United Launch Alliance

Delta IV Launch Services User's Guide | June 2013

DELTA IV LAUNCH SERVICES USER'S GUIDE

The Delta IV Launch Services User's Guide has been cleared for public release by the Chief, Office of Security Review, Department of Defense, as stated in letter 13-S-1948, dated June 04, 2013.

THIS DOCUMENT SUPERSEDES PREVIOUS ISSUES OF THE COMMERCIAL DELTA IV PAYLOAD PLANNERS GUIDE, MDC 00H0043, DATED OCTOBER 2000, APRIL 2002, AND 06H0233 DATED SEPTEMBER 2007.

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CHANGE RECORD

Section	Change
All	• Reordered and merged sections to reflect ULA branding • Deleted Section 10 and moved content to Sections 8 and 9 • Replaced "Delta Program Office" with "ULA" • Minor corrections throughout
Introduction	• Minor updates to coincide with entire guide
Section 1	• Added upgraded RS-68A first-stage engine information (para 1.2.1) • Added Fleet Standardization Program information (para 1.2.1.1) • Updated maximum dimensions of launch vehicle insignia (para 1.4)
Section 2	• Updated Figures 2-4 & 2-6 to reflect RS68A timing • Updated maximum mission operation time to 8.0 hrs (para 2.2.3) • Removed Flight Termination System constraint information • Updated 3-σ Orbit Accuracy to reflect Common Avionics (Ref Figure 2-8) • Removed Recent Delta IV Missions (previous Figure 2-8) • Updated Delta IV Mission Capabilities (Figure 2-9) • Updated Figure Numbers for the Delta IV Vehicle Performance Curves (Figure 2-10) • Updated performance curves graphics (Figures 2-11 to 2-18) • Removed Delta IV M+(5,2) from Figure 2-10 & Performance Curves
Section 3	• Added composite fairing air conditioning inlet locations (Figures 3-2 & 3-3) • Clarified environmental control specifications at Eastern and Western Ranges (Figures 3-4 & 3-5) • Clarified cleanliness levels (para 3.1.5) • Clarified SC compatibility demonstration (para 3.2.5)
Section 4	• Consolidated Mission Integration and Safety sections into one section • Complete revision to the previous "Payload Integration" section to be consistent with current ULA integration processes • Added policy information on Suspended Load Exposures; "T-10 Second" Spacecraft Hold Call during Terminal Count; Spacecraft Compatibility to Transport, Hoist, and Launch Environments; and Spacecraft/Launch Vehicle Functional Interfaces for Mission Success (paras 4.2.4 thru 4.2.7)
Section 5	• Deleted 1194 and 1666 PAFs • Added 4293-5 PAF (Figure 5-1 & para 5.2.3) • Added C-Adapters (Figure 5-23 & para 5.3.1) • Added 937, 1194, 1666, and 6915 Payload Adapters (Figure 5-23 & para 5.3.5) • Updated capabilities and figures for PAFs
Section 6	• Deleted callouts to obsolete references
Section 7	• Consolidated Eastern and Western Range information into one section • Updated facility, process, and schedule information

Section	Change
Section 8	• Added new future capabilities and upgrades under consideration: RL10C-2 Second-Stage Engine, Advanced Common Evolved Stage, and Integrated Vehicle Fluids (para 8.2) • Common Avionics discussed in paragraphs 8.2.1 and 8.3.2
Section 9	• Added auxiliary and dual payload accommodations: P-PODs, C-Adapter Platform, Integrated Payload Carrier, 4-m Dual Spacecraft System, and 5-m Dual Spacecraft System (paras 9.1 & 9.2)
Appendix A	• Added Appendix to document Standard Service Parts List for each Delta IV configuration
Appendix B	• Added Appendix to document the Spacecraft Payload Questionnaire

INTRODUCTION

This guide describes the Delta IV launch system including its heritage, performance capabilities, and payload environments. Additionally, launch facilities, operations, and mission integration are discussed, as are the payload mechanical and electrical interfaces. Documentation and procedural requirements associated with preparing and conducting the launch are also defined.

The Delta IV configurations described herein are the latest evolution of our reliable Delta family, developed to provide our customers reliable access to space. In more than five decades of use, Delta launch systems have succeeded through evolutionary design upgrades to meet the growing needs of the user community while maintaining high reliability.

Delta IV launch vehicles can be launched from either of two launch sites within the continental United States–Eastern Range (ER) in Florida, and Western Range (WR) in California, depending on mission requirements. Our Space Launch Complex (SLC) of the ER, designated SLC-37, is located at Cape Canaveral Air Force Station (CCAFS) and is used for Geosynchronous Transfer Orbit (GTO) missions as well as missions requiring low- and medium-inclination orbits, while our SLC-6 of the WR at Vandenberg Air Force Base (VAFB) is typically used for high-inclination orbit missions. Both launch complexes are fully operational.

Depending on whether the satellite end-user customer is a United States Government or commercial entity, the customer will contract for launch services with either United Launch Services (ULS) or Boeing Launch Services (BLS), respectively.

ULS is the single point of contact for all United States Government customer new-business activities. ULS offers full-service launch solutions using the Atlas V, Delta II, and Delta IV families of launch vehicles. The customer is supported by an ULS organization consisting of highly knowledgeable technical and managerial personnel who are dedicated to open communication and responsive to all customer needs. ULS has the ultimate responsibility, authority, and accountability for all Atlas and Delta United States Government customer opportunities. This includes developing mission-unique launch solutions to meet customer needs, as well as providing customers with a launch service agreement for the selected launch services.

BLS is the single point of contact for all commercial customer new-business activities, and like ULS, provides full-service launch solutions on either the Delta II or Delta IV launch vehicles. While the customer will interface directly with BLS, all technical services will be supplied to BLS by United Launch Alliance (ULA).

ULS, BLS, and the ULA program office work together to ensure that all customer technical requirements are fully coordinated. ULA is responsible for the development, production, integration, test, mission integration, and launch of the Delta IV system.

When providing commercial launch services, ULA acts as the coordinating agent for the customer in interfacing with the United States Air Force (USAF), National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), and any other relevant agencies. Commercialization agreements with the USAF and NASA make available to Boeing the use of launch facilities and services for Delta IV launch campaigns.

For contracted launch services, a dedicated mission manager and engineering integration manager are appointed from within ULA to support the customer. The mission manager and engineering integration manager also work with ULS and BLS early in the process to define customer mission requirements and the appropriate launch solution and then transition to provide the day-to-day mission integration support necessary to successfully satisfy the customer's launch requirements. The mission manager and engineering integration manager support the customer's mission from contract award through launch and postflight analysis.

The ULA team addresses each customer's specific concerns and requirements, employing a meticulous, systematic, user-specific process that addresses advance mission planning and analysis of payload design; coordination of systems interface between payloads and Delta IV; processing of all necessary documentation, including government requirements; prelaunch systems integration and checkout; launch-site operations dedicated exclusively to the user's schedule and needs; and comprehensive postflight analysis.

The ULA team works closely with its customers to optimize the payload's operational life. In many cases, we can provide innovative trade studies to augment the performance values shown in Section 2. Our demonstrated capability to use the flexibility of the Delta launch vehicle and design team, together with our experience in supporting customers worldwide, makes ULA the ideal choice as a launch services provider.

PREFACE

This Delta IV Launch Services User's Guide is issued to the spacecraft user community to provide information about the Delta IV family of launch vehicles, its related systems, and launch services.

This document contains current Delta IV information and includes United Launch Alliance (ULA) plans and projections for Delta IV launch services launch vehicle specifications. Included are Delta IV family vehicle descriptions, target vehicle performance figures, payload envelopes, anticipated spacecraft environments, mechanical and electrical interfaces, payload processing, and other related information of interest to our potential customers.

As new developments in the Delta IV program progresses, 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.

Inquiries regarding the content of the Delta IV Launch Services User's Guide should be directed to:

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CONTENTS

Section 1
LAUNCH VEHICLE DESCRIPTION

This section provides an overall description of the Delta IV launch system and its major components. In addition, Delta IV vehicle designations are explained.

1.1 DELTA LAUNCH VEHICLES

The Delta launch vehicle program was initiated in the late 1950s by the National Aeronautics and Space Administration (NASA). The Delta vehicle was developed as an interim space launch vehicle using a modified Thor missile as the first stage and Vanguard components as the second and third stages capable of delivering a payload of 54 kg (120 lb) to Geosynchronous Transfer Orbit (GTO) and 181 kg (400 lb) to Low-Earth Orbit (LEO). The Delta program's commitment to vehicle improvement to meet customer needs continued over the last 50 years, culminating in the current Delta family of launch vehicles, with a wide range of increasing capability to GTO (Figure 1-1).

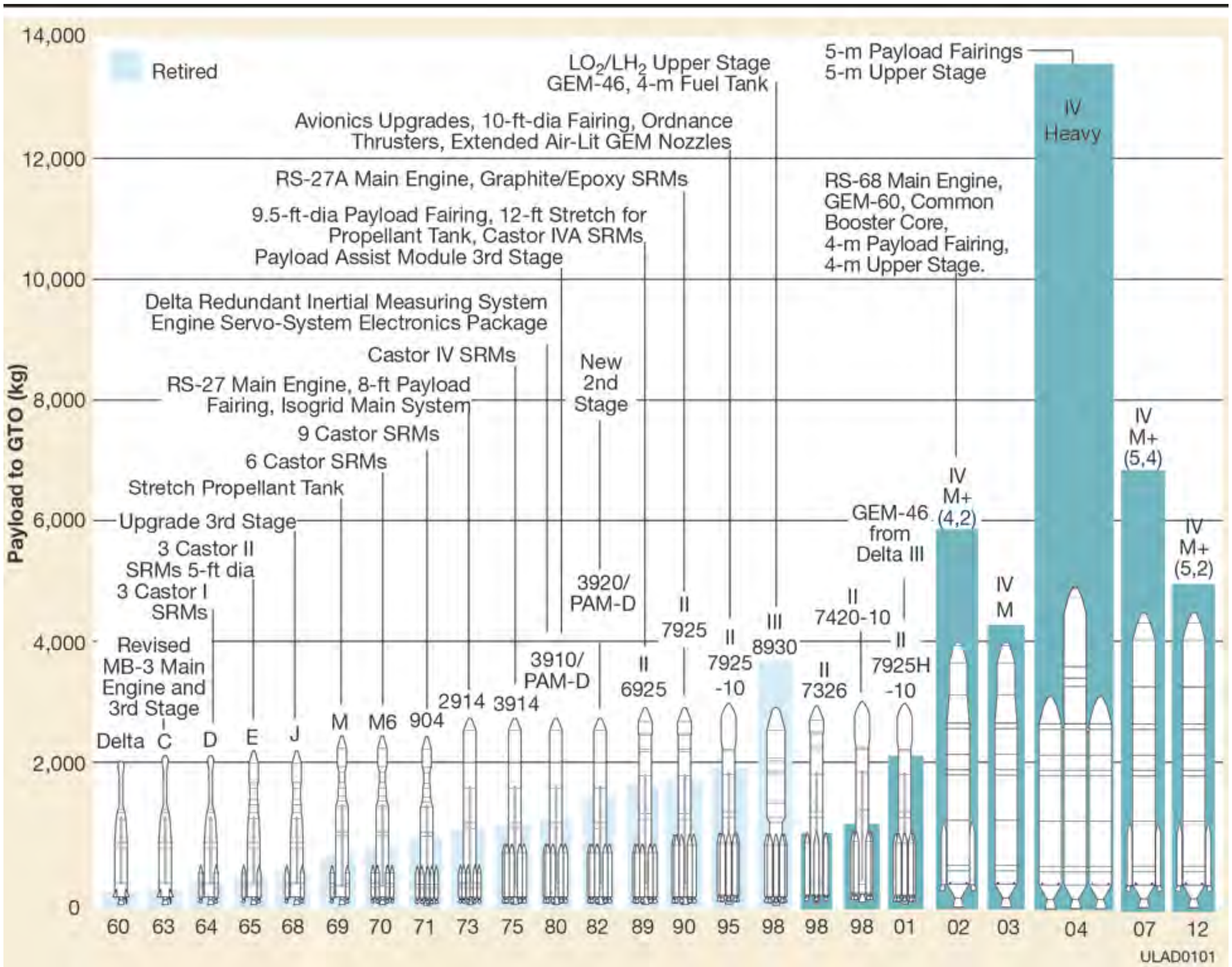

Figure 1-1. Heritage of the Delta Family

ULA's dedication to delivering superior launch services to its customers is evidenced by the many configurations developed to date. Delta II has provided customers with a demonstrated world-class success rate of over 98%, and processing times on the launch pad have been reduced from 40 to 24 calendar days. The Delta IV launch system is the latest example of this 50-year evolution, providing even more capability by incorporating heritage hardware and processes and a new robust propulsion system. ULA is committed to working with our customers to satisfy payload requirements while providing the best value for launch services across the entire Delta fleet.

1.2 DELTA IV LAUNCH SYSTEM DESCRIPTION

The newest member of the Delta family is the Delta IV launch system, which comes in five vehicle configurations: the Delta IV Medium, three variants of the Delta IV Medium-Plus (Delta IV M+), and the Delta IV Heavy, as shown in Figures 1-2 and 1-3. Each has a newly developed first-stage, called the Common Booster Core (CBC) using cryogenic propellants, Liquid Oxygen (LO_2)/Liquid Hydrogen (LH_2).

- The Delta IV Medium employs a first-stage CBC, a 4-m (159.7 in.) - dia cryogenic second stage, and a 4-m (160.4 in.) - dia composite Payload Fairing (PLF).
- The Delta IV M+ vehicle comes in three different configurations. One configuration uses two strap-on Solid Rocket Motors (SRMs) to augment the first-stage CBC, a 4-m (159.7 in.) - dia cryogenic second stage, and a 4-m (160.4 in.) - dia composite PLF. This configuration is designated as Delta IV M+(4,2); the first digit in parentheses refers to the diameter of the PLF in meters, and the second digit refers to the number of strap-on SRMs. The other two configurations are the Delta IV M+(5,2) and Delta IV M+(5,4) that have two and four SRMs, respectively, to augment the first-stage CBC. Both of these configurations employ a 5-m (202.0 in.) - dia cryogenic second stage, and a 5-m (202.0 in.) - dia composite payload fairing.
- The Delta IV Heavy employs two additional CBCs as strap-on Liquid Rocket Boosters (LRBs) to augment the first-stage CBC, a cryogenic 5-m second stage, and either a 5-m composite fairing or a 5-m metallic fairing.

The Delta IV launch system is designed to place payloads into various orbits by launching from either the Eastern Range (ER) at Cape Canaveral Air Force Station (CCAFS), Florida, or the Western Range (WR) at Vandenberg Air Force Base (VAFB), California, whichever is appropriate for mission requirements. Each mission will be allocated to a specific Delta IV launch vehicle to support the required launch date, performance, delivery-to-orbit, and overall mission requirements.

Note: Appendix A shows a Standard Service Parts list for each configuration of the Delta IV launch vehicle.

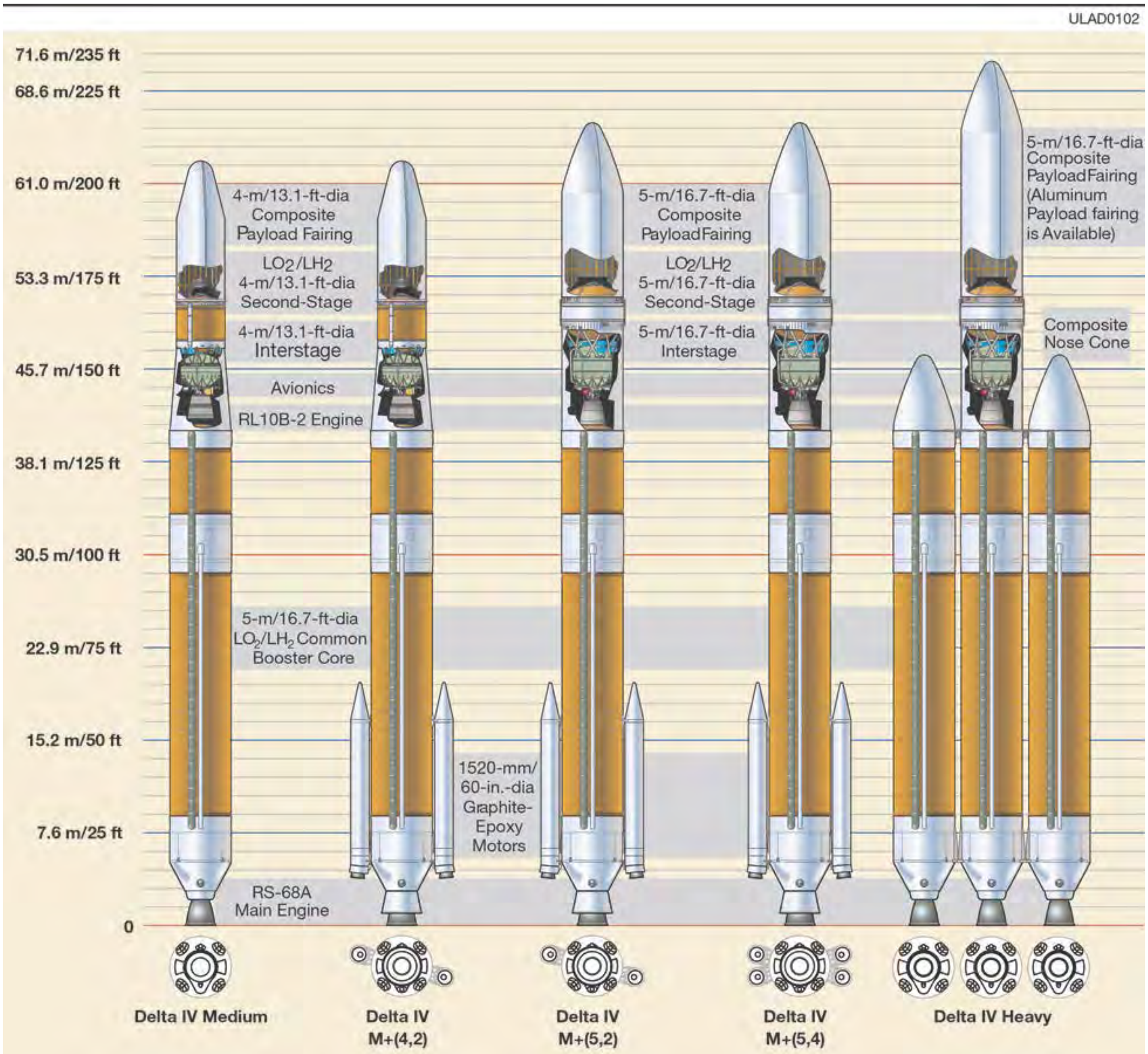

Figure 1-2. Configurations of the Delta IV Launch Vehicle

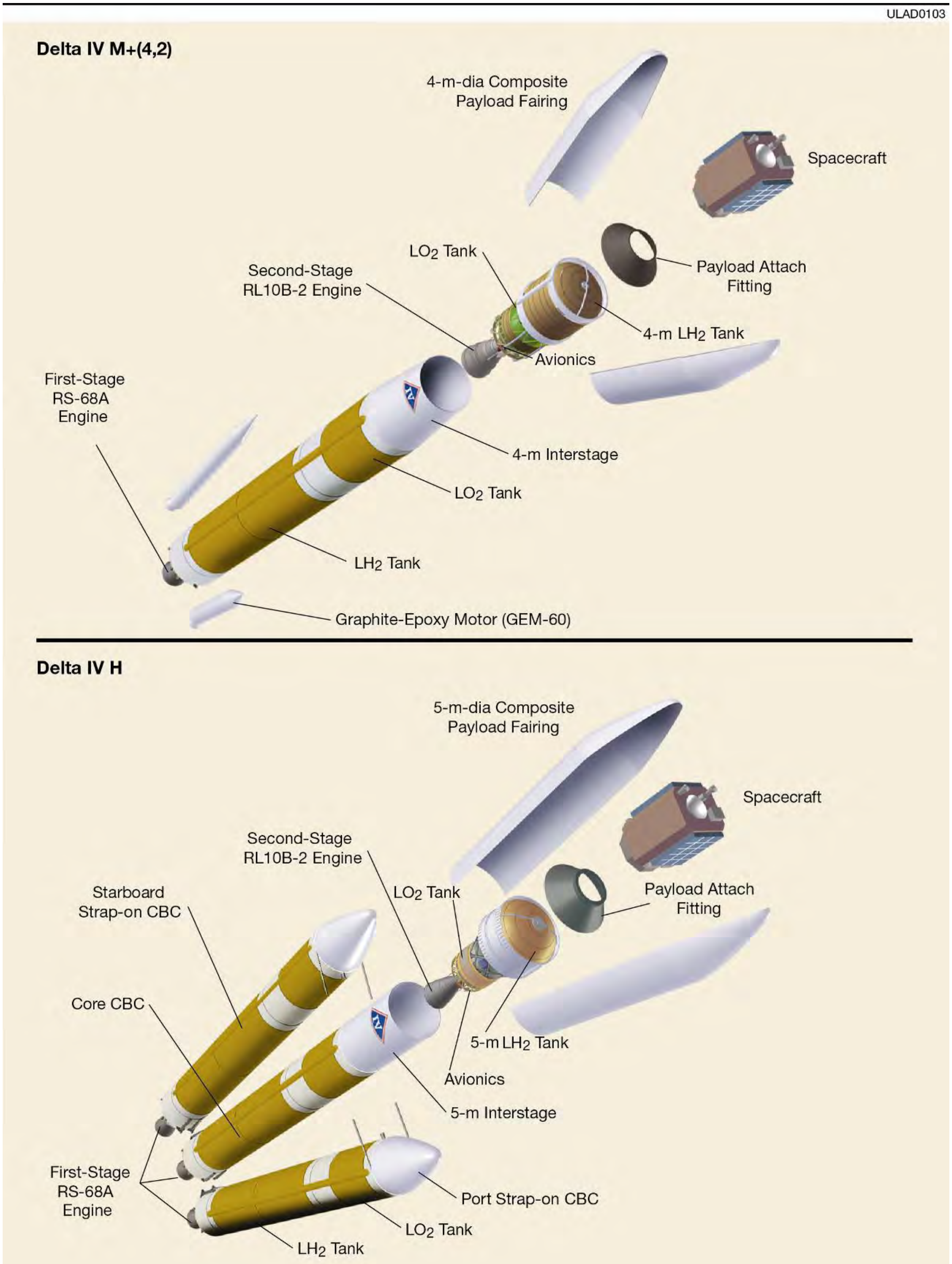

Figure 1-3. Delta IV Launch Vehicles

1.2.1 First Stage

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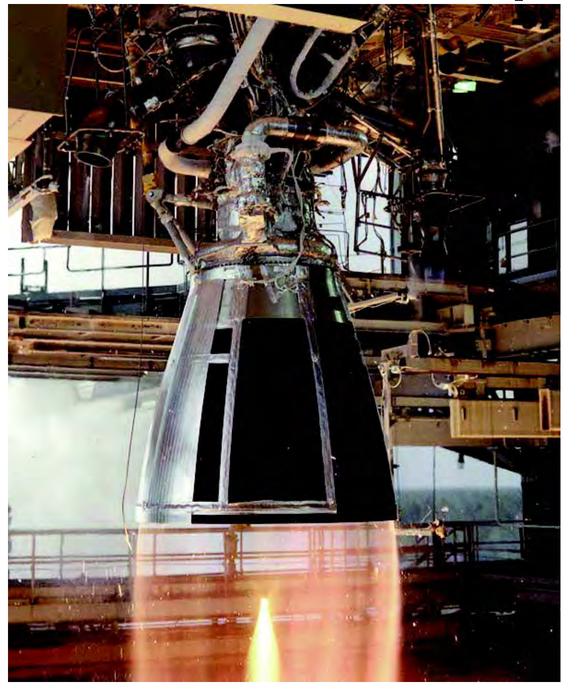

Figure 1-4. RS-68A Engine

The first-stage CBC, as illustrated in Figure 1-3, consists of the RS-68A engine, LH2 tank, centerbody, LO2 tank, and interstage.

The first-stage CBC is powered by the Rocketdyne RS-68A engine (Figure 1-4), a state-of-the-art engine burning LO2 and LH2 cryogens, capable of delivering 3137kN (705,250 lbf) of sea level thrust and having a vacuum specific impulse of 411.9 sec. The RS-68A can throttle down to 55% of full thrust level in a simple, single-step throttle profile designed to enhance reliability. It features proven technologies with the use of standard materials and minimum part count. The coaxial injector is derived from the Space Shuttle Main Engine (SSME) and uses low-cost materials and advanced fabrication techniques. The thrust chamber is an innovative Hot Isostatic Press (HIP)-bonded evolution of the SSME design. The engine has a 21.5 to 1 expansion ratio and employs a gas generator, two turbopumps, and a regeneratively cooled thrust chamber. The thrust chamber and nozzle are hydraulically gimbaled to provide pitch and yaw control. Roll control for single-CBC vehicles is provided during main engine burn primarily by vectoring the RS-68A hydrogen turbopump exhaust gases. Roll control for the Heavy vehicle is provided by gimbaling the RS-68A engines of the two strap-on LRBs.

The Delta IV M+ configurations use either two or four 1.55 m (60 in.) dia SRMs manufactured by Alliant Techsystems, Inc. (ATK) and designated as Graphite Epoxy Motors (GEM)-60. Ordnance for motor ignition and separation systems is completely redundant. Separation is accomplished by initiating ordnance thrusters that provide a radial thrust to jettison the expended SRMs away from the first stage. The Delta IV Heavy uses two strap-on LRBs with nose cones and Booster Separation Rocket Motors (BSRM).

The CBC has an overall dia of 5-m, so the interstage is tapered down to 4-m (159.7 in.) - dia for the Delta IV Medium and Delta IV M+(4,2) configurations that use a 4-m cryogenic second stage. The interstages for the Delta IV M+(5,2), Delta IV M+(5,4), and Delta IV Heavy configurations have a 5-m-dia cylinder. For aerodynamic purposes, the strap-on LRBs for the Delta IV Heavy employ nose cones in place of the interstage.

1.2.1.1 Fleet Standardization Program (FSP). The Fleet Standardization Program (FSP) leverages the enhanced RS-68A first stage engine's additional performance capability and implements a standardized CBC for Delta IV Medium and Medium-Plus configurations. Implementing this capability provides improved production flow and manifest flexibility, and lower production and engineering support costs. The FSP-standardized CBC maintains full commonality between all of the Medium and Medium-Plus configurations until reaching the final Integration, Assembly, and Check-Out area of the Decatur Production facility, where the CBC is configured into the specific mission configuration. By maintaining a single, standardized CBC design much later in the production flow, the capability to switch CBCs between missions late into the production flow is enabled, providing additional manifest flexibility while reducing overall production costs. All data contained in this document utilizes the FSP capabilities and environments.

1.2.2 Second Stage

Two second-stage configurations (Figure 1-5) are offered on Delta IV: a 4-m version used on the Delta IV Medium and Delta IV M+(4,2) and a 5-m version used on the Delta IV M+(5,2), Delta IV M+(5,4), and Delta IV Heavy.

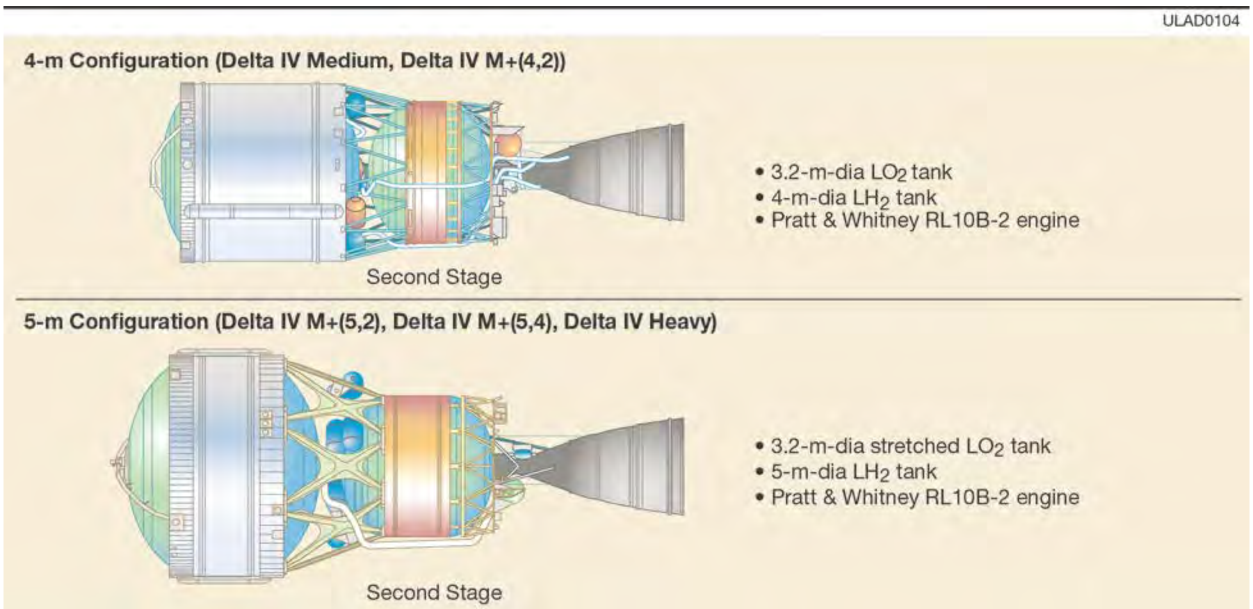

Figure 1-5. Delta IV Second-Stage Configurations

Both second stages use the cryogenic Pratt & Whitney Rocketdyne (PWR) RL10B-2 engine, derived from the flight-proven RL10 family. With an extendable nozzle, this engine produces a thrust of 110 kN (24,750 lb) and has a specific impulse of 465 sec. The engine gimbal system uses electromechanical actuators that provide high reliability while reducing both cost and weight. The RL10B-2 propulsion system and Attitude Control System (ACS) use flight-proven off-the-shelf components. The 4-m second stage has a total propellant load of 20,410 kg (45,000 lb), providing a total burn time of approximately 850 sec.

The 5-m second stage is based on the 4-m version. The LO_2 tank is lengthened by approximately 0.5 m, while the LH_2 tank's diameter is enlarged to 5 m. The total propellant load increases to 27,200 kg (60,000 lb), allowing a burn time of over 1,125 sec.

Propellants are managed during coast by directing hydrogen boil-off through aft-facing thrusters to provide propellant settling thrust, and by the use of the ACS, as required. Propellant tank pressurization during burn is accomplished using hydrogen bleed from the engine for the LH_2 tank and helium for the LO_2 tank. Missions with more than one engine restart (up to two) are accommodated by adding up to two helium bottles to the 4-m second stage and one additional
bottle to the 5-m second stage for tank repressurization. The mission duration capability is 2.3 hr nominally, but may be increased to over 7 hr by adding an additional hydrazine bottle and two additional batteries on the second stage. After payload separation, a Contamination and Collision Avoidance Maneuver (CCAM) is conducted to ensure adequate separation distance from the payload orbit prior to safing the stage.

1.2.3 Third Stage

The Delta Program is evaluating the use of a third stage for the Delta IV M+ and Delta IV Heavy launch vehicles for interplanetary missions. The third-stage design would be based on the proven Delta II design.

The heritage Delta II third stage consists of a Star 48B solid rocket motor, a payload attach fitting (PAF) with Nutation Control System (NCS), and a spin table containing small rockets for spin-up of the third stage/spacecraft. The Star 48B SRM has been flown on numerous missions and was developed from a family of high-performance apogee and perigee kick motors made by Alliant Techsystems. The flight-proven NCS, using monopropellant hydrazine prepressurized with helium, maintains orientation of the spin-axis of the third-stage/spacecraft stack during flight until spacecraft separation. This simple system has inherent reliability, with only one moving component and a leak-free design. Additional information about the heritage third-stage design is available in the Delta II Payload Planners Guide. Because the third-stage configuration is not currently baselined in the Delta IV program, no other reference to the third stage is made in this Payload Planners Guide at this time. For more information regarding use of a third stage, please contact the Delta Program Office.

1.2.4 Payload Attach Fittings (PAF)

The Payload Attach Fitting (PAF) provides the mechanical interface between the payload and the launch vehicle. The Delta IV launch system offers a selection of standard and modifiable

PAFs to accommodate a variety of payload requirements. The customer has the option to provide the payload separation system and mate directly to a PAF provided by ULA; or ULA can supply the entire separation system. Payload separation systems typically incorporated on the PAF include clampband systems or explosive attach-bolt systems. The PAFs, with associated separation systems, are discussed in greater detail in Section 5.

ULA has extensive experience designing and building satellite dispensing systems for multiple satellite launches. Our dispensers have a 100% success rate. For more information regarding satellite dispensing systems, please see Section 9.

1.2.5 Payload Fairing (PLF)

The Payload Fairing (PLF) protects the payload post encapsulation through boost flight. The Delta IV launch system offers PLFs (Figure 1-6) for different launch vehicle configurations.

The 4-m fairing is a composite bisector design. The 5-m composite fairing for single-manifest missions comes in two standard lengths: 14.3 m (47 ft) and 19.1 m (62.7 ft).

The 5-m metallic trisector fairing is a modified version of the flight-proven Titan IV aluminum isogrid fairing that was designed and manufactured by Boeing.

All PLFs are configured for off-pad payload encapsulation (Sections 7.1.3 and 7.2.3) to enhance payload safety and security, and to minimize on-pad time. Interior acoustic blankets as well as flight-proven contamination-free separation joints are incorporated into the fairing design for payload protection. Mission-specific fairing modifications incorporating spacecraft (SC) access doors, additional acoustic blankets, Radio Frequency (RF) windows, and RF re-rad antennas may be made available to meet customer requirements. Payload fairings are discussed in more detail in Section 6.

1.2.6 Avionics and Flight Software

The Delta IV launch system uses a fully fault-tolerant avionics suite, including a Redundant Inertial Flight Control Assembly (RIFCA) and automated launch operations processing using an advanced launch control system.

The RIFCA, supplied by L3 Communications, uses ring laser gyros and accelerometers to provide redundant three-axis attitude and velocity data. In addition to RIFCA, both the first- and second-stage avionics include interface and control electronics to support vehicle control and sequencing, a power and control box to support power distribution, and an ordnance box to issue ordnance commands. A Pulse Code Modulation (PCM) Telemetry (TM) system delivers real-time launch vehicle data directly to ground stations or relays through the Tracking and Data Relay Satellite System (TDRSS). If ground coverage is not available, instrumented aircraft or TDRSS may be available, in coordination with NASA, to provide flexibility with telemetry coverage.

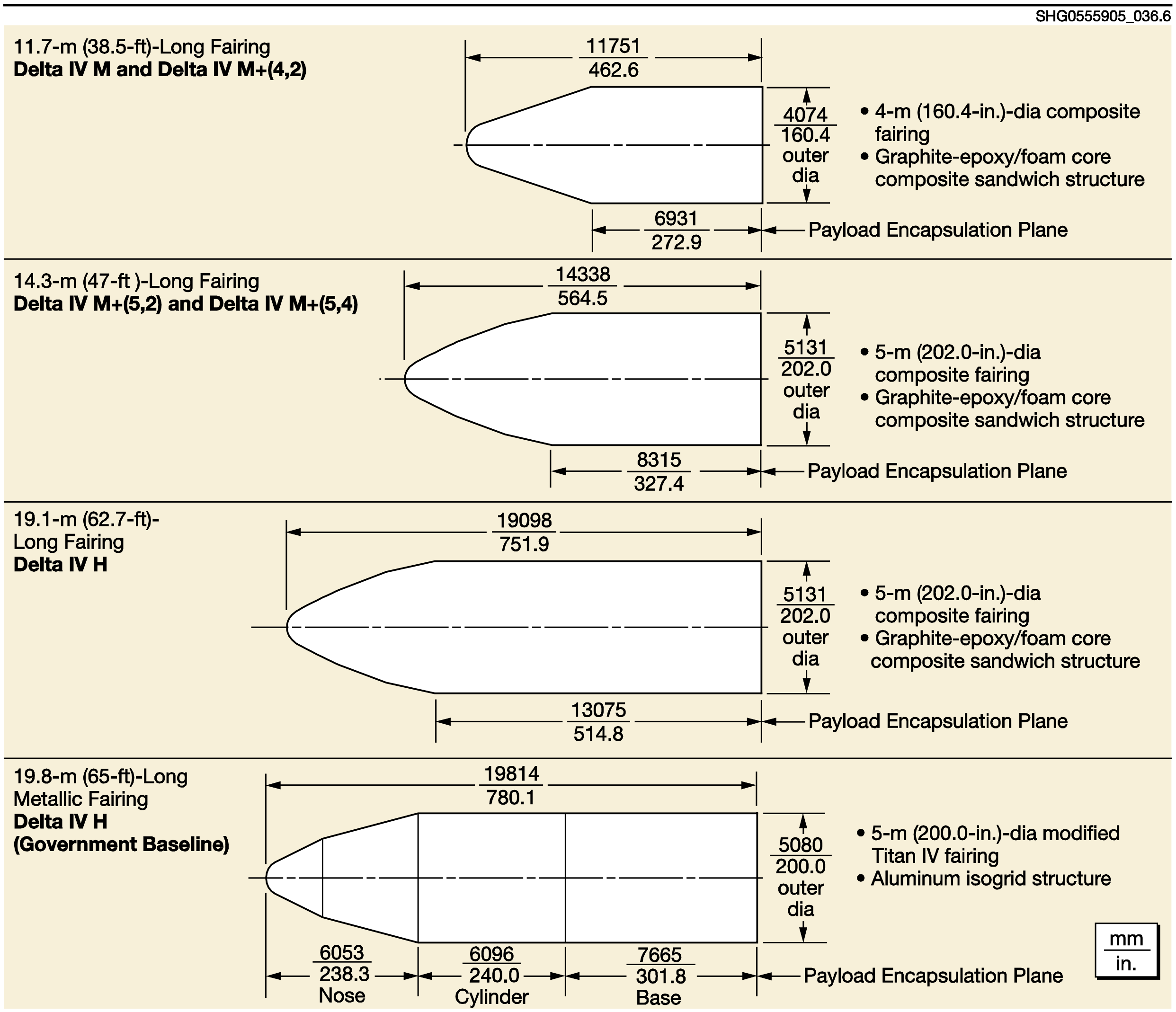

Figure 1-6. Delta IV Fairing Configurations

The flight software comprises a standard flight program and a mission-constants database specifically designed to meet each customer's mission sequence requirements. Mission requirements are implemented by configuring the mission-constants database, which is designed to fly the mission trajectory and to separate the satellite at the proper attitude and time. The mission-constants database is validated during the hardware/software functional validation tests and the systems integration tests. The final software validation test is accomplished during a full-length simulated flight test at the launch site.

The RIFCA contains the control logic that processes rate and accelerometer data to form the proportional and discrete control output commands needed to drive the control actuators and hydrazine control thrusters.

Position and velocity data are explicitly computed to derive guidance steering commands. Early in flight, a load-relief mode turns the vehicle into the wind to reduce angle of attack, structural loads, and control effort. After dynamic pressure decay, the guidance system corrects trajectory dispersions caused by winds and vehicle performance variations, and directs the vehicle to the nominal end-of-stage orbit. Payload separation in the desired transfer orbit is accomplished by applying time adjustments to the nominal engine start/stop sequence, in addition to the required guidance steering commands.

1.3 DELTA IV VEHICLE COORDINATE SYSTEM

The vehicle axes are defined in Figure 1-7. An overhead view shows the vehicle orientation to the launch pad. The launch vehicle coordinate system is shown with the vehicle pitch, roll and yaw axes. The vehicle centerline is the longitudinal axis of the vehicle. Axis II (+Z) is on the downrange side of the vehicle, and axis IV (-Z) is on the up-range side. The vehicle pitches about axes I (+Y) and III (-Y). Positive pitch rotates the nose of the vehicle up, toward axis IV. The vehicle yaws about axes II and IV. Positive yaw rotates the nose to the right, toward axis I. The vehicle rolls about the centerline. Positive roll is clockwise rotation, looking forward from the aft end of the vehicle (i.e., from axis I toward axis II). In this User's Guide, all coordinates are in the launch vehicle coordinate system unless otherwise stated.

1.3.1 Orientation

A second coordinate system of interest to the spacecraft customer is the Payload Accommodations (PLA) Coordinate System (CSYS). Figure 1-8 shows the orientation of the payload accommodations coordinate system relative to the launch vehicle coordinate system. The PLA coordinate system is similar to the launch vehicle coordinate system but is clocked positive 33 deg from the launch vehicle coordinate system.

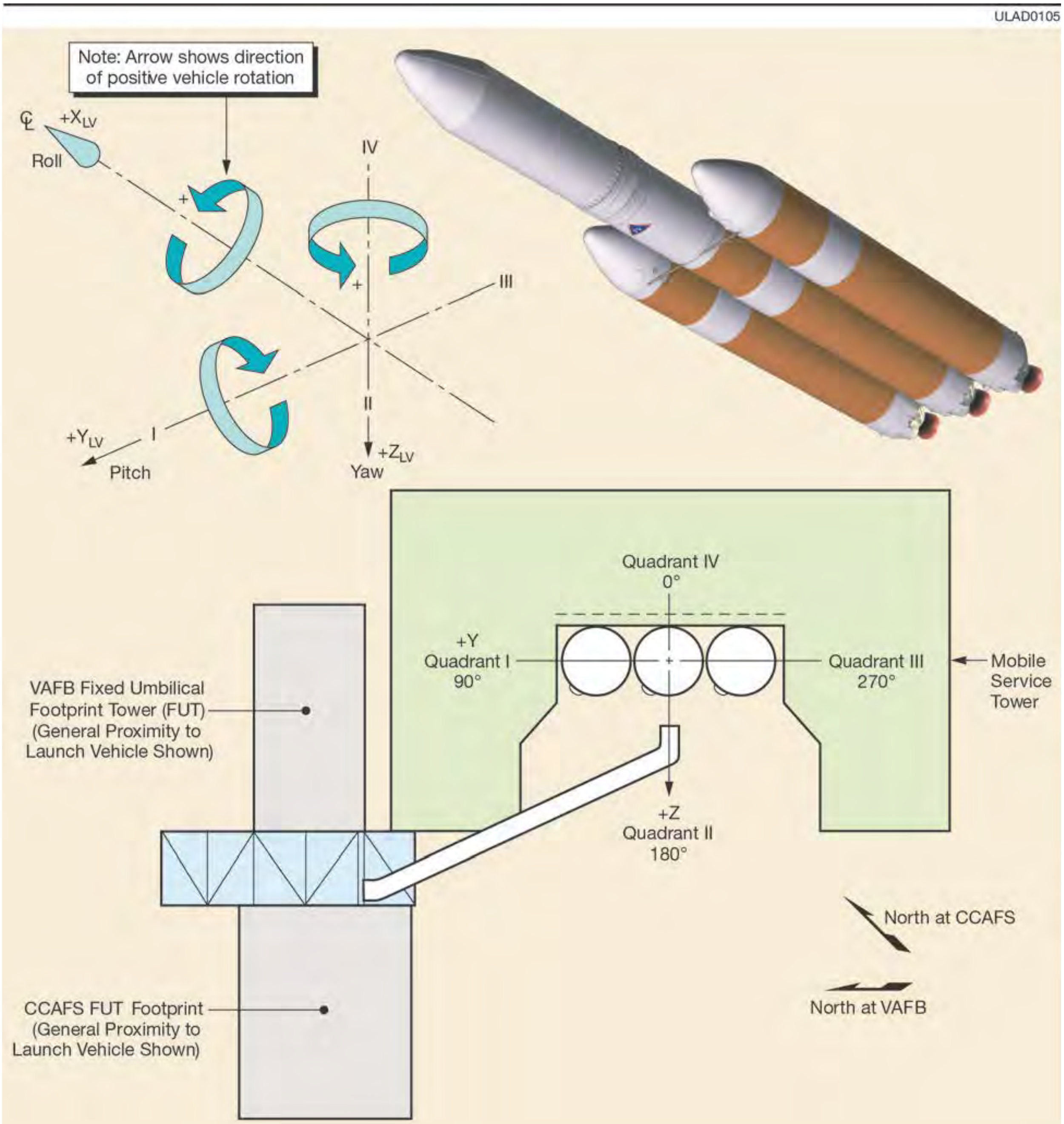

Figure 1-7. Launch Vehicle Axes

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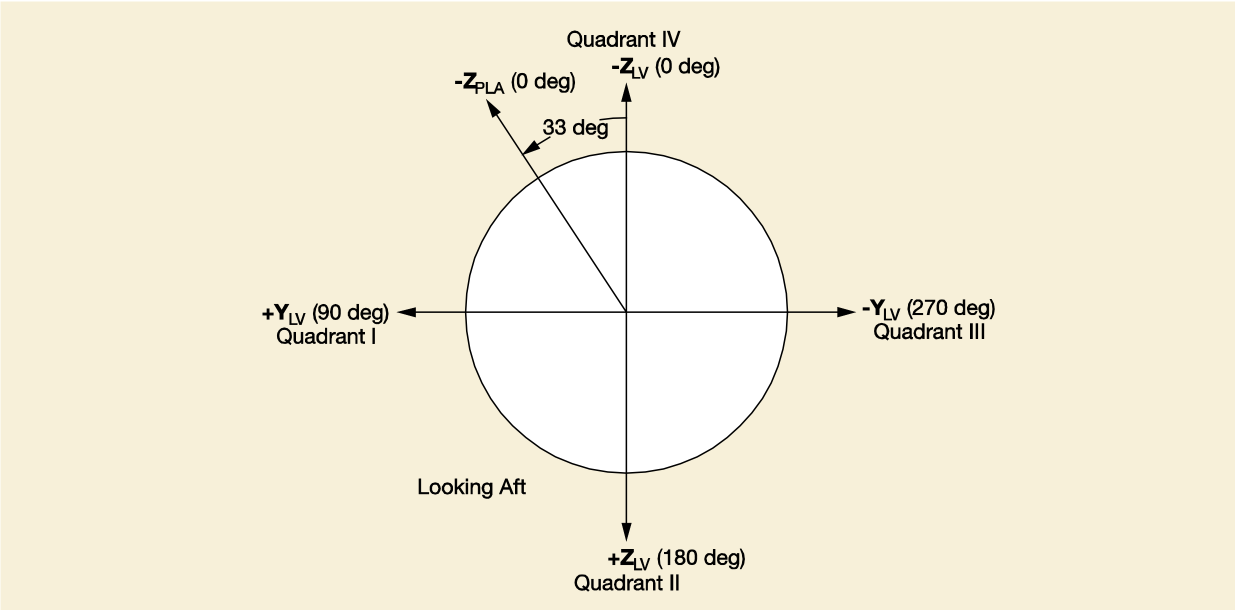

Figure 1-8. Launch Vehicle vs. Payload Accommodations Coordinate System

1.3.2 Station Number

Station number units are in inches and measured along the X-axis of the launch vehicle coordinate system. The origin of the launch vehicle coordinate system is near the top of the mobile service tower. Refer to Section 3 for launch vehicle station locations at the payload encapsulation plane.

1.4 LAUNCH VEHICLE LOGO

Delta IV customers are invited to create a mission-specific logo to be placed on their launch vehicles. The customer is requested to submit the proposed design at the beginning of the mission integration schedule for review and approval. The maximum size of the logo is 3.05 m by 3.05 m (10 ft by 10 ft). Following approval, the flight logo will be prepared and placed on the up-range side of the launch vehicle. See Section 4.2.1 for further information.

Section 2
GENERAL PERFORMANCE CAPABILITY

The Delta IV launch system can accommodate a wide variety of mission requirements from both the Eastern and Western launch ranges. This section describes the Delta IV launch vehicle performance for planning purposes. Individual mission requirements and specifications will be used to perform detailed performance analyses for specific customer missions. United Launch Alliance (ULA) mission designers can provide innovative performance trades to meet specific requirements. Additionally, future performance improvements are discussed in detail in Section 8. Our customers are encouraged to contact ULA for further information.

2.1 LAUNCH SITES

Depending on the specific mission requirement and range safety restrictions, the Delta IV can be launched from either the Eastern Range (ER) or Western Range (WR).

2.1.1 Eastern Range Launch Site

The Delta IV eastern launch site is Space Launch Complex 37 (SLC-37) at Cape Canaveral Air Force Station (CCAFS), Florida. This site can accommodate flight azimuths in the range of 42 deg to 110 deg, with 95 deg being the most commonly flown.

2.1.2 Western Range Launch Site

The western launch site for Delta IV is Space Launch Complex 6 (SLC-6) at Vandenberg Air Force Base (VAFB), California. This site can accommodate flight azimuths in the range of 151 deg to 210 deg.

2.2 MISSION PROFILES

Delta IV mission profiles are derived from our long history of reliable Delta II trajectories and sequences of events. Our flight-proven Redundant Inertial Flight Control Assembly (RIFCA) inserts payloads into highly accurate orbits (Section 2.3), increasing spacecraft lifetimes. Global Positioning System (GPS) Metric Tracking or ground-based C-band coverage is provided for range safety. Once safe orbit is achieved the command-destruct receivers are turned off. After first/second-stage separation, the telemetry may be switched to the NASA Tracking and Data Relay Satellite System (TDRSS). Payload fairing jettison and payload separation events will be tailored during the mission integration process to satisfy mission requirements. A typical two-stage Low Earth Orbit (LEO) mission profile is shown in Figure 2-1.

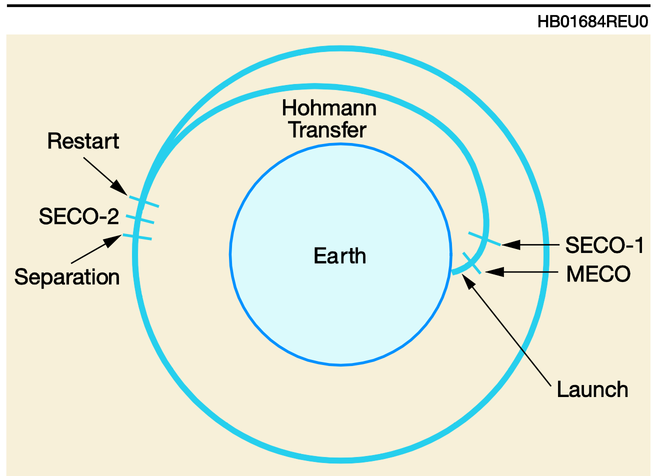

Figure 2-1. Typical LEO Mission Profile

After separation of the spacecraft, a coast period is allowed to provide the required launch-vehicle-to-spacecraft separation distance prior to a Collision and Contamination Avoidance Maneuver (CCAM), which is performed to remove the second stage from the spacecraft's orbit, followed by vehicle safing (burning or venting of propellants). Preliminary and final nominal mission Three-Degree-of-Freedom (3-DOF) trajectories will simulate the distance and attitude time histories of the launch vehicle from separation through end of mission, including CCAM, orbit disposal, and launch vehicle safing. Spacecraft separation clearance will be verified using Six-Degree-of-Freedom (6-DOF) simulation. Six-DOF simulations will verify that the control system can adequately perform the required attitude maneuvers and determine the duty cycle of the control thrusters, which will be input to the contamination analysis. Closed-loop guided 6-DOF simulations will verify that the guidance can steer the launch vehicle and perform Delta IV maneuvers properly. For payloads requiring spin stabilization prior to separation (Delta IV can achieve spin rates up to 5 rpm), 6-DOF simulations will be used to verify control system adequacy and spacecraft clearance during spinup, separation, launch vehicle coast, and despin. Our experience, capability, and accuracy assure that all customer requirements are met to ensure mission success.

2.2.1 GTO Mission Profile

The typical sequence of events for the Delta IV family of launch vehicles to a Geosynchronous Transfer Orbit (GTO) of 185 km by 35,786 km (100 nmi by 19,323 nmi) at 27.0 deg inclination is shown in Figures 2-2, 2-3, and 2-4. Injection into GTO may occur on either the descending or ascending node to accommodate spacecraft needs.

Following insertion into GTO, the second stage reorients to the correct three-axis attitude for spacecraft deployment, using the attitude control system's hydrazine thrusters. Our second stage is capable of any desired orientation required for spacecraft deployment. Spacecraft may also be spin stabilized prior to separation for spin stabilization or thermal management. Separation immediately follows the required maneuvering. The mission operation time is less than 2.3 hr nominally.

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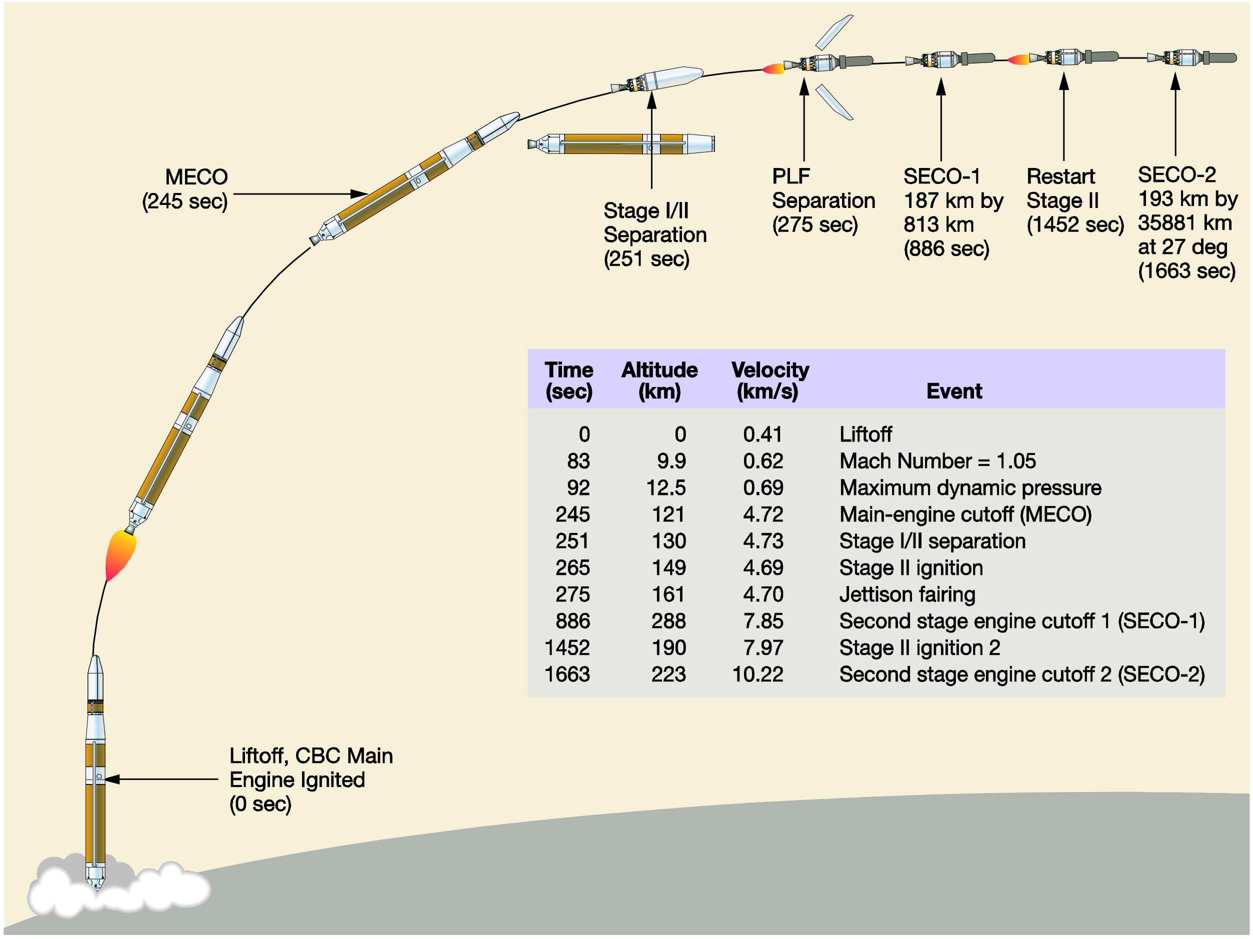
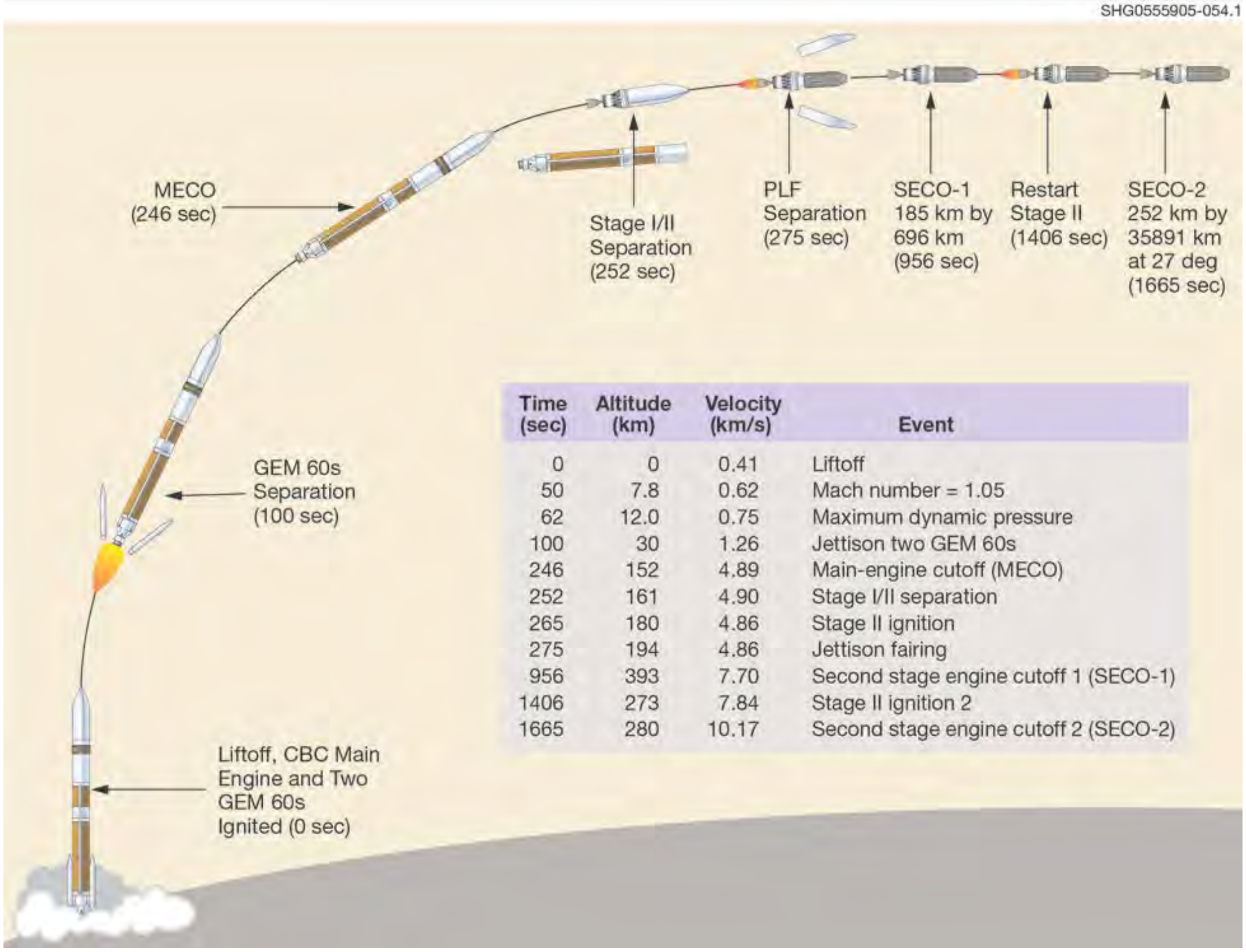


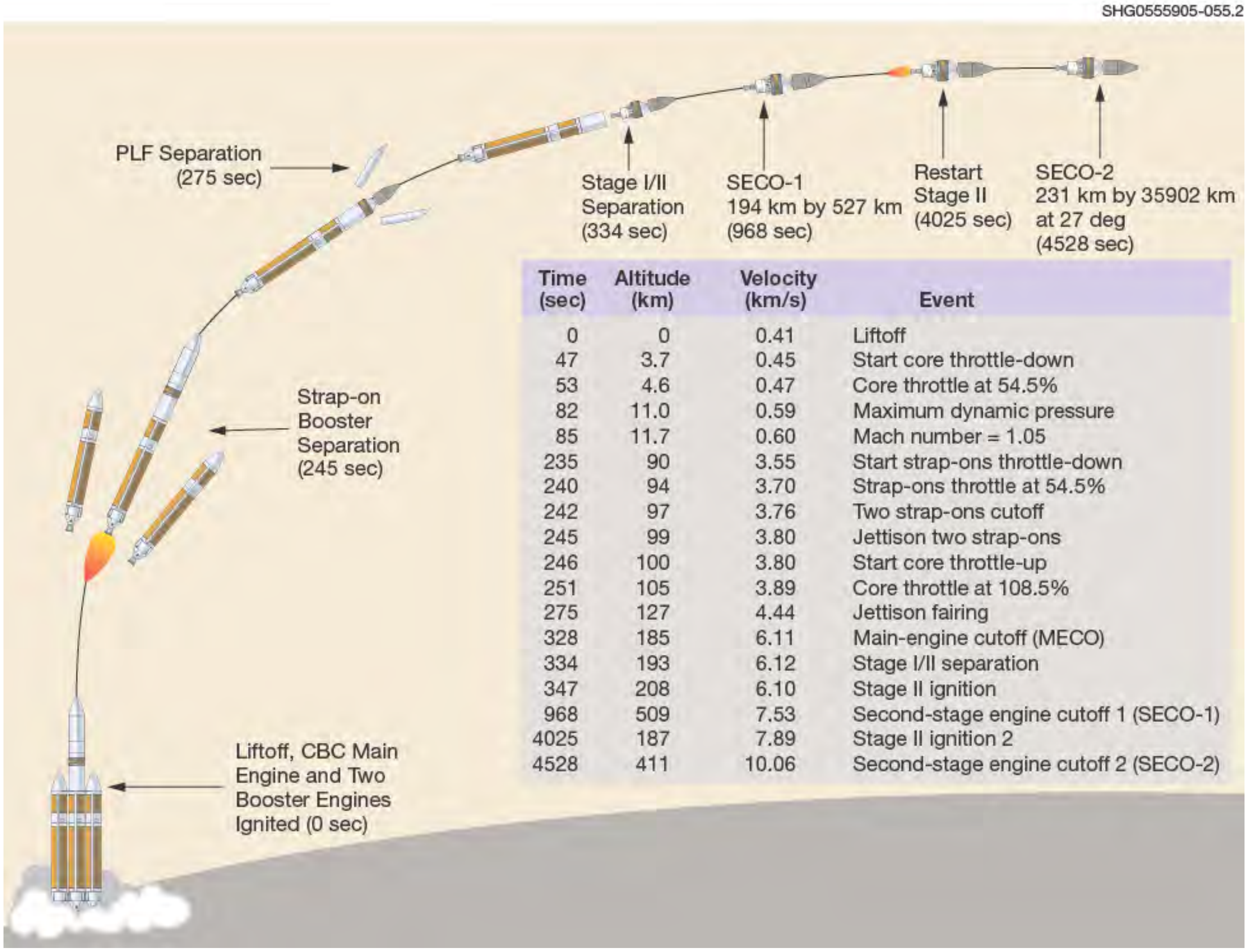
Time (sec)	Altitude (km)	Velocity (km/s)	Event
0	0	0.41	Liftoff
83	9.9	0.62	Mach Number = 1.05
92	12.5	0.69	Maximum dynamic pressure
245	121	4.72	Main-engine cutoff (MECO)
251	130	4.73	Stage I/II separation
265	149	4.69	Stage II ignition
275	161	4.70	Jettison fairing
886	288	7.85	Second stage engine cutoff 1 (SECO-1)
1452	190	7.97	Stage II ignition 2
1663	223	10.22	Second stage engine cutoff 2 (SECO-2)

Figure 2-2. Delta IV Medium Sequence of Events for a GTO Mission (Eastern Range)



Time (sec)	Altitude (km)	Velocity (km/s)	Event
0	0	0.41	Liftoff
50	7.8	0.62	Mach number = 1.05
62	12.0	0.75	Maximum dynamic pressure
100	30	1.26	Jettison two GEM 60s
246	152	4.89	Main-engine cutoff (MECO)
252	161	4.90	Stage I/II separation
265	180	4.86	Stage II ignition
275	194	4.86	Jettison fairing
956	393	7.70	Second stage engine cutoff 1 (SECO-1)
1406	273	7.84	Stage II ignition 2
1665	280	10.17	Second stage engine cutoff 2 (SECO-2)

Figure 2-3. Delta IV M+(5,2) Sequence of Events for a GTO Mission (Eastern Range)



Time (sec)	Altitude (km)	Velocity (km/s)	Event
0	0	0.41	Liftoff
47	3.7	0.45	Start core throttle-down
53	4.6	0.47	Core throttle at 54.5%
82	11.0	0.59	Maximum dynamic pressure
85	11.7	0.60	Mach number = 1.05
235	90	3.55	Start strap-ons throttle-down
240	94	3.70	Strap-ons throttle at 54.5%
242	97	3.76	Two strap-ons cutoff
245	99	3.80	Jettison two strap-ons
246	100	3.80	Start core throttle-up
251	105	3.89	Core throttle at 108.5%
275	127	4.44	Jettison fairing
328	185	6.11	Main-engine cutoff (MECO)
334	193	6.12	Stage I/II separation
347	208	6.10	Stage II ignition
968	509	7.53	Second-stage engine cutoff 1 (SECO-1)
4025	187	7.89	Stage II ignition 2
4528	411	10.06	Second-stage engine cutoff 2 (SECO-2)

Figure 2-4. Delta IV Heavy Sequence of Events for a GTO Mission (Eastern Range)

2.2.2 LEO Mission Profile

The typical sequence of events for the Delta IV to LEO is summarized in Figures 2-5 and 2-6. The profile follows a sequence similar to the GTO trajectories, using a gravity turn followed by several pitch maneuvers to arrive at the target orbits while maximizing payload lift capability. The second stage is capable of deploying multiple spacecraft simultaneously or singly, with reorientation and hold periods between each separation event (see Section 2.2.4). The mission operation time is less than 2.3 hr nominally.

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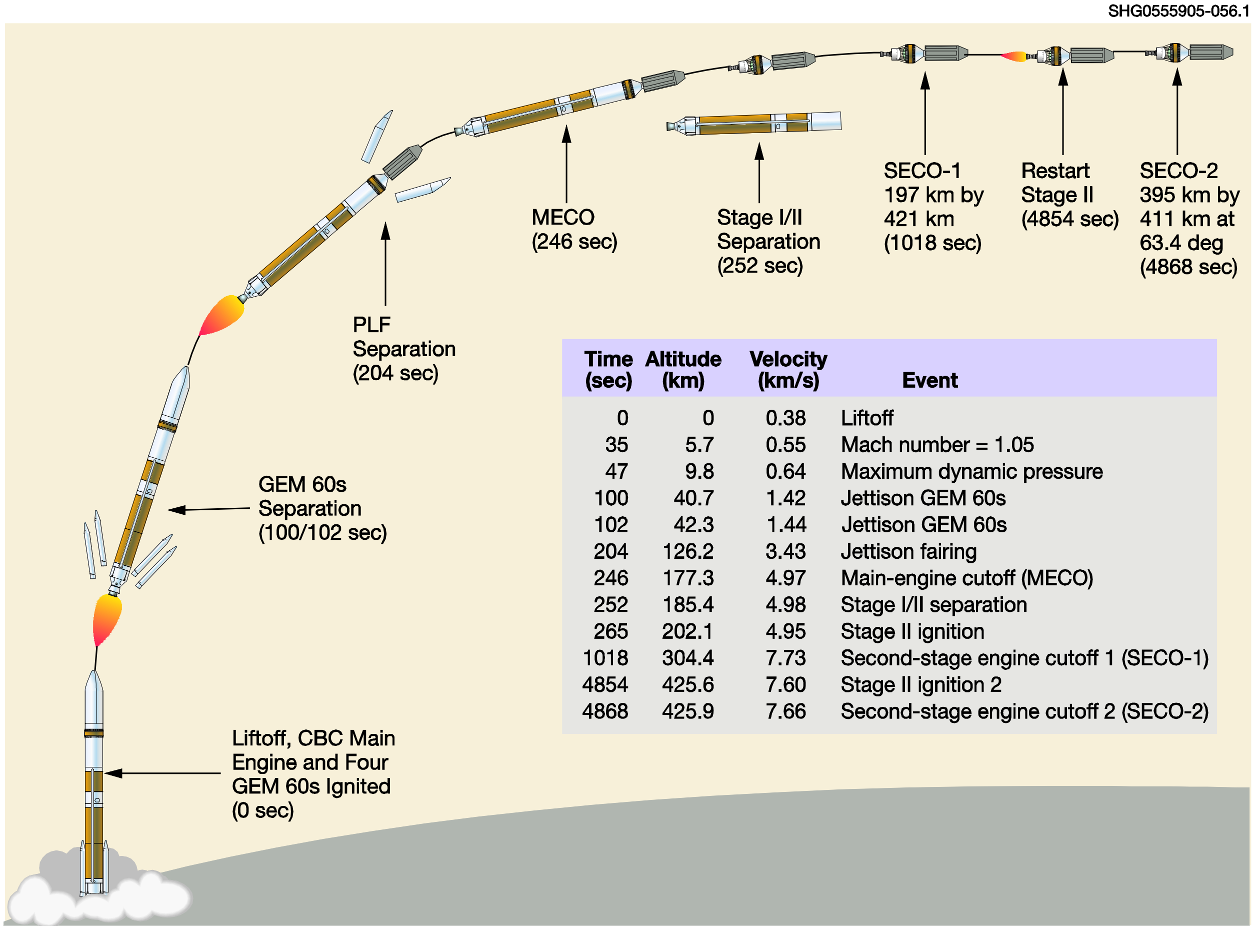

Time (sec)	Altitude (km)	Velocity (km/s)	Event
0	0	0.38	Liftoff
35	5.7	0.55	Mach number = 1.05
47	9.8	0.64	Maximum dynamic pressure
100	40.7	1.42	Jettison GEM 60s
102	42.3	1.44	Jettison GEM 60s
204	126.2	3.43	Jettison fairing
246	177.3	4.97	Main-engine cutoff (MECO)
252	185.4	4.98	Stage I/II separation
265	202.1	4.95	Stage II ignition
1018	304.4	7.73	Second-stage engine cutoff 1 (SECO-1)
4854	425.6	7.60	Stage II ignition 2
4868	425.9	7.66	Second-stage engine cutoff 2 (SECO-2)

Figure 2-5. Delta IV M+(5,4) Sequence of Events for a LEO Mission (Western Range)

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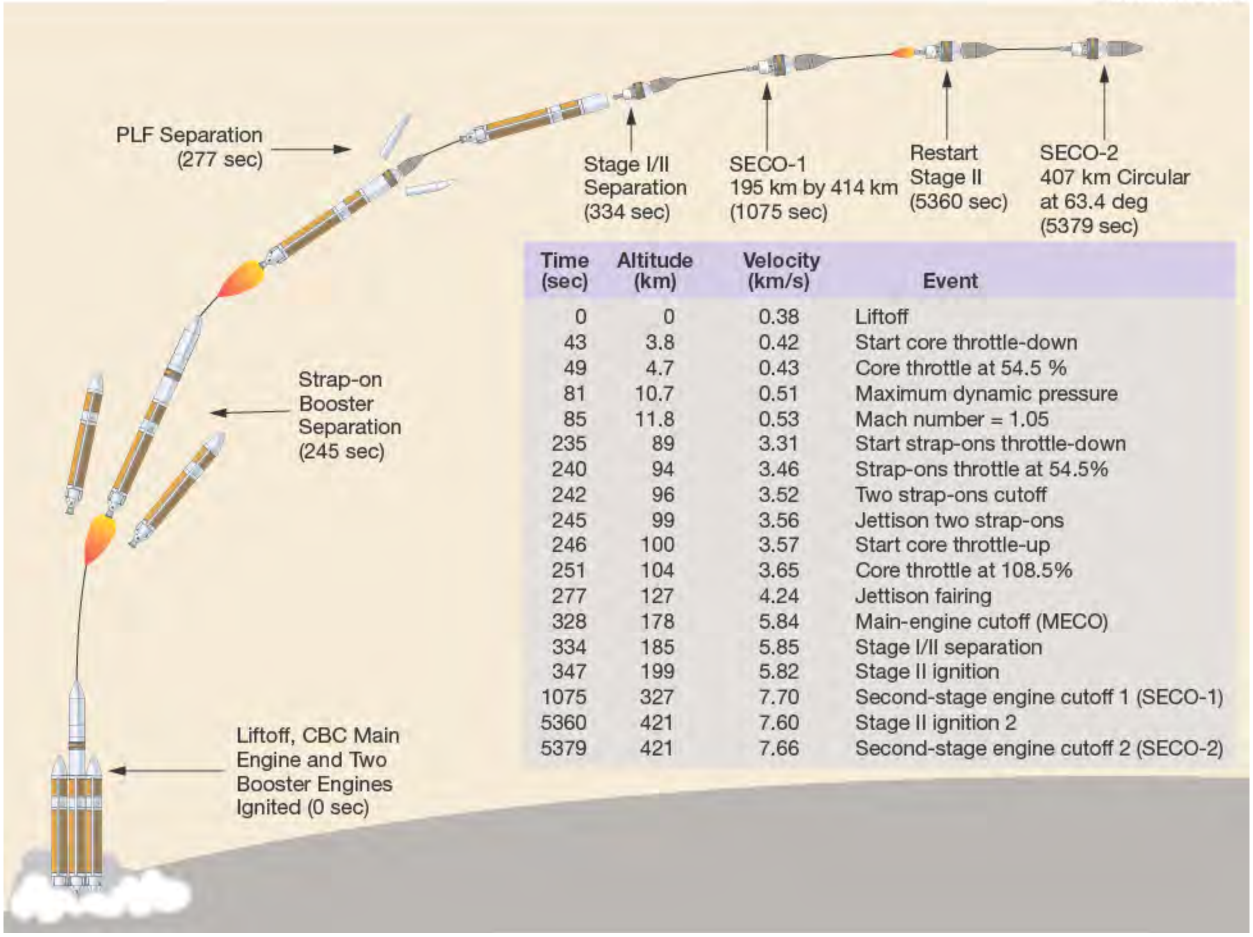

Time (sec)	Altitude (km)	Velocity (km/s)	Event
0	0	0.38	Liftoff
43	3.8	0.42	Start core throttle-down
49	4.7	0.43	Core throttle at 54.5 %
81	10.7	0.51	Maximum dynamic pressure
85	11.8	0.53	Mach number = 1.05
235	89	3.31	Start strap-ons throttle-down
240	94	3.46	Strap-ons throttle at 54.5%
242	96	3.52	Two strap-ons cutoff
245	99	3.56	Jettison two strap-ons
246	100	3.57	Start core throttle-up
251	104	3.65	Core throttle at 108.5%
277	127	4.24	Jettison fairing
328	178	5.84	Main-engine cutoff (MECO)
334	185	5.85	Stage I/II separation
347	199	5.82	Stage II ignition
1075	327	7.70	Second-stage engine cutoff 1 (SECO-1)
5360	421	7.60	Stage II ignition 2
5379	421	7.66	Second-stage engine cutoff 2 (SECO-2)

Figure 2-6. Delta IV Heavy Sequence of Events for LEO Mission (Western Range)

2.2.3 GEO Mission Profile

The Delta IV family is also capable of directly injecting the spacecraft into a Geosynchronous Earth Orbit (GEO) (Figure 2-7). Through the addition of a GEO-unique extended mission kit, the Delta IV can carry the spacecraft directly to its desired GEO orbit or anywhere in between. Maximum mission operation time is 8.0 hr.

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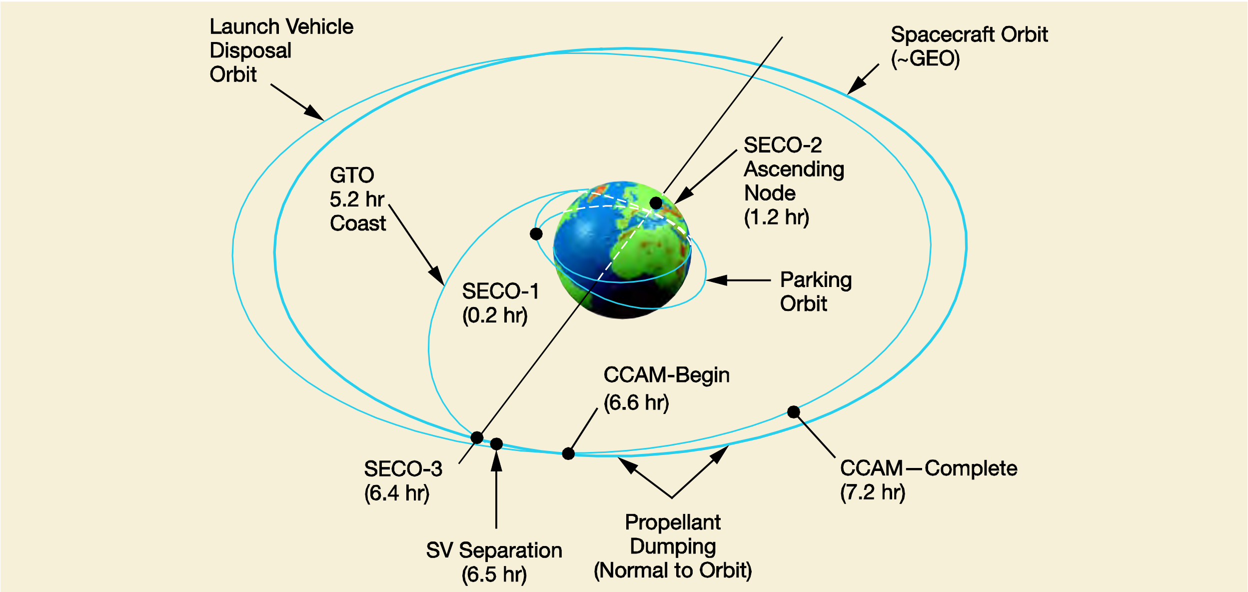

Figure 2-7. Ascending Node GEO Mission Profile

2.2.4 Multiple-Manifest Mission Profile

ULA has extensive experience with multiple-manifest spacecraft and special on-orbit operations, including dual payloads, secondary payloads, and multiple payload dispensers. Our experience with the deployment of multiple spacecraft has resulted in 100% successful deployment of the Iridium® and Globalstar™ spacecraft. We have successfully conducted missions involving rendezvous operations and multiple payloads flying in formation, both of which involve very precise orbits and tolerances. Our high level of experience with multiple-manifest missions and special on-orbit operations helps ensure complete mission success. Contact ULA for more information.

2.3 ORBITAL ACCURACY

All Delta IV configurations employ the RIFCA system. This system provides precise pointing and orbit accuracy.

Figure 2-8 summarizes currently predicted 3-σ orbit accuracy for the Delta IV family to typical LEO, GTO, and GEO orbits. These data are presented as general indicators only. Individual mission requirements and specifications will be used to perform detailed analyses for specific missions. The customer is invited to contact ULA for further information.

Orbit	Parameter	3-σ Accuracy
GTO 185 km by 35,786 km at 27 deg (100 nmi by 19,323 nmi at 27 deg) Ascending node injection	Perigee altitude	±5.6 km (±3.0 nmi)
	Apogee altitude	±93 km (±50 nmi)
	Inclination	±0.03 deg
LEO 500 km circular at 90 deg (270 nmi circular at 90 deg)	Perigee altitude	■ ±11 km (±5.9 nmi)
	Apogee altitude	■ ±12 km (±6.5 nmi)
	Inclination	■ ±0.08 deg
GEO 35,786 km circular at 4 deg (19,323 nmi circular at 4 deg)	■ Perigee altitude	■ ±150 km (±81 nmi)
	■ Apogee altitude	■ ±150 km (±81 nmi)
	Inclination	±0.10 deg

Figure 2-8. Predicted 3-σ Orbit Accuracies for the Delta IV Family of Launch Vehicles

2.4 PERFORMANCE SUMMARIES

Performance data are presented in the following pages for the Delta IV launch vehicle family. A summary of performance data for common mission orbits is presented in Figure 2-9. Descriptions and figure numbers of the detailed performance curves for both Eastern and Western Range launches are listed in Figure 2-10. The performance estimates include the following assumptions:

- Nominal Delta IV performance models from 2012 are used
- No weight growth or allowances for future vehicle hardware changes or mission-unique requirements are included
- Second-stage propellant reserve is sufficient to provide a 99.865% Probability of Command Shutdown (PCS) by the guidance system
- Payload Fairing separation occurs at a time when the free-molecular heating rate is equal to or less than 1,135 W/m^2 (0.1 Btu/ft^2-sec)

Spacecraft Mass Capabilities (Useful Load Mass)(1)(3)						
Mission	**Orbit**	**Medium**	**M+(4,2)**	**M+(5,2)**	**M+(5,4)**	**Heavy**
GEO(2)	35,786 x 35,786 km (19,323 x 19,323 nmi), 0.0 deg inclination	1,270 kg (2,800 lb)	2,320 kg (5,115 lb)	2,250 kg (4,960 lb)	3,120 kg (6,878 lb)	6,750 kg (14,881 lb)
GTO (1,804 m/s)	35,786 x 185 km (19,323 x 100 nmi), 27.0 deg inclination	4,440 kg (9,789 lb)	6,390 kg (14,088 lb)	5,490 kg (12,103 lb)	7,300 kg (16,094 lb)	14,220 kg (31,350 lb)
GTO(4) (1,500 m/s)	35,786 x 7960 km (19,323 x 4298 nmi), 27.0 deg inclination	3,060 kg (6,746 lb)	4,490 kg (9,899 lb)	4,100 kg (9,039 lb)	5,400 kg (11,905 lb)	10,100 kg (22,267 lb)
LEO (Reference)	200 x 200 km (108 x 108 nmi), 28.7 deg inclination	9,420 kg (20,768 lb)	13,140 kg (28,969 lb)	11,470 kg (25,287 lb)	14,140 kg (31,173 lb)	28,790 kg (63,471 lb)
LEO (Polar; VAFB)	200 x 200 km (108 x 108 nmi), 90.0 deg inclination	7690 kg (16,954 lb)	10,250 kg (22,597 lb)	9600 kg (21,164 lb)	11,600 kg (25,574 lb)	23,560 kg (51,941 lb)

Notes:
(1) Useful Load Mass - PAF Mass = Payload Mass; PAF masses listed in Section 5.2
(2) Descending Node Injection
(3) RS-68A Engine Performance Reflected
(4) Performance based on a fixed 27.0° inclination which differs from optimized inclination in Figures 2-13 & 2-14

Figure 2-9. Delta IV Mission Capabilities

Figure Description	Delta IV Medium	Delta IV M+(4,2)	Delta IV M+(5,4)	Delta IV Heavy
Low Earth Orbit (LEO), Eastern Range	2-11	2-11	2-11	2-12
Geosynchronous Transfer Orbit (GTO), Eastern Range	2-13	2-13	2-13	2-14
Low Earth Orbit (LEO), Western Range, 90 deg	2-15	2-15	2-15	2-16
Low Earth Orbit (LEO), Western Range, Sun-Synchronous	2-17	2-17	2-17	2-18

Figure 2-10. Figure Numbers for the Delta IV Vehicle Performance Curves

2.4.1 Useful Load Mass and Payload Mass

Delta IV launch vehicle performance capability is presented as useful load mass. The useful load mass is defined as the total mass available to be distributed between the payload mass and the Payload Attach Fitting (PAF) (i.e., the PAF mass is not included as part of the Delta IV second-stage mass). Payload mass is defined as the mass located above the forward end of the PAF that is available to the customer for the spacecraft, the spacecraft adapter, and any related hardware. To determine payload mass, subtract the PAF mass from the useful load mass. PAF masses are listed in Section 5.2.

2.4.2 Flight Termination System Constraint (Eastern Range)

The flight termination system constraint has been removed and is no longer included in this guide. All performance numbers reflect the removal of this constraint.

2.4.3 GTO Performance Capability

The standard Delta IV GTO mission profile uses two burns of the second stage. The Delta IV family of launch vehicles is capable of an apogee burn or third burn of the second stage to enhance performance for certain payload mass ranges to GTO. Through the addition of a long duration mission kit to accommodate mission durations of up to 8.0 hr, Delta IV can perform three burns to raise perigee and/or lower inclination, which will be performed at an apogee altitude of 35,786 km (19,323 nmi). For some spacecraft mass ranges, this provides the benefit of a lower spacecraft ΔV-to-GEO than the standard two-burn mission profile. Figures 2-13 and 2-14 provide spacecraft ΔV-to-GEO curves for two-burn and three-burn cases for all Delta IV vehicles. These performance curves assume the use of TDRSS for tracking coverage after Second Stage Engine Cutoff-1 (SECO-1). The use of ground stations in place of TDRSS could constrain the 2nd stage restart burn to be at a nonoptimal location, with a corresponding degradation to performance. For specific mission analyses or questions about these curves, please contact ULA.

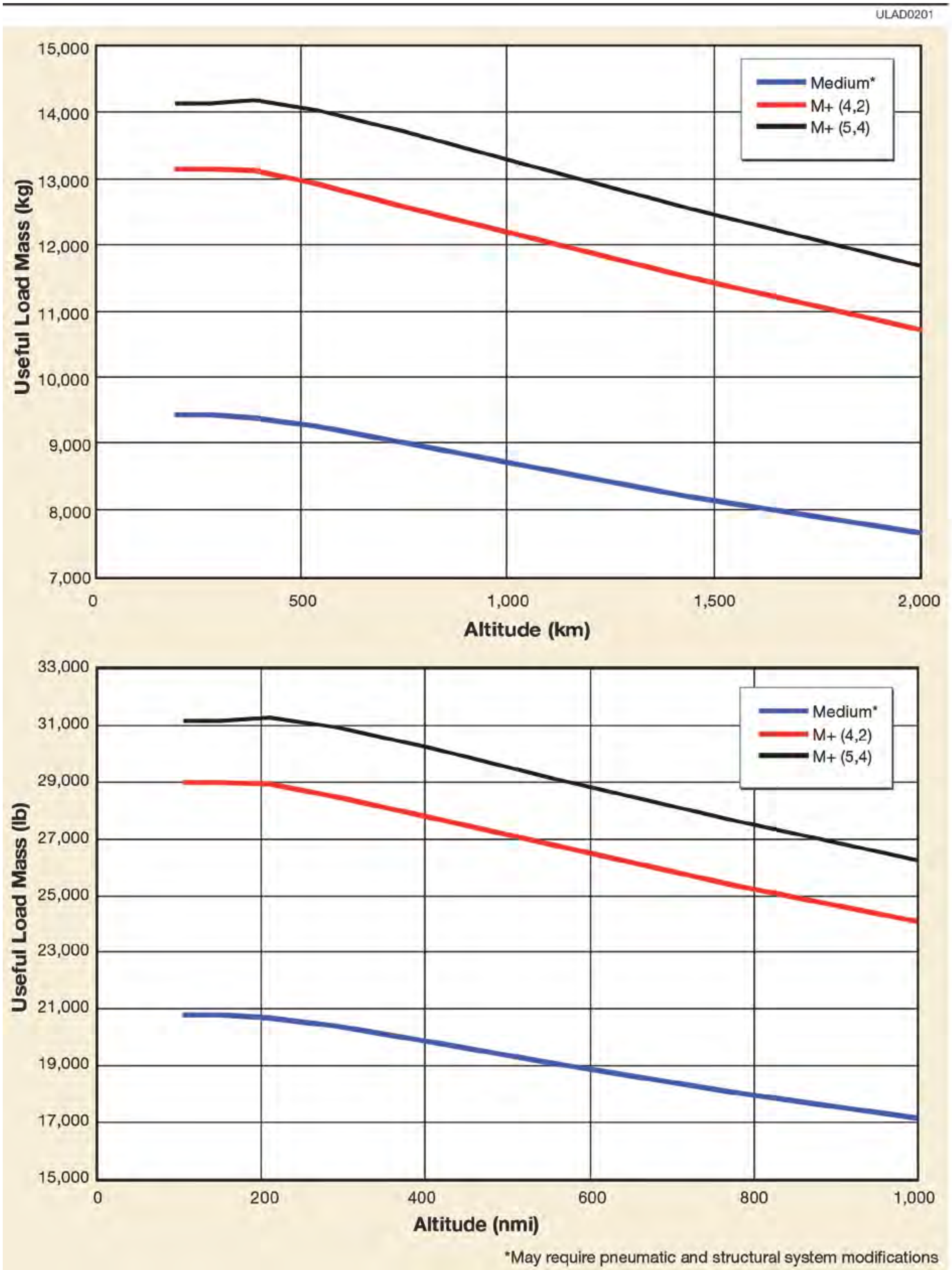

Figure 2-11. Delta IV Medium, M+(4,2), M+(5,4) LEO Performance Capability, Eastern Range (28.7 deg)

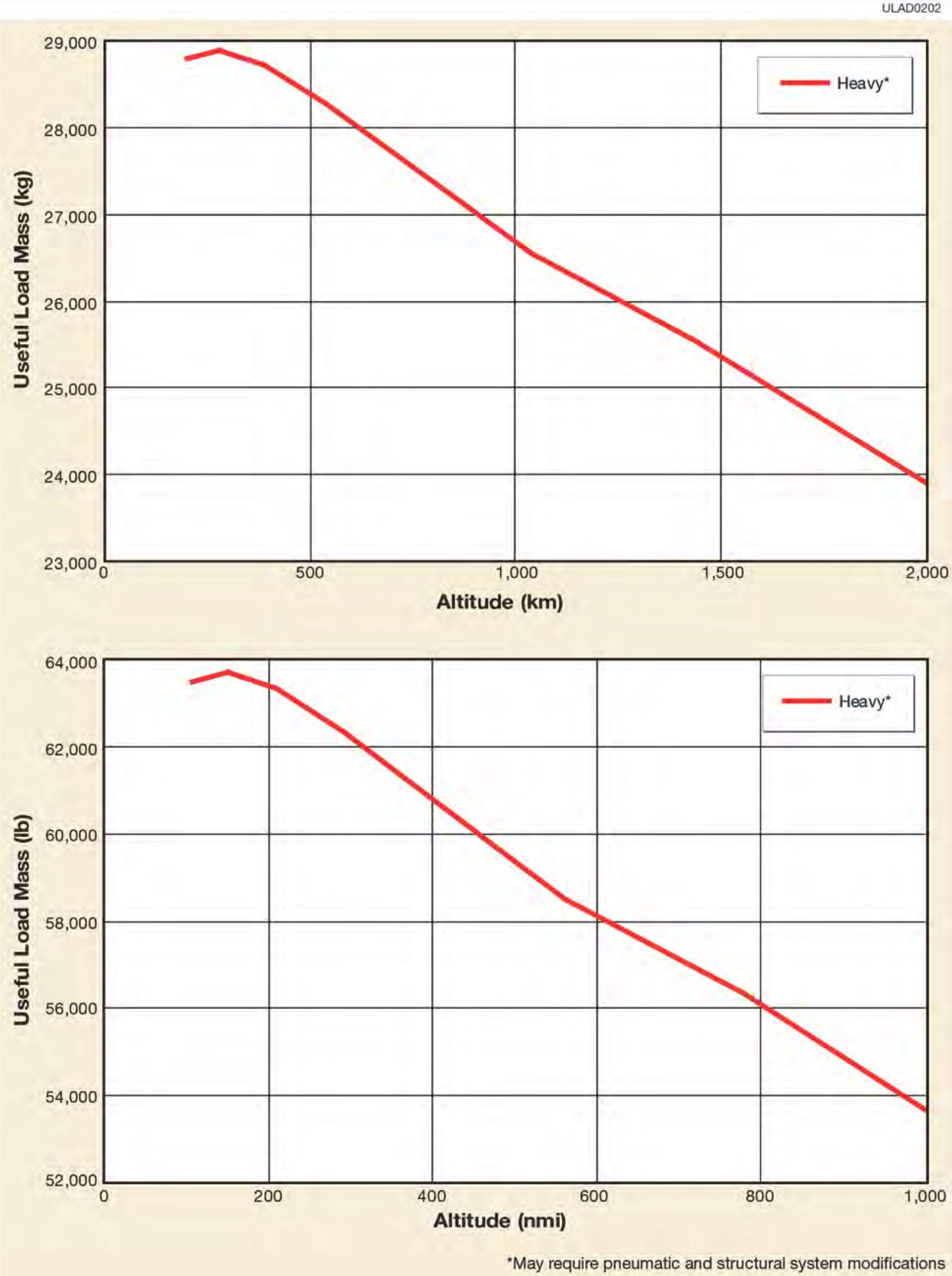

Figure 2-12. Delta IV Heavy LEO Performance Capability, Eastern Range (28.7 deg)

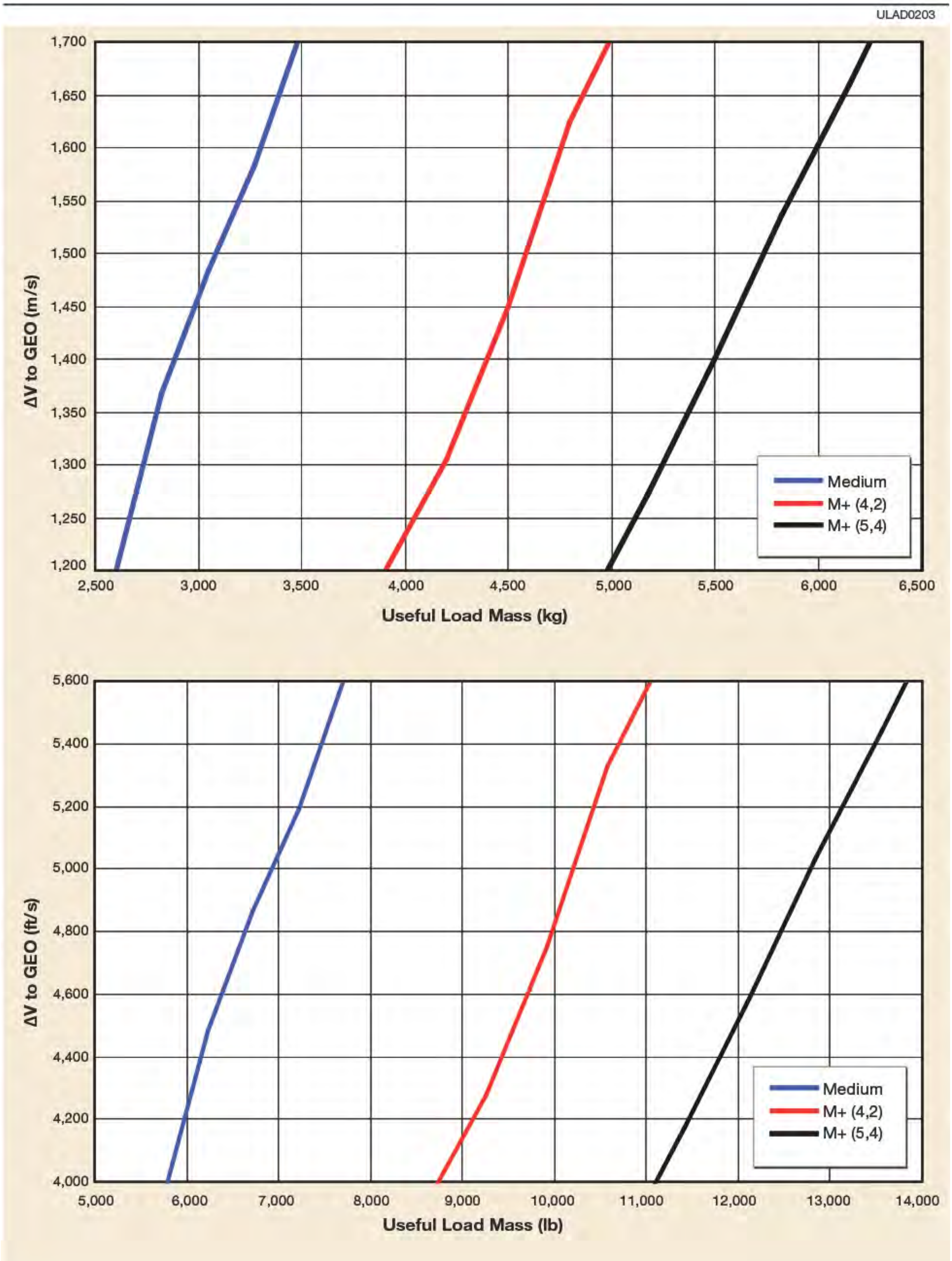

Figure 2-13. Delta IV Medium, M+(4,2), M+(5,4) GTO Performance Capability

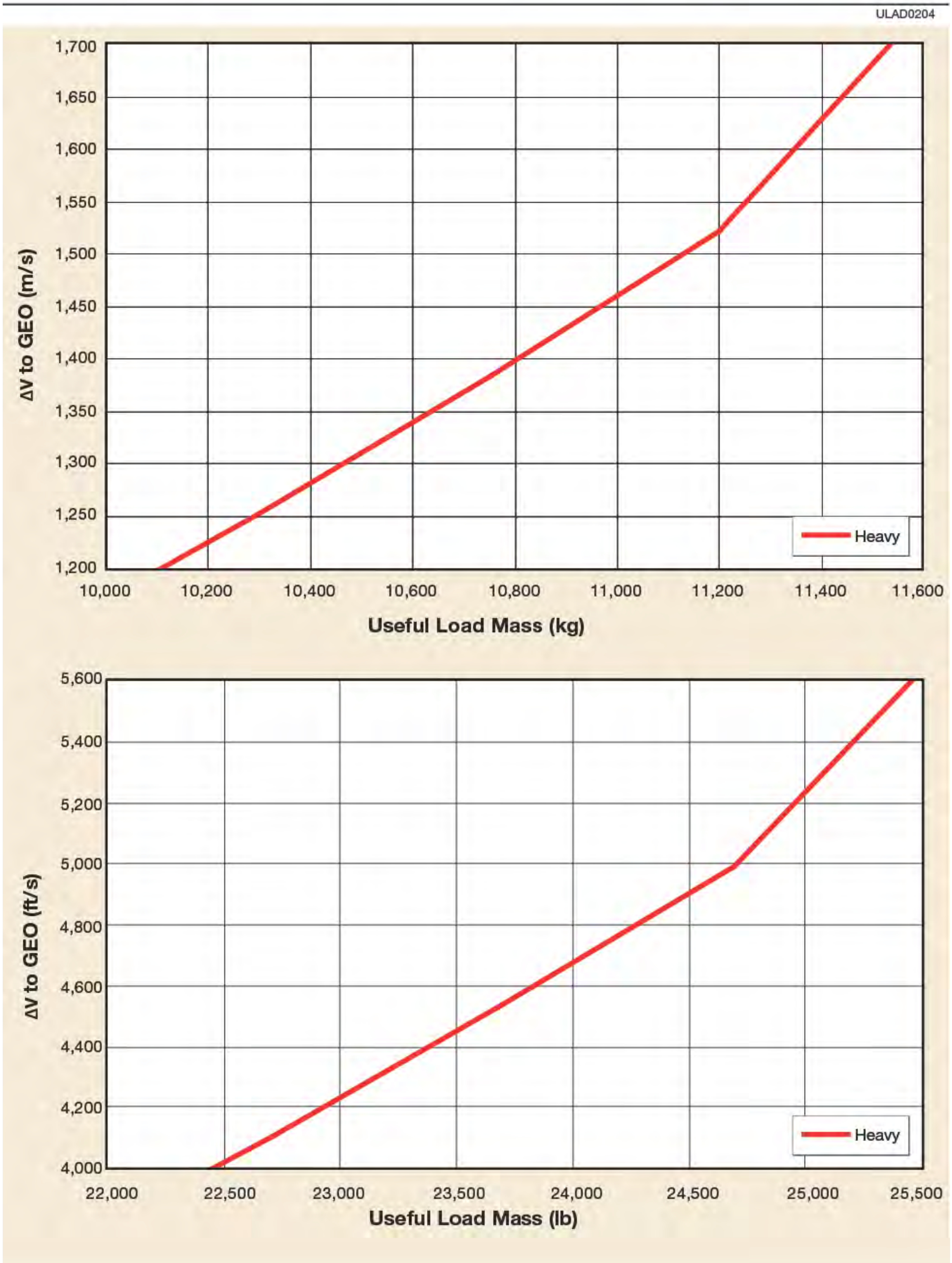

Figure 2-14. Delta IV Heavy GTO Performance Capability

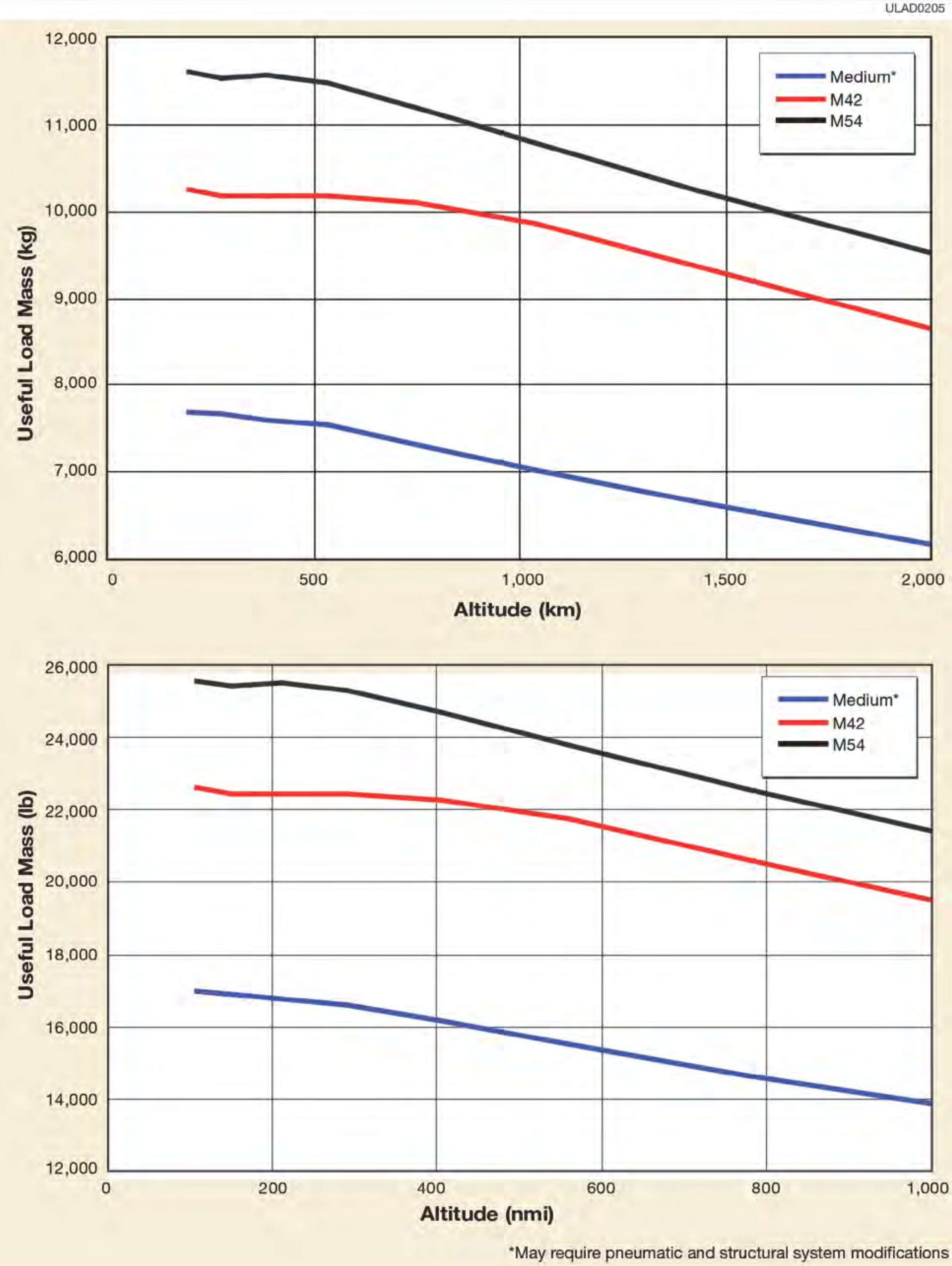

Figure 2-15. Delta IV Medium, M+(4,2), M+(5,4) LEO Performance Capability, Western Range (90.0 deg)

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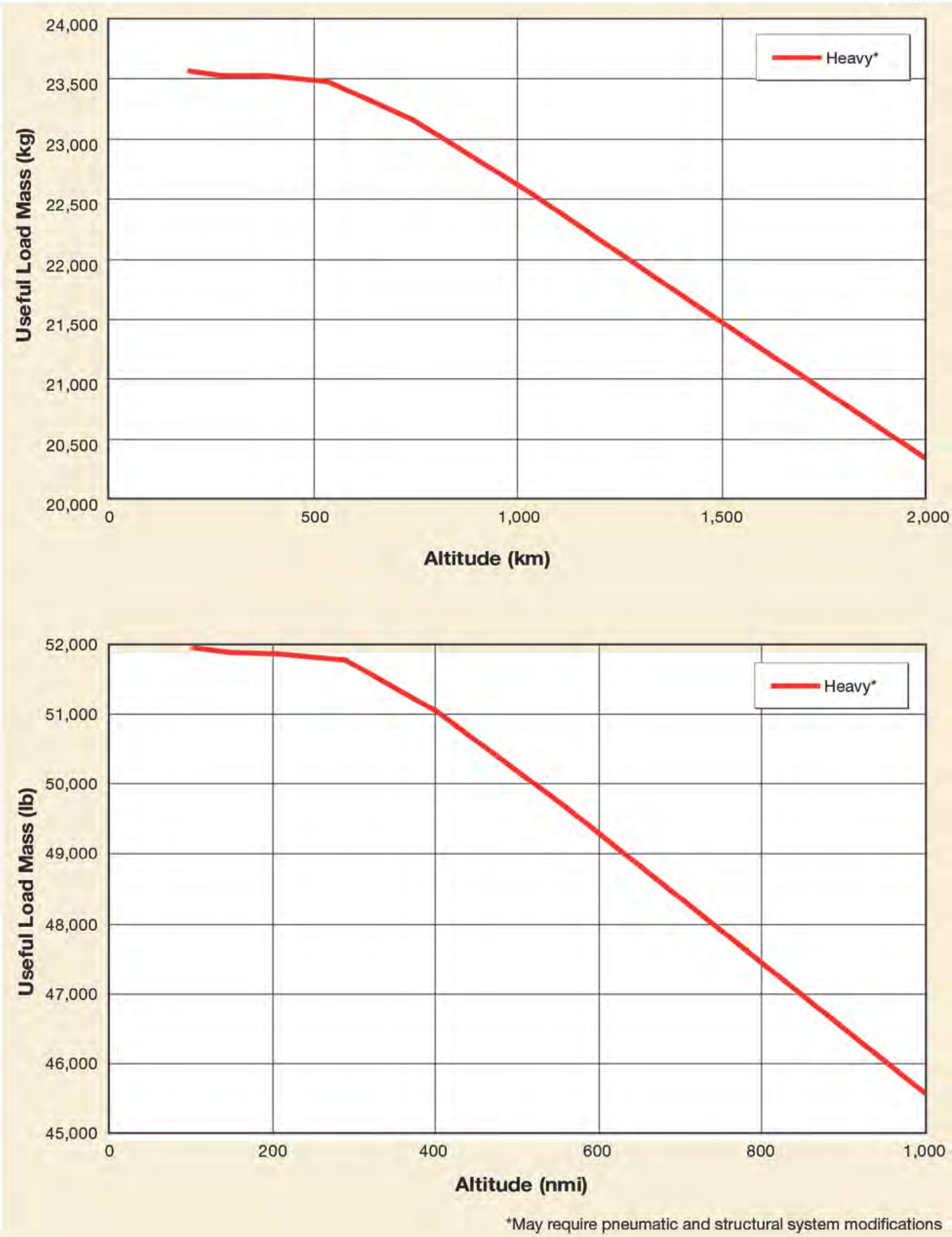

Figure 2-16. Delta IV Medium, M+(4,2), M+(5,4) LEO Performance Capability, Western Range (90.0 deg)

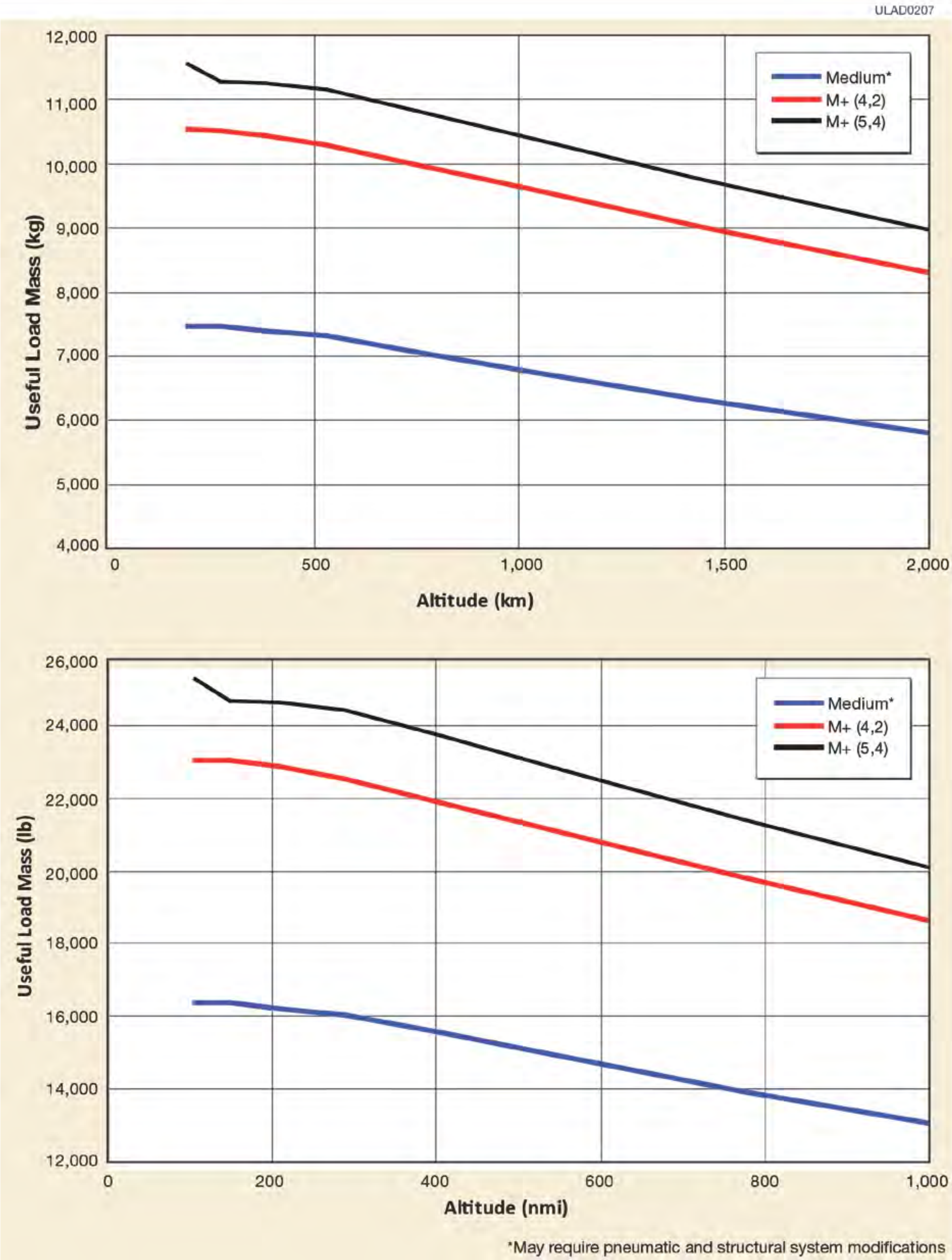

Figure 2-17. Delta IV Medium, M+(4,2), M+(5,4) LEO Performance Capability, Western Range (Sun-Synchronous)

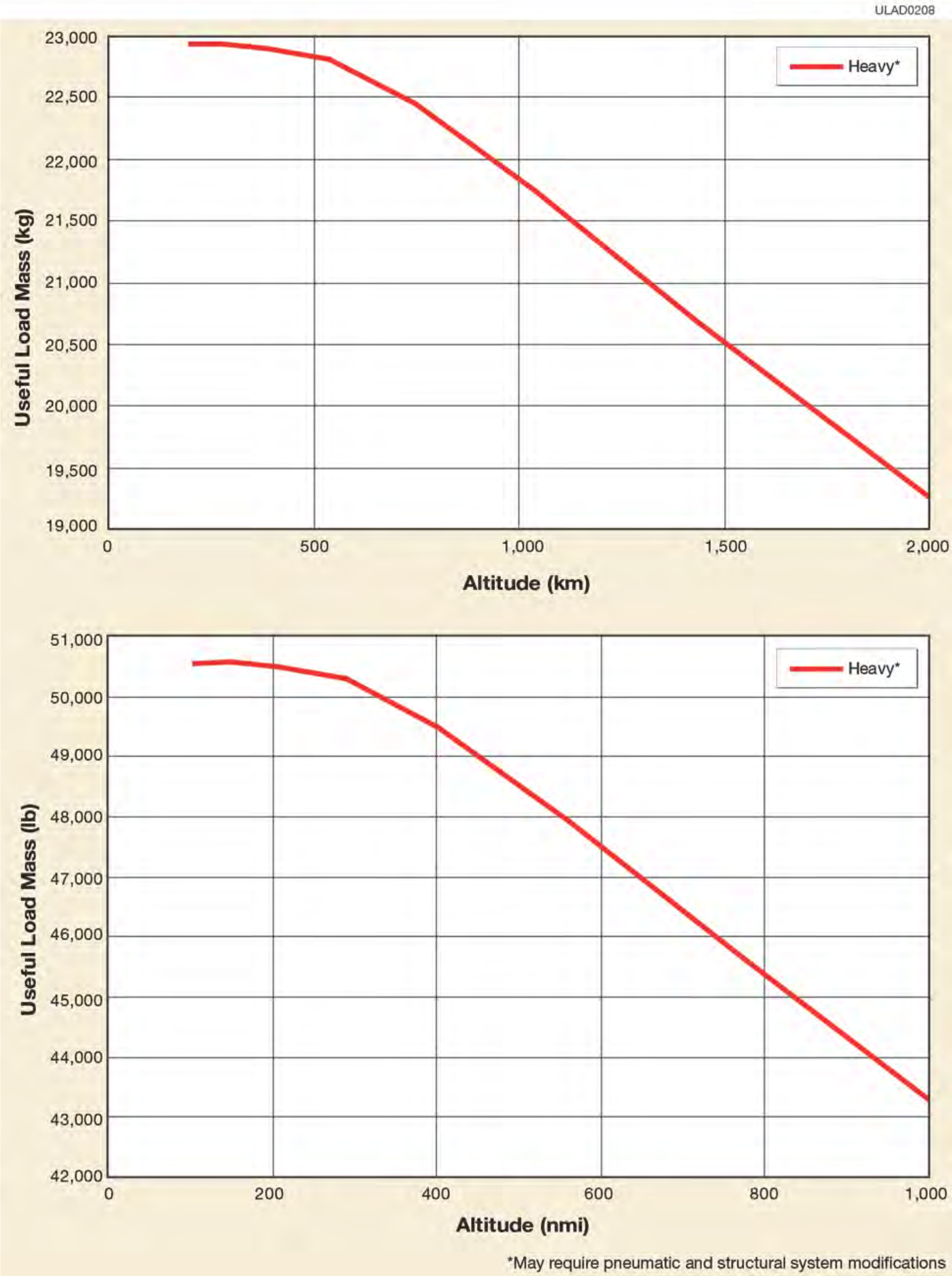

Figure 2-18. Delta IV Heavy LEO Performance Capability, Western Range (Sun-Synchronous)

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Section 3
ENVIRONMENTS

This section describes the environments to which the payload is exposed from delivery at launch site through launch. Section 3.1 presents prelaunch environments for processing facilities at both the Eastern and Western ranges. Section 3.2 presents the Delta IV launch and flight environments for the payload.

3.1 PRELAUNCH ENVIRONMENTS

3.1.1 Air Conditioning (A/C) and Gaseous Nitrogen (GN_2) Purge

During processing, the payload environment is carefully controlled for temperature, condensation, relative humidity, and cleanliness. This includes the processing conducted before the payload is encapsulated within the Payload Fairing (PLF), during transportation to the launch pad, and while lifting onto the Delta IV Launch Vehicle (LV). During transportation, Air Conditioning (A/C) is supplied through a Portable Environmental Control System (PECS). A/C is supplied to the payload by an umbilical after the encapsulated payload is mated to the Delta IV LV. Just prior to the start of Second Stage cryogenic tanking until launch (or after completion of detanking in the event of a launch scrub) conditioning can be provided with Gaseous Nitrogen (GN_2) to the payload. The payload air/GN_2-distribution system (Figure 3-1 for 4-m and 5-m composite fairings and Figure 3-2 for the 5-m metallic fairing option) provides air or GN_2 at the required cleanliness, temperature, dew point, and flow rate. Figure 3-3 provides standard inlet locations for composite payload fairings. The air or GN_2 is supplied to the payload at a maximum flow rate of 36.3 kg/min to 72.6 kg/min (80 to 160 lb/min) for 4-m fairing LVs; and 90.7 kg/min to 136.0 kg/min (200 to 300 lb/min) for 5-m fairing LVs. Air/GN_2 flow around the payload is discharged through vents in the aft end of the fairing. Both SLC-37 and SLC-6 Space Launch Complexes have a backup system for Fairing A/C. The 4-m and 5-m composite fairings' air-distribution systems use a diffuser on the inlet A/C duct at the fairing interface. The metallic fairing air-distribution system is ducted up to the nose and the air enters the payload compartment through a diffuser. The A/C umbilical is pulled away at liftoff by lanyard disconnects, and the inlet door on the fairing automatically closes.

The air/GN_2-conditioning duct is below the cone/cylinder junction in the Quad I/Quad II half for the 4-m and 5-m composite fairings and in the middle of sector II for the 5-m metallic fairing. Unique mission requirements or equipment and mission-specific options should be coordinated with ULA.

Various payload environmental control capabilities are available at the launch site for use by the customer. Environmental control specifications are listed in Figures 3-4 and 3-5 for the Eastern and Western ranges, respectively. Payload Fairing gas conditioning capabilities using these facility specifications are listed in Figure 3-6. The facilities to be used depend on payload program requirements.

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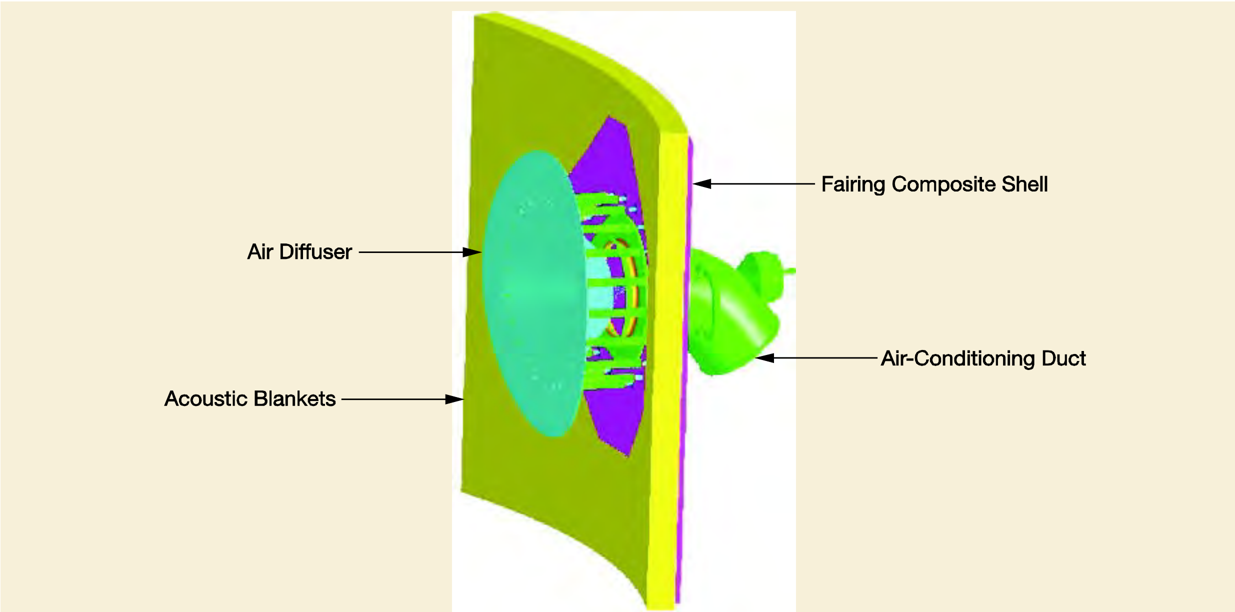

Figure 3-1. Standard 4-m Composite Fairing and 5-m Composite Fairing Air Conditioning Duct Inlet Configuration

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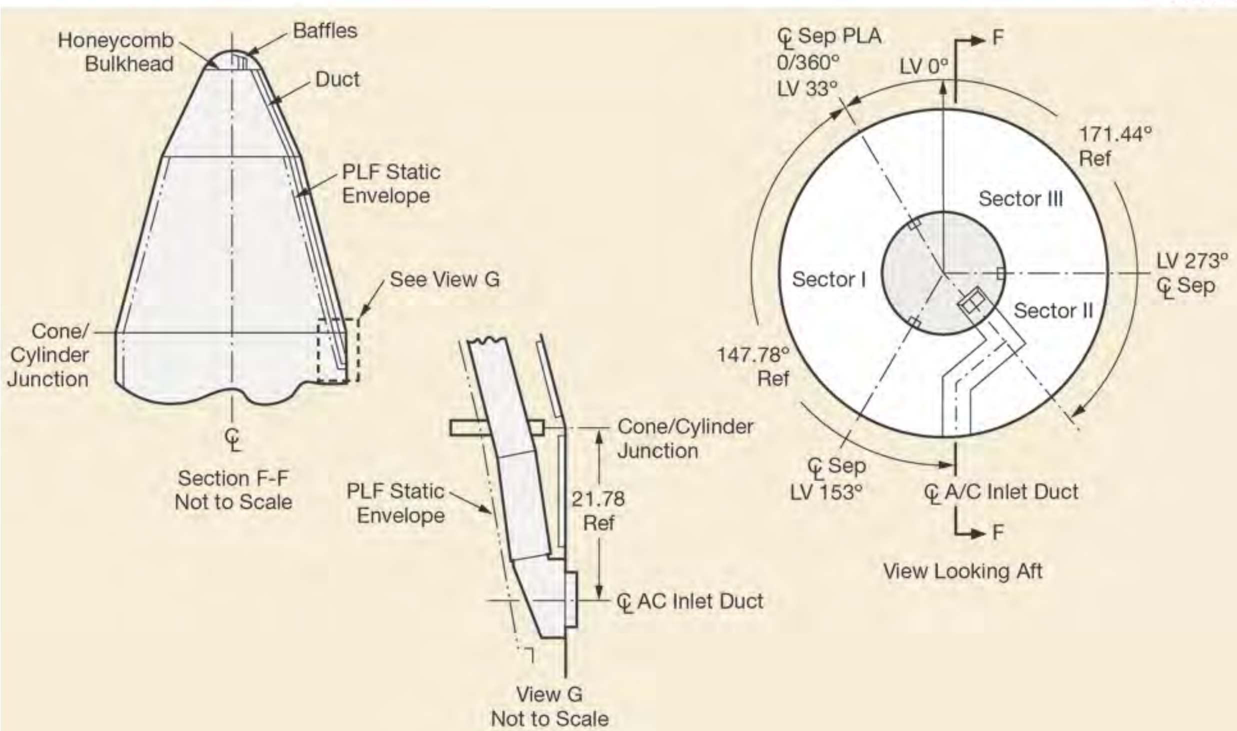

Figure 3-2. 5-m Metallic Fairing Payload Air Distribution System

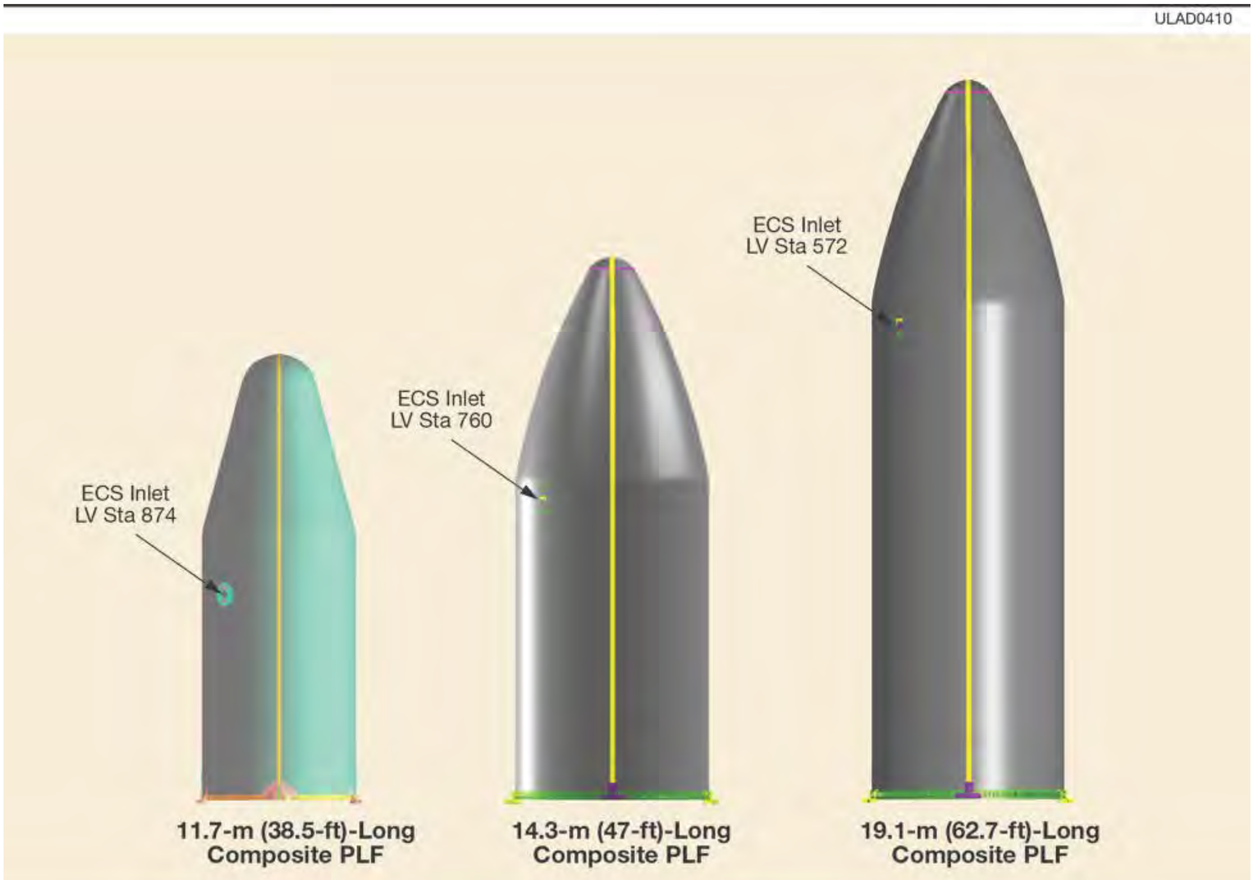

Figure 3-3. Inlet Locations for Composite Payload Fairings

Location		Temperature	Relative Humidity/ Dew Point	Particulate Class[2]
Encapsulated payload	Mobile (PLF PECS)	18.3° to 26.7° ±2.8°C (65° to 80° ±5°F)	≤48°F Dew Point Not selectable	Class 5000[3]
	Fairing (PLF ECS)	Any specified between 10° and 26.7° ±1.7°C (50° and 80° ±3°F)	≤30°F Dew Point Not selectable	Class 5000 inlet

Notes: The PLF environmental control systems can only limit the dew point. They do not have the capability to directly select specific dew point values.
These numbers are provided for planning purposes only. Specific values should be obtained from the controlling agency.
[2]Verified/sampled at duct outlet.
[3]FED-STD-209D.

Figure 3-4. Eastern Range Environmental Control Specifications

Location		Temperature	Dew Point	Particulate Class
Encapsulated payload	Mobile (PLF PECS)	16.1° to 33.3° ±2.8°C (61° to 92° ±5°F)	≤48°F Not selectable	Class 5000[1]
MST	SLC-6 MST/MAS	Not controlled	Not controlled	Not controlled
	Fairing (PLF PECS)	Any specified between 10° and 26.7° ±1.7°C (55° and 85° ±3°F)	≤25°F Not selectable	Class 5000 inlet

Notes: The PLF environmental control systems can only limit the dew point. They do not have the capability to directly select specific dew point values.
These numbers are provided for planning purposes only. Specific values should be obtained from the controlling agency.
[1]FED-STD-209D.

Figure 3-5. Western Range Environmental Control Specifications

Location	Facility Specifications		Temperature Range Inside Payload Fairing**		
CCAFS	Inlet Temperature Capability* (Degrees F)	Inlet Flow Rate Capability (lb/min)	4-m Composite (Degrees F)	5-m Composite (Degrees F)	5-m Metallic (Degrees F)
PECS	65-80 (+/-5)	160 +/-5 (4m) 200 +/-5 (5m)	52-78	52-78	48-86
Inside MST	50-80 (+/-3)	160 +/-12.5 (4m) 300 +/-12.5 (5m)	44-62	44-60	40-69
Outside MST	50-80 (+/-3)	160 +/-12.5 (4m) 300 +/-12.5 (5m)	43-64	43-62	38-73
VAFB	Inlet Temperature Capability* (Degrees F)	Inlet Flow Rate Capability (lb/min)	4-m Composite (Degrees F)	5-m Composite (Degrees F)	5-m Metallic (Degrees F)
PECS	61-92 (+/-5)	160 +/-5 (4m) 200 +/-5 (5m)	48-75	49-74	45-86
Inside MST	55-85 (+/-3)	160 +/-10 (4m) 300 +/-10 (5m)	49-67	49-64	44-73
Outside MST	55-85 (+/-3)	160 +/-10 (4m) 300 +/-10 (5m)	47-68	48-66	41-76

Notes:
*Inlet temperature setpoints are determined by analysis to meet SC internal PLF gas temperature, no condensation and/or relative humidity requirements.
**Internal PLF temperatures are not selectable within these ranges. SCs must be compatible with the full ranges. Ranges shown assume a nominal 72.6 kg/min (160 lb/min) for 4-m ECS flow rate; 136.2 kg/min (300 lb/min) for 5-m ECS flow rate with dispersions.

Figure 3-6. Delta IV PLF Gas Conditioning Capabilities

3.1.2 MST Enclosure

The Mobile Service Tower (MST) provides customers access to the encapsulated payload once it is mated to the LV. On a mission unique basis, a Portable Clean Environmental Shelter (PCES), as shown in Figure 3-7, can be provided that allows clean, environmentally controlled (class10,000) access through one PLF door within the MST operational constraints while the encapsulated payload is housed within the MST. The PCES comprises three major components: (1) entrance/changing chamber, (2) working chamber, and (3) PLF interface. This interface provides some environmental sealing around the PLF access doors and protects the encapsulated payload from being contaminated. The PCES can be modified to provide some Radio Frequency (RF) shielding on a mission unique basis. This enclosure is typically used at levels 9 and 10 in the MST and provides improved environmental control during PLF ingress/egress operations, while the MST provides weather protection.

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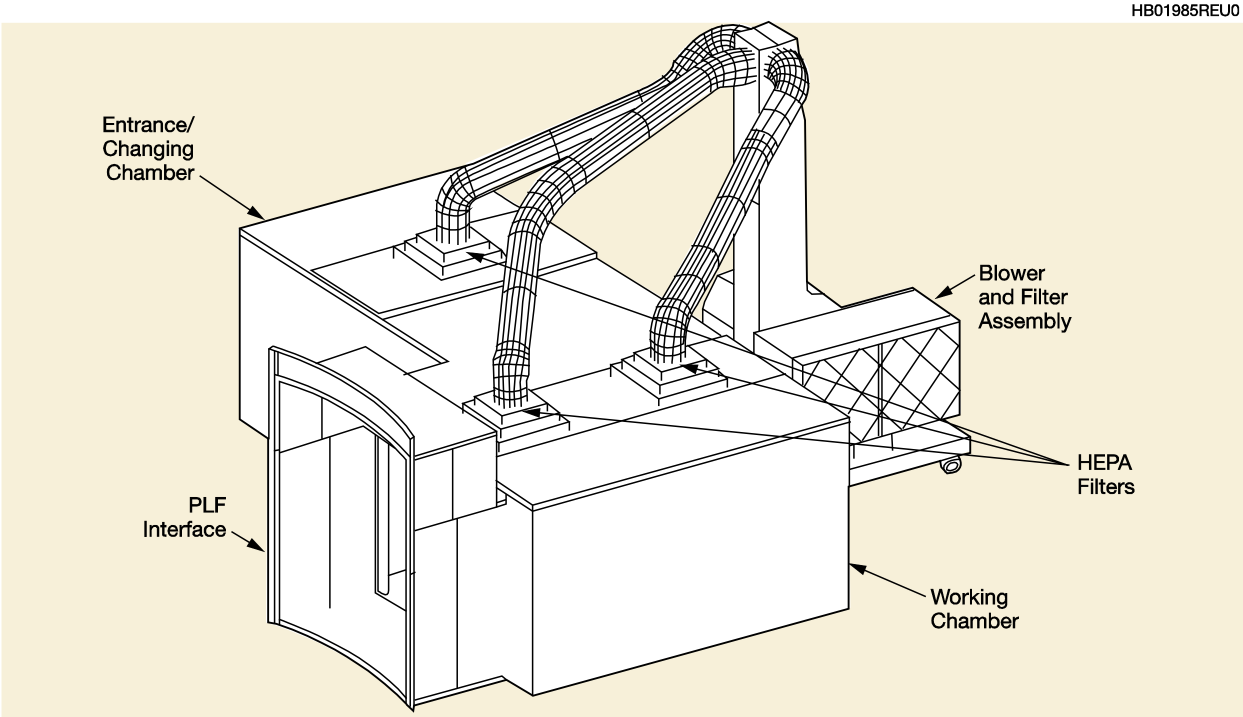

Figure 3-7. Portable Clean Environmental Shelter (PCES)

3.1.3 Radiation and Electromagnetic Environments

The Delta IV LV transmits on several frequencies to provide LV telemetry and beacon signals to the appropriate ground stations and the Tracking and Data Relay Satellite System (TDRSS). The LV also has uplink capability for command destruct. An S-band telemetry system, two Command Receiver Decoder (CRD) systems, and a C-band transponder (beacon) are provided on the Second Stage. The notional radiation characteristics of these systems are listed in Figure 3-8. The RF systems are switched on prior to launch and remain on until mission completion.

Global Positioning System (GPS) Metric Tracking (MT) System is now being integrated on all Delta IV LVs. The characteristics of these components are included in Figure 3-9 for the GPS transmitter and Figure 3-10 for the GPS Receiver. The GPS MT Receiver can receive on both L1 and L2 bands. Additional transmitters may be used in conjunction with non-standard services such as video cameras and special flight instrumentation; contact ULA for mission-specific transmitter characteristics.

	Second-Stage Telemetry Radiation Characteristics	**Second-Stage C-band Beacon Characteristics**
	Transmitter	
Nominal frequency	2241.5 MHz	5765 MHz (transmit) 5690 MHz (receive)
Power output	30.0 W min	400 W min peak, 0.52 W min average
Modulation data rate	1.92 Mbps (Delta IV Heavy) or 1.28 Mbps (Delta IV Medium) from launch to conclusion of range safety authority and 192 kbps via TDRSS until the Contamination and Collision Avoidance Maneuver (CCAM)	6 MHz at 6 dB
	Antenna	
	S-Band	**C-Band**
Type	Patch	Spiral
Polarization	Right-hand circular	Right-hand circular
Location	5-m Second Stage—Sta 1172.88 4-m Second Stage—Sta 1232.36	5-m Sta 1172.88 4-m Sta 1232.36
Pattern coverage	Launch to 2 deg above radar horizon = 95% From 2 deg above radar horizon to CCAM = 95% ±60 deg boresight via one of four selected antennas around the circumference of the LV	

Figure 3-8. Delta IV Transmitter Characteristics

GPS MT S-band Transmitter	
Nominal Frequency	2287.5 MHz
Bandwidth	4 MHz
Modulation	BPSK
Antenna Type	Patch
Polarization	RHC
Output Power	10 W maximum
Telemetry Rate	115.2 kbps

Figure 3-9. GPS MT Transmitter Characteristics

GPS MT L-band Receiver	
Frequency	1575.42 MHz (L1), 1227.6 MHz (L2)
3 dB Bandwidth	24 MHz
Sensitivity	-130 dBm min
Low Noise Amplifier Gain	38 +/- 2 dB
Antenna Type	Patch
Polarization	RHC

Figure 3-10. GPS MT Receiver Characteristics

3.1.3.1 Launch Range RF Environment. At the Eastern and Western Ranges, the electromagnetic environment to which the payload is exposed results from the operation of Range radars and LV transmitters and antennas. Additionally, off-base emitters, including weather radar, air-traffic control radar and various broadcast emitters will contribute to the overall RF environment. Note that off-base emitters may not be controlled. On customer request, the LV contractor will coordinate with the Range to address spacecraft issues with Range controlled emitters during transport from the payload processing facility to the launch site and at the launch complex itself. This coordination should be identified to ULA early in the integration process. Figure 3-11 is representative of the RF environment during transport from a Payload Processing Facility (PPF) to SLC-37 at the Eastern Test Range (ETR). Figure 3-12 is representative of the RF environment during transport from a PPF to SLC-6 at the Western Test Range (WTR). Note that these tables are not to be considered complete or definitive. These environments are subject to change. Please refer to the Aerospace Corporation Technical Operation Requirement (TOR) documentation of the ETR and WTR for the latest environments.

Name of Emitter	Frequency (MHz)	Peak E-field at POCA (V/m)	Avg. E-field at POCA (V/m)	Avg. E-field at PPF (V/m)	Avg. E-field at LC-37 (V/m)
Radar 1.16	5690	122.61	3.10	2.16	2.68
Radar 19.39	5710	39.80	2.81	2.84	2.53
Radar 19.14	5690	145.53	5.82	5.49	5.38
Radar 19.17	5690	49.55	1.40	1.31	1.08
Radar 28.14	5690	16.15	0.65	0.63	0.64
WSR-74C	5625	12.83	1.03	0.97	1.00
TDR 43-250	5625	11.16	0.61	0.61	0.58
WSR-88D (NEXRAD)	2865	14.47	1.12	1.07	1.10
Channel 2 Weather	5570	4.69	0.27	0.27	0.26
Channel 9 Weather	5555	10.04	1.00	1.00	0.95
TDWR	5640	10.30	1.03	1.03	1.00
Channel 35 Weather	5470	17.65	1.76	1.76	1.67
SLS Solid State S-Band (North)	3100	0.12	0.04	0.04	0.03
SLS Solid State S-Band (South)	3100	0.18	0.06	0.06	0.05
GPS Gnd Antenna	1783.74	8.78	8.78	3.67	4.73
GPS Gnd Sta (Mobile)	1783.74	6.09	6.09	2.54	4.63
CSAS Orbit No. A1	406.5/416.5/421.0	0.62	0.62	0.33	0.35
SRB Recovery Ship X-Band	9413.6	3.44	0.09	0.04	0.05
SRB Recovery Ship S-Band	3049.4	14.25	0.38	0.17	0.19
Cruise Ships	9410	5.28	0.18	0.10	0.11
Radar Test Bed	5690	49.31	1.97	1.15	1.19

Figure 3-11. Representative Transport Environment from the PPF to SLC-37 (ETR), Point of Closest Approach (POCA)

Name of Emitter	Frequency (MHz)	Peak E-field at POCA (V/m)	Avg. E-field at POCA (V/m)	Avg. E-field at PPF (V/m)	Avg. E-field at SLC-6 (V/m)
CT-5	416.5/421/425	17.72	17.72	0.92	0.90
CT-3	416.5/421/425	6.71	6.71	0.60	5.95
ATCBI-6	1030	0.08	0.08	0.01	0.07
AN/FRN-45	1146	2.64	0.42	0.04	0.00
ARSR-4	1262/1345	37.11	5.97	1.01	5.85
SGLS-46	1750-1850	3.77	3.77	3.70	1.61
NEXRAD	2890	37.13	2.91	2.66	1.61
HAIR	5650	1120.37	50.10	50.12	7.87
FPS-16-1	5725	109.75	2.78	0.91	2.77
FPS-16 (PM)	5725	5.66	0.14	0.14	0.14
TPQ-18	5840	2133.68	41.81	6.84	5.73
PULSTAR	9245/9392	50.36	5.04	1.01	1.08
OSS No. 1	9410	21.78	0.58	0.05	0.59
OSS No. 3	9410	9.74	0.26	0.26	0.04

Figure 3-12. Representative Transport Environment from PPF to SLC-6 (WTR), Point of Closest Approach (POCA)

3.1.3.2 Spacecraft Allowable Emissions. The maximum allowable spacecraft radiated emissions at the spacecraft/vehicle separation plane are provided in Figure 3-13. These levels include the GPS Metric Tracking System receiver. Spacecraft are permitted to radiate inside the fairing provided that the emissions, including cavity effects, do not exceed the maximum level deemed safe for LV avionics and ordnance circuits. An RF compatibility analysis is also performed to verify that the vehicle and satellite transmitter frequencies do not have interfering intermodulation products or image rejection problems.

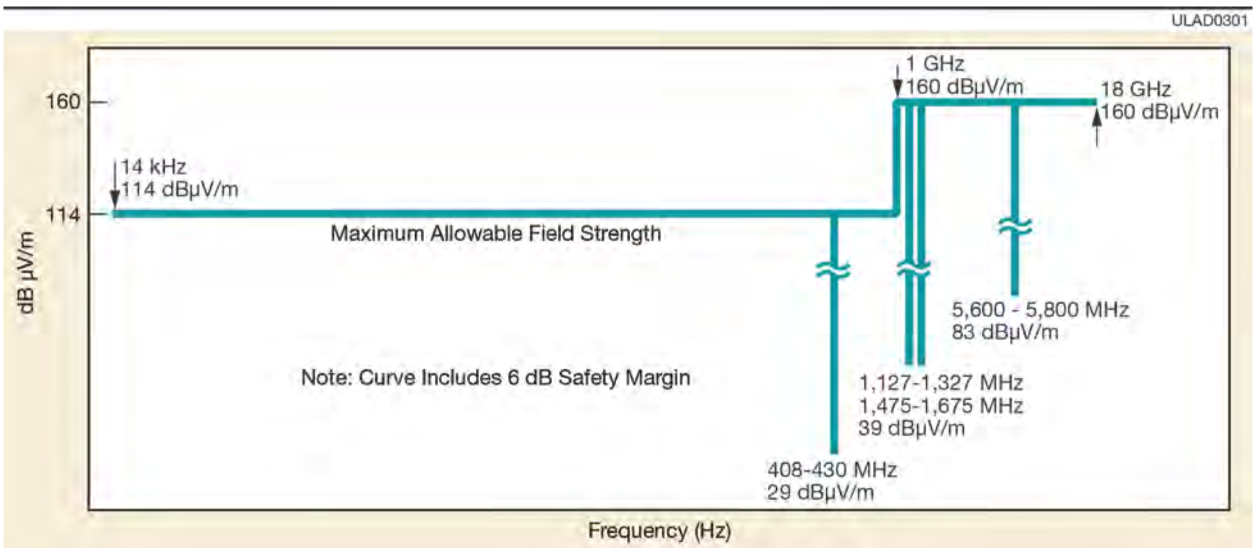

Figure 3-13. Maximum Allowable Payload Radiated Emissions at the Payload/ Launch Vehicle Separation Plane

3.1.3.3 Launch Vehicle Emissions. Figure 3-14 shows the LV emissions the payload will see at the top of the Payload Attach Fitting (PAF). These levels are unintentional emissions from avionics boxes and intentional emissions from transmitters.

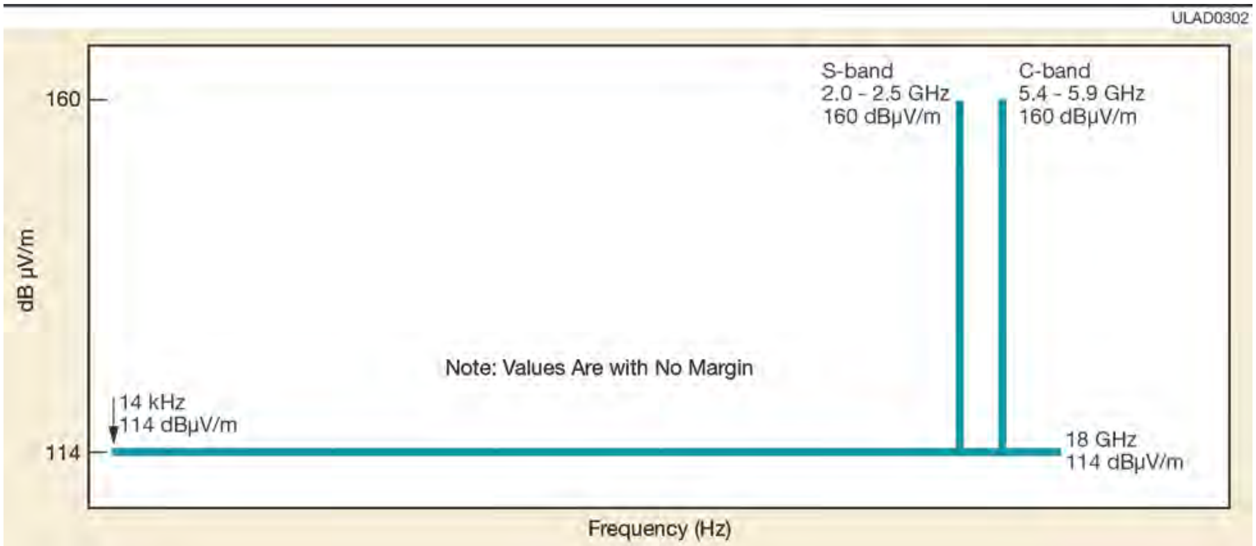

Figure 3-14. Launch Vehicle Emissions at the top of the PAF

3.1.3.4 Lightning Mitigation. Direct attachment lightning mitigation is provided by the catenary system, MST structure, the PLF, and the umbilical harness shield. Energy from a nearby lightning strike can couple into LV harnessing. This is mitigated by wire twisting and shielding and established lightning re-test criteria. Additional measures beyond these standard capabilities will be the responsibility of the Spacecraft contractor.

3.1.4 Electrostatic Potential

During ground processing, the payload must be equipped with an accessible ground attachment point to which a conventional alligator-clip ground strap can be attached. The payload/launch vehicle interface provides the conductive path for grounding the payload to the LV. Therefore, dielectric coatings should not be applied to the payload interface.

3.1.5 Contamination and Cleanliness

The Delta IV launch system has been designed to limit contamination depositions from all launch system sources onto spacecraft surfaces to a molecular thickness of 150 Angstroms and a particle obscuration of 1.0%. These deposition limitations include all launch system sources from the start of spacecraft encapsulation operations through the end of the Collision and Contamination Avoidance Maneuver (CCAM), which follows spacecraft separation. This section addresses Delta contamination control during prelaunch operations. Section 3.2.3 addresses in-flight LV contamination sources.

LV hardware that comes into contact with the spacecraft environment has been designed and manufactured according to strict contamination control guidelines. This hardware is defined as "contamination critical." Contamination critical surfaces include the PAF forward surfaces and PLF interior surfaces.

In addition, ground operations at the launch sites have been designed to ensure a clean environment for the spacecraft. A comprehensive Contamination Control Plan has been written to identify these requirements and procedures. Mission unique requirements that are more stringent than those baselined in the control plan may be identified in the mission Interface Control Document (ICD). The following standard guidelines and practices ensure that payload contamination is minimized during encapsulation, transport, and launch site operations.

3.1.5.1 Contamination Control Before Launch Site Delivery. Design and Assembly – Contamination control principles are implemented in design and manufacturing processes to limit the amount of contamination from LV components. Interior surfaces include maintainability features to facilitate the removal of manufacturing contaminants. Contamination critical hardware is entered into a controlled production phase in which the hardware is cleaned and maintained clean to prevent contaminants in difficult-to-clean places at the end of production. To support this effort, final assembly of the PAFs and PLFs is performed in a Class 100,000 facility to ensure that hardware surfaces are maintained at an acceptable level of cleanliness before shipment to the launch site. Inspection points are provided to verify cleanliness throughout the assembly process. Approved cleanroom wrapping is used to protect critical surfaces during contaminant generating activities.

Materials Selection – In general, materials are selected for contamination critical hardware inside the PLF that will not become a source of contamination to the spacecraft. Metallic or nonmetallic materials that are known to chip, flake, or peel are prohibited. Materials that are cadmium-plated, zinc-plated, or made of unfused electrodeposited tin are avoided inside the PLF volume. Because most nonmetallic materials are known to exhibit some outgassing, these materials are evaluated against criteria that were developed using National Aeronautics and Space Administration (NASA) SP-R-0022 as a starting point.

The PLF and PAF are cleaned at the manufacturing site using approved solvents and then inspected for cleanliness prior to double-bagging for shipment to the launch site. The standard cleanliness level inspection confirms the absence of all particulate and molecular contaminants visible to the unaided eye at a distance of 15.2-45.7 cm (6-18 in.) with a minimum illumination of 1,076 lumen/m^2 (100 foot-candles). Hardware that is cleaned to this criterion at the production facility is protected to maintain this level of cleanliness through transportation and encapsulation.

Certain spacecraft may require that contamination critical hardware surfaces be cleaned to a level of cleanliness other than the standard described above. Because additional cleaning and verification may be necessary, these requirements are implemented on a mission unique basis.

3.1.5.2 Contamination Control Before Spacecraft Encapsulation. Encapsulation of the payload into the fairing is performed in a facility that is environmentally controlled to Class 100,000 conditions. All handling equipment is cleanroom compatible and is cleaned and inspected before it enters the facility. These environmentally controlled conditions are available for all encapsulation facilities.

All contamination critical hardware surfaces are visually inspected to verify required cleanliness levels. In addition, contamination critical surfaces are also verified to have less than 1.0 mg/ft^2 of Nonvolatile Residue (NVR). The additional verification techniques shown below can be provided on a mission unique basis:

- Particulate Obscuration – Tape lift sampling
- Particulate Obscuration – Ultraviolet light inspection
- Particulate and Molecular Fallout – Witness plates

3.1.5.3 Contamination Control After Encapsulation. PLF Purge – During transport of the encapsulated payload and time at the launch pad after mate to the LV, the PLF environment is continuously purged with filtered nitrogen or High-Efficiency Particulate Air (HEPA) filtered air to ensure the cleanliness of the environment.

Personnel Controls – Personnel controls are used to limit access to the PLF to maintain spacecraft cleanliness. Contamination control training is provided to all LV personnel working in or around the encapsulated payload.

Launch Complex MST – Access to the encapsulated spacecraft is available following mate to the LV. Work procedures and personnel controls are established to maintain the spacecraft environment within the PLF to Class 100,000 standards. Garments are provided to personnel making PLF entry to provide optimum cleanliness control as dictated by spacecraft requirements. A portable clean room is available as a mission unique service for entry through mission-peculiar access doors as required (Section 3.1.2).

3.2 LAUNCH AND FLIGHT ENVIRONMENTS

The following payload launch environments, such as low- and high-frequency vibration, acceleration transients, shock, velocity increments, and payload status, are our best predictions as to the launch environments during flight. The actual data will be obtained from the LV telemetry system for validation.

3.2.1 Fairing Internal Pressure Environment

As a Delta IV LV ascends through the atmosphere, venting occurs through the aft section of the fairing and other leak paths in the vehicle. The expected extremes of payload fairing internal pressure during ascent are presented in Figures 3-15, 3-16, 3-17, 3-18, 3-19, and 3-20 for the Delta IV family of LVs.

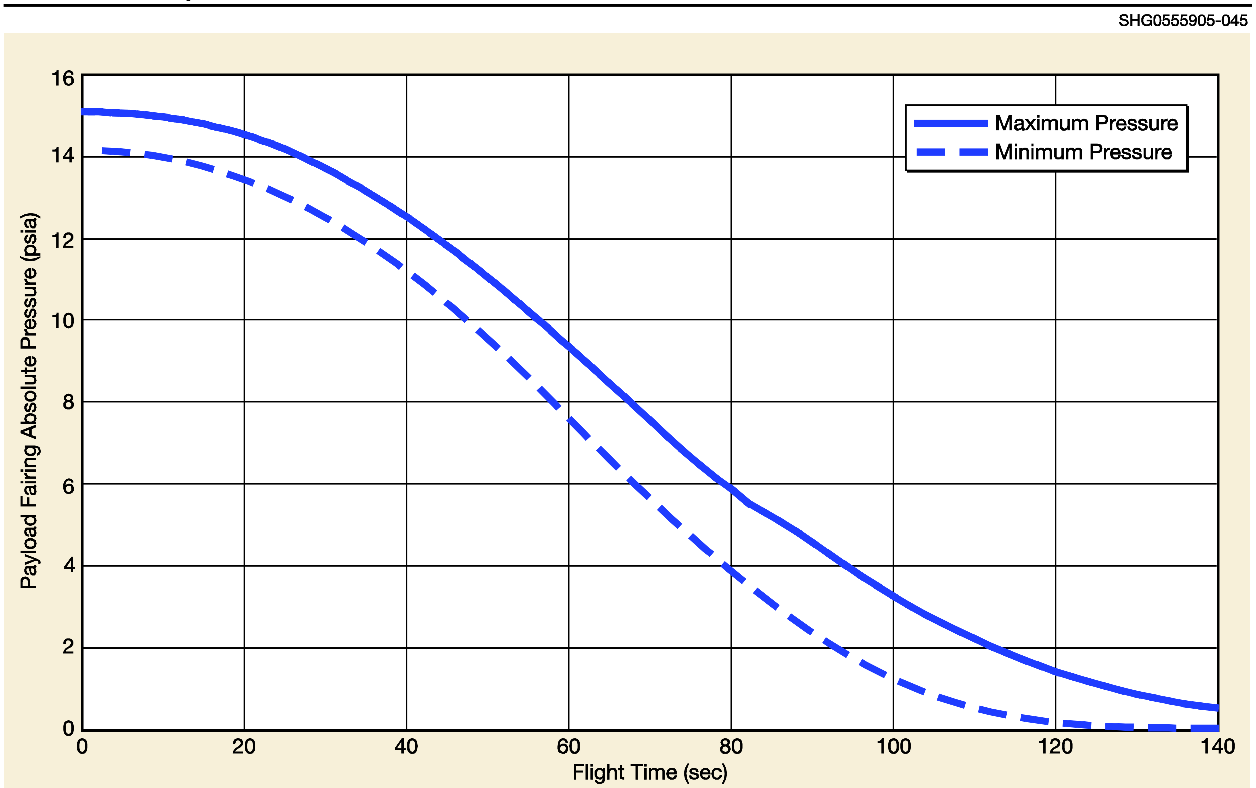

Figure 3-15. Delta IV Medium Absolute Pressure Envelope

SHG0555905-046

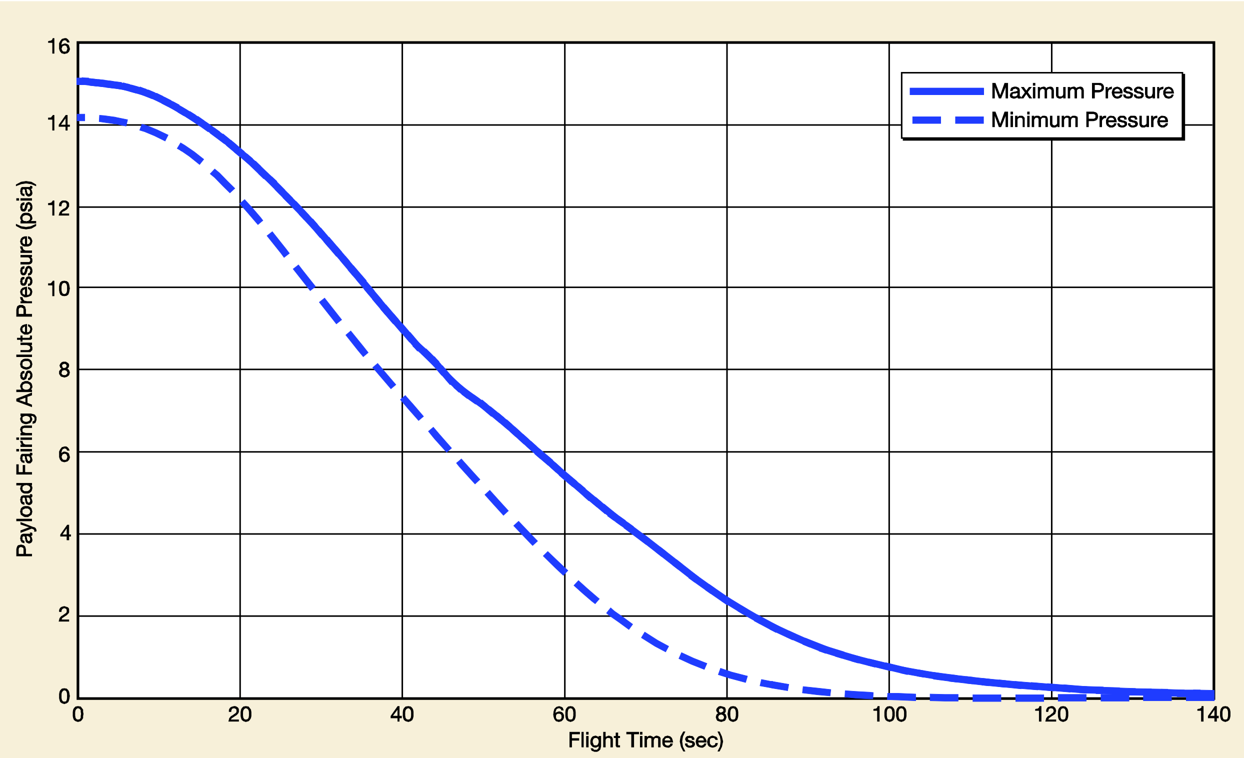

Figure 3-16. Delta IV M+(4,2) Absolute Pressure Envelope

SHG0555905-047

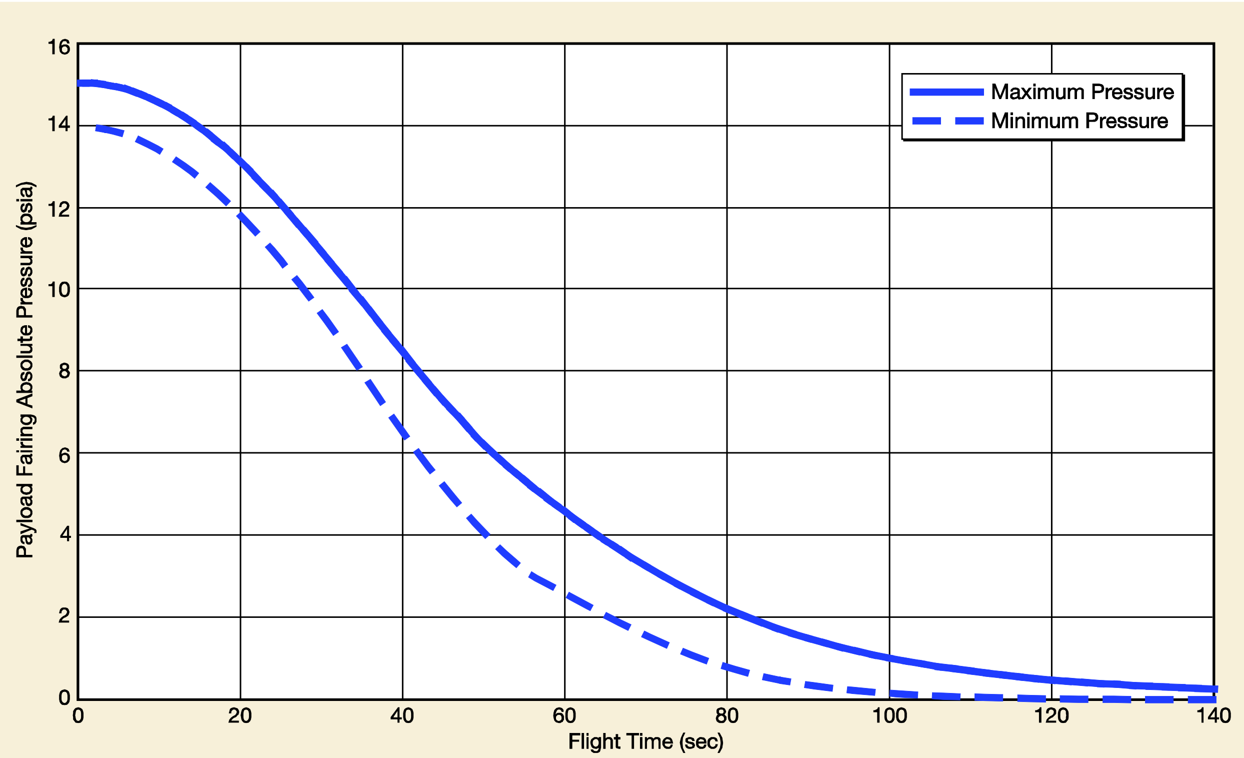

Figure 3-17. Delta IV M+(5,2) Absolute Pressure Envelope

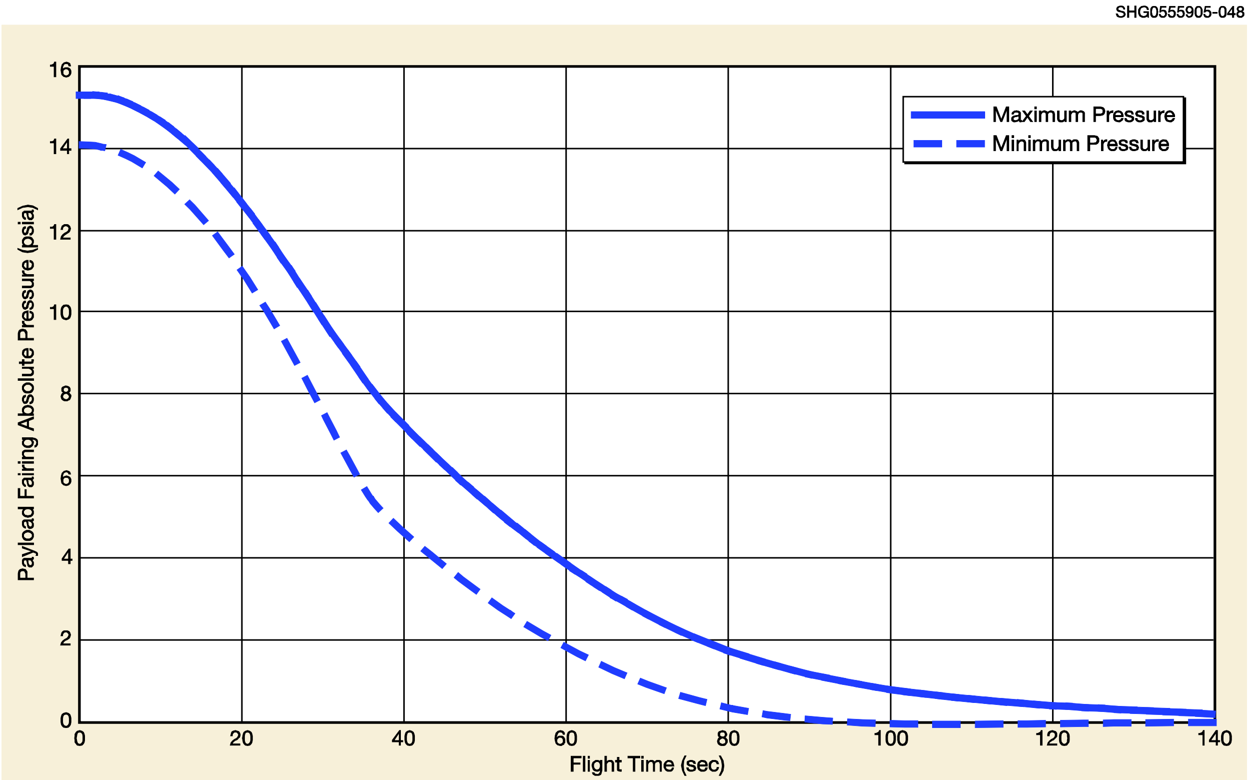

Figure 3-18. Delta IV M+(5,4) Absolute Pressure Envelope

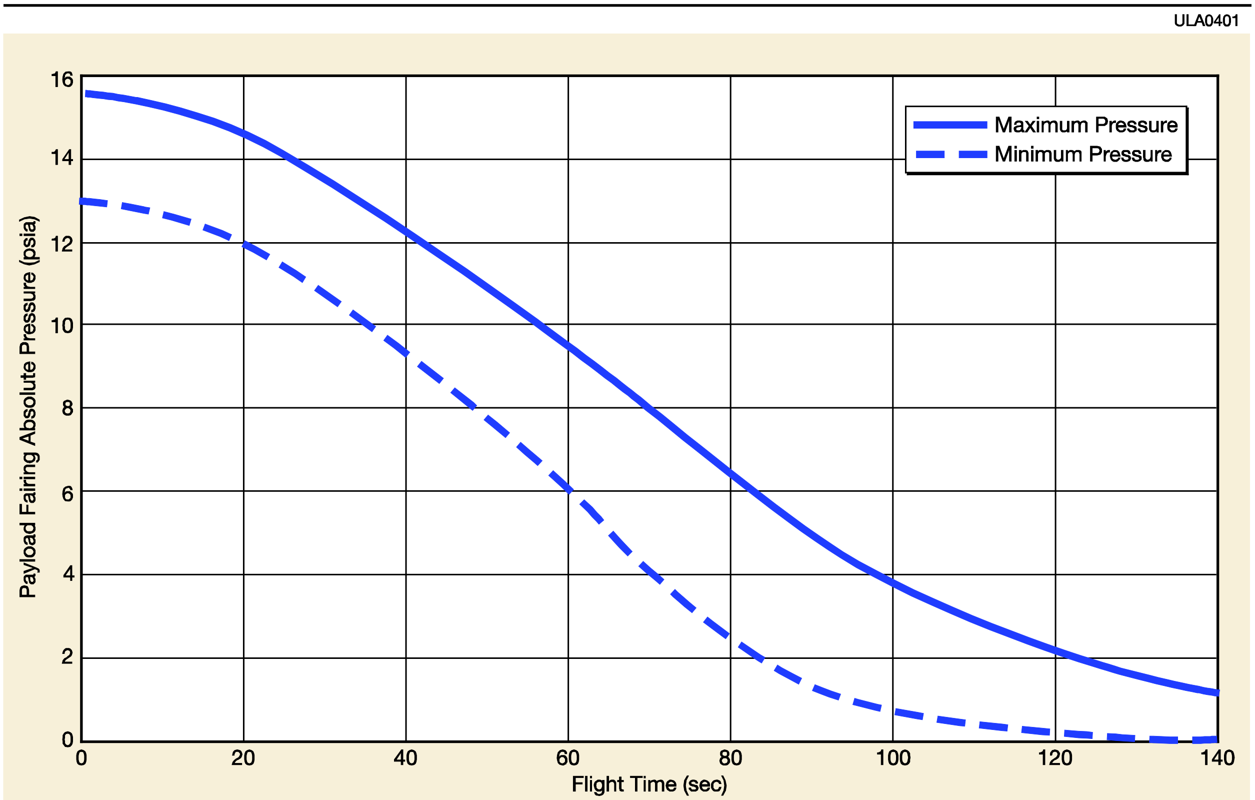

Figure 3-19. Delta IV Heavy (Composite PLF) Absolute Pressure Envelope

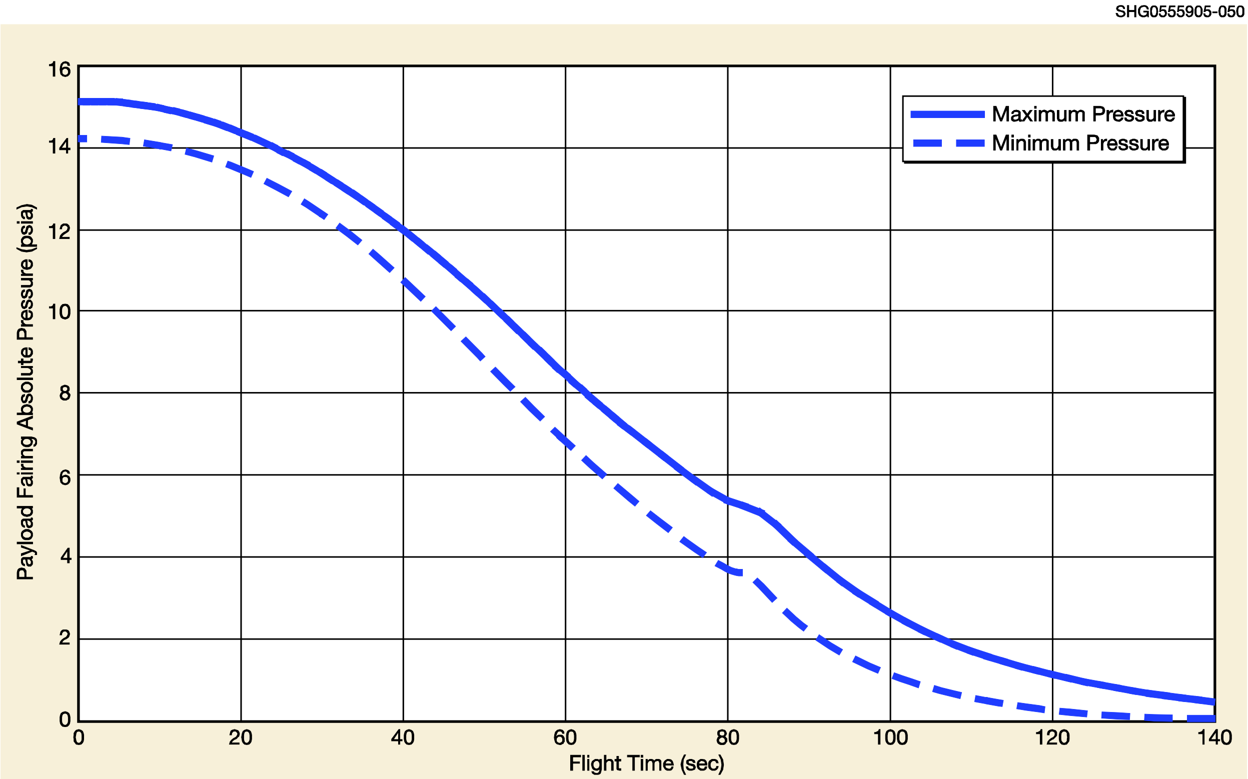

Figure 3-20. Delta IV Heavy (Metallic PLF) Absolute Pressure Envelope

The rate of pressure decay inside the fairing is also important in establishing the payload flight environment. The fairing internal pressure decay rate for all Delta IV LVs will generally be constrained to a sustained level of 2.48 kPa/sec (0.36 psi/sec) or less with a single brief allowable peak of up to 5.03 kPa/sec (0.73 psi/sec). While Figures 3-15 to 3-20 illustrate typical bounding pressure profiles, these figures are not intended for use with respect to Spacecraft (SC) venting design. Paragraph 3.2.1.1 contains data that is appropriate for design purposes.

3.2.1.1 Static Pressure (PLF Venting) Environment for Design Considerations. For SC venting design purposes, the payload compartment depressurization environment for the 4-m, 5-m composite, and 5-m metallic PLF will be no more severe than as depicted in Figure 3-21, with the corresponding data specified in Figure 3-22. The "transonic" profile design bounds the peak depressurization, which occurs during transonic flight. The remaining two profiles ("early" and "late") are intended to bound longer-term venting. The use of all three curves is necessary to adequately assess the full range of flight environments.

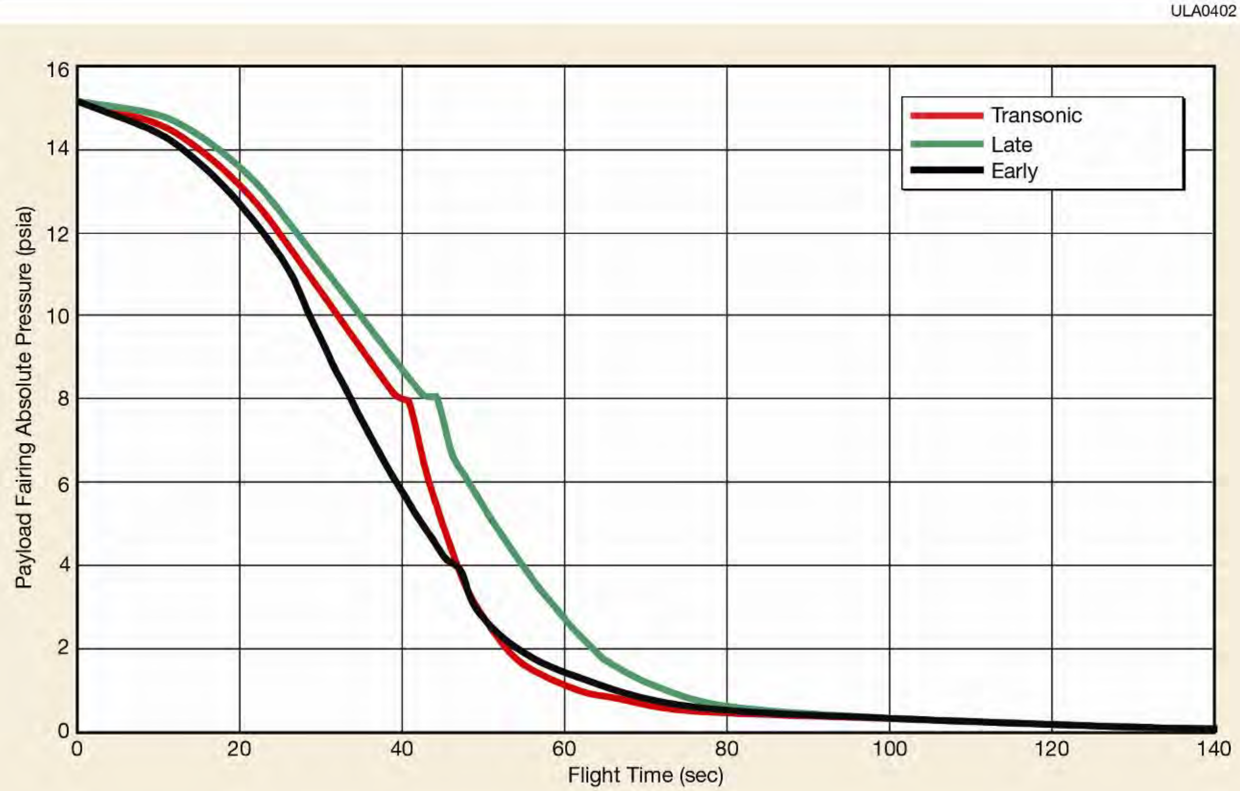

Figure 3-21. Delta IV Design Time Pressure History Curves

Transonic		Late		Early	
sec	psi	sec	psi	sec	psi
0.00	14.7000	0.00	14.7000	0.00	14.7000
10.00	14.2000	10.00	14.4000	10.00	14.0000
15.00	13.7000	15.00	14.0000	15.00	13.4000
20.00	12.9500	20.00	13.3500	20.00	12.5500
25.00	11.9500	25.00	12.4500	25.00	11.4500
41.20	7.9000	44.80	7.9000	28.00	10.6400
43.20	7.7000	46.80	7.8000	30.20	9.7500
45.20	6.2400	48.80	6.5000	32.20	9.0000
46.60	5.4000	50.40	6.0000	33.50	8.5000
48.70	4.3000	52.10	5.5000	35.00	8.0000
50.90	3.3000	53.80	5.0000	36.40	7.5000
54.00	2.4000	55.30	4.6000	37.90	7.0000
58.00	1.6000	56.80	4.2000	39.40	6.5000
65.00	1.0000	58.40	3.8000	41.00	6.0000
70.00	0.8000	60.00	3.4000	42.70	5.5000
80.00	0.5000	61.40	3.1000	44.40	5.0000
110.00	0.3000	62.80	2.8000	46.30	4.5000
150.00	0.0500	64.20	2.5000	48.00	4.0500
		65.50	2.2500	50.00	3.7500
		66.90	2.0000	52.00	2.8800
		68.00	1.8000	57.00	2.0000
		68.80	1.6800	65.00	1.3000
		75.00	1.1000	80.00	0.6000
		85.00	0.6000	110.00	0.3000
		110.00	0.3000	150.00	0.0500
		150.00	0.0500		

Figure 3-22. Delta IV Design Time Pressure History Data Points

3.2.2 Thermal Environment

Prior to and during launch, the payload fairing and Second Stage contribute to the thermal environment of the payload.

3.2.2.1 Payload Fairing Thermal Environment. The ascent thermal environments of the Delta IV fairing surfaces facing the payload are shown in Figure 3-23 for the 4-m and 5-m composite fairings, and Figure 3-24 for the 5-m metallic fairing. Temperatures are provided for the PLF inner surfaces facing the payload. Unblanketed regions of the PLF include, but are not limited to, the aft-end of both metal and composite fairings, the forward-end of the metallic fairing nose module, A/C door, electrical access doors, lower PLF ECS doors and any mission-specific access doors. All temperatures presented are maximum upper bounds based on depressed (worst-case) versions of design trajectories and hot-day launch conditions.

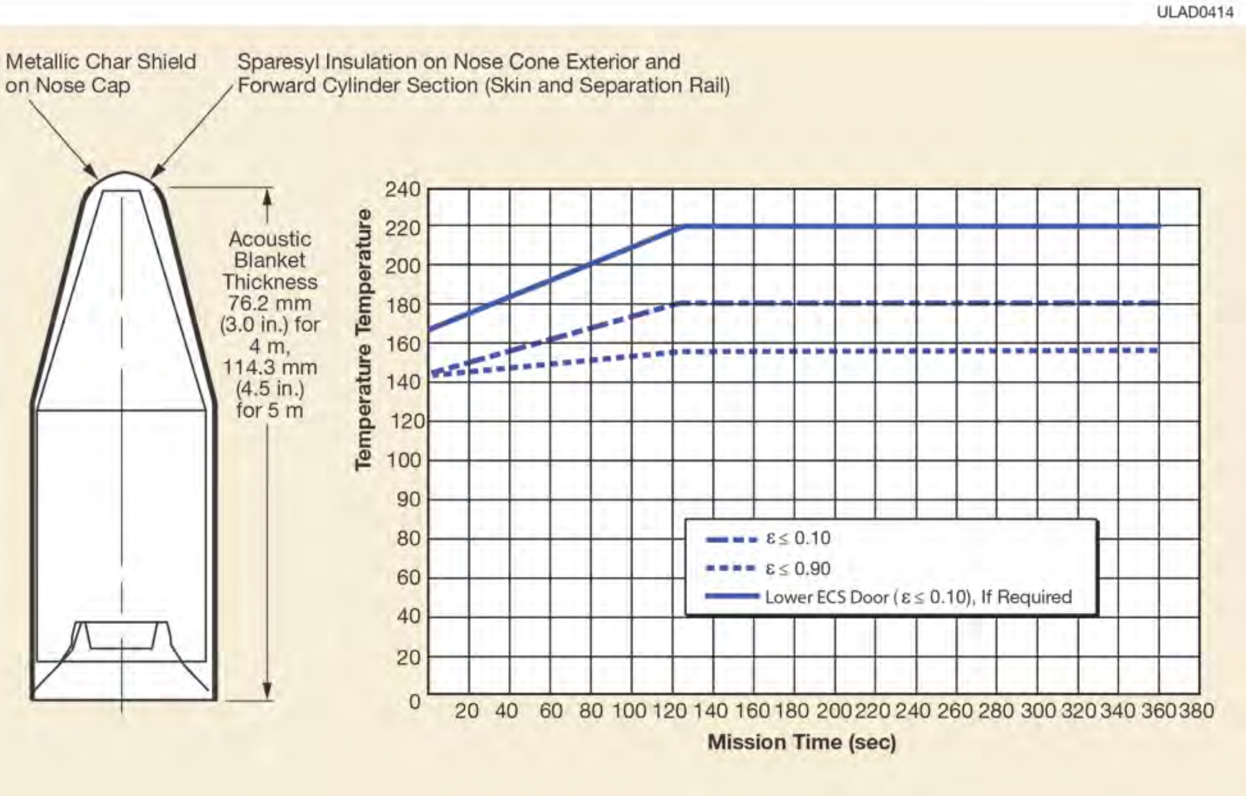

Figure 3-23. Maximum Inner Surface Temperature (Environments to Spacecraft), 4-m and 5-m Composite PLFs

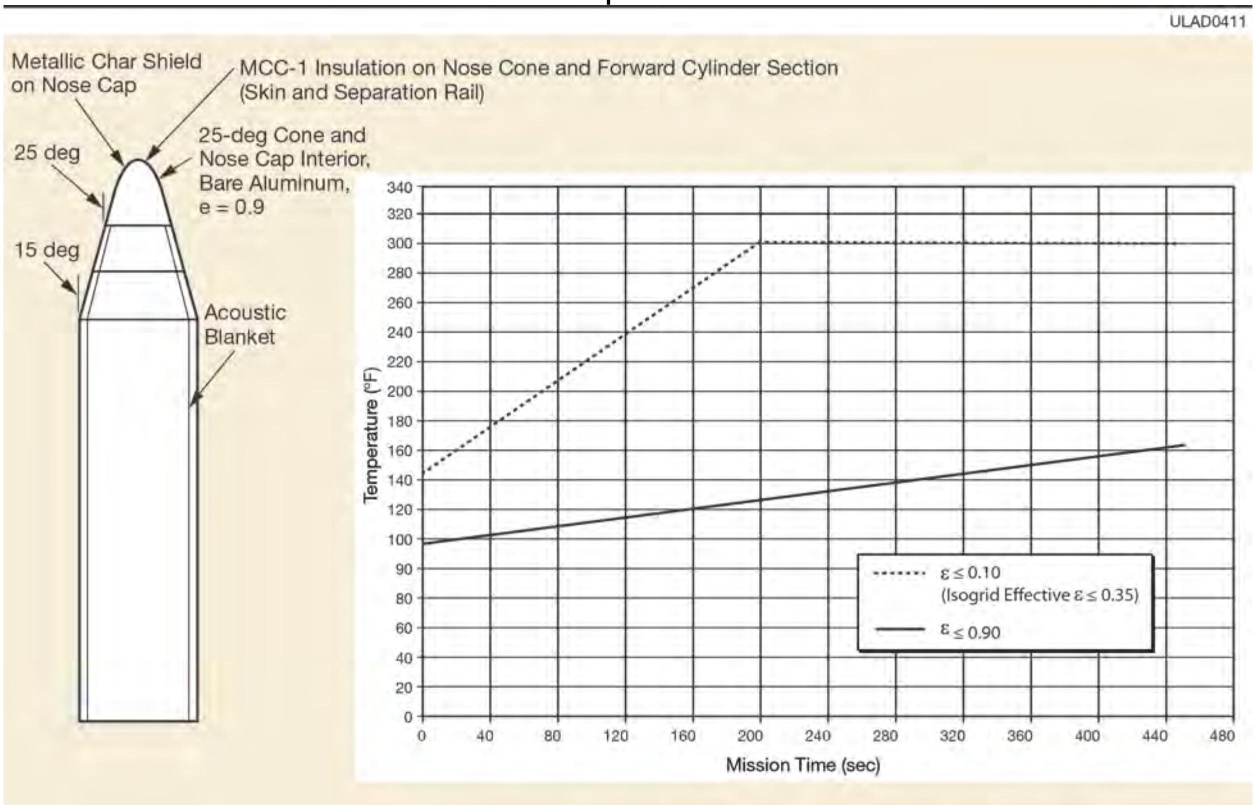

Figure 3-24. Maximum Inner Surface Temperature (Environments to Spacecraft), 5-m Aluminum Isogrid PLFs

The acoustic blankets provide a relatively stable radiation environment by effectively shielding the payload from ascent heating. Slight variations in blanket coverage may exist due to payload-peculiar requirements. Unless otherwise requested, fairing jettison for Delta IV missions will occur shortly after the 3-sigma high theoretical free molecular heating for a flat plate normal to the free stream drops below 1135 W/m^2 (360 Btu/hr ft^2) based on the 1962 United States Standard Atmosphere. Other free molecular heating requirements may be accommodated by the Delta IV family through coordination with ULA.

3.2.2.2 On-Orbit Thermal Environment. During coast periods, the Delta IV LV can be oriented to meet specific sun-angle requirements. A Passive Thermal Control (PTC) roll with the LV broadside to the sun will be performed to moderate orbital heating and cooling. The Delta IV roll rate for thermal control typically ranges from 0.5 deg/sec to 1.5 deg/sec.

3.2.2.3 Payload/Launch Vehicle Integrated Thermal Analysis. The Delta Program can perform a thermal analysis using a customer-provided payload thermal model to define payload temperatures as coordinated with ULA.

3.2.2.4 Stage-Induced Thermal Environments. The plume of the RL10B-2 engine does not impinge on the payload. Similarly, the ACS system does not impinge on the payload.

3.2.3 In-Flight Contamination Environments

For most missions, the Delta launch system will limit contamination depositions from all launch system sources onto spacecraft surfaces to a molecular thickness of 150 Angstroms and a particle obscuration of 1.0%, from the start spacecraft encapsulation operations through the end of the CCAM, which follows spacecraft separation. Launch system ground contamination sources were addressed in Paragraph 3.1.5. Ascent contamination sources are discussed below.

3.2.3.1 Molecular Outgassing. Nonmetallic materials outgas molecules that can deposit on spacecraft surfaces. This source is limited by choosing low outgassing materials where possible and by limiting, encapsulating, or vacuum baking higher outgassing materials. Sources of contamination from payload fairings have been quantified for Delta IV. Delta IV PLFs have a unique acoustic blanket configuration that virtually eliminates the PLF as a source of contamination to the spacecraft. The acoustic blankets are made of Melamine foam covered with carbon-filled Kapton face sheets. The blankets are attached to the PLF interior using double-sided tape or hook-and-loop fasteners. All blanket seams are sealed with Kapton tape. The PLFs and blankets are cleaned with isopropyl alcohol. During ascent, the blankets vent to the bottom of the PLF, away from the payload. Outgassing from nonmetallics in the fairing is low due to the low composite fairing temperatures, which are generally below 48.9°C (120°F). The potential for molecular contamination from PAF sources is minimized because there are very few nonmetallic materials mounted to the PAFs (avionics systems and assemblies are located outside of the payload compartment).

3.2.3.2 Nonvolatile Residue (NVR) Redistribution. PLF and PAF surfaces within the PLF volume will have small amounts of adsorbed molecules that may desorb when these surfaces are warmed and exposed to low pressure conditions. They can deposit on spacecraft surfaces that are cooler than the condensation temperature of these molecules. Delta IV hardware is cleaned and tested to less than 1 mg/ft^2 of NVR.

3.2.3.3 Particle Redistribution. Particles on surfaces within the PLF volume can shake loose and redistribute to spacecraft surfaces during launch and flight. This source is limited by cleaning hardware as described in Section 3.1.5.1 before encapsulation. Redistribution of particle from PLF surfaces during ascent is the single largest source of particle contamination on the Delta IV vehicle. Additional LV hardware cleanliness levels may be specified to meet mission unique requirements.

3.2.3.4 Payload Fairing Separation. The Delta IV PLFs are separated by a linear pyrotechnic separation system that is fully contained in an expandable bellows. The bellows expands forcing the shearing of a rivet line. The sheared rivets are also retained by tape. SC contamination from this system is negligible based on the results of analyses and tests.

3.2.3.5 First Stage/Second Stage Separation. Depending upon specific mission trajectory requirements, the PLF may be jettisoned prior to First Stage/Second Stage separation. The First Stage is separated by the Sure-Sep frangible joint system and separation clearance is provided by a pneumatic actuator system. The Delta IV First Stage separation event generates no contamination.

3.2.3.6 Spacecraft Separation.

3.2.3.7 Collision and Contamination Avoidance Maneuver. Delta IV second-stage attitude control systems use hydrazine (N_2H_4) thrusters. High-purity grade hydrazine is used for all missions, resulting in thruster plumes that have extremely low contaminant content. The second-stage motor plumes do not expand enough to impinge on the payload envelope during Second Stage flight. A CCAM is performed after the payload has moved away from the Second Stage which is designed to prevent recontact of the Second Stage with the separated spacecraft while minimizing contamination of the spacecraft. Some minor spacecraft impingement from thruster exhaust plumes may occur during the CCAM, but molecular contamination deposition on the spacecraft is negligible because of the high purity grade of the hydrazine.

3.2.4 Flight Dynamic Environments

The acoustic, sinusoidal vibration, and shock environments cited herein are based on maximum flight levels for a 95th-percentile statistical estimate with a 50 percent confidence (P95/50).

3.2.4.1 Steady-State Acceleration. Plots of representative steady-state axial accelerations during first-stage burn versus payload weight are shown in Figures 3-25, 3-26, 3-27, 3-28, and 3-29 for the Delta IV Medium, M+(4,2), M+(5,2), M+(5,4), and Heavy vehicles, respectively. For a specific mission, the maximum axial acceleration may be reduced with First Stage throttling, with some performance impacts. Please contact ULA for details. Typical steady-state axial accelerations versus space vehicle weight at second-stage burnout are shown in Figures 3-30, 3-31, 3-32, 3-33, and 3-34 for the Delta IV Medium, M+(4,2), M+(5,2), M+(5,4), and Heavy vehicles, respectively.

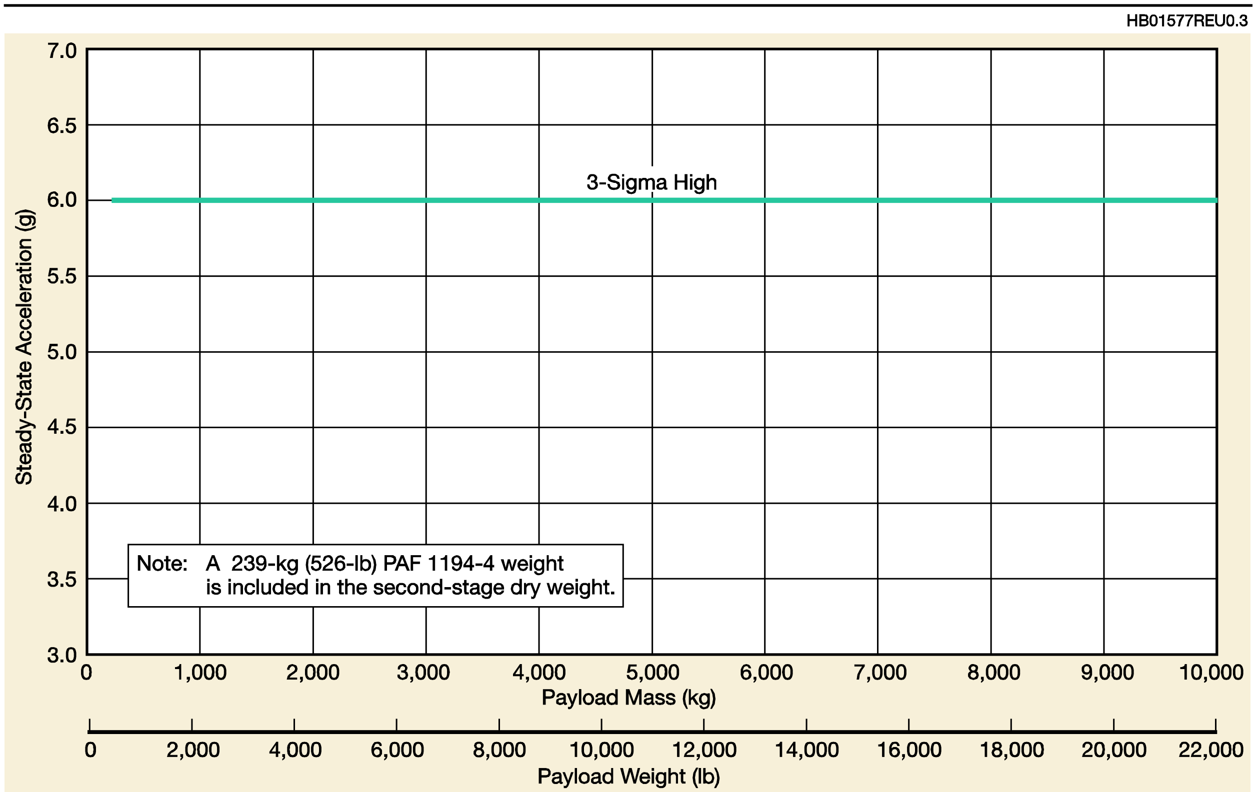

Figure 3-25. Delta IV Medium Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second Stage Payload Weight

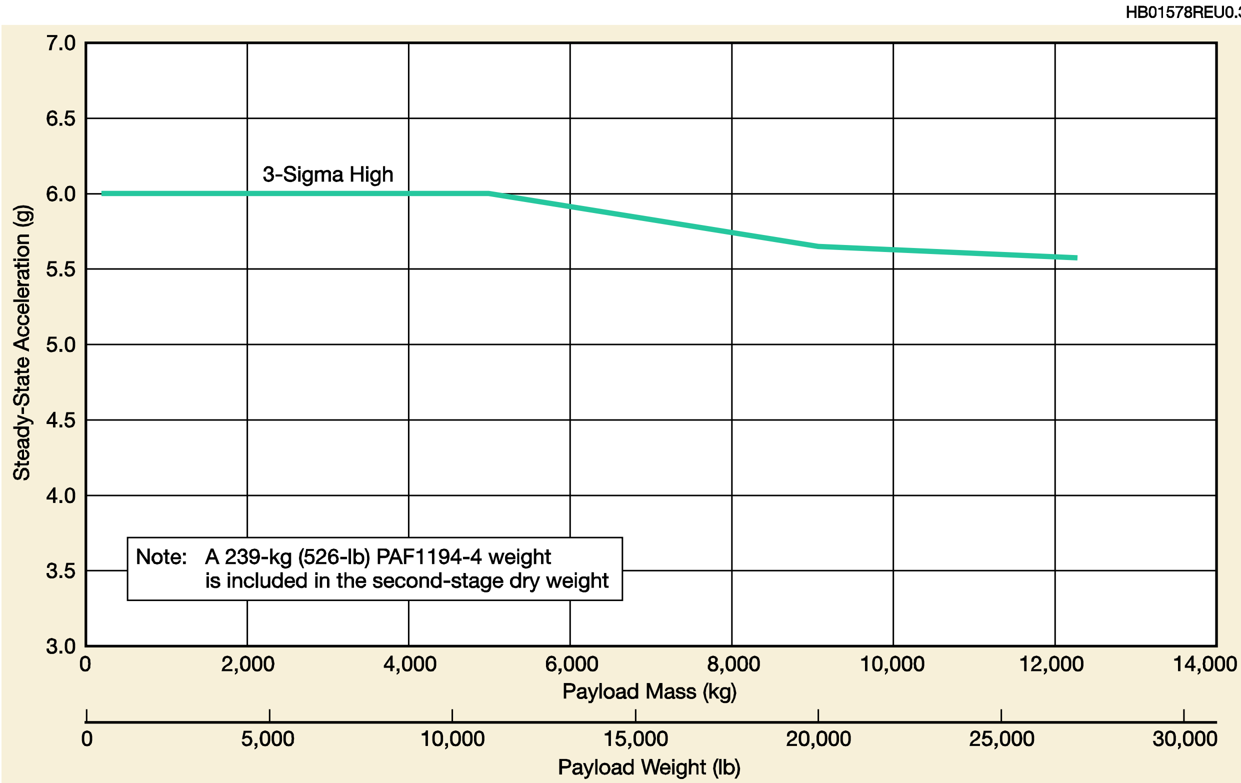

Figure 3-26. Delta IV M+(4,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second Stage Payload Weight

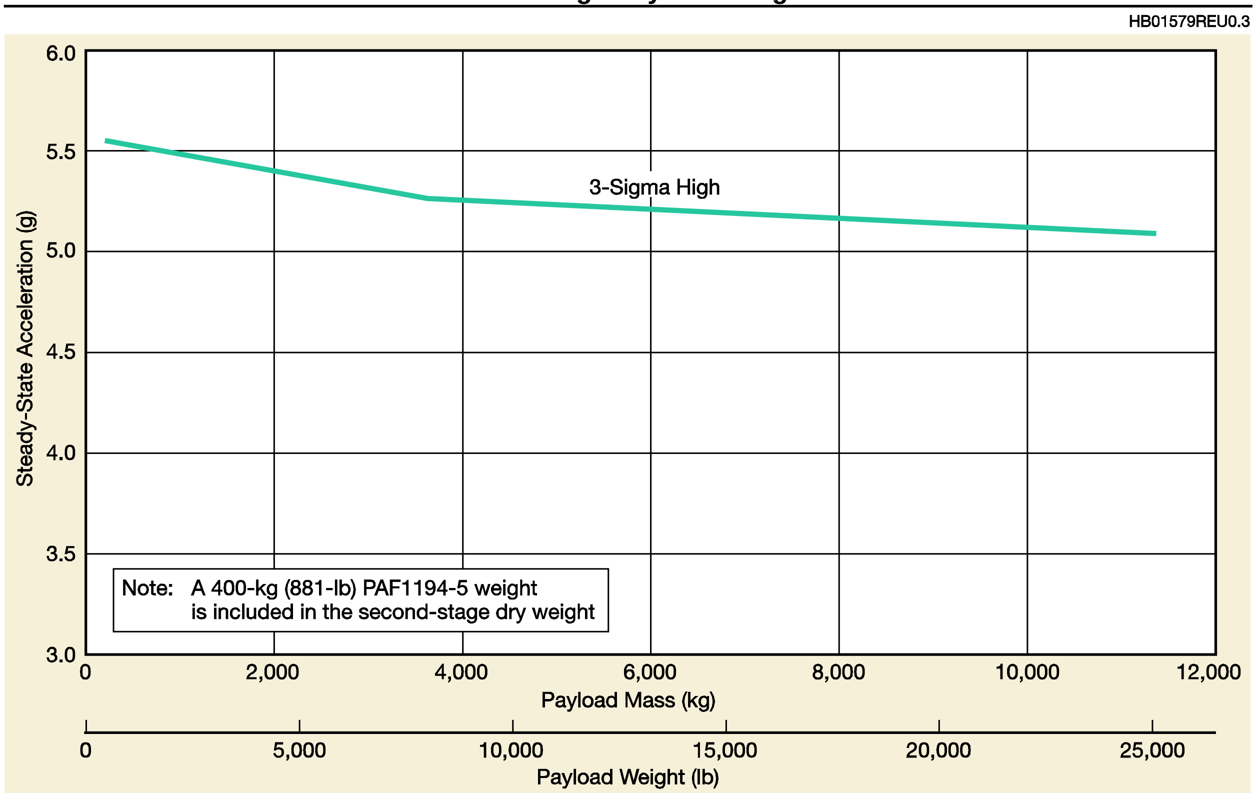

Figure 3-27. Delta IV M+(5,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second Stage Payload Weight

HB01580REU0.3

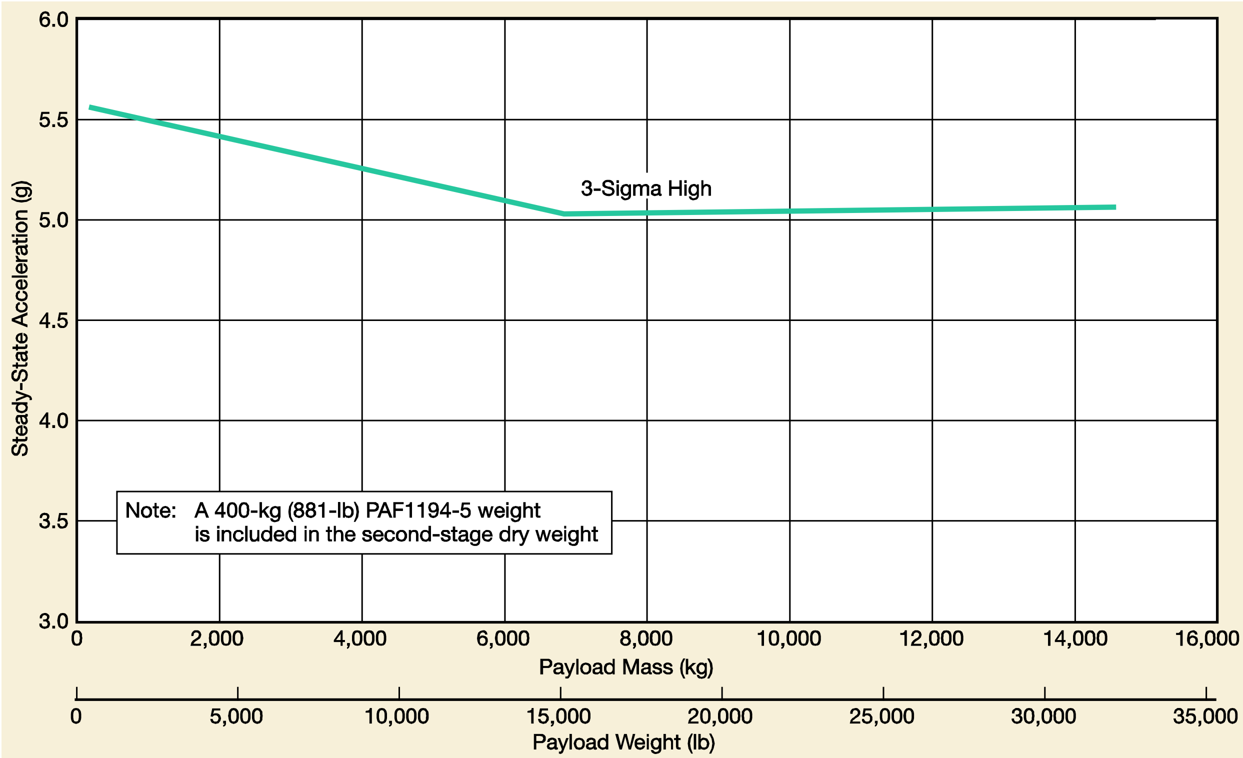

Figure 3-28. Delta IV M+(5,4) Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second Stage Payload Weight

HB01581REU0.3

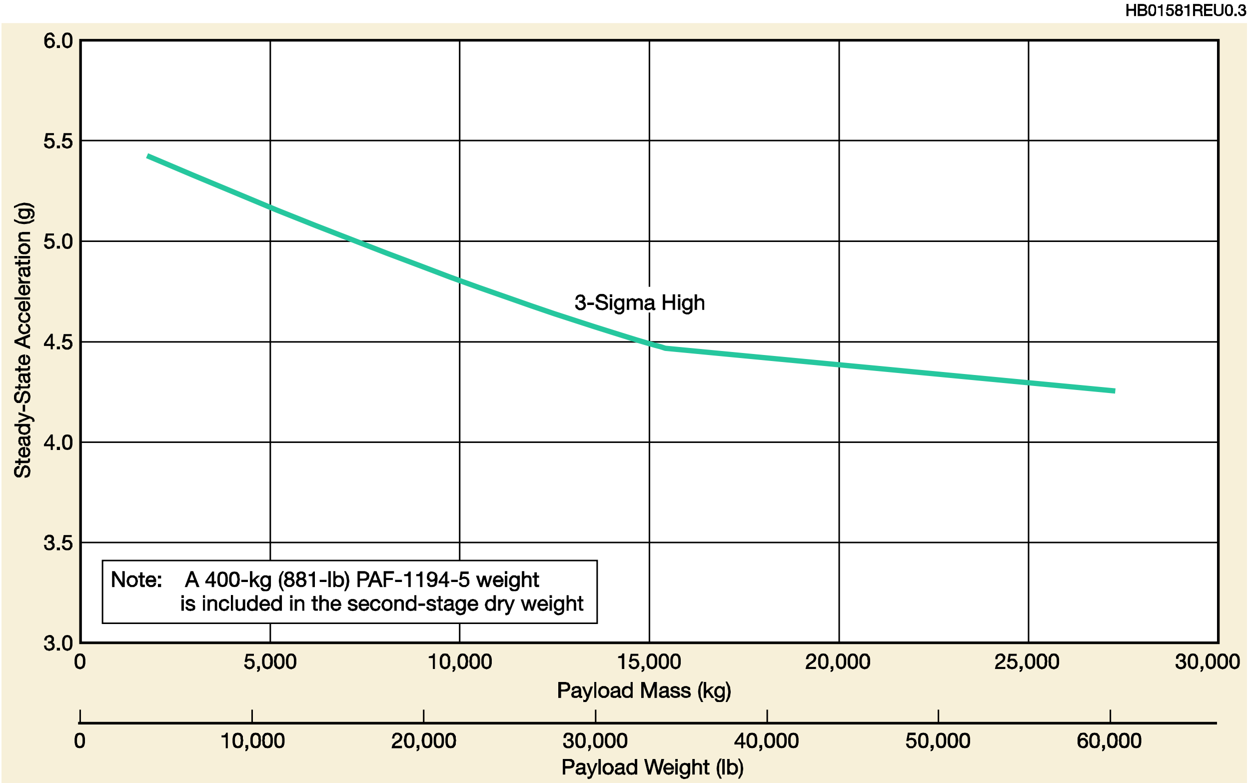

Figure 3-29. Delta IV Heavy Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second Stage Payload Weight

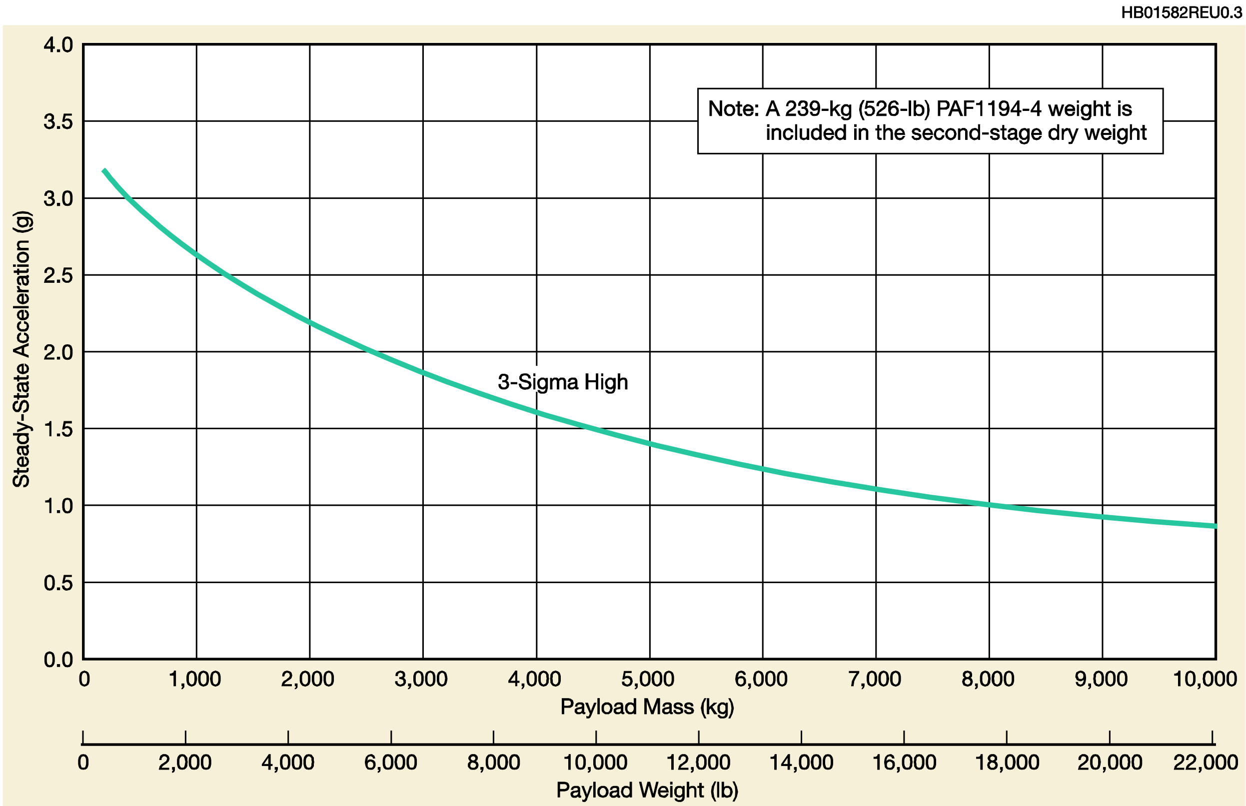

Figure 3-30. Delta IV Medium Maximum Axial Steady-State Acceleration at Second Stage Cutoff

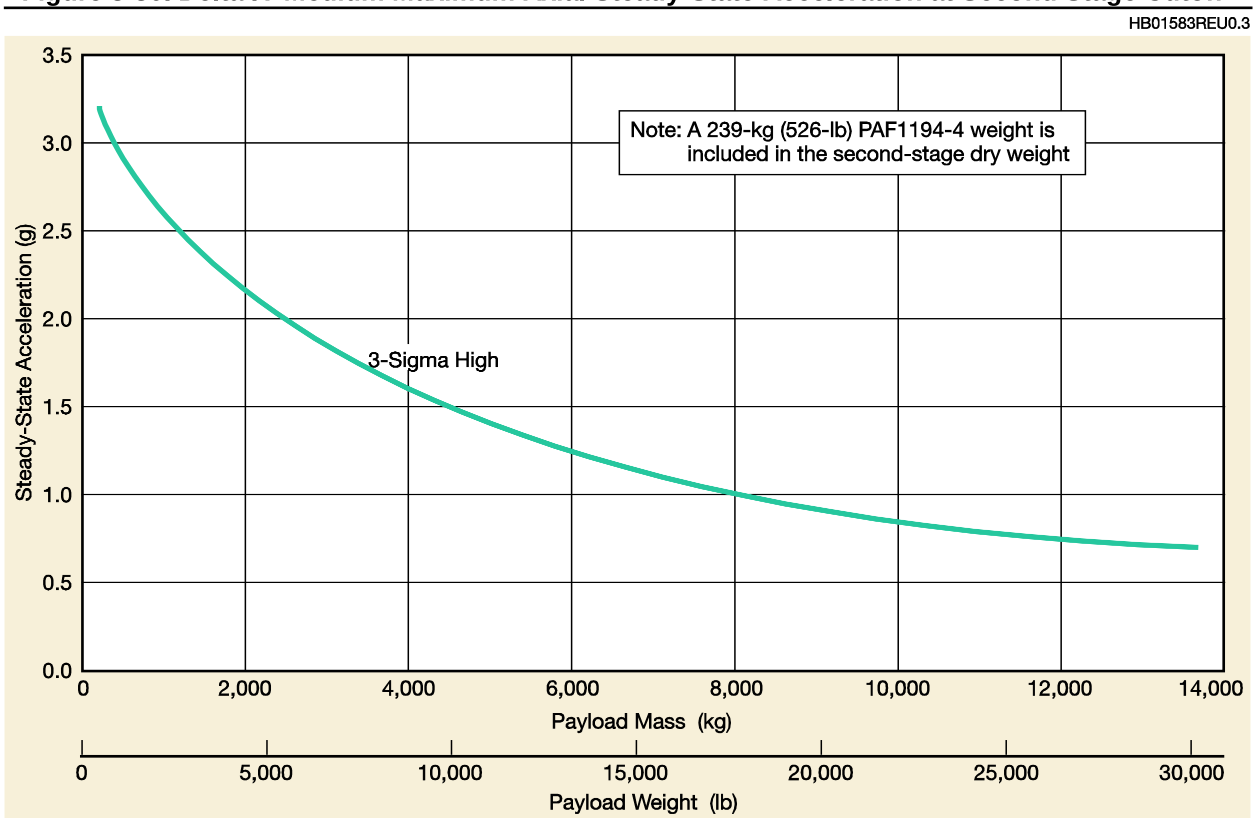

Figure 3-31. Delta IV M+(4,2) Axial Steady-State Acceleration at Second Stage Cutoff

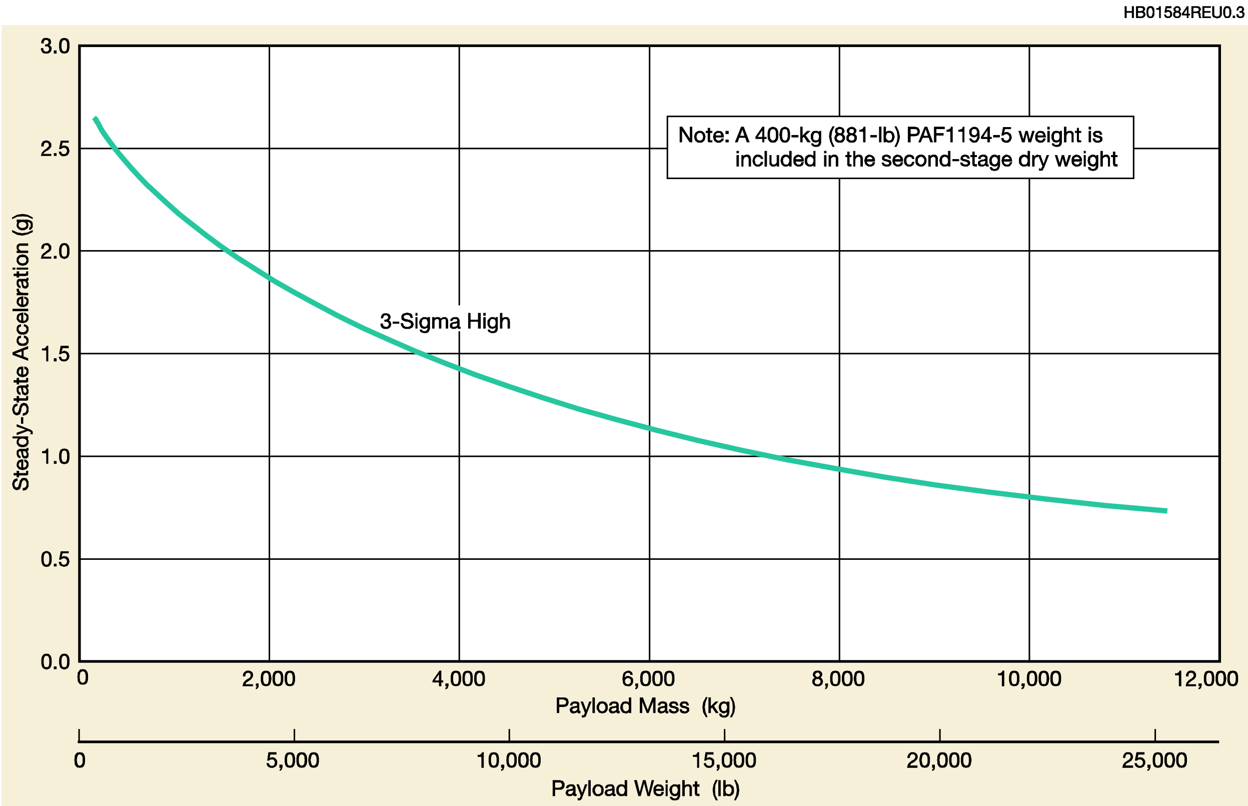

Figure 3-32. Delta IV M+(5,2) Axial Steady-State Acceleration at Second Stage Cutoff

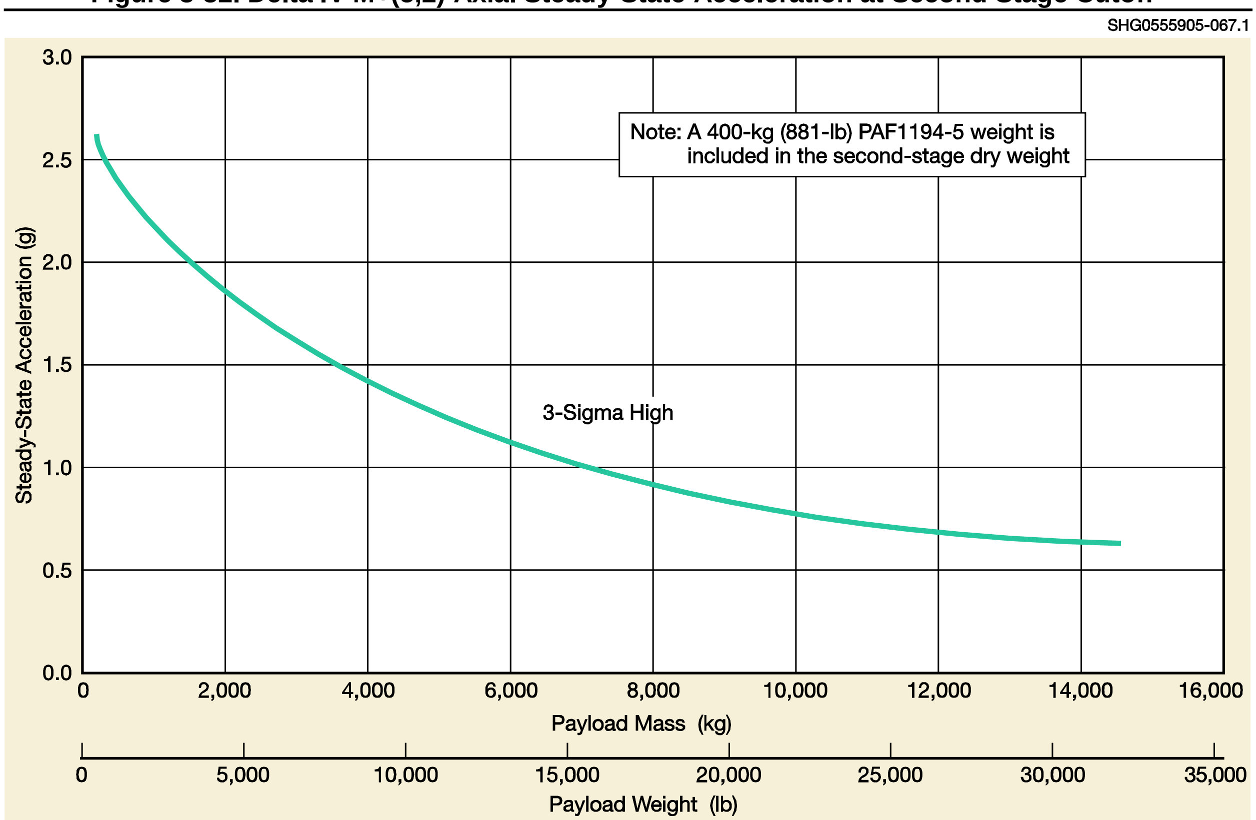

Figure 3-33. Delta IV M+(5,4) Axial Steady-State Acceleration at Second Stage Cutoff

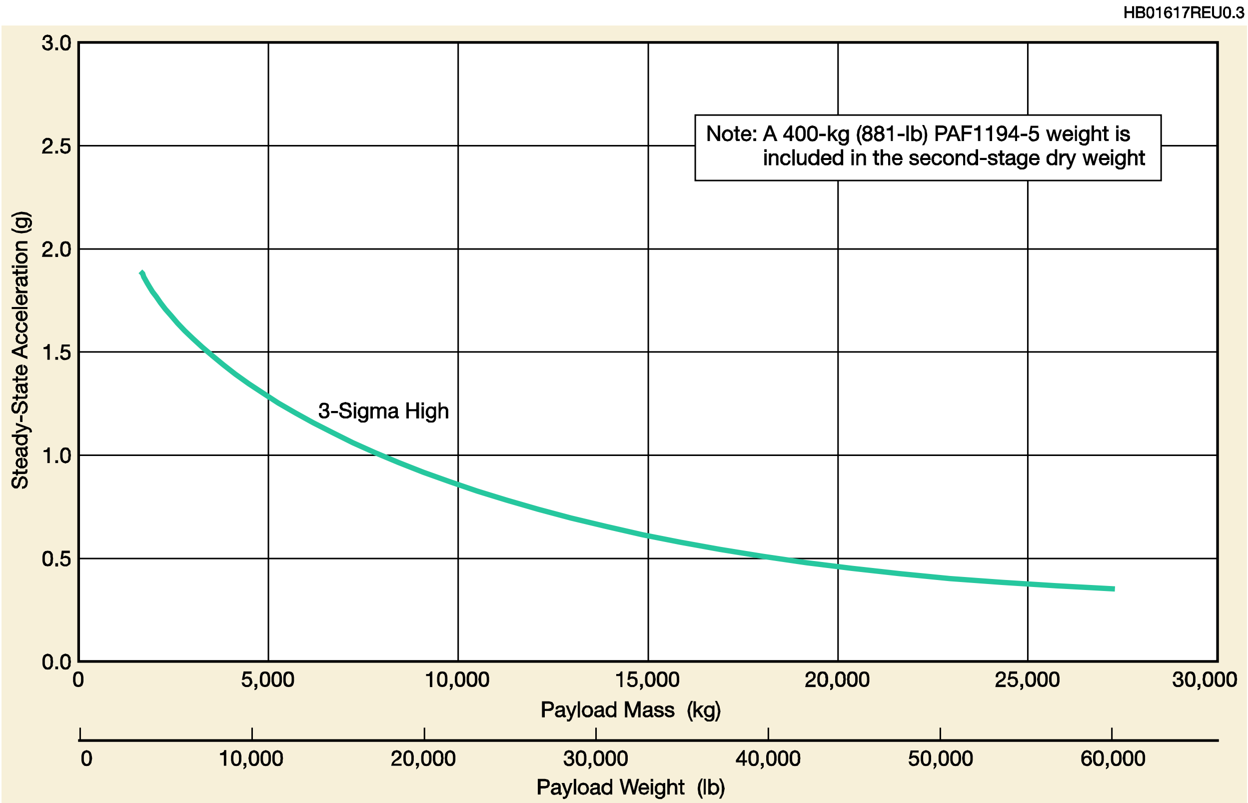

Figure 3-34. Delta IV Heavy Axial Steady-State Acceleration at Second Stage Cutoff

3.2.4.2 Combined Loads. Dynamic excitations, occurring predominantly during liftoff and transonic periods of Delta IV LV flights, are superimposed on steady-state accelerations to produce combined accelerations that must be used in the spacecraft structural design. The combined spacecraft accelerations are a function of LV characteristics as well as spacecraft dynamic characteristics and mass properties. The spacecraft design limit-load factors and corresponding fundamental frequencies are presented in Figure 3-35. The design load factors for various types of Delta IV LVs are shown in Figures 3-36, 3-37, and 3-38. For spacecraft that weigh less than that noted in Figure 3-35, the quasi-static load factors may be higher. Please contact ULA for more information.

Static Envelope Requirements					Maximum Lateral		Maximum Axial	
Launch Vehicle Type	**Overall Payload Fairing length (M/ft)**	**Minimum Axial Frequency (Hz)**	**Minimum Lateral Frequency (Hz)**	**Minimum Weight (Kg/lb)**	**Maximum Axial (g)**	**Maximum Lateral (g)**	**Maximum* Axial (g)**	**Maximum Lateral (g)**
Delta IV Medium	11.7/38.5	27	8	907 (2,000)	See Figure 3-36			
Delta IV M+(4,2)	11.7/38.5	27	8	2,721 (6,000)	See Figure 3-36			
Delta IV M+(5,2)	14.3/47	27	8	2,721 (6,000)	See Figure 3-37			
Delta IV M+(5,4)	14.3/47	27	8	4,989 (11,000)	See Figure 3-37			
Delta IV Heavy	19.8/62.7	30	8	6,577 (14,500)	See Figure 3-38			

*Lower customer axial requirements may be accommodated through coordination with ULA.

Figure 3-35. Spacecraft Minimum Frequency and Quasi-Static Load Factors

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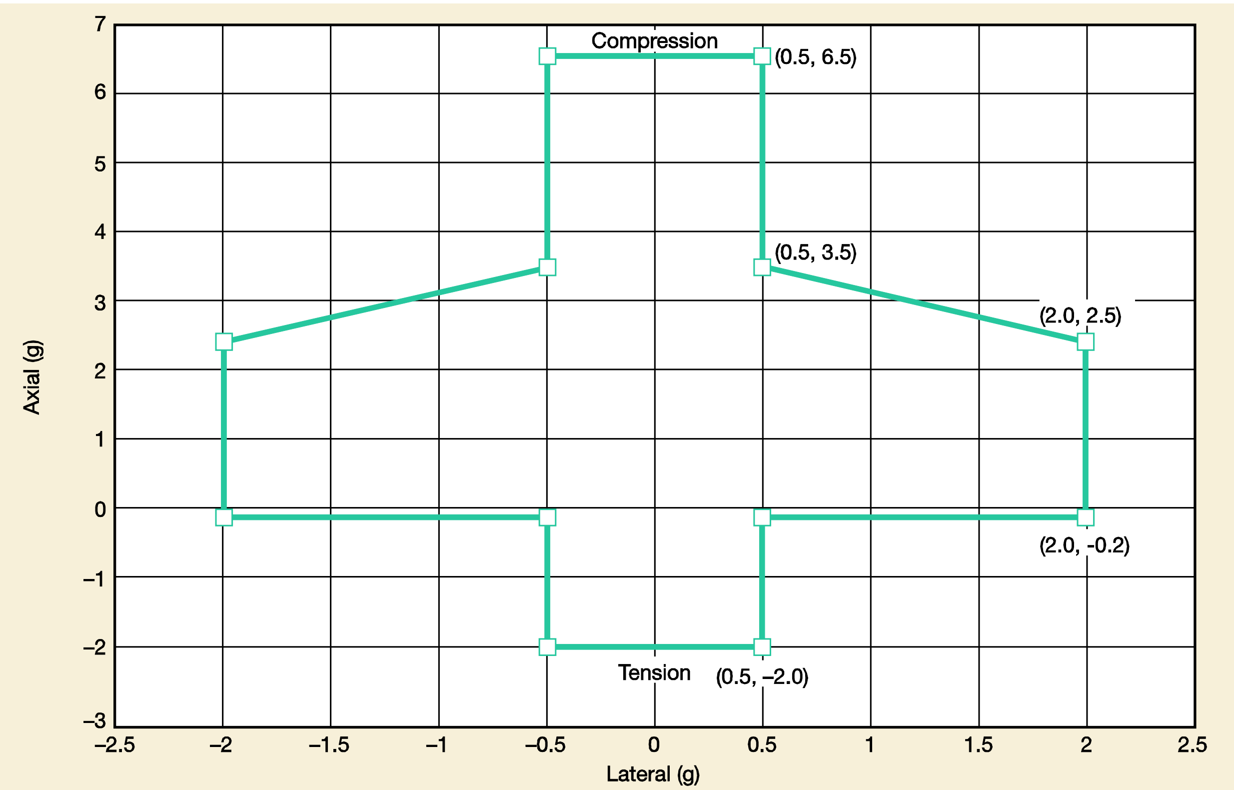

Figure 3-36. Delta IV Medium and M+(4,2) Design Load Factors

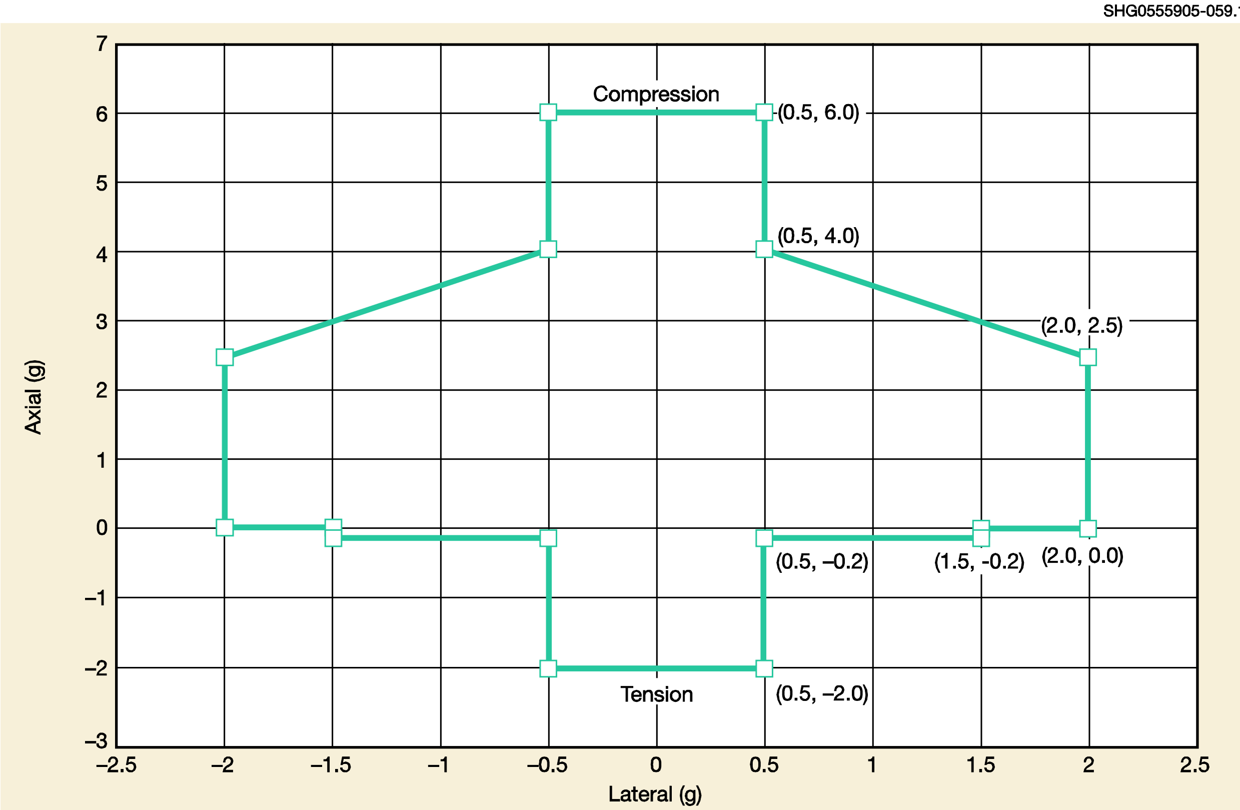

Figure 3-37. Delta IV M+(5,2) and M+(5,4) Design Load Factors

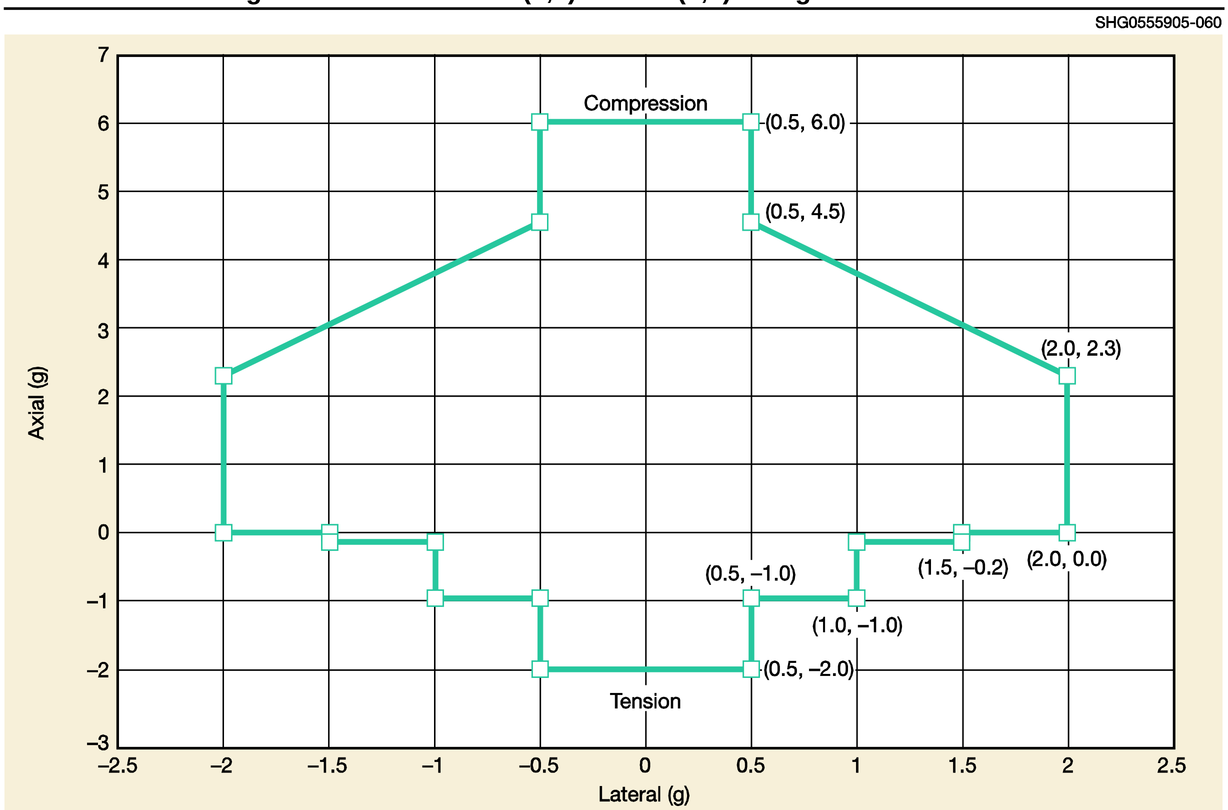

Figure 3-38. Delta IV Heavy Design Load Factors

Customers are required to specify an accurate definition of the physical location of all points on the payload that are within 51 mm (2.0 in.) of the identified static envelope. This information is required to verify no contact between the payload and the fairing as a result of dynamic deflections. To prevent dynamic coupling between low-frequency LV and payload modes, the stiffness of the payload structure should produce fundamental frequencies above the levels stated in Figure 3-35 for the corresponding LVs. These frequencies are for a payload hard-mounted at the separation plane without compliance from the PAF and associated separation system accounted for or, in the case of multiple-manifested payloads, at the dispenser-to-launch-vehicle interface. Secondary structure mode frequencies should be above 35 Hz to prevent undesirable coupling with LV modes and/or large fairing-to-payload relative dynamic deflections. For very flexible payloads, the combined accelerations and subsequent design load factors could be higher than shown; users should consult ULA so that appropriate analyses can be performed to better define loading conditions.

3.2.4.3 Acoustic Environment. The maximum acoustic environment experienced by the payload occurs during liftoff and transonic flight. The payload acoustic environment is a function of the configuration of the LV, the fairing, the fairing acoustic blankets, and the payload. Figures 3-39, 3-40, 3-41, and 3-42 define the payload acoustic environment for all versions of the Delta IV LV system. The acoustic levels are presented as one-third octave-band sound pressure levels (dB, ref: 2×10^{-5} N/m^2) versus one-third octave band center frequency. These levels apply to the blanketed section of the fairing and represent a 95^{th} percentile space average flight environment for a fairing with a 50% confidence prediction and a 60% payload volume fill effect. A larger payload may increase the acoustic environments shown. Customers should contact ULA to coordinate any payload acoustic requirements below the levels shown.

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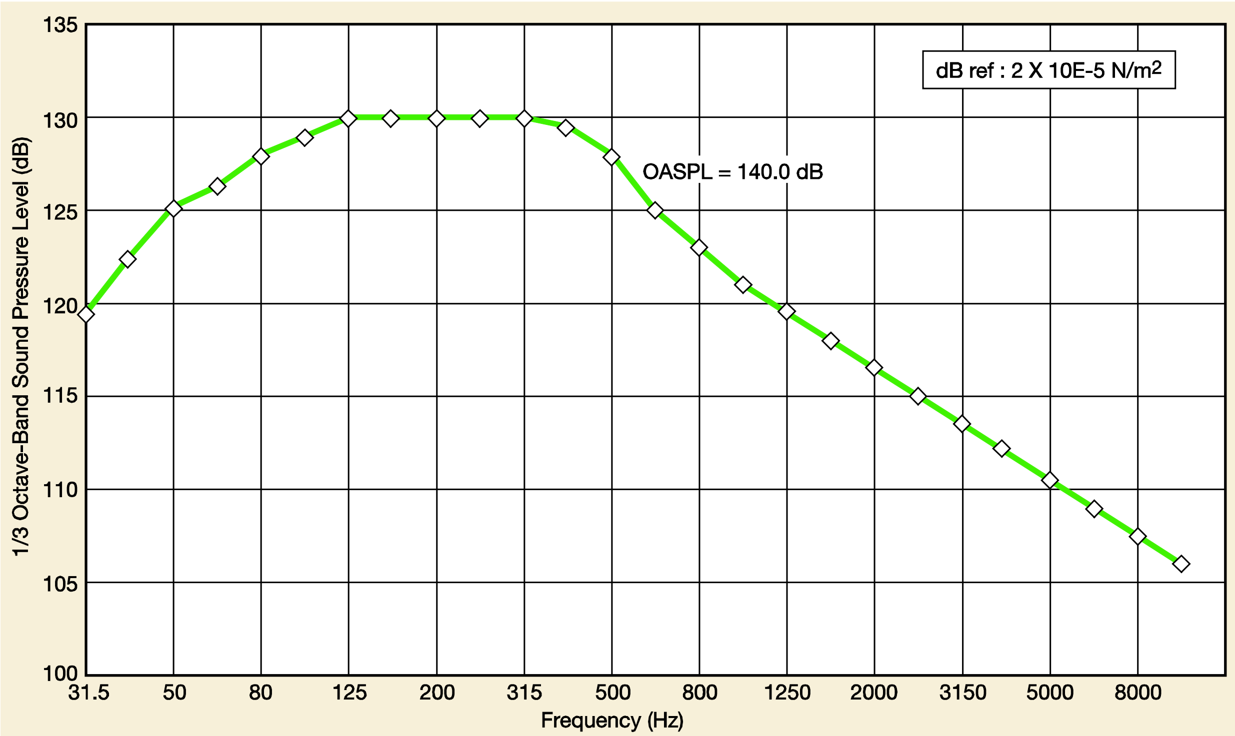

Figure 3-39. Delta IV Medium and Delta IV M+(4,2) (4-m Composite Fairing) Internal Payload Acoustics, Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included

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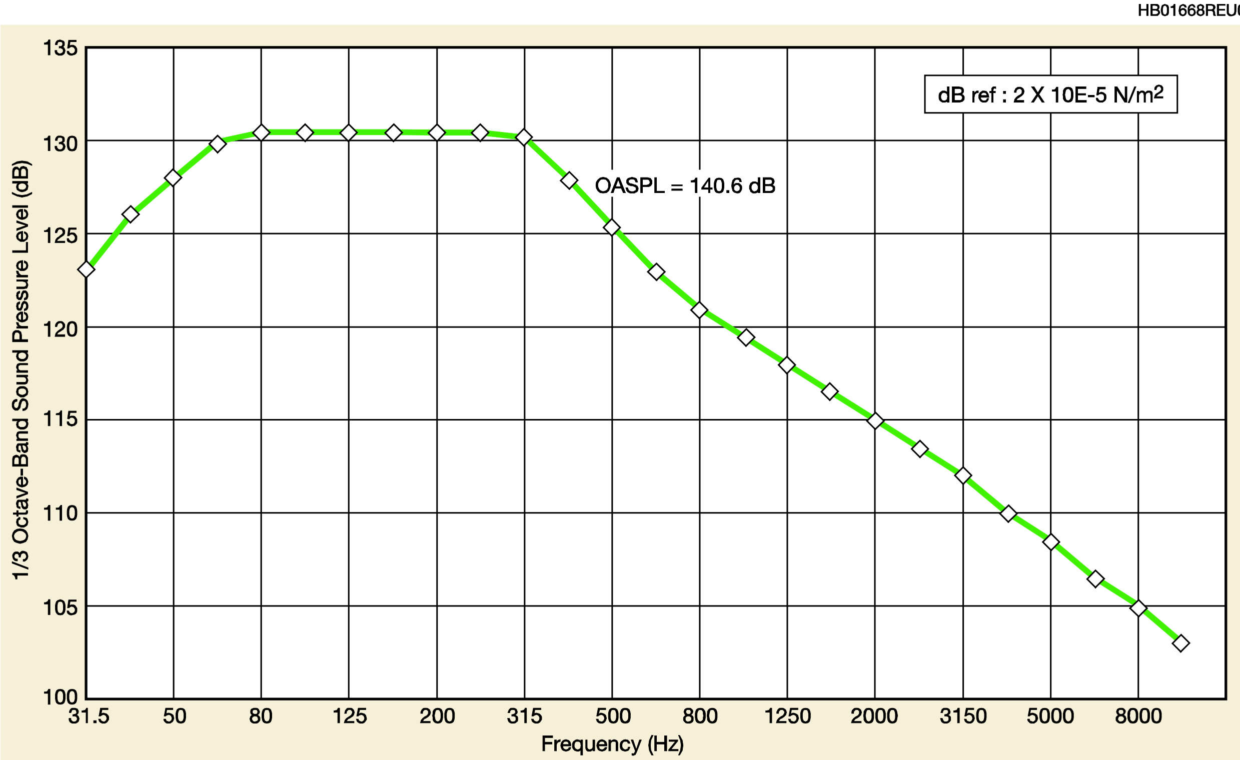

Figure 3-40. Delta IV M+(5,2) and M+(5,4) (5-m Composite Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included

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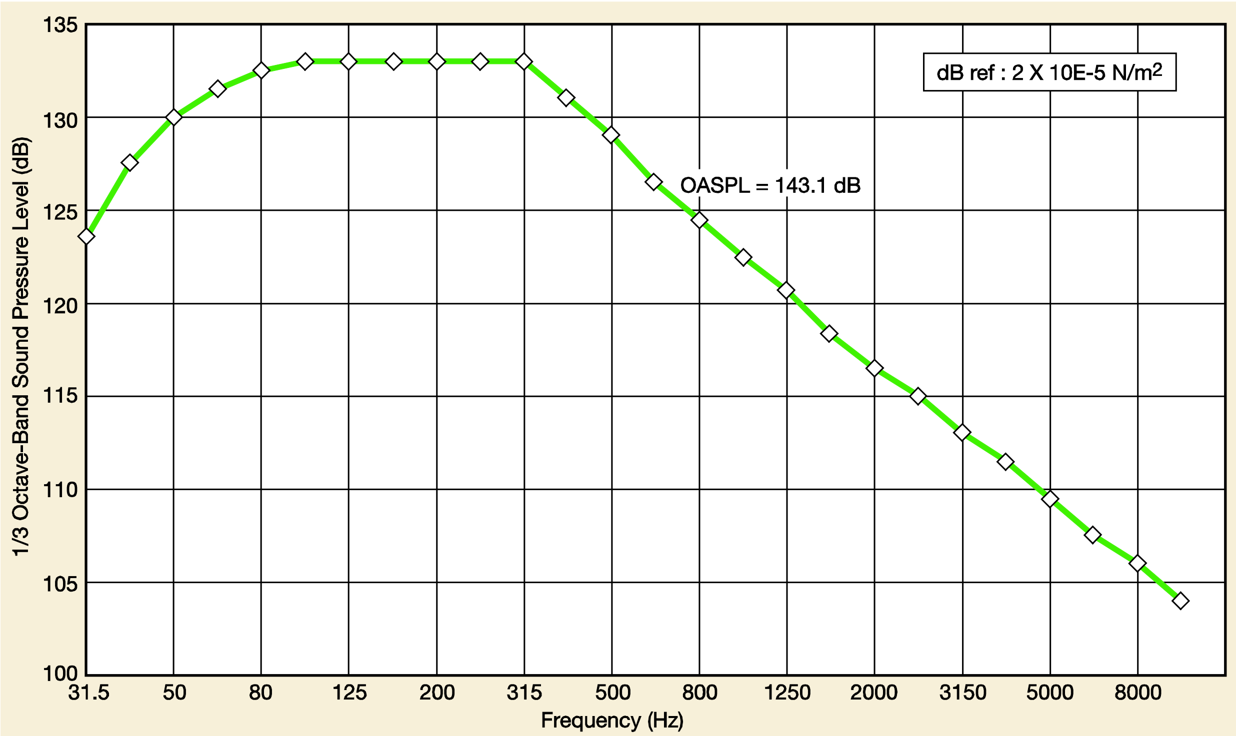

Figure 3-41. Delta IV Heavy (5-m Composite Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included

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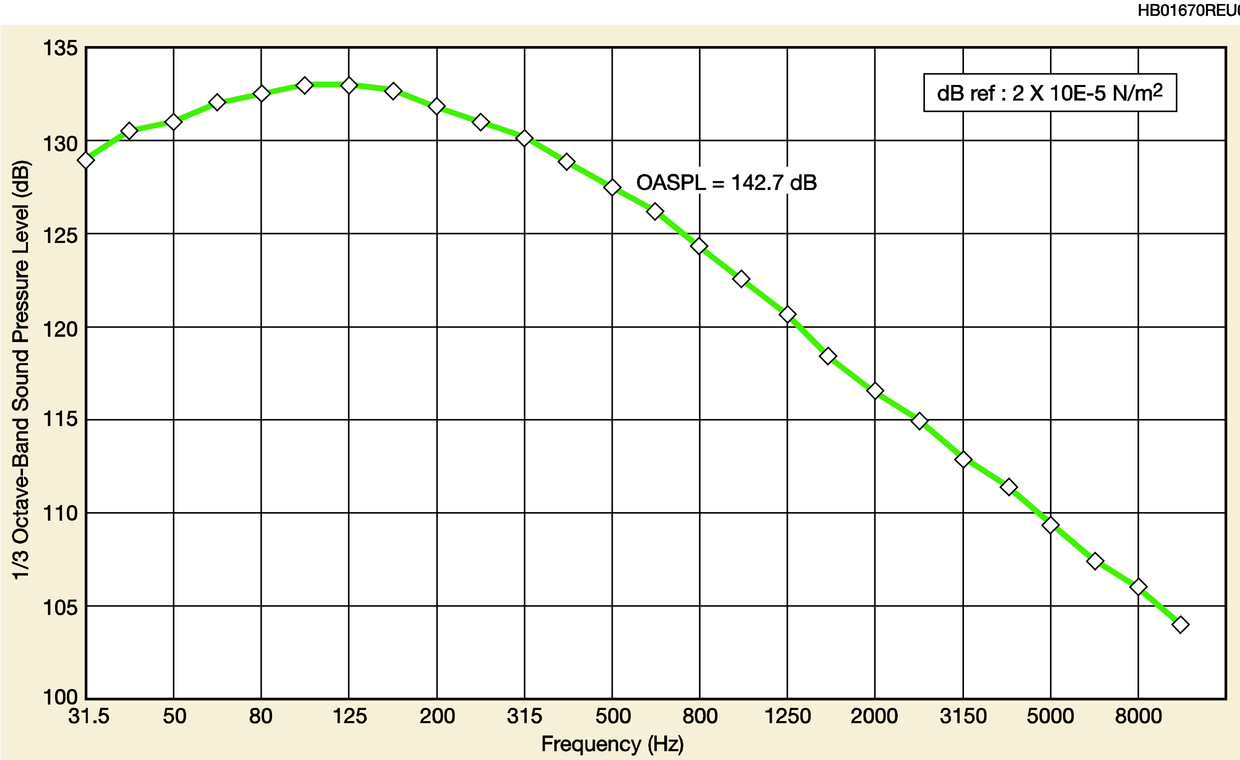


Figure 3-42. Delta IV Heavy (5-m Metallic Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included

When the size, shape, and overall dimensions of a spacecraft are defined, a mission-specific analysis can be performed to define the specific payload's acoustic environment. The acoustic environment produces the dominant high-frequency random vibration responses in the payload. Thus, a properly performed acoustic test is the best simulation of the acoustically induced random vibration environment (see Section 3.2.5.2). No significant high-frequency random vibration inputs at the PAF interface are generated by Delta IV LVs; consequently, a Delta IV PAF interface random vibration environment is not specified.

3.2.4.4 Sinusoidal Vibration Environment. The payload will experience sinusoidal vibration inputs as a result of the launch, due to numerous transients and oscillatory flight events during ascent. The maximum predicted flight level sinusoidal vibration inputs, which are the same for all Delta IV LV configurations, are defined in Figure 3-43 at the spacecraft separation plane. These predicted sinusoidal vibration levels generally envelope low-frequency flight dynamic events such as liftoff transients, transonic/max-Q oscillations, Main Engine Cutoff (MECO) transients, pre-MECO sinusoidal oscillations, and second-stage events.

Axis	Frequency (Hz)	Maximum flight levels
Thrust	5 to 6.2 6.2 to 100	1.27 cm (0.5 in.) double amplitude 1.0 g (zero to peak)
Lateral	5 to 100	0.7 g (zero to peak)

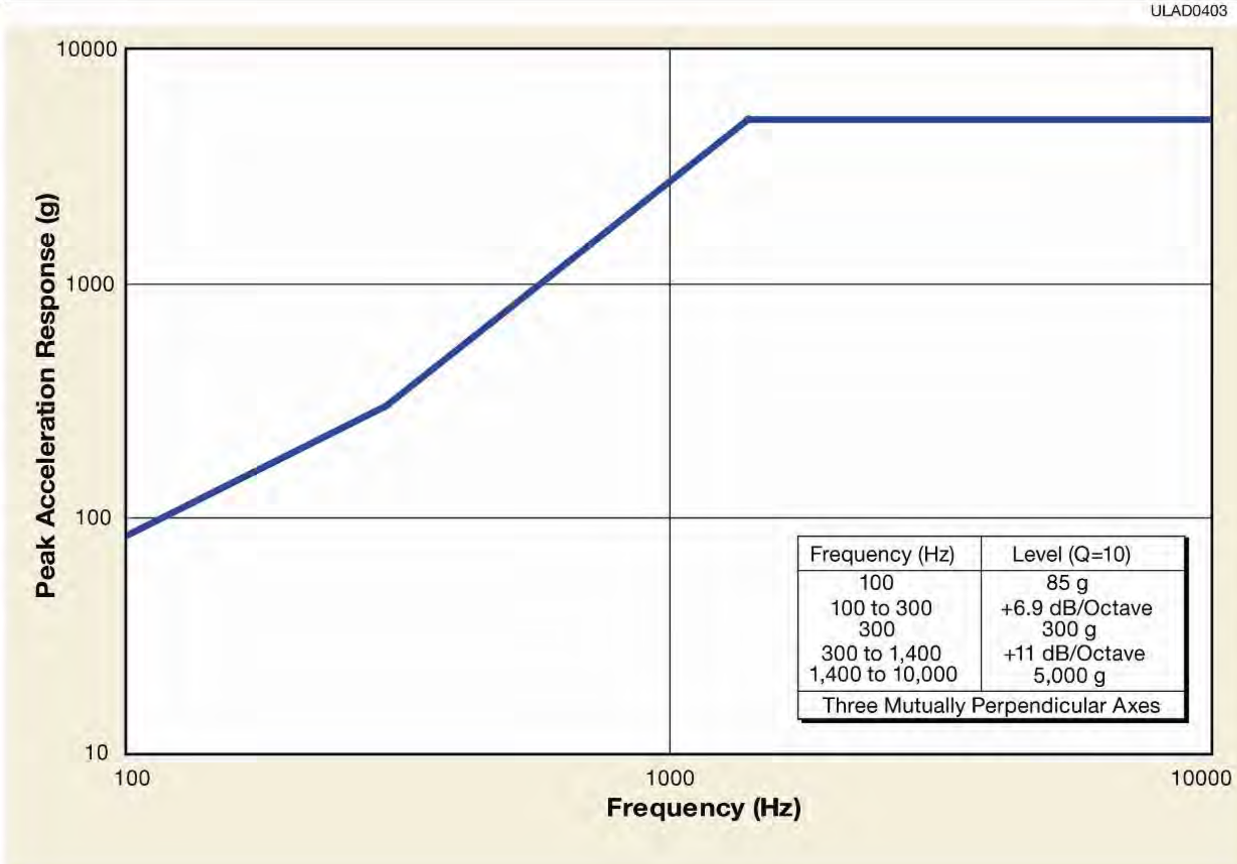
Figure 3-43. Delta IV Sinusoidal Vibration Levels

The sinusoidal vibration levels in Figure 3-43 are not intended for use in the design of spacecraft primary structure. Load factors for spacecraft primary structure design are specified in Figure 3-35.

The sinusoidal vibration levels should be used in conjunction with the results of the coupled dynamic loads analysis to aid in the design of spacecraft secondary structure (e.g., solar arrays, antennae, appendages) that may experience dynamic loading due to coupling with Delta IV LV low-frequency dynamic oscillations. Notching of the sinusoidal vibration input levels at spacecraft fundamental frequencies may be required during testing and should be based on the results of the LV coupled dynamic loads analysis (see Section 3.2.5.3).

3.2.4.5 Shock Environment. The significant shock events at the payload/launch vehicle interface typically include first- and second-stage separation, fairing separation, and spacecraft separation. The customer has the option to provide their own separation system but should be aware that while other launch vehicle induced shock events satisfy the environments defined in Section 3.2.4.6 the as-tested shock levels (Section 3.2.5.4) for spacecraft separation may not envelope the other actual LV induced shock environments.

3.2.4.6 Payload Attach Fitting Shock Environments. For customer-supplied separation system interfaces, the maximum allowable spacecraft separation-induced shock that the LV can withstand is shown in Figure 3-44 for the 1575-4 PAF and Figure 3-45 for the 1575-5 PAF. These levels represent a 95th-percentile statistical estimate with a 50 percent confidence (P95/50) and are specified on the payload side of the bolted interface. Any other commanded/ expected mechanical or pyrotechnic payload induced events occurring prior to spacecraft separation shall be coordinated with ULA during the mission integration process. Maximum allowable spacecraft separation induced shock for the 4394-5 PAF and 4293-5 PAF shall be coordinated with ULA during the mission integration process.



Frequency (Hz)	Level (Q=10)
100	85 g
100 to 300	+6.9 dB/Octave
300	300 g
300 to 1,400	+11 dB/Octave
1,400 to 10,000	5,000 g
Three Mutually Perpendicular Axes	

Figure 3-44. Maximum Spacecraft Separation Shock Level to Launch Vehicle, 1575-4 PAF (95th Percentile, 50% Confidence)

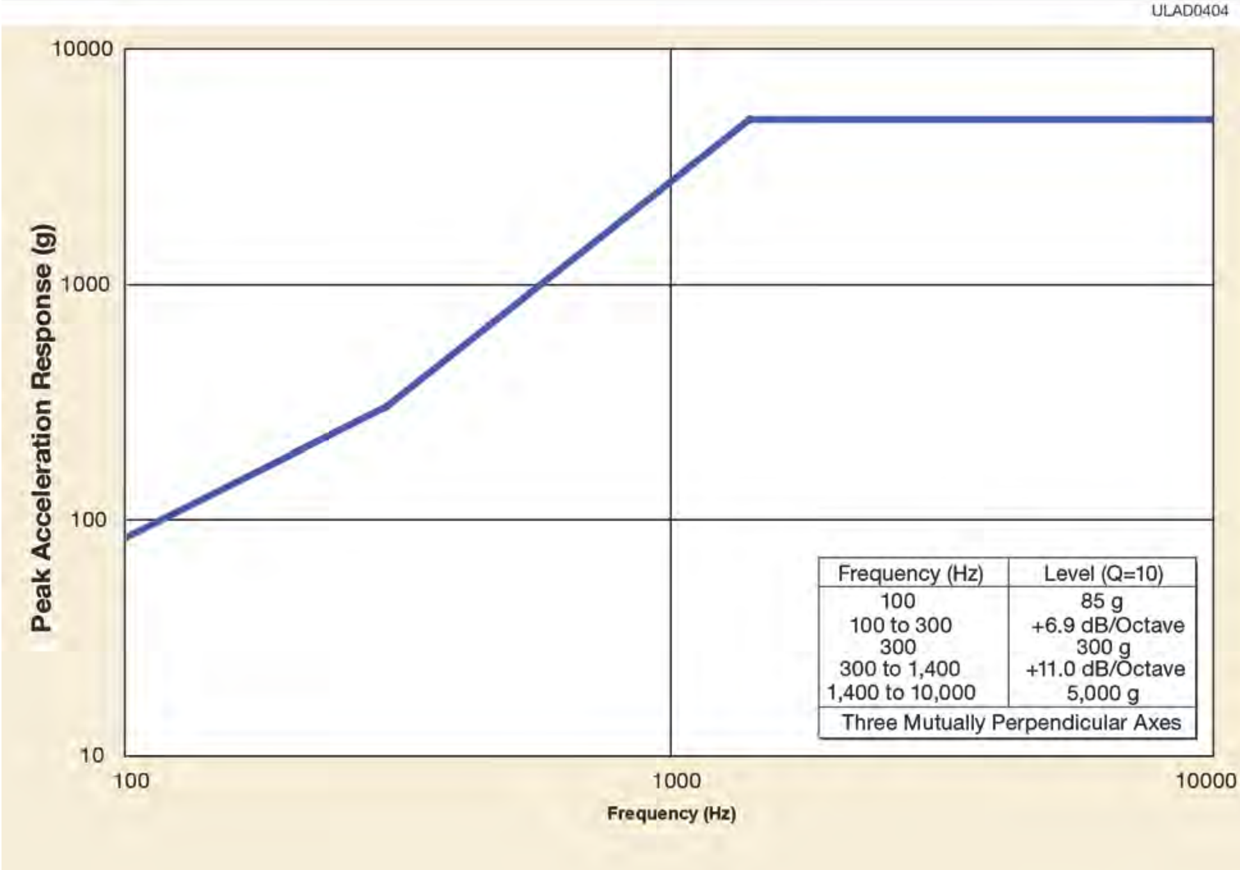


Figure 3-45. Maximum Spacecraft Separation Shock Level to Launch Vehicle, 1575-5 PAF (95^{th} Percentile, 50% Confidence)

For customer-supplied separation system interfaces, Figure 3-46 identifies the figures that define the shock environments for all launch-vehicle-induced high frequency shock events prior to spacecraft separation. These levels represent a 95th-percentile statistical estimate with a 50 percent confidence (P95/50) and are specified on the LV side of the bolted interface. Users should contact the ULA to coordinate any payload shock requirements below the levels shown in Figures 3-47 and 3-48. The shock environments for all launch-vehicle-induced high frequency shock events prior to spacecraft separation for the 4394-5 PAF and 4293-5 PAF shall be coordinated with the ULA during the mission integration process.

Payload Attach Fitting	Interface Type	Payload Attach Fitting Interface Environment
1575-4	1575 mm (63 in.) dia bolted interface with the 4-meter composite payload fairing	See Figure 3-47
1575-5	1575 mm (63 in.) dia bolted interface with the 5-meter composite payload fairings	See Figure 3-48
4394-5	4394 mm (173 in.) dia bolted interface with the 5-meter isogrid payload fairing	Contact ULA
4293-5	4293 mm (169 in.) dia 3 point bolted interface with the 5-meter 62.7 ft composite payload fairing	Contact ULA

Figure 3-46. PAF Interface Shock Environment Figure Reference for Launch Vehicle Generated Environments for Customer Supplied Separation Systems

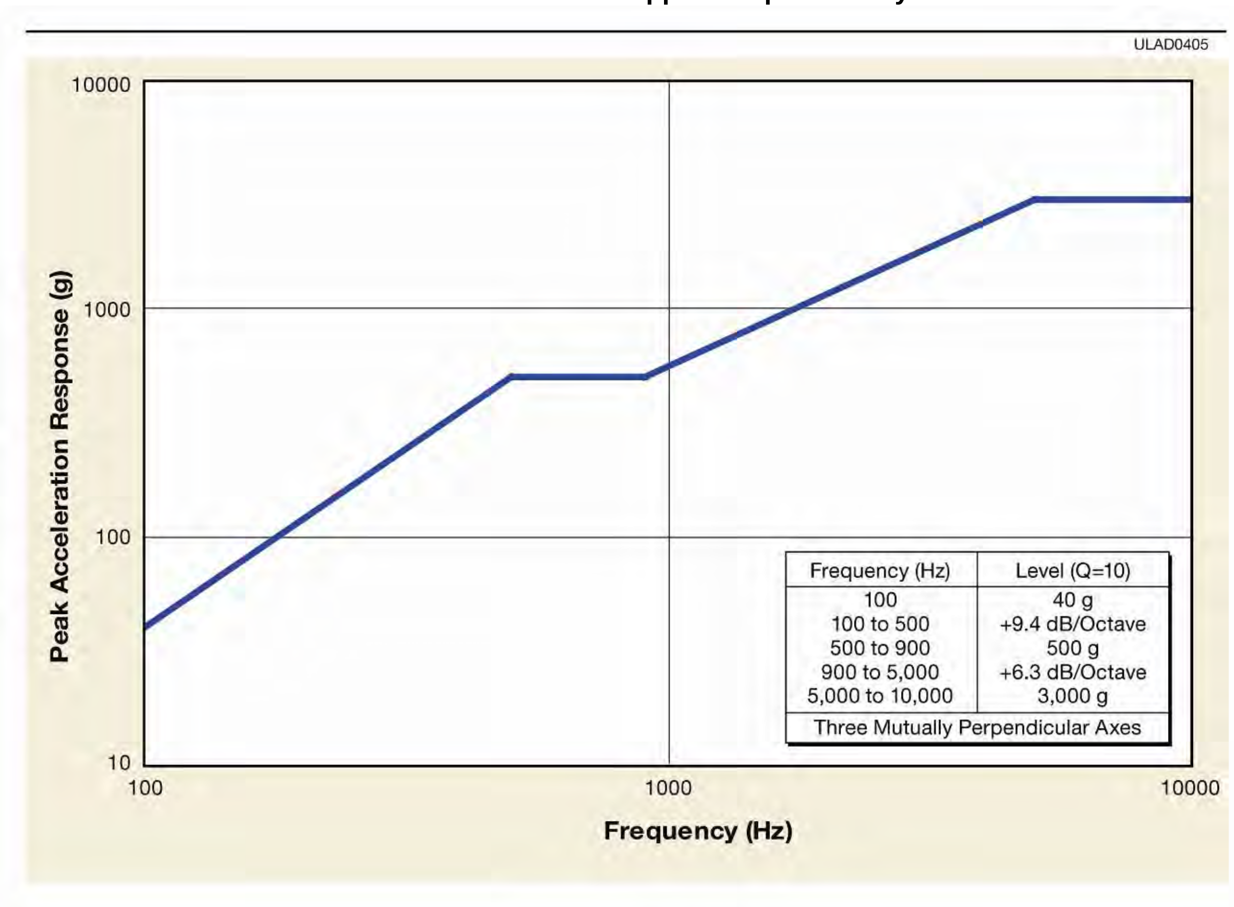


Figure 3-47. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1575-4 Payload Attach Fitting

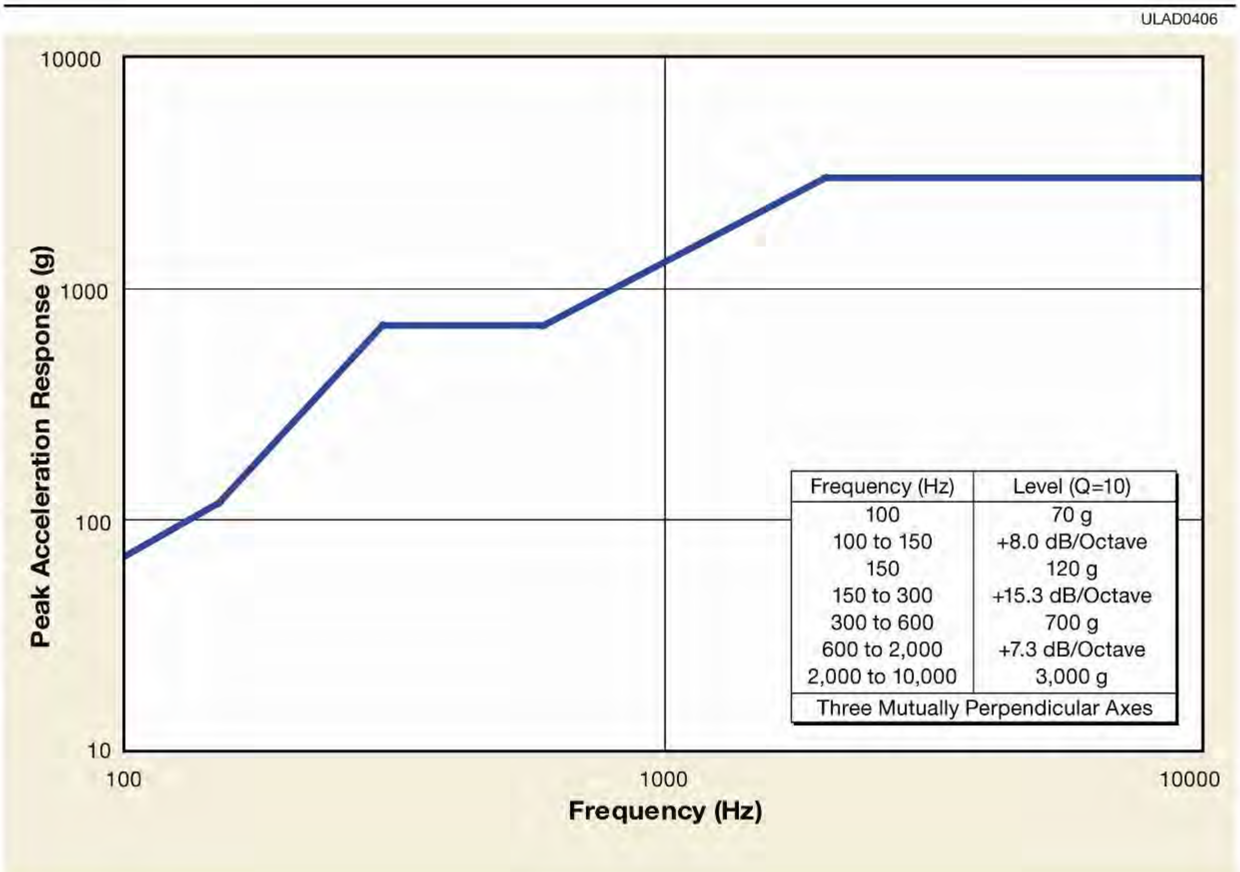


Figure 3-48. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1575-5 Payload Attach Fitting

Figure 3-49 identifies the figures that define the launch-vehicle-induced spacecraft interface shocks for all available ULA provided spacecraft separation systems configurations for spacecraft separation. The interface shock levels represent a 95th percentile environment with a 50% confidence prediction (P95/50). Users should contact ULA to coordinate any payload shock requirements below the levels shown in Figures 3-50, 3-51, and 3-52. LV induced environments occurring prior to spacecraft separation (which can be the dominant LV induced environment depending on LV configuration) will be coordinated with ULA during the mission integration process. The shock environments for spacecraft separation for the 6915 interface shall be coordinated with ULA during the mission integration process.

PSR / Clampband / Sep System	Interface Type	PSR \ Clampband Environment
937	937 mm (37 in.) dia clampband PSR interface configured with the 1575-4 and the 4-meter composite payload fairing or the 1575-5 and the 5-meter composite payload fairing	See Figure 3-50
1194	1194 mm (47 in.) dia clampband PSR interface configured with the 1575-4 and the 4-meter composite payload fairing or the 1575-5 and the 5-meter composite payload fairing	See Figure 3-51
1666	1666 mm (66 in.) dia clampband PSR interface configured with the 1575-4 and the 4-meter composite payload fairing or the 1575-5 and the 5-meter composite payload fairing	See Figure 3-52
6915	1752.6 mm (69 in.) dia Four explosive separation nuts	Contact ULA

Figure 3-49. PAF Interface Shock Environment Figure Reference for Separation System Shock Environments

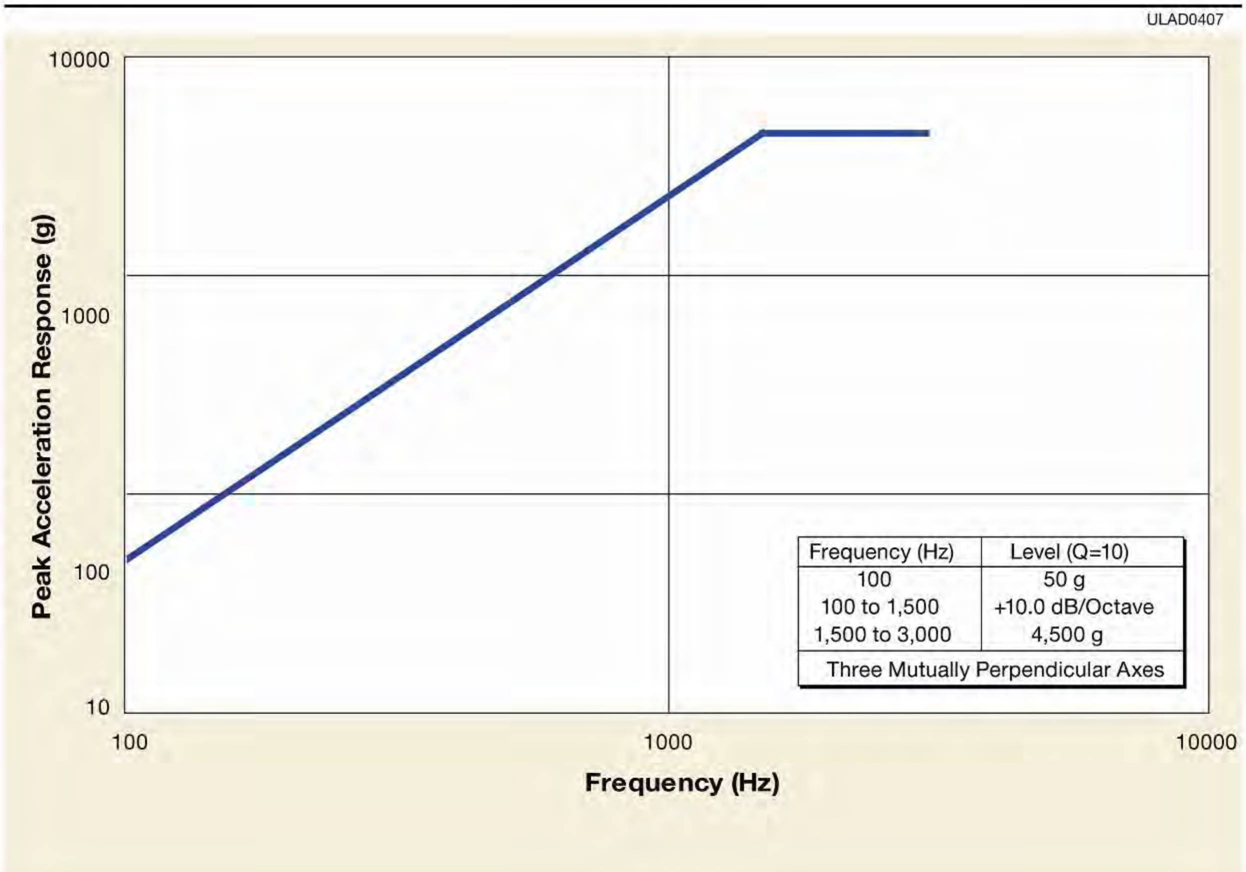


Figure 3-50. Separation System-Induced Payload Interface Shock Environment (95^{th} Percentile, 50% Confidence)—937PSR Clampband

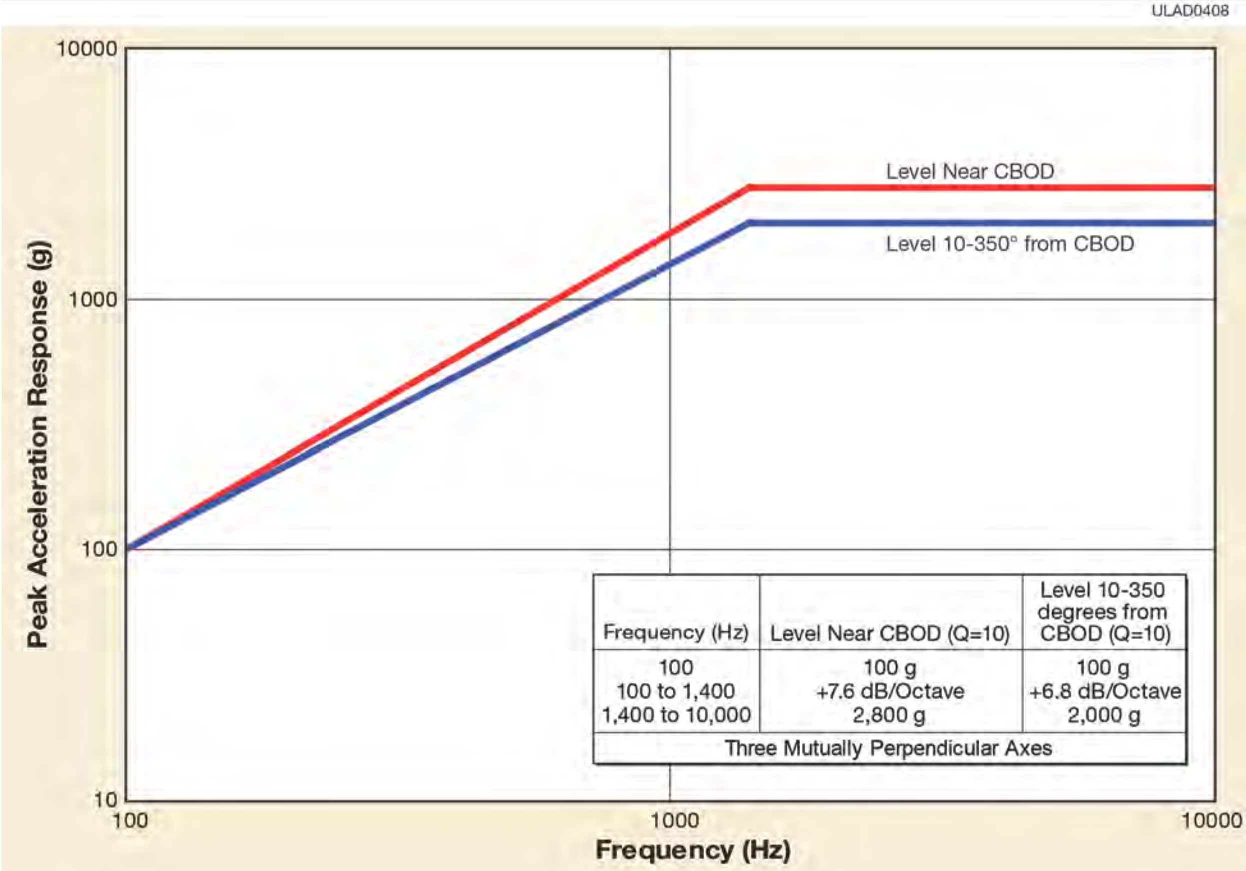


Figure 3-51. Separation System -Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1194 PSR Clampband

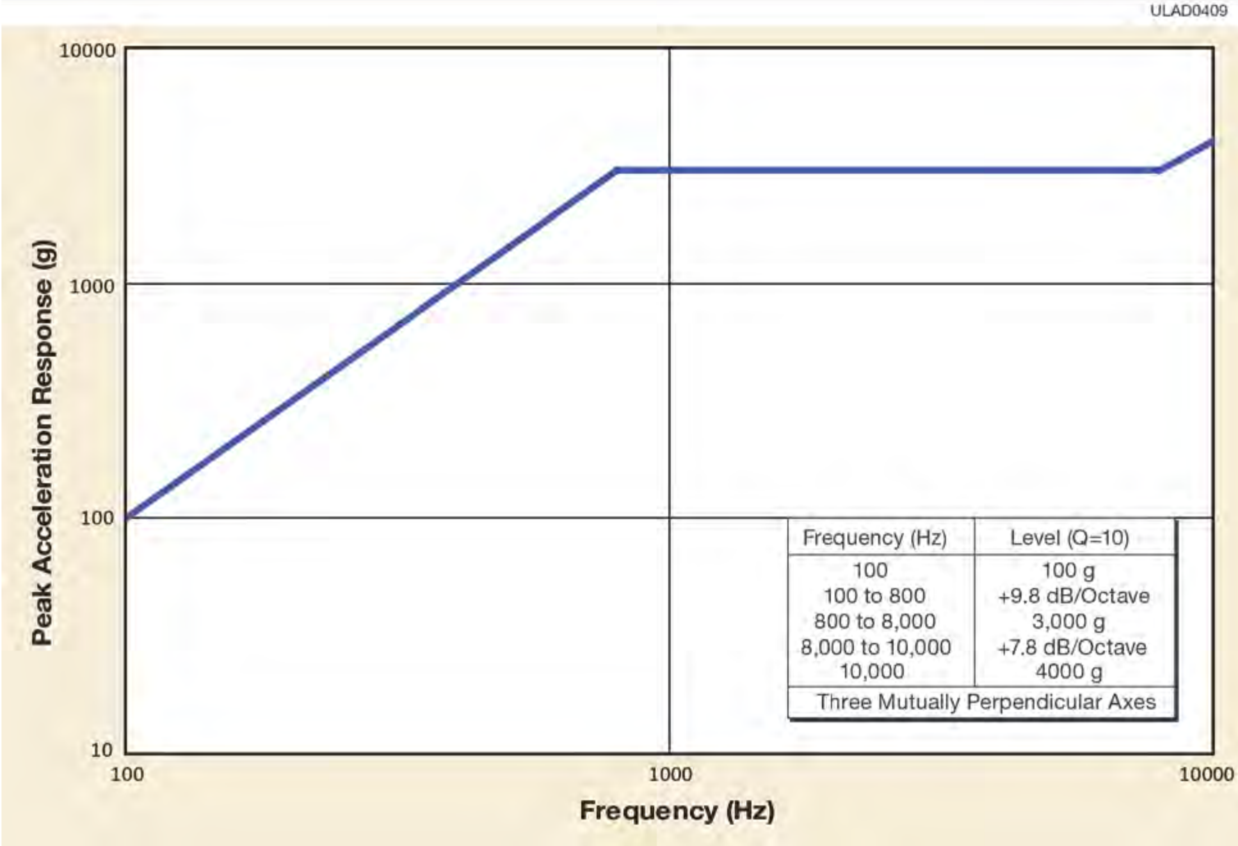


Figure 3-52. Separation System-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1666 PSR Clampband

3.2.5 Spacecraft Qualification, Acceptance and Protoflight Compatibility

ULA recommends that a series of environmental system-level qualification, acceptance, and protoflight tests be performed for spacecraft launched on Delta IV LVs. These tests are generalized to encompass numerous payload configurations. Coordination with ULA during the development of spacecraft test specifications is encouraged to ensure the compatibility of the spacecraft test and/or analysis approach with LV specified environments. As part of the mission integration process, spacecraft must demonstrate both design qualification and flight unit acceptance, relative to structural integrity and functions where failure modes may impair the successful execution of the launch phase of fight, when subjected to specified vibration, shock, acoustic and low frequency dynamic/quasi-static loading environments.

Verification rationale and evidence must be provided to ULA for review to ensure clear and complete communication, and closing the loop between requirement definition and verification.

The qualification test levels presented in this section are intended to ensure that the spacecraft possesses adequate design margin to withstand the maximum expected Delta IV dynamic environmental loads, even with minor weight and design variations. The acceptance test levels are intended to verify adequate spacecraft manufacture and workmanship by subjecting the payload to maximum expected flight environments. The protoflight test approach is intended to combine verification of design margin and adequacy of spacecraft manufacture and workmanship by subjecting the payload to protoflight test levels that are equal to qualification test levels with reduced durations.

3.2.5.1 Structural Load Testing. Structural load testing is performed by the customer to demonstrate the design integrity of the primary structure of the spacecraft. These loads are based on worst-case conditions anticipated. Maximum flight loads will be increased by a factor of 1.25 to determine qualification test loads.

A test PAF may be required to provide proper load distribution at the payload interface. The payload user shall consult ULA before developing the structural load test plan and shall obtain concurrence for the test load magnitude to ensure that the PAF is not stressed beyond its load-carrying capability.

Spacecraft combined-loading qualification testing is accomplished by a static load test. Generally, static load tests can be readily performed on structures with easily defined load paths. If the spacecraft primary structural capability is to be demonstrated by analysis, minimum factors of 1.6 on yield and 2.0 on ultimate must be utilized.

3.2.5.2 Acoustic Testing. The maximum flight level acoustic environments defined in Section 3.2.4.3 are increased by 3 dB for spacecraft acoustic qualification and protoflight testing. The acoustic test duration is 120 sec for qualification testing and 60 sec for protoflight testing. For spacecraft acoustic acceptance testing, the acoustic test levels are equal to the maximum flight level acoustic environments defined in Section 3.2.4.3. The acoustic acceptance test duration is 60 sec. The acoustic qualification, acceptance, and protoflight test levels for the Delta IV LV configurations are defined in Figure 3-53.

The acoustic test tolerances are +4 dB and -2 dB from 50 Hz to 2000 Hz. Above and below these frequencies the acoustic test levels should be maintained as close to the nominal test levels as possible within the limitations of the test facility. The Overall Acoustic Sound Pressure Level (OASPL) should be maintained within +3 dB and -1 dB of the nominal overall test level. Customers should contact ULA to coordinate any spacecraft acoustic requirements below the test levels provided in Figure 3-53 to ensure compatibility with the launch vehicle as defined in Section 3.2.5.

3.2.5.3 Sinusoidal Vibration Testing. The maximum flight level sinusoidal vibration environments defined in Section 3.2.4.4 are increased by 3 dB (a factor of 1.4) for payload qualification and protoflight testing. For payload acceptance testing, the sinusoidal vibration test levels are equal to the maximum flight level sinusoidal vibration environments defined in Section 3.2.4.4. The sinusoidal vibration test levels at acceptance, protoflight, and qualification for all Delta IV LV configurations are defined in Figures 3-54, 3-55, and 3-56 at the spacecraft separation plane.

One-Third Octave-Band Center Freq (Hz)	Acceptance Levels				Protoflight and Qualification Levels			
	Delta IV-M/-M+ 4-m PLF (dB)	Delta IV-M+ 5-m PLF (dB)	Delta IV-H iso grid PLF 5-m (dB)	Delta IV-H Composite PLF 5-m (dB)	Delta IV-M/-M+ 4-m PLF (dB)	Delta IV-M+ 5-m PLF (dB)	Delta IV-H iso grid PLF 5-m (dB)	Delta IV-H Composite PLF 5-m (dB)
31.5	119.5	123.0	129.0	123.5	122.5	126.0	132.0	126.5
40	122.5	126.0	130.5	127.5	125.5	129.0	133.5	130.5
50	125.2	128.0	131.0	130.0	128.2	131.0	134.0	133.0
63	126.3	130.0	132.0	131.5	129.3	133.0	135.0	134.5
80	128.0	130.5	132.5	132.5	131.0	133.5	135.5	135.5
100	129.0	130.5	133.0	133.0	132.0	133.5	136.0	136.0
125	130.0	130.5	133.0	133.0	133.0	133.5	136.0	136.0
160	130.0	130.5	132.7	133.0	133.0	133.5	135.7	136.0
200	130.0	130.5	131.8	133.0	133.0	133.5	134.8	136.0
250	130.0	130.5	131.0	133.0	133.0	133.5	134.0	136.0
315	130.0	130.2	130.2	133.0	133.0	133.2	133.2	136.0
400	129.5	128.0	128.8	131.0	132.5	131.0	131.8	134.0
500	128.0	125.5	127.5	129.0	131.0	128.5	130.5	132.0
630	125.0	123.0	126.2	126.5	128.0	126.0	129.2	129.5
800	123.0	121.0	124.3	124.5	126.0	124.0	127.3	127.5
1000	121.0	119.5	122.5	122.5	124.0	122.5	125.5	125.5
1250	119.5	118.0	120.7	120.7	122.5	121.0	123.7	123.7
1600	118.0	116.5	118.3	118.3	121.0	119.5	121.3	121.3
2000	116.5	115.0	116.5	116.5	119.5	118.0	119.5	119.5
2500	115.0	113.5	115.0	115.0	118.0	116.5	118.0	118.0
3150	113.5	112.0	113.0	113.0	116.5	115.0	116.0	116.0
4000	112.0	110.0	111.5	111.5	115.0	113.0	114.5	114.5
5000	110.5	108.5	109.5	109.5	113.5	111.5	112.5	112.5
6300	109.0	106.5	107.5	107.5	112.0	109.5	110.5	110.5
8000	107.5	105.0	106.0	106.0	110.5	108.0	109.0	109.0
10000	106.0	103.0	104.0	104.0	109.0	106.0	107.0	107.0
OASPL (dB)	140.0	140.6	142.7	143.1	143.0	143.6	145.7	146.1
Acceptance test duration	60 sec	60 sec	60 sec	60 sec	—	—	—	—
Protoflight test duration	—	—	—	—	60 sec	60 sec	60 sec	60 sec
Qualification test duration	—	—	—	—	120 sec	120 sec	120 sec	120 sec

001950.4

Figure 3-53. Spacecraft Acoustic Test Levels

Axis	Frequency (Hz)	Acceptance Test Levels	Sweep Rate
Thrust	5 to 6.2 6.2 to 100	1.27 cm (0.5 in.) double amplitude 1.0 g (zero to peak)	4 octaves/min
Lateral	5 to 100	0.7 g (zero to peak)	4 octaves/min

0000593.2

Figure 3-54. Sinusoidal Vibration Acceptance Test Levels

Axis	Frequency (Hz)	Protoflight Test Levels	Sweep Rate
Thrust	5 to 7.4 7.4 to 100	1.27 cm (0.5 in.) double amplitude 1.4 g (zero to peak)	4 octaves/min
Lateral	5 to 6.2 6.2 to 100	1.27 cm (0.5 in) double amplitude 1.0 g (zero to peak)	4 octaves/min

0000594.3

Figure 3-55. Sinusoidal Vibration Protoflight Test Levels

Axis	Frequency (Hz)	Qualification Test Levels	Sweep Rate
Thrust	5 to 7.4 7.4 to 100	1.27 cm (0.5 in.) double amplitude 1.4 g (zero to peak)	2 octaves/min
Lateral	5 to 6.2 6.2 to 100	1.27 cm (0.5 in) double amplitude 1.0 g (zero to peak)	2 octaves/min

0000592.3

Figure 3-56. Sinusoidal Vibration Qualification Test Levels

The spacecraft sinusoidal vibration qualification test consists of one sweep through the specified frequency range using a logarithmic sweep rate of two octaves per minute. For spacecraft acceptance and protoflight testing, the test consists of one sweep through the specified frequency range using a logarithmic sweep rate of four octaves per minute. The sinusoidal vibration test input levels should be maintained within ±10% of the nominal test levels throughout the test frequency range.

When testing a spacecraft with a shaker in the laboratory, it is not within the current state of the art to duplicate at the shaker input the boundary conditions that actually occur in flight. This is notably evident in the spacecraft lateral axis, during test, when the shaker applies large vibratory forces to maintain a constant acceleration input level at the spacecraft fundamental lateral test frequencies. The response levels experienced by the spacecraft at these fundamental frequencies during test are usually much more severe than those experienced in flight. The significant lateral loading to the spacecraft during flight is usually governed by the effects of payload/launch vehicle dynamic coupling.

Where it can be shown by a payload/launch vehicle coupled dynamic loads analysis that the payload or PAF would experience unrealistic response levels during test, the sinusoidal vibration input level can be reduced (notched) at the fundamental resonances of the hard-mounted payload or PAF to more realistically simulate flight loading conditions. This has been accomplished in the lateral axis on many previous spacecraft by correlating one or several accelerometers mounted on the spacecraft to the bending moment at the PAF spacecraft separation plane. The bending moment is then limited by introducing a narrow-band notch into the sinusoidal vibration input program or by controlling the input by a servo system using a selected accelerometer on the payload as the limiting monitor. A redundant accelerometer is usually used as a backup monitor to prevent shaker runaway.

The Delta Program will normally conduct a payload/launch vehicle coupled dynamic loads analysis for various spacecraft configurations to define the maximum expected bending moment in flight at the spacecraft separation plane. In the absence of a specific dynamic analysis, the bending moment is limited to protect the PAF, which is designed for a wide range of payload configurations and weights. The payload user should consult ULA before developing the sinusoidal vibration test plan for information on the payload/launch vehicle coupled dynamic loads analysis. In many cases, the notched sinusoidal vibration test levels are established from previous similar analyses.

3.2.5.4 Shock Testing. High-frequency pyrotechnic shock levels are very difficult to simulate mechanically on a shaker at the spacecraft system level. A common method for this testing is to use a Delta IV flight configuration PAF spacecraft separation system and PAF structure with functional ordnance devices. Payload qualification and protoflight shock testing typically is performed by installing the in-flight configuration of the PAF spacecraft separation system and activating the system twice. Spacecraft shock acceptance testing is similarly performed by activating the PAF spacecraft separation system once. However Customers should be aware that while other launch vehicle induced shock events satisfy the environments defined in Section 3.2.4.6 the as-tested shock levels for spacecraft separation may not envelope the other actual LV induced shock environments so alternative testing or analyses will be required to demonstrate compatibility to the launch vehicle as defined in Section 3.2.5.

3.2.6 Spacecraft Separation

Pointing accuracy and angular rates at spacecraft separation are a function of guidance system hardware/software, control system capabilities, and spacecraft mass properties. While there are no specific static and dynamic balance constraints for the spacecraft at separation, these parameters do affect the pointing accuracy and angular rates after separation. Typical payload separation attitude and rate control capabilities are shown in Figure 3-57. Mission-specific pointing and rate control capabilities are defined in the spacecraft pre-separation/separation analysis. If the target spacecraft attitude at separation is a function of launch day/time then additional allocation beyond the values shown in Figure 3-57 may be required and must be coordinated with ULA. If the values noted in the table are problematic to the spacecraft then coordination with ULA is recommended.

The relative separation velocity between the spacecraft and the Delta Cryogenic Second Stage is a function of the mass properties of the separated spacecraft and the separation mechanism. The Delta IV separation systems are designed to preclude re-contact between the spacecraft and the upper stage and provide adequate separation for collision and contamination avoidance. Typically, the separation system achieves at least 1 ft/sec (0.3 m/sec) minimum relative separation velocity. If the spacecraft provides the separation mechanism, it should be designed to this minimum capability.

Separation Condition	Pre-Separation		After Separation	
	Pointing	Angular Rates	Pointing	Angular Rates
Non-Spinning	≤ 1.4 deg/axis	±0.25 deg/sec (Roll) ±0.20 deg/sec (Pitch/Yaw, each)	≤ 1.4 deg/axis	±0.5 deg/sec (Roll) ±1.5 deg/sec (Pitch/Yaw, each)
Spinning	≤ 2.0 deg (Roll)	≤ 30.0 ± 3.0 deg/sec (Roll) ±0.70 deg/sec (Pitch/Yaw, each)	≤ 2.0 deg (Roll)	≤ 30.0 ± 3.0 deg/sec (Roll) ±1.5 deg/sec (Pitch/Yaw, each)

Figure 3-57. Typical Payload Separation Attitudes/Rate Control Capabilities

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Section 4
MISSION INTEGRATION AND SAFETY

United Launch Alliance (ULA) provides the engineering products and services that integrate the Launch Vehicle (LV) and the Spacecraft (SC) as part of the launch service. This includes mission-specific tasks defined in the integration and the mission Interface Control Document (ICD). The ULA Integration Management Group is the principal technical interface with the SC customer and is responsible for developing, disseminating, and verifying requirements and schedules, and for coordinating internally within ULA engineering.

The ULA Mission Integration process operates under AS9100 certification, following established methods and practices. All products are reviewed by a supervisor or lead, or through a peer review. In addition, most products are exposed to an established set of formal reviews.

The principal spacecraft-related products and services supplied by ULA as part of the launch service include the following:

1. Requirements and interface definition and verification, as documented in the mission ICD;
2. Mission design to satisfy mission specific requirements including the LV performance capability, guidance, and software to fly the specific mission; mission-specific targeting strategy; and Range Safety data and Radio Frequency (RF) link margins;
3. Compatibility of the integrated launch vehicle/spacecraft ground and airborne systems, and effects of LV and mission design-induced dynamics and environments on SC components, including coupled loads and loss of clearance between the SC and the Payload Accommodations, integrated thermal analyses, prelaunch gas conditioning, PLF venting, RF system and Electro-Explosive Device (EED) analyses, and SC contamination from LV and processing sources;
4. Implementation and verification of specific SC requirements, including injection accuracy and SC separation attitude and rates;
5. Third-party representation of integrated launch/space vehicle and SC systems, particularly as the System Safety agent with the Range for the launch vehicle-unique and SC Missile System Prelaunch Safety Package (MSPSP), the SC propellant leak contingency plan, hazardous procedures, and SC pyrotechnic device photographs.

4.1 INTEGRATION MANAGEMENT

Clear communication between SC and LV contractors is vital to accomplishing mission success. Procedures and interfaces have been established to delineate areas of responsibility and authority.

The ULA mission integration and management process defined in this section has been successfully used on commercial and government missions. The typical, standard integration period is 24 months.

As an additional information resource, Section 4.4 of this document details the preferred approach and process for the submission of data required for mission integration. When necessary, deviations from these specified practices can be accommodated.

4.1.1 Launch Vehicle Responsibilities

ULA is responsible for Delta IV design, integration, checkout, and launch. As the spacecraft-to-launch vehicle integrating contractor, ULA is responsible for spacecraft integration with the LV, including electrical, mechanical, environmental, and electromagnetic compatibilities; guidance system integration; mission analysis; software design; Range Safety documentation and support; launch site processing and coordination.

4.1.2 Spacecraft Responsibilities

Since each SC mission has unique requirements, interested Delta IV customers are encouraged to discuss their particular needs with ULA. Section 4.4, SC Data Requirements, can be used as a guide to initiating dialog. Items in Section 4.4 should be used as the basis for the first meeting between ULA and the customer to assist in determining SC and LV compatibility.

Customers are encouraged to contact ULA to verify the latest launch information, including:

- Hardware status and plans
- Launch and launch complex schedules
- Hardware production schedule and costs

4.1.3 Mission Management and Integration

The Customer Program Office (CPO) is the organization that provides the mission management and primary customer interface functions for ULA. Within CPO are three distinct offices, each headed by a Customer Program Manager, focused on mission management. They are the USAF, NRO/OSL, and NASA/Commercial program offices. A Mission Manager is assigned from within one of these offices to represent each mission and their customer within ULA. The Mission Manager has full accountability for the successful execution of their specific launch services contract and is responsible for all programmatic activities associated with the mission. Figure 4-1 shows the typical ULA Agency Interfaces.

Delta IV launch services are offered to commercial customers by contracting with Boeing Launch Services (BLS). United States Government customers contract directly with United Launch Services, L.L.C. (ULS). ULS is a subsidiary and the contracting agent of ULA. For commercial Delta missions, Boeing Launch Services assigns a Mission Manager to serve as the

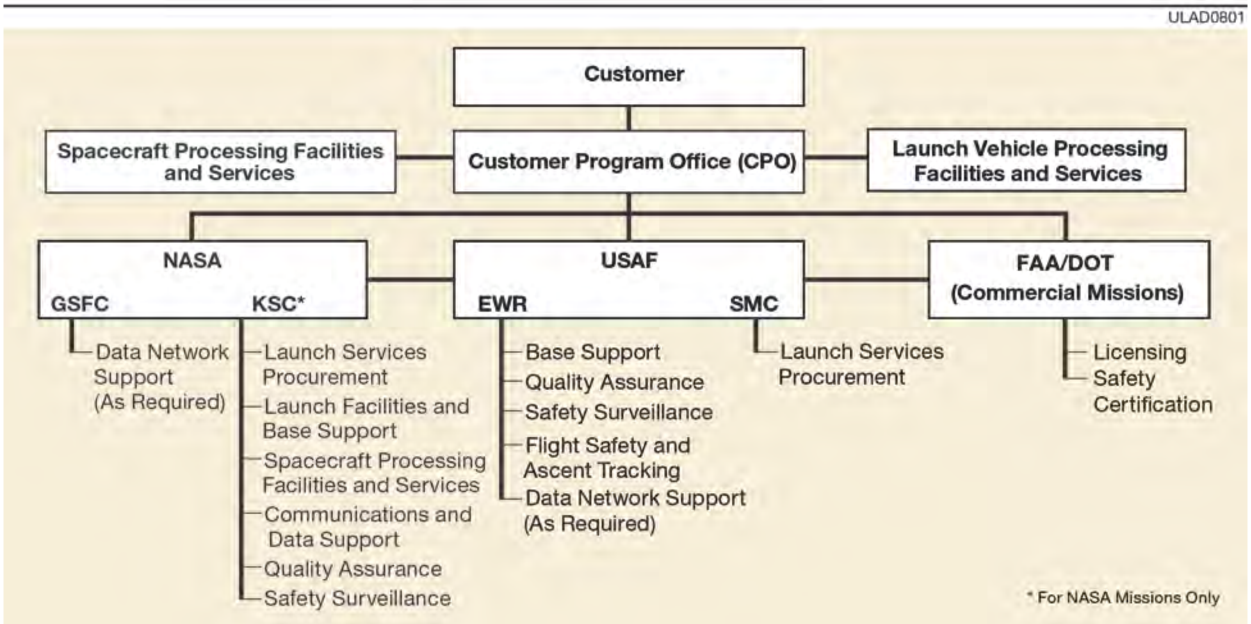

Figure 4-1. Typical ULA Agency Interfaces

primary interface with the commercial customer. The BLS Mission Manager works closely with the ULA Mission Integration Team (MIT) to ensure all customer requirements are met.

Technical integration for a specific Delta IV mission is the responsibility of the Engineering Integration Manager (EIM), assigned by the ULA Systems Integration and Analysis organization. The EIM focuses on engineering integration of the mission/spacecraft with the Delta IV LV, development of the ICD, tracking of action items, and coordination of technical requirements across engineering disciplines.

To provide maximum efficiency in managing the many launch site operations, a launch site Spacecraft Integrator is assigned to each mission by the ULA Launch Operations organization. The Spacecraft Integrator is responsible for the development, integration, and installation of all SC mission-specific items at the launch site and provides direct customer support at the launch site following arrival of the SC.

Using a customer-focused MIT consisting of the ULA Mission Manager, Engineering Integration Manager, Spacecraft Integrator, and in the case of commercial missions, a BLS Mission Manager, has proven effective over hundreds of missions. This team ensures on-time delivery of hardware and software, manages mission-unique and launch readiness reviews, and coordinates mission requirements with other areas of the broader program. This team strives to satisfy all customer needs and keep the customer informed on the status of the program's implementation of the mission specific launch service.

4.1.4 Mission Readiness Reviews

ULA has established a Mission Readiness Review (MRR) process to conduct a series of technical readiness reviews on all product lines. The purpose of this series of reviews is to perform an incremental assessment of mission readiness and mission-critical risk leading up to launch. This process establishes a high degree of confidence that the launch system (LV and associated Ground Support Equipment [GSE] and facilities) will perform reliably and meet the mission objectives.

The ULA MRR process includes two levels of reviews: Engineering- and Quality-chaired reviews addressing launch system product readiness; and Program Management-chaired reviews addressing launch system, launch operations, SC operations, and Range operations readiness. Review of mission technical risk is conducted incrementally at each individual review to mitigate program schedule risk. Residual risk items that are identified, reviewed and approved by the Engineering/Quality/Mission Success community in lower level reviews are summarized in the aggregate for the mission at these reviews. All open items and accepted residual-risk items will be reviewed for concurrence to proceed into the next major operation. Note that customer-conducted readiness reviews (e.g., Flight Readiness Review [FRR]) are supported by ULA, however, these reviews are not considered part of the ULA Mission Readiness Review process.

A summary of the focus of each of the Mission Readiness Reviews follows:

Integrated Mission Review #1 (IMR-1) – Perform an integrated system level evaluation of the LV hardware design for a designated mission in order to verify compliance of hardware to mission requirements, verify compatibility of vehicle modifications and changes, and communicate configuration for use in mission analysis.

Integrated Mission Review #2 (IMR-2) – Review the mission specific analyses for acceptability to mission and system requirements for a known vehicle mission configuration and provide updated system level description of hardware design changes since IMR-1 as necessary.

Certified Responsible Engineer (CRE) Readiness Review (CRR) – Conduct an integrated assessment of the maturity and residual risk of the mission and LV design, build, analysis, and test activities to determine acceptability to proceed into integrated launch operations.

Vehicle Product Acceptance Reviews (VPARs) – Provide a hardware acceptance review that assures the as-built system satisfies the design requirements. This review also establishes hardware acceptability along with readiness for delivery to the receiving customer.

Vehicle Assessment Review (VAR) – Review vehicle hardware pedigree and maturity compared with previously-flown vehicles in the same launch family.

President's Mission Readiness Review (PMRR) – Assess the readiness of the launch system and obtain concurrence from the ULA President and Chief Executive Officer (CEO) to proceed with final vehicle processing, ensuring all significant issues and risks have been addressed and closed, or an acceptable closure plan is in place.

Launch Facility Systems Review (LFSR) – Assess all site facility systems for suitability to support final launch preparations.

System Certification Review (SCR) – Establish readiness of launch system to proceed into countdown operations. Review any updates to verification & validation results, summary/status for launch system configuration and operations, resolution of any new significant issues identified during launch site activities, Engine/Motor Subcontractor readiness, and final aggregate list of accepted residual risk (total launch system).

Vehicle Completion Review (VCR) – Validate all required items are complete to enable the signing of a Certificate of Completion (CoC) prior to launch. The CoC is signed at the Launch Sites and is used to transfer title from ULA to United Launch Services (ULS) prior to a launch.

Launch Readiness Review (LRR) – Assess the readiness of the SC, LV, facilities, mission assets, and local weather to proceed into final launch countdown.

Figure 4-2 shows the general timing of these reviews, the organization with primary responsibility, and their relationship to other significant reviews.

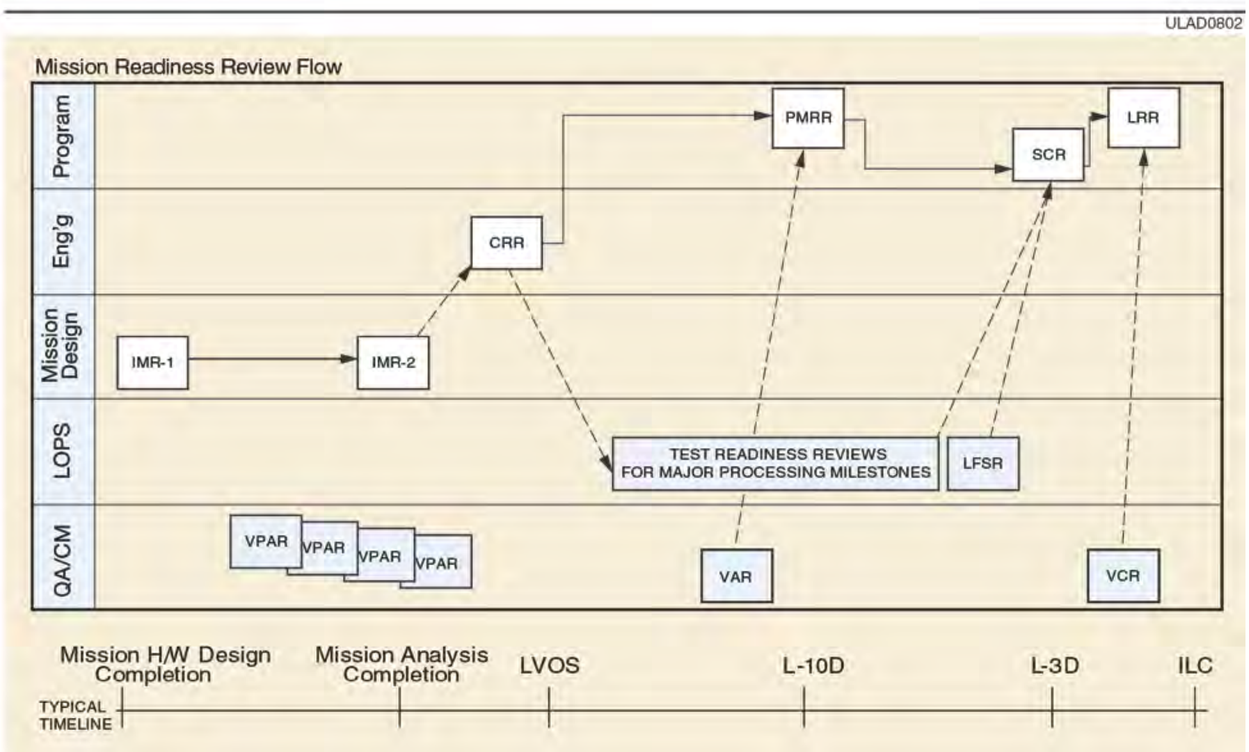

Figure 4-2. Mission Readiness Review Process Flow Timeline

4.1.5 Early Mission Integration Studies

Early integration studies may be utilized to identify mission-unique requirements for first-of-kind and complex payloads. Studies are typically performed prior to the standard mission integration period-of-performance within sufficient time to ensure mission feasibility/ compatibility, and to authorize mission-unique design, development, integration analysis, and software for a standard mission integration life-cycle. In some cases, this authorization may be required as early as L-60 months.

4.1.6 Integration Control Documentation

Figure 4-3 shows the typical document interfaces.

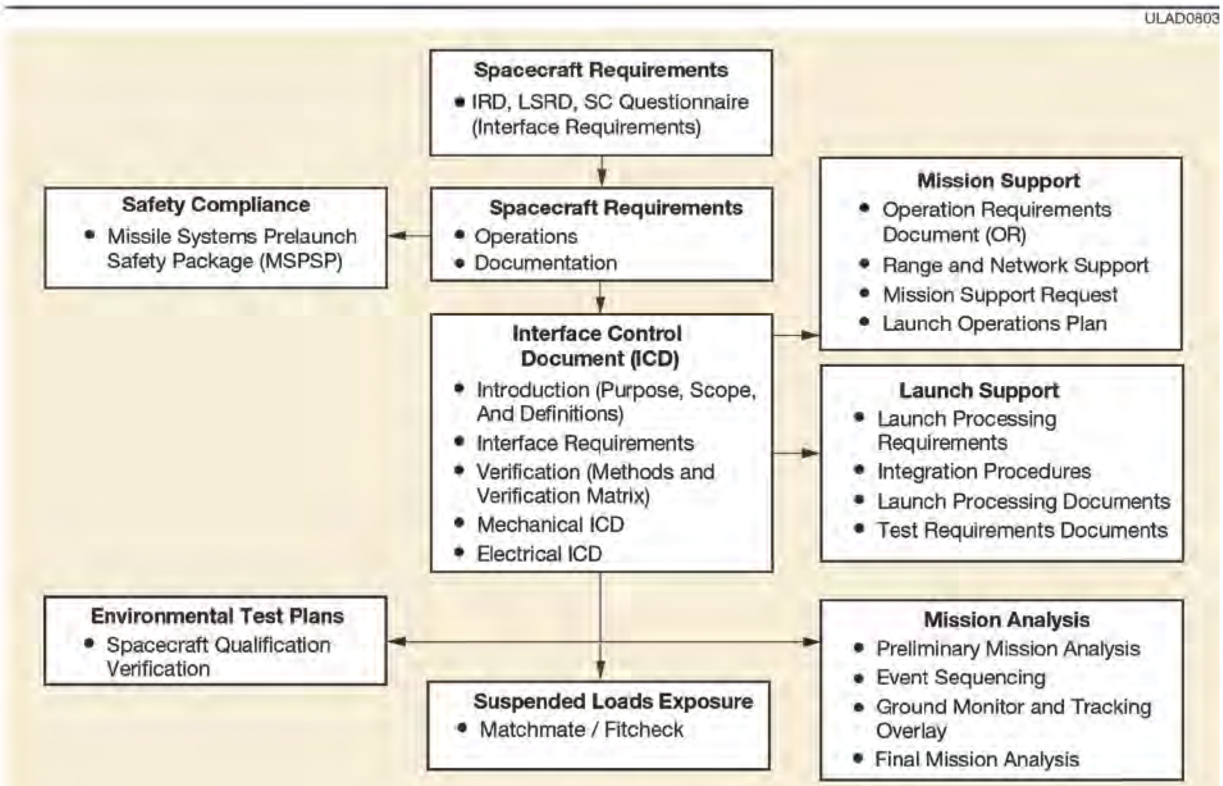

Figure 4-3. Typical Document Interfaces

4.1.6.1 Mission Integration Schedule. This schedule is prepared by ULA and managed by the Mission Integration Team. It is a tool used to maintain visibility and control of all major program milestone requirements, including working group meetings, major integrated reviews, design and analysis requirements, and major launch operations tests. It is developed from tasks and schedule requirements identified during initial integration meetings and is used by all participating organizations and working groups to develop and update sub-tier schedules. The mission integration schedule facilitates a systematic process to manage program activities. The mission integration schedule is used to track and monitor the mission progress to avoid significant schedule issues and possible cost impacts. The mission integration schedule contains sufficient mission details and contract Statement of Work (SOW) milestones to assist the Mission Manager and the EIM in managing the launch service.

4.1.6.2 Interface Requirements Documents. The customer creates the Interface Requirements Document (IRD) or Launch Services Requirement Document (LSRD) to define technical and functional requirements imposed by the SC on the LV system. The document contains applicable SC data identified in Section 4.4. Information typically includes:

1. Mission Requirements – Including orbit parameters, launch window parameters, separation functions, and any special trajectory requirements, such as thermal maneuvers and separation over a telemetry and tracking ground station;
2. SC Characteristics – Including physical envelope, mass properties, dynamic characteristics, contamination requirements, acoustic and shock requirements, thermal requirements, and any special safety issues;
3. Mechanical and Electrical Interfaces – Including SC mounting constraints, SC access requirements, umbilical power, command and telemetry, electrical bonding, and electromagnetic compatibility requirements;
4. Mechanical and Electrical Requirements for Ground Equipment and Facilities – Including SC handling equipment, checkout and support services, prelaunch and launch environmental requirements, SC gases and propellants, SC Radio Frequency (RF) power, and monitor-and-control requirements;
5. Test Operations – Including SC integrated testing, matchmate / fitcheck, countdown operations, and checkout and launch support.

4.1.6.3 Interface Control Document (ICD). The Interface Control Document (ICD) defines spacecraft-to-launch vehicle and launch complex interfaces. All mission interface requirements are documented in the ICD. The ICD is prepared by ULA and is under configuration control after formal signoff. The document contains appropriate technical and functional requirements specified in the IRD or LSRD and any additional requirements developed during the integration process. The ICD supersedes the IRD, LSRD, or SC questionnaire and is approved with signature by ULA program management and the launch service customer. Subsequent changes to the mission ICD require agreement of the signing parties. If any conflict or inconsistency exists between the signed mission ICD and the IRD or LSRD or the contract SOW, the signed mission ICD is given precedence.

ICD technical development is led by the EIM with management decisions coordinated by the Mission Manager. The ICD contains physical, functional, environmental, operational, and performance requirements for the interface and is a contractually binding document. The document establishes how each interface requirement is to be verified to ensure that all interface details have been accomplished in compliance with ICD requirements. It identifies interface verification activities that link the designed, built, and tested interface back to the functional and performance requirement the interface was meant to satisfy.

4.2 POLICIES

This section provides potential and current launch services customers with information concerning pertinent management, integration, and production policies to ensure efficient integration and launch of the customer's SC.

4.2.1 Launch Vehicle Logos

As part of our standard launch service, ULA offers customers the option of placing a mission or company logo on a portion of that mission's PLF hardware. The logo can be placed in standard locations on the PLF cylindrical section. To support manufacture of the mission PLF, the Delta IV program typically needs to have final artwork for the logo by 19 months before launch. This timeframe allows for procurement and delivery of the decal (logo) to support installation onto the PLF during standard production flow and prior to shipment to the launch site. Delivery of the customer PLF logo design is a schedule milestone required to support nominal assembly spans for PLF fabrication. Changes to the logo shall be supplied at a time that supports the scheduled PLF completion date.

4.2.2 Launch Scheduling Guidelines

General Policy – Missions are contracted and scheduled into available launch opportunities typically no later than (NLT) 24 months in advance of the desired Launch Date or earlier for Delta IV Heavy Missions. Every effort is made to conduct customer launches in the timeframe desired by the customer.

- Should a customer's desired launch date conflict with that of another customer, the customer with the earlier effective contract date may be given priority in determining which customer is entitled to launch first
- If a customer contracts for two or more launches, SC may be interchanged subject to mutual agreement
- Scheduling and rescheduling launches in the manifest requires the equitable treatment of all customers. Sequential scheduling of launches in the queue, the customer's position in the queue, and vehicle processing flow time will dictate the earliest launch date(s).
- ULA endeavors to fill each position in the launch queue. Consequently, once in queue, close coordination is required should the customer desire rescheduling. Rescheduling and protecting potential launch opportunities requires mutual agreement between the customer and ULA.

Schedule Delays – For LV initiated delays the mission will retain, subject to certain exceptions, its position in the launch queue. The LV delay may result in a delay to the mission and to other adjacent missions, without re-sequencing the launch queue. Exceptions that may require mission re-sequencing include, but are not limited to

- Missions with Planetary Launch Window requirements
- Reflight launches associated with LV failure
- Range constraints that limit launch re-scheduling opportunities
- National Security priorities

For Customer initiated delays the mission may have its launch queue position re-sequenced to accommodate the delay and mitigate the impact on missions of other customers. ULA will actively work with the customer to explore all possible options to re-position the customer's mission as close to the preferred launch date as possible. ULA may be able to protect the mission for an earlier launch opportunity should an appropriate launch slot become available. The mission may be re-assigned to the next available launch opportunity that does not conflict with an already scheduled mission.

These Launch Scheduling Guidelines are general guidelines only and are subject to change. Please contact the appropriate persons identified in the Preface for more information.

4.2.3 Spacecraft Launch Window Options

Delta IV can be launched at any time of the day, year round. However, seasonal weather patterns should be considered in setting launch windows when possible. To ensure on-time launches and avoid cost or schedule delays, Cape Canaveral Air Force Station (CCAFS) missions that will be scheduled during June, July, August, and September should be planned for morning launches. Launches in the afternoon during these months have an increased probability of delays due to seasonal thunderstorm activity. Scheduling in the morning will reduce the risk of such delays and avoid the associated costs. Options for afternoon summer launches may be available with recognition of the additional schedule delay potential.

4.2.4 Suspended Load Exposures

During the payload integration process, integrated procedures may result in a Suspended Load Exposure (SLE). As part of this planning and preparation a SLE mitigation plan may be developed; therefore ULA will require specific information about the crane used for the operation. This information is required 180 days prior to the SLE.

4.2.5 Spacecraft Hold Call During Terminal Count

The terminal count portion of a launch countdown is defined as the time after T-4 minutes and counting to LV and SC liftoff (T-0). Significant re-cycle durations and potential risk to the LV and integrated stack may occur for any launch holds that are called during the terminal count.

After T-4 minutes, the SC team should monitor only critical parameters and use persistence and/or redundant parameters for determining a SC "No-Go" condition. The SC team will identify their key personnel who are authorized to call a launch hold. The SC team will have the opportunity to call a launch hold during the terminal count, up until T-10 seconds. The SC manual monitoring and associated hold call capability will be discontinued at T-10 seconds.

4.2.6 Spacecraft Compatibility to Transport, Hoist and Launch Environments

ULA and the SC contractor will ensure that all payloads that ULA transports into space are compatible with ULA launch systems and are able to withstand the transportation and launch environments. Spacecraft design and manufacturing processes must be qualified for flight relative to structural integrity or functions where SC failure modes may impair LV performance when subjected to vibration, shock, and acoustic environments. Spacecraft flight units and production must be deemed acceptable for flight relative to structural integrity or functions where SC failure modes may impair LV performance when subjected to vibration, shock, and acoustic environments.

4.2.7 Spacecraft/Launch Vehicle Functional Interfaces for Mission Success

Effective spacecraft-to-launch vehicle integration requires timely, clear, and thorough communication of interface information. A ULA process has been established to assess the SC-to-LV functional interfaces for mission critical functions. Mission critical functions are defined as planned SC functions or operations that, if they were to occur prematurely or out-of-sequence, could result in an anomalous mission or even mission failure. The functional interface assessments are targeted to identify potential spacecraft-to-launch vehicle interface information that may have been assumed during SC development or not explicitly defined through the pre-integration process. There is a distinct difference between this mission success imperative versus the typical range safety functions which encompasses prelaunch operations and end with Range responsibility for sub-orbital flight. Mission critical functions encompass all phases of flight, through the SC separation from the LV.

ULA will request SC inputs to support the SC-to-LV functional interfaces assessments for mission critical functions. The compilation of this information will facilitate future discussions between the SC representatives, SC customers, LV customers, and ULA. This ULA process will be introduced early in the SC-to-LV mission integration process to provide the greatest opportunity to identify any potential mission success incompatibilities as well as to jointly determine if any mitigation might be warranted during the remainder of the mission integration process. This information request may be redundant or overlap the information already provided through other documentation, such as the SC IRD, Safety Data Package (SDP), or LSRD; however, it is prudent to request this specific information to ensure the proper information exchange and subsequent discussions. If critical information is identified between the SC and LV in this process, it may translate into formal requirements that become part of the standard spacecraft-to-launch vehicle mission interface requirements process.

4.3 MISSION INTEGRATION ANALYSIS

ULA will perform analyses, summarized in Figure 4-4, to support a given mission. This figure indicates the specific output of analyses to be performed, required SC data, the timing during the integration cycle that the analysis is to be completed, and the application of analyses to first-of-a-kind and re-flight missions. In this context a re-flight mission is an exact copy of a previous mission, with no change to functional requirements or physical interfaces. For a re-flight mission, all analyses are reassessed to ensure the original analysis is still applicable. Figure 4-4 represents standard integration analyses. For many missions, ULA uses generic versions of these analyses and may not be required to perform a mission-specific version.

Analysis	SC Data	Analysis Products	Approximate No. of Cycles		Schedule
			USG	Commercial	
1. Coupled Loads	SC Dynamic Math Model	• SC Loads • Dynamic Loss of Clearance • Launch Availability • PLF Jettison Evaluation	3	2	Model Delivery + 6 months
2. Integrated Thermal	SC Geometric & Thermal Math Models & Power Dissipation Profile	• SC Component Temperatures • Free Molecular Heating after PLF Jettison	2	2	IMR-2
3. PLF Gas Conditioning	ICD Maximum prelaunch SC Power Dissipation SC Geometric Model	• PLF ECS Gas Conditioning Analysis Results & ECS Set Points/Delivery	2	2	IMR-2
4. PLF Aeroheating	ICD	• Maximum PLF Inner Surface Temperatures and/or Heat Fluxes to the SC	2	2	IMR-2
5. PLF Venting & ECS Impingement	SC Venting Volume SC Geometric Model	• Pressure Profiles • Depressurization Rates (DR) • ECS Impingement Velocity & PLF Positive Pressure Evaluation	2	2	L-12 months L-6 months
6. Critical Clearance	SC Geometric Model SC Dynamic Model	• Loss of Clearance Drawing	3	2	SC Model Delivery + 6 months
7. Spacecraft Separation & Clearance	SC Mass Properties SC Geometric Model SC Sep System Model SC Propellant Slosh Model (Documented in ICD)	• SC Sep Clearance • SC Sep Attitude, Rate & Spin-Up Verification	1	1	IMR-2

Figure 4-4. Summary of Typical Delta IV Mission Integration Analyses (continued on next page)

Analysis	SC Data	Analysis Products	Approximate No. of Cycles		Schedule
			USG	Com-mercial	
8. Post Injection Analysis		• LV-SC Post-Separation History	2	2	PMA FMA
9. LV-to-SC Shock & SC-to-LV Shock	SC Separation Plane Definition (Both Sides of Sep Plane)	• LV-to-SC Shock Environment • SC-to-LV Shock Environment	1	1	IMR-2
10. Acoustics	SC Geometry Fill Factors	• SC Acoustics Environment	1	1	IMR-2
11. EMI/EMC	• SC Radiated Emissions Curve • SC Radiated Susceptibility Curve • SC Rec Op & Demise Thresholds • SC Diplexer Rejection • SC Transmitter Characteristics • SC Ordnance Configuration	• Preliminary Assessment of margins • Integrated EMI/EMC Preliminary Analysis • Final Version of the Above Two Analyses	2	2	IMR-2
12. Contamination	SC Contamination Limits for Sensitive, Critical, Vertical & Horizontal Surfaces SC Geometric & Thermal Math Model	• Contamination Analysis or Contamination Assessment	1	1	IMR-2
13. RF Link Compatibility & Telemetry Coverage (Airborne)	• SC Transmitter Characteristics • SC Receiver Characteristics • Receiver Preselector & IF Filter Characteristics	• Link Margins • Frequency Compatibility • EEDs Susceptibility	2	2	Preliminary L-15 months Final IMR-2
14. RF Link Compatibility & Telemetry Coverage (Ground)	SC Transmitter & Receiver Characteristics	• Link Margins • Identify Required Hardware	1	1	IMR-2
15. Performance	SC Mass & Mission Requirements Definition	• PMA • FMA • BET	3	3	PMA: L-17 months FMA: L-9 months BET: L-1 month
16. Stability	• SC Mass Properties • SV Propellant Slosh Characteristics (ICD) SC Dynamic Math Model	• Control System Margins • ACS Use	1	1	L-7 months
17. Mass Properties	SC Mass Properties	• Mass Properties Report	3	3	PMA-60 days FMA-60 days BET-60 days

Figure 4-4. Summary of Typical Delta IV Mission Integration Analyses **(continued on next page)**

Analysis	SC Data	Analysis Products	Approximate No. of Cycles		Schedule
			USG	Com-mercial	
18. Flight Safety	SC Breakup Data & Propulsion Characteristics	• Trajectory Data & Tapes for Range Approval	2	2	Preliminary L-1 year Final L-2 months
19. Electrical Compatibility	Electrical Interface Requirements	• End-to-End Circuit Analysis	1	1	IMR-2
20. Launch Window	Window Definition	• FMA	1	1	L-9 months
21. Wind Placard	SC Mass Properties	• LV Ground & Flight Winds Restrictions	1	1	IMR-2
22. Guidance Analysis & Injection Accuracy	Mission Requirements	• Mission Targeting Capability & Accuracies (MTCA) • LV System Orbit Injection Accuracy	2	2	L-2 months
23. Mission Targeting	Final Target Spec	Targeting Parameters	1	1	L-3 weeks
24. Mission Parameters	Final Target Spec	Mission Parameters	1	1	L-3 weeks
25. Flight Software	Mission Requirements	LV Software	1	1	L-3 weeks
26. Postflight	SC-Derived Injection State Vector	Evaluation of Mission Data, LV Performance & Environment	1	1	L + 60 days

Figure 4-4. Summary of Typical Delta IV Mission Integration Analyses (concluded)

Figures 4-5 and 4-6 show the generic schedules for a typical Delta IV mission. The full-scale integration process begins at approximately L-24 months.

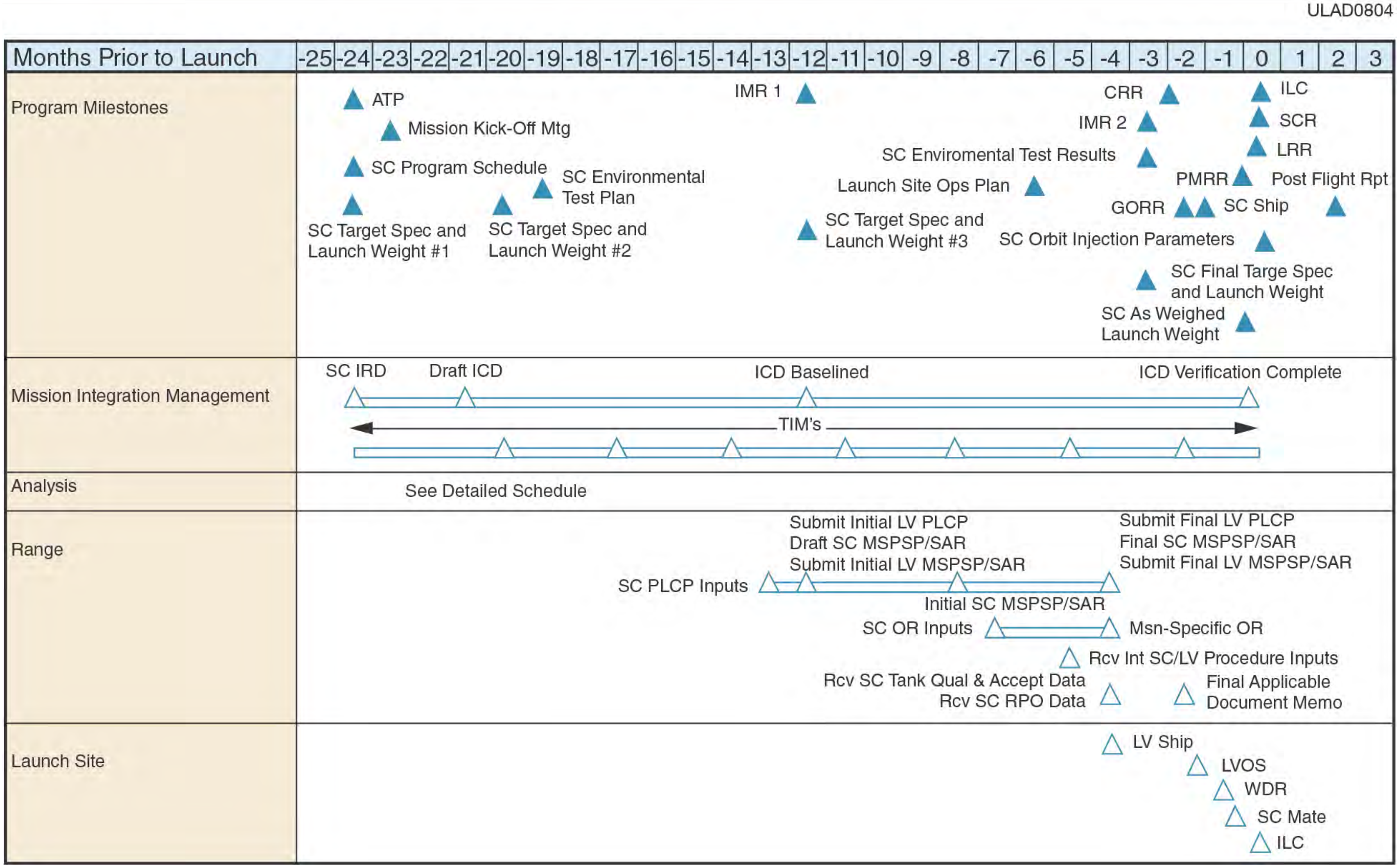

Figure 4-5. Twenty-Four Month Generic Mission Integration Schedule (Commercial)

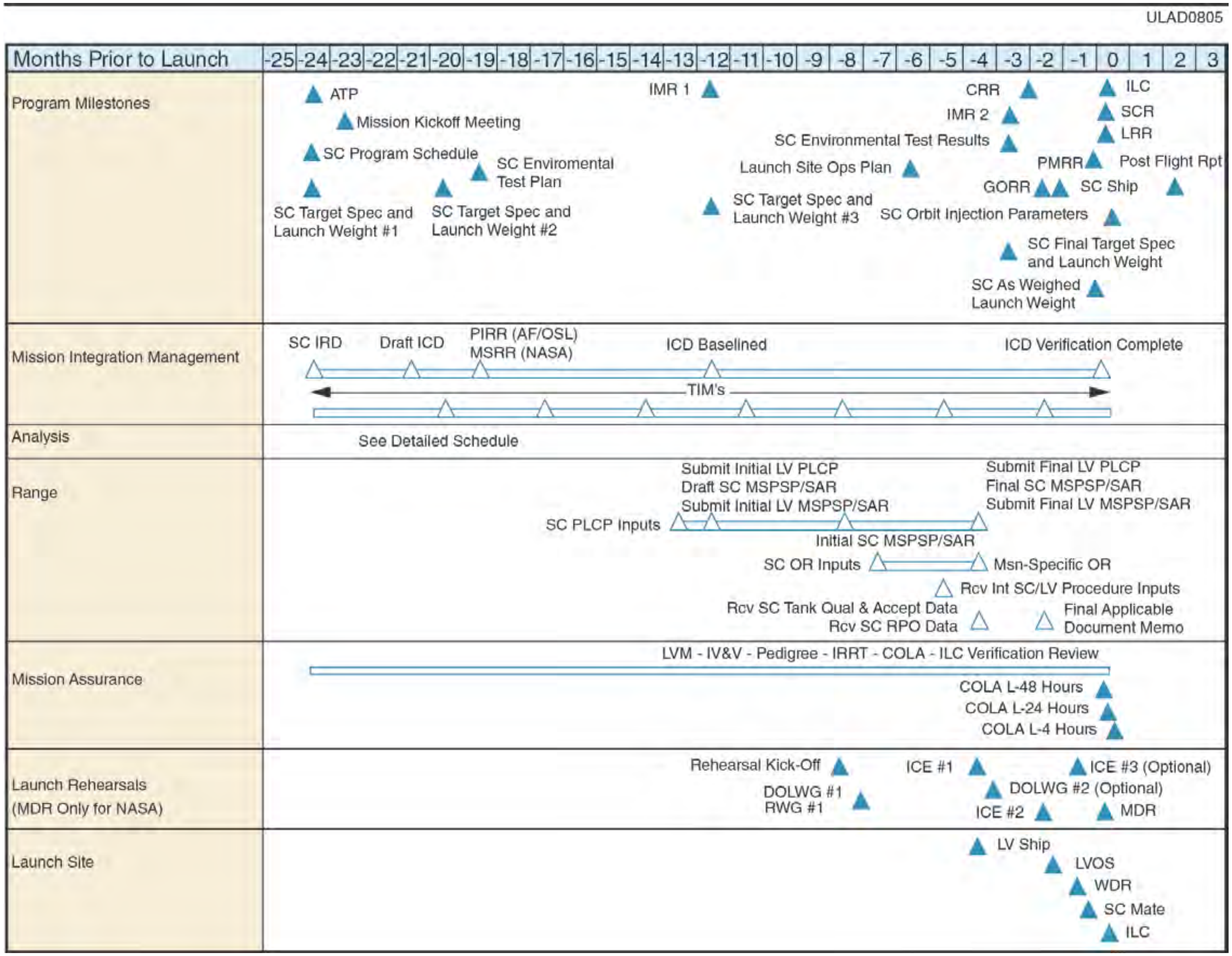

Figure 4-6. Twenty-Four Month Generic Mission Integration Schedule (Government)

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4.3.1 Coupled Loads Analysis

During the Delta IV program, a set of test-correlated three-dimensional (3-D) analytical LV models is generated for the mission-specific dynamic Coupled Loads Analysis (CLA). Mission coupled loads analysis will be run for all mission configuration critical flight events. Analysis of all events uses state-of-the-art finite element models of the booster coupled with a customer-supplied dynamic math model of the SC. Section 4.4.2.2 of this document describes the type and format of the SC dynamic model.

4.3.2 Integrated Thermal Analysis

ULA performs an integrated launch vehicle/spacecraft analysis using thermal environments imposed on the SC under prelaunch conditions and for flight mission phases up to SC separation. The integrated thermal analysis (ITA) is performed with customer supplied SC geometric and thermal math models and a detailed SC power dissipation timeline. Results are provided to the customer for evaluation and can be used to design thermal interfaces and mission operations to maintain predicted SC temperatures within allowable limits.

4.3.3 PLF Gas Conditioning Analysis

The PLF gas conditioning analysis is performed to calculate the range of PLF ECS inlet temperature setpoints vs. outside ambient temperature which will meet ICD internal PLF gas temperature and relative humidity limits and thermal requirements derived from the ITA.

4.3.4 PLF Aeroheating Analysis

The PLF aeroheating analysis is performed to verify thermal/structural compatibility with the worst case mission unique ascent aeroheating trajectory and to verify that internal PLF surface temperatures and/or radiated heat fluxes to the SC are below ICD allowable limits.

4.3.5 PLF Venting Analysis (Ascent Phase)

A PLF venting analysis is performed to determine mission-specific pressure profiles in the payload compartment during LV ascent. Existing models that have been validated with flight data are used for this analysis. The analysis incorporates the customer-provided SC venting configuration and any mission-specific PLF requirements. Analysis outputs provided to the customer include PLF pressure profiles and depressurization rates as a function of flight time.

4.3.6 Critical Clearance Analysis (Loss of Clearance)

The static payload envelope defines the usable volume for a SC. This envelope represents the maximum allowable SC static dimensions (including manufacturing tolerances) relative to the SC and payload adapter interface. For clearances between the SC and PLF/PAF, the primary clearance concerns are for dynamic deflections of the SC and PLF and the resulting relative loss of clearance between these components. A critical clearance analysis is performed to verify that these deflections do not result in contact between the SC and LV hardware. This analysis considers SC and PLF static tolerances and misalignments, dynamic deflections, and out-of-tolerance conditions, and ensures that a minimum 25 mm (1 in.) clearance between the SC and the PLF is maintained. During this analysis, dynamic deflections are calculated for ground handling, flight (from the coupled dynamic loads analysis), and PLF jettison conditions. Clearance layouts and analyses are performed for each SC configuration, and if necessary, critical clearance locations are measured after the SC is encapsulated inside the PLF to ensure positive clearance during flight.

4.3.7 Spacecraft Separation Analysis

Extensive Monte Carlo analysis of pre-separation dynamics, using a simulation of the vehicle and attitude control system, demonstrates compliance with all SC attitude pointing and angular rate and spin rate requirements under nominal and 3-sigma dispersions.

4.3.8 Spacecraft Post Separation Clearance Analysis

After the SC has separated from the Second Stage, a Collision and Contamination Avoidance Maneuver (CCAM) is performed. The CCAM is designed to positively preclude physical recontact with the SC and eliminate the possibility of significant impingement of Second Stage effluents on the SC.

4.3.9 Pyroshock Analysis

Shock analyses incorporate all significant shock events that affect the payload/launch vehicle interface as well as other locations on the launch vehicle. Spacecraft separation, PLF separation, first- and second-stage separation are the typical significant events that are included in shock analyses at the payload/launch vehicle interface. Customers should be aware that no single event typically envelopes the others at all frequencies so the maximum expected shock environment will typically be defined as an envelope of all the significant events. Verifications include measurements taken from flight and ground testing of representative PLF and spacecraft configurations.

4.3.10 Acoustic Analysis

Analysis of the acoustic environment of the payload compartment includes effects of noise reduction of the PLF and payload fill factors. Verification includes flight measurements taken from several Delta IV flights and ground acoustic testing of representative PLF/spacecraft configurations.

4.3.11 Electromagnetic Interference/Electromagnetic Compatibility Analysis

An Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) Control Plan is maintained to ensure compatibility between all avionics equipment. This plan covers requirements for bonding, lightning protection, wire routing and shielding, and procedures. ULA analyzes intentional and unintentional RF sources to confirm 6 decibel (dB) margins with respect to all general EMI/EMC requirements. In addition, EED RF susceptibility analyses are performed to Range requirements for both the LV and SC. The SC analysis is performed by the SC manufacturer and reviewed by ULA. The presence of an RF environment will affect safety margins of EEDs. This analysis is intended to confirm a minimum 20 dB margin with respect to the direct current (dc) EED no-fire power level. The purpose of the EED susceptibility analysis is to demonstrate that safety margins of each EED are maintained when exposed to the flight vehicle and site sources RF environment. Comprehensive reports are published describing requirements and results of these analyses.

4.3.12 Contamination Analysis

ULA provides customers with an assessment of contamination contributions from Delta IV LV sources, as required. Starting from PLF encapsulation of the SC through CCAM, contamination sources are identified and analyzed. This provides a qualitative assessment of the factors affecting SC contamination to allow the SC customer to approximate final on-orbit contamination budgets. A more detailed mission-specific analysis can be provided to the SC customer if mission unique deposition requirements are specified in the ICD.

4.3.13 RF Link Compatibility and Telemetry Coverage Analysis (Airborne)

ULA conducts an airborne link analysis on all RF links between ground stations and the Delta IV LV to determine whether the signal strength between the RF system on the LV and the RF system at the receiving station meets mission requirements. The S-band telemetry system, the active C-band vehicle tracking system, and the flight termination system are analyzed. ULA uses a program that considers airborne and ground station equipment characteristics, vehicle position, and attitude. This analysis determines if adequate link margins can be obtained with the receiving ground stations and the Tracking and Data Relay Satellite System (TDRSS) when the TDRSS-compatible transmitter is used. A comprehensive report is published describing link requirements and results.

ULA conducts an RF compatibility analysis between all active airborne RF transmitters and receivers to ensure proper function of the integrated system. Transmit frequencies and their harmonics are analyzed for potential interference to each active receiver. The SC contractor provides details of active transmitters and receivers for this analysis. A report is published describing analysis results.

4.3.14 RF Link Compatibility and Telemetry Coverage Analysis (Ground)

For customers who require communication with their SC during prelaunch activities, ULA conducts a ground link analysis on SC RF systems to ensure that a positive link exists between the SC and the SC checkout equipment to checkout the SC telemetry and command system. The analysis will demonstrate that the RF reradiate system provides sufficient margin to minimize effects of deviations or fluctuations in RF power and will provide consistent system performance to ensure positive link margin during the required time periods.

4.3.15 Performance Analysis

Preliminary Mission Analysis (PMA) – This analysis is normally the first step in the mission-planning process. It uses the best-available mission requirements (SC weight, orbit requirements, tracking requirements, etc) and is primarily intended to uncover and resolve any unusual problems inherent in accomplishing the mission objectives. Specifically, information pertaining to LV environment, performance capability, sequencing, and orbit dispersion is presented. Parametric performance and accuracy data are usually provided to assist the user in selection of final mission orbit requirements. The orbit dispersion data are presented in the form of variations of the critical orbit parameters as functions of probability level. A covariance matrix and a trajectory printout are also included.

Final Mission Analysis (FMA) – ULA will issue an FMA trajectory that provides the mission reference trajectory. The FMA contains a description of the flight objectives, the nominal trajectory printout, a sequence of events, vehicle attitude rates, SC and LV tracking data, and other pertinent information. The trajectory is used to develop mission targeting constants and represents the flight trajectory.

Best Estimate Trajectory (BET) – This analysis is the final trajectory published just prior to launch and includes closed-loop guided flight trajectory simulations and trajectory printouts that incorporate the mission's guidance and controls constants, as well as the best estimate of the actual mission's vehicle hardware weight and propulsion data, and an estimate of the actual launch day flight trajectory and performance.

4.3.16 Trajectory Analysis and Design

The ULA trajectory design process ensures that all SC, LV, and range-imposed environmental and operational constraints are met during flight, while simultaneously providing performance-efficient flight designs. This process typically provides Propellant Margin above required performance reserves.

The trajectory design and simulation process provides the vehicle performance capability for the mission. It provides the basis, by simulation, of dispersed vehicle and environmental parameters, for analyses of flight performance reserve and injection accuracy. Telemetry coverage assessment, RF link margins, PLF venting, and in-flight thermal analyses also rely on the reference mission design. The status report documents the trajectory design and gives detailed insight into the tradeoffs used.

The ULA trajectory analysis tools incorporate detailed propulsion, mass properties, aerodynamic, and steering control modeling, as well as oblate Earth and gravity capability, selectable atmospheric models, and other selectable routines, such as Sun position and tracker locations, to obtain output for these areas when they are of interest.

These simulation tools interface directly with actual flight computer software. This feature bypasses the need to have engineering equivalents of flight software. Another powerful feature is compatibility with 6-DOF modeling of the vehicle, which will facilitate key dynamic analyses for our vehicle family. Other features include significant flexibility in variables used for optimization, output, and simulation interrupts.

4.3.17 Stability and Control Analysis

Linear stability analysis, primarily a frequency response technique, is performed to determine Delta IV autopilot configurations; establish gain and filter requirements for satisfactory rigid body, slosh, and elastic mode stability margins; and demonstrate Second Stage maneuver and attitude hold capabilities. Uncertainties affecting control system stability and performance are evaluated through a rigorous stability dispersion analysis. Tolerances are applied to vehicle and environmental parameters and analyzed using frequency response, ensuring that the Delta IV autopilot maintains robust stability throughout the defined mission. Correlation of simulation results with previous postflight data have confirmed the adequacy of these techniques.

4.3.18 Mass Properties Analysis

ULA performs mass properties analysis, reporting, and verification to support performance evaluation, structural loads analysis, SC and LV separation analysis, ground operations planning, airborne shipping requirements, and customer reporting requirements.

4.3.19 Flight Safety Analyses and Data

Flight Safety analyses will be conducted and submitted as required to comply with Eastern/Western Range regulations to obtain both Preliminary Flight Plan Approval (PFPA) and Final Flight Plan Approval (FFPA). For new Delta IV missions that are: Single Flight Azimuth (SFA) and similar in configuration and flight azimuth to previously flown Delta IV missions, these submittals typically occur approximately one year before launch for the Preliminary Flight Data Package (PFDP) and approximately 60 days before launch for the Final Flight Data Package (FFDP). For new Delta IV missions that are: Variable Flight Azimuth (VFA) and/or not similar in configuration or flight azimuth to previously flown Delta IV missions, the PFDP may need to be submitted up to two years prior to launch, and the FFDP up to six months prior to launch. Required PFDP and FFDP documentation and digital media are provided to the applicable Range Safety agency in specified formats and include vehicle and mission descriptions, nominal and dispersed trajectories, impact locations of jettisoned hardware, and an overflight risk analysis.

4.3.20 Destruct System Analysis

LV destruct system analysis is provided in our Range Safety System Reports (RSSR). RSSR documents provide an overview of each vehicle configuration and detailed descriptions of the Flight Termination System (FTS), C-band tracking system, S-band telemetry system, and ground support equipment for Eastern and Western Range Safety systems. Component and system-level testing is also described. Antenna patterns, link margins, and FTS battery load capacity analyses are included.

As indicated in Section 4.5, the Delta IV program develops a SC FTS configuration concurrence request for each mission (dedicated SC destruct capabilities are generally not required for communications SC).

4.3.21 End-to-End Electrical Compatibility Analysis

ULA conducts an Independent End-to-End Electrical Circuit Compatibility Analysis (ICA) to verify proper voltage and current parameters and any required timing and sequencing interfaces between all SC and LV airborne interfaces (through to the end function). The ICA will verify ICD/EICD requirements against SC and LV released engineering to ensure electrical compatibility between the LV and the SC interfaces prior to the fabrication of flight hardware. Verification of electrical compatibility between the LV and the SC interfaces will be reviewed to the first active circuit on the LV and the SC side of the interface, mission critical ground and airborne circuits.

This analysis requires SC data from released electrical schematics and build/installation engineering, such as contact assignments, wiring interfaces, and circuit detail of avionics (first level) to verify end-to-end (spacecraft-to-launch vehicle) compatibility. All "in-between" wiring and circuits are analyzed to verify proper routing, connections, and functionality of the entire system interface. This analysis is documented as part of the ICD verification process and used to generate inputs for all necessary launch site interface testing.

4.3.22 Launch Window Analysis

Launch window analyses are performed to define the open and close of mission-specific launch windows that satisfy mission-specific requirements on each launch day within the launch period. The Delta IV LV can accommodate launch windows, any time of day, any day of the year within performance capability constraints for a given mission design. Customers are requested to provide opening and closing times for the maximum launch window the SC is capable of supporting. If the launch windows are several hours long or multiple windows in a single day, then a span within the total launch opportunity will be jointly chosen by ULA and the customer. This decision can be made as late as a few days before launch. The selected span will be chosen based on operational considerations, such as preferred time of day or predicted weather.

Some missions may have more complicated window constraints requiring analysis by ULA. For example, launch system performance capability constrains windows for missions that require precise control of the right ascension of the ascending node. That control is achieved by designing trajectories at discrete times throughout the launch window. We have successfully analyzed a variety of window constraints for past missions, and we are prepared to accommodate required window constraints for future missions.

4.3.23 Wind Placard Analysis (Prelaunch, Flight)

Wind tunnel tests of the Delta IV configurations have been performed to determine loading for ground and flight wind conditions. This information, combined with launch site wind statistics, is used to determine the wind placards and subsequent launch availability for any given launch date. The Delta IV launch system provides at least an 80% probability of launching any vehicle within an 11 calendar daytime period (original launch day and then 10 successive days after). The probability will be calculated assuming the launch window is during the most severe weather (combination of general weather, ground winds, and winds aloft) hour of the year. The Delta IV shall have the capability to fly through winds aloft with a probability of at least 70% with regard to controllability and structures. This probability assumes the launch window is during the most severe winds aloft month of the year.

4.3.24 Guidance Analysis

Analyses are performed to demonstrate that SC guidance and navigation requirements are satisfied. Analyses include targeting, standard vehicle dispersions, and guidance accuracy. The targeting analysis verifies that the guidance program achieves all mission requirements across launch windows throughout the launch opportunity. Standard vehicle dispersion analysis demonstrates that guidance algorithms are insensitive to 3-sigma vehicle dispersions by showing that the guidance program compensates for these dispersions while minimizing orbit insertion errors.

4.3.25 Injection Accuracy Analysis

The guidance accuracy analysis combines vehicle dispersions and guidance hardware and software error models to evaluate total guidance system injection accuracy. Hardware errors model off-nominal effects of guidance system gyros and accelerometers. Software errors include Redundant Inertial Flight Control Assembly (RIFCA) computation errors and vehicle dispersion effects. Positive and negative dispersions of more than 40 independent vehicle and atmospheric parameters that perturb Delta IV performance are simulated. The accuracy analysis includes sensor noise, effects of vehicle prelaunch twist and sway on guidance system alignment during gyro compassing, and the covariance error analysis of the guidance hardware.

4.3.26 Mission Targeting

Mission targeting is conducted to define target orbit parameters that will be used to guide the LV into the desired orbit. This process requires a target specification from the SC agency and results in publication of flight parameter loads used for the flight computer and mission-specific software configuration drawing documentation.

4.3.27 Mission Peculiar Flight Software

The mission-specific software activity for mission integration is a controlled process that ensures the generation and release of validated flight software to support the launch schedule. The modular software design minimizes the impact of changes due to mission-specific requirements. This is achieved through the generic software design philosophy, which has been applied during development and evolution of the Delta IV Flight Software architecture. A parameterized software design has been implemented so that baseline Flight Software is able to support the functionality necessary to fly most Delta IV missions. Parameters are then set to properly implement the required mission-specific functionality.

Periodic updates to flight software baselines are scheduled to support updates in the vehicle hardware configuration or to implement capability enhancements as required by the Delta IV program.

A rigorous software validation test program is executed using the specific-mission trajectory and targeting parameters to validate the flight software and parameter data load before release for flight. Testing and validation are completed in the Systems Integration Laboratory (SIL), which includes flight-like avionics components operating in conjunction with the Flight Software and its built-in vehicle simulation model.

4.3.28 Postflight Data Analysis

For Delta IV missions, ULA uses proven analysis techniques to obtain the individual stage performance information derived from available LV telemetry data. In addition, the postflight report presents historical data for past flights of similar family and statistics of the parameters of interest. The report provides a trajectory listing of simulated flight that effectively matches observed data from the actual flight.

In addition to the performance evaluation of the LV, the postflight report provides an assessment of injection conditions in terms of orbital parameters and deviations from target values and SC separation attitude and rates. The report also documents environments at the LV/SC interface to the extent that the LV instrumentation permits. These environments could include interface loads, acoustics, vibration, and shock.

Finally, the report presents analyses of individual LV system performance and documents any anomalies noted during the Terminal Count and launch phase. LV and landline telemetry data provide the primary source of information for these analyses. Additionally, results of the review of optical data (from both fixed cameras at the launch site and tracking cameras) and radar data are also presented in the report.

4.4 SPACECRAFT DATA REQUIREMENTS

The items listed in this section are representative of the information required for SC integration and launch activities. Additional information may be required for specific SC.

4.4.1 Interface Control Document (ICD) Inputs

Appendix B (ULA Spacecraft Questionnaire) addresses the SC information required to assess the SC's compatibility with the Delta IV LV. Data usually are provided by the customer in the form of an IRD, or LSRD for NASA missions, and are the basis for preparing the ICD. The IRD or LSRD provides the initial definition of SC requirements, interface details, launch site facilities, and preliminary safety data for ULA's various agencies. The questionnaire is generalized and applies to any candidate mission. If ULA has experience with the SC bus or SC contractor, less information can be provided initially (assuming the SC contractor is willing to use a "same as mission _____" designation for purposes of assessing preliminary compatibility). Of particular interest are data that specify requirements in conflict with constraints specified in this User's Guide. A complete IRD or LSRD is typically supplied within 30 days of contract signing.

4.4.2 Spacecraft Integration Inputs

Figure 4-7 provides a list of typical SC 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.

Spacecraft Data Input	Typical Need Date	Comments
IRD/LSRD	Program Kickoff	See Section 4.4.1
Initial Target Specification	Program Kickoff	SC Weight, Target Orbit, Separation Attitude; See Section 4.4.2.4
Range Safety Mission Orientation Briefing Input	Program Kickoff	Top-Level Description of SC & Mission Design
Prelim SC MSPSP	13 months Before Launch	See Section 4.4.2.6.1
In-Flight Breakup Data	Program Kickoff	See Section 4.4.2.6.4.2
CAD Model	30 days After Program Kickoff	See Section 4.4.2.1
Procedures Used at Payload Processing Facility	2 months Before SC Arrival	See Section 4.4.2.6.2
Procedures Used at Launch Site	4 months Before Launch	See Section 4.4.2.6.2
Thermal Models	5 months Before IMR-2	See Section 4.4.2.3
Preliminary Launch Windows	6 months Before IMR-2	Support Thermal Analysis; See Section 4.4.2.3
Coupled Loads Model	Program Kickoff	See Section 4.4.2.2
SC EMI/EMC Cert Letter	6 months Before Launch	See Section 4.4.2.5
SC EED Analysis	6 months Before IMR-2	See Section 4.4.2.5
Crane Information for Suspended Load Exposure	120 days Before the Operation	See Section 4.2.4
Final Target Specification	90 days Before Launch	Date Depends on Mission Design; See Section 4.4.2.4
SC Environment Qualification Test Reports	As Available	See IRD, LSRD, or Spacecraft Questionnaire for Environment Qualification Requirements

Figure 4-7. Spacecraft Inputs to Integration Process

4.4.2.1 Computer-Aided Design (CAD) Data Transfer Requirements. ULA uses Unigraphics for Delta IV. Computer-Aided Design (CAD) data should be provided according to this specified software format. When feasible, ULA prefers to receive solid or surface model data translated through the Standard for the Exchange of Product Model Data (STEP) converter. Wireframe geometry may be included with the solid or surface model transfer.

4.4.2.1.1 Prerequisites to Data Transfer. The following criteria should be met before transferring CAD data:

1. The SC 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 SC components for best integration to the Delta IV LV; All internal structures are not necessary and should be removed from model transfer files.
3. Write out the Unigraphics, and/or STEP model files as assemblies and not as a single part file.
4. Remove all non-essential geometry such as points, axis lines and lines-of-action before creating the data.

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

4.4.2.1.2 Data Transfer. Use of a ULA-hosted electronic file server (i.e., iDM/LiveLink or File Transfer Protocol [FTP]) is the preferred transfer methods for all data files. An account can be established on a ULA firewall server for electronic 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. If using an FTP server, proprietary or sensitive data should be encrypted using PGP keys or equivalent. Because of security concerns, email transfers are not recommended at this time. Data transfer via Compact Disks (CDs) or Digital Versatile Disks (DVDs) is also acceptable. If the electronic file server and CD/DVD 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. SC models security status must be clearly communicated (Proprietary Data, 3rd Party Proprietary, Non-Public Spacecraft Data, etc)
2. Name and phone number of the contact person who is familiar with the model in case problems or questions arise
3. SC axis and coordinate system
4. SC access requirements for structure not defined on CAD model (i.e. fill and drain valve locations)
5. Multiview plot or jpeg(s) file of model
6. Uudecode (UNIX-based) information, if applicable

4.4.2.2 Coupled-Loads Analysis Model Requirements. The customer-supplied dynamic mathematical model of the SC should consist of generalized mass, stiffness and damping matrices. If a damping matrix is not provided then a recommended modal damping schedule is needed. The desired format of the model is Craig-Bampton, constrained at the LV interface in terms of SC modal coordinates and discrete interface points. The interface should be indeterminate (multi-point) and should represent a load path and stiffness consistent with the non-reduced Finite Element Model (FEM). The SC dynamic model should have a minimum upper frequency cutoff of 100 Hz. The Output Transformation Matrices (OTM) should be in the form that, when multiplied by the SC modal and interface generalized coordinate responses, will recover the desired accelerations, displacements, or internal loads. One of the OTMs should contain data that will allow calculation of loss of clearance between the payload fairing and critical points on the SC.

Documentation of the model should consist of the following: Free-free modes, cantilevered modes, mass properties, description of coordinate system(s), model uncertainty factors, coordinates of points for Loss of Clearance (LOC) and definition of coordinate system that LOC points were defined in.

4.4.2.3 Spacecraft Propellant Slosh Modeling. ULA models SC propellant slosh as part of the LV attitude control system stability analysis. The SC propellant tank geometry, tank locations, minimum and maximum tank fill levels, propellant densities and propellant slosh damping ratios are required to perform this analysis. The data will be documented in the mission specific ICD.

4.4.2.4 Spacecraft Thermal Analysis Input Requirements. SC 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 2000 nodes/surfaces each.

The preferred GMM format should be coordinated at the Integration Kickoff or through the ULA Customer Program Office. The documentation of the GMM should include illustrations of all surfaces at both the SC 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 SC 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.

4.4.2.5 Target Specifications. Target specifications normally include the final mission transfer orbit (apogee and perigee radii, argument of perigee, and inclination), SC weight, launch windows, and, if required, requirements for right ascension of the ascending node.

4.4.2.6 Spacecraft Electromagnetic Interference and Electromagnetic Compatibility Certification Letter and Electroexplosive Device Analysis. A final confirmation of SC transmitter and receiver parameters, and emission and susceptibility levels of electronic systems is required six months before launch. 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 EEDs 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 SC data to develop a final analysis for the combined spacecraft/launch vehicle and site environment.

4.4.2.7 Safety Data. To launch from CCAFS on the Eastern Range or VAFB on the Western Range, SC design and ground operations must meet the applicable launch-site safety regulations. Refer to Section 4.5.1 for a listing of these regulations. Mission-specific schedules for development and submittal of the SC safety data will be coordinated in safety working group meetings during the safety integration process. Refer to Section 4.5.2 for additional information on this process.

4.4.2.7.1 SC Missile System Prelaunch Safety Package. The SC Missile System Prelaunch Safety Package (MSPSP) is the data package that describes in detail the hazardous and safety-critical SC systems/subsystems, their interfaces, and the associated GSE and tailoring. In addition, the SC MSPSP provides verification of compliance with the applicable Range Safety requirements. For ULA purposes, the SC MSPSP must be approved by Range Safety prior to SC fueling.

4.4.2.7.2 Spacecraft Launch Site Procedures. Before any procedures are performed at the launch site, hazardous SC procedures must be approved by the Range Safety Office and/or the safety organization at the appropriate SC processing facility (e.g., Payload Processing Facility, NASA, DOD). Since the approving authority must also concur with the nonhazardous designation of procedures, all SC launch-site procedures must be submitted for review. ULA's System Safety Group will access and review hazardous integrated procedures.

4.4.2.7.3 Radiation Protection Officer Data. Permission must be received from the Range Radiation Protection Officer (RPO) before SC 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.

4.4.2.7.4 Spacecraft Breakup Data Requirements. The SC data described in the following two subsections is required for the Delta IV program to complete mission-specific analyses that satisfy 45th Space Wing/SEL and 30th Space Wing/SEL requirements for submitting a request for Range Safety PFPA and FFPA.

4.4.2.7.4.1 Inadvertent Spacecraft Separation and Propulsion Hazard Analysis. This data set is related to inadvertent separation of the SC during early ascent and the potential for launch area hazards that could exist in the event SC engine(s) fire. Typical SC 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.

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

4.5 RANGE AND SYSTEM SAFETY INTERFACES

4.5.1 Requirements and Applicability

To launch from either Cape Canaveral Air Force Station (CCAFS), FL, or Vandenberg Air Force Base (VAFB), CA, LV/SC design and ground operations must comply with applicable launch site Range Safety regulations, USAF requirements concerning explosives safety, and U.S. consensus safety standards. In addition, compliance with applicable facility safety policies is also required when using SC processing facilities operated by Spaceport Systems International (SSI), Astrotech Space Operations, Inc. (ASO), NASA, or the USAF. CCAFS and VAFB Range Safety organizations have regularly updated their safety requirements documents.

Effective 1 July 2004, the single safety document for both CCAFS and VAFB (Eastern and Western Range Regulation [EWR] 127-1) was replaced by AFSPCMAN 91-710. Existing LV and SC programs may not be affected by the new AFSPCMAN 91-710 regulations unless required by the SC contracting agency. New programs introduced after 1 July 2004 will negotiate applicable regulations with the Range Safety Office (45^{th} Space Wing for Eastern Range and/or 30^{th} Space Wing for the Western Range). Earlier versions of Range regulations may still apply to a given SC or mission, depending on when the SC bus was originally designed and constructed and approved by the Eastern and/or Western Range Safety organizations.

Applicable safety compliance documents are determined during negotiations with Range Safety, ULA, and the SC at the outset of the mission integration process.

Other safety documents that may also apply to the launch site safety interface are:

1. Radiation Protection Program, 45 Space Wing Instruction 40-201
2. Air Force Manual (AFM) 91-201, Explosives Safety Standard
3. Air Force Regulation (AFR) 127-12, Air Force Occupational Safety, Fire Prevention, and Health Program
4. MIL-STD 1522A, Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems
5. MIL-STD 1576, Electro-explosive Subsystem Safety Requirements and Test Methods for Space Systems
6. NASA KHB 1710.2, KSC Safety Practices Handbook (for SC processed at Kennedy Space Center facilities)

7. Delta Launch Site Safety Manual/Launch Complex Safety Plan (CCAFS Launch Ops Safety Plan, 06H0004A / Vandenberg AFB Launch Ops Safety Plan, ULA V09 Rev A)
8. Payload Processing Facility (PPF) Safety Manual (e.g., Astrotech Space Operations, Facility Safety Manual [SHI-ASO-M008 or SHI-ASO-M0011])

At the start of the safety integration process, Range Safety documents applicable to SC design and ground processing operations will be determined.

ULA System Safety engineers will evaluate mission-specific SC designs and ground processing operations and provide guidance for successful completion of the Range review and approval process. Should areas of noncompliance be identified, ULA will evaluate each area and as appropriate, provide guidance for resolution of specific noncompliance items while still meeting the intent of the applicable safety requirements. For commercial programs, ULA, if requested, will act as the SC contractor's safety liaison and facilitate interface activities with the launch site Range Safety Office.

Range Safety requirements require three inhibits (dual-fault tolerance) if system failures could result in catastrophic events and two inhibits (single-fault tolerance) if failures could result in critical events. Critical and catastrophic events are defined in EWR 127-1 or AFSPCMAN 91-710 as applicable. The Range typically applies the three-inhibit requirement to safety-critical electrical systems, including the SC's Category A ordnance circuits, during ground processing operations at the launch site (e.g., encapsulation of SC at the processing facility, transport of encapsulated SC to SLC-37B/SLC-6, mate of encapsulated assembly to the LV). When Category A SC circuits use the Delta IV LV's ordnance controller during transport to the SLC-37B/SLC-6 pad, the three-inhibit requirement is satisfied. If the SC's Category A ordnance circuits are independent from the LV, SC customers should review their designs and ground operations plans and notify ULA if SC systems do not provide the required fault tolerance. As stated above, ULA will then assess mission-specific designs, evaluate hazard controls, and work with Range Safety to develop and implement "meets-intent" resolutions.

4.5.2 Safety Integration Process

Figure 4-8 shows the ULA process to facilitate Range and system safety coordination and receive Range Safety approval and/or permission to launch. This figure identifies responsibilities of the SC and/or Launch Services Integration Contractor (LSIC), and/or NASA, and/or other government contracting agency, 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 provides qualified engineers to assist the SC contractor during the Range review and approval process. For commercial missions ULA obtains all Range Safety and system safety approvals. The following paragraphs summarize the safety integration process and define safety data to be developed by the SC customer during implementation of this process.

Mission Orientation – Soon after contract award, ULA and the SC introduce the mission to Range Safety during a mission orientation meeting at the Range Safety Office or a similar venue. Figure 4-8, Block A, shows basic elements of this orientation. The orientation provides a general overview of the mission and provides a forum for coordination of mission-unique requirements, schedules, and data submittals. Mission-unique designs and operational issues are reviewed so agreements can be established during the early phase of mission integration. Range

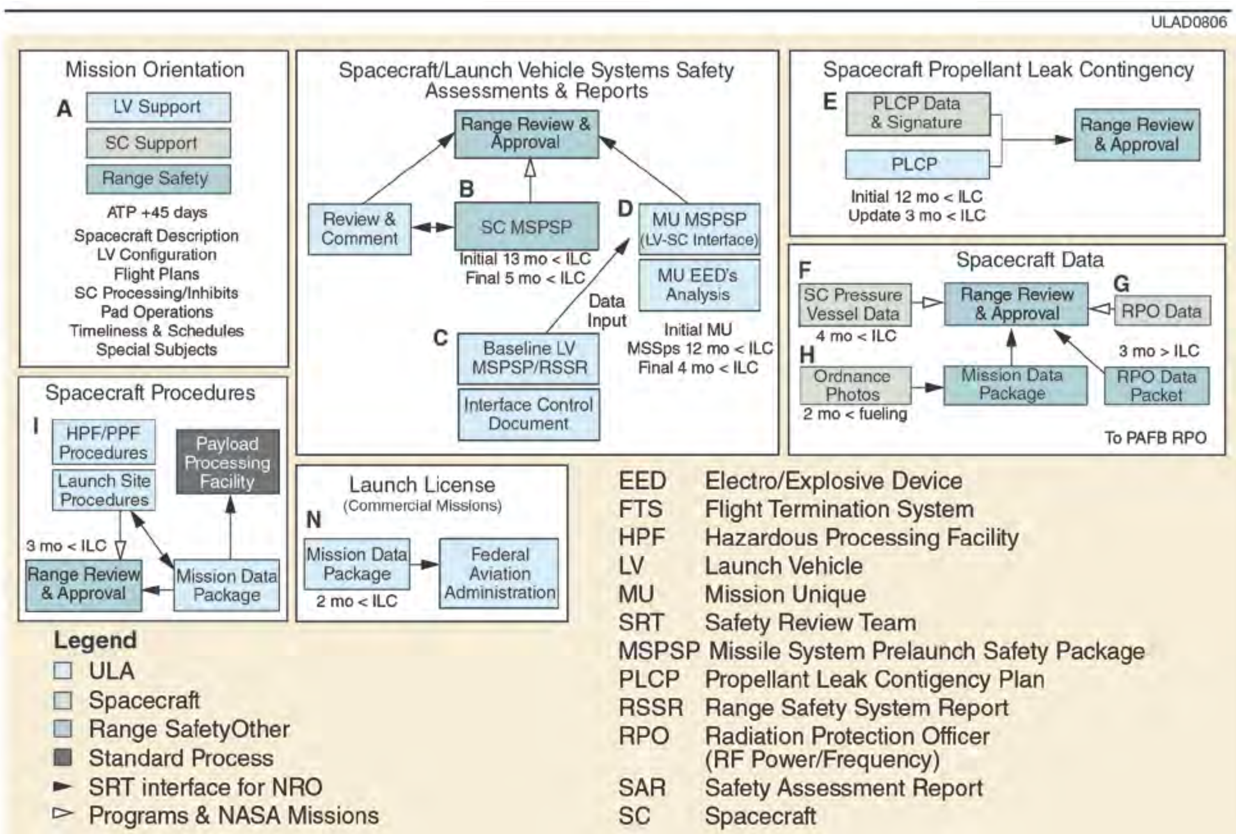


Figure 4-8. ULA Safety Integration Process

Safety requirements that will be imposed on SC designs and ground processing operations are identified.

For follow-on missions, a formal meeting is generally not necessary. In those cases, ULA will develop and submit a mission orientation letter to coordinate mission-unique requirements, schedules, and data submittals. The SC contractor will be required to provide inputs to the mission orientation letter.

Spacecraft and Launch Vehicle Safety Assessments – Mission-unique SC designs and ground processing operations are documented in the Missile System Prelaunch Safety Package (MSPSP) or Safety Assessment Report (SAR), (Figure 4-8, Block B). The SC develops the SC MSPSP/SAR to describe the SC, document potential hazards associated with ground processing operations at the Range (e.g., pressure systems, propellant systems, propulsion system, ordnance control systems, toxic and hazardous materials, SC access requirements, RF testing, ionizing and non-ionizing sources hazard controls, battery charging at the pad, etc., and affiliated ground support equipment and operations), and define the means by which each hazard is controlled to an acceptable level of risk. Range Safety regulations provide details on the format and contents of the MSPSP/SAR.

The initial or Phase 1 SC MSPSP/SAR is typically submitted to the Range and ULA approximately 13 months before Initial Launch Capability (ILC). The Phase II SC MSPSP/SAR is

typically submitted to ULA about five months before scheduled ILC. The Phase III or final SC MSPSP/SAR typically incorporates verification close-out data and the tracking log and is typically submitted approximately one month prior to hardware arrival at the PPF.

For commercial missions, ULA will forward the MSPSP/SAR to Range Safety, review it, and provide comments if necessary. ULA also forwards the ULA comments to the Range and SC for additional formal review and disposition. For other missions, the SC/LSIC may submit the MSPSP/SAR directly to Range Safety; however, ULA also reviews the MSPSP/SAR in parallel with Range Safety.

ULA accesses data from the SC MSPSP/SAR in addition to data from existing baseline Delta IV LV safety reports (Figure 4-8, Block C, integrated procedures) and the mission-specific ICD to develop and document a safety assessment of the LV-to-SC interface. Results of this assessment will be delivered to the Range as the Mission-Unique LV MSPSP (Figure 4-8, Block D).

For Western Range programs, ULA develops and submits a seismic assessment for ULA hardware, operations, and integrated ULA-to-SC encapsulation configurations. Some SCs may also be required to perform a similar assessment.

Spacecraft Propellant Leak Contingency Plan (PLCP) – Based on data supplied by the SC contractor (e.g., hardware locations, access requirements, ground support equipment), ULA develops the integrated SC PLCP (Figure 4-8, Block E). The PLCP provides a top-level plan for depressurization and/or offload of SC propellants should leakage occur. The provisions of this plan become applicable once the SC is fueled and the integrated operations begin to include encapsulation at the PPF, during transport, and once it has been mated to the Delta LV at the launch complex, and remains in effect until completion of final PLF closeout activities. Selected elements of this plan may also be implemented if an incident occurs after completion of closeout efforts. The SC is required to develop detailed procedures to implement depressurization and offload operations.

Spacecraft Data – The SC will provide pressure vessel qualification and acceptance test data to the Range for review and acceptance. This data appear in Figure 4-8, Block F. For follow-on missions, if the previously submitted pressure vessel qualification data remains unchanged, only acceptance data are required. ULA is provided a copy for review.

The SC contractor should also submit data specifying the type and intensity of RF radiation that the SC may transmit during ground testing, processing, and launch at the Range. The data should be included in the SC MSPSP/SAR. For Eastern Range launches, this data is forwarded for comparison to the RPO for review and approval of RF related operations required at the launch site. At the Western Range, SC contractors communicate this data directly with the Range. A copy of the RPO response letter should be provided to ULA. The process appears in Figure 4-8, Block G. Detailed descriptions of data required can be found in the MSPSP content requirements of Range Safety Requirements (EWR 127-1 or AFSPCMAN 91-710). The SC contractor may be required to complete the appropriate RPO forms such as AFSC Form 2246 and 2257.

The Range requires photographs showing locations of ordnance items installed on the SC. These data appear in Figure 4-8, Block H. This data will be provided to the Range prior to SC transport to the launch site from the PPF. If the SC selects the direct submittal option, ULA requires notification that photographs have been delivered. A follow-up meeting between the Range and the SC contractor is typically required to review ordnance data.

Spacecraft Procedures – The SC submits onsite processing procedures, PPF procedures, and launch pad procedures (SLC-37B and/or SLC-6) (Figure 4-8, Block I) to the operator of the PPF (e.g., Astrotech, SSI, NASA, or Air Force) and the Range for review and approval. Procedures to be implemented at either launch pad must comply with applicable Range Safety regulations and ULA policies. Procedures and operations that involve ULA personnel (e.g., SC mate, encapsulation, etc), or that are performed at the launch site, require ULA review. As indicated in Section 9.1, PPF procedures must also comply with the applicable processing facility's safety policy. For first time missions, the Range requires submittal of all SC procedures (hazardous and non-hazardous). For follow-on missions, only hazardous procedures may be required for submittal. For commercial missions, ULA forwards the SC procedures to Range Safety and the PPF operator if requested.

SC RF – Inadvertent SC RF Transmitter/Emitter "ON" is not acceptable and is considered a potentially catastrophic hazard. Inadvertent/unplanned SC RF transmissions could encroach upon required EWR 127-1 EMI Safety Margins (EMISM) (20 dB for Ordnance and 6 dB for Avionics). Inadvertent SC transmissions may also interfere with Delta FTS and/or other avionics operations. If inadvertent SC RF transmission is controlled by three independent inhibits, then the hazard is considered adequately controlled. If the SC has less than three independent inhibits, ULA may be able to perform an "RF Reverberant Cavity Analysis" that shows no EMISM margin encroachment; however, if that analysis shows encroachment, then the SC may be required to change the SC design or may be required to submit a Requirements Relief Request (i.e., a waiver) to Range Safety and ULA.

SC Power-Off During LV Ordnance Activity – During LV ordnance connections at the launch site, the SC must be powered OFF (includes RF silence, power switching, and EGSE connections to the SC). The schedule for SC power off times and duration will be coordinated with the SC at the Ground Operations Working Group (GOWG) and daily schedule meetings at the SC PPF. However, if SC power OFF is not possible, then ULA will analyze the SC power-on configuration (i.e., Battery trickle charge, thermal conditioning heaters, Telemetry [TM], memory keep-alive, etc) to determine if there is interference with LV ordnance operations. If that analysis shows interference, then the SC may be required to change the SC design or operations, or may be required to submit a Requirements Relief Request (i.e., a waiver) to Range Safety and ULA.

Launch License (Commercial Missions) – For commercial missions, ULS maintains a launch license (Figure 4-8, Block N) from the FAA. The Delta launch license requires a mission supplement to address each commercial mission. ULA develops a mission-specific addendum to the baseline license for each commercial flight and submits this data package to the FAA. SC information included in the FAA data package will include MSPSP approval status and overviews of hazardous SC commodities (propellants, pressure systems, batteries, etc). The required Mission Data Package is due at no later than L-2 months.

Section 5
PAYLOAD INTERFACES

This section presents detailed descriptions of the interfaces between the payload and the Delta IV launch vehicle family. Our Delta IV payload interfaces are designed to meet present and future demands of the global satellite market. The Delta Program uses a heritage design approach for its payload attach systems which are used to adapt the Delta IV 2nd stage to the Spacecraft (SC) interface. Payload Attach Fittings (PAF) are required for all launch vehicle configurations. For medium class payload configurations the payload attach fitting can be configured with Payload Adapters (PLA) and Payload Separation Systems (PSS) to accommodate various spacecraft interfaces. Unique interface requirements can be accommodated by modifying existing designs as required. Selection of an appropriate PAF or PLA should be coordinated with the United Launch Alliance (ULA) Customer Program Office as early as possible. For further details, contact the ULA Customer Program Office.

5.1 HERITAGE DESIGN PHILOSOPHY

Delta IV PAFs and ULA PLAs are based on heritage designs that have been developed and qualified by ULA for the Delta and Atlas launch vehicles. This approach offers several advantages, primarily in reducing development time and costs for new attach fittings. Additionally, ULA has significant experience providing physical verification services for checkout of interfacing payload and launch vehicle hardware. Physical verifications of interfacing hardware can be implemented to provide early risk mitigation for first-of-a-kind payloads or to insure repeated success of re-flight payloads with the Delta IV Launch Vehicle.

5.1.1 Payload Attach Fitting Design

The Delta IV PAFs utilize a structural design developed and successfully qualified on the heritage Delta programs. This design has evolved from a demand for a lighter weight structure with minimal part count. Some of the key features are:

- A high-modulus graphite-epoxy/foam core sandwich construction for the conic shell
- One-piece aluminum rings at each end for interfaces to the 2nd stage and payload
- Efficient double-splice lap joints to join end rings to the conic shell
- A high-modulus graphite-epoxy/foam core sandwich diaphragm structure that provides a barrier to the 2nd stage

This design is adapted easily to accommodate different interface diameters and payload sizes simply by adding a PLA configuration as referenced in Section 5.3.3. As a result, much of the secondary structure developed for a PAF or PLA is adaptable readily to another.

The PAF for the Evolved Expendable Launch Vehicle (EELV) missions utilizing a 5-m metallic fairing adopts a different heritage design. This PAF makes use of a heritage truss structure designed, developed, and flown by Boeing Space Structures in Kent, Washington. The design's extensive use of advanced composites, lightweight materials, and bonded structures fits well with the key objectives for this particular PAF.

5.1.2 Payload Adapter and Separation System Design

The ULA PLAs utilize a structural design developed and successfully qualified on heritage ULA launch vehicles. Some of the key features are:

- Fully configurable modular design to accommodate mission unique interface requirements
- Aluminum monocoque design structure
- Separating interface designs

The Delta product line has extensive flight experience with both Marmon-type clampbands and discrete bolted-interface separation systems. Previous Delta vehicles have developed and flown Marmon-type clampbands over a broad range of diameters from 229 mm (9 in.) to 1666 mm (66 in.). In addition, ULA has successfully employed a separation bolt with release-nut system on various missions. For each type of interface, redundant pyrotechnic devices enable spacecraft separation from the launch vehicle. Separation is achieved through the actuation of separation springs. Locations and quantities of these springs can be tailored to suit each customer's needs.

5.2 DELTA IV PAYLOAD ATTACH FITTINGS

The Delta IV program offers several PAFs for use with 4-m and 5-m payload fairings, as shown in Figure 5-1. Each PAF is designated by its payload interface diameter in millimeters, followed by a dash and the corresponding fairing diameter in meters. All PAFs are designed with electrical interfaces to accommodate specific customer requirements.

Sections 5.2.1 through 5.2.4 describe the available PAFs in detail, including dimensional drawings. Figure 5-2 applies to the various PAF configuration drawing notes that accompany this section.

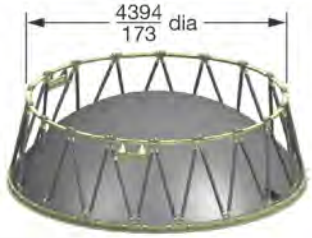
Model/ Mass	Note: All dimensions are in $\frac{mm}{in.}$	Separation Mechanism	Features
Delta IV 1575-4 PAF 240 kg/ 530 lb		120 or 121 bolts in a $\frac{1575}{62}$ dia bolt circle	1575 mm (62.010 in.) bolted interface. EELV Medium Launch Vehicle/Intermediate Launch Vehicle MLV/ILV standard interface. Height: 1104.6 mm (43.49 in.)
Delta IV 1575-5 PAF 418 kg/ 921 lb		120 or 121 bolts in a $\frac{1575}{62}$ dia bolt circle	1575 mm (62.010 in.) bolted interface. EELV MLV/ILV standard interface. Height: 1807.4 mm (71.16 in.)
Delta IV 4293-5 PAF 1221 kg/ 2699 lb		24 bolts in a $\frac{4293}{169}$ dia bolt circle	4293 mm (169 in.) bolted 3 point interface. Height: 2041.1 mm (80.37 in.)
Delta IV 4394-5 PAF 385 kg/ 848 lb		72 bolts in a $\frac{4394}{173}$ dia bolt circle	4394 mm (173 in.) bolted 18 point interface. Standard only for 5-m metallic fairing. Height: 1579.6 mm (62.19 in.) ULAD0501

Figure 5-1. Delta IV Payload Attach Fittings

1. Interpret dimensional tolerance symbols in accordance with American National Standards Institute (ANSI) Y14.5M-1982. The symbols used in this section are as follows:	
Flatness	⏥
Circularity	○
Parallelism	//
Perpendicularity (squareness)	⊥
Angularity	∠
Circular runout	↗
Total runout	⌰
True position	⊕
Concentricity	◎
Profile of a surface	⌓
Diameter	⌀
2. Unless otherwise specified, tolerances are as follows:	
Decimal	
mm	0.X = ±0.7 0.XX = ±0.25
in.	0.XX = ±0.03 0.XXX = ±0.010
Angles	= ±0 deg 30 min
3. Dimensions apply at 69°F (20°C) with interface in unrestrained condition	
4. All machine surface roughness is √125 per ANSI B46.1, 1985	
5. The V-block/PAF mating surface is chemically conversion-coated per MIL-C-5541, Class 3	

Figure 5-2. Notes Used in Configuration Drawings

5.2.1 1575-4 (62 in.) Payload Attach Fitting (PAF)

The 1575-4 PAF (Figure 5-3) provides a standard 120- or 121-bolt mating interface to the payload at a diameter of 1575 mm (62.01 in.) and uses a 4-m Composite Payload Fairing.

The fixed interface is intended to mate with a customer-provided separation system and/or payload adapter. Should the customer require ULA to provide either the separation system or payload adapter, this can be arranged by contacting ULA.

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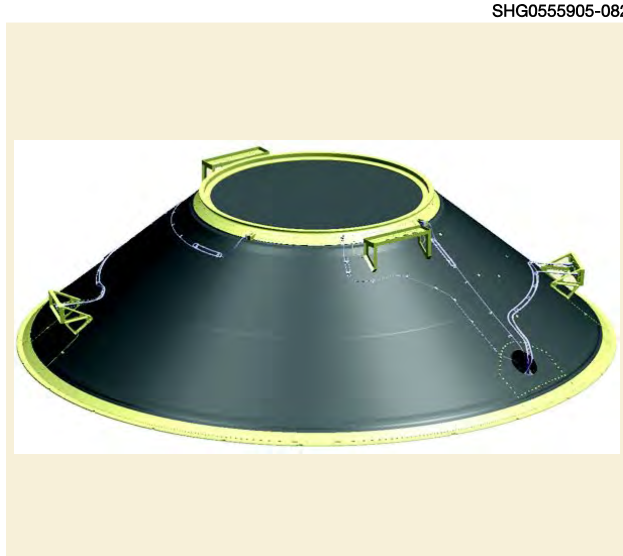

Figure 5-3. 1575-4 (62 in.) Payload Attach Fitting (PAF)

The 1575-4 PAF has a total of nine electrical connectors at two fixed locations. The connectors have the ability to provide prelaunch spacecraft power and monitoring, as well as discrete commands, telemetry, and ordnance during ascent. Figure 5-4 shows the capability of the 1575-4 PAF in terms of integrated payload stack mass and center-of-gravity (CG) location above the forward interface of the PAF. Figures 5-5 through 5-9 show PAF and SC interface details.

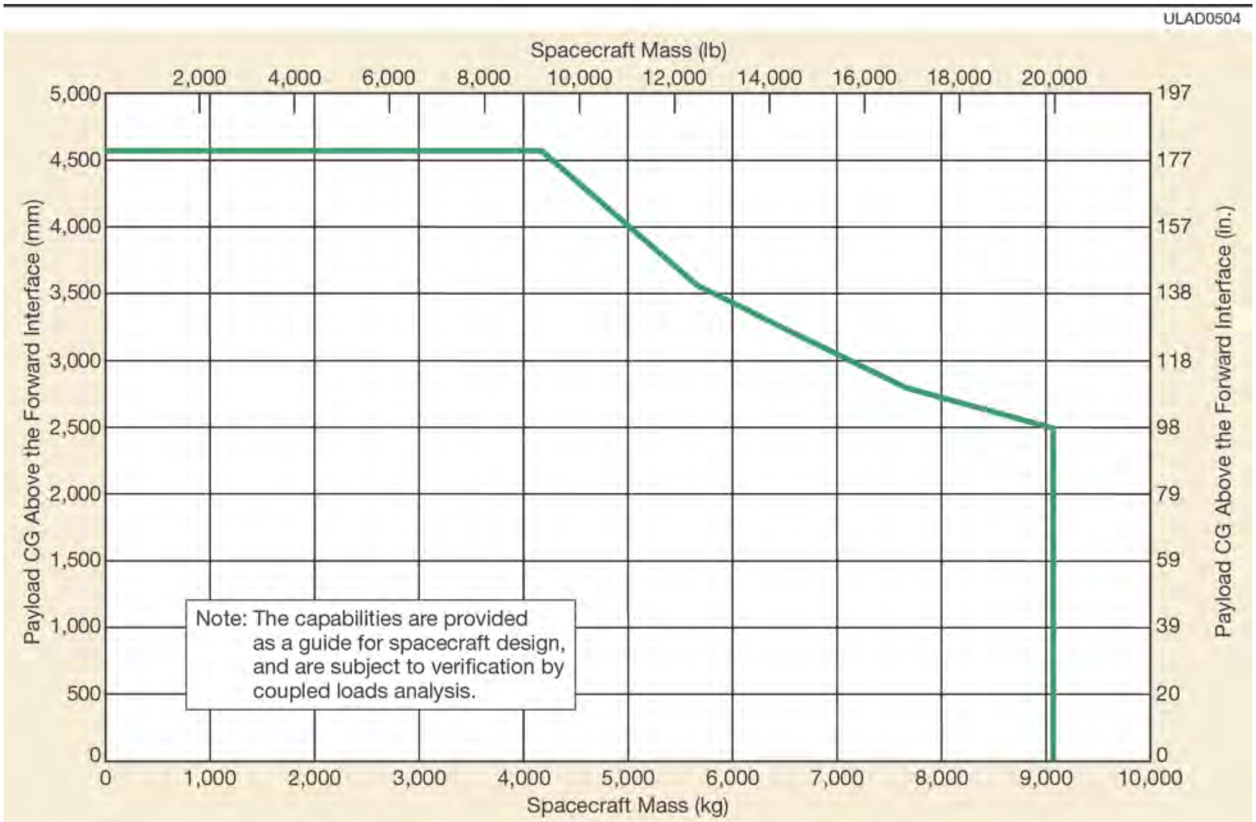

Figure 5-4. 1575-4 PAF Structural Capability

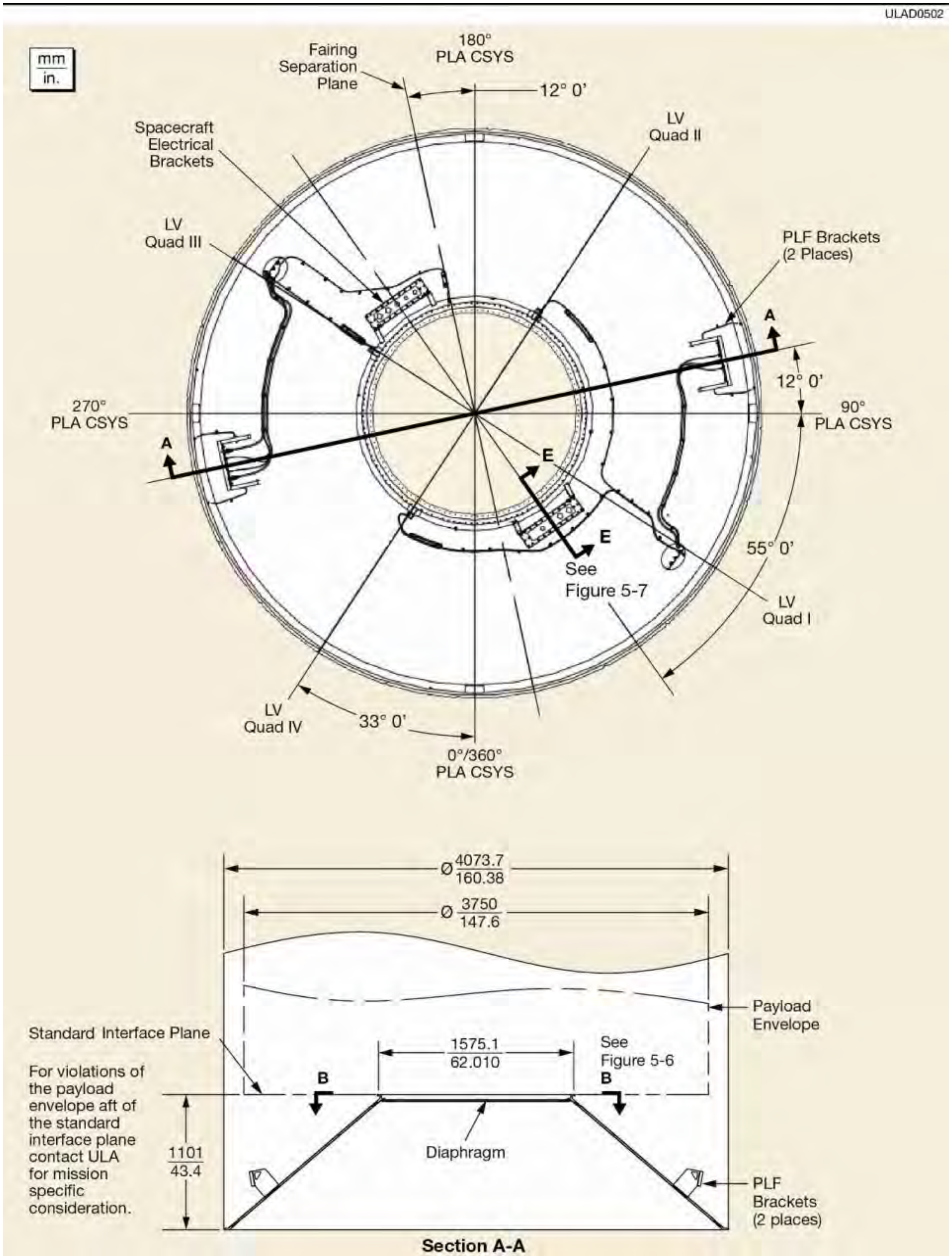

Figure 5-5. 1575-4 PAF Detailed Assembly

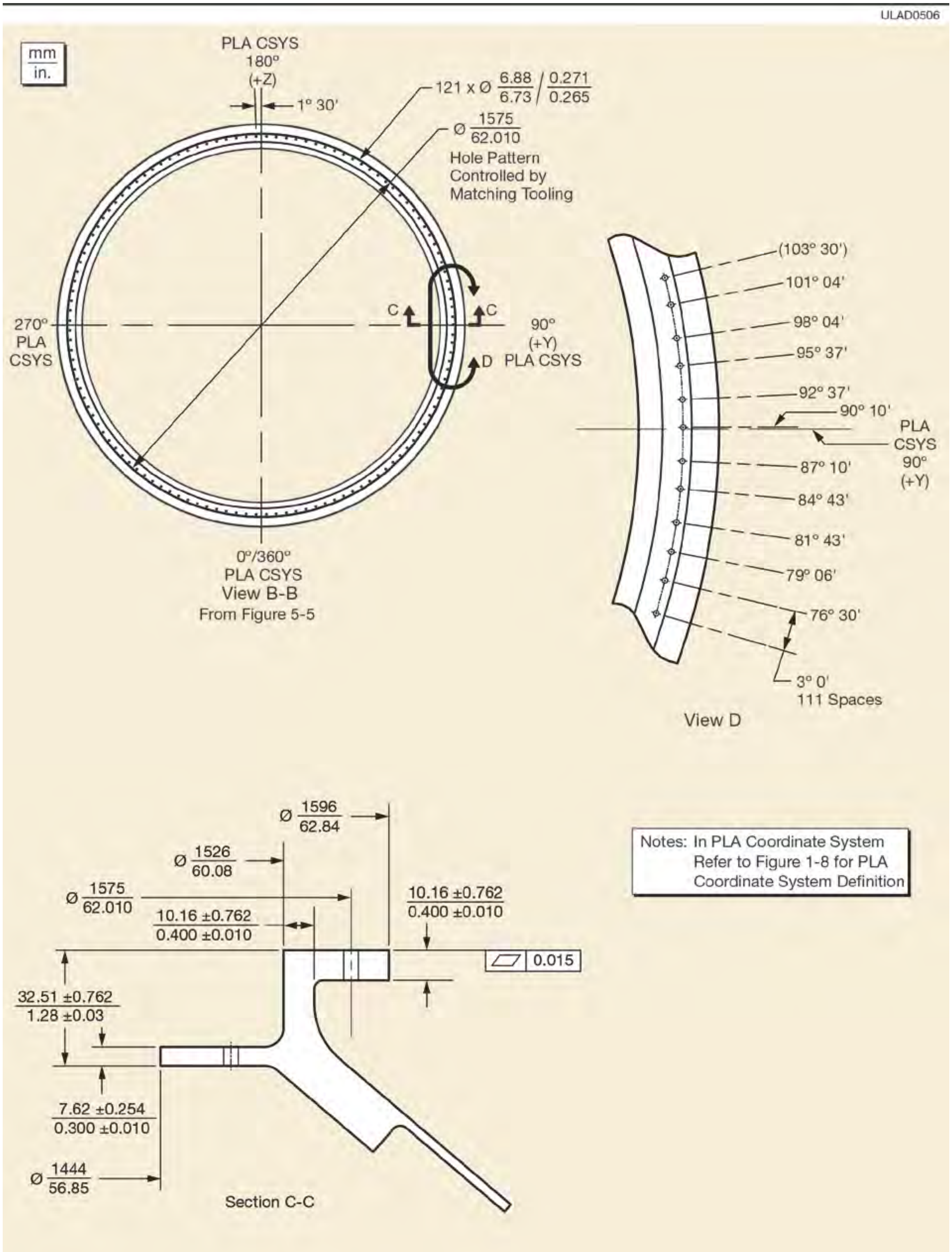

Figure 5-6. 1575-4 PAF Detailed Dimensions

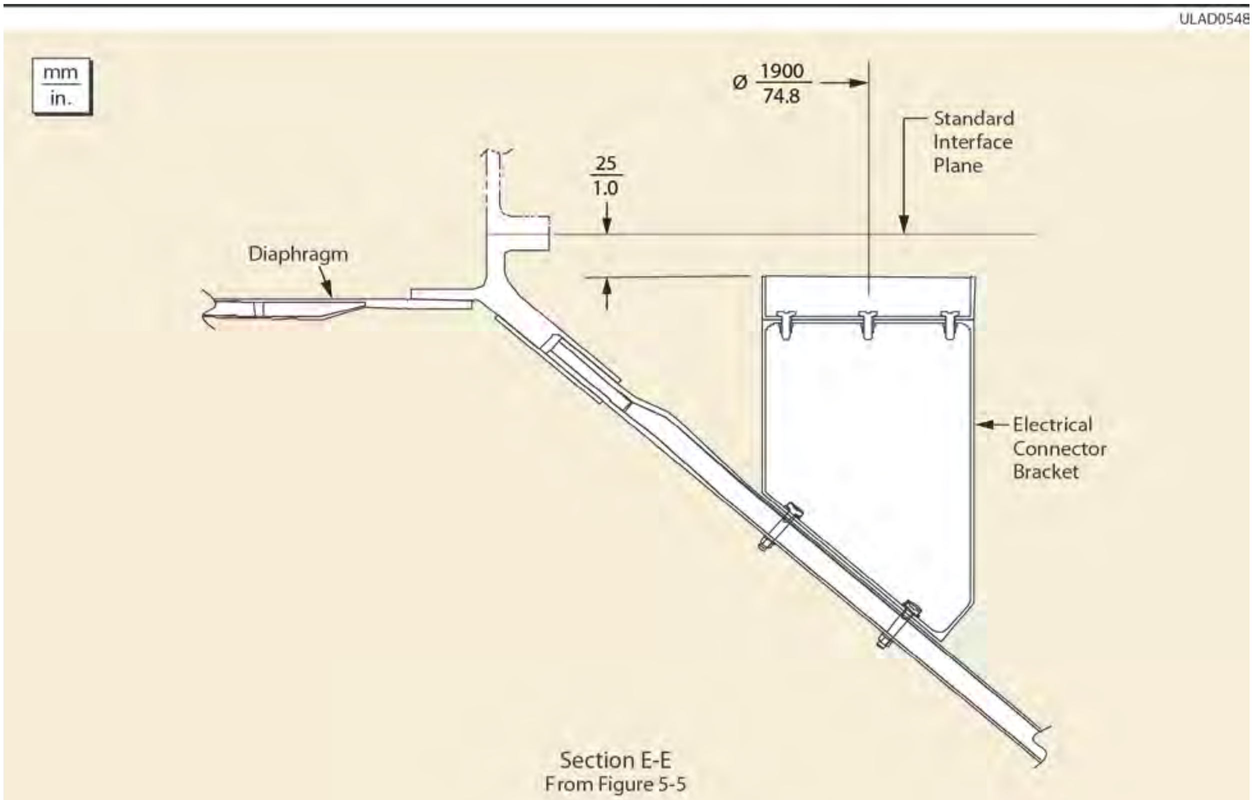

Figure 5-7. 1575-4 PAF Electrical Connector Bracket (2 places)

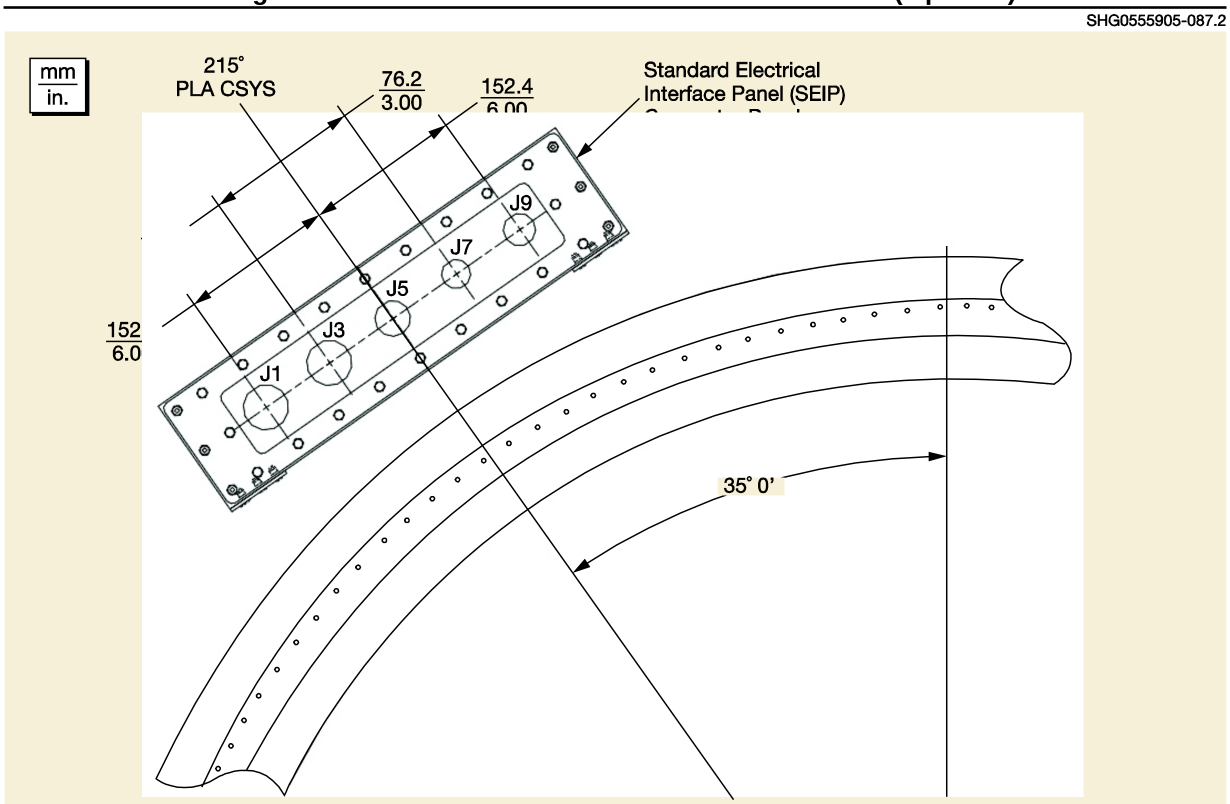

Figure 5-8. 1575-4 PAF Electrical Connector Bracket Detail (215 deg PLA CSYS)

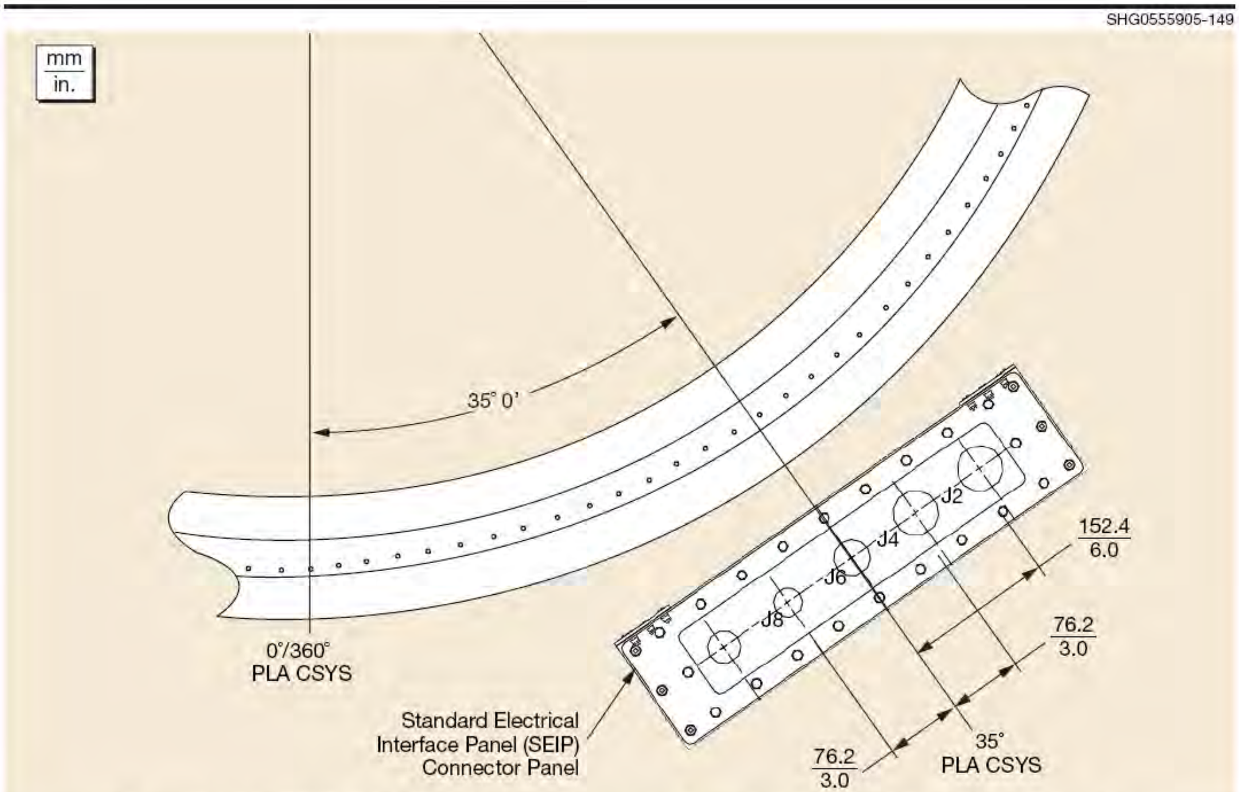

Figure 5-9. 1575-4 PAF Electrical Connector Bracket Detail (35 deg PLA CSYS)

5.2.2 1575-5 (62 in.) Payload Attach Fitting (PAF)

The 1575-5 PAF (Figure 5-10) provides a standard 120- or 121-bolt mating interface to the payload at a diameter of 1575 mm (62.01 in.) and uses a 5-m composite payload fairing.

The fixed interface is intended to mate with a customer-provided separation system and/or payload adapter. Should the customer require ULA to provide either the separation system or payload adapter, this can be arranged by contacting the ULA Customer Program Office.

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Figure 5-10. 1575-5 PAF

The 1575-5 PAF has a total of nine electrical connectors at two fixed locations. The connectors have the ability to provide prelaunch spacecraft power and monitoring, as well as discrete commands, telemetry, and ordnance during ascent.

Figure 5-11 shows the capability of the 1575-5 PAF in terms of integrated payload stack mass and CG location above the forward interface of the PAF. Figures 5-12 through 5-16 show PAF and SC interface details.

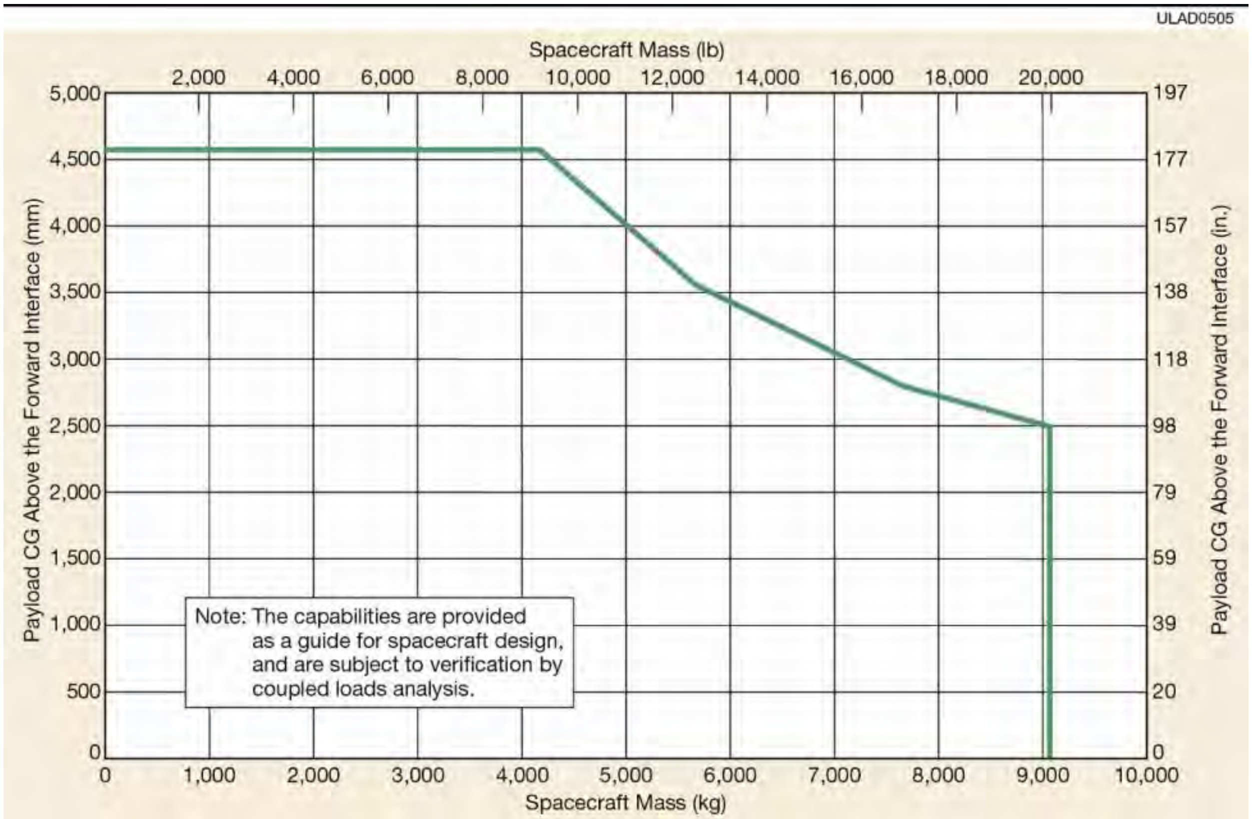

Figure 5-11. 1575-5 PAF Structural Capability

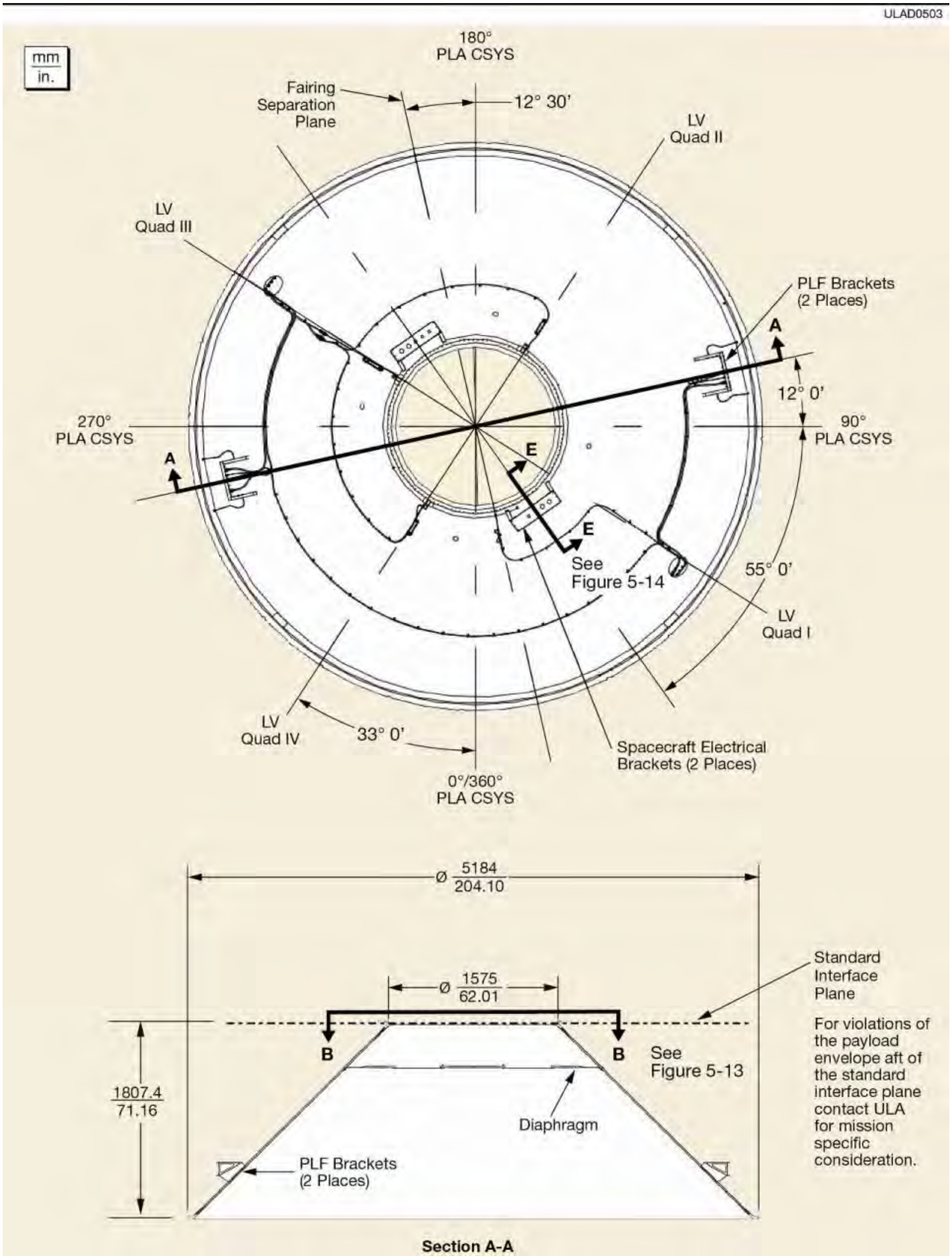

Figure 5-12. 1575-5 PAF Detailed Assembly

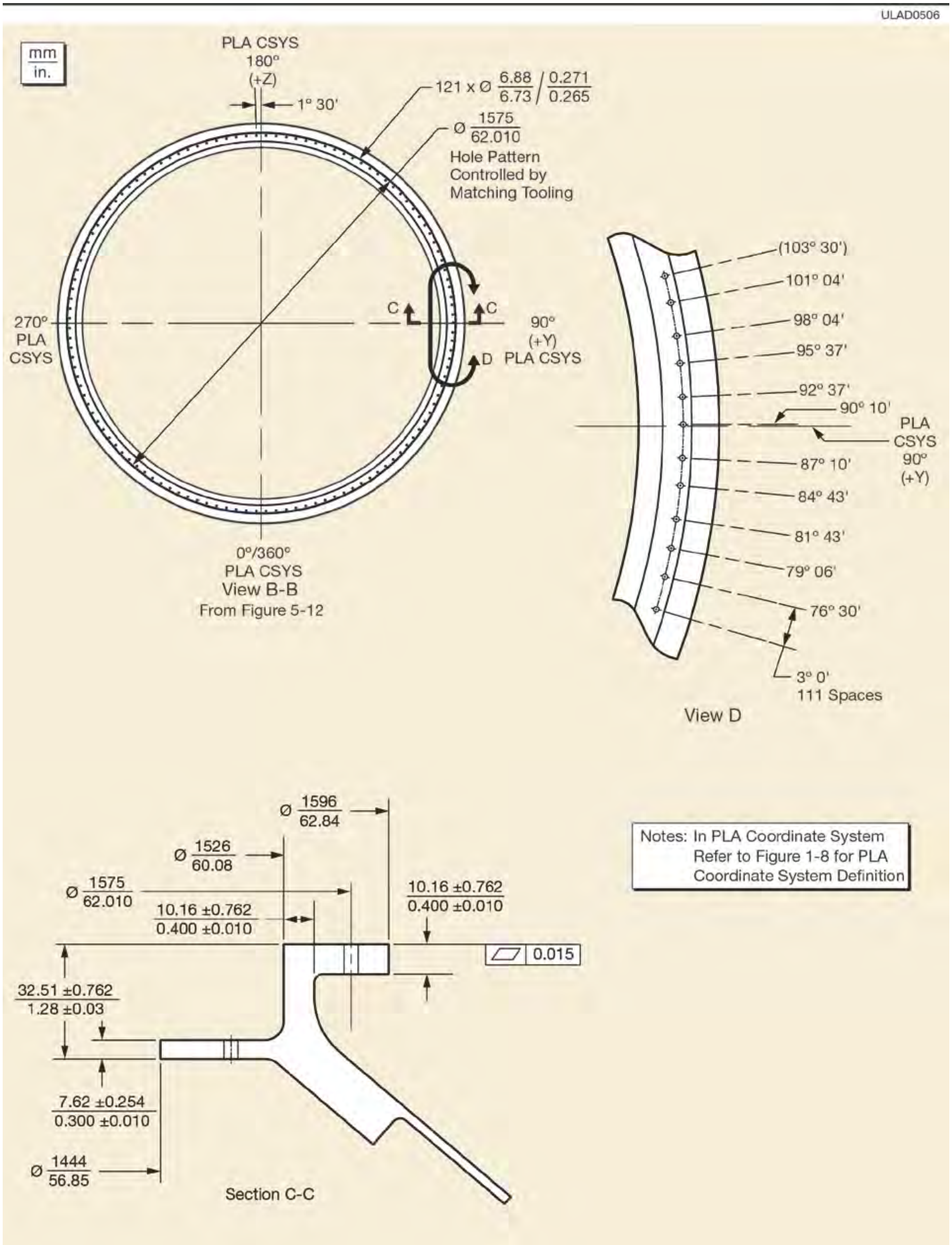

Figure 5-13. 1575-5 PAF Detailed Dimensions

ULAD0549

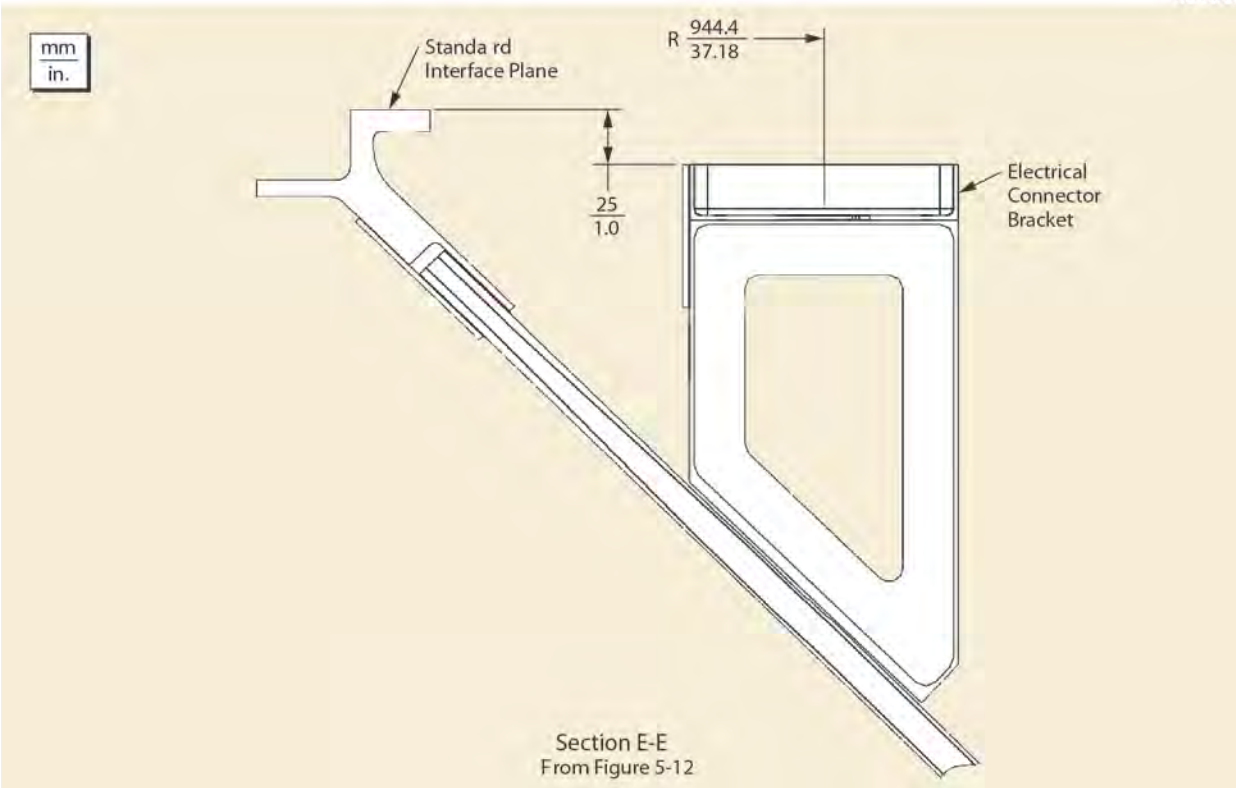

Figure 5-14. 1575-5 PAF Electrical Connector Bracket (2 places)

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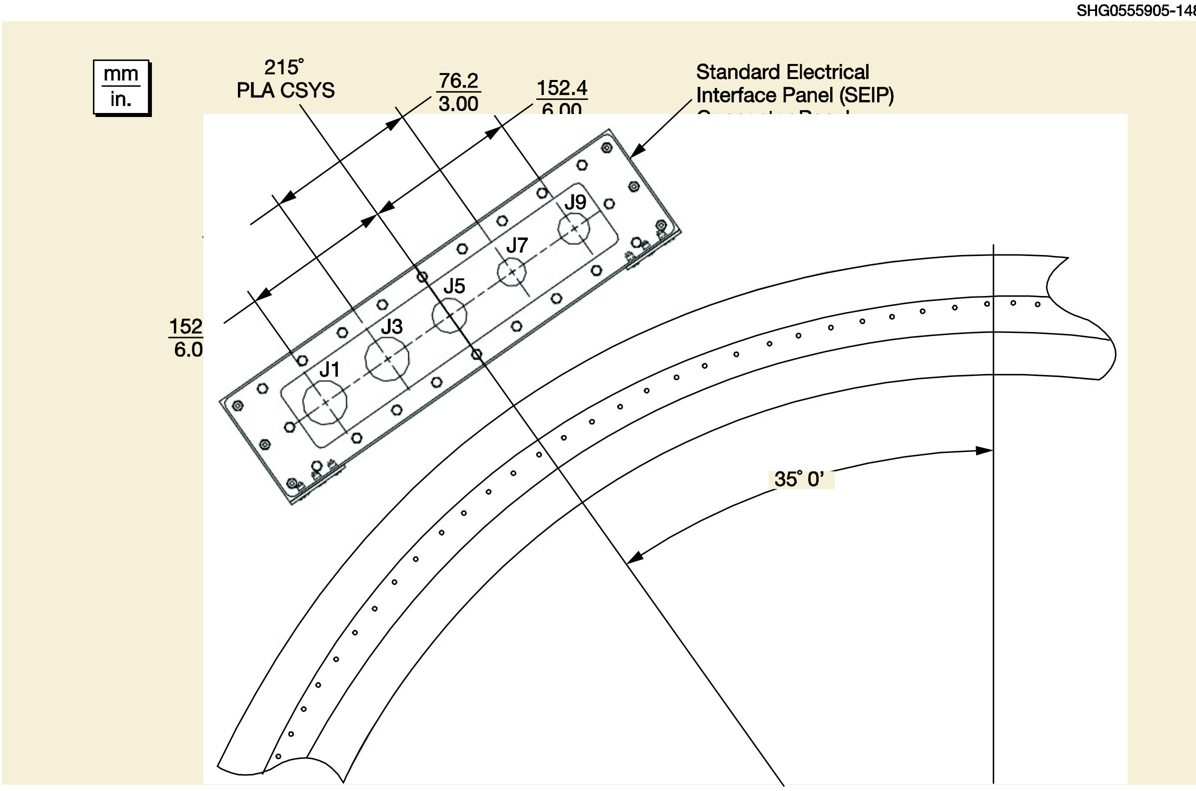


Figure 5-15. 1575-5 PAF Electrical Connector Bracket Detail (215 deg PLA CSYS)

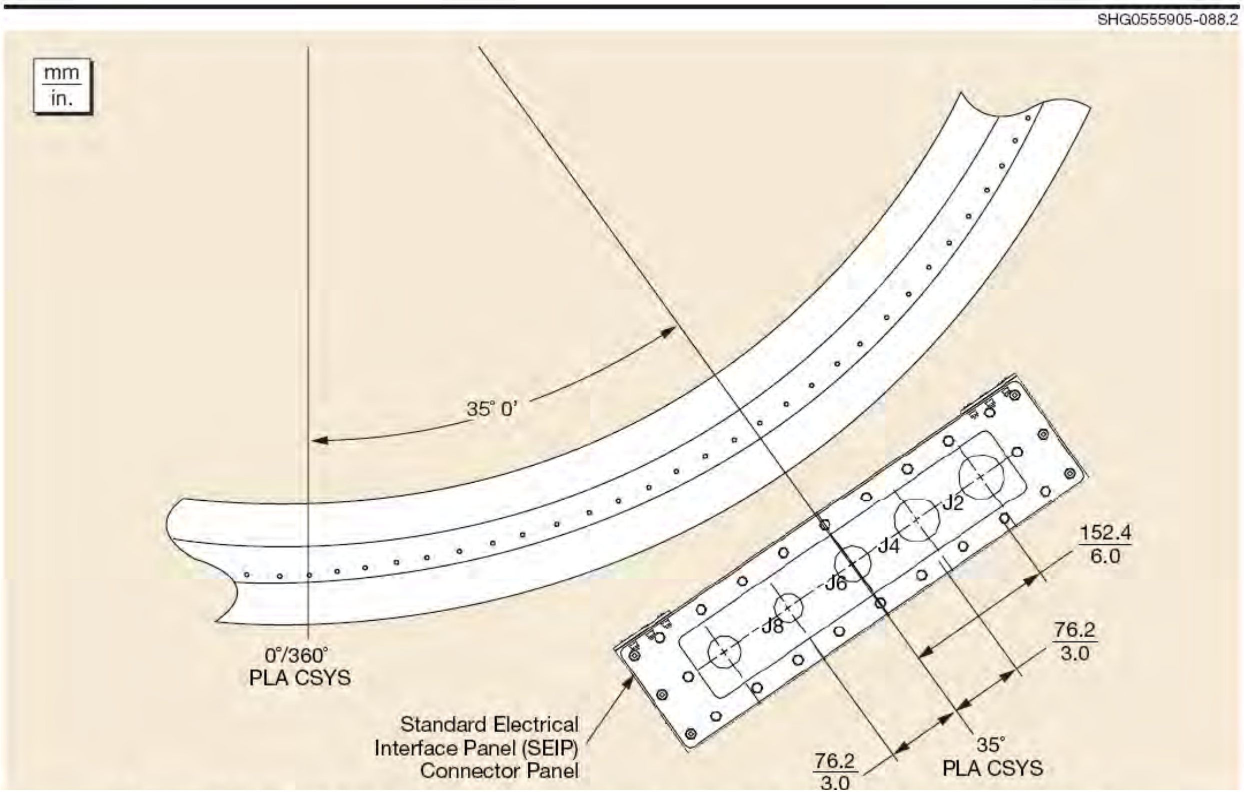


Figure 5-16. 1575-5 PAF Electrical Connector Bracket Detail (35 deg PLA CSYS)

5.2.3 4293-5 (169 in.) Payload Attach Fitting (PAF)

The 4293-5 PAF (Figure 5-17) provides a payload interface at a diameter of 4293 mm (169 in.) and uses a 5-m composite payload fairing.

The fixed interface mates with a customer-provided separation system and/or payload adapter. Should the customer require ULA to provide either the separation system or payload adapter, this can be arranged by contacting the ULA Customer Program Office.

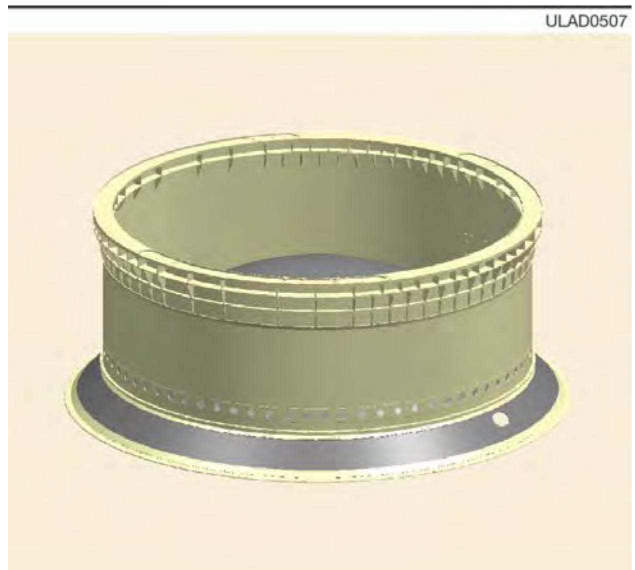


Figure 5-17. 4293-5 PAF

The 4293-5 PAF can accommodate several electrical connectors at a single fixed location. The connectors have the ability to provide prelaunch spacecraft power and monitoring, as well as discrete commands, telemetry, and ordnance during ascent.

The 4293-5 PAF is designed for heavy payload class missions. Its capability is highly dependent on the interface attach method and the vehicle and payload weights used to generate load factors. The full capability is dependent on the required customer interface and the vehicle coupled loads analysis. Contact ULA for capabilities matching specific payload configuration needs. Figure 5-18 shows details of this PAF.

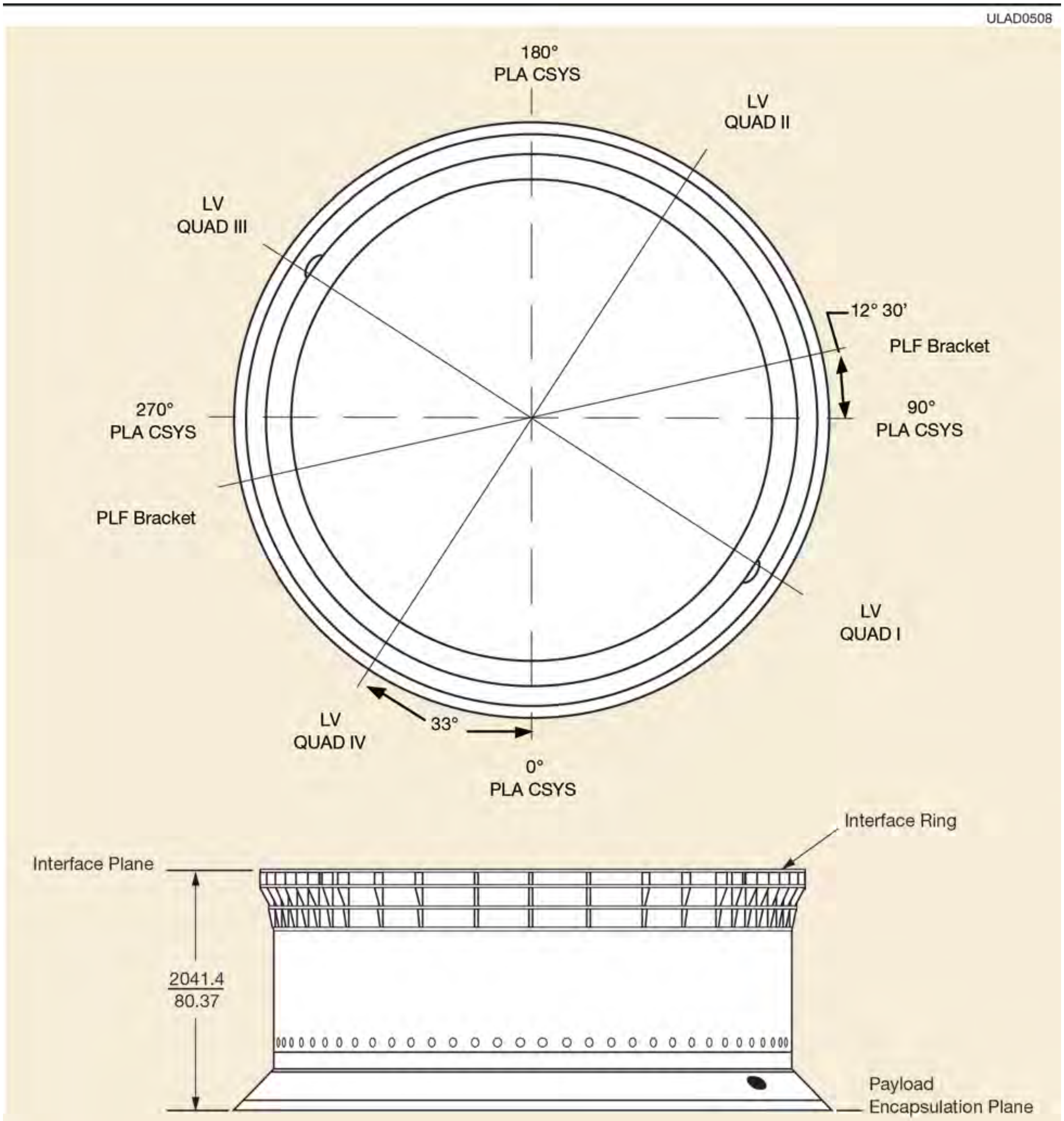


Figure 5-18. 4293-5 PAF Detailed Assembly

5.2.4 4394-5 (173-in.) Payload Attach Fitting (PAF)

The 4394-5 PAF (Figure 5-19) provides an 18-point, 72-bolt interface pattern with a 4394 mm (173 in.) diameter interface and uses a 5m metallic fairing. The 4394-5 PAF incorporates a truss structure design, which offers a higher stiffness-to-weight ratio for the larger interface diameter.

Figure 5-20 shows the capability of the 4394-5 PAF in terms of integrated payload stack mass and CG location above the forward interface of the PAF. Figures 5-21 and 5-22 show PAF details. SC interface details are highly dependent on Customer requirements. Contact ULA for capabilities matching specific payload configuration needs.

Figure 5-19. 4394-5 PAF

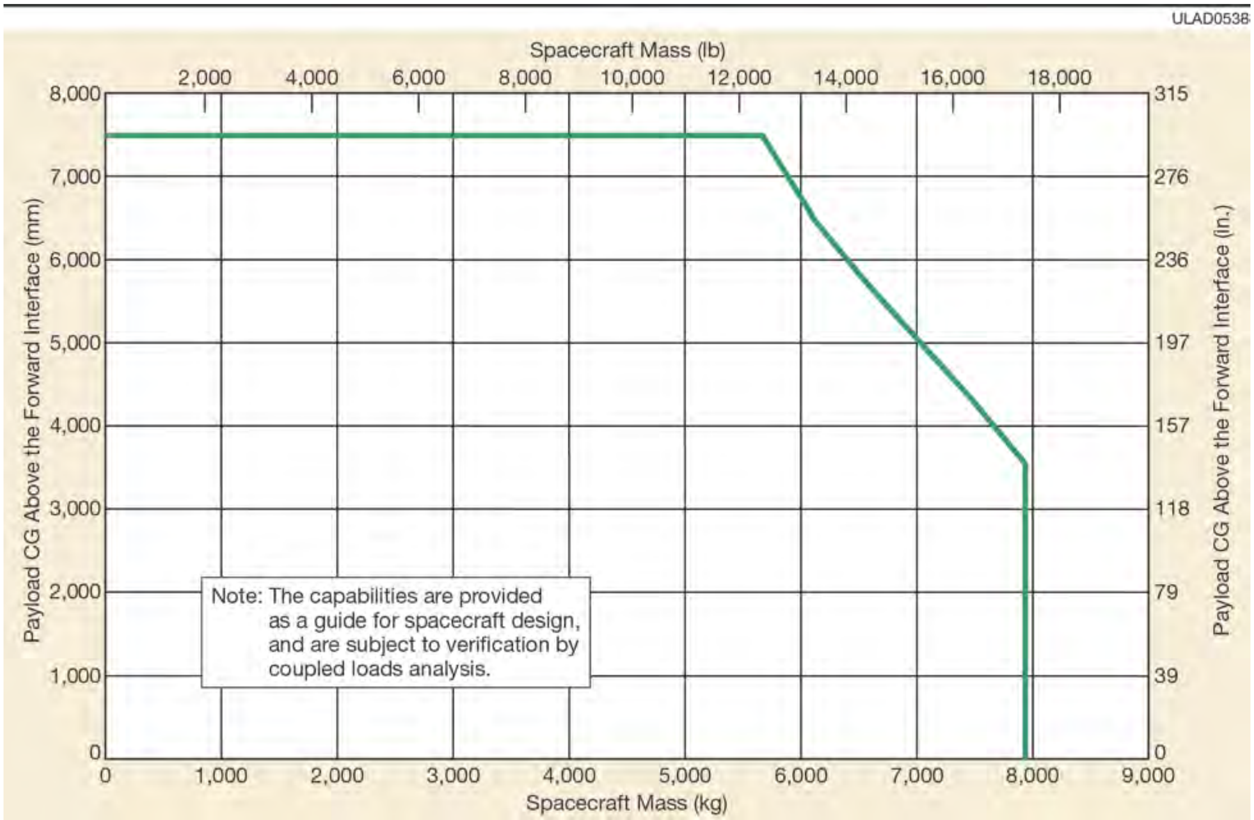


Figure 5-20. 4394-5 PAF Structural Capability

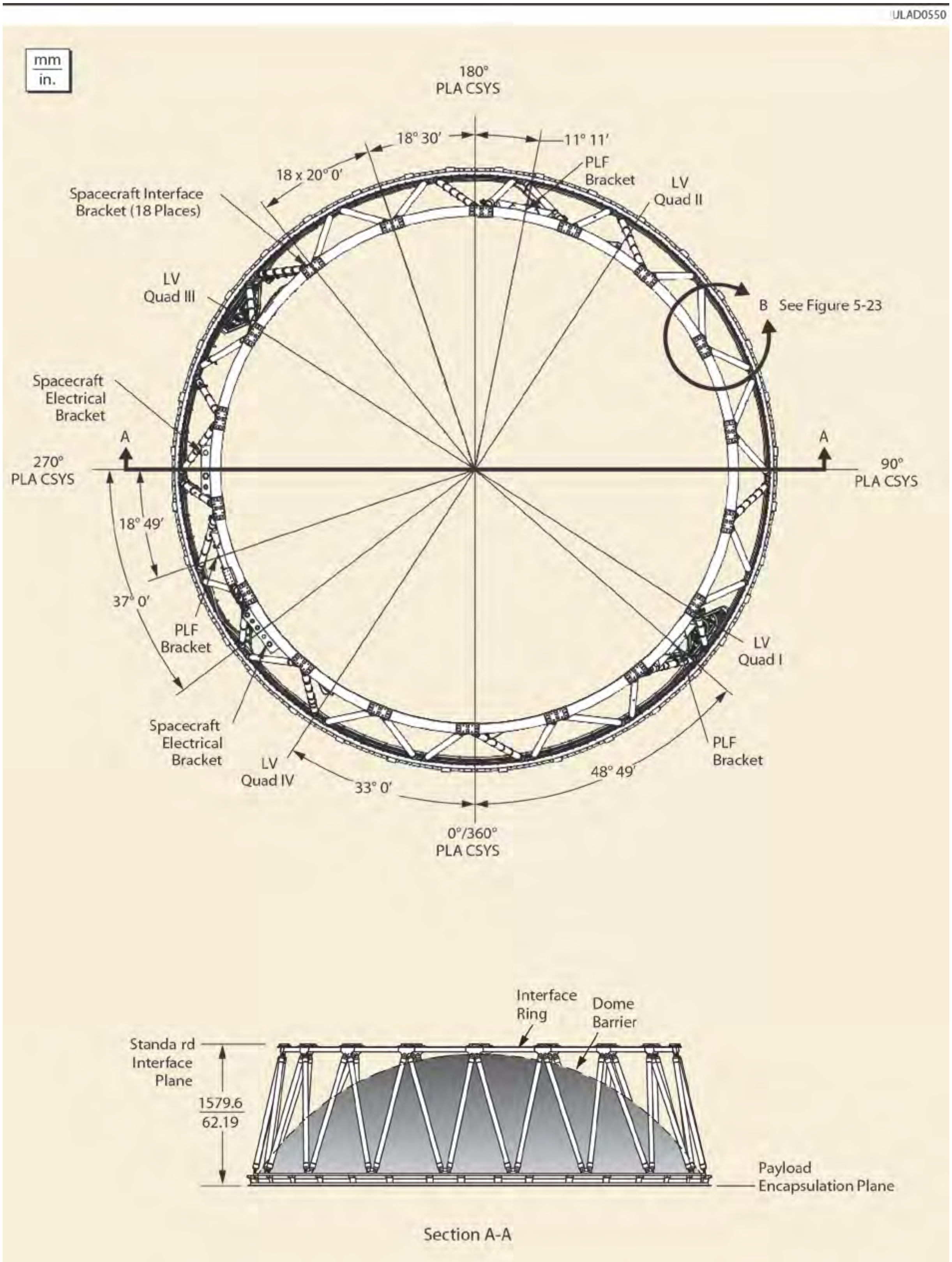


Figure 5-21. 4394-5 PAF Detailed Assembly

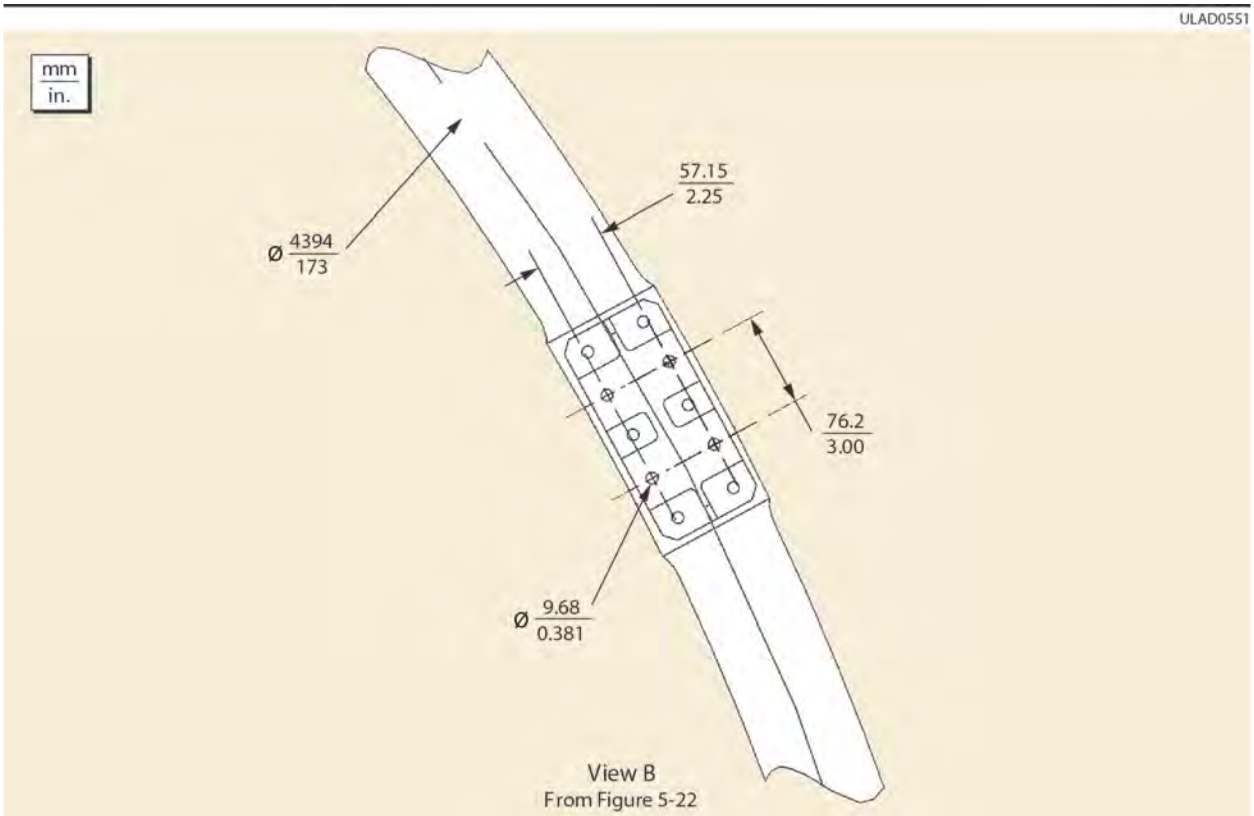


Figure 5-22. 4394-5 PAF Detailed Dimensions

5.3 PAYLOAD ADAPTERS AND PAYLOAD SEPARATION SYSTEMS

The ULA common payload adapter and separation system interface designs meet the requirements of currently defined SC and offer the flexibility to adapt to mission unique needs. These components are designed to provide mechanical and electrical interfaces required by the SC and to provide a suitable environment during integration and launch activities. The interface information in the following sections should be used only as a guideline. Modifications to these systems may be accommodated on a mission unique basis.

The Interface Control Document (ICD) governs ultimate control of interface information for a given mission. Section 4 discusses how the ICD is developed and maintained during the mission integration process.

Payload interface options include a 120- or 121-place bolted interface forward of the Standard Interface Plane (SIP) to increase SC station height, a bolted interface forward of the SIP that adds the ability to manifest secondary payloads, a four-point explosive-bolt separating interface, and multiple standard payload adapter configurations. Figure 5-23 summarizes these SC interface options. The following sections describe these mechanical interfaces in detail.

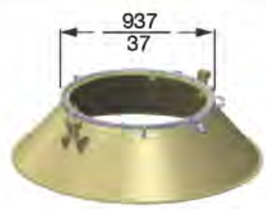
Model/ Mass	Note: All dimensions are in mm/in.	Separation Mechanism	Features
C Adapters: C8, C9, C13, C15, C19, C22 C25, C29, C44 13.9-68.4 kg/ 30.6-150.9 lb		Not applicable; non-separating; bolted interface	Integrally machined cylindrical aluminum forging. Bolted interface: 120 or 121 fasteners. Height: 330.2 mm to 1117.6 mm (13 in. to 44 in.).
EELV Secondary Payload Adapter (ESPA) 136 kg/ 300 lb		381/15 dia Clampband (ESPA- ports only)	Integrally machined aluminum forging. Primary bolted interface: 120 or 121 fasteners. Six secondary payload interfaces. Secondary Bolted Interface: 24 fasteners. Secondary bolt circle diameter: 381.0 mm (15.00 in.). Height: 609.6 mm (24 in.).
A937 39.9 kg/ 88 lb		937/37 dia Clampband	Integrally machined aluminum forging. Forward Ring Diameter: 945.3 mm (37.215 in.). Low-shock Marmon-type clampband. Height: 406.4 mm (16.00 in.).
B1194 29.5 kg/ 65 lb		1194/47 dia Clampband	Integrally machined aluminum forging. Forward Ring Diameter: 1,215.0 mm (47.835 in.). Low-shock Marmon-type clampband. Height: 254 mm (10.00 in.)
D1666 27.7 kg/ 61 lb		1666/66 dia Clampband	Integrally machined aluminum forging. Forward Ring Diameter: 1,666.1 mm (65.594 in.). Low-shock Marmon-type clampband. Height: 330.2 mm (13.00 in.)
6915 93.0 kg/ 205 lb		Four Bolts and Separation Secondary Latch System or Springs	Integrally machined aluminum forging. Forward Ring Diameter: 1,742.2 mm (68.590 in.). Separation bolts released by redundantly-initiated explosive nuts. Four matched spring actuators. Height: 381 mm (15.0 in.). ULAD0562

Figure 5-23. ULA Payload Adapters

5.3.1 ULA Launch Vehicle Adapters

The Launch Vehicle Adapter (LVA), also known as a Type C Adapter, is a machined aluminum structure in a monocoque cylinder form. The forward and aft rings have an outer diameter of 1596 mm (62.84 in.) and a bolt circle diameter of 1575 mm (62.010 in.) and can contain 120 or 121 bolt holes to meet ULA SIP requirements or to allow proper mating with the payload separation rings. The nominal height of the LVA is 558.8 mm (44.00 in.) but this height may be varied from 203.2 mm (8.00 in.) to 1117.6 mm (44.00 in.) to meet mission unique requirements.

ULA C8, C9, C13, C15, C19, C22, C25, C29, and C44 LVA characteristics are summarized in Figure 5-24. The C-Adapter configuration is shown in Figure 5-25.

For customers that provide their own payload adapter and payload separation system, LVAs are available as a mission unique option. This allows the customer to raise the position of the SIP relative to the Launch Vehicle (LV) for additional clearance.

Construction Standard Height LVA	Integrally Machined Aluminum Construction
C8	203.2 mm (8.00 in.)
C9	228.6 mm (9.00 in.)
C13	330.2 mm (13.00 in.)
C15	384.8 mm (15.15 in.)
C19	485.14 mm (19.10 in.)
C22	558.8 mm (22 in.)
C25	634.9 mm (25 in.)
C29	736.3 mm (29 in.)
C44	1117.6 mm (44.00 in.)
Structural Capability	See Figure 5-26

Figure 5-24. ULA Launch Vehicle Adapters

5.3.1.1 Launch Vehicle Adapter Structural Capabilities. Allowable integrated payload stack mass and longitudinal centers of gravity for LVAs are shown in Figure 5-26. These integrated payload stack mass and CG capabilities were determined using generic SC interface ring geometry and quasi-static load factors. Actual SC design allowables may vary depending on interface ring stiffness and results of SC mission unique coupled loads analyses. Coordination with the ULA Customer Program Office is required to define appropriate structural capabilities for SC designs that exceed these generic allowables. Additional LVA structural capability or lighter weight adapters are available on a mission unique basis.

Figure 5-25. ULA Launch Vehicle C-Adapter

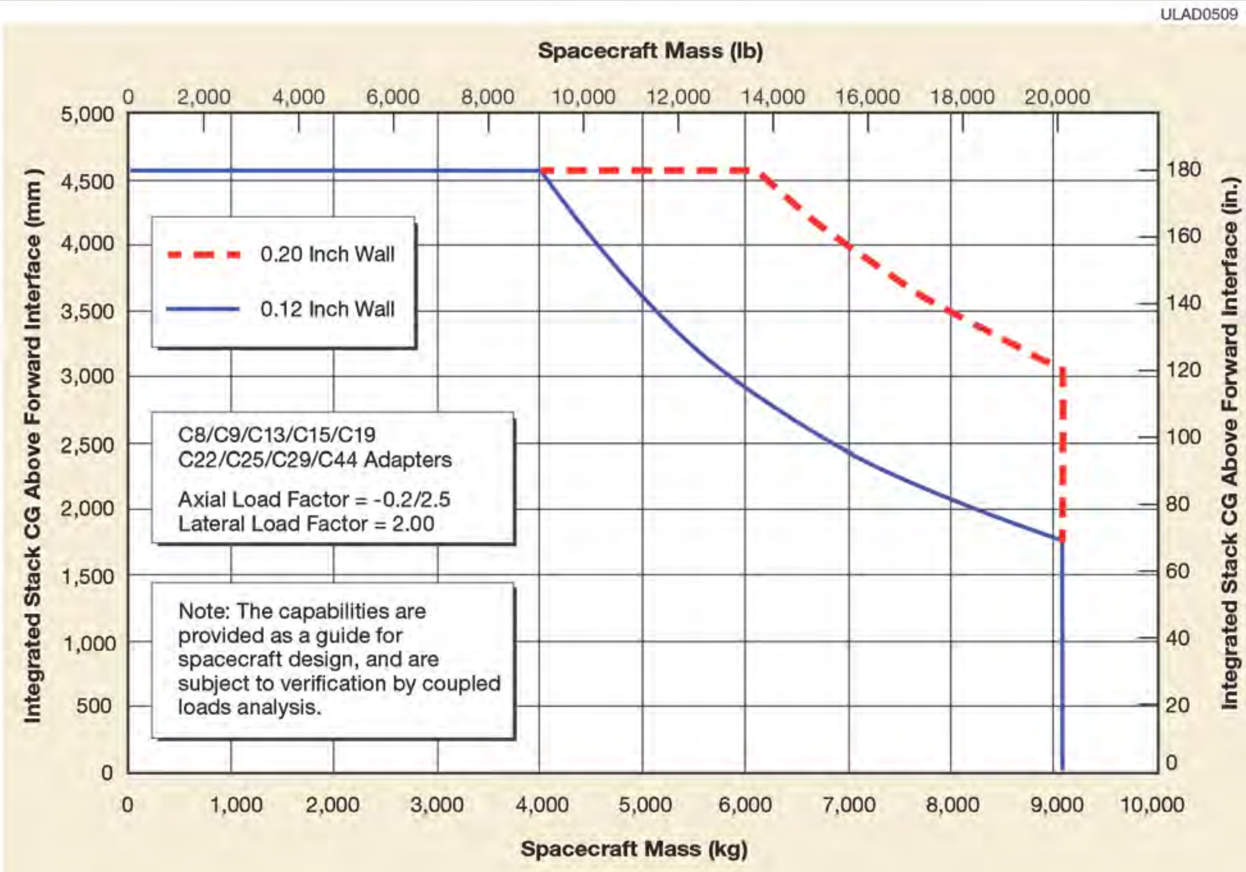


Figure 5-26. ULA Launch Vehicle Adapter Structural Capability

5.3.1.2 Launch Vehicle Adapter Interfaces. Figure 5-27 shows the configuration and dimensional requirements for ULA LVA interfaces. ULA-provided tooling controls the hole pattern for this interface. This tooling is available to customers for fabrication of matching hardware as a part of mission integration activities. Alternative hole patterns for this interface can be incorporated on a mission unique basis.

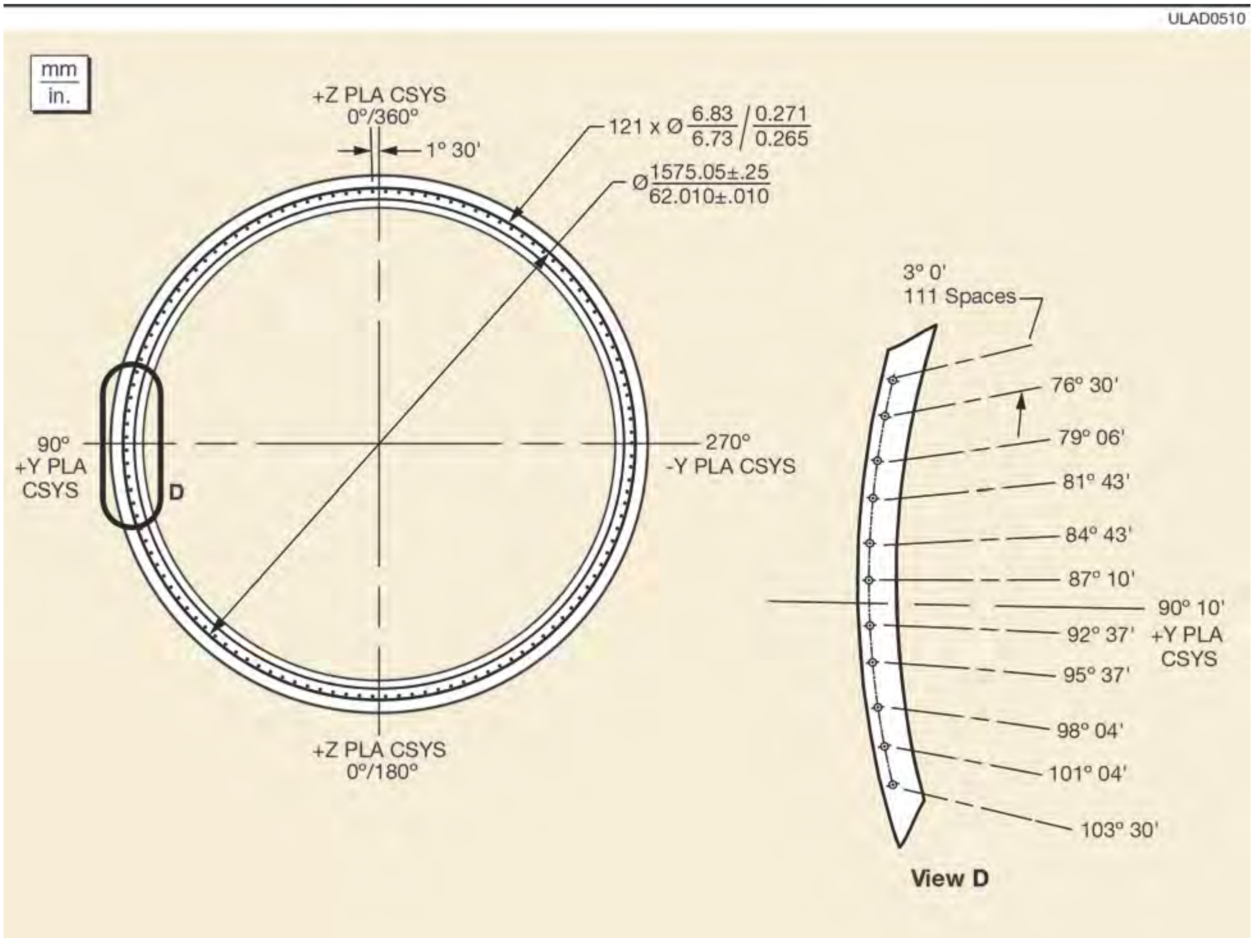


Figure 5-27. ULA Launch Vehicle Adapter Detailed Dimensions

5.3.2 EELV Secondary Payload Adapter (ESPA)

For missions with excess volume and mass margin available, secondary payloads can be launched using the EELV Secondary Payload Adapter (ESPA). The ESPA is a 1.5 m diameter, 61 cm tall ring structure that can support up to six secondary payloads around its circumference. Developed by the United States Air Force and CSA Engineering, the ESPA is mounted between the top of the 1575-4/5 PAF and the bottom of the spacecraft adapter (Figure 5-28), duplicating the EELV SIP and passing the electrical interfaces through to the primary payload.

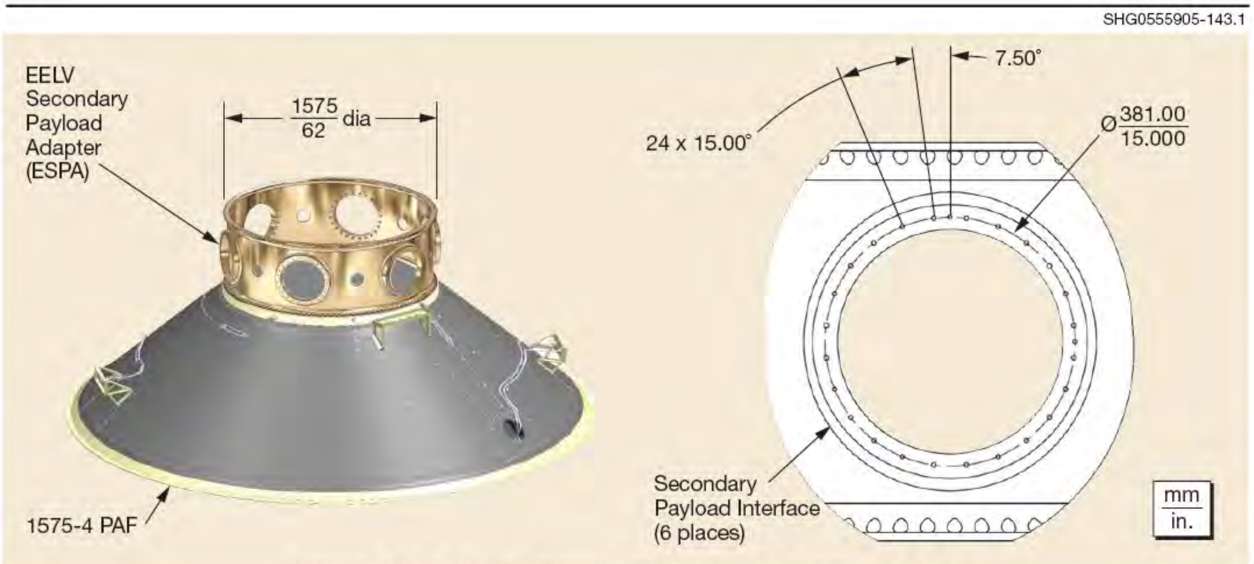


Figure 5-28. EELV Secondary Payload Adapter (ESPA)

The ESPA ring consists of six 381 mm (15 in.) diameter bolt circle interfaces, with each interface able to accommodate a single secondary payload of up to 181 kg (400 lbs) in mass and a volume of 61.0 cm x 71.1 cm x 96.5 cm (24 in. x 28 in. x 38 in.). Each secondary payload can be deployed via separation signal after the primary payload has been separated. Further information on the ESPA can be found at CSA Engineering's website: http://www.csaengineering.com/products-services/espa/.

Allowable integrated payload stack mass and longitudinal centers of gravity for ESPA are shown in Figure 5-29. These integrated payload stack mass and center-of-gravity capabilities were determined using generic SC interface ring geometry and quasi-static load factors. Actual SC design allowables may vary depending on interface ring stiffness and results of SC mission unique coupled loads analyses. Coordination with the ULA Customer Program Office is required to define appropriate structural capabilities for SC designs that exceed these generic allowables.

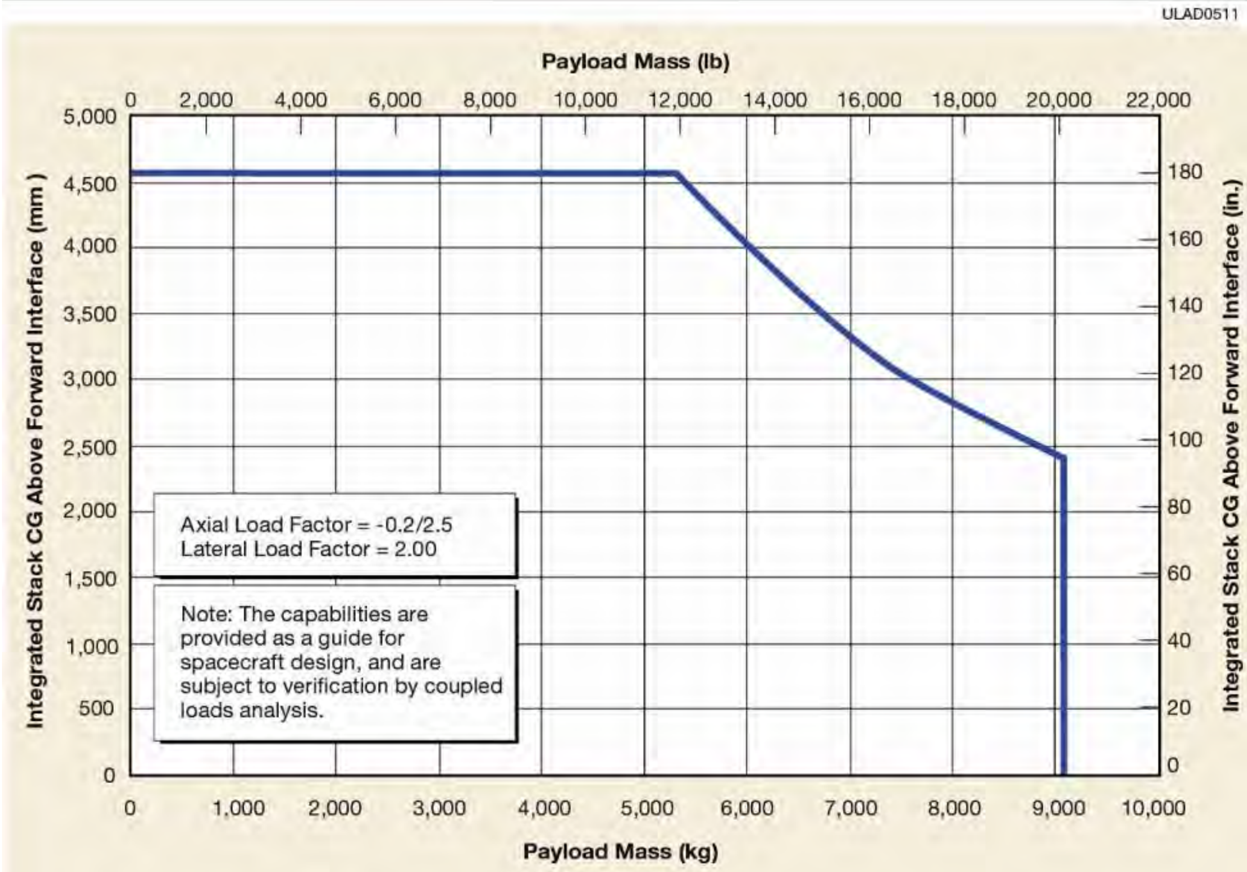


Figure 5-29. EELV Secondary Payload Adapter Structural Capability

5.3.3 ULA Payload Adapters

The ULA payload adapter designs can handle heavier SC to take advantage of the higher performance of the ULA vehicle. The available systems include the ULA Type A937, B1194, D1666, and 6915 payload adapters.

These payload adapters consist of three major components: the Payload Separation Ring (PSR), the LVA described in Section 5.3.1, and the Payload Separation System (PSS). A typical PLA is shown in Figure 5-30.

The PSR is a machined aluminum component in the form of a truncated cone. The forward ring forms the SC separation plane. The aft ring has an outer diameter of 1596 mm (62.84 in.) and a bolt circle diameter of 1575.06 mm (62.010 in). The PSR contains 120 evenly spaced bolt holes that allow it to be joined to the LVA. This symmetrical bolt hole pattern allows the payload separation ring and attached SC to be rotated relative to the LV in 3-degree increments to meet mission unique requirements. The PSR supports all hardware that directly interfaces with the SC, including the payload separation system, electrical connectors, and mission-unique options.

Figure 5-30. ULA Payload Adapter Configuration — PSR with LVA

5.3.4 Payload Separation System

ULA common payload adapters use a LV-provided, low-shock, Marmon-type clampband payload separation system. Figure 5-31 shows this separation system, which consists of a clampband set, release mechanism, and separation springs. The clampband set consists of a clampband for holding the SC and adapter rings together plus devices to catch and retain the clampband on the adapter structure after separation. The clampband includes aluminum clamp segments that hold the payload adapter and SC rings together and a single-piece aluminum retaining band that holds the clamp segments in place. The ends of the retaining band are held together by the low-shock Clampband Opening Device (CBOD). The CBOD includes release bolts that engage the ends of the clampband. These release bolts are threaded into a flywheel mechanism. During installation and flight, the flywheel is restrained against rotation by a restraining pin. For separation, a pyrotechnically activated pin-puller retracts this pin from the flywheel, allowing it to rotate and eject the release bolts. This separation system reduces shock compared to a conventional bolt-cutter system and is resettable, allowing the actual flight hardware to be tested during component and system acceptance testing.

Separation spring assemblies provide the necessary separation energy after the clampband is released. The spring assemblies are mounted to the payload adapter forward ring and bear on the SC aft ring. Positive SC separation is detected through continuity loops installed in the SC electrical connector and wired to the 2nd stage instrumentation for monitoring and telemetry verification.

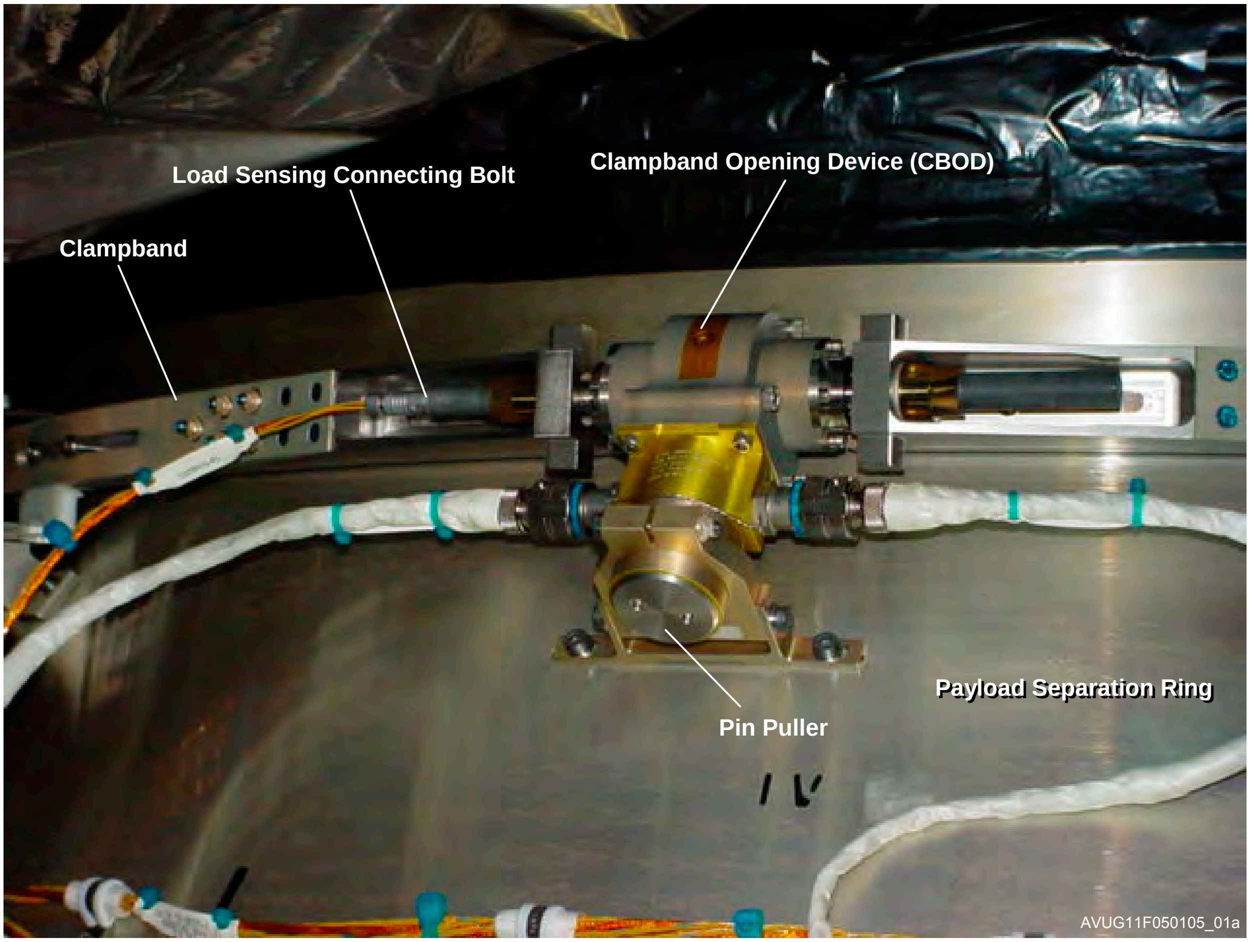


Figure 5-31. ULA Low-Shock Payload Separation System Configuration

5.3.5 Payload Adapters

5.3.5.1 Type A937 Payload Adapter. The ULA Type A937 payload adapter (Figure 5-32) design supports an SC with an aft ring diameter of 937 mm (37 in.). Figure 5-33 summarizes the major characteristics of this payload adapter.

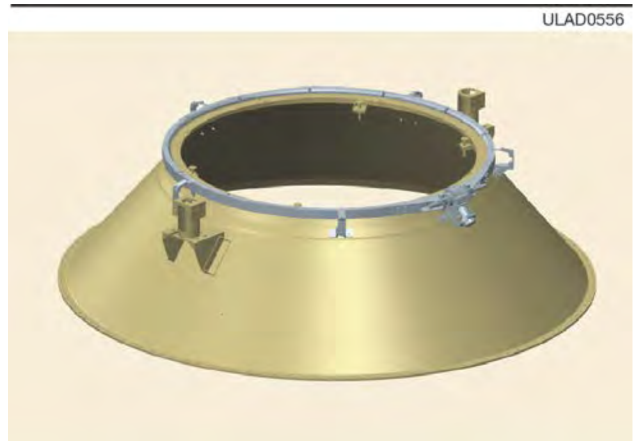


Figure 5-32. A937 PLA

The Type A937 payload adapter consists of two major sections: the payload separation ring (with separation system) and the LVA described in Section 5.3.1. The payload separation ring is a machined aluminum component in the form of a 406.4 mm (16 in.) high truncated cone. The forward ring has an outer diameter of 945 mm (37.215 in.) and forms the SC separation plane. The aft ring has an outer diameter of 1596 mm (62.84 in.) and contains 120 evenly spaced bolt holes that allow it to be joined to the LVA. This symmetrical bolt hole pattern allows the payload separation ring and attached SC to be rotated relative to the LV in 3-degree increments to meet mission unique requirements. The payload separation ring supports all hardware that directly interfaces with the SC, including the payload separation system, electrical connectors, and mission unique options.

5.3.5.1.1 Payload Separation System. The Type A937 payload adapter uses a LV-provided, Marmon-type clampband (937 mm diameter) payload separation system as described in detail in Section 5.3.4.

5.3.5.1.2 Payload Adapter Structural Capabilities. Allowable integrated payload stack mass and longitudinal centers of gravity for the Type A937 payload adapter/separation systems are shown in Figure 5-34. These integrated payload stack mass and center of gravity capabilities are determined using generic SC interface ring geometry as shown in Figures 5-38 and 5-39, and quasi-static load factors. Actual SC design allowables may vary depending on

Construction	Two-Piece, Integrally Machined Aluminum Construction
Structural Capability	See Figure 5-34
P/L Sep System	SS937S
Max Shock Levels	4,500 G
Clampband Preload — Installation	45.2 +0.5/ -0 kN (10,161 +112/-0 lb)
Clampband Preload — Flight	40.0 ± 0.5 kN (8,992 ± 112 lb)
Separation Springs	
Number	4, 6 or 8
Force per Spring — Max	1 kN (225 lb)

Figure 5-33. A937 PLA Characteristics

interface ring stiffness and results of SC mission-unique coupled loads analyses.

5.3.5.1.3 Payload Adapter Interfaces. The primary structural interface between the LV and SC occurs at the payload adapter forward ring. This ring interfaces with the SC aft ring. A payload separation system holds the two rings together for the structural joint and provides the release mechanism for SC separation. Electrical bonding is provided across all interface planes associated with these components. The payload adapter also provides mounting provisions for separation springs and supports interfacing components for electrical connectors between the LV and SC. Figures 5-35 through 5-39 show the interface requirements for these components. For more specific SC interface requirements, please contact ULA. Additional mission unique provisions, including SC purge provisions, SC range safety destruct units, and instrumentation, may be added as necessary.

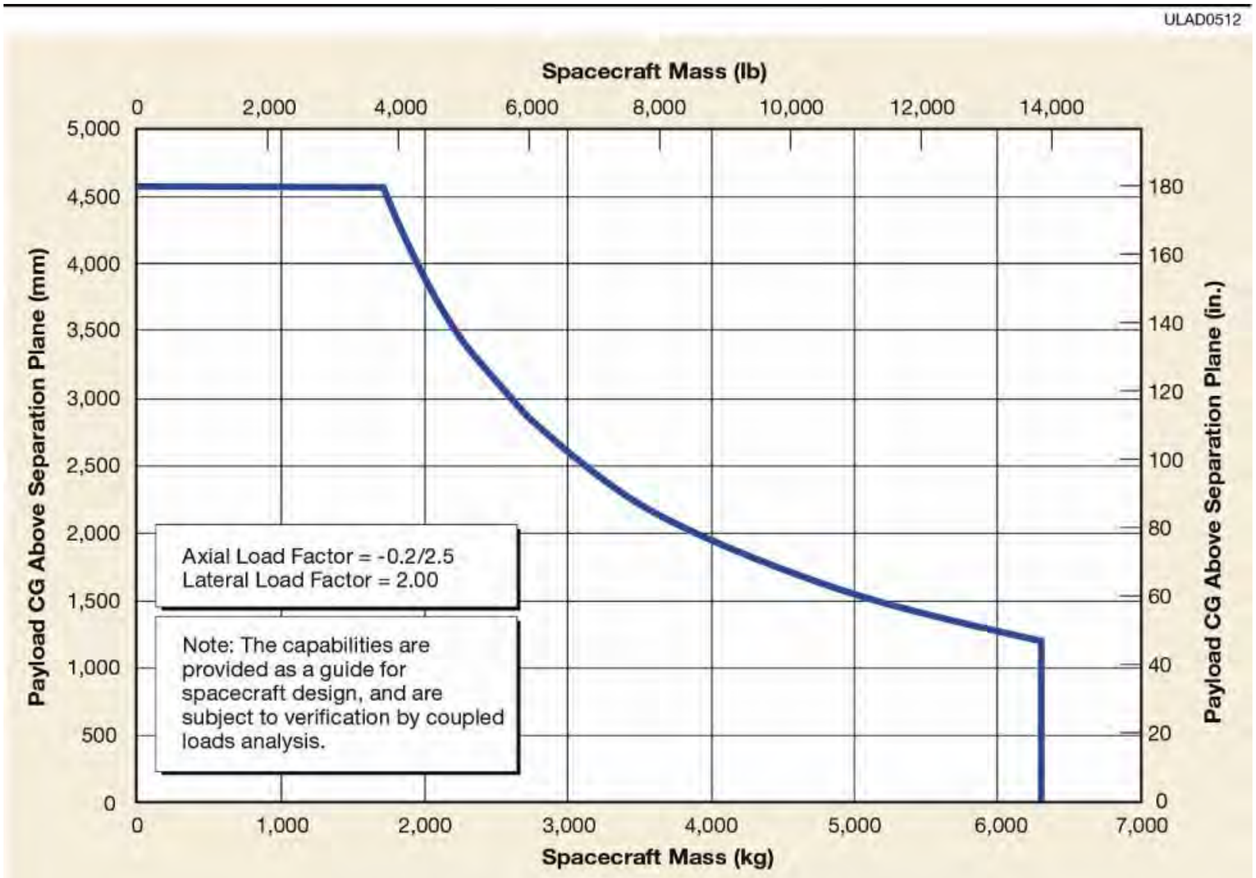


Figure 5-34. A937 PLA Structural Capability

5.3.5.1.4 Static Payload Envelope. The static payload envelope defines the usable volume for the SC relative to the payload adapter. This envelope represents the maximum allowable SC static dimensions (including manufacturing tolerances) relative to the SC/payload adapter interface. This envelope design allows access to mating components and payload separation system for integration and installation operations, motion of the payload separation system during its operation, and the movement of the SC and LV after separation of the SC. Clearance layouts and separation analyses are performed for each SC configuration, and if necessary, critical clearance locations are measured during SC-to-payload-adapter mate operations to ensure positive clearance during flight and separation.

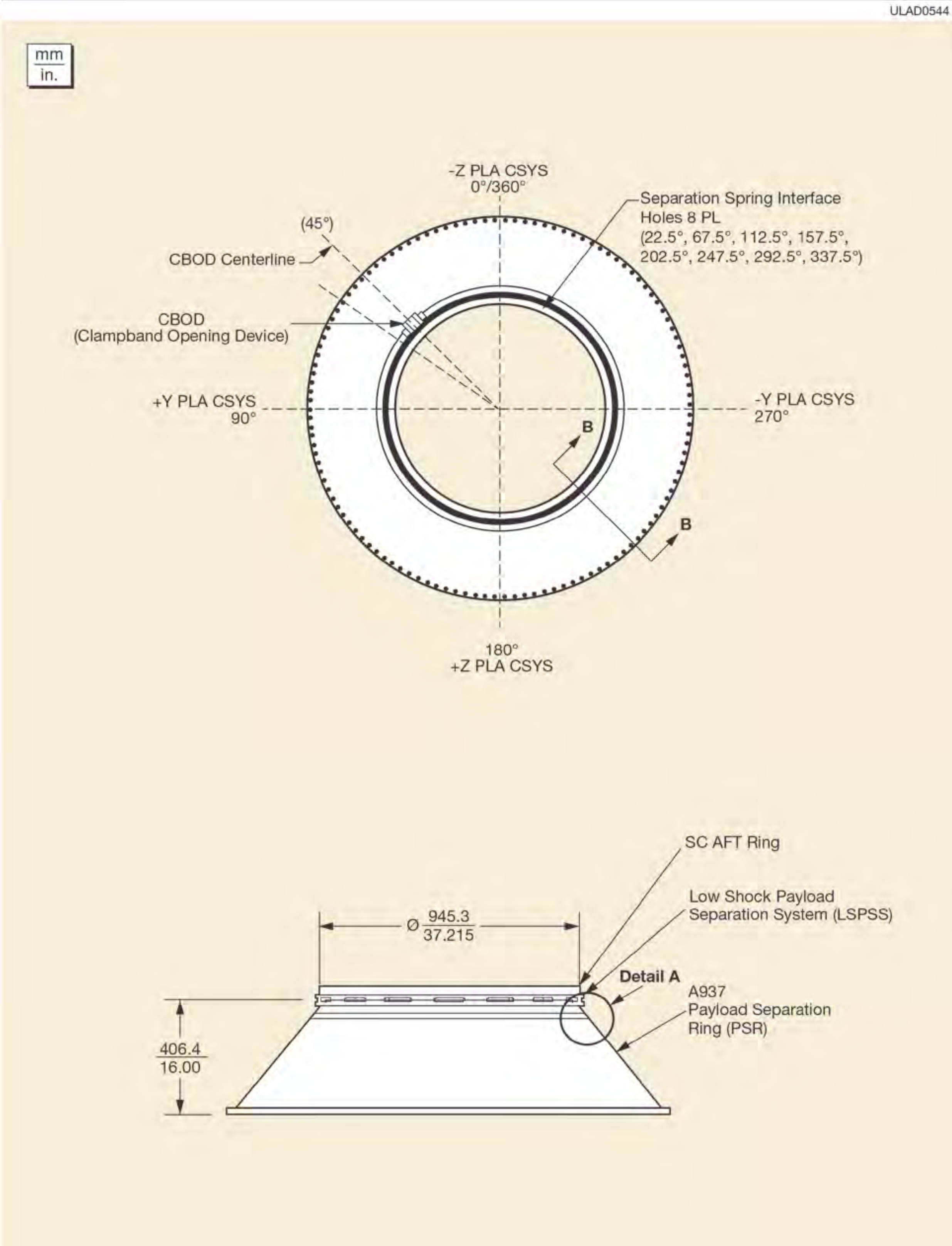


Figure 5-35. Interface Requirements for Type A937 PSR

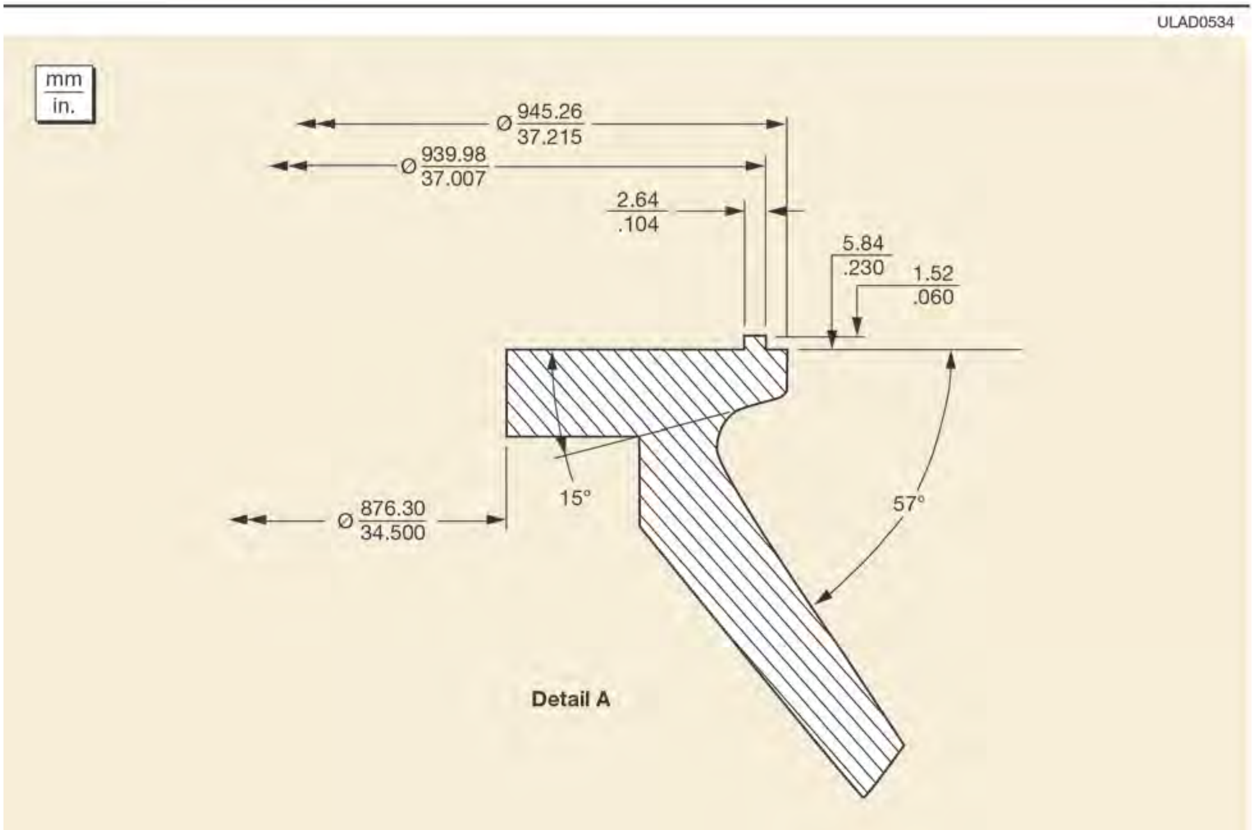


Figure 5-36. A937 PLA Spacecraft Interface Dimensional Constraints

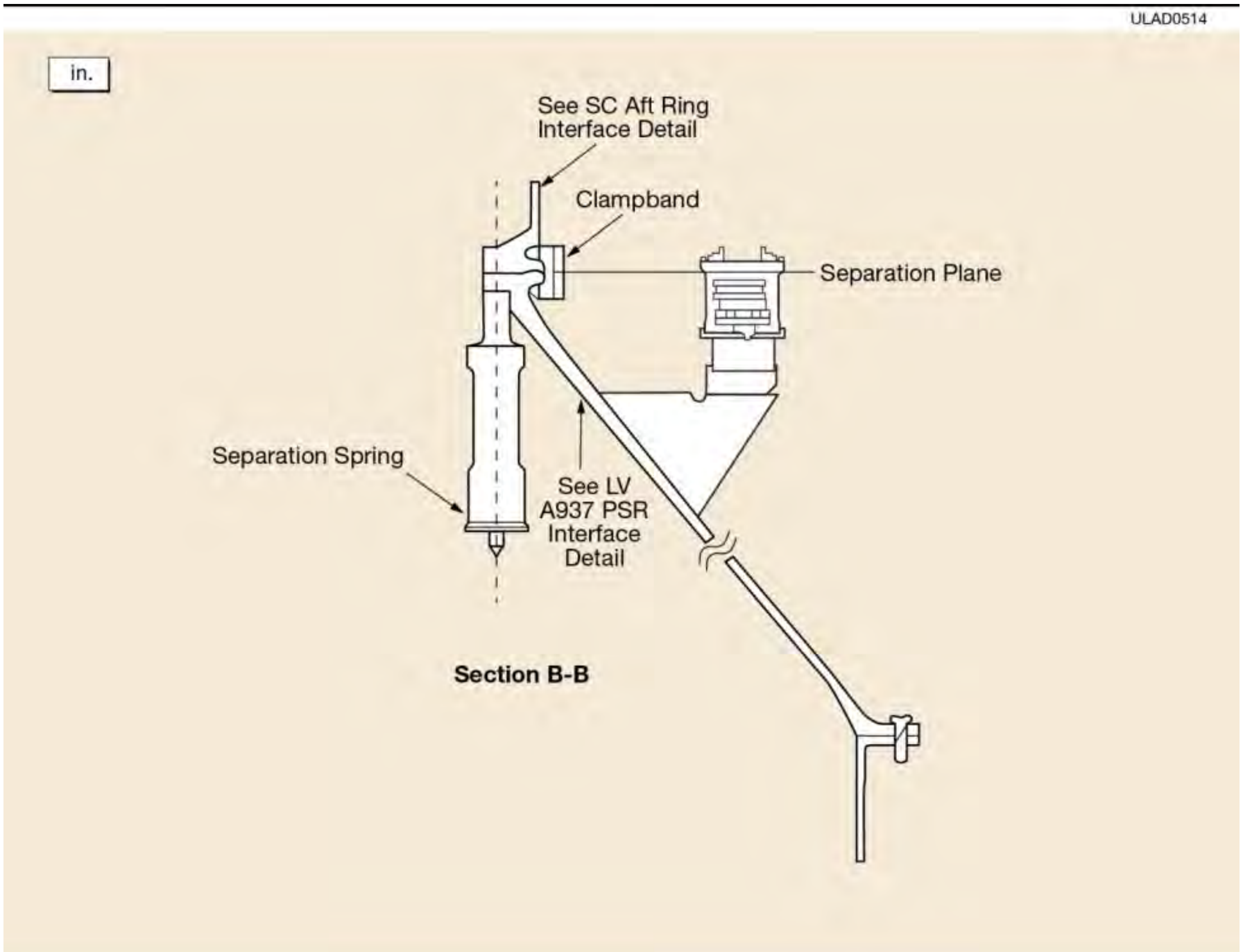


Figure 5-37. A937 PLA Separation Spring Assembly and Electrical Connector Bracket

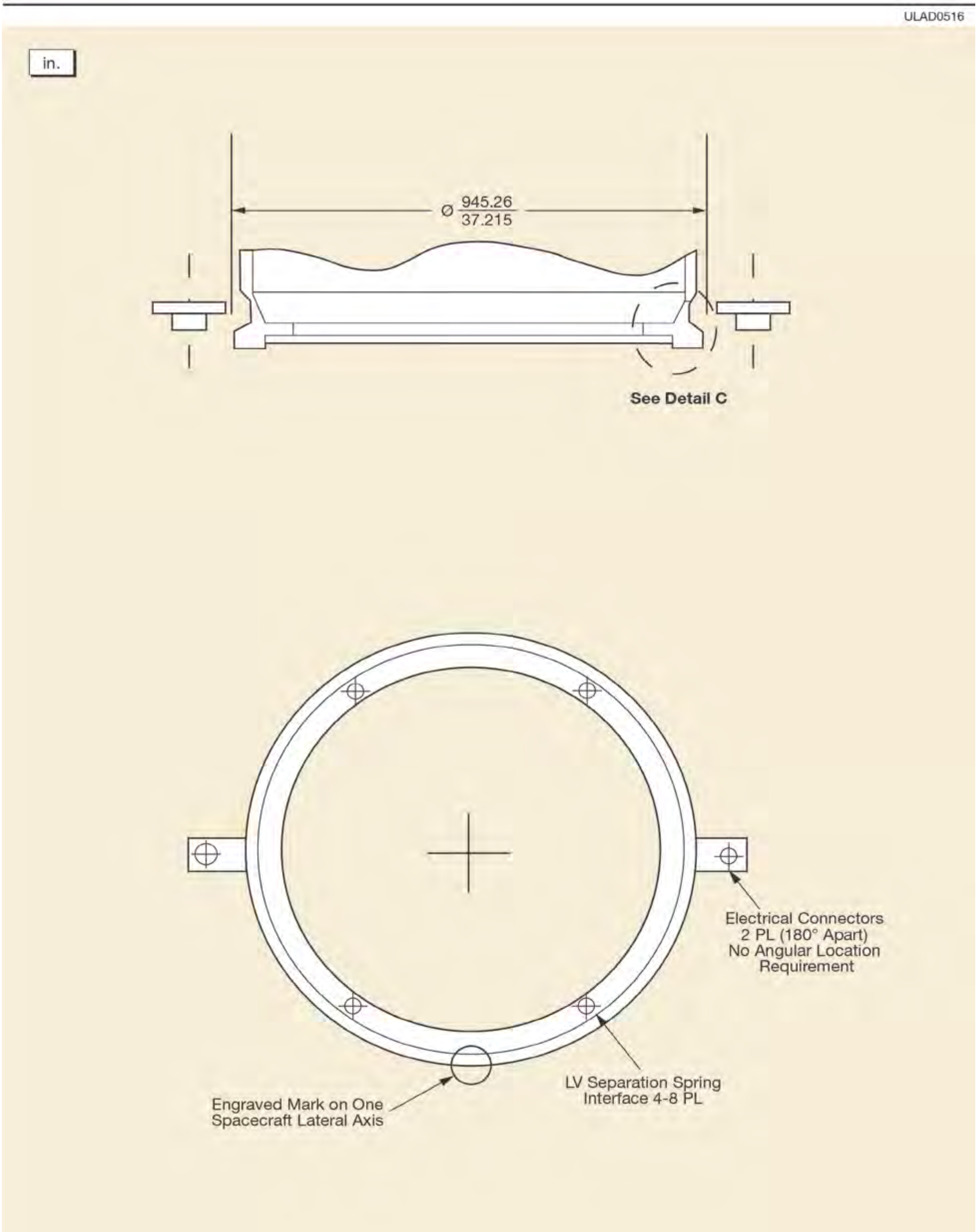


Figure 5-38. A937 PLA Spacecraft Interface

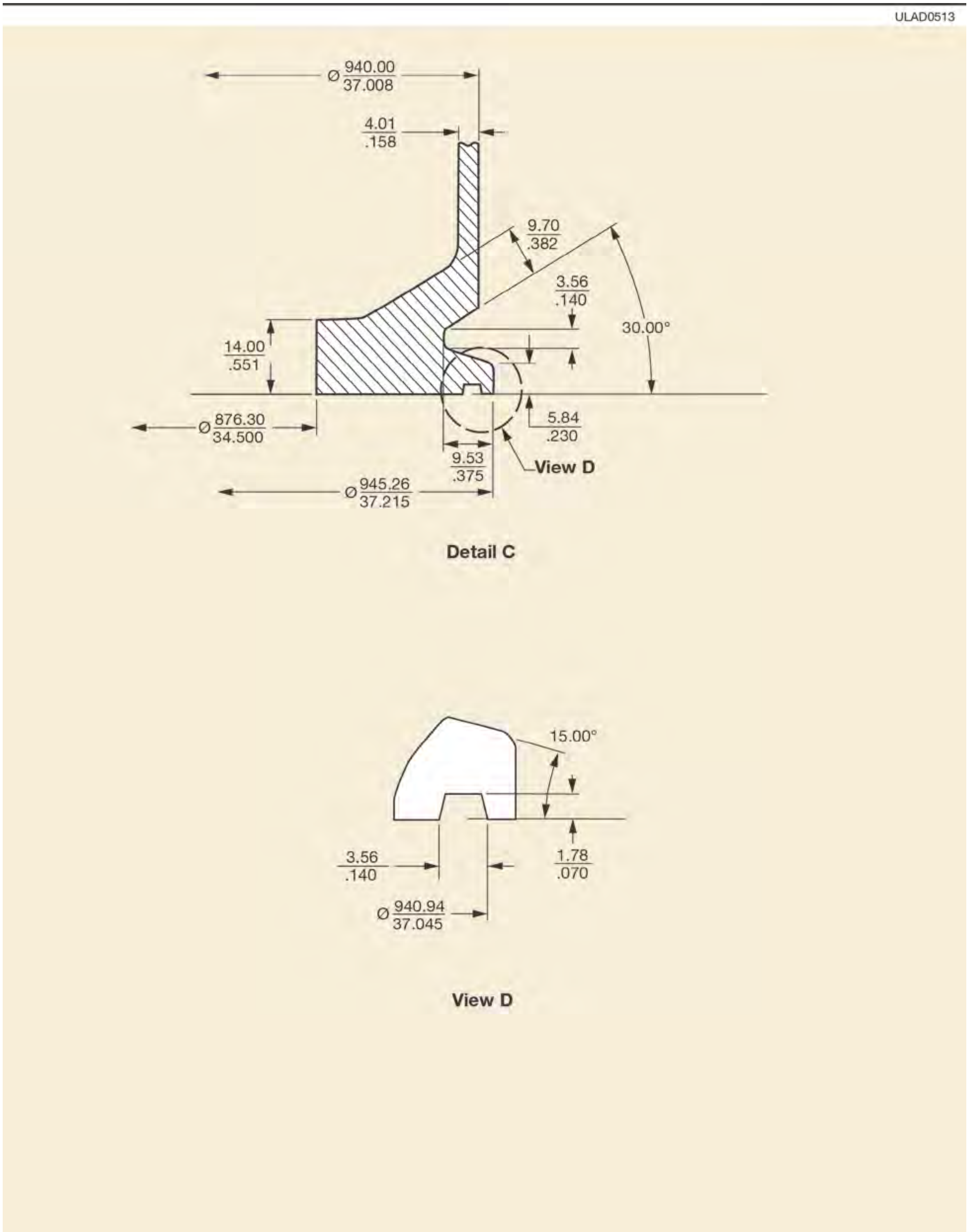


Figure 5-39. A937 PLA Spacecraft Interface Dimensional Constraints

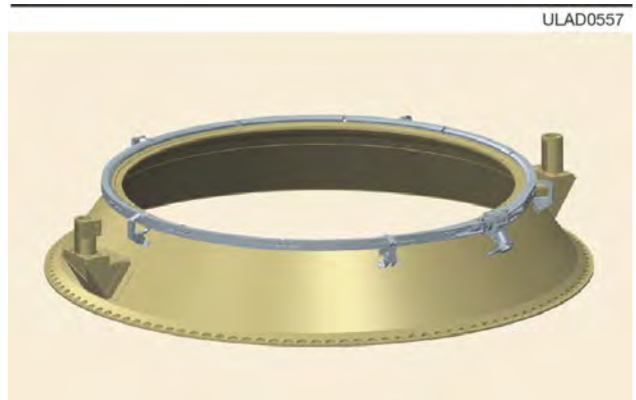


Figure 5-40. B1194 PLA

5.3.5.2 Type B1194 Payload Adapter. The ULA Type B1194 payload adapter design (Figure 5-40) supports an SC with an aft ring diameter of 1194 mm (47 in.). Figure 5-41 summarizes the major characteristics of this payload adapter.

The Type B1194 payload adapter consists of two major sections: the Payload Separation Ring (PSR) (with separation system) and the LVA described in Section 5.3.1. The PSR is a machined aluminum component in the form of a 254 mm (10 in.) high truncated cone. The forward ring has an outer diameter of 1215 mm (47.835 in.) and forms the SC separation plane. The aft ring has an outer diameter of 1596 mm (62.84 in.) and contains 120 evenly spaced bolt holes that allow it to be joined to the LVA. This symmetrical bolt hole pattern allows the payload separation ring and attached SC to be rotated relative to the LV in 3-degree increments to meet mission-unique requirements. The PSR supports all hardware that directly interfaces with SC, including the PSS, electrical connectors, and mission unique options.

Construction	Two-Piece, Integrally Machined Aluminum Construction
Payload Capability	See Figure 5-42
Payload Sep System	SS1194VS
Max Shock Levels	2,800 G
Clampband Preload — Installation	67.8 +0.5/ -0 kN (15,242 +112/-0 lb)
Clampband Preload — Flight	60.0 ± 0.5 kN (13,490 ± 112 lb)
Separation Springs	
Number	4, 6 or 8
Force per Spring — Max	1 kN (225 lb)

Figure 5-41. B1194 PLA Characteristics

5.3.5.2.1 Payload Separation System. The ULA Type B1194 payload adapter uses a LV-provided, Marmon-type (1194 mm diameter) clampband PSS as described in detail in Section 5.3.4.

5.3.5.2.2. Payload Adapter Structural Capabilities. Figure 5-42 shows the allowable integrated payload stack mass and longitudinal centers of gravity for the Type B1194 payload adapter/separation systems. These integrated payload stack mass and center of gravity capabilities were determined using generic SC interface ring geometry shown in Figures 5-46 and 5-47 and quasi-static load factors. Actual SC design allowables may vary depending on interface ring stiffness and results of SC mission-unique coupled loads analyses. Additional structural testing may be performed to increase the capabilities defined in Figure 5-42.

Coordination with ULA is required to define appropriate structural capabilities for SC designs that exceed these generic allowables.

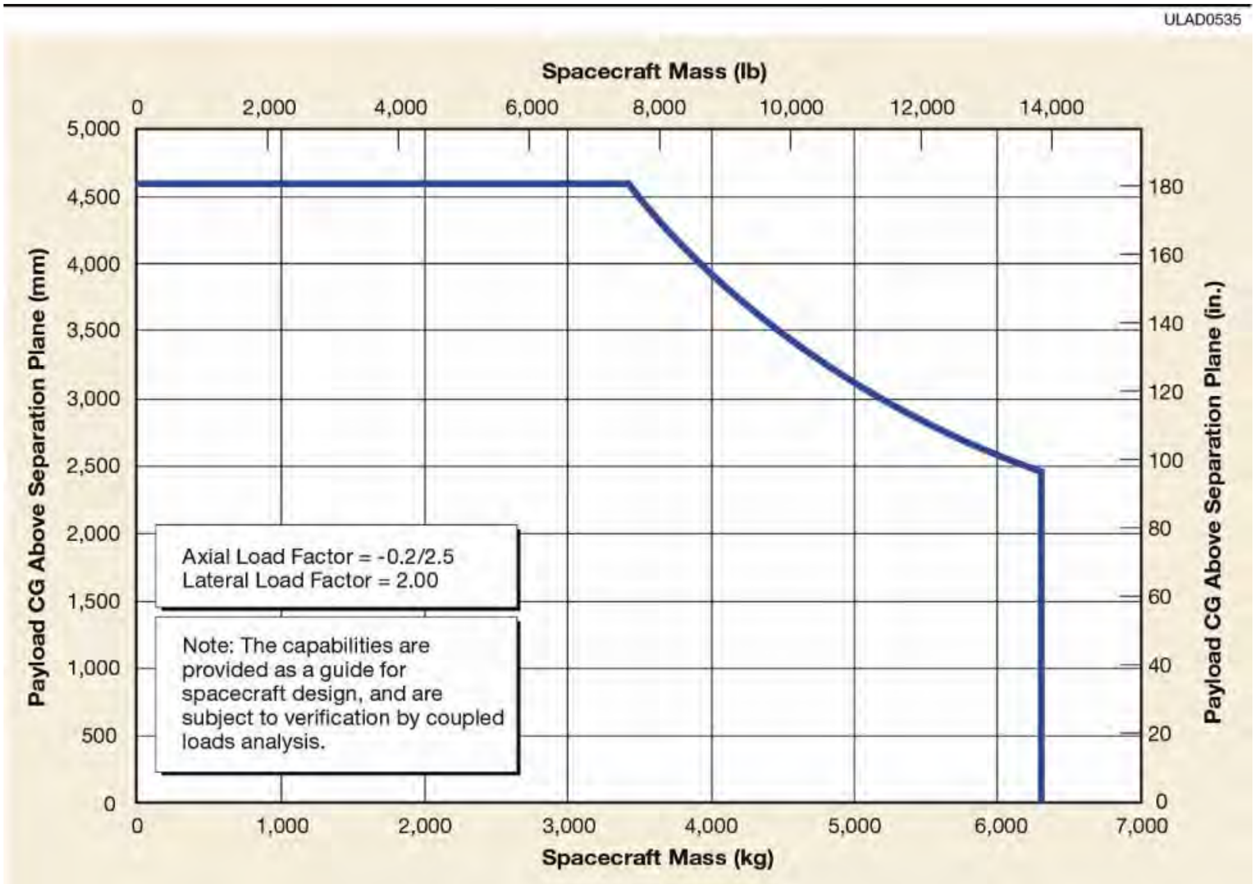


Figure 5-42. B1194 PLA Structural Capability

5.3.5.2.3 Payload Adapter Interfaces. The primary structural interface between the LV and SC occurs at the payload adapter forward ring. This ring interfaces with the SC aft ring. A payload separation system holds the two rings together for the structural joint and provides the release mechanism for SC separation. Electrical bonding is provided across all interface planes associated with these components. The payload adapter also provides mounting provisions for separation springs and supports interfacing components for electrical connectors between the LV and SC. Figures 5-43 through 5-47 show the interface requirements for these components. For more specific SC interface requirements, please contact ULA. Additional mission unique provisions, including SC purge provisions, SC range safety destruct units, and instrumentation, may be added as necessary.

5.3.5.2.4 Static Payload Envelope. The static payload envelope defines the usable volume for the SC relative to the payload adapter. This envelope represents the maximum allowable SC static dimensions (including manufacturing tolerances) relative to the SC/payload adapter interface. This envelope design allows access to the mating components and payload separation system for integration and installation operations, motion of the payload separation system during its operation, and movement of the SC and LV after separation of the SC. Clearance layouts and separation analyses are performed for each SC configuration and, if necessary, critical clearance locations are measured during SC-to-payload-adapter mate operations to ensure positive clearance during flight and separation.

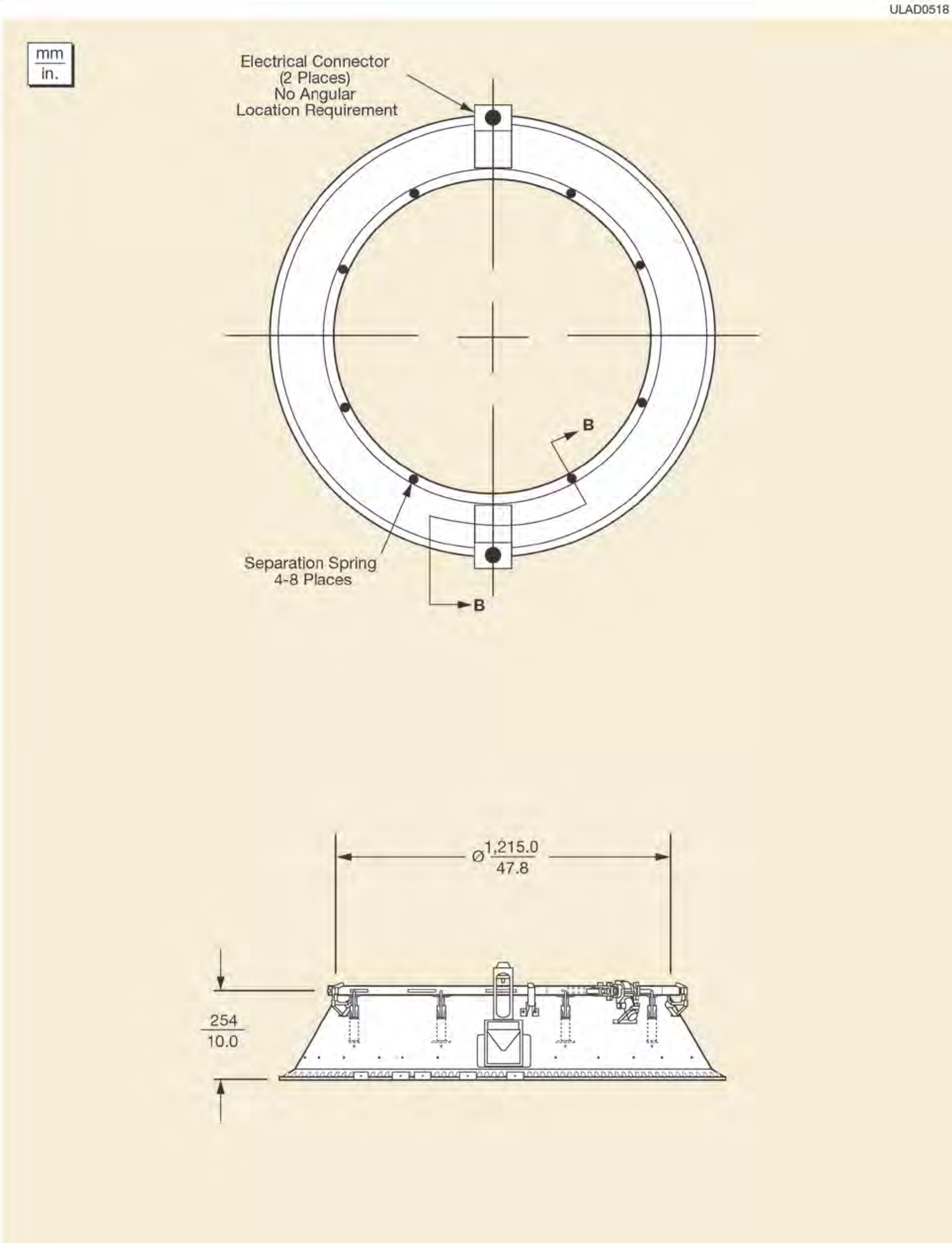


Figure 5-43. B1194 PLA Detailed Assembly

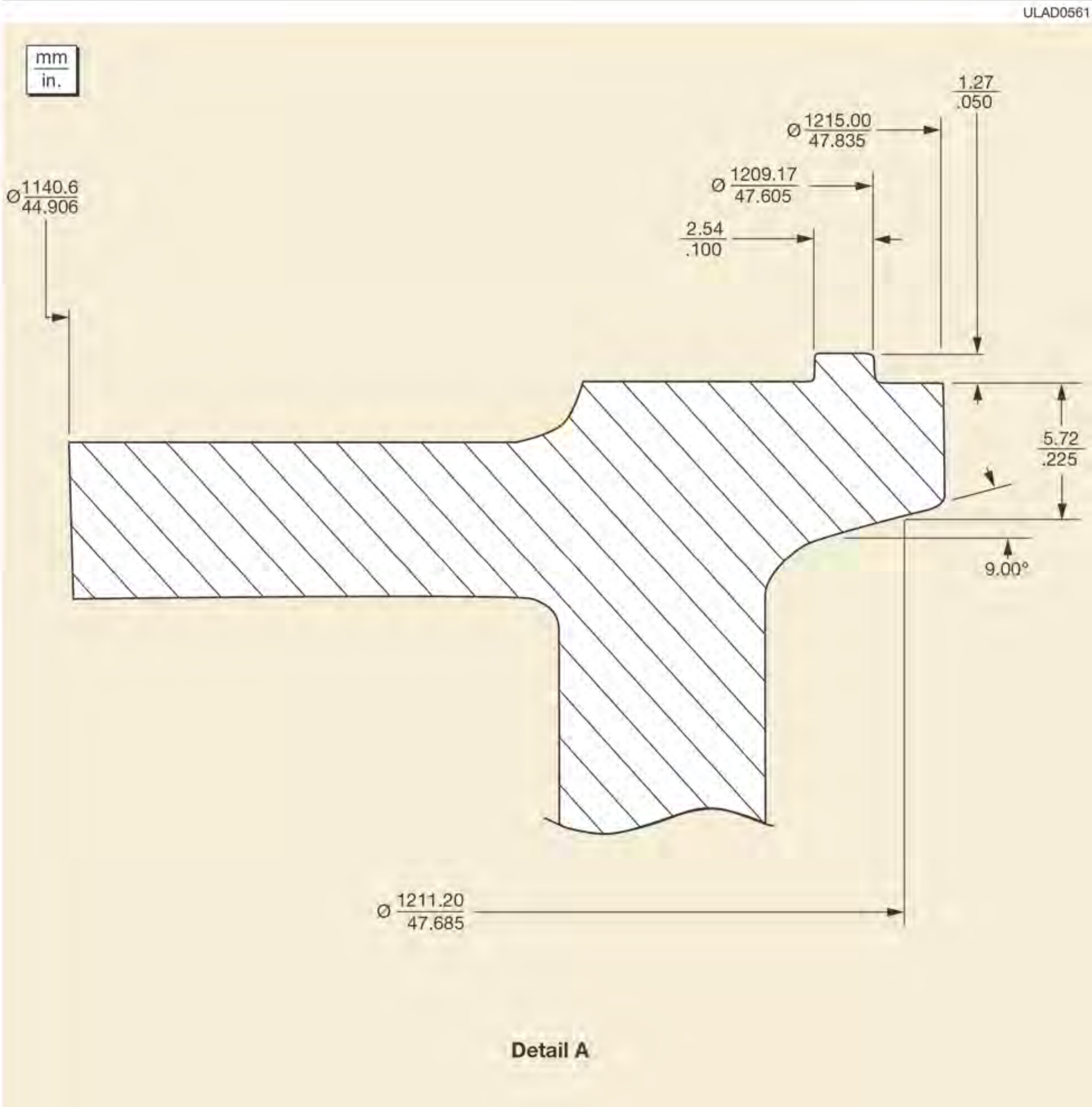


Figure 5-44. B1194 PLA Detailed Dimensions

ULAD0521

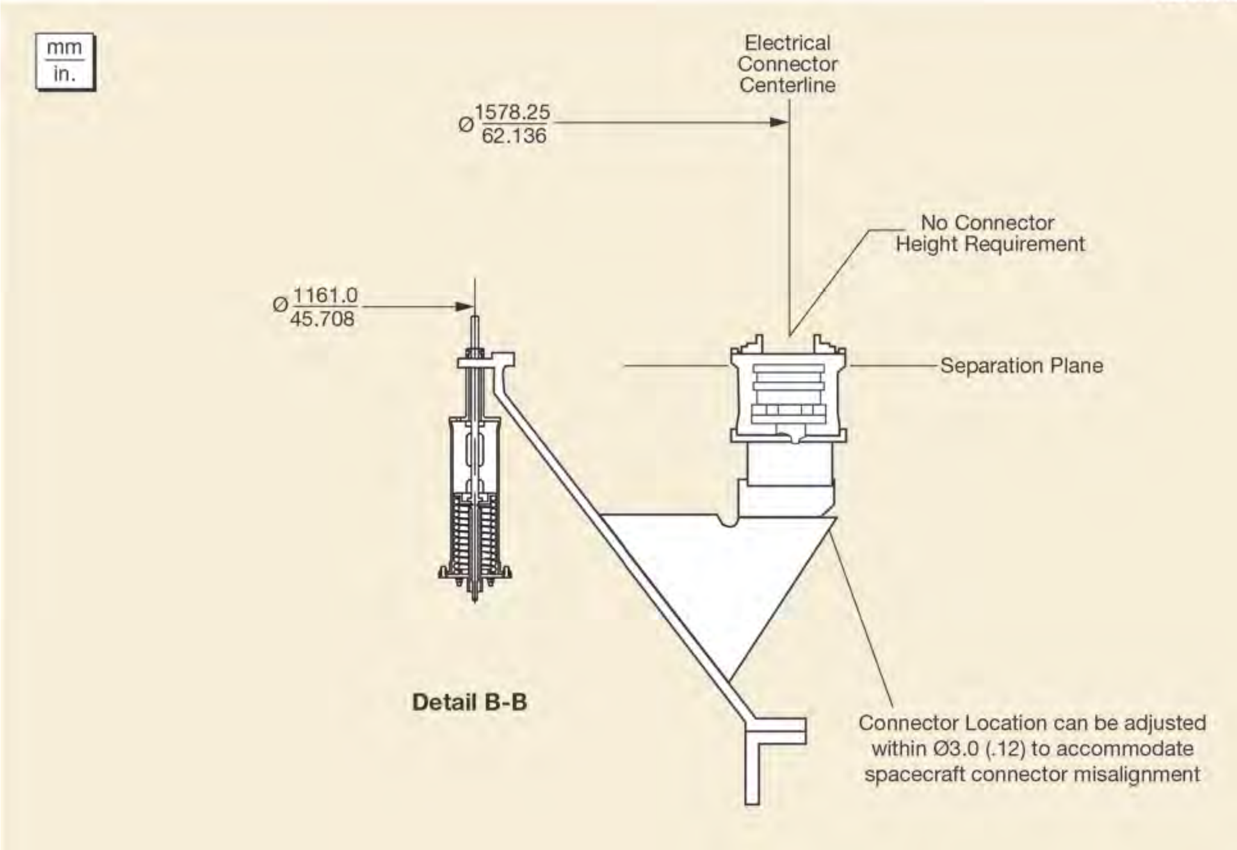


Figure 5-45. B1194 PLA Separation Spring Assembly and Electrical Connector Bracket

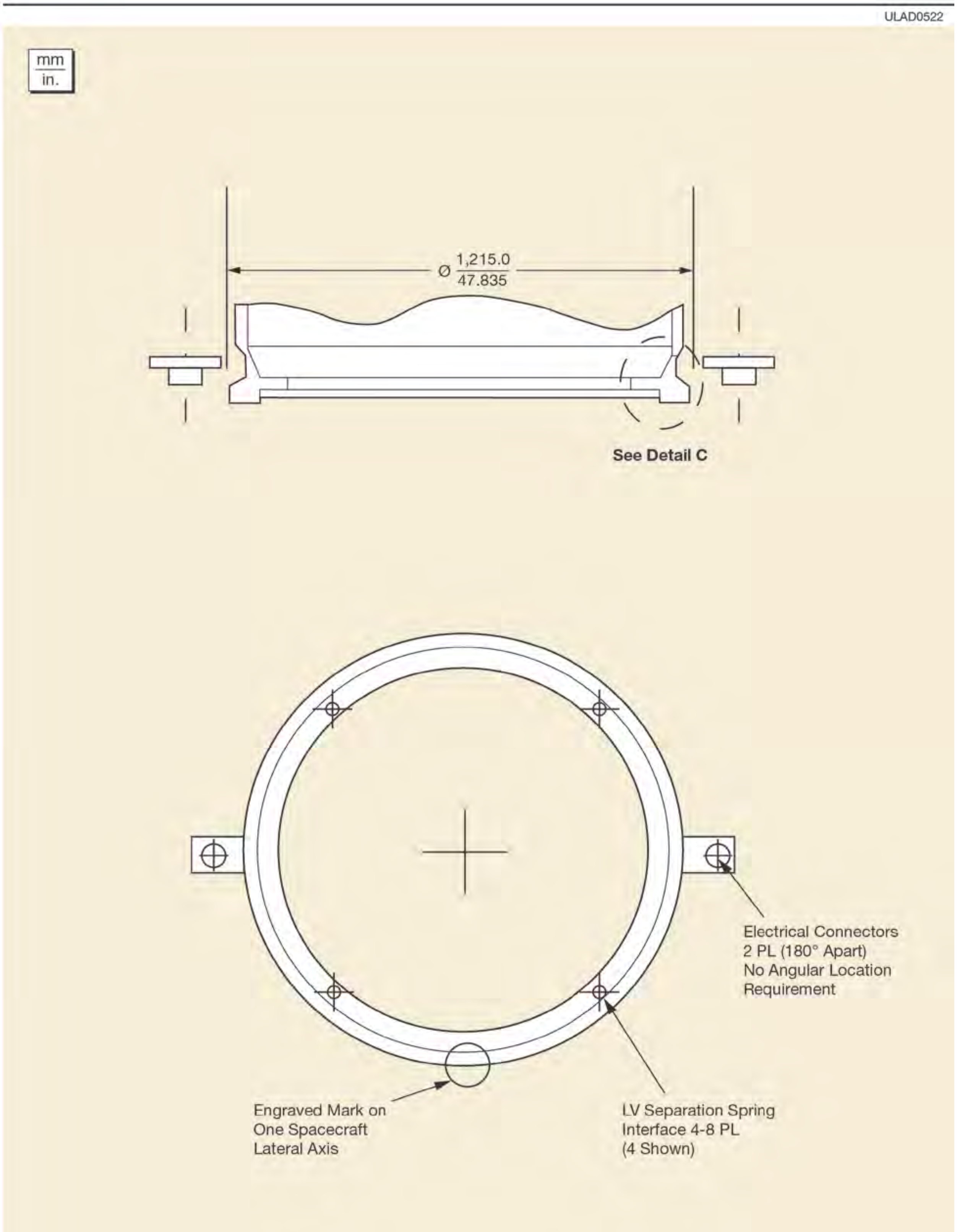


Figure 5-46. B1194 PLA Spacecraft Interface Dimensional Constraints

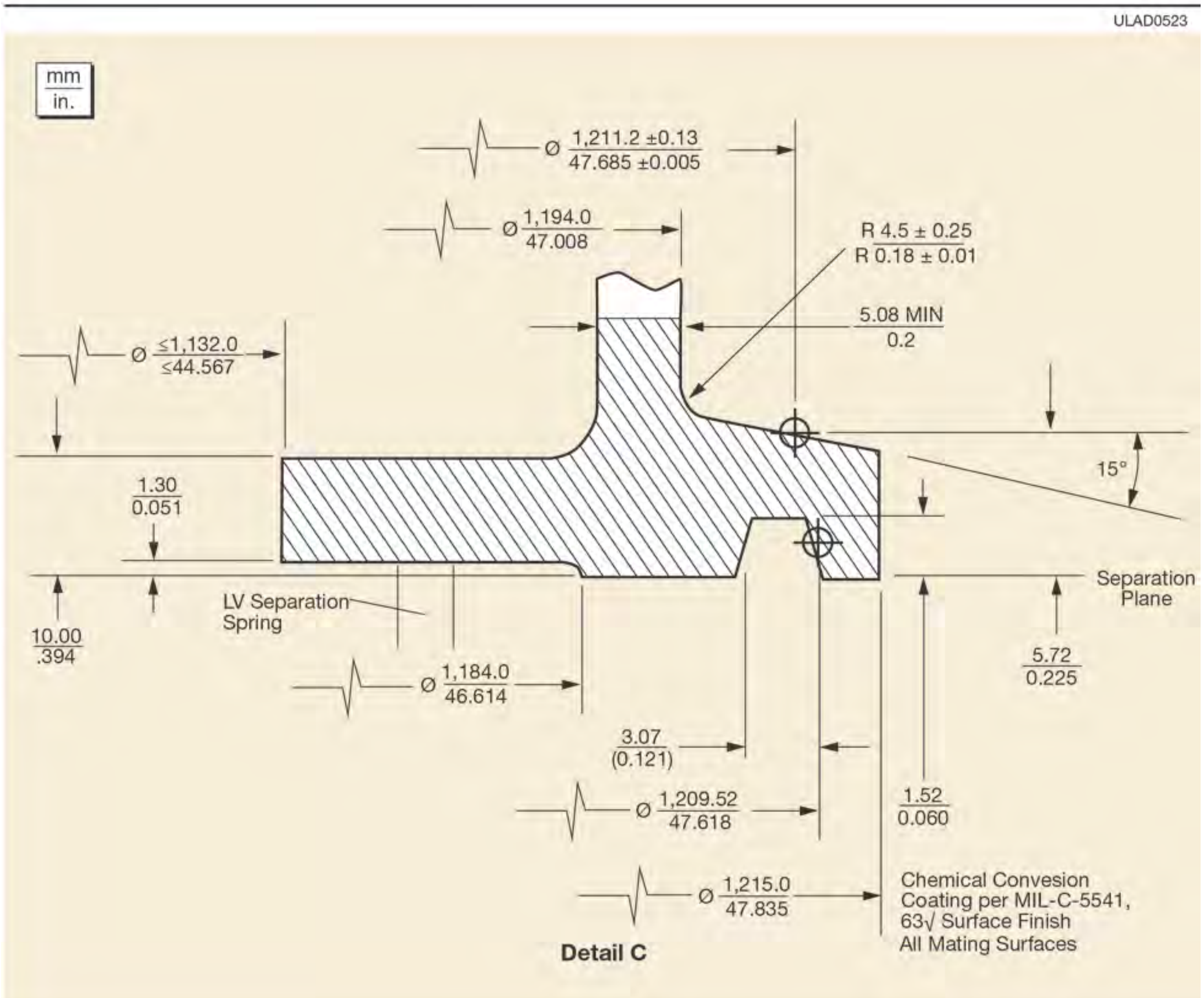


Figure 5-47. B1194 PLA Spacecraft Interface Dimensional Constraints

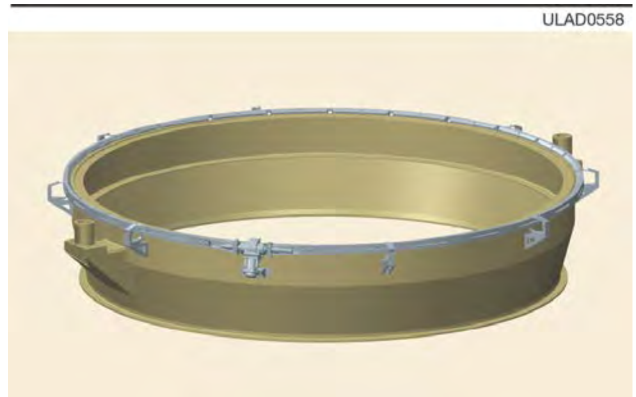


Figure 5-48. D1666 PLA

5.3.5.3 Type D1666 Payload Adapter. The ULA Type D1666 payload adapter (Figure 5-48) design supports an SC with an aft ring diameter of 1666 mm (66 in.). Figure 5-49 summarizes major characteristics of this payload adapter.

The Type D1666 payload adapter consists of two major sections: the payload separation ring (with separation system) and the LVA described in Section 5.3.1. The payload separation ring is a machined aluminum component in the form of a 330.2 mm (13 in.) high truncated cone. The forward ring has an outer diameter of 1666.1 mm (65.594 in.) and forms the SC separation plane. The aft ring has an outer diameter of 1596 mm (62.84 in.) and contains 120 evenly spaced holes that allow it to be joined to the LVA. This symmetrical hole pattern allows the payload separation ring and attached SC to be rotated relative to the LV in 3-degree increments to meet mission unique requirements. The payload separation ring supports all hardware that directly interfaces with SC, including the payload separation system, electrical connectors, and mission unique options.

Construction	Two-Piece, Integrally Machined Aluminum
Payload Capability	See Figure 5-50
P/L Sep System	SS66VS
Max Shock Levels	3,000 G
Clampband Preload — Installation	45.2 +0.5/-0 kN (10,160 +112/-0 lb)
Clampband Preload — Flight	40.0 ± 0.5 kN (8,990 ± 112 lb)
Separation Springs	
Number	4, 6 or 8
Force per Spring — Max	1 kN (225 lb)

Figure 5-49. D1666 PLA Characteristics

5.3.5.3.1 Payload Separation System. The Type D1666 payload adapter uses a LV-provided Marmon-type (1666 mm diameter) clampband payload separation system as described in detail in Section 5.3.4.

5.3.5.3.2 Payload Adapter Structural Capabilities. Figure 5-50 shows the allowable integrated payload stack mass and longitudinal centers of gravity for the Type D1666 payload adapter/separation systems. These integrated payload stack mass and center-of-gravity capabilities were determined using generic SC interface ring geometry shown in Figures 5-55 and 5-56 and quasi-static load factors. Actual SC design allowables may vary depending on interface ring stiffness and results of SC mission unique coupled loads analyses. Coordination with ULA is required to define appropriate structural capabilities for SC designs that exceed these generic allowables.

5.3.5.3.3 Payload Adapter Interfaces. The primary structural interface between the LV and SC occurs at the payload adapter forward ring. This ring interfaces with the SC aft ring. A payload separation system holds the two rings together at the structural joint and provides the release mechanism for SC separation. Electrical bonding is provided across all interface planes associated with these components. Figures 5-51 through 5-56 show the interface requirements for these components. The payload adapter also provides mounting provisions for separation springs and supports interfacing components for electrical connectors between the LV and SC. For more specific SC interface requirements, please contact ULA. Additional mission-unique provisions, including SC purge provisions, SC range safety destruct units, and instrumentation may be added as necessary.

ULAD0536

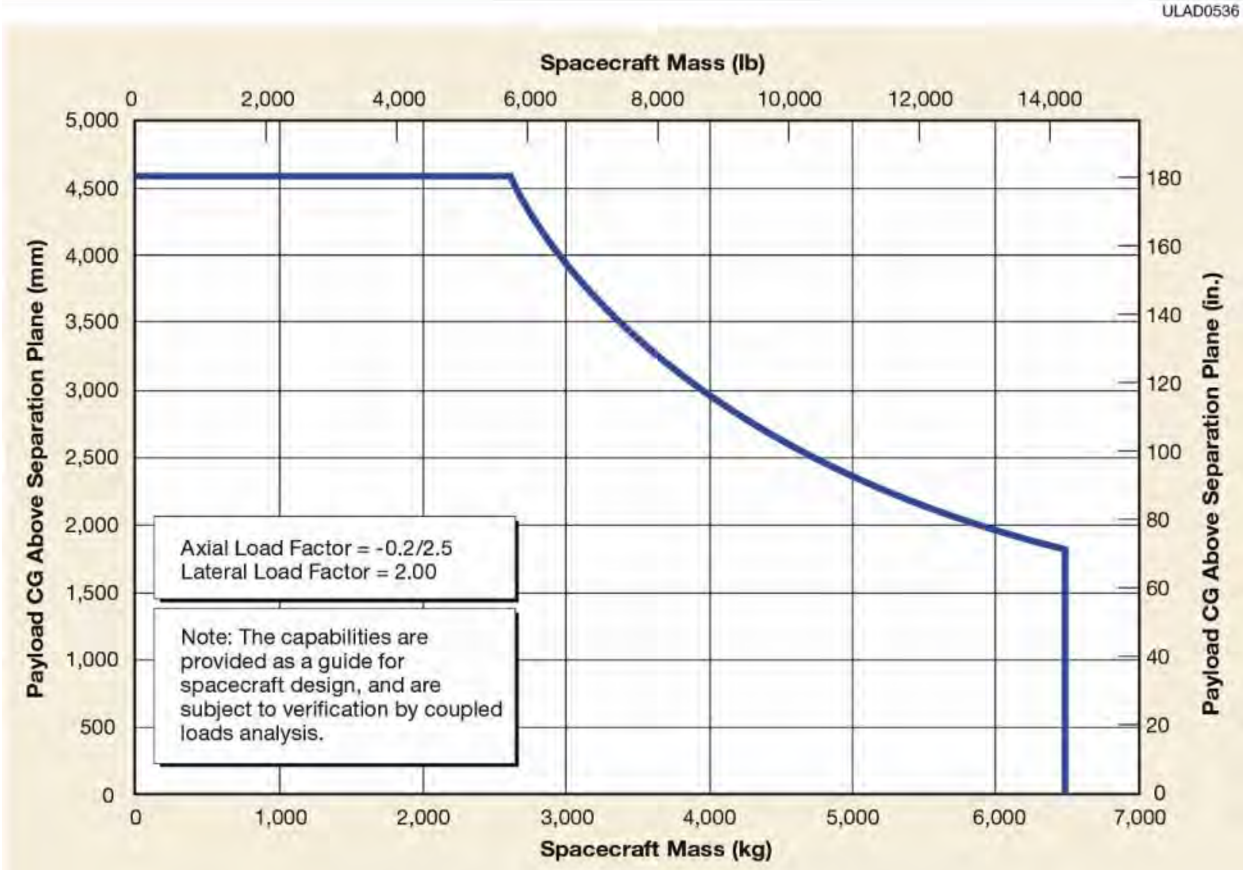


Figure 5-50. D1666 PLA Structural Capability

5.3.5.3.4 Static Payload Envelope. The static payload envelope defines the usable volume for the SC relative to the payload adapter. This envelope represents the maximum allowable SC static dimensions (including manufacturing tolerances) relative to the SC/payload adapter interface. This envelope design allows access to the mating components and payload separation system for integration and installation operations, motion of the payload separation system during its operation, and movement of the SC and LV after separation of the SC. Clearance layouts and separation analyses are performed for each SC configuration, and if necessary, critical clearance locations are measured during SC-to-payload-adapter mate operations to ensure positive clearance during flight and separation.

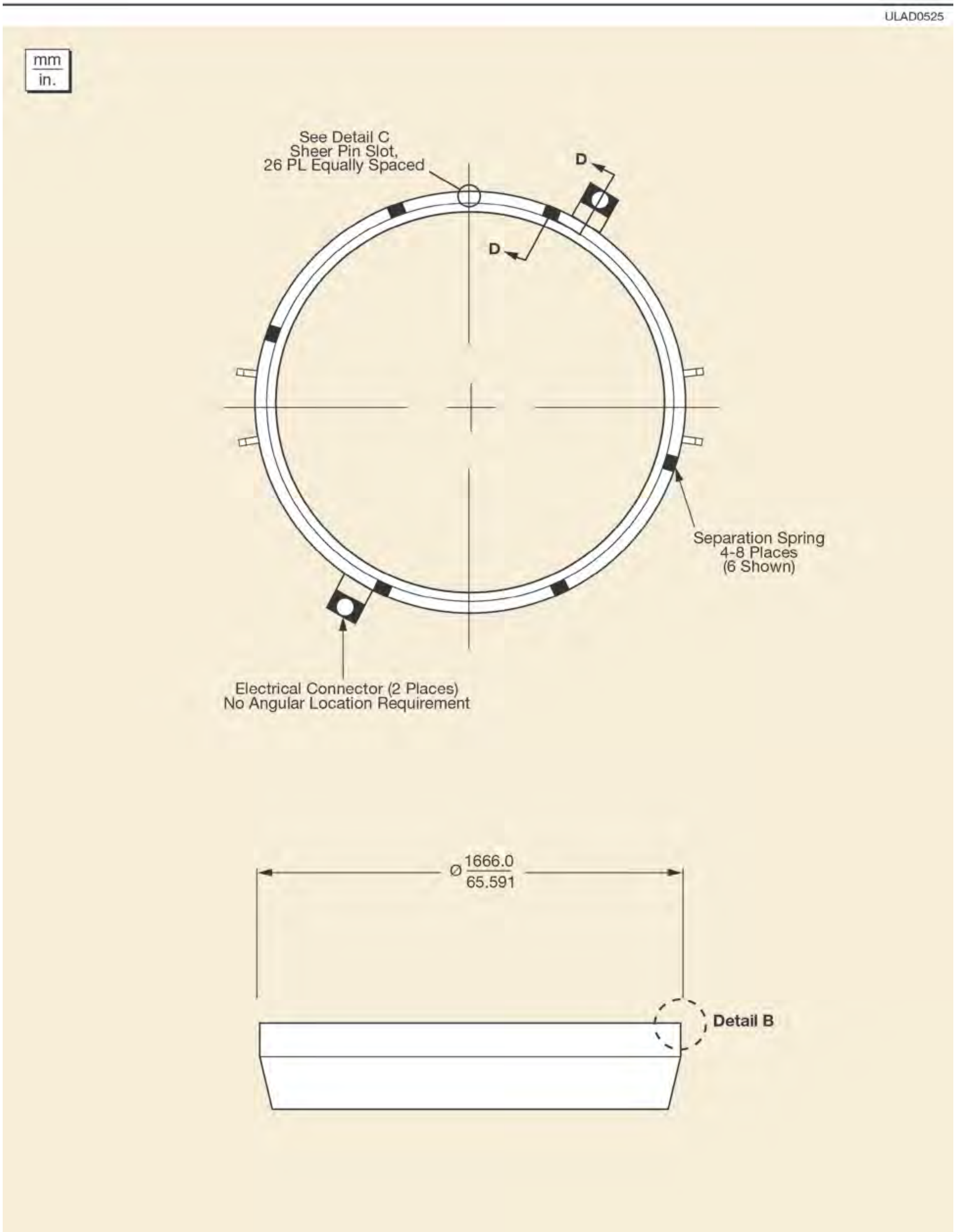


Figure 5-51. Interface Requirements for Type D1666 PSR

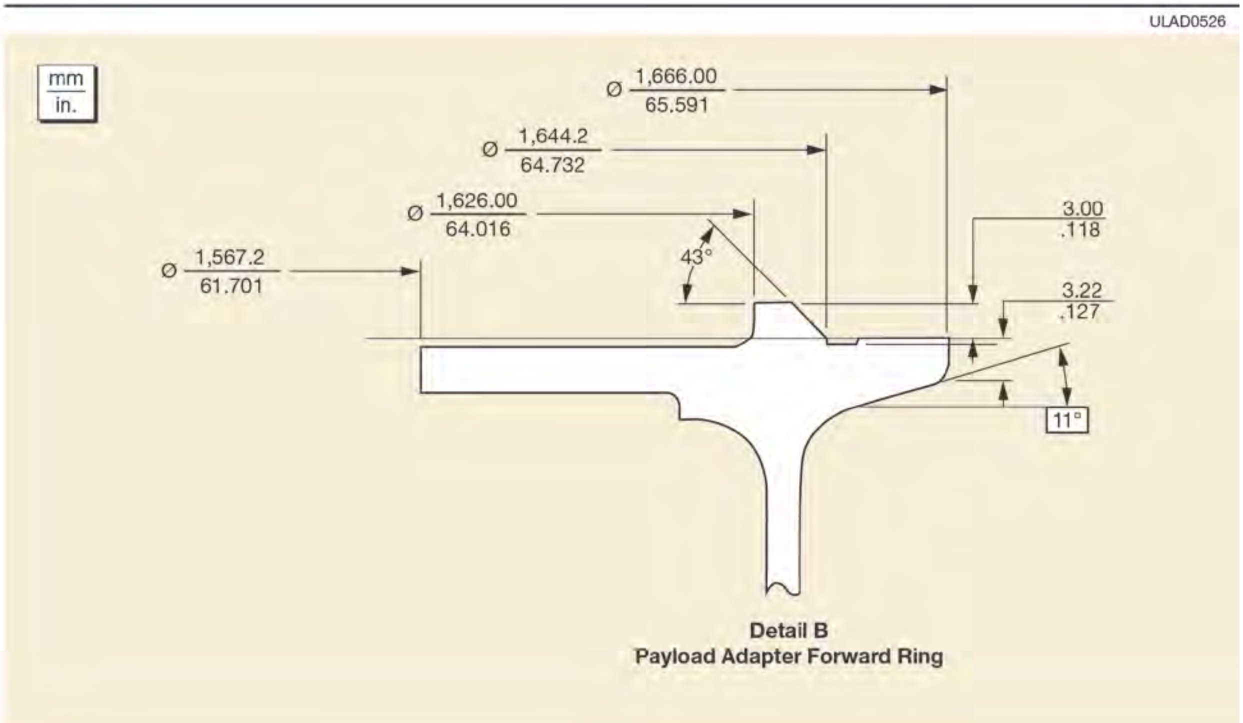


Figure 5-52. D1666 PLA Detailed Dimensions

Figure 5-53. D1666 PLA Detailed Dimensions

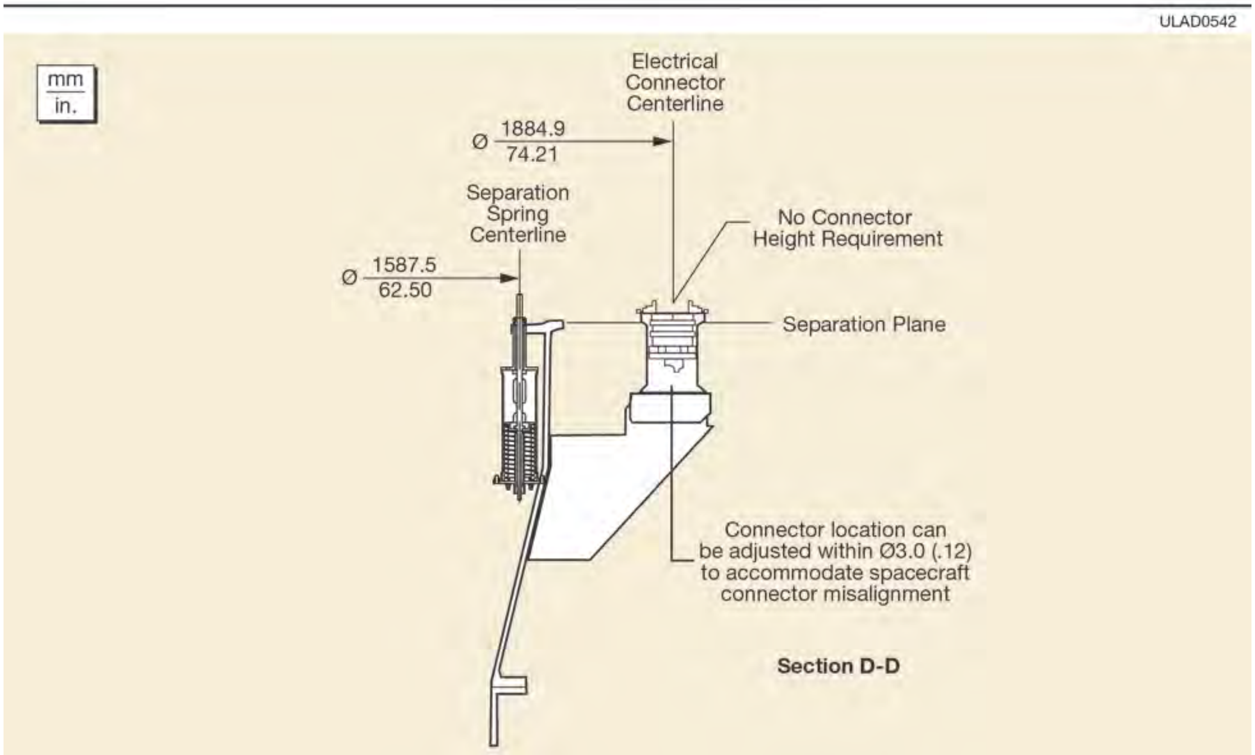


Figure 5-54. D1666 PLA Separation Spring Assembly and Electrical Connector Bracket

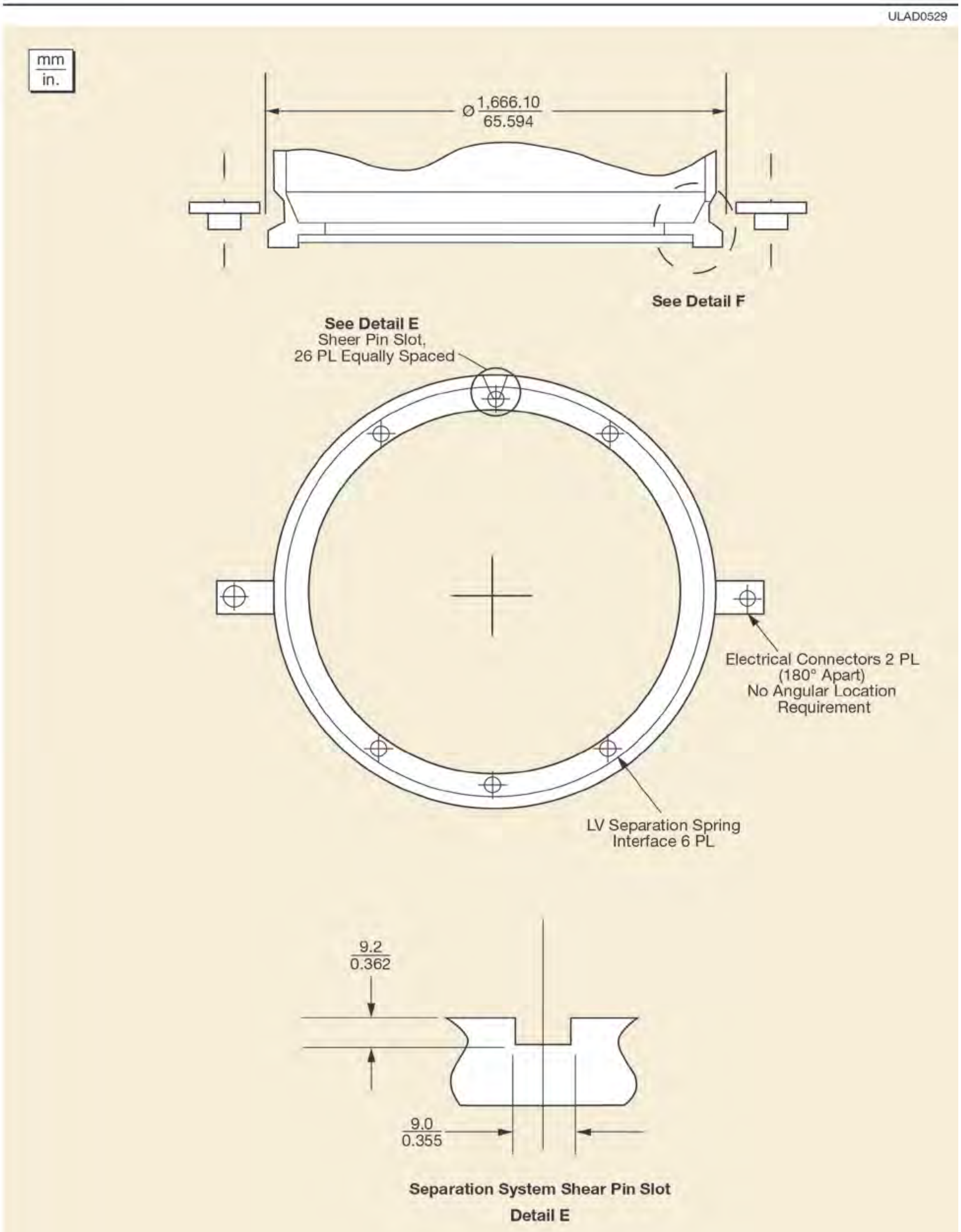


Figure 5-55. D1666 PLA Spacecraft Interface Dimensional Constraints

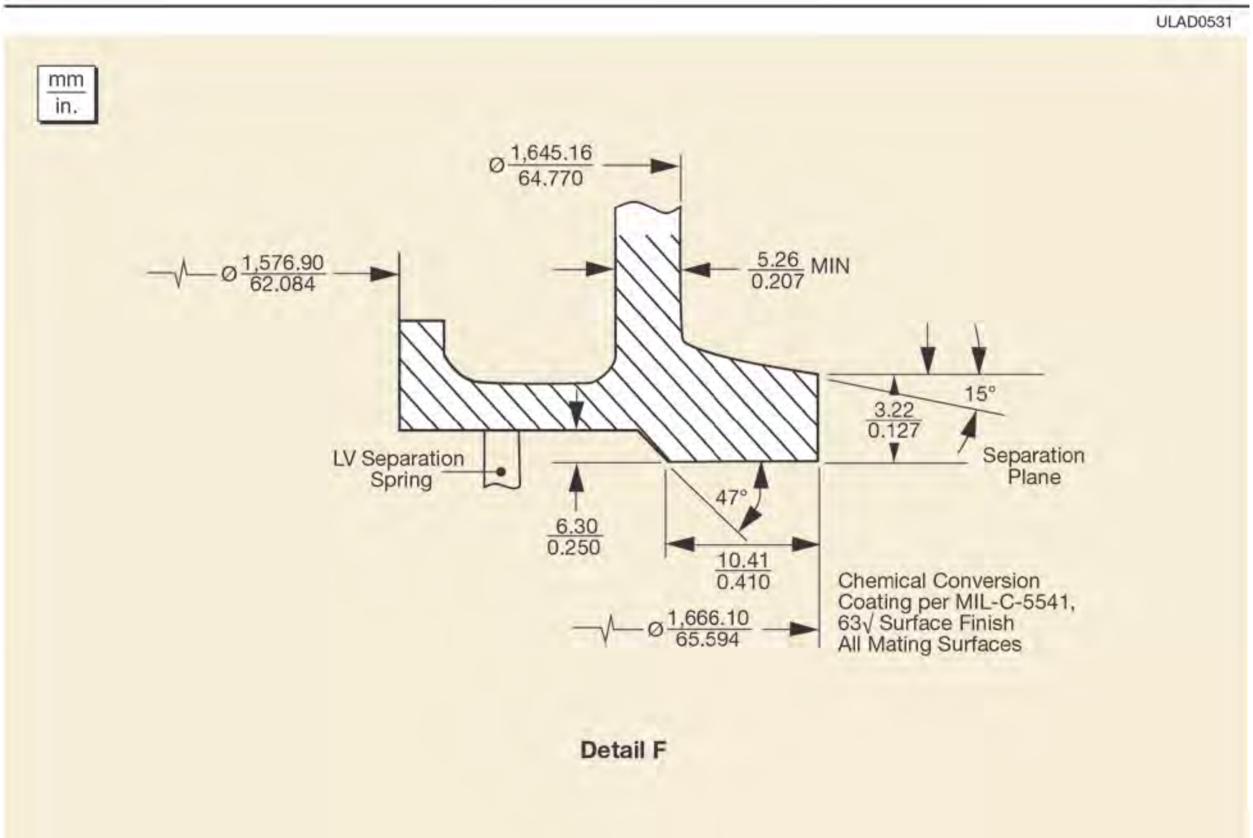


Figure 5-56. D1666 PLA Spacecraft Interface Dimensional Constraints

Figure 5-57. 6915 PLA

5.3.5.4 Type 6915 Payload Adapter. The one-piece machined aluminum 6915 PLA assembly (Figure 5-57) is approximately 381 mm (15 in.) high and 1743 mm (68.6 in.) in diameter and utilizes explosive nuts. The PLA base is attached to a launch vehicle adapter. The spacecraft is fastened to the 1742.6 mm (68.6 in.) diameter PLA at four equally spaced hard-points using 15.9 mm (0.625 in.) diameter bolts that are preloaded to 53,378 N (12,000 lb). Figure 5-58 shows the capability of the PLA in terms of spacecraft weight and CG location above the separation plane. The capability for a specific spacecraft (with its own unique mass, size, flexibility, etc) might vary from that presented; therefore, as the spacecraft configuration is finalized, ULA will initiate a coupled-loads analysis to verify that the structural capability of the launch vehicle is not exceeded. The spacecraft interface is shown in Figures 5-59 through 5-62. Matched tooling for spacecraft interface to PLA is provided upon request.

Separation of the spacecraft from the launch vehicle occurs when the explosive nuts are activated, allowing the four guided separation spring actuators to push the space vehicle away from the launch vehicle. Note that ULA requires access on the spacecraft side of the separation plane for installation of the separation bolts and bolt-catcher assemblies which are retained on the spacecraft after separation.

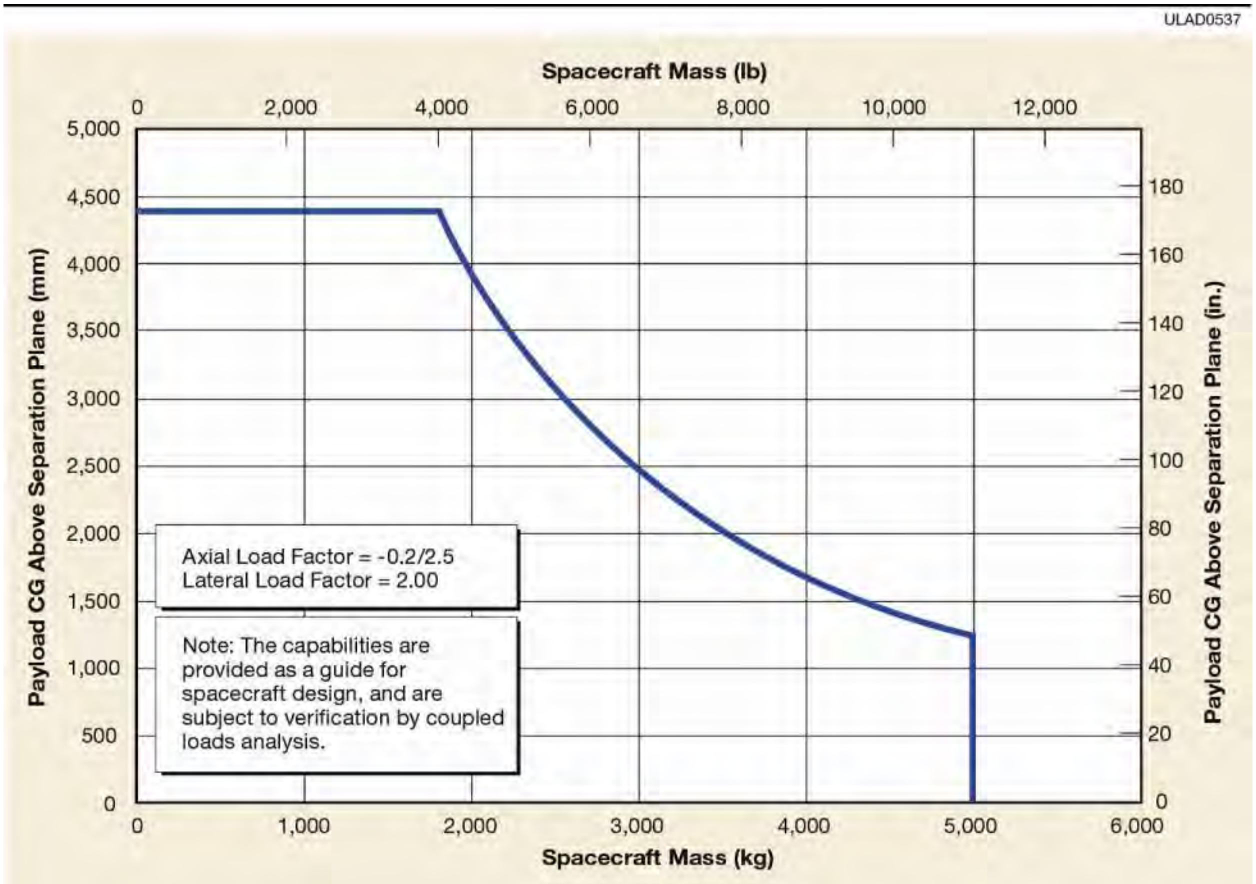


Figure 5-58. 6915 PLA Structural Capability

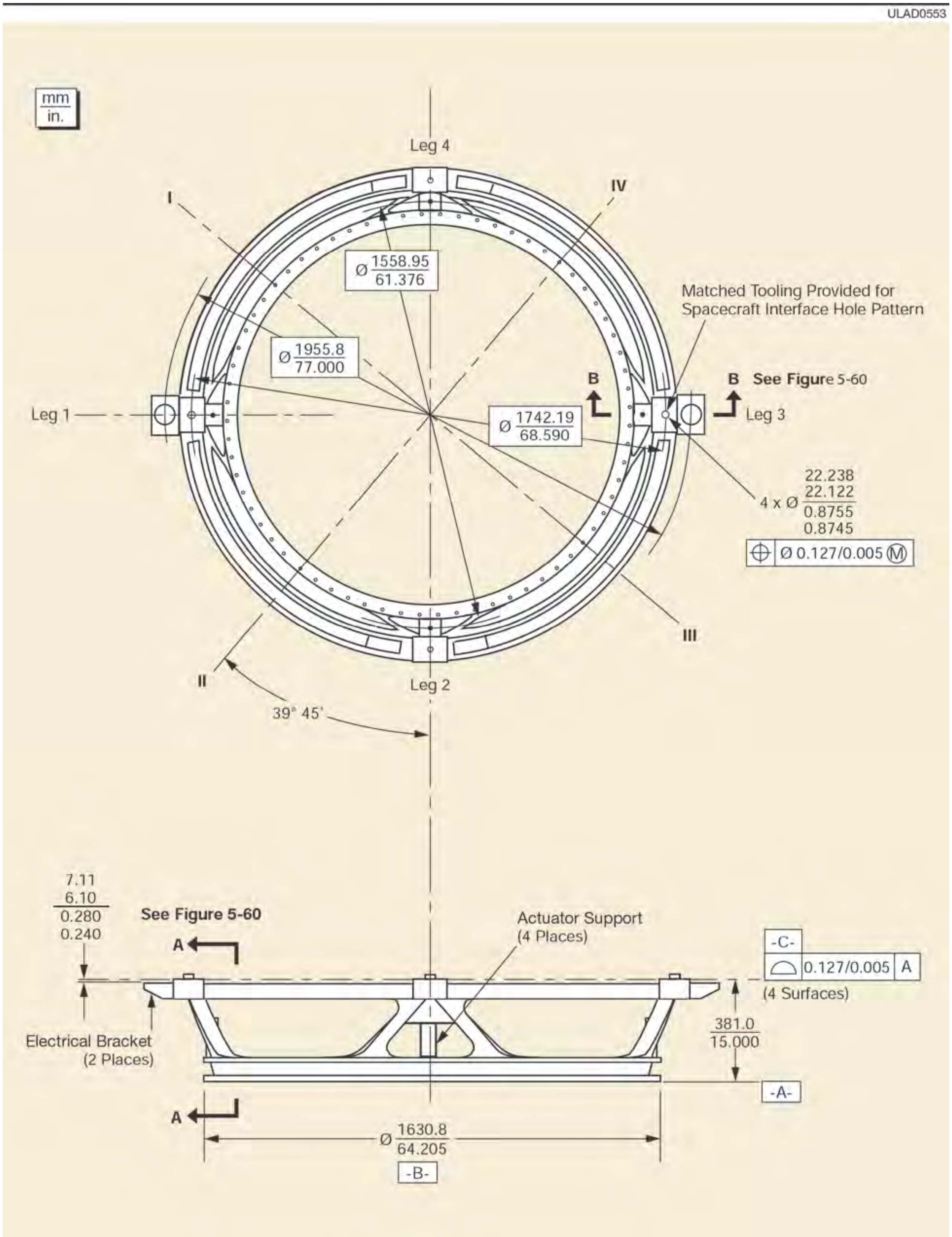


Figure 5-59. 6915 PLA Detailed Assembly

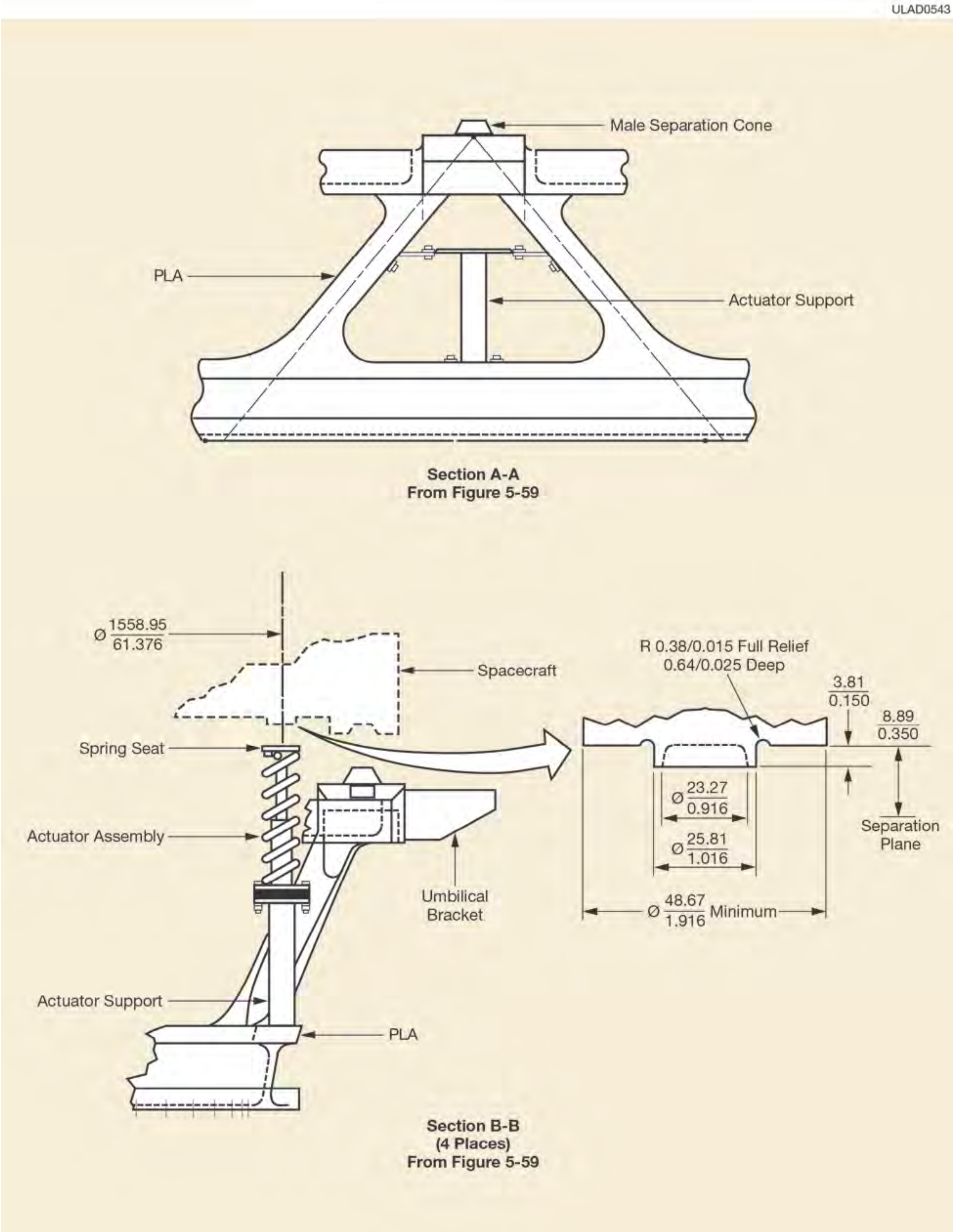


Figure 5-60. 6915 PLA Detailed Dimensions

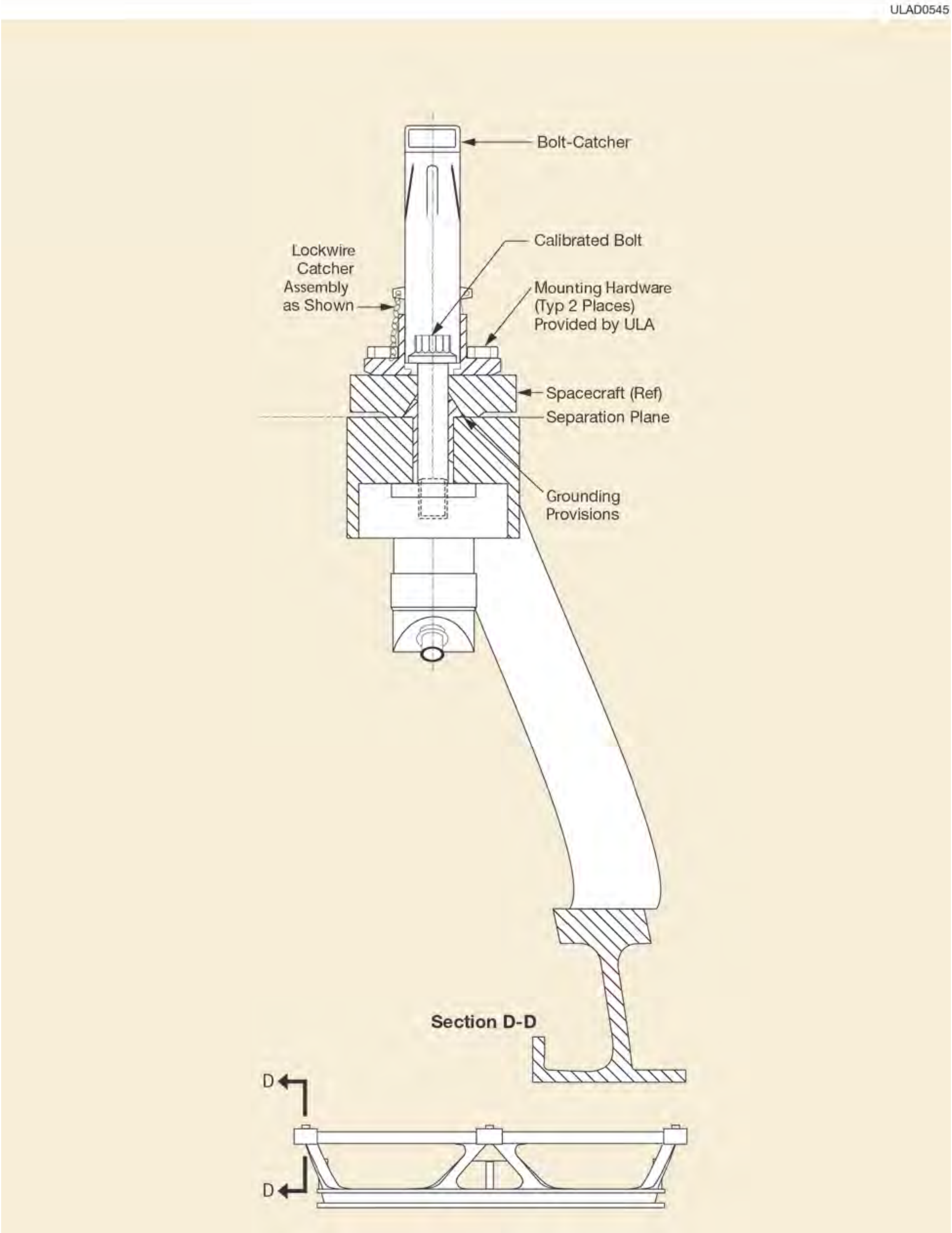


Figure 5-61. 6915 PLA Separation Spring Assembly

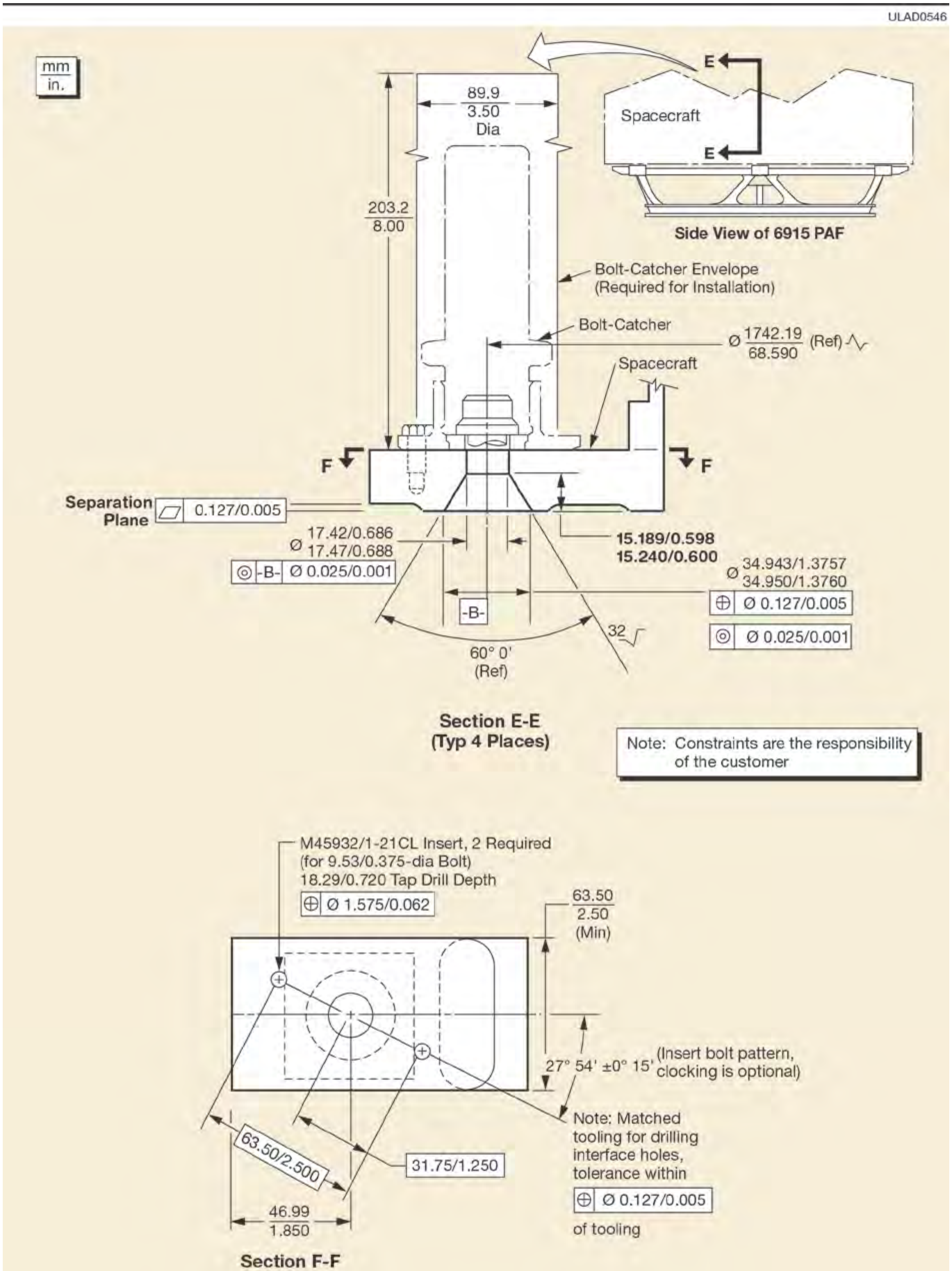


Figure 5-62. 6915 PLA Spacecraft Interface Dimensional Constraints

5.4 DELTA IV ELECTRICAL INTERFACES

The standard electrical interfaces with the payload are common for all Delta IV configurations and for either launch site. The interface is defined at the Standard Electrical Interface Panel (SEIP) on the PAF for bolted SV/LV interfaces, or at the payload In Flight Disconnect (IFD) separation connectors for clampband separation bolt type interfaces. At that location, electrical cables from the launch vehicle mate with cables from the payload until time of payload separation. For multiple spacecraft with special dispenser systems, or other special configurations, this interface may be mechanized differently. Similarly, some payloads may require additional capacity and/or special electrical functions not provided by the standard interface. The ULA team will work closely with its customers to define the necessary enhancements to meet their needs

The Delta IV avionics system, with two independent power systems, system data buses, and interface electronics, provides full redundancy to the payload interface and is designed to sustain a single-point failure without degradation of avionics performance.

This standard interface supports several different electrical functions and can be separated into two categories, ground-to-payload functions and launch-vehicle-to-payload functions, as summarized in Figure 5-63.

Signal Function	Signal Quantity	Wire Count	Max Current	Max Voltage
Ground-to-Payload Functions				
Ground Power	15 Pairs	30	11 A	126 VDC
Data/Command/Monitoring	54 Pairs; 2 Triplets	120	3 A	126 VDC
Serial Digital	8 Twin Axial (78 ohm)	16	—	—
Launch Vehicle-to-Payload Functions				
Ordnance Discretes	8 Redundant Pairs	32	18 A	36 VDC
28 VDC Command Discretes or Switch Closures	8 Redundant Pairs	32	500 mA 1000 mA	33 VDC 32 VDC
Breakwire Separation Monitors	1 Redundant Pair	4	—	—
Telemetry Channels (Data & Clock)	2 Redundant Pairs	8	—	—

Figure 5-63. Electrical Interface Signal Functions

This guide does not identify all electrical interface capabilities. Customers should contact ULA for additional interface requirements.

5.4.1 Ground-to-Payload Functions

The standard electrical interface provides for the direct interconnection of payload power, command, and monitoring signals to a specially provided Space Vehicle Interface Panel (SVIP) in an Electrical Ground Support Equipment (EGSE) room provided by Delta for the payload customer. In this room, the payload customer can install any special equipment needed to monitor and maintain the payload while it is on the launch pad. This interface is available from the time of mating the encapsulated payload to the launch vehicle until launch.

The feed-through cabling goes from the SEIP or IFD, through the 2nd stage of the launch vehicle, out one of the vehicle's electrical umbilical connectors, over to a junction box, down the Fixed Umbilical Tower (FUT), and finally to the EGSE room, where another junction box provides interface to the customer cabling. Fifteen twisted pairs of power lines can be used to provide external power to the payload and charge its batteries, or other high-current applications, up to 11A per pair (at 126 VDC maximum). Another 54 twisted pairs and 2 twisted triplets of data/control/monitoring lines support up to 3A per pair (at 126 VDC maximum) for such functions as voltage, current and temperature monitoring, battery-voltage sensing, initiating, and monitoring self-test. Additionally, eight pairs of 78 Ω controlled impedance twin axial wires are provided for transmission of serial digital data. The above noted junction boxes provide the ability to configure the EGSE cabling to support the unique electrical requirements for each mission, and have the capability to accommodate customer-provided signal conditioning equipment within them if it is required (see Figure 64).

Three-phase, uninterruptible facility power is available to the customer in the EGSE room as follows:

Voltage:	120/208 VAC + 5%
Frequency:	60 Hz + 1%
Total Harmonic Distortion (THD)	Less than 5%
Voltage transients:	Less than 200% of nominal RMS voltage for not more than 200 μsec
Maximum load current:	20 kVA

Note: 50 Hz power can be provided through coordination with ULA.

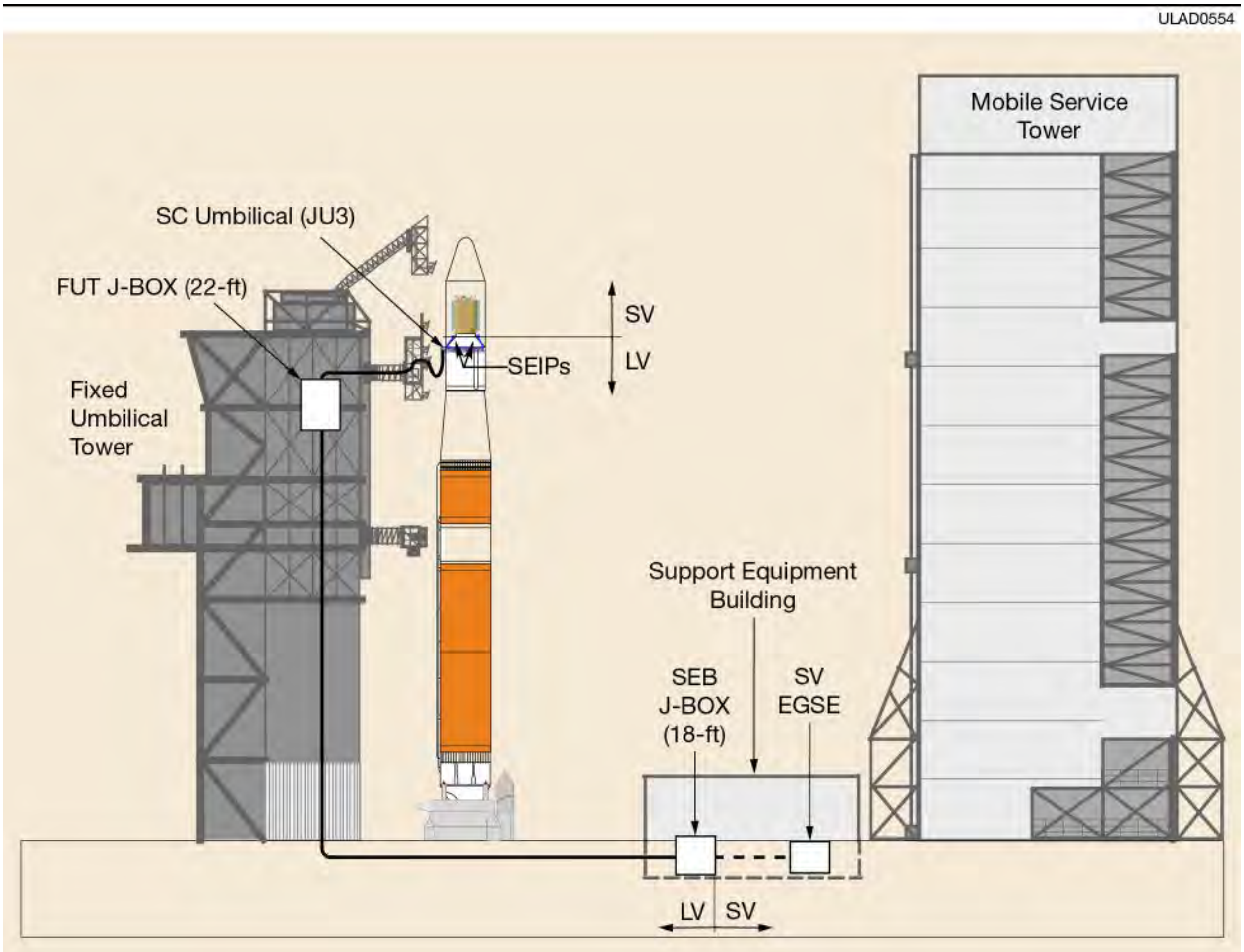


Figure 5-64. EGSE Cabling Support at Space Launch Complex 37B

5.4.2 Launch-Vehicle-to-Payload Functions

The standard electrical interface provides for four launch-vehicle-to-payload functions while in flight as described in the following sections.

5.4.2.1 Ordnance Discretes. The standard electrical interface provides for eight primary and eight redundant ordnance circuits to ignite up to eight pairs of Electro-Explosive Devices (EEDs) provided by the payload (or dispenser system).

Each circuit provides (one time only) a minimum of 5 A into a 0.9 Ω to 2.0 Ω load (wiring and one EED) with a nominal duration of 180 msec and is current-limited to 18 A. Other pulse durations can be provided to meet customer requirements. The primary/redundant firing pulses will be turned ON either within 5 msec of each other, or timing can be staggered, depending on customer requirements. Any number of the eight pairs of ordnance circuits may be commanded ON at the same time.

When commanded ON, each circuit appears as a 28 VDC (nominal) current source across the two-wire interface (High and Return), and as a direct short (for safety purposes) when not commanded ON.

5.4.2.2 28 VDC Command Discretes or Switch Closures. The standard electrical interface provides for eight primary and eight redundant circuits that can be configured as either 28 VDC command discretes or switch closures, depending on customer needs. Depending on customer requirements, the circuits may also be configured for four 28 V discretes and four switch closures.

If the circuits are configured as 28 VDC command discretes, the two-wire interface (High and Return) avionics circuits will provide the payload with up to 500 mA with a voltage of 23 to 33 VDC when commanded ON. When configured as switch closures, the two-wire (In and Out) avionics circuits will act as a solid-state relay and support the passage of up to 1 A at a voltage of 22 to 32 VDC when commanded ON. (When OFF, the leakage current shall be less than 1 mA.) In either case, the circuits can be commanded in any sequence with up to ten changes in state (ON/OFF) for each circuit, with each command user-defined with a minimum 20 msec duration. Unique command sequences can be accommodated; contact ULA for more information. Circuits that initiate SC mission-critical functions are required to be single fault tolerant, and must be able to tolerate discontinuities of up to 100 microseconds. Any identified failed criteria will be addressed on a case-by-case basis. The intent of this requirement is to ensure protection against inadvertent initiation of SC mission-critical functions during LV ascent, and is applicable to LV commanded discrete and SC separation detection circuits that the SC may be utilizing.

5.4.2.3 Breakwire Separation Monitors. The standard electrical interface provides for one pair of redundant separation monitor circuits. Typically, the payload provides a shorting jumper on its side of the circuit, and the avionics detects an open circuit when separation occurs. The jumper (and any wiring) in the payload must present less than 1 Ω before separation, and the circuit must open or be greater than 1 MΩ after separation.

If there is more than one payload and monitoring of each is required, the customer should request that additional pairs of monitors be provided.

5.4.2.4 Telemetry Channels. The standard electrical interface provides for two telemetry channels, each capable of receiving up to 4.0 kBps of data, and each transmitting to the Master Telemetry Unit (MTU) in the 2nd stage.

Each avionics channel consists of two RS-422 differential line receivers, one for data (non-return-to-zero—phase L) and one for the clock. Data is sampled on the FALSE-to-TRUE transition of the clock.

5.4.2.5 Additional Telemetry or Video. Delta IV has the capability to provide a non-standard launch service option of additional telemetry data and/or in-flight video. The telemetry is down-linked in real time, and the video can be down-linked in either real time or delayed, depending on mission requirements.

5.4.3 Spacecraft Connectors

On a mission-specific basis, the Delta IV launch system will provide to the payload customer mating connector halves for the payload side of the SEIP or IFD. Typical connector allocations and part numbers for SEIP and IFD interfaces are shown in Figure 5-65, but alternative interfaces can be accommodated. Contact ULA for more information.

SEIP Interface					
	LV		SC		
Signal Type	**Conn**	**MS Equivalent Connector Part Number**	**Conn**	**MS Equivalent Connector Part Number**	**Contacts**
Power	J1	D38999/24FJ19SN	P1	D38999/26FJ19PN	19 size 12
Power	J2	D38999/24FJ19SA	P2	D38999/26FJ19PA	19 size 12
SC Commands/Monitor (Ground)	J3	D38999/24FJ61SN	P3	D38999/26FJ61PN	61 size 20
SC Commands/Monitor (Ground)	J4	D38999/24FJ61SA	P4	D38999/26FJ61PA	61 size 20
Serial Data	J5	D38999/24FF32SN	P5	D38999/26FF32PN	32 size 20
SC Commands (Flight)	J6	D38999/24FD19SN	P6	D38999/26FD19PN	19 size 20
SC Commands (Flight)	J7	D38999/24FD19SA	P7	D38999/26FD19PA	19 size 20
Ordnance Commands	J8	D38999/24FE26SN	P8	D38999/26FE26PN	26 size 20
Ordnance Commands	J9	D38999/24FE26SA	P9	D38999/26FE26PA	26 size 20
IFD Interface					
	P1	MS3446E61-50P (D8179E61-0PN-4010)	J1	MS3464E61-50S (D8174E61-0SN-4010)	61 size 20
	P2	MS3446E61-50P (D8179E61-0PN-4010)	J2	MS3424E61-50S (D8174E61-0SN-4010)	61 size 20

Figure 5-65. Delta IV Spacecraft Connectors

5.4.4 Customer Wiring Documentation

To ensure proper attention to the customer's needs, information regarding customer wiring documentation shall be furnished by the customer; this information to include signal name, signal function, resistance or voltage drop requirements, and circuit maximum currents. To prevent damage to LV airborne and ground systems in the event of a fault, the SC customer will be required to verify that the SC EGSE interface design will provide current limiting protection for the individual circuits. For SC/LV In-Flight Disconnect electrical connectors, vibration and shock environments will need to be provided by the SV. This data would be derived by using the ULA-provided environment data at the SV/LV primary mechanical interface and determining what the connector interface response would be, either through analysis or test. This data will be used to confirm there is sufficient margin, of the connector components, between the demonstrated environments and the maximum predicted flight environments of the electrical IFD interface.

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Section 6
PAYLOAD FAIRINGS

The payload launched on a Delta IV Medium, Delta IV M+, or Delta IV Heavy launch vehicle is protected by a fairing that shields it from the external environment and contamination during the prelaunch and ascent phases. The Delta IV launch system uses a wide variety of heritage-based fairings to meet the broad needs of our customers (Figure 6-1). Fairings are jettisoned during either late 1st stage or early 2nd stage powered flight when an acceptable free molecular heating rate is reached (Section 2.2). A general discussion of the Delta IV fairings is presented in Section 6.1. Detailed fairing descriptions and envelopes are given in Sections 6.2 and 6.3. Information on future payload fairing capabilities is provided in Section 8.

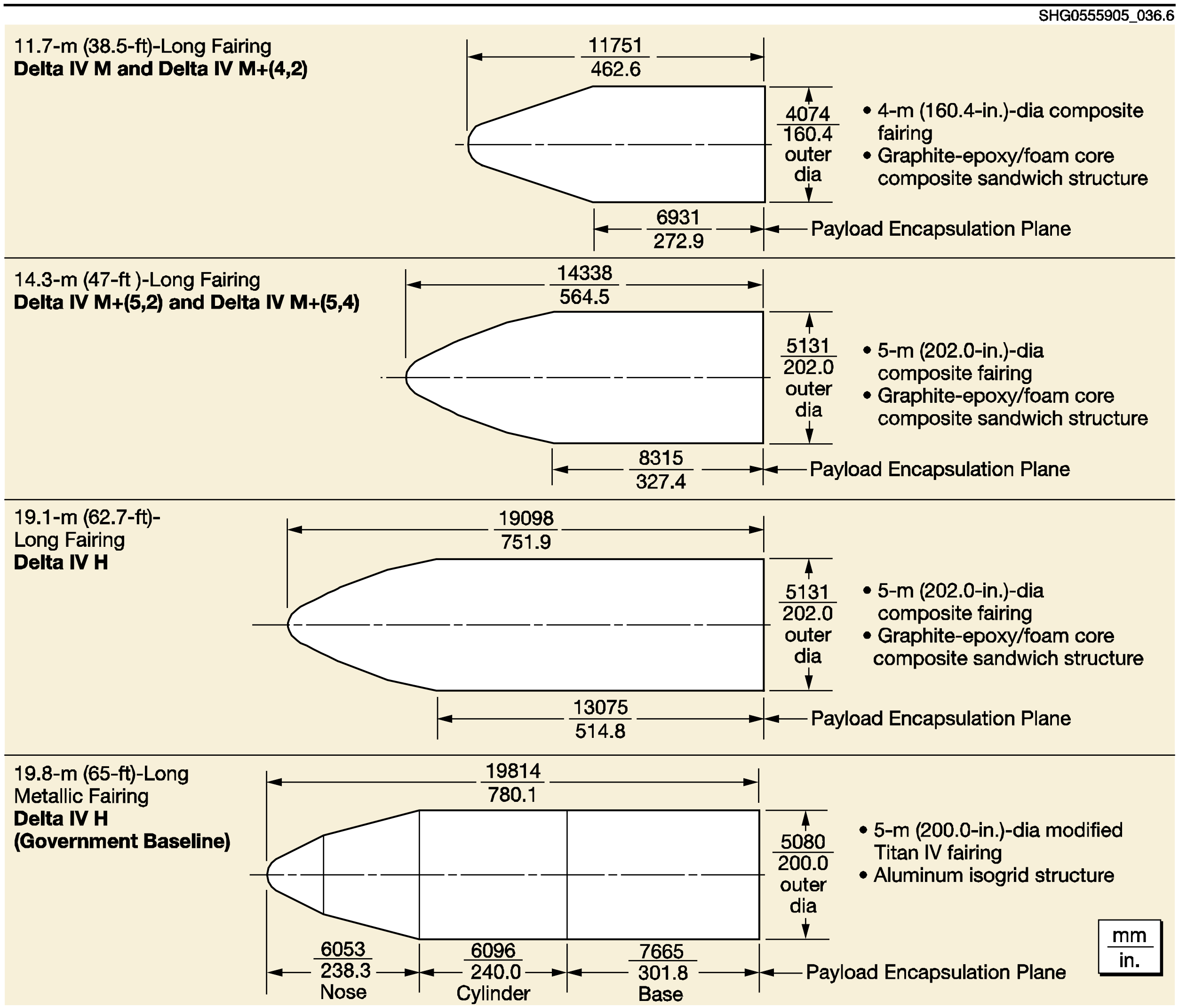

Figure 6-1. Delta IV Fairing Configurations

6.1 GENERAL DESCRIPTION

The internal fairing envelopes presented in the following text and figures define the maximum allowable static dimensions of the payload (including manufacturing tolerances) relative to the payload/attach fitting interface. If the payload dimensions are maintained within these envelopes, there will be no contact of the payload with the fairing during flight as long as the payload's frequency and structural stiffness characteristics are within the guidelines specified in Section 3.2.4.2. Payload envelopes include allowances for relative deflections between the launch vehicle and payload. Also included are launch vehicle manufacturing tolerances and the thickness (including billowing) of the acoustic blankets that are installed on the interior of the fairing.

Typical acoustic blanket configurations are described in Figure 6-2.

Fairing	Location
4-m Delta IV Medium and Delta IV M+(4,2)	The baseline configuration for acoustic blankets is 76 mm (3 in.) thick, running from just below the nose cap to the base of the fairing.
5-m Delta IV M+(5,2), Delta IV M+(5,4), and Delta IV Heavy composite fairing	The baseline configuration for acoustic blankets is 114 mm (4.5 in.) thick, running from just below the nose cap to the base of the fairing.
5-m Delta IV Heavy, metallic fairing	The baseline configuration for acoustic blankets is 76 mm (3 in.) thick, running from just below the 15 deg to 25 deg cone joint in the nose cone to the base of the fairing.
▪ The configurations may be modified to meet mission-specific requirements.	
▪ Blankets for the Delta IV composite fairings are constructed of acoustic dampening material and are vented through the aft section of the fairings. These blankets are designed to meet the intent of the 1.0% maximum total weight loss and 0.10% maximum volatile condensable material.	
▪ Blankets for the Delta IV metallic fairing are constructed of silicone-bonded heat-treated glass-fiber batting enclosed between two 0.076 mm (0.003 in.) conductive Teflon-impregnated fiberglass facesheets. The blankets are vented through a 5 μm stainless steel mesh filter that controls particulate contamination to levels better than a class 10,000 clean-room environment. Outgassing of the acoustic blankets meets the criteria of 1.0% maximum total weight loss and 0.10% maximum volatile condensable material.	

Figure 6-2. Typical Acoustic Blanket Configurations

Clearance layouts and analyses are performed and, if necessary, critical clearances between the payload and fairing are measured after the fairing is installed to ensure positive clearance during flight. To facilitate this, the payload description must include an accurate definition of the physical location of all points on the payload that are within 51 mm (2 in.) of the allowable envelope. (Refer to Section 4, Mission Integration and Safety) The dimensions must include the maximum payload manufacturing tolerances (and, if applicable, payload blanket billowing).

An air-conditioning inlet door on the fairing provides a controlled environment for the encapsulated payload while on the launch stand (Section 3.1.1). A gaseous nitrogen (GN2) purge system can be incorporated on a mission-unique basis to provide continuous dry nitrogen to the payload until liftoff.

Payload contamination is minimized by cleaning the fairing in a class 100,000 cleanroom prior to shipment to the field site. More stringent cleanliness levels for the fairing and inspection using an ultraviolet (UV) light are available on request (see Section 3.1.5 for a description of cleanliness levels).

6.2 4-M AND 5-M-DIA COMPOSITE PAYLOAD FAIRING

The 4-m-dia by 11.7-m (38.5-ft)-long composite fairing is used on the Delta IV Medium and Delta IV M+(4,2) launch vehicles. The 5-m-dia by 14.3m (47.1-ft)-long composite fairing is used on the Delta IV M+(5,2) and Delta IV M+(5,4) launch vehicles. The 5-m-dia by 19.1-m (62.7-ft)-long composite fairing is used on the Delta IV Heavy launch vehicle.

The 4-m composite fairing (Figure 6-3) and the 5-m composite fairing (Figures 6-4 and 6-5) are composite sandwich structures that separate into two bisectors. Each bisector is constructed in a single co-cured layup, eliminating the need for module-to-module manufacturing joints and intermediate ring stiffeners. The resulting smooth inside skin provides the flexibility to install access doors almost anywhere in the cylindrical portion of the fairing (Figures 6-6, 6-7, and 6-8).

Figure 6-3 defines the envelopes for the 4-m fairing with the 1575-4 payload attach fitting. Figures 6-4 and 6-5 define the envelopes for the 14.3-m (47.1-ft) and 19.1-m (62.7-ft)-long 5-m composite fairings with the 1575-5 payload attach fitting.

These figures assume that the payload stiffness guidelines in Section 3.2.4.2 are observed. All payload intrusions outside of the payload envelopes or below the payload separation plane require coordination with and approval of ULA.

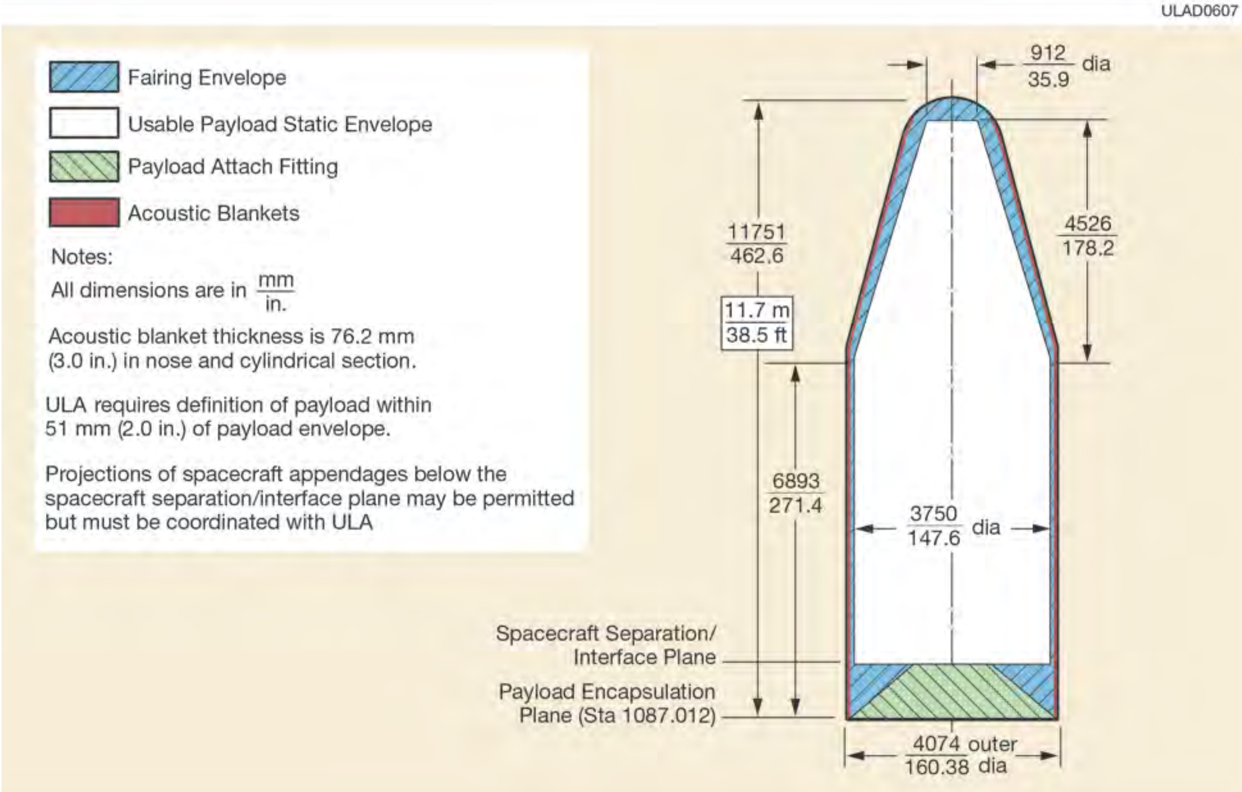

Figure 6-3. Payload Static Envelope, 4-m-dia Composite Fairing

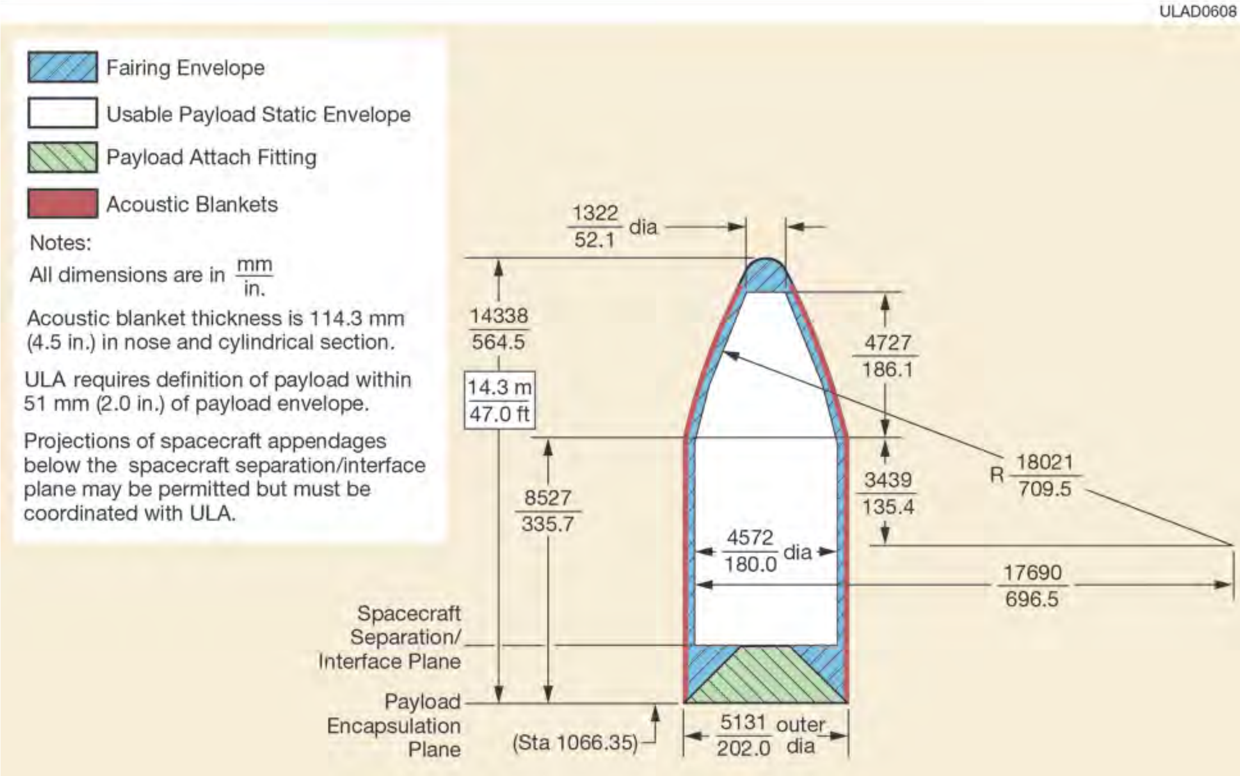

Figure 6-4. Payload Static Envelope, 5-m-dia by 14.3-m-Long Composite Fairing

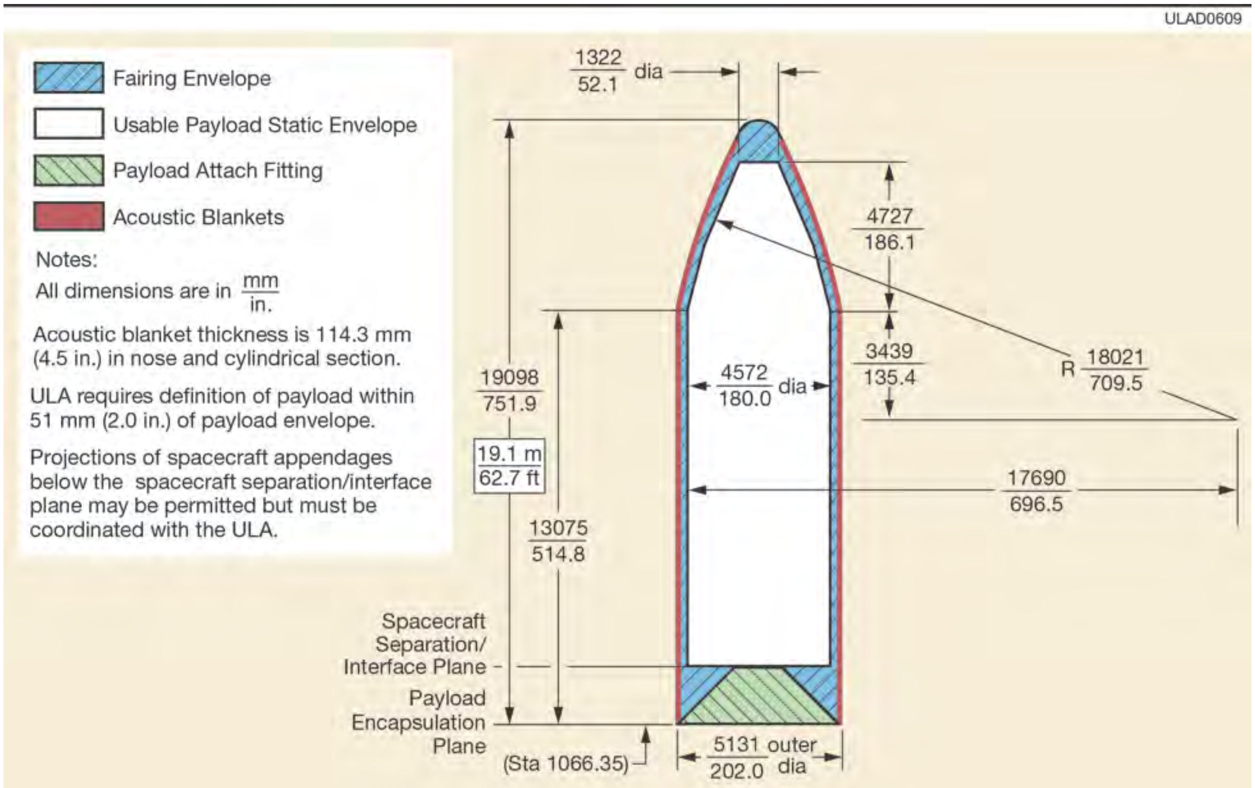

Figure 6-5. Payload Static Envelope, 5-m-dia by 19.1-m Composite Fairing

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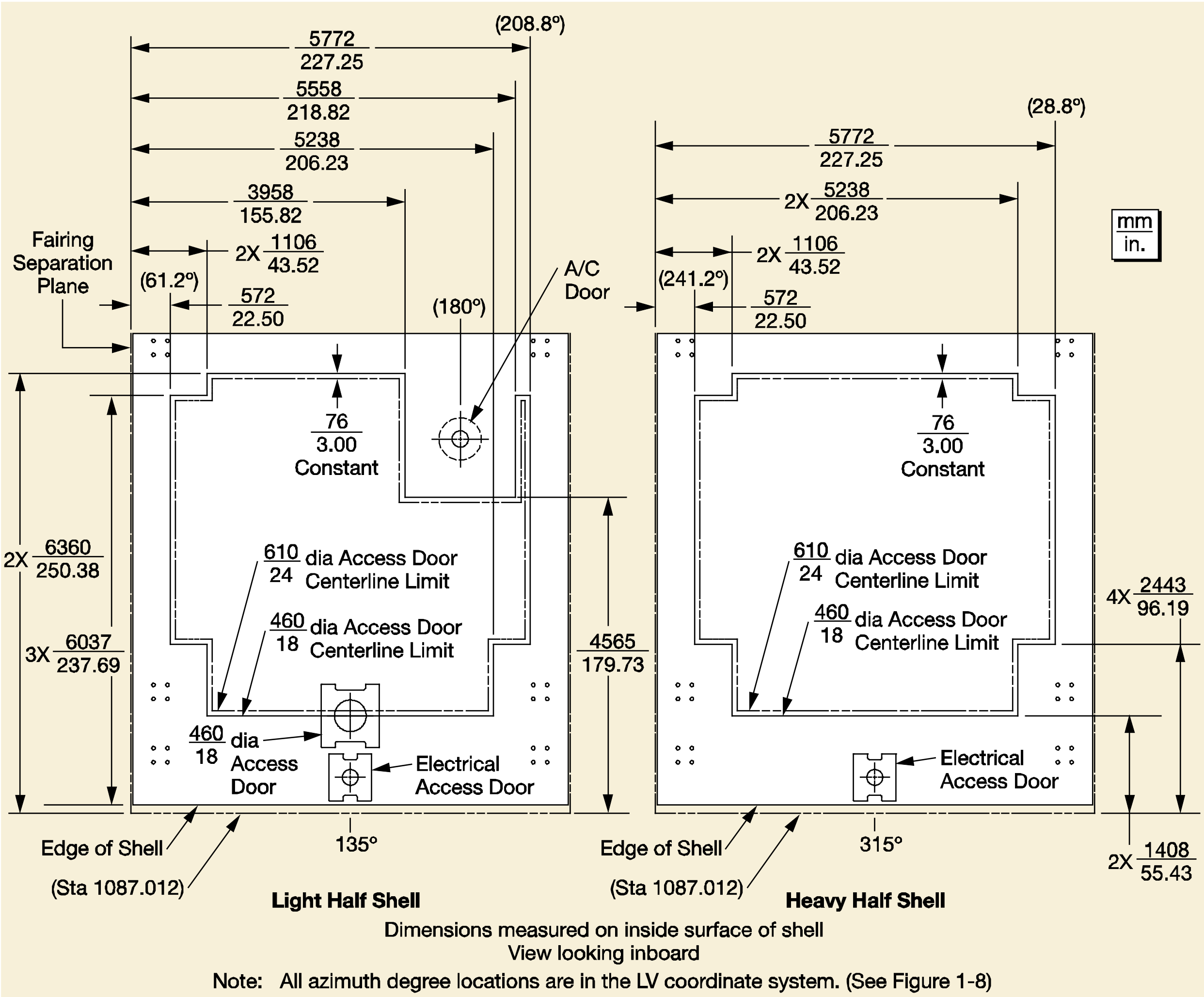

Figure 6-6. Allowable Access Door Locations for 4-m-dia by 11.7-m-Long Composite Fairing

Two standard access doors, 0.46 m (18 in.) dia or 0.61 m (24 in.) dia, are provided in the fairing cylindrical section. Because it is understood that customers may need access to items such as payload ordnance devices, electrical connectors, and fill-and-drain valves for payloads using liquid propellants, additional access doors can be installed on a mission-unique basis. Also, differing diameters or shapes for the two standard access doors can be accommodated on a mission-unique basis. Access doors typically do not have acoustic blankets attached to their inboard surfaces but can have them, on a mission-unique basis, to provide additional acoustic attenuation. Access door locations and sizes should be coordinated with ULA.

Radio frequency (RF) windows and/or RF re-rad antennas can be accommodated on a mission-unique basis. RF window requirements should be coordinated with ULA.

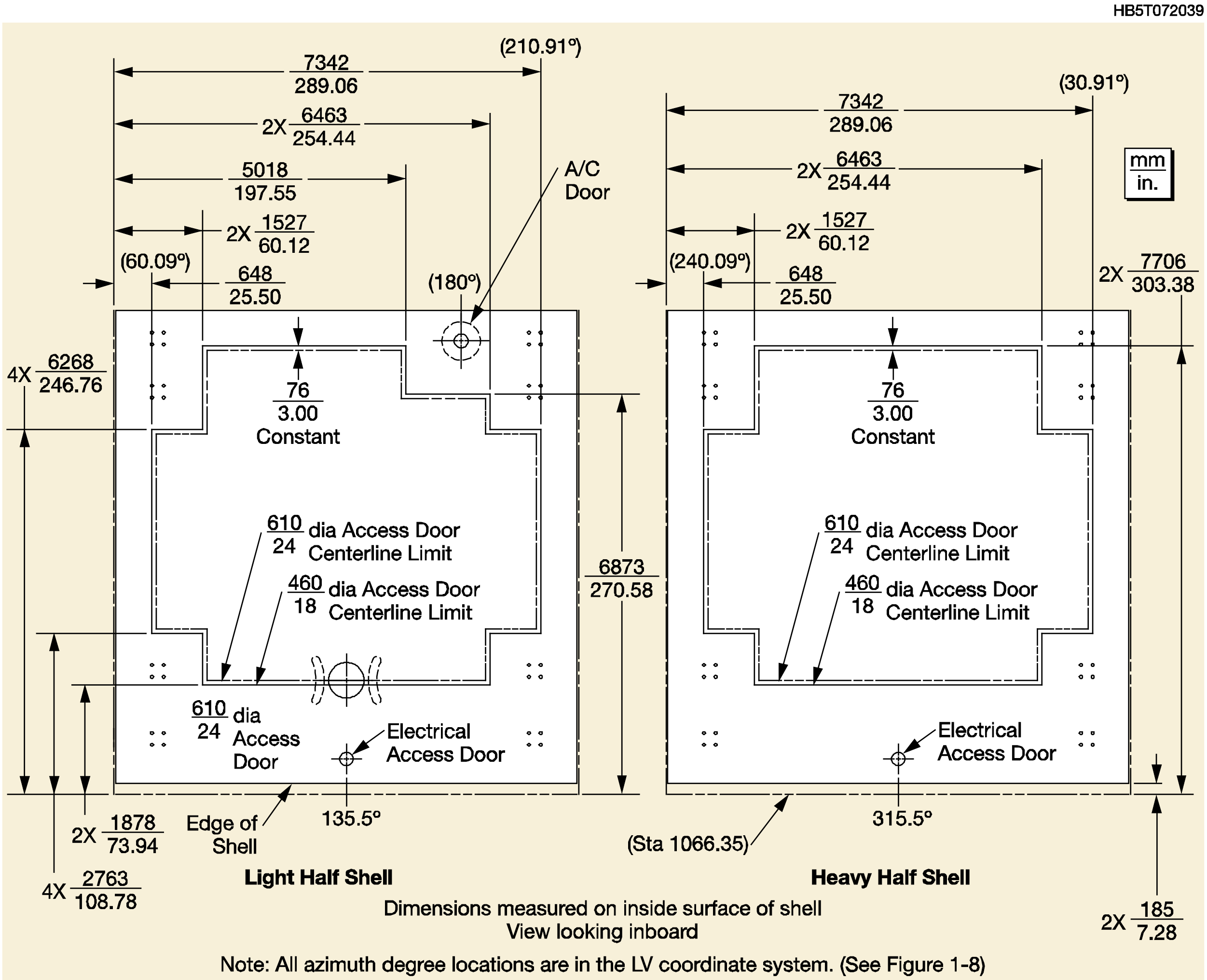

Figure 6-7. Allowable Access Door Locations for 5-m-dia by 14.3-m-Long Composite Fairing

The bisectors are joined by a contamination-free linear piston/cylinder thrusting separation rail system that runs the full length of the fairing. Two functionally redundant explosive bolt assemblies provide structural continuity at the base ring of the fairing.

The fairing bisectors are jettisoned by actuating the explosive bolt assemblies and then detonating the linear explosive strands in the thrusting joint cylinder rail cavity. Separation augmentation springs are provided to ensure positive separation clearance. A bellows assembly in each cylinder rail retains the combustion product gases and thereby prevents payload contamination during the fairing separation event.

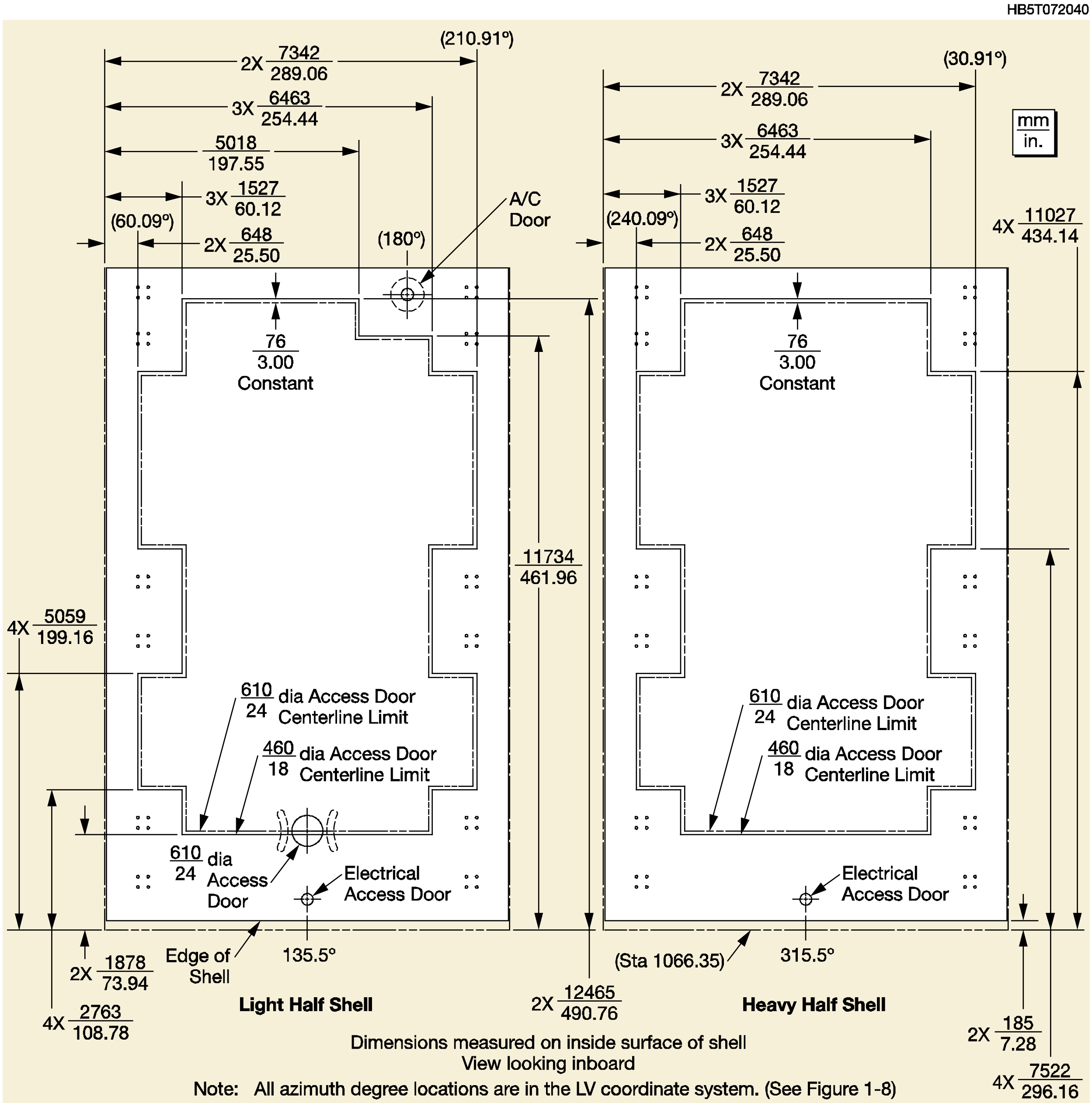

Figure 6-8. Allowable Access Door Locations for 5-m-dia by 19.1-m-Long Composite Fairing

6.3 5-M-DIA METALLIC PAYLOAD FAIRING

The 5-m-dia modified Titan IV metallic fairing (Figure 6-9) is an aluminum isogrid structure that separates into three sectors. Its flight-proven, frame-stabilized isogrid skin is designed to provide a lightweight structure while maintaining sufficient strength, stiffness, and aerial density, to withstand the flight environments. This fairing is 19.8-m (65-ft)-long and is the baseline 5-m fairing for heritage government payloads flying on Delta IV Heavy launch vehicles. This fairing is compatible only with the 4394-5 PAF.

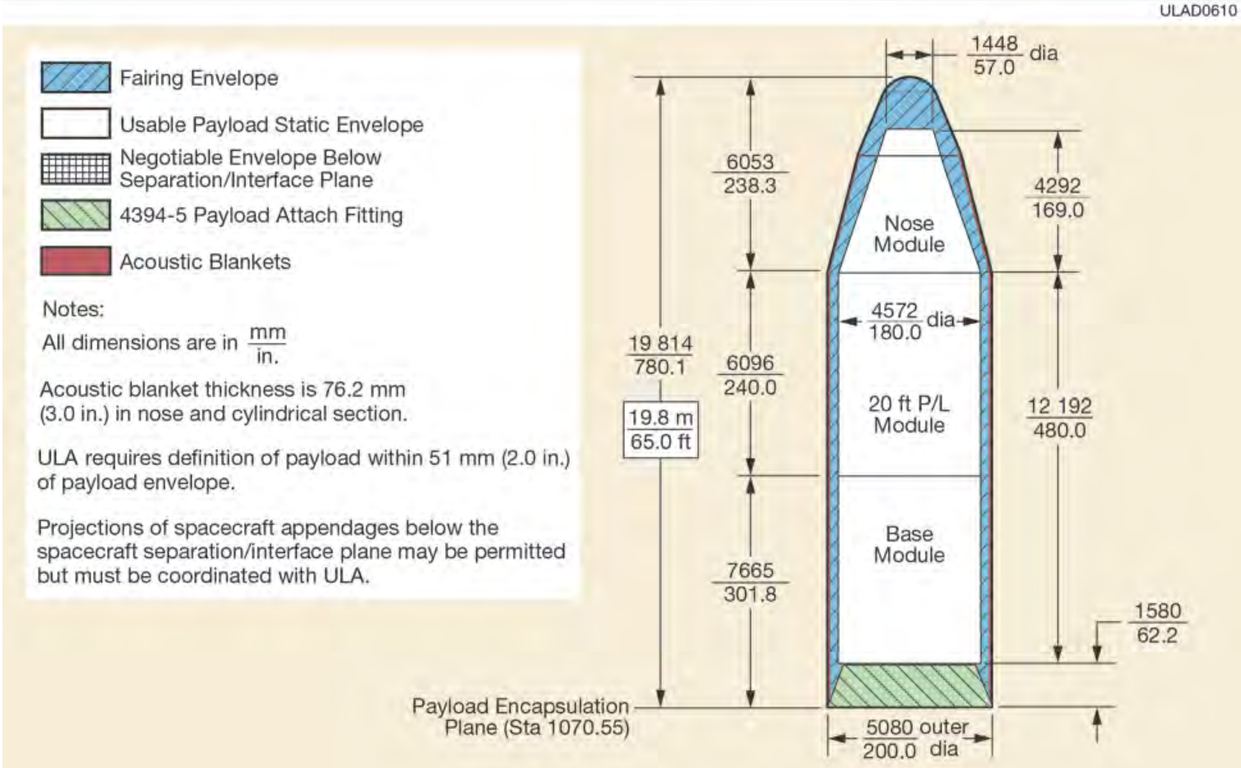

Figure 6-9. Payload Static Envelope, 5-m-dia by 19.8-m-Long Metallic Fairing Payload Envelope–4394-5 PAF

The fairing trisectors are joined by a contamination-free linear piston/cylinder thrusting separation rail system that runs the full length of the fairing. Two functionally redundant release nuts and studs provide structural continuity at the cone/cylinder junction and at the base of the fairing at each trisector separation rail interface. The fairing trisectors are jettisoned by actuating the release nut and studs first and then by detonating the linear explosive assembly in the thrusting joint cylinder rail cavity. The bellows assembly in each cylinder rail retains the combustion product gases, preventing contamination of the payload during the fairing separation event.

The baseline acoustic blanket configuration is described in Figure 6-2. The Delta Program can provide acoustic blankets varying in thickness from 38 mm (1.5 in.) up to 152 mm (6 in.) in 13 mm (0.5 in.) increments, including the addition of acoustic blankets in the biconic nose above the 15 deg to 25 deg cone joint. Two payload access doors will be provided to suit the user's needs on a standard basis. The customer may choose from several door sizes that are all flight-qualified for production. Additional access doors can be provided. All access door sizes and locations must be coordinated with ULA.

Figure 6-9 assumes that the payload stiffness guidelines in Section 3.2.4.2 are observed. Intrusion into any portion of the fairing envelope that is below the separation plane or local protuberances outside the usable payload static envelope requires coordination with and approval by ULA.

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Section 7
SPACECRAFT PROCESSING AND LAUNCH OPERATIONS

7.1 LAUNCH OPERATIONS AT EASTERN RANGE

This section presents a description of Delta IV launch vehicle operations associated with Space Launch Complex 37 (SLC-37) at Cape Canaveral Air Force Station (CCAFS), Florida. Delta IV prelaunch processing (Figure 7-1) and spacecraft operations conducted prior to launch are described.

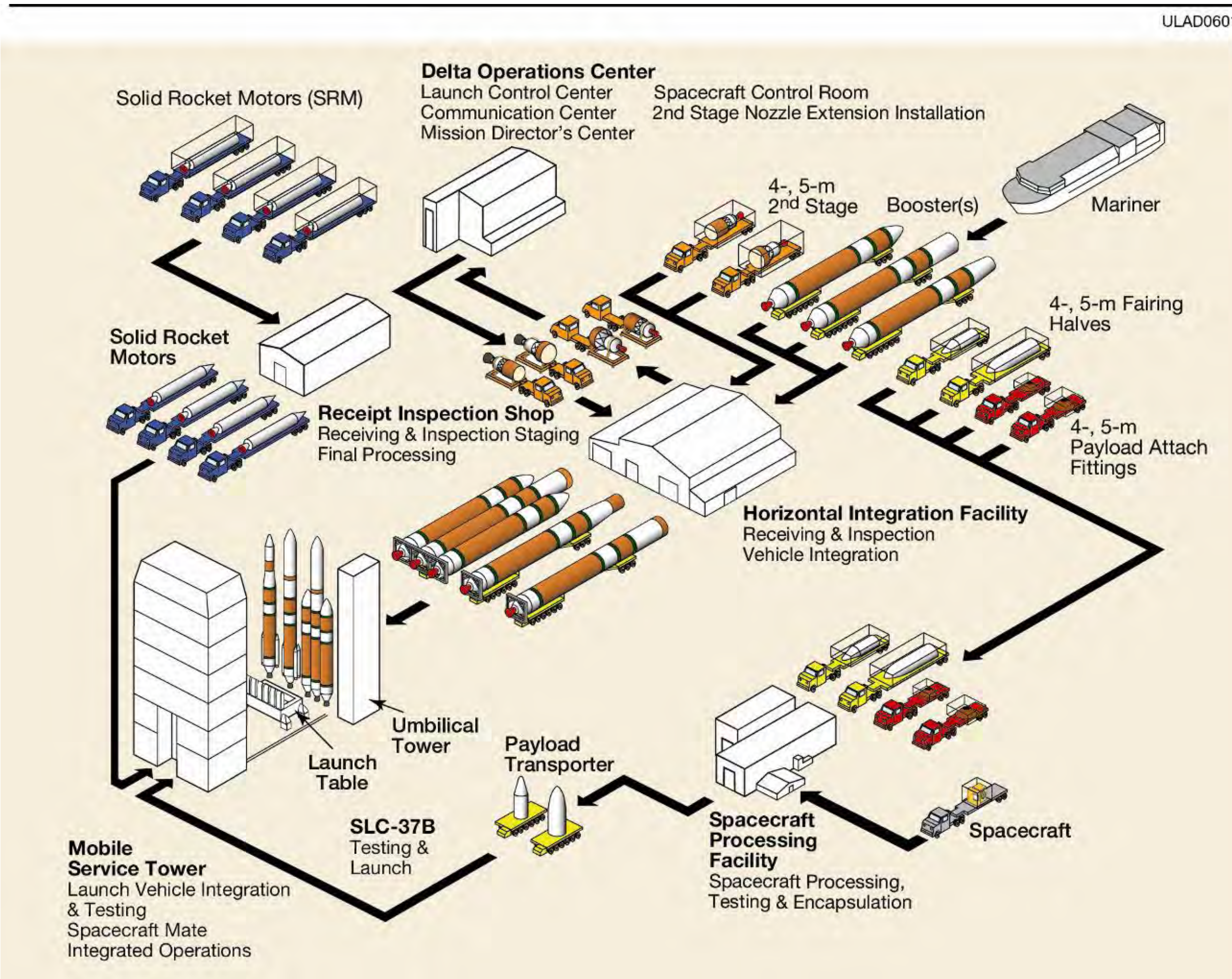

Figure 7-1. CCAFS Processing Flow

7.1.1 Organizations

ULA operates the Delta launch system and maintains a team that provides launch services to the National Reconnaissance Office (NRO), United States Air Force (USAF), National Aeronautics and Space Administration (NASA), and Commercial Customers at CCAFS. ULA provides the interface to the Federal Aviation Administration (FAA) and the Department of Transportation (DOT) for the licensing and certification needed to launch commercial payloads using Delta IV.

ULA interfaces with the USAF 45th Space Wing (45 SW) Directorate of Plans. The USAF designates a Program Support Manager (PSM) to be a representative of 45 SW. The PSM serves as the official interface for all USAF support and services requested. These services include range instrumentation; facilities/equipment operation, maintenance and safety; security and logistics support. Requirements for range services are described in documents prepared and submitted to the government by ULA, based on inputs from the Space Vehicle Contractor/ Customer (SVC) and using the government's Universal Documentation System (UDS) format (see Section 4, Mission Integration and Safety). The organizations that support a launch are shown in Figure 7-2. For each mission, a site integrator from the ULA CCAFS launch team is assigned to assist the spacecraft team during the launch campaign by helping to obtain safety approval of the payload test procedures and operations, integrating the spacecraft operations into the launch vehicle activities, and serving as the interface between the payload Customer and test conductor in the Launch Control Center (LCC) during the countdown and launch. ULA interfaces with NASA at Kennedy Space Center (KSC) through the Launch Services Program Office. NASA designates a Launch Site Integration Manager (LSIM) who arranges for all of the support requested from NASA for a launch from CCAFS.

ULA also has an established working relationship with Astrotech Space Operations (ASO). Astrotech owns and operates a processing facility for commercial payloads in Titusville, Florida, in support of Evolved Expendable Launch Vehicles (EELV) missions. Use of these facilities and services may be arranged for the Customer by the ULA Customer Program Office.

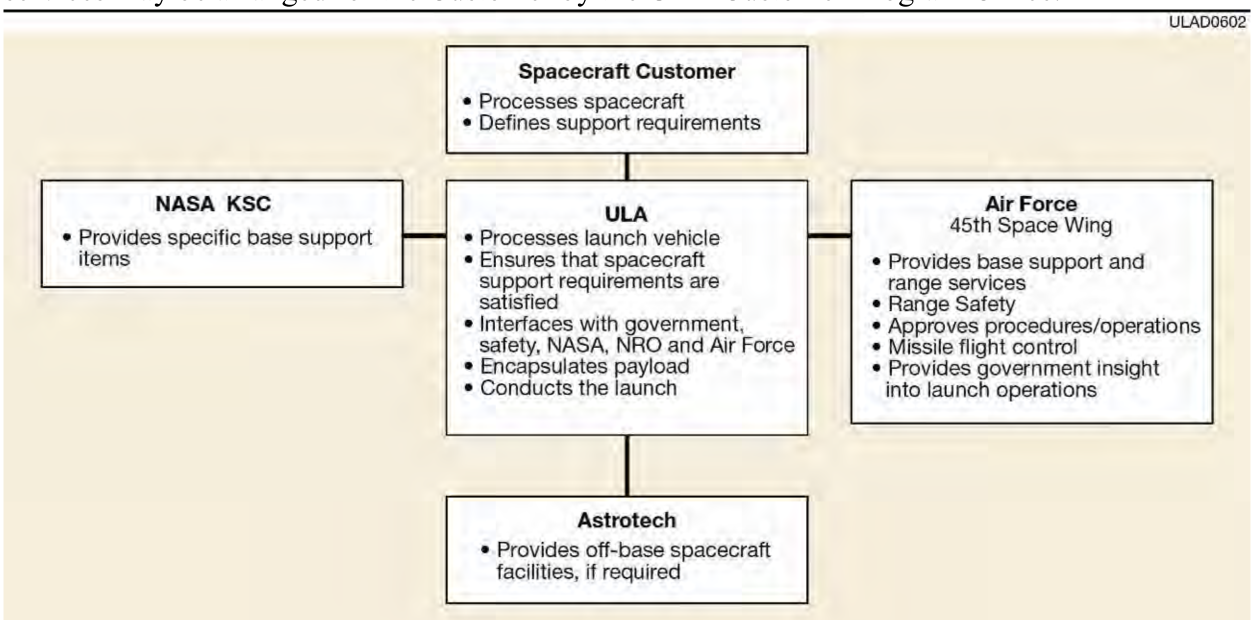

Figure 7-2. Organizational Interfaces

7.1.2 Facilities

In addition to the facilities required for Delta IV launch vehicles, the specialized Payload Processing Facilities (PPFs) listed below are provided for checkout and preparation of government and commercial spacecraft. Laboratories, cleanrooms, receiving and shipping areas, hazardous operations areas, and offices are provided for use by payload project personnel.

USAF Facilities

- Eastern Processing Facility (EPF) – NRO Facility
- Defense Satellite Communication System (DSCS) Processing Facility (DPF)
- Large Processing Facility (LPF)

Hazardous processing may be accomplished at these facilities as well

NASA Facilities

- Multi-Payload Processing Facility (MPPF)
- Payload Hazardous Servicing Facility (PHSF)

Commercial Facilities

- Astrotech Space Operations (ASO)

Commercial spacecraft will normally be processed through the Astrotech facilities. Payload processing facilities controlled by NASA, NRO, and the USAF will be used for commercial launches only under special circumstances.

The SVC must provide its own test equipment for spacecraft preparations, including telemetry receivers and command and control ground stations. Communications equipment, including antennas, is available as base equipment for voice and data transmissions.

Transportation and handling of the spacecraft and associated equipment from any of the local airports to the spacecraft processing facility are provided by the processing facility selected by the SVC with assistance from ULA. Equipment and personnel are also available for loading and unloading operations. Shipping containers and handling fixtures attached to the spacecraft are provided by the SVC.

Shipping and handling of hazardous materials such as Electro-Explosive Devices (EEDs) and radioactive sources must be in accordance with applicable regulations. It is the responsibility of the SVC to identify these items and become familiar with such regulations. ULA can provide assistance if required. Included are regulations imposed by NASA, NRO, USAF, and FAA (refer to Section 4).

7.1.2.1 Astrotech Space Operations Facilities. The Astrotech facility is located approximately 5.6 km (3 mi) west of the Gate 3 entrance to KSC near the intersection of State Road 405 and State Road 407 in the Spaceport Industrial Park in Titusville, Florida. A complete description of the Astrotech facilities can be found on the Astrotech Website at: http://www.astrotechcorp.com/business-units/astrotech-so.

7.1.2.2 CCAFS Operations and Facilities. Prelaunch operations and testing of Delta IV payloads at CCAFS takes place in the Cape Canaveral industrial area and SLC-37.

7.1.2.2.1 Cape Canaveral Industrial Area. Delta IV payload support facilities are located in the CCAFS industrial area (Figure 7-3). USAF shared facilities or work areas at CCAFS are available for supporting spacecraft activities and SVCs. These areas include the following:

- Solid propellant storage area
- Explosive storage magazines
- Electrical-mechanical testing facility
- Liquid propellant storage area

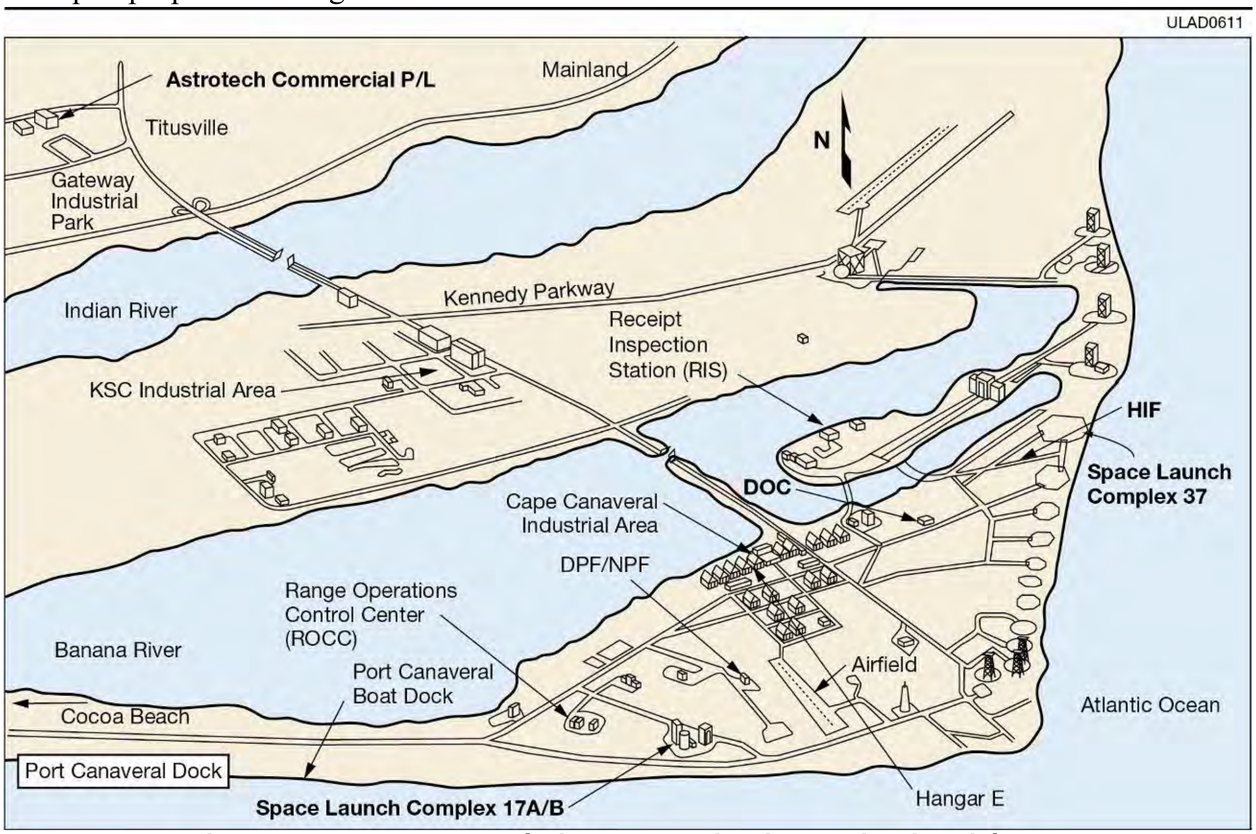

Figure 7-3. Cape Canaveral Air Force Station (CCAFS) Industrial Area

7.1.3 Spacecraft Encapsulation and Transport to the Launch Site

As mentioned in Section 7.1.2, ULA provides payload integration with the Payload Attach Fitting (PAF) and fueled payload encapsulation at the PPF. This capability enhances payload safety and security while mitigating contamination concerns, and greatly reduces launch pad operations in the vicinity of the payload. The basic sequence of operations is illustrated in Figure 7-4.

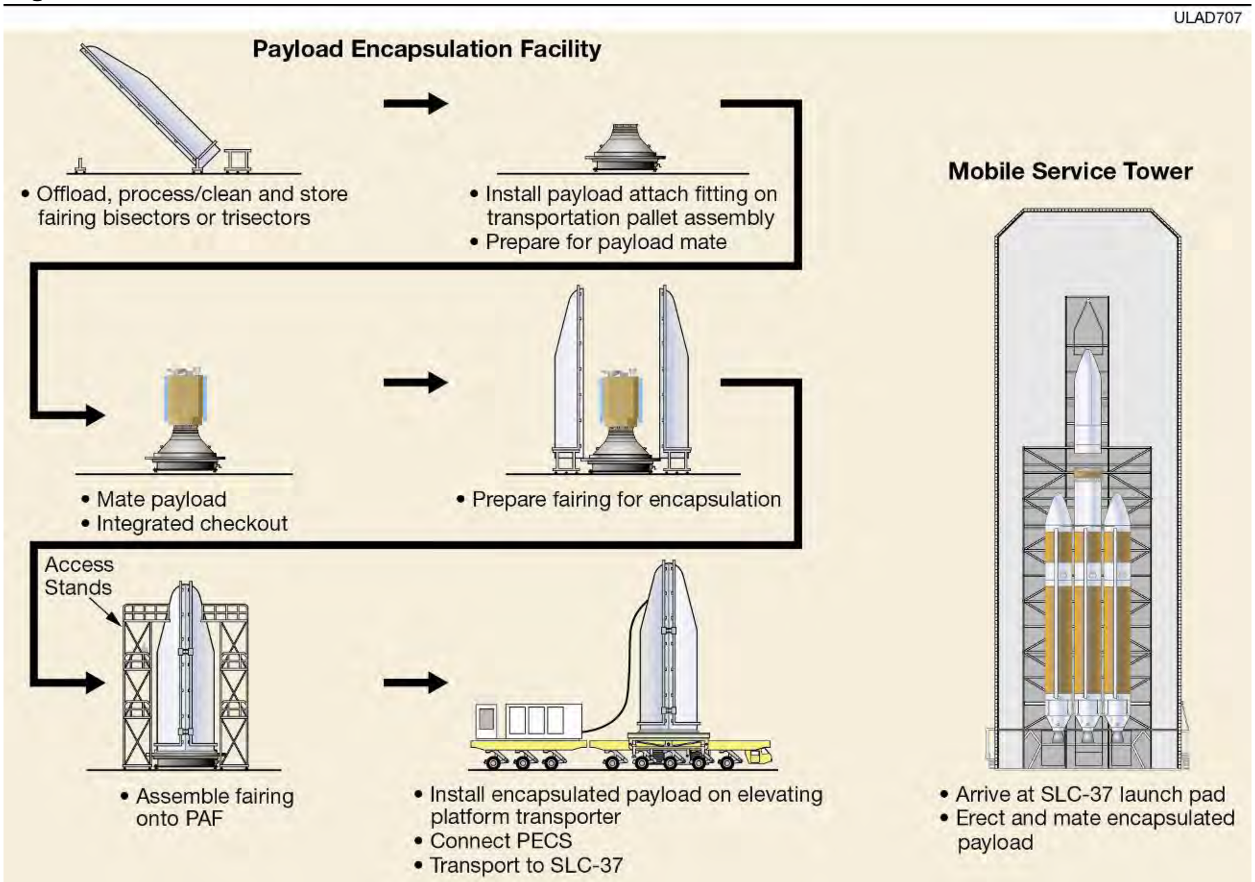

Figure 7-4. Payload Encapsulation, Transport, and On-Pad Mate

Prior to payload arrival, the Payload Fairing (PLF) and PAF are prepared for payload encapsulation. The fairing bisectors or trisectors are erected and stored on rolling transfer dollies. The PAF is installed on the encapsulation pallet and prepared for payload mate. After payload arrival and pre-mate operations are completed, including payload weighing if required in lieu of a certified weight statement, the payload is mated to the PAF, and an integrated checkout is performed. The previously prepared fairing bisectors or trisectors are rolled into position for final mate, and the access stands are positioned for personnel access to the fairing mating plane(s). These access stands can also be used for payload access prior to fairing mate. Interface connections are made and verified. A final payload telemetry test through the fairing can be accommodated at this time. The encapsulated payload is transferred to the elevating platform transporter provided by ULA and prepared for transport to the launch pad. Environmental controls are established, and a protective road barrier is installed on a mission unique basis.

After arrival at SLC-37, environmental control is discontinued and the encapsulated payload is lifted into the Mobile Service Tower (MST) and immediately mated to the second stage. Environmental control is re-established as soon as possible with class 5000 air while the MST enclosure is secured. Should subsequent operations require access through the fairing, a portable clean-environment shelter can be erected over the immediate area to prevent payload contamination, if required on a mission-unique basis.

The six Eastern Range payload processing facilities that are adequate for encapsulation operations with/without modification are listed in Figure 7-5.

Facility	Location	Encapsulation Capability
Vertical Processing Facility (VPF)	Kennedy Space Center, FL	4-m and 5-m fairings
Multi-Payload Processing Facility (MPPF)	Kennedy Space Center, FL	4-m fairings
Payload Hazardous Servicing Facility (PHSF)	Kennedy Space Center, FL	4-m and 5-m fairings
DSCS Processing Facility (DPF)	Cape Canaveral Air Force Station, FL	4-m fairings
Large Processing Facility (LPF)	Cape Canaveral Air Force Station, FL	4-m and 5-m fairings
Astrotech Space Operations (ASO)	Titusville, FL	4-m and 5-m fairings

Figure 7-5. Eastern Range Payload Processing Facilities

7.1.4 Space Launch Complex 37

SLC-37 is located in the northeastern section of CCAFS (Figure 7-6) between SLC-36 and SLC-40. It consists of one launch pad (pad B), a Mobile Service Tower (MST), a Fixed Umbilical Tower (FUT), a Common Support Building (CSB), a Support Equipment Building (SEB), ready room, shops, and other facilities needed to prepare, service, and launch the Delta IV vehicles.

The pad can launch any of the five Delta IV vehicle configurations. An aerial view of SLC-37 is shown in Figure 7-7; the general arrangement is illustrated in Figure 7-8.

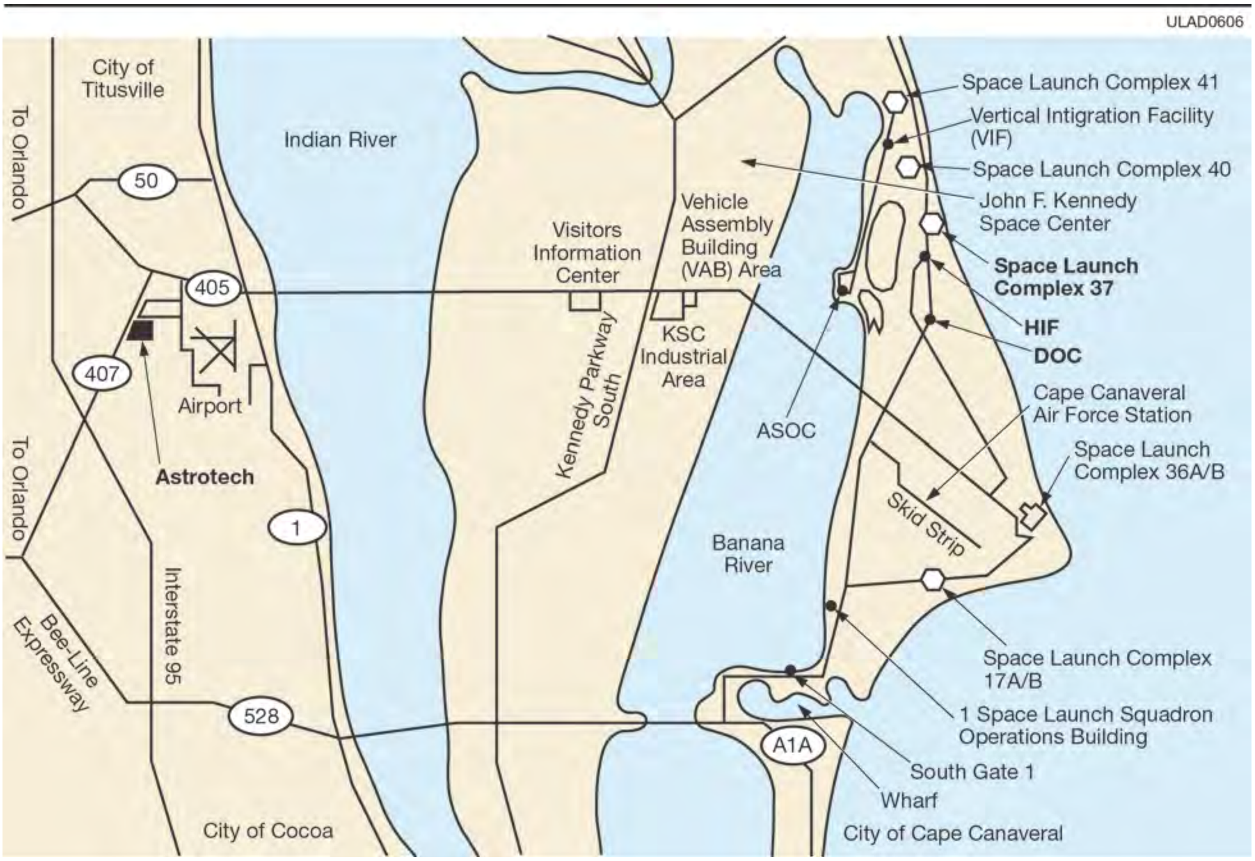

Figure 7-6. Cape Canaveral Air Force Station (CCAFS) Facilities

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Figure 7-7. Space Launch Complex 37, CCAFS—Aerial View

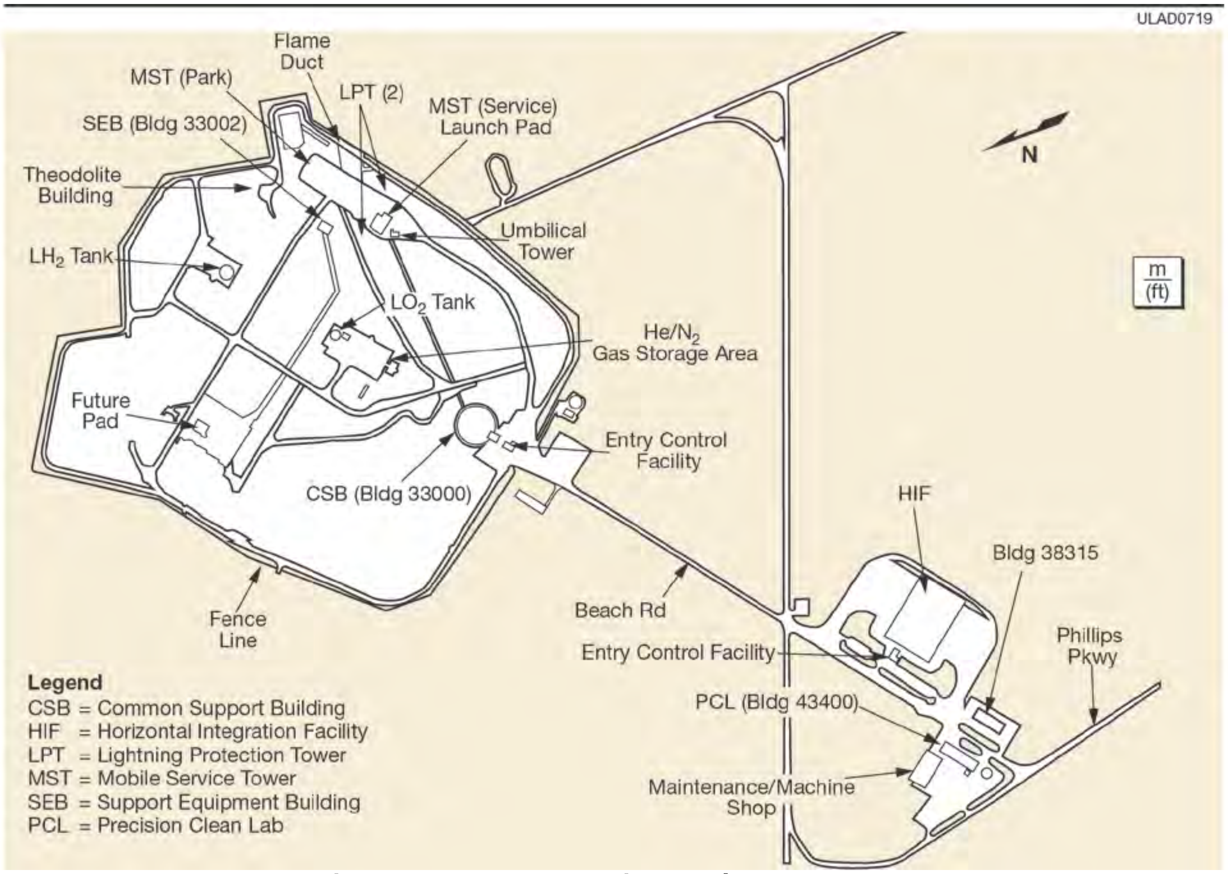

Figure 7-8. Space Launch Complex 37, CCAFS

Because all operations in the launch complex involve or are conducted in the vicinity of liquid or solid propellants and explosive ordnance devices, the number of personnel permitted in the area, the safety clothing to be worn, the types of activities permitted, and equipment allowed are strictly regulated. Adherence to all safety regulations specified in Section 4 of this document is required. ULA provides mandatory safety briefings on these subjects for persons required to work in the launch complex area.

7.1.4.1 Mobile Service Tower (MST). The MST (Figure 7-9) is used to provide environmental protection and access to the launch vehicle after mating it to the launch table in the vertical position. The MST houses a 45,360 kg (50 ton) overhead bridge crane with a 91.5 m (300 ft) hook height capacity used during solid rocket motor mating and payload hoisting/mating operations.

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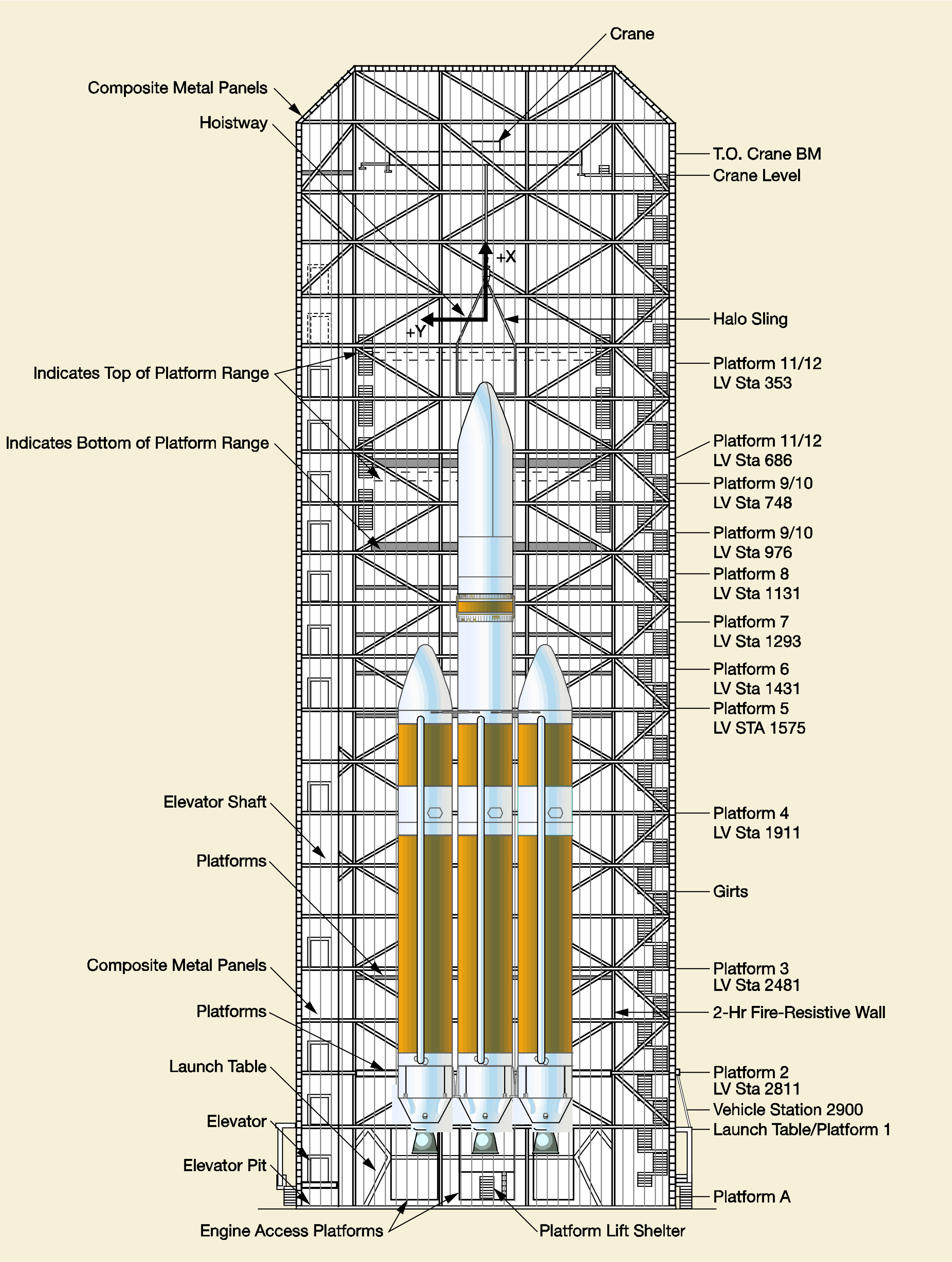

Figure 7-9. Space Launch Complex 37 Mobile Service Tower (MST)

The MST moves on rails to the service position using a hydraulic drive system before the launch vehicle is mated to the launch table. Pneumatic and hydraulic work platforms are extended to access the launch vehicle and payload during integration, assembly, and final checkout. The work platforms are retracted to clear the launch vehicle and the MST is rolled to the parked position and cleared of all personnel during final launch countdown.

The work platforms on Levels 5 through 7 provide a weather-protected area for launch vehicle interstage access. The work platforms on Levels 8 through 12 provide a weather-protected, area for 2^{nd} stage and payload checkout. There is a payload user's room located on Level 8 that can be used to house Customer electrical ground support equipment. This room is 3.05 m by 6.10 m by 4.12 m high (10 ft by 20 ft by 13.5 ft high) with a 1.45 m by 2.1 m (4.75 ft by 6.8 ft) double door. The room can support a floor loading of 366.18 kg/m^2 (75 lb/ft^2) and point loading of 907.2 kg (2000 lb) distributed over a 0.76 m by 0.76 m (2.5 ft by 2.5 ft) area. The work platform floor plan for Level 8 is shown in Figure 7-10. The movable work platform floor plans for Levels 9 through 12 are shown in Figures 7-11 and 7-12.

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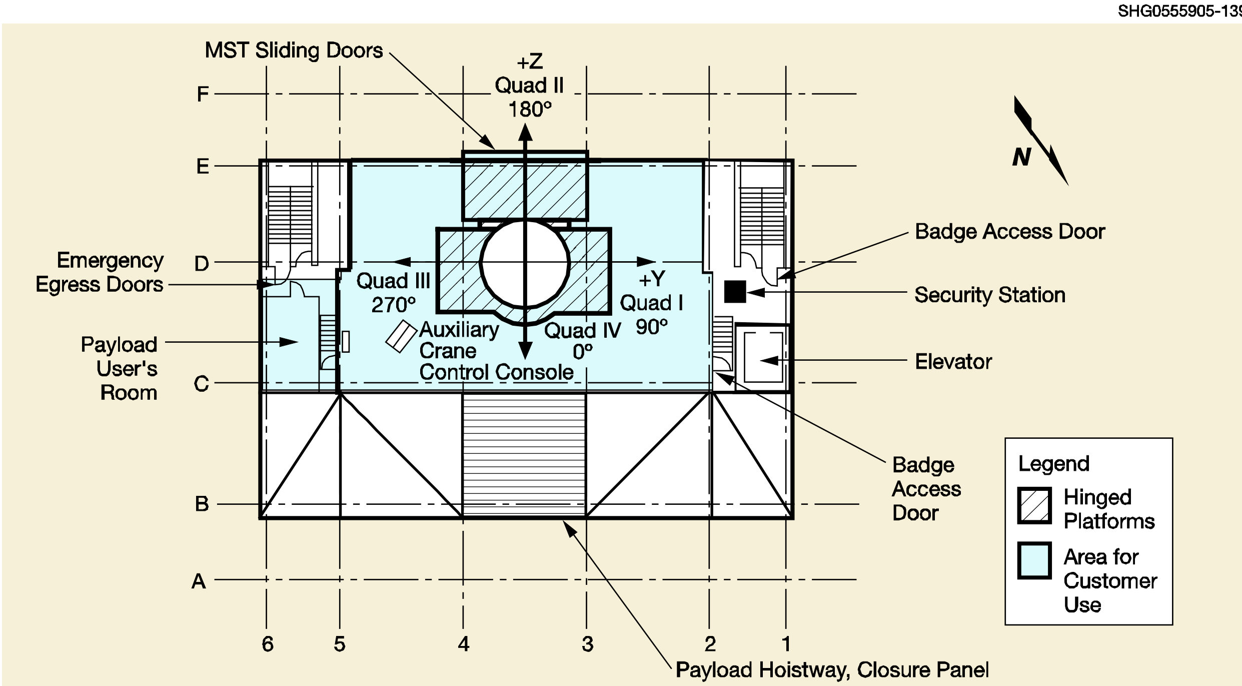

Figure 7-10. Fixed Platform (Level 8)

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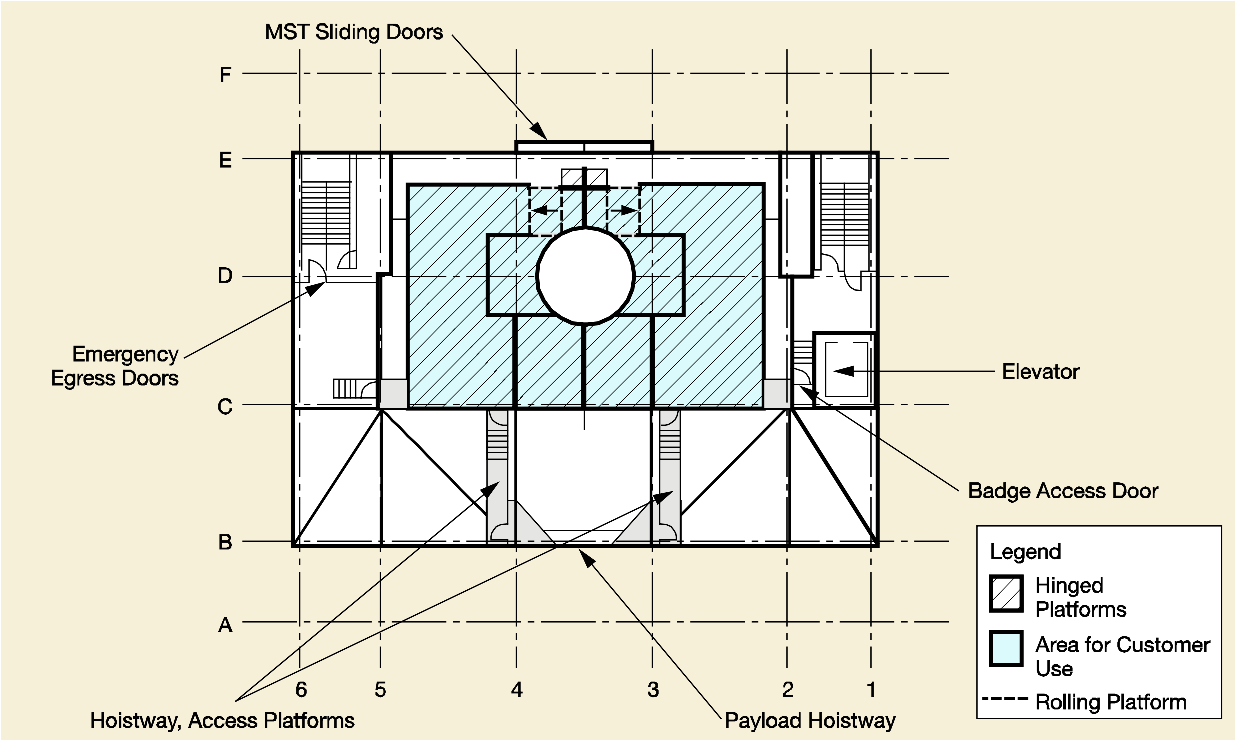

Figure 7-11. Adjustable Platform (Levels 9 and 10)

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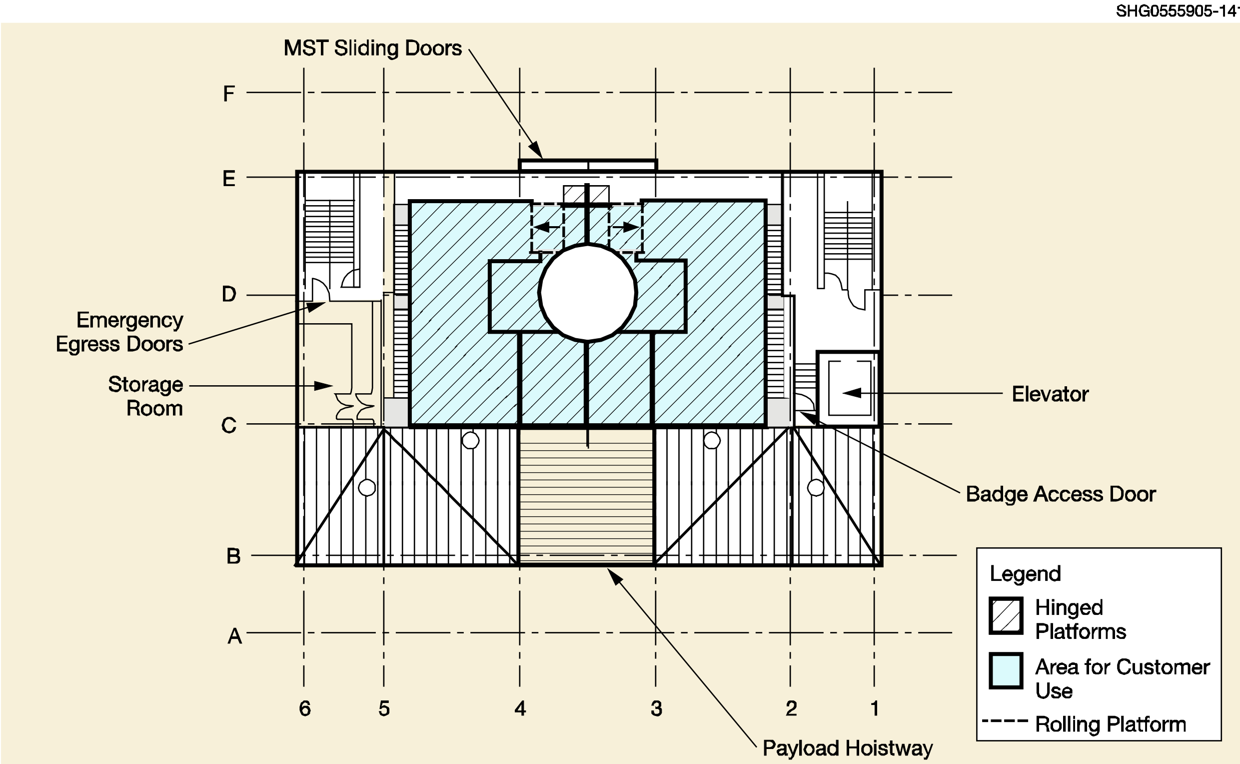

Figure 7-12. Adjustable Platform (Levels 11 and 12)

7.1.4.2 Fixed Umbilical Tower (FUT). The FUT is the 73.15 m (240 ft) steel structure located on the southwest corner of the launch deck. Three Swing Arm (SA) assemblies are attached to the northeast corner of the FUT at levels 7, 10, and 12. SA No. 1 (level 7) connects umbilical cables and propellant lines to the centerbody of the Common Booster Core (CBC). SA No. 2 (Level 10) connects umbilicals and propellant lines to the launch vehicle's 2nd stage. SA No. 3 (Level 12) connects an air conditioning duct to the launch vehicles payload fairing.

The FUT houses a Hydraulic Pump Unit (HPU) that controls SA movement during testing and launch. Liquid Oxygen (LO_2) and Liquid Hydrogen (LH_2) transfer pump assemblies are located on the FUT middle level. Steel siding is installed on the north and east sides of the FUT to lend additional protection to installed equipment located on the structure.

7.1.4.3 Common Support Building (CSB). The CSB contains the offices, supply rooms, tool rooms, break rooms, locker rooms, and other similar functional spaces necessary to support personnel at the launch pad. Existing Facility 33000, which served as the launch control center for SLC-37, has been modified to provide space for these activities. This structure is not occupied during launch (Figure 7-13).

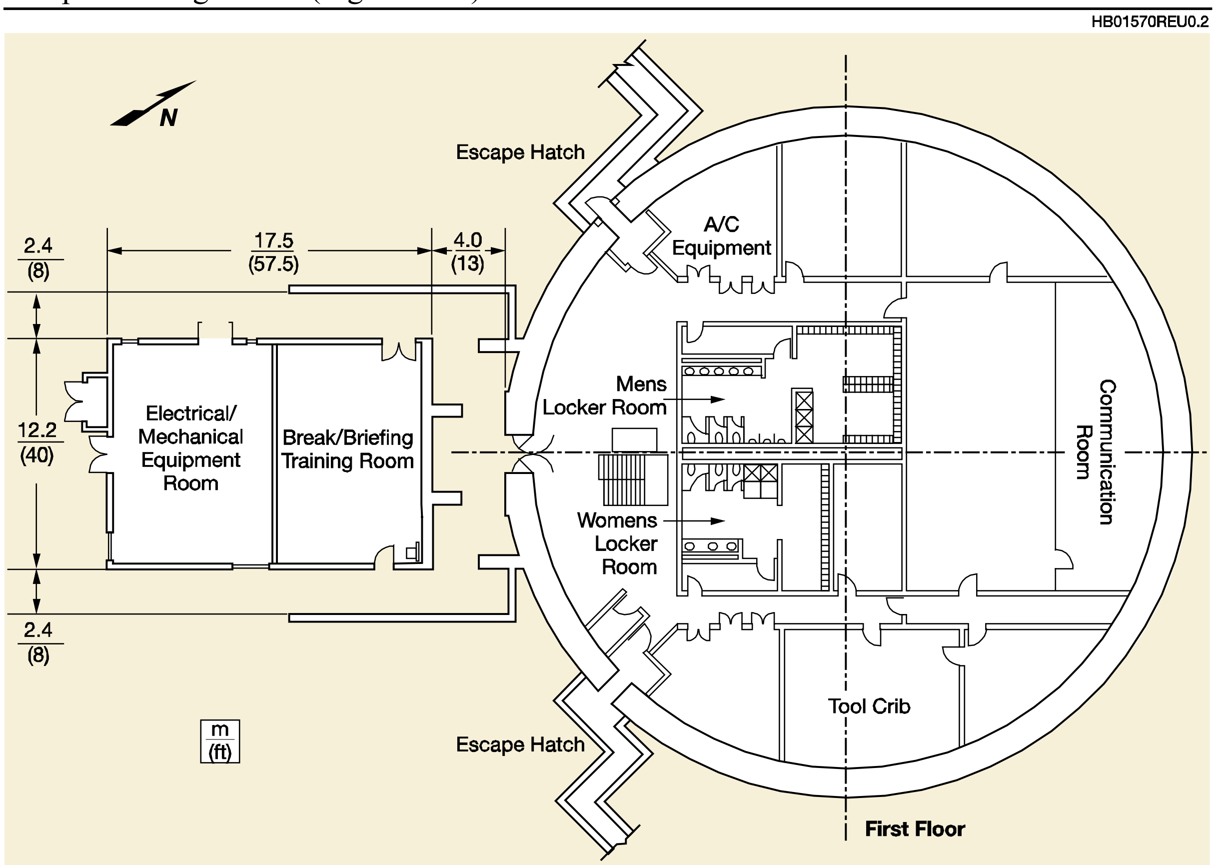

Figure 7-13. Space Launch Complex 37 Common Support Building (CSB) Sample Layout

7.1.4.4 Support Equipment Building (SEB). Facility 33002, the existing building at complex 37B, is used as the SEB (Figure 7-14). The SEB contains the payload, launch vehicle and facility air conditioning equipment, and electrical and data communications equipment needed near the launch vehicle. The SEB can be activated as a Special Compartmented Information Facility (SCIF) if required. The SEB also includes minimal personnel support areas such as small restrooms and a break room. The personnel support items are sized to support the limited number of personnel expected to be working on the pad at any one time. Limited office space and some parts storage facilities are also provided. This structure is not occupied during launch.

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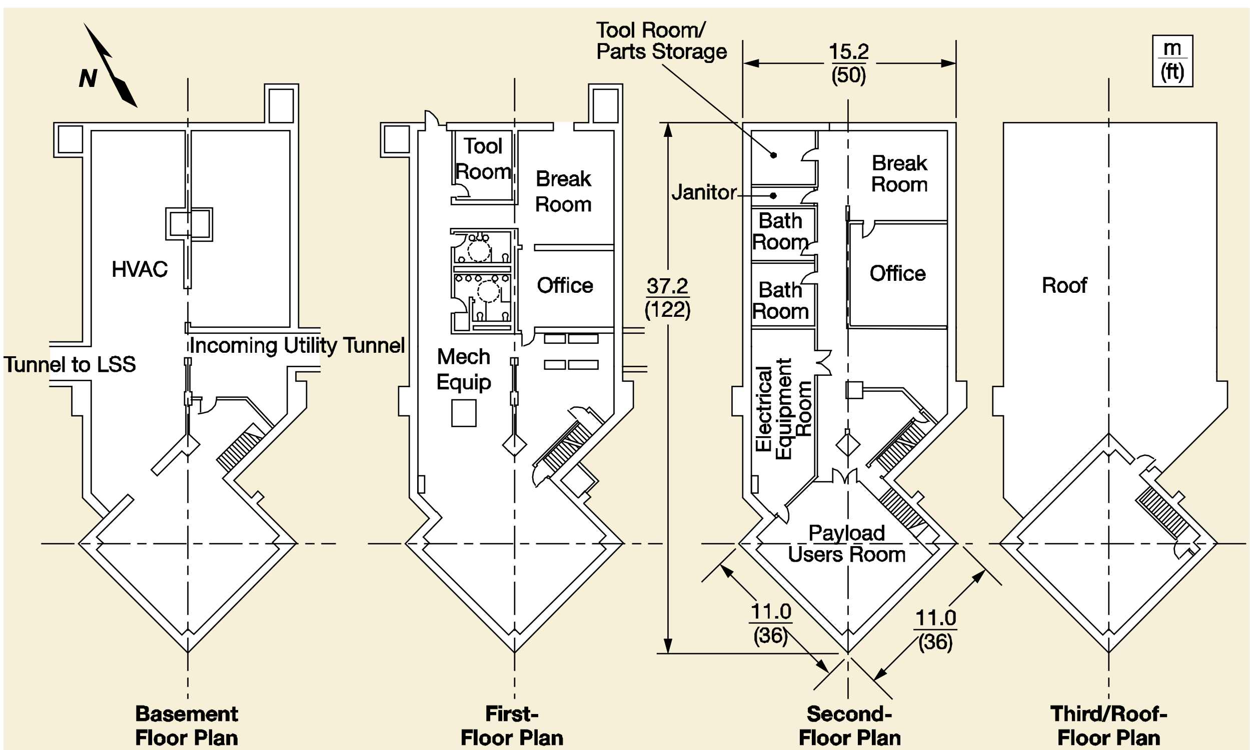

Figure 7-14. Space Launch Complex 37 Support Equipment Building (SEB)

7.1.4.5 Horizontal Integration Facility (HIF). Although not part of the SLC-37 complex, the HIF (Figures 7-15 and 7-16) is used to process the launch vehicles after their transport from the Decatur manufacturing facility. Work areas are used for assembly and checkout to provide fully integrated launch vehicles ready for transfer to the launch pad. The HIF has two bays to accommodate four single core Delta IV Medium and Delta IV M+ process areas or two single core Delta IV Medium and Delta IV M+ process areas and a Delta IV Heavy process area. Each bay is 76.2 m by 30.5 m (250 ft by 100 ft). Each bay has one 22,675 kg (25 ton) utility bridge crane. Both bays have a 22.6 m (74 ft) door on each end.

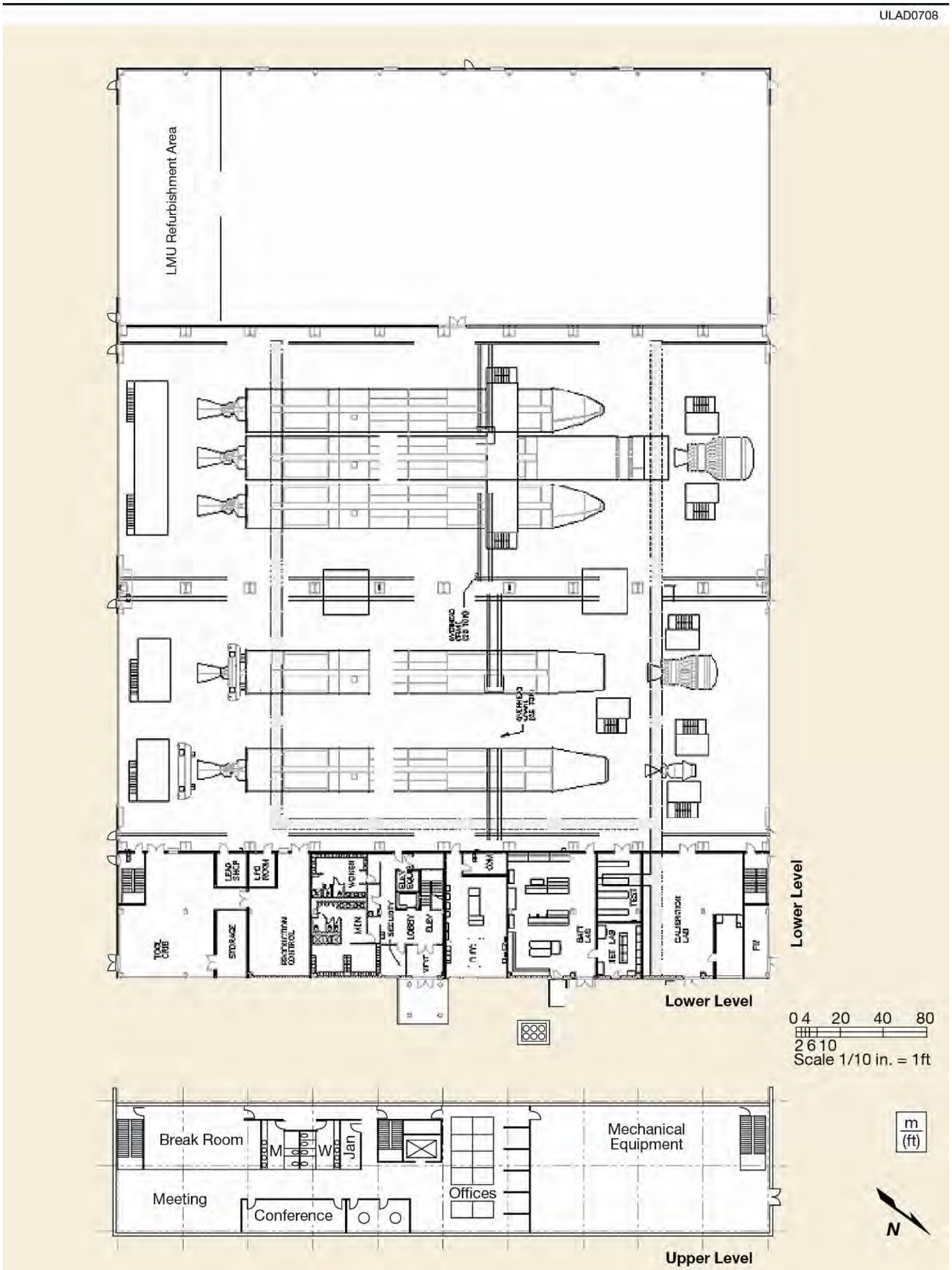

Figure 7-15. Space Launch Complex 37, Horizontal Integration Facility (HIF)

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Figure 7-16. Space Launch Complex 37, Horizontal Integration Facility—Aerial View

The HIF has space for support activities such as shipping and receiving, storage for special tools and supplies, and calibration and battery labs. The HIF annex provides an additional staging and Launch Mate Unit (LMU) refurbishment area.

HIF offices are for administrative and technical personnel. A conference room is also provided. Employee support facilities include a training room, breakroom, locker rooms, and restrooms (Figure 7-15).

7.1.5 Support Services

7.1.5.1 Launch Support. For countdown operations, the launch team is normally located in the Delta Operations Center (DOC) and supported by many other organizations. Payload command and control equipment can be located at payload processing facilities or the DOC.

The following paragraphs describe the organizational interfaces and the launch decision process.

7.1.5.2 Delta Operations Center. All Delta IV launch operations will be controlled from the LCC in the DOC (Figure 7-17). A spacecraft control room and office adjacent to the LCC is available during launch. Communication equipment in the computer room provides signal interface between the LCC, the launch pad, and the PPF.

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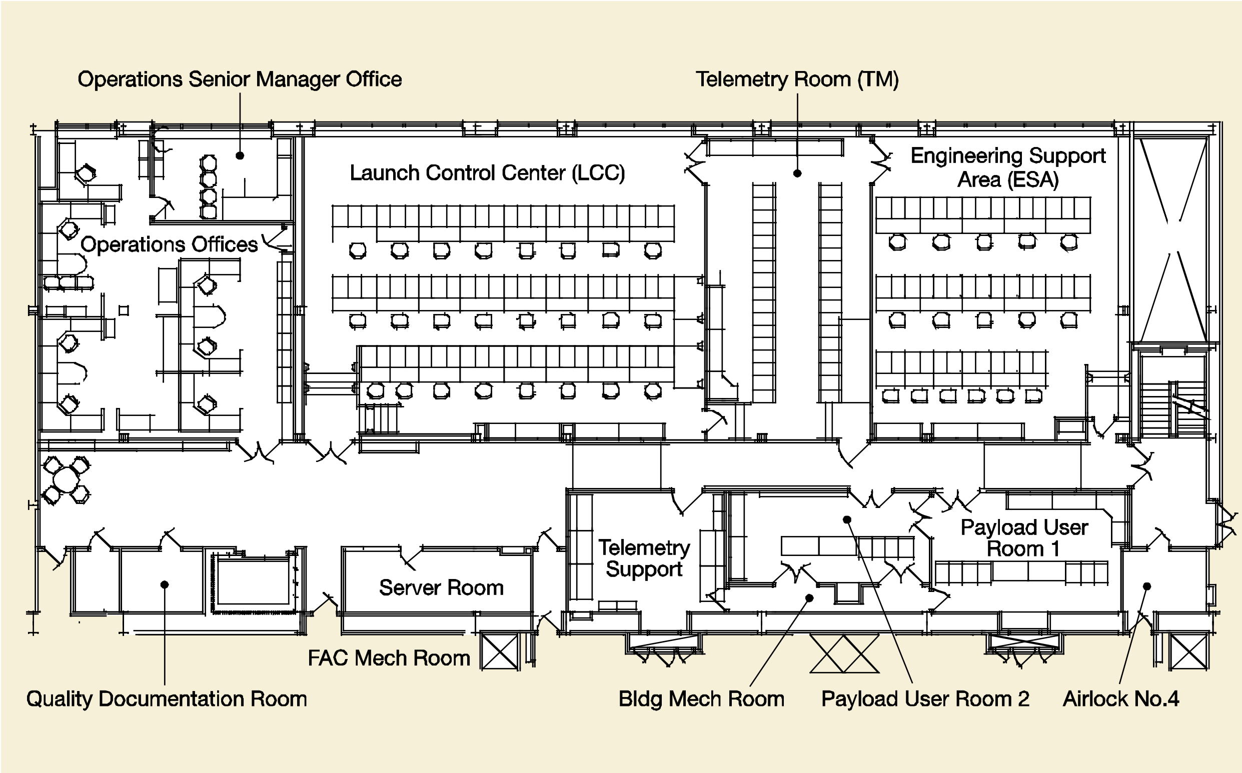

Figure 7-17. Space Launch Complex 37 Launch Control Center (LCC)

7.1.5.3 Mission Director Center (MDC). The Mission Director Center, located on the fourth floor of the DOC, provides the necessary seating, data display, and communication to observe the launch process. Seating is provided for key personnel from the spacecraft control team (Figure 7-18).

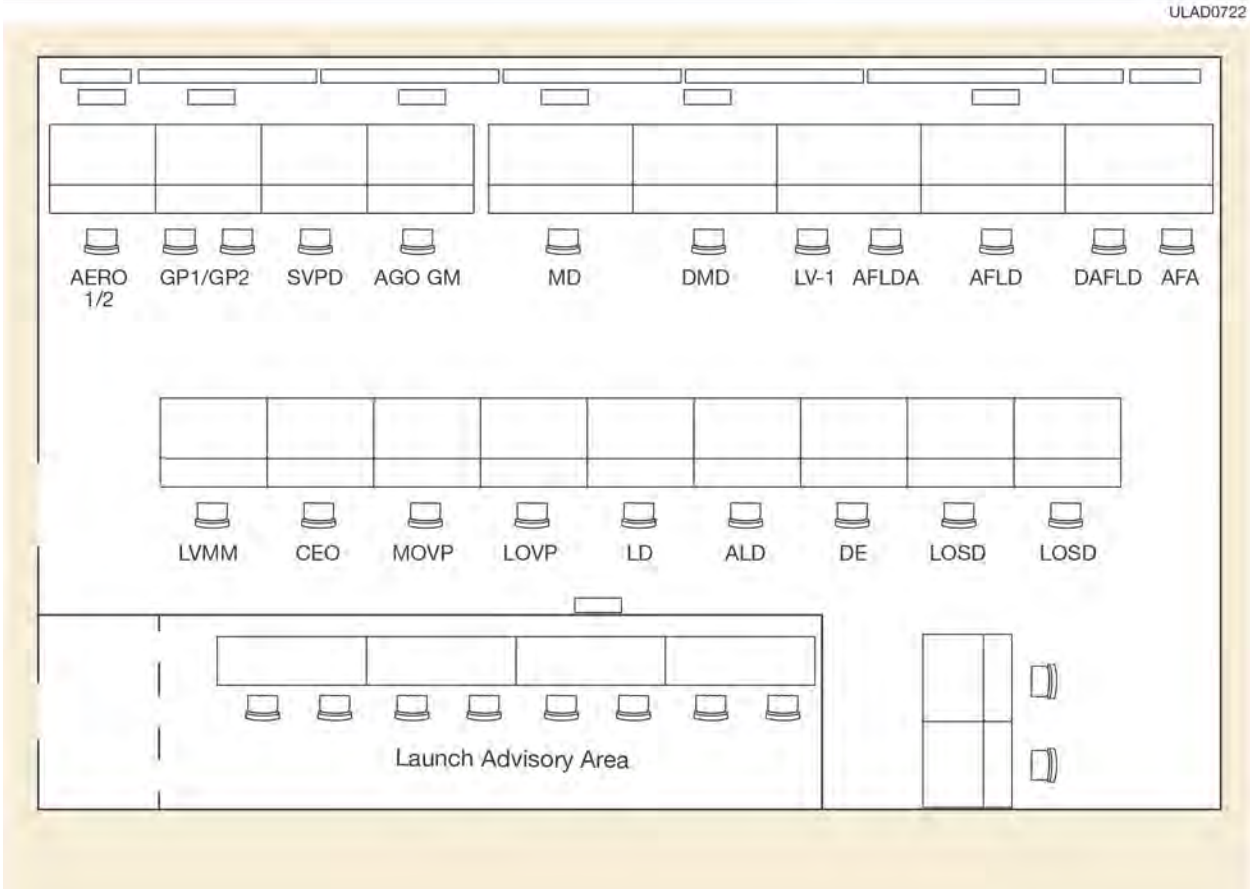

Figure 7-18. Space Launch Complex 37 Mission Director Center (MDC)

7.1.5.4 Launch Decision Process. The launch decision process is conducted by appropriate management personnel representing the payload, the launch vehicle, and the Eastern Range. Figure 7-19 shows the typical communication flow required to make the launch decision for Delta IV.

7.1.5.4 Operational Safety. Safety requirements are covered in Section 4 of this document. In addition, it is the operating policy at both CCAFS and Astrotech that all personnel be given safety orientation briefings prior to obtaining a non-escort badge to hazardous areas. These briefings are scheduled by ULA and presented by appropriate safety personnel.

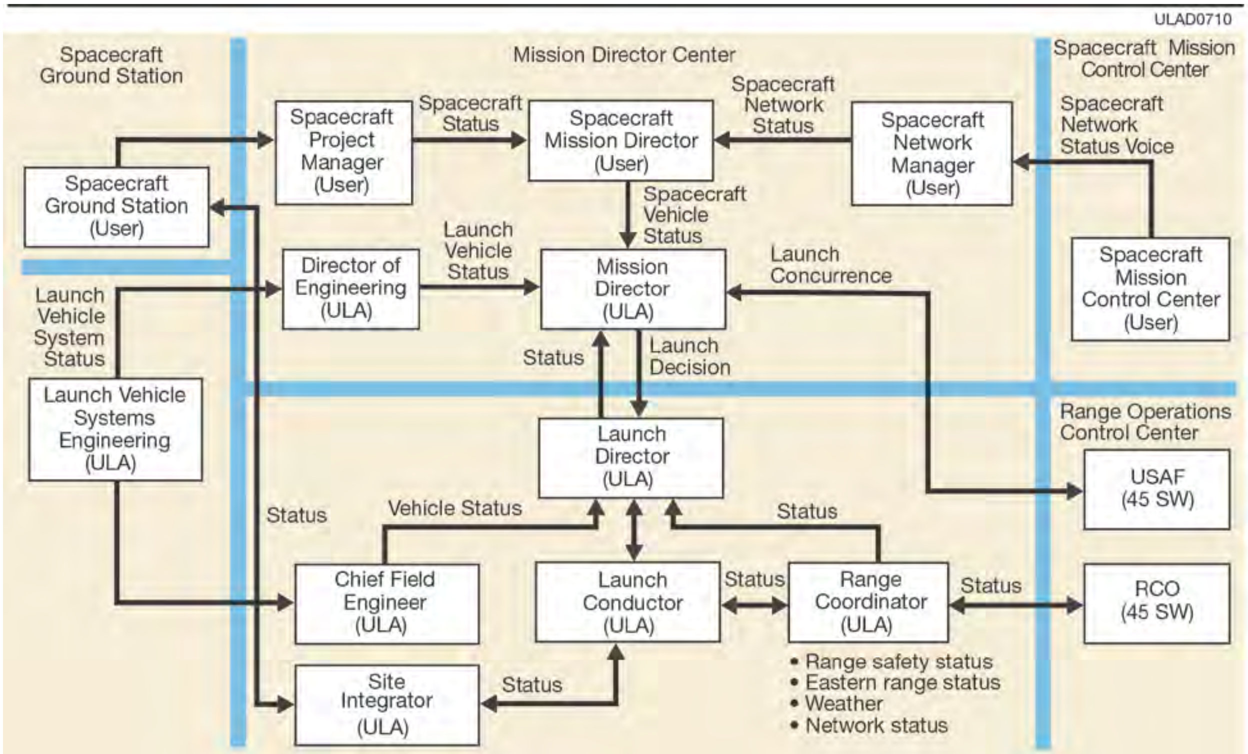

Figure 7-19. Launch Decision Flow for Commercial Missions—Eastern Range

7.1.5.5 Security.

7.1.5.5.1 CCAFS Security. To gain access to CCAFS, United States citizens must provide visit notification to the ULA Security Office. This notification must contain full name (last, first, middle), date of birth, social security number, company affiliation and address, purpose of visit, and dates of visit (beginning and ending) at least 7 days prior to the expected arrival date. The ULA Security Office will arrange for the appropriate badging credentials for entry to CCAFS for commercial missions or individuals sponsored by ULA. Access by NASA personnel or NASA-sponsored foreign nationals will be coordinated through the appropriate NASA Center and the ULA Security Office. Foreign nationals and United States citizens affiliated with non-United States firms, or United States firms with foreign contracts, must follow the appropriate accreditation process. The ULA Launch Site Mission Integration and Security Office will be advised of those individuals who are approved for access to the Delta IV Launch Site. ULA Security will coordinate the foreign national visitor(s) visit notification to obtain badging for CCAFS. All foreign national visits to CCAFS are approved by the 45 SW Foreign Disclosure Manager. The following foreign national information must be submitted to the ULA Security Office to obtain appropriate badging approval:

1. Full Name (last, first, middle)
2. Date/place of birth
3. Home address
4. Organizational affiliation and address
5. Citizenship
6. Passport number
7. Passport date/place of issue
8. Visa number and date of expiration
9. Job title/description
10. Dates of visit
11. Purpose of visit (mission name)

This information must be provided to the ULA Security Office 60 days prior to the CCAFS entry date.

7.1.5.5.2 Launch Complex Security. SLC-37 is surrounded by perimeter fencing with an intrusion detection system and alarms. Closed-Circuit Television (CCTV) is used for immediate visual assessment of the fence line. The SLC is protected by an electronic security system that consists of personnel entry/exit accountability using electronic proximity card readers, and intrusion door alarms on MST Levels 8 through 14, and in the payload user rooms located on MST Level 8 and in the SEB. Security guards are posted at the SLC-37 Security Entry Control Building (SECB) 7 days per week, 24 hours per day, or as operationally required to support launch preparation activities. For badging purposes, arrangements must be made through the ULA Security Office at least 30 days prior to the intended arrival date at the SLC.

7.1.5.5.3 Astrotech Security. Physical security at Astrotech facilities is provided by chain-link perimeter fencing, door locks, and guards. Details of payload security requirements will be arranged through the ULA site integrator.

7.2 LAUNCH OPERATIONS AT WESTERN RANGE

This section presents a description of Delta IV launch vehicle operations associated with Space Launch Complex 6 (SLC-6) at Vandenberg Air Force Base (VAFB), California. Prelaunch processing (Figure 7-20) of the Delta IV launch system is discussed, as are payload processing and operations conducted prior to launch day.

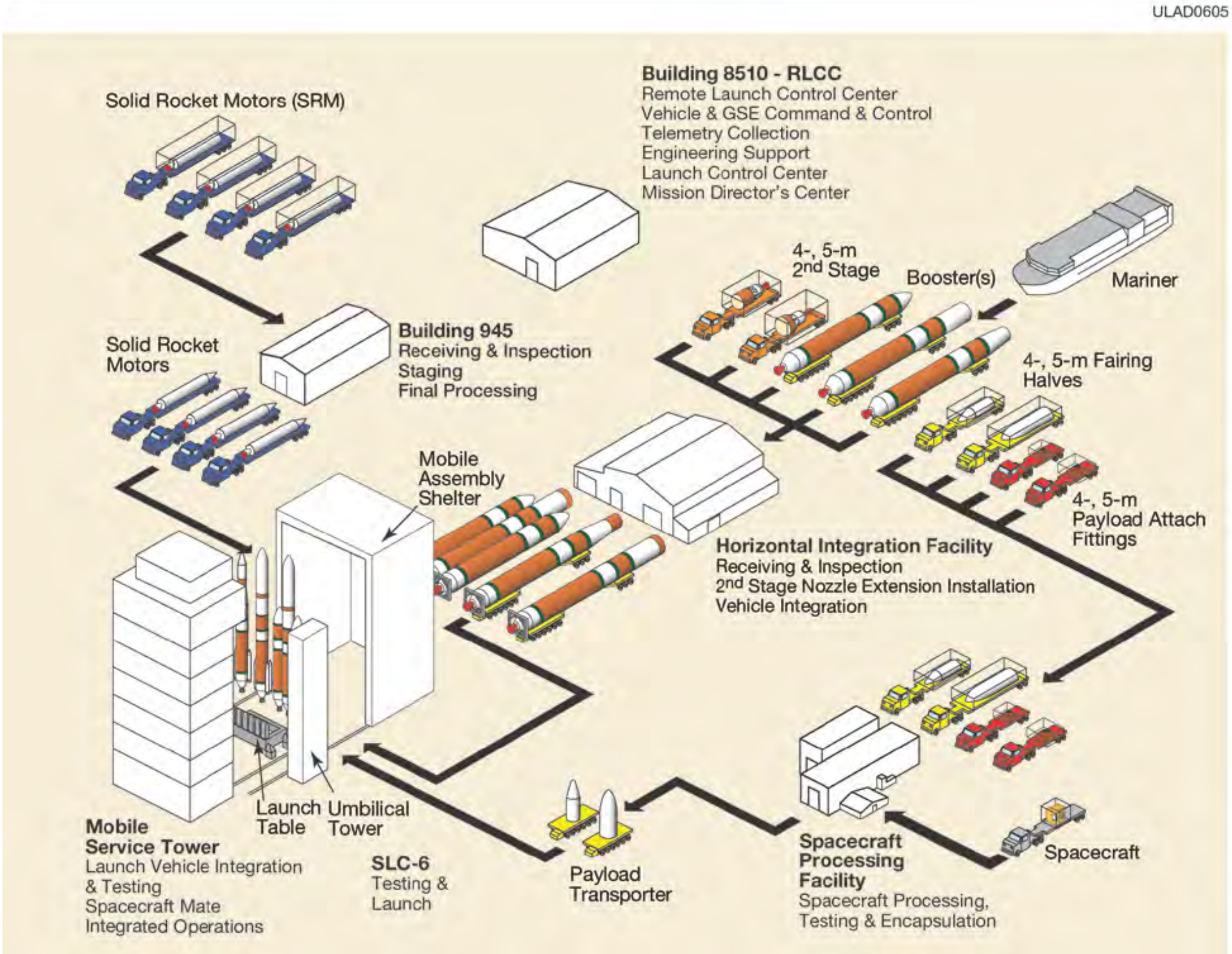

Figure 7-20. VAFB Processing Flow

7.2.1 Organizations

As operator of the Delta IV launch system, ULA maintains an operations team at VAFB that provides launch services to the USAF, NASA, NRO, and Commercial Customers. ULA provides the interface to the FAA and DOT for licensing and certification to launch commercial payloads using the Delta IV family of launch vehicles.

ULA has established an interface with the USAF 30th Space Wing (30 SW) Directorate of Plans; the Western Range has designated a range PSM to represent the 30 SW. The PSM serves as the official interface for all launch support and services requested. These services include range instrumentation, facilities/equipment operation and maintenance, safety, security, and logistics support. Requirements for range services are described in documents prepared and submitted to the government by ULA, based on inputs from the Customer, using the Government's UDS format (see Section 4, Mission Integration and Safety). ULA and the Customer generate the Program Requirements Document (PRD). Formal submittal of these documents to the government agencies is arranged by ULA.

For Commercial Customer launches, ULA makes all the arrangements for the PPF and services. The organizations that support a launch from VAFB are listed in Figure 7-21. For each mission, a site integrator from the ULA VAFB launch team is assigned to assist the spacecraft team during the launch campaign by helping to obtain safety approval of the payload test procedures and operations; integrating the spacecraft operations into the launch vehicle activities; and, during the countdown and launch, serving as the interface between the payload and launch conductor in the ULA LCC. ULA interfaces with local US Government focals at VAFB such as NROV and the VAFB resident office.

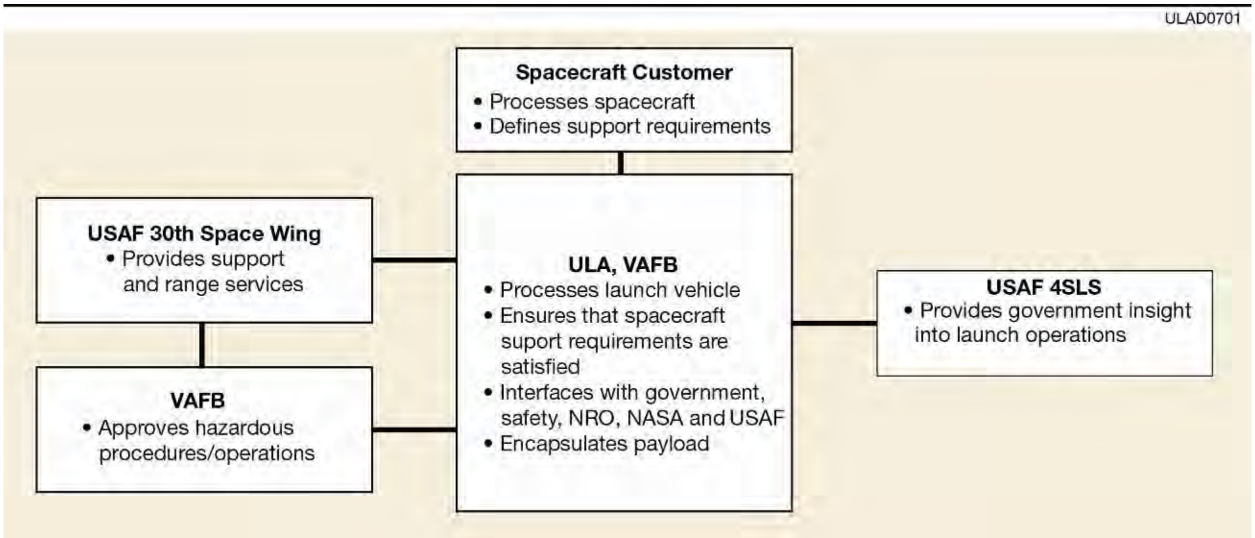

Figure 7-21. Launch Base Organization at VAFB

7.2.2 Facilities

In addition to facilities required for Delta IV launch vehicle processing, specialized PPFs are provided for checkout and preparation of the payload. Laboratories, cleanrooms, receiving and shipping areas, hazardous operations areas, and offices are provided for payload project personnel.

A map of VAFB illustrated in Figure 7-22 shows the location of all major facilities and space launch complexes.

Commonly used facilities at the western launch site for US Government or commercial payloads are:

A. Payload Processing Facilities (PPFs)

1. Astrotech Space Operations, Building 1032 and 5 M High Bay
2. Spaceport Systems International, Building 375, commonly known as the Integrated Processing Facility (IPF)
3. NRO-provided Building 2520

B. Hazardous Processing Facilities (HPFs)

1. Astrotech Space Operations, Building 1032
2. Spaceport Systems International, Building 375, commonly known as the Integrated Processing Facility (IPF)
3. NRO-provided Building 2520

While there are other spacecraft processing facilities located on VAFB that are under NRO control, commercial spacecraft will normally be processed through the commercial facilities of ASO (www.astrotechcorp.com) or Spaceport Systems International (SSI) (www.calspace.com). Government facilities for spacecraft processing (USAF or NASA) can be used for commercial spacecraft only under special circumstances (use requires negotiations between ULA, the Customer, and USAF, NRO or NASA). For spacecraft preparations, the Customer must provide their own test equipment including telemetry receivers and telemetry ground stations.

After the payload and its associated equipment arrive at VAFB by road or by air (via the VAFB airfield), transportation of the spacecraft and associated equipment to the PPF is provided by the spacecraft program. This can be supported with range provided escorts with assistance from ULA. All transporters, shipping containers and handling fixtures for the payload are provided by the Customer.

Shipping and handling of hazardous materials, such as EEDs or radioactive sources, must be in accordance with applicable regulations. It is the responsibility of the Customer to identify these items and to become familiar with such regulations. Included are regulations imposed by NASA, USAF, and FAA (refer to Section 4).

7.2.2.1 Astrotech Space Operations Facilities. The Astrotech facilities are located on 24.3 hectares (60 acres) of land at Vandenberg AFB. The complex is situated at the corner of Tangair Road and Red Road adjacent to the Vandenberg AFB runway. A complete description of the Astrotech facilities can be found on the Astrotech Web site: http://www.astrotechcorp.com/business-units/astrotech-so.

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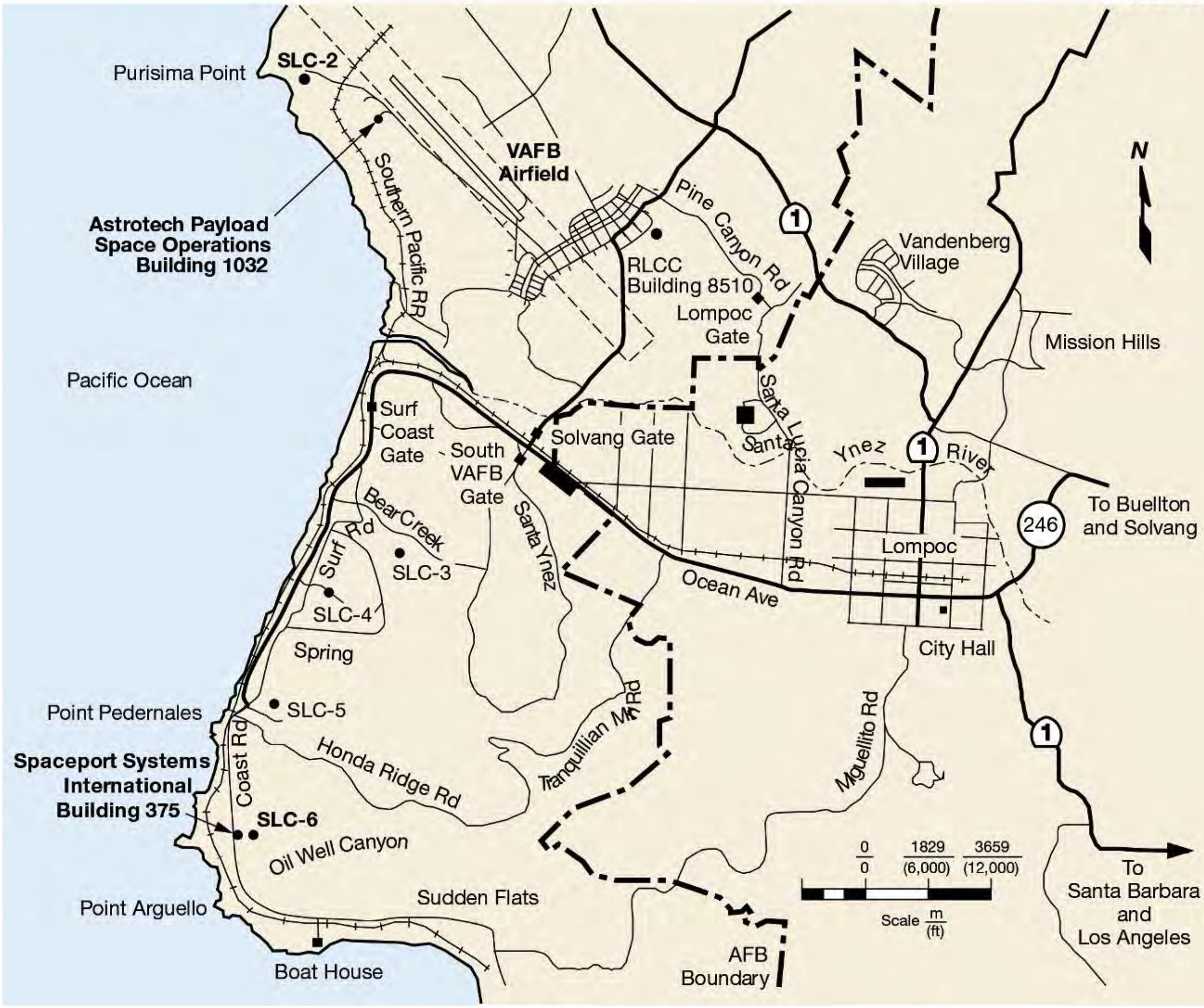

Figure 7-22. Vandenberg Air Force Base (VAFB) Facilities

7.2.2.2 Spaceport Systems International (SSI) Facilities. The SSI payload processing facility is located at SLC-6 on South Vandenberg adjacent to the SSI commercial spaceport. This processing facility is called the IPF because both booster components and payloads can be processed in the building at the same time. A complete description of the SSI facilities can be found on the Spaceport Systems International Web site: www.calspace.com.

7.2.3 Payload Encapsulation And Transport To SLC-6

Delta IV provides fueled payload encapsulation in the fairing at the payload processing facility. This capability enhances payload safety and security while mitigating contamination concerns and greatly reduces launch pad operations in the vicinity of the payload.

Payload integration with the PAF and encapsulation in the fairing is planned using either Astrotech or SSI facilities for government, NASA, or commercial payloads. Both the Astrotech and SSI facilities can accommodate payload encapsulation for 4-m and 5-m fairings. For purposes of this document, discussions are limited to ASO and SSI facilities.

Prior to or after payload arrival, the fairing and PAF enter an airlock, then a high bay clean room to be prepared for payload encapsulation. The fairing bisectors are staged horizontally on roll transfer dollies. The PAF is installed on the Delta buildup stand and prepared for payload mate. After payload arrival and premate operations are completed, including payload weighing, if required, the payload is mated to the PAF and integrated checkout is performed. The previously prepared fairing bisectors are then moved into position for final mate, and the access platforms are positioned for personnel access to the fairing mating plane. Interface connections are made and verified. A final payload telemetry test, through the fairing, can be accommodated at this time. The encapsulated payload is transferred to the transporter provided by ULA and prepared for transport to the launch pad. Environmental controls are established. The basic sequence of operations is illustrated in Figure 7-23.

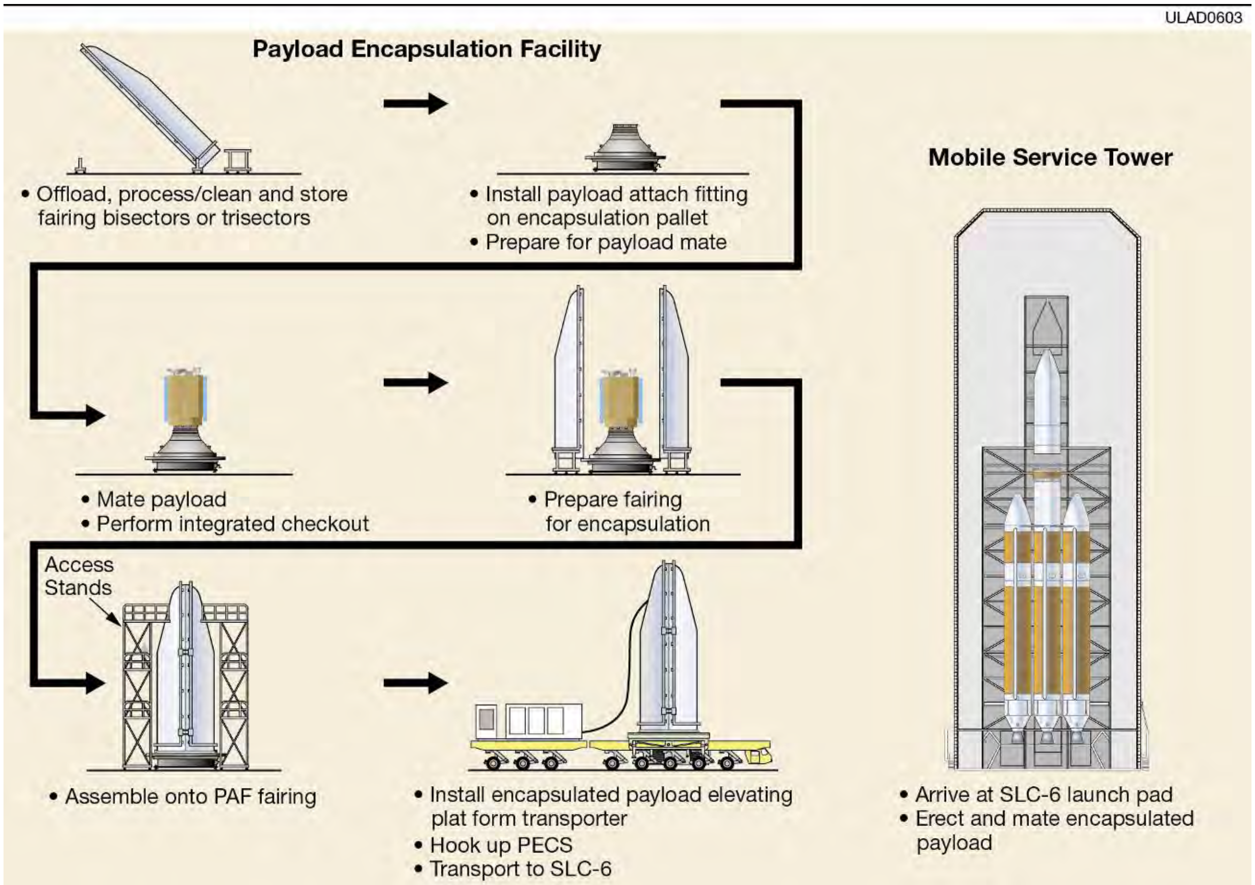

Figure 7-23. Payload Encapsulation, Transport, and On-Pad Mate

The payload is transported to the launch pad at a maximum speed of 8 km/hr (5 mph). ULA uses monitors to measure and record the transport dynamic loads. The transport loads will be less than flight loads. The encapsulated fueled payload is environmentally controlled during transportation. After arrival at SLC-6, environmental control is discontinued, and the encapsulated payload is lifted into the MST and immediately mated to the second stage. Environmental control is re-established as soon as possible with class 5000 air. If ECS service is required during payload hoist operation, that service will be negotiated separately with the Customer.

Should subsequent operations require access through the fairing, a portable clean environmental shelter can be erected over the immediate area to prevent payload contamination if required.

7.2.4 Space Launch Complex 6

Space Launch Complex 6 (SLC-6) (Figure 7-24) consists of one launch pad, the DOC, a SEB, a HIF, and other facilities necessary to prepare, service, and launch the Delta IV launch vehicles. A site plan of SLC-6 is shown in Figure 7-25.

Because all operations in the launch complex involve or are conducted in the vicinity of liquid or solid propellants and/or explosive ordnance devices, the number of personnel permitted in the area, safety clothing to be worn, type of activity permitted, and equipment allowed are strictly regulated. Adherence to all safety regulations is required. ULA provides mandatory safety briefings on these subjects for persons required to work in the launch complex area.

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Figure 7-24. Space Launch Complex 6

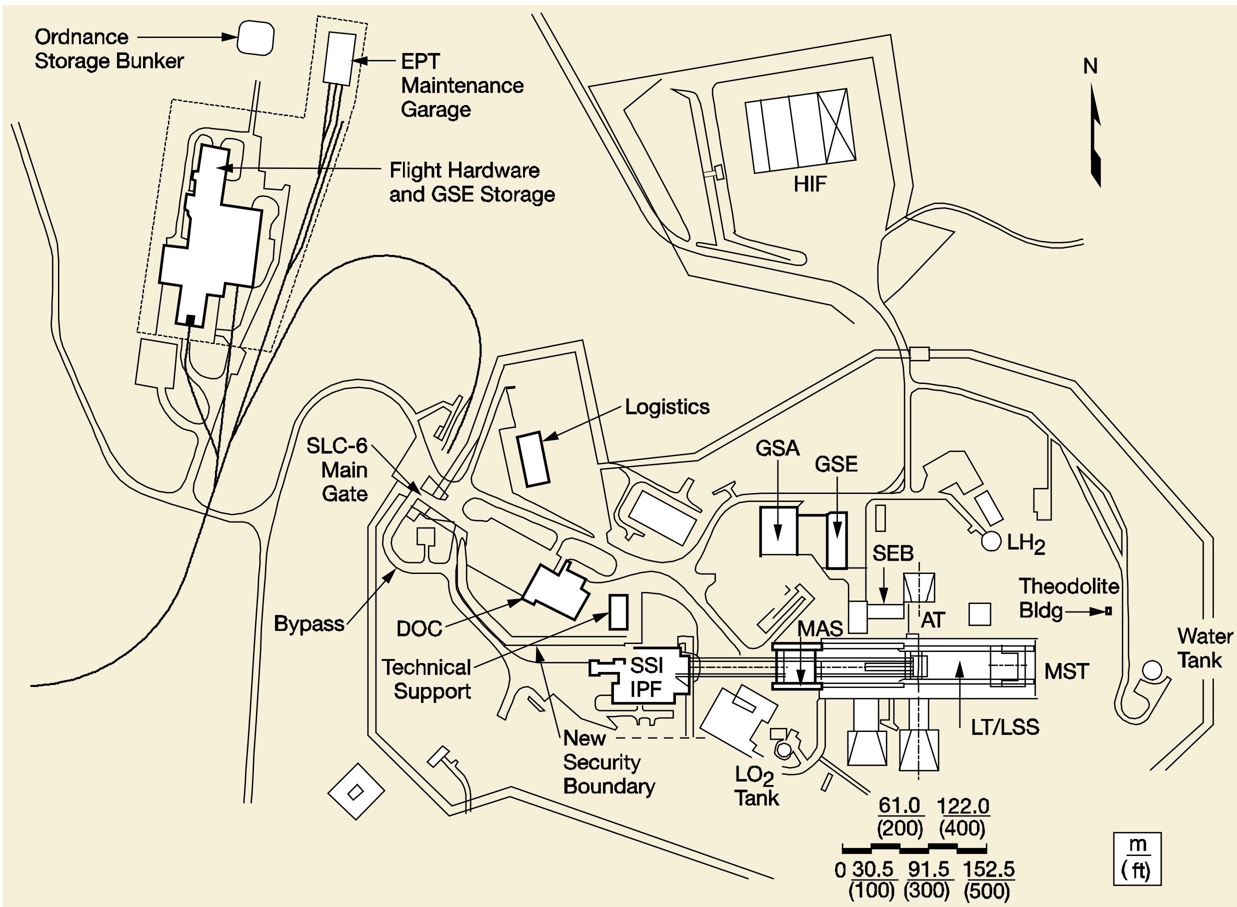

Figure 7-25. Space Launch Complex 6, VAFB Site Plan

7.2.4.1 Mobile Service Tower. The SLC-6 MST (Figure 7-26) provides a 79.2 m (260 ft) hook height with nine working platform levels. An elevator provides access to the working levels. The payload area encompasses Platforms 8 through 9/10. Platform 8 (Figure 7-27) is the initial level through which all traffic to the upper levels is controlled. Figure 7-27 is also an illustration of a typical layout of all upper levels with a few exceptions. Suitable space is available on Platforms 8 to 10 for spacecraft Ground Support Equipment (GSE). Its placement must be coordinated with ULA, and appropriate seismic restraints provided by the spacecraft Customer.

The working platform levels of the MST are constructed to meet explosion-proof safety requirements. The restriction on the number of personnel admitted to the payload area is governed by safety requirements, as well as by the limited amount of work space. Cleanroom access to the payload is provided by a portable cleanroom enclosure if required.

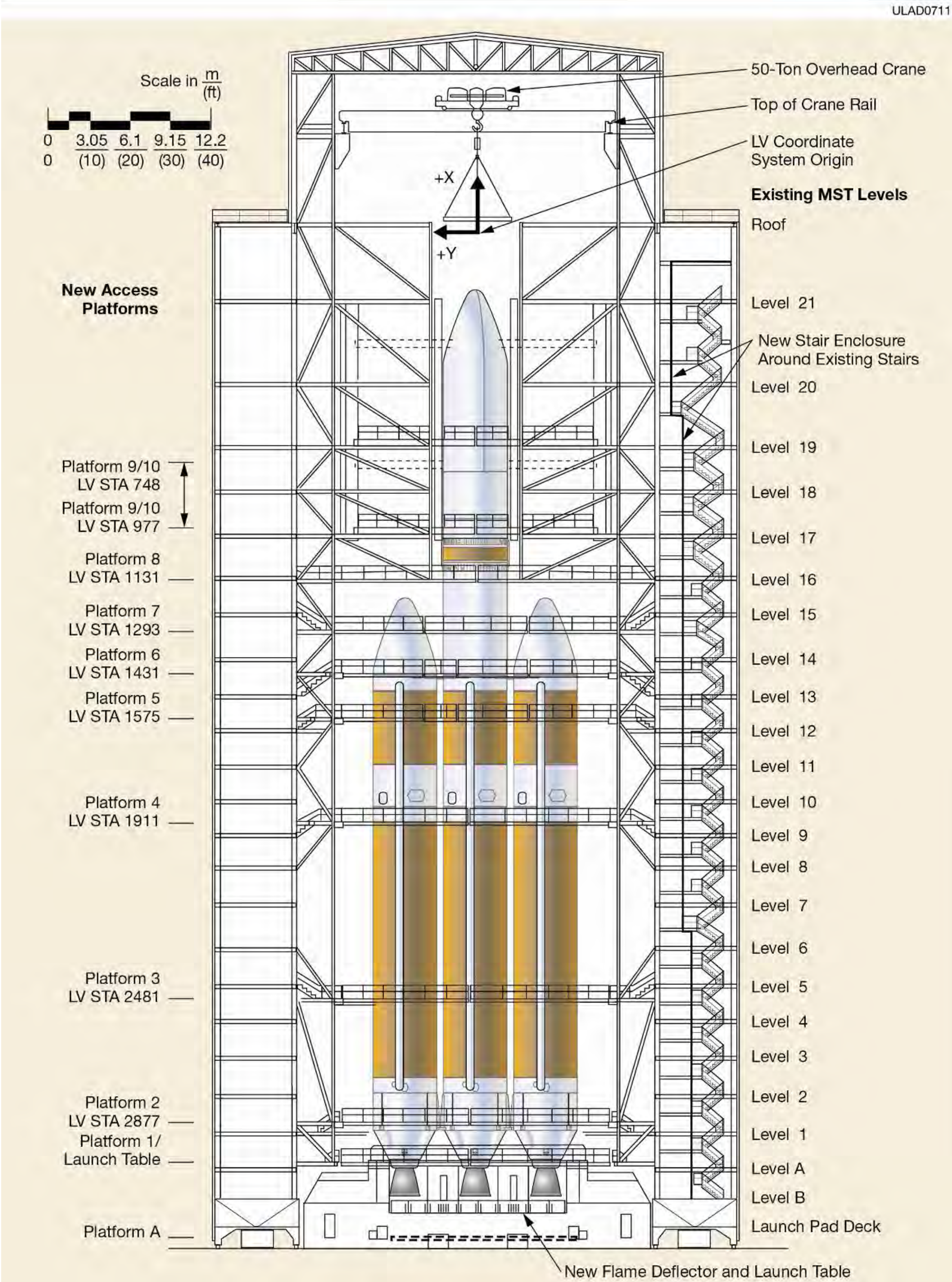

Figure 7-26. Space Launch Complex 6 MST Elevation

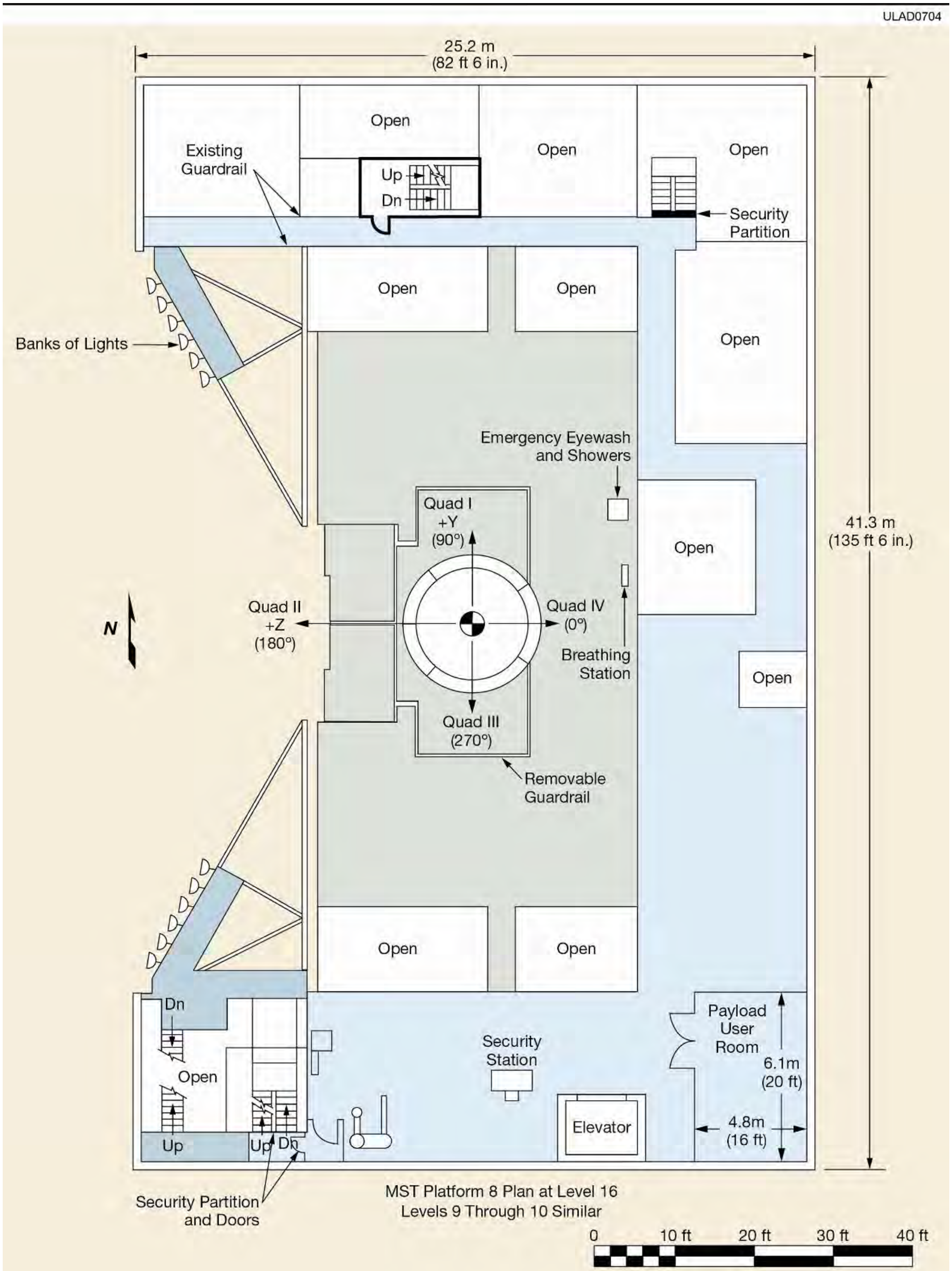

Figure 7-27. Platform 8 of Space Launch Complex 6 Mobile Service Tower Plan View

7.2.4.2 Fixed Umbilical Tower (FUT). The FUT is the 73.15 m (240 ft) steel structure located on the north side of the launch deck. Two swing arm (SA) assemblies are attached to the southeast corner of the FUT at Levels 7 and 10. Swing arm No. 1 (Level 7) connects umbilical cables and propellant lines to the centerbody of the CBC. Swing arm No. 2 (Level 10) connects umbilicals and propellant lines to the 2nd stage and connects an air conditioning duct to the PLF.

The FUT houses a HPU that controls swing arm movement during testing and launch. LO_2 and LH_2 transfer pump assemblies are located on the FUT middle level. Steel siding is installed on the south side of the FUT to lend additional protection to installed equipment located on the structure.

7.2.4.3 Common Support Buildings. The DOC and Technical Support Building (TSB) (Buildings 384 and 392) are used for offices, supply rooms, tool rooms, break rooms, and other like items necessary to support operations at the launch pad (refer to Figures 7-28, 7-29, and 7-30 for a floor plan of these facilities). These structures will not be occupied during launch.

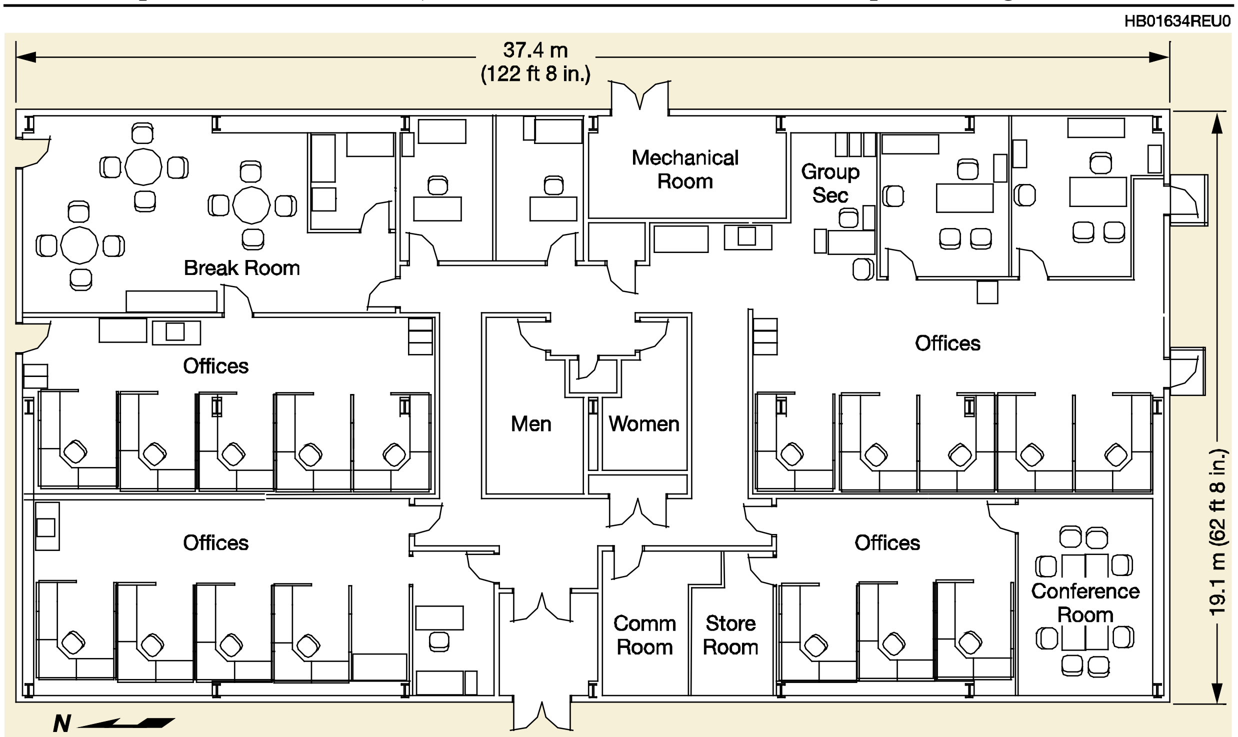

Figure 7-28. Technical Support Building (TSB) (Building 384)

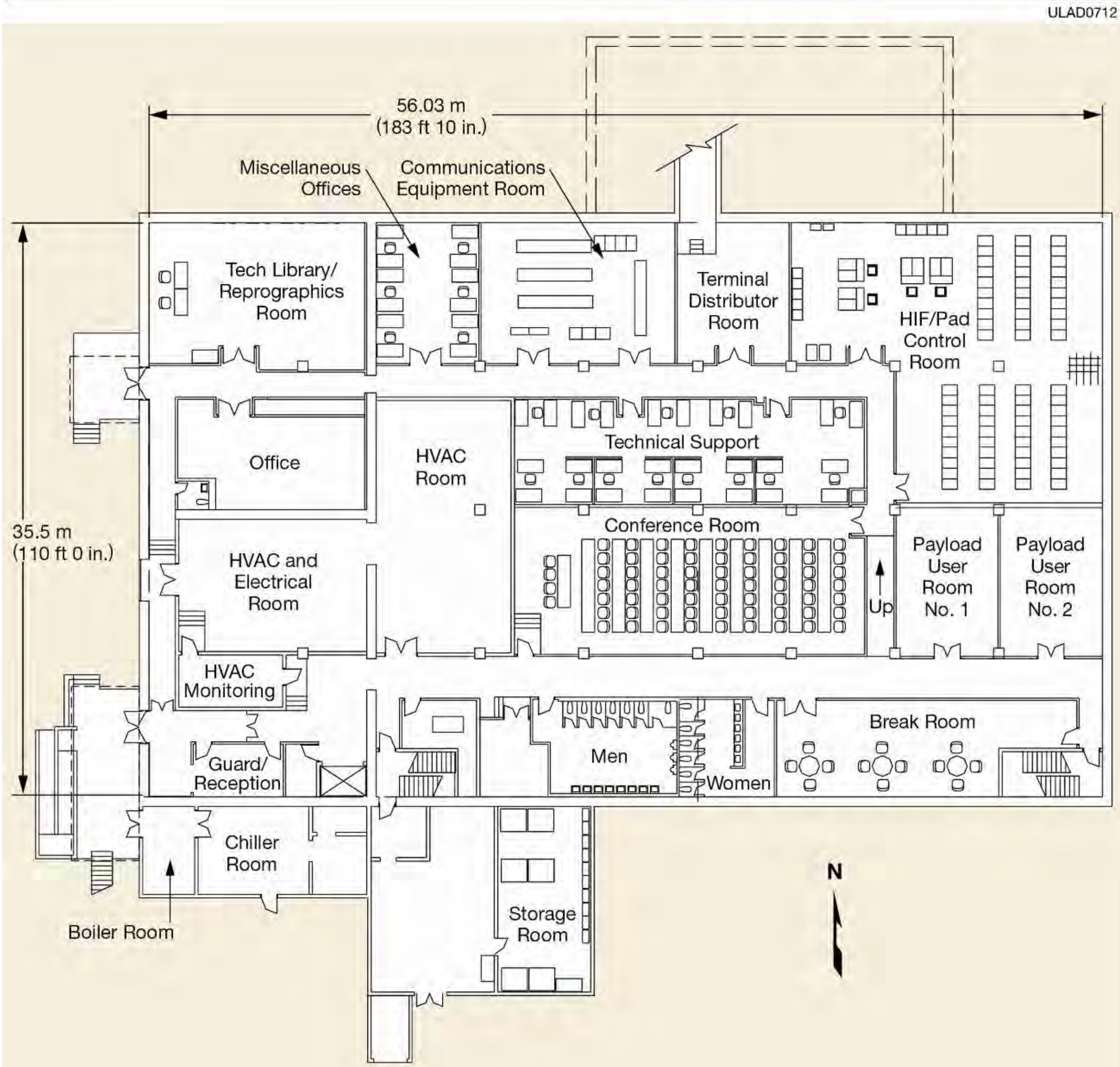

Figure 7-29. Delta Operations Center (DOC) First Floor (Building 392)

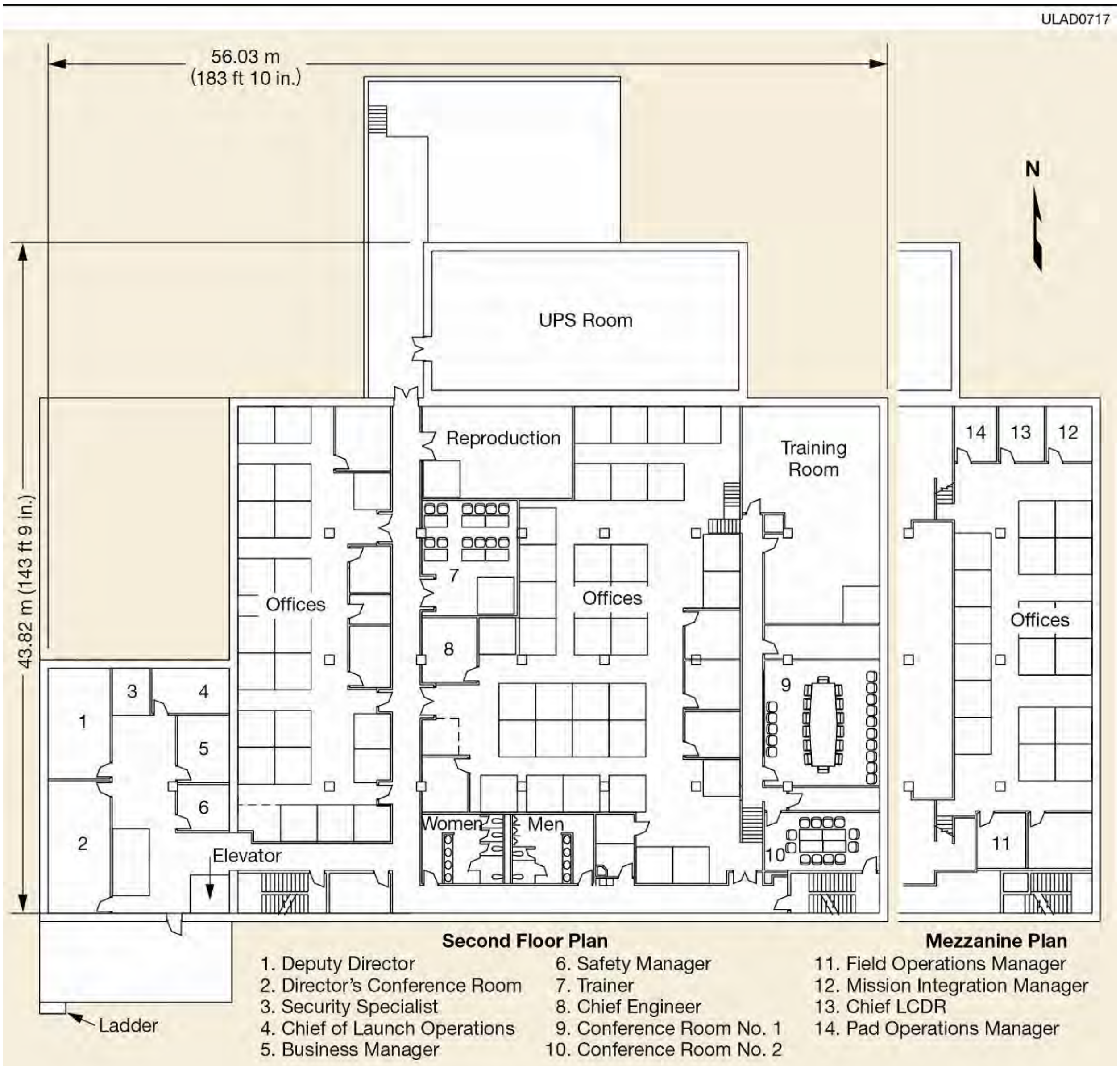

Figure 7-30. Delta Operations Center (DOC) Second Floor (Building 392)

7.2.4.4 Support Equipment Building. The existing SEB and air-conditioning shelter (facilities 395 and 395A) are collectively called the SEB (Figures 7-31 and 7-32.) The SEB contains the PLF air conditioning equipment and electrical and data communications equipment needed for connectivity for Payload interfaces. Space is dedicated for use by payload personnel. A payload console that will accept a standard rack mounted panel is available. Terminal board connections in the console provide electrical connection to the payload umbilical wires. In addition, dedicated Uninterruptible Power Supply (UPS) and power distribution units are available for payload GSE. This structure will not be occupied during launch and is cleared prior to pre-launch cryo loading during countdown. The SEB also includes personnel support facilities such as restrooms and locker rooms, break room/meeting area, and parts storage and tool issue (Figure 7-32). The personnel support facilities are sized to support only the small number of personnel that are expected to be working on the pad at any one time.

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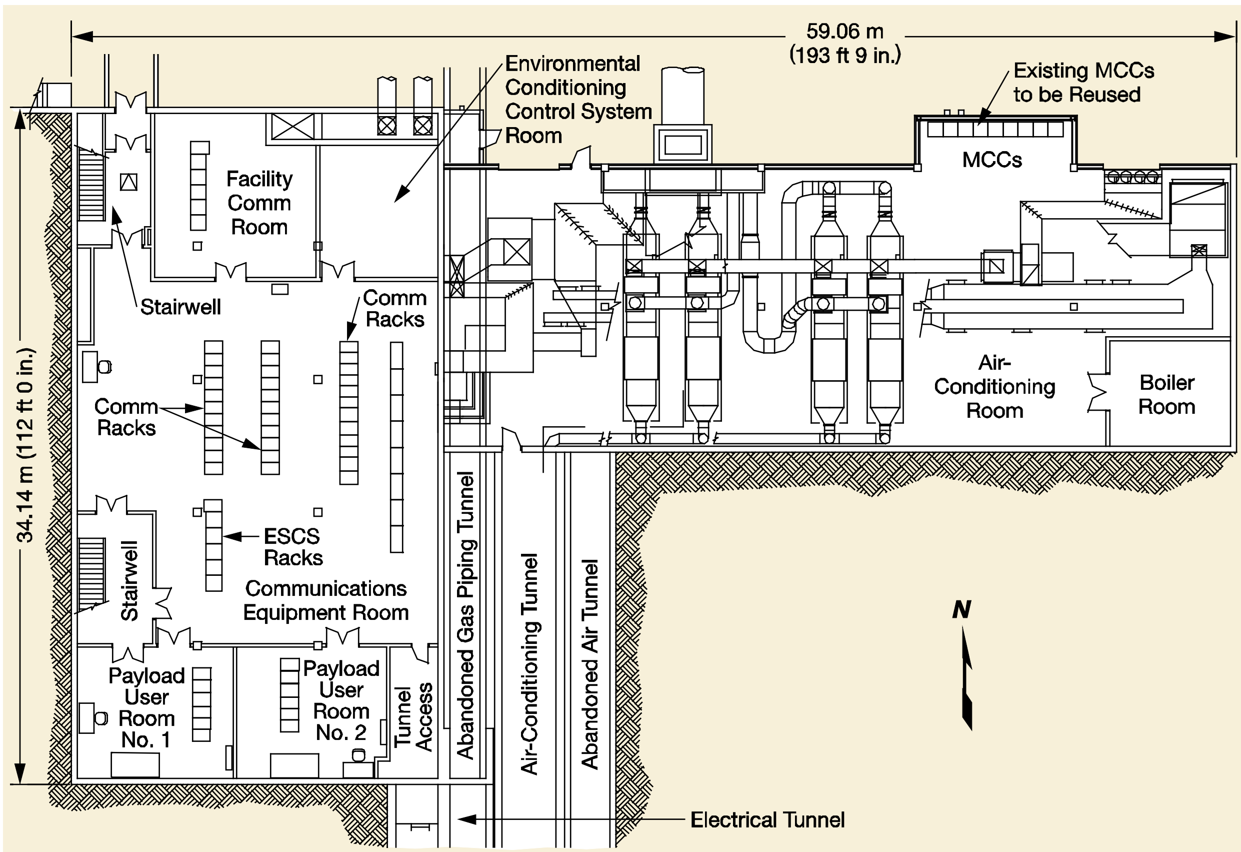

Figure 7-31. Support Equipment Building (SEB) (Building 395) First Floor Plan

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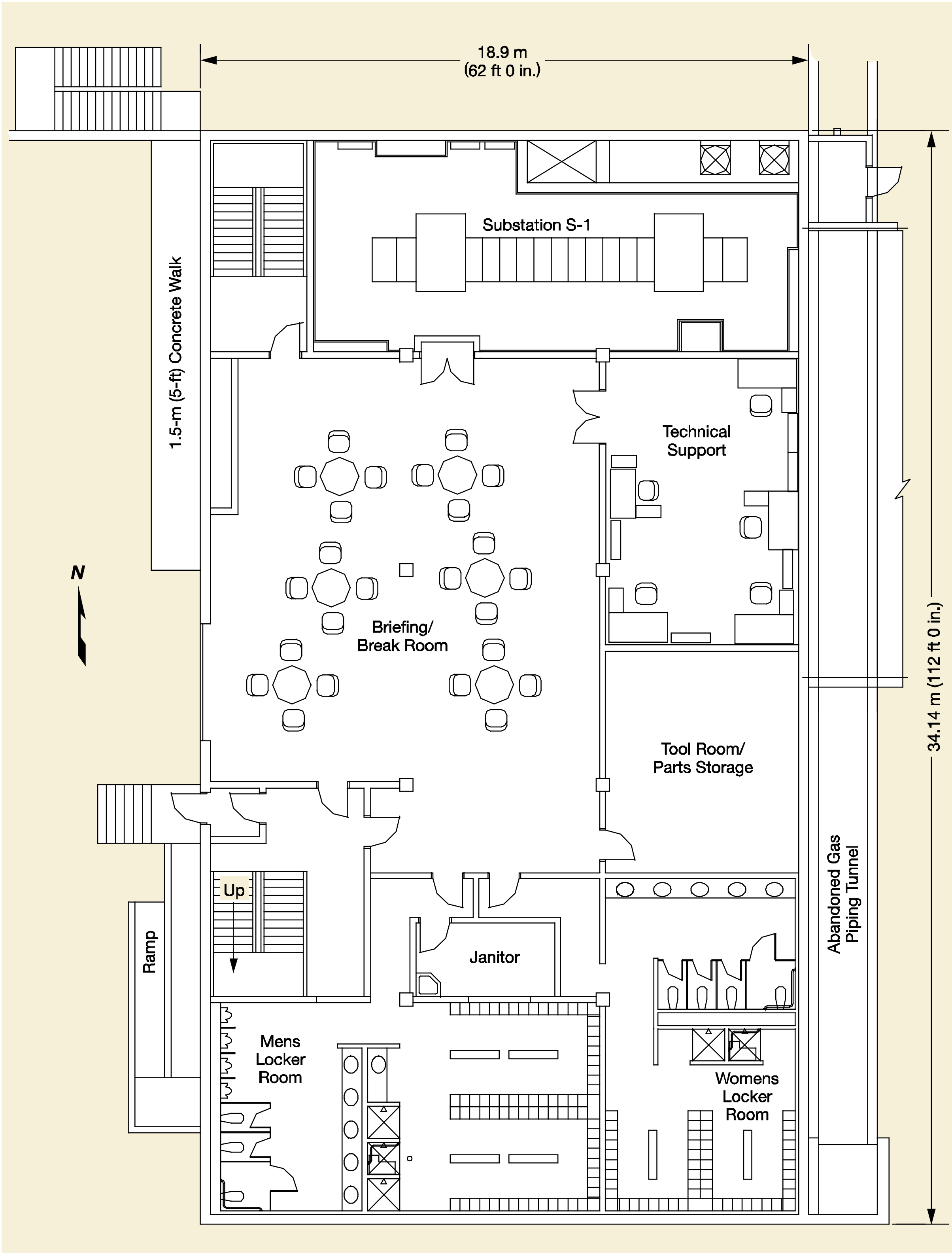

Figure 7-32. Support Equipment Building (SEB) (Building 395) Second Floor Plan

7.2.4.5 Horizontal Integration Facility. Located at the north side of SLC-6, the HIF (Figure 7-33) is used to receive and process the launch vehicles after their transport from the vessel dock to the facility. Work areas are used for assembly and checkout to provide fully integrated launch vehicles ready for transfer to the launch pad. The HIF has two bays for four single-core (Delta IV Medium and Delta IV M+) process areas or two single-core (Delta IV Medium and Delta IV M+) process areas and a Delta IV Heavy process area (Figure 7-34).

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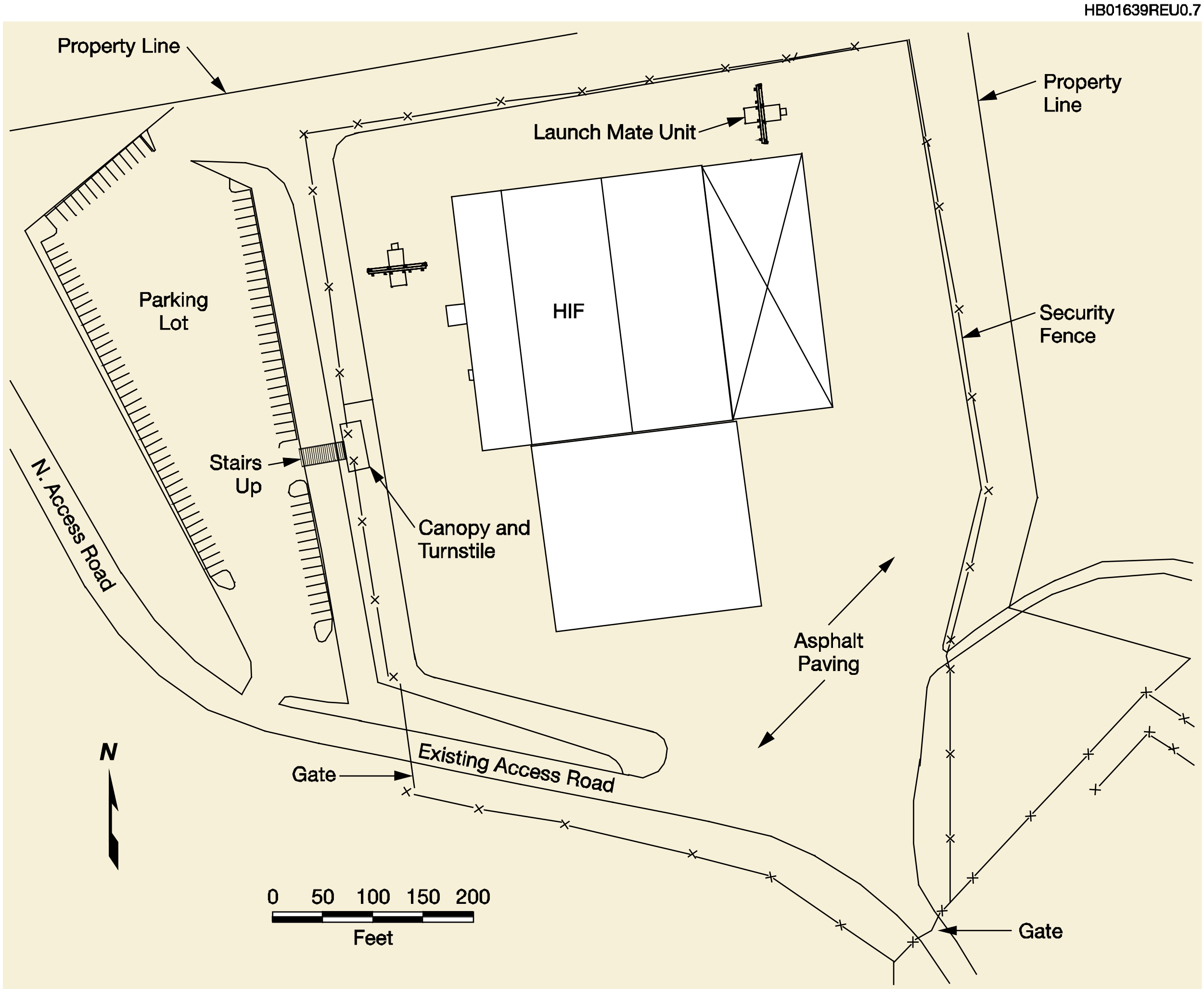

Figure 7-33. Horizontal Integration Facility (HIF) Site Plan

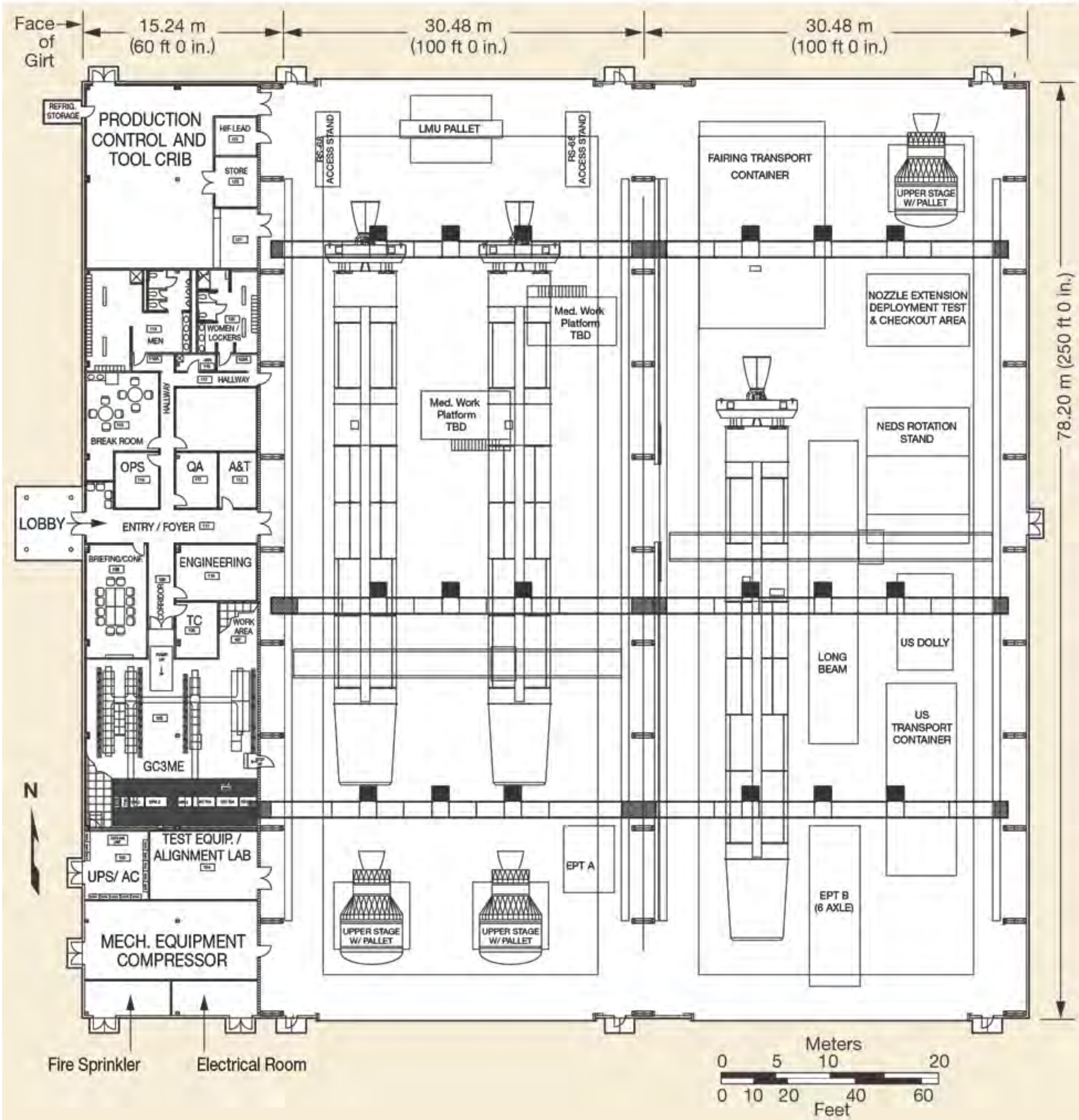

Figure 7-34. Horizontal Integration Facility (HIF) Floor Plan

7.2.5 Support Services

7.2.5.1 Launch Support. For countdown operations, the launch team is located in the Remote Launch Control Center (RLCC) (Figure 7-35) and MDC in Building 8510 with support from other base organizations.

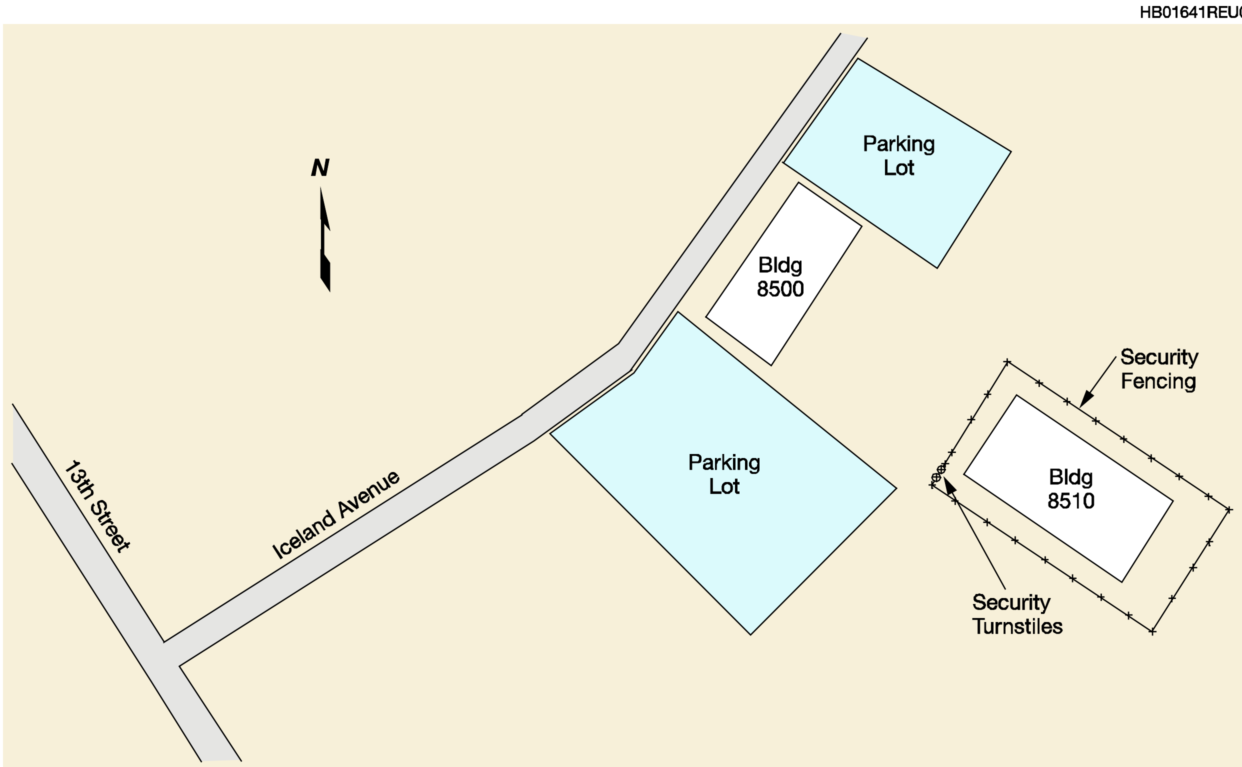

Figure 7-35. Remote Launch Control Center (Building 8510) Site Plan

7.2.5.1.1 Mission Director Center (Building 8510). The MDC provides the necessary seating, data display, and communications to observe the launch process. Seating is provided for key personnel from ULA, the Western Range and the payload control team (Figure 7-36).

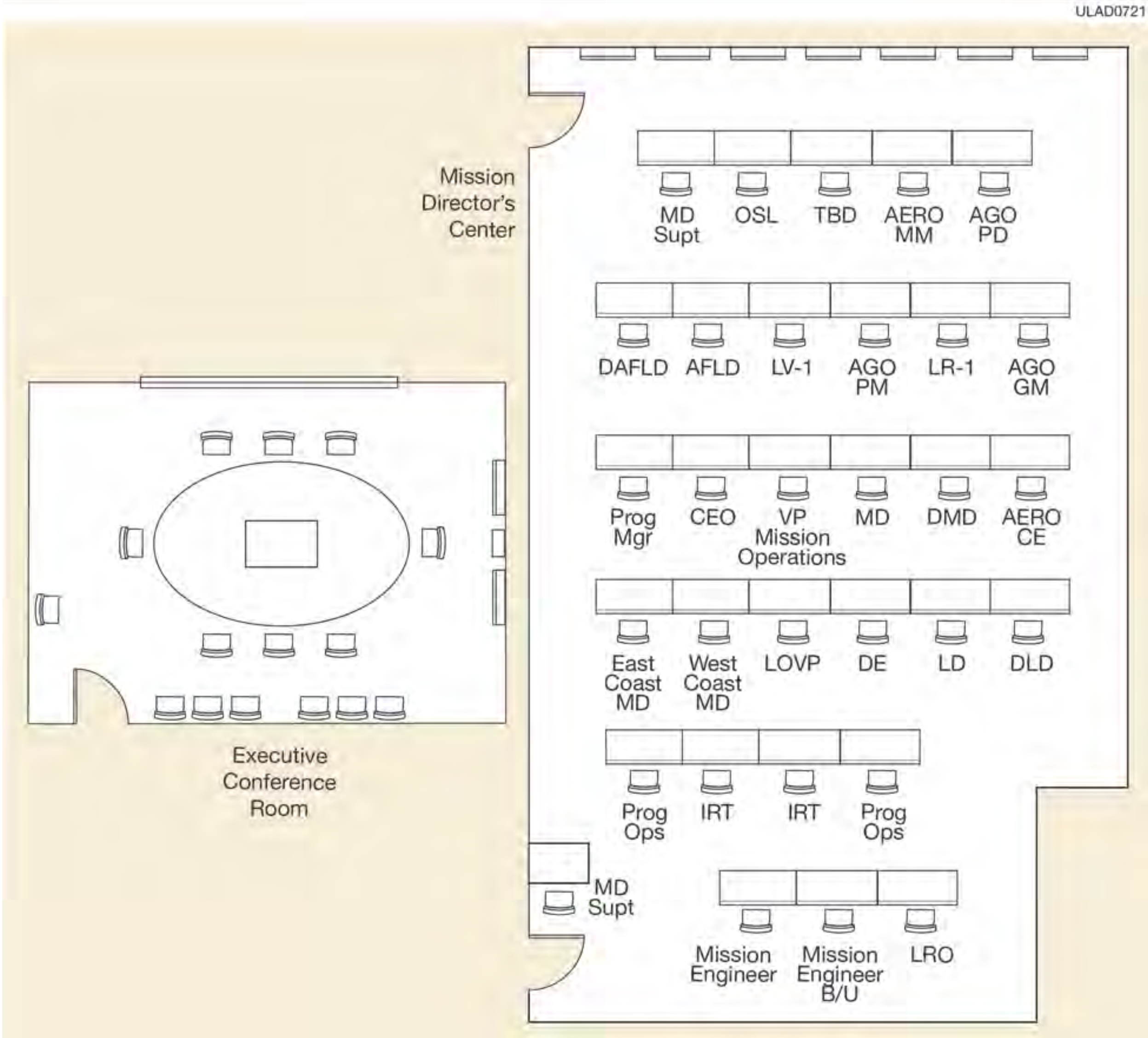

Figure 7-36. Mission Director Center (Building 8510)

7.2.5.1.2 Building 8510 Remote Launch Control Center (RLCC). Launch operations are controlled from the RLCC (Building 8510), located on north base behind Building 8500 in a secure area (Figure 7-37). It is equipped with launch vehicle monitoring and control equipment. Space is allocated for the space vehicle RLCC consoles and console operators. Terminal board connections in the payload RLCC junction box provide electrical connection to the payload umbilical cables.

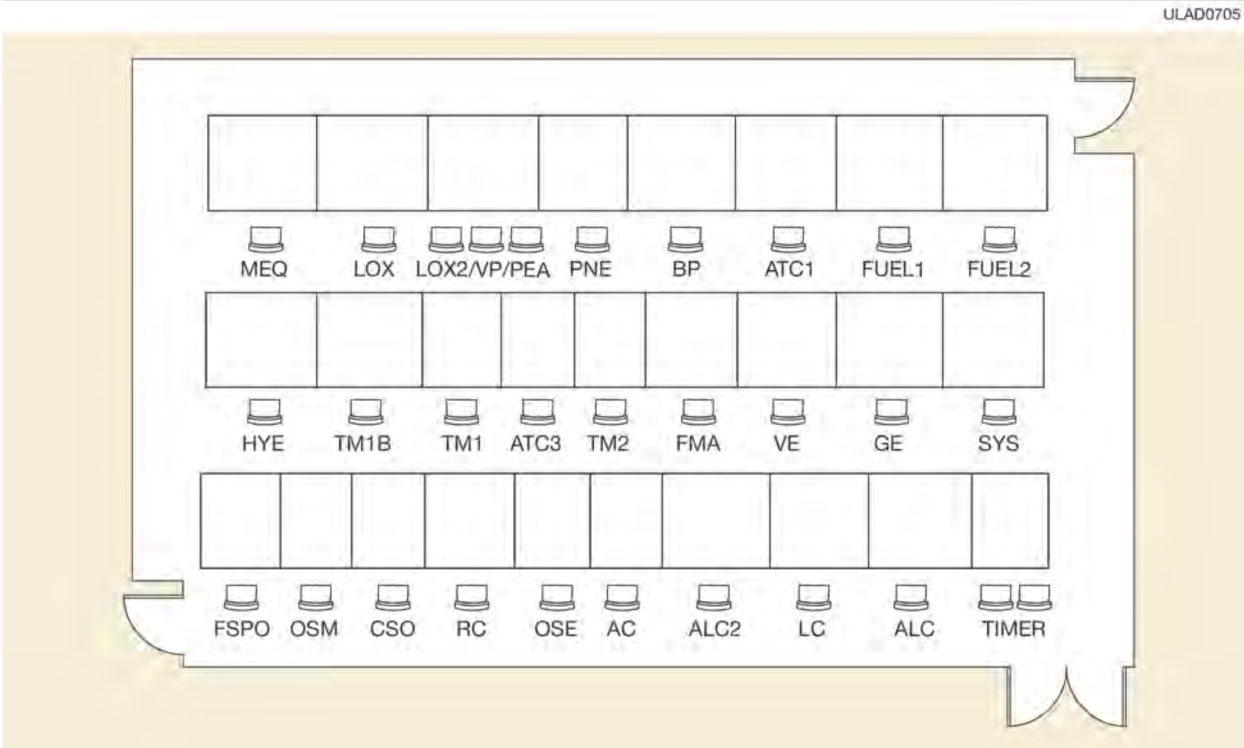

Figure 7-37. Remote Launch Control Center (Building 8510)

7.2.5.1.3 Launch Decision Process. The launch decision process is made by the appropriate management personnel representing the payload, launch vehicle, and range. Figure 7-38 shows the Delta IV communications flow required to make the launch decision.

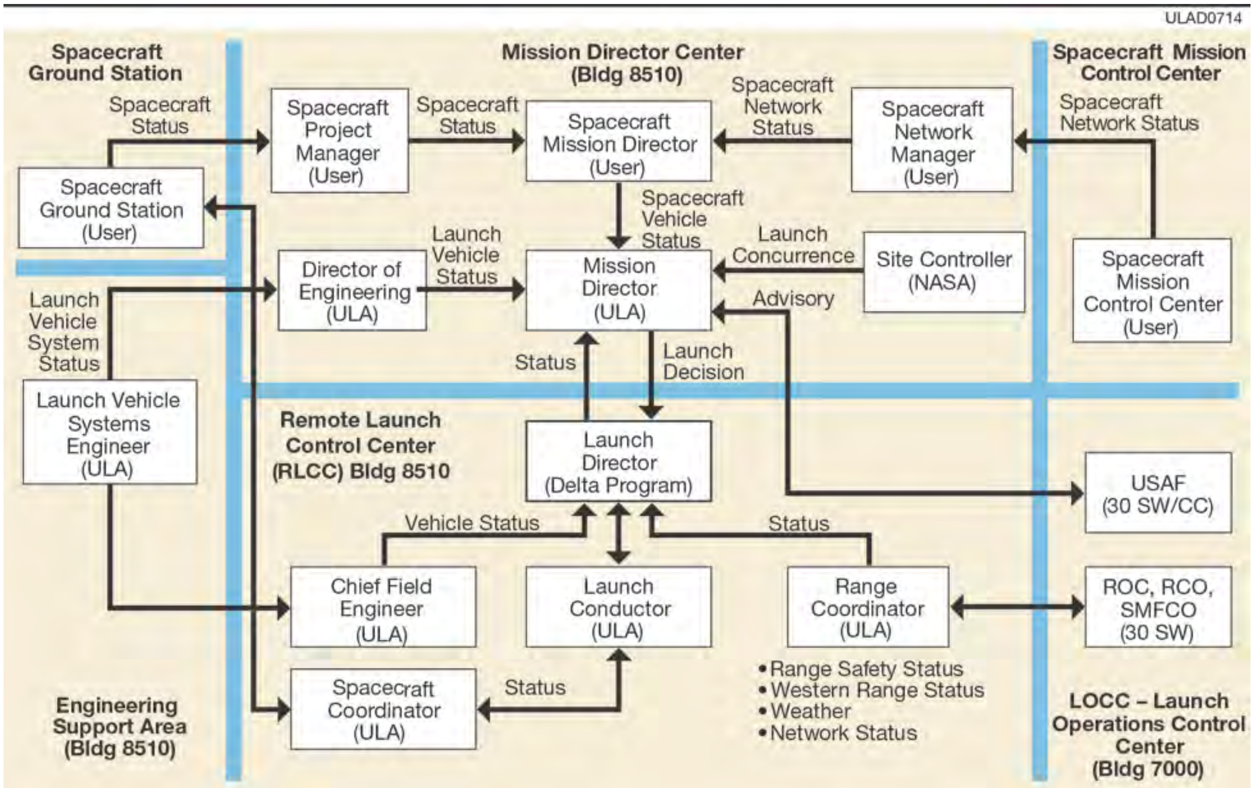

Figure 7-38. Launch Decision Flow for Commercial Missions—Western Range

7.2.5.2 Operational Safety. Safety requirements are covered in Section 4 of this document. In addition, it is ULA operating policy that all personnel will be given safety orientation briefings prior to entrance to hazardous areas such as SLC-6. These briefings will be scheduled by the ULA spacecraft coordinator and presented by appropriate safety personnel.

7.2.5.3 Security

7.2.5.3.1 VAFB Security. For access to VAFB, United States citizens must provide to the ULA security coordinator no later than (NLT) 7 days prior to arrival, full name with middle initial (if applicable), company name, company address and telephone number, date of arrival and expected departure. ULA security will arrange for entry authority for commercial missions or individuals sponsored by ULA. Access by US Government-sponsored foreign nationals is coordinated by their sponsor directly with the USAF at VAFB. For non-United States citizens, entry authority information (name, nationality/citizenship, date and place of birth, passport number and date/place of issue, visa number and date of expiration, and title or job description and organization, company address, and home address) must be furnished to ULA two months prior to the VAFB entry date. Government sponsored individuals must follow United States government guidelines as appropriate.

For security requirements at facilities other than those listed below, please see the appropriate facility user guide.

7.2.5.3.2 VAFB Security, Space Launch Complex 6. SLC-6 security is ensured by perimeter fencing, interior fencing, guards, and access badges.

Unique badging is required for unescorted entry into the fenced area at SLC-6. Arrangements must be made through ULA security at least 30 days prior to usage, in order to begin badging arrangements for personnel requiring such access. ULA personnel are also available 24 hours a day to provide escort to others requiring access.

7.2.5.3.3 Payload Processing Facilities. Physical security at the payload processing facilities (Buildings 375, 1032 or 2520) is provided by door locks and guards. Details of the payload security requirements are arranged through the ULA site integrator or appropriate payload processing facility.

7.3 FIELD RELATED SERVICES

At both launch sites, ULA employs certified propellant handlers wearing propellant handler's ensemble SCAPE suits, equipment drivers, welders, riggers, and explosive ordnance handlers, in addition to personnel experienced in most electrical and mechanical assembly skills such as torquing, soldering, crimping, precision cleaning, and contamination control. ULA has access to a machine shop, metrology laboratory, LO_2 cleaning facility, and proof-loading facility, and hydrostatic proof test equipment. ULA operational team members are familiar with USAF, NASA, and commercial payload processing facilities at CCAFS and VAFB and may offer any of these skills and services to the payload project during the launch program if required

7.4 DELTA IV PLANS AND SCHEDULES

7.4.1 Mission Plan

Prior to each launch campaign, a mission launch operations schedule is developed that shows major tasks in a weekly timeline format. The plan includes launch vehicle activities, prelaunch reviews, and PPF and HIF occupancy time.

7.4.2 Integrated Schedules

The schedule of payload activities occurring before integrated activities in the HIF varies from mission to mission. The extent of payload field testing varies and is determined by the Customer.

Payload/launch vehicle schedules are similar from mission to mission, from the time of payload weighing until launch.

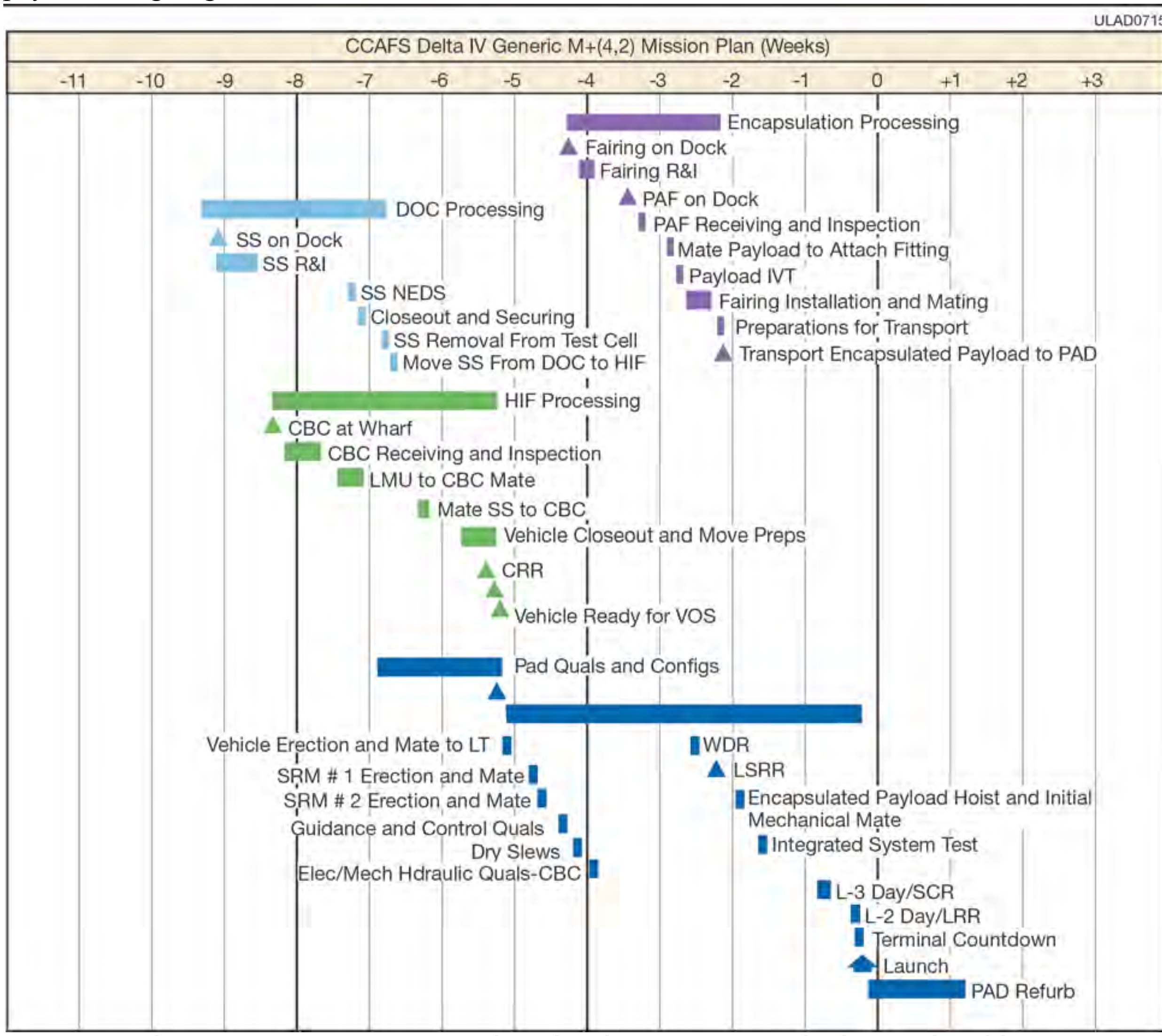

Figure 7-39. Example Processing Timeline—Delta IV M+(4,2) Launch Vehicle

Daily schedules are prepared on hourly timelines for these integrated activities. These daily schedules typically cover the encapsulation effort in the PPF and all day-of-launch countdown activities. Tasks include payload weighing, spacecraft-to-PAF mate, encapsulation, and interface verification. Figures 7-39 and 7-40 show notional integrated processing timelines for the Delta IV M+(4,2) and Delta IV Heavy with composite fairing, respectively. Actual mission countdown schedules will provide a detailed, day-to-day, hour-by-hour breakdown of launch pad operations, illustrating the flow of activities from spacecraft erection through terminal countdown and reflecting inputs from the SVC.

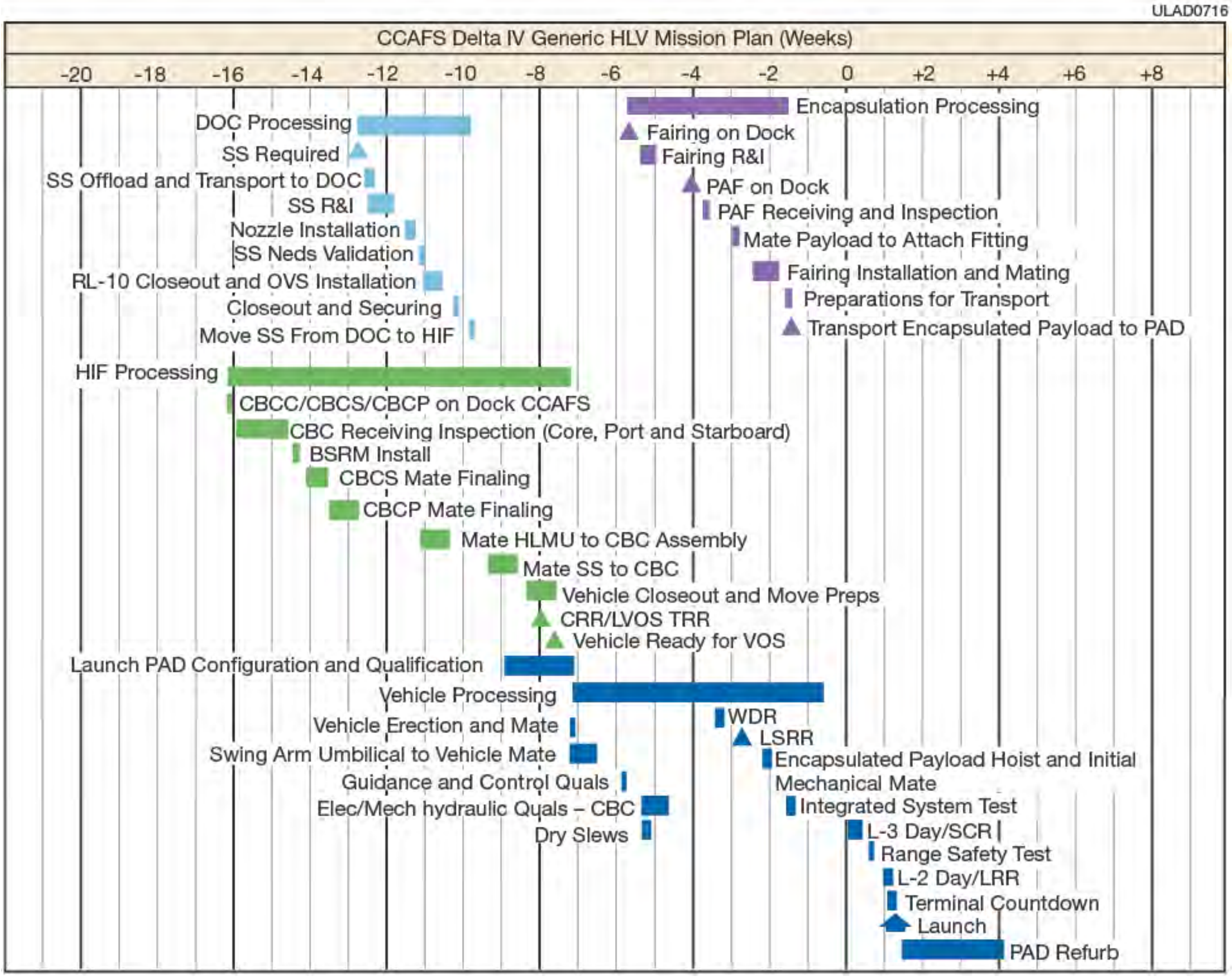

Figure 7-40. Example Processing Timeline—Delta IV Heavy Launch Vehicle

The integrated processing timelines do not normally include Saturdays, Sundays, or holidays. The schedules, from spacecraft mate through launch, are coordinated with each Customer to optimize on-pad testing. All operations are formally conducted and controlled using approved procedures. The schedule of payload activities during that time is controlled by the ULA launch operations manager.

7.4.3 Launch Vehicle Schedules

One set of facility-oriented three week schedules is developed, on a daily timeline, to show processing of multiple launch vehicles through each facility (i.e., for the launch pad, HIF, and PPFs) as required. These schedules are revised daily and reviewed at regularly scheduled Delta status meetings. Another set of daily timeline launch vehicle specific schedules is generated covering a period that shows the complete processing of each launch vehicle component. Individual schedules are made for the HIF, PPF, and launch pad.

The countdown schedules provide detailed hour-by-hour breakdowns of launch pad operations, illustrating the flow of activities from payload erection through terminal countdown, and reflecting inputs from the SVC. These schedules comprise the integrating document to ensure timely launch pad operations.

The integrated processing time lines do not normally include Saturdays, Sundays, or holidays. These days are held in reserve as contingency days to accommodate unplanned events. The schedules, from payload mate through launch, are coordinated with each Customer to optimize on-pad testing. All operations are formally conducted and controlled using launch operations procedures.

7.4.4 Spacecraft Schedules

The Customer will supply spacecraft schedules to the ULA site integrator, who will arrange support as required.

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Section 8
FUTURE CAPABILITIES AND UPGRADES

This section provides an overview of new capabilities and enhancements to the Delta IV launch vehicle family that are being evaluated or developed for possible future implementation. These upgrades represent the United Launch Alliance (ULA) commitment to continuous improvement to the Delta IV vehicle.

8.1 PAYLOAD ACCOMMODATIONS

ULA is continuously striving to develop additional capability. This allows ULA to not only meet existing industry standards, but to provide the flexibility to work with customers to easily incorporate spacecraft purges, re-radiating antennas, special flight instrumentation, or other new emerging spacecraft technologies.

8.1.1 Payload Fairings

The current Delta IV fleet has 4- and 5-m-dia payload fairings of various lengths available for customer use as described in Section 6. Should a customer have a unique requirement to accommodate a larger payload, longer and wider payload fairings could be developed. Payload fairings as large as 6.5 m (255 in.) in diameter and up to 25.9 m (85 ft long), as shown in Figure 8-1, have been evaluated and appear feasible. Larger fairings would require modest vehicle changes and modifications to the launch pad, limited mostly to secondary MST structure. Additional information on larger fairings can be obtained by contacting ULA.

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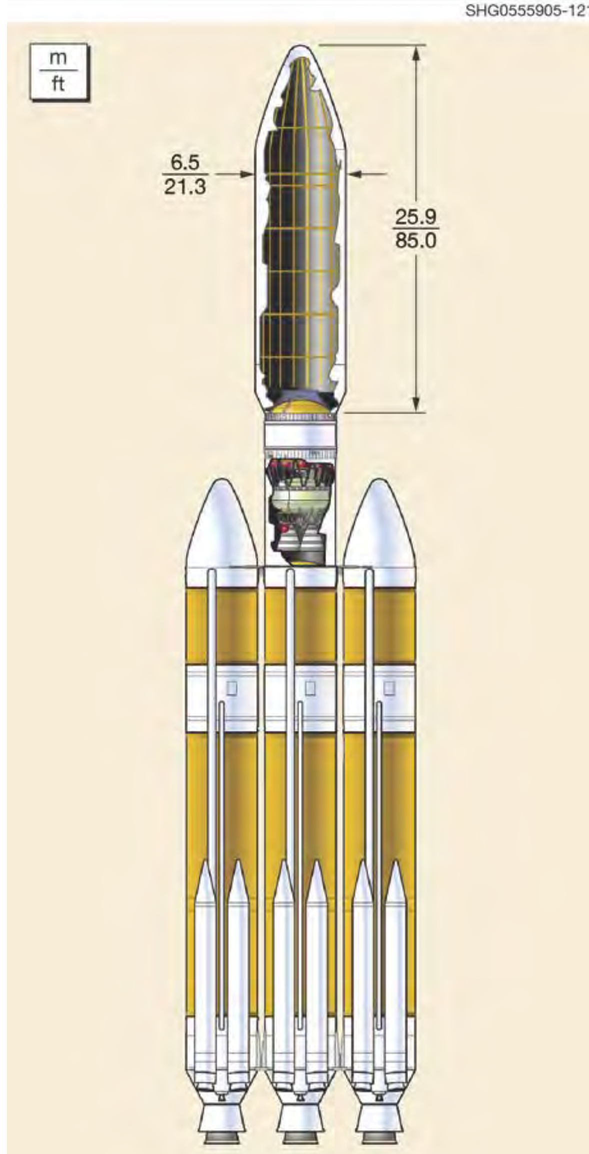

Figure 8-1. Delta IV Heavy with 6.5-m-dia. x 25.9-m-long PLF

8.2 PERFORMANCE UPGRADES

Delta IV enhancement options range across the availability timeline from ongoing performance upgrades to second-stage engine, to mid-term options for adding additional GEM-60 solids to M+ or Heavy configurations, to longer-term upgrades for higher performing Delta IV Heavy variants, and even to

Heavy-derived lifters capable of exceeding the performance of the Saturn V. Each section below describes the potential upgrades in greater detail. For additional information, please contact ULA.

8.2.1 RL10C-2 2nd Stage Engine Upgrade

To improve commonality between the Atlas and Delta launch vehicles, ULA and Pratt & Whitney Rocketdyne (PWR) are currently developing the RL10C-1 engine for the Centaur upper stage of the Atlas launch vehicle. This engine uses similar chamber and nozzle configuration as the RL10B-2 engine currently used on Delta. Use of this common engine allows for future upgrades to the RL10B-2 engine, to be called the RL10C-2 (Figure 8-2).

The RL10C-2 engine will incorporate all improvements from the RL10C-1, including an upgraded redundant ignition system to improve reliability, changes to the engine plumbing to improve starting operations, a propellant valve design update, and a number of improvements previously qualified under the Assured Access to Space program including a revised gear train and seal improvements.

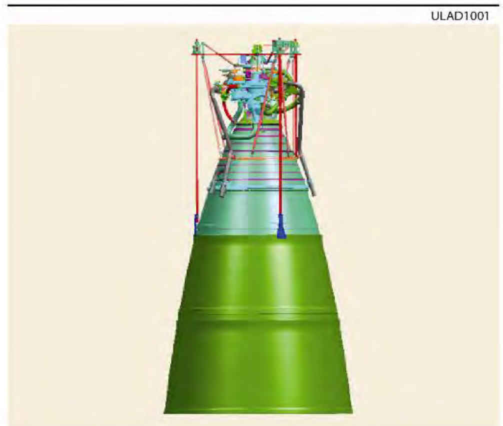

Figure 8-2. RL10C-2 Engine

The RL10C-2 development will be managed through the RL10 Sustainment and Modernization Program. This program is intended to incorporate improved manufacturing methods for turbomachinery, propellant valves, and injector hardware, revised large plumbing to reduce weight, and more robust solenoid valves. Additionally, the RL10C-2 is intended to be qualified to operate with active Mixture Ratio control, a capability available on Atlas/Centaur missions dating back to 1965. This feature, enabled on Delta IV by the addition of Common Avionics (Section 8.3.2), could result in a performance improvement of up to 200 lb for certain Delta missions. The RL10C-2 will continue to use the 3-segment extendible nozzle currently used on the RL10B-2. The C-2 will look virtually the same as an RL10B-2, with slight changes to the Ignition and Engine Instrumentation Boxes and realignment of some of the large plumbing.

Changes incorporated as part of the Sustainment and Modernization effort will be qualified for both the RL10C-1 for Atlas and the RL10C-2 for Delta at the same time, using the same common core engine. The end result will be an engine that can be built and acceptance tested using a common bill of material and test program, and then configured as necessary with bolt-on hardware to support either Atlas V or Delta IV vehicles.

8.2.2 Advanced Common Evolved Stage (ACES)

ULA is focused on the development of the Advanced Common Evolved Stage (ACES), supporting both Atlas V and Delta IV launch vehicle families, as a mechanism to enhance launch vehicle performance and reduce customer costs. ACES will increase the Delta IV M+(5,4) performance to cover the heavy medium class currently requiring an Atlas 551, and will increase Delta IV Heavy performance up to 37 mT.

ACES is a 5-m diameter, monocoque, common bulkhead stage that combines key features from both the Centaur and Delta Cryogenic second stages. ULA is focusing on an ACES stage containing 110 klb of propellant to satisfy a broad range of mission requirements. The ACES design is flexible enough to accommodate substantially larger or smaller propellant masses to meet future evolving mission demands. ACES will nominally use two RL10C engines. For LEO missions, ACES will accommodate four RL10C engines. Figure 8-3 shows a conceptual diagram of the ACES compared to the existing Atlas Centaur upper stage and the 5-m Delta Cryogenic Second Stage.

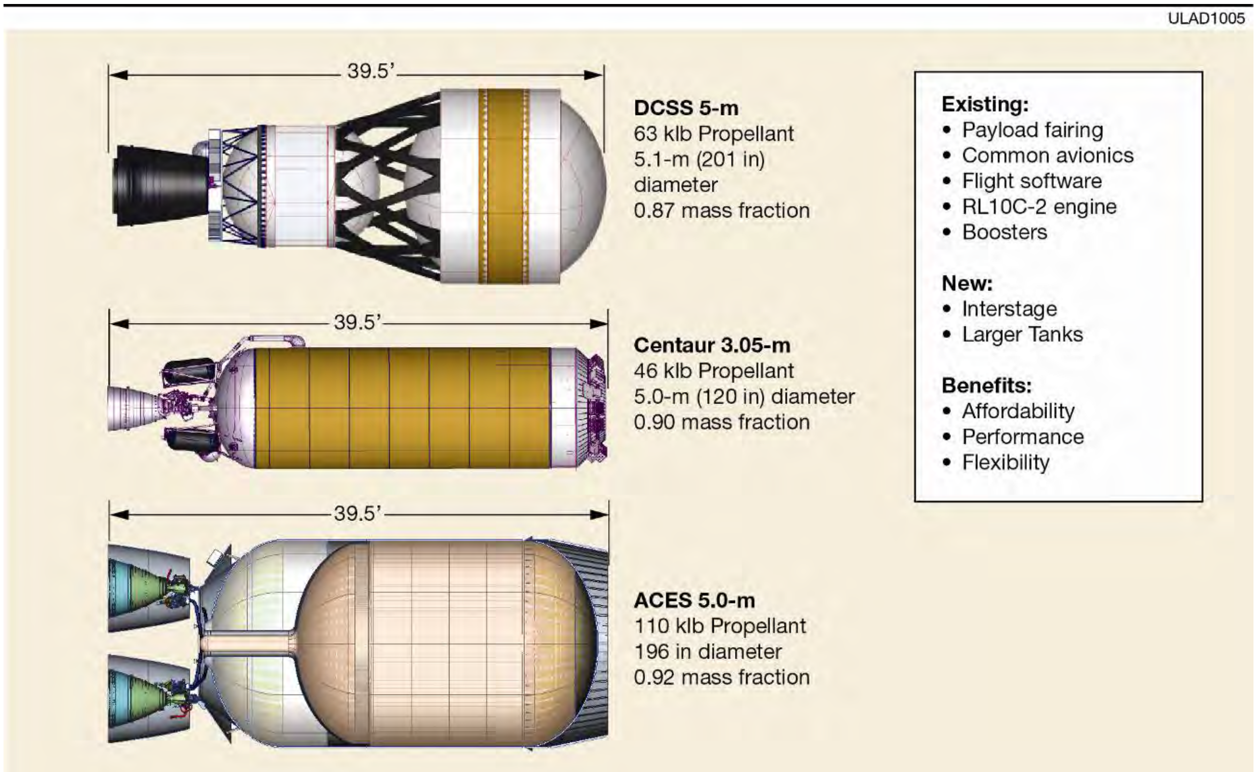

Figure 8-3. Upper Stage Comparisons

8.2.3 Delta IV Medium+ Vehicle Configurations

The Delta IV family uses a modular approach to providing incremental performance across the Medium-Plus family by adding pairs of GEM-60s. Currently, only two GEM-60s are available on the M+(4,2), while two or four are available on the M+(5,x) single-core boosters. The Delta Program is currently evaluating expanding these offerings to include up to four GEM-60s on the 4-m variant, enabling an M+(4,4), or an increase to six or eight GEM-60s for the 5-m variants. The addition of more GEM-60s provides customers added flexibility, reducing spacecraft risk to unexpected or unavoidable mass growth in addition to providing a wider range of payload performance. The performance capability of these three options is shown in Figure 8-4, and discussed in additional detail below.

8.2.3.1 M+(4,4)

The M+(4,4), which adds two more GEM-60 solid strap-ons to the existing M+(4,2) single-core vehicle, is the easiest modification to make in this class of upgrades. Modeled after the existing 5-m variant with four strap-ons, the M+(5,4), this vehicle would simply use the smaller 4-m second stage and fairing instead of the 5-m versions of that hardware, providing a lower-cost option with slightly less payload volume but more mass-to-orbit performance than the current M+(5,4). This vehicle could be made available to its first customer within 36 months of order.

8.2.3.2 M+(5,6) and M+(5,8)

Adding two or four more GEM-60 strap-ons to the M+(5,4) provides even greater performance, bridging the gap in capability with the Delta IV Heavy while remaining a lower-cost single-core solution. The M+(5,6) and M+(5,8) are straightforward but require more extensive upgrade options than the M+(4,4) discussed above, due to the tight space availability at the existing launch facility, requiring some minor pad infrastructure modifications. The vehicle would also require a modest redesign to accommodate the additional strap-ons and the higher flight loading. Even with these modest modifications, the M+(5,6) and M+(5,8) could be available to customers within 48 months.

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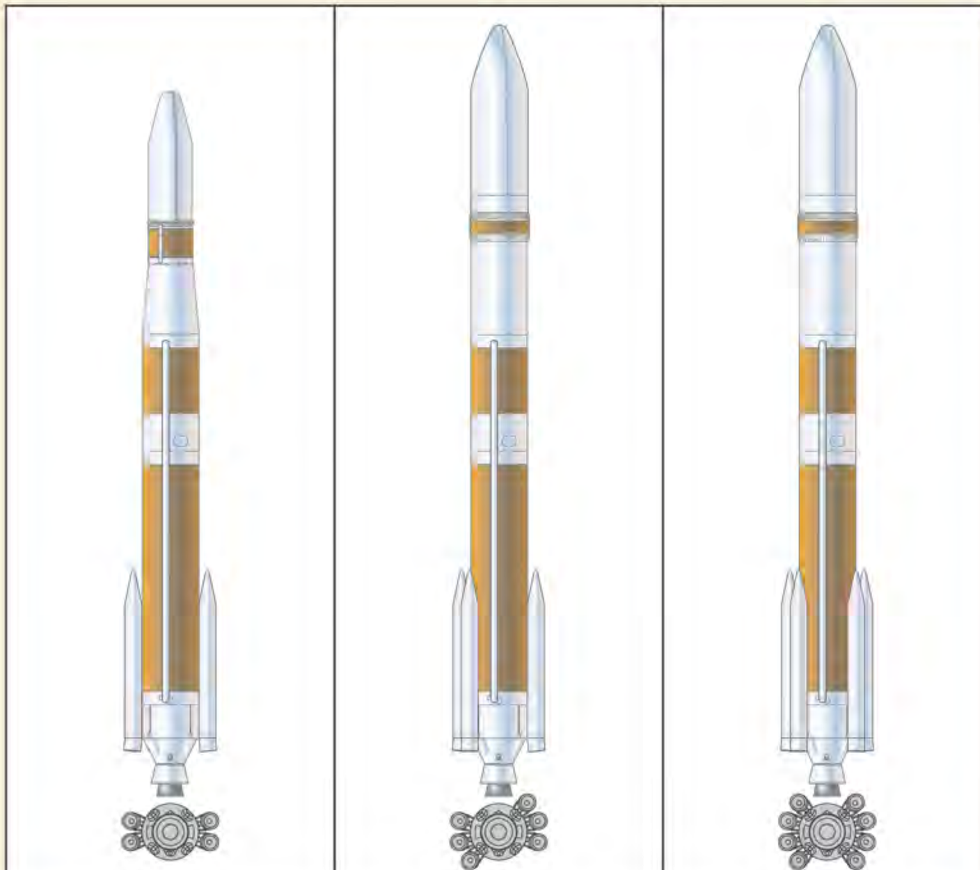

	M+(4,4)	M+(5,6)	M+(5,8)
GTO	7,500 kg (16,600 lb)	7,700 kg (17,000 lb)	9,200 kg (20,200 lb)
LEO	14,800 kg (32,700 lb)	15,000 kg (33,000 lb)	17,200 kg (38,100 lb)

GTO = 35,786 km x 185 km (19,323 nmi x 100 nmi) at 27.0 deg
LEO = 407 km (220 nmi) circular at 51.6 deg

Figure 8-4. Delta IV M+ Improved Vehicle Configurations

8.2.3.3 Delta IV Heavy Upgrades

There are a considerable number of upgrades available for improving performance of the Delta IV family beyond the current Heavy capabilities. A selection of possible upgrades is shown in Figure 8-5.

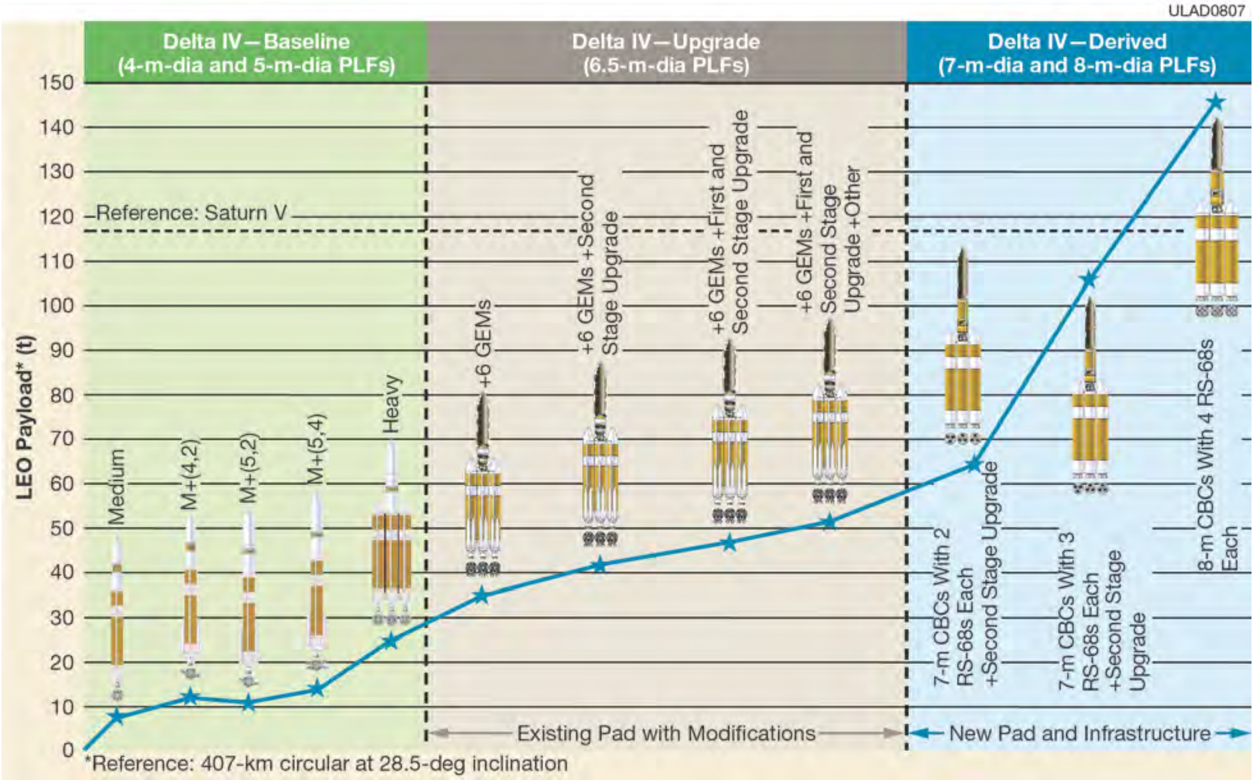

Figure 8-5. Range of Upgrade Options Available to Improve Performance of the Delta IV Heavy

The lowest cost options for upgrading the Heavy are shown in Figure 8-5. These options can double Heavy performance, beyond 50-t to LEO, even with a much larger 6.5-m diameter fairing included. These modifications continue to use the existing launch infrastructure with only modest modifications, providing tremendous payload capability improvements with only limited investment. Upgrades include adding up to six GEM-60s to the Heavy, use of larger and longer fairings, increased first and second stage engine thrust and/or Isp, and other related vehicle changes such as use of lighter weight structure (Aluminum-Lithium alloys) and propellant crossfeed. Availability of these upgrades varies with each specific upgrade, but generally require four to five years development time.

Should more than 50-t to LEO be needed, the Delta IV family provides the building blocks and experience for a Delta-derived "super-heavy" solution, also shown in Figure 8-5. These vehicles take the basic Delta IV Heavy solution and grow it in size, increasing the CBC diameter from the current 5-m to 7-m, 8-m, or even larger diameters with two, three, or more RS-68A engines per CBC. The second stage is also enlarged, with multiple RL10 engines or the use of new, higher-thrust engines. All of these alternatives would require new launch infrastructure, including a new launch pad and integration facility. Therefore, these solutions are much more expensive and further away from first flight than the other options described above.

For additional information on any of these Delta upgrades, please contact ULA.

8.2.4 Third Stage

ULA is evaluating the use of a third stage for the Delta IV M+ and Delta IV Heavy launch vehicles for interplanetary missions. The 3rd stage design would be based on the proven Delta II design.

The heritage Delta II third stage consists of a Star 48B solid rocket motor, a Payload Attach Fitting (PAF) with Nutation Control System (NCS), and a spin table containing small rockets for spin-up of the third stage/spacecraft. The Star 48B Solid Rocket Motor (SRM) has flown on numerous missions and was developed from a family of high-performance apogee and perigee kick motors made by Alliant Techsystems, Inc. (ATK). The flight-proven NCS, using monopropellant hydrazine prepressurized with helium, maintains orientation of the spin-axis of the 3rd stage/spacecraft stack during flight until spacecraft separation. This simple system has inherent reliability, with only one moving component and a leak-free design. Additional information about the heritage 3rd stage design is available in the Delta II Payload Planners Guide. Because the 3rd stage configuration is not currently baselined in the Delta IV program, no other reference to the 3rd stage is made in this User's Guide at this time. For more information regarding use of a 3rd stage, please contact ULA.

8.3 OTHER ENHANCEMENTS

In addition to payload accommodations and performance improvements, ULA is developing other concepts to provide additional capabilities to the space community. The following sections describe these concepts.

8.3.1 Integrated Vehicle Fluids (IVF)

ULA is presently developing a system called Integrated Vehicle Fluids (IVF) that will ultimately replace the existing hydrazine reaction control system, the high pressure helium storage and tank pressurization and vent system, and the large-capacity batteries which power the Centaur and Delta IV second stages. The heart of the IVF system is a small auxiliary power unit which burns waste hydrogen and oxygen from the main vehicle tanks, to produce shaft power for electrical generation and to drive small compressors which perform tank pressurization. Small hydrogen/oxygen thrusters are used for attitude control. IVF drastically reduces hardware mass by removing heavy and bulky pre-loaded storage vessels and high pressure control valving. More importantly it makes use of waste gases and hence effectively eliminates the mass of these secondary propellants and gases. Because power unit exhaust is used for continuous vehicle settling, propellant heating is reduced which maximizes usable propellants. The overall benefit to the payload is dependent on mission architecture, with the greatest benefit accruing to multiple-burn missions with long coast durations. Applied to Centaur, Delta IV second stage, or ACES, the IVF system can improve GSO performance by up to 1,000 pounds.

For the first time, primary vehicle propellants can be directly applied to secondary propulsion needs such as vehicle disposal or orbital maneuvers which cannot be presently accomplished. Because power can be provided as long as gaseous residuals remain on board, missions can be extended to durations of many days. Up to 8 kW of electrical power is available for vehicle or payload needs – a substantial increase over existing systems. The number of engine restarts is only bounded by engine qualification and available propellant.

These performance amplifications are accomplished while providing complete block redundancy of function since there are two independent IVF modules on board – each capable of executing the mission. With removal of high pressures, toxic and corrosive propellants and by having large functional margins, overall vehicle reliability is significantly improved.

8.3.2 Common Avionics

A common avionics suite is being developed for use on both the Delta IV and Atlas V product lines. This set of avionics is the best value combination of cost, reliability, weight, technical capability and protection against near-term future obsolescence from both heritage programs. The common avionics system is based on the heritage Atlas V Block 2 avionics with multiple enhancements incorporated to improve system fault tolerance and operability. All major subsystems will be re-designed, including power, telemetry, guidance, navigation and control, and ordnance control.

The new common avionics will provide many benefits to the ULA customer, including increased avionics system capability and reliability, modern and efficient technologies, a more vibrant supplier base and common processes based on ULA's best practices. The first flight of the common avionics is planned for the third quarter of 2015 aboard an Atlas V.

Section 9
AUXILIARY AND DUAL PAYLOAD ACCOMMODATIONS

This section outlines how United Launch Alliance (ULA) is fostering frequent and affordable launch services for rideshare payloads and the capabilities to support a wide range of size and weight payloads. ULA is continually enhancing rideshare capabilities by working closely with our primary payload and auxiliary payload customers. ULA is actively expanding rideshare payloads process and support including identification of rideshare mission opportunities; links to the governing rideshare policies; and guidance to the auxiliary and dual manifest spacecraft developer on qualification, certification, and interface specifications. For the latest information regarding the Delta IV rideshare payload capabilities, please refer to ULA's website at www.ulalaunch.com, or contact ULA directly.

9.1 AUXILIARY PAYLOADS

ULA remains committed to supporting the auxiliary spacecraft community. Auxiliary payloads fly as a secondary passenger with a primary payload mission. Section 9 discusses a spectrum of the Delta IV rideshare accommodations for various classes of auxiliary spacecraft.

9.1.1 C-Adapter Platform

The C-Adapter Platform (CAP) is located within the payload fairing and attached to the side of a C-adapter. It can carry an auxiliary payload with a mass up to 45 kg (100 lb). With additional qualification, it may be possible to increase the mass capability. Figure 9-1 shows the usable volume dimension of the CAP (13 in. x 9 in. x 12 in.) and its location on the side of a typical C-Adapter. The number of CAPs and the positioning of the CAPs around the circumference of the C-adapter are subject to available mission margins and mission requirements. The CAP can accommodate various deployment options. It is large enough to accommodate an 8-inch Motorized Lightband, which can be mounted on either the base of the CAP or on the wall.

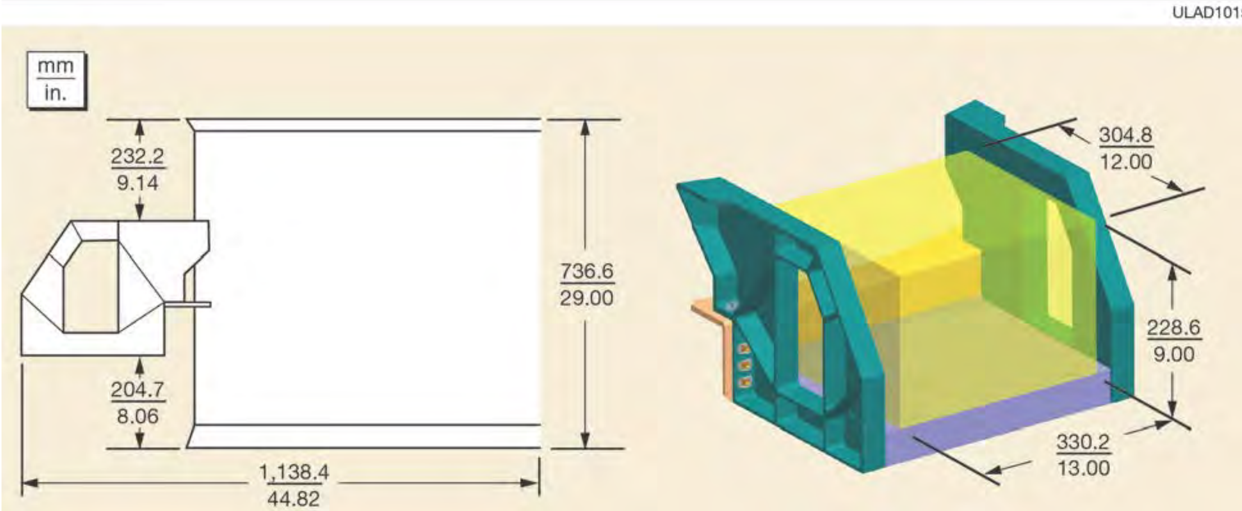

Figure 9-1. CAP Location and Volume

9.1.2 EELV Secondary Payload Adapter

For missions that have excess mass and volume margins, auxiliary payloads can be launched using the EELV Secondary Payload Adapter (ESPA), a 1.5 m diameter (62 in. diameter), 61 cm tall (24 in. tall) ring that can support up to six Auxiliary Payloads (APL) around its circumference. The ESPA ring is mounted between the top of a C-adapter and the bottom of the primary Spacecraft payload adapter (Figure 9-2). The ESPA ring replicates the EELV Standard Interface Plane (SIP) for the primary spacecraft, and provides the ability to pass the electrical interfaces through to the primary payload.

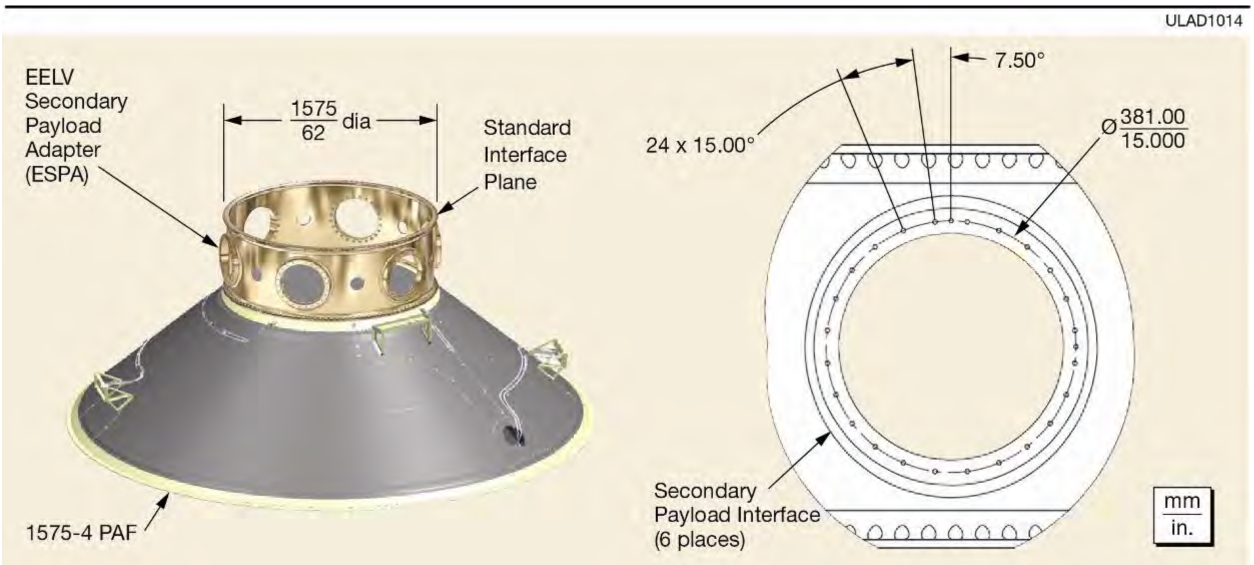

Figure 9-2. Notional Delta ESPA Structural Stack

The ESPA ring contains six 381 mm diameter (15 in. diameter) bolt circle interfaces, able to accommodate a single auxiliary payload up to 181 kg (400 lb) in mass, and a volume of

61.0 cm x 71.1 cm x 96.5 cm (24 in. x 28 in. x 38 in.). This total volume includes provisions for a 5.33 cm (2.1 inch) separation system operational envelope as shown in Figure 9-3. Only the separation system, its mounting hardware and its harnesses are permitted inside the separation system operational envelope.

An auxiliary payload provided separation system mechanical interface shall match the standard ESPA Ring interface provisions as defined in the Rideshare User's Guide (RUG). In the future, an auxiliary payload may be attached to the ESPA Ring with a ULA-provided Planetary Systems Corporation (PSC) 15 in. Motorized Lightband (MLB) separation system.

For additional details regarding the design of the ESPA System, reference the ESPA RUG, or contact ULA.

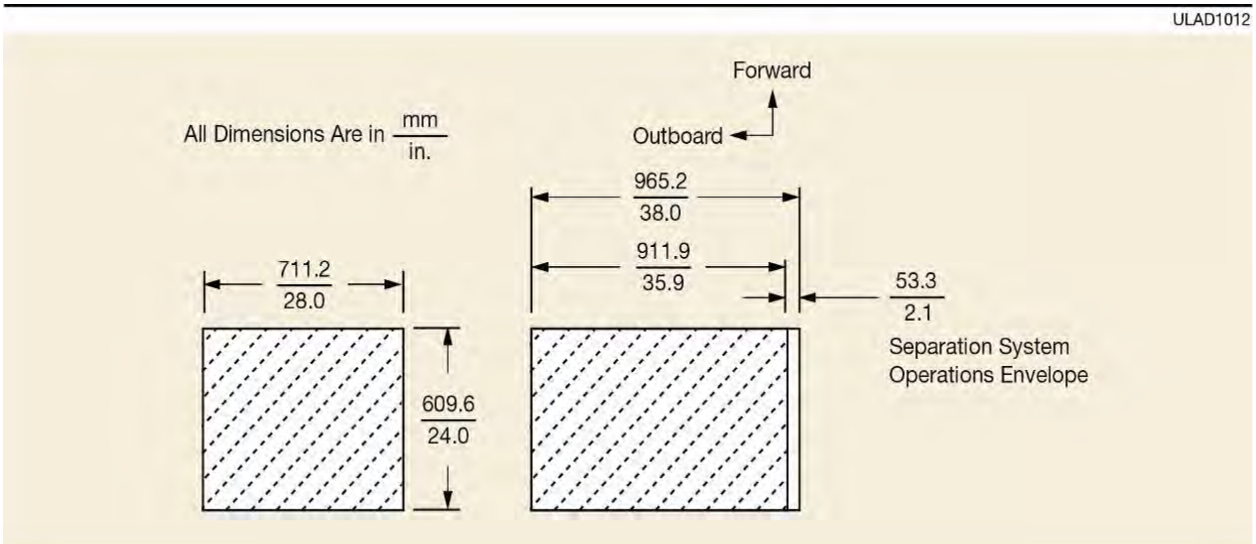

Figure 9-3. ESPA APL Envelope Definition

9.1.3 Integrated Payload Carrier

The Integrated Payload Carrier (IPC) is a flexible stack of ring segments that can accommodate various auxiliary payload types by providing a variety of configurations depending on the particular needs of the mission. It consists primarily of a mix of C-adapters of various heights (13, 15, 22, 25, or 29 inches) (Section 5.1.3). Additionally, a D-1666 separation system could be added in order to separate the upper portion of the IPC from the lower portion. Also, an ESPA ring could be added in place of a C-adapter in support of multi-manifest missions. Several examples of possible configurations appear in Figure 9-4.

Using either an isogrid flat-deck or a conic section inside the IPC as the spacecraft interface, Delta IV can deploy one or multiple auxiliary payloads from within the internal volume, once the primary payload has separated. The internal diameter of a C-Adapter segment is 60 inches that can accommodate auxiliary payloads diameters of up to approximately 50 inches. The height available to the auxiliary payload can vary by the types and number of adapters used. There are limitations on what can be configured and launched, based on performance margins, primary payload volume requirements, etc.

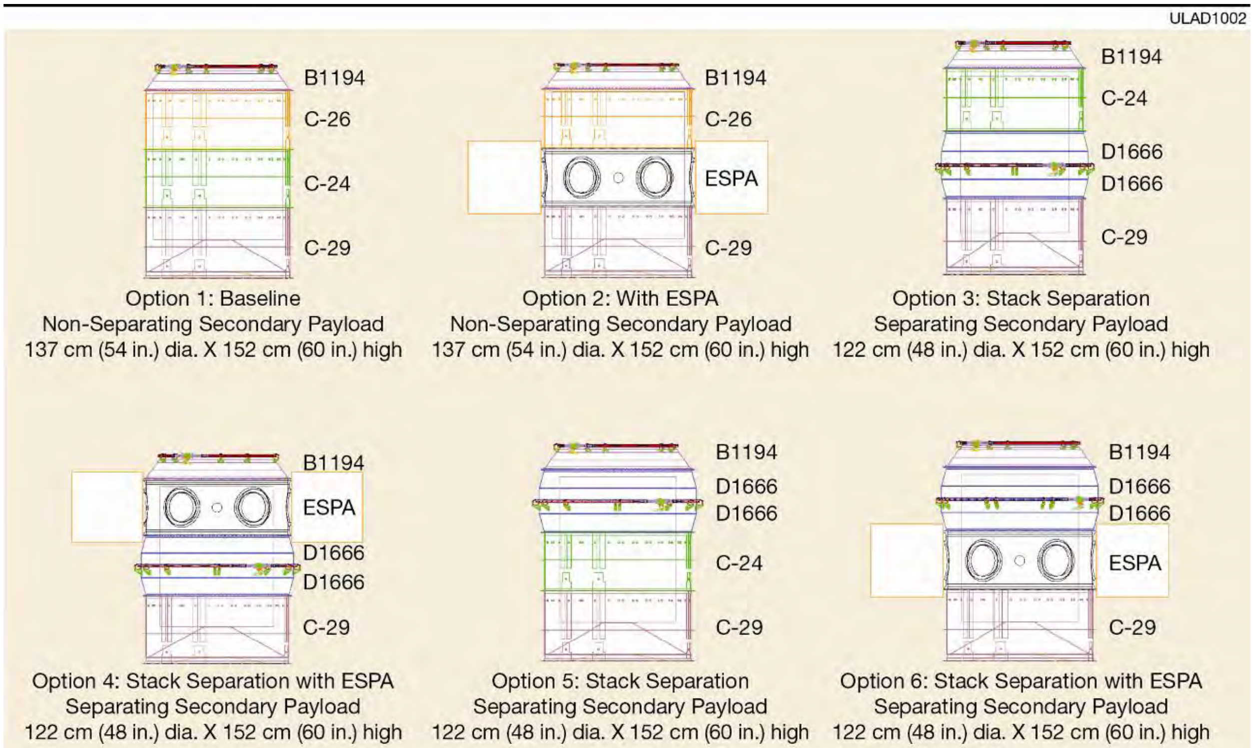

Figure 9-4. IPC Stack Options

9.2 DUAL PAYLOAD ACCOMMODATIONS

ULA is developing dual manifest capabilities for both 4-m and 5-m missions, as described below.

9.2.1 Dual Spacecraft System, 4-m (DSS-4)

Dual-spacecraft mission capabilities accomplish dual spacecraft deployments using a single launch vehicle, thereby reducing launch services costs. The DSS-4 (Figure 9-5) is well-suited to launching small-to-medium class spacecraft, which are generally too big to be considered auxiliary payloads, but smaller in mass and volume than the typical product line lift capabilities. The DSS-4 makes extensive use of existing Atlas/Centaur qualified hardware components with well-understood capabilities.

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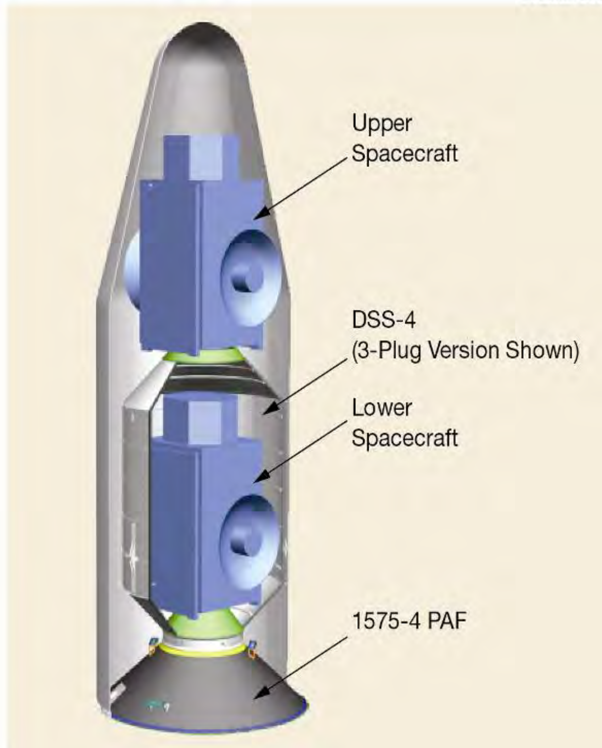

Figure 9-5. Dual Spacecraft System, 4-m (DSS-4)

The DSS-4 canister consists of two back-to-back (Atlas) Centaur Forward Adapters (CFAs) with options to add one to four cylindrical plug sections to provide additional volume for the aft encapsulated spacecraft volume, based on the configuration/requirements of the forward spacecraft. The Delta IV 4-m diameter payload fairing completely encapsulates both the upper spacecraft and the DSS-4 system containing the lower spacecraft. The upper spacecraft mechanically interfaces to the top of the DSS-4 canister requiring the flight loads from the upper spacecraft to be carried through the DSS-4 structure during the vehicle ascent. The DSS-4 mechanical interface is the 62-inch Standard Interface Specification (SIS) payload interface, permits use of existing payload adapters and separation systems. The aft interface attaches using a standard C-13 cylindrical payload adapter providing DSS canister venting capability. Conditioned Environmental Control System (ECS) air and/or GN_2 (transitioned prior to cryogenic propellant loading) are available to the encapsulated spacecraft located within the DSS-4 canister.

The DSS-4 design has successfully completed a series of Systems Design Reviews including the System Requirements Review (SRR) in June 2008, Preliminary Design Review (PDR) in September 2008, and the Critical Design Review (CDR) in December 2009. The system-level and derived requirements have been defined, and verification of all requirements will be accomplished based on initial mission assignments. ULA has performed coupled loads analyses using Craig-Bampton models of 'indicator payloads' (tuned spring/mass/damper assemblies intended to simulate actual spacecraft) and actual medium-class spacecraft.

The DSS-4 hardware has previously been qualified with extensive flight experience. Structural test results are available and structural capabilities are well understood and compatible with the Delta launch vehicles. Design implementation risk is simplified and nonrecurring costs are reduced compared to those of a brand-new development program.

The DSS-4 requires three separation systems: one for the upper spacecraft, one to separate the upper portion of the canister assembly, and one for the encapsulated spacecraft. The spacecraft separation systems depend on a given mission's requirements.

The DSS canister separation system uses explosive bolts identical to those currently used to separate the Atlas V 4-m diameter payload fairing. These bolts have also flown on heritage launch vehicles such as Titan/Centaur and Atlas I, II, and III. The fittings that house these separation bolts are derived from those used on the Atlas V 4 m fairing. These separation bolts and similar fittings have been used over 2,700 times since the Atlas G first flew in 1984 to deploy various hardware configurations.

These following spacecraft weights should be considered preliminary estimates, not necessarily maximums or limits. Analyses have rated the no-cylindrical plug DSS-4 configuration to carry a spacecraft up to 10,000 lbs in the forward position and a spacecraft up to 8,000 lbs internal to the canister. Configurations with up to four cylindrical plugs may have reduced weight limitations for the forward spacecraft, depending on the number of plugs and spacecraft center of gravity distance from the interface plane. A specific mission's coupled loads analyses will determine spacecraft responses, verify that the DSS-4 loads are within its structural capability, and assess loss-of-clearance between spacecraft and Payload Fairing (PLF) hardware elements and will. Since the DSS-4 is comprised of CFA components, and loads from both spacecraft and the DSS-4 are carried through the CFA, it is likely the CFA will be constrained by load capability rather than other system design constraints. To date, our coupled loads analysis has verified that spacecraft assemblies which remain within the mass and center of gravity limits corresponding to the Standard Interface Plane structural capability have not resulted in load exceedance for the DSS-4 hardware. The minimum spacecraft lateral bending mode guidelines are provided in Section 3.2.4.2.

ULA has developed the preliminary payload envelopes that appear in Figures 9-6 through 9-10.

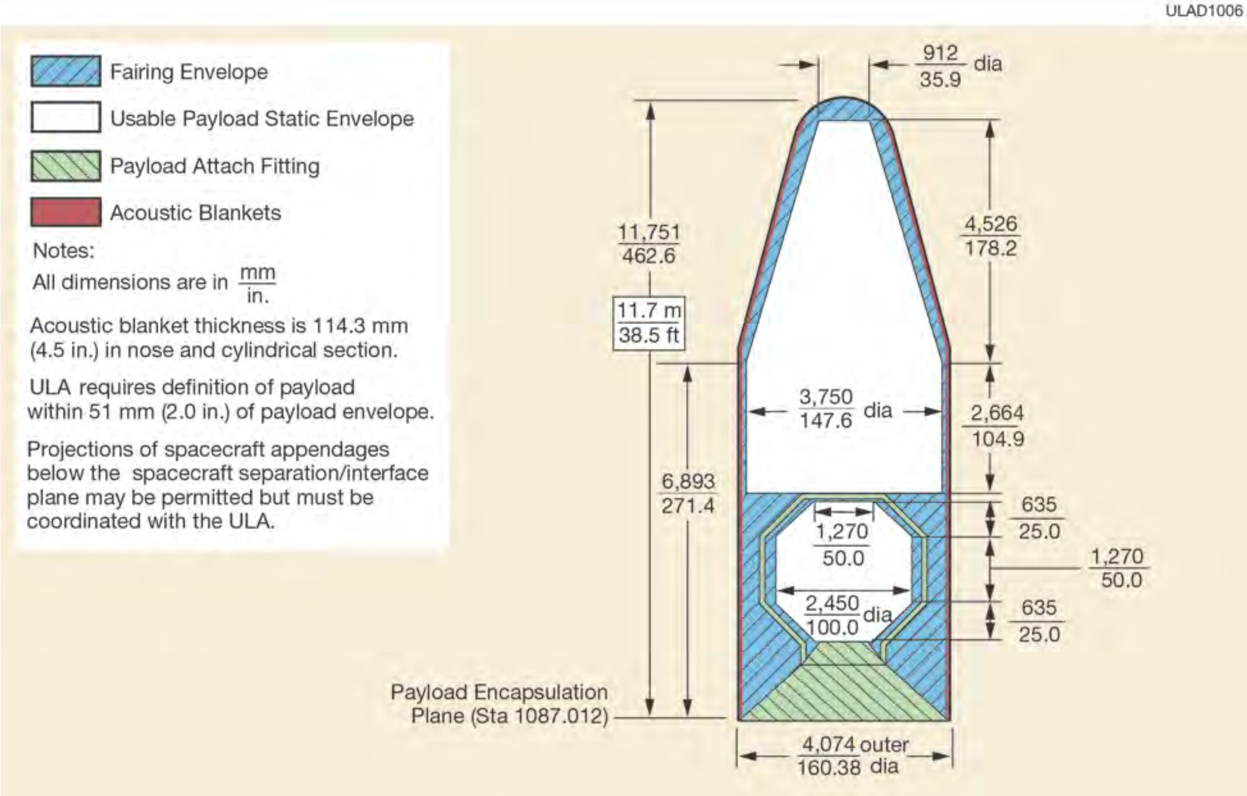

Figure 9-6. Preliminary DSS-4 Payload Envelope — 4-m PLF with No DSS Plugs

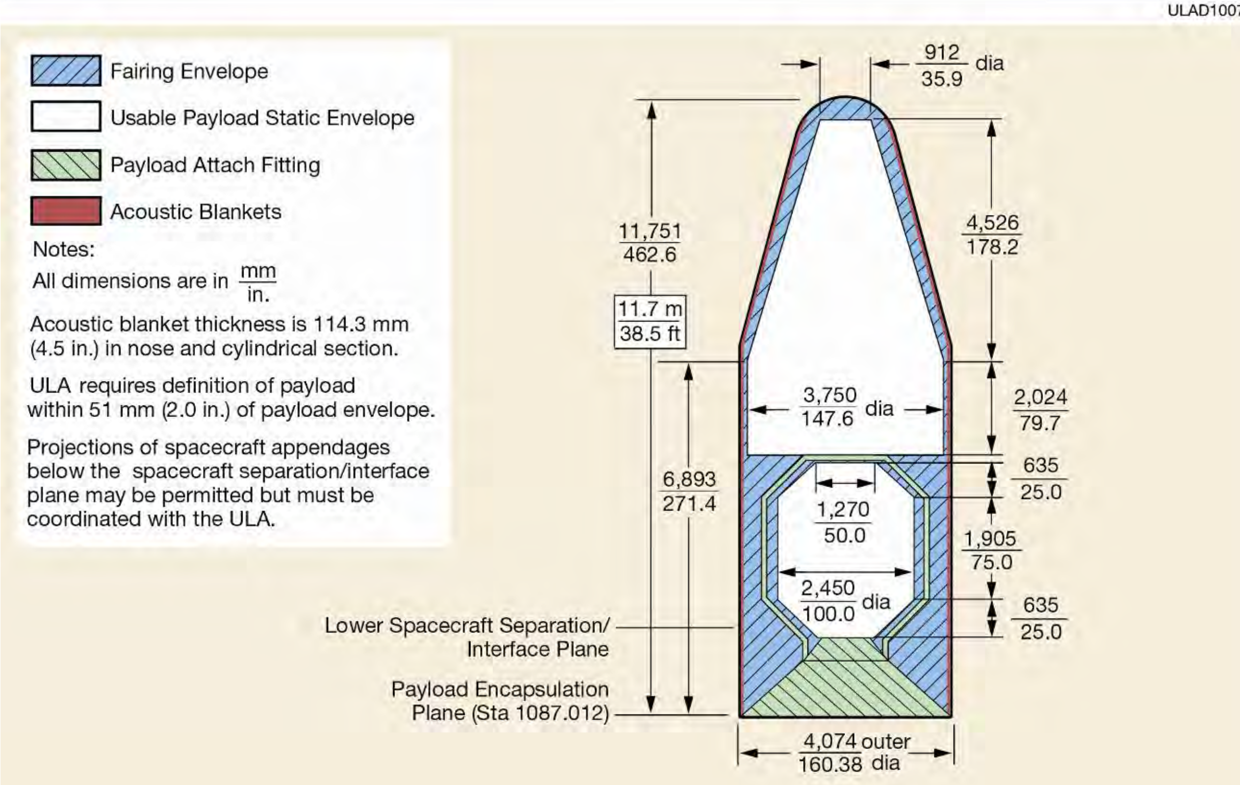

Figure 9-7. Preliminary DSS-4 Payload Envelope — 4-m PLF with One DSS Plug

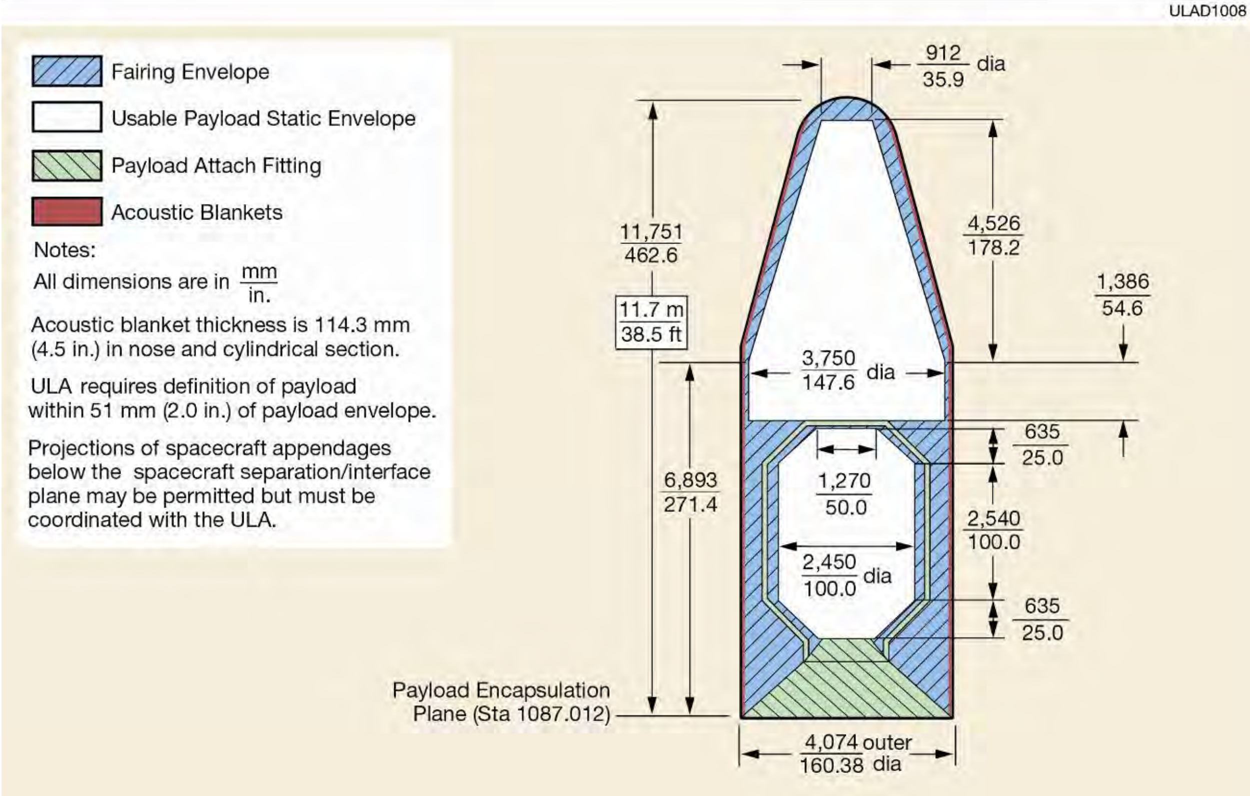

Figure 9-8. Preliminary DSS-4 Payload Envelope — 4-m PLF with Two DSS Plugs

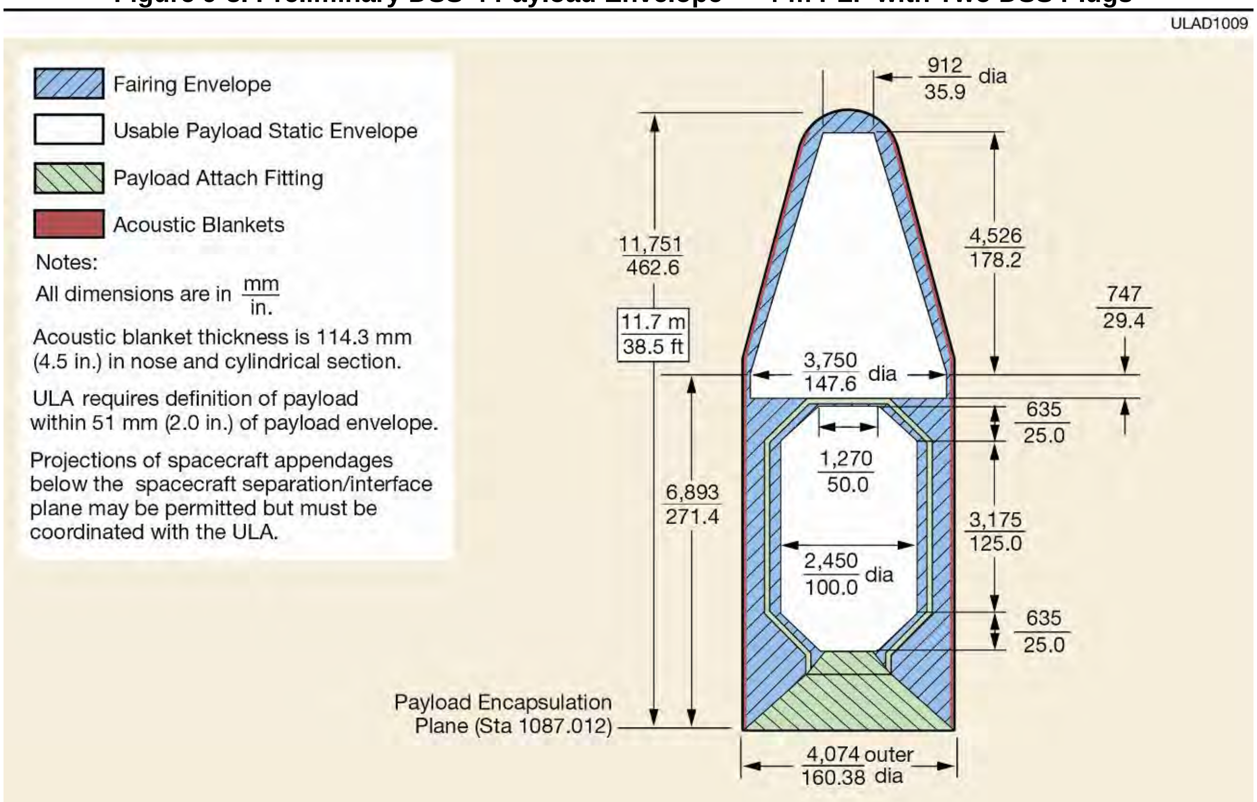

Figure 9-9. Preliminary DSS-4 Payload Envelope — 4-m PLF with Three DSS Plugs

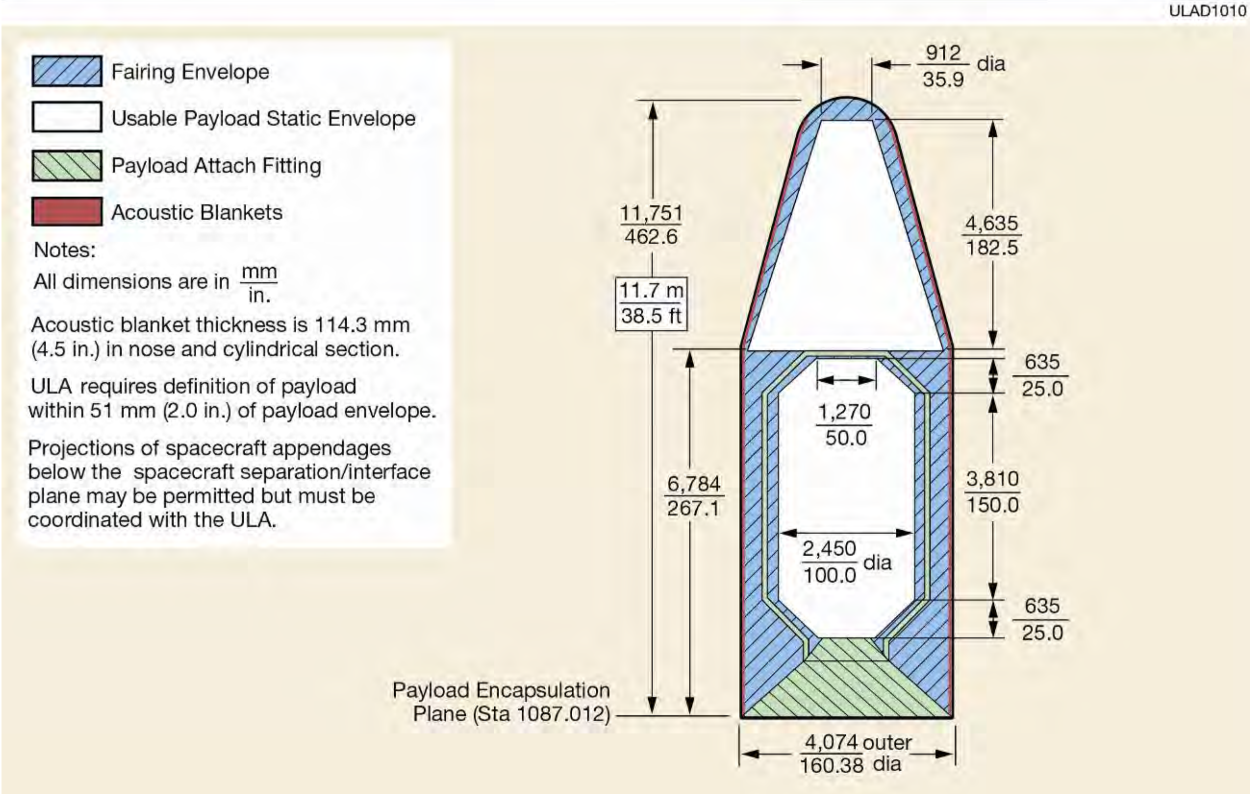

Figure 9-10. Preliminary DSS-4 Payload Envelope — 4-m PLF with Four DSS Plugs

9.2.2 Dual Spacecraft System, 5-m (DSS-5)

ULA has designed a new dual launch capability for use on both ULA launch vehicles (Atlas V and Delta IV) using their respective 5-m PLFs. The 5 m Dual Spacecraft System (DSS-5), designed up through a Preliminary Design Review (PDR), enables delivery of two medium- or intermediate-class spacecraft to orbit with a single launch.

The DSS-5 is designed to be encapsulated within the Delta IV 5-m 63 ft PLF providing an upper and encapsulated lower spacecraft vehicle launch capability (Figure 9-11). The forward compartment payload static envelope has a diameter of 4,572 mm (180.0 in.) at the base, and conforms to the shape of the PLF as it extends forward. The forward spacecraft mates to a Delta IV or customer-provided adapter that, in turn, mates to the 1,575 mm (62.01 in.) diameter forward interface ring of the DSS-5.

The DSS-5 canister encapsulates the aft spacecraft, which interfaces through a complement of ULA or Customer provided adapters/separation system to a Delta IV or customer-provided payload adapter which, in turn, mates to the 1,575 mm (62.01 in.) diameter Delta IV Payload Attach Fitting (PAF). This aft compartment payload static envelope has a diameter of 4,000 mm (157.5 in.) diameter. Figure 9-12 shows preliminary forward and aft payload static envelopes.

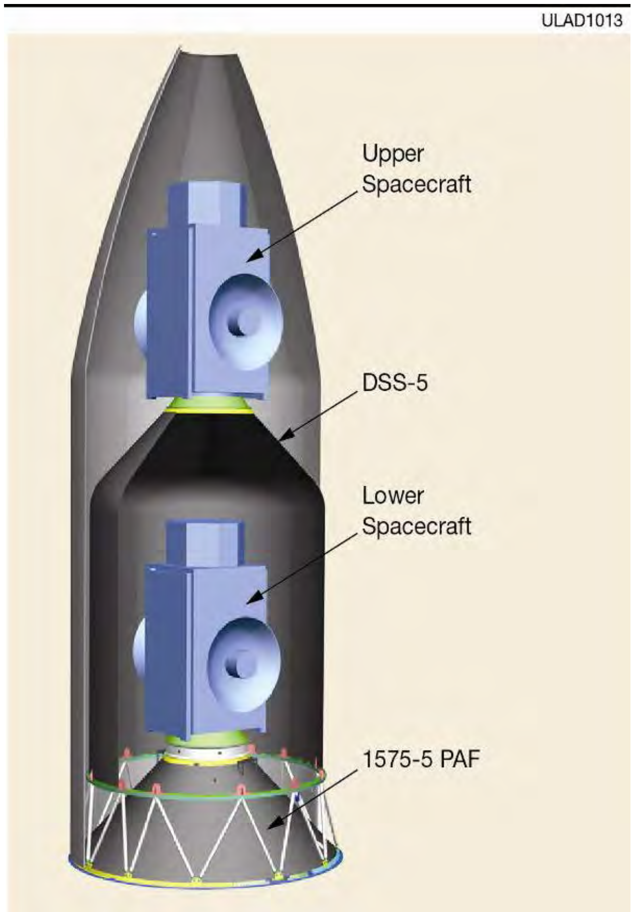

Figure 9-11. Dual Spacecraft System, 5-m (DSS-5)

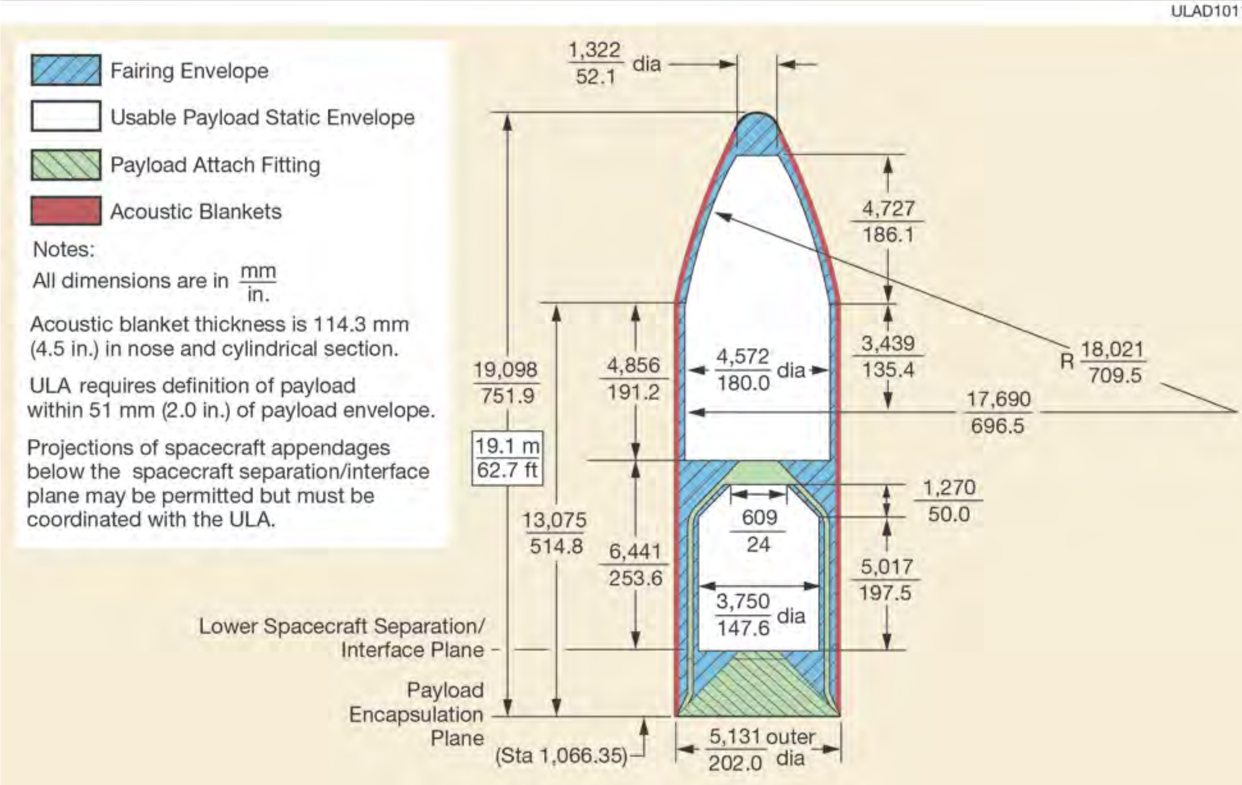

Figure 9-12. DSS-5 Preliminary Payload Envelopes

The DSS-5 provides access to the aft spacecraft through standard 600 mm (23.6 in.) diameter doors. Ports in the DSS-5 structure will ensure adequate conditioned air passes through the aft compartment to maintain the required thermal environment for the aft spacecraft.

The DSS-5 canister, a lightweight, carbon fiber-reinforced composite sandwich structure, attaches to the forward interface of the 4,394 mm (173 in.) Delta adapter, which in turn attaches to the aft end of the PAF.

To facilitate DSS-5 jettison after the forward spacecraft deployment, the DSS-5 cylinder section contains a separation ring near its aft end. This pyrotechnic, frangible joint-type separation system captures all combustion byproducts and debris. After separation system actuation, a set of force-balanced springs pushes the DSS-5 canister away from the encapsulated spacecraft, ensuring adequate loss-of-clearance is provided. The Delta IV second stage then turns to the required separation attitude and commands aft spacecraft separation.

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Appendix A
Delta IV Launch Vehicle Standard Service Parts List

Part	Medium	M+(4,2)	M+(5,2)	M+(5,4)	Heavy Port CBC	Heavy Center CBC	Heavy Starboard CBC
First-Stage							
Common Booster Core (CBC) with RS-68A	1	1	1	1	1	1	1
Helium Bottles (CBC On Board Helium Storage Bottles/COPV @ 4500 psi)	5	5	5	5	5	7	5
Main Vehicle Batteries 28 vdc/30 Ahr	2	2	2	2	2	2	2
Telemetry Remote Terminal Unit (RTU 511/Equipment Shelf & RTU 509/RS-68 engine)	2	2	2	2	0	2	0
4-m Interstage	1	1	NA	NA	NA	NA	NA
5-m Interstage	NA	NA	1	1	1	1	1
Solid Rocket Motor							
Graphite-Epoxy Motor (GEM)	0	2	2	4	NA	NA	NA
Second-Stage							
Delta Cryogenic Second Stage (DCSS) with RL10B-2	1	1	1	1	NA	1	NA
Helium Bottles (DCSS On-Board Helium Storage Bottles/COPV @ 4500 psi) for LEO/GTO	5	7	8	8	NA	9	NA
Helium Bottles (DCSS On-Board Helium Storage Bottles/COPV @ 4500 psi) for GSO	7	7	9	9	NA	9	NA
Main upper stage vehicle batteries 80 Ahr (LEO/GTO missions)	2	2	2	2	NA	2	NA
Main upper stage vehicle batteries 80 Ahr/95 Ahr (1st cycle for 7.2 hr mission)/GEO missions	4	4	4	4	NA	4	NA
Flight Termination System (FTS) Batteries 28 vdc/1.5 Ahr	2	2	2	2	NA	2	NA
Telemetry Master Terminal Unit	1	1	1	1	NA	1	NA
Telemetry S-Band Transmitter	1	1	1	1	NA	1	NA
Telemetry S-Band Antennas	4	4	4	4	NA	4	NA
C-Band Tracking Transponder	1	1	1	1	NA	1	NA
C-Band Tracking Receive/Transmit Antennas	2	2	4	4	NA	4	NA
SEIP Connectors (Mission-specific; ULA provides mating connector halves for payload side of SEIP)							
Power J1 (LV)/P1 (SV)	1	1	1	1	NA	1	NA
Power J2 (LV)/P2 (SV)	1	1	1	1	NA	1	NA
SV command/monitor (ground) J3	1	1	1	1	NA	1	NA
SV command/monitor (ground) J4	1	1	1	1	NA	1	NA
Serial data J5	1	1	1	1	NA	1	NA
SV command (flight) J6	1	1	1	1	NA	1	NA
SV command (flight) J7	1	1	1	1	NA	1	NA
Ordnance commands J8	1	1	1	1	NA	1	NA
Ordnance commands J9	1	1	1	1	NA	1	NA
Payload Electrical Interface Panel (PEI) Connectors (Mission-specific; ULA provides mating connector halves for payload side of PEI)							
P1 (LV)/J1 (SV)	1	1	1	1	NA	1	NA

Part	Medium	M+(4,2)	M+(5,2)	M+(5,4)	Heavy Port CBC	Heavy Center CBC	Heavy Starboard CBC
P2 (LV)/J2 (SV)	1	1	1	1	NA	1	NA
GPS Metric Tracking Hardware Components							
GPS Tracking Unit (GTU)	1	1	1	1	NA	1	NA
Low Noise Amplifier (LNA)	2	2	2	2	NA	2	NA
S-Band Transmitter	1	1	1	1	NA	1	NA
S-Band Multiplexer	1	1	1	1	NA	1	NA
S-Band Antenna	2	2	2	2	NA	2	NA
L-Band Antenna	2	2	2	2	NA	2	NA
Payload Accommodations							
4-m-dia. 11.7-m long Composite Payload Fairing	1	1	NA	NA	NA	NA	NA
5-m-dia. 14.3-m long Composite Payload Fairing	NA	NA	1	1	NA	NA	NA
5-m-dia. 19.1-m long Composite Payload Fairing	NA	NA	NA	NA	NA	1	NA
5-m-dia. 19.8-m long Metallic Payload Fairing (Mission-specific item)	NA	NA	NA	NA	NA	1 (MS)	NA
1575-4 PAF with 9 SEIP connectors	1	1	NA	NA	NA	NA	NA
1575-5 PAF with 9 SEIP connectors	NA	NA	1	1	NA	1	NA
4394-5 PAF (Optional mission-specific item)	NA	NA	NA	NA	NA	1 (MS)	NA
Acoustic Blanket/3 inches thick foam/standard service	1	1	1	1	NA	1	NA
Standard access doors (.46m or .61m in diameter)	0-2	0-2	0-2	0-2	NA	0-2	NA
Environmental Control System (ECS)/Air Conditioning Inlet Door	1	1	1	1	NA	1	NA
PLF logo/SV mission insignia/customer supplied artwork/mission specific/ULA standard service	1	1	1	1	NA	1	NA
GN2 (Gaseous Nitrogen) Service	Yes	Yes	Yes	Yes	NA	Yes	NA

Appendix B
ULA SPACECRAFT QUESTIONNAIRE

Note: When providing numerical parameters, please specify either English or metric units.

Spacecraft Name: ________________________________ Spacecraft Manufacturer: ______________________
Spacecraft Owner: ________________________________ Spacecraft Model No.: ______________________
Name of Principal Contact: __________________________ Number of Launches: ______________________
Telephone Number: ______________________________ Date of Launches: ___________________________
Date: ____

1. Payload/Constellation Characteristics
   1.1 Payload Description

   1.2 Size and Space Envelope (Refer to User's Guide Section 6, Payload Fairings)
      1.2.1 Dimensioned Drawings/CAD Model of the Spacecraft in the Launch Configuration
      1.2.2 Extent of Equipment Remaining with Adapter After Spacecraft Separation
      1.2.3 Spacecraft Critical Orientations
      1.2.4 Location and Direction of Antennas during Checkout, Prelaunch and Orbit
      1.2.5 Location, Look Angle and Frequency of Sensors
      1.2.6 Location and Size of Solar Arrays
      1.2.7 Configuration Drawings
         1.2.7.1 Drawings Showing the Configuration, Shape, Dimensions and Protrusions near the Mechanical Interface (Ground, Launch and Deployment Configurations)
         1.2.7.2 Coordinates (Spacecraft Relative to Launch Vehicle)
         1.2.7.3 Special Clearance Requirements

   1.3 Payload Mass Properties
      1.3.1 Weight, Moments and Products of Inertia, and CG Location
         1.3.1.1 Mass Properties (Launch and Orbit Configurations)
         1.3.1.2 Weight — Specify Total, Separable & Retained Masses
         1.3.1.3 Center of Gravity — Specify in 3 Orthogonal Coordinates Parallel to the Booster Roll, Pitch and Yaw Axes for Total, Separable and Retained Masses
         1.3.1.4 Changes in Center of Gravity Due to Deployment of Appendages
         1.3.1.5 Propellant Slosh Models
         1.3.1.6 Moments and Products of Inertia (Launch and Orbit Configurations) - Specify About the Axes Through the Spacecraft Center of Gravity That Are Parallel to the Launch Vehicle Roll, Pitch and Yaw Axes for Total, Separable, and Retained Masses

Table 1.3.1.1. Separated Payload Mass Properties

Description	Axis	Value	±3-σ Uncertainty
Weight (unit)	N/A		
Center of Gravity (unit)	X Y Z		
Moments of Inertia (unit)	I_{XX} I_{YY} I_{ZZ}		
Products of Inertia (unit)	I_{XY} I_{YZ} I_{ZX}		

Table 1.3.1.2. Entire Payload Mass Properties

Description	Axis	Value	±3-σ Uncertainty
Weight (unit)	N/A		
Center of Gravity (unit)	X Y Z		
Moments of Inertia (unit)	I_{XX} I_{YY} I_{ZZ}		
Products of Inertia (unit)	I_{XY} I_{YZ} I_{ZX}		

      1.3.2 Principal Axis Misalignment
      1.3.3 Fundamental Frequencies (Thrust Axis/Lateral Axis)
      1.3.4 Are All Significant Vibration Modes Above Levels Specified in Section 3 of the User's Guide?

Table 1.3.4.1. Payload Stiffness Requirements

Spacecraft	Fundamental Frequency (Hz)	Axis
		Lateral Axial

1.3.5 Structural Characteristics at interface to launch vehicle
  1.3.5.1 Spring Ratio of Structure
  1.3.5.2 Elastic Deflection Constants
  1.3.5.3 Shear Stiffness
  1.3.5.4 Bending Moments and Shear Loads Allowables at Launch Vehicle/Spacecraft Interface
  1.3.5.5 Limitations, Include Acoustic, Shock, Acceleration, Temperature and Bending Moments

1.3.6 Description of Payload Dynamic Model
The Craig – Bampton format is the requested description of the payload dynamic model. For SC with liquid tanks that are located off the centerline axis of the LV, the payload dynamic model must include the slosh characteristics.
Note: Models Must Include Rigid Body and Normal Modes
  1.3.6.1 Mass Matrix
  1.3.6.2 Stiffness Matrix
  1.3.6.3 Response Recovery Matrix
  1.3.6.4 Description of the Model, Geometry and Coordinate System

1.3.7 Time Constant and Description of Spacecraft Energy Dissipation Sources and Locations (e.g., Hydrazine Fill Factor, Passive Nutation Dampers, Flexible Antennae)

1.3.8 Spacecraft Coordinate System

1.4 Payload Hazardous Systems
This section contains information that may be included in the mission specification/ICD but are not payload to launch vehicle requirements. This section will be included in the payload safety approval package as required by range.

1.4.1 Propulsion System
  1.4.1.1 Apogee Motor (Solid or Liquid)
  1.4.1.2 Hydrazine (Quantity, Spec, etc.)
  1.4.1.3 Do Pressure Vessels Conform to Safety Requirements of User's Guide Section 4.5?
  1.4.1.4 Location Where Pressure Vessels Are Loaded and Pressurized

Table 1.4.1.5. Propulsion System Characteristics

Parameter	Value
Propellant Type, Orbit Insertion	
Propellant Type, Stationkeeping	
Multiple Burn Capability (Y/N)	
Propellant Weight, Nominal (unit)	
Effective Isp	
Propellant Weight, Nominal (unit)	
Propellant Fill Fraction	
Propellant Density (unit)	
Propellant Tanks	
Propellant Tank Location (SC coordinates) Station (unit) Azimuth (unit) Radius (unit)	
Internal Volume (unit)	
Capacity (unit)	
Diameter (unit)	
Shape	
Internal Description	
Operating Pressure Flight (unit)	
Operating Pressure (MEOP) Ground (unit)	
Design Burst Pressure Calculated (unit)	
Factor of Safety (Design Burst/Ground MEOP)	
Actual Burst PressureTest (unit)	
Proof Pressure Test (unit)	
Pressurized at (location)	
Tank Material	

Table 1.4.1.6. Pressurized Tank Characteristics

Parameter	Value
Operating Pressure—Flight (unit)	
Operating Pressure—MEOP Ground (unit)	
Design Burst Pressure—Calculated (unit)	

Factor of Safety (Design Burst/Ground MEOP) (unit)	
Actual Burst Pressure—Test (unit)	
Proof Pressure—Test (unit)	
Vessel Contents	
Capacity—Launch (unit)	
Quantity—Launch (unit)	
Purpose	
Pressurized at (location)	
Pressure When ULA Personnel Are Exposed (unit)	
Tank Material	
Number of Vessels Used	

1.4.2 Nonpropulsion Pressurized Systems
1.4.2.1 High-Pressure Gas (Quantity, Spec, etc.)
1.4.2.2 Other
1.4.3 Spacecraft Batteries (Quantity, Voltage, Environmental/Handling Constraints, etc.)

Table 1.4.3.1. Spacecraft Battery

Parameter	Value
Electrochemistry	
Battery Type	
Electrolyte	
Battery Capacity (unit)	
Number of Cells	
Average Voltage/Cell (unit)	
Cell Pressure (Ground MEOP) (unit)	
Specification Burst Pressure (unit)	
Actual Burst (unit)	
Proof Tested (unit)	

1.4.4 RF Environments
1.4.4.1 RF Inhibit
1.4.4.2 RF Radiation Levels (Personal Safety)

Table 1.4.4.3. Transmitters and Receivers

	Antennas			
Parameter	Receiver 1	Transmitter 2	3	4
Nominal Frequency (MHz)				
Transmitter Tuned Frequency (MHz)				
Receiver Frequency (MHz)				
Data Rates, Downlink (kbps)				
Symbol Rates, Downlink (kbps)				
Type of Transmitter				
Transmitter Power, Maximum (dBm)				
Losses, Minimum (dB)				
Peak Antenna Gain (dB)				
EIRP, Maximum (dBm)				
Antenna Location (base)				
Station (unit)				
Angular Location				
Planned Operation: Prelaunch: In PPF Pre launch: Pre-Fairing Inspection, On Pad Post launch: Before SC Separation, During Ascent				

Table1.4.4.4. Radio Frequency Environment

Frequency	E-Field

1.4.5 Deployable Systems
- 1.4.5.1 Antennas
- 1.4.5.2 Solar Panels
- 1.4.5.3 Any Deployment Prior to Separation?

1.4.6 Radioactive Devices
- 1.4.6.1 Can Spacecraft Produce Nonionizing Radiation at Hazardous Levels?
- 1.4.6.2 Other

1.4.7 Electro-Explosive Devices (EED)
- 1.4.7.1 Category A EEDs (Function, Type, Part Number, When Installed, When Connected)
- 1.4.7.2 Are Electrostatic Sensitivity Data Available on Category A EEDs? List References
- 1.4.7.3 Category B EEDs (Function, Type, Part Number, When Installed, When Connected)
- 1.4.7.4 Do Shielding Caps Comply With Safety Requirements?
- 1.4.7.5 Are RF Susceptibility Data Available? List References

Table1.4.7.8. Electro-Explosive Devices

Quantity	Type	Use	Firing Current (amps)		Bridgewire (ohms)	Where Installed	Where Connected	Where Armed
			No Fire	All Fire				

1.4.8 Non-EED Release Devices

Table1.4.8.1. Non-Electric Ordnance and Release Devices

Quantity	Type	Use	Quantity Explosives	Type	Explosives	Where Installed	Where Connected	Where Armed

1.4.9 Other Hazardous Systems
- 1.4.9.1 Other Hazardous Fluids (Quantity, Spec, etc.)
- 1.4.9.2 Other

1.5 Contamination-Sensitive Surfaces

1.5.1 LV Processing/Flight Contamination Allocation. Fill out Table 1.5.2.1 to reflect the total contaminaiton budget allocation due to launch vehicle integration of payload and delivery to orbit.

1.5.2 Surface Sensitivity (e.g., Susceptibility to Propellants, Gases and Exhaust Products, and Other Contaminants)

Table1.5.2.1. Contamination-Allocation of Sensitive Surfaces

Component	Location/Orientation	Sensitive To	NVR Budget	Particulate Budget

1.6 Spacecraft Systems Activated Prior to Spacecraft Separation

1.7 Spacecraft Volume & Venting (Ventable and Nonventable)
- 1.7.1 Spacecraft Venting (Volume, Rate, etc.)
- 1.7.2 Nonventable Volume
- 1.7.3 Venting Characteristics (e.g., Quantity, Timing and Nature of Gases Vented from Spacecraft)

2 Mission Parameters

2.1 Mission Description

2.1.1 Summary of Overall Mission Description and Objectives

2.2 Orbit Characteristics

Table 2.2.1. Orbit Characteristics

Parameter	Value	Tolerance
Apogee		
Perigee		
Inclination		
Argument of perigee at insertion		
RAAN		

2.3 Launch Dates and Times

2.3.1 Launch Windows (over 1-year span)

2.3.2 Launch Exclusion Dates

Table 2.3.2.1. Launch Windows

Launch number	Window Open mm/ dd/yy hh:mm:ss	Window Close mm/ dd/yy hh:mm:ss	Window Open mm/ dd/yy hh:mm:ss	Window Close mm/ dd/yy hh:mm:ss
1				
2				
3				
4				
5				
6....				

Table 2.3.2.2. Launch Exclusion Dates

Month	Exclusion Dates

2.4 Spacecraft Constraints on Mission Parameters

2.4.1 Sun-Angle Constraints

2.4.2 Eclipse

2.4.3 Ascending Node

2.4.4 Inclination

2.4.5 Maximum Apogee

2.4.6 Minimum Perigee

2.4.7 Telemetry Constraint

2.4.8 Thermal Attitude Constraints

2.4.9 Contamination and Collision Avoidance Maneuver Constraints

2.4.10 Other

2.5 Trajectory and Spacecraft Separation Requirement

2.5.1 Special Trajectory Requirements

2.5.1.1 Thermal Maneuvers

2.5.1.2 Telemetry Maneuvers

2.5.1.3 Free Molecular Heating Constraints

2.5.2 Spacecraft Separation Requirements

2.5.2.1 Position

2.5.2.2 Attitude

2.5.2.3 Sequence and Timing

2.5.2.4 Tipoff and Coning

2.5.2.5 Spin

2.5.2.5.1 Rate

2.5.2.5.2 Axis

2.5.2.5.3 Orientation (Pitch, Yaw, Roll)
2.5.2.5.4 Location
2.5.2.5.5 Acceleration Constraint
2.5.2.6 Max Angular Rate and Uncertainty (Pitch, Yaw, Roll)
2.5.2.7 Max Angular Acceleration
2.5.2.8 Other

Table 2.5.2.-1 Separation Requirements

Parameter	Value
Angular Momentum Vector (Pointing Error)	
Nutation Cone Angle	
Relative Separation Velocity (unit)	
Tip-Off Angular Rate (unit)	
Spin Rate (unit)	
Note: The nutation coning angle is a half angle with respect to the angular momentum vector.	

2.6 Launch And Flight Operation Requirements
2.6.1 Operations—Prelaunch
2.6.1.1 Location of Spacecraft Operations Control Center
2.6.1.2 Spacecraft Ground Station Interface Requirements
2.6.1.3 Mission-Critical Interface Requirements
2.6.2 Operations—Launch Through Spacecraft Separation
2.6.2.1 Spacecraft Uplink Requirement
2.6.2.2 Spacecraft Downlink Requirement
2.6.2.3 Systems Activated Prior to Payload Separation
List all spacecraft events that will take place during the launch sequence, from liftoff to spacecraft separation, by completing the following chart:

Table 2.6.2.4. Events During Launch Phase

Event	Time from Liftoff	Constraints/Comments

2.6.3 Operations—Post-Spacecraft Separation
2.6.3.1 Spacecraft Tracking Station
2.6.3.2 Spacecraft Acquisition Assistance Requirements

3 Launch Vehicle Configuration

3.1 Dispenser/Payload Attach Fitting (PAF) / Payload Adapter (PLA) Mission-Specific Configuration

3.1.1 Type of PAF / PLA

3.2 Fairing Mission-Specific Configuration

3.2.1 Access Doors and RF Windows / RF Reradiation Antenna in Fairing

Table 3.2.1.1. Access Doors and RF Windows/ RF Reradiation Antenna

Size (unit)	LV Station (unit)[1]	Clocking (deg)[2]	Purpose

Notes:
1. Doors are centered at the locations specified.
2. Clocking needs to be measured from Quadrant IV (0/360 deg) toward Quadrant I (90 deg).

3.2.2 Acoustic Blanket Modifications

3.2.3 Air-Conditioning Distribution

3.2.3.1 Spacecraft In-Flight Requirements

3.2.3.2 Spacecraft Ground Requirements (Fairing Installed)

3.2.3.3 Critical Surfaces (i.e., Type, Size, Location)

3.3 Mission-Specific Reliability Requirements

3.4 Mission-Specific Configuration

3.4.1 Extended-Mission Modifications

3.4.2 Retro System

4 Spacecraft Handling and Processing Requirements

4.1 Temperature and Humidity

Table 4.1.1. Ground Handling Environmental Requirements

Location	Temperature (Unit)	Temperature Control	Relative Humidity at Inlet (Unit)	Cleanliness (Unit)
During Encapsulation				
During Transport (Encapsulated)				
On-Pad (Encapsulated)				

4.2 Airflow and Purges

- 4.2.1 Airflow and Purges During Transport
- 4.2.2 Airflow and Purges During Hoist Operations
- 4.2.3 Airflow and Purges On-Pad
- 4.2.4 GN_2 Instrument Purge
- 4.2.5 GN_2 Purge Interface Design

4.3 Contamination/Cleanliness Requirements

- 4.3.1 In PPF
- 4.3.2 During Transport to Pad
- 4.3.3 On Pad
- 4.3.4 Post-SC Separation

4.4 Spacecraft Weighing and Balancing

- 4.4.1 Spacecraft Balancing
- 4.4.3 Spacecraft Weighing

4.5 Security

- 4.5.1 PPF Security
- 4.5.2 Transportation Security
- 4.5.3 Pad Security

4.6 Special Handling Requirements

- 4.6.1 Payload Processing Facility Preference and Priority
- 4.6.2 List the Hazardous Processing Facilities the Spacecraft Project Desires to Use
- 4.6.3 What Are the Expected Dwell Times the Spacecraft Project Would Spend in the Payload Processing Facilities?
- 4.6.4 Is a Multi-shift Operation Planned?
- 4.6.5 Additional Special ULA Handling Requirements?
- 4.6.6 During Transport
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- 4.6.8 Sequence from Spacecraft Delivery Through Mating with the Launch Vehicle

4.7 Special Equipment and Facilities Supplied by ULA

- 4.7.1 What Are the Spacecraft and Ground Equipment Space Requirements?
- 4.7.2 What Are the Facility Crane Requirements?
- 4.7.3 What Are the Facility Electrical Requirements?
- 4.7.4 List the Support Items the Spacecraft Project Needs from NASA, USAF, or Commercial Providers to Support the Processing of Spacecraft. Are There Any Unique Support Items?
- 4.7.5 Special GSE or Facilities Supplied by ULA
- 4.7.6 Spacecraft Launch Vehicle Integration
  - 4.7.6.1 Handling Equipment Required
  - 4.7.6.2 ULA-Provided Protective Covers or Work Shields Required
  - 4.7.6.3 Identify the Space Envelope, Installation, Clearance, and Work Area Requirements
  - 4.7.6.4 Any Special Encapsulation Requirements Support Services Required

4.8 Spacecraft Checkout GSE & Cabinet Data

- 4.8.1 List of All GSE and Location Where Used (e.g., Storage Requirements on the Launch Pad)
- 4.8.2 Installation Criteria for GSE Items:
  - 4.8.2.1 Size and Weight
  - 4.8.2.2 Mounting Provisions

4.8.2.3 Grounding and Bonding Requirements
4.8.2.4 Proximity to the Spacecraft When In Use
4.8.2.5 Period of Use
4.8.2.6 Environmental Requirements
4.8.2.7 Compatibility with Range Safety Requirements and Launch Vehicle Propellants
4.8.2.8 Access Space to Cabinets Required for Work Area, Door Swing, Slideout Panels, etc
4.8.2.9 Cable Entry Provisions & Terminal Board Types in Cabinets and/or Interface Receptacle Locations and Types
4.8.2.10 Power Requirements and Characteristics of Power for Each Cabinet

4.9 Range Safety
4.9.1 Range Safety Console Interface

4.10 Spacecraft Environmental Protection (Preflight)
4.10.1 Environmental Protection Requirements by Area, Including Cleanliness Requirements:
4.10.1.1 Spacecraft Room
4.10.1.2 Transport to Launch Pad
4.10.1.3 Mating
4.10.1.4 Inside PLF
4.10.1.5 During Countdown
4.10.2 Air-Conditioning Requirements for Applicable Area (Pad Area) by:
4.10.2.1 Temperature Range
4.10.2.2 Humidity Range
4.10.2.3 Particle Limitation
4.10.2.4 Impingement Velocity Limit
4.10.2.5 Flow Rate
4.10.3 Indicate if Spacecraft Is Not Compatible with Launch Vehicle Propellants and What Safety Measures Will Be Required
4.10.4 Environmental Monitoring and Verification Requirements

4.11 Space Access Requirements
4.11.1 Access for Spacecraft Mating and Checkout
4.11.2 Access During Transportation to the Launch Pad and Erection Onto the Launch Vehicle
4.11.3 Access for Checkout and Achieving Readiness Prior to Fairing Installation
4.11.4 Access After Fairing Installation; State Location, Size of Opening and Inside Reach Required
4.11.5 Access During the Final Countdown, if Any
4.11.6 GSE Requirements for Emergency Removal

4.12 Umbilicals
4.12.1 Ground Servicing Umbilicals by Function and Location in Excess of Launch Vehicle Baseline
4.12.2 Structural Support Requirements and Retraction Mechanisms
4.12.3 Installation (e.g., When and by Whom Supplied and Installed)

4.13 Commodities Required for Both Spacecraft, GSE & Personnel
4.13.1 Gases, Propellants, Chilled Water and Cryogenics in Compliance with Ozone-Depleting Chemicals Requirements
4.13.2 Source (e.g., Spacecraft or Launch Vehicle)
4.13.3 Commodities for Personnel (e.g., Work Areas, Desks, Phones)

4.14 Spacecraft Guidance Alignment Requirements

4.15 Hardware Needs (Including Dates)
4.15.1 Electrical Simulators
4.15.2 Structural Simulators

4.16 Interface Test Requirements
4.16.1 Structural Test
4.16.2 Fit Test
4.16.3 Compatibility Testing of Interfaces (Functional)
4.16.4 EMC Demonstration (Integrated System Test)
4.16.5 Launch Vehicle / Spacecraft RF Interface Test
4.16.6 Environmental Demonstration Test

4.17 Launch Operations
4.17.1 Detailed Sequence & Time Span of All Spacecraft-Related Launch Site Activities Including:
4.17.1.1 GSE Installation,
4.17.1.2 Facility Installation and Activities,
4.17.1.3 Spacecraft Testing and Spacecraft Servicing
4.17.2 Recycle Requirements
4.17.3 Launch Operations Restrictions Including:
4.17.3.1 Launch Site Activity Limitations,
4.17.3.2 Constraints on Launch Vehicle Operations,
4.17.3.3 Security Requirements
4.17.3.4 Personnel Access Limitations and Safety Precautions
4.17.4 Special Requirements Include Handling of Radioactive Materials, Security and Access Control
4.17.5 Support Requirements To Include Personnel, Communications and Data Reduction
4.17.6 Launch and Flight Requirements for Real-Time Data Readout, Postflight Data Analysis, Data Distribution, Postflight Facilities

4.18 Ground Equipment and Facility Requirements (Electrical)
4.18.1 Spacecraft Electrical Conductor Data
SC System Schematic Showing All Connectors Required Between SC Equipment, & SC Terminal Board Position or Receptacle Pin Assigned to Each Conductor; Electrical Characteristics of Each Connector Including Maximum End-to-End Resistance, Shielding, Capacitance & Spare Conductors
4.18.2 Electrical Power (GSE & Facility)
4.18.2.1 Frequency, Voltage, Watts, Tolerance, Source
4.18.2.2 Isolation Requirements
4.18.2.3 Identify if Values Are Steady or Peak Loads
4.18.2.4 High-Voltage Transient Susceptibility
4.18.3 RF Transmission
4.18.3.1 Antenna Requirements (e.g., Function, Location, Physical Characteristics, Beam Width & Direction & Line-of-Sight)
4.18.3.2 Frequency & Power Transmission
4.18.3.3 Operation
4.18.4 Cabling
4.18.4.1 All Cabling, Ducting, or Conduits To Be Installed in the Mobile Service Tower;
4.18.4.2 Who Will Supply, Install, Checkout & Remove
4.18.5 Monitors & Controls
4.18.5.1 Specify Which Signals from Spacecraft Are To Be Monitored During Readiness & Countdown;
4.18.5.2 Specify Signal Power Source (Spacecraft, Launch Vehicle)
4.18.5.3 Transmission Method (e.g., Spacecraft Telemetry, Launch Vehicle Telemetry, Landline, or Launch Vehicle Readiness Monitor)
4.18.5.4 Location of Data Evaluation Center, Evaluation Responsibility, Measurement Limits and Go/No-Go Constraints;
4.18.5.5 Identify Where in the Operational Sequence Measurements Are To Be Monitored and Evaluated;
4.18.5.6 Specify Frequency and Duration of Measurements
4.18.5.7 Video Output Characteristics of Telepaks (if Available) for Closed-Loop Prelaunch Checkout at the Launch Pad;
4.18.5.8 Data To Include Location and Type of Interface Connector(s), and Characteristics of Signal at Source;
4.18.5.9 This Includes Voltage Level, Output Impedance, Output Current Limitation, Maximum Frequency of Data Train and Output Loading Requirements

5 Spacecraft/Launch Vehicle Interface Requirements

5.1 Mechanical Interfaces
- 5.1.1 Fairing Envelope
  - 5.1.1.1 Fairing Envelope Violations
  - 5.1.1.2 Payload Components Within 50.8 mm/2.0 in. of Allowable Fairing Envelope Below Separation Plane (Identify Component and Location)
  - 5.1.1.1 Payload Components Below Separation Plane (Identify Component and Location)

Table 5.1.1.1.1. Payload Components Within 2.0 in. or Beyond the Fairing Envelope

Item	LV Vertical Station (unit)	Radial Distance from LV Centerline[1]	Payload Clocking (deg)	LV Clocking (deg)[2]	Clearance from Stay-out Zone

Notes:
1. Location of payload components should include maximum tolerances.
2. Clocking is measured from LV Quad IV (0/360 deg) toward LV Quad I (90 deg).

Table 5.1.1.2.1. Payload Components Beyond the Separation Plane Envelope

Item	LV Vertical Station (unit)	Radial Distance from LV Centerline[1]	Payload Clocking (deg)	LV Clocking (deg)[2]	Clearance from Stay-out Zone

Notes:
1. Location of payload components should include maximum tolerances.
2. Clocking is measured from LV Quad IV (0/360 deg) toward LV Quad I (90 deg).

- 5.1.2 Base Diameter of Spacecraft Interface
- 5.1.3 Structural Attachments at Spacecraft Interface
- 5.1.4 Required Accessibility to Spacecraft in Mated Condition
- 5.1.5 Extent of Equipment Remaining with Adapter After Spacecraft Separation
- 5.1.6 Umbilical Requirements
  - 5.1.6.1 Separation from Launch Vehicle
  - 5.1.6.2 Flyaway at Launch
    - 5.1.6.2.1 Manual Disconnect (Including When)
- 5.1.7 Separation System
  - 5.1.7.1 Clampband/Attachment System Desired and Interface Diameter

Table 5.1.7.1.1. Spacecraft Mechanical Interface Definition

SC Bus	Size of SC Interface to LV (unit)	Type of SC Interface to LV Desired

  - 5.1.7.2 Separation Springs

5.2 Electrical Interfaces
- 5.2.1 Spacecraft/Payload Attach Fitting Electrical Connectors
  - 5.2.1.1 Connector Types, Location, Orientation, and Part Number
  - 5.2.1.2 Electrical Connector Configuration
  - 5.2.1.3 Connector Pin Assignments in the Spacecraft Umbilical Connector(s)
  - 5.2.1.4 Spacecraft Separation Indication
  - 5.2.1.5 Spacecraft Data Requirements

Table 5.2.1.5. Interface Connectors

Item	P1	P2
Vehicle Connector		
SC Mating Connectors (J1 and J2)		
Distance Forward of SC Mating Plane (unit)		
Launch Vehicle Station		
Clocking* (deg)		
Radial Distance of Connector Centerline from Vehicle Centerline (unit)		
Polarizing Key		
Maximum Connector Force (+Compression, Tension) (unit)		
*Positional tolerance defined in Payload Planners Guide (reference launch vehicle coordinates).		

5.2.2 Separation Switches
- 5.2.2.1 Separation Switch Pads (Launch Vehicle)
- 5.2.2.2 Separation Switches (Spacecraft)
- 5.2.2.3 Spacecraft/Fairing Electrical Connectors
- 5.2.2.4 Does Spacecraft Require Discrete Signals From Delta?

5.2.3 Power Requirements (Current, Duration, Function Time and Tolerances)
- 5.2.3.1 28-Vdc Power
- 5.2.3.2 Other Power
- 5.2.3.3 Overcurrent Protection

5.2.4 Command Discrete Signals
- 5.2.4.1 Number
- 5.2.4.2 Sequence
- 5.2.4.3 Timing (Including Duration, Tolerance, Repetition Rate, etc)
- 5.2.4.4 Voltage (Nominal and Tolerance)
- 5.2.4.5 Frequency (Nominal and Tolerance)
- 5.2.4.6 Current (Nominal and Tolerance)
- 5.2.4.7 When Discretes Are for EED Activation, Specify:
  - 5.2.4.7.1 Minimum, Maximum and Nominal Fire Current;
  - 5.2.4.7.2 Minimum and Maximum Resistance;
  - 5.2.4.7.3 Minimum Fire Time;
  - 5.2.4.7.4 Operating Temperature Range and
  - 5.2.4.7.5 Manufacturer's Identification of Device

5.2.5 Other Command & Status Signals
- 5.2.5.1 Status Displays
- 5.2.5.2 Abort Signals
- 5.2.5.3 Range Safety Destruct
- 5.2.5.4 Inadvertent Separation Destruct

5.2.6 Ordnance Circuits
- 5.2.6.1 Safe/Arm Requirements

5.2.7 Telemetry Requirements
- 5.2.7.1 Spacecraft Measurements Required To Be Transmitted by Launch Vehicle Telemetry:
  - 5.2.7.1.1 Quantity
  - 5.2.7.1.2 Type of Measurements (e.g., Temperature, Vibration, Pressure, etc);
  - 5.2.7.1.3 Details Concerned with Related System Including Operating Characteristics (Response Definition of System) and Locations and Anticipated Time of Operation; Impedance, Capacitance, Operating Range and Full-Scale Range of Each Measurement
- 5.2.7.2 Signal Conditioning Requirements (e.g., Input Impedance, Impedance Circuit Load Limits, Overcurrent Protection and Signal-to-Noise Ratio)
- 5.2.7.2 Discrete Events (Bi-level)
- 5.2.7.3 Analog Measurements
- 5.2.7.4 Transducers Required To Be Furnished by Launch Vehicle Contractor
- 5.2.7.5 Minimum Acceptable Frequency Response for Each Measurement
- 5.2.7.6 Minimum Acceptable System Error for Each Measurement (Sampling Rate Is Also Governed by This Requirement)
- 5.2.7.7 Period of Flight for Which Data from Each Measurement Are of Interest (e.g., from Liftoff to Spacecraft Separation)*
- 5.2.7.8 Launch Vehicle Flight Data Required by Spacecraft Contractor

5.2.8 Bonding Requirements at Interface (MIL-B-5087, Class R for Launch Vehicle)

5.2.8.1 Material and Finishes at Interface (for Compatibility with Launch Vehicle Adapter)
5.2.9 EMC
5.2.9.1 Test or Analyze Spacecraft Emissions and Susceptibility
5.2.9.2 EMC Protection Philosophy for Low-Power, High-Power and Pyrotechnic Circuits
5.2.9.3 Launch Vehicle, Transport and Site Emissions (Provided by ULA)
5.2.10 Grounding Philosophy
5.2.10.1 Structure (e.g., Use of Structural As Ground and Current Levels)
5.2.10.2 Electrical Equipment (e.g., Grounding Method for Signals and Power Supplies)
5.2.10.3 Single-Point Ground (e.g., Location and Related Equipment)
5.2.11 Interface Connectors
5.2.11.1 Connector Item (e.g., Location and Function)*
5.2.11.2 Connector Details
5.2.11.3 Electrical Characteristics of Signal on Each Pin
5.2.12 Shielding Requirements
5.2.12.1 Each Conductor or Pair
5.2.12.2 Overall
5.2.12.3 Grounding Locations for Termination

5.3 Ground Electrical Interfaces
5.3.1 Spacecraft-to-LCC Wiring Requirements
5.3.1.1 Number of Wires Required
5.3.1.2 Pin Assignments in the Spacecraft Umbilical Connector(s)
5.3.1.3 Purpose and Nomenclature of Each Wire Including Voltage, Current, Polarity Requirements, and Maximum Resistance
5.3.1.4 Shielding Requirements
5.3.1.5 Voltage of the Spacecraft Battery and Polarity of the Battery Ground

Table 5.3.1.6. Pin Assignments

Pin no.	Designator	Function	Volts	Amps	Max Resistance to EED (ohms)	Polarity Requirements
1						
2						
3						
4						
5...						

5.3.2 Spacecraft Ground Support Equipment
5.3.2.1 List of All GSE and Location Where Used (e.g., Storage Requirements on the Launch Pad)
5.3.2.2 Equipment Consoles (Sizes, Weight, etc.)
5.3.2.3 Interface Ground Cables
5.3.2.4 Auxiliary Boxes (Sizes, Weight, etc.)
5.3.2.5 Installation Criteria for GSE Items:
5.3.2.6 Size and Weight
5.3.2.7 Mounting Provisions
5.3.2.8 Grounding and Bonding Requirements
5.3.2.9 Proximity to the Spacecraft When In Use
5.3.2.10 Period of Use
5.3.2.11 Environmental Requirements
5.3.2.12 Compatibility with Range Safety Requirements and Launch Vehicle Propellants
5.3.2.13 Access Space to Cabinets Required for Work Area, Door Swing, Slideout Panels, etc
5.3.2.14 Cable Entry Provisions & Terminal Board Types in Cabinets and/or Interface Receptacle Locations and Types
5.3.2.15 Power Requirements and Characteristics of Power for Each Cabinet
5.3.3 Electrical Power (GSE & Facility)
5.3.3.1 Frequency, Voltage, Watts, Tolerance, Source
5.3.3.2 Isolation Requirements
5.3.3.3 Identify if Values Are Steady or Peak Loads
5.3.3.4 High-Voltage Transient Susceptibility
5.3.3.5 Cabling
5.3.3.5.1 All Cabling, Ducting, or Conduits To Be Installed in the Mobile Service Tower;

5.3.3.5.2 Who Will Supply, Install, Checkout & Remove

5.3.4 Monitors & Controls
- 5.3.4.1 Specify Which Signals from Spacecraft Are To Be Monitored During Readiness & Countdown;
- 5.3.4.2 Specify Signal Power Source (Spacecraft, Launch Vehicle)
- 5.3.4.3 Transmission Method (e.g., Spacecraft Telemetry, Launch Vehicle Telemetry, Landline, or Launch Vehicle Readiness Monitor)
- 5.3.4.4 Location of Data Evaluation Center, Evaluation Responsibility, Measurement Limits and Go/No-Go Constraints;
- 5.3.4.5 Identify Where in the Operational Sequence Measurements Are To Be Monitored and Evaluated;
- 5.3.4.6 Specify Frequency and Duration of Measurements
- 5.3.4.7 Video Output Characteristics of Telepaks (if Available) for Closed-Loop Prelaunch Checkout at the Launch Pad;
- 5.3.4.8 Data To Include Location and Type of Interface Connector(s), and Characteristics of Signal at Source;
- 5.3.4.9 This Includes Voltage Level, Output Impedance, Output Current Limitation, Maximum Frequency of Data Train and Output Loading Requirements

5.4 Preflight Environment
- 5.4.1 PLF Separation (e.g., Altitude, Cleanliness, Shock, Aeroheating and Airload Constraints)
- 5.4.2 Acoustic Environment Constraints
- 5.4.3 Special Environmental Requirements
- 5.4.4 Requirements
- 5.4.5 Cleanliness
- 5.4.6 Temperature and Relative Humidity
- 5.4.7 Air Conditioning
- 5.4.8 Air Impingement Limits
- 5.4.9 Monitoring and Verification Requirements

5.5 Spacecraft Environmental Protection (Preflight)
- 5.5.1 Environmental Protection Requirements by Area, Including Cleanliness Requirements:
- 5.5.1 Spacecraft Room
- 5.5.1 Transport to Launch Pad
- 5.5.1 Mating
- 5.5.1 Inside PLF
- 5.5.1 During Countdown
- 5.5.1 Air-Conditioning Requirements for Applicable Area (Pad Area) by:
- 5.5.1 Temperature Range
- 5.5.1 Humidity Range
- 5.5.1 Particle Limitation
- 5.5.1 Impingement Velocity Limit
- 5.5.1 Flow Rate
- 5.5.1 Indicate if Spacecraft Is Not Compatible with Launch Vehicle Propellants and What Safety Measures Will Be Required
- 5.5.1 Environmental Monitoring and Verification Requirements

6 Spacecraft Development and Test Programs

6.1 Test Schedule at Launch Site

6.1.1 Operations Flow Chart (Flow Chart Should Be a Detailed Sequence of Operations Referencing Days and Shifts and Location)

6.2 Spacecraft Development and Test Schedules

6.2.1 Flow Chart and Test Schedule

6.2.2 Is a Test PAF Required? When?

6.2.3 Is Clamp Band Ordnance Required? When?

6.3 Special Test Requirements

6.3.1 Spacecraft Spin Balancing

6.3.2 Other

6.4 Spacecraft Design Elements to Be Certified by Analysis or Test

6.4.1 Payload Fairing Envelope

6.4.2 Payload Attach Fitting or Payload Adapter Envelope

6.4.3 Payload Attach Fitting or Payload Adapter Interface

6.4.4 Two or Fewer Separation Commands

6.4.5 16 or Fewer Control Commands (28-V Discretes or Dry Loop)

6.4.6 Instrumentation Interface, 2 or Fewer Inputs for SC Separation Detection, 4 or Fewer Analog Inputs for General Use; 10 or Fewer Command Feedback Discretes, 2 or Fewer Serial Data I/F for Downlinking SC Data

6.4.7 Two Umbilical Connectors at SC Interface

6.4.8 Design Load Factors

6.4.9 First Lateral Mode & First Axial Mode

6.4.10 Spacecraft Mass vs cg Range

6.4.11 Design Factor of Safety per Applicable Range Safety Documentation & MIL-STD-1522 (or Submit Deviations for Review)

6.4.12 Spacecraft Test Requirements

6.4.13 Quasi-Sinusoidal Vibration

6.4.14 Acoustic Levels in the PLF

6.4.15 Shock Induced by PLF Jettison & Spacecraft Separation

6.4.16 Payload Compartment Pressures & Depressurization Rates

6.4.17 Gas Velocity Across SC Components

6.4.18 Electric Fields

6.4.19 Spacecraft Radiation Limit

6.4.20 EM Environment at Launch Range

6.4.21 All Spacecraft Propellant Fill and Drain Valves, All Pressurant Fill and Vent Valves Readily Accessible When Spacecraft Is Fully Assembled and Serviced in Launch Configuration (Encapsulated and on Launch Pad)

6.4.22 Requirements in Range Safety Regulation

7 Identify Any Additional Spacecraft or Mission Requirements That Are Outside of the Boundary of the Constraints Defined in the User's Guide

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GLOSSARY

ΔV .... Delta Velocity

°C .... Celsius

°F .... Fahrenheit

μm .... micrometer

μsec .... microsecond

σ .... Standard Deviation

Ω........ ohm

3-D .... Three-Dimensional

3-DOF .... Three-Degree-of-Freedom

30 SW........ USAF 30th Space Wing

45 SW........ USAF 45th Space Wing

4-m 4-Meter

4SLS........ 4th Space Launch Squadron

5-m 5-Meter

6-DOF .... Six-Degree-of-Freedom

A........ ampere

Ahr .... Ampere Hour

ABC .... Aft Bulkhead Carrier

A/C .... Air Conditioning

ACES .... Advanced Common Evolved Stage

ACS........ Attitude Control System

AFM........ Air Force Manual

AFR........ Air Force Regulation

AFSMC........ Air Force Space & Missile Systems Center

AFSPCMAN........ Air Force Space Command Manual

ANSI .... American National Standards Institute

APL .... Auxiliary Payloads

ASO .... Astrotech Space Operations, Inc.

ASOC .... Atlas Spaceflight Operations Center

AT .... access tower

ATK .... Alliant Techsystems, Inc.

ATP .... Authority to Proceed

BET .... Best Estimate Trajectory

BLS .... Boeing Launch Services

BPSK .... Binary Phase Shift Keyed

BSRM .... Booster Separation Rocket Motors

btu .... British Thermal Unit

CAD .... computer-aided drawing; computer-aided design

CAP .... C-Adapter Platform

CBC .... Common Booster Core

CBCC .... Common Booster Core Centerbody

CBCP .... Common Booster Core Port

CBCS .... Common Booster Core Starboard

CBOD .... Clampband Opening Device

CCAFS .... Cape Canaveral Air Force Station

CCAM .... Contamination and Collision Avoidance Maneuver

CCTV .... Closed-Circuit Television

CD .... Compact Disk

CDR .... Critical Design Review

CEO .... Chief Executive Officer

CFA .... Centaur Forward Adapter

CG .... center-of-gravity

CLA .... Coupled Loads Analysis

cm..centimeter

CoC..Certificate of Completion

COLA..Collision Avoidance

CPO..Customer Program Office

CRD..Command Receiver Decoder

CRE..Certified Responsible Engineer

CRR..CRE Readiness Review

CSA..Chad Stewart & Associates

CSB..Common Support Building

CSYS..Coordinate System

dB..Decibel

DCSS..Delta Cryogenic Second Stage

dc..Direct Current

deg..Degree

dia..Diameter

DOC..Delta Operations Center

DOD..Department of Defense

DOF..Degrees of Freedom

DoLWG..Day of Launch Working Group

DOT..Department of Transportation

DPF..DSCS Processing Facility

dps..degrees per second

DSCS..Defense Satellite Communication System

DSS-4..Dual Spacecraft System, 4-m

DSS-5..Dual Spacecraft System, 5-m

DVD..Digital Versatile Disk

ECS..Environmental Control System

EED .... Electro-Explosive Device

EELV .... Evolved Expendable Launch Vehicle

EGSE .... Electrical Ground Support Equipment

EICD .... Electrical Interface Control Document

EIM .... Engineering Integration Manager

EMC .... Electromagnetic Compatibility

EMI .... Electromagnetic Interference

EMISM .... EMI Safety Margin

EPF .... Eastern Processing Facility

EPT .... Elevating Platform Transporter

ER .... Eastern Range

ESPA .... EELV Secondary Payload Adapter

ETR .... Eastern Test Range

EWR .... Eastern and Western Regulation

FAA .... Federal Aviation Administration

FEM .... Finite Element Model

FFDP .... Final Flight Data Package

FFPA .... Final Flight Plan Approval

FMA .... Final Mission Analysis

FRR .... Flight Readiness Review

ft .... feet

FSP .... Fleet Standardization Program

FTP .... File Transfer Protocol

FTS .... Flight Termination System

FUT .... Fixed Umbilical Tower

GEM .... Graphite Epoxy Motors

GEO .... Geosynchronous Earth Orbit

GMM .... Geometric Mathematical Model

GN_2 .... Gaseous Nitrogen

GORR .... Ground Operations Readiness Review

GOWG .... Ground Operations Working Group

GPS .... Global Positioning System

GSA .... gas storage area

GSE .... Ground Support Equipment

GSO .... Geosynchronous Orbit

GTO .... Geosynchronous Transfer Orbit

GTU .... GPS Tracking Unit

HEPA .... High-Efficiency Particulate Air

HIF .... Horizontal Integration Facility

HIP .... Hot Isostatic Press

HPF .... Hazardous Processing Facilities

HPU .... Hydraulic Pump Unit

HVAC .... heating, ventilating, and air conditioning

Hz .... Hertz

ICA .... Independent End-to-End Electrical Circuit Compatibility Analysis

ICD .... Interface Control Document

ICE .... Integrated Crew Exercise

IFD .... In Flight Disconnect

ILC .... Initial Launch Capability

IMR .... Integrated Mission Review

in .... inch

IPC .... Integrated Payload Carrier

IPF .... Integrated Processing Facility

IRD .... Interface Requirements Document

ITA .... Integrated Thermal Analysis

IVF .... Integrated Vehicle Fluids

IVT .... Interface Verification Test

kBps .... Kilobits per Second

kg........ kilogram

klb .... Thousands of Pounds

km .... kilometer

kN........ kilonewton

KPa........ kilopascal

KSC .... Kennedy Space Center

kVA .... Kilovoltampere

kW........ Kilowatt

lb .... pound

lbf .... pound force

LCC .... Launch Control Center

LCDR .... Launch Conductor

LEO .... Low-Earth Orbit

LFSR .... Launch Facility Systems Review

LH_2 .... Liquid Hydrogen

LMU........ Launch Mate Unit

LNA .... Low Noise Amplifier

LO_2 .... Liquid Oxygen

LOC........ Loss of Clearance

LOCC .... Launch Operations Control Center

LPF........ Large Processing Facility

LPT .... Lightning Protection Tower

LRB .... Liquid Rocket Booster

LRR .... Launch Readiness Review
LSIC .... Launch Services Integration Contractor
LSIM .... Launch Site Integration Manager
LSPSS .... Low Shock Payload Separation System
LSRD .... Launch Services Requirements Document
LSRR .... Launch Site Readiness Review
LSS .... Launch Support Shelter
LT .... Launch Table
LV .... Launch Vehicle
LVA .... Launch Vehicle Adapter (a.k.a. C-adapter)
LVOS .... Launch Vehicle on Stand
m .... meter
mA .... Milliampere
MAS .... Mobile Assembly Structure
Mbps .... megabits per second
MCC .... Mission Control Center
MD .... Mission Director
MDC .... Mission Director Center
MDR .... Mission Dress Rehearsal
MECO .... Main Engine Cutoff
MHz .... megahertz
MIL .... military
MIL-STD .... military standard
min .... minutes
MIT .... Mission Integration Team
MLB .... Motorized Lightband
MLV .... medium launch vehicle

mm .... millimeter

mph .... miles per hour

MPPF .... Multi-payload Processing Facility

MRR.......... Mission Readiness Review

msec .... millisecond

MSPSP .... Missile System Prelaunch Safety Package

MSRR .... Mission Specific Requirements Review

MST .... Mobile Service Tower

MT.......... Metric Tracking

MTCA .... Mission Targeting Capability & Accuracies

MTU.......... Master Telemetry Unit

MU .... Mission Unique

N_2H_4 .... Hydrazine

NASA.......... National Aeronautics and Space Administration

NCS.......... Nutation Control System

NLT .... No Later Than

nmi .... nautical mile

NPF .... Navstar Processing Facility

NRO .... National Reconnaissance Office

NROV .... NRO Vandenberg

NVR .... Nonvolatile Residue

OASPL.......... Overall Acoustic Sound Pressure Level

OR.......... operations requirement

OSL.......... Office of Space Launch

OTM.......... Output Transformation Matrices

PAF .... Payload Attach Fitting

PCES.......... Portable Clean Environmental Shelter

PCL .... Precision Clean Lab

PCM .... Pulse Code Modulation

PCS .... Probability of Command Shutdown

PDR .... Preliminary Design Review

PECS .... Portable Environmental Control System

PEI .... Payload Electrical Interface

PFDP .... Preliminary Flight Data Package

PFPA .... Preliminary Flight Plan Approval

PGP .... Pretty Good Privacy

PHSF .... Payload Hazardous Servicing Facility

PIRR .... Program Introduction Requirements Review

PLA .... Payload Accommodations

PLA .... Payload Adapter

PLF .... Payload Fairing

PLCP .... (Spacecraft) Propellant Leak Contingency Plan

PMA .... Preliminary Mission Analysis

PMRR .... President's Mission Readiness Review

POCA .... Point of Closest Approach

PPF .... Payload Processing Facilities

PPOD .... Poly Pico satellite Orbital Deployer

PRD .... Program Requirements Document

PSC .... Planetary Systems Corporation

psi .... Pounds per Square Inch

PSM .... Program Support Manager

PSR .... Payload Separation Ring

PSS .... Payload Separation System

PTC .... Passive Thermal Control

PWR........Pratt & Whitney Rocketdyne

Quad........quadrant

R&I........Receipt and Inspection

RCO........Range Control Officer

RF........Radio Frequency

RHC........Right Hand Circularized

RIFCA........Redundant Inertial Flight Control Assembly

RIS........Receipt Inspection Station

RLCC........Remote Launch Control Center

RMS........Root Mean Squared

ROC........Range Operations Center

ROCC........Range Operations Control Center

RPO........Radiation Protection Officer

RSSR........Range Safety System Reports

RTU........Remote Terminal Unit

RUG........Rideshare User's Guide

RWG........Rehearsal Working Group

SA........Swing Arm

SAR........Safety Assessment Report

SC........Spacecraft

SCIF........Special Compartmented Information Facility

SCR........System Certification Review

SDP........Safety Data Package

SEB........Support Equipment Building

sec........second

SECB........Security Entry Control Building

SECO........Second Stage Engine Cutoff

SEIP .... Standard Electrical Interface Panel

SIL .... Systems Integration Laboratory

SINDA .... System-Improved Numerical Differencing Analyzer

SIP .... Standard Interface Plane

SLC .... Space Launch Complex

SLE .... Suspended Load Exposure

SMFCO .... Senior Mission Flight Control Officer

SOW .... Statement of Work

SRM .... Solid Rocket Motor

SRR .... System Requirements Review

SRT .... Safety Review Team

SS .... Second Stage

SSI .... Spaceport Systems International

SSME .... Space Shuttle Main Engine

STA, sta .... station

STD .... standard

STEP .... Standard for the Exchange of Product Model Data

SV .... Space Vehicle

SVC .... Space Vehicle Contractor/Customer

SVIP .... Space Vehicle Interface Panel

SW .... Space Wing

TDRSS .... Tracking and Data Relay Satellite System

TDWR .... Terminal Doppler Weather Radar

THD .... total harmonic distortion

TM .... Telemetry

TMM .... Thermal Mathematical Model

TOR .... Technical Operations Requirement

TRR .... Test Readiness Review

TSB .... Technical Support Buildling

UDS .... Universal Documentation System

U.S. .... United States

ULA .... United Launch Alliance

ULS .... United Launch Services

UPS .... Uninterruptible Power Supply

USAF .... United States Air Force

UV .... Ultraviolet

V .... volt

VAB .... Vehicle Assembly Building

VAC .... Volts Alternating Current

VAFB .... Vandenberg Air Force Base

VAR .... Vehicle Assessment Review

VCR .... Vehicle Completion Review

VDC .... Volts Direct Current

VFA .... Variable Flight Azimuth

VIF .... Vertical Integration Facility

VPAR .... Vehicle Product Acceptance Reviews

VPF .... Vertical Processing Facility

W .... watt

WDR .... Wet Dress Rehearsal

WTR .... Western Test Range

WR .... Western Range

United Launch Alliance

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