, this is expected by L-90 days, but could be longer. Extended durations driven by primary SV could result in being in the ASOC/Building 7525 or on stand indefinitely.

Physical and visual access control to the AP is consistent with that for the aft end of the Centaur upper stage. No additional security measures to limit access will be implemented.

Ground operations near the Centaur Aft Bulkhead will be required by ULA ground operations personnel in close proximity to the AP and may result in gentle physical contact with the AP.

4.4.1 Access to APs – Timelines

ABC/AP standard service does not provide for access to the AP on a regular basis. Access to the AP may be provided on a limited basis if requested by the APC. The AP will be capable of withstanding extended durations in the ASOC/Building 7525.

4.4.2 AP Battery Charging Restrictions

Battery charging procedure will need to meet applicable Range Safety regulations documented in AFSPCMAN 91-710. The battery charging procedure will be capable of being discontinued to be compatible with launch vehicle operations and ordnance operations. Battery charging will be scheduled with Integrated Operations.

4.4.2.1 Full Power Charging. Battery charging heat loss will have negligible impact to the Centaur thrust section environment.

4.4.3 AP Power Down for Hazardous Ops

The AP will be required to power down during hazardous operations (such as ordnance installation and fueling operations) to meet applicable Range Safety regulations documented in AFSPCMAN 91-710.

4.4.4 LV Aborts and Recycles

The APC will not be polled during the launch sequence.

4.4.4.1 Compatibility with LV Abort. The AP will be compatible with Launch Vehicle fail-safe launch abort anytime prior to launch commit.

4.4.4.2 Compatibility with LV Window Recycle on Same Day. The AP will be compatible with the LV recycling capability any time within the SV launch window. The AP will be compatible with the LV recycle out of Terminal Count within L- 4 minutes.

4.4.4.3 Launch Attempts. The AP will support launch recycles without access to the vehicle for a minimum of 4 launch attempts.

4.4.5 Mechanical GSE Interfaces for Transport and Handling Equipment

The APC shall provide a single crane pick point for a stable vertical lift of the AP with the AP mounting interface facing down and level within +/- .25 inch. If any other configuration is desired, it will have to be worked with ULA and the customer on a mission unique basis.

4.4.6 Matchmate

Flight hardware interface checks include matchmate/fitcheck activities of the mechanical, electrical, and functional interfaces between the Atlas V launch system and the AP system. The mission specific mechanical and electrical interfaces are specified in the LV/AP ICD. The LVC will support matchmate activities to be conducted at a mutually agreed upon facility prior to the start of integrated operations. Matchmate activities may include but are not limited to mating of the ABC and the AP system mechanical interfaces, confirmation of applicable electrical harnesses routing, and confirmation of other interfaces as identified during the integration process.

APPENDIX A
AP STANDARD DELIVERABLES

Figure A-1 provides a list of typical/standard AP inputs required for the integration process, the approximate need date, and a brief description of the contents. Further details on some items are provided in the following sections.

AP Standard Data Input	**Approximate Need Date**	**Comments**
Program Kickoff Meeting	L - 23 months	AP Overview
Initial Target Specification	Program Kickoff Meeting	AP Mass Properties, Target Orbit, and AP Separation Attitude. See Section A.4
Interface Requirements Document	Program Kickoff Meeting	IRD
Intact Impact Breakup Data	Program Kickoff Meeting	See Section A.6.4.2
Inflight Breakup Data	Program Kickoff Meeting	See Section A.6.4.3
Preliminary Coupled Loads Model*	Program Kickoff Meeting	See Section A.2
Preliminary CAD Model*	Program Kickoff Meeting + 1 month	See Section A.1
Range Safety Mission Orientation Briefing Input	Program Kickoff Meeting + 4 months	Top-Level Description of AP
Final CAD Model*	Program Kickoff Meeting + 6 months	See Section A.1
Final Coupled Loads Model*	Program Kickoff Meeting + 7 months	See Section A.2
Procedures Used at PPF	AP Arrival - 2 months	A.6.2
Preliminary AP MSPSP*	L - 12 months	See Section A.6.1
Thermal Models	L - 12 months	See Section A.3
AP EMI/EMC Analysis	L - 7 months	See Section A.5
AP EED Analysis	L - 7 months	See Section A.5
Final AP MSPSP*	L - 5 months	See Section A.6.1
AP Environment Qualification Test Reports*	L - 5 months	
Procedures Used at Launch Site	First Use - 2 months	A.6.2
Final Target Specification	L - 90 days	Final AP Mass Properties. See Section A.4
*These inputs are required for both the AP and the Mass Simulator		

Figure A-1. AP Inputs to Integration Process

A.1 COMPUTER-AIDED DESIGN DATA TRANSFER REQUIREMENTS

The Atlas program uses both the UNIX and MS Windows based operating systems and supports two Computer Aided Design (CAD) software programs: Parametric Technology Corporation Pro-Engineer (Pro-E) and Structural Dynamics Research Corporation I-DEAS Master Series. CAD data should be provided according to these specified software formats. When CAD data does not come from these supported software platforms, ULA prefers to receive solid model data translated through the Standard for the Exchange of Product Model Data (STEP) converter. An alternative to this is an Initial Graphics Exchange Specification (IGES) 4.0 or higher file from a three-dimensional (3-D) surface model or wireframe extracted from a solid model.

A.1.1 Prerequisites to Data Transfer

The following criteria should be met before transferring CAD data:

1. The spacecraft contractor should verify that the data files contain the desired results by reading them back onto the originating CAD system from the source file before transmittal to ULA.
2. Provide entire representation of all external spacecraft components for best integration to the Atlas Launch Vehicle. All internal structures are not necessary and should be removed from model transfer files.
3. Write out STEP and IGES files as assemblies and not as a single part file.

If feasible, the entire directory should be compressed and transferred as a single file using (UNIX) Tar (tarcvf/dev/rmt0 part name), or (Windows) “WinZip” or equivalent.

A.1.2 Data Transfer

Compact Disk media and/or File Transfer Protocol (FTP) are the preferred transfer methods for all data files. An account can be established on a ULA firewall server for FTP data transfers. Once the account is set up and a password is provided for access, up to 1.5GB of data can be transmitted at one time. An alternative method would involve the contractor providing similar access to one of their systems via a temporary account. In either case, the transfer type should be set to binary. Proprietary or sensitive data should be encrypted using PGP keys or equivalent. Because of security concerns email transfers are not recommended at this time. If CDROM or FTP transfer methods are not feasible, contact appropriate ULA personnel to provide a coordinated and acceptable method of data transfer.

The following information must be sent with the CAD data regardless of transfer method:

1. Name and phone number of the contact person who is familiar with the model in case problems or questions arise
2. Spacecraft axis and coordinate system

3. Spacecraft access requirements for structure not defined on CAD model (i.e. fill and drain valve locations)
4. Multiview plot of model
5. Uudecode (UNIX-based) information, if applicable.

A.2 COUPLED-LOADS ANALYSIS MODEL REQUIREMENTS

The customer-supplied dynamic mathematical model of the spacecraft should consist of generalized mass and stiffness matrices, and a recommended modal damping schedule. The desired format is Craig-Bampton, constrained at the LV/AP interface in terms of spacecraft modal coordinates and discrete LV/AP interface points. The spacecraft dynamic model should have an upper frequency cutoff of 90 to 100 Hz. The Output Transformation Matrices (OTM) should be in the form that, when multiplied by the spacecraft modal and interface generalized coordinate responses, will recover the desired accelerations, displacements, or internal loads. Typically, the size of the OTMs is 200 to 500 rows for accelerations, 50 to 200 rows for displacements, and 300 to 1,000 rows for internal loads.

A.3 SPACECRAFT THERMAL ANALYSIS INPUT REQUIREMENTS

Spacecraft geometric and thermal mathematical models are required to perform the integrated thermal analysis. These models should be delivered electronically or on a computer diskette with printed listings of all the files. The Geometric Mathematical Model (GMM) and Thermal Mathematical Model (TMM) size should be less than 800 nodes each.

The preferred GMM format is Thermal Desktop input format. Alternate formats are TSS, TRASYS, ESABASE, or NEVADA input formats. The documentation of the GMM should include illustrations of all surfaces at both the spacecraft and component levels, descriptions of the surface optical properties, and the correspondences between GMM and TMM nodes.

The preferred TMM format is System-Improved Numerical Differencing Analyzer (SINDA). The TMM documentation should include illustrations of all thermal modeling; detailed component power dissipations for prelaunch, ascent, and on-orbit mission phases; steady-state and transient test case boundary conditions, output to verify proper conversion of the input format to ULA analysis codes; maximum and minimum allowable component temperature limits; and internal spacecraft convection and radiation modeling.

In addition to the TMM and GMM, launch window open and close times for the entire year are required inputs to the integrated thermal analysis.

A.4 TARGET SPECIFICATIONS

Target specifications normally include the final mission transfer orbit (apogee and perigee radius, argument of perigee, and inclination), separation attitude, and AP mass properties. The AP initial target specification is due to ULA at the Program Kickoff Meeting. The AP final target specification is due to ULA 90 days before launch and will include the final AP mass properties. The AP will support launch windows defined by the primary SV.

The ABC/AP standard service provides for AP delivery to the same transfer orbit as the primary SV. The target specification should include AP orbital constraints, if any. AP transfer orbits that differ from the primary SV transfer orbit may be negotiated on a mission unique basis.

A.5 SPACECRAFT EMI AND EMC ANALYSIS AND ELECTROEXPLOSIVE DEVICE ANALYSIS

A confirmation of spacecraft transmitter and receiver parameters, and emission and susceptibility levels of electronic systems is required 7 months before launch (a final update may be provided at L-3 months, if required). This includes consideration of emissions from such electronic equipment as internal clocks, oscillators, and signal or data generators; and likelihood of electronics and items such as Electroexplosive Devices (EED) to cause upset, damage, or inadvertent activation. These characteristics are to be considered according to MIL-STD-1541 requirements to assure that appropriate margins are available during launch operations. ULA will use the spacecraft data to develop a final analysis for the combined spacecraft/launch vehicle and site environment.

A.6 SAFETY DATA

See Section 4.3.3.

A.6.1 Missile System Prelaunch Safety Package

The Missile System Prelaunch Safety Package (MSPSP) is the data package that describes in detail the hazardous and safety-critical spacecraft systems/subsystems, their interfaces, and the associated Ground Support Equipment (GSE). In addition, the Spacecraft MSPSP provides verification of compliance with the applicable Range Safety requirements. The spacecraft MSPSP must be approved by Range Safety before the arrival of spacecraft elements at the launch site.

A.6.2 Spacecraft Launch Site Procedures

See Section 4.3.3.2.

A.6.3 Radiation Protection Officer Data

Permission must be received from the Range Radiation Protection Officer (RPO) before spacecraft Radio Frequency (RF) emissions are allowed at the launch complex. The required

RPO data includes descriptions of the equipment involved, the procedures that will be used, and information on the personnel who will be running the procedures.

A.6.4 Spacecraft Breakup Data Requirements

The spacecraft data described in the following three subsections is required for the Atlas V program to complete mission-specific analyses that satisfy 45th Space Wing/SEOE and 30th Space Wing/SESE requirements for submitting a request for Range Safety Flight Plan Approval (FPA).

A.6.4.1 Inadvertent Spacecraft Separation and Propulsion Hazard Analysis. This data set is related to inadvertent separation of the spacecraft during early ascent and the potential for launch area hazards that could exist in the event spacecraft engine(s) fire. Typical spacecraft propulsion system data provided by the customer include the maximum tanked weight, maximum loaded propellant weight, maximum axial thrust (all motors), and maximum resultant specific impulse.

A.6.4.2 Intact Impact Analysis. This data set is related to the ground impact of the spacecraft. The intact impact analysis assumes ground impact of a fully loaded, fueled, intact spacecraft. It also assumes propellants will combine and explode.

Typical spacecraft data provided by the customer include the types and weights of explosive propellants; estimates of the number of pieces of the spacecraft that could break off in an explosion; and the location, size, weight, and shape of each piece.

A.6.4.3 Destruct Action Analysis. This data set is related to the Flight Termination System (FTS) destruction of the launch vehicle. The destruct action analysis assumes in-flight destruction of the vehicle by detonation of the Range Safety charge. Typical spacecraft data provided by the customer include an estimate of the number of spacecraft pieces that could break off because of commanded vehicle destruction and estimates of their size, weight, shape, and location on the spacecraft.

APPENDIX B
AP MISSION UNIQUE DELIVERABLES

B.1 MISSION UNIQUE CONTROL AND SEPARATION SYSTEM CAPABILITIES

The LVC approval of mission unique AP separation requirements, mass properties, and APC provided separation systems (if applicable) requires the APC to submit the following data a minimum of 24 months prior to ILC for LV analysis purposes:

1. AP mass properties (including 3 sigma uncertainties)
2. AP hardware drawings
3. Separation system manufacturer hardware tests and analysis reports

Note that LV mission unique analysis is not included in the ABC/AP standard service.

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