United Launch Alliance

# Delta IV

## Payload Planners Guide

September 2007

# DELTA IV
# PAYLOAD PLANNERS GUIDE

The Delta IV Payload Planners Guide has been cleared for public release by the Chief, Office of Security Review, Department of Defense, as stated in letter 07-S-1966, dated June 27, 2007.

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



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## *CHANGE RECORD*

| Revision Date | Version | Change Description |
|---|---|---|
| October 2000 | 2000 | **Section 1 –** Updates include:<br>■ Revised Launch Vehicle discussion |
| | | **Section 2 –** Updates include:<br>■ Updated performance curves of all Delta IV vehicle configurations |
| | | **Section 3 –** Updates include:<br>■ Updated static payload envelopes for all fairing<br>■ Added static payload envelop for new 1575-mm interface PAF |
| | | **Section 4 –** Updates include:<br>■ Updated Eastern Range and Western Range facility environments<br>■ Updated radiation and electromagnetic environments<br>■ Updated figures for fairing pressure envelope<br>■ Updated figures for payload environments: thermal, steady-state acceleration, acoustic, shock |
| | | **Section 5 –** Updates include:<br>■ Added new 1575-mm dia interface PAF<br>■ Updated PAFs discussion<br>■ Updated figures for PAFs |
| | | **Section 6 –** Updates include:<br>■ Updated launch site facilities discussion<br>■ Revised figures for launch site facilities<br>■ Revised Launch Control Center discussion<br>■ Revised launch integration schedule |
| | | **Section 7 –** Updates include:<br>■ Updated launch site facilities discussion<br>■ Updated California Spaceport facilities discussion<br>■ Revised figures for launch site facilities<br>■ Revised launch integration schedule |
| | | **Section 8 –** Updates include:<br>■ Revised figures for Mission Integration process<br>■ Revised Table 8-4, Spacecraft Questionnaire |
| | | **Section 9 –** Updates include:<br>■ Revised Safety requirements discussion |
| | | **Appendixes –** Updates include:<br>Appendix A – Updates lightning launch commit criteria discussion<br>Appendix B – Updated Payload Safety Requirements<br>Appendix C – Revised history of flight mission accomplishments |

# *PREFACE*

This Delta IV Payload Planners Guide (PPG) is issued to the spacecraft user community to provide information about the Delta IV family of launch vehicles and its related systems and launch services.

This document contains current Delta IV information and includes United Launch Alliance 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 development in the Delta IV program progresses, United Launch Alliance will periodically update the information presented in the following pages. To this end, you are urged to visit our Web site so that you can download updates as they become available.

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

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# GLOSSARY

ΔV ........ delta velocity

°C ........ Celsius

°F ........ Fahrenheit

ε ........ emittance

μm ........ micrometer

μV ........ microvolt

σ ........ standard deviation

Ω ........ ohm

30 SW ........ 30th Space Wing

45 SW ........ 45th Space Wing

A ........ ampere

A-50 ........ Aerozine 50

AC ........ alternating current

AC, A/C ........ air-conditioning

ACS ........ attitude control system/auxiliary control system

AFB ........ Air Force Base

AFSMC ........ Air Force Space & Missile Systems Center

AFSPCMAN ........ Air Force Space Command Manual

AGE ........ aerospace ground equipment

AKM ........ apogee kick motor

ANSI ........ American National Standards Institute

ASO ........ Astrotech Space Operations, LP

AST ........ Associate Administration for Commercial Space Transportation

AT ........ access tower

B&W ........ black and white

BLS ........ Boeing Launch Services

BPS ........ bits per second

Btu ........ British Thermal Unit
C3 ........ launch energy
CAD ........ computer-aided drawing; computer-aided design
CBC ........ common booster core
CBOD ........ clampband opening device
CCAFS ........ Cape Canaveral Air Force Station
CCAM ........ contamination and collision avoidance maneuver
CCTV ........ closed-circuit television
CDR ........ critical design review
CFR ........ Code of Federal Regulations
CG ........ center-of-gravity
CL ........ centerline
CLA ........ coupled loads analysis
cm ........ centimeter
COMSTAC ........ Commercial Space Transportation Advisory Committee
CRD ........ command receiver decoder
CSB ........ common support building
CSYS ........ coordinate system
dB ........ decibel
DE ........ director of engineering
deg ........ degree
dia ........ diameter
DIV H ........ Delta IV Heavy
DIV M ........ Delta IV Medium
DIV M+ ........ Delta IV Medium Plus
DMA ........ direct mate adapter
DMCO ........ Delta mission checkout
DOC ........ Delta Operations Center

DOF....................degrees of freedom

DOT....................Department of Transportation

DPAF....................dual-payload attach fitting

DPF....................DSCS Processing Facility

dps....................degrees per second

DSCS....................Defense Satellite Communications System

ECS....................environmental control system

EED....................electro-explosive device

EELV....................evolved expendable launch vehicle

EGSE....................electrical ground support equipment

EMT....................electrical-mechanical testing

EPT....................elevating platform transporter

ER....................Eastern Range

ESA....................engineering support area

ESPA....................EELV Secondary Payload Adapter

ESS....................electronic security system

EWR....................Eastern and Western Regulation

FAA....................Federal Aviation Administration

fc....................foot-candle

FDLC....................final design loads cycle

FED-STD....................Federal Standard

FMA....................final mission analysis

FRR....................flight readiness review

ft....................feet

FTS....................flight termination system

FUT....................fixed umbilical tower

g....................gravity

$GC^3ME$....................ground command, control, communications, and mission equipment

GEM ........ graphite-epoxy motor

GEO ........ geosynchronous Earth orbit

GHz ........ gigahertz

$GN_2$ ........ gaseous nitrogen

GOP ........ ground operations plan

GPS ........ global positioning system

GSA ........ gas storage area

GSE ........ ground support equipment

GSFC ........ Goddard Space Flight Center

GSO ........ geosynchronous orbit

GTO ........ geosynchronous transfer orbit

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

IL ........ interline distance

ILV ........ intermediate launch vehicle

IMP ........ integrated management plan

in ........ inch

IPF ........ integrated processing facility

IRD ........ interface requirements document

ISS ........ International Space Station

IVA ........ immediate visual assessment

K ........ Kelvin

kg ........ kilogram

km .......... kilometer

kN.......... kilonewton

KPa.......... kilopascal

KSC.......... Kennedy Space Center

kVA.......... kilovoltampere

lb .......... pound

LCC.......... launch control center

LEO.......... low-Earth orbit

$LH_2$.......... liquid hydrogen

LMU.......... launch mate unit

$LO_2$.......... liquid oxygen

LOCC.......... launch operations control center

LOP.......... launch operations plan

LPD.......... launch processing document

LPT .......... lightning protection tower

LRB.......... liquid rocket booster

LRR.......... launch readiness review

LSRR.......... launch site readiness review

LSS.......... launch support shelter

LSTP .......... launch site test plan

lux .......... lumen per square meter

LV .......... launch vehicle

LVDC.......... Launch Vehicle Data Center

m .......... meter

mA.......... milliampere

MAS.......... mobile assembly structure

MD .......... mission director

MDC .......... Mission Director Center

MECO ........ main engine cutoff

MHz ........ megahertz

MIL ........ military

MIL-STD ........ military standard

MIM ........ mission integration manager

MLV ........ medium launch vehicle

mm ........ millimeter

MPPF ........ multipayload processing facility

MSPSP ........ missile systems prelaunch safety package

MSR ........ mission support request

MST ........ mobile service tower

MTU ........ master telemetry unit

N ........ newton

$N_2H_4$ ........ hydrazine

NASA ........ National Aeronautics and Space Administration

NCS ........ nutation control system

nmi ........ nautical mile

NOAA ........ National Oceanographic and Atmospheric Administration

NPF ........ Navstar processing facility

NVR ........ nonvolatile residue

OASPL ........ overall sound pressure level

OR ........ operations requirement

P/L ........ payload

Pad ........ Pascals differential

PAF ........ payload attach fitting

PAM ........ payload assist module

PCES ........ portable clean environment shelter

PCL ........ precision clean lab

PCM ........ pulse code modulated

PCS ........ probability of command shutdown

PDR ........ preliminary design review

PECS ........ portable environmental control system

PEI ........ payload electrical interface

PHE ........ propellant handler’s equipment

PHPF ........ payload hazardous processing facility

PLA ........ payload accommodations

PLF ........ payload fairing

PMA ........ preliminary mission analysis

PPF ........ payload processing facilities

PPG ........ payload planners guide

P-Pod ........ Poly Picosatellite Orbital Deployer

PPRD ........ Payload Processing Requirements Document

PRD ........ Program Requirements Document

psi ........ pounds per square inch

psia ........ pounds per square inch absolute

psid ........ pounds per square inch differential

PSM ........ program support manager

Q ........ dynamic pressure

Quad ........ quadrant

R ........ radius

rad ........ radian

RCO ........ Range Control Officer

RCS ........ reaction control system

$R_E$ ........ equatorial radius

RF ........ radio frequency

RFA ........ radio frequency application

RFI ........ radio frequency interference

RH ........ relative humidity

RIFCA ........ redundant inertial flight control assembly

RIS ........ receipt inspection station

RLCC ........ remote launch control center

ROC ........ Range Operations Center

ROCC ........ range operations control center

rpm ........ revolutions per minute

S&A ........ safe and arm

SA ........ swing arm

SAEF 2 ........ Spacecraft Assembly and Encapsulation Facility Number 2

SAM ........ secondary attach mounting

SC, S/C ........ spacecraft

SCAPE ........ self-contained atmospheric protection ensemble

SEB ........ support equipment building

sec ........ second

SECB ........ security entry control building

SECO ........ second-stage engine cutoff

SEIP ........ standard electrical interface panel

sigma (σ) ........ standard deviation

SIP ........ standard interface plane

SLC ........ Space Launch Complex

SMC ........ Space and Missile Systems Center

SMFCO ........ senior mission flight control officer

SPIF ........ Shuttle payload integration facility

SRM ........ solid-rocket motor

SSI ........ Spaceport Systems International

SSME ........ Space Shuttle main engine

STA, sta ........ station
STD ........ standard
STP ........ special technical publication
SV ........ space vehicle
SVAFB ........ South Vandenberg Air Force Base
SVIP ........ space vehicle interface panel
SW ........ Space Wing
SW/CC ........ Space Wing Commander
sync ........ synchronous
t ........ metric ton
T/M ........ telemetry
TDRSS ........ tracking and data relay satellite system
THD ........ total harmonic distortion
TIM ........ technical interchange meeting
TM ........ telemetry
TT&C ........ telemetry, tracking, and command
TV ........ television
U.S. ........ United States
ULA ........ United Launch Alliance
UDS ........ Universal Document System
ULS ........ United Launch Services
UPS ........ uninterruptible power supply
US ........ upper stage, United States
USAF ........ United States Air Force
UV ........ ultraviolet
V ........ volt
VAB ........ vehicle assembly building
VAC ........ volts alternating current

VAFB ........ Vandenberg Air Force Base

VC ........ visible cleanliness

VDC ........ volts direct current

VIM ........ vehicle information memorandum

VLC ........ verification loads cycle

VOS ........ vehicle on stand

VPF ........ vertical processing facility

W ........ watt

WR ........ Western Range

# 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 is the payload environment during ascent. 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 four 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 U.S.—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 U.S. Government or commercial entity, the customer will contract for launch services with either United Launch Services (ULS) or Boeing Launch Services (BLS), respectively.

United Launch Services (ULS), is the single point of contact for all U.S. Government customer new-business activities. ULS offers full-service launch solutions using the Delta II and Delta IV family of launch vehicles. The customer is supported by an 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 Delta U.S. 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.

Boeing Launch Services 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 Delta IV program office work together to ensure that all customer technical requirements are fully coordinated. The Delta IV program 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 integration manager is appointed from within the Delta IV program to support the customer. The mission integration manager also works with ULS and BLS early in the process to define customer mission requirements and the appropriate launch solution and then transitions to provide the day-to-day mission integration support necessary to successfully satisfy the customer’s launch requirements. The mission integration manager supports the customer’s mission from contract award through launch and postflight analysis.

The Delta 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 Delta team works closely with its customers to optimize the payload’s operational life. In many cases, we can provide innovative trades 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 Delta the ideal choice as a launch services provider.

## 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. The vehicle was 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 led to the Delta family of launch vehicles, with a wide range of increasing capability to GTO (Figure 1-1).

The Delta Program’s dedication to delivering superior launch service to its customers is evidenced by the many configurations developed to date. Delta II has provided customers with a demonstrated

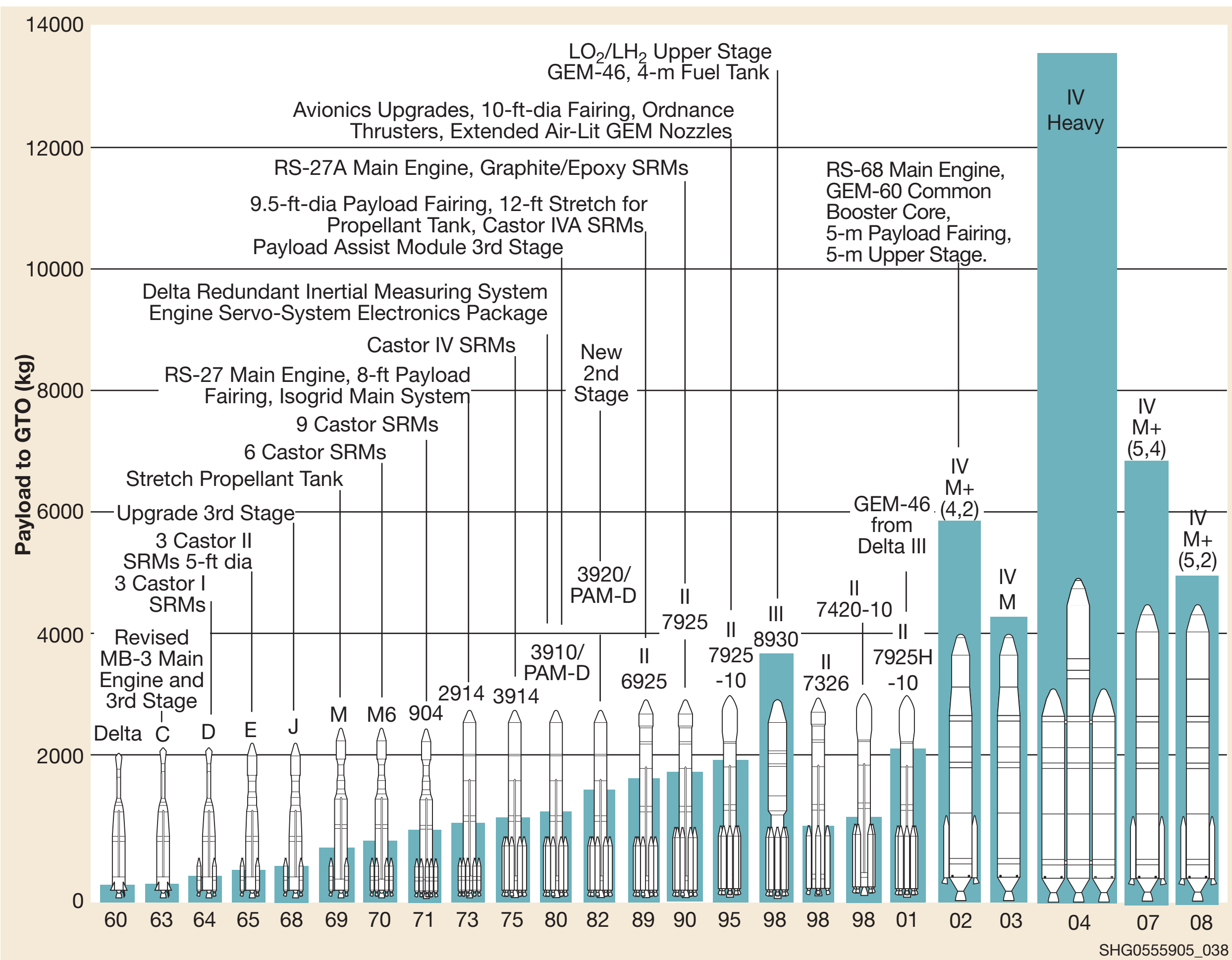


**Figure 1-1. Heritage of the Delta Family**

world-class success rate of over 98%, and processing times on the launch pad have been reduced from 40 to 24 days. The Delta IV launch system is the latest example of this 40-year evolution, providing even more capability by incorporating heritage hardware and processes and a new robust propulsion system. The Delta Program 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 (Delta IV M), three variants of the Delta IV Medium-Plus (Delta IV M+), and the Delta IV Heavy (Delta IV H), 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, $LH_2$).

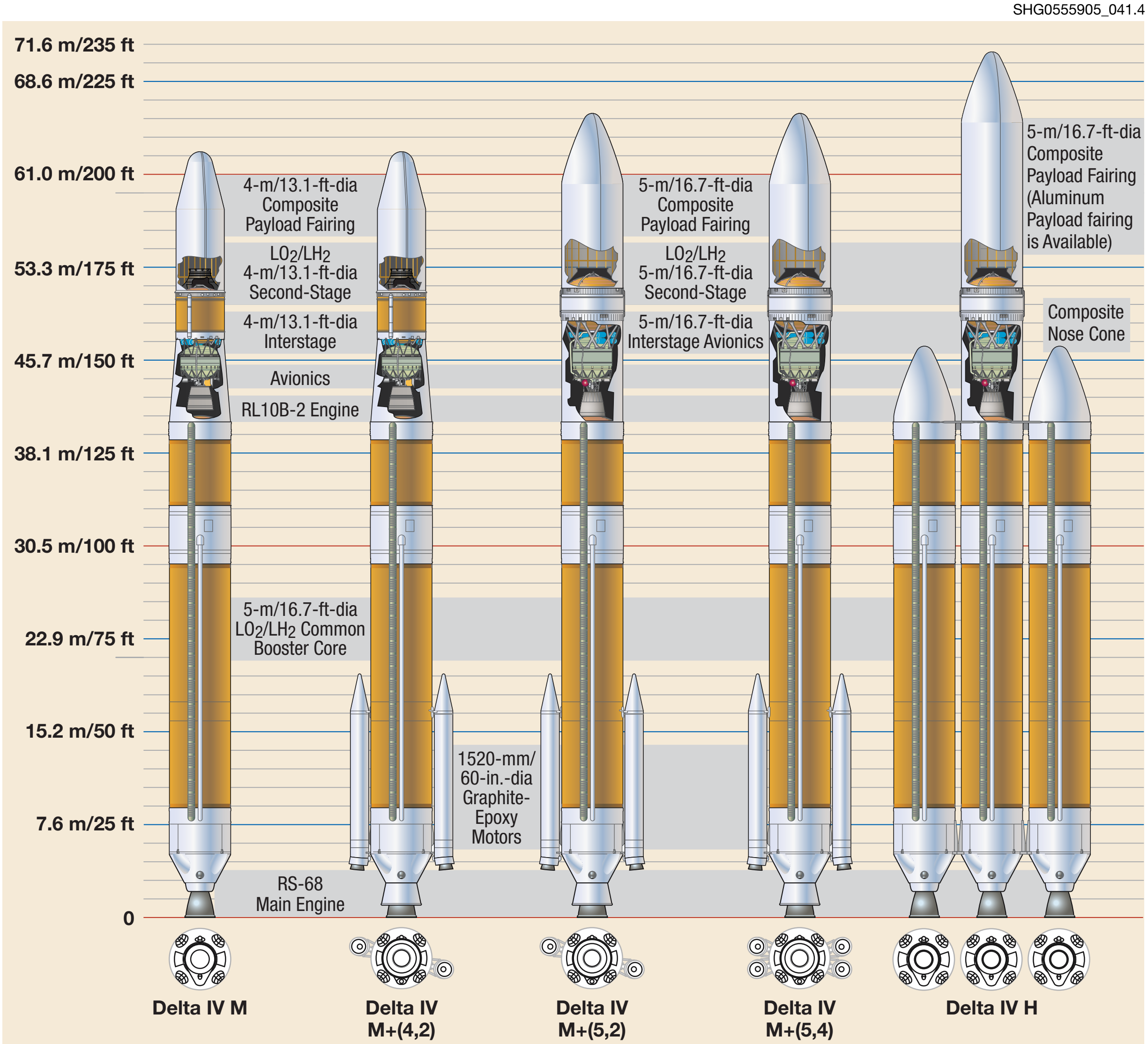


**Figure 1-2. Configurations of the Delta IV Launch Vehicle**

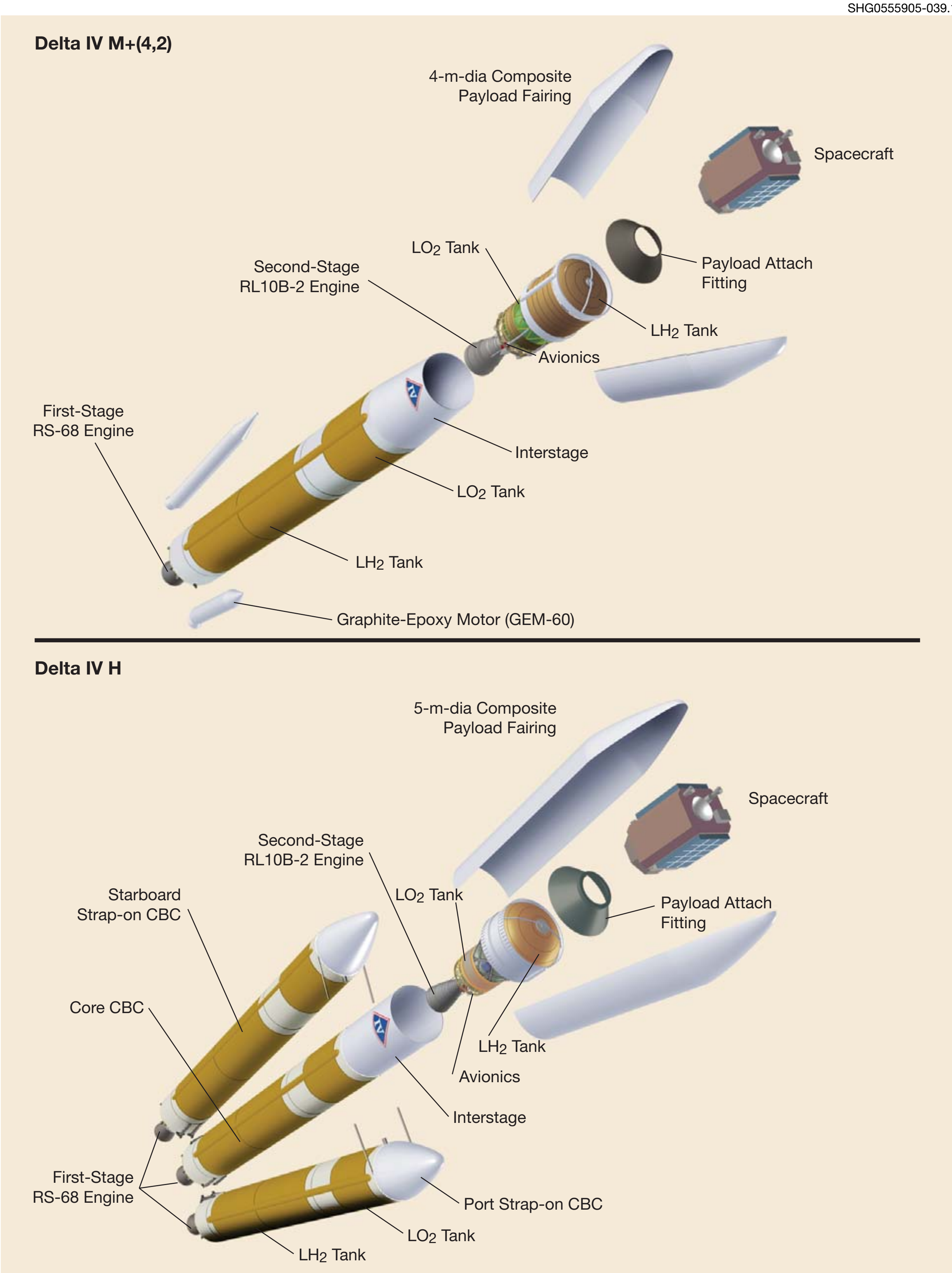


**Figure 1-3. Delta IV Launch Vehicles**

- The Delta IV M employs a first-stage CBC, a 4-m (157.5-in.)-dia cryogenic second stage, and a 4-m (160.4-in.)-dia composite payload fairing (PLF).
- The Delta IV M+ comes in three different configurations. One configuration uses two strap-on solid rocket motors (SRMs) to augment the first-stage CBC, a 4-m (160.4-in.)-dia cryogenic second stage, and a 4-m (160.4-in.)-dia composite payload fairing (PLF). This configuration is designated as Delta IV M+(4,2); the first digit in parentheses refers to the diameter of the second stage 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 H 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.

### 1.2.1 First Stage

The first-stage CBC (Figure 1-3) consists of the RS-68 engine, liquid hydrogen ($LH_2$) tank, centerbody, liquid oxygen ($LO_2$) tank, and interstage.

The first stage CBC is powered by the Rocketdyne RS-68 engine (Figure 1-4), a state-of-the-art engine burning $LO_2$ and $LH_2$ cryogens, that is capable of delivering 2,891 kN (650,000 lb) of thrust and having a specific impluse of 410 sec. The RS-68 can throttle down to 60% 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

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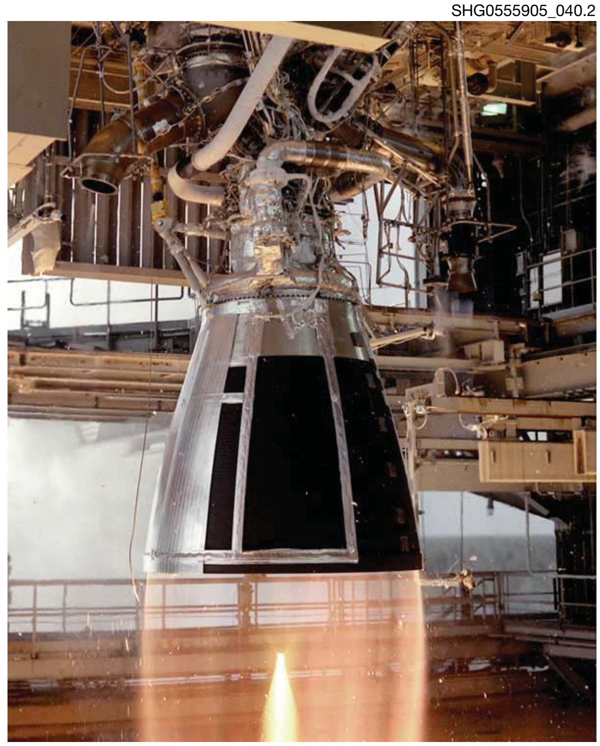

**Figure 1-4. RS-68 Engine**

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 by vectoring the RS-68 turbine exhaust gases. Roll control for the Heavy vehicle is provided by gimbaling the RS-68 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 and designated as graphite-epoxy motors (GEM-60). These motors are derived from the smaller GEM-46 previously used on Delta III. 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 H uses two strap-on liquid rocket boosters (LRBs) with nose cones and separation motors.

The CBC has an overall dia of 5 m, so the interstage is tapered down to 4-m (157.5-in.) dia for the Delta IV M 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 H configurations have a 5-m-dia cylinder. For aerodynamic purposes, the liquid strap-on CBCs for the Delta IV H employ nose cones in place of the interstage.

### 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 M 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 H.

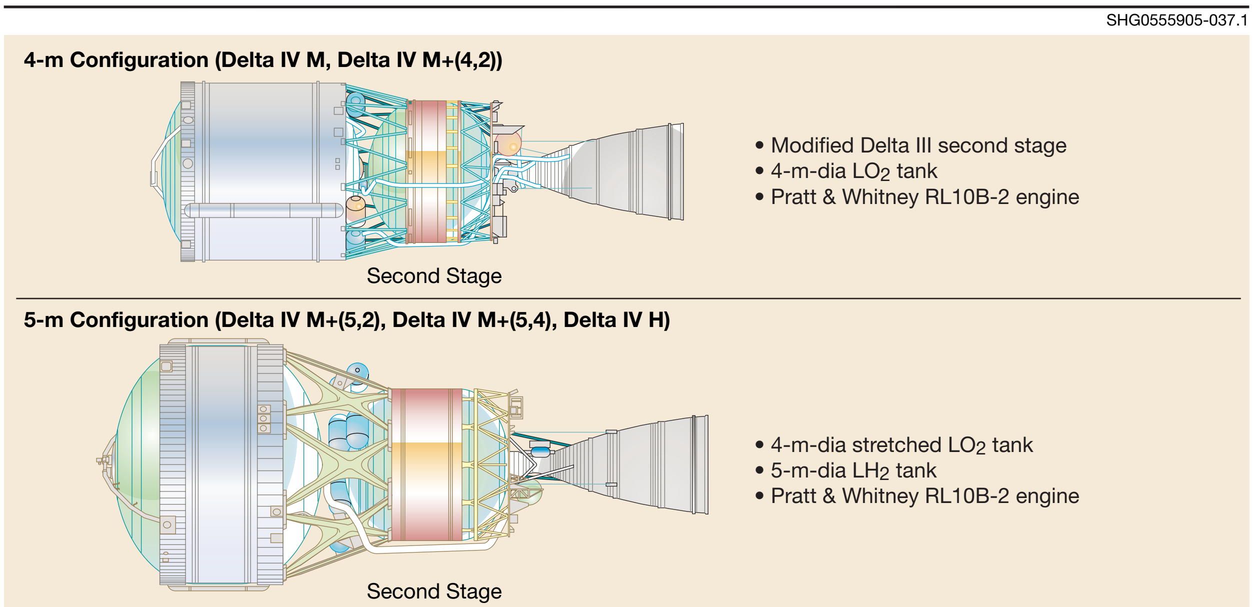


**Figure 1-5. Delta IV Second-Stage Configurations**

Both second stages use the cryogenic Pratt & Whitney 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 impluse of 462 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 is modified from that of Delta III with the total propellant load increased to 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 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 restart (up to two) are accommodated by adding an extra helium bottle to the second stage for additional tank repressurization. The mission duration is 2.3 hr nominally, but may be increased to over 7 hr by adding hydrazine bottles and batteries on the second stage. After payload separation, a contamination and collision avoidance maneuver (CCAM) is conducted to ensure adequate 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 H 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 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 the Delta Program; or the Delta Program 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.

The Delta Program 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 contact the Delta Program Office.

### 1.2.5 Payload Fairings (PLF)

The fairings protect the payload once the payload is encapsulated through boost flight. The Delta IV launch system offers PLFs (Figure 1-6) for different launch vehicle configurations.

The 4-m fairing is a stretched Delta III 4-m composite bisector design. The 5-m composite fairing for single-manifest missions is also based on that of Delta III and comes in two standard lengths: 14.3 m (47 ft) and 19.1 m (62.7 ft).

The 5-m metallic trisector fairing (the baseline for heritage government programs) 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 6.3 and 7.3) 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 can be made as required by the customer. These include access doors, additional acoustic blankets, and radio frequency (RF) windows. Payload fairings are discussed in more detail in Section 3.

### 1.2.6 Avionics and Flight Software

The Delta IV launch system uses a modified Delta III avionics system with 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 (T/M) system delivers real-time

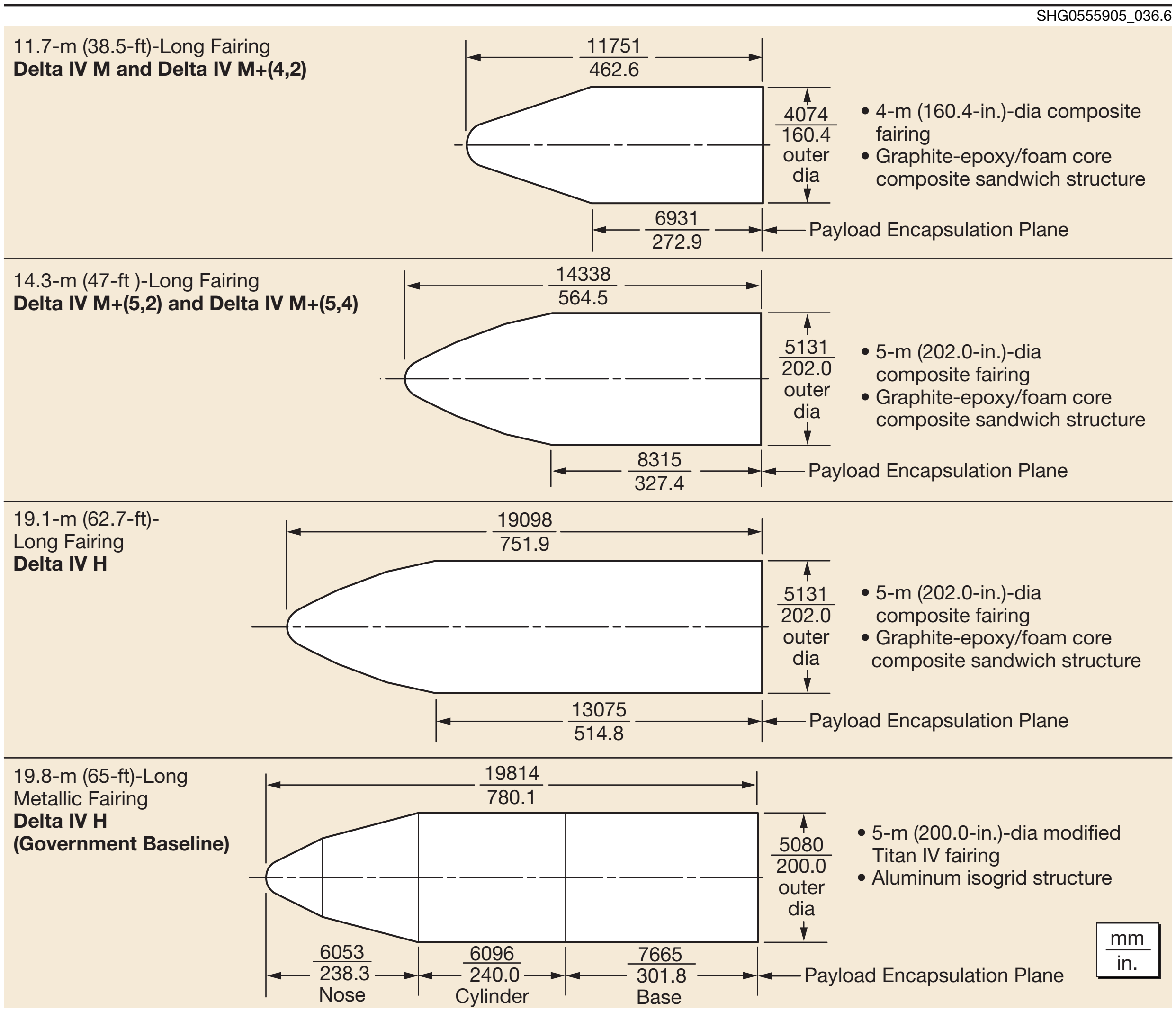


**Figure 1-6. Delta IV Fairing Configurations**

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.

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. The vehicle centerline is the longitudinal axis of the vehicle. Axis II (+Z) is on the down-range 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).

### 1.3.1 Orientation

Two distinct coordinate systems are of interest to the spacecraft customer. The first is the launch vehicle coordinate system that has already been discussed. The second 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. In this Payload Planners Guide, all coordinates are in the launch vehicle coordinate system unless otherwise stated.

### 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 INSIGNIA

Delta IV customers are invited to create a mission-specific insignia 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 insignia is 4.7 m by 4.7 m (15 ft by 15 ft). Following approval, the flight insignia will be prepared and placed on the up-range side of the launch vehicle.

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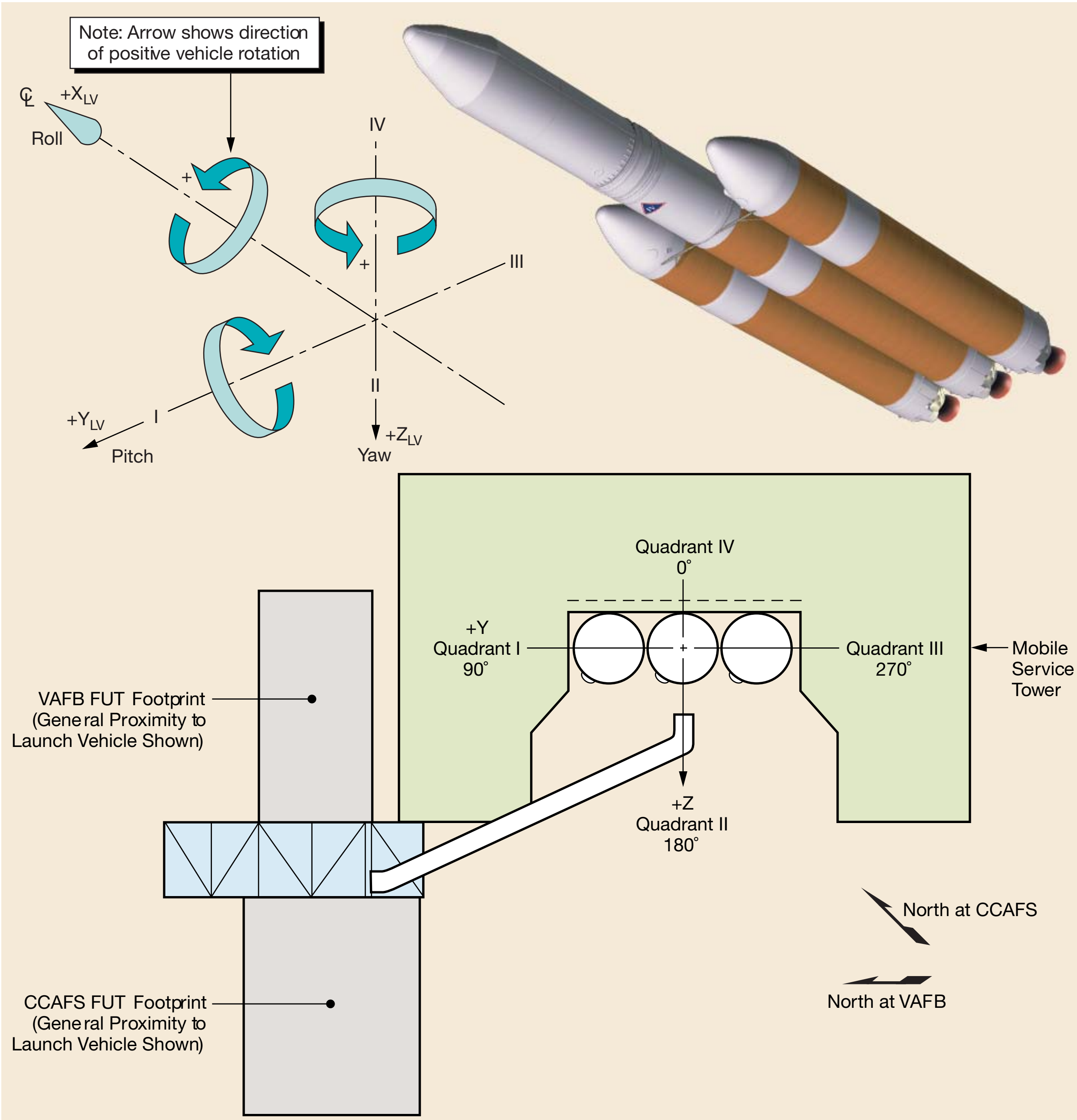


**Figure 1-7. Launch Vehicle Axes**

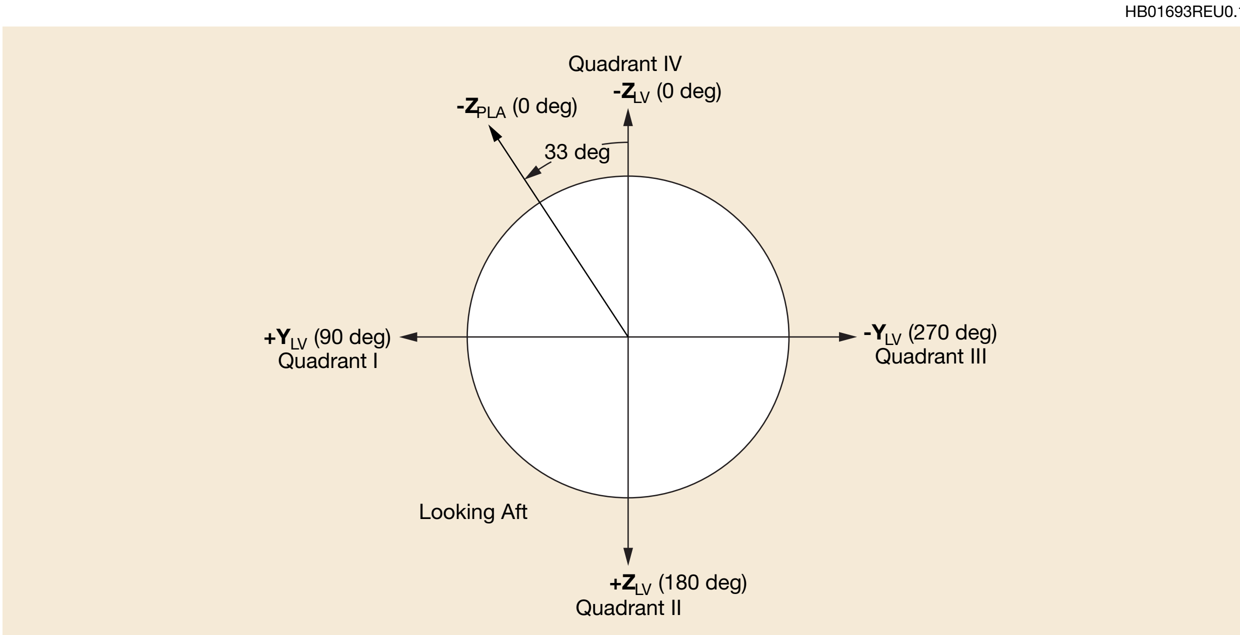


**Figure 1-8. Launch Vehicle vs. Payload Accommodations Coordinate System**

# 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. The following sections are presented to describe 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. Delta mission designers can provide innovative performance trades to meet specific requirements. Additionally, future performance improvements are discussed in detail in Section 10. Our customers are encouraged to contact the Delta Program Office 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. C-band coverage for range safety is provided by ground stations until safe orbit is achieved and the command-destruct receivers are turned off. After first/second-stage separation, the telemetry is 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 mission profile is shown in Figure 2-1.

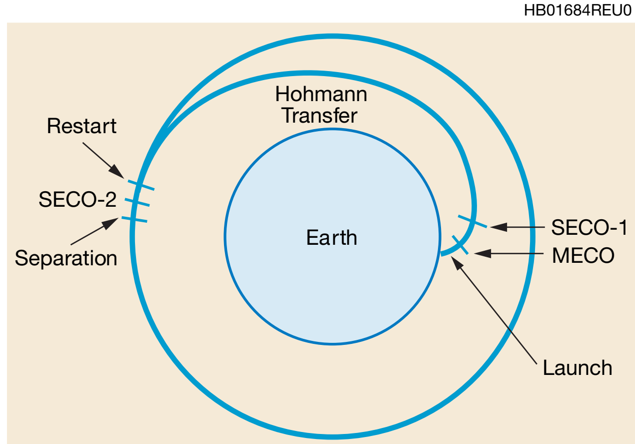


**Figure 2-1. Typical LEO Mission Profile**

After separation of the spacecraft, a coast period is allowed to provide the required launch-vehicle-to-spacecraft separation distance prior to a contamination and collision avoidance maneuver (CCAM), which is performed to remove the second stage from the spacecraft's orbit, and is then followed by vehicle safing (burning or venting of propellants). Preliminary and final nominal mission three-degrees-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 6-DOF simulation, as required. Six-DOF simulations will be used to verify that the control system can adequately perform the required attitude maneuvers and to determine the duty cycle of the control thrusters, which will be input to the contamination analysis. Closed-loop guided 5-DOF simulations will verify that the guidance can steer the launch vehicle and perform Delta IV maneuvers properly. For payloads requiring spin up 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. The profile follows a sequence similar to Delta II trajectories to maximize payload lift capability. 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 spun up 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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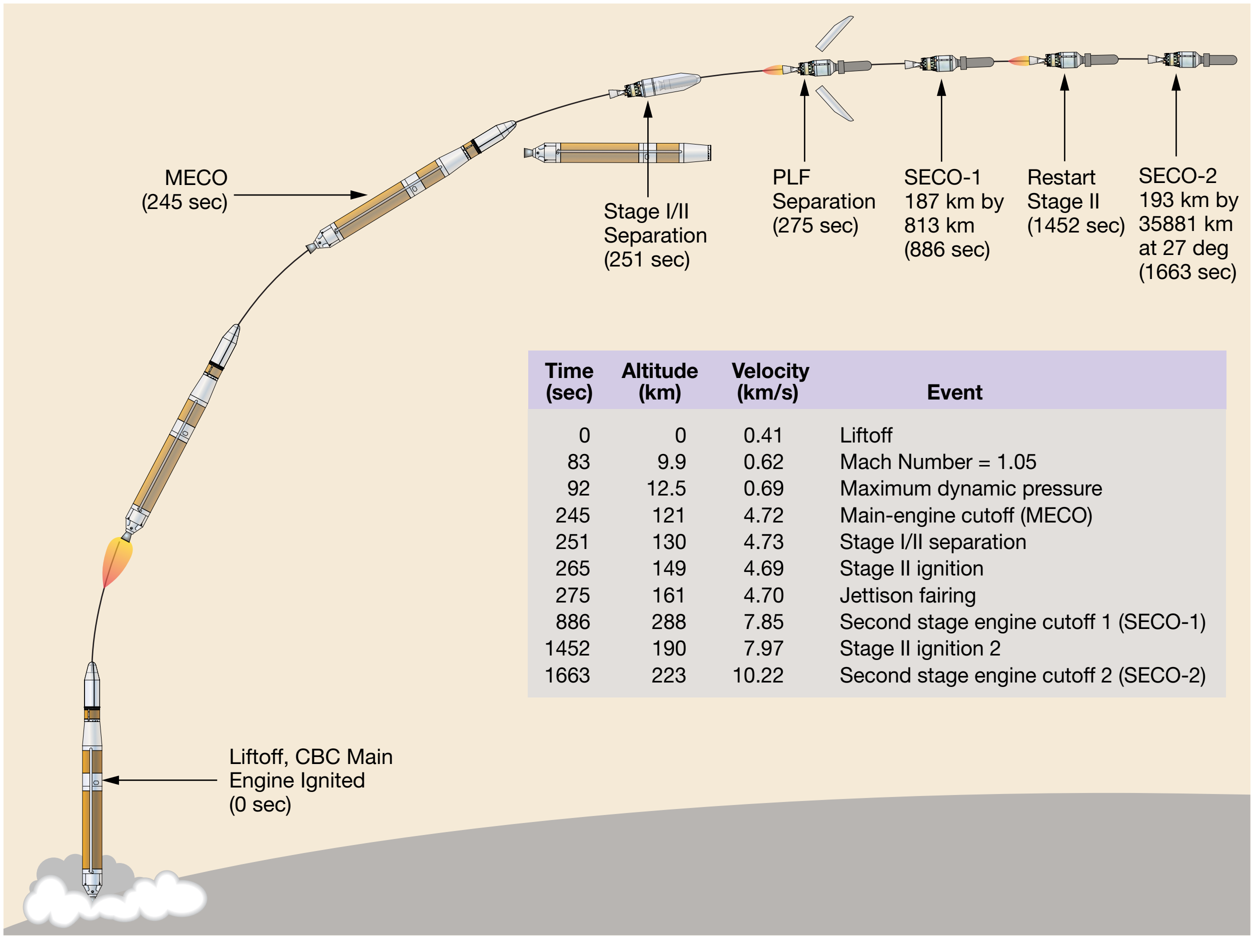


| Time (sec) | Altitude (km) | Velocity (km/s) | Event |
|---|---|---|---|
| 0 | 0 | 0.41 | Liftoff |
| 83 | 9.9 | 0.62 | Mach Number = 1.05 |
| 92 | 12.5 | 0.69 | Maximum dynamic pressure |
| 245 | 121 | 4.72 | Main-engine cutoff (MECO) |
| 251 | 130 | 4.73 | Stage I/II separation |
| 265 | 149 | 4.69 | 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 M Sequence of Events for a GTO Mission (Eastern Range)**

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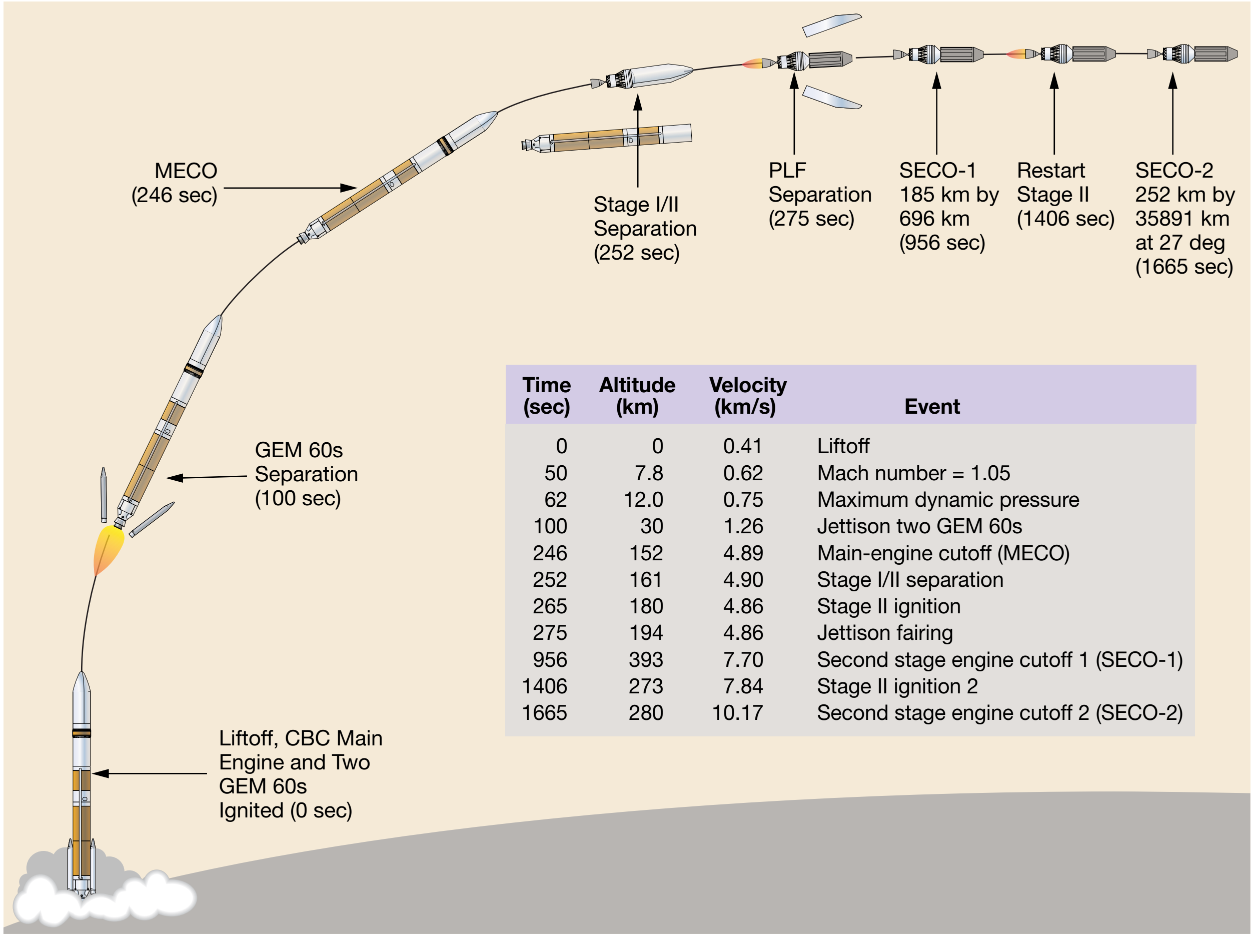
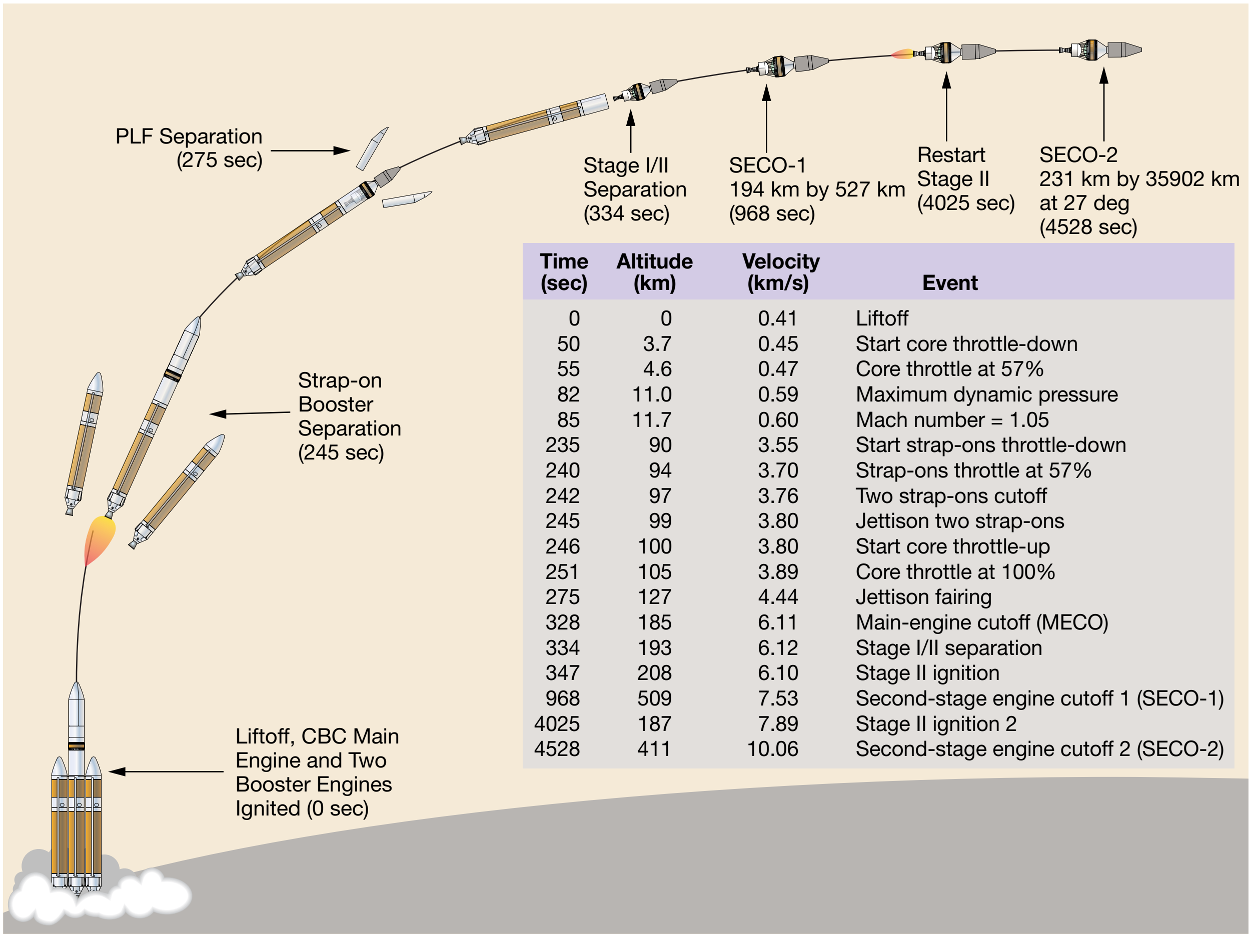



| Time (sec) | Altitude (km) | Velocity (km/s) | Event |
|---|---|---|---|
| 0 | 0 | 0.41 | Liftoff |
| 50 | 7.8 | 0.62 | Mach number = 1.05 |
| 62 | 12.0 | 0.75 | Maximum dynamic pressure |
| 100 | 30 | 1.26 | Jettison two GEM 60s |
| 246 | 152 | 4.89 | Main-engine cutoff (MECO) |
| 252 | 161 | 4.90 | 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)**

SHG0555905-055.2




| Time (sec) | Altitude (km) | Velocity (km/s) | Event |
|---|---|---|---|
| 0 | 0 | 0.41 | Liftoff |
| 50 | 3.7 | 0.45 | Start core throttle-down |
| 55 | 4.6 | 0.47 | Core throttle at 57% |
| 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 57% |
| 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 100% |
| 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 H 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 low-Earth orbit (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 rates 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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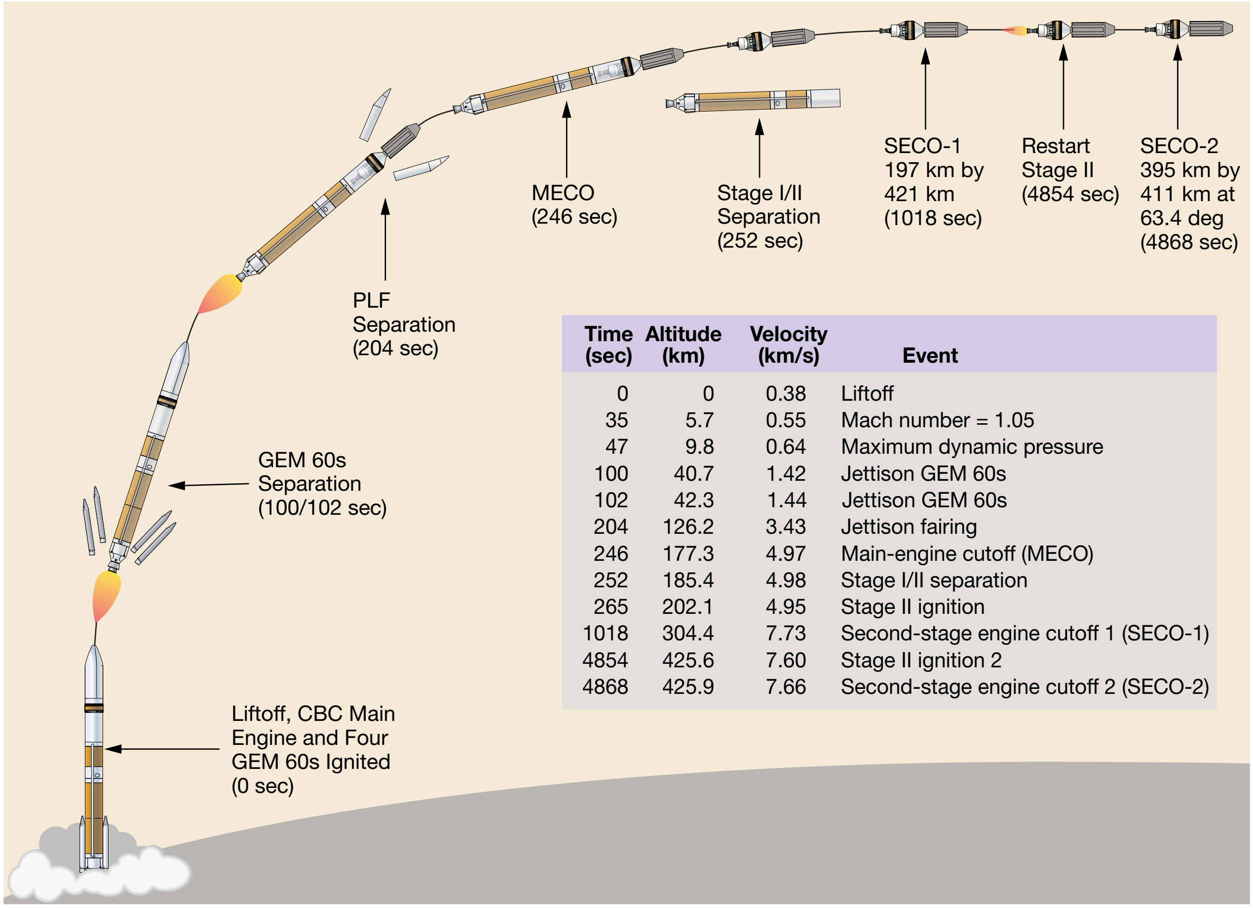


| Time (sec) | Altitude (km) | Velocity (km/s) | Event |
|---|---|---|---|
| 0 | 0 | 0.38 | Liftoff |
| 35 | 5.7 | 0.55 | Mach number = 1.05 |
| 47 | 9.8 | 0.64 | Maximum dynamic pressure |
| 100 | 40.7 | 1.42 | Jettison GEM 60s |
| 102 | 42.3 | 1.44 | Jettison GEM 60s |
| 204 | 126.2 | 3.43 | Jettison 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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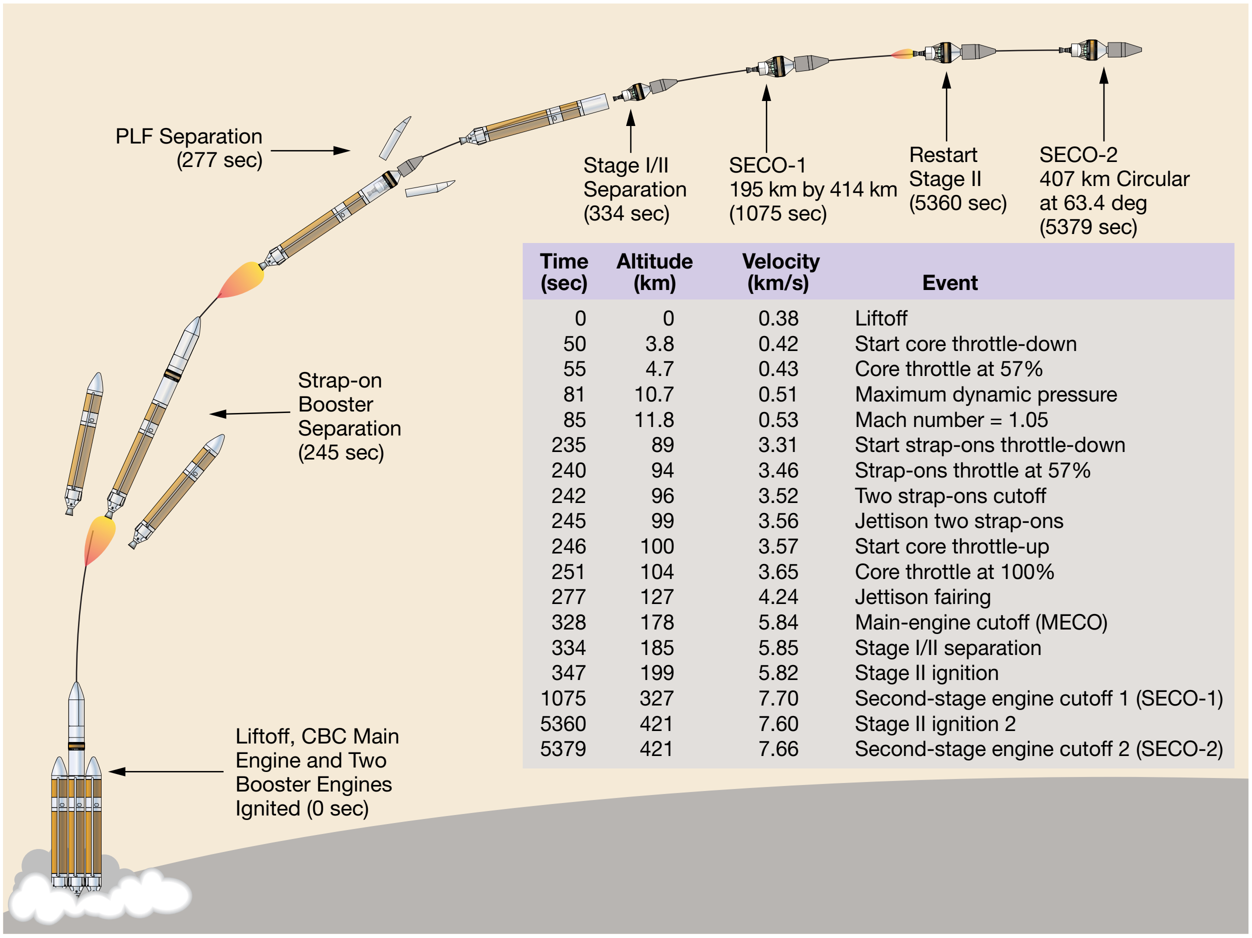


| Time (sec) | Altitude (km) | Velocity (km/s) | Event |
|---|---|---|---|
| 0 | 0 | 0.38 | Liftoff |
| 50 | 3.8 | 0.42 | Start core throttle-down |
| 55 | 4.7 | 0.43 | Core throttle at 57% |
| 81 | 10.7 | 0.51 | Maximum dynamic pressure |
| 85 | 11.8 | 0.53 | Mach number = 1.05 |
| 235 | 89 | 3.31 | Start strap-ons throttle-down |
| 240 | 94 | 3.46 | Strap-ons throttle at 57% |
| 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 100% |
| 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 H 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 7.2 hr.

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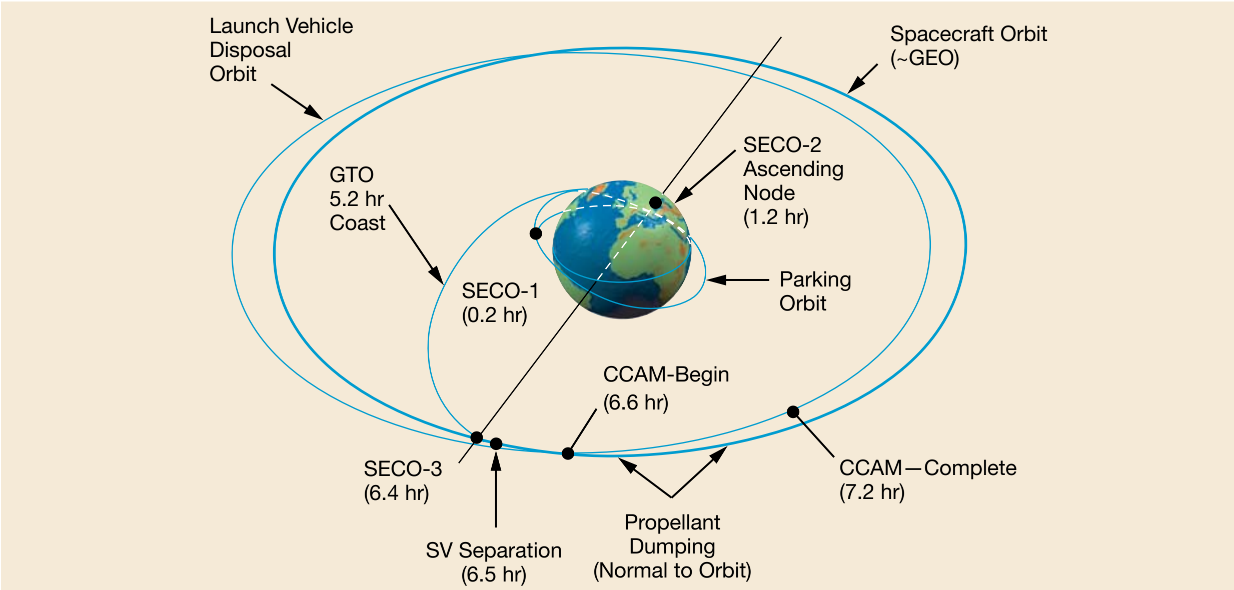



**Figure 2-7. Ascending Node GEO Mission Profile**

### 2.2.4 Multiple-Manifest Mission Profile

The Delta Program 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 the Delta Program Office for more information.

## 2.3 ORBITAL ACCURACY

All Delta IV configurations employ the Delta II-proven redundant inertial flight control assembly (RIFCA) system. This system provides precise pointing and orbit accuracy. Our heritage of inserting payloads into highly accurate orbits is well demonstrated. While successful Delta missions have inserted payloads to better than the 3-$\sigma$ orbit requirements, the achieved orbits of ten recent Delta II and Delta IV missions are presented in Figure 2-8 as a sampling of the effectiveness of our highly accurate avionics system.

| Mission | Launch date | Orbit Dispersions: Perigee Altitude (nmi) Predicted 3σ | Perigee Altitude (nmi) Achieved | Apogee Altitude (nmi) Predicted 3σ | Apogee Altitude (nmi) Achieved | Inclination (deg) Predicted 3σ | Inclination (deg) Achieved |
|---|---|---|---|---|---|---|---|
| **Delta II Two-Stage Missions** | | | | | | | |
| Gravity Probe-B | 4/20/2004 | +2.1 | +0.1 | +2.7 | +0.2 | -0.03 | -0.001 |
| Aura | 7/15/2004 | +1.6 | +0.2 | +3.0 | +0.6 | +0.03 | +0.002 |
| Swift | 11/20/2004 | -4.6 | -0.6 | +3.7 | +0.2 | +0.083 | +0.003 |
| NOAA-N | 4/20/2005 | -20.2 | -0.2 | +4.2 | +2.0 | +0.027 | +0.009 |
| CALIPSO/CloudSat | 4/28/2006 | +2.4 | +0.9 | +2.7 | +1.0 | +0.026 | +0.001 |
| **Delta IV Missions** | | | | | | | |
| W5 | 11/20/2002 | -1.7/+1.8 | +1.4 | +73 | -15 | +0.02 | -0.01 |
| DSCS III A3 | 3/03/2003 | -0.7/+2.2 | +1.2 | -72/+62 | +15 | ±0.013 | +0.00 |
| DSCS III B6 | 8/29/2003 | -0.7/+1.9 | +1.6 | -74/+60 | +23 | -0.013/+0.012 | +0.00 |
| GOES-N | 5/24/2006 | -11/+17 | +5 | -60/+66 | +13 | -0.04/+0.04 | +0.01 |
| NROL-22 | 6/27/2006 | -2.0/+2.2 | +1 | -55.3/+55.1 | +17 | -0.025/+0.024 | -0.002 |

**Figure 2-8. RIFCA 3-σ Orbit Accuracy—Recent Delta II and Delta IV Missions**

Figure 2-9 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 the Delta Program Office for further information.

| Orbit | Parameter | 3-σ Accuracy |
|---|---|---|
| **GTO**<br>185 km by 35 786 km at 27 deg<br>(100 nmi by 19,323 nmi at 27 deg)<br>Ascending node injection | Perigee altitude | ±5.6 km (±3.0 nmi) |
| | Apogee altitude | ±93 km (±50 nmi) |
| | Inclination | ±0.03 deg |
| **LEO**<br>500 km circular at 90 deg<br>(270 nmi circular at 90 deg) | Perigee altitude | ±7.4 km (±4.0 nmi) |
| | Apogee altitude | ±7.4 km (±4.0 nmi) |
| | Inclination | ±0.04 deg |
| **GEO**<br>35,786 km circular at 4 deg<br>(19,323 nmi circular at 4 deg) | Altitude | ±130 km (±70 nmi) |
| | Inclination | ±0.07 deg |
| | Eccentricity | ±0.005 |

002387.4

**Figure 2-9. 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 2-10. Descriptions and figure numbers of the detailed performance curves for both Eastern and Western Range launches are listed in Figure 2-11. The performance estimates include the following assumptions:

- Nominal Delta IV performance models from 2006 are used.
- No holdbacks 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 1135 W/m$^2$ (0.1 Btu/ft$^2$-sec).

| Spacecraft Mass Capabilities (Useful Load Mass)[1] | | | | | | |
|---|---|---|---|---|---|---|
| **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 | 1,348 kg (2,974 lb) | 2,208 kg (4,870 lb) | 2,105 kg (4,640 lb) | 3,116 kg (6,869 lb) | 6,573 kg (14,490 lb) |
| GTO (Without FTS Constraint)[3] | 35,786 x 185 km (19,323 x 100 nmi), 27.0 deg inclination | 4,541 kg (10,012 lb) | 6,267 kg (13,817 lb) | 5,433 kg (11,978 lb) | 7,434 kg (16,389 lb) | 13,399 kg (29,540 lb) |
| GTO (With FTS Constraint)[3] | 35,786 x 185 km (19,323 x 100 nmi), 27.0 deg inclination | 4,508 kg (9,938 lb) | 6,200 kg (13,669 lb) | 5,124 kg (11,297 lb) | 6,905 kg (15,222 lb) | 13,248 kg (29,205 lb) |
| LEO | 407 x 407 km (220 x 220 nmi), 28.7 deg inclination | 9,390 kg (20,702 lb) | 12,477 kg (27,507 lb) | 11,062 kg (24,387 lb) | 13,774 kg (30,365 lb) | 22,977 kg (50,656 lb) |
| LEO (ISS) | 407 x 407 km (220 x 220 nmi), 51.6 deg inclination | 8,809 kg (19,422 lb) | 11,915 kg (26,268 lb) | 10,582 kg (23,329 lb) | 13,452 kg (29,656 lb) | 22,977 kg (50,656 lb) |
| LEO (Polar; VAFB) | 407 x 407 km (220 x 220 nmi), 90.0 deg inclination | 7,746 kg (17,078 lb) | 10,441 kg (23,019 lb) | 9,094 kg (20,048 lb) | 11,721 kg (25,840 lb) | 21,556 kg (47,522 lb) |
| LEO (Weather; VAFB) | 833 x 833 km (450 x 450 nmi), 98.7 deg inclination | 7,087 kg (15,625 lb) | 9,586 kg (21,134 lb) | 8,327 kg (18,358 lb) | 10,820 kg (23,854 lb) | 19,839 kg (43,737 lb) |
| GPS (Transfer) | 20,368 x 185 km (10,998 x 100 nmi), 39.0 deg inclination | 5,021 kg (11,070 lb) | 7,038 kg (15,517 lb) | 5,698 kg (12,562 lb) | 7,322 kg (16,141 lb) | 14,606 kg (32,201 lb) |
| GPS (Direct)[4] | 20,368 x 20,368 km (10,998 x 10,998 nmi), 55.0 deg inclination | 1,988 kg (4,385 lb) | 2,986 kg (6,583 lb) | 2,823 kg (6,224 lb) | 4,057 kg (8,944 lb) | 7,986 kg (17,607 lb) |
| Molniya (VAFB) | 40,094 x 370 km (21,649 x 200 nmi), 63.4 deg inclination | 3,908 kg (8,617 lb) | 5,351 kg (11,798 lb) | 4,668 kg (10,291 lb) | 6,211 kg (13,693 lb) | 11,655 kg (25,695 lb) |
| C3 (-2.0 $km^2/sec^2$) | 185-km (100-nmi) Perigee, 28.7 deg inclination | 3,437 kg (7,578 lb) | 4,815 kg (10,616 lb) | 4,011 kg (8,842 lb) | 5,579 kg (12,299 lb) | 10,745 kg (23,688 lb) |
| C3 (-0.6 $km^2/sec^2$) | 185-km (100-nmi) Perigee, 28.7 deg inclination | 3,341 kg (7,366 lb) | 4,690 kg (10,341 lb) | 3,903 kg (8,603 lb) | 5,447 kg (12,008 lb) | 10,505 kg (23,159 lb) |
| C3 (0.0 $km^2/sec^2$) | 185-km (100-nmi) Perigee, 28.7 deg inclination | 3,300 kg (7,276 lb) | 4,638 kg (10,225 lb) | 3,857 kg (8,502 lb) | 5,391 kg (11,886 lb) | 10,403 kg (22,934 lb) |
| C3 (10.0 $km^2/sec^2$) | 185-km (100-nmi) Perigee, 28.7 deg inclination | 2,669 kg (5,884 lb) | 3,825 kg (8,434 lb) | 3,141 kg (6,925 lb) | 4,519 kg (9,963 lb) | 8,808 kg (19,418 lb) |
| C3 (20.0 $km^2/sec^2$) | 185-km (100-nmi) Perigee, 28.7 deg inclination | 2,116 kg (4,665 lb) | 3,123 kg (6,886 lb) | 2,514 kg (5,542 lb) | 3,740 kg (8,245 lb) | 7,414 kg (16,346 lb) |

Notes:
(1) Useful Load Mass - PAF Mass = Payload Mass; PAF masses listed in Section 5.1
(2) Descending Node Injection
(3) See Section 2.4.2 for more information on the Flight Termination System (FTS) constraint
(4) Southeast Descending Node Injection

**Figure 2-10. Delta IV Mission Capabilities**

| Figure Description | Delta IV Medium | Delta IV M+(4,2) | Delta IV M+(5,2) | Delta IV M+(5,4) | Delta IV Heavy |
|---|---|---|---|---|---|
| Low Earth Orbit (LEO) - ER | 2-12 | 2-13 | 2-14 | 2-15 | 2-16 |
| Medium Earth Orbit (MEO) - ER | 2-17 | 2-18 | 2-19 | 2-20 | 2-21 |
| Sub- and Super-Synchronous Transfer Orbit – ER | 2-22/2-23 | 2-24/2-25 | 2-26/2-27 | 2-28/2-29 | 2-30/2-31 |
| Geosynchronous Transfer Orbit (GTO) - ER | 2-32 | 2-33 | 2-34 | 2-35 | 2-36 |
| C3 Launch Energy - ER | 2-37 | 2-37 | 2-37 | 2-37 | 2-38 |
| Low Earth Orbit (LEO) - WR | 2-39 | 2-40 | 2-41 | 2-42 | 2-43 |

**Figure 2-11. 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 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 shown on the performance curves, and are also listed in Section 5.2.

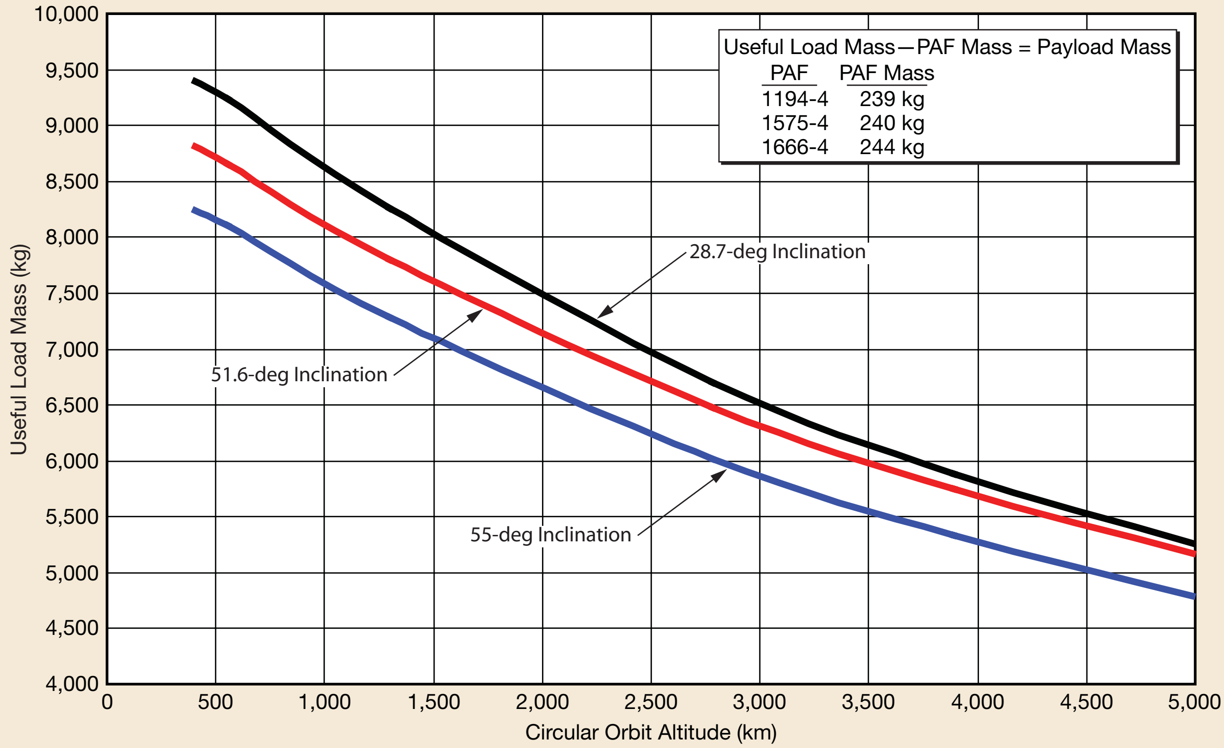
### 2.4.2 Flight Termination System Constraint (Eastern Range)

EWR 127-1, Range Safety Requirements, requires all launch vehicles originating from the Eastern Range (ER) to be equipped with a flight termination system (FTS) capable of terminating thrust and destroying the propulsive capability on all stages at any time during the flight up to orbital insertion. Current ER trajectories are designed to be within sight of a ground Range Safety command control tracking/telemetry station site to ensure that Range Safety has positive control of the vehicle until orbit is achieved. To meet this requirement, the current Delta IV ER trajectories are designed with an FTS constraint (i.e., radar elevation angle equals to or greater than 2 degrees above the horizon until SECO-1) which degrades the mass-to-orbit capability. All mission orbits flown from the ER are affected, with due East (GTO and GEO) missions having the largest impact to performance. The Delta Program is working with the 45th Space Wing to develop solutions that could mitigate the impact to vehicle performance on future missions. Until solutions are implemented, customers should use performance data with the FTS constraint for mission planning purposes. Figure 2-10 shows Delta IV performance to GTO with and without this FTS constraint. All other values in Figure 2-10, as well as the performance curves in Figures 2-12 through 2-38, include the FTS 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 7.2 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 $\Delta V$ to GEO than the standard two-burn mission profile. Figures 2-32 through 2-36 provide spacecraft $\Delta V$-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 SECO-1. The use of ground stations in place of TDRSS could constrain the upper 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 the Delta Program Office.

SHG0555905-001



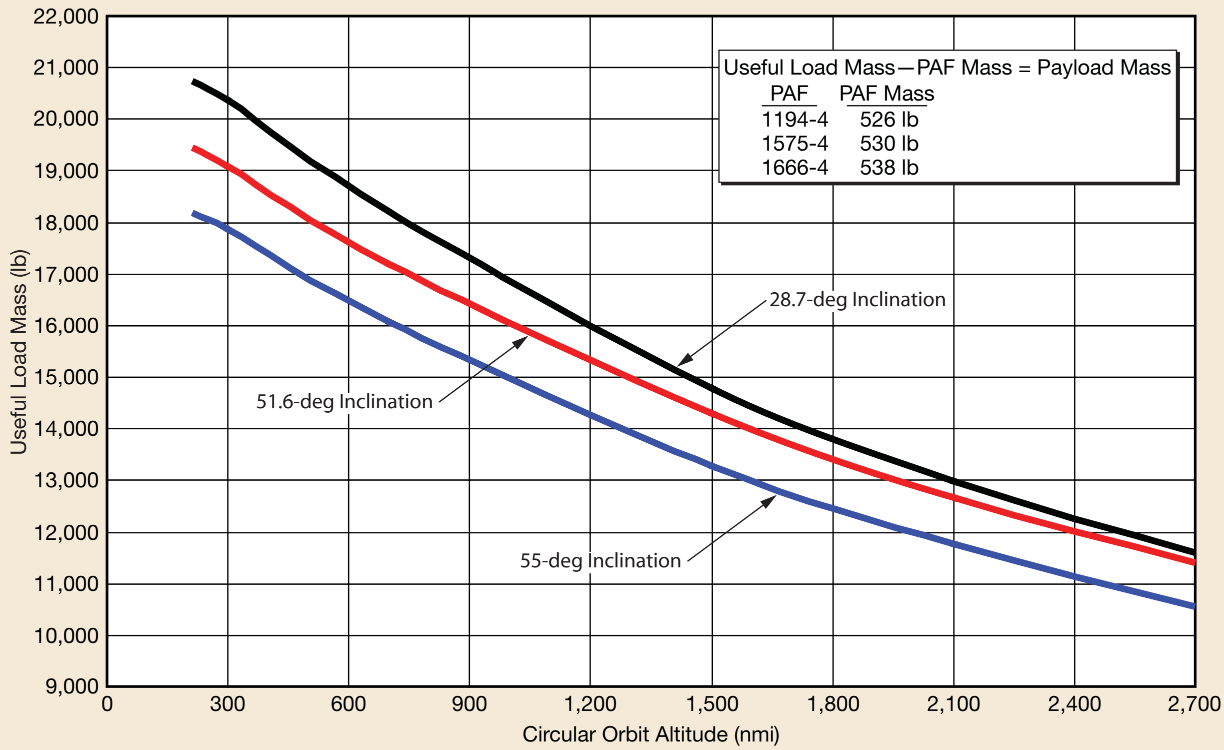




**Figure 2-12. Delta IV M—LEO Circular Orbit Capability (Eastern Range)**

SHG0555905-002

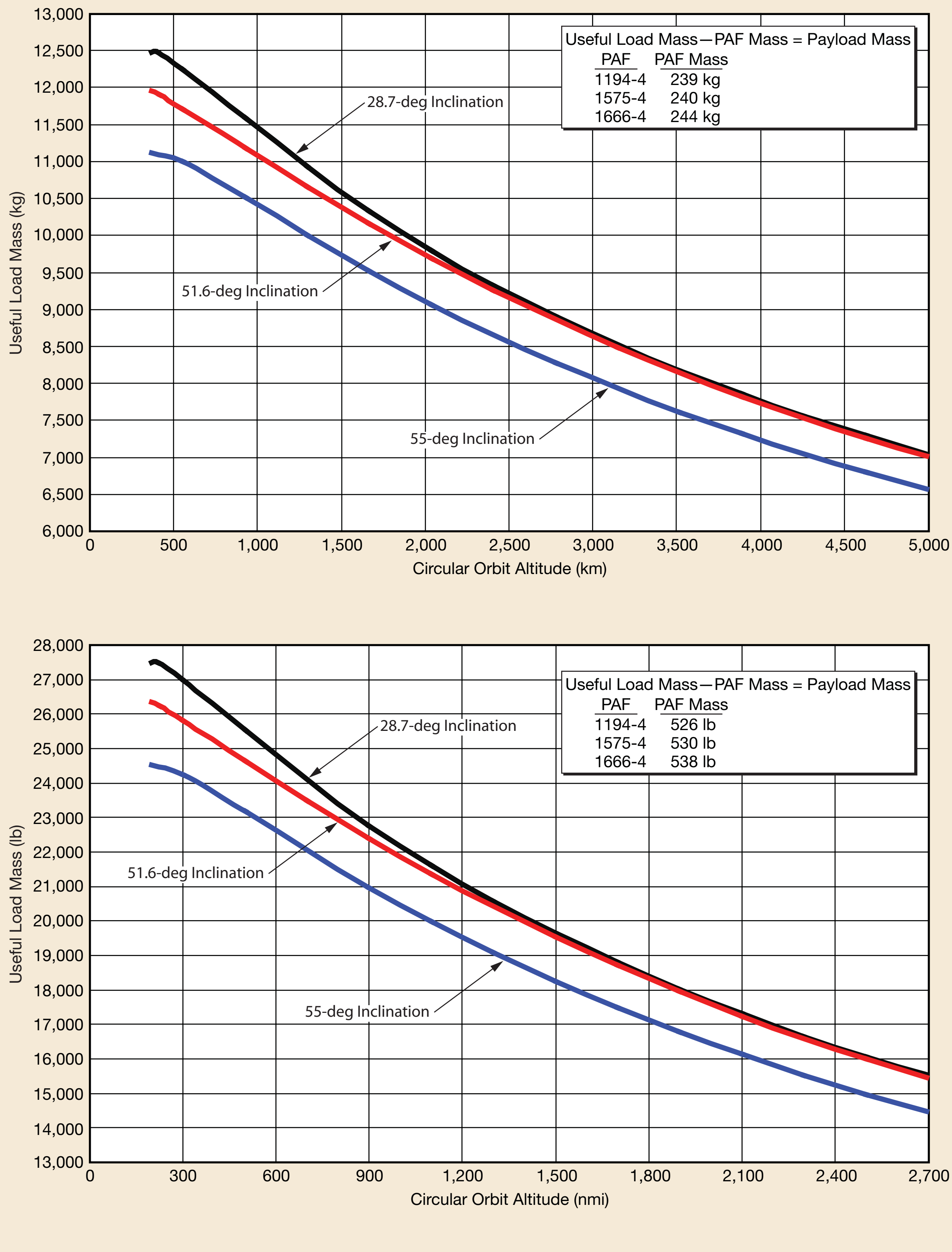



**Figure 2-13. Delta IV M+(4,2)—LEO Circular Orbit Capability (Eastern Range)**

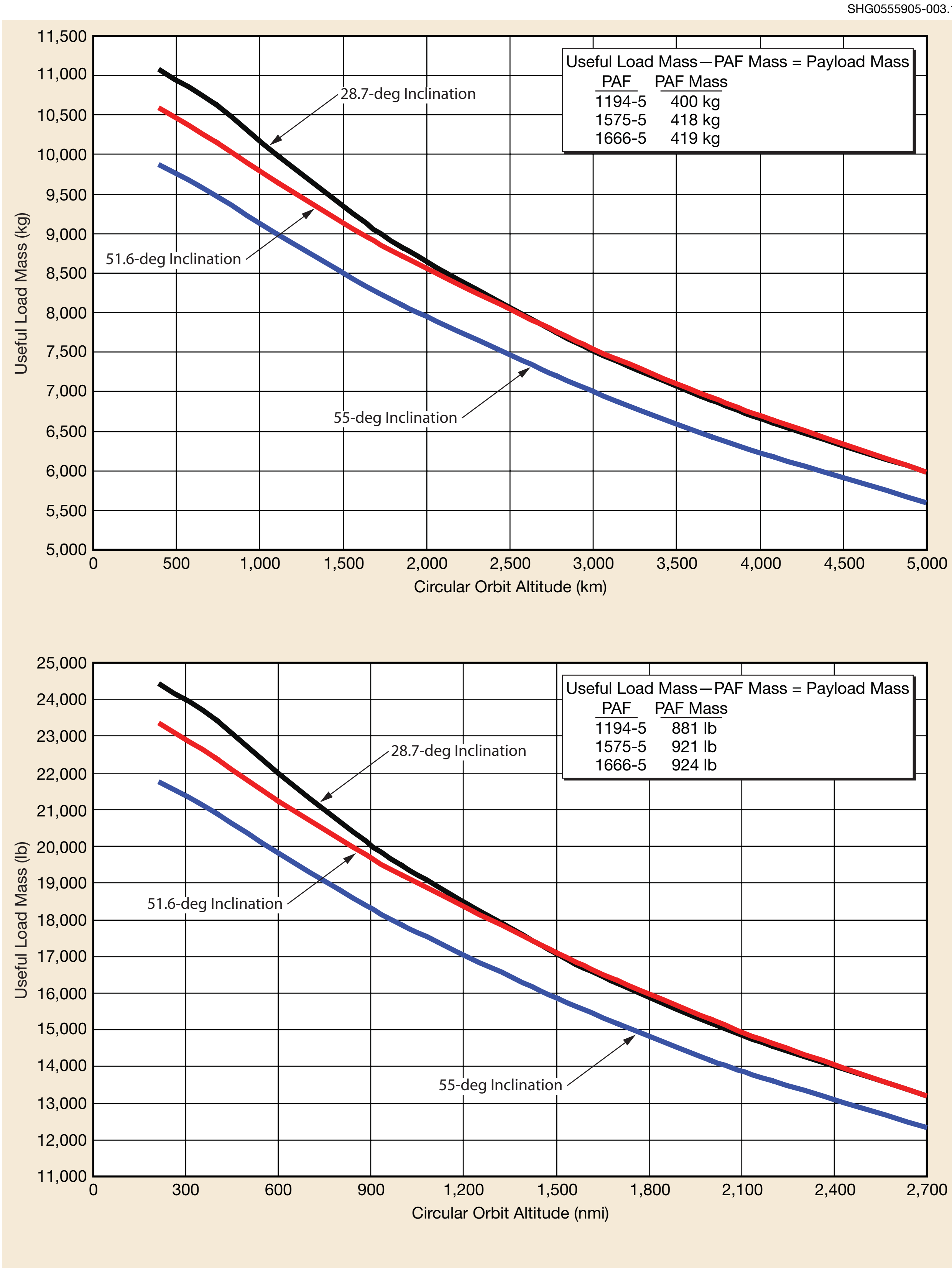



**Figure 2-14. Delta IV M+(5,2)—LEO Circular Orbit Capability (Eastern Range)**

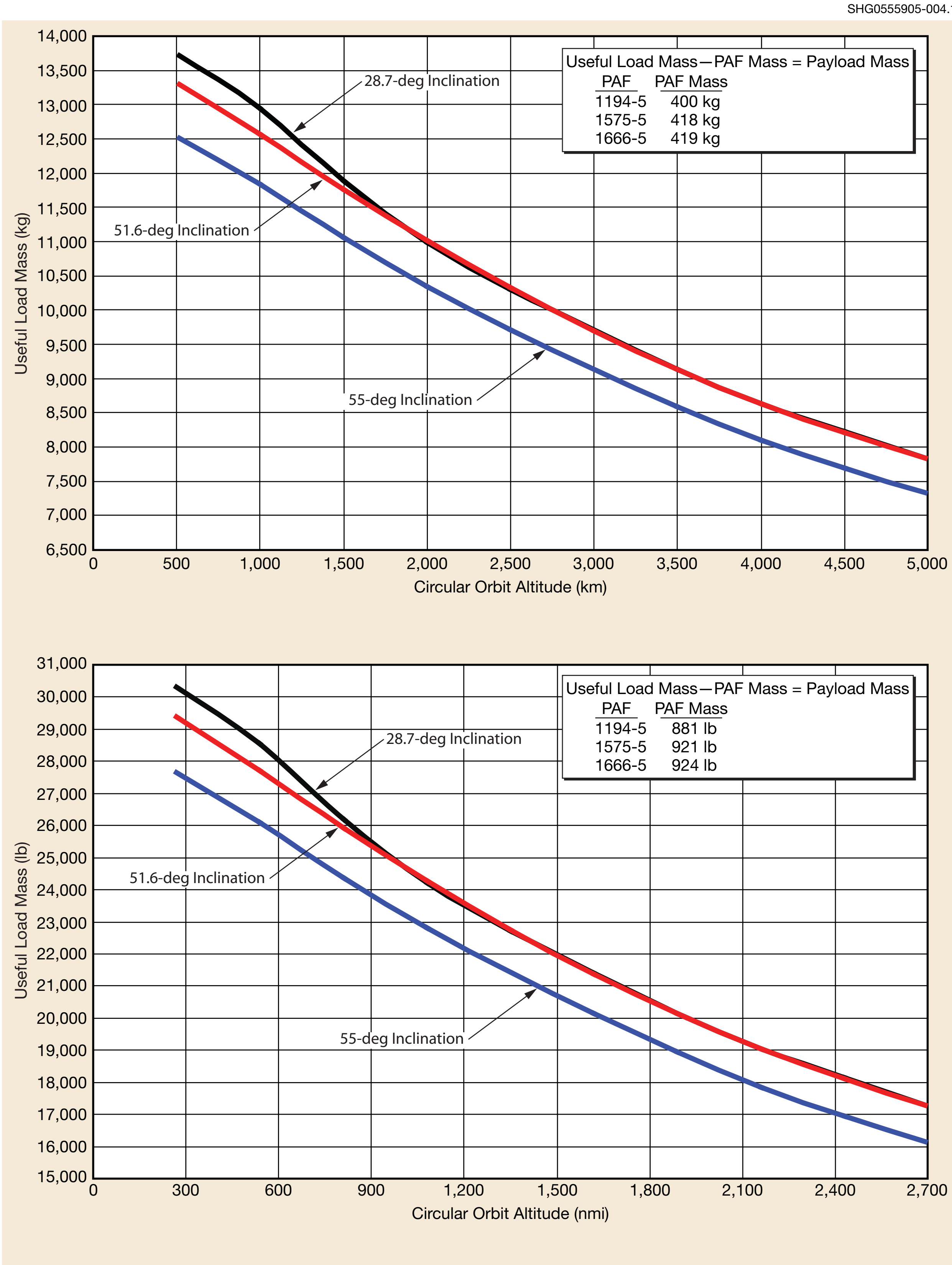



**Figure 2-15. Delta IV M+(5,4)—LEO Circular Orbit Capability (Eastern Range)**

SHG0555905-005.2

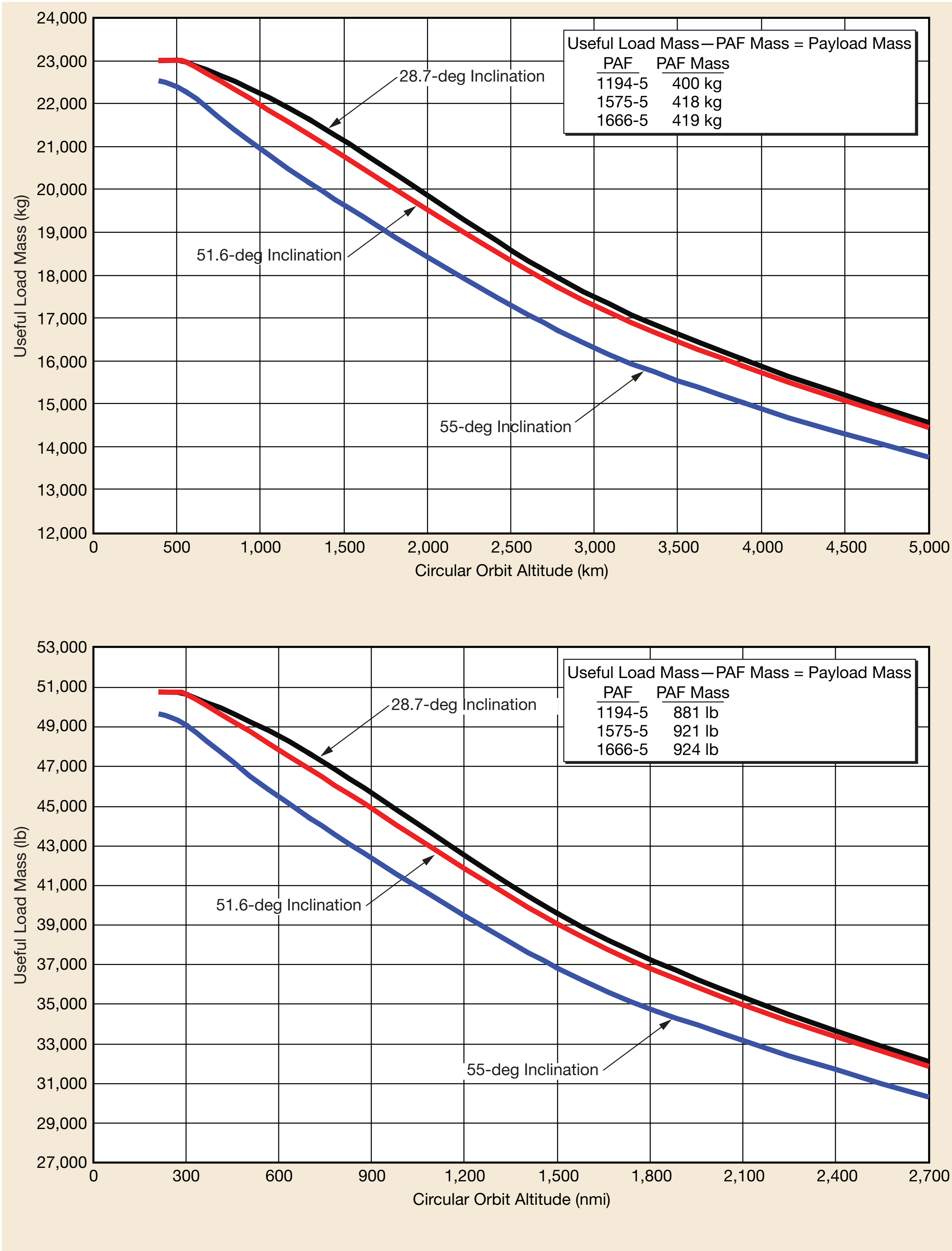



**Figure 2-16. Delta IV H—LEO Circular Orbit Capability (Eastern Range)**

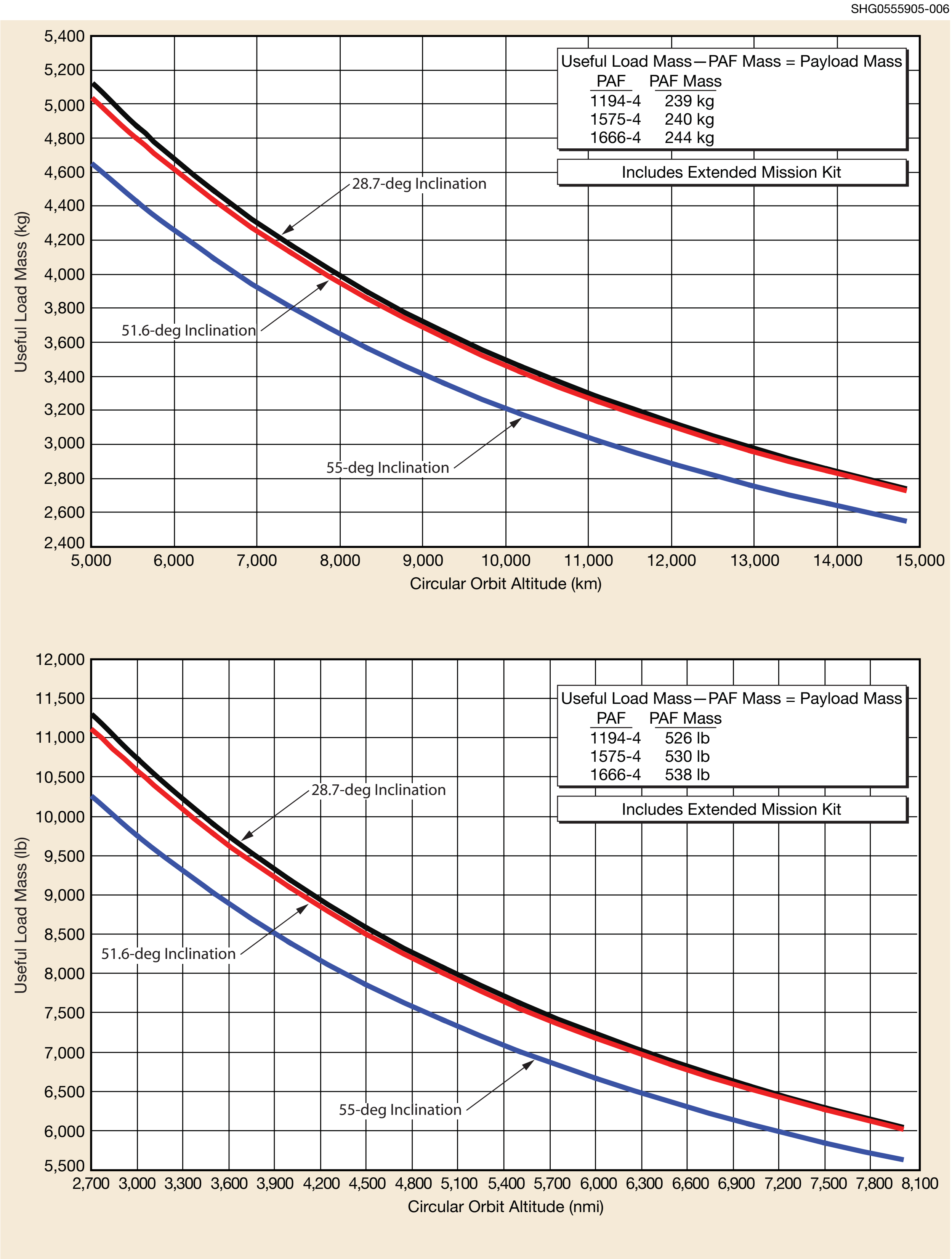
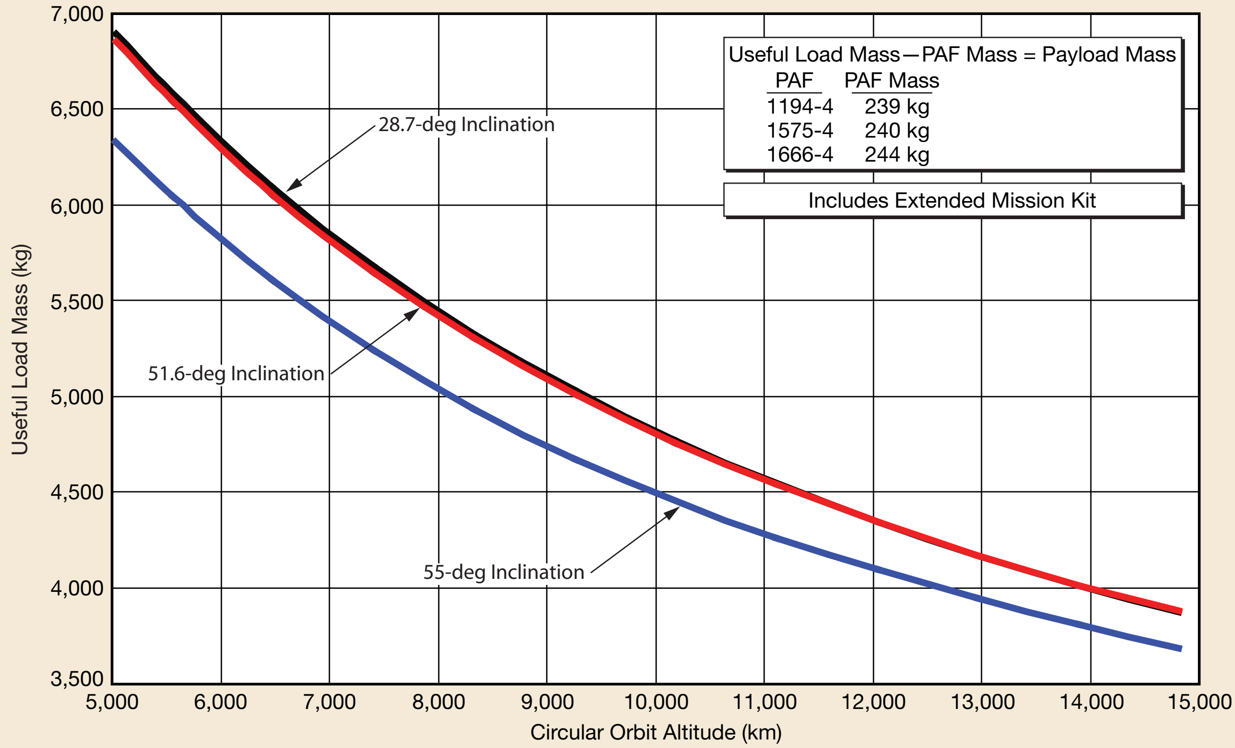



**Figure 2-17. Delta IV M—MEO Circular Orbit Capability (Eastern Range)**

SHG0555905-007



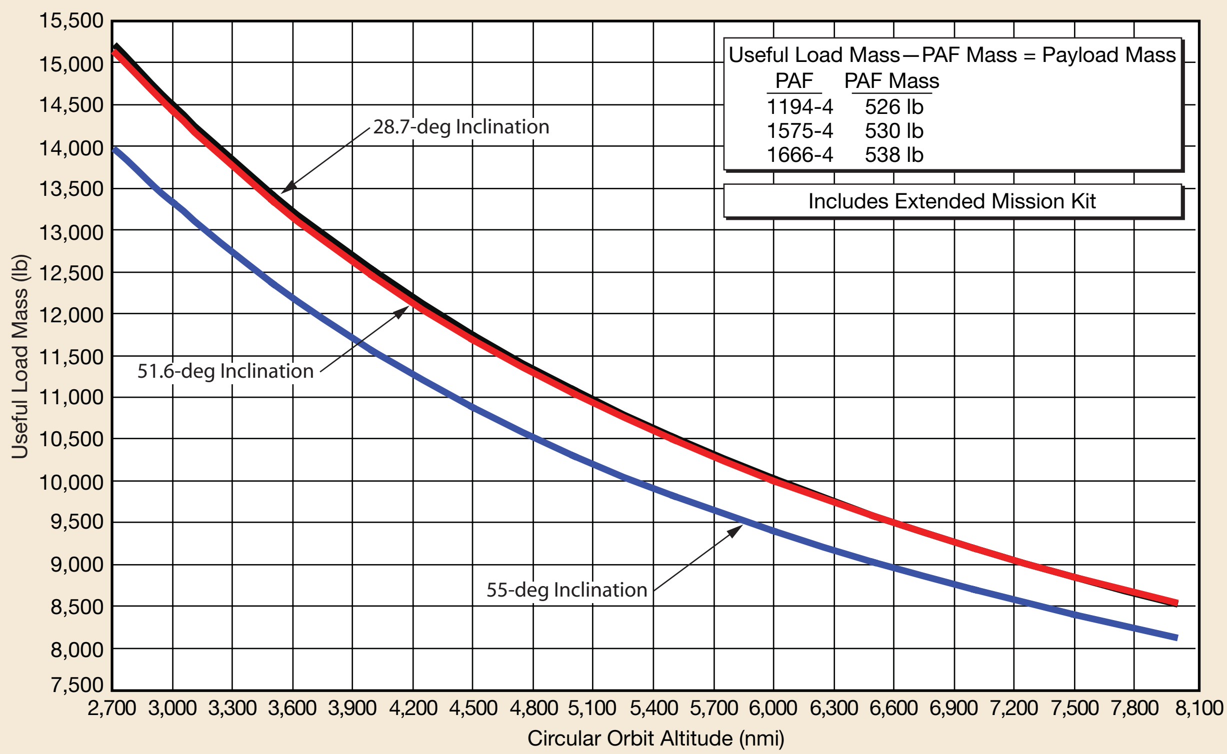
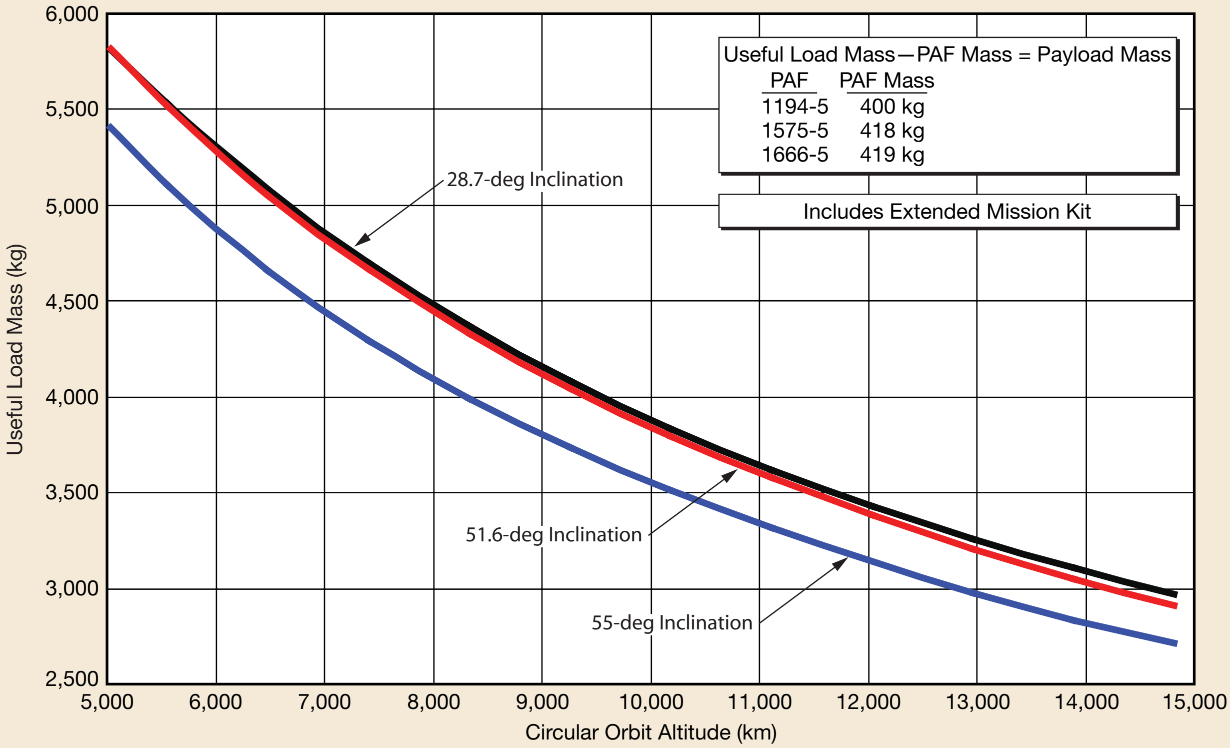




**Figure 2-18. Delta IV M+(4,2)—MEO Circular Orbit Capability (Eastern Range)**

SHG0555905-008.1



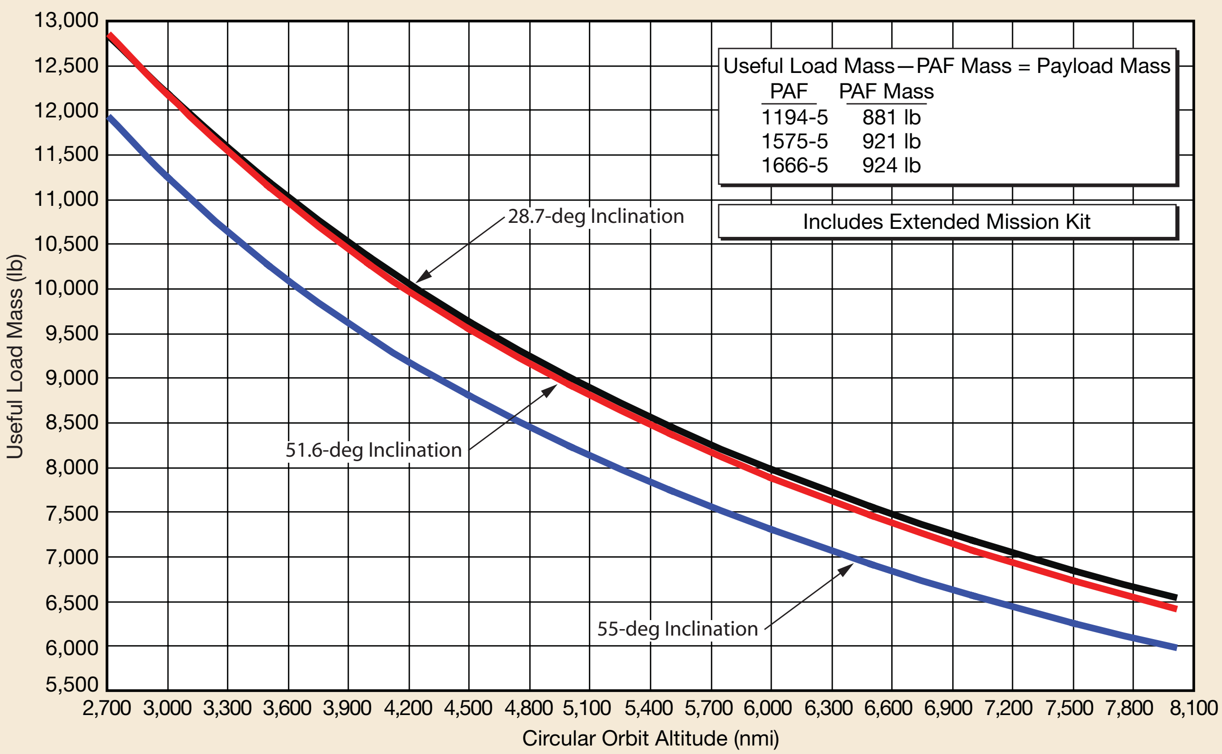




**Figure 2-19. Delta IV M+(5,2)—MEO Circular Orbit Capability (Eastern Range)**

SHG0555905-009.1

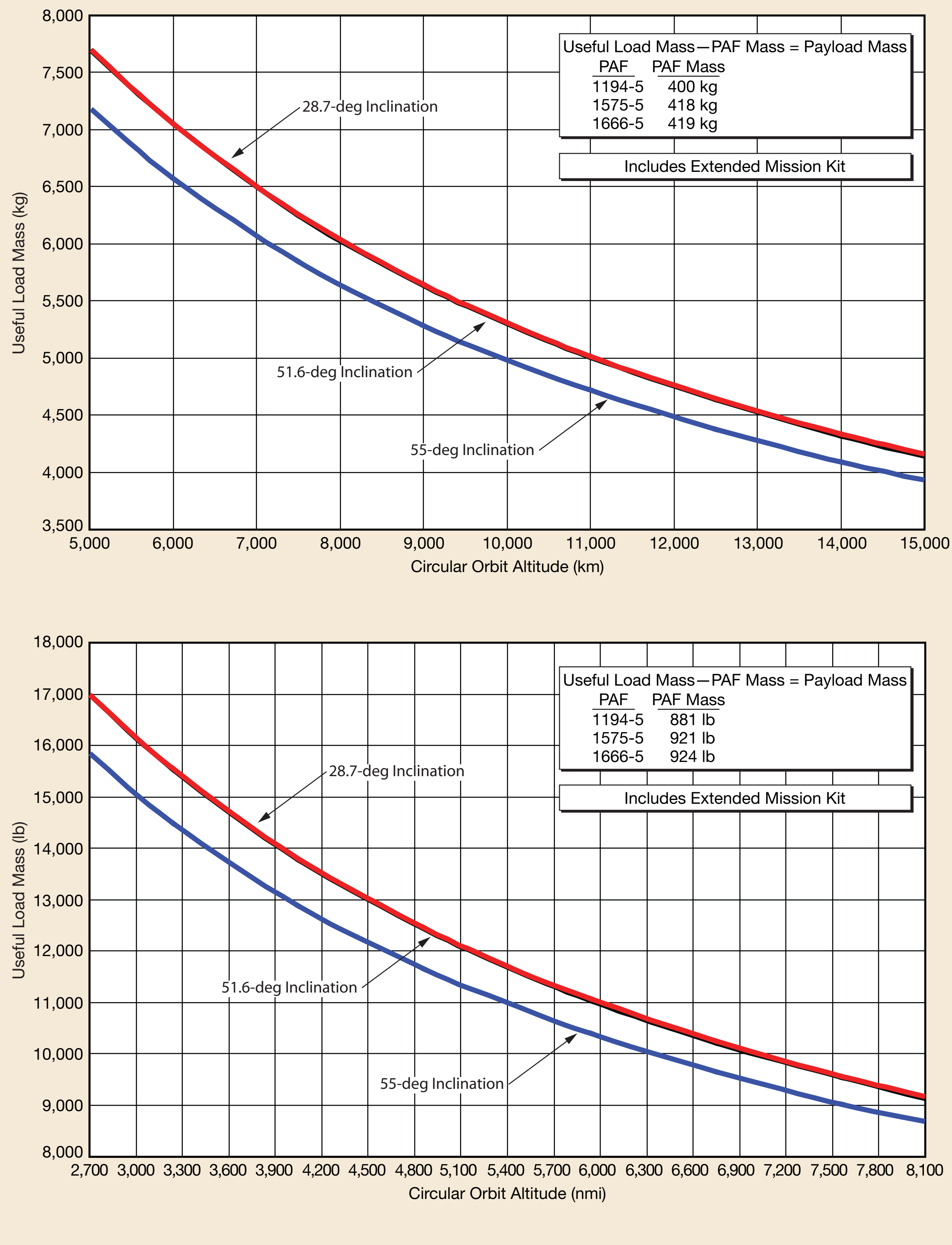
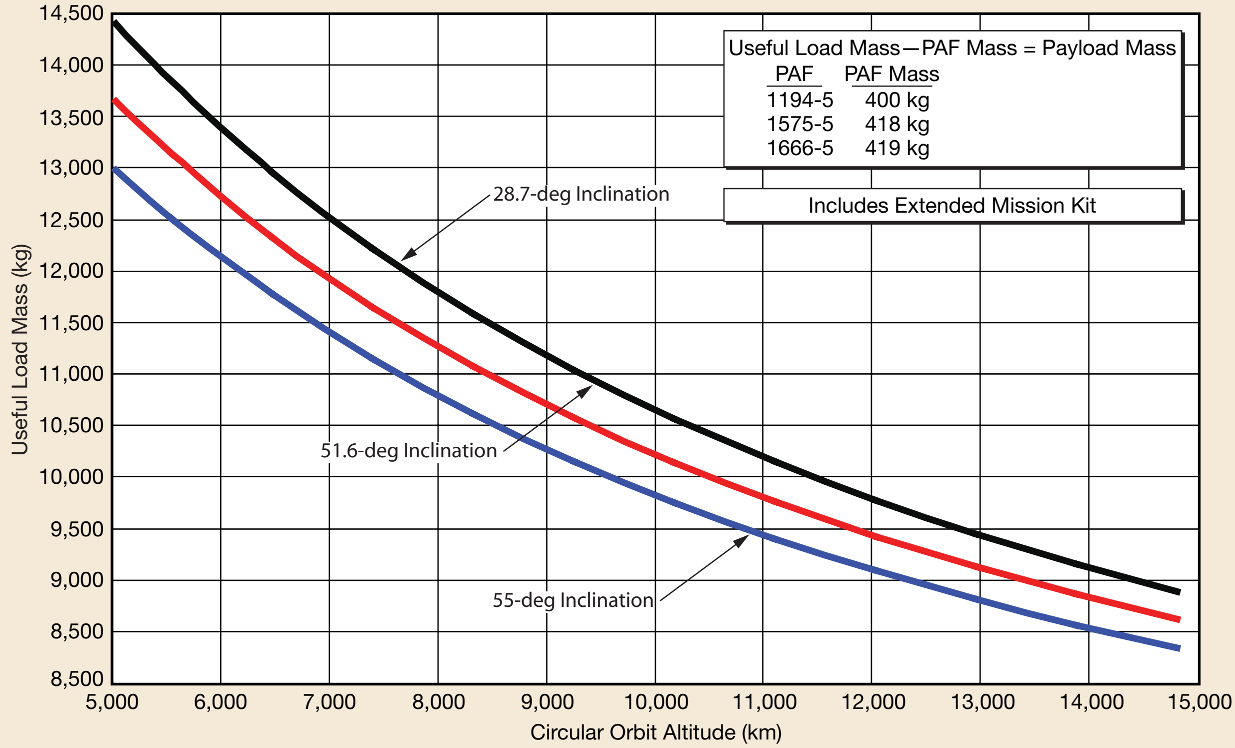



**Figure 2-20. Delta IV M+(5,4)—MEO Circular Orbit Capability (Eastern Range)**

SHG0555905-010.1



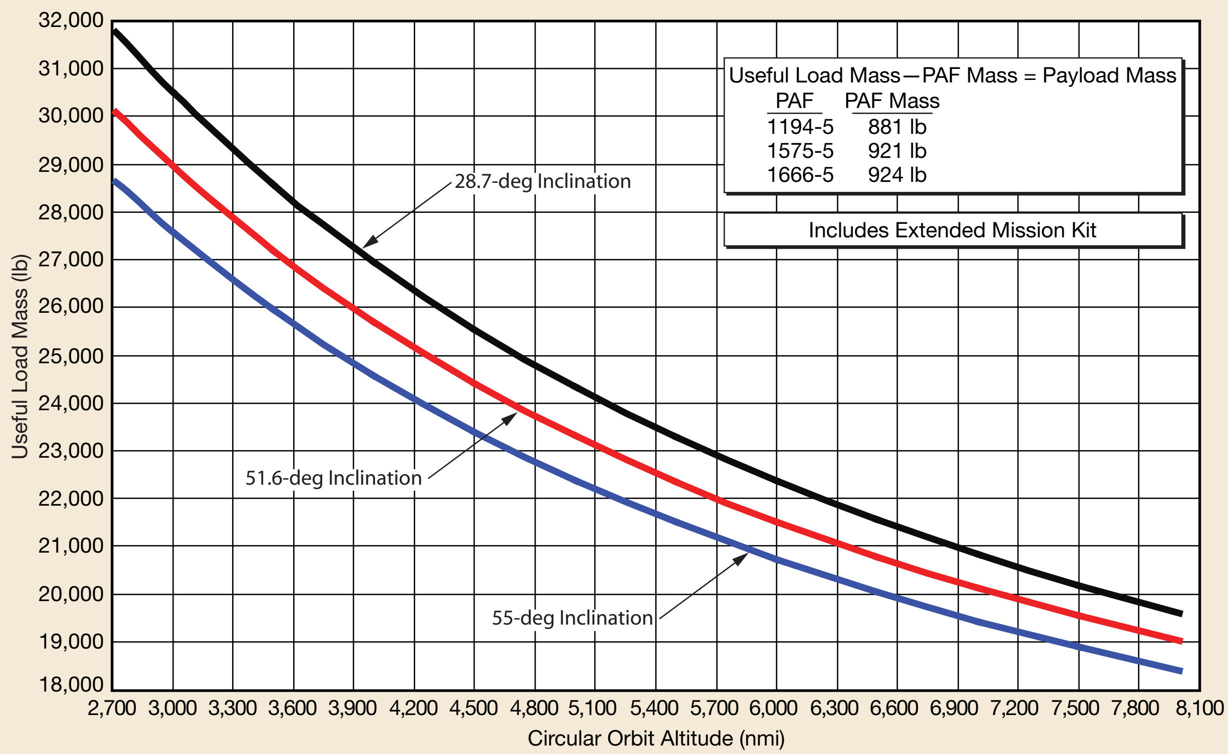
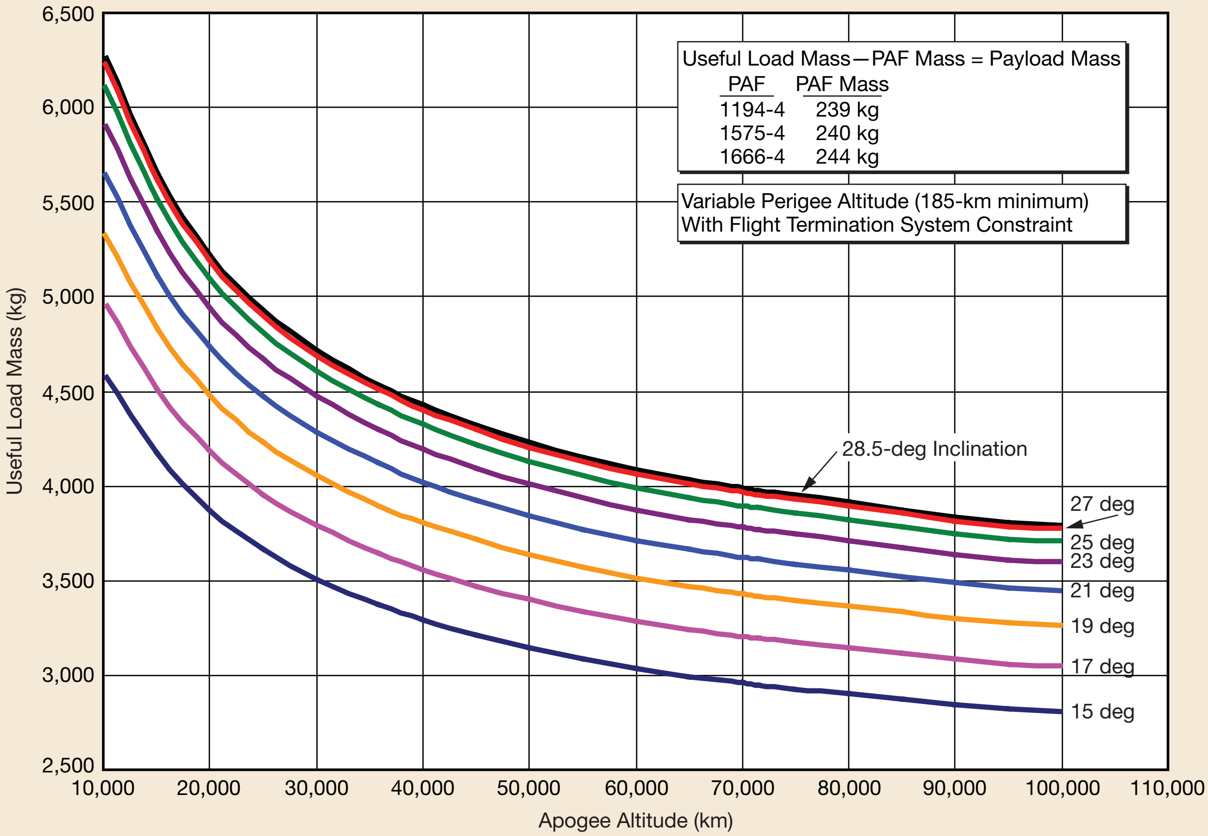




**Figure 2-21. Delta IV H—MEO Circular Orbit Capability (Eastern Range)**

SHG0555905-011.1

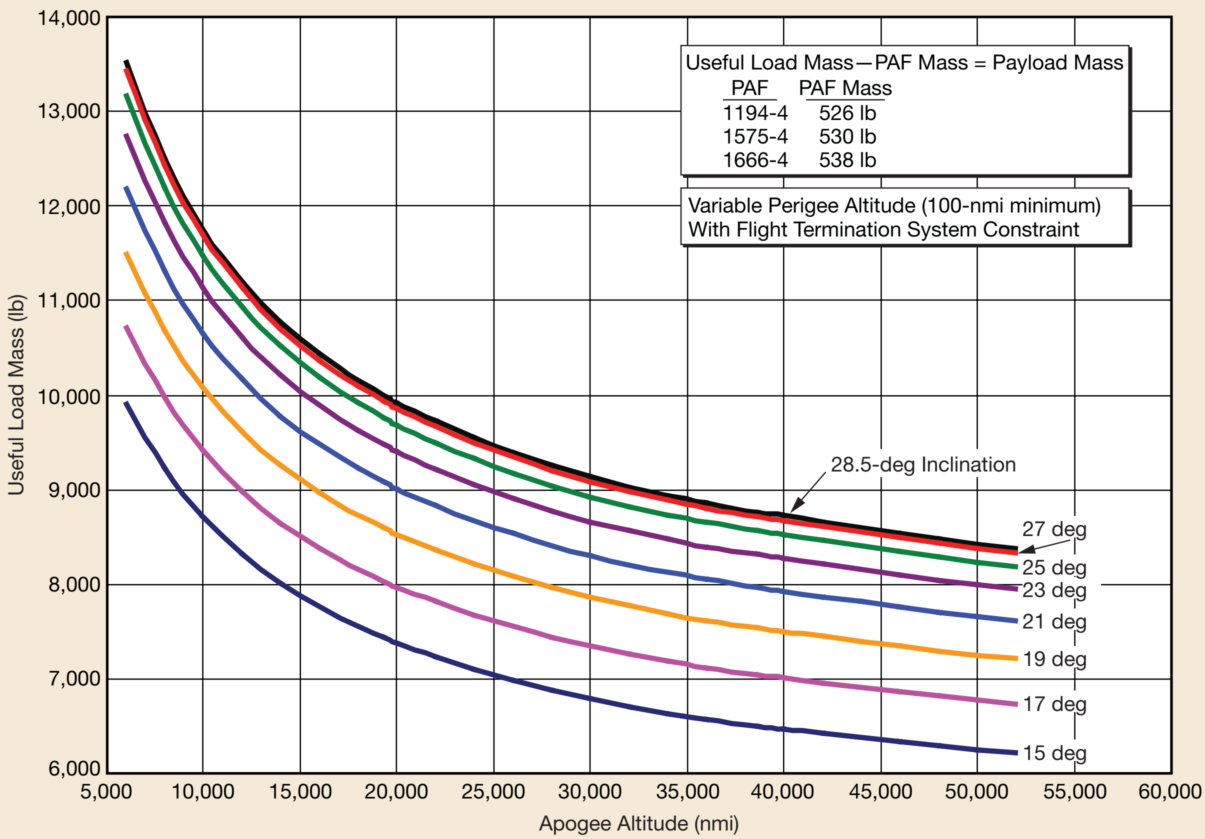



| Apogee Altitude (km)* | Useful Load Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **10,000** | 6,295 | 6,251 | 6,127 | 5,928 | 5,661 | 5,341 | 4,979 | 4,601 |
| **15,000** | 5,654 | 5,618 | 5,515 | 5,345 | 5,114 | 4,832 | 4,511 | 4,174 |
| **20,000** | 5,223 | 5,192 | 5,100 | 4,948 | 4,738 | 4,481 | 4,186 | 3,876 |
| **25,000** | 4,928 | 4,898 | 4,813 | 4,671 | 4,475 | 4,234 | 3,956 | 3,664 |
| **30,000** | 4,717 | 4,688 | 4,606 | 4,471 | 4,284 | 4,054 | 3,789 | 3,507 |
| **35,786** | 4,535 | 4,508 | 4,428 | 4,298 | 4,118 | 3,898 | 3,643 | 3,371 |
| **40,000** | 4,429 | 4,402 | 4,324 | 4,197 | 4,022 | 3,807 | 3,557 | 3,291 |
| **45,000** | 4,321 | 4,295 | 4,219 | 4,095 | 3,925 | 3,715 | 3,472 | 3,211 |
| **50,000** | 4,229 | 4,204 | 4,130 | 4,009 | 3,842 | 3,638 | 3,399 | 3,143 |
| **55,000** | 4,151 | 4,127 | 4,055 | 3,936 | 3,772 | 3,572 | 3,338 | 3,085 |
| **60,000** | 4,086 | 4,063 | 3,992 | 3,875 | 3,714 | 3,516 | 3,286 | 3,036 |
| **65,000** | 4,032 | 4,011 | 3,941 | 3,825 | 3,665 | 3,470 | 3,242 | 2,995 |
| **70,000** | 3,988 | 3,967 | 3,898 | 3,782 | 3,624 | 3,431 | 3,205 | 2,960 |
| **71,572** | 3,976 | 3,955 | 3,885 | 3,770 | 3,612 | 3,419 | 3,194 | 2,950 |
| **75,000** | 3,950 | 3,929 | 3,860 | 3,746 | 3,588 | 3,396 | 3,173 | 2,929 |
| **80,000** | 3,913 | 3,892 | 3,824 | 3,711 | 3,555 | 3,365 | 3,143 | 2,901 |
| **85,000** | 3,875 | 3,855 | 3,788 | 3,676 | 3,522 | 3,333 | 3,114 | 2,874 |
| **90,000** | 3,837 | 3,817 | 3,751 | 3,641 | 3,489 | 3,303 | 3,085 | 2,848 |
| **95,000** | 3,805 | 3,786 | 3,720 | 3,611 | 3,460 | 3,276 | 3,061 | 2,825 |
| **100,000** | 3,795 | 3,776 | 3,710 | 3,600 | 3,448 | 3,264 | 3,048 | 2,812 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-22. Delta IV M—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—Metric Units**

SHG0555905-012.1

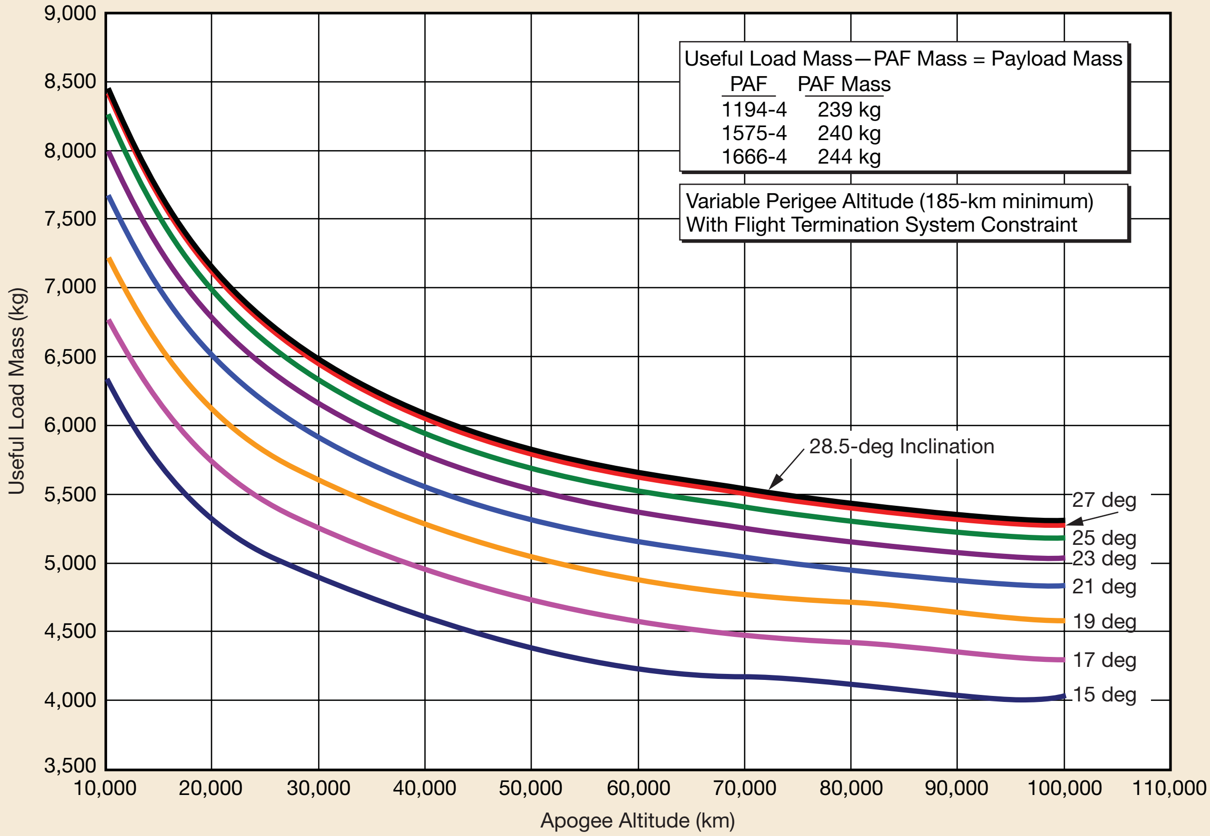



| Apogee Altitude (nmi)* | Useful Load Mass (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 13,515 | 13,423 | 13,160 | 12,740 | 12,173 | 11,488 | 10,714 | 9,904 |
| **8,000** | 12,509 | 12,429 | 12,199 | 11,825 | 11,312 | 10,688 | 9,977 | 9,233 |
| **10,000** | 11,760 | 11,688 | 11,479 | 11,135 | 10,660 | 10,080 | 9,416 | 8,717 |
| **12,000** | 11,198 | 11,131 | 10,934 | 10,611 | 10,163 | 9,615 | 8,983 | 8,319 |
| **14,000** | 10,768 | 10,703 | 10,515 | 10,206 | 9,778 | 9,252 | 8,646 | 8,006 |
| **16,000** | 10,430 | 10,367 | 10,185 | 9,886 | 9,472 | 8,964 | 8,377 | 7,755 |
| **18,000** | 10,156 | 10,094 | 9,916 | 9,625 | 9,223 | 8,729 | 8,157 | 7,550 |
| **19,323** | 9,999 | 9,938 | 9,763 | 9,477 | 9,080 | 8,594 | 8,032 | 7,432 |
| **20,000** | 9,925 | 9,865 | 9,691 | 9,406 | 9,013 | 8,531 | 7,972 | 7,377 |
| **22,000** | 9,726 | 9,668 | 9,497 | 9,218 | 8,833 | 8,361 | 7,814 | 7,228 |
| **24,000** | 9,551 | 9,494 | 9,327 | 9,053 | 8,675 | 8,212 | 7,675 | 7,097 |
| **26,000** | 9,395 | 9,340 | 9,176 | 8,906 | 8,535 | 8,080 | 7,551 | 6,982 |
| **28,000** | 9,256 | 9,203 | 9,042 | 8,777 | 8,411 | 7,964 | 7,442 | 6,880 |
| **30,000** | 9,134 | 9,083 | 8,924 | 8,663 | 8,302 | 7,860 | 7,345 | 6,789 |
| **32,000** | 9,028 | 8,978 | 8,822 | 8,563 | 8,206 | 7,769 | 7,260 | 6,709 |
| **34,000** | 8,936 | 8,888 | 8,732 | 8,476 | 8,122 | 7,690 | 7,185 | 6,638 |
| **36,000** | 8,856 | 8,809 | 8,655 | 8,400 | 8,049 | 7,620 | 7,119 | 6,576 |
| **38,646** | 8,766 | 8,720 | 8,567 | 8,313 | 7,965 | 7,539 | 7,043 | 6,504 |
| **40,000** | 8,724 | 8,678 | 8,525 | 8,273 | 7,926 | 7,502 | 7,008 | 6,471 |
| **42,000** | 8,663 | 8,618 | 8,466 | 8,215 | 7,870 | 7,449 | 6,958 | 6,424 |
| **44,000** | 8,603 | 8,558 | 8,408 | 8,159 | 7,816 | 7,398 | 6,910 | 6,380 |
| **46,000** | 8,541 | 8,496 | 8,348 | 8,101 | 7,762 | 7,347 | 6,863 | 6,336 |
| **48,000** | 8,478 | 8,434 | 8,288 | 8,044 | 7,708 | 7,297 | 6,816 | 6,293 |
| **50,000** | 8,419 | 8,377 | 8,232 | 7,991 | 7,657 | 7,250 | 6,773 | 6,252 |
| **52,000** | 8,376 | 8,335 | 8,191 | 7,950 | 7,618 | 7,213 | 6,738 | 6,218 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-23. Delta IV M—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—English Units**

SHG0555905-013.2

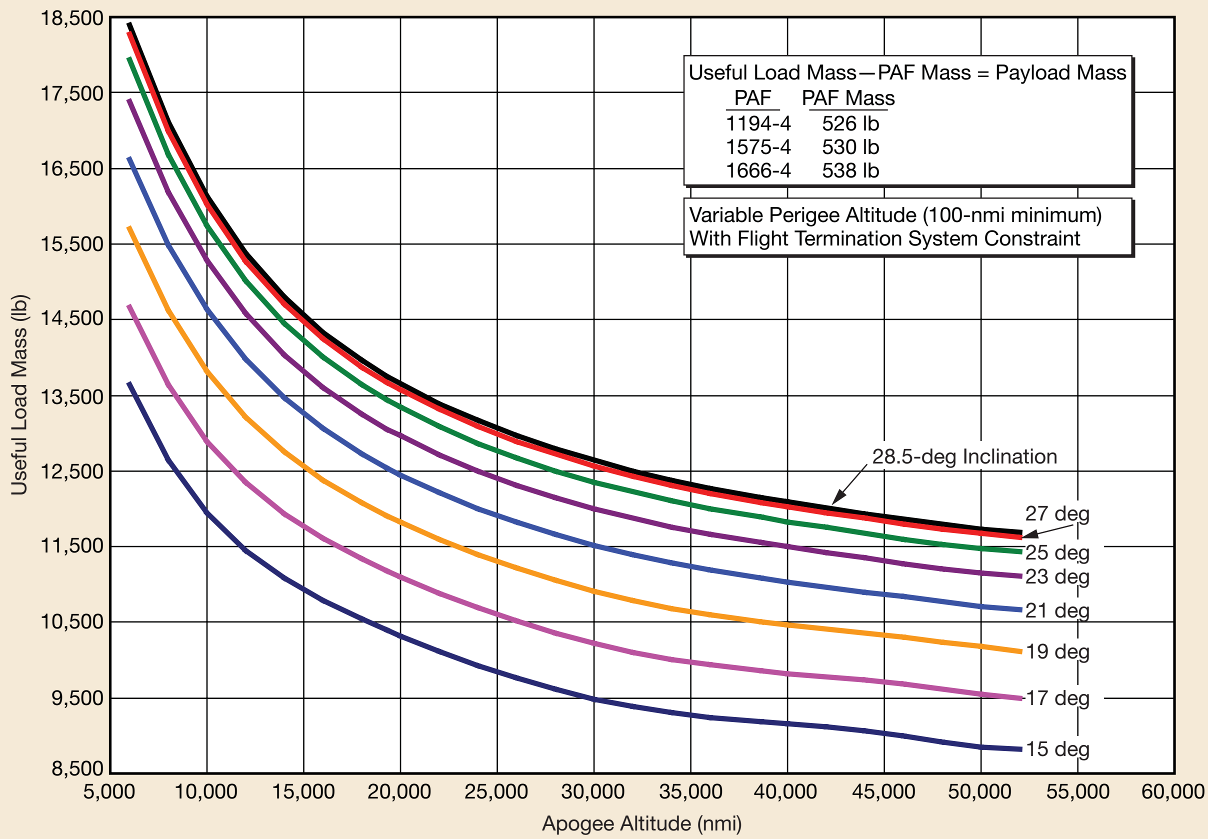



| Apogee Altitude (km)* | Useful Load Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **10,000** | 8,551 | 8,493 | 8,333 | 8,075 | 7,723 | 7,296 | 6,826 | 6,356 |
| **15,000** | 7,737 | 7,681 | 7,545 | 7,320 | 7,005 | 6,610 | 6,166 | 5,714 |
| **20,000** | 7,170 | 7,120 | 6,997 | 6,795 | 6,509 | 6,149 | 5,739 | 5,319 |
| **25,000** | 6,771 | 6,726 | 6,612 | 6,424 | 6,160 | 5,830 | 5,454 | 5,064 |
| **30,000** | 6,482 | 6,442 | 6,333 | 6,154 | 5,906 | 5,600 | 5,250 | 4,882 |
| **35,786** | 6,236 | 6,200 | 6,094 | 5,921 | 5,687 | 5,398 | 5,068 | 4,714 |
| **40,000** | 6,096 | 6,061 | 5,957 | 5,788 | 5,559 | 5,278 | 4,956 | 4,607 |
| **45,000** | 5,957 | 5,923 | 5,821 | 5,656 | 5,431 | 5,154 | 4,837 | 4,492 |
| **50,000** | 5,841 | 5,807 | 5,708 | 5,545 | 5,323 | 5,048 | 4,733 | 4,392 |
| **55,000** | 5,743 | 5,709 | 5,613 | 5,453 | 5,232 | 4,958 | 4,644 | 4,310 |
| **60,000** | 5,659 | 5,627 | 5,532 | 5,375 | 5,156 | 4,884 | 4,573 | 4,248 |
| **65,000** | 5,588 | 5,557 | 5,465 | 5,310 | 5,093 | 4,824 | 4,520 | 4,205 |
| **70,000** | 5,527 | 5,498 | 5,407 | 5,255 | 5,041 | 4,778 | 4,481 | 4,175 |
| **71,572** | 5,510 | 5,481 | 5,391 | 5,239 | 5,027 | 4,765 | 4,470 | 4,167 |
| **75,000** | 5,475 | 5,446 | 5,356 | 5,206 | 4,997 | 4,740 | 4,451 | 4,149 |
| **80,000** | 5,427 | 5,399 | 5,309 | 5,160 | 4,957 | 4,707 | 4,423 | 4,120 |
| **85,000** | 5,382 | 5,354 | 5,263 | 5,116 | 4,917 | 4,673 | 4,392 | 4,081 |
| **90,000** | 5,341 | 5,312 | 5,221 | 5,075 | 4,878 | 4,636 | 4,354 | 4,037 |
| **95,000** | 5,307 | 5,278 | 5,190 | 5,044 | 4,845 | 4,599 | 4,315 | 4,005 |
| **100,000** | 5,291 | 5,267 | 5,186 | 5,039 | 4,830 | 4,572 | 4,291 | 4,027 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-24. Delta IV M+(4,2)—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—Metric Units**

SHG0555905-014.1

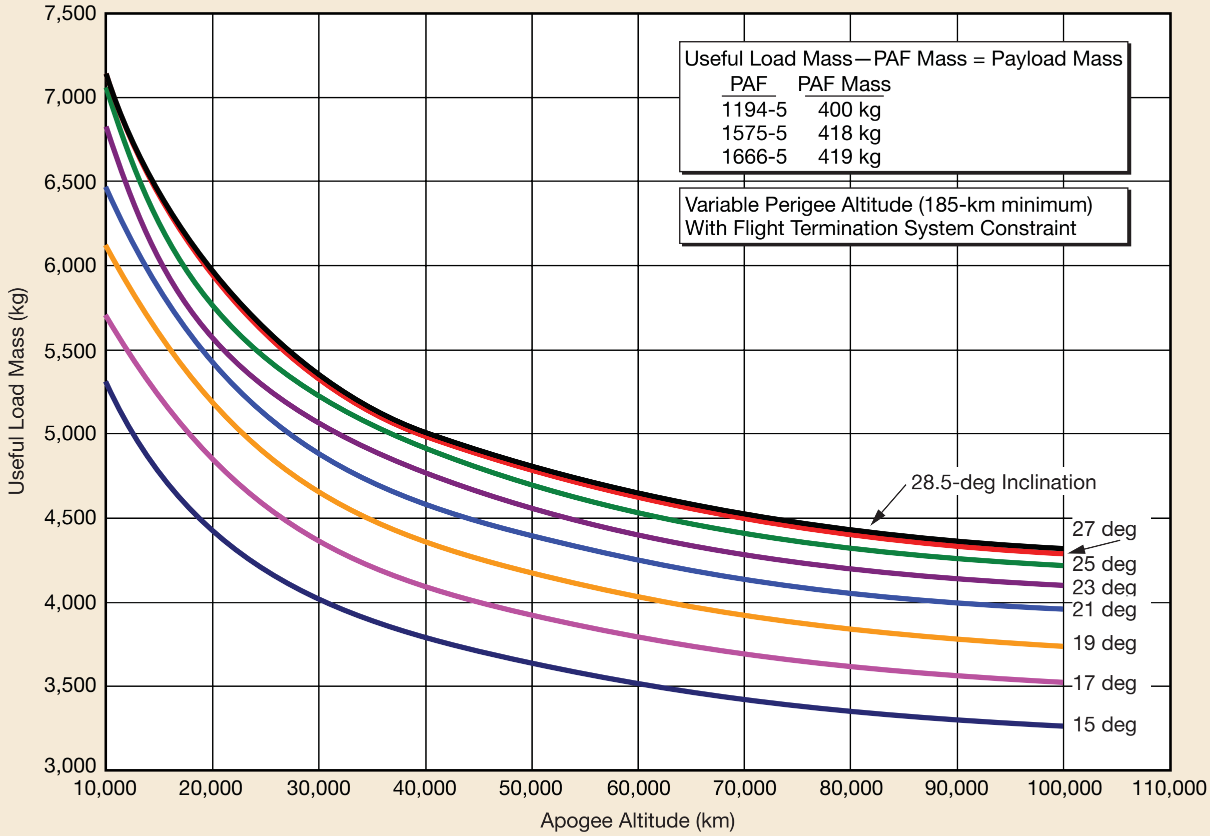



| Apogee Altitude (nmi)* | Useful Load Mass (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 18,395 | 18,267 | 17,929 | 17,379 | 16,622 | 15,696 | 14,668 | 13,636 |
| **8,000** | 17,114 | 16,990 | 16,687 | 16,190 | 15,492 | 14,620 | 13,637 | 12,639 |
| **10,000** | 16,134 | 16,018 | 15,740 | 15,282 | 14,633 | 13,818 | 12,892 | 11,944 |
| **12,000** | 15,380 | 15,275 | 15,013 | 14,583 | 13,976 | 13,213 | 12,345 | 11,449 |
| **14,000** | 14,795 | 14,698 | 14,448 | 14,038 | 13,464 | 12,748 | 11,932 | 11,081 |
| **16,000** | 14,332 | 14,244 | 14,001 | 13,605 | 13,058 | 12,379 | 11,605 | 10,789 |
| **18,000** | 13,959 | 13,876 | 13,640 | 13,254 | 12,727 | 12,076 | 11,334 | 10,542 |
| **19,323** | 13,750 | 13,669 | 13,435 | 13,055 | 12,538 | 11,902 | 11,175 | 10,394 |
| **20,000** | 13,651 | 13,572 | 13,339 | 12,962 | 12,449 | 11,819 | 11,098 | 10,321 |
| **22,000** | 13,391 | 13,314 | 13,085 | 12,714 | 12,211 | 11,593 | 10,885 | 10,118 |
| **24,000** | 13,166 | 13,090 | 12,865 | 12,499 | 12,003 | 11,393 | 10,692 | 9,931 |
| **26,000** | 12,968 | 12,894 | 12,672 | 12,311 | 11,819 | 11,213 | 10,516 | 9,761 |
| **28,000** | 12,794 | 12,720 | 12,502 | 12,146 | 11,657 | 11,052 | 10,358 | 9,612 |
| **30,000** | 12,639 | 12,566 | 12,353 | 12,001 | 11,515 | 10,911 | 10,221 | 9,486 |
| **32,000** | 12,502 | 12,430 | 12,222 | 11,874 | 11,390 | 10,789 | 10,104 | 9,384 |
| **34,000** | 12,381 | 12,311 | 12,106 | 11,763 | 11,282 | 10,686 | 10,009 | 9,306 |
| **36,000** | 12,273 | 12,206 | 12,004 | 11,664 | 11,189 | 10,599 | 9,933 | 9,246 |
| **38,646** | 12,148 | 12,084 | 11,885 | 11,550 | 11,083 | 10,506 | 9,857 | 9,187 |
| **40,000** | 12,091 | 12,027 | 11,830 | 11,496 | 11,035 | 10,466 | 9,824 | 9,159 |
| **42,000** | 12,011 | 11,949 | 11,751 | 11,421 | 10,967 | 10,410 | 9,779 | 9,114 |
| **44,000** | 11,935 | 11,874 | 11,675 | 11,348 | 10,902 | 10,356 | 9,733 | 9,061 |
| **46,000** | 11,863 | 11,801 | 11,601 | 11,276 | 10,838 | 10,300 | 9,680 | 8,995 |
| **48,000** | 11,794 | 11,731 | 11,531 | 11,208 | 10,774 | 10,240 | 9,619 | 8,922 |
| **50,000** | 11,733 | 11,670 | 11,471 | 11,149 | 10,714 | 10,178 | 9,554 | 8,856 |
| **52,000** | 11,686 | 11,625 | 11,432 | 11,110 | 10,667 | 10,120 | 9,494 | 8,826 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-25. Delta IV M+(4,2)—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—English Units**

SHG0555905-015.1

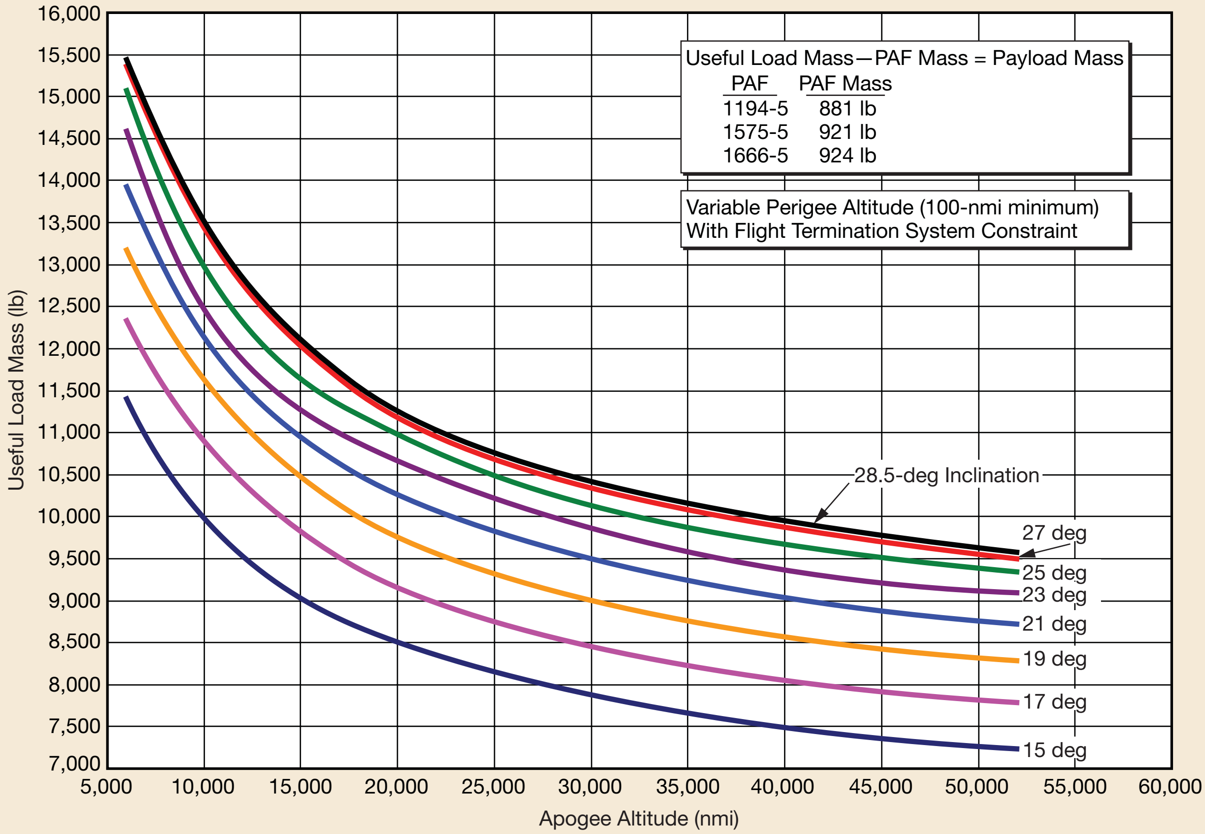



| Apogee Altitude (km)* | Useful Load Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **10,000** | 7,191 | 7,137 | 7,037 | 6,821 | 6,484 | 6,109 | 5,703 | 5,301 |
| **15,000** | 6,509 | 6,461 | 6,253 | 6,042 | 5,857 | 5,569 | 5,216 | 4,786 |
| **20,000** | 6,013 | 5,969 | 5,750 | 5,553 | 5,414 | 5,170 | 4,853 | 4,436 |
| **25,000** | 5,651 | 5,611 | 5,424 | 5,244 | 5,100 | 4,876 | 4,581 | 4,196 |
| **30,000** | 5,386 | 5,348 | 5,203 | 5,040 | 4,876 | 4,656 | 4,376 | 4,026 |
| **35,786** | 5,161 | 5,124 | 5,019 | 4,872 | 4,689 | 4,467 | 4,198 | 3,882 |
| **40,000** | 5,035 | 5,000 | 4,910 | 4,771 | 4,584 | 4,360 | 4,096 | 3,799 |
| **45,000** | 4,914 | 4,880 | 4,797 | 4,664 | 4,480 | 4,257 | 3,998 | 3,715 |
| **50,000** | 4,815 | 4,781 | 4,696 | 4,566 | 4,392 | 4,172 | 3,917 | 3,642 |
| **55,000** | 4,731 | 4,698 | 4,605 | 4,476 | 4,314 | 4,100 | 3,849 | 3,577 |
| **60,000** | 4,659 | 4,627 | 4,527 | 4,399 | 4,244 | 4,038 | 3,791 | 3,520 |
| **65,000** | 4,597 | 4,565 | 4,463 | 4,335 | 4,184 | 3,984 | 3,740 | 3,471 |
| **70,000** | 4,542 | 4,511 | 4,413 | 4,286 | 4,132 | 3,937 | 3,696 | 3,429 |
| **71,572** | 4,526 | 4,495 | 4,399 | 4,273 | 4,118 | 3,924 | 3,683 | 3,417 |
| **75,000** | 4,494 | 4,463 | 4,373 | 4,248 | 4,090 | 3,896 | 3,658 | 3,394 |
| **80,000** | 4,452 | 4,421 | 4,340 | 4,218 | 4,057 | 3,860 | 3,623 | 3,363 |
| **85,000** | 4,415 | 4,384 | 4,309 | 4,190 | 4,028 | 3,827 | 3,593 | 3,336 |
| **90,000** | 4,381 | 4,351 | 4,277 | 4,160 | 4,000 | 3,798 | 3,566 | 3,310 |
| **95,000** | 4,351 | 4,321 | 4,246 | 4,127 | 3,988 | 3,771 | 3,540 | 3,286 |
| **100,000** | 4,324 | 4,294 | 4,225 | 4,099 | 3,962 | 3,748 | 3,518 | 3,267 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-26. Delta IV M+(5,2)—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—Metric Units**

SHG0555905-016.1

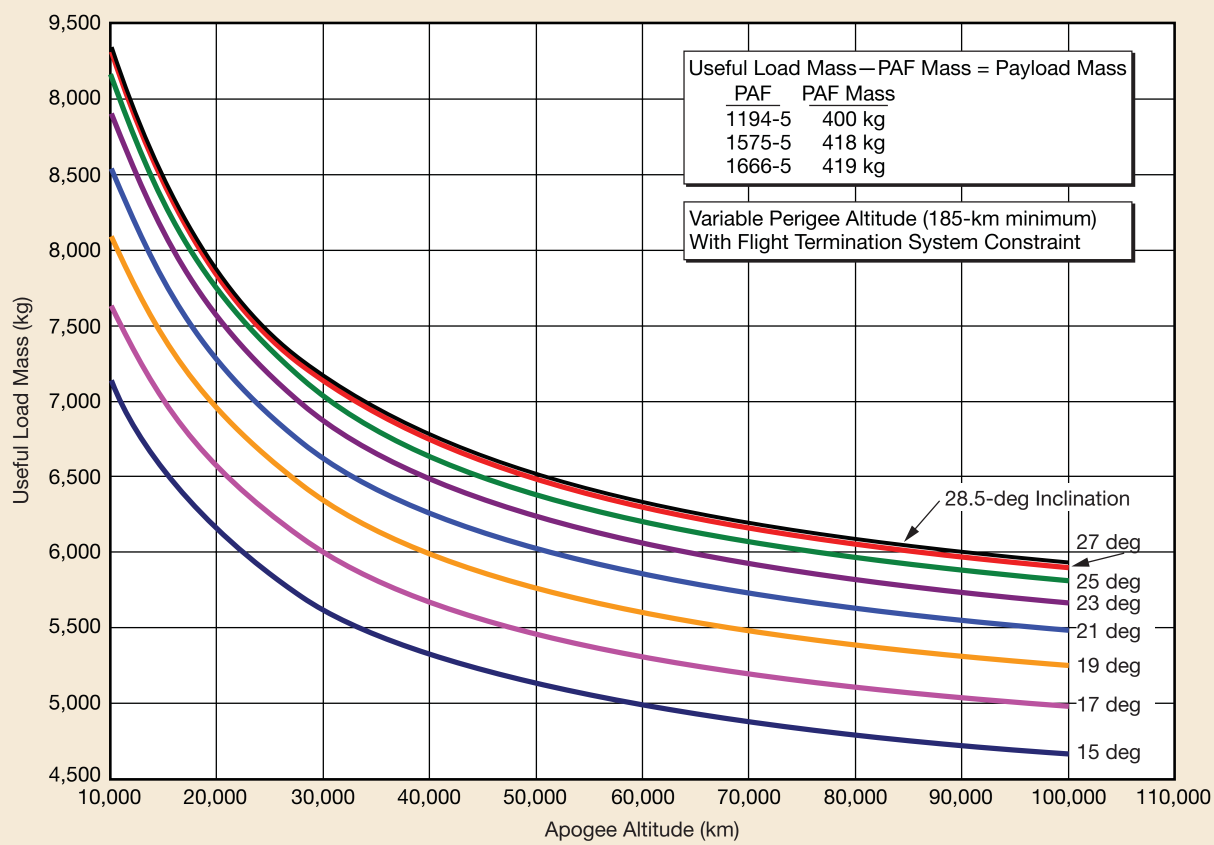



| Apogee Altitude (nmi)* | Useful Load Mass (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 15,476 | 15,360 | 15,061 | 14,585 | 13,945 | 13,171 | 12,306 | 11,395 |
| **8,000** | 14,396 | 14,290 | 13,836 | 13,370 | 12,955 | 12,315 | 11,534 | 10,586 |
| **10,000** | 13,543 | 13,445 | 12,955 | 12,511 | 12,189 | 11,631 | 10,912 | 9,978 |
| **12,000** | 12,870 | 12,777 | 12,319 | 11,902 | 11,598 | 11,085 | 10,411 | 9,520 |
| **14,000** | 12,336 | 12,248 | 11,853 | 11,464 | 11,140 | 10,648 | 10,006 | 9,171 |
| **16,000** | 11,910 | 11,826 | 11,500 | 11,139 | 10,781 | 10,295 | 9,676 | 8,899 |
| **18,000** | 11,567 | 11,486 | 11,222 | 10,884 | 10,496 | 10,009 | 9,406 | 8,681 |
| **19,323** | 11,376 | 11,297 | 11,064 | 10,740 | 10,338 | 9,848 | 9,254 | 8,559 |
| **20,000** | 11,288 | 11,209 | 10,990 | 10,671 | 10,264 | 9,773 | 9,183 | 8,501 |
| **22,000** | 11,056 | 10,979 | 10,786 | 10,482 | 10,069 | 9,575 | 8,995 | 8,346 |
| **24,000** | 10,859 | 10,784 | 10,602 | 10,307 | 9,901 | 9,407 | 8,835 | 8,210 |
| **26,000** | 10,690 | 10,616 | 10,431 | 10,143 | 9,751 | 9,262 | 8,697 | 8,086 |
| **28,000** | 10,542 | 10,469 | 10,274 | 9,989 | 9,615 | 9,135 | 8,576 | 7,974 |
| **30,000** | 10,411 | 10,339 | 10,131 | 9,848 | 9,491 | 9,022 | 8,469 | 7,871 |
| **32,000** | 10,293 | 10,222 | 10,004 | 9,721 | 9,378 | 8,921 | 8,374 | 7,778 |
| **34,000** | 10,187 | 10,116 | 9,893 | 9,610 | 9,275 | 8,830 | 8,288 | 7,694 |
| **36,000** | 10,091 | 10,021 | 9,799 | 9,517 | 9,183 | 8,747 | 8,211 | 7,619 |
| **38,646** | 9,978 | 9,909 | 9,698 | 9,419 | 9,079 | 8,650 | 8,120 | 7,533 |
| **40,000** | 9,926 | 9,857 | 9,655 | 9,378 | 9,033 | 8,605 | 8,078 | 7,495 |
| **42,000** | 9,855 | 9,787 | 9,598 | 9,327 | 8,974 | 8,543 | 8,020 | 7,443 |
| **44,000** | 9,790 | 9,722 | 9,547 | 9,280 | 8,923 | 8,486 | 7,967 | 7,395 |
| **46,000** | 9,730 | 9,663 | 9,496 | 9,235 | 8,878 | 8,434 | 7,918 | 7,351 |
| **48,000** | 9,675 | 9,608 | 9,445 | 9,186 | 8,833 | 8,386 | 7,873 | 7,309 |
| **50,000** | 9,623 | 9,556 | 9,392 | 9,134 | 8,780 | 8,341 | 7,831 | 7,269 |
| **52,000** | 9,575 | 9,509 | 9,345 | 9,080 | 8,713 | 8,300 | 7,791 | 7,232 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-27. Delta IV M+(5,2)—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—English Units**

SHG0555905-017.1

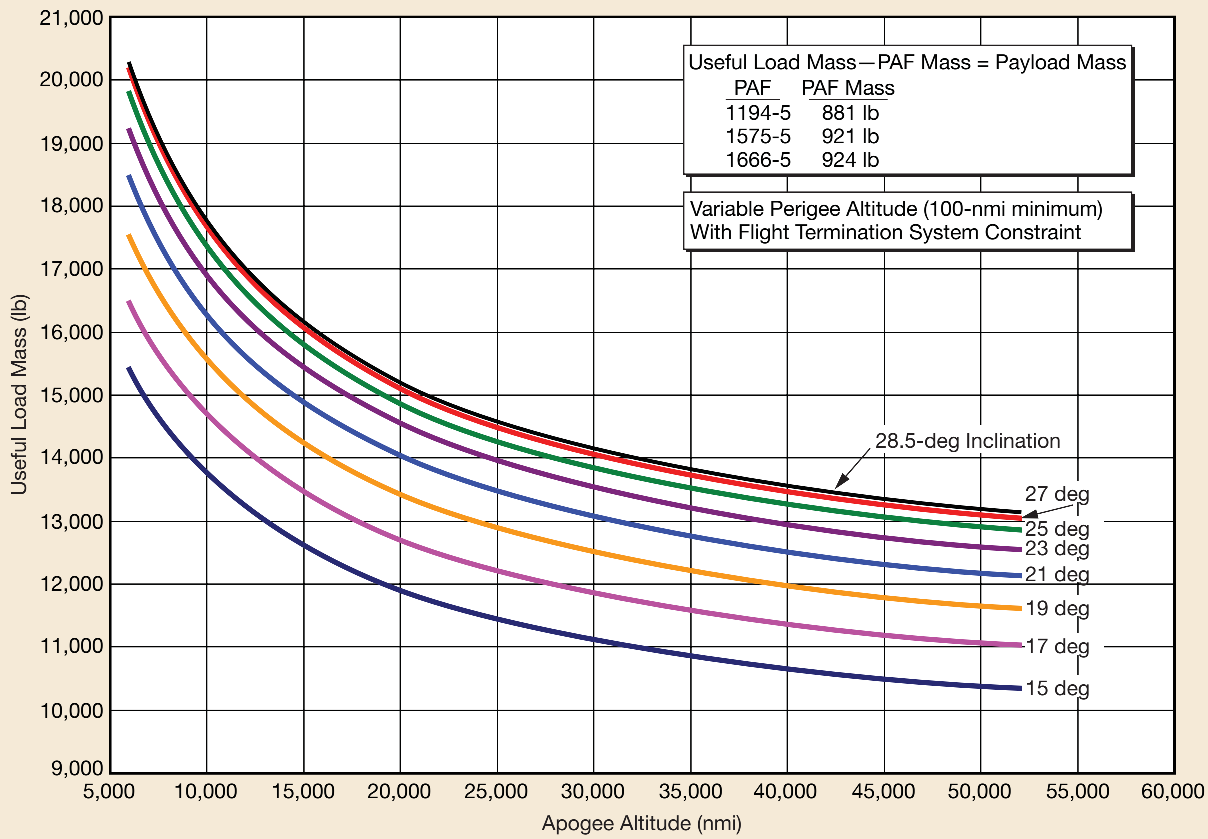



| Apogee Altitude (km)* | Useful Load Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **10,000** | 9,432 | 9,367 | 9,198 | 8,930 | 8,567 | 8,127 | 7,638 | 7,137 |
| **15,000** | 8,513 | 8,462 | 8,320 | 8,094 | 7,788 | 7,416 | 6,994 | 6,545 |
| **20,000** | 7,910 | 7,863 | 7,736 | 7,535 | 7,263 | 6,930 | 6,548 | 6,136 |
| **25,000** | 7,500 | 7,454 | 7,336 | 7,151 | 6,900 | 6,589 | 6,231 | 5,845 |
| **30,000** | 7,206 | 7,161 | 7,049 | 6,874 | 6,636 | 6,340 | 5,998 | 5,629 |
| **35,786** | 6,949 | 6,905 | 6,798 | 6,631 | 6,404 | 6,121 | 5,794 | 5,438 |
| **40,000** | 6,795 | 6,753 | 6,650 | 6,488 | 6,267 | 5,992 | 5,673 | 5,325 |
| **45,000** | 6,650 | 6,609 | 6,509 | 6,351 | 6,136 | 5,868 | 5,557 | 5,216 |
| **50,000** | 6,529 | 6,490 | 6,392 | 6,237 | 6,027 | 5,765 | 5,460 | 5,126 |
| **55,000** | 6,427 | 6,389 | 6,293 | 6,141 | 5,934 | 5,677 | 5,378 | 5,048 |
| **60,000** | 6,339 | 6,302 | 6,207 | 6,057 | 5,854 | 5,601 | 5,307 | 4,982 |
| **65,000** | 6,263 | 6,226 | 6,133 | 5,985 | 5,785 | 5,535 | 5,245 | 4,924 |
| **70,000** | 6,196 | 6,161 | 6,068 | 5,922 | 5,724 | 5,478 | 5,191 | 4,873 |
| **71,572** | 6,177 | 6,142 | 6,050 | 5,904 | 5,707 | 5,462 | 5,175 | 4,859 |
| **75,000** | 6,138 | 6,103 | 6,012 | 5,868 | 5,672 | 5,428 | 5,143 | 4,829 |
| **80,000** | 6,088 | 6,053 | 5,962 | 5,820 | 5,625 | 5,384 | 5,102 | 4,790 |
| **85,000** | 6,044 | 6,008 | 5,919 | 5,777 | 5,585 | 5,345 | 5,065 | 4,755 |
| **90,000** | 6,004 | 5,968 | 5,879 | 5,739 | 5,548 | 5,309 | 5,031 | 4,724 |
| **95,000** | 5,967 | 5,932 | 5,843 | 5,704 | 5,514 | 5,277 | 5,001 | 4,696 |
| **100,000** | 5,929 | 5,899 | 5,811 | 5,671 | 5,482 | 5,248 | 4,975 | 4,670 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-28. Delta IV M+(5,4)—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—Metric Units**

SHG0555905-018.1

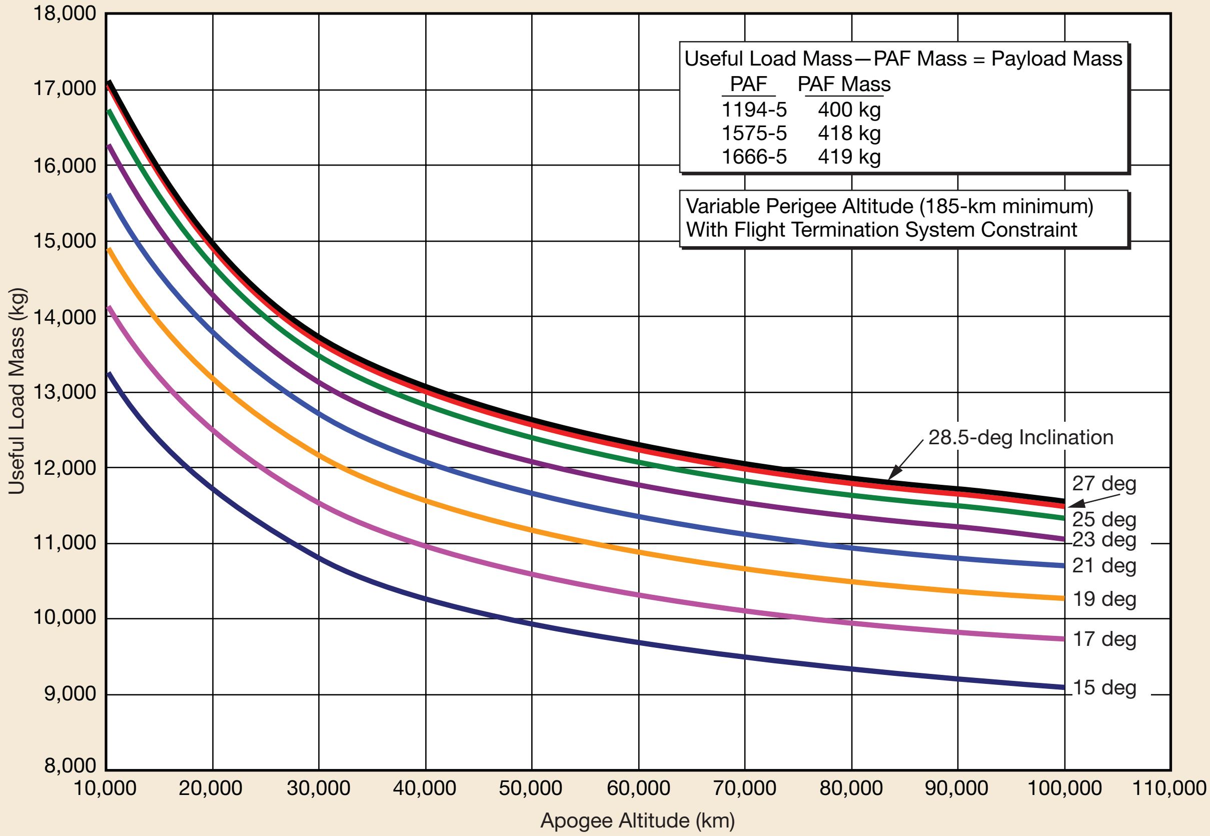



| Apogee Altitude (nmi)* | Useful Load Mass (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 20,265 | 20,132 | 19,776 | 19,208 | 18,443 | 17,513 | 16,474 | 15,400 |
| **8,000** | 18,829 | 18,716 | 18,401 | 17,898 | 17,221 | 16,396 | 15,461 | 14,470 |
| **10,000** | 17,777 | 17,672 | 17,384 | 16,927 | 16,310 | 15,554 | 14,690 | 13,762 |
| **12,000** | 16,995 | 16,893 | 16,624 | 16,198 | 15,621 | 14,911 | 14,096 | 13,216 |
| **14,000** | 16,399 | 16,297 | 16,041 | 15,638 | 15,090 | 14,411 | 13,631 | 12,787 |
| **16,000** | 15,929 | 15,827 | 15,580 | 15,193 | 14,666 | 14,012 | 13,257 | 12,441 |
| **18,000** | 15,542 | 15,443 | 15,203 | 14,829 | 14,318 | 13,683 | 12,949 | 12,154 |
| **19,323** | 15,319 | 15,222 | 14,987 | 14,619 | 14,118 | 13,494 | 12,772 | 11,989 |
| **20,000** | 15,213 | 15,117 | 14,884 | 14,519 | 14,023 | 13,405 | 12,689 | 11,911 |
| **22,000** | 14,928 | 14,836 | 14,609 | 14,253 | 13,768 | 13,165 | 12,465 | 11,701 |
| **24,000** | 14,692 | 14,603 | 14,380 | 14,031 | 13,555 | 12,964 | 12,277 | 11,524 |
| **26,000** | 14,487 | 14,400 | 14,181 | 13,837 | 13,370 | 12,788 | 12,112 | 11,369 |
| **28,000** | 14,306 | 14,221 | 14,006 | 13,667 | 13,206 | 12,633 | 11,967 | 11,233 |
| **30,000** | 14,146 | 14,062 | 13,850 | 13,515 | 13,061 | 12,495 | 11,837 | 11,112 |
| **32,000** | 14,002 | 13,920 | 13,710 | 13,379 | 12,930 | 12,371 | 11,721 | 11,003 |
| **34,000** | 13,872 | 13,791 | 13,584 | 13,257 | 12,812 | 12,260 | 11,616 | 10,905 |
| **36,000** | 13,755 | 13,676 | 13,470 | 13,146 | 12,706 | 12,159 | 11,521 | 10,816 |
| **38,646** | 13,618 | 13,540 | 13,337 | 13,016 | 12,581 | 12,040 | 11,409 | 10,711 |
| **40,000** | 13,554 | 13,477 | 13,275 | 12,956 | 12,523 | 11,985 | 11,357 | 10,662 |
| **42,000** | 13,469 | 13,391 | 13,191 | 12,875 | 12,445 | 11,910 | 11,286 | 10,595 |
| **44,000** | 13,391 | 13,314 | 13,114 | 12,801 | 12,374 | 11,842 | 11,221 | 10,535 |
| **46,000** | 13,321 | 13,242 | 13,044 | 12,733 | 12,308 | 11,779 | 11,162 | 10,479 |
| **48,000** | 13,255 | 13,176 | 12,979 | 12,670 | 12,248 | 11,721 | 11,107 | 10,428 |
| **50,000** | 13,193 | 13,114 | 12,918 | 12,610 | 12,191 | 11,667 | 11,056 | 10,381 |
| **52,000** | 13,132 | 13,057 | 12,862 | 12,555 | 12,137 | 11,616 | 11,009 | 10,337 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-29. Delta IV M+(5,4)—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—English Units**

SHG0555905-019.1

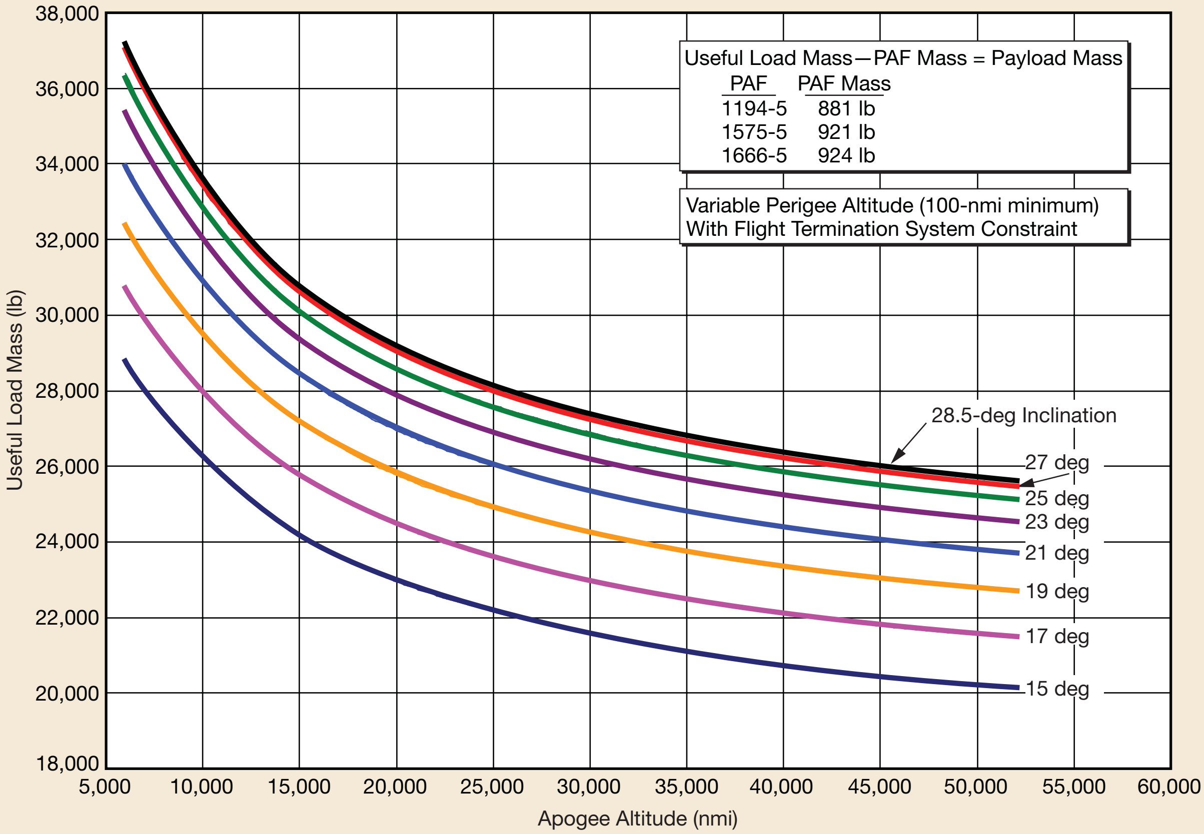



| Apogee Altitude (km)* | Useful Load Mass (kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **5,000** | 18,875 | 18,884 | 18,495 | 17,885 | 17,128 | 16,281 | 15,327 | 14,449 |
| **10,000** | 17,183 | 17,127 | 16,822 | 16,328 | 15,696 | 14,963 | 14,146 | 13,280 |
| **15,000** | 15,916 | 15,827 | 15,574 | 15,157 | 14,606 | 13,948 | 13,222 | 12,388 |
| **20,000** | 14,975 | 14,876 | 14,652 | 14,283 | 13,784 | 13,173 | 12,505 | 11,711 |
| **25,000** | 14,280 | 14,182 | 13,975 | 13,634 | 13,165 | 12,585 | 11,952 | 11,199 |
| **30,000** | 13,764 | 13,675 | 13,475 | 13,149 | 12,699 | 12,140 | 11,528 | 10,810 |
| **35,000** | 13,375 | 13,298 | 13,100 | 12,782 | 12,344 | 11,801 | 11,201 | 10,512 |
| **35,786** | 13,323 | 13,248 | 13,050 | 12,733 | 12,296 | 11,755 | 11,157 | 10,472 |
| **40,000** | 13,075 | 13,008 | 12,812 | 12,497 | 12,068 | 11,539 | 10,946 | 10,279 |
| **45,000** | 12,834 | 12,774 | 12,581 | 12,269 | 11,848 | 11,332 | 10,744 | 10,090 |
| **50,000** | 12,632 | 12,576 | 12,387 | 12,078 | 11,665 | 11,162 | 10,579 | 9,933 |
| **55,000** | 12,456 | 12,402 | 12,218 | 11,913 | 11,508 | 11,018 | 10,440 | 9,798 |
| **60,000** | 12,301 | 12,246 | 12,067 | 11,767 | 11,371 | 10,890 | 10,317 | 9,678 |
| **65,000** | 12,162 | 12,105 | 11,932 | 11,638 | 11,249 | 10,775 | 10,206 | 9,572 |
| **70,000** | 12,040 | 11,981 | 11,813 | 11,526 | 11,142 | 10,670 | 10,105 | 9,477 |
| **71,572** | 12,005 | 11,946 | 11,779 | 11,494 | 11,110 | 10,638 | 10,074 | 9,450 |
| **75,000** | 11,935 | 11,876 | 11,711 | 11,429 | 11,047 | 10,574 | 10,012 | 9,394 |
| **80,000** | 11,847 | 11,789 | 11,625 | 11,349 | 10,967 | 10,489 | 9,928 | 9,322 |
| **85,000** | 11,773 | 11,718 | 11,554 | 11,281 | 10,897 | 10,415 | 9,856 | 9,260 |
| **90,000** | 11,707 | 11,655 | 11,491 | 11,219 | 10,835 | 10,353 | 9,798 | 9,205 |
| **95,000** | 11,636 | 11,584 | 11,422 | 11,151 | 10,773 | 10,301 | 9,756 | 9,151 |
| **100,000** | 11,541 | 11,482 | 11,329 | 11,060 | 10,697 | 10,257 | 9,733 | 9,087 |

*Note: Trajectories have a perigee altitude of 185 km

**Figure 2-30. Delta IV H—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—Metric Units**

SHG0555905-020.1

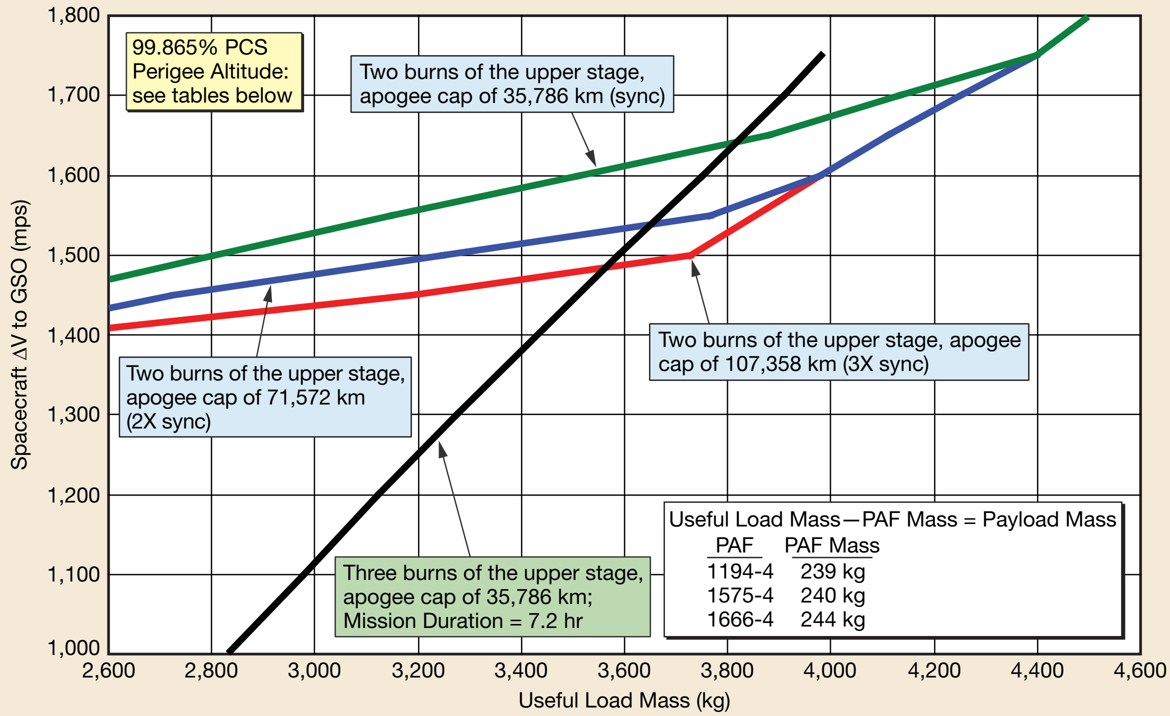



| Apogee Altitude (nmi)* | Useful Load Mass (lb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Inclination (deg) | | | | | | | |
| | 28.5 | 27 | 25 | 23 | 21 | 19 | 17 | 15 |
| **6,000** | 37,188 | 37,043 | 36,400 | 35,356 | 34,010 | 32,436 | 30,688 | 28,793 |
| **8,000** | 35,177 | 34,983 | 34,422 | 33,497 | 32,278 | 30,821 | 29,215 | 27,373 |
| **10,000** | 33,564 | 33,348 | 32,840 | 32,001 | 30,872 | 29,498 | 27,994 | 26,217 |
| **12,000** | 32,275 | 32,055 | 31,581 | 30,799 | 29,733 | 28,419 | 26,986 | 25,276 |
| **14,000** | 31,244 | 31,032 | 30,578 | 29,834 | 28,811 | 27,541 | 26,157 | 24,512 |
| **16,000** | 30,416 | 30,220 | 29,777 | 29,056 | 28,062 | 26,826 | 25,475 | 23,888 |
| **18,000** | 29,747 | 29,568 | 29,131 | 28,425 | 27,452 | 26,243 | 24,913 | 23,376 |
| **19,323** | 29,372 | 29,205 | 28,770 | 28,070 | 27,108 | 25,916 | 24,595 | 23,086 |
| **20,000** | 29,198 | 29,037 | 28,603 | 27,905 | 26,948 | 25,763 | 24,448 | 22,951 |
| **22,000** | 28,739 | 28,594 | 28,163 | 27,470 | 26,527 | 25,365 | 24,059 | 22,593 |
| **24,000** | 28,347 | 28,214 | 27,787 | 27,098 | 26,168 | 25,029 | 23,731 | 22,287 |
| **26,000** | 28,005 | 27,879 | 27,458 | 26,774 | 25,857 | 24,739 | 23,450 | 22,020 |
| **28,000** | 27,699 | 27,578 | 27,164 | 26,485 | 25,582 | 24,485 | 23,203 | 21,782 |
| **30,000** | 27,421 | 27,301 | 26,896 | 26,224 | 25,335 | 24,256 | 22,983 | 21,568 |
| **32,000** | 27,166 | 27,045 | 26,649 | 25,986 | 25,111 | 24,048 | 22,782 | 21,373 |
| **34,000** | 26,932 | 26,808 | 26,421 | 25,769 | 24,905 | 23,854 | 22,596 | 21,194 |
| **36,000** | 26,718 | 26,591 | 26,213 | 25,571 | 24,717 | 23,674 | 22,423 | 21,029 |
| **38,646** | 26,466 | 26,337 | 25,968 | 25,339 | 24,494 | 23,453 | 22,210 | 20,833 |
| **40,000** | 26,351 | 26,221 | 25,856 | 25,234 | 24,391 | 23,348 | 22,108 | 20,742 |
| **42,000** | 26,199 | 26,070 | 25,708 | 25,094 | 24,252 | 23,204 | 21,966 | 20,619 |
| **44,000** | 26,066 | 25,941 | 25,580 | 24,972 | 24,129 | 23,072 | 21,837 | 20,509 |
| **46,000** | 25,949 | 25,828 | 25,467 | 24,864 | 24,018 | 22,955 | 21,723 | 20,410 |
| **48,000** | 25,841 | 25,724 | 25,363 | 24,763 | 23,916 | 22,851 | 21,626 | 20,319 |
| **50,000** | 25,731 | 25,617 | 25,258 | 24,659 | 23,817 | 22,762 | 21,548 | 20,232 |
| **52,000** | 25,605 | 25,488 | 25,136 | 24,538 | 23,710 | 22,683 | 21,491 | 20,140 |

*Note: Trajectories have a perigee altitude of 100 nmi

**Figure 2-31. Delta IV H—Sub- and Super-Synchronous Transfer Orbit Capability (Eastern Range)—English Units**

SHG0555905-021.2




| Two-Burn Apogee Cap = 35,786 km (Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,800 m/sec | 194 x 35,786 km at 26.8 deg |
| 1,750 m/sec | 195 x 35,786 km at 24.4 deg |
| 1,700 m/sec | 204 x 35,786 km at 21.9 deg |
| 1,650 m/sec | 320 x 35,786 km at 19.7 deg |
| 1,600 m/sec | 462 x 35,786 km at 17.4 deg |
| 1,550 m/sec | 1,140 x 35,786 km at 17.6 deg |
| 1,500 m/sec | 1,627 x 35,786 km at 16.9 deg |
| 1,450 m/sec | 1,892 x 35,786 km at 15.2 deg |
| 1,400 m/sec | 2,355 x 35,786 km at 14.2 deg |

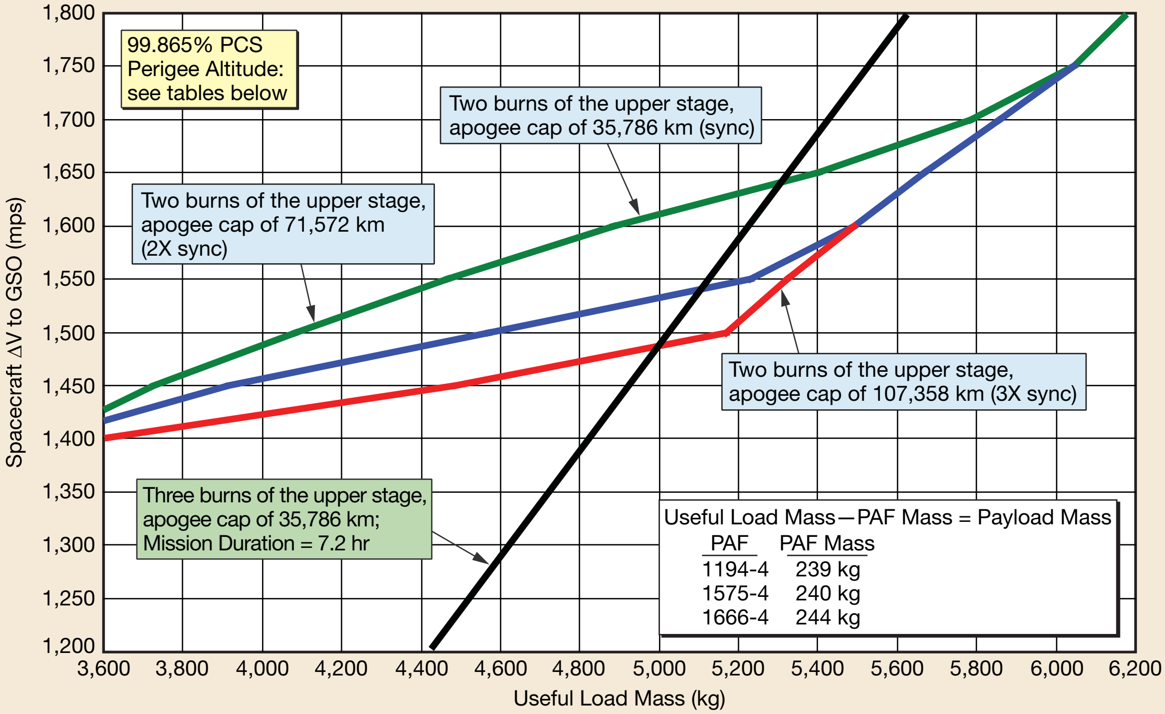
| Two-Burn Apogee Cap = 107,358 km (3X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,600 m/sec | 196 x 67,053 km at 26.3 deg |
| 1,550 m/sec | 197 x 85,179 km at 26.7 deg |
| 1,500 m/sec | 198 x 107,357 km at 26.2 deg |
| 1,450 m/sec | 277 x 107,343 km at 19.0 deg |
| 1,400 m/sec | 2,142 x 107,349 km at 21.0 deg |
| 1,350 m/sec | 7,441 x 44,983 km at 23.6 deg |

| Two-Burn Apogee Cap = 71,572 km (2X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 196 x 36,102 km at 24.6 deg |
| 1,700 m/sec | 195 x 43,789 km at 25.2 deg |
| 1,650 m/sec | 195 x 53,772 km at 25.8 deg |
| 1,600 m/sec | 196 x 66,593 km at 26.3 deg |
| 1,550 m/sec | 199 x 71,569 km at 23.0 deg |
| 1,500 m/sec | 426 x 71,570 km at 18.7 deg |
| 1,450 m/sec | 1,735 x 71,560 km at 20.1 deg |
| 1,425 m/sec | 2,913 x 71,570 km at 22.1 deg |

| Three-Burn Apogee = 35,786 km | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 981 x 31,608 km at 23.3 deg |
| 1,700 m/sec | 1,028 x 33,772 km at 23.1 deg |
| 1,600 m/sec | 1,298 x 35,786 km at 20.9 deg |
| 1,500 m/sec | 2,304 x 35,783 km at 19.2 deg |
| 1,400 m/sec | 3,036 x 35,674 km at 16.7 deg |
| 1,300 m/sec | 4,171 x 35,786 km at 15.1 deg |
| 1,200 m/sec | 5,328 x 35,786 km at 13.5 deg |
| 1,100 m/sec | 6,915 x 35,786 km at 12.6 deg |
| 1,000 m/sec | 7,893 x 35,786 km at 10.2 deg |
| 900 m/sec | 9,420 x 35,786 km at 8.8 deg |
| 800 m/sec | 11,335 x 35,786 km at 7.9 deg |

**Figure 2-32. Delta IV M—GTO Performance Capability (Eastern Range)**

SHG0555905-022.2




| Two-Burn Apogee Cap = 35,786 km (Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,800 m/sec | 213 x 35,037 km at 26.3 deg |
| 1,750 m/sec | 214 x 35,786 km at 24.5 deg |
| 1,700 m/sec | 218 x 35,786 km at 22.0 deg |
| 1,650 m/sec | 241 x 35,786 km at 19.3 deg |
| 1,600 m/sec | 913 x 35,786 km at 19.5 deg |
| 1,550 m/sec | 1,198 x 35,786 km at 17.9 deg |
| 1,500 m/sec | 1,594 x 35,786 km at 16.7 deg |
| 1,450 m/sec | 2,141 x 35,786 km at 16.2 deg |
| 1,400 m/sec | 3,469 x 35,786 km at 17.9 deg |

| Two-Burn Apogee Cap = 107,358 km (3X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,600 m/sec | 209 x 66,377 km at 26.1 deg |
| 1,550 m/sec | 207 x 83,218 km at 26.3 deg |
| 1,500 m/sec | 210 x 107,354 km at 26.3 deg |
| 1,450 m/sec | 281 x 107,359 km at 19.0 deg |
| 1,400 m/sec | 2,006 x 107,355 km at 20.4 deg |

| Two-Burn Apogee Cap = 71,572 km (2X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 214 x 36,136 km at 24.7 deg |
| 1,700 m/sec | 212 x 43,471 km at 25.1 deg |
| 1,650 m/sec | 210 x 53,937 km at 25.9 deg |
| 1,600 m/sec | 209 x 66,382 km at 26.2 deg |
| 1,550 m/sec | 213 x 71,554 km at 23.0 deg |
| 1,500 m/sec | 467 x 71,571 km at 19.0 deg |
| 1,450 m/sec | 1,666 x 71,572 km at 19.8 deg |
| 1,400 m/sec | 3,542 x 71,557 km at 21.9 deg |

| Three-Burn Apogee = 35,786 km | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,800 m/sec | 970 x 29,671 km at 23.7 deg |
| 1,750 m/sec | 1,003 x 31,636 km at 23.4 deg |
| 1,700 m/sec | 1,108 x 34,153 km at 23.7 deg |
| 1,650 m/sec | 1,165 x 35,781 km at 22.8 deg |
| 1,600 m/sec | 1,426 x 35,786 km at 21.3 deg |
| 1,550 m/sec | 2,033 x 35,786 km at 20.8 deg |
| 1,500 m/sec | 2,374 x 35,786 km at 19.4 deg |
| 1,450 m/sec | 2,779 x 35,786 km at 18.3 deg |
| 1,400 m/sec | 3,231 x 35,786 km at 17.2 deg |
| 1,350 m/sec | 4,012 x 35,786 km at 17.0 deg |
| 1,300 m/sec | 4,222 x 35,786 km at 15.3 deg |
| 1,250 m/sec | 4,998 x 35,786 km at 14.9 deg |
| 1,200 m/sec | 5,440 x 35,786 km at 13.7 deg |

**Figure 2-33. Delta IV M+(4,2)—GTO Performance Capability (Eastern Range)**

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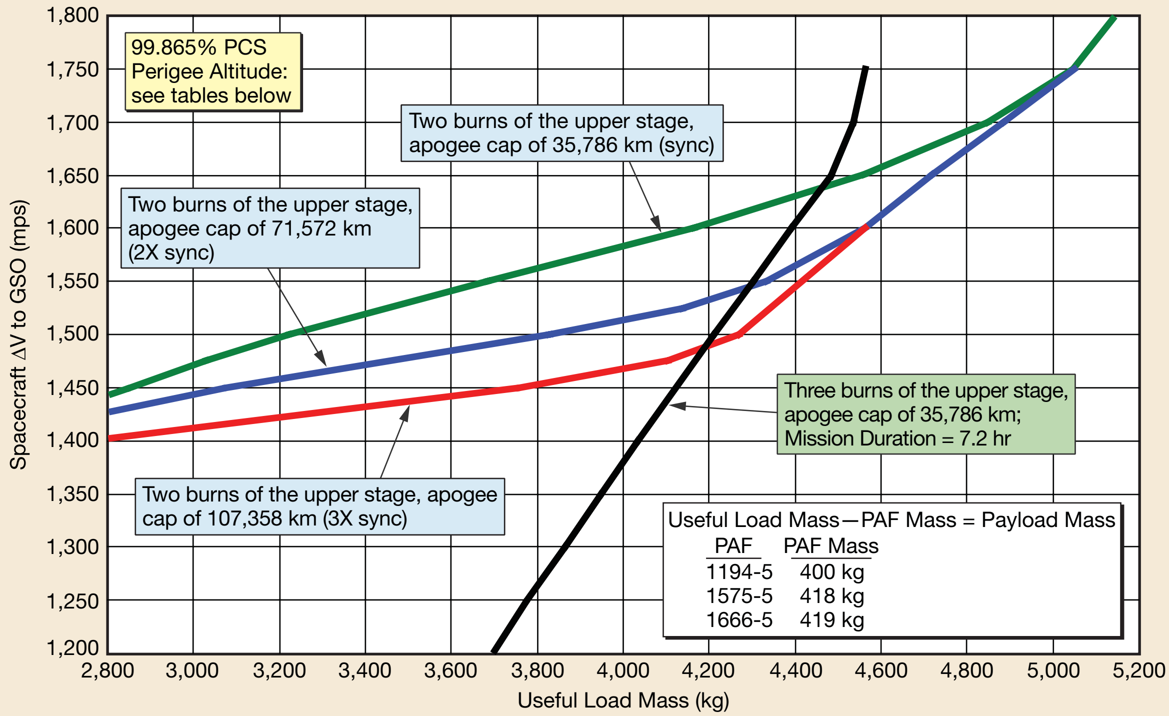



| Two-Burn Apogee Cap = 35,786 km (Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,800 m/sec | 259 x 34,171 km at 25.7 deg |
| 1,750 m/sec | 264 x 35,783 km at 24.7 deg |
| 1,700 m/sec | 278 x 35,786 km at 22.2 deg |
| 1,650 m/sec | 309 x 35,785 km at 19.6 deg |
| 1,600 m/sec | 346 x 35,786 km at 16.8 deg |
| 1,550 m/sec | 606 x 35,786 km at 15.0 deg |
| 1,500 m/sec | 996 x 35,786 km at 13.8 deg |
| 1,475 m/sec | 1,429 x 35,786 km at 14.5 deg |
| 1,450 m/sec | 1,828 x 35,786 km at 14.8 deg |
| 1,400 m/sec | 2,034 x 35,786 km at 12.7 deg |

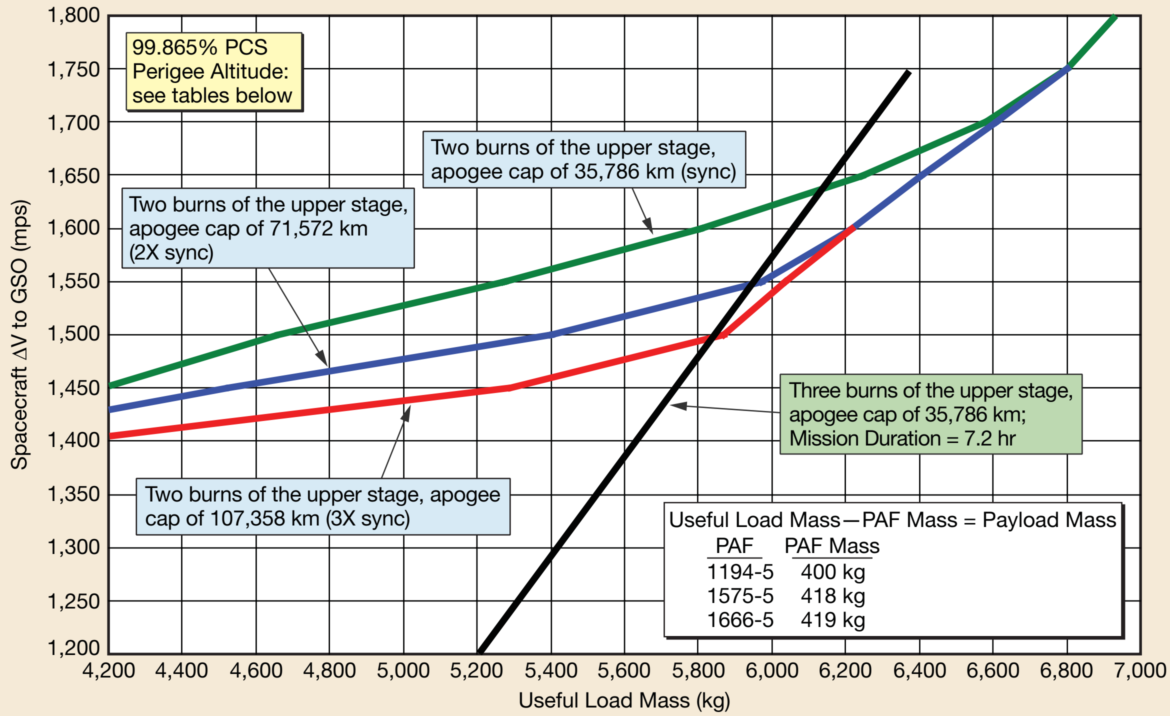
| Two-Burn Apogee Cap = 107,358 km (3X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,600 m/sec | 264 x 65,864 km at 26.2 deg |
| 1,550 m/sec | 262 x 83,814 km at 26.6 deg |
| 1,500 m/sec | 265 x 107,334 km at 26.5 deg |
| 1,475 m/sec | 280 x 107,350 km at 23.0 deg |
| 1,450 m/sec | 323 x 107,358 km at 19.3 deg |
| 1,400 m/sec | 1,430 x 107,345 km at 17.5 deg |

| Two-Burn Apogee Cap = 71,572 km (2X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 265 x 35,798 km at 24.7 deg |
| 1,700 m/sec | 266 x 43,392 km at 25.3 deg |
| 1,650 m/sec | 266 x 52,448 km at 25.6 deg |
| 1,600 m/sec | 264 x 65,864 km at 26.2 deg |
| 1,550 m/sec | 270 x 71,547 km at 23.3 deg |
| 1,525 m/sec | 299 x 71,571 km at 20.8 deg |
| 1,500 m/sec | 336 x 71,569 km at 18.2 deg |
| 1,450 m/sec | 1,070 x 71,572 km at 16.7 deg |
| 1,400 m/sec | 1,938 x 71,571 km at 15.7 deg |

| Three-Burn Apogee = 35,786 km | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 1,038 x 35,786 km at 26.9 deg |
| 1,700 m/sec | 1,053 x 35,786 km at 24.8 deg |
| 1,650 m/sec | 1,090 x 35,786 km at 22.6 deg |
| 1,600 m/sec | 1,546 x 35,786 km at 21.7 deg |
| 1,550 m/sec | 1,898 x 35,786 km at 20.4 deg |
| 1,500 m/sec | 2,361 x 35,786 km at 19.4 deg |
| 1,450 m/sec | 2,826 x 35,786 km at 18.4 deg |
| 1,400 m/sec | 3,224 x 35,786 km at 17.2 deg |
| 1,350 m/sec | 3,677 x 35,786 km at 16.1 deg |
| 1,300 m/sec | 4,160 x 35,786 km at 15.1 deg |
| 1,250 m/sec | 4,557 x 35,786 km at 13.8 deg |
| 1,200 m/sec | 5,349 x 35,786 km at 13.5 deg |

**Figure 2-34. Delta IV M+(5,2)—GTO Performance Capability (Eastern Range)**

SHG0555905-024.2




| Two-Burn Apogee Cap = 35,786 km (Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,800 m/sec | 335 x 35,786 km at 27.2 deg |
| 1,750 m/sec | 366 x 35,786 km at 25.0 deg |
| 1,700 m/sec | 360 x 35,786 km at 22.5 deg |
| 1,650 m/sec | 396 x 35,786 km at 20.0 deg |
| 1,600 m/sec | 508 x 35,786 km at 17.6 deg |
| 1,550 m/sec | 582 x 35,786 km at 14.8 deg |
| 1,500 m/sec | 829 x 35,786 km at 12.8 deg |
| 1,450 m/sec | 1,537 x 35,786 km at 13.4 deg |
| 1,400 m/sec | 1,851 x 35,786 km at 11.7 deg |

| Two-Burn Apogee Cap = 107,358 km (3X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 366 x 35,786 km at 25.0 deg |
| 1,700 m/sec | 351 x 41,069 km at 24.7 deg |
| 1,650 m/sec | 351 x 48,997 km at 24.7 deg |
| 1,600 m/sec | 345 x 64,285 km at 26.0 deg |
| 1,550 m/sec | 345 x 83,569 km at 16.1 deg |
| 1,500 m/sec | 344 x 107,330 km at 26.8 deg |
| 1,450 m/sec | 417 x 107,358 km at 19.9 deg |
| 1,400 m/sec | 1,192 x 107,358 km at 16.1 deg |

| Two-Burn Apogee Cap = 71,572 km (2X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 366 x 35,786 km at 25.0 deg |
| 1,700 m/sec | 351 x 41,069 km at 24.7 deg |
| 1,650 m/sec | 351 x 48,997 km at 24.7 deg |
| 1,600 m/sec | 345 x 64,285 km at 26.0 deg |
| 1,550 m/sec | 370 x 71,551 km at 23.8 deg |
| 1,500 m/sec | 437 x 71,556 km at 18.8 deg |
| 1,450 m/sec | 945 x 71,571 km at 15.9 deg |
| 1,400 m/sec | 2,286 x 71,571 km at 17.5 deg |

| Three-Burn Apogee = 35,786 km | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 1,040 x 31,677 km at 23.6 deg |
| 1,700 m/sec | 1,075 x 33,978 km at 23.4 deg |
| 1,650 m/sec | 1,156 x 35,786 km at 22.8 deg |
| 1,600 m/sec | 1,654 x 35,784 km at 22.0 deg |
| 1,550 m/sec | 1,979 x 35,780 km at 20.6 deg |
| 1,500 m/sec | 2,185 x 35,748 km at 18.9 deg |
| 1,450 m/sec | 2,737 x 35,786 km at 18.2 deg |
| 1,400 m/sec | 3,344 x 35,786 km at 17.5 deg |
| 1,350 m/sec | 3,780 x 35,786 km at 16.4 deg |
| 1,300 m/sec | 4,290 x 35,786 km at 15.4 deg |
| 1,250 m/sec | 4,534 x 35,786 km at 13.7 deg |
| 1,200 m/sec | 5,651 x 35,786 km at 14.2 deg |

**Figure 2-35. Delta IV M+(5,4)—GTO Performance Capability (Eastern Range)**

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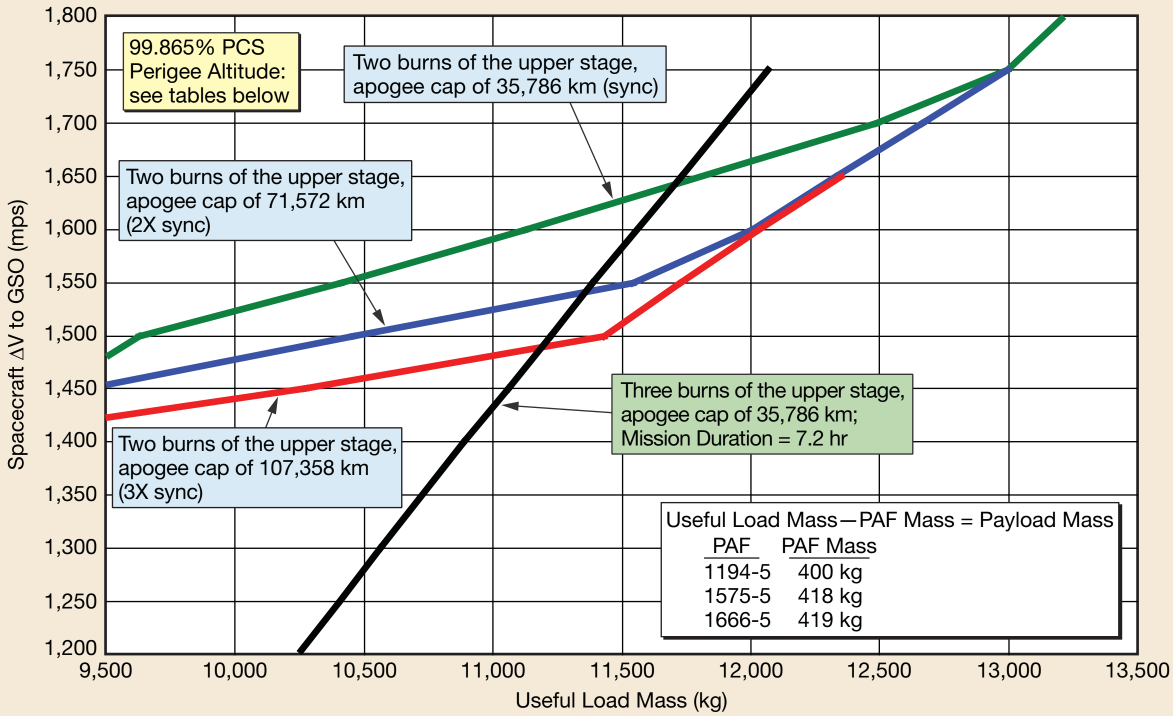


| Two-Burn Apogee Cap = 35,786 km (Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,800 m/sec | 225 x 35,785 km at 27.0 deg |
| 1,750 m/sec | 243 x 35,786 km at 24.6 deg |
| 1,700 m/sec | 289 x 35,785 km at 22.2 deg |
| 1,650 m/sec | 575 x 35,786 km at 20.8 deg |
| 1,600 m/sec | 875 x 35,786 km at 19.3 deg |
| 1,550 m/sec | 1,423 x 35,785 km at 18.8 deg |
| 1,500 m/sec | 1,922 x 35,785 km at 18.0 deg |
| 1,450 m/sec | 2,494 x 35,785 km at 17.4 deg |

| Two-Burn Apogee Cap = 107,358 km (3X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,650 m/sec | 247 x 53,736 km at 26.0 deg |
| 1,600 m/sec | 255 x 66,764 km at 26.4 deg |
| 1,550 m/sec | 259 x 84,356 km at 26.8 deg |
| 1,500 m/sec | 262 x 107,358 km at 26.5 deg |
| 1,450 m/sec | 532 x 107,357 km at 20.5 deg |
| 1,400 m/sec | 1,826 x 107,358 km at 19.6 deg |

| Two-Burn Apogee Cap = 71,572 km (2X Sync) | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 241 x 36,400 km at 24.9 deg |
| 1,700 m/sec | 249 x 43,294 km at 25.2 deg |
| 1,650 m/sec | 257 x 52,780 km at 25.7 deg |
| 1,600 m/sec | 262 x 66,076 km at 26.3 deg |
| 1,550 m/sec | 270 x 71,572 km at 23.3 deg |
| 1,500 m/sec | 671 x 71,572 km at 20.1 deg |
| 1,450 m/sec | 1,595 x 71,572 km at 19.4 deg |

| Three-Burn Apogee = 35,786 km | |
|---|---|
| Spacecraft ΔV to GSO | Orbit (Perigee Altitude by Apogee Altitude at Inclination) |
| 1,750 m/sec | 954 x 34,699 km at 25.9 deg |
| 1,700 m/sec | 966 x 35,786 km at 24.5 deg |
| 1,650 m/sec | 1,392 x 35,782 km at 23.5 deg |
| 1,600 m/sec | 1,837 x 35786 km at 22.5 deg |
| 1,550 m/sec | 1,986 x 35,680 km at 20.6 deg |
| 1,500 m/sec | 2,557 x 35,786 km at 20 deg |
| 1,450 m/sec | 2,991 x 35,780 km at 18.9 deg |
| 1,400 m/sec | 3,300 x 35,786 km at 17.4 deg |
| 1,350 m/sec | 3,898 x 35,780 km at 16.7 deg |
| 1,300 m/sec | 4,332 x 35,786 km at 15.6 deg |
| 1,250 m/sec | 4,933 x 35,786 km at 14.8 deg |
| 1,200 m/sec | 5,653 x 35,786 km at 14.2 deg |

**Figure 2-36. Delta IV H—GTO Performance Capability (Eastern Range)**

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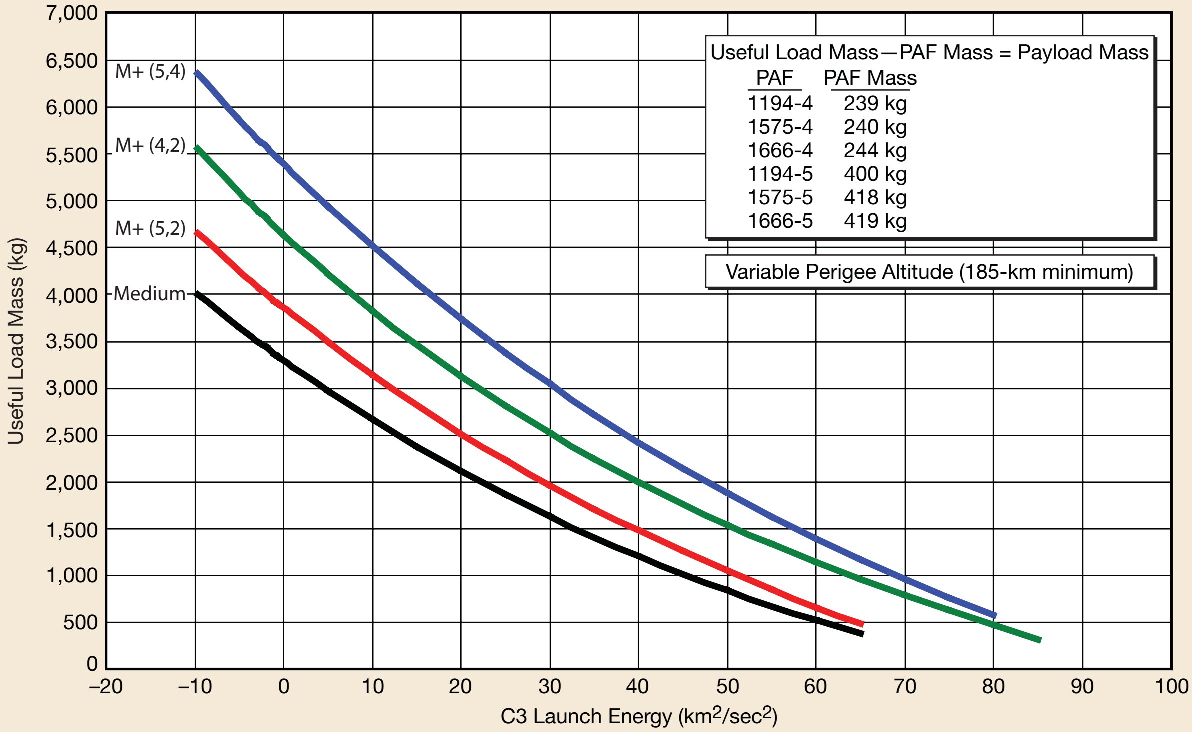


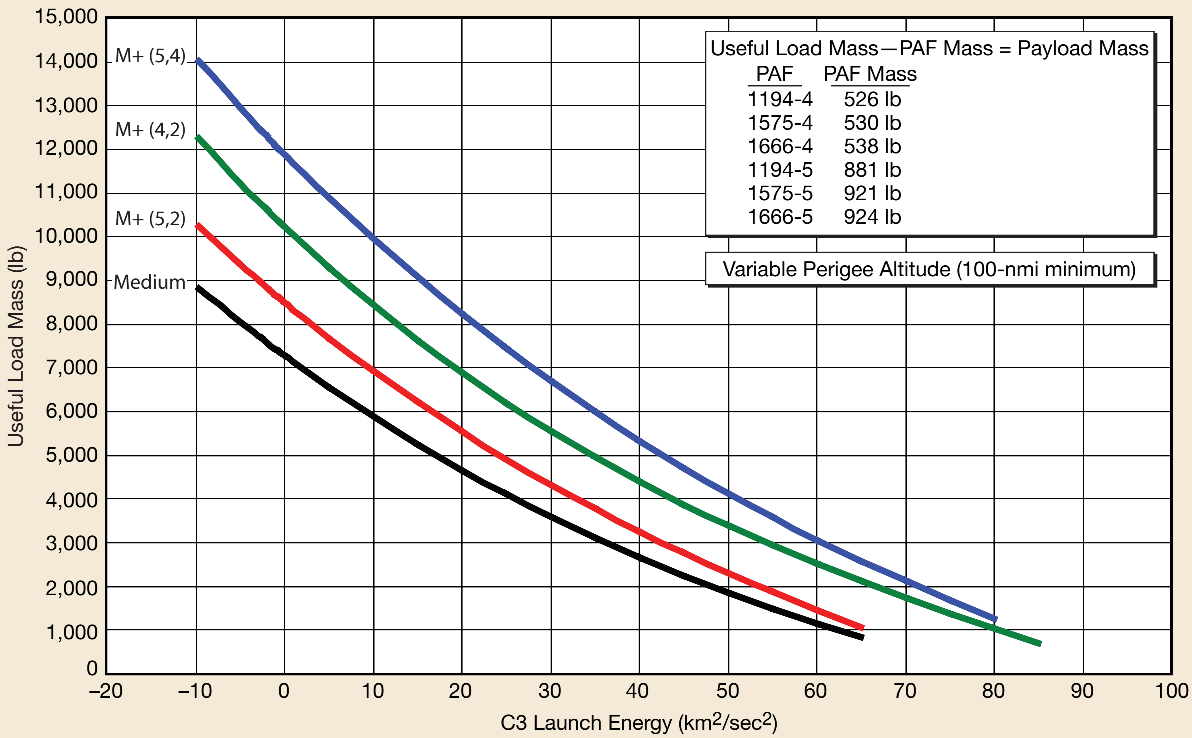


**Figure 2-37. Delta IV M, M+(4,2), M+(5,2), M+(5,4)—C3 Launch Energy Capability (Eastern Range)**

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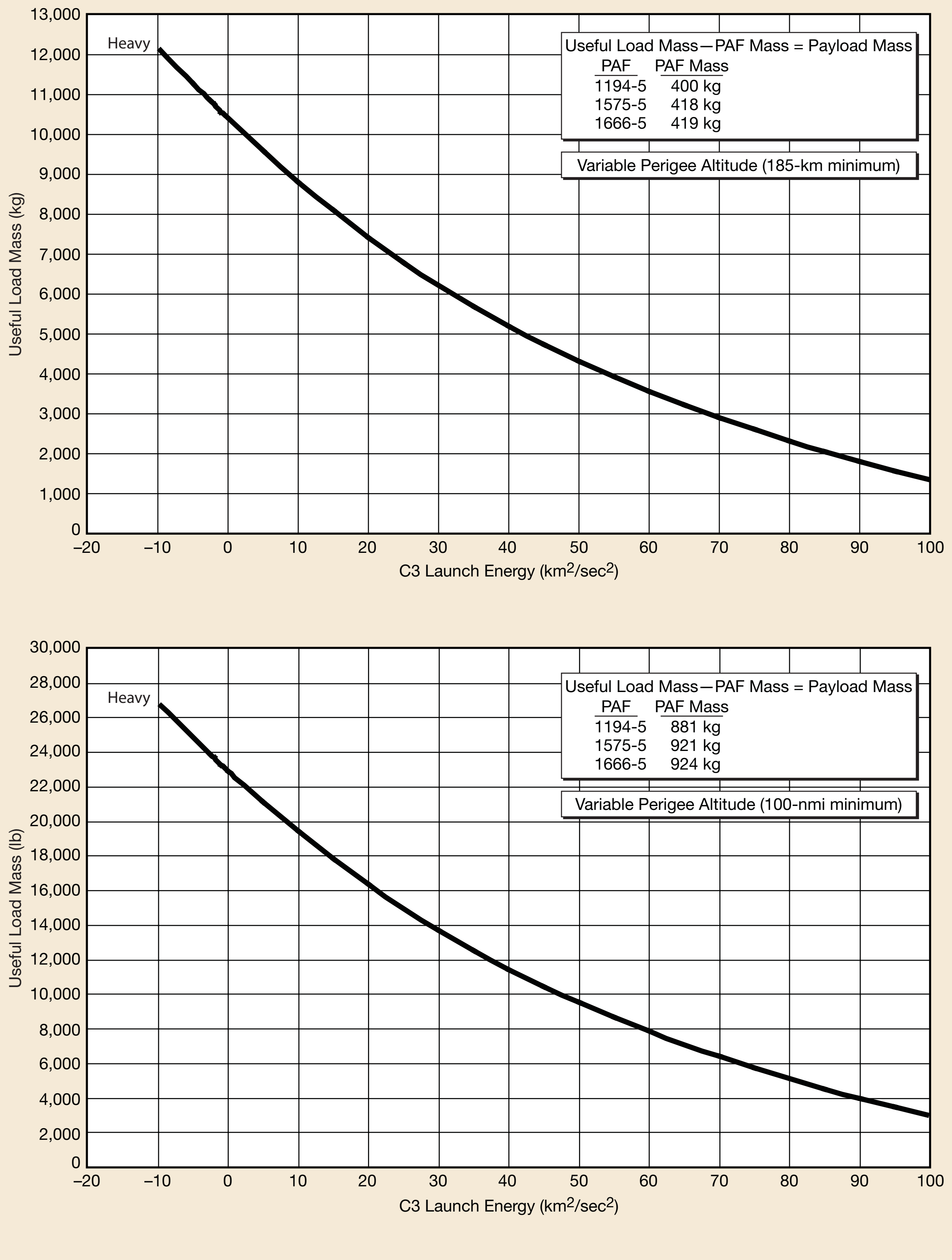
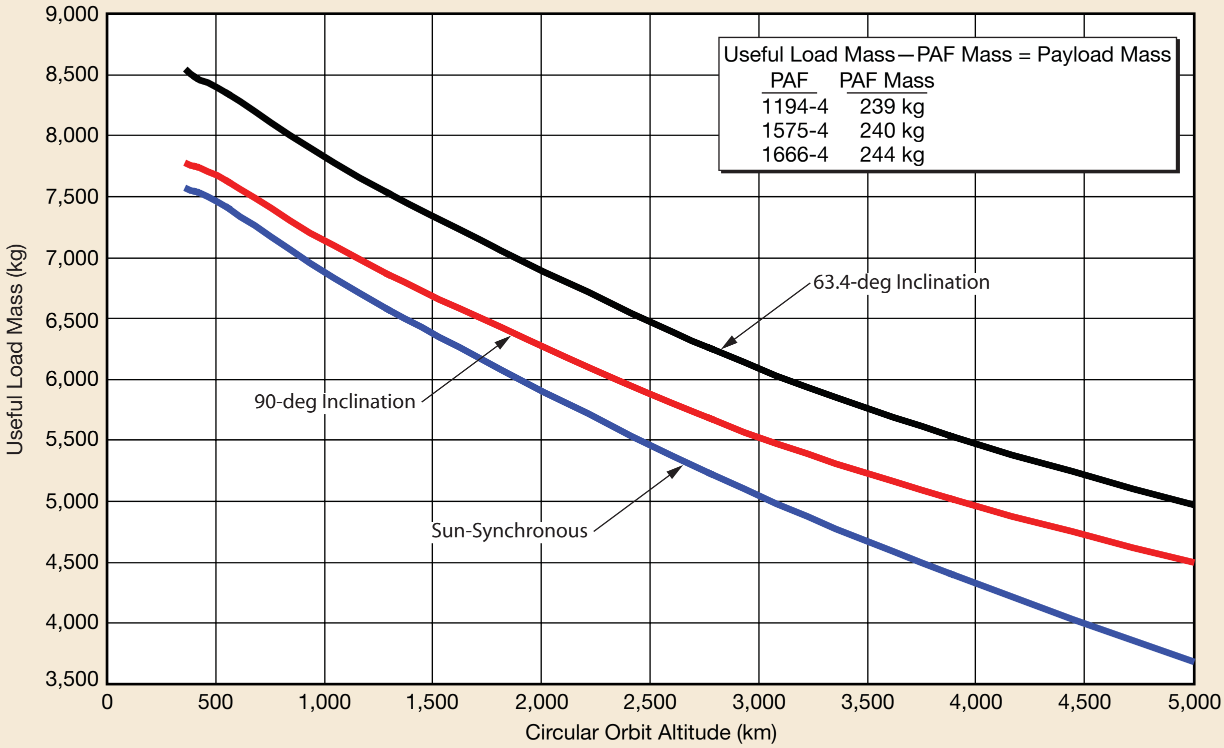



**Figure 2-38. Delta IV H—C3 Launch Energy Capability (Eastern Range)**

SHG0555905-028



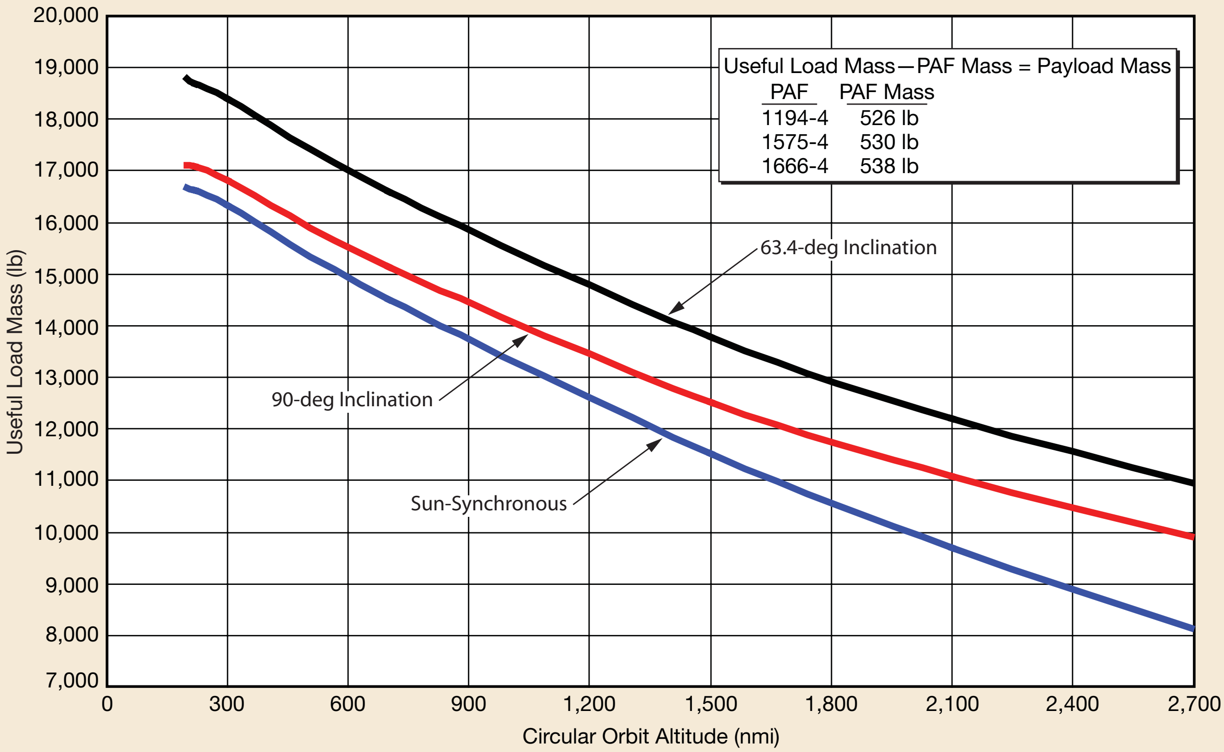




**Figure 2-39. Delta IV M—LEO Circular Orbit Capability (Western Range)**

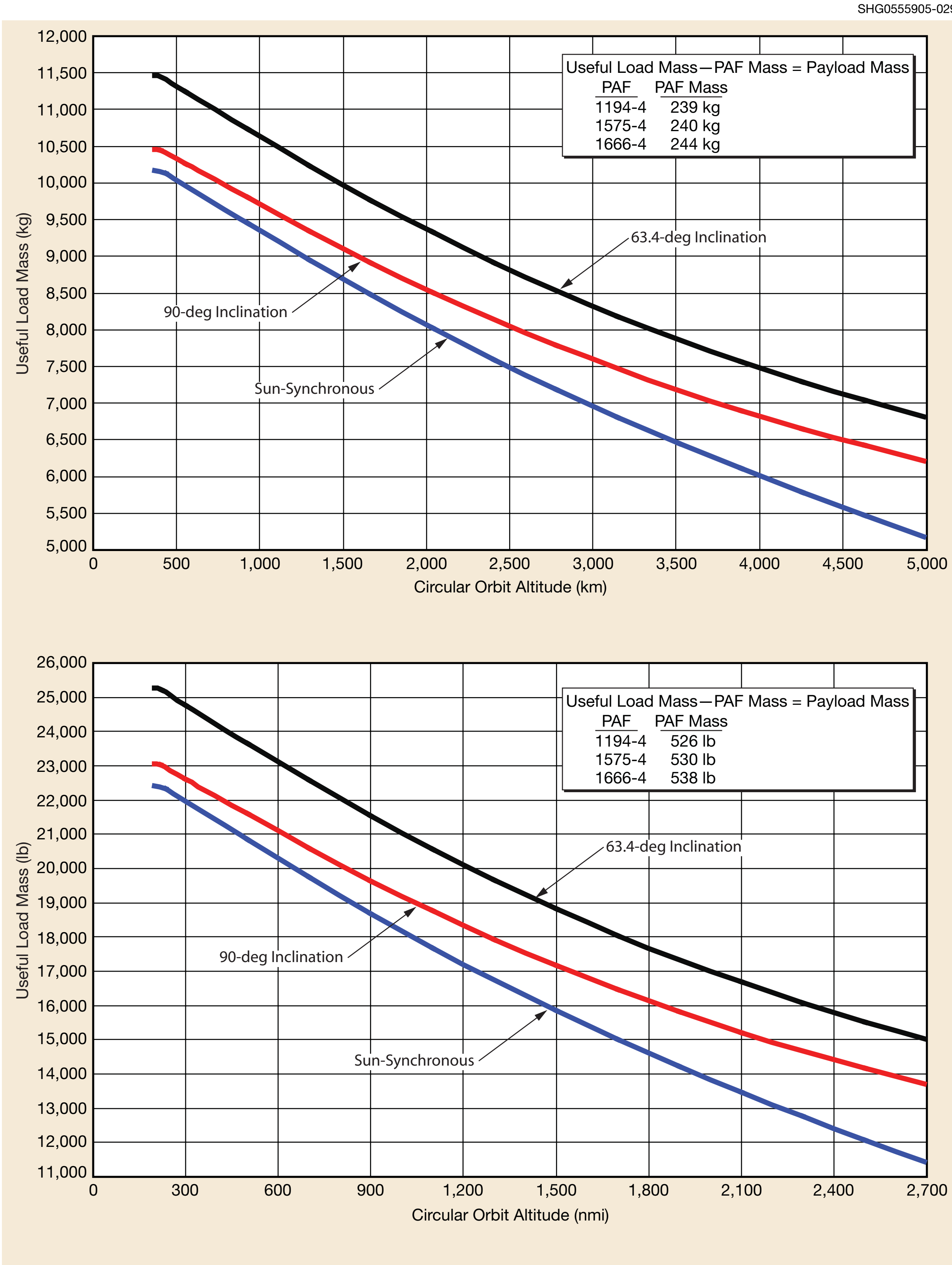



**Figure 2-40. Delta IV M+(4,2)—LEO Circular Orbit Capability (Western Range)**

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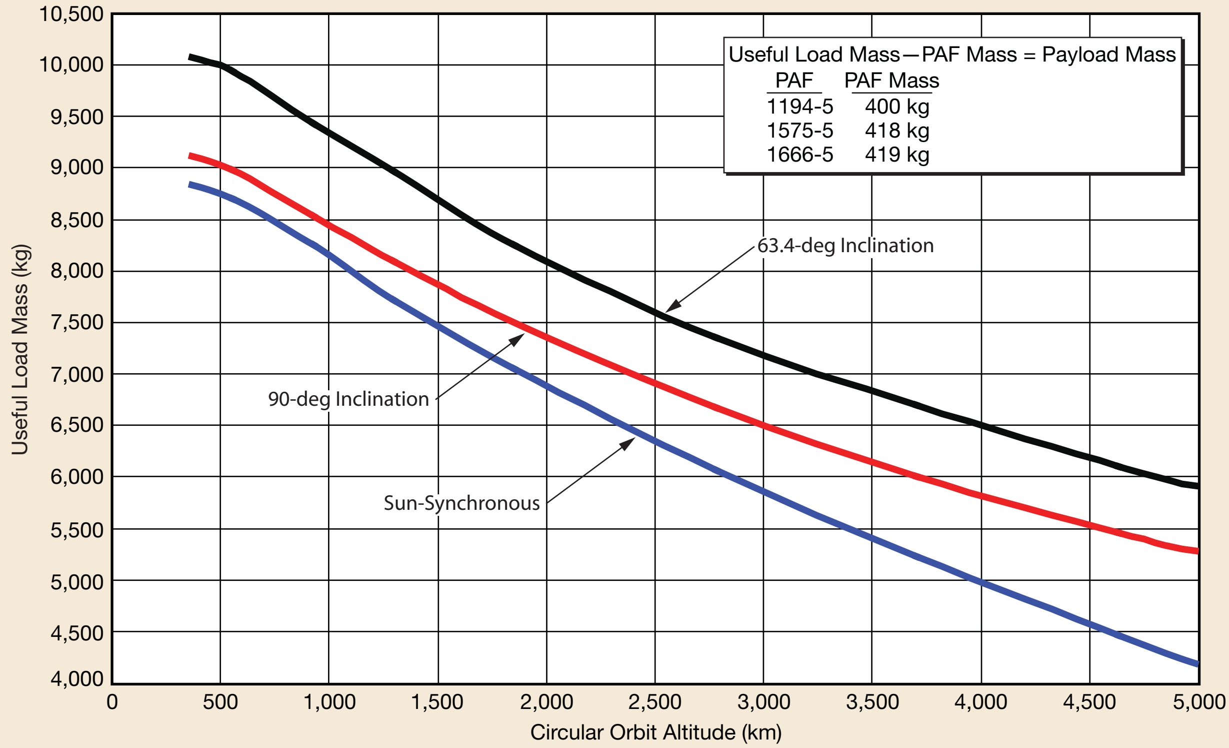


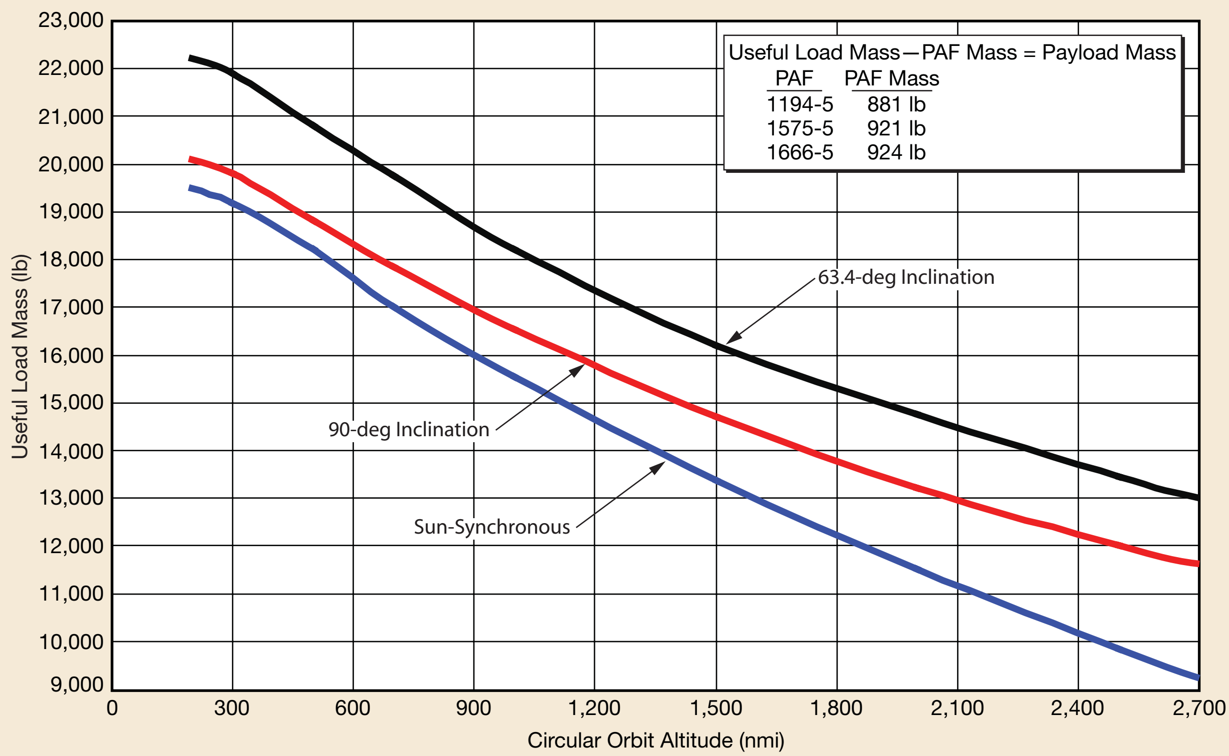


**Figure 2-41. Delta IV M+(5,2)—LEO Circular Orbit Capability (Western Range)**

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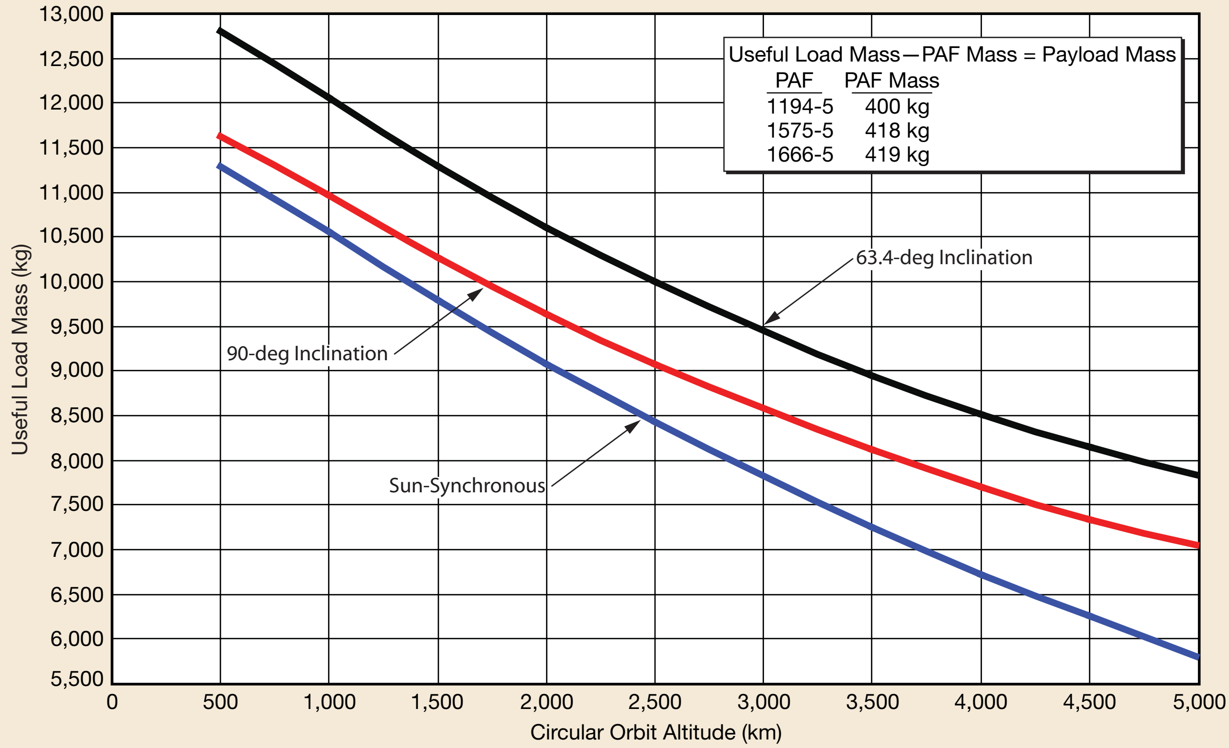


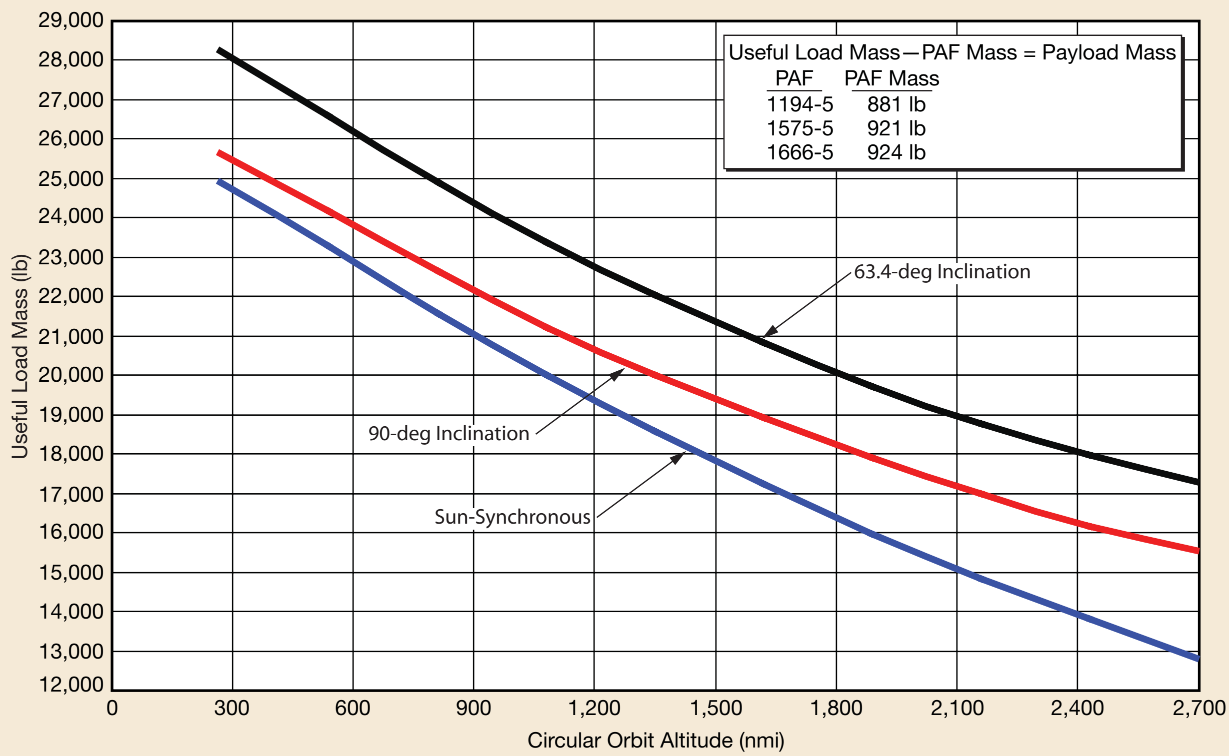


**Figure 2-42. Delta IV M+(5,4)—LEO Circular Orbit Capability (Western Range)**

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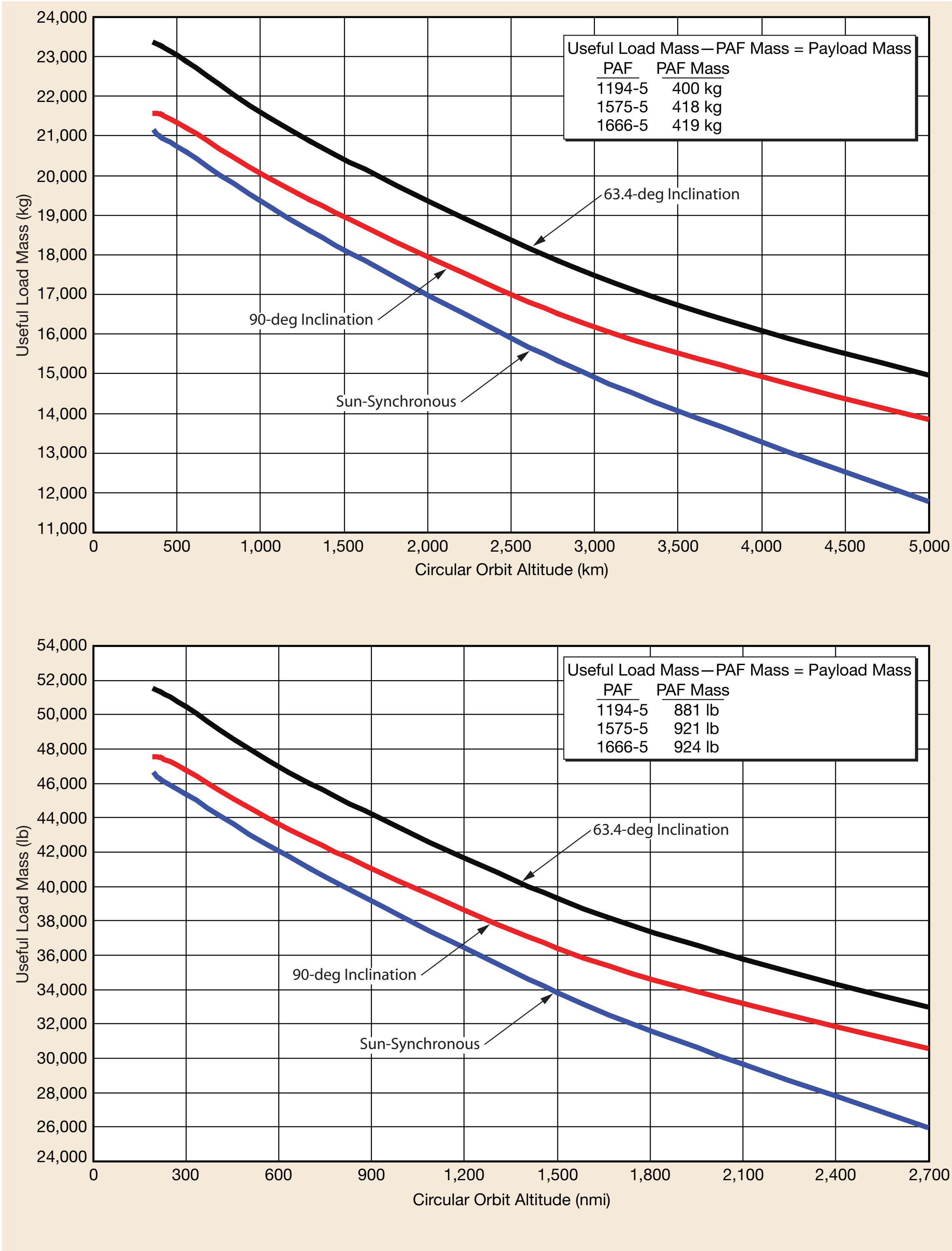


**Figure 2-43. Delta IV H—LEO Circular Orbit Capability (Western Range)**

# Section 3
# PAYLOAD FAIRINGS

The payload launched on a Delta IV M, Delta IV M+, or Delta IV H launch vehicle is protected by a fairing that shield 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 3-1). Fairings are jettisoned during either late first-stage or early second-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 3.1. Detailed fairing descriptions and envelopes are given in Sections 3.2 and 3.3. Information on future payload fairing capabilities is provided in Section 10.

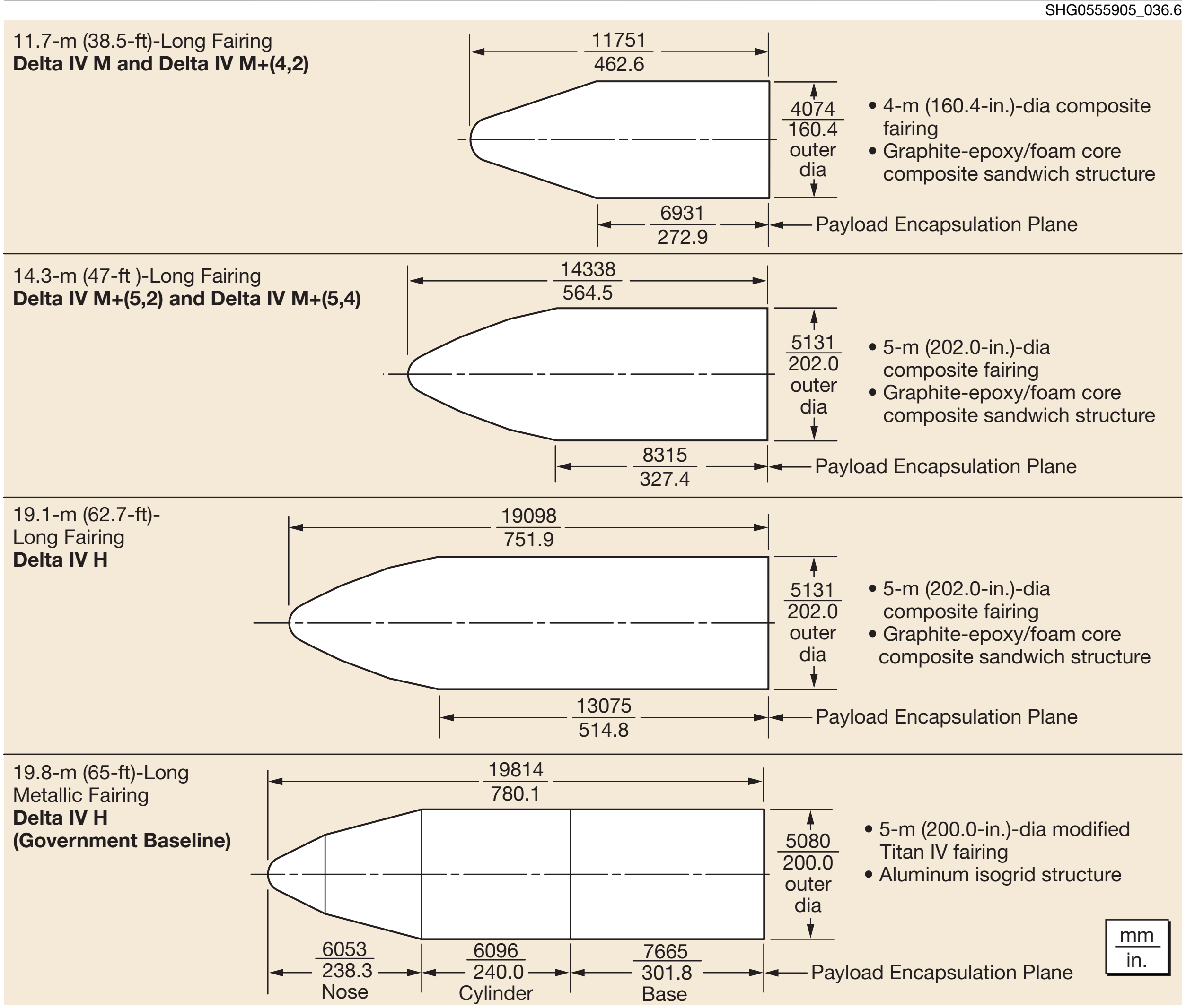


**Figure 3-1. Delta IV Fairing Configurations**

## 3.1 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 4.2.3.2. 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 3-2.

| Fairing | Location |
|---|---|
| 4-M Delta IV M 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 H 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 H, 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 3-2. 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 8, Payload Integration.) 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 4.1.1). A gaseous nitrogen ($GN_2$) 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 Figure 4-8 and Section 4.1.5 for a description of cleanliness levels.)

## 3.2 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 M and Delta IV M+(4,2) launch vehicles. The 5-m-dia by 14.3-m (47-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 H launch vehicle.

The 4-m composite fairing (Figure 3-3) and the 5-m composite fairing (Figures 3-4 and 3-5) 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 3-6, 3-7, and 3-8).

Figure 3-3 defines the envelopes for the 4-m fairing with the 1194-4, 1575-4, and 1666-4 payload attach fittings. Figures 3-4 and 3-5 define the envelopes for the 14.3-m (47-ft) and 19.1-m (62.7-ft)-long 5-m composite fairings with the 1194-5, 1575-5, and 1666-5 payload attach fittings.

These figures assume that the payload stiffness guidelines in Section 4.2.3 are observed. All payload extrusions outside of the payload envelopes or below the payload separation plane require coordination with and approval of the Delta Program Office.

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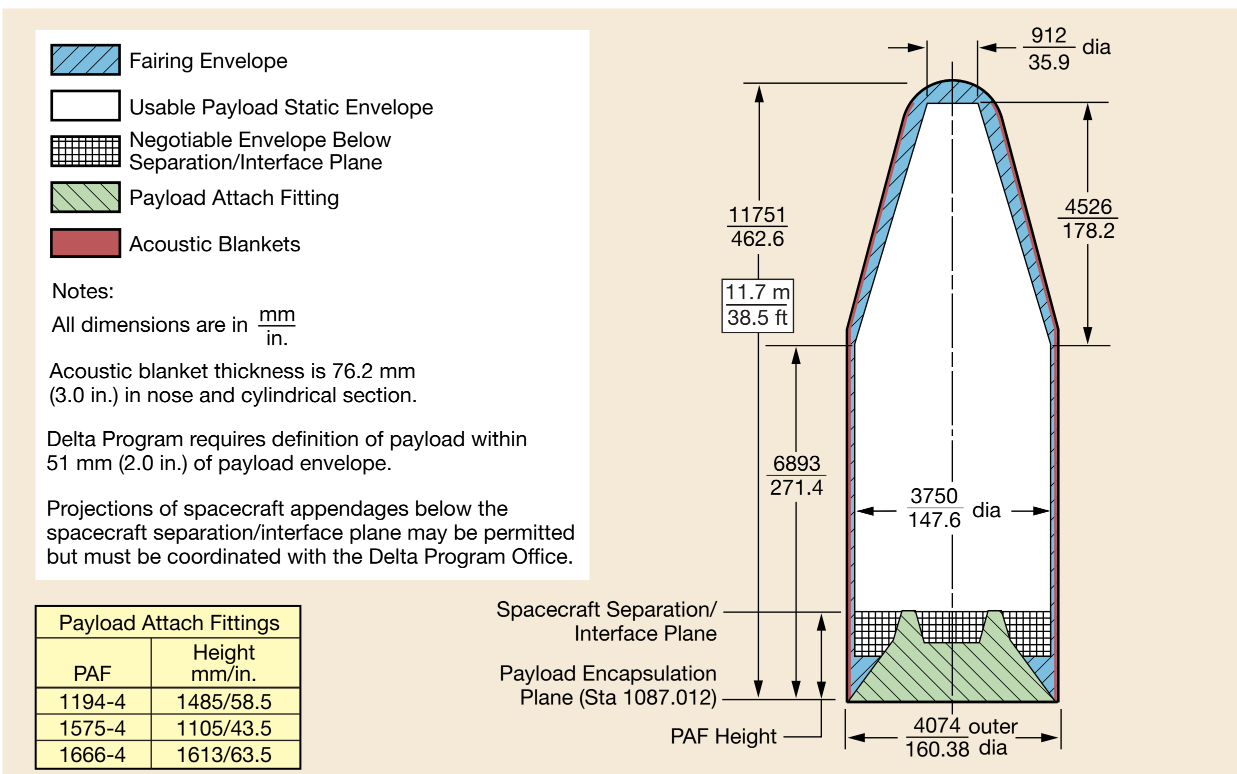


| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/in. |
| 1194-4 | 1485/58.5 |
| 1575-4 | 1105/43.5 |
| 1666-4 | 1613/63.5 |

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

HB5T072043.1

- Fairing Envelope
- Usable Payload Static Envelope
- Negotiable Envelope Below Separation/Interface Plane
- Payload Attach Fitting
- Acoustic Blankets

Notes:

All dimensions are in $\frac{mm}{in.}$

Acoustic blanket thickness is 114.3 mm (4.5 in.) in nose and cylindrical section.

Delta Program requires definition of payload within 51 mm (2.0 in.) of payload envelope.

Projections of spacecraft appendages below the spacecraft separation/interface plane may be permitted but must be coordinated with the Delta Program Office.

| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/in. |
| 1194-5 | 2088/82.2 |
| 1575-5 | 1807/71.2 |
| 1666-5 | 2134/84.0 |

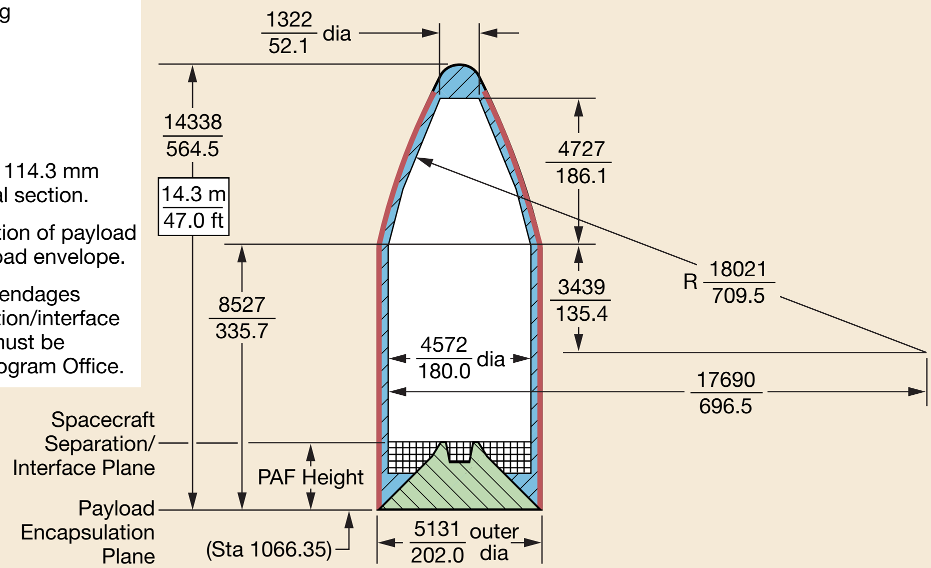


**Figure 3-4. Payload Static Envelope, 5-m-dia by 14.3-m-Long Composite Fairing**

HB5T-72042.1

- Fairing Envelope
- Usable Payload Static Envelope
- Negotiable Envelope Below Separation/Interface Plane
- Payload Attach Fitting
- Acoustic Blankets

Notes:

All dimensions are in $\frac{mm}{in.}$

Acoustic blanket thickness is 114.3 mm (4.5 in.) in nose and cylindrical section.

Delta Program requires definition of payload within 51 mm (2.0 in.) of payload envelope.

Projections of spacecraft appendages below the spacecraft separation/interface plane may be permitted but must be coordinated with the Delta Program Office.

| Payload Attach Fittings | |
|---|---|
| PAF | Height mm/in. |
| 1194-5 | 2088/82.2 |
| 1575-5 | 1807/71.2 |
| 1666-5 | 2134/84.0 |

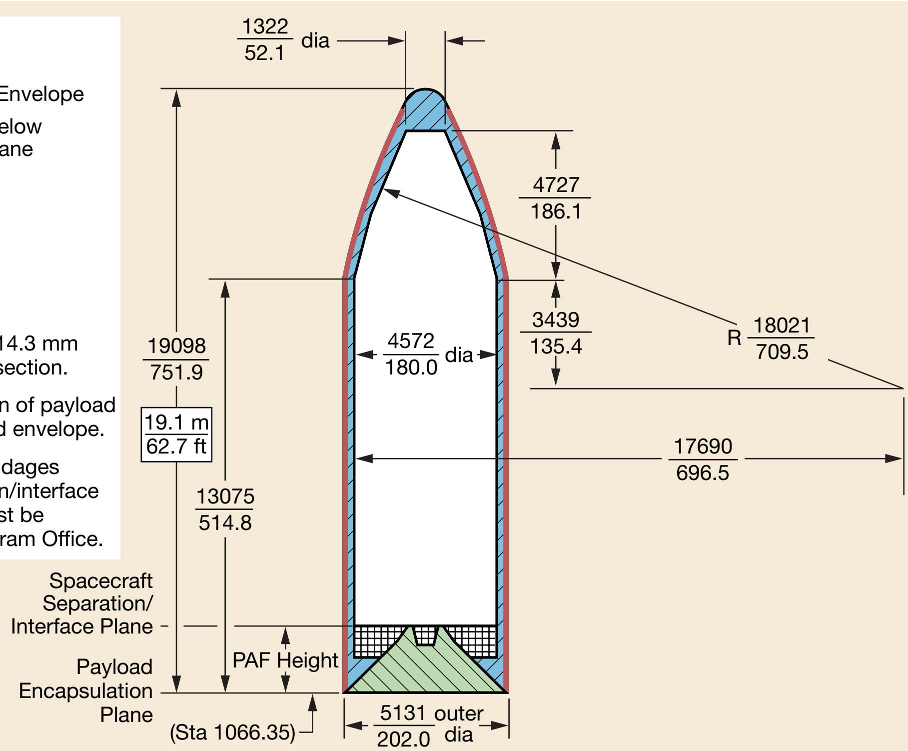


**Figure 3-5. Payload Static Envelope, 5-m-dia by 19.1-m Composite Fairing**

HB5T072038.1

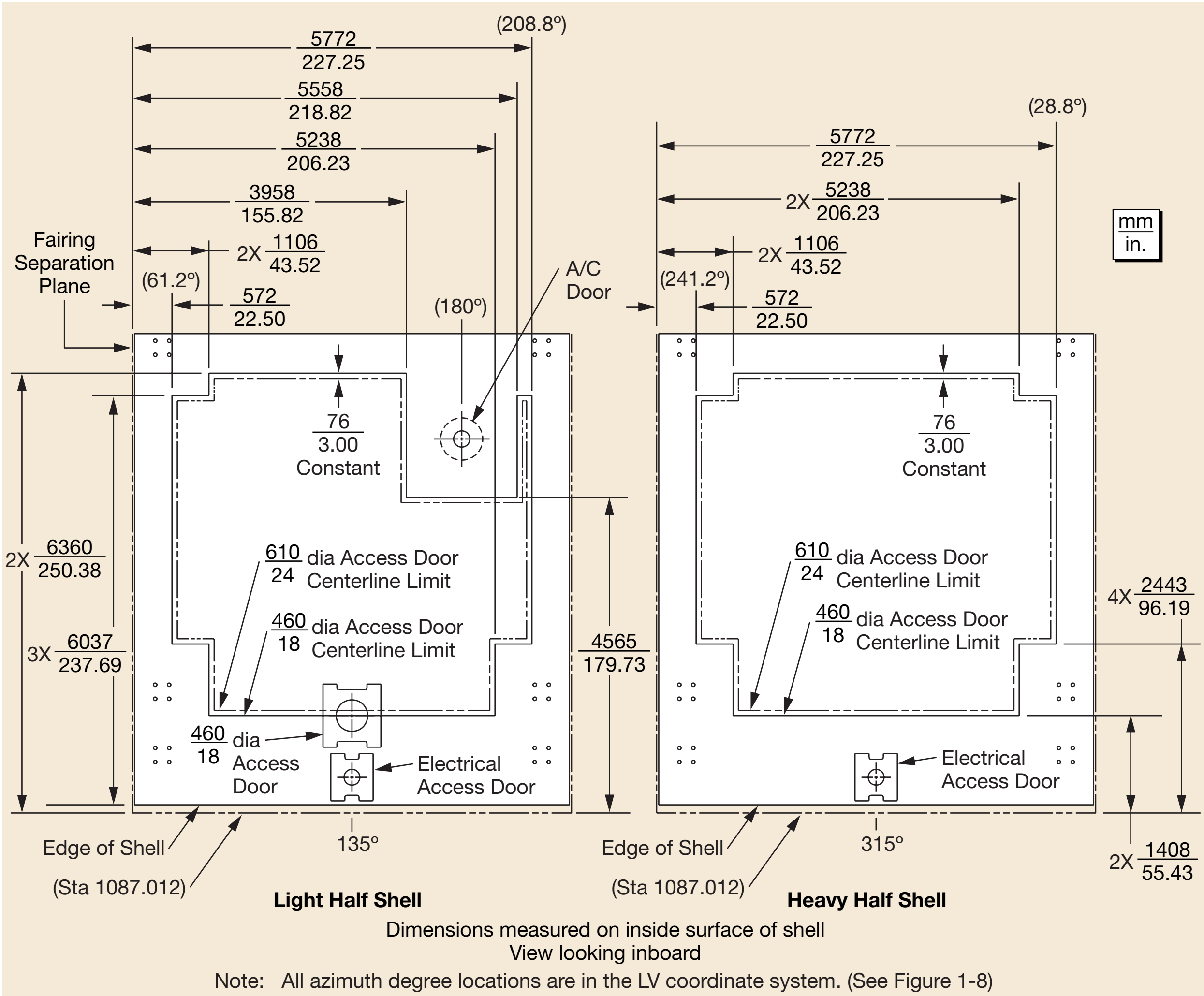


**Figure 3-6. Allowable Access Door Locations for 4-m-dia by 11.7-m-Long Composite Fairing**

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 the Delta Program Office.

Radio frequency (RF) windows can be accommodated on a mission-unique basis. RF window requirements should be coordinated with the Delta Program Office.

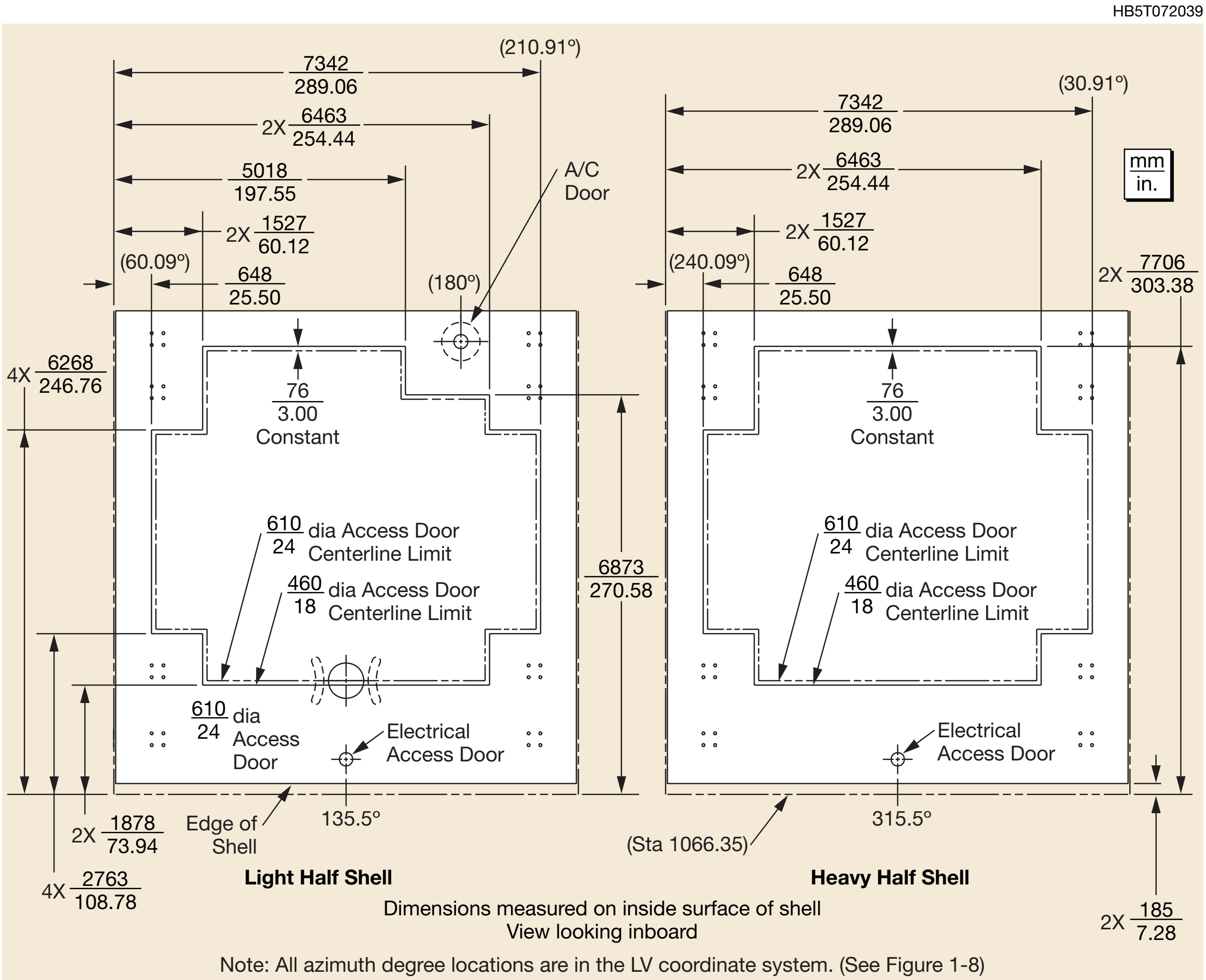


**Figure 3-7. Allowable Access Door Locations for 5-m-dia by 14.3-m-Long Composite Fairing**

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.

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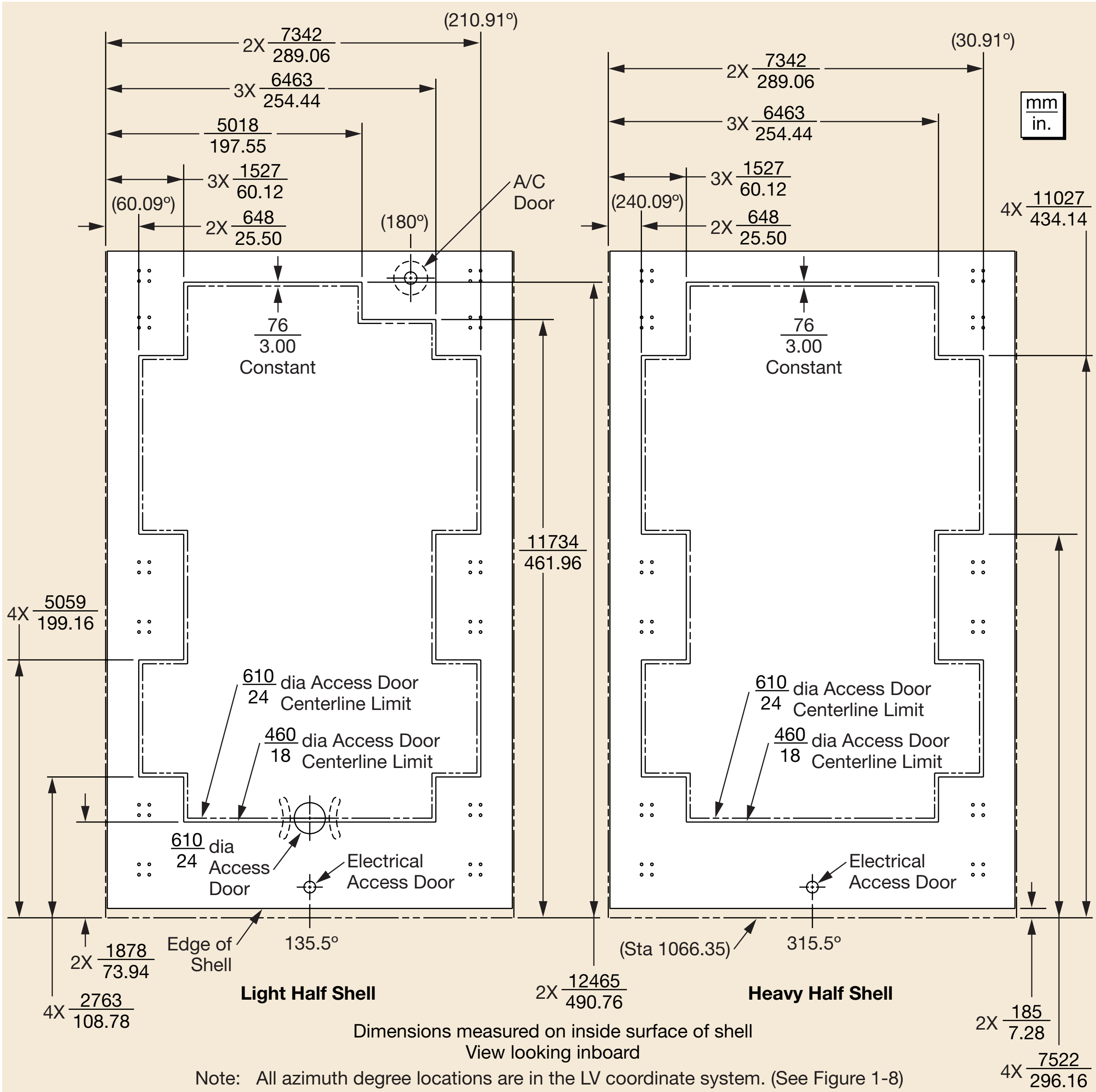


**Figure 3-8. Allowable Access Door Locations for 5-m-dia by 19.1-m-Long Composite Fairing**

## 3.3 5-M-DIA METALLIC PAYLOAD FAIRING

The 5-m-dia modified Titan IV metallic fairing (Figure 3-9) 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 H launch vehicles. This fairing is compatible only with 4394-5 PAF.

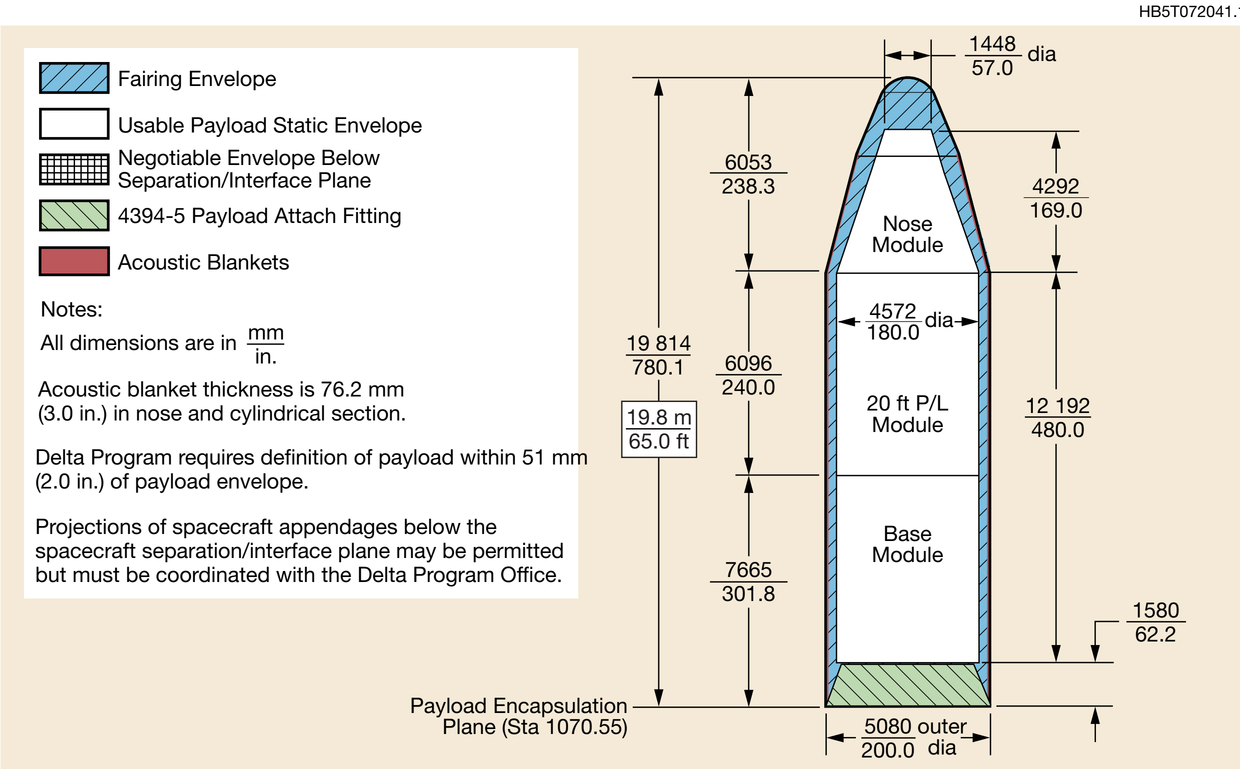


**Figure 3-9. Payload Static Envelope, 5-m-dia by 19.8-m-Long Metallic Fairing Payload Envelope—4394-5 PAF**

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 3-2. 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 the Delta Program Office.

Figure 3-9 assumes that the payload stiffness guidelines in Section 4.2.3.2 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 the Delta Program Office.

# Section 4
# PAYLOAD ENVIRONMENTS

This section describes the environments to which the payload is exposed from delivery at launch site through launch. Section 4.1 presents prelaunch environments for processing facilities at both the Eastern and Western ranges. Section 4.2 presents the Delta IV launch and flight environments for the payload.

## 4.1 PRELAUNCH ENVIRONMENTS

### 4.1.1 Air-Conditioning and Gaseous Nitrogen ($GN_2$) Purge

During processing, the payload environment is carefully controlled for temperature, relative humidity, and cleanliness. This includes the processing conducted before the payload is encapsulated within the payload fairing, transported to the launch pad, and lifted onto the Delta IV launch vehicle. During transportation, air-conditioning is supplied through a portable environmental control system (PECS). Air-conditioning is supplied to the payload by an umbilical after the encapsulated payload is mated to the Delta IV launch vehicle. The payload air-distribution system (Figure 4-1 for 4-m and 5-m composite fairings and Figure 4-2 for the 5-m metallic fairing option) provides air at the required cleanliness, temperature, relative humidity, and flow rate. The air 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 launch vehicles; and 90.7 kg/min to 136.0 kg/min (200 to 300 lb/min) for 5-m fairing launch vehicles. Air flow around the payload is discharged through vents in the aft end of the fairing. Both Space Launch Complexes, SLC-37 and SLC-6, have a backup system for fairing air-conditioning. The 4-m and 5-m composite fairings' air-distribution systems use a diffuser on the inlet air-conditioning 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 air-conditioning umbilical is pulled away at liftoff by lanyard disconnects, and the inlet door on the fairing automatically closes.

A $GN_2$ purge line to the payload can be accommodated through the air-conditioning duct. The air-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 the Delta Program Office.

Various payload processing facilities are available at the launch site for use by the customer. Environmental control specifications for these facilities are listed in Figures 4-3 and 4-4 for the Eastern and Western ranges, respectively. The facilities to be used depend on payload program requirements.

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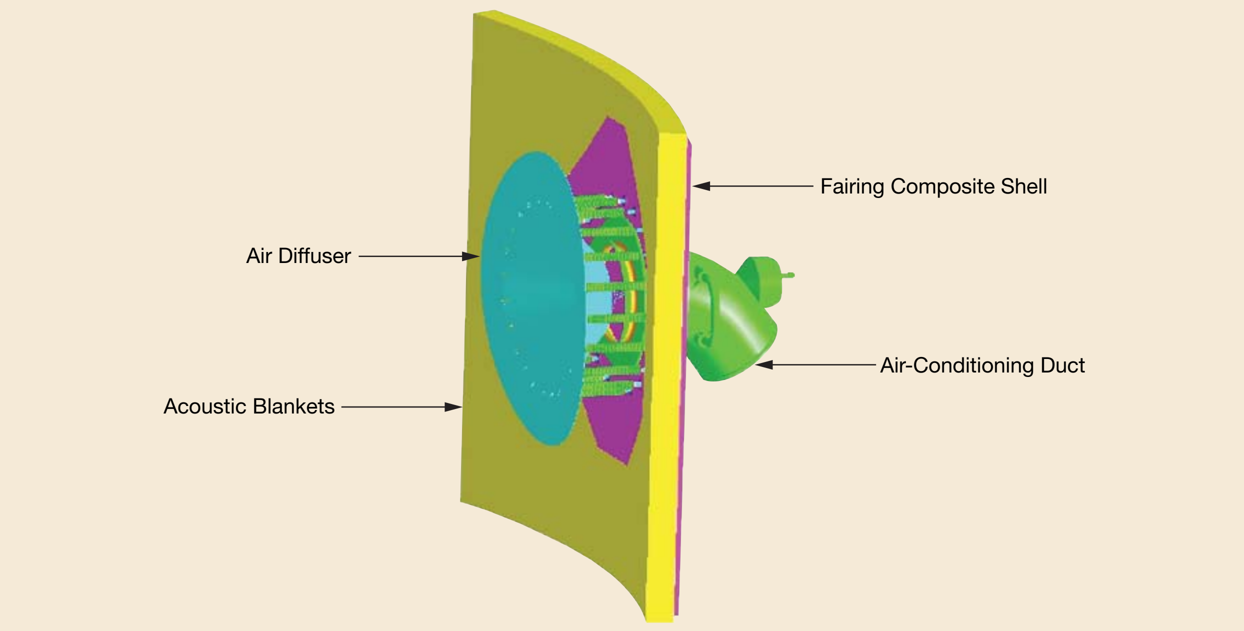


**Figure 4-1. Standard 4-m Composite Fairing and 5-m Composite Fairing Air-Conditioning Duct Inlet Configuration**

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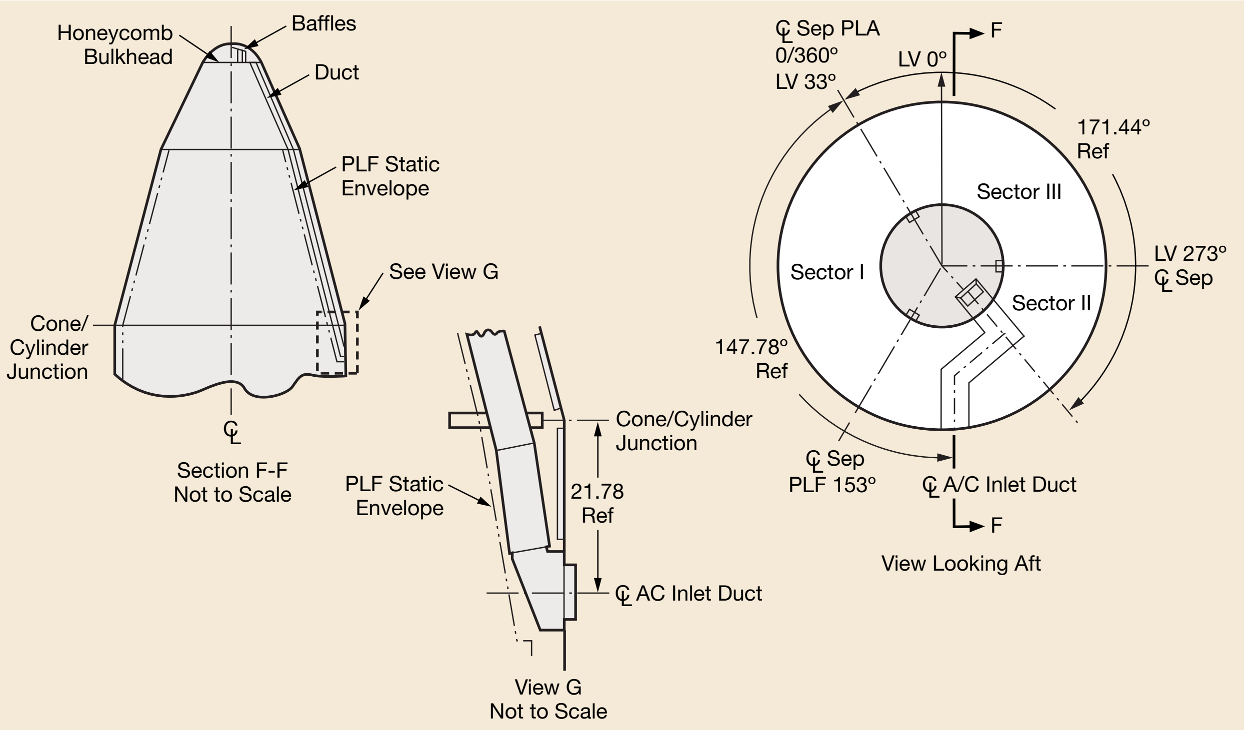


**Figure 4-2. 5-m Metallic Fairing Payload Air-Distribution System**

| Location | | Temperature | Relative Humidity[1] | Particulate Class[2] |
|---|---|---|---|---|
| Encapsulated payload | Mobile | 18.3° to 29.4° ±2.8°C<br>(65° to 85° ±5°F) | Max 50%<br>Min not controlled | Class 5000[3] |
| MST[4] | Environmental enclosure<br><br>Fairing | 20° to 25.6°C (68° to 78°F)<br><br>Any specified between 10° and 29.4° ±2.8°C<br>(50° and 85° ±5°F) | Max 75%<br>Min not controlled<br>20 to 50% | Not controlled<br><br>Class 5000 inlet |

Note: The facilities listed can only limit the maximum humidity level. The facilities do not have the capability to maintain a minimum RH value.
These numbers are provided for planning purposes only. Specific values should be obtained from the controlling agency.
(1)PCES only: A 50% relative humidity maximum can be maintained at a temperature of 18.3°C (65°F). At higher temperatures, the relative humidity can be reduced by drying the conditioned air to a minimum specific humidity of 48 grains of moisture per 0.45 kg (1 lb) of dry air.
(2)Verified/sampled at duct outlet.
(3)FED-STD-209D.
(4)A backup system exists for the mobile service tower (MST) air-conditioning.

**Figure 4-3. Eastern Range Facility Environments**

| Location | | Temperature | Relative Humidity | Particulate Class |
|---|---|---|---|---|
| Encapsulated payload | Mobile | 18.3° to 29.4° ±2.8°C<br>(65° to 85° ±5°F) | Max 50%<br>Min not controlled | Class 5000[1] |
| MST | SLC-6 MST/MAS<br><br>Fairing | Not controlled<br><br>Any specified between 10° and 29.4° ±2.8°C (50° and 85° ±5°F) | Not controlled<br><br>20 to 50% | Not controlled<br><br>Class 5000 inlet[2] |

(1)FED-STD-209D.
(2)Controlled per customer requirement within range, shown.

**Figure 4-4. Western Range Facility Environments**

### 4.1.2 MST Enclosure

The mobile service tower (MST) provides customers access to the encapsulated payload once it is mated to the launch vehicle. This enclosure is located at levels 8 to 12 in the MST to provide weather protection. A portable clean environmental shelter (PCES), as shown in Figure 4-5, can be provided that allows environmentally controlled (class 5000) access through one payload fairing (PLF) door within the MST operational constraints while the encapsulated payload is housed within the MST. Multiple doors may be accessed with PCESs. This will be considered on a case-by-case basis. The PCES comprises three major components: (1) entrance/changing chamber, (2) working chamber, and (3) PLF interface. This interface provides shielding/sealing around the PLF access doors and protects the encapsulated payload from being contaminated.

### 4.1.3 Radiation and Electromagnetic Environments

The Delta IV launch vehicle transmits on several frequencies to provide launch vehicle telemetry and beacon signals to the appropriate ground stations and the tracking and data relay satellite system (TDRSS). The launch vehicle 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 4-6. The radio frequency (RF) systems are switched on prior to launch and remain on until mission completion. Additional transmitters may be used in conjunction with non-standard services such as video cameras and special flight instrumentation; contact the Delta Program Office for mission-specific transmitter characteristics.

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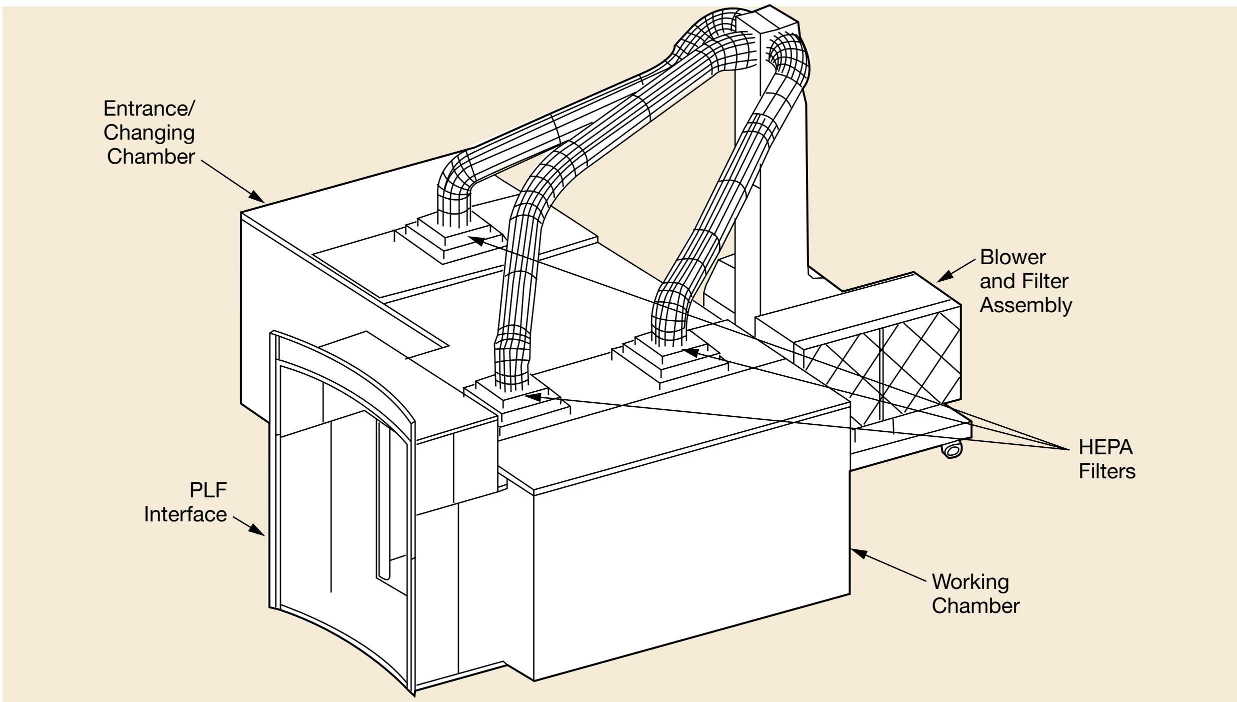


**Figure 4-5. Portable Clean environmental Shelter (PCES)**

| | Second-Stage Telemetry Radiation Characteristics | Second-Stage C-band Beacon Characteristics |
|---|---|---|
| **Transmitter** | | |
| Nominal frequency | 2241.5 MHz | 5765 MHz (transmit)<br>5690 MHz (receive) |
| Power output | 30.0 W min | 400 W min peak,<br>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<br>4-m second stage—Sta 1232.36 | 5-m Sta 1172.88<br>4-m Sta 1232.36 |
| Pattern coverage | Launch to 2 deg above radar horizon = 95%<br>From 2 deg above radar horizon to CCAM = 95% ±60 deg boresight via one of four selected antennas around the circumference of the launch vehicle | |

**Figure 4-6. Delta IV Transmitter Characteristics**

At the Eastern and Western ranges, the electromagnetic environment to which the payload is exposed results from the operation of range radars and launch vehicle transmitters and antennas. The maximum RF environment at the launch site is controlled through coordination with the range and with protective masking of radars. The launch pads are protected to an environment of 20 V/m at frequencies from 14 kHz to 40 GHz and 40 V/m in the S- and C-band frequencies used for vehicle range tracking and telemetry. This does not include maritime, broadcast, and overhead flying aircraft emitters. Effects of launch vehicle emitters on spacecraft RF environment do not include any payload fairing effects. Reduced levels of range controlled emitters may be negotiated; if reduced levels are desired, they should be identified to the Delta Program Office early in the integration process.

The maximum allowable spacecraft radiated emissions at the spacecraft/vehicle separation plane are provided in Figure 4-7. Spacecraft are permitted to radiate inside the fairing provided that the emissions, including cavity effects, do not exceed the maximum level deemed safe for launch vehicle avionics and ordnance circuits. The RF field strength inside the fairing is a function of the spacecraft antenna gains, locations, and other physical characteristics of the spacecraft, and the RF properties of the fairing with the acoustic blanket accounted for. RF emissions from spacecraft emitters within a closed volume such as a payload fairing generally exceed free space levels. The Delta Program will calculate E-field levels within the payload fairing for all spacecraft transmitters using spacecraft-supplied data, empirical and analytic formulas that account for cavity resonances and other influencing factors. 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.

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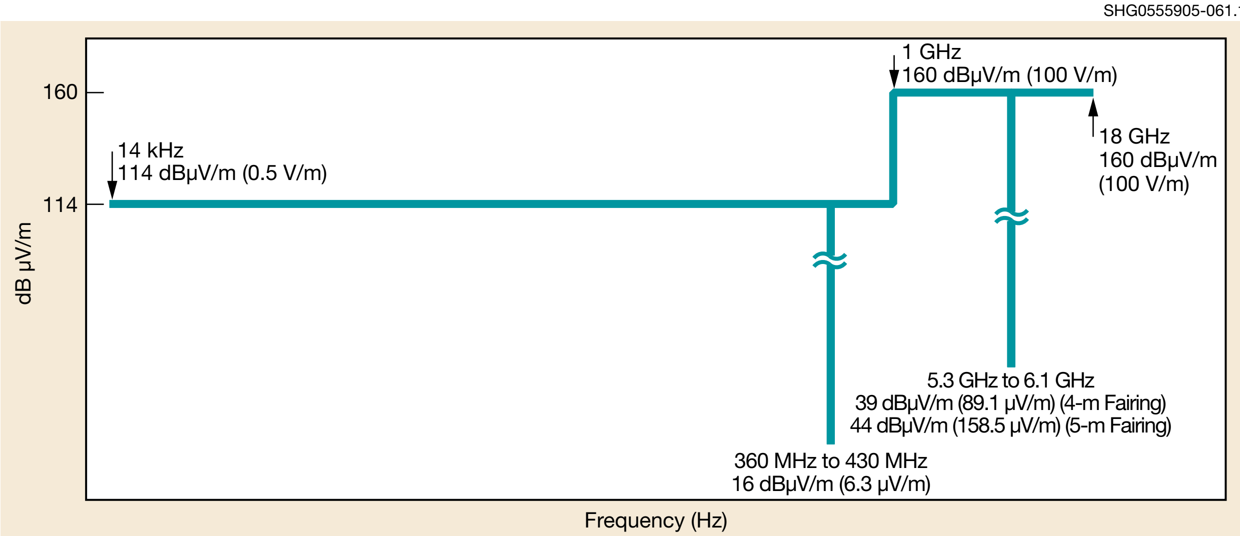


**Figure 4-7. Maximum Allowable Payload Radiated Emissions at the Payload/Launch Vehicle Separation Plane**

The customer should contact the Delta Program Office for induced RF environments.

### 4.1.4 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. Preferably, the ground attachment point is located on or near the base of the payload, at least 31.8 mm (1.25 in.) above the separation plane. The launch vehicle/payload interface provides the conductive path for grounding the payload to the launch vehicle. Therefore, dielectric coating should not be applied to the payload interface. The electrical resistance of the payload-to-payload attach fitting (PAF) interface surfaces must be 0.0025 ohm or less and is verified during payload-to-PAF mate (reference MIL-B-5087B, Class R).

### 4.1.5 Contamination and Cleanliness

The following guidelines and practices ensure that payload contamination is minimized during encapsulation, transport, and launch site operations.

Precautions are taken during manufacture, assembly, test, and shipment of the Delta IV second-stage area, fairing, and PAF to prevent contaminant accumulations.

The fairing and PAF are cleaned at the manufacturing site using approved solvents, then inspected for cleanliness prior to double-bagging for shipment to the launch site. Figure 4-8 provides the Delta Program's Cleanliness Specification STP0407 visible cleanliness (VC) levels with their NASA SN-C-0005 equivalents. STP0407 defines the cleanliness levels available to payload customers. The standard level for a Delta IV mission using a composite fairing is VC 3. Other cleanliness levels must be negotiated with the Delta Program Office.

| Delta Program STP0407-0X | NASA SN-C-0005 |
|---|---|
| VC 1 | None |
| VC 2 | VC Standard |
| VC 3 | VC Highly Sensitive, Standard Level |
| VC 4 | VC Sensitive + UV (Closest equivalent; Delta Program is more critical) |
| VC 5 | VC Highly Sensitive |
| VC 6 | VC Highly Sensitive +UV |
| VC 7 | VC Highly Sensitive + NVR Level A |

**Figure 4-8. Cleanliness Level Definitions**

### Cleanlines Level Definitions

**VC 1**—All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are defined as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. Inspection operations shall be performed under normal shop lighting conditions at a maximum distance of 0.915 m (3 ft).

**VC 2**—All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are defined as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. Inspection operations shall be performed at incident light levels of 538.2 lux (50 footcandles [fc]) and observation distances of 1.52 m to 3.05 m (5 ft to 10 ft).

**VC 3**—All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. Incident light levels shall be 1076.4 lux to 1345.5 lux (100 fc to 125 fc) at an observation distance of 45.2 cm (18 in.) or less.

**VC 4**—All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. The source of incident light shall be a 300-W explosion-proof droplight held at distance of 1.52 m (5 ft), maximum, from the local area of inspection. There shall be no hydrocarbon contamination on surfaces specifying VC 4 cleanliness.

**VC 5**—All surfaces shall be visibly free of all particulates and nonparticulates visibly to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. Incident light levels shall be 1076.4 lux to 1345.5 lux (100 fc to 125 fc) at an observation distance of 15.2 cm to 45.7 cm (6 in. to 18 in.). Cleaning must be done in a class 100,000 or better cleanroom.

**VC 6**—All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. Incident light levels shall be 1076.4 lux to 1345.5 lux (100 fc to 125 fc) at an observation distance of 15.2 cm to 45.7 cm (6 in. to 18 in.). Additional incident light requirements are 8 V minimum of long-wave ultraviolet (UV) light at 15.2 cm to 45.7-cm (6 in. to 18-in.) observation distance in a darkened work area. Protective eyewear may be used as required with UV lamps. Cleaning must be done in a class 100,000 or better cleanroom.

**VC 7**—All surfaces shall be visibly free of particulates and nonparticulates visible to the normal unaided/corrected-vision eye. Particulates are identified as matter of miniature size with observable length, width, and thickness. Nonparticulates are film matter without definite dimension. This level requires no particulate count. Incident light levels shall be 1076.4 lux to 1345.5 lux (100 fc to125 fc) at an observation distance of 15.2 cm to 45.7 cm (6 in. to 18 in.). Cleaning must be done in a class 100,000 or better cleanroom. The nonvolatile residue (NVR) is to be one microgram or less per square centimeter (one milligram or less per square foot) of surface area as determined by the laboratory using a minimum of two random NVR samples per quadrant per bisector or trisector.

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 remote encapsulation facilities. A transporter provided by the Delta Program is used to transport the encapsulated payload to the launch pad and a portable environmental control system is used to provide environmental protection for the payload during transport.

Personnel and operational controls are employed during payload encapsulation and access at the pad (if required) to maintain payload cleanliness. Such standard controls are detailed in the Delta IV Contamination Control Implementation Plan, MDC 98H1056.

## 4.2 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 launch vehicle telemetry system for validation.

### 4.2.1 Fairing Internal Pressure Environment

As a Delta IV launch vehicle 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 4-9, 4-10, 4-11, 4-12, 4-13, and 4-14 for the Delta IV family of launch vehicles.

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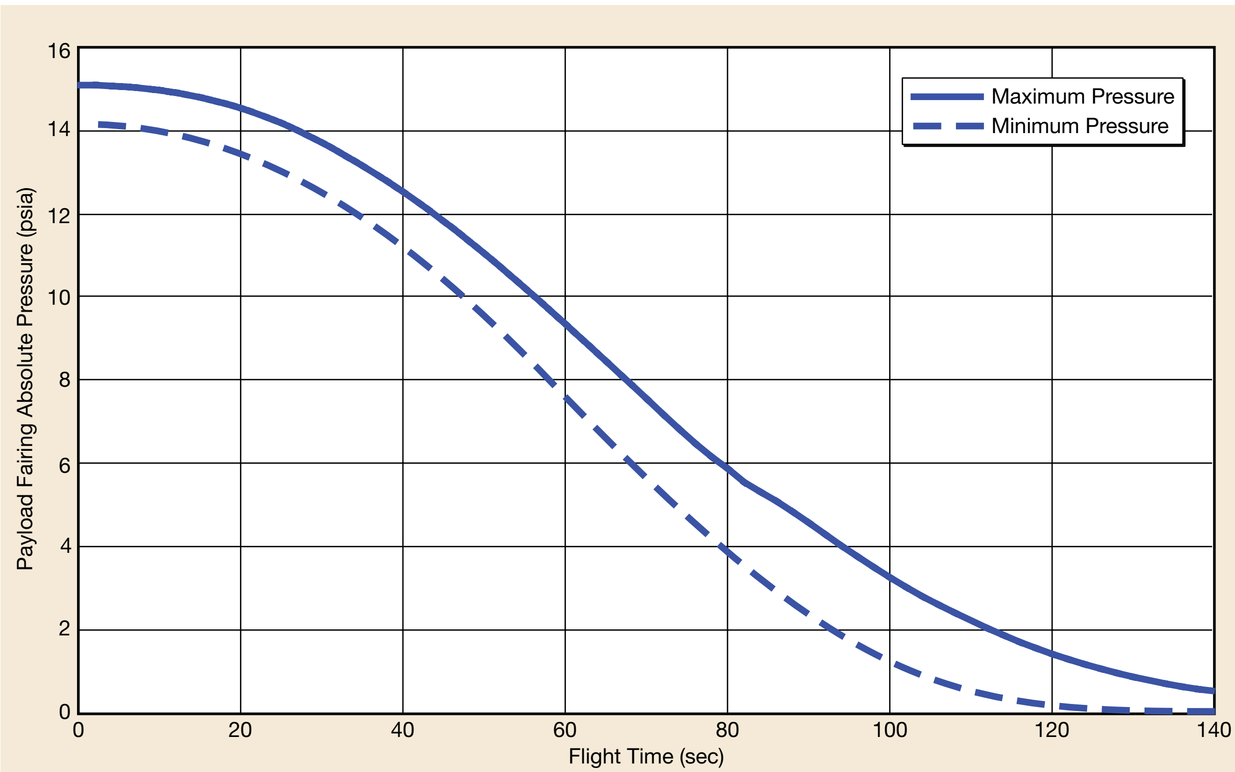


**Figure 4-9. Delta IV Medium Absolute Pressure Envelope**

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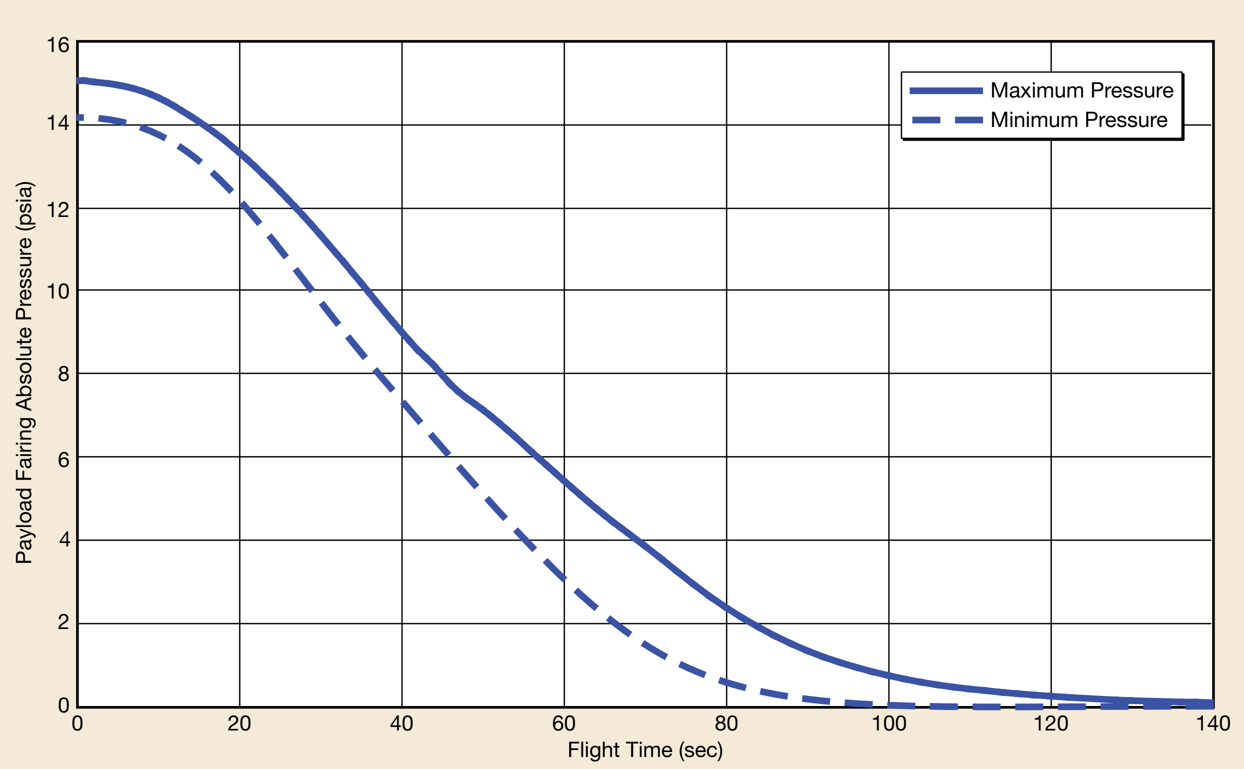


**Figure 4-10. Delta IV M+(4,2) Absolute Pressure Envelope**

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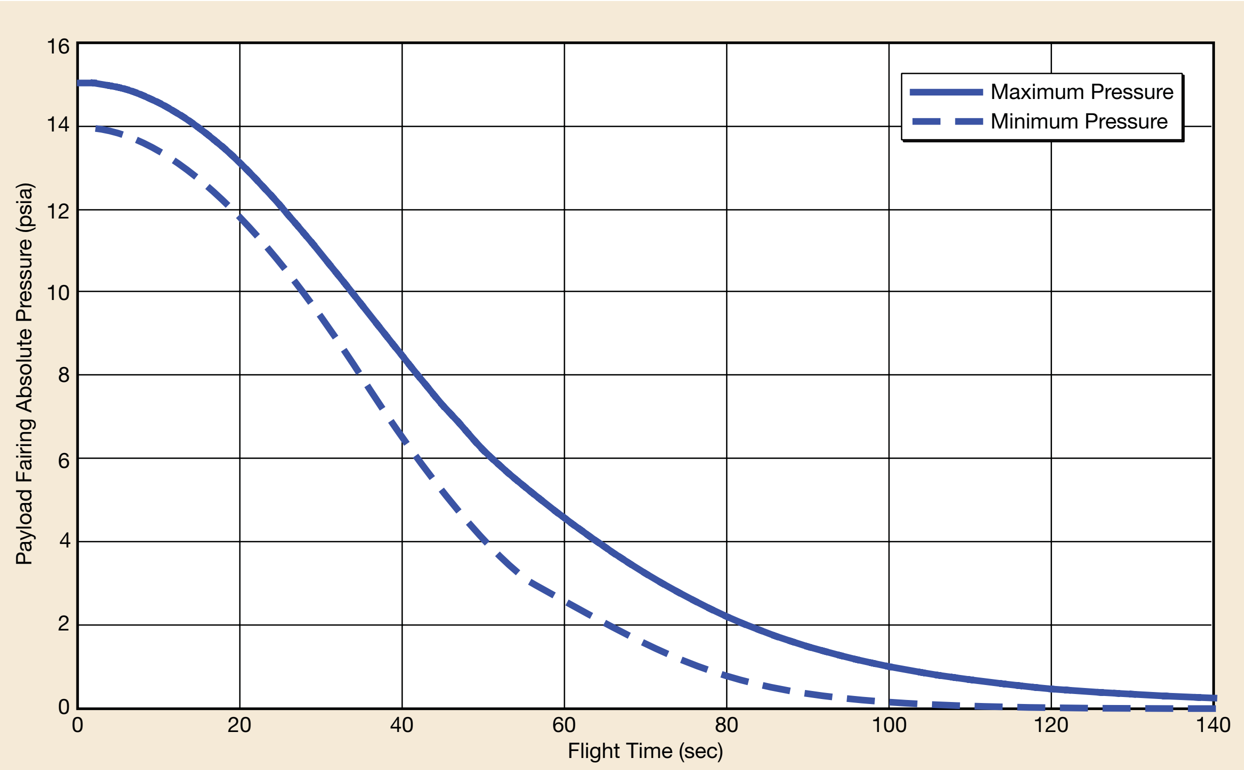


**Figure 4-11. Delta IV M+(5,2) Absolute Pressure Envelope**

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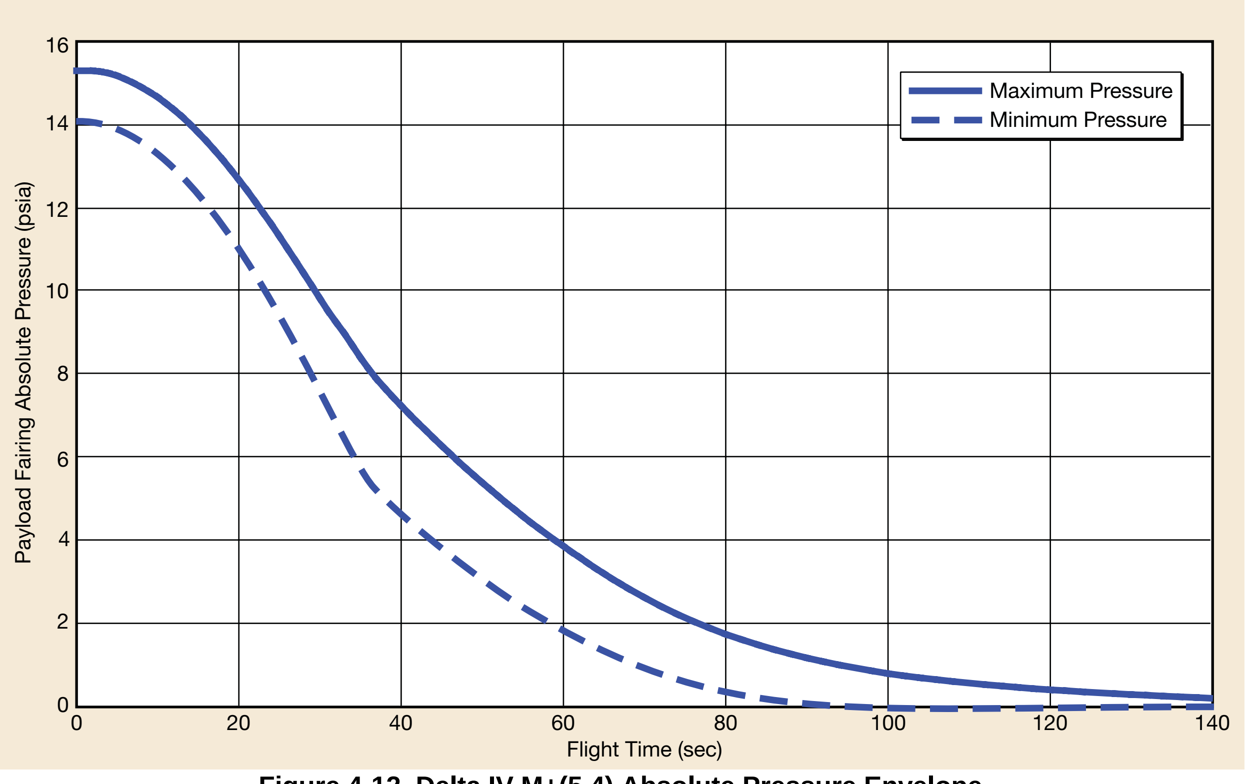


**Figure 4-12. Delta IV M+(5,4) Absolute Pressure Envelope**

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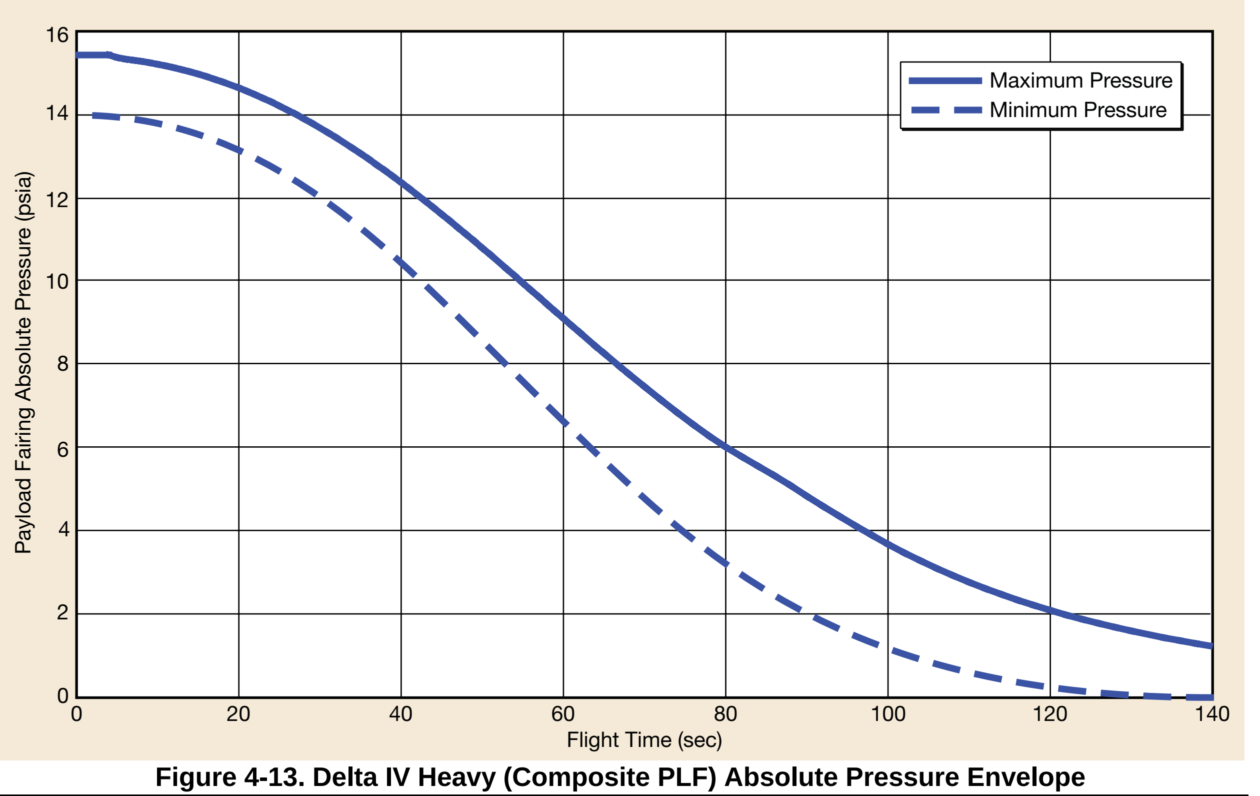


**Figure 4-13. Delta IV Heavy (Composite PLF) Absolute Pressure Envelope**

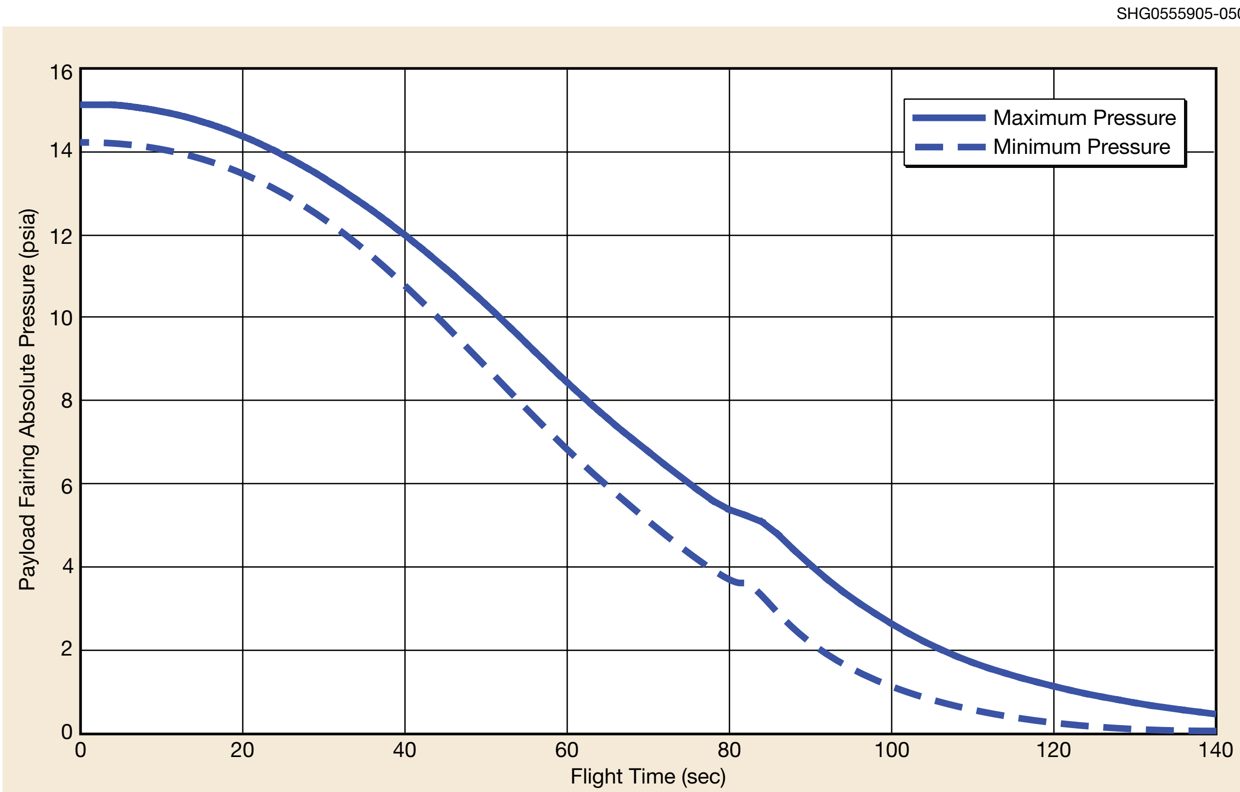


**Figure 4-14. Delta IV Heavy (Metallic PLF) Absolute Pressure Envelope**

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 launch vehicles will generally be constrained to a sustained level of 2.76 kPa/sec (0.4 psi/sec) or less with a single brief allowable peak of up to 4.14 kPa/sec (0.6 psi/sec).

### 4.2.2 Thermal Environment

Prior to and during launch, the payload fairing and second stage contribute to the thermal environment of the payload.

**4.2.2.1 Payload Fairing Thermal Environment.** The ascent thermal environments of the Delta IV fairing surfaces facing the payload are shown in Figure 4-15 for the 4-m and 5-m composite fairings, and Figure 4-16 for the 5-m metallic fairing. Temperatures are provided for the PLF inner acoustic blankets, unblanketed regions, and separation rail sections 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, air conditioning door, electrical access 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.

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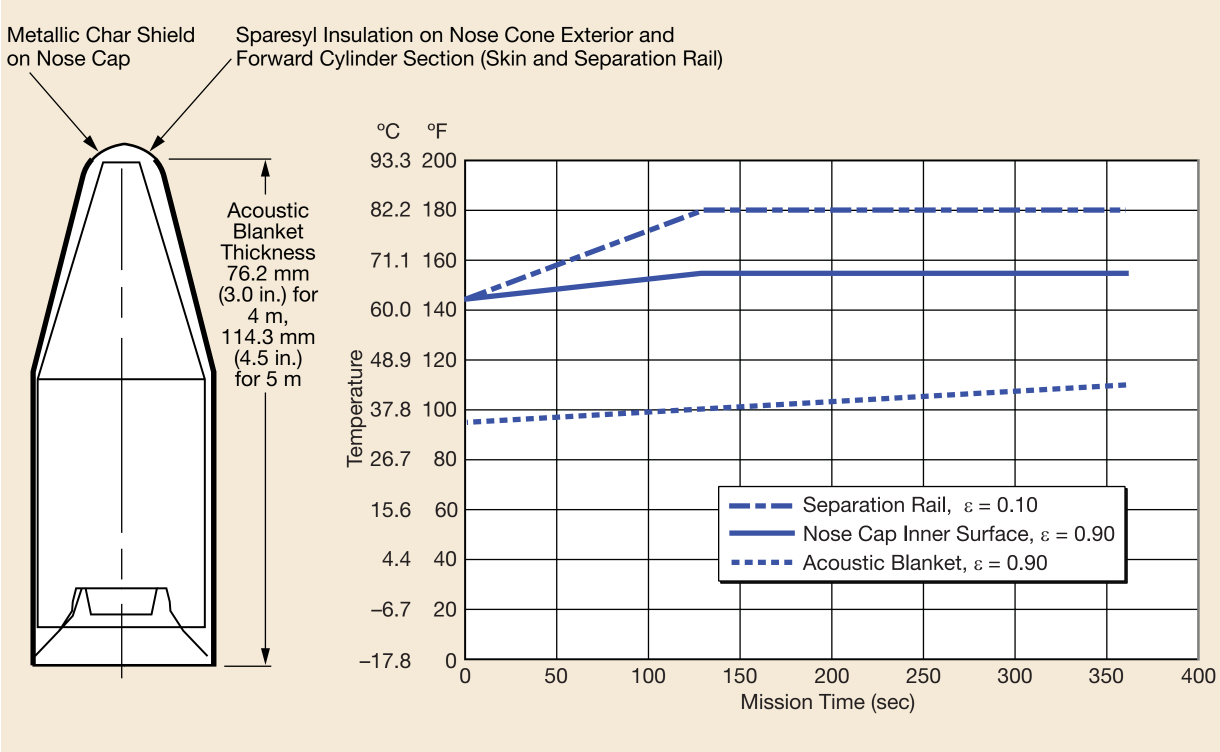


**Figure 4-15. Maximum Inner Surface Temperature (Environments to Spacecraft), 4-m and 5-m Composite PLFs**

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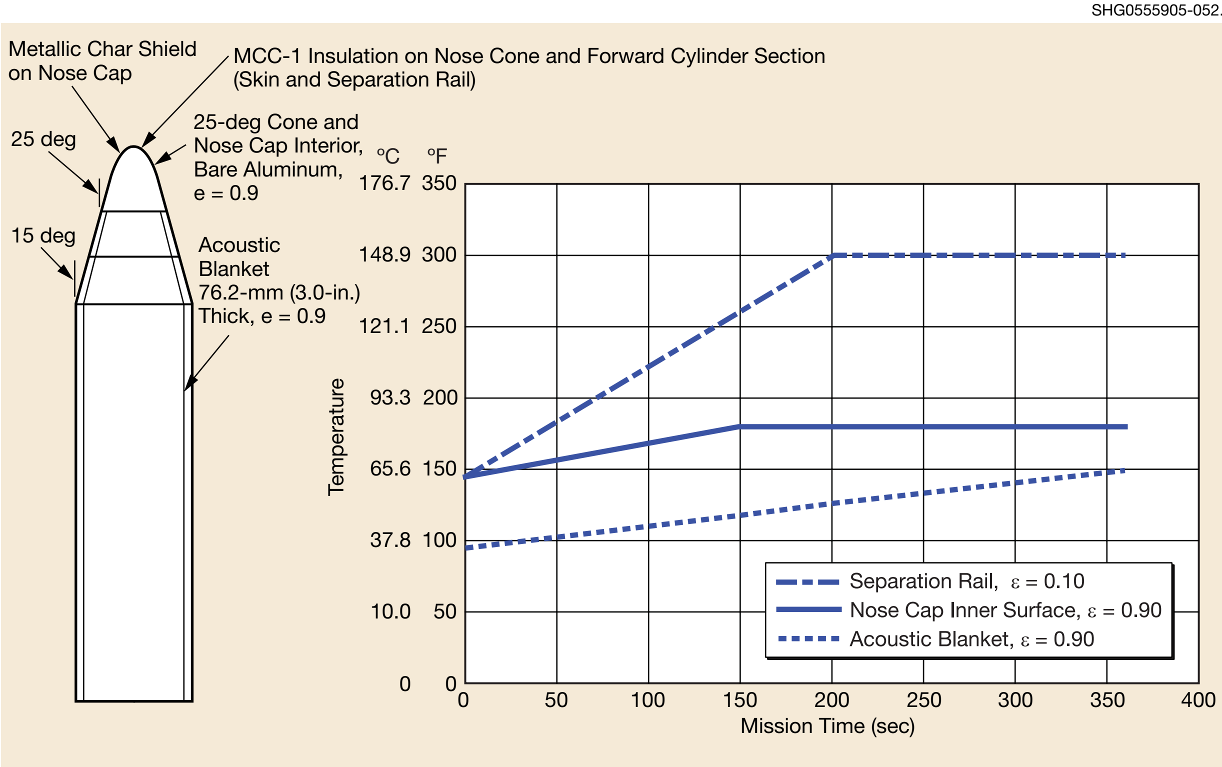


**Figure 4-16. Maximum Inner Surface Temperature (Environments to Spacecraft), 5-m Aluminum Isogrid PLFs**

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. The Commercial Space Transportation Advisory Committee (COMSTAC) limit for maximum heat flux from the fairing to the payload of 500 $W/m^2$ is met by a large margin due to the relatively benign thermal environments intrinsic to the Delta IV fairings.

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 US Standard Atmosphere. Other free molecular heating requirements may be accommodated by the Delta IV family through coordination with the Delta Program Office.

4.2.2.2 On-Orbit Thermal Environment. During coast periods, the Delta IV launch vehicle can be oriented to meet specific sun-angle requirements. A passive thermal control (PTC) roll with the launch vehicle 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.

4.2.2.3 Payload/Launch Vehicle Interface. The Delta Program can perform a thermal analysis using a customer-provided payload thermal model to define payload temperatures as coordinated with the Delta Program Office.

4.2.2.4 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.

4.2.2.5 In-Flight Contamination Environments. Sources of contamination from the second-stage propulsion system and payload fairings have been quantified for Delta II and Delta III. Delta IV 4-m and 5-m composite PLFs are comparable to the Delta II and Delta III PLFs, with a unique acoustic blanket configuration that virtually eliminates launch vehicle’s sources of contamination to the payload. 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. Blanket pressures are kept below 827 Pad (0.12 psid) (with respect to the fairing internal pressure) to prevent debonding of the blankets. Blanket pressure models have been verified with flight data. Outgassing from nonmetallics in the fairing is low due to the low composite fairing temperatures, which are generally below 48.9°C (120°F). Analysis shows that deposition on the payload envelope from exposed composite material and the carbon-filled sheets is less than 15Å.

Delta IV second-stage attitude control systems use hydrazine ($N_2H_4$) thrusters. The second-stage motor plumes do not expand enough to impinge on the payload envelope. For payload temperatures above 93 K (–293°F), only aniline from the $N_2H_4$ system plumes will deposit, but eventually evaporate, due to its high volatility. A collision contamination avoidance maneuver (CCAM) is performed after the payload has moved away from the second stage, with a goal of limiting payload contamination to less than 10 Å. Analysis shows that deposition levels are typically less than 1 Å.

### 4.2.3 Flight Dynamic Environment

The acoustic, sinusoidal, and shock environments cited herein are based on maximum flight levels for a 95th-percentile statistical estimate.

**4.2.3.1 Steady-State Acceleration.** Plots of representative steady-state axial accelerations during first-stage burn versus payload weight are shown in Figures 4-17, 4-18, 4-19, 4-20, and 4-21 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 common booster core (CBC) throttling, with some performance impacts. Please contact the Delta Program Office for details. Typical steady-state axial accelerations versus space vehicle weight at second-stage burnout are shown in Figures 4-22, 4-23, 4-24, 4-25, and 4-26 for the Delta IV Medium, M+(4,2), M+(5,2), M+(5,4), and Heavy vehicles, respectively.

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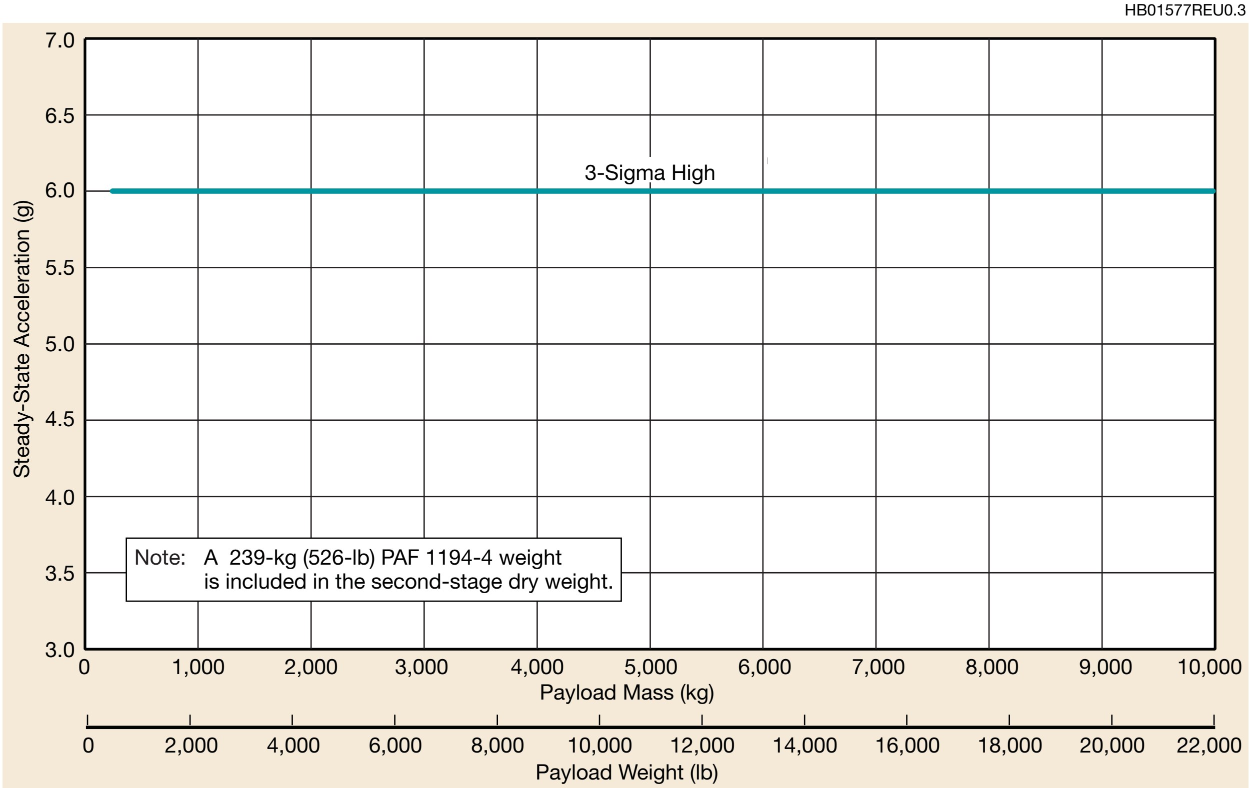


**Figure 4-17. Delta IV Medium Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

HB01578REU0.3

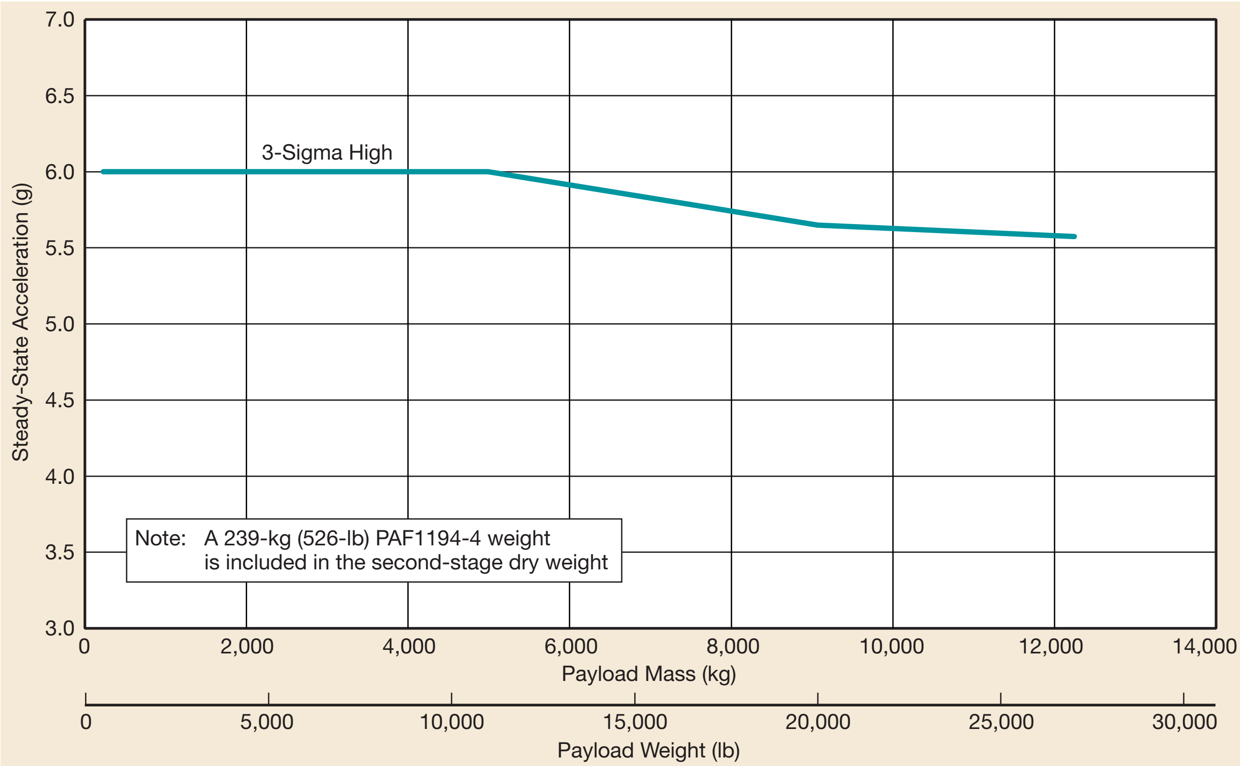


**Figure 4-18. Delta IV M+(4,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

HB01579REU0.3

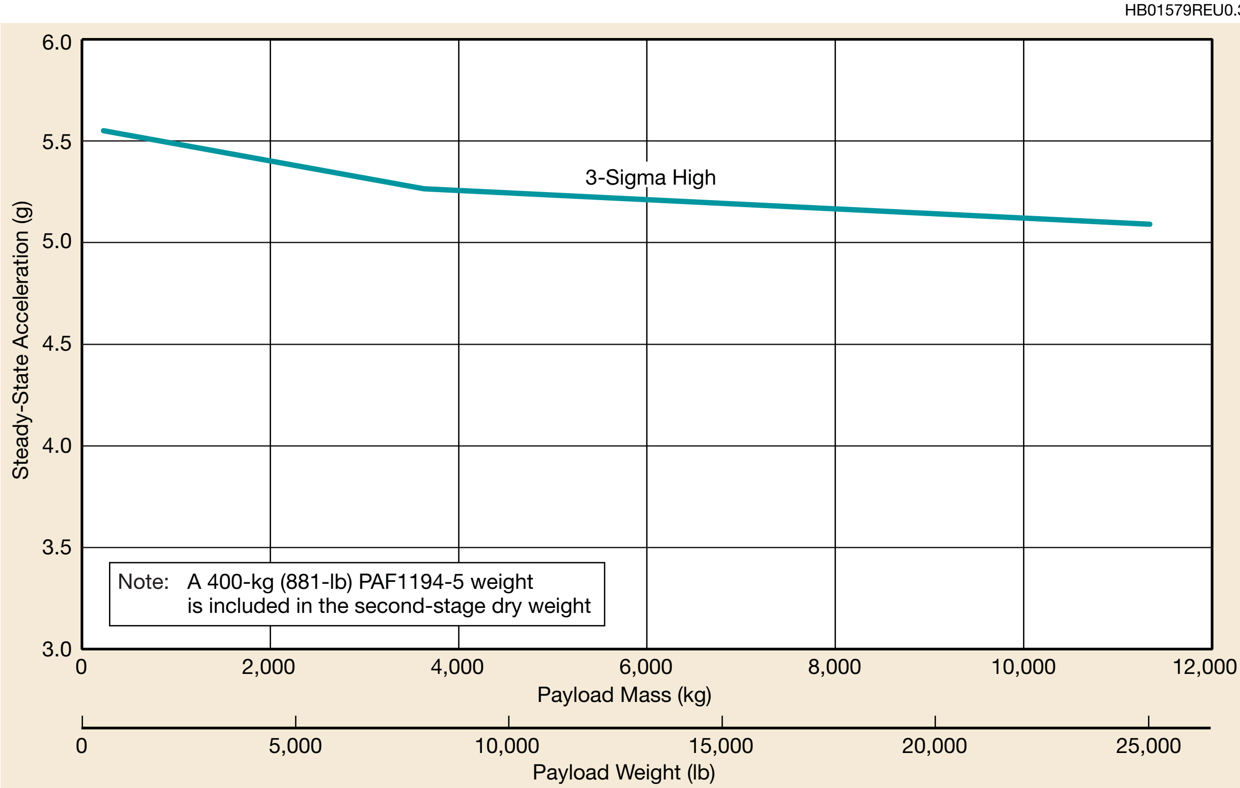


**Figure 4-19. Delta IV M+(5,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

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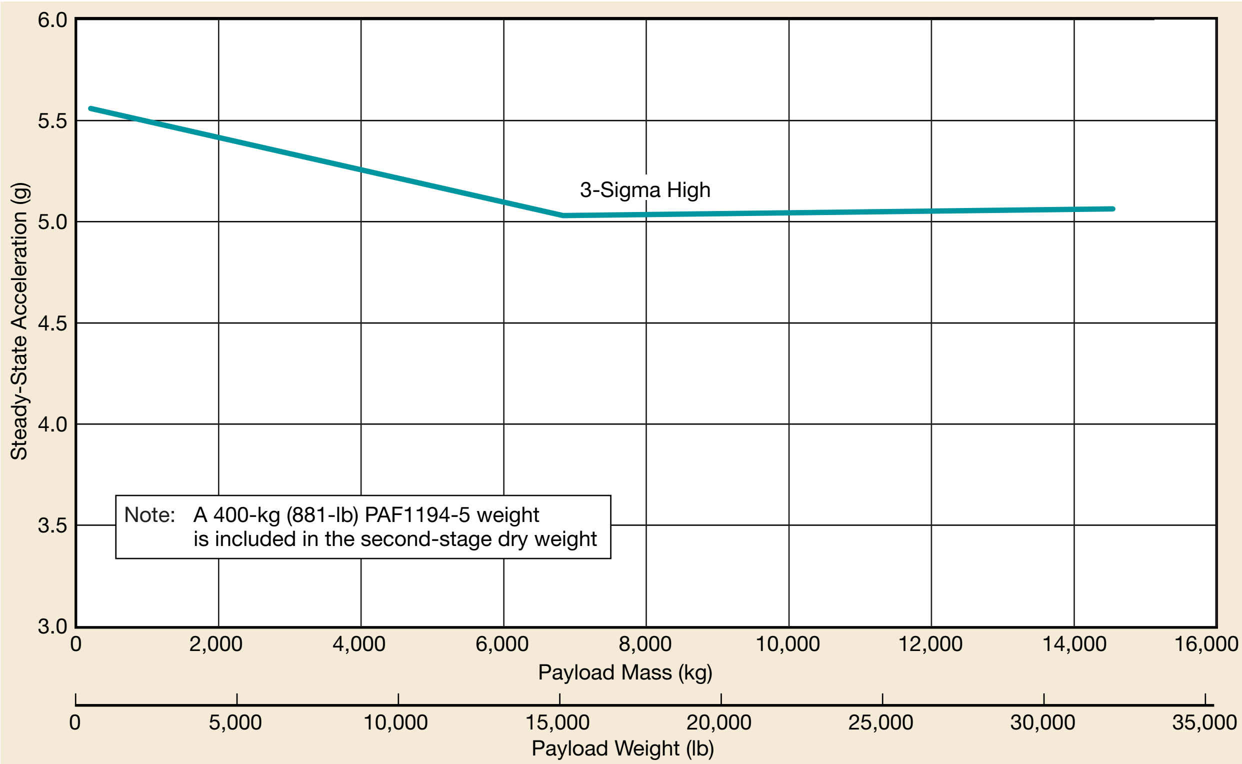


**Figure 4-20. Delta IV M+(5,4) Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

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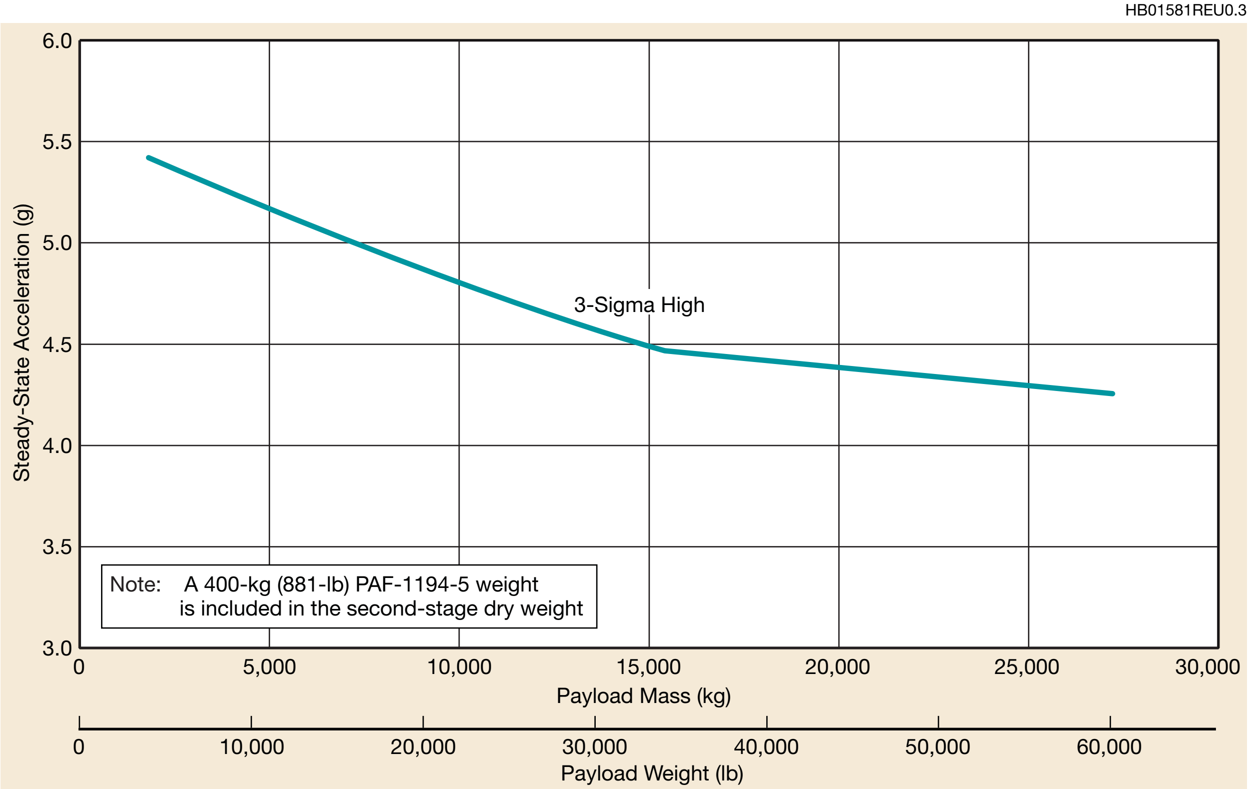


**Figure 4-21. Delta IV Heavy Maximum Axial Steady-State Acceleration During First-Stage Burn vs. Second-Stage Payload Weight**

HB01582REU0.3

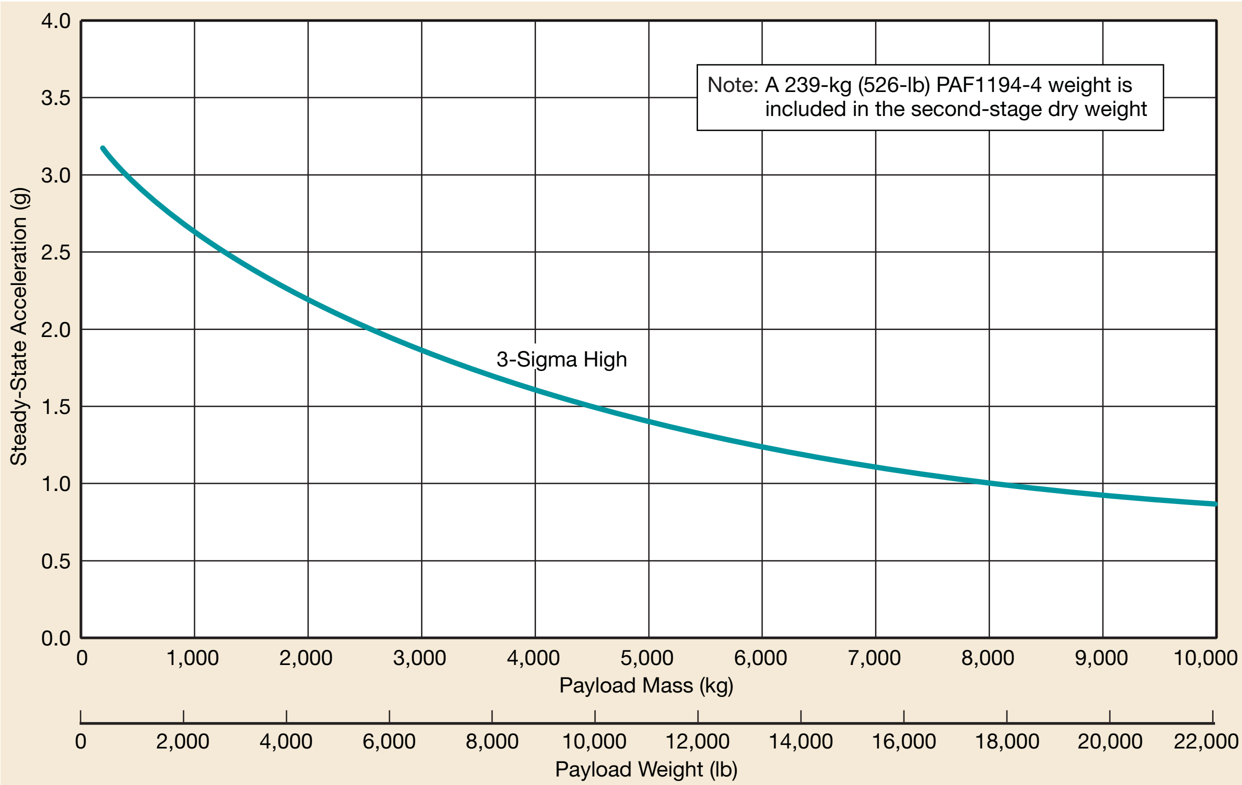


**Figure 4-22. Delta IV Medium Maximum Axial Steady-State Acceleration at Second-Stage Cutoff**

HB01583REU0.3

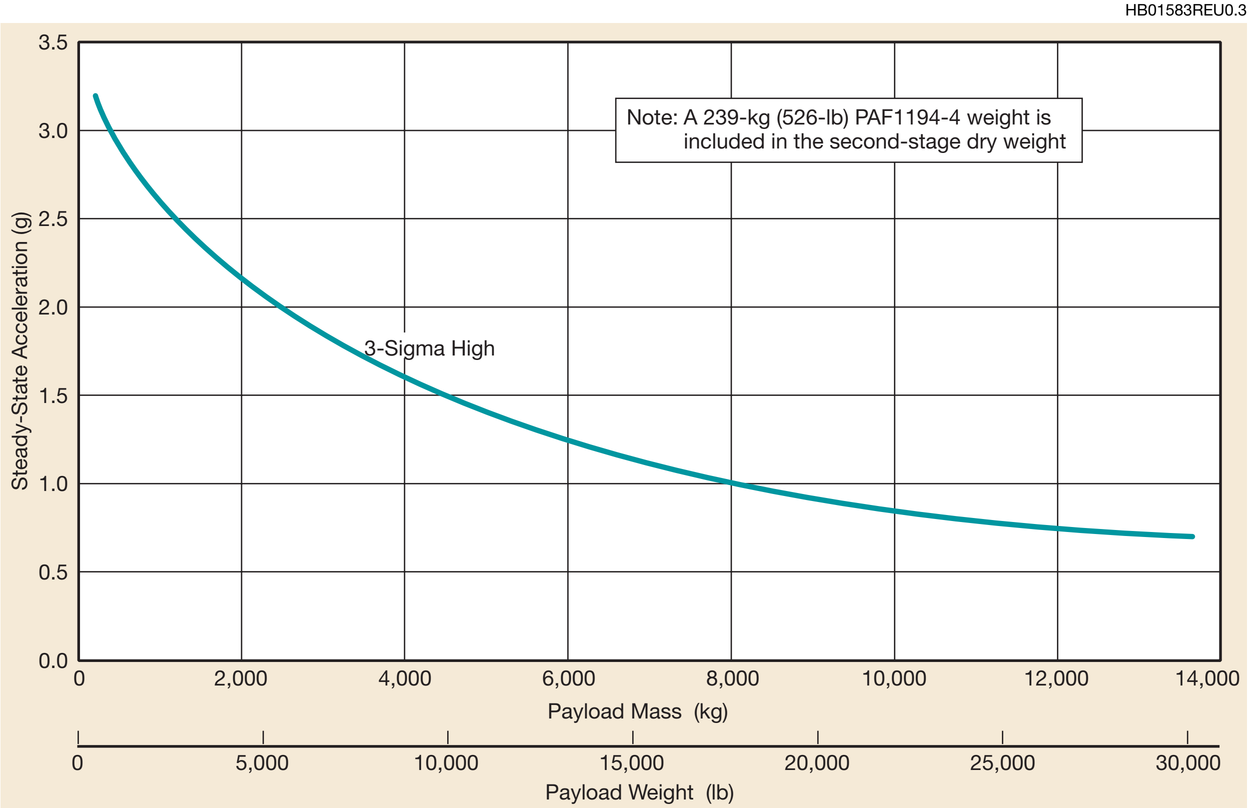


**Figure 4-23. Delta IV M+(4,2) Axial Steady-State Acceleration at Second-Stage Cutoff**

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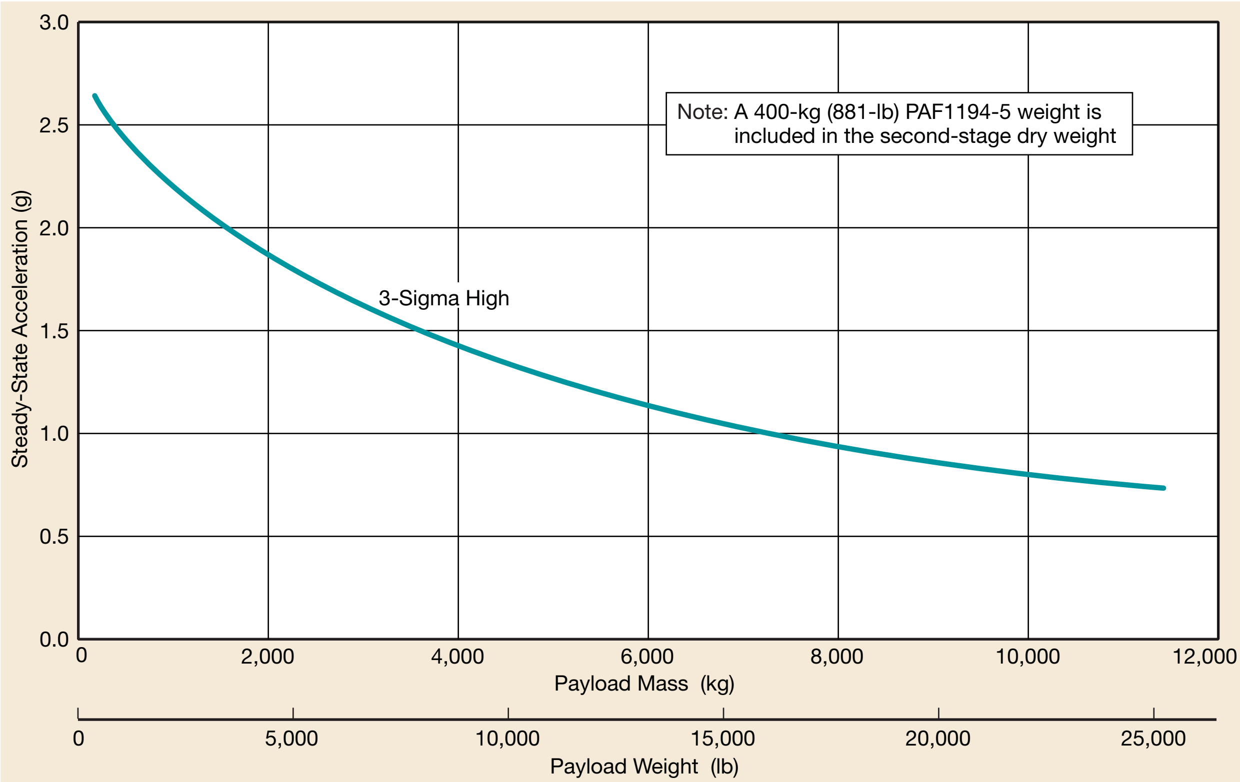


**Figure 4-24. Delta IV M+(5,2) Axial Steady-State Acceleration at Second-Stage Cutoff**

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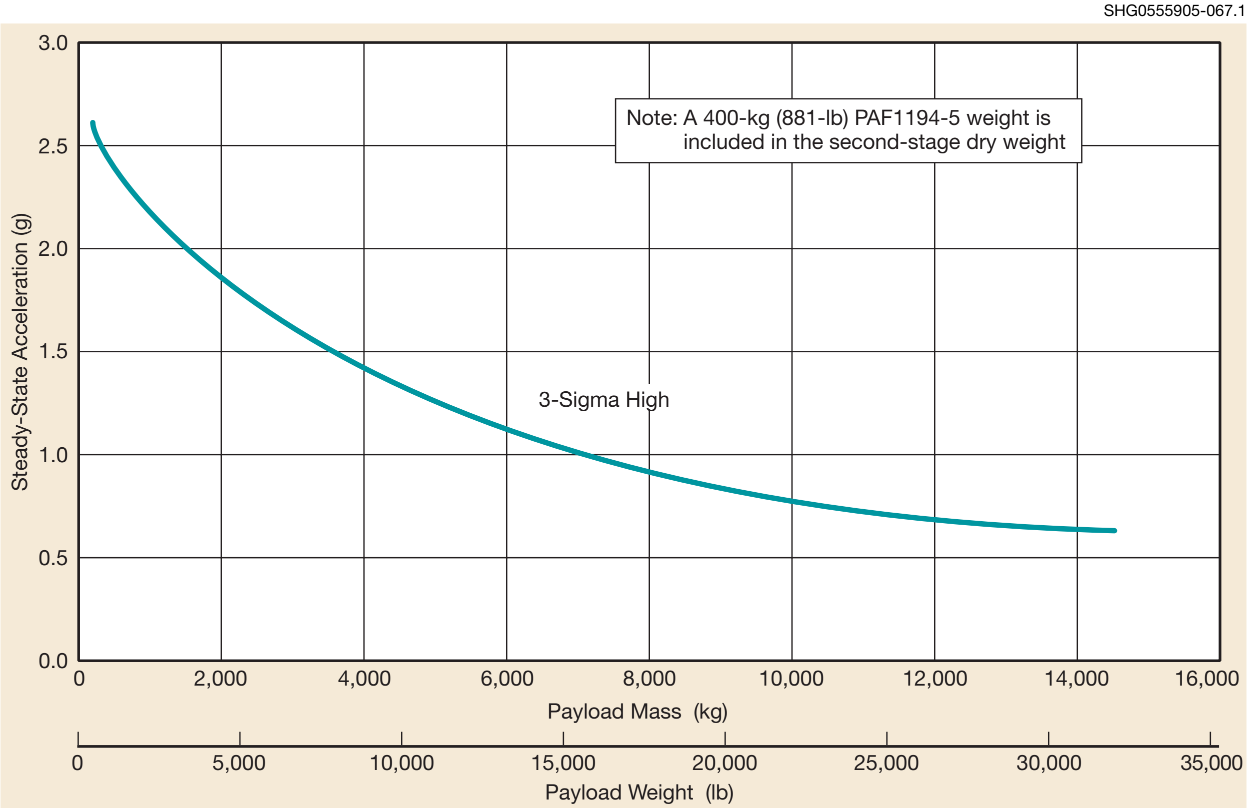


**Figure 4-25. Delta IV M+(5,4) Axial Steady-State Acceleration at Second-Stage Cutoff**

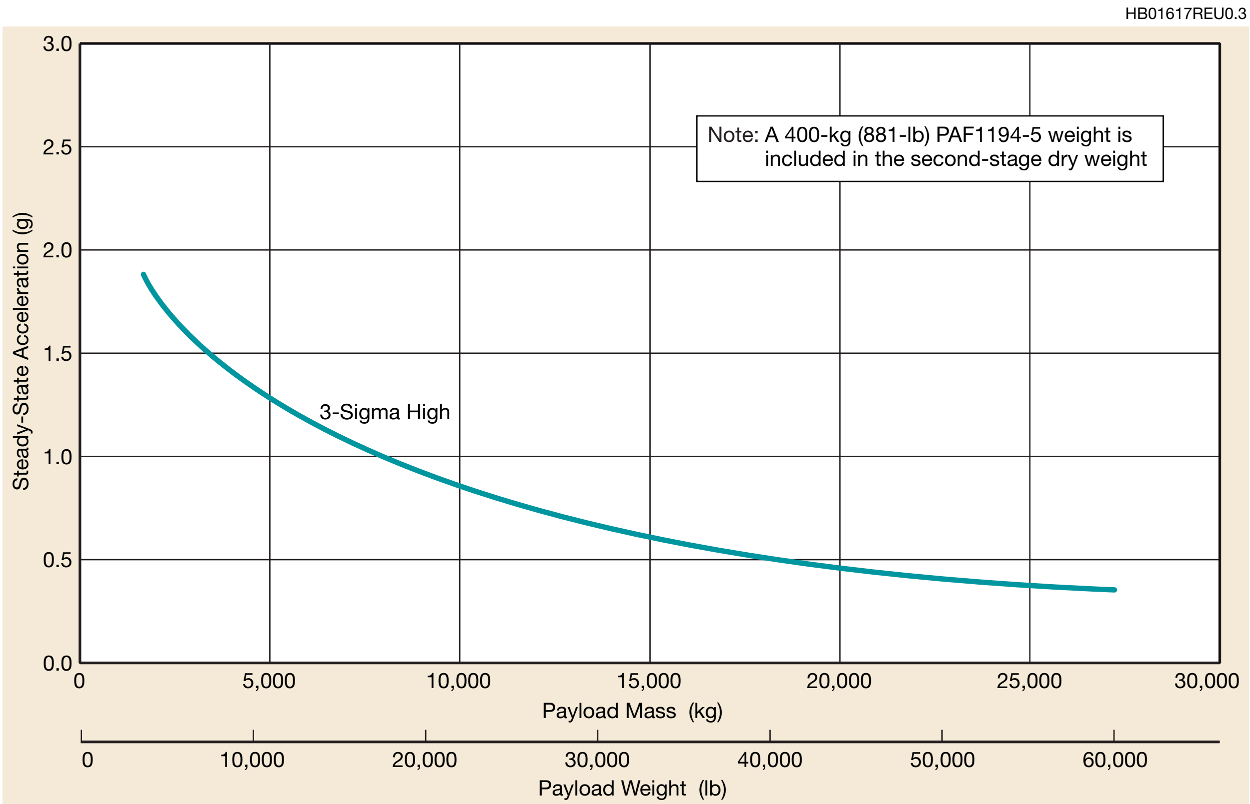


**Figure 4-26. Delta IV Heavy Axial Steady-State Acceleration at Second-Stage Cutoff**

4.2.3.2 Combined Loads. Dynamic excitations, occurring predominantly during liftoff and transonic periods of Delta IV launch vehicle 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 launch vehicle characteristics as well as spacecraft dynamic characteristics and mass properties. The spacecraft design limit-load factors and corresponding fundamental frequencies are presented in Figure 4-27. The design load factors for various types of Delta IV launch vehicles are shown in Figures 4-28, 4-29, and 4-30. For spacecraft that weigh less than that noted in Figure 4-27, the quasi-static load factors may be higher. Please contact the Delta Program Office for more information.

| Static Envelope Requirements | | | | | Maximum Lateral | | Maximum Axial | |
|---|---|---|---|---|---|---|---|---|
| LV 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 (2000) | See Figure 4-28 | | | |
| Delta IV M+(4,2) | 11.7/38.5 | 27 | 8 | 2721 (6000) | See Figure 4-28 | | | |
| Delta IV M+(5,2) | 14.3/47 | 27 | 8 | 2721 (6000) | See Figure 4-29 | | | |
| Delta IV M+(5,4) | 14.3/47 | 27 | 8 | 4989 (11,000) | See Figure 4-29 | | | |
| Delta IV Heavy | 19.8/62.7 | 30 | 8 | 6577 (14,500) | See Figure 4-30 | | | |
| *Lower customer axial requirements may be accommodated through coordination with the Delta Program Office. | | | | | | | | |

**Figure 4-27. Spacecraft Minimum frequency and Quasi-Static Load Factors**

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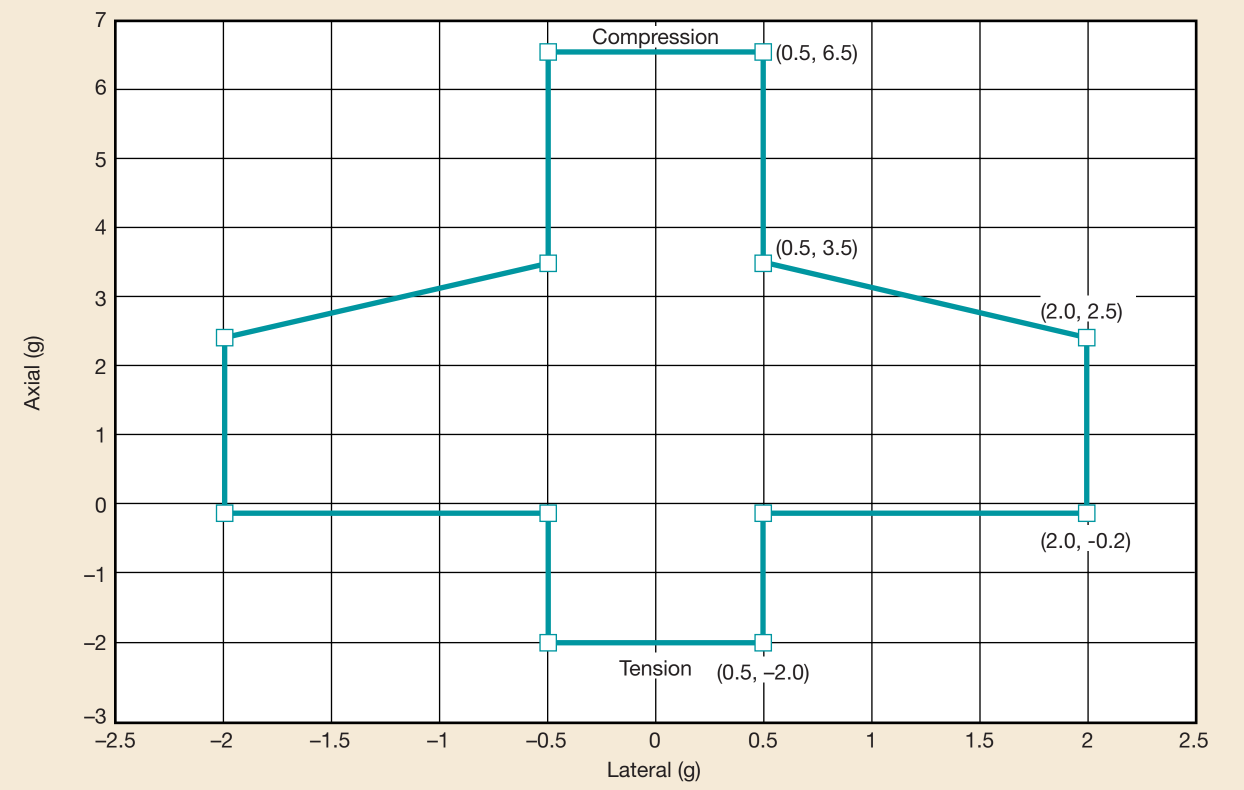


**Figure 4-28. Delta IV Medium and M+(4,2) Design Load Factors**

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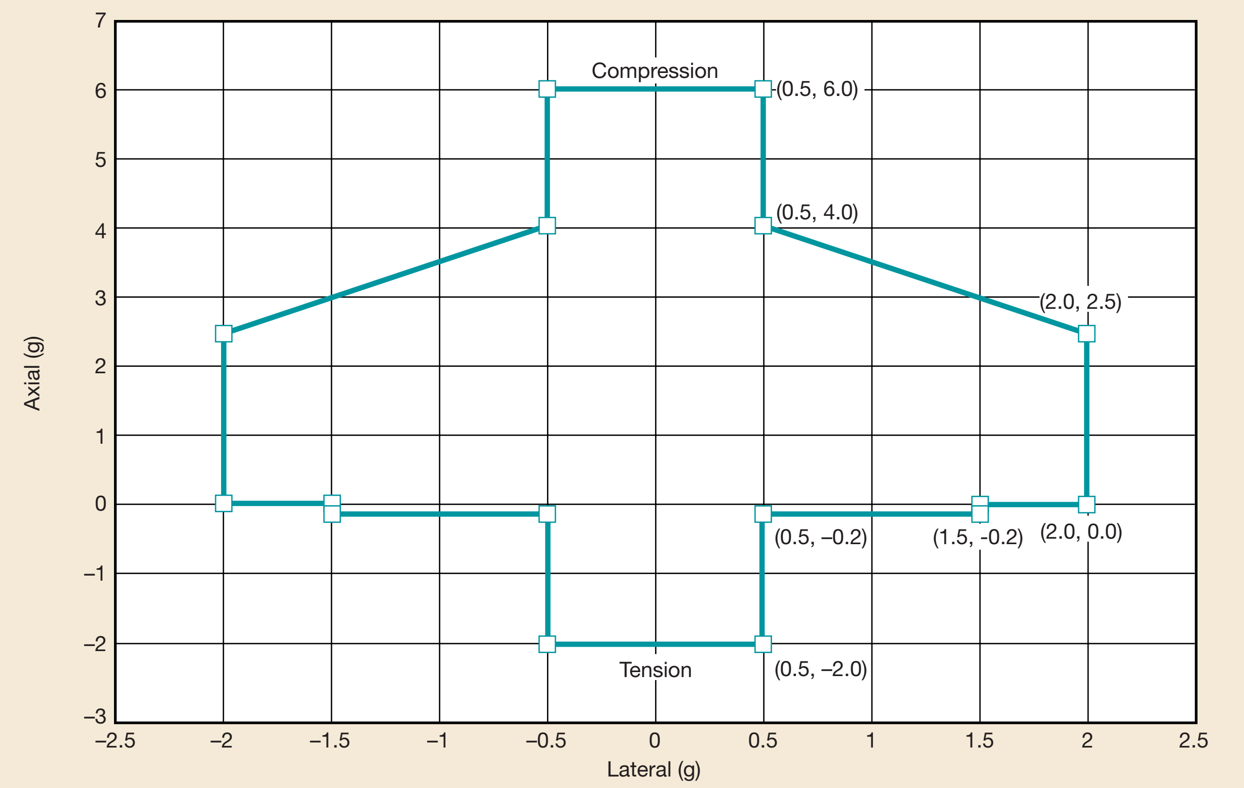


**Figure 4-29. Delta IV M+(5,2) and M+(5,4) Design Load Factors**

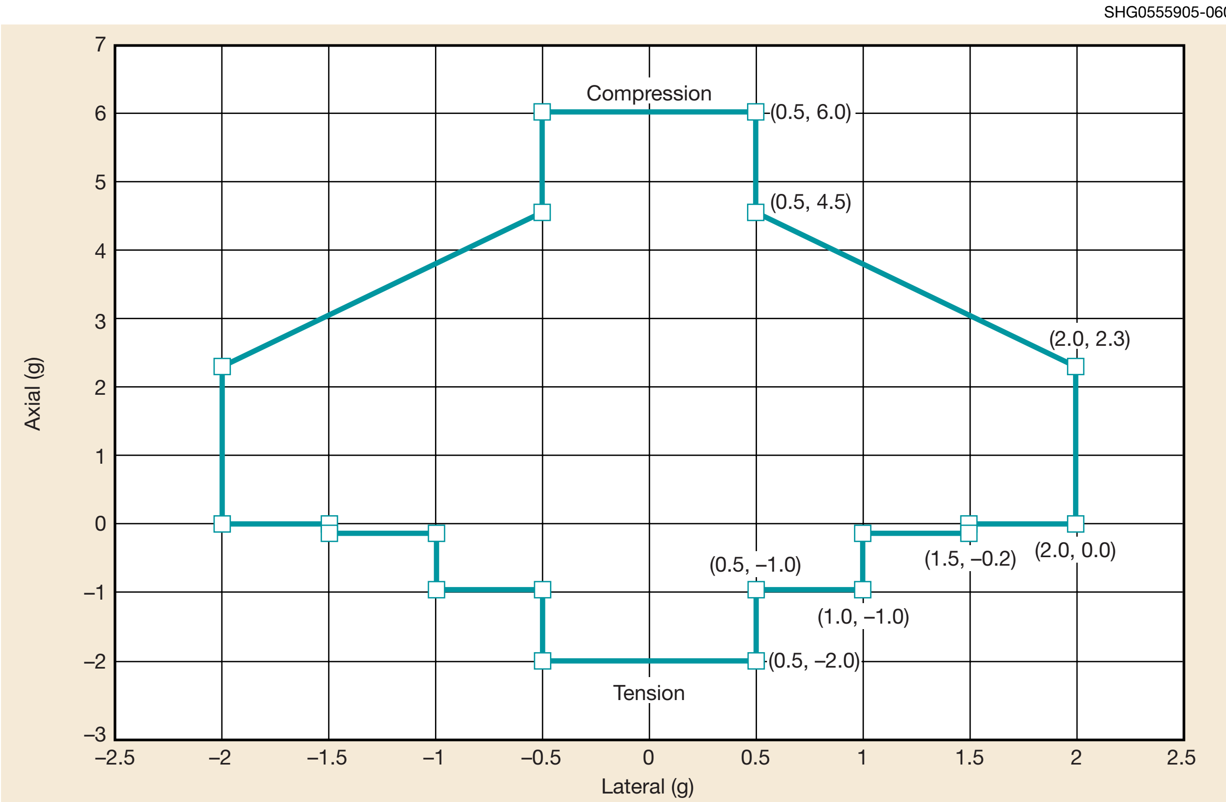


**Figure 4-30. Delta IV Heavy Design Load Factors**

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 launch vehicle and payload modes, the stiffness of the payload structure should produce fundamental frequencies above the levels stated in Figure 4-27 for the corresponding launch vehicles. 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 launch vehicle 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 the Delta Program Office so that appropriate analyses can be performed to better define loading conditions.

4.2.3.3 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 launch vehicle, the fairing, the fairing acoustic blankets, and the payload. Figures 4-31, 4-32, 4-33, and 4-34 define the payload acoustic environment for all versions

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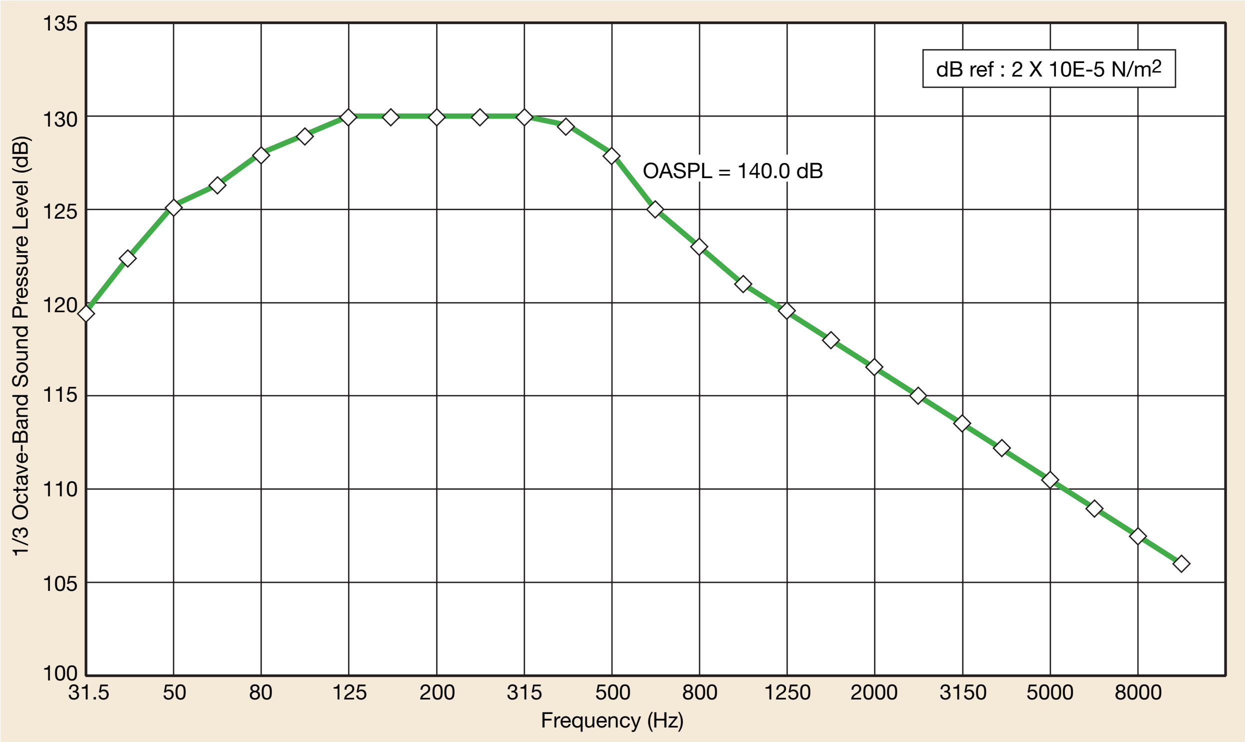


**Figure 4-31. Delta IV Medium and Delta IV M+(4,2) (4-m Composite Fairing) Internal Payload Acoustics, Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

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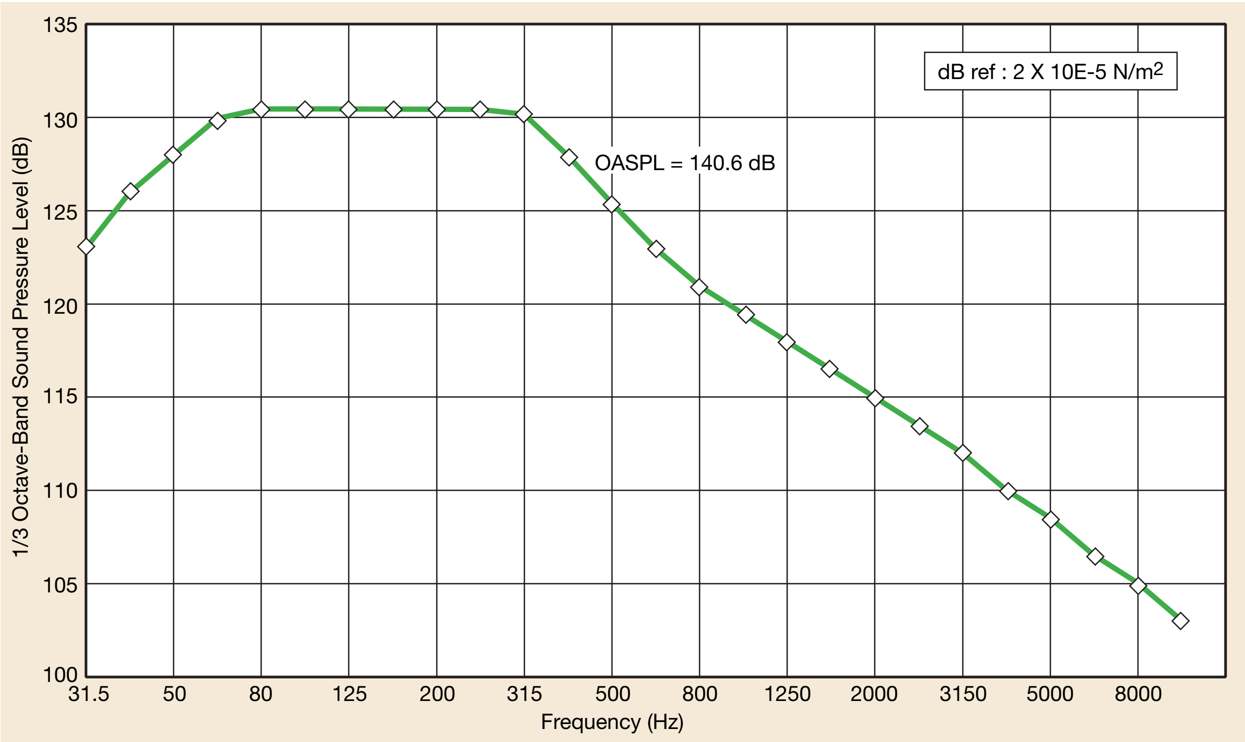


**Figure 4-32. Delta IV M+(5,2) and M+(5,4) (5-m Composite Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

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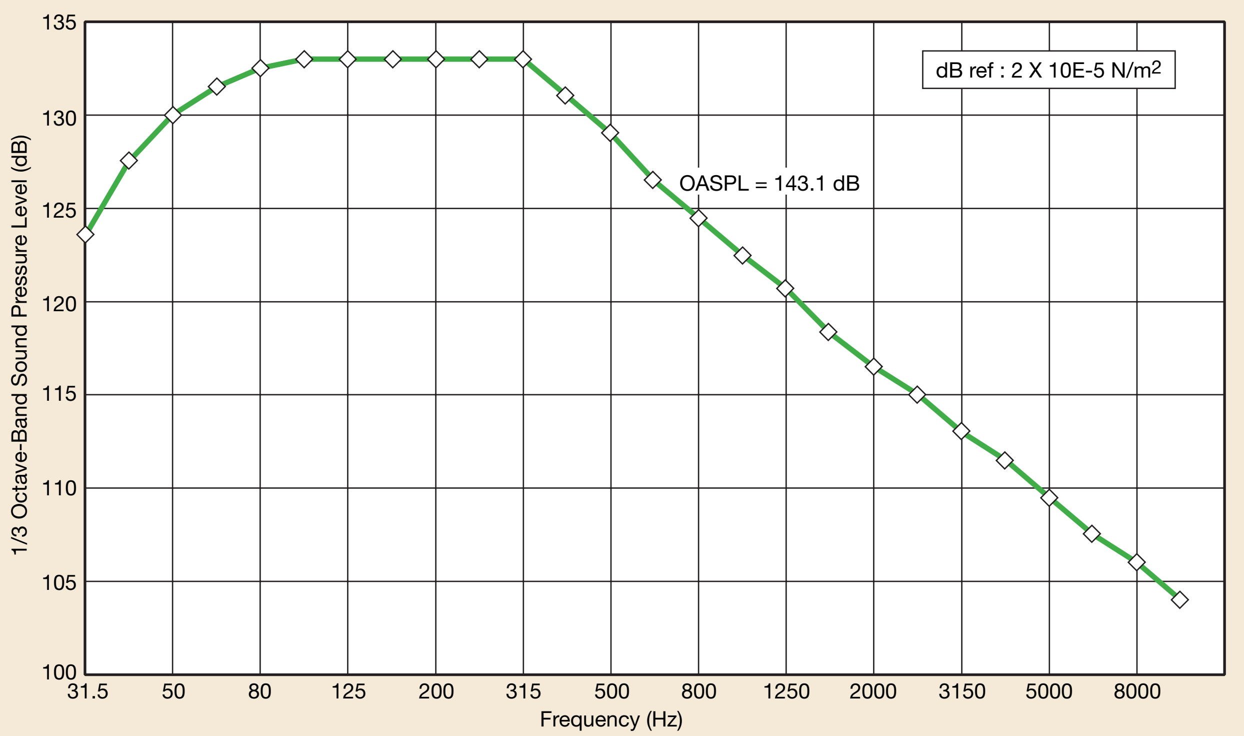


**Figure 4-33. Delta IV Heavy (5-m Composite Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

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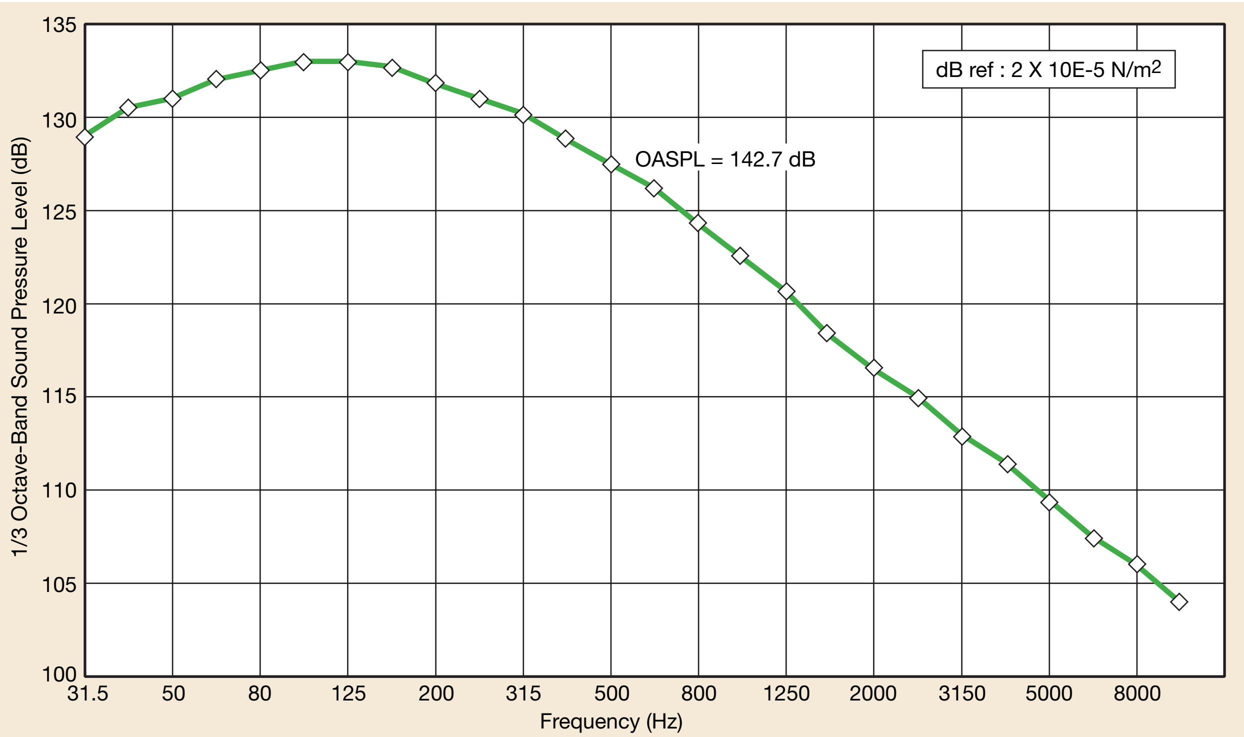


**Figure 4-34. Delta IV Heavy (5-m Metallic Fairing) Internal Payload Acoustics Typical 95th Percentile, 50% Confidence Predictions, 60% Fill Effect Included**

of the Delta IV launch vehicle system. The acoustic levels are presented as one-third octave-band sound pressure levels (dB, ref: 2 x $10^{-5}$ N/m$^2$) versus one-third octave band center frequency. These levels apply to the blanketed section of the fairing and represent a 95th 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 the Delta Program Office to coordinate any payload acoustic requirements below the levels shown.

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 4.2.4.2). No significant high-frequency random vibration inputs at the PAF interface are generated by Delta IV launch vehicles; consequently, a Delta IV PAF interface random vibration environment is not specified.

4.2.3.4 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 launch vehicle configurations, are defined in Figure 4-35 at the spacecraft separation plane. These predicted sinusoidal vibration levels provide general 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<br>6.2 to 100 | 1.27 cm (0.5 in.) double amplitude<br>1.0 g (zero to peak) |
| Lateral | 5 to 100 | 0.7 g (zero to peak) |

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**Figure 4-35. Delta IV Sinusoidal Vibration Levels**

The sinusoidal vibration levels in Figure 4-35 are not intended for use in the design of spacecraft primary structure. Load factors for spacecraft primary structure design are specified in Figure 4-27.

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 launch vehicle 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 launch vehicle coupled dynamic loads analysis (see Section 4.2.4.3).

4.2.3.5 Shock Environment. The maximum shock environment typically occurs during spacecraft separation from the Delta IV launch vehicle and is a function of the separation system configuration. The customer has the option to provide their own separation system. High-frequency shock levels at the payload/launch vehicle interface due to other shock events, such as first-and second-stage separation and fairing separation, are typically exceeded by spacecraft separation shock environment.

The data provided are intended to aid in the design of spacecraft components and secondary structures that may be sensitive to high-frequency pyrotechnic shock. Typical of this type of shock, the level dissipates rapidly with distance and the number of joints between the shock source and the component of interest. A properly performed system-level shock test is the best simulation of the high-frequency pyrotechnic shock environment (Section 4.2.4.4)

4.2.3.5.1 Payload Attach Fitting Shock Environments. For customer-supplied separation system interface, the maximum allowable payload-induced shock that the launch vehicle can withstand is shown in Figure 4-36 for all launch vehicle configurations.

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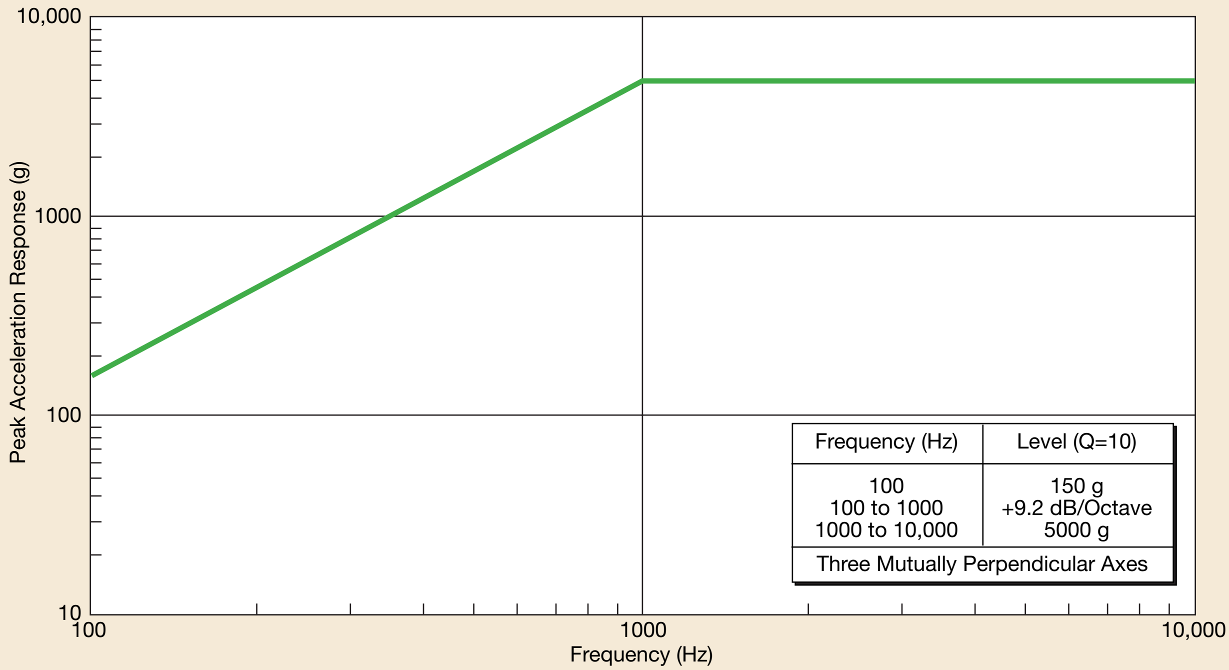


| Frequency (Hz) | Level (Q=10) |
|---|---|
| 100<br>100 to 1000<br>1000 to 10,000 | 150 g<br>+9.2 dB/Octave<br>5000 g |
| Three Mutually Perpendicular Axes | |

**Figure 4-36. Maximum Payload-Induced Shock Level to Launch Vehicle (95th Percentile, 50% Confidence)**

Figure 4-37 identifies the figures that define the launch-vehicle-induced PAF interface shocks for all available Delta IV PAF configurations. The interface shock levels represents a 95th percentile environment with a 50% confidence prediction (P95/50) for all launch-vehicle-induced high frequency shock events. Users should contact the Delta Program Office to coordinate any payload shock requirements below the levels shown in Figures 4-38, 4-39, 4-40, and 4-41, and 4-42.

| Payload Attach Fitting | Interface Type | Payload Attach Fitting Interface Environment |
|---|---|---|
| 1194-4, -5 | 1194-mm (47-in.) dia clampband<br>31-kN (7000-lb) preload | See Figure 4-38 |
| 1575-4, -5 | Bolted interface | See Figures 4-39 and 4-40 |
| 1666-4, -5 | 1666-mm (66-in.) dia clampband<br>31-kN (7000-lb) preload | See Figure 4-41 |
| 1194VS-4, -5 | 1194-mm (47-in.) dia low-shock clampband<br>60-kN (13,500-lb) preload | See Figure 4-42 |

**Figure 4-37. PAF Interface Shock Environment Figure Reference**

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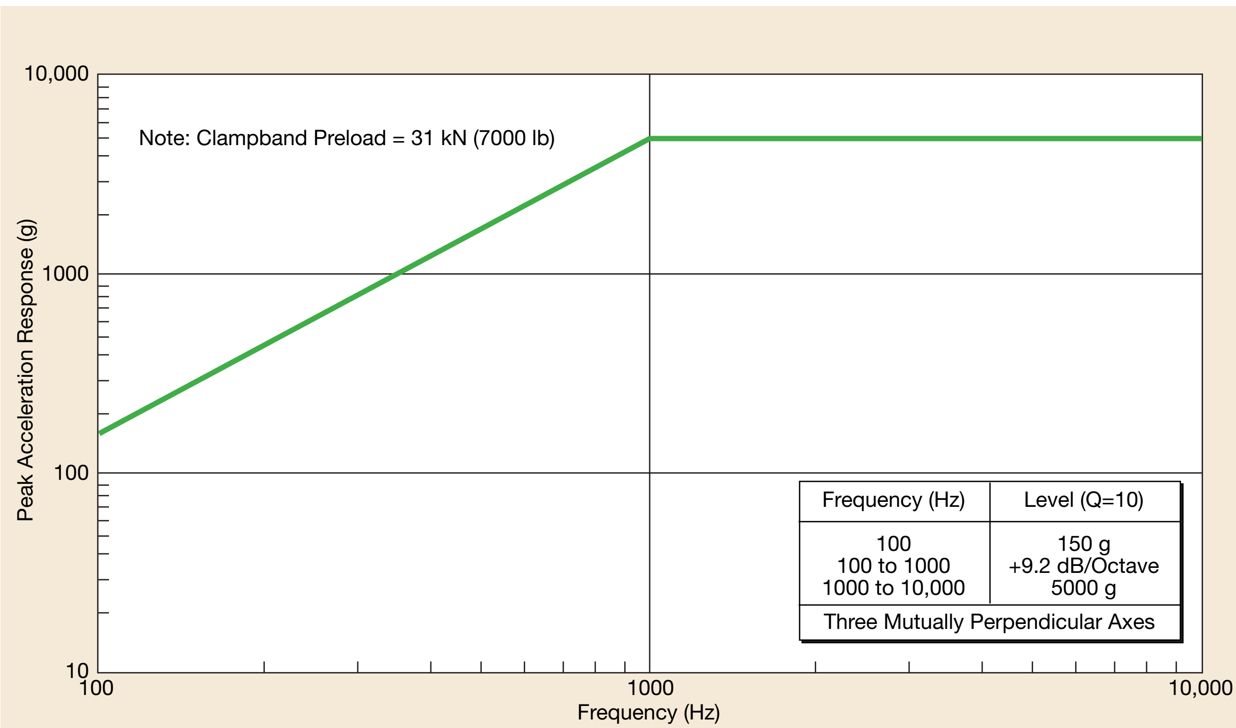


**Figure 4-38. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1194-4, -5 Payload Attach Fittings**

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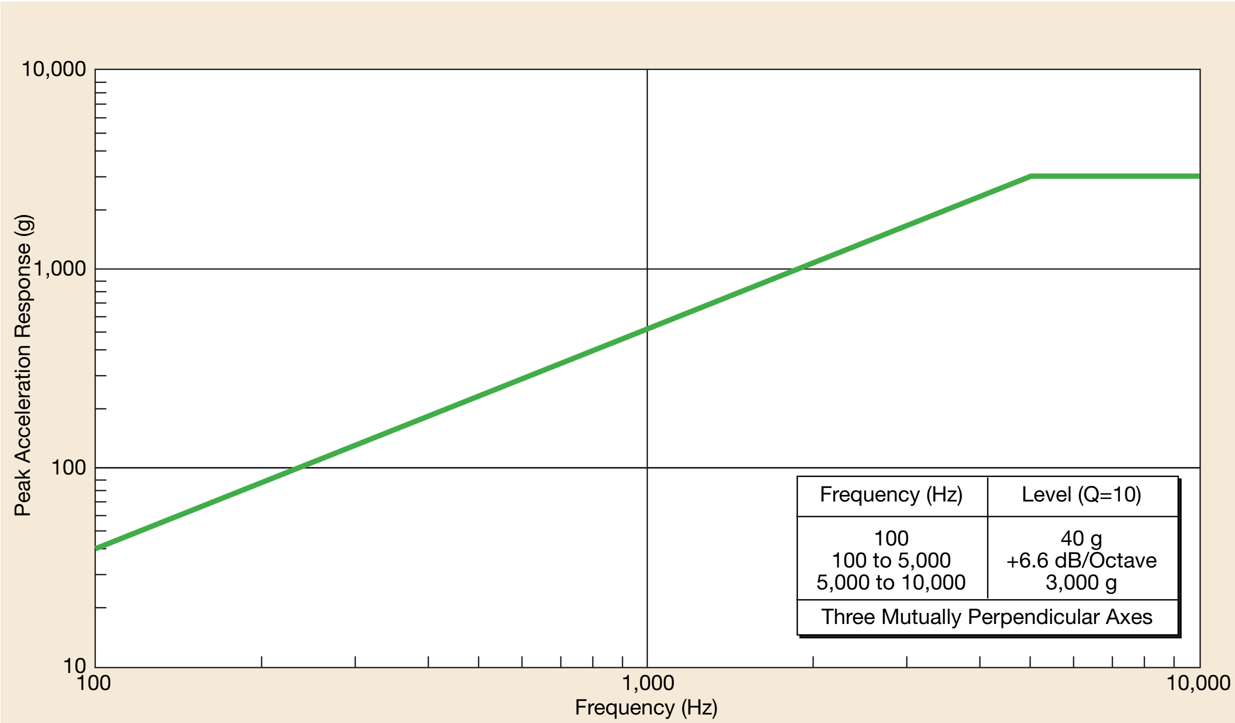


**Figure 4-39. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1575-4 Payload Attach Fittings**

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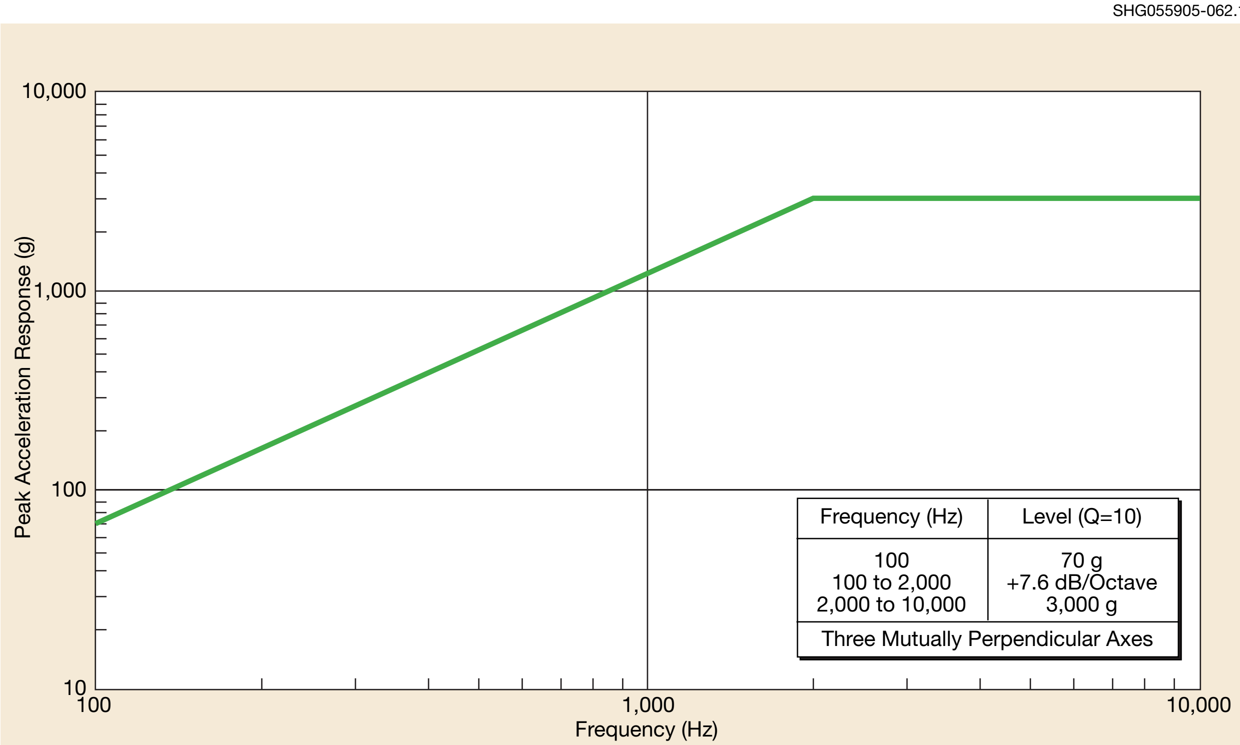


**Figure 4-40. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1575-5 Payload Attach Fittings**

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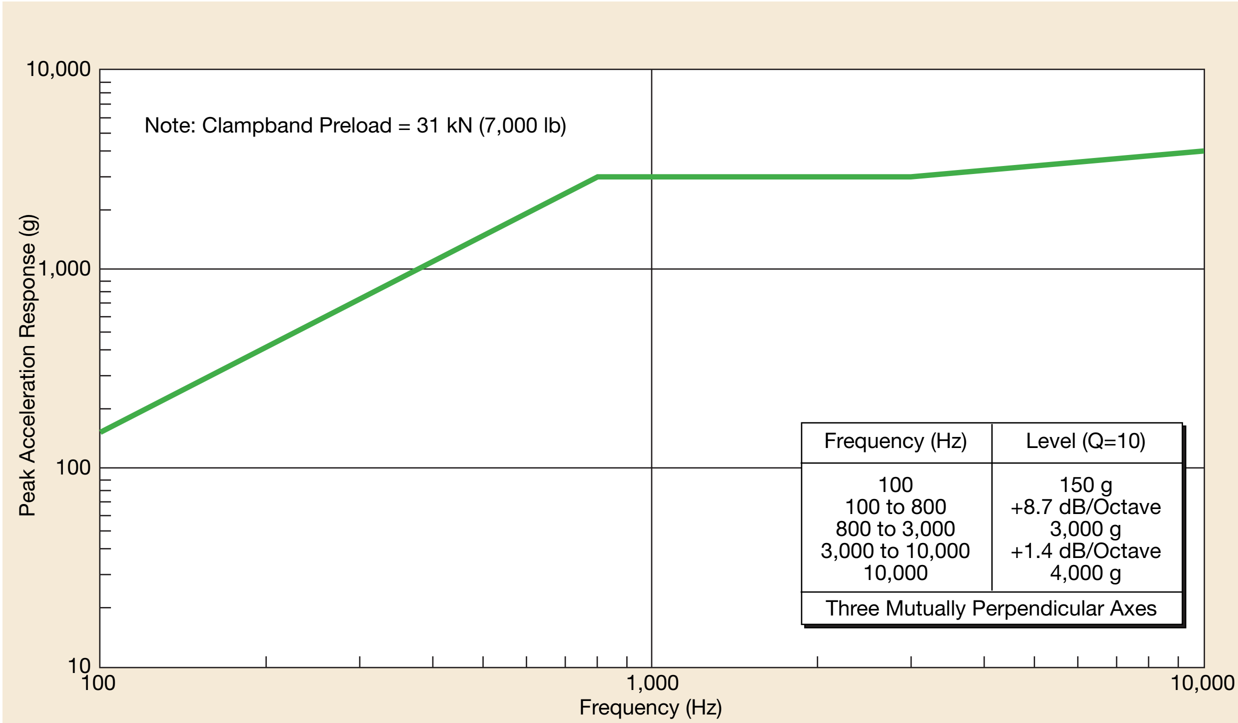


**Figure 4-41. Launch-Vehicle-Induced Payload Interface Shock Environment (95th Percentile, 50% Confidence)—1666-4, -5 Payload Attach Fittings**

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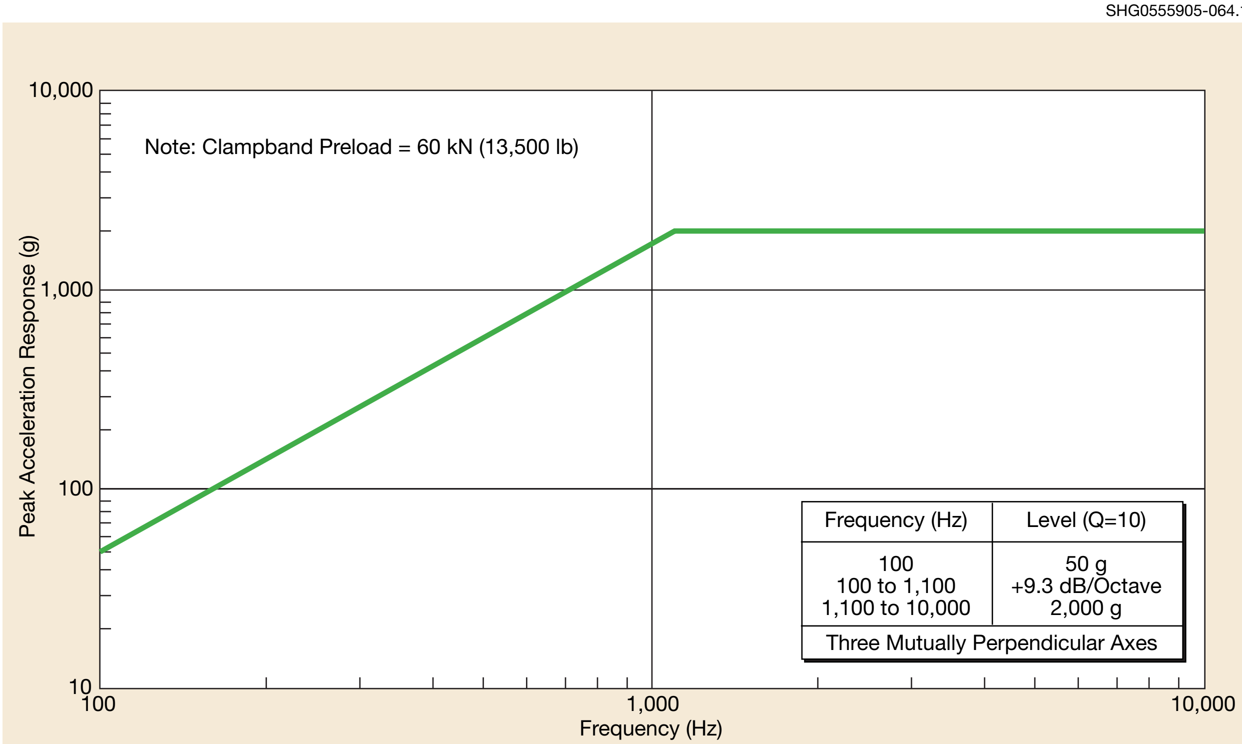


**Figure 4-42. Launch-Vehicle-Induced Payload Interface Shock Environmental (95th Percentile, 50% Confidence)—1194VS-4, -5 Payload Attach Fittings**

**4.2.3.5.2 Low-Shock Separation System.** To meet the ever-increasing mass of today's satellites, a low-shock separation system for satellites featuring an 1194-mm interface, for both 4-m and 5-m applications, is available. Designated the 1194VS, the low-shock separation system is designed to accommodate satellites weighing up to 8 metric tonnes (17,632 lb) and requiring clampband preloads up to 60 kN (13,500 lb). The only significant difference from the current Saab 1194 separation system is the release device. The 1194VS uses a separation system based on a nonexplosive design known as the clampband opening device (CBOD). A 100% success rate has been achieved on the approximately 270 Saab satellite separation systems flown to date. The maximum shock environment with the 1194VS separation system is shown in Figure 4-42.

As part of our continual evolution to meet our customers' needs, we will be introducing additional low-shock separation systems to support other spacecraft interfaces at a later date.

### 4.2.4 Spacecraft Qualification and Acceptance Testing

Outlined here are a series of environmental system-level qualification, acceptance, and protoflight tests for spacecraft launched on Delta IV launch vehicles. All of the tests and subordinate requirements in this section are recommendations, not requirements, except for Section 4.2.4.1, Structural Load Testing. If the spacecraft primary structural capability is to be demonstrated by test, this section becomes a requirement. If the spacecraft primary structural capability is to be demonstrated by analysis (minimum factors of 1.6 on yield and 2.0 on ultimate), Section 4.2.4.1 is only a recommendation. These tests are generalized to encompass numerous payload configurations. For this reason, managers of each payload project should critically evaluate its specific requirements and develop detailed, tailored test specifications. Coordination with the Delta Program Office during the development of spacecraft test specifications is encouraged to ensure the adequacy of the spacecraft test approach.

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.

**4.2.4.1 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 is required to provide proper load distribution at the payload interface. The payload user shall consult the Delta Program Office 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.

4.2.4.2 Acoustic Testing. The maximum flight level acoustic environments defined in Section 4.2.3.3 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 4.2.3.3. The acoustic acceptance test duration is 60 sec. The acoustic qualification, acceptance, and protoflight test levels for the Delta IV launch vehicle configurations are defined in Figure 4-43.

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 sound pressure level (OASPL) should be maintained within +3 dB and -1 dB of the nominal overall test level. Customers should contact the Delta Program Office to coordinate any spacecraft acoustic requirements below the test levels provided in Figure 4-43.

4.2.4.3 Sinusoidal Vibration Testing. The maximum flight level sinusoidal vibration environments defined in Section 4.2.3.4 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 4.2.3.4. The sinusoidal vibration test levels at acceptance, protoflight, and qualification for all Delta IV launch vehicle configurations are defined in Figures 4-44, 4-45, and 4-46 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 |

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**Figure 4-43. Spacecraft Acoustic Test Levels**

| Axis | Frequency (Hz) | Acceptance Test Levels | Sweep Rate |
|---|---|---|---|
| Thrust | 5 to 6.2<br>6.2 to 100 | 1.27 cm (0.5 in.) double amplitude<br>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 4-44. Sinusoidal Vibration Acceptance Test Levels**

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

0000594.3

**Figure 4-45. Sinusoidal Vibration Protoflight Test Levels**

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

0000592.3

**Figure 4-46. 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 2 octaves per min. For spacecraft acceptance and protoflight testing, the test consists of one sweep through the specified frequency range using a logarithmic sweep rate of 4 octaves per min. 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 the Delta Program Office 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.

4.2.4.4 Shock Testing. High-frequency pyrotechnic shock levels are very difficult to simulate mechanically on a shaker at the spacecraft system level. The most direct 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 are 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.

### 4.2.5 Dynamic Analysis Criteria and Balance Requirements

Typical payload separation attitude and rate dispersions are shown in Figure 4-47. Dispersions are defined for each vehicle configuration and consist of all known error sources. Dispersions are affected by spacecraft mass properties and center of gravity (CG) offsets. Mission-specific attitude and rate dispersions are defined in the payload/expended stage separation analysis.

| Configuration | Spinning | Payload Separation Attitude and Rate Dispersions (3-$\sigma$ Values) | |
|---|---|---|---|
| | | Attitude (deg) | Rate (dps) |
| Two stage | No | <1.4 | <2.0 (trans), <1.0 (roll) |
| | Up to 5 rpm (±1 deg/sec) | <2.0 | <3.0 (transverse) |

**Figure 4-47. Typical Payload Separation Attitudes/Rates**

4.2.5.1 Two-Stage Missions. Two-stage missions use the capability of the second stage to provide terminal velocity, roll, final spacecraft orientation, and separation.

4.2.5.1.1 Balance Requirements. There are no specific static and dynamic balance constraints for the spacecraft. However, for both nonspinning and spinning spacecraft, the static imbalance directly influences the spacecraft angular rates at separation. When there is a separation tip-off rate constraint, the spacecraft cg offset must be coordinated with the Delta Program Office for evaluation. For spinning spacecraft, the dynamic balance directly influences the angular momentum vector pointing and centerline pointing. When there are spacecraft constraints on these parameters, the dynamic balance must be coordinated with the Delta Program Office for evaluation.

4.2.5.1.2 Second-Stage Roll Rate Capability. For some two-stage missions, the spacecraft may require a roll rate at separation. The Delta IV second stage can command roll rates up to 5 rpm (0.52 rad/sec) using control jets. Higher roll rates are also possible; however, accuracy is degraded as the rate increases. Roll rates higher than 5 rpm (0.52 rad/sec) must be assessed relative to specific spacecraft requirements.

# *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 fittings (PAFs). Unique interface requirements can be accommodated by modifying existing designs as required. In addition, multiple-payload dispenser systems are also available. For further details, coordinate with the Delta Program Office.

## 5.1 HERITAGE DESIGN PHILOSOPHY

Delta IV payload attach fittings are based on heritage designs that have been developed and qualified by the Delta Program. This approach offers several advantages, primarily in reducing development time and costs for new attach fittings.

### 5.1.1 Structural 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:

- A high-modulus graphite-epoxy/foam core sandwich construction for the conic shell.
- One-piece aluminum rings at each end for interfaces to the second 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 second stage.

This design is easily adapted to accommodate different interface diameters and payload sizes simply by extending or reducing the conic shell and sizing the sandwich structure and end-ring design. As a result, much of the secondary structure developed for one PAF is readily adaptable to another.

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

### 5.1.2 Mechanical Design

The Delta Program has extensive flight experience with both Marmon-type clampband and discrete bolted interface separation systems. Previous Delta vehicles have developed and flown Marmon-type clampbands over a broad range of diameters: 229 mm (9 in.) to 1666 mm (66 in.). In addition, Delta II 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 Delta IV PAF. 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 5-2. 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 such that payload electrical interfaces and separation springs can be located to accommodate specific customer requirements. Selection of an appropriate PAF should be coordinated with the Delta Program Office as early as possible.

Sections 5.2.1 through 5.2.7 describe the available PAFs in detail, including dimensional drawings. Figure 5-1 applies to the various PAF configuration drawing notes that accompany this section.

| | |
|---|---|
| 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<br>0.XX = ±0.25 |
| in. | 0.XX = ±0.03<br>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. | |

002249.3

**Figure 5-1. Notes Used in Configuration Drawings**

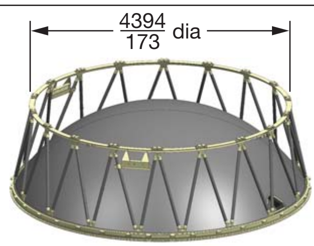
| Model/ Mass | Note: All dimensions are in mm/in. | Separation Mechanism | Features |
|---|---|---|---|
| **Delta IV 1194-4 PAF** 239 kg/ 526 lb |  | 1194/47 dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact. |
| **Delta IV 1575-4 PAF** 240 kg/ 530 lb |  | 121 bolts in a 1575/62 dia bolt circle | 1575-mm (62.010-in.) bolted interface. EELV Medium Launch Vehicle/Intermediate Launch Vehicle MLV/ILV standard interface. |
| **Delta IV 1666-4 PAF** 244 kg/ 538 lb |  | 1666/66 dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact. |
| **Delta IV 1194-5 PAF** 400 kg/ 881 lb |  | 1194/47 dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact. |
| **Delta IV 1575-5 PAF** 418 kg/ 921 lb |  | 121 bolts in a 1575/62 dia bolt circle | 1575-mm (62.010-in.) bolted interface. EELV MLV/ILV standard interface. |
| **Delta IV 1666-5 PAF** 419 kg/ 924 lb |  | 1666/66 dia clampband | Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact. |
| **Delta IV 4394-5 PAF** 385 kg/ 848 lb |  | 72 bolts in a 4394/173 dia bolt circle | 4394 (173-in.) bolted interface. Standard only for 5-m metallic fairing. SHG0555905-068.1 |

**Figure 5-2. Delta IV Payload Attach Fittings**

### 5.2.1 1194-4 (47-in.) Payload Attach Fitting (PAF)

The 1194-4 PAF (Figure 5-3) provides an 1194 mm (47 in.) payload interface, and uses a 4-m-diameter composite payload fairing.

The separation system consists of a Marmon-type clampband separation system, and comes standard with four separation spring actuators. The separation actuators may be clocked in 15-deg increments. Combined with the ability to add additional actuators, this feature allows the 1194 family of PAFs to meet a wide range of spacecraft separation requirements.

SHG0555905-069

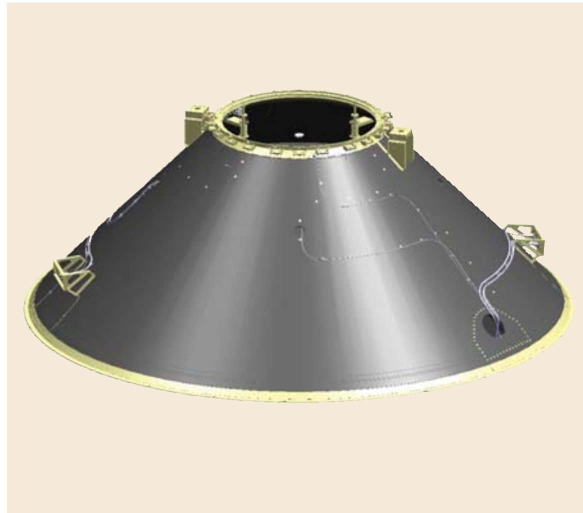


Figure 5-3. 1194-4 PAF

Two electrical connectors, which can be located at the customer's discretion, have the ability to provide prelaunch spacecraft power and monitoring, as well as discrete commands and telemetry during ascent.

Figure 5-4 shows the capability of the 1194-4 PAF in terms of spacecraft mass and CG location above the separation plane. Figures 5-5 through 5-10 show PAF and spacecraft interface details.

SHG0555905-070

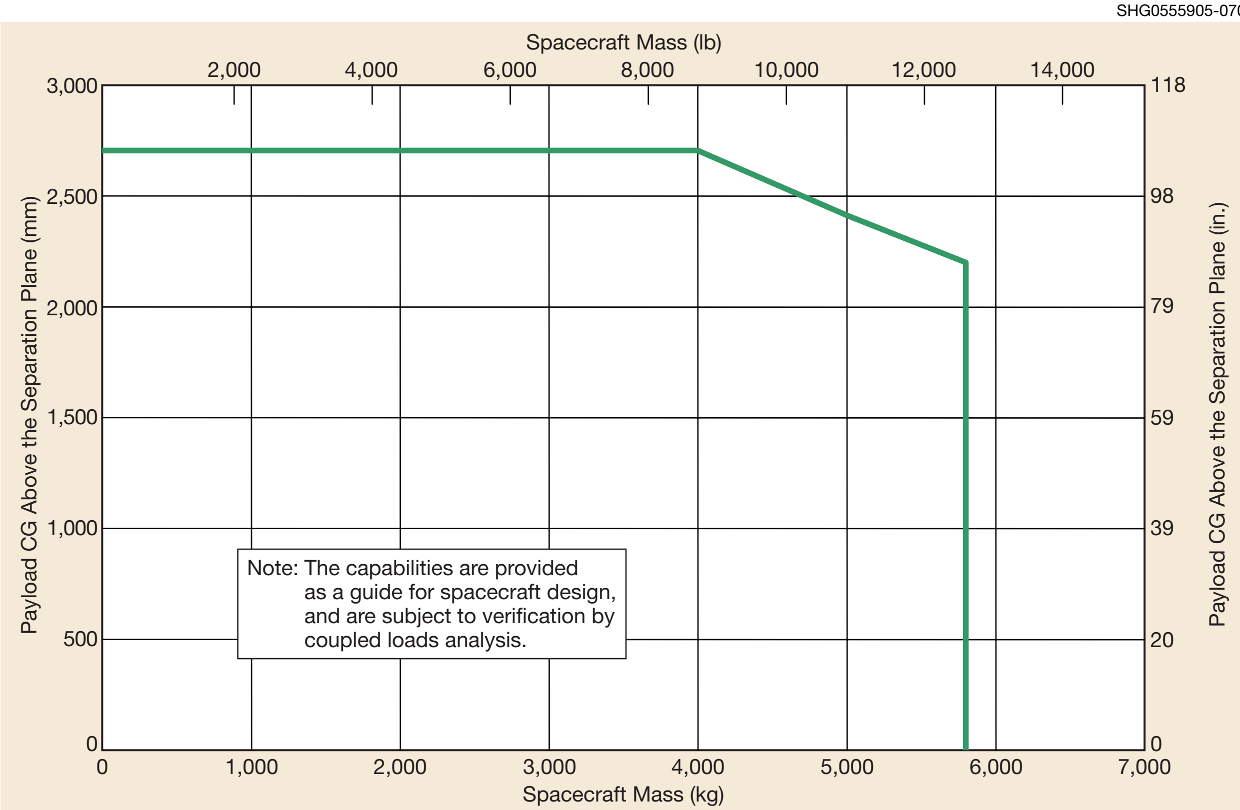



Figure 5-4. Capability of 1194-4 PAF

SHG0555905-071.3

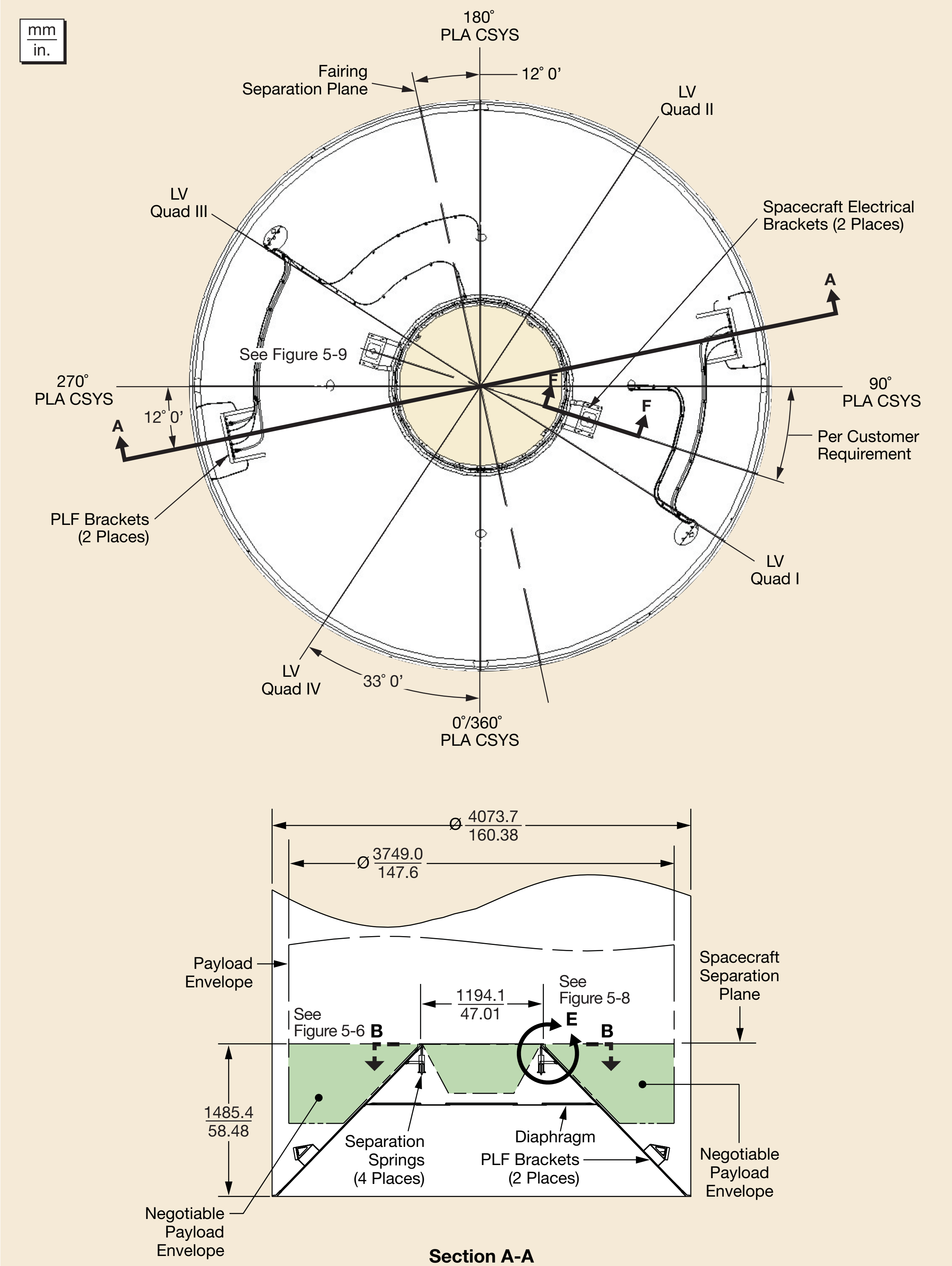



**Figure 5-5. 1194-4 PAF Detailed Assembly**

SHG0555905-072.2

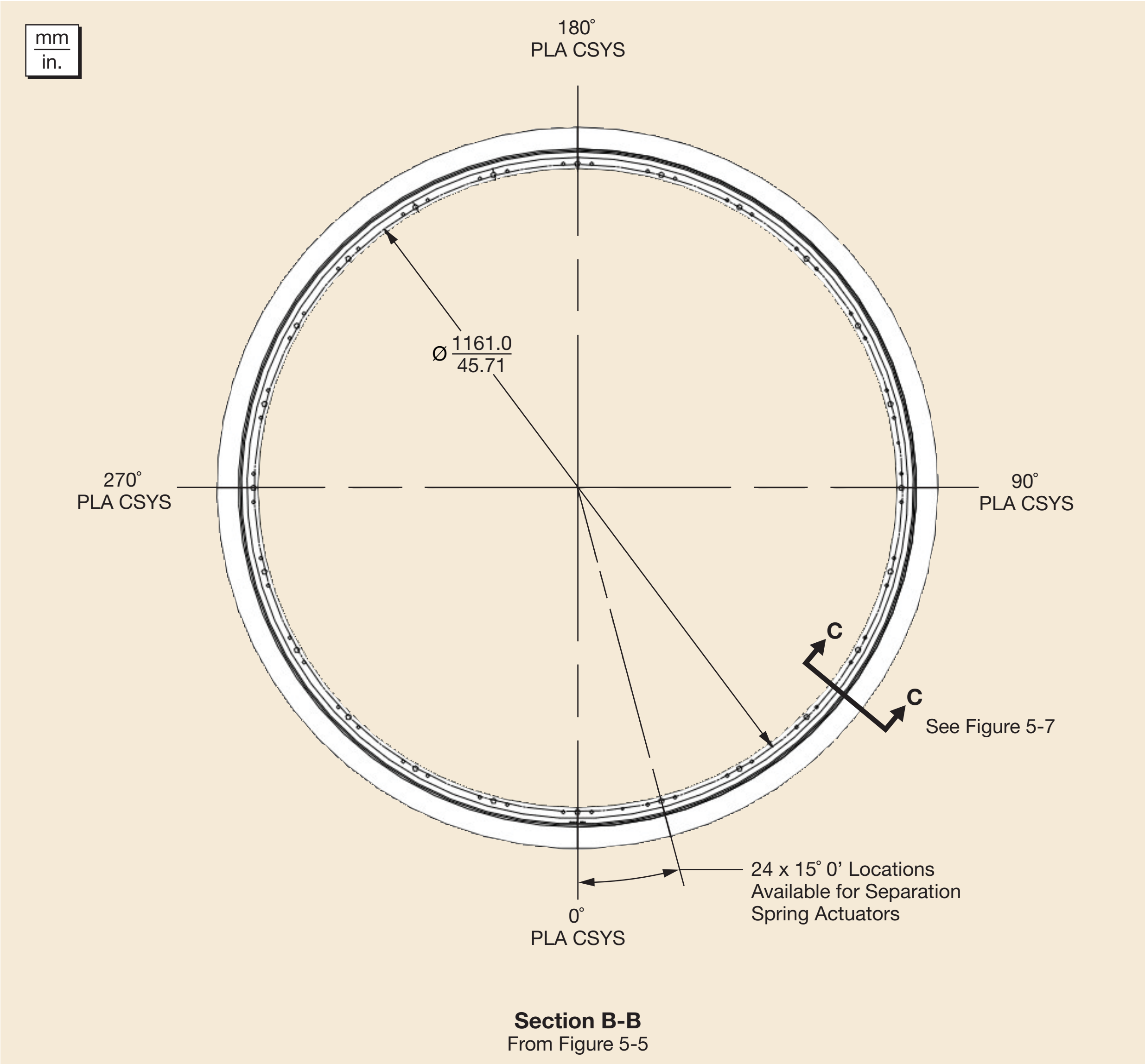



**Figure 5-6. 1194-4 PAF Detailed Dimensions**

HB5T072011.4

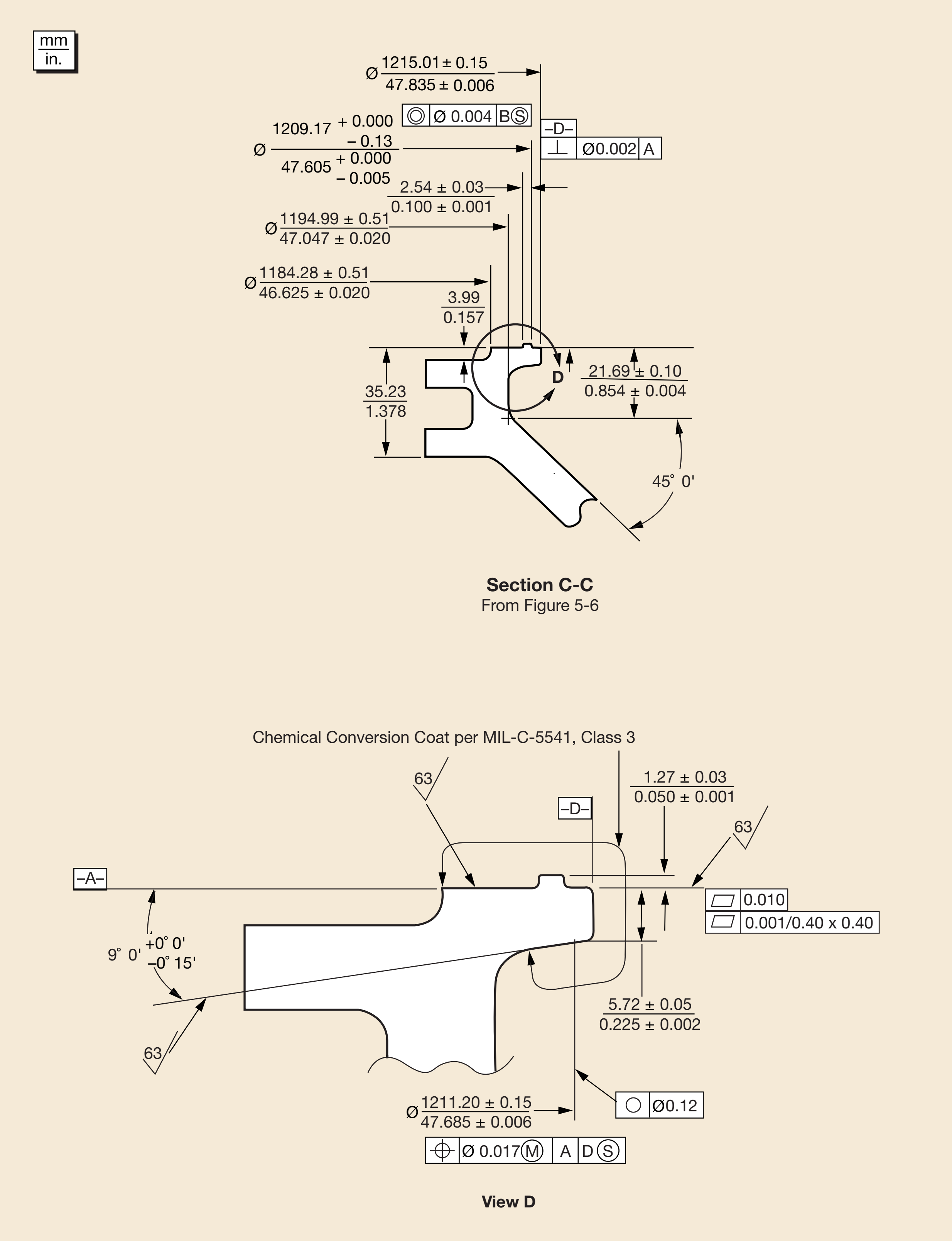



**Figure 5-7. 1194-4 PAF Detailed Dimensions**

SHG0555905-073.1

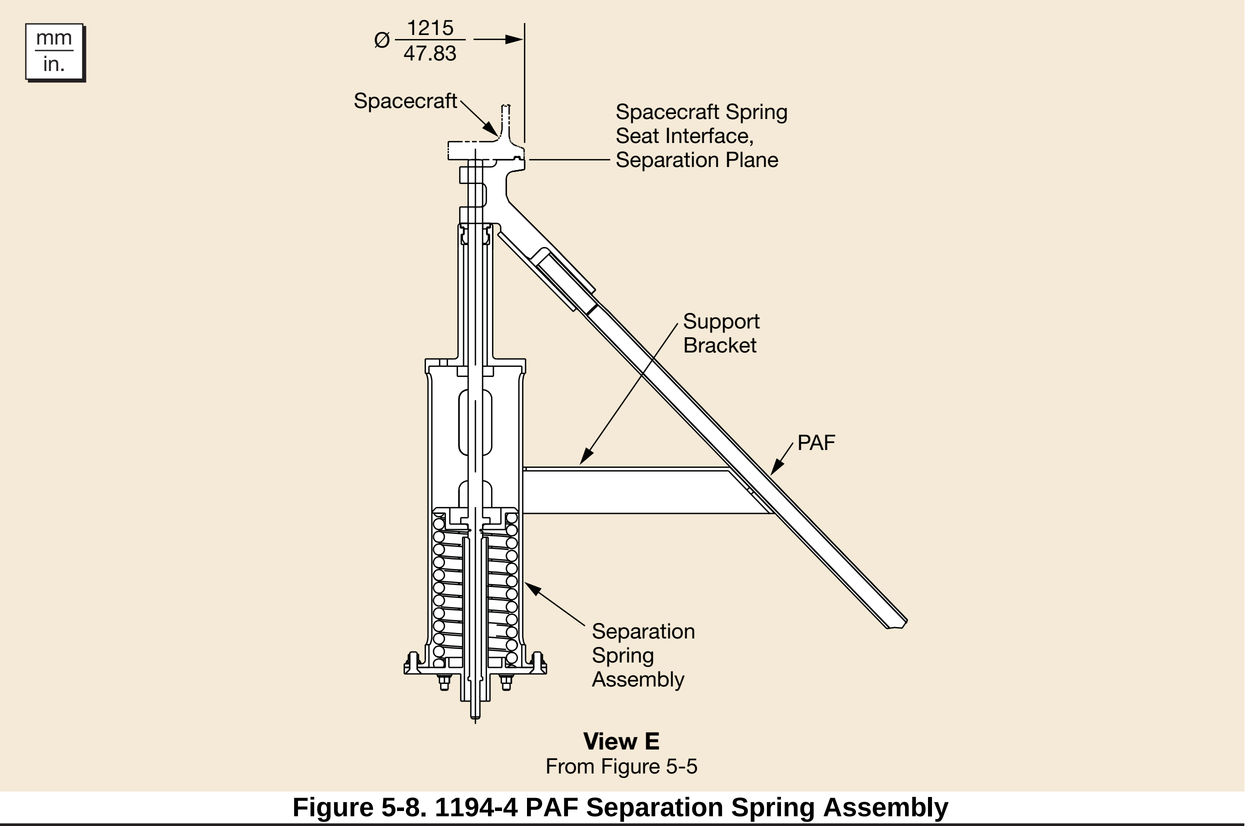



**Figure 5-8. 1194-4 PAF Separation Spring Assembly**

SHG0555905-074.2

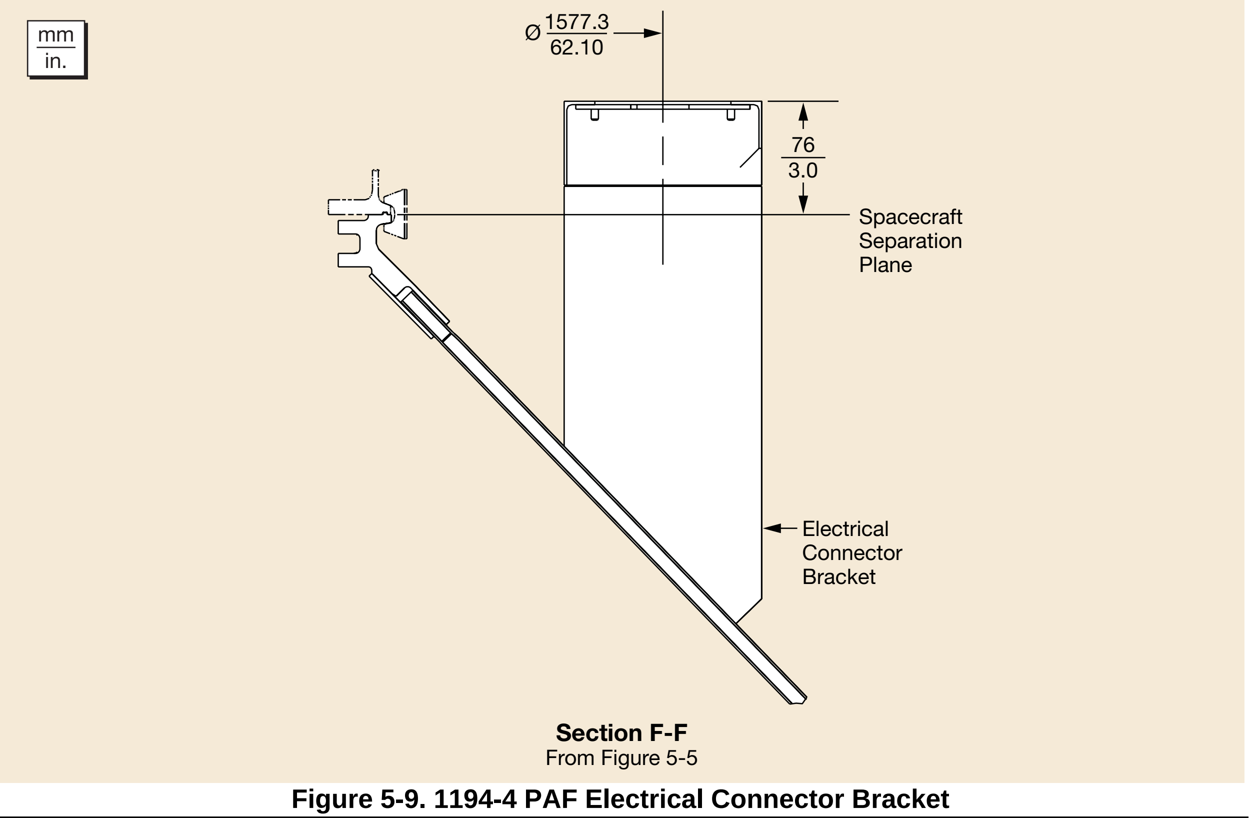



**Figure 5-9. 1194-4 PAF Electrical Connector Bracket**

HB5T072028.5

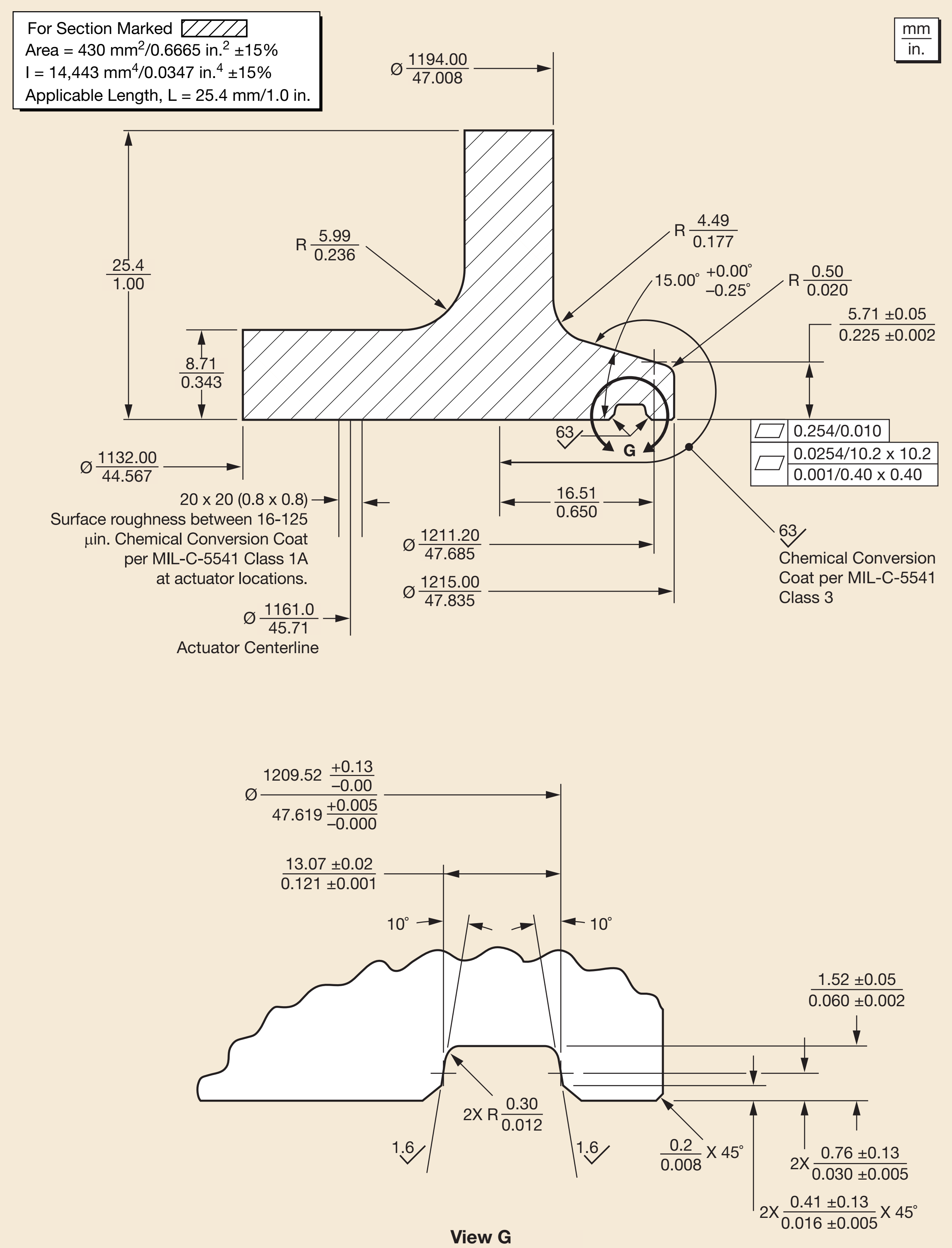



**Figure 5-10. Dimensional Constraints on Spacecraft Interface to 1194-4 PAF**

### 5.2.2 1194-5 (47-in.) Payload Attach Fitting (PAF)

The 1194-5 PAF (Figure 5-11) provides an 1194 mm (47 in.) payload interface, and uses a 5-m-diameter composite payload fairing.

The separation system consists of a Marmon-type clampband separation system, and comes standard with four separation spring actuators. The separation actuators may be clocked in 15-deg increments. Combined with the ability to add additional actuators, this feature allows the 1194 family of PAFs to meet a wide range of spacecraft separation requirements.

SHG0555905-075

**Figure 5-11. 1194-5 PAF**

Two electrical connectors, which can be located at the customers discretion, have the ability to provide prelaunch spacecraft power and monitoring, as well as discrete commands, telemetry, and ordnance during ascent.

Figure 5-12 shows the capability of the 1194-5 PAF in terms of spacecraft mass and CG location above the separation plane. Figures 5-13 through 5-18 show PAF and spacecraft interface details.

SHG0555905-076

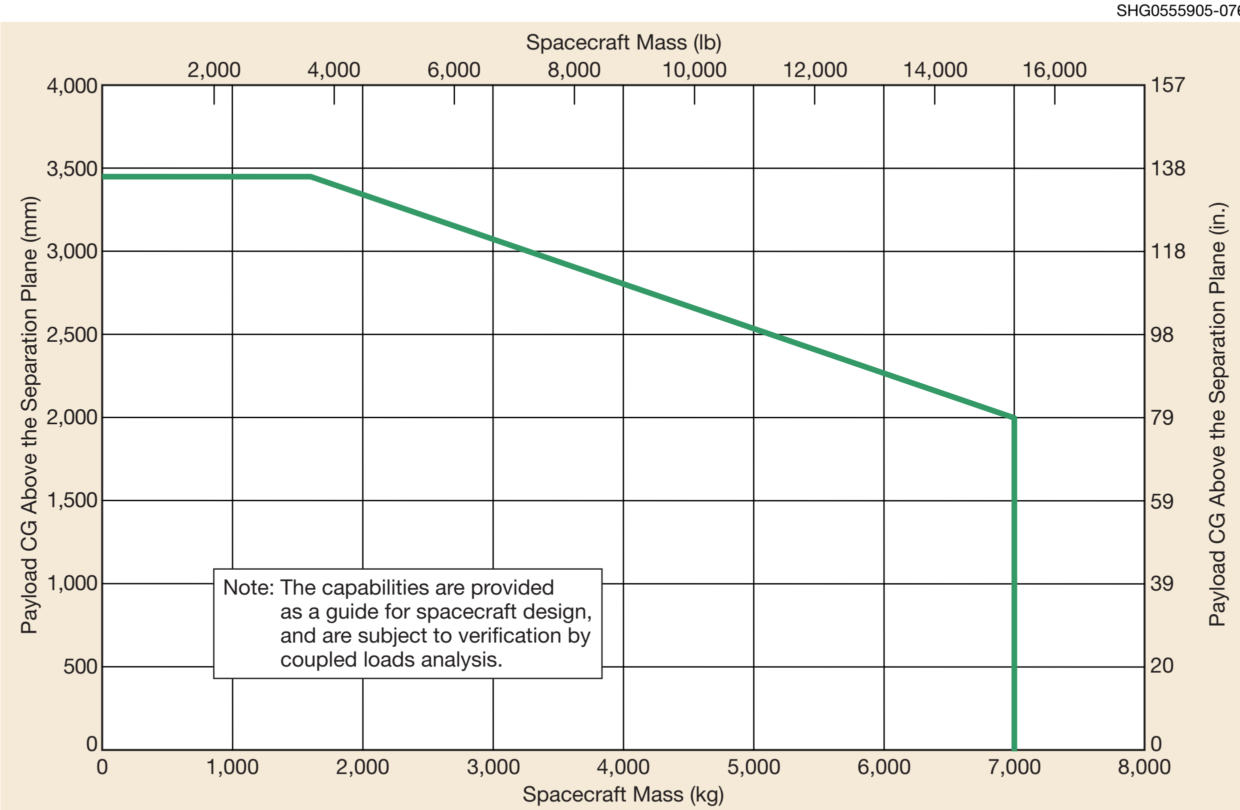



**Figure 5-12. Capability of 1194-5 PAF**

SHG0555905-077.2

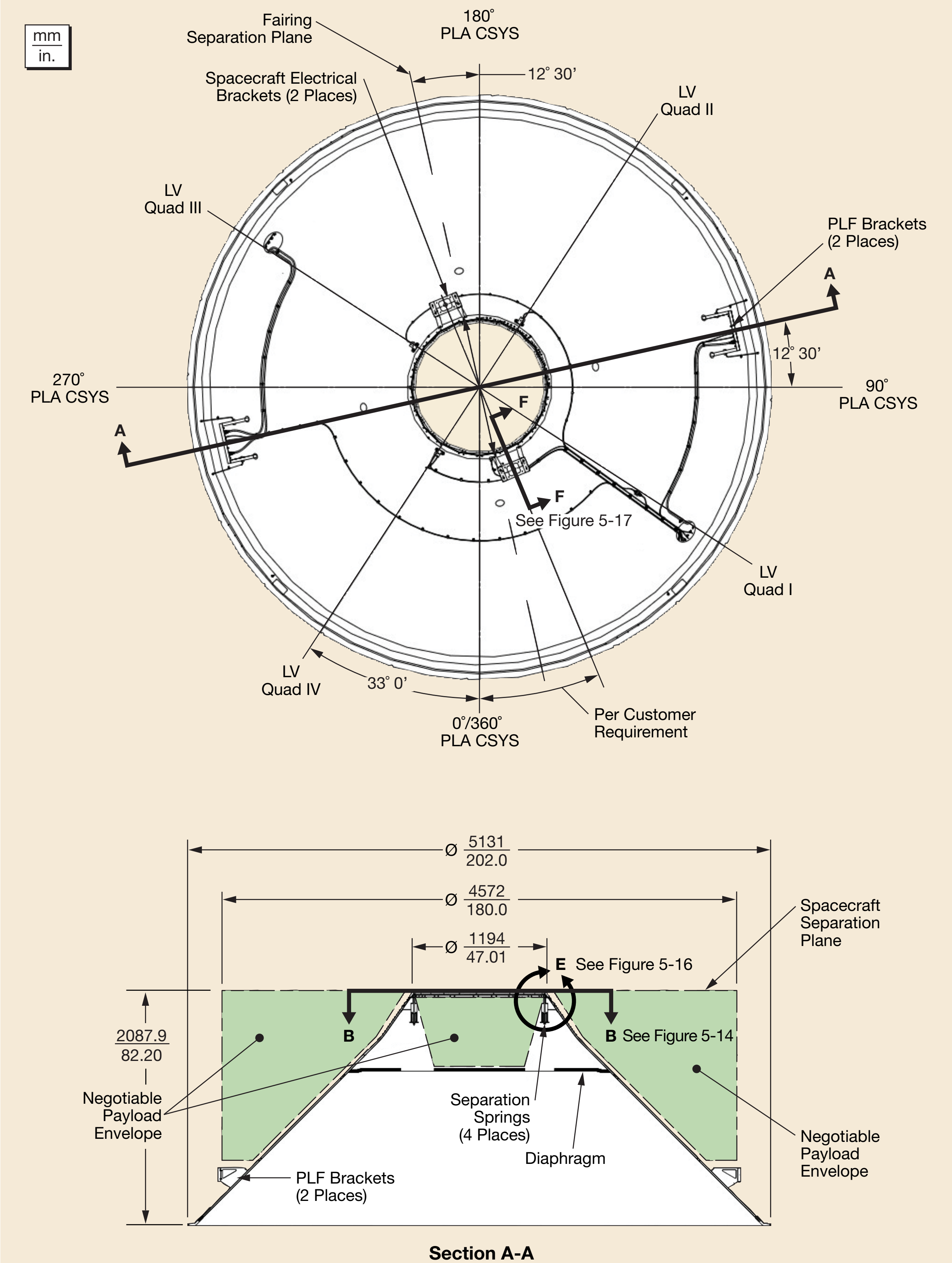
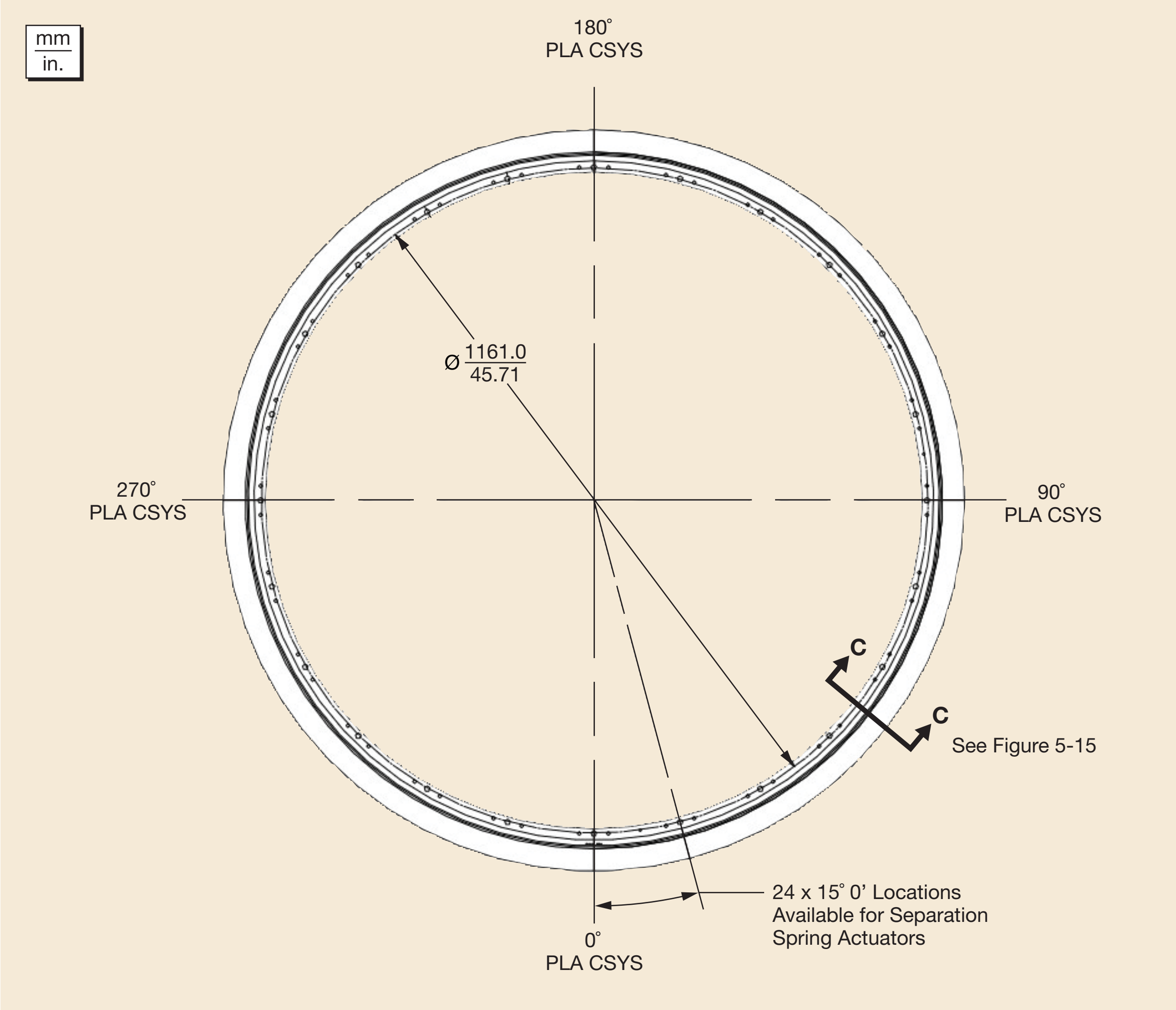



**Figure 5-13. 1194-5 PAF Detailed Assembly**

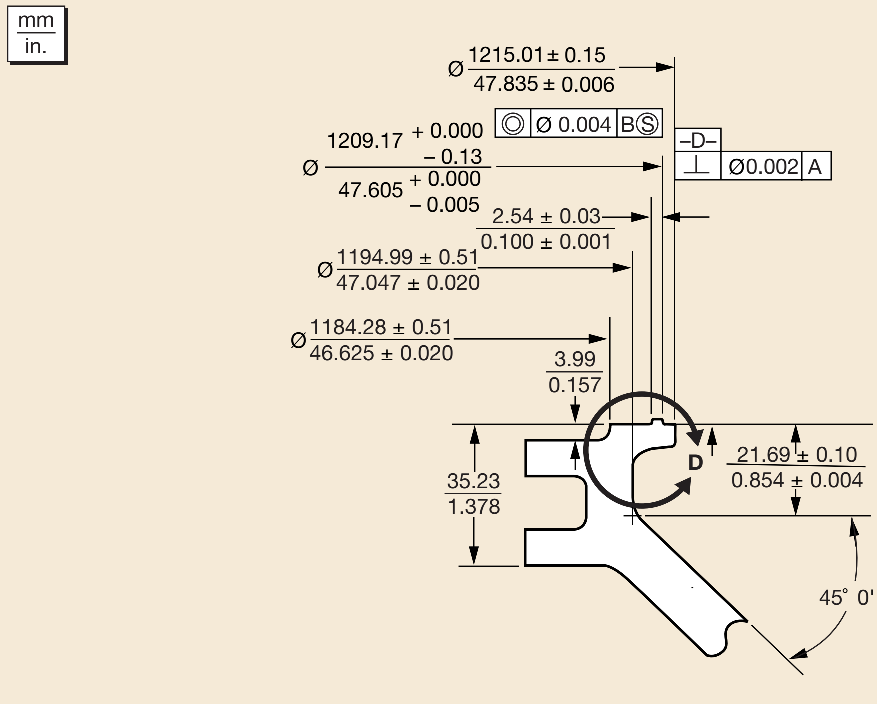
SHG0555905-078.2




**Section B-B**
From Figure 5-13

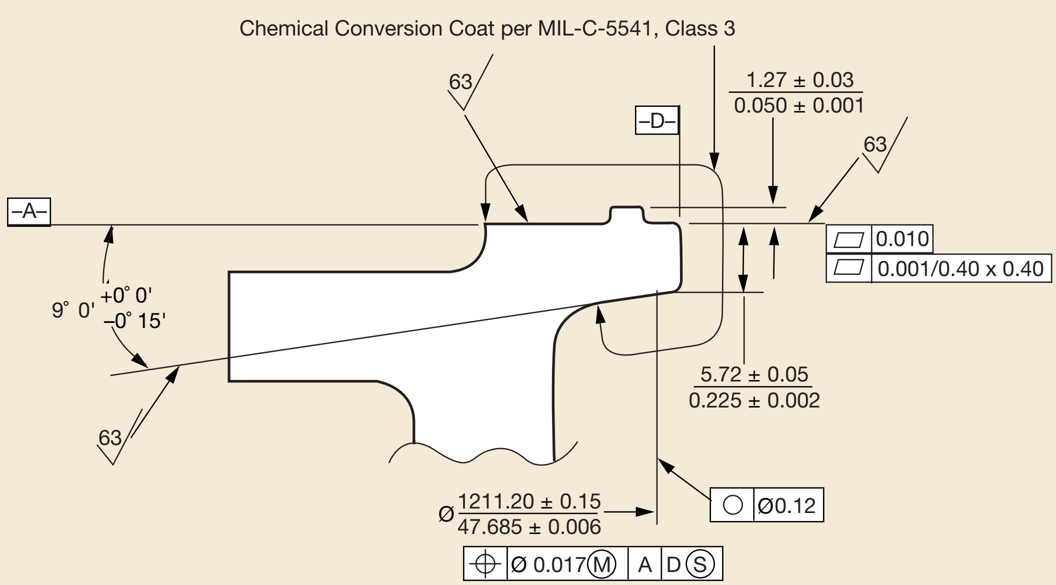
**Figure 5-14. 1194-5 PAF Detailed Dimensions**

SHG0555905-079.1




**View C**

From Figure 5-14




**View D**

**Figure 5-15. 1194-5 PAF Detailed Dimensions**

SHG0555905-080.2

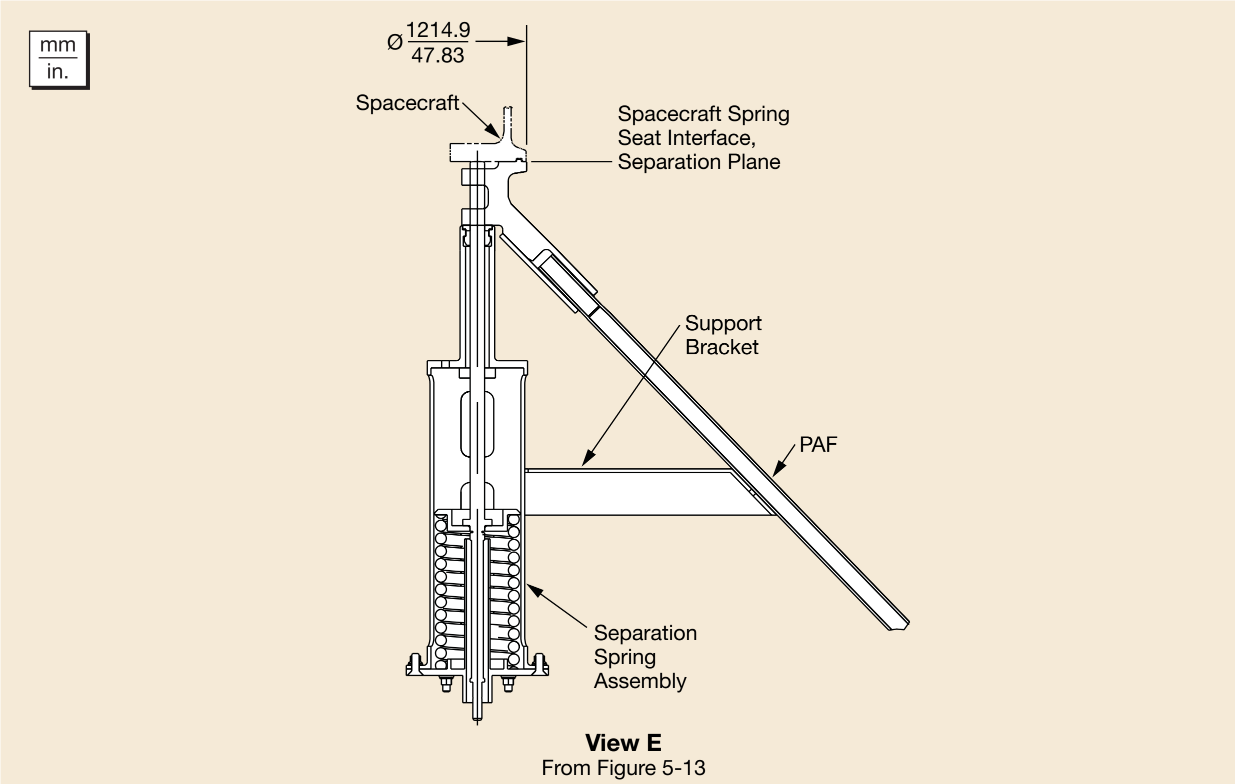



**Figure 5-16. 1194-5 PAF Separation Spring Assembly**

SHG0555905-081.2

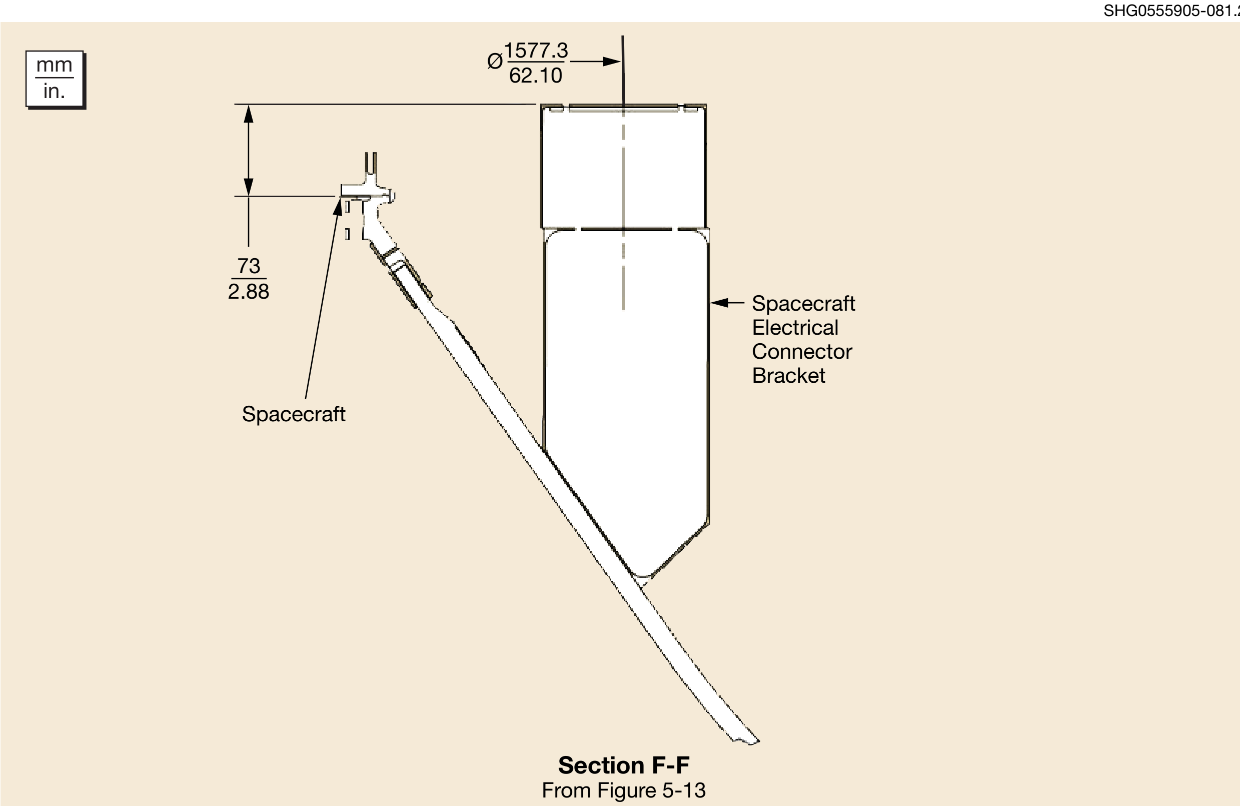



**Figure 5-17. 1194-5 PAF Electrical Connector Bracket**

HB5T072045

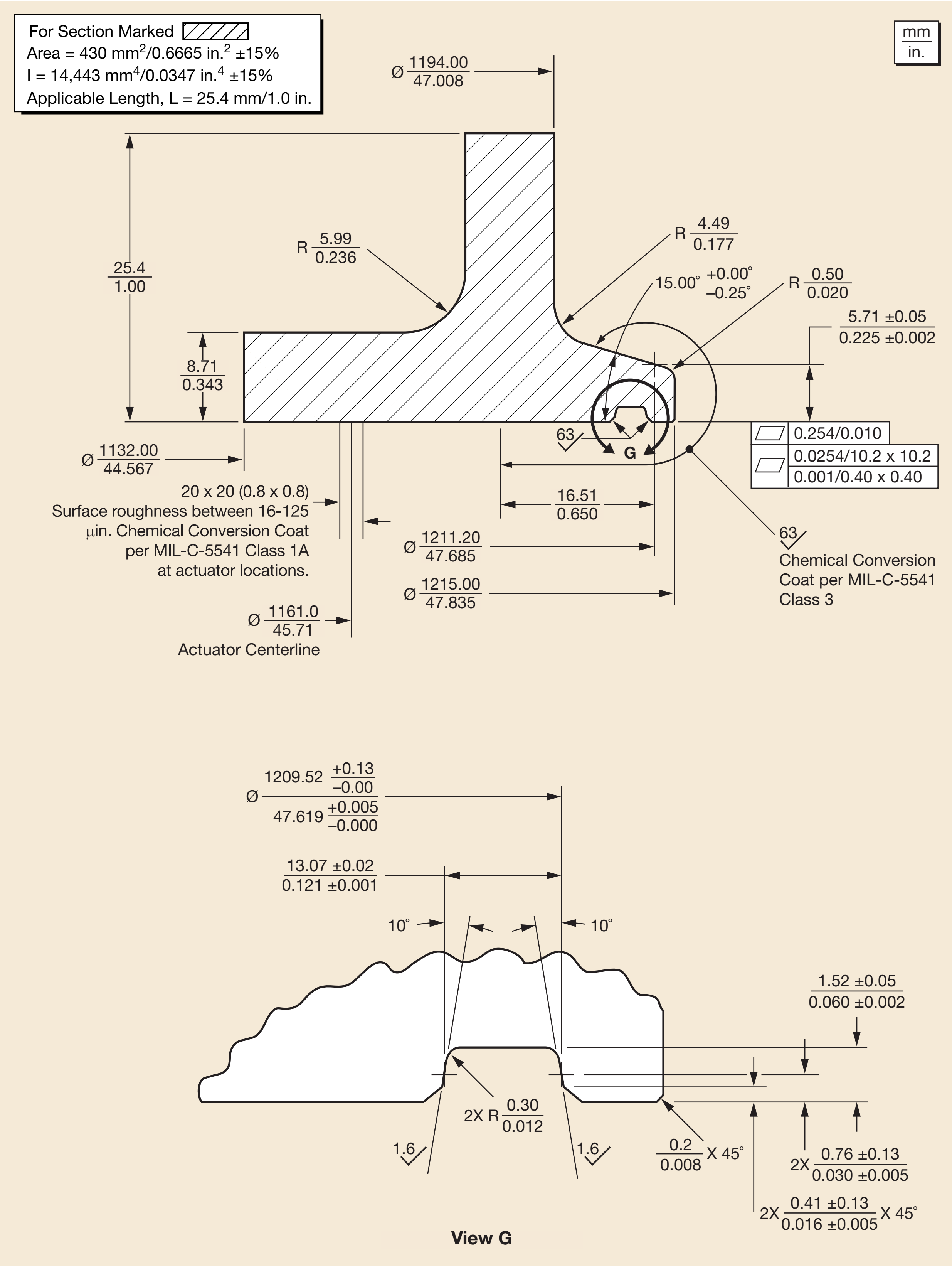



**Figure 5-18. Dimensional Constraints on Spacecraft Interface to 1194-5 PAF**

### 5.2.3 1575-4 (62-in.) Payload Attach Fitting (PAF)

The 1575-4 PAF (Figure 5-19) provides a standard 121-bolt mating interface to the payload at a 1575-mm (62.01 in.) diameter, and uses a 4-m composite payload.

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

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.

SHG0555905-082

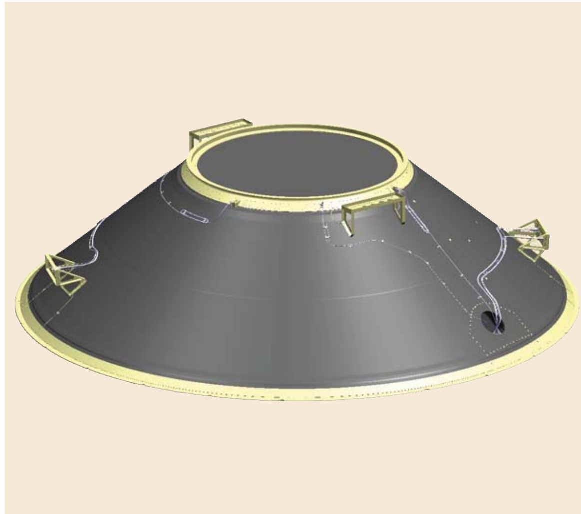


Figure 5-19. 1575-4 PAF

Figure 5-20 shows the capability of the 1575-4 PAF in terms of spacecraft mass and CG location above the separation plane. Figures 5-21 through 5-25 show PAF and spacecraft interface details.

SHG0555905-083

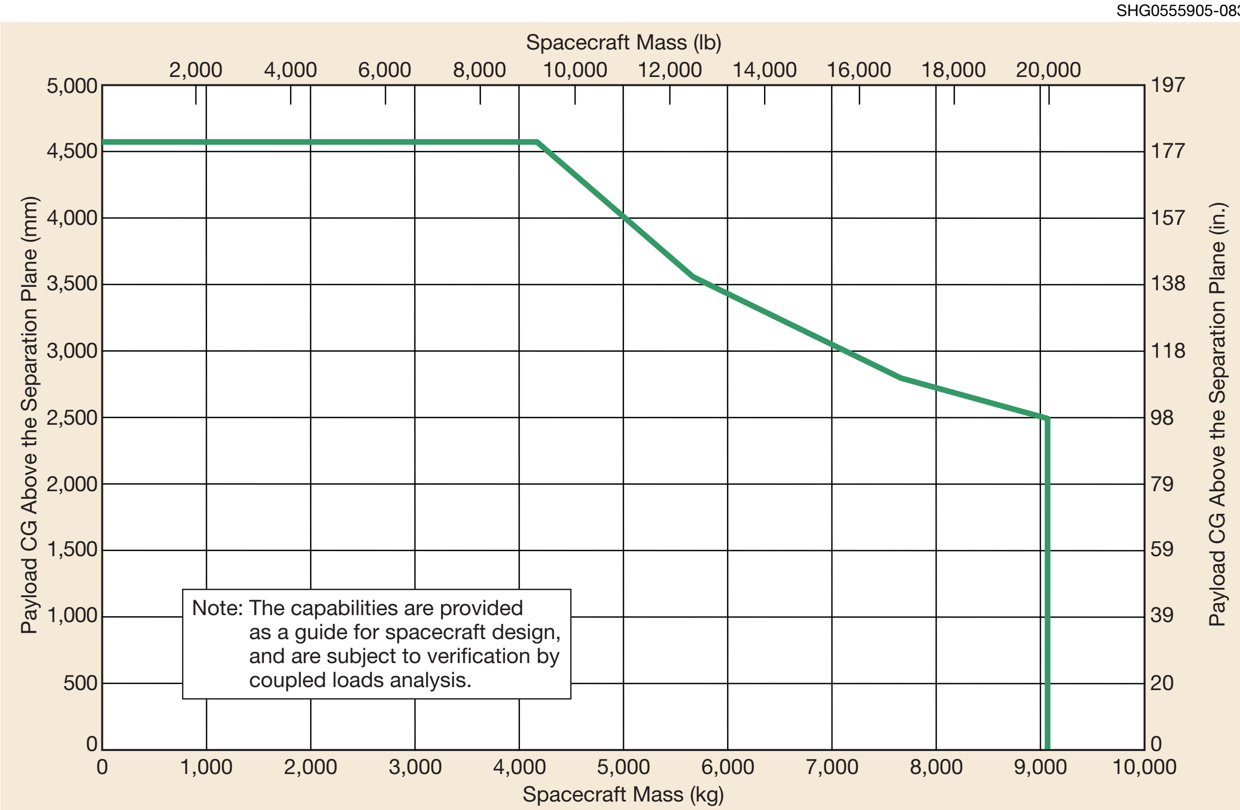



Figure 5-20. Capability of 1575-4 PAF

SHG0555905-084.2

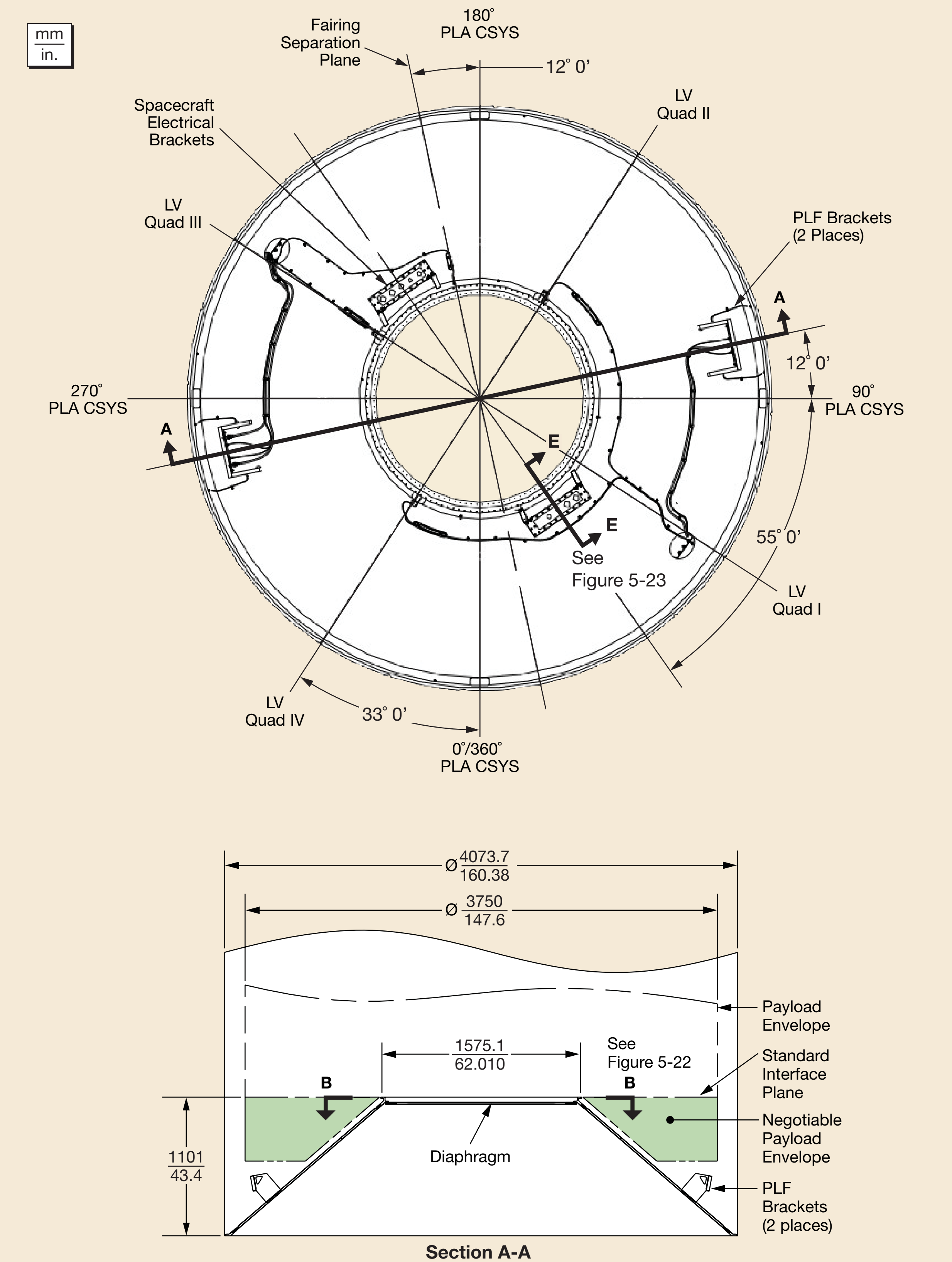



**Figure 5-21. 1575-4 PAF Detailed Assembly**

SHG0555905-085.1

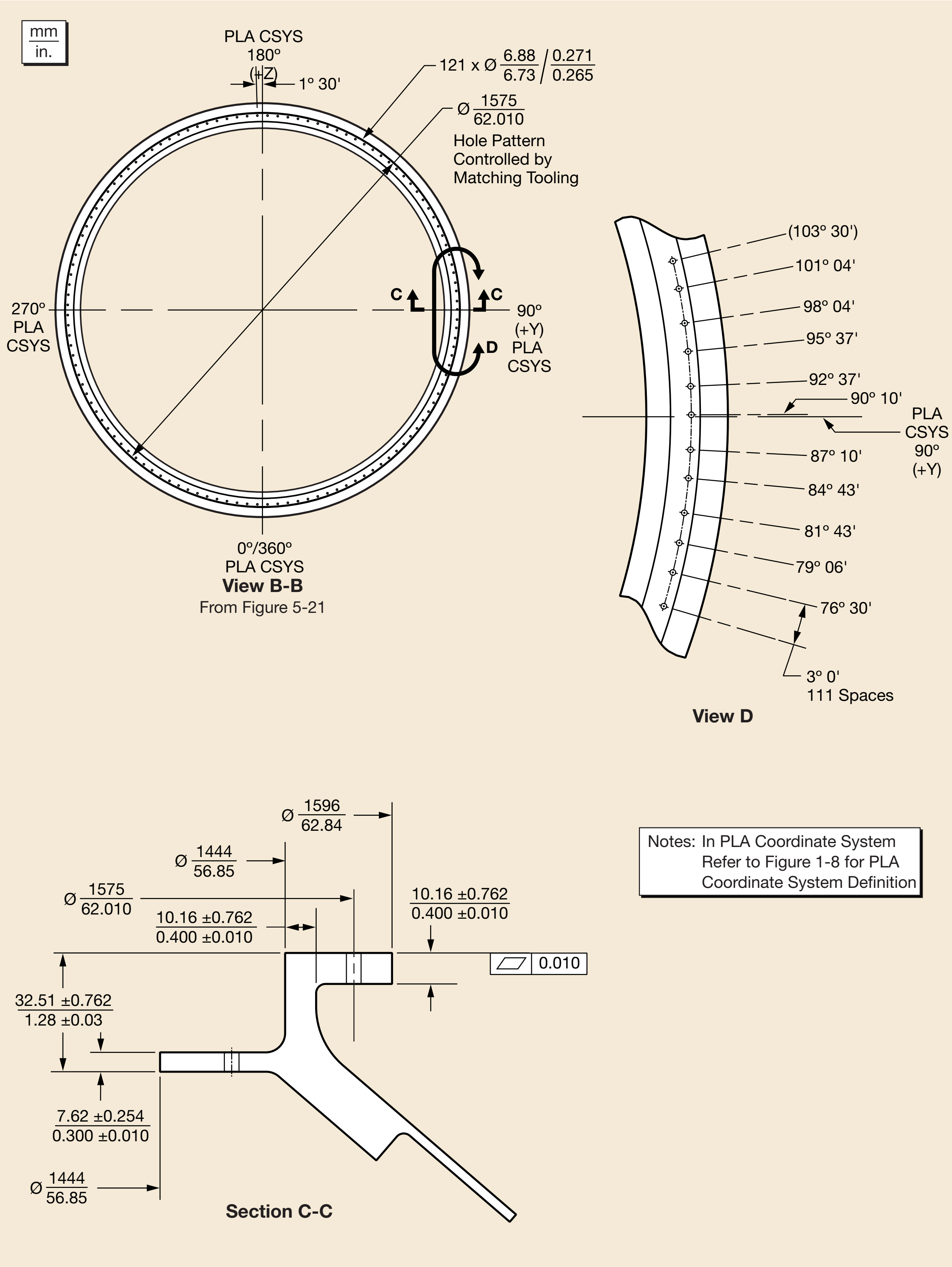
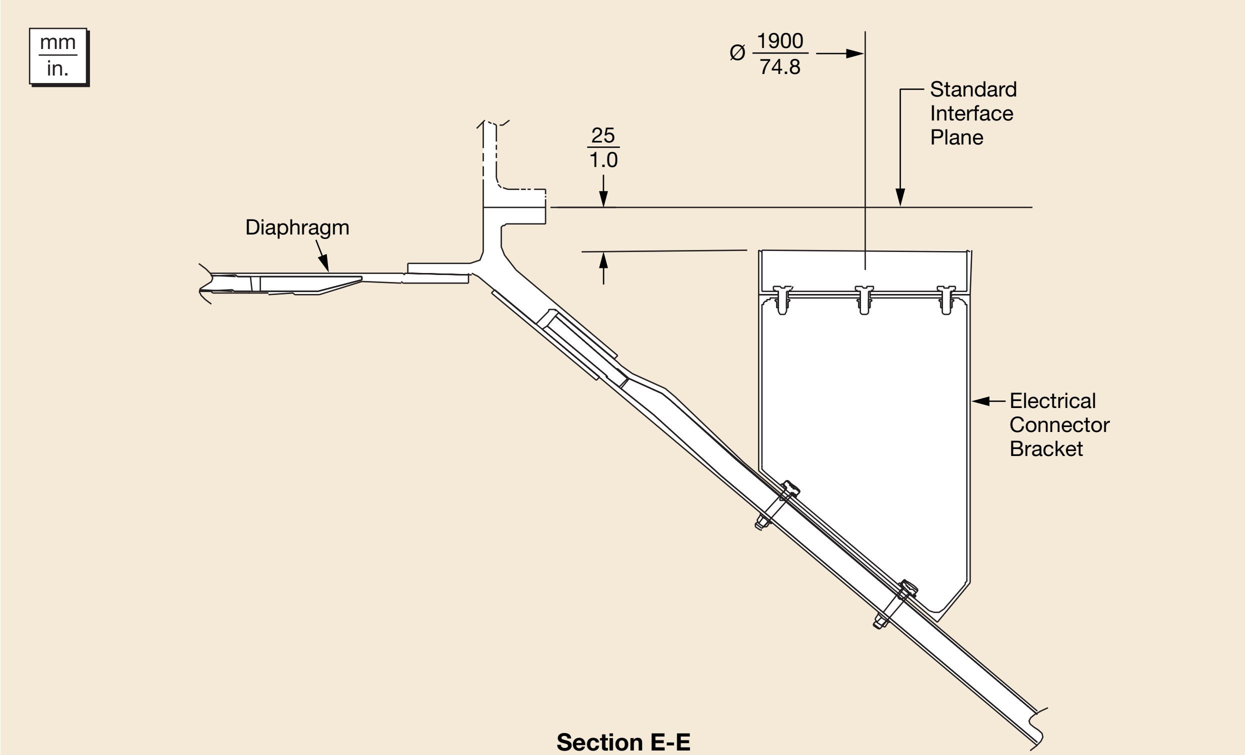



**Figure 5-22. 1575-4 PAF Detailed Dimensions**

SHG0555905-086




**Section E-E**
From Figure 5-21

**Figure 5-23. 1575-4 PAF Electrical Connector Bracket (2 places)**

SHG0555905-087.2

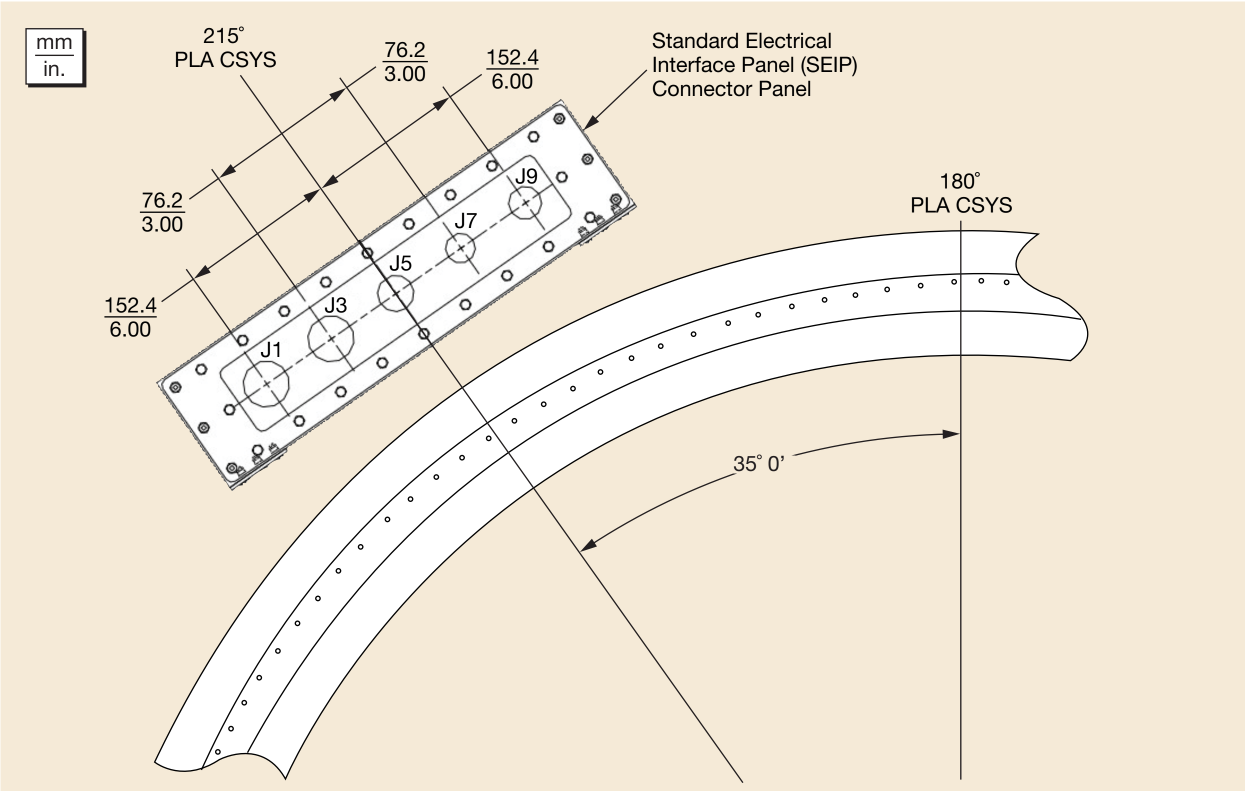



**Figure 5-24. 1575-4 PAF Electrical Connector Bracket Detail (215 deg PLA CSYS)**

SHG0555905-149

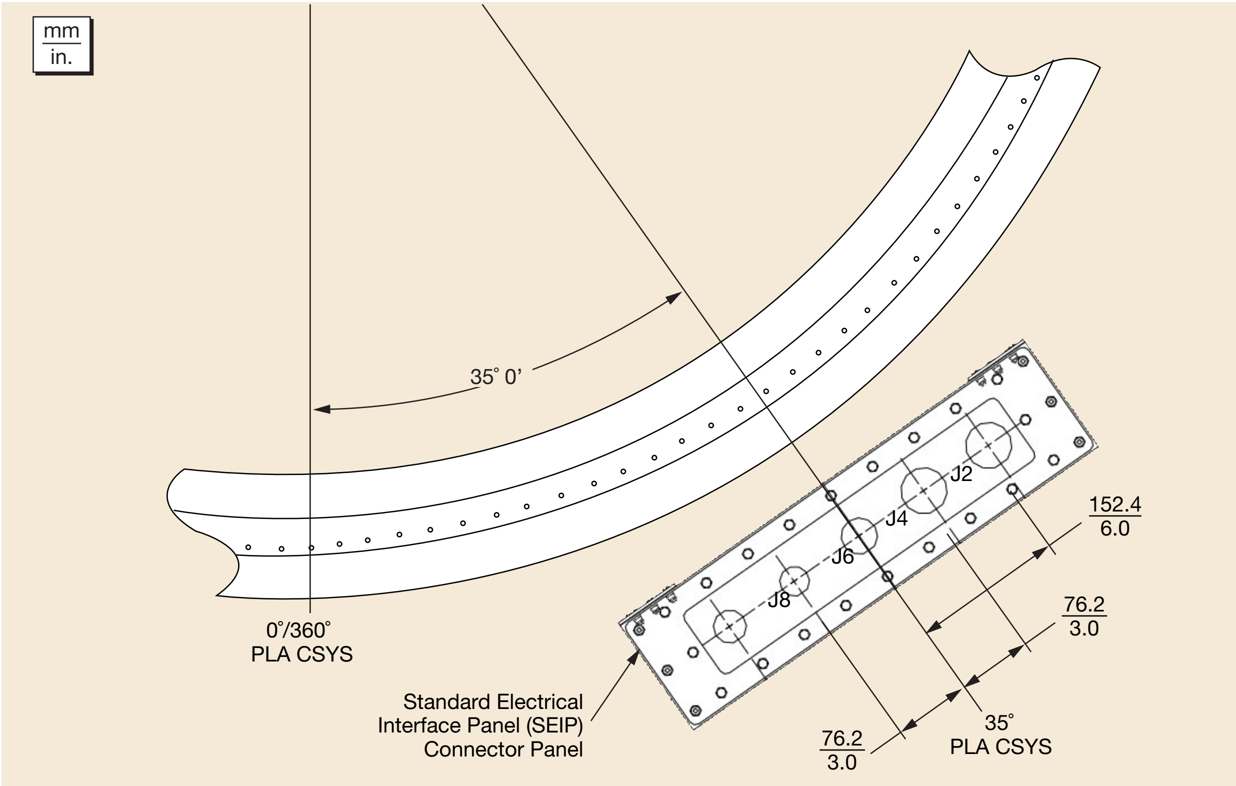



**Figure 5-25. 1575-4 PAF Electrical Connector Bracket Detail (35 deg PLA CSYS)**

### 5.2.4 1575-5 (62 in.) Payload Attach Fitting (PAF)

The 1575-5 PAF (Figure 5-26) provides a standard 121-bolt mating interface to the payload at a 1575-mm (62.01 in.) diameter, and uses a 5-m composite payload.

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

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.

SHG0555905-089

**Figure 5-26. 1575-5 PAF**

Figure 5-27 shows the capability of the 1575-5 PAF in terms of spacecraft mass and CG location above the separation plane. Figures 5-28 through 5-32 show PAF and spacecraft interface details.

SHG0555905-090

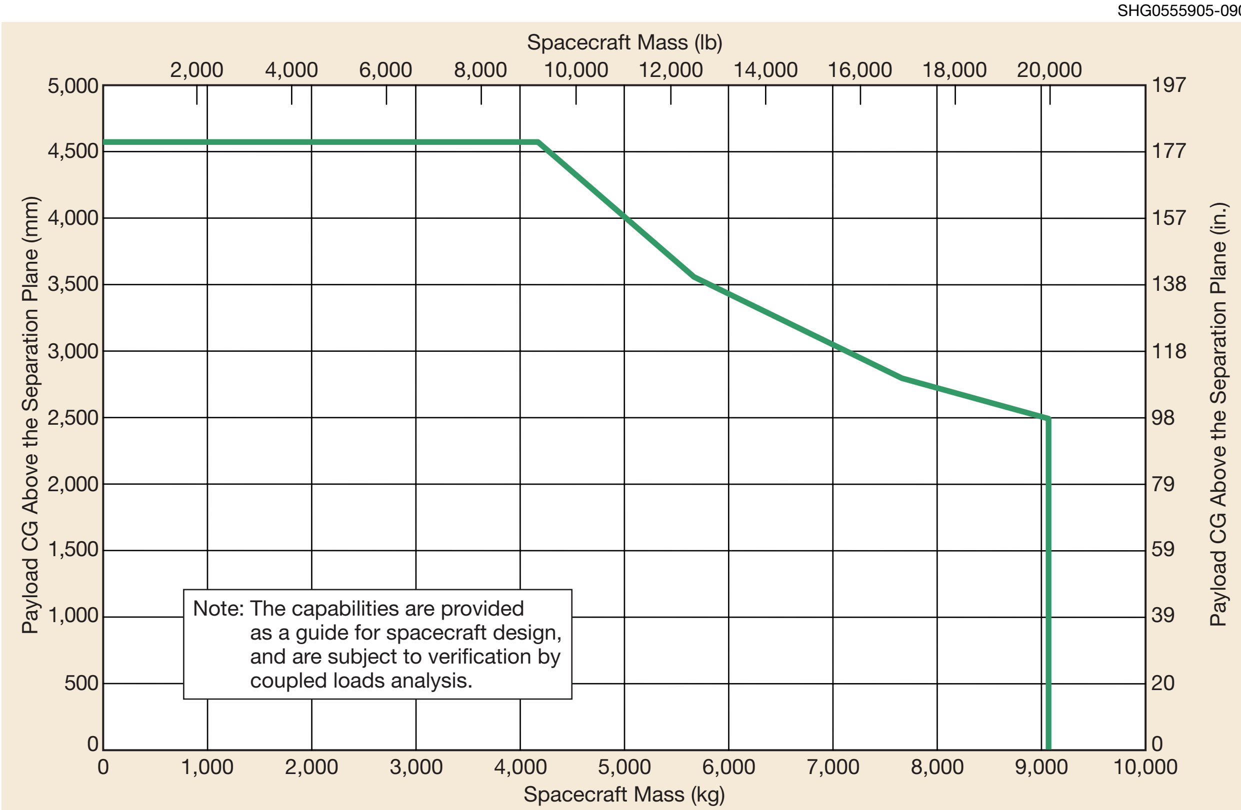



**Figure 5-27. Capability of 1575-5 PAF**

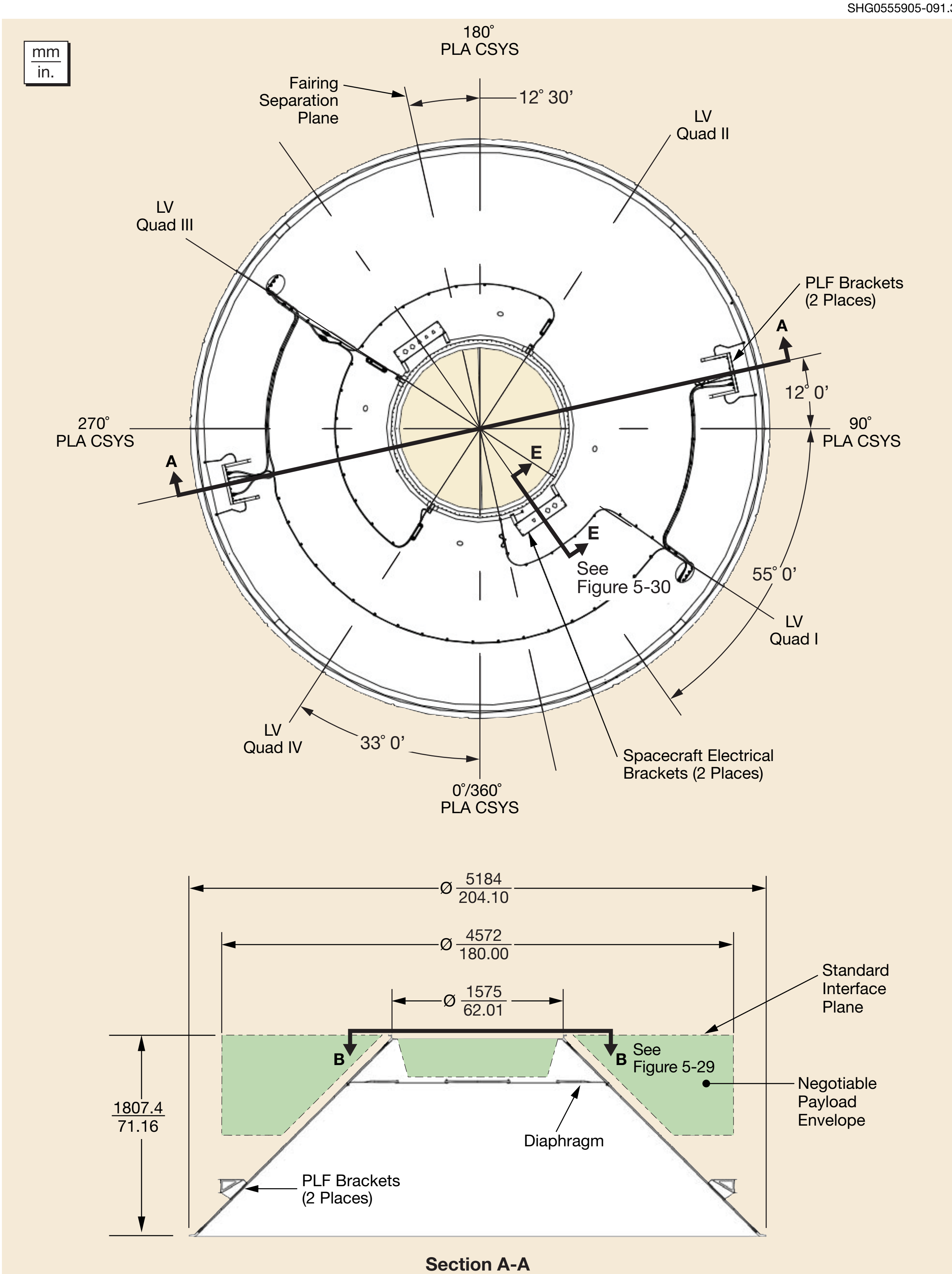



**Figure 5-28. 1575-5 PAF Detailed Assembly**

SHG0555905-092.1

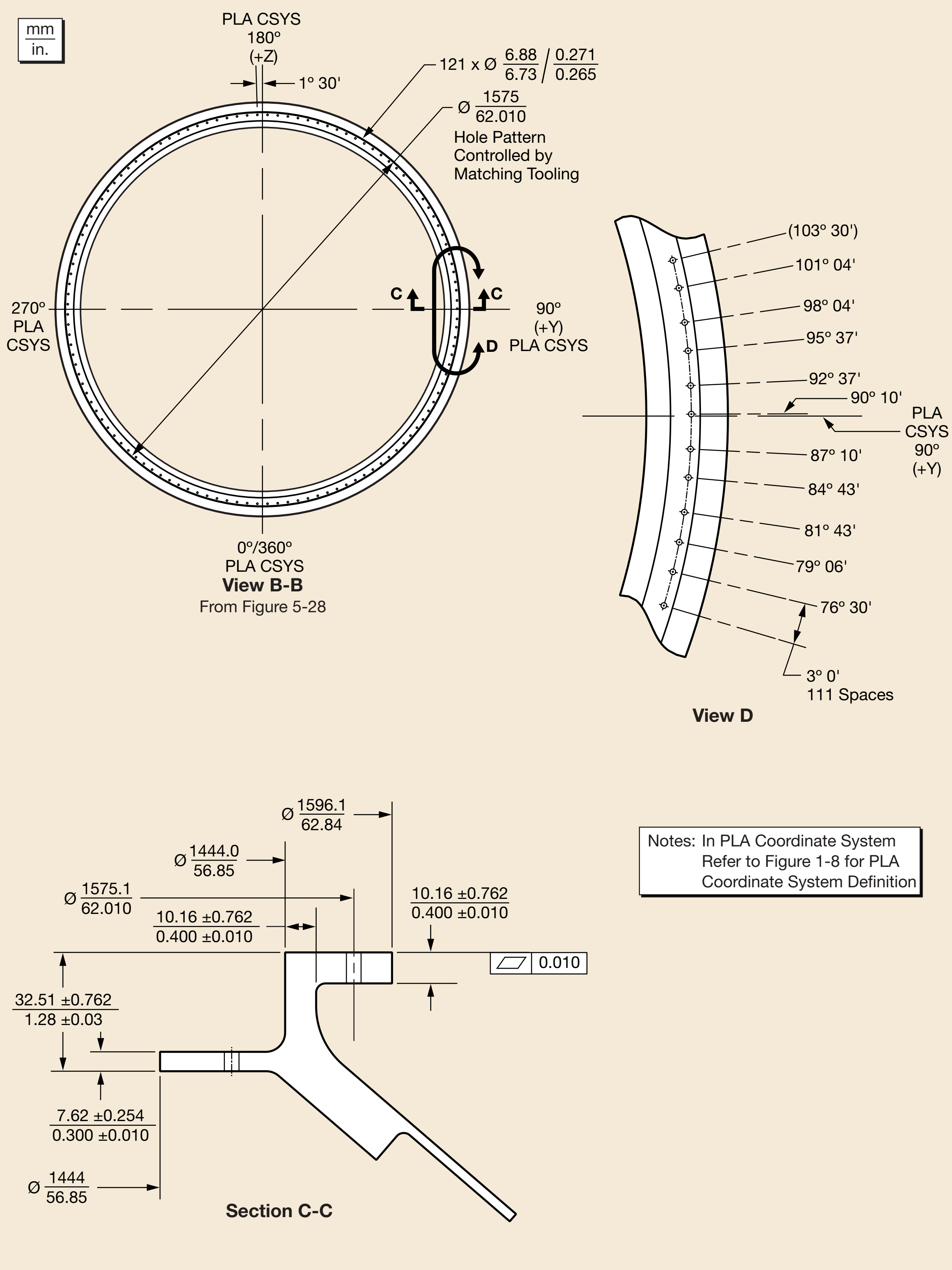



**Figure 5-29. 1575-5 PAF Detailed Dimensions**

SHG0555905-093

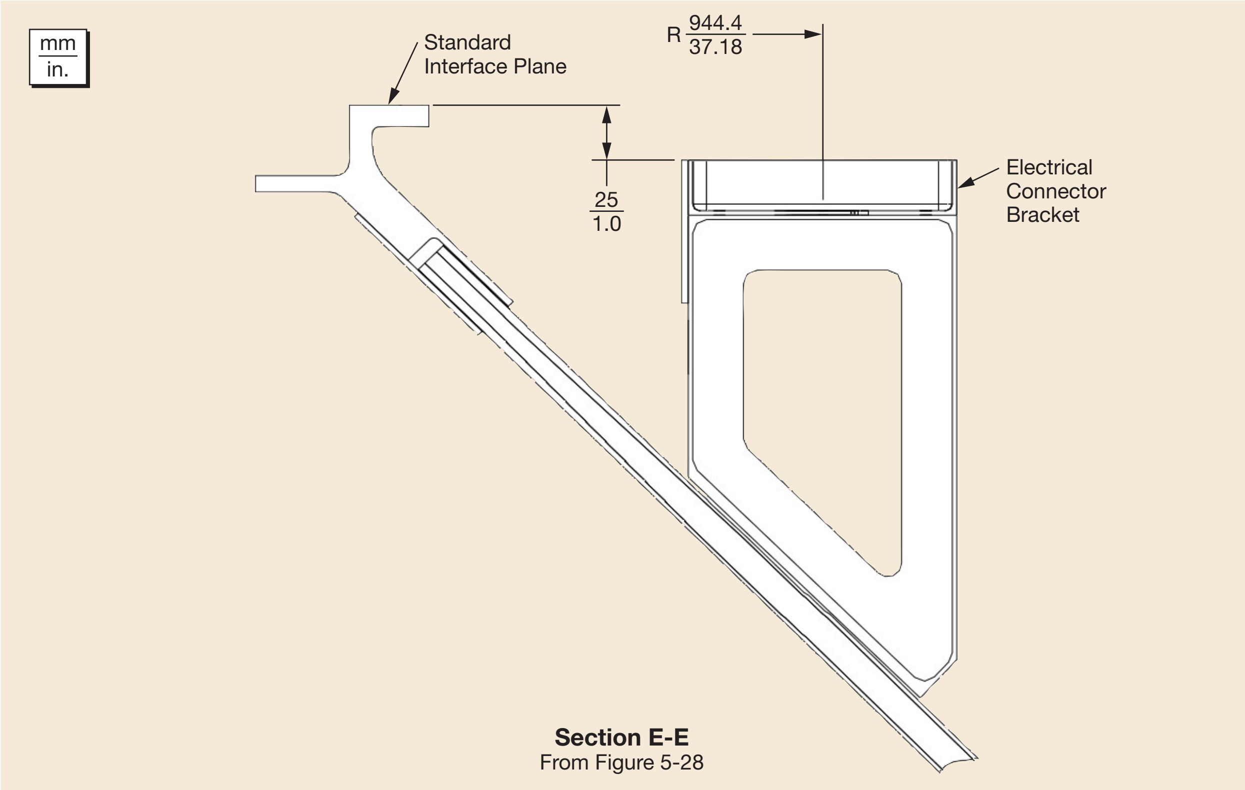



**Figure 5-30. 1575-5 PAF Electrical Connector Bracket (2 places)**

SHG0555905-148

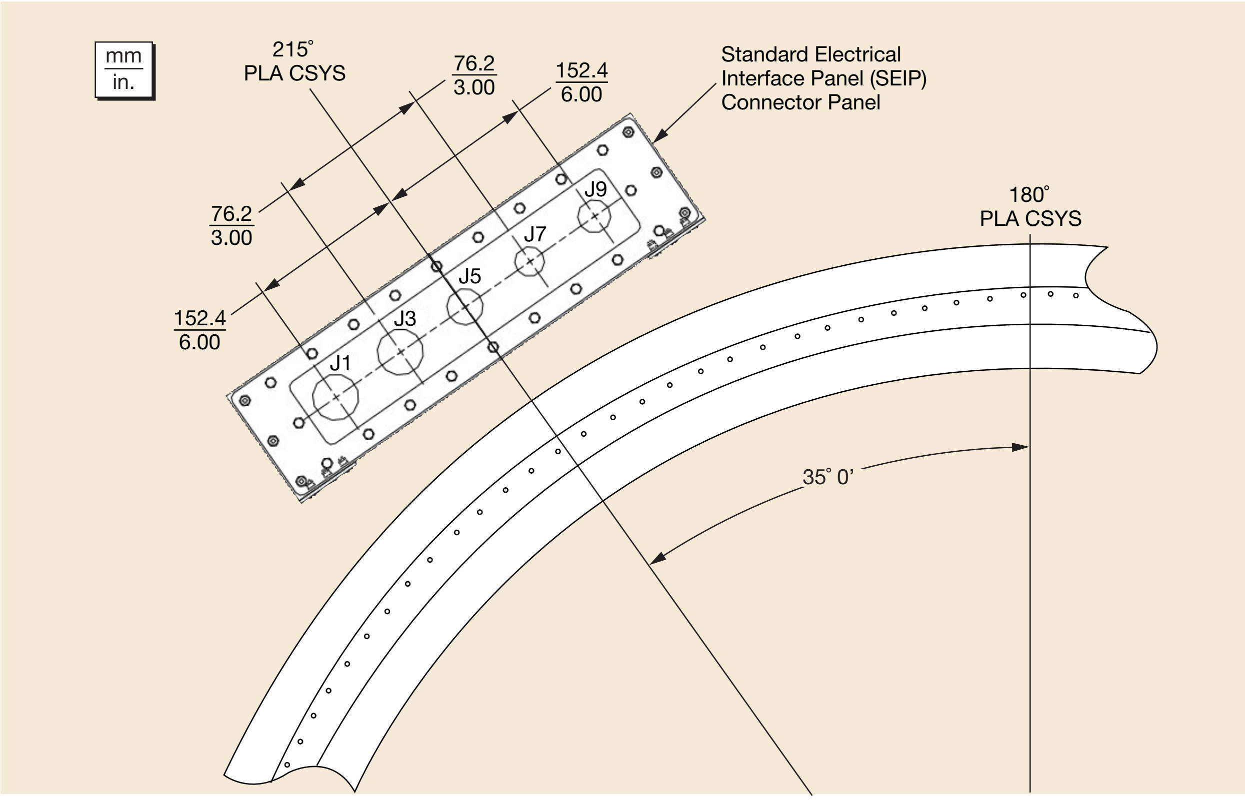



**Figure 5-31. 1575-5 PAF Electrical Connector Bracket Detail (215 deg PLA CSYS)**

SHG0555905-088.2

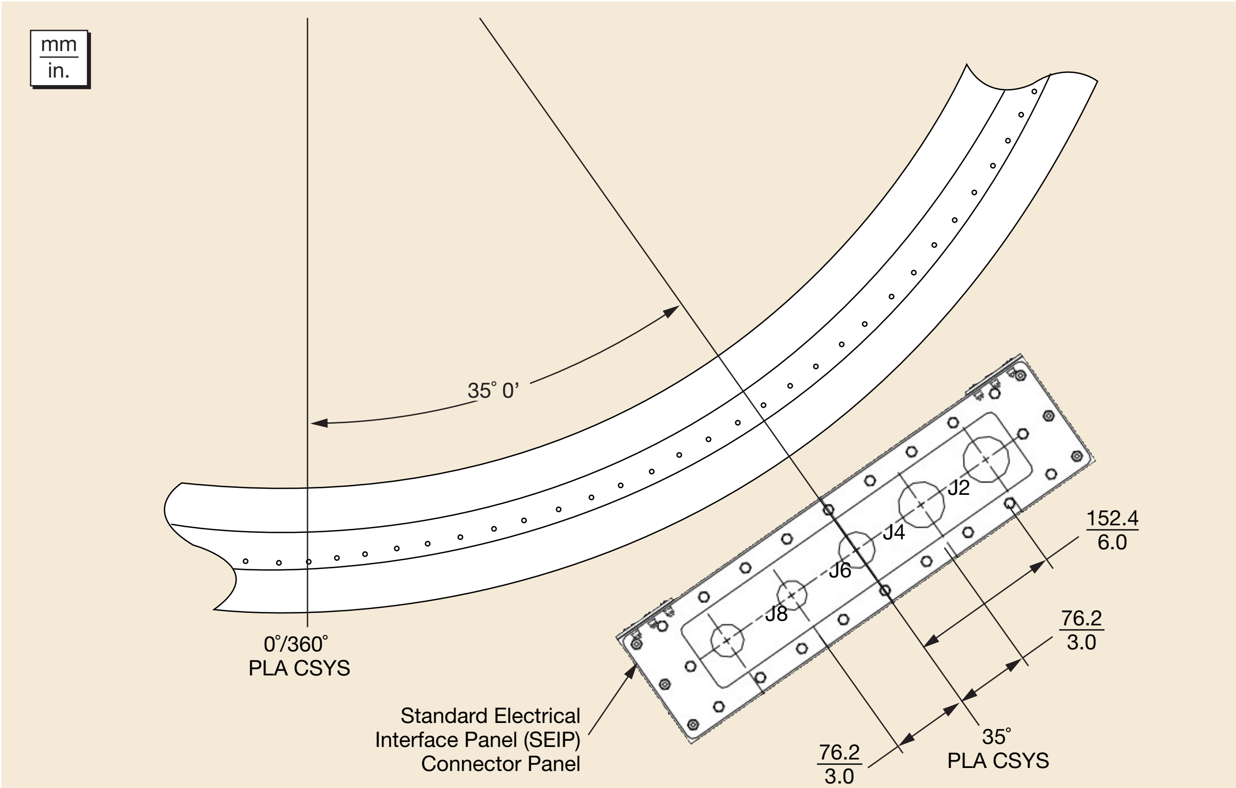



**Figure 5-32. 1575-5 PAF Electrical Connector Bracket Detail (35 deg PLA CSYS)**

### 5.2.5 1666-4 (66-in.) Payload Attach Fitting (PAF)

The 1666-4 PAF (Figure 5-33) provides a 1666 mm (66 in.) payload interface, and uses a 4-m-diameter composite payload fairing.

The separation system consists of a Marmon-type clampband separation system, and comes standard with four separation spring actuators. The separation actuators may be clocked in 15-deg increments. Combined with the ability to add additional actuators, this feature allows the 1666 family of PAFs to meet a wide range of spacecraft separation requirements.

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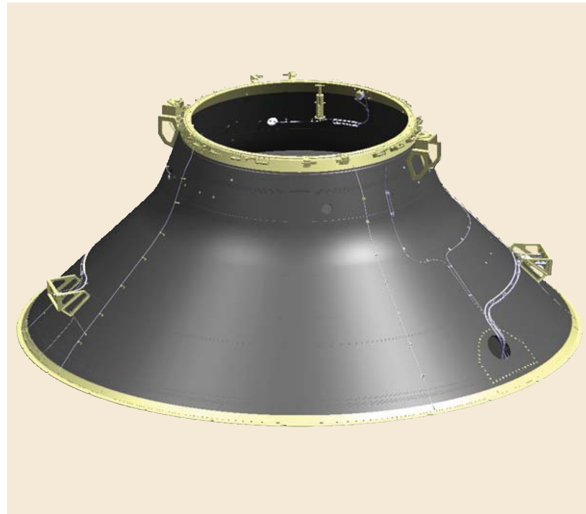

**Figure 5-33. 1666-4 PAF**

Two electrical connectors, which can be located at the customer's discretion, have the ability to provide pre-launch spacecraft power and monitoring, as well as discrete commands, and telemetry during ascent.

Figure 5-34 shows the capability of the 1666-4 PAF in terms of spacecraft mass and CG location above the separation plane. Figures 5-35 through 5-40 show PAF and spacecraft interface details.

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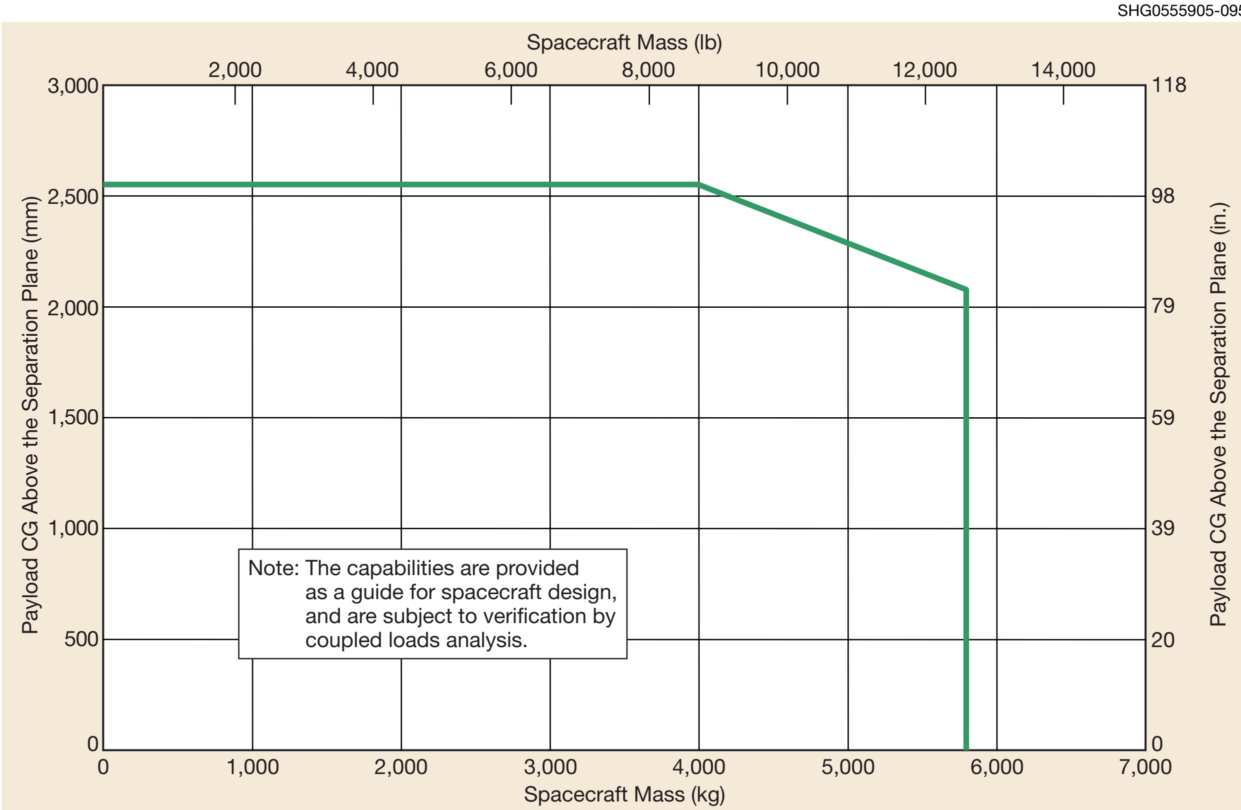


**Figure 5-34. Capability of 1666-4 PAF**

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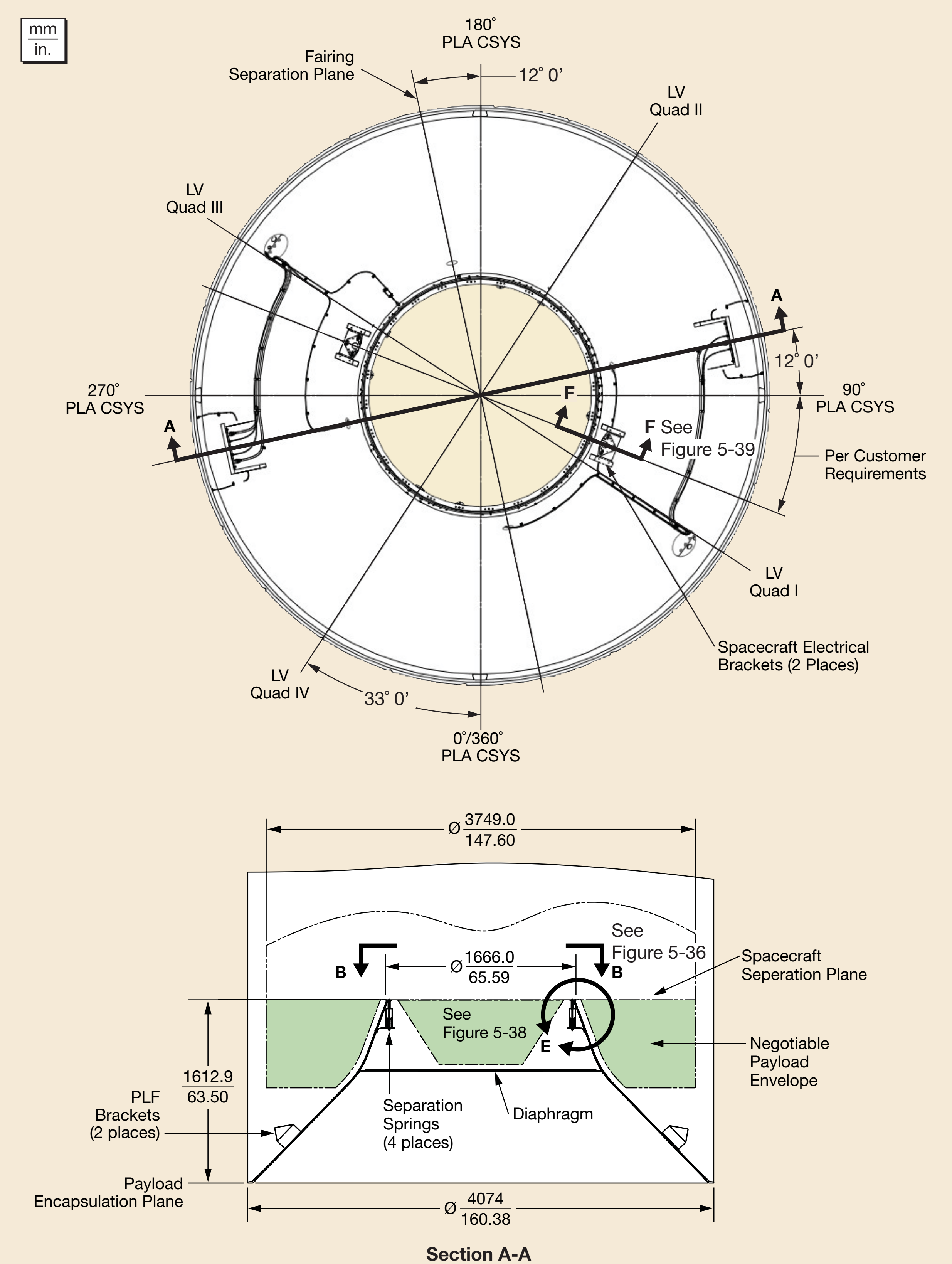


**Figure 5-35. 1666-4 PAF Detailed Assembly**

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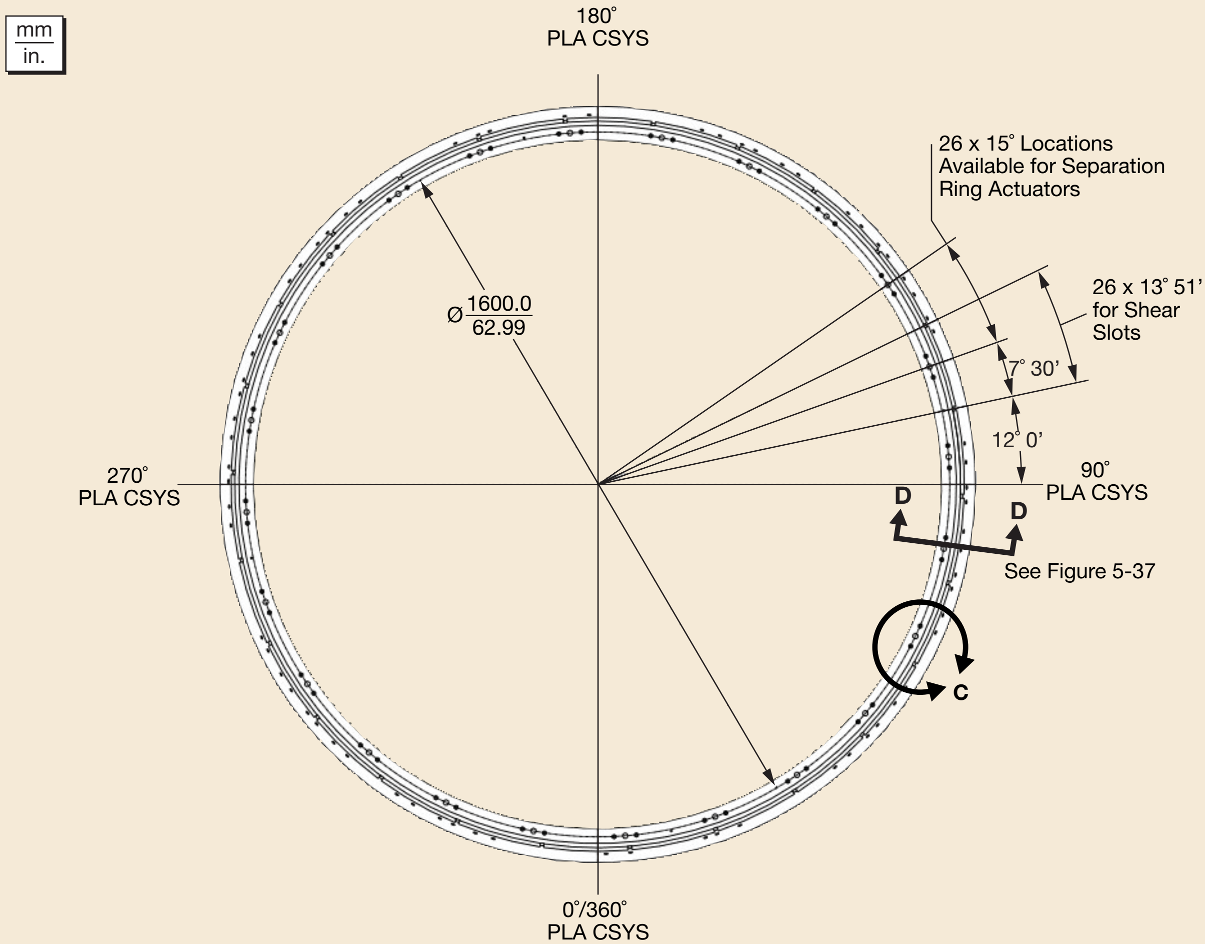
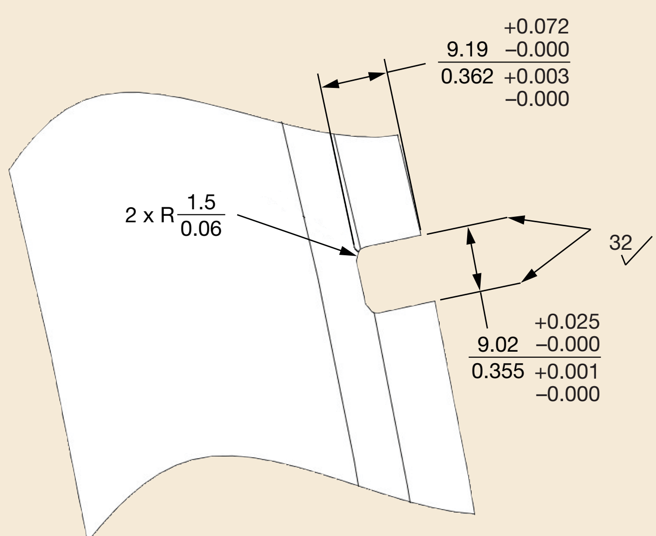



**Section B-B**
From Figure 5-35




**View C**

**Figure 5-36. 1666-4 PAF Detailed Dimensions**

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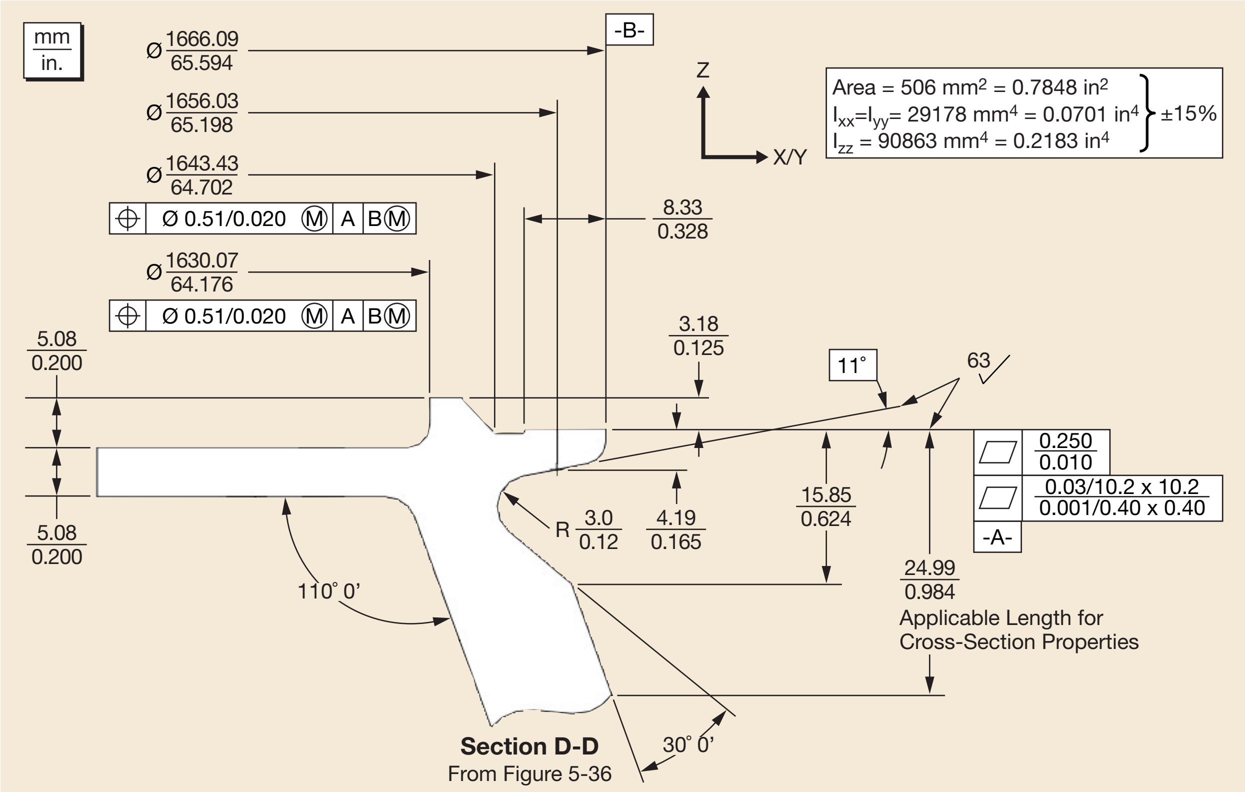


**Figure 5-37. 1666-4 PAF Detailed Dimensions**

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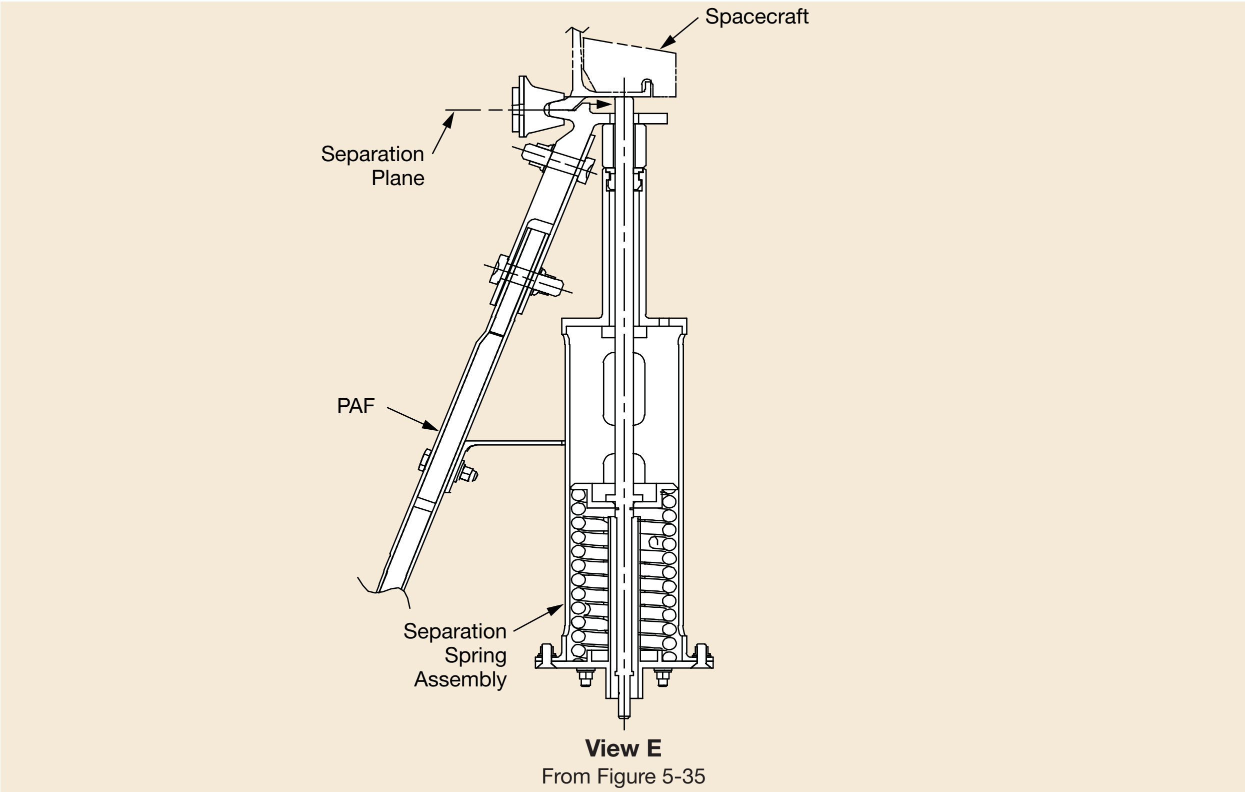


**Figure 5-38. 1666-4 PAF Separation Spring Assembly**

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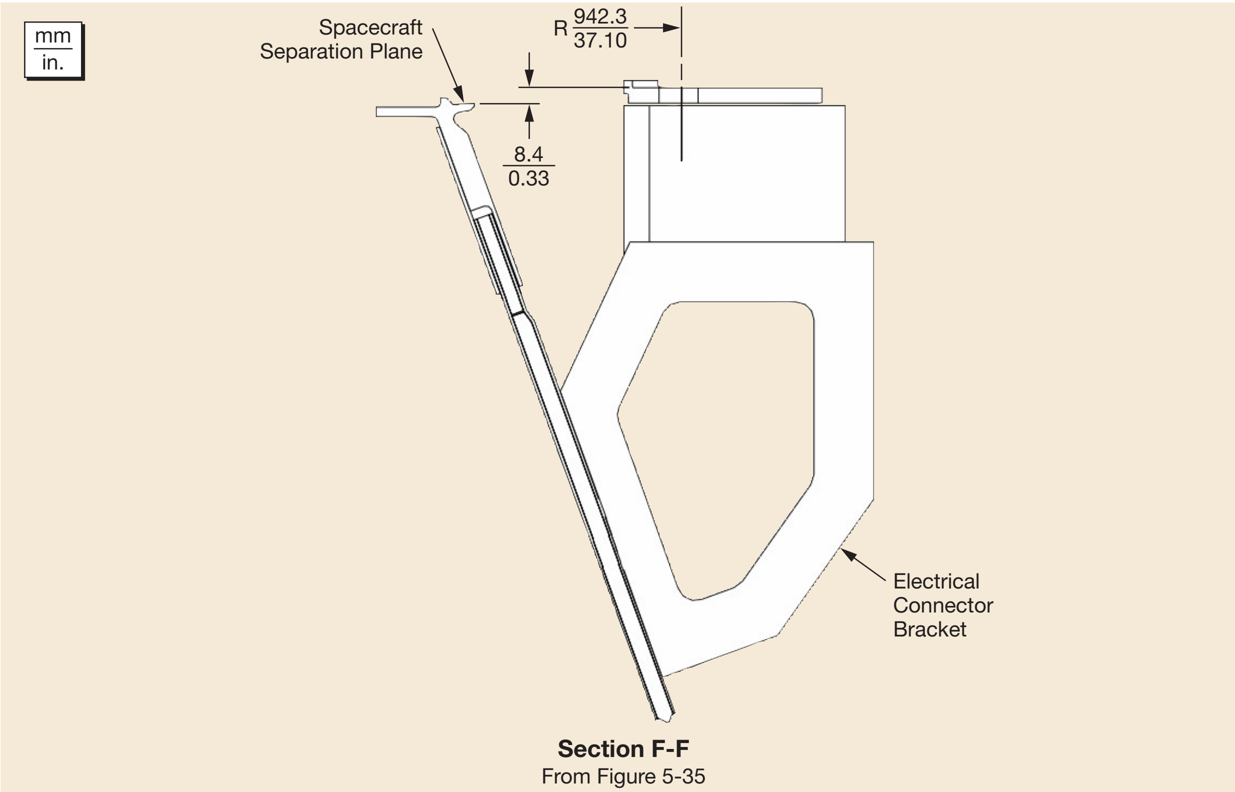


**Figure 5-39. 1666-4 PAF Electrical Connector Bracket**

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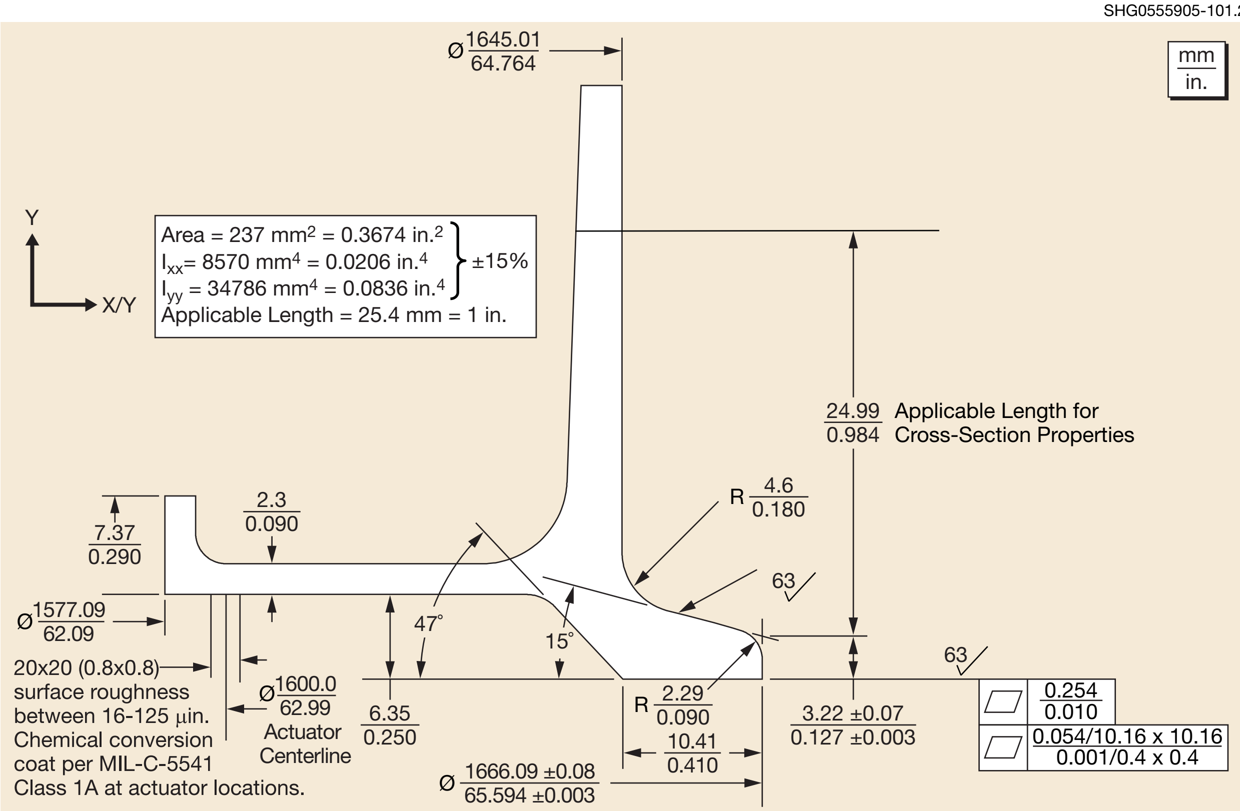


**Figure 5-40. Dimensional Constraints on Spacecraft Interface to 1666-4 PAF**

### 5.2.6 1666-5 (66-in.) Payload Attach Payload (PAF)

The 1666-5 PAF (Figure 5-41) provides a 1666 mm (66 in.) payload interface, and uses a 5-m-diameter composite payload fairing.

The separation system consists of a Marmon-type clampband separation system, and comes standard with four separation spring actuators. The separation actuators may be clocked in 15-deg increments. Combined with the ability to add additional actuators, this feature allows the 1666 family of PAFs to meet a wide range of spacecraft separation requirements.

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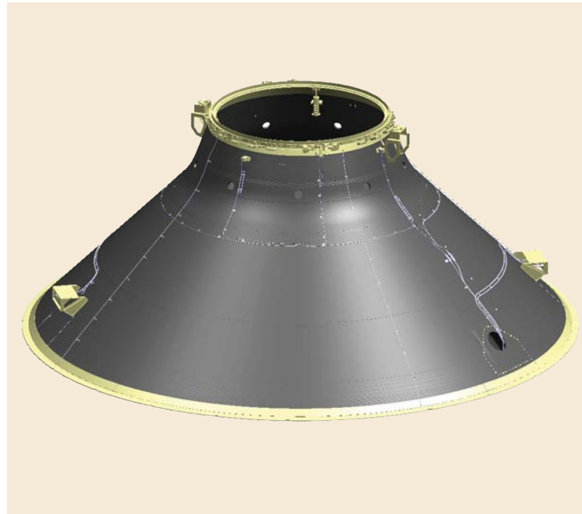

**Figure 5-41. 1666-5 PAF**

Two electrical connectors, located at the customer's discretion, have the ability to provide prelaunch spacecraft power and monitoring, as well as discrete commands, and telemetry during ascent.

Figure 5-42 shows the capability of the 1666-5 PAF in terms of spacecraft mass and CG location above the separation plane. Figures 5-43 through 5-48 show PAF and spacecraft interface details.

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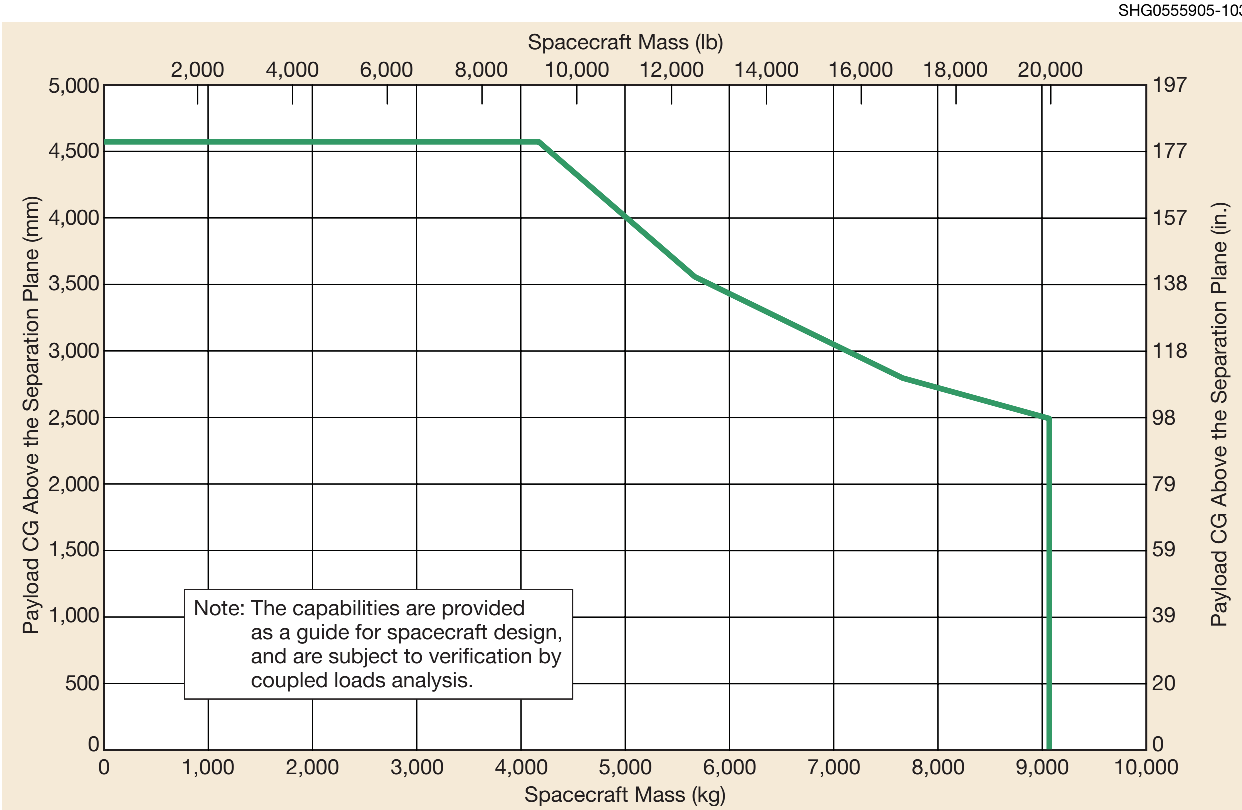


**Figure 5-42. Capability of 1666-5 PAF**

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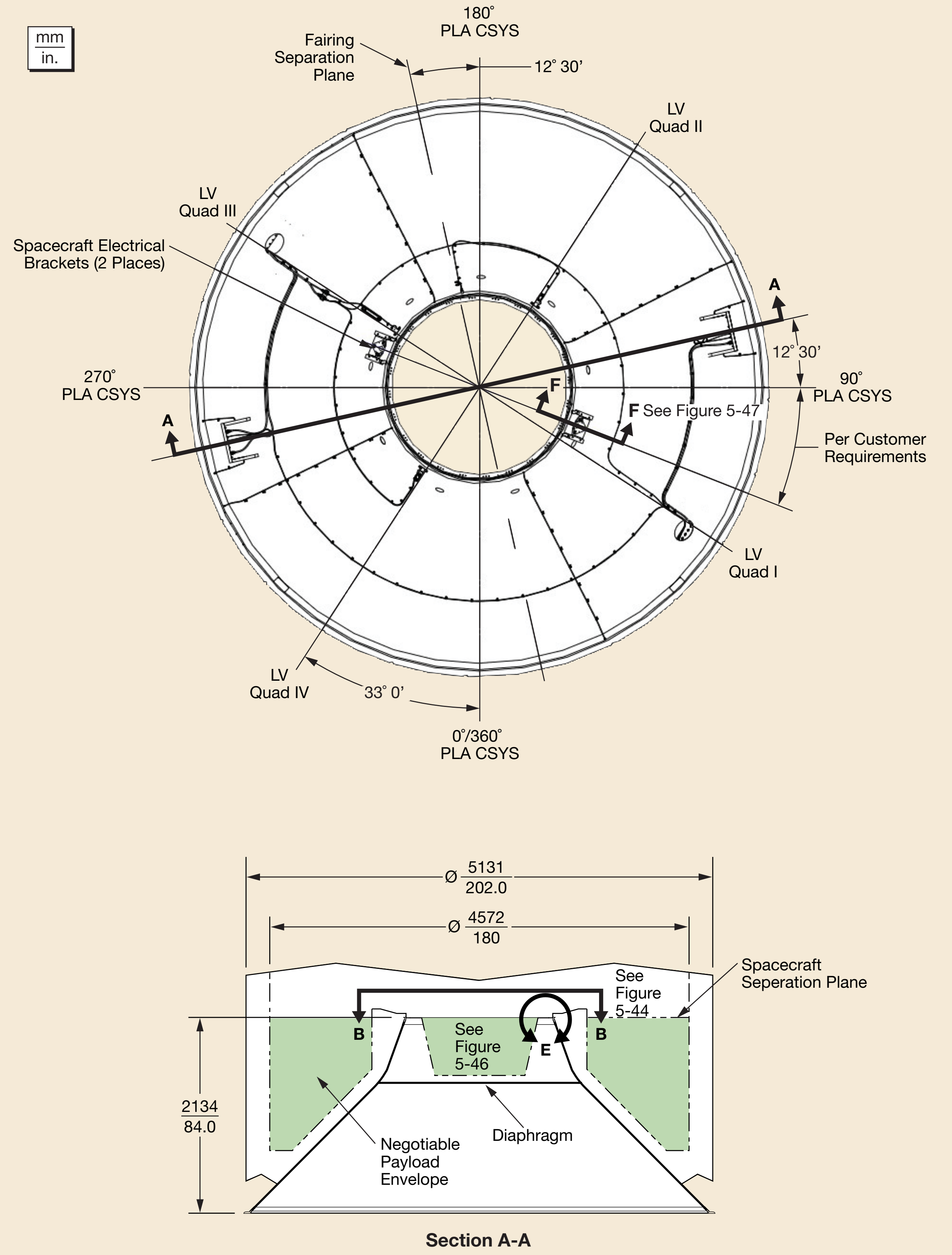


**Figure 5-43. 1666-5 PAF Detailed Assembly**

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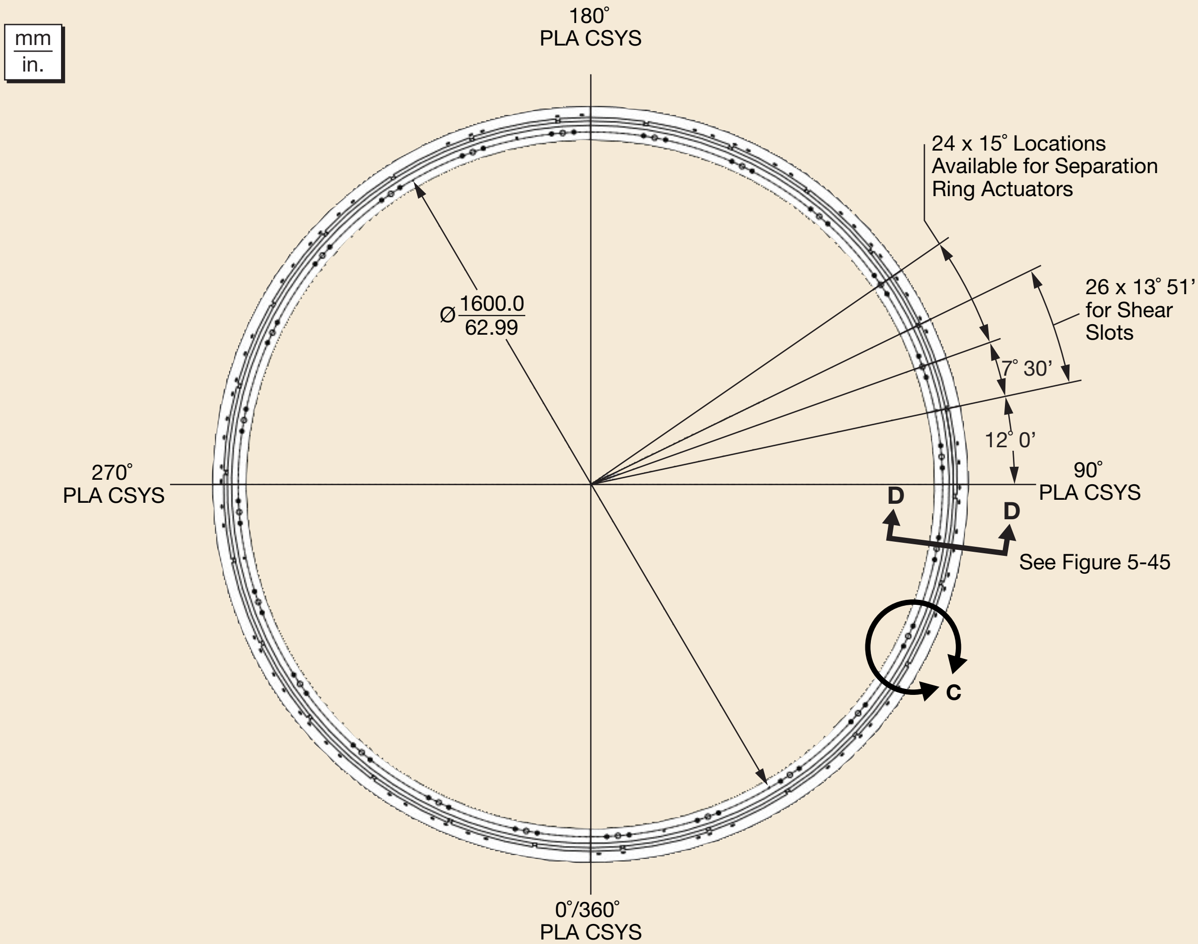
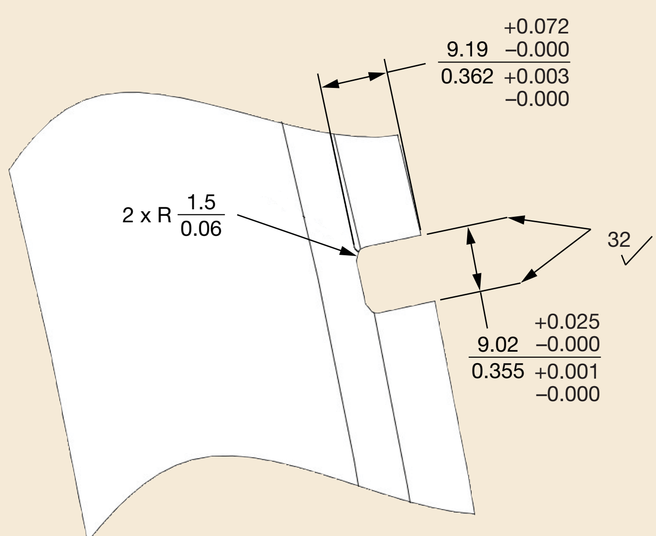



**Section B-B**
From Figure 5-43




**View C**

**Figure 5-44. 1666-5 PAF Detailed Dimensions**

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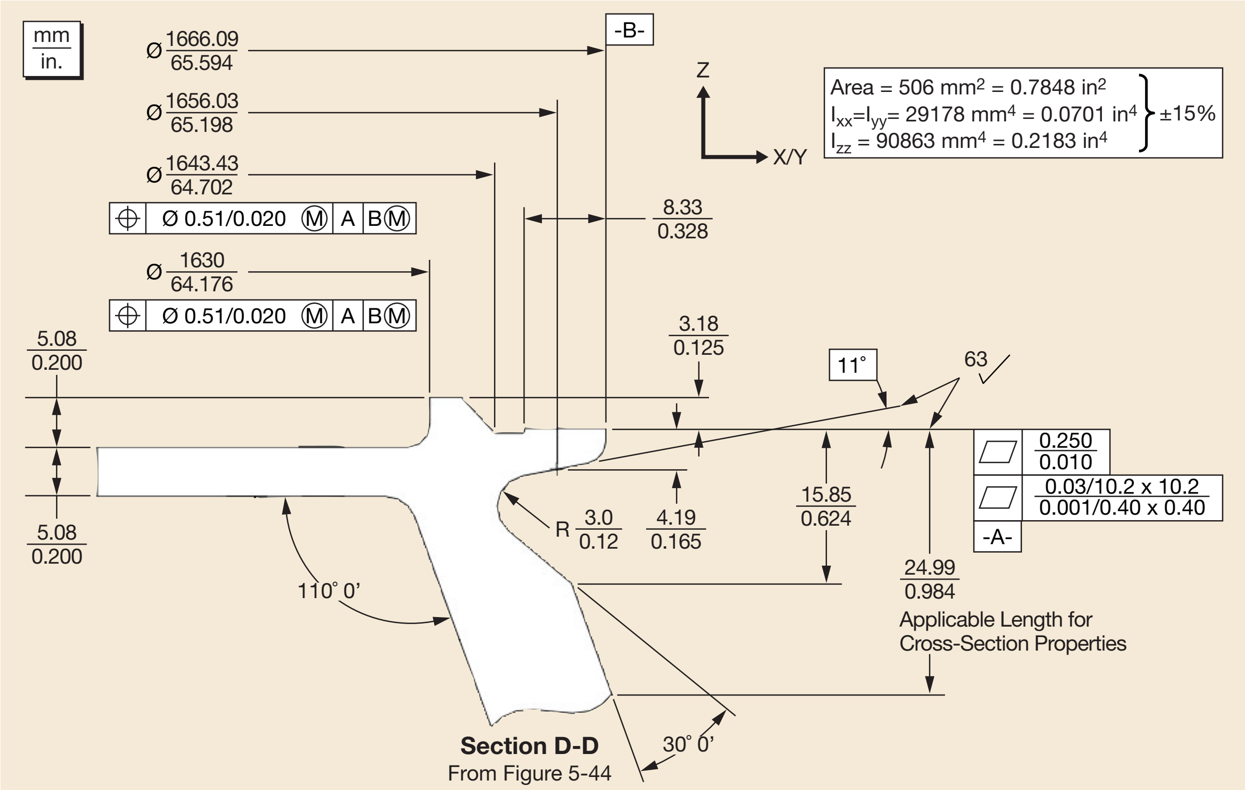


**Figure 5-45. 1666-5 PAF Detailed Dimensions**

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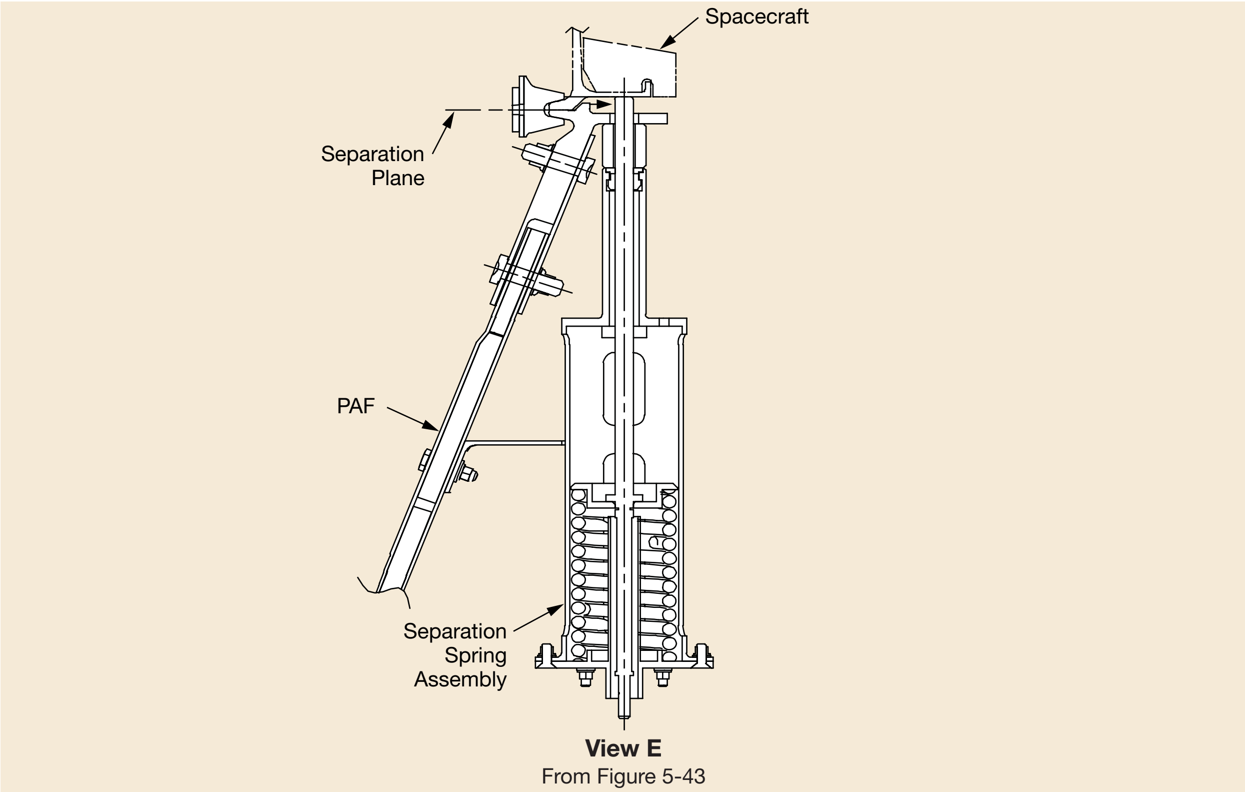


**Figure 5-46. 1666-5 PAF Separation Spring Assembly**

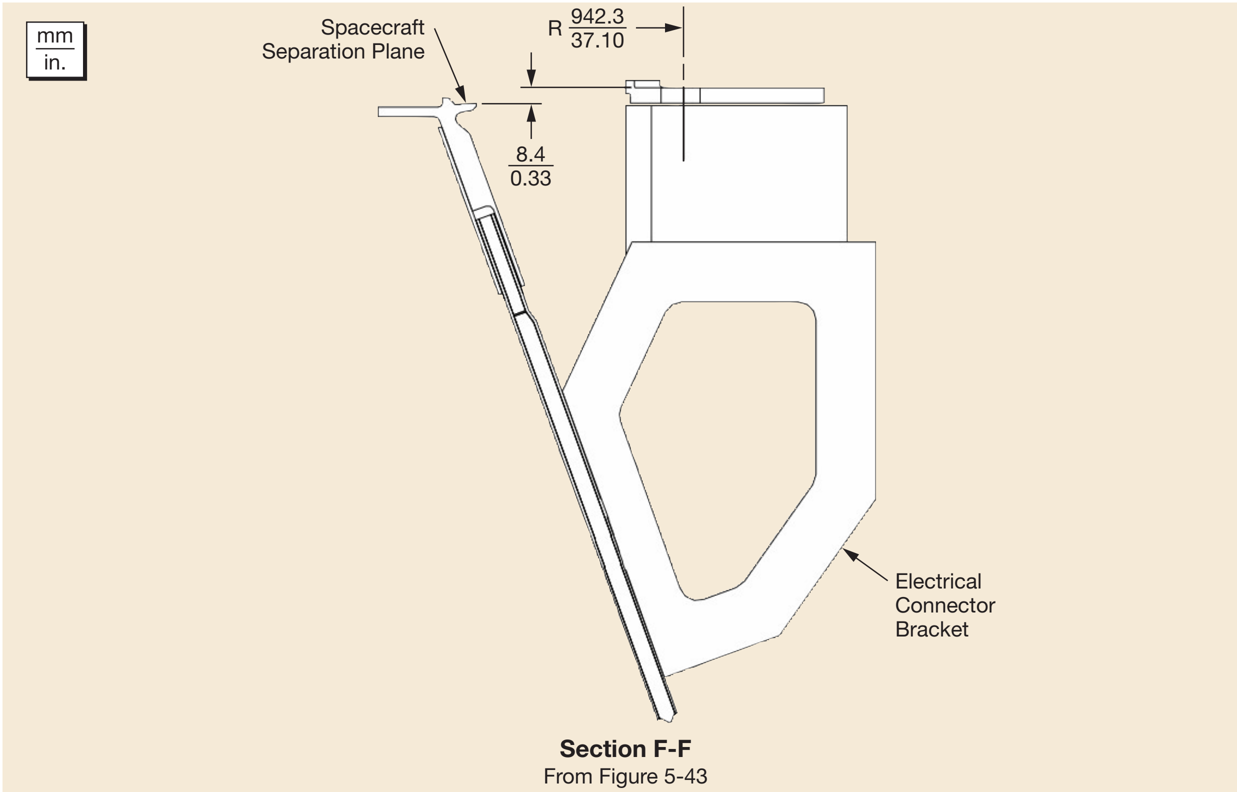


**Figure 5-47. 1666-5 PAF Electrical Connector Bracket**

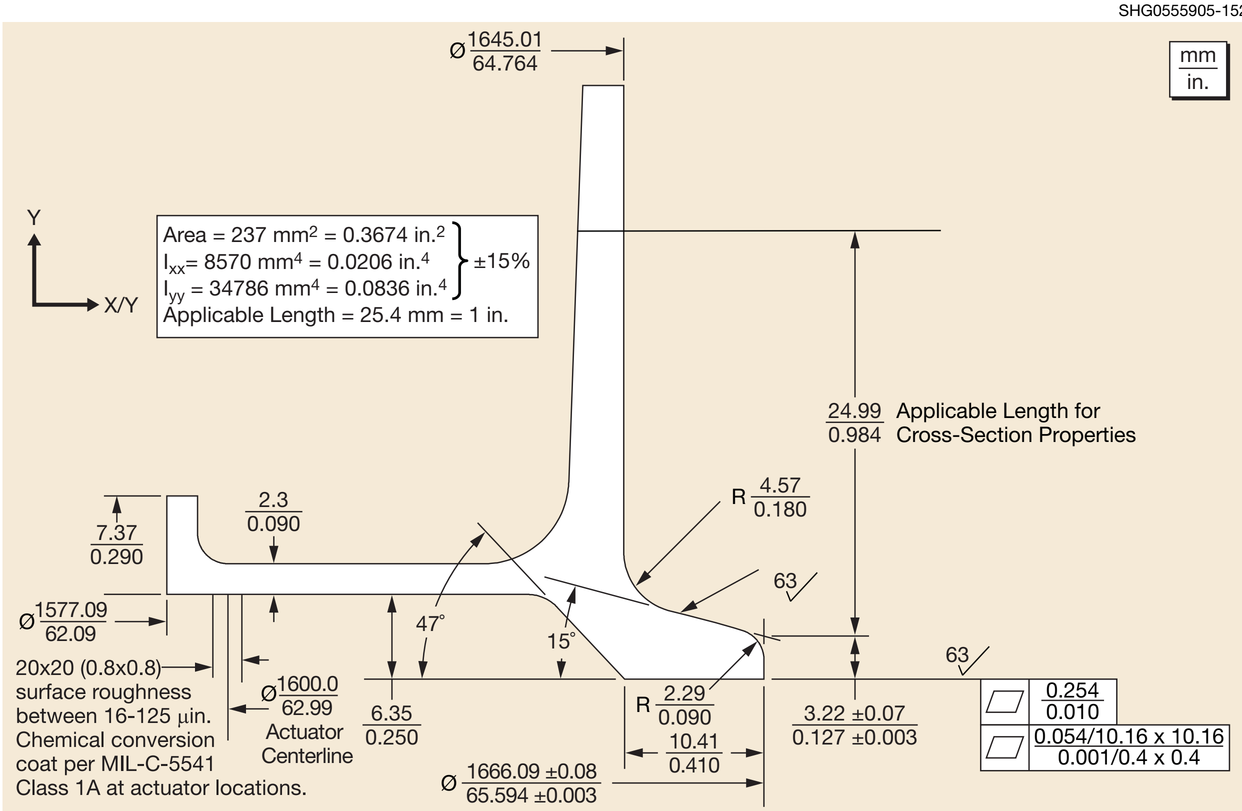


**Figure 5-48. Dimensional Constraints on Spacecraft Interface to 1666-5 PAF**

## 5.2.7 4394-5 (173-in.) Payload Attach Fitting (PAF)

The 4394-5 PAF (Figure 5-49) uses an 18-point, 72-bolt interface pattern with a 4394-mm (173-in.)-diameter interface, and is used in conjunction with a 5-m metallic fairing. The 4394-5 PAF uses a truss structure design, which offers a higher stiffness-to-weight ratio for the larger interface diameter.

Figure 5-50 shows the capability of the 4394-5 PAF in terms of spacecraft mass and CG location above the separation plane. Figures 5-51 and 5-52 show PAF and spacecraft interface details.

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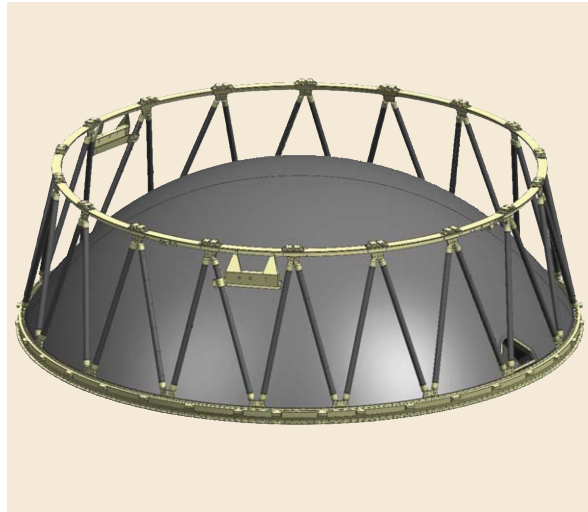

**Figure 5-49. 4394-5 PAF**

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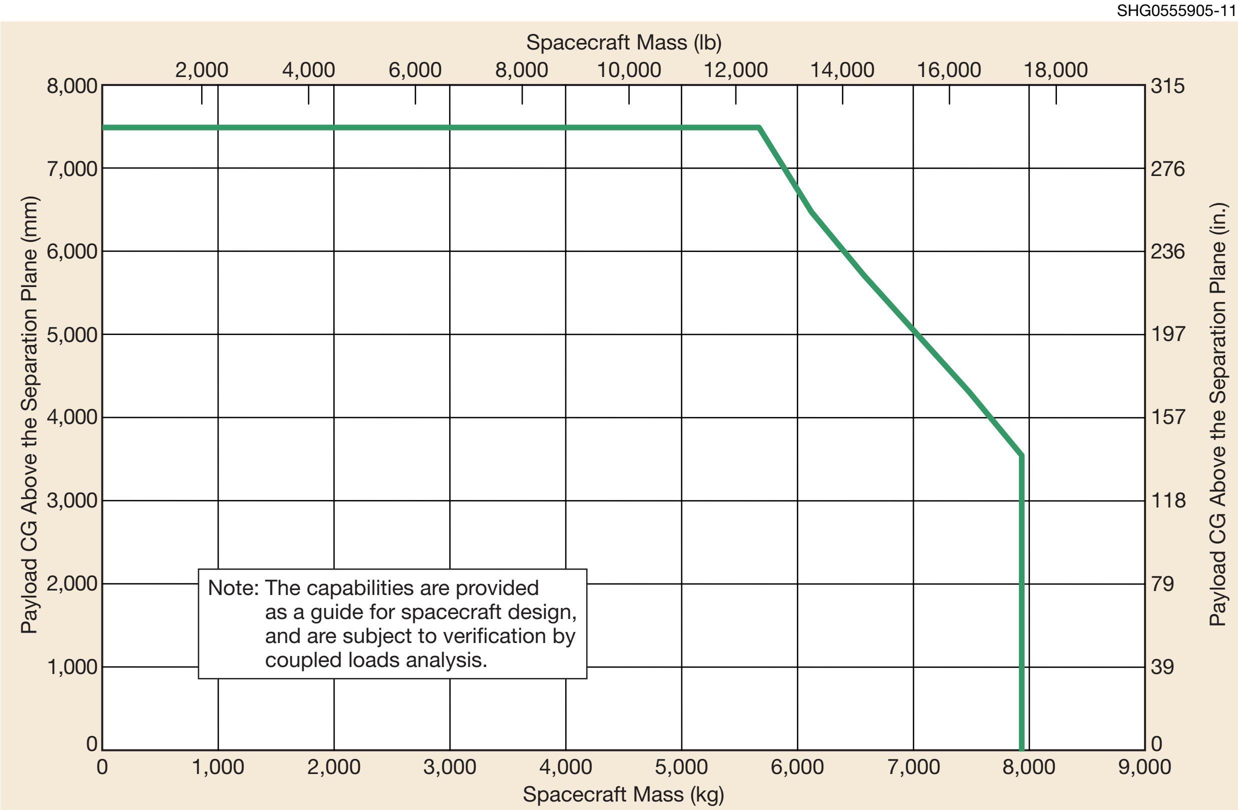


**Figure 5-50. Capability of 4394-5 PAF**

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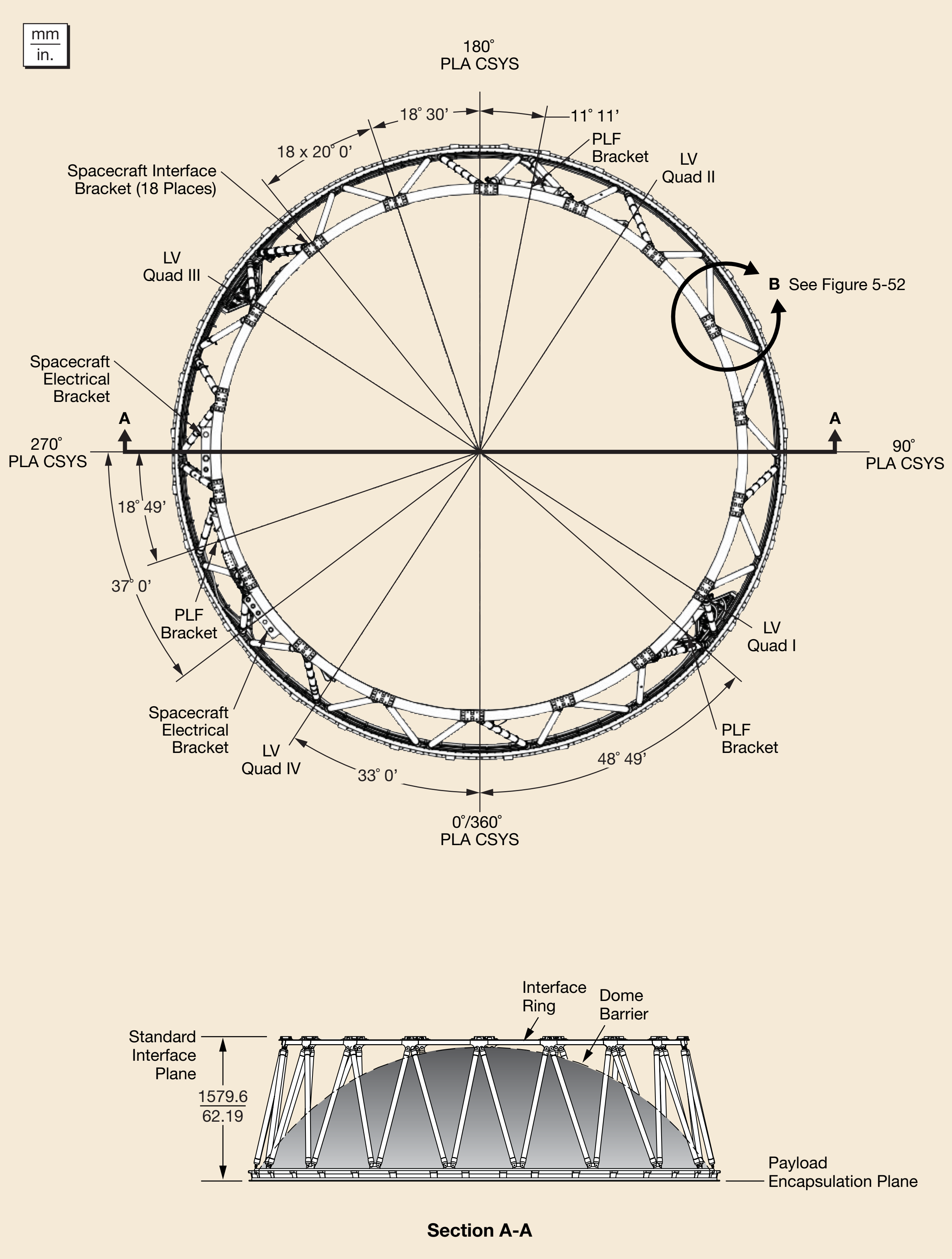


**Figure 5-51. 4394-5 PAF Detailed Assembly**

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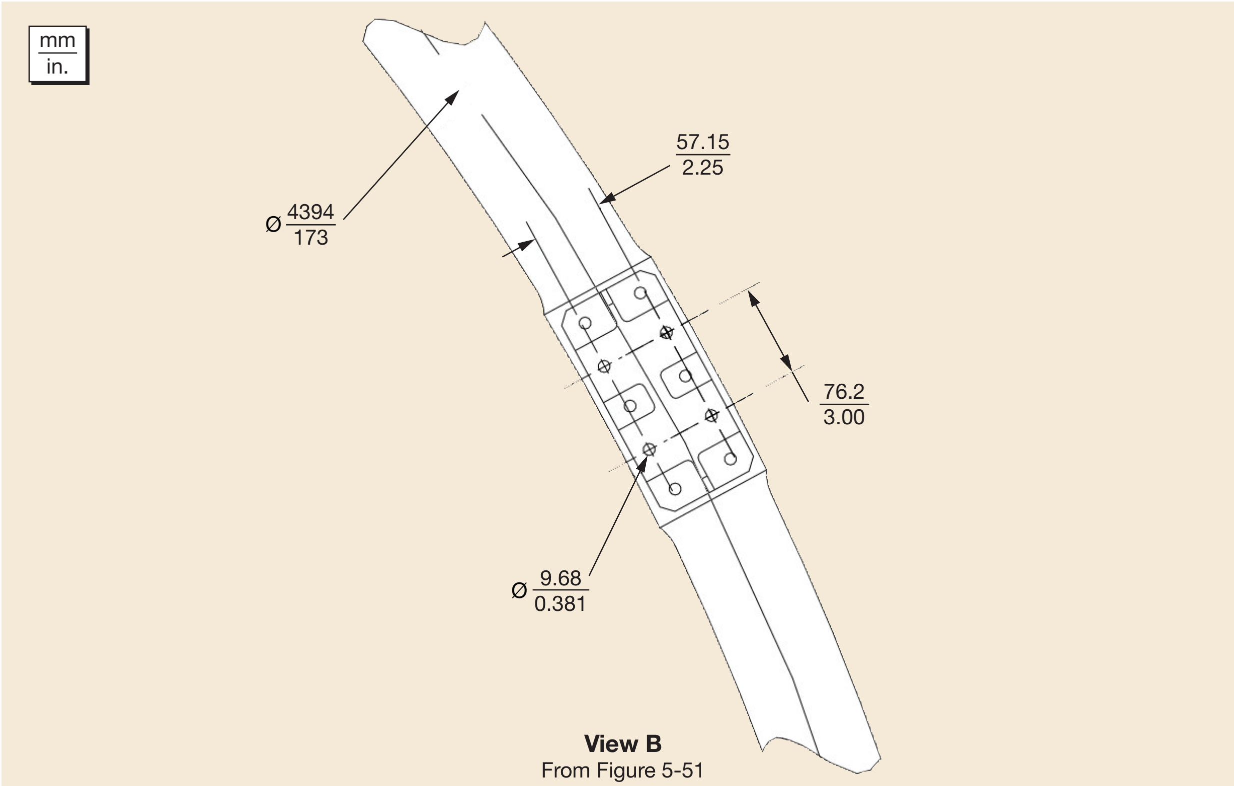


**Figure 5-52. 4394-5 PAF Detailed Dimensions**

### 5.2.8 Other Payload Attach Fittings

Customers with a unique interface incompatible with the Delta IV 4-m or 5-m PAFs discussed in this section should contact the Delta Program Office for more options. Other requirements may also be accommodated through coordination with the Delta Program Office. The PAF interfaces that are considered as future growth options are discussed in greater detail in Section 10.

### 5.2.9 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), a 1.5-m-dia, 61-cm-tall ring structure that can support up to six secondary payloads around its circumference. Developed by the U.S. 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 5-53), duplicating the EELV standard interface plane (SIP) and passing the electrical interfaces through to the primary payload.

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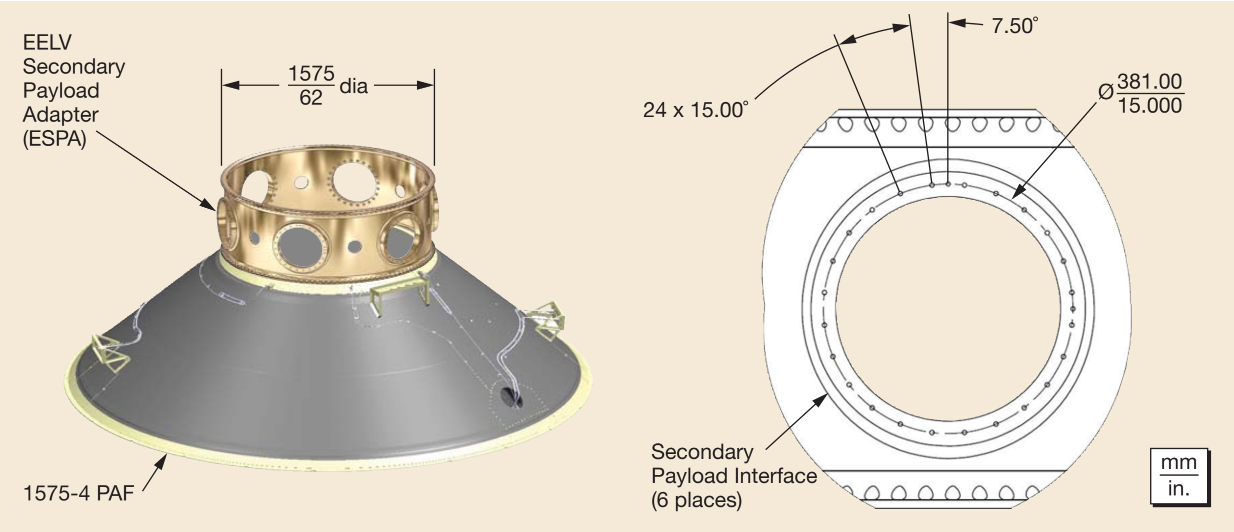


**Figure 5-53. EELV Secondary Payload Adapter (ESPA)**

The ESPA ring consists of six 381-mm-dia (15-in.-dia) bolt circle interfaces, with each slot being able to accommodate a single secondary payload of 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.). 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 the DOD Space Test Program (http://www.smc.kirtland.af.mil/stp/documents/index.html) and CSA Engineering (http://www.csaengineering.com/espa/espa.shtml) Web sites.

## 5.3 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 electrical interface (PEI) 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 Delta 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 5-54.

| 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 twinax (75 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<br>1000 mA | 33 VDC<br>32 VDC |
| Breakwire separation monitors | 1 redundant pair | 4 | — | — |
| Telemetry channels (data and clock) | 2 | 8 | — | — |

**Figure 5-54. Electrical Interface Signal Functions**

This guide does not identify all electrical interface requirements. Customers should contact the Delta Program Office for additional interface requirements.

### 5.3.1 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 PEI, through the second stage of the launch vehicle, out one of the vehicle's electrical umbilical connectors, over and down the fixed umbilical tower (FUT), and finally to the EGSE room. 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 3 A 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 75-ohm controlled impedance twinax wires are provided for transmission of serial digital data.

Three-phase, uninterruptible facility power is available to the customer in the ESGE 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 Delta Launch Services.

### 5.3.2 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.

5.3.2.1 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 ohm- to 2.0-ohm load (wiring and one EED) with a nominal duration of 40 ±10 msec and is current-limited to 18 A (pulse duration is extended from 40 msec to assist telemetry capture). Each pair of circuits (the primary and the redundant) 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.

5.3.2.2 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 (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 the Delta Program Office for more information.

5.3.2.3 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.

5.3.2.4 Telemetry Channels. The standard electrical interface provides for two telemetry channels, each capable of receiving up to 4.8 kBps of data, and each transmitting to the master telemetry unit (MTU) in the second 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.

### 5.3.3 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 PEI. Typical connector allocations and part numbers for SEIP and PEI interfaces are shown in Figure 5-55, but alternative interfaces can be accommodated. Contact the Delta Program Office for more information.

| SEIP Interface | | | | | |
|---|---|---|---|---|---|
| | LV | | SV | | |
| 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 |
| SV commands/monitor (ground) | J3 | D38999/24FJ61SN | P3 | D38999/26FJ61PN | 61 size 20 |
| SV commands/monitor (ground) | J4 | D38999/24FJ61SA | P4 | D38999/26FJ61PA | 61 size 20 |
| Serial data | J5 | D38999/24FF32SN | P5 | D38999/26FF32PN | 32 size 20 |
| SV commands (flight) | J6 | D38999/24FD19SN | P6 | D38999/26FD19PN | 19 size 12 |
| SV commands (flight) | J7 | D38999/24FD19SA | P7 | D38999/26FD19PA | 19 size 12 |
| Ordnance commands | J8 | D38999/24FE26SN | P8 | D38999/26FE26PN | 26 size 20 |
| Ordnance commands | J9 | D38999/24FE26SA | P9 | D38999/26FE26PA | 26 size 20 |
| PEI Interface | | | | | |
| | P1 | MS3446E61-50P | J1 | MS3424E61-50S | 61 size 20 |
| | P2 | MS3446E61-50P | J2 | MS3424E61-50S | 61 size 20 |

**Figure 5-55. Delta IV Spacecraft Connectors**

### 5.3.4 Customer Wiring Documentation

To ensure proper attention to the customer's needs, information regarding customer wiring documentation shall be furnished by the customer.

# Section 6
# LAUNCH OPERATIONS AT EASTERN RANGE

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

## 6.1 ORGANIZATIONS

The Delta Program operates the Delta launch system and maintains a team that provides launch services to the USAF, NASA, and commercial customers at CCAFS. The Delta Program 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.

The Delta Program interfaces with the USAF 45th Space Wing (SW) Directorate of Plans. The USAF designates a program support manager (PSM) to be a representative of the 45th Space Wing. The PSM serves as the official interface for all USAF support and services requested. These services include range instrumentation, facilities/equipment operation and maintenance, and safety, security, and logistics support. Requirements for range services are described in documents prepared and submitted to the government by the Delta Program, based on inputs from the spacecraft contractor and using the government’s universal documentation system (UDS) format (see Section 8, Payload Integration). The organizations that support a launch are shown in Figure 6-1. For each mission, a spacecraft integrator from the Delta 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. The Delta Program interfaces with NASA at Kennedy Space Center (KSC) through the Launch Services Program Office. NASA designates a launch service integration manager who arranges for all of the support requested from NASA for a launch from CCAFS.

The Delta Program 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 Delta missions. Use of these facilities and services may be arranged for the customer by the Delta Program Office.

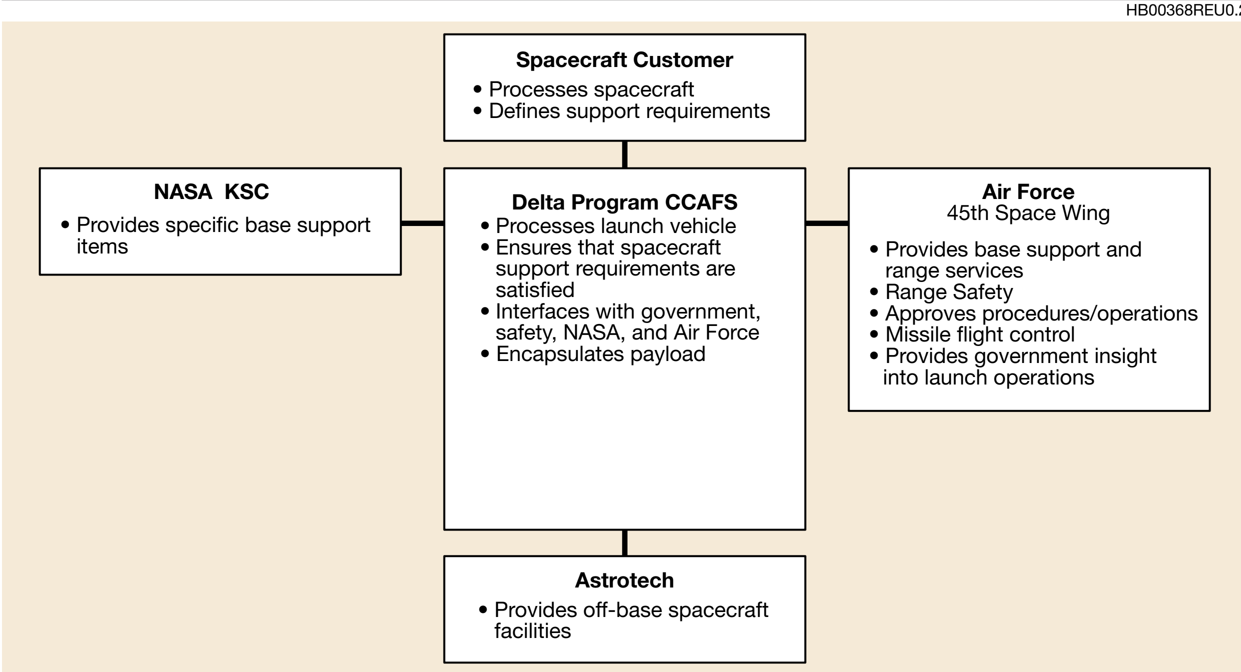


**Figure 6-1. Organizational Interfaces for Commercial Users**

## 6.2 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

- Defense Satellite Communication System (DSCS) processing facility (DPF).
- Shuttle payload integration facility (SPIF).

Hazardous processing may be accomplished at these facilities as well. Department of Defense (DOD) payloads will be processed through the SPIF.

### NASA Facilities

- Vertical processing facility (VPF).
- Spacecraft assembly and encapsulation facility (SAEF-2).
- Multi-payload processing facility (MPPF).
- Payload hazardous processing facility (PHPF).

### Commercial Facilities

- Astrotech Space Operations (ASO).

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

The spacecraft contractor 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 spacecraft contractor-selected processing facility with assistance from the Delta Program. Equipment and personnel are also available for loading and unloading operations. Shipping containers and handling fixtures attached to the spacecraft are provided by the spacecraft contractor.

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 spacecraft contractor to identify these items and become familiar with such regulations. Included are regulations imposed by NASA, USAF, and FAA (refer to Section 9).

### 6.2.1 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 (Figures 6-2). A complete description of the Astrotech facilities can be found on the Astrotech Web site: www.spacehab.com/aso/reference.htm.

### 6.2.2 CCAFS Operations and Facilities

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

**6.2.2.1 Cape Canaveral Industrial Area.** Delta IV payload support facilities are located in the CCAFS industrial and support area (Figure 6-3). USAF-shared facilities or work areas at CCAFS are available for supporting spacecraft projects and spacecraft contractors. These areas include the following:

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

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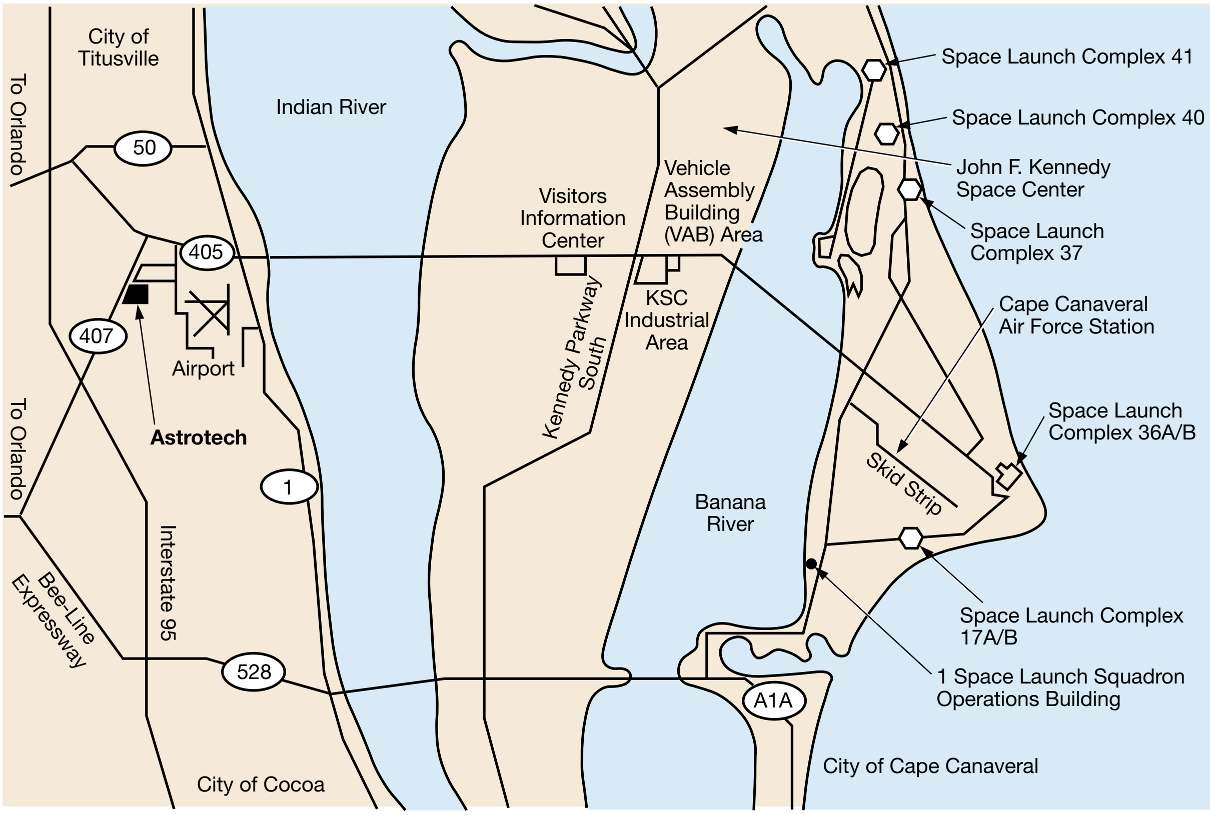


**Figure 6-2. Astrotech Site Location**

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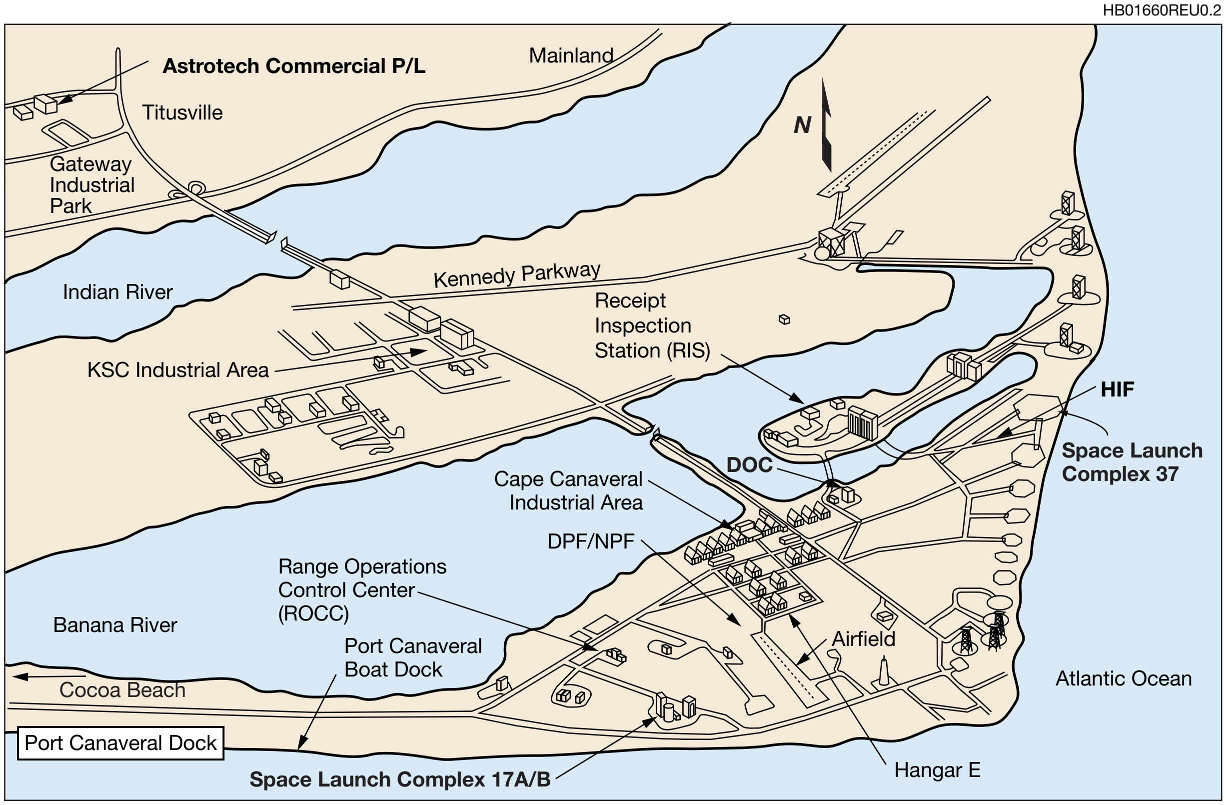


**Figure 6-3. Cape Canaveral Air Force Station (CCAFS) Facilities**

### 6.2.3 Delta Operations Center

All Delta IV launch operations will be controlled from the launch control center (LCC) in the Delta Operations Center (DOC). 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 (Figure 6-4).

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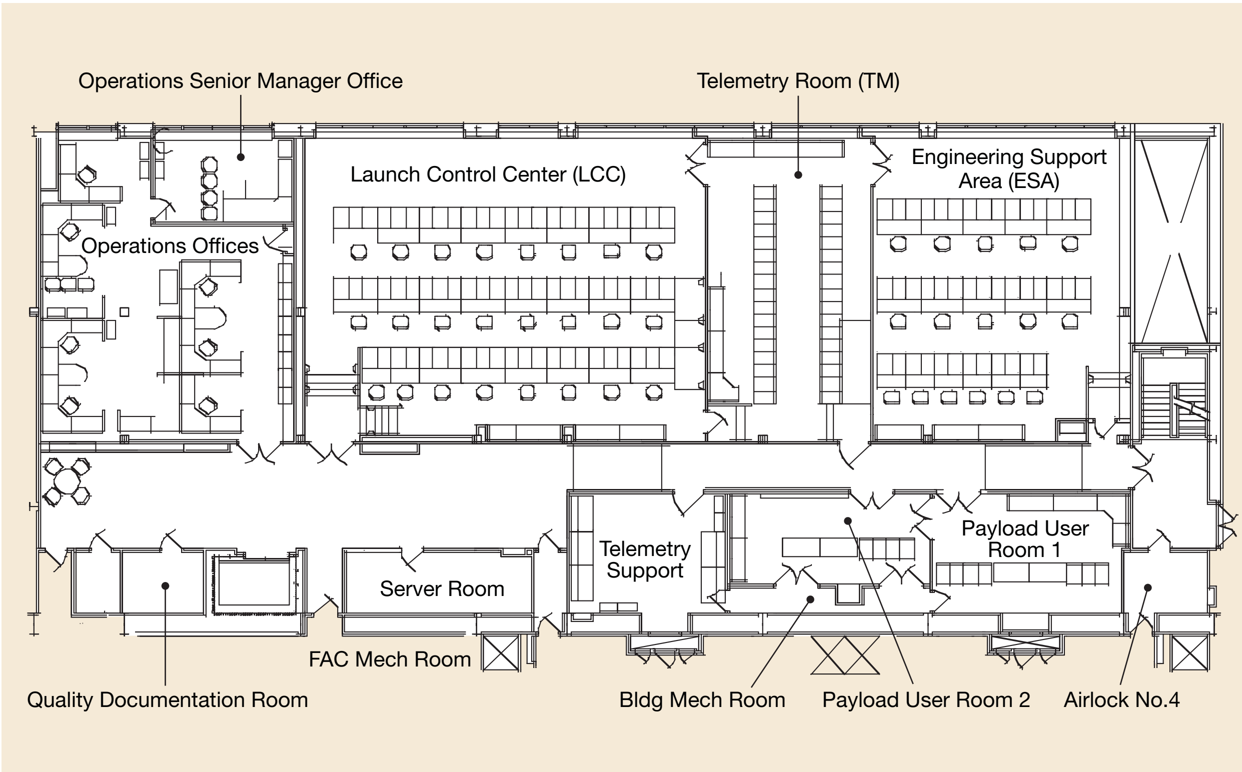


**Figure 6-4. Space Launch Complex 37 Launch Control Center (LCC)**

### 6.2.4 Solid-Propellant Storage Area, CCAFS

The facilities and support equipment in this area are maintained and operated by USAF range contractor personnel, who also provide ordnance-item transport. Preparation of ordnance items for flight (i.e., safe-and-arm (S&A) devices and EEDs) is performed by spacecraft contractor personnel using spacecraft-contractor-prepared, range-safety-approved procedures. Range-contractor-supplied test consoles contain the items listed in Figure 6-5. Tests are conducted according to spacecraft contractor procedures, approved by range safety personnel.

| | |
|---|---|
| Resistance measurement controls | Alinco bridge and null meter |
| Digital current meter | Resistance test selector |
| Digital voltmeter | Digital ammeter |
| Auto-ranging digital voltmeter | Digital stop watch |
| Digital multimeter | Replay power supply |
| High-current test controls | Test power supply |
| Power supply (5 V) | Power control panel |
| High-current test power supply | Blower |

**Figure 6-5. Test Console Items**

6.2.4.1 Storage Magazines, CCAFS. Storage magazines are concrete bunker-type structures located at the north end of the storage area. Only two magazines are used for spacecraft ordnance. One magazine is environmentally controlled to 23.9° ± 2.8°C (75° ± 5°F) with 65% maximum relative humidity. This magazine contains small ordnance items such as S&A devices, igniter assemblies, initiators, bolt cutters, and electrical squibs. The other magazine is used for storage of solid-propellant motors. It is environmentally controlled to 29.4° ± 2.8°C (85° ± 5°F) with 65% maximum relative humidity.

6.2.4.2 Electrical-Mechanical Testing Facility, CCAFS. The electrical-mechanical testing (EMT) facility (Figure 6-6), operated by range contractor personnel, can be used for functions such as ordnance-item bridgewire resistance checks and S&A device functional tests, as well as for test-firing small self-contained ordnance items.

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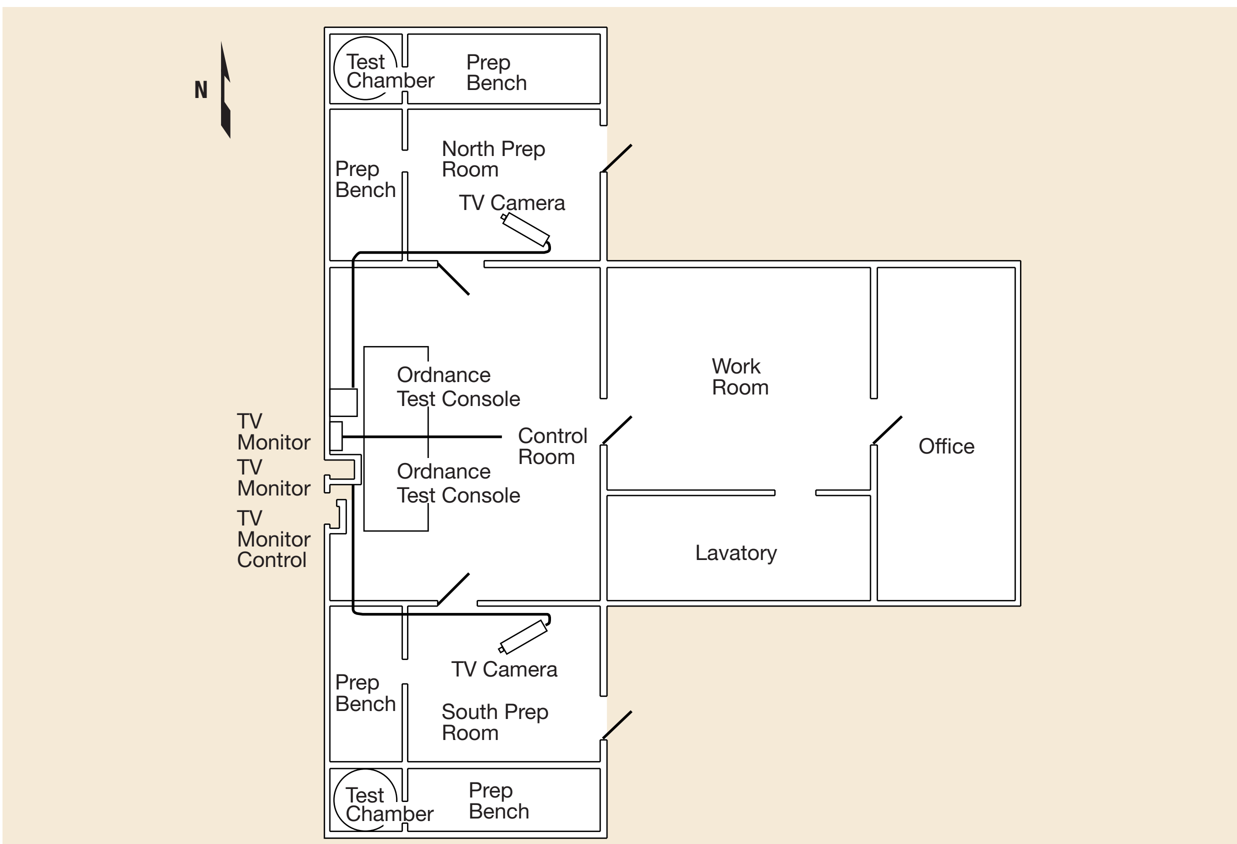


**Figure 6-6. Electrical-Mechanical Testing Building Floor Plan**

Existing electrical cables provide the interface between ordnance items and test equipment for most devices commonly used at CCAFS. These cables are tested before each use, and the test data are documented. If a cable or harness does not exist for a particular ordnance item, it is the responsibility of the spacecraft contractor to provide the proper mating connector for the ordnance item to be tested. Six weeks of lead time are required for cable fabrication.

## 6.3 SPACECRAFT ENCAPSULATION AND TRANSPORT TO THE LAUNCH SITE

As mentioned in Section 6.2, Delta IV provides fueled payload encapsulation in the fairing at the payload processing facilities (PPF): the USAF PPFs in the CCAFS industrial area for USAF payloads, NASA PPFs for NASA payloads, and, normally, ASO for commercial customers. This capability enhances payload safety and security while mitigating contamination concerns, and greatly reduces launch pad operations in the vicinity of the payload. In this document, discussions are limited to the ASO facility.

Payload integration with the PAF and encapsulation in the fairing are planned in the PPF of Astrotech building 2 for Delta IV launches that use the 4-m composite fairing and, in Astrotech building 9, for Delta IV launches that use the 5-m composite and metallic fairings. The basic sequence of operations at Astrotech is illustrated in Figure 6-7.

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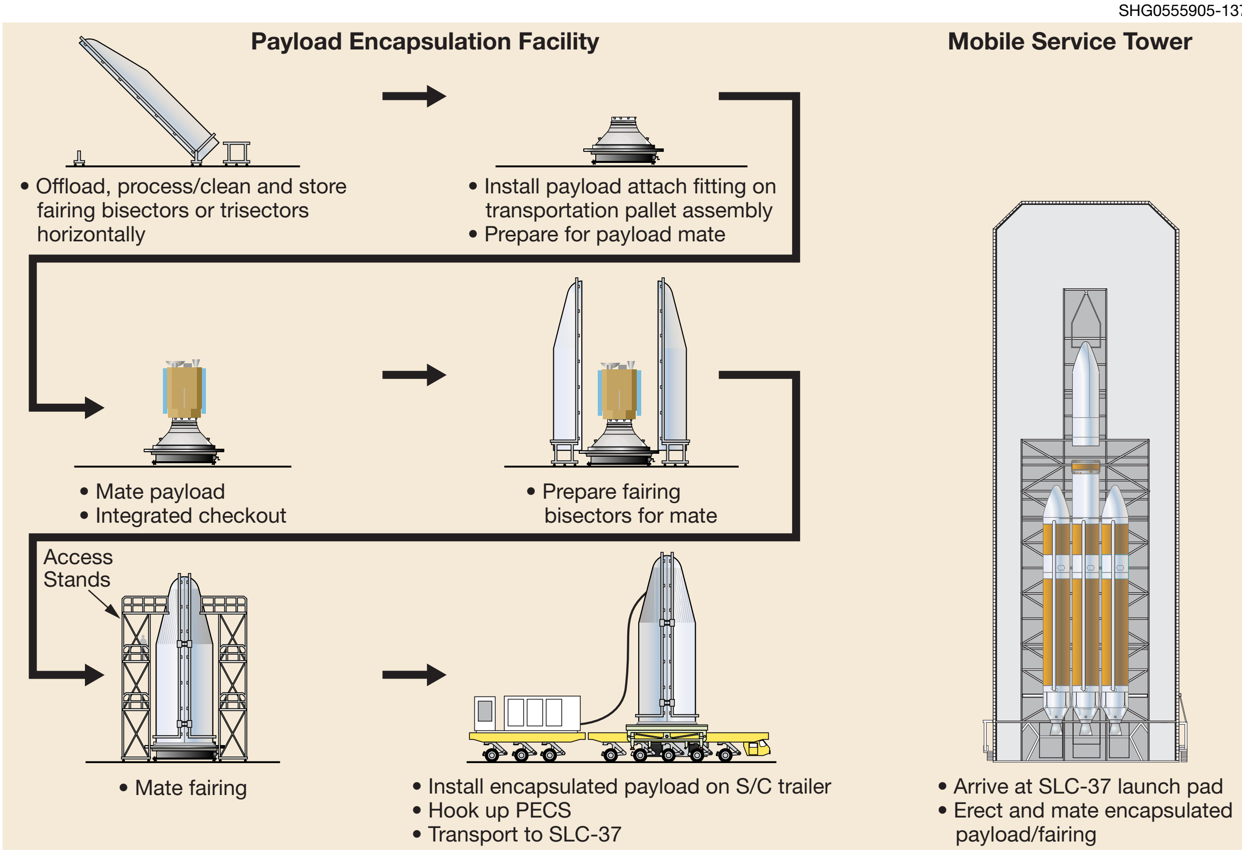


**Figure 6-7. Payload Encapsulation, Transport, and On-Pad Mate**

Prior to payload arrival, the fairing and PAF(s) enter the high bay to be prepared for payload encapsulation. The fairing bisectors or trisectors are erected and stored on rolling transfer dollies. The PAF is installed on the Delta Program buildup stand and prepared for payload mate. After payload arrival and premate operations are completed, including payload weighing if required in lieu of a certified weight statement, the payload is mated to the PAF, and integrated checkout is performed. The previously prepared fairing bisectors or trisectors are rolled into position for final mate, and the personnel access stands are positioned for personnel access to the fairing mating plane. 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 transporter provided by the Delta Program 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 reestablished as soon as possible with class-5000 air while the MST enclosure is closed and secured. Should subsequent operations require access through the fairing, a portable clean-environment shelter will be erected over the immediate area to prevent payload contamination.

The six Eastern Range payload processing facilities that are adequate for encapsulation operations with/without modification are listed in Figure 6-8.

| 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 processing facility (PHPF) | Kennedy Space Center, FL | 4-m and 5-m fairings |
| DSCS processing facility (DPF) | Cape Canaveral Air Force Station, FL | 4-m fairings |
| Shuttle payload integration facility (SPIF) | Cape Canaveral Air Force Station, FL | 4-m and 5-m fairings |
| Astrotech Space Operations | Titusville, FL | 4-m and 5-m fairings |

**Figure 6-8. Eastern Range Payload Processing Facilities**

## 6.4 SPACE LAUNCH COMPLEX 37

SLC-37 is located in the northeastern section of CCAFS (Figure 6-2) 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 6-9; the general arrangement is shown in Figure 6-10.

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**Figure 6-9. Space Launch Complex 37, CCAFS—Aerial View**

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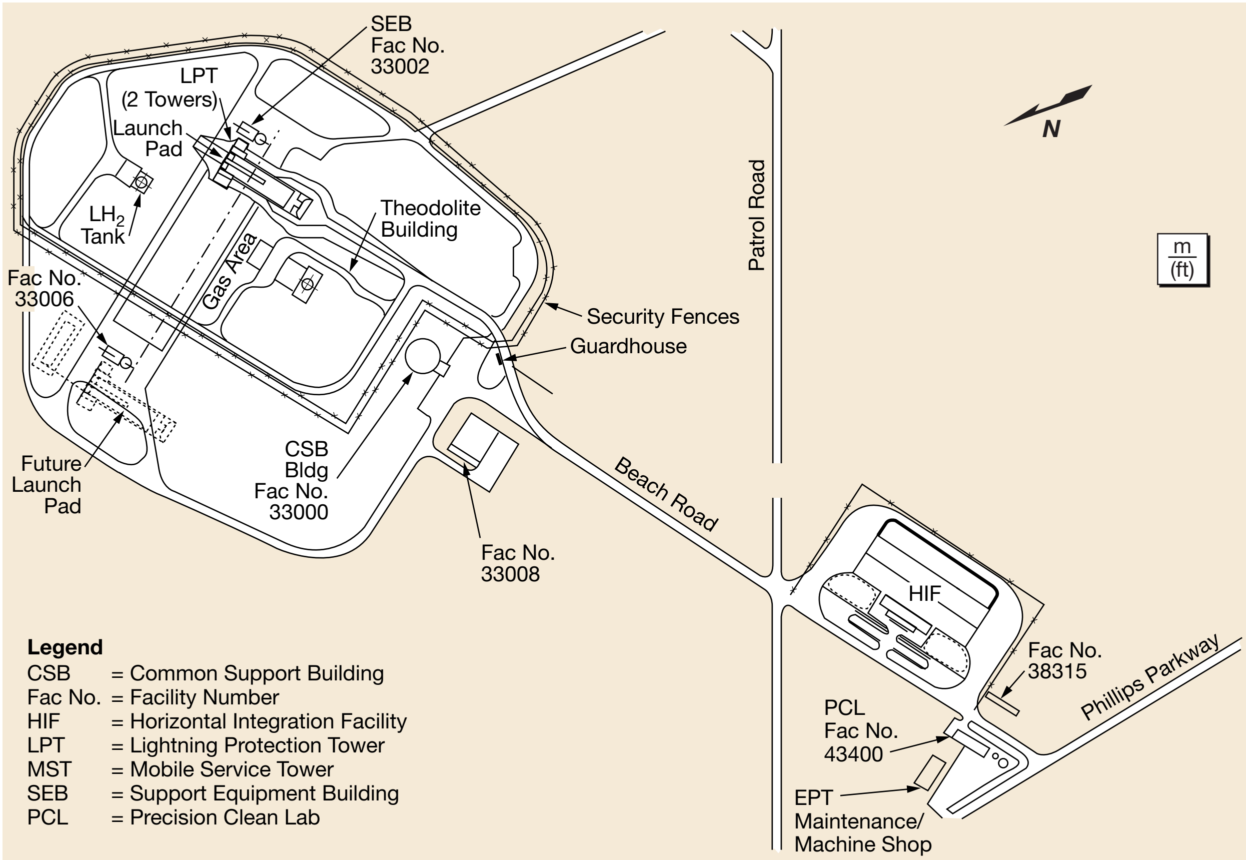


**Figure 6-10. Space Launch Complex 37, CCAFS**

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 9 of this document is required. The Delta Program provides mandatory safety briefings on these subjects for persons required to work in the launch complex area.

### 6.4.1 Mobile Service Tower (MST)

The MST (Figure 6-11) 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.

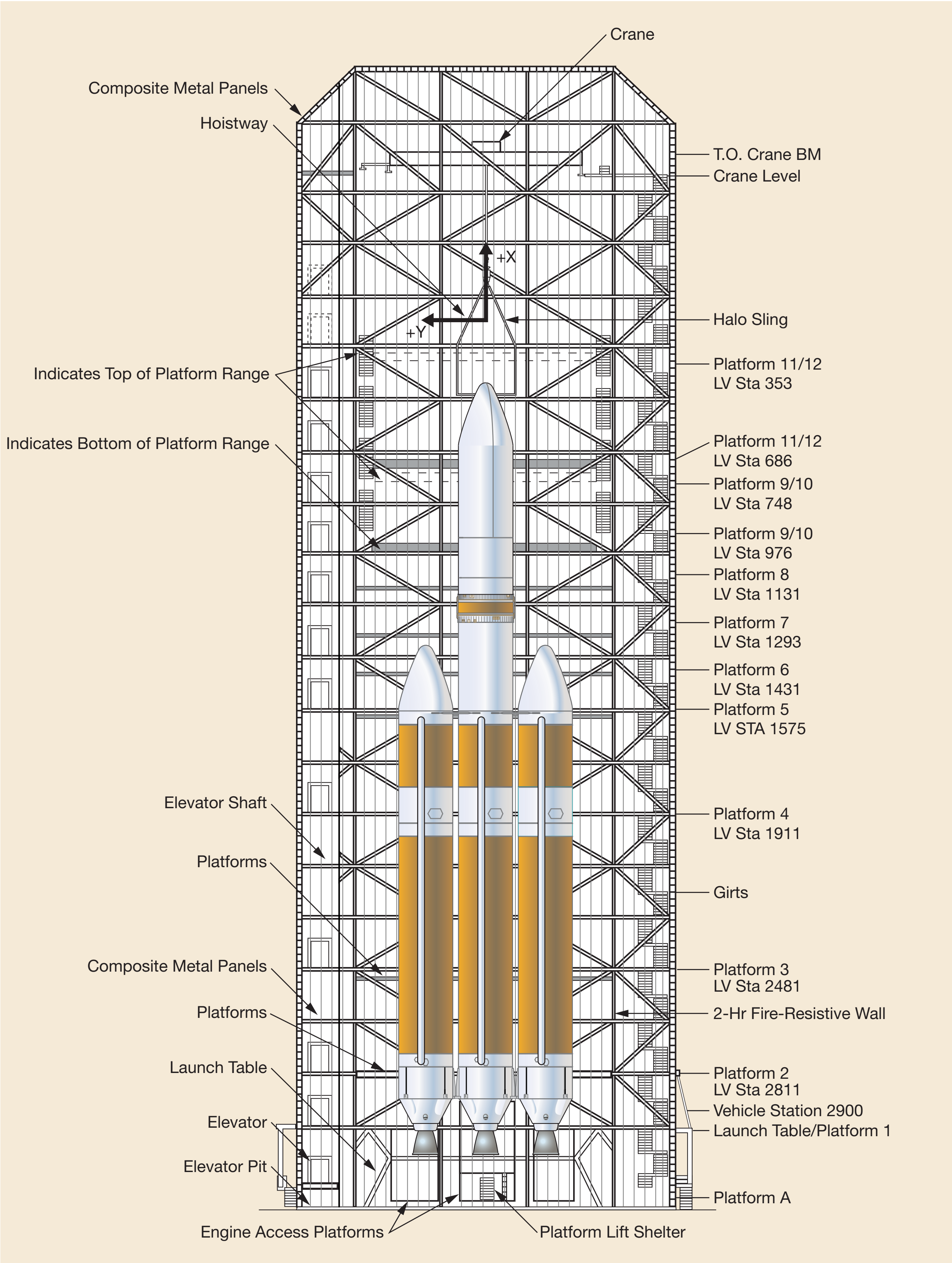


**Figure 6-11. Space Launch Complex 37 Mobile Service Tower (MST)**

The MST moves on rails to the service position (launch vehicle), using a hydraulic drive system, after the launch vehicle is mated to the launch table. Pneumatically and hydraulically operated work platforms are lowered to access the launch vehicle and payload during integration assembly and final checkout. The work platforms are raised 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, climate-controlled area for upper-stage and payload checkout. There is a payload users room located on level 8 that customers can use to house 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 6-12. The movable work platform floor plans for levels 9 through 12 are shown in Figures 6-13 and 6-14.

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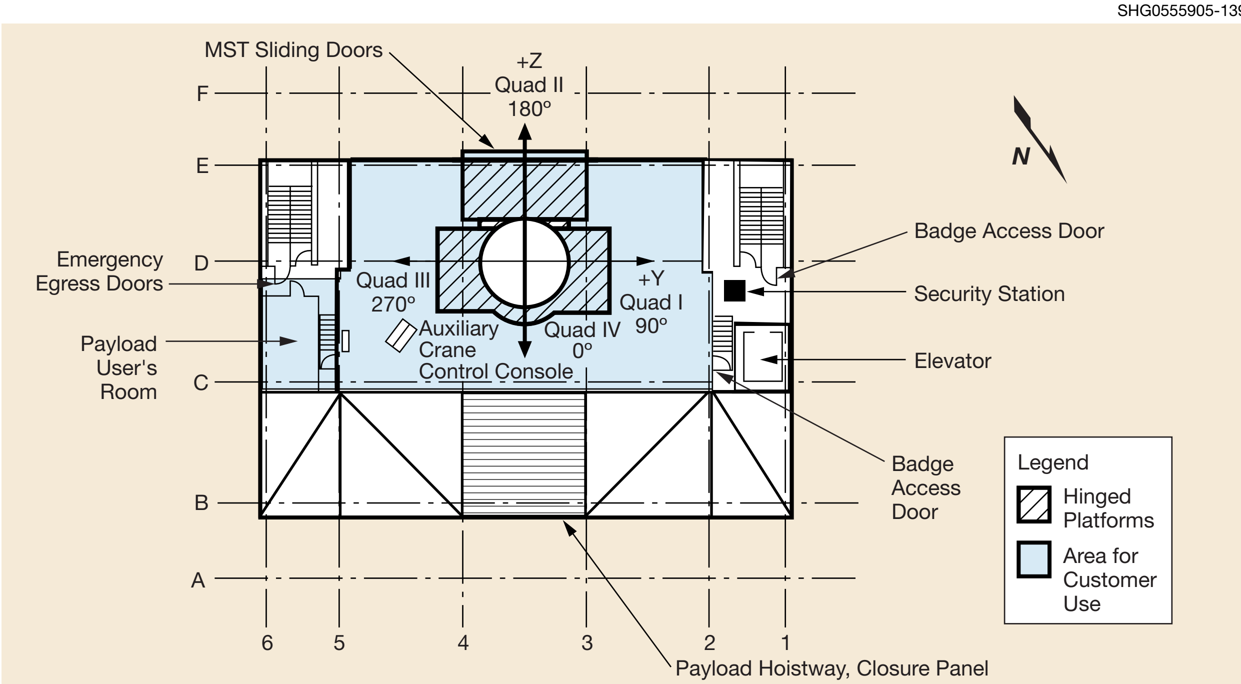


**Figure 6-12. Fixed Platform (Level 8)**

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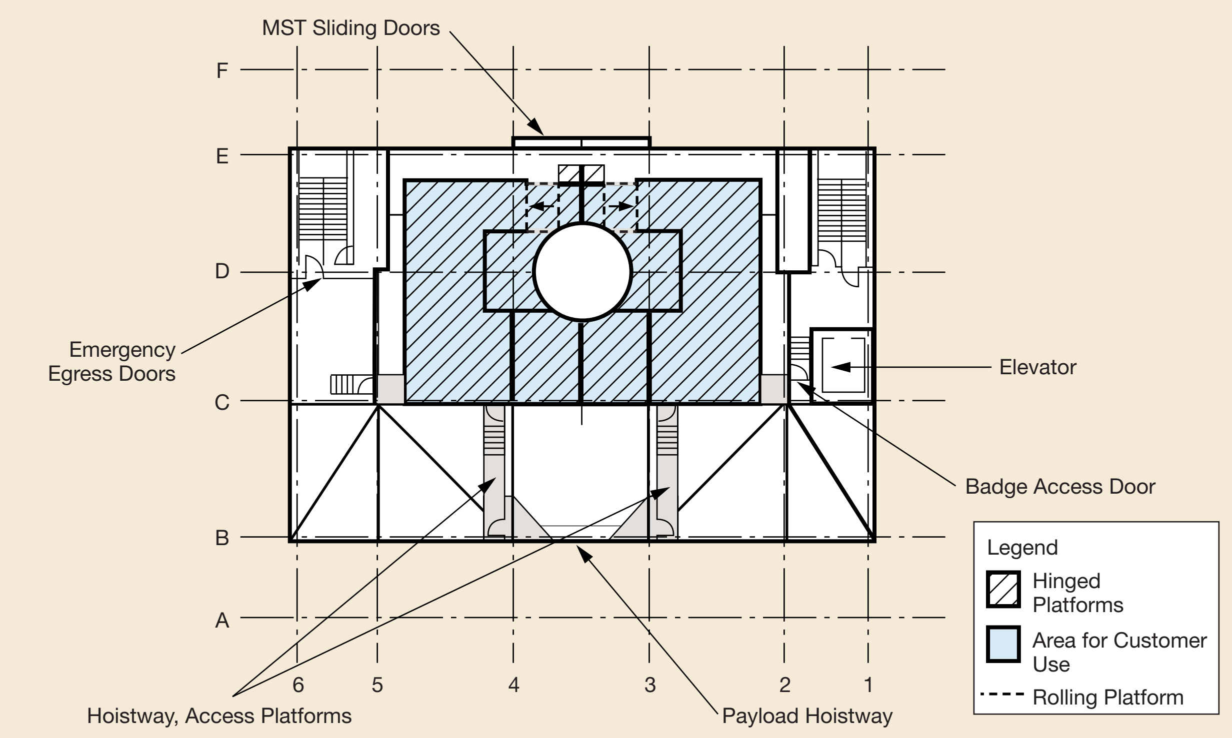


**Figure 6-13. Adjustable Platform (Levels 9 and 10)**

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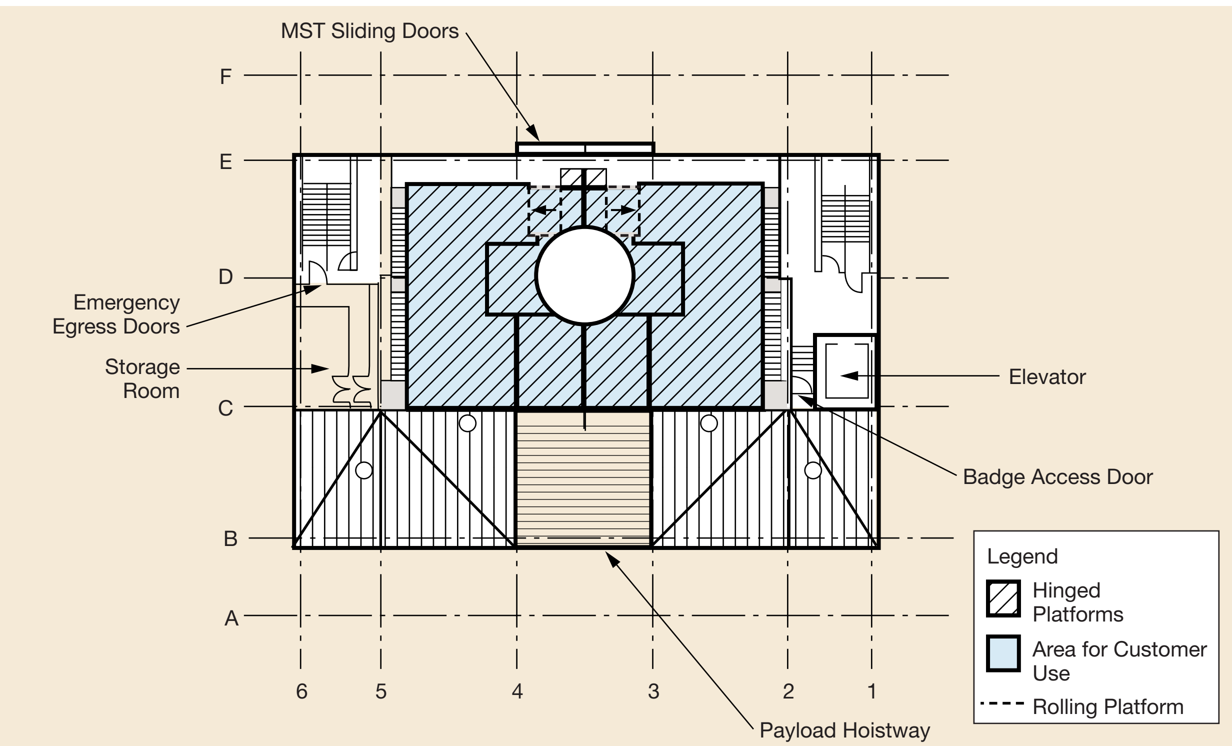


**Figure 6-14. Adjustable Platform (Levels 11 and 12)**

### 6.4.2 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. Swing arm No. 1 (level 7) connects umbilical cables and propellant lines to the centerbody of the common booster core. Swing arm No. 2 (level 10) connects umbilicals and propellant lines to the launch vehicle's upper stage. Swing arm No. 3 (level 12) connects an air-conditioning duct to the launch vehicle's payload fairing.

The FUT houses a hydraulic pump unit (HPU) that controls swing arm movement during testing and launch. Liquid oxygen ($LO_2$) and liquid hydrogen ($LH_2$) transfer pump assemblies are located on the FUT middle levels. Steel siding is installed on the north and east sides of the FUT to lend additional protection to installed equipment located on the structure.

### 6.4.3 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 (Figures 6-10 and 6-15).

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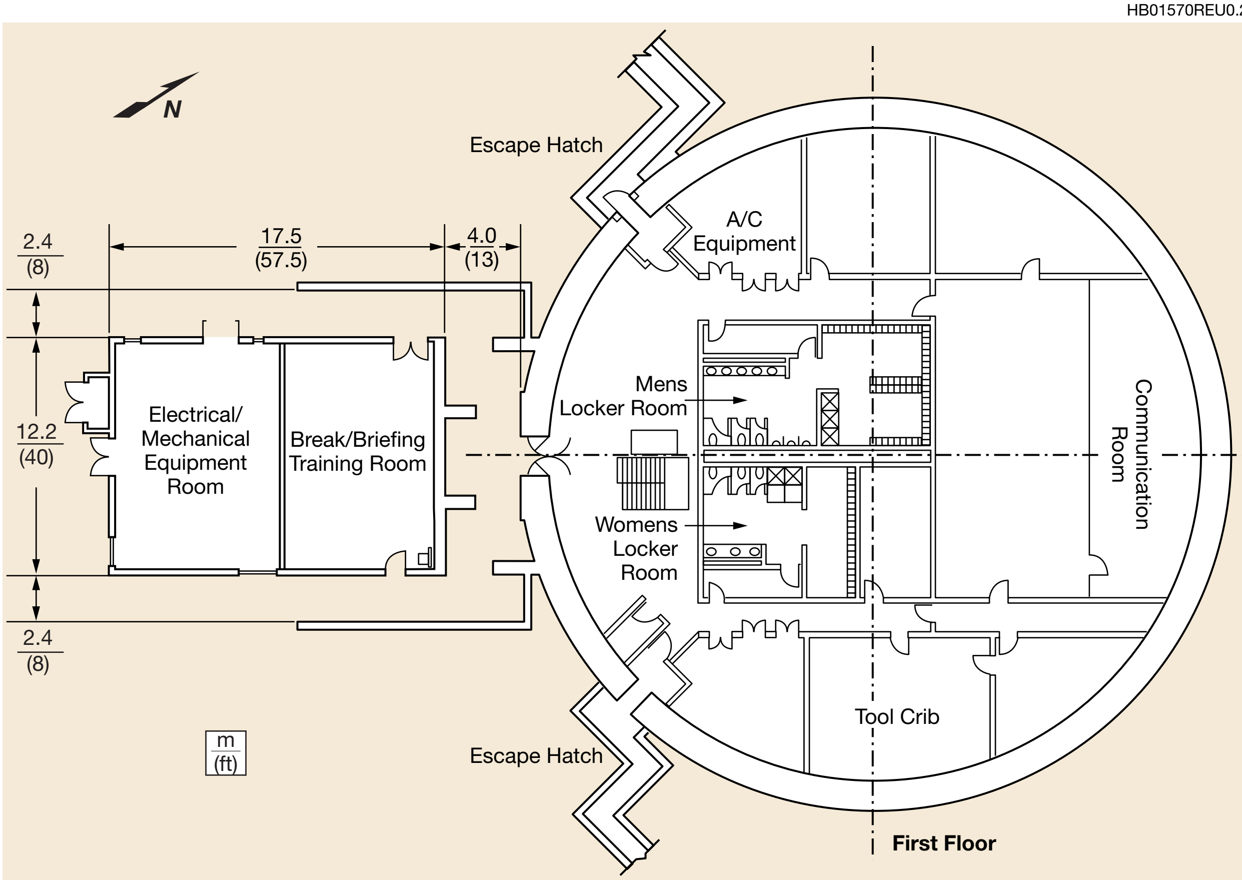


**Figure 6-15. Space Launch Complex 37 Common Support Building (CSB) Sample Layout**

### 6.4.4 Support Equipment Building (SEB)

Facility 33002, the existing building at complex 37B, is used as the SEB (Figures 6-10 and 6-16). The SEB contains the payload, launch vehicle and facility air-conditioning equipment, and electrical and data communications equipment needed near the launch vehicle. All equipment is new. The SEB also includes minimal personnel support areas such as small restrooms and a small 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 will be provided. This structure is not occupied during launch.

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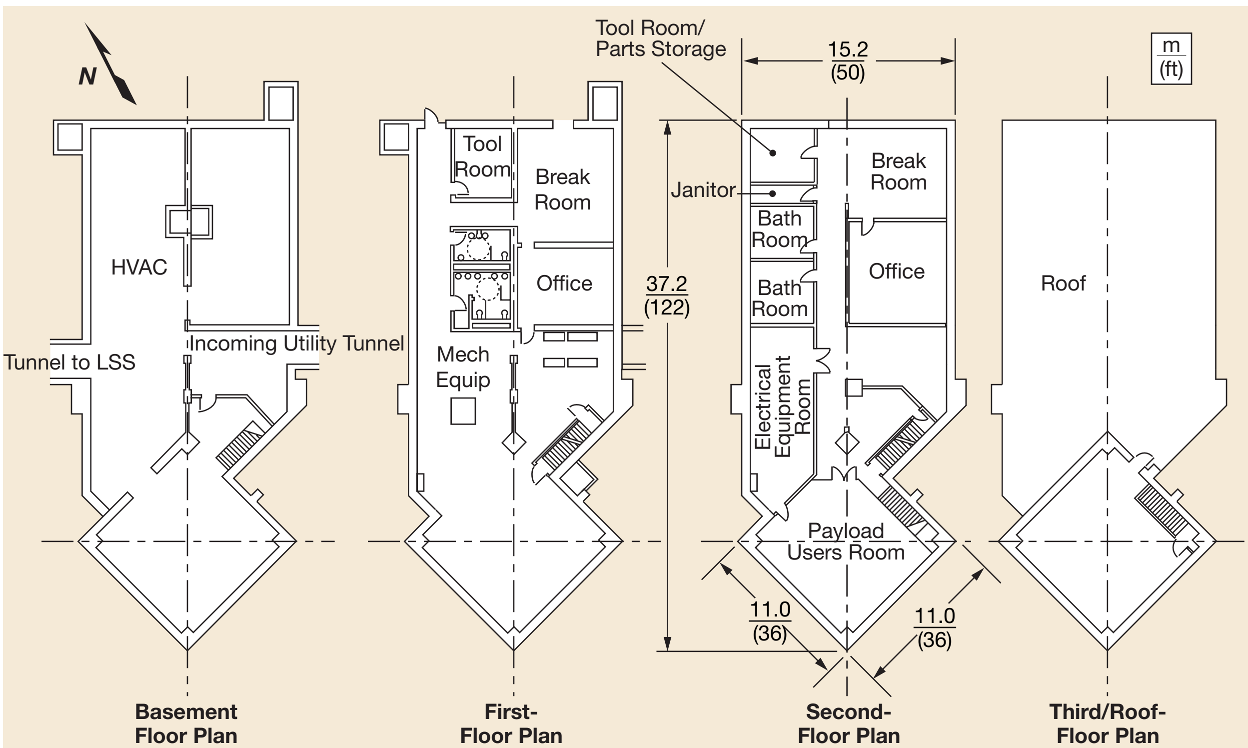


**Figure 6-16. Space Launch Complex 37 Support Equipment Building (SEB)**

### 6.4.5 Horizontal Integration Facility (HIF)

Although not part of the SLC-37 complex, the HIF (Figures 6-10, 6-17, and 6-18) is used to process the launch vehicles after their transport from the receiving and storage 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.

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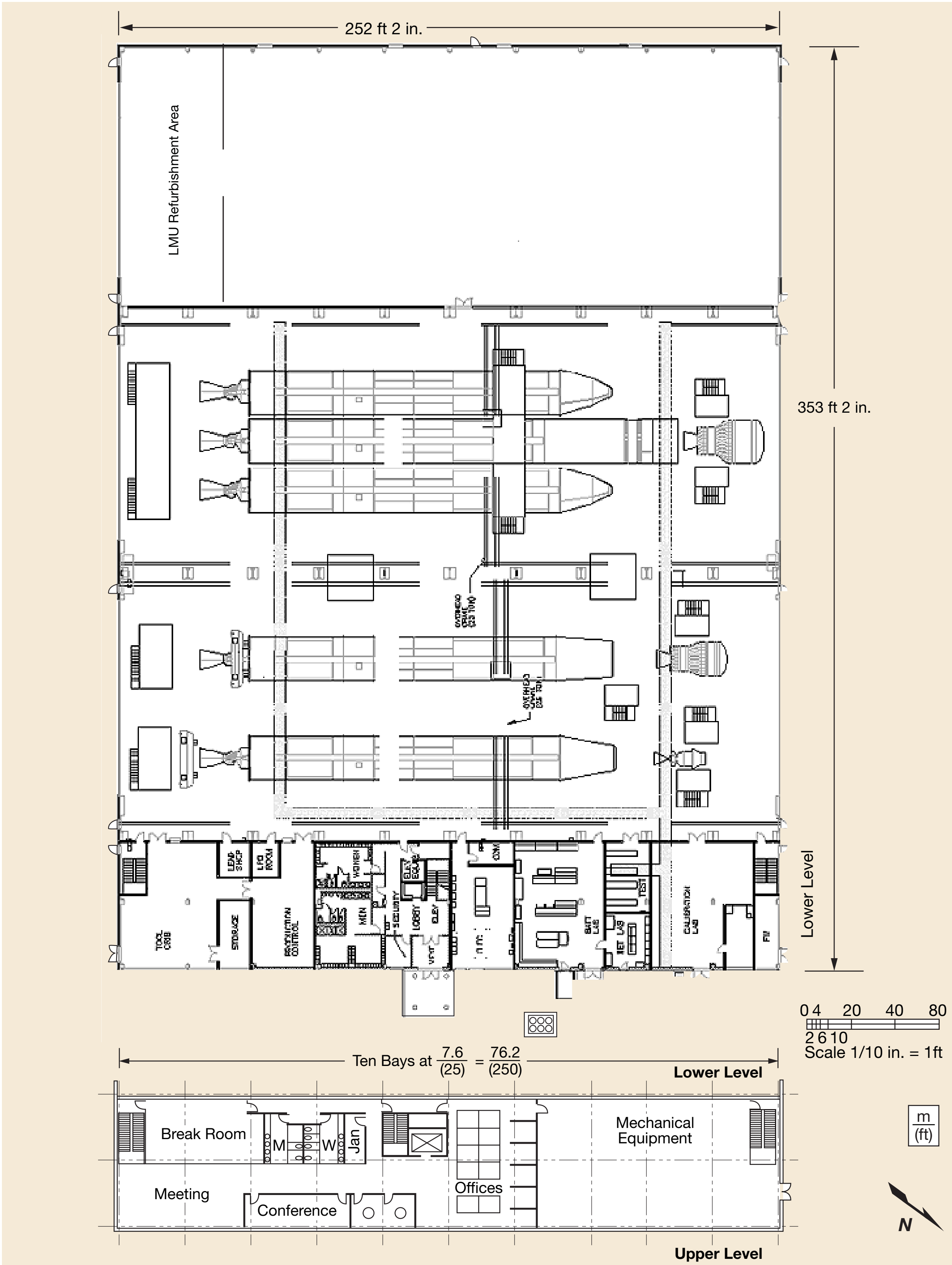


**Figure 6-17. Space Launch Complex 37, Horizontal Integration Facility (HIF)**

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**Figure 6-18. 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 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 6-24).

## 6.5 SUPPORT SERVICES

### 6.5.1 Launch Support

For countdown operations, the launch team is normally located in the DOC, with support from 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.

6.5.1.1 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 6-19).

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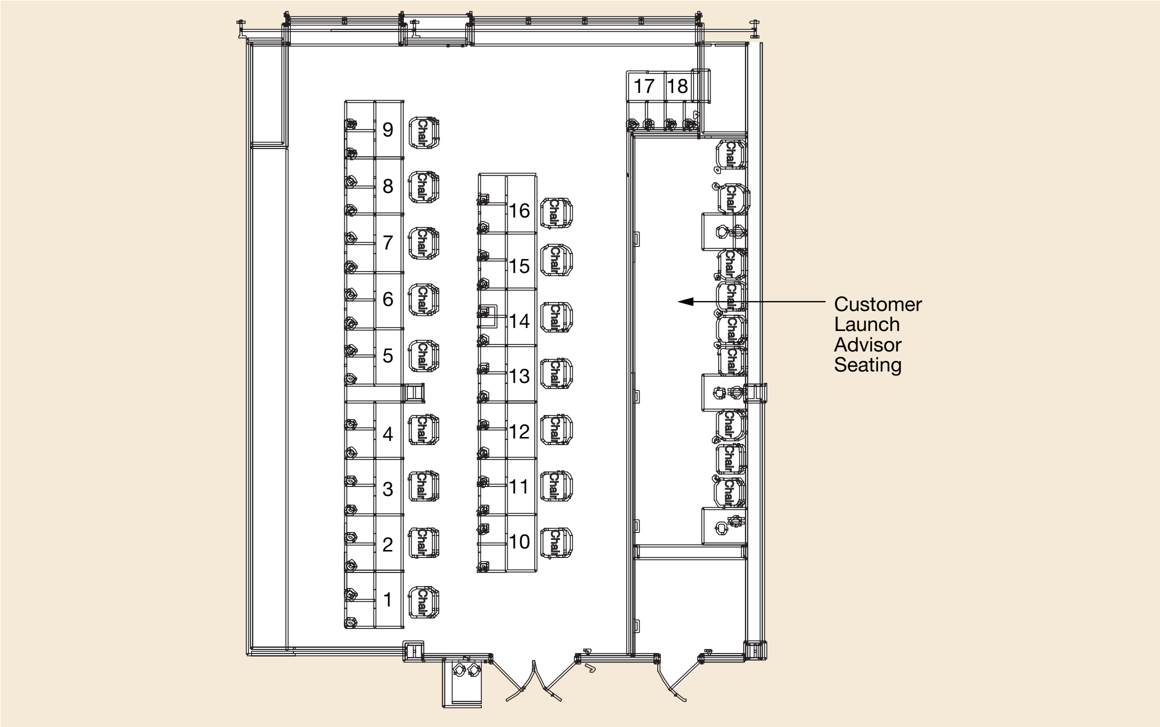


**Figure 6-19. Space Launch Complex 37 Mission Director Center (MDC)**

6.5.1.2 Launch Decision Process. The launch decision process is conducted by appropriate management personnel representing the payload, the launch vehicle, and the range. Figure 6-20 shows the typical communication flow required to make the launch decision for Delta IV.

### 6.5.2 Operational Safety

Safety requirements are covered in Section 9 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 entrance to hazardous areas. These briefings are scheduled by the Delta Program spacecraft integrator and presented by appropriate safety personnel.

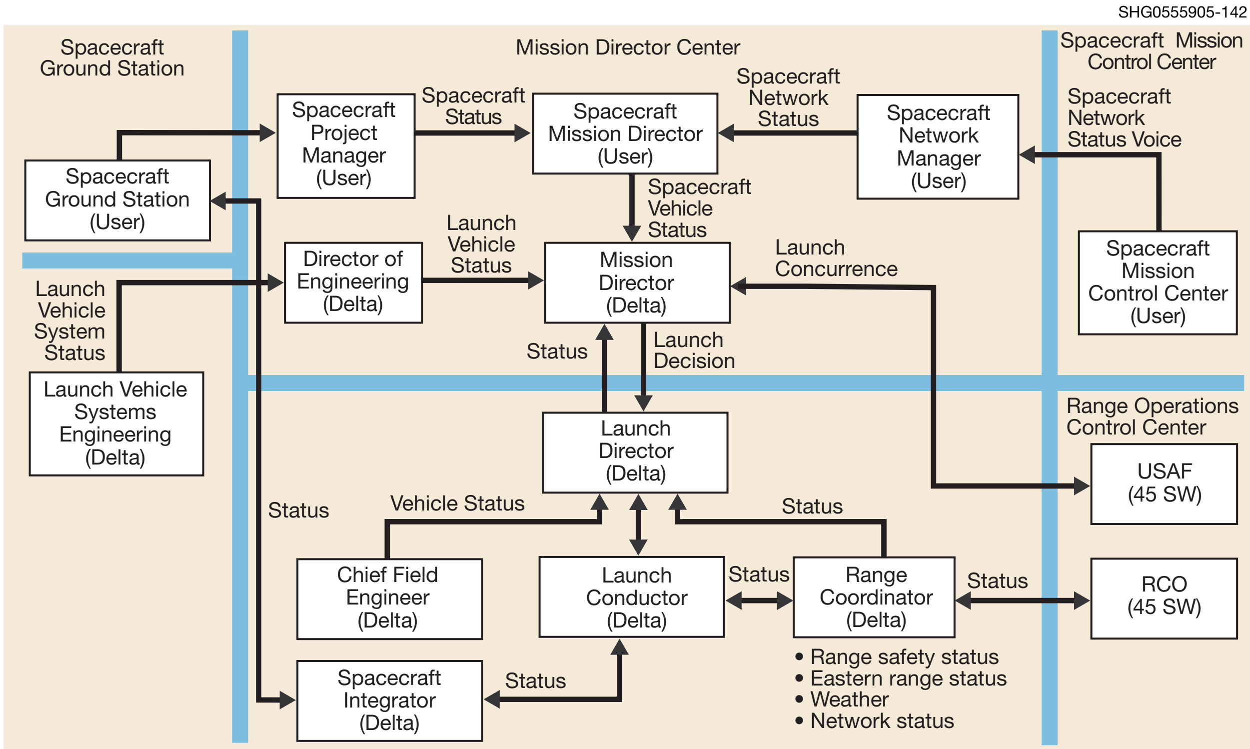


**Figure 6-20. Launch Decision Flow for Commercial Missions—Eastern Range**

## 6.5.3 Security

6.5.3.1 CCAFS Security. To gain access to CCAFS, U.S. citizens must provide visit notification to the Delta Program 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 Delta Program Security Office will arrange for the appropriate badging credentials for entry to CCAFS for commercial missions or individuals sponsored by the Delta Program. Access by NASA personnel or NASA-sponsored foreign nationals will be coordinated through the appropriate NASA Center and the Delta Program Security Office. Foreign nationals and U.S. citizens affiliated with non-U.S. firms, or U.S. firms with foreign contracts, must follow the appropriate accreditation process. The Delta IV Launch Site Mission Integration and Security Office will be advised of those individuals who are approved for access to the Delta IV Launch Site. Delta Program 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 45th Space Wing Foreign Disclosure Manager. The following foreign national information must be submitted to the Delta Program 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 Delta Program Security Office 60 days prior to the CCAFS entry date.

6.5.3.2 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 (IVA) of the fence line. The SLC is protected by an electronic security system (ESS) that consists of personnel entry/exit accountability using electronic proximity card readers, intrusion door alarms on MST levels 8 through 14, and payload user rooms located on MST level 8 and in the support equipment building (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 Delta Program Security Office at least 30 days prior to the intended arrival date at the SLC.

6.5.3.3 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 Delta Program spacecraft integrator.

### 6.5.4 Field-Related Services

The Delta Program employs certified handlers wearing propellant handler's ensemble (PHE) 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. The Delta Program has access to a machine shop, metrology laboratory, $LO_2$ cleaning facility, proof-load facility, and hydrostatic proof test equipment. Delta Program operational team members are familiar with the payload processing facilities and can offer all these skills and services to the spacecraft contractor during the launch program.

## 6.6 DELTA IV PLANS AND SCHEDULES

### 6.6.1 Mission Plan

At least 12 months 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 payload processing facility (PPF) and horizontal integration facility (HIF) occupancy time.

### 6.6.2 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.

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 6-21 and 6-22 show notional integrated processing timelines for the Delta IV (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 spacecraft contractor.

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 Boeing launch operations manager.

### 6.6.3 Launch Vehicle Schedules

One set of facility-oriented 3-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.

### 6.6.4 Spacecraft Schedules

The spacecraft project team will supply schedules to the appropriate agency for flowdown to the Delta Program spacecraft integrator, who will arrange support as required.

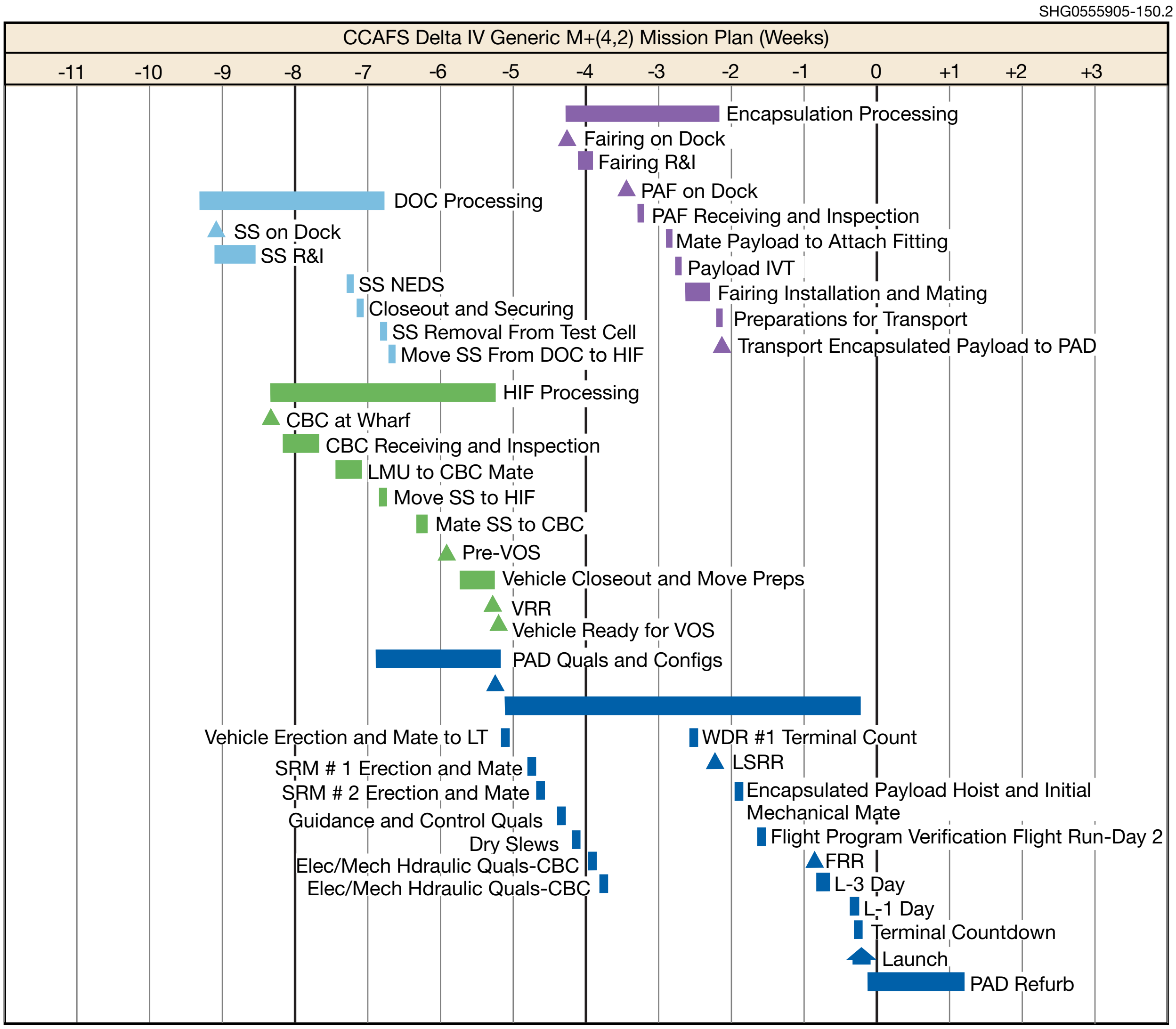


**Figure 6-21. Projected Processing Timeline—Delta IV M+(4,2) Launch Vehicle (rev. Q)**

## 6.7 DELTA IV MEETINGS AND REVIEWS

During launch preparation, meetings and reviews are scheduled as required to assure mission success. Some of these will require spacecraft customer input while others allow the customer to monitor the progress of the overall mission. The Delta Program mission integration manager will ensure adequate customer participation.

### 6.7.1 Meetings

Delta status meetings are generally held once a week. These meetings include a review of the activities scheduled and accomplished since the last meeting, a discussion of problems and their solutions, and a general review of the mission schedule and specific mission schedules. Customers are encouraged to attend these meetings.

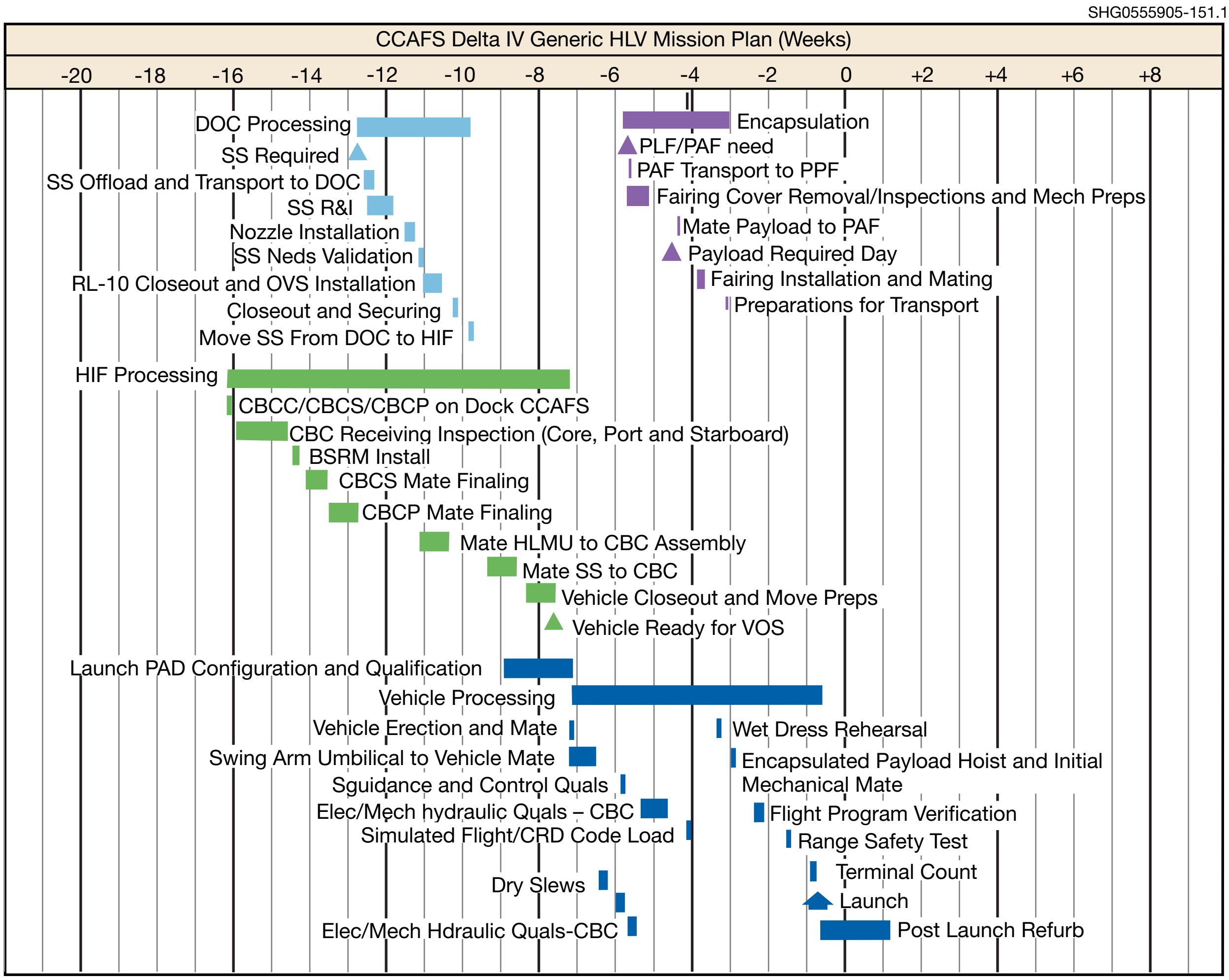


**Figure 6-22. Projected Processing Timeline—Delta IV Heavy Launch Vehicle (rev. Q)**

Daily schedule meetings provide the team members with their assignments and summaries of the previous or current day's accomplishments. These meetings are attended by the launch conductor, technicians, inspectors, engineers, supervisors, and the spacecraft integrator. Depending on testing activities, these meetings are held at the beginning of the first shift.

### 6.7.2 Prelaunch Review Process

Periodic reviews are held to ensure that the payload and launch vehicle are ready for launch. The mission plan will show the relationship of the reviews to the program assembly and test flow.

The following paragraphs describe Delta IV readiness reviews.

6.7.2.1 Postproduction Review. At this meeting, conducted at Decatur, Alabama, flight hardware that is at the end of production and ready for shipment to CCAFS is reviewed.

6.7.2.2 Mission Analysis Review. This meeting is held approximately 3 months prior to launch to review mission-specific drawings, studies, and analyses.

6.7.2.3 Pre-Vehicle-On-Stand Review. A pre-vehicle-on-stand (pre-VOS) review is held approximately on L-12 day at CCAFS subsequent to completion of HIF processing and prior to erection of the vehicle on the launch pad. It includes an update of the activities since manufacturing, the results of HIF processing, and hardware history changes. Launch facility readiness is also discussed.

6.7.2.4 Flight Readiness Review. The flight readiness review (FRR), typically held on L-5 week, defines the status of the launch vehicle after initial pad processing and a mission analysis update. It is conducted to determine that the launch vehicle and payload are ready for countdown and launch. Upon completion of this review, authorization is given to proceed with the final phases of countdown preparation. This review also assesses the readiness of the range to support launch and provides predicted weather data.

6.7.2.5 Launch Readiness Review. The launch readiness review (LRR) is held on L-1 day. All agencies and contractors are required to provide a ready-to-launch statement. Upon completion of this meeting, authorization to enter terminal countdown is given.

# Section 7
# LAUNCH OPERATIONS AT WESTERN RANGE

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

## 7.1 ORGANIZATIONS

As operator of the Delta IV launch system, the Delta Program office maintains an operations team at VAFB that provides launch services to the United States Air Force (USAF), National Aeronautics and Space Administration (NASA), and commercial customers. The Delta Program provides the interface to the Federal Aviation Administration (FAA) and Department of Transportation (DOT) for licensing and certification to launch commercial payloads using the Delta IV family of launch vehicles.

The Delta Program has established an interface with the USAF 30th Space Wing Directorate of Plans; the Western Range has designated a range program support manager (PSM) to represent the 30th Space Wing. 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 the Delta Program, based on inputs from the customer, using the government’s universal documentation system (UDS) format (see Section 8, Payload Integration). The Delta Program and the customer generate the program requirements document (PRD). Formal submittal of these documents to the government agencies is arranged by the Delta Program.

For commercial customer launches, the Delta Program makes all the arrangements for the payload processing facilities (PPF) and services. The organizations that support a launch from VAFB are listed in Figure 7-1. For each mission, a spacecraft coordinator from the Delta-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 test conductor in the launch control center (LCC). The Delta Program interfaces with NASA at VAFB through the VAFB Kennedy Space Center (KSC) resident office.

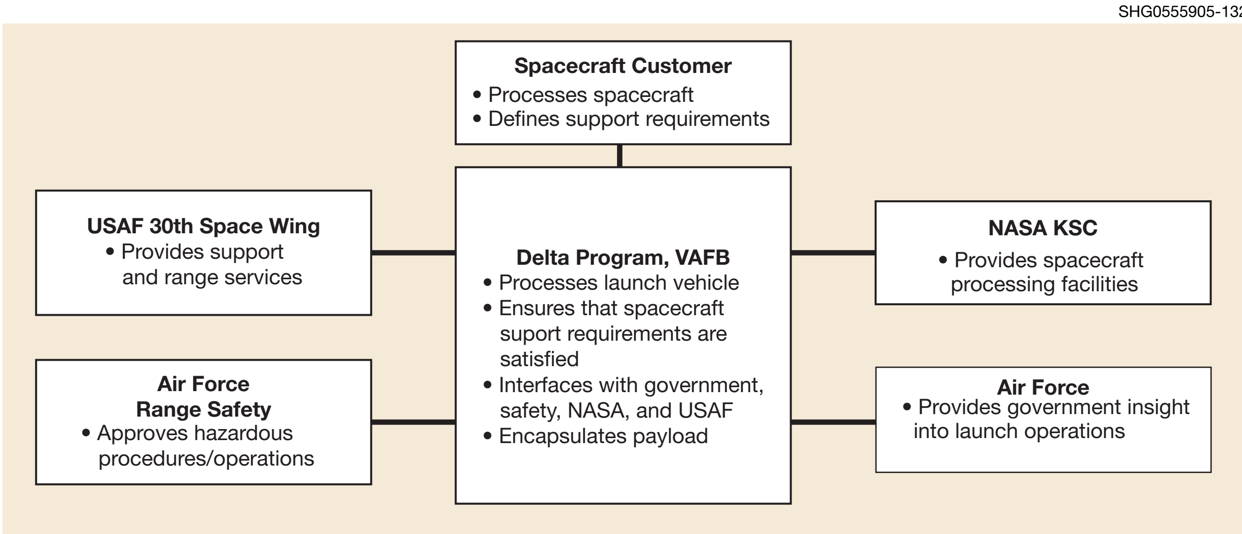


**Figure 7-1. Launch Base Organization at VAFB**

## 7.2 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 (Figure 7-2), shows the location of all major facilities and space launch complexes.

The commonly used facilities at the western launch site for NASA or commercial payloads are the following:

A. Payload processing facilities (PPF):
   1. NASA-provided facility: building 836.
   2. Astrotech Space Operations: building 1032.
   3. Spaceport Systems International building 375.

B. Hazardous processing facilities (HPF):
   1. NASA-provided facility: building 1610.
   2. Astrotech Space Operations: building 1032.
   3. Spaceport Systems International: building 375.

While there are other spacecraft processing facilities located on VAFB that are under USAF control, commercial spacecraft will normally be processed through the commercial facilities of ASO or SSI. Government facilities for spacecraft processing (USAF or NASA) can be used for commercial spacecraft only under special circumstances (use requires negotiations between the Delta Program office, the customer, and USAF or NASA). For spacecraft preparations, the customer must provide its own test equipment including telemetry receivers and telemetry ground stations.

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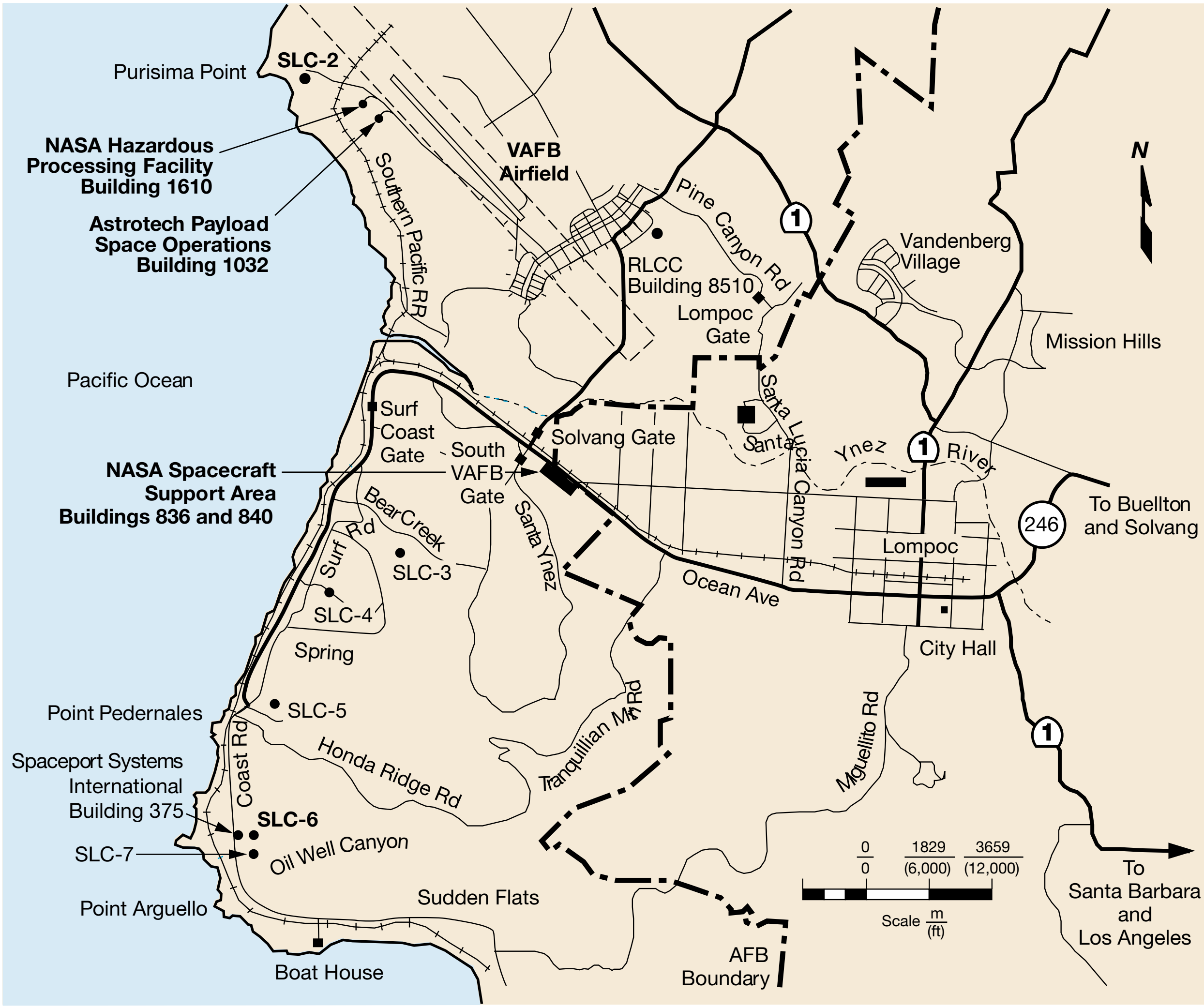


**Figure 7-2. Vandenberg Air Force Base (VAFB) Facilities**

After arrival of the payload and its associated equipment at VAFB by road or by air (via the VAFB airfield), transportation of the spacecraft and associated equipment to the spacecraft processing facility is a service provided by the customer-selected processing facility with assistance from the Delta Program. Equipment and personnel are also available for loading and unloading operations. It should be noted that the size of the shipping containers often dictates the type of aircraft used for transportation to the launch site. The carrier should be consulted for the type of freight unloading equipment that will be required at the Western Range. Shipping containers and handling fixtures attached to the payload are provided by the customer.

Shipping and handling of hazardous materials, such as electro-explosive devices (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 9).

### 7.2.1 NASA Facilities on South VAFB

NASA spacecraft facilities are located in the NASA support area on South VAFB (SVAFB) (Figure 7-3). The spacecraft support area is adjacent to Ocean Avenue on Clark Street and is accessible through the SVAFB South Gate. The support area consists of the spacecraft laboratory (building 836), NASA technical shops, NASA supply, and NASA engineering and operations building (building 840).

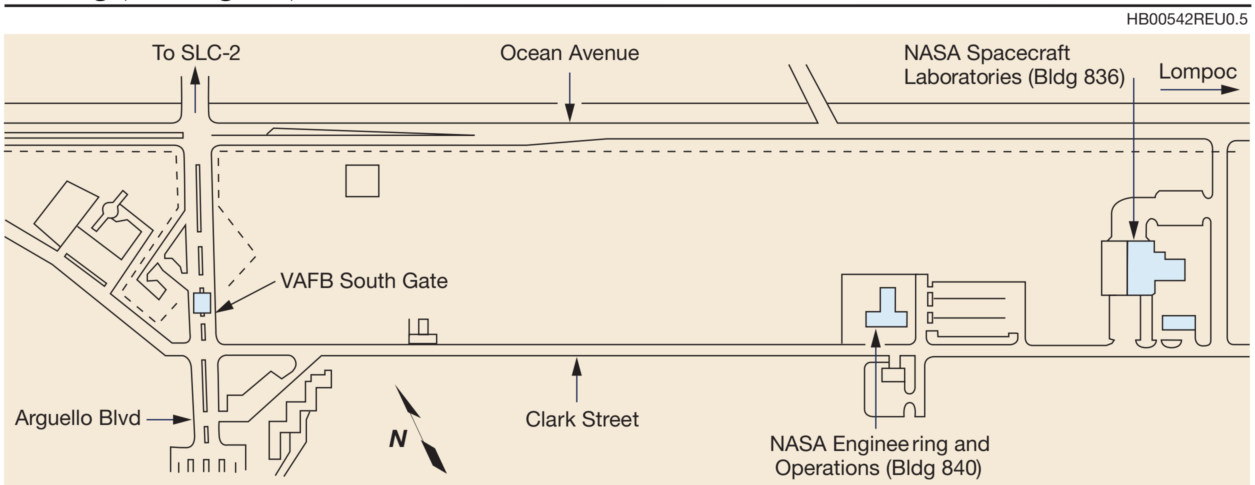


**Figure 7-3. Spacecraft Support Area**

7.2.1.1 NASA Telemetry Station and Spacecraft Laboratories. The NASA telemetry station and spacecraft laboratories, building 836 (Figure 7-4), are divided into work and laboratory areas and include the Mission Director Center (MDC), the Launch Vehicle Data Center (LVDC), spacecraft assembly areas, laboratory areas, cleanrooms, computer facility, office space, conference room, and the telemetry station.

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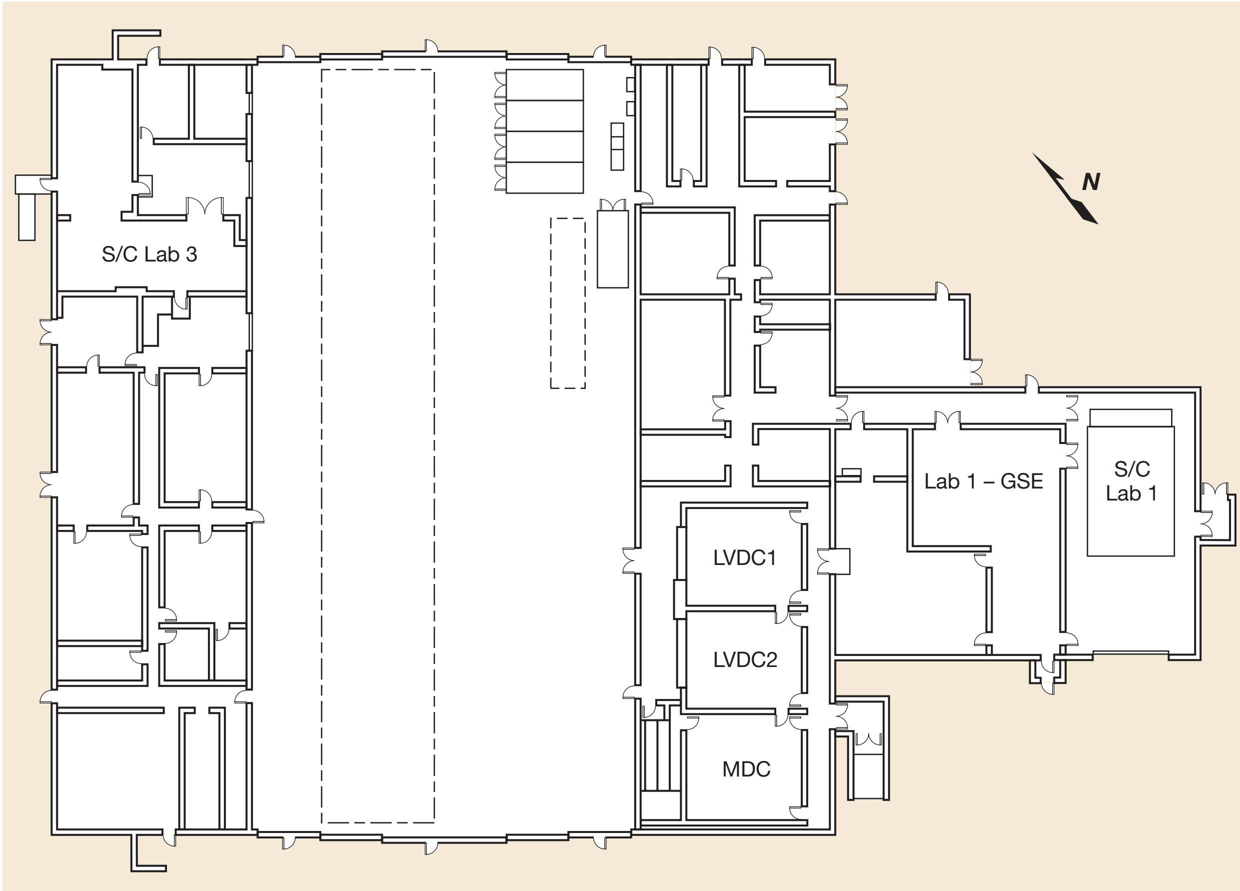


**Figure 7-4. NASA Telemetry Station (Building 836)**

Spacecraft laboratory 1 (Figure 7-5) consists of a high bay 20.4 m (67 ft) long by 9.8 m (32 ft) wide by 9.1 m (30 ft) high and an adjoining 334-m$^2$ (3600-ft$^2$) support area. Personnel access doors and a sliding door 3.7 m (12 ft) by 3.7 m (12 ft) connect the two portions of this laboratory. The outside cargo entrance door to the spacecraft assembly room in laboratory 1 is 6.1 m (20 ft) wide by 7.8 m (25 ft, 7 in.) high. A bridge crane, with an 8.8-m (29-ft) hook height and a 4545-kg (5-ton) capacity, is available for handling spacecraft and associated equipment. This assembly room contains a class 10,000 horizontal laminar flow cleanroom, 10.4 m (34 ft) long by 6.6 m (21.5 ft) wide by 7.6 m (25 ft) high. The front of the cleanroom opens for free entry of the spacecraft and handling equipment. The cleanroom has crane access in the front-to-rear direction only; however, the crane cannot operate over the entire length of the laboratory without disassembly because its path is obstructed by the horizontal beam that serves as the cleanroom divider. Spacecraft laboratory 1 will also support computer, telemetry, and checkout equipment in a separate room containing raised floors and an under-floor power distribution system. This room has an area of approximately 334 m$^2$ (3600 ft$^2$).

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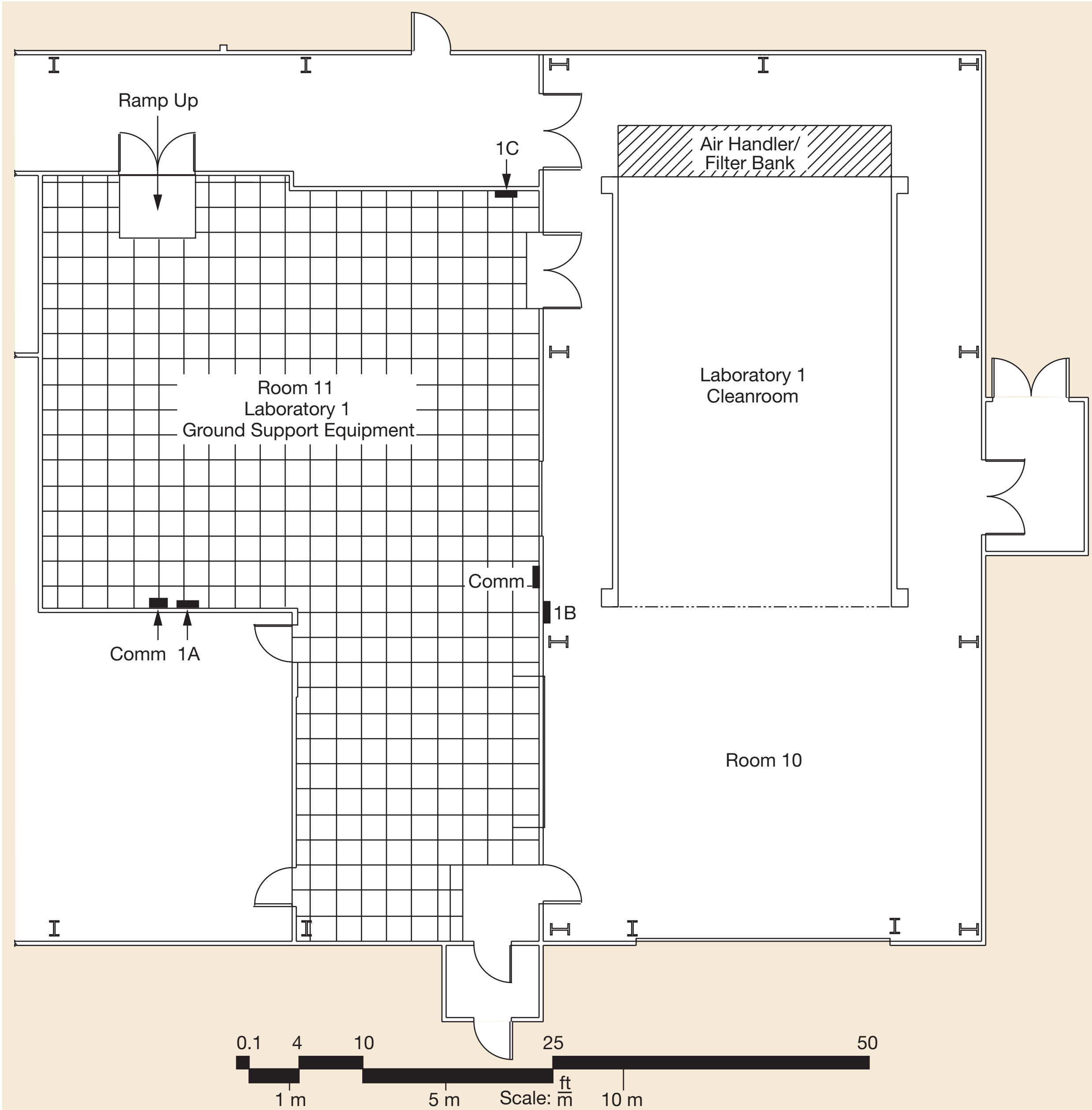


**Figure 7-5. Spacecraft Laboratory 1 (Building 836)**

Spacecraft laboratory 3 (Figure 7-6) has an area of 2323 $m^2$ (25,000 $ft^2$). This laboratory is assigned to the NOAA Environmental Monitoring Satellite Program.

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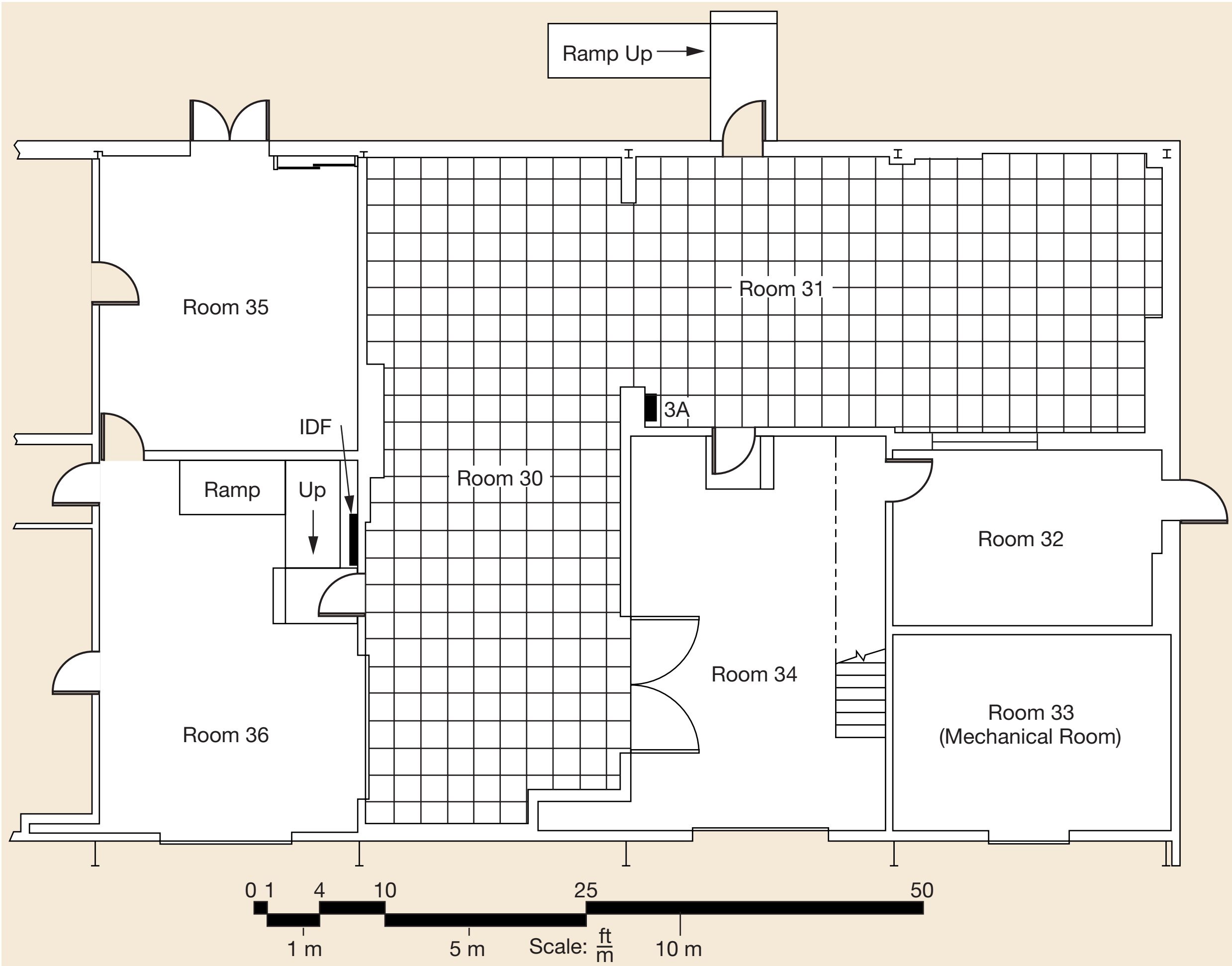


**Figure 7-6. Spacecraft Laboratory 3 (Building 836)**

Launch vehicle data center 1 (LVDC-1) (Figure 7-7) is an area containing 24 consoles for Delta Program office management and technical support personnel. These positions are manned during countdown and launch to provide technical assistance to the launch team in the remote launch control center (RLCC) and to the Mission Director in the Mission Director Center (MDC). These consoles have individually programmed communications panels for specific mission requirements. This provides LVDC personnel with technical communications to monitor and coordinate both prelaunch and launch activities. Video data display terminals in the LVDC are provided for display of range and launch vehicle technical information.

Launch vehicle data center 2 (LVDC-2), a second data center, is provided with equipment similar to LVDC-1, and may also be used by spacecraft personnel.

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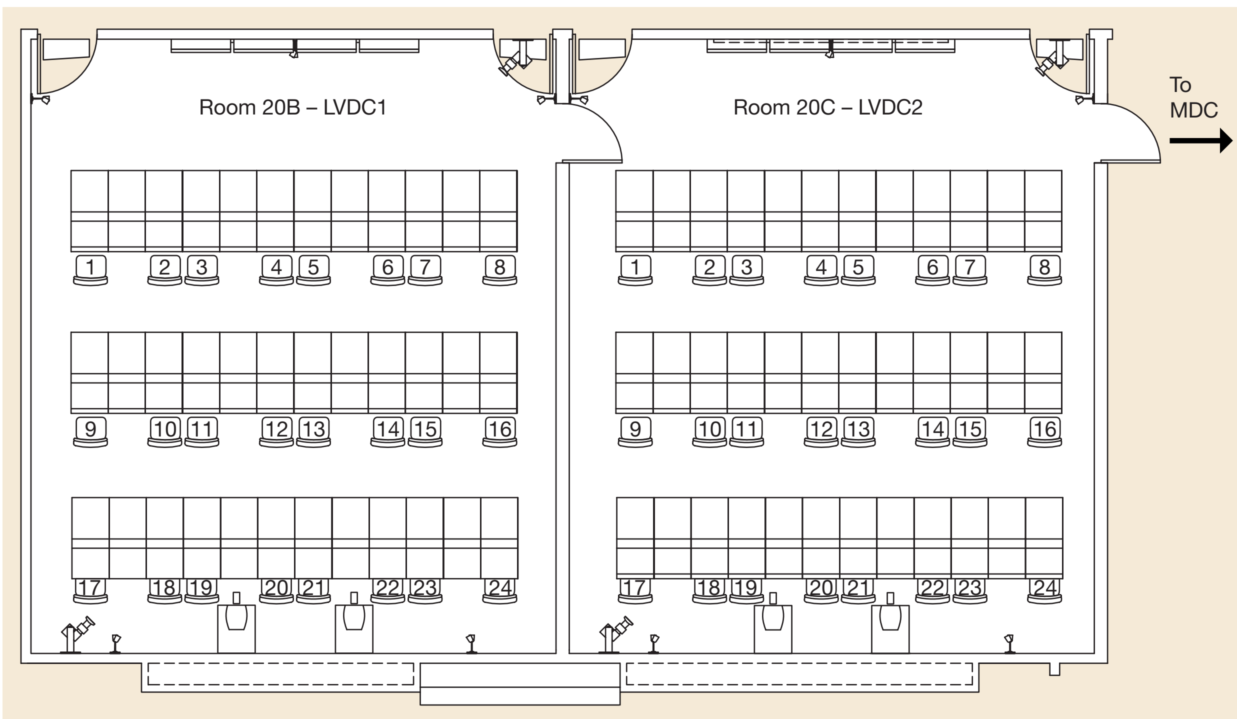


**Figure 7-7. Launch Vehicle Data Center (Building 836)**

The MDC (Figure 7-8) provides 32 communication consoles for use by the Mission Director, spacecraft and launch vehicle representatives, experimenters, display controller, and communications operators. These consoles have individually programmed communications for specific mission requirements. This provides Delta Program personnel with technical communications to monitor and coordinate both prelaunch and postlaunch activities.

Video data display terminals at the MDC are provided to display range and vehicle technical information. A readiness board and an events display board provide range and launch vehicle/spacecraft status during countdown and launch operations. Many TV display monitors display preselected launch activities.

An observation room, separated from the MDC by a glass partition, is used for authorized visitors. Loudspeakers in the room monitor the communication channels used during the launch.

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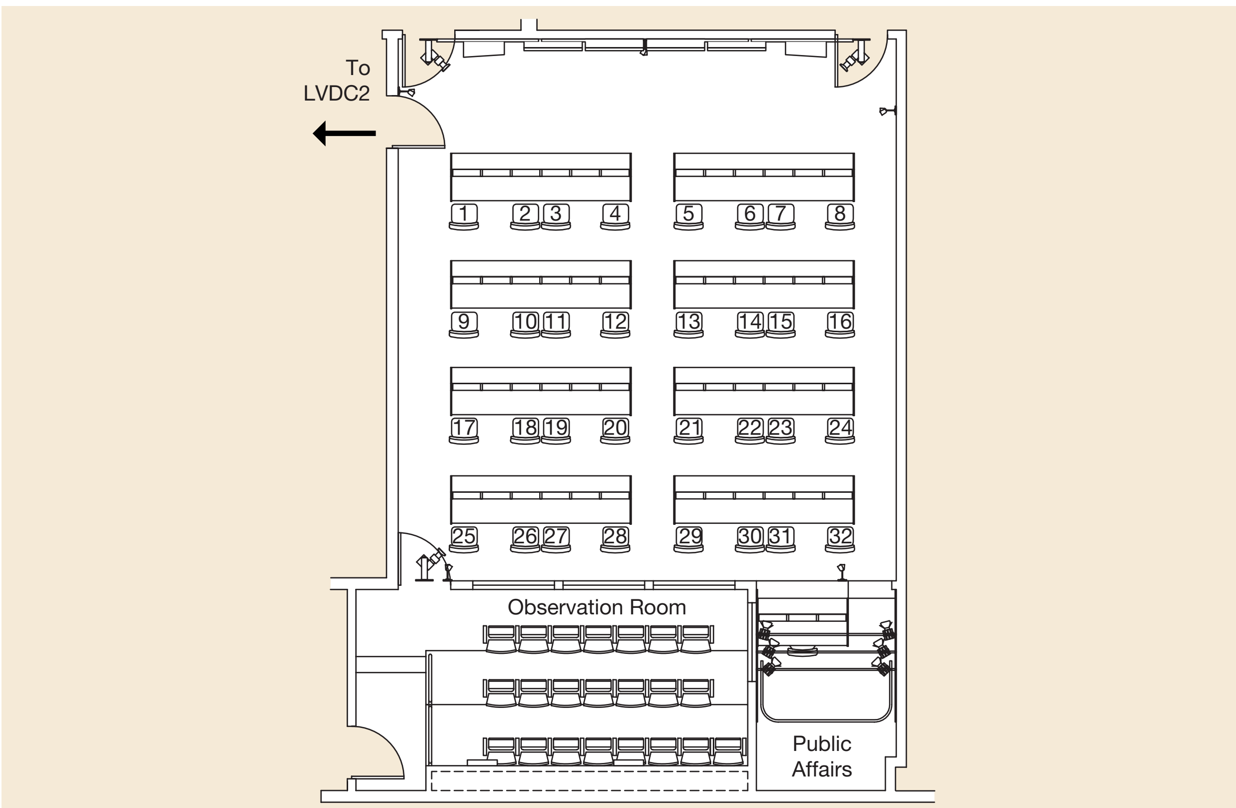


**Figure 7-8. Mission Director Center (Building 836)**

7.2.1.2 NASA Engineering and Operations Facility. The NASA engineering and operations facility in building 840 (Figure 7-9) is located on SVAFB at the corner of Clark and Scarpino Streets. It contains the NASA offices, NASA contractor offices, observation room, conference room, and other office space.

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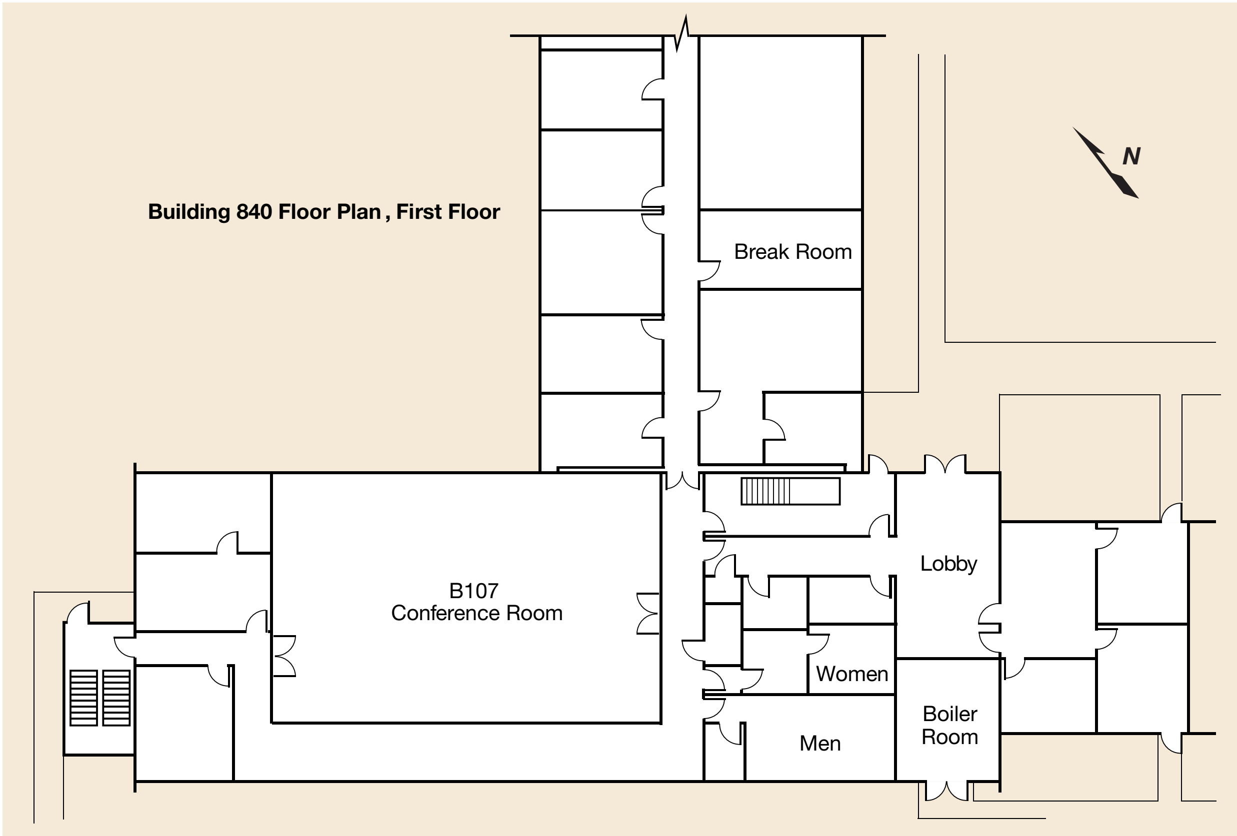


**Figure 7-9. NASA Building 840**

## 7.2.2 NASA Facilities on North Vandenberg

7.2.2.1 Hazardous Processing Facility (HPF). The NASA hazardous processing facility (building 1610) is located approximately 3.2 km (2 mi) east of SLC-2 and adjacent to Tangair Road (Figure 7-10). This facility provides capabilities for the dynamic balancing of spacecraft, solid motors, and combinations thereof. It is also used for fairing processing, solid-motor buildup, spacecraft buildup, mating of spacecraft and solid motors, ordnance installation, and loading of hazardous propellants. It houses the Schenk treble dynamic balancing machine and equipment for buildup, alignment, and balancing of the second-stage solid-propellant motors and spacecraft. Composite spin balancing of the spacecraft/third-stage combination is not required. The spin-balancing machine is in a pit in the floor of building 1610. The machine interfaces with stages and/or spacecraft at floor level. Facilities consist of the hazardous processing facility (building 1610), control room (building 1605), UPS/generator building (building 1604), guard station, and fire pumping station. Hazardous operations are conducted in building 1610, which is separated from the control room by an earth revetment 4.6 m (15 ft) high. The two buildings are 47.2 m (155 ft) apart.

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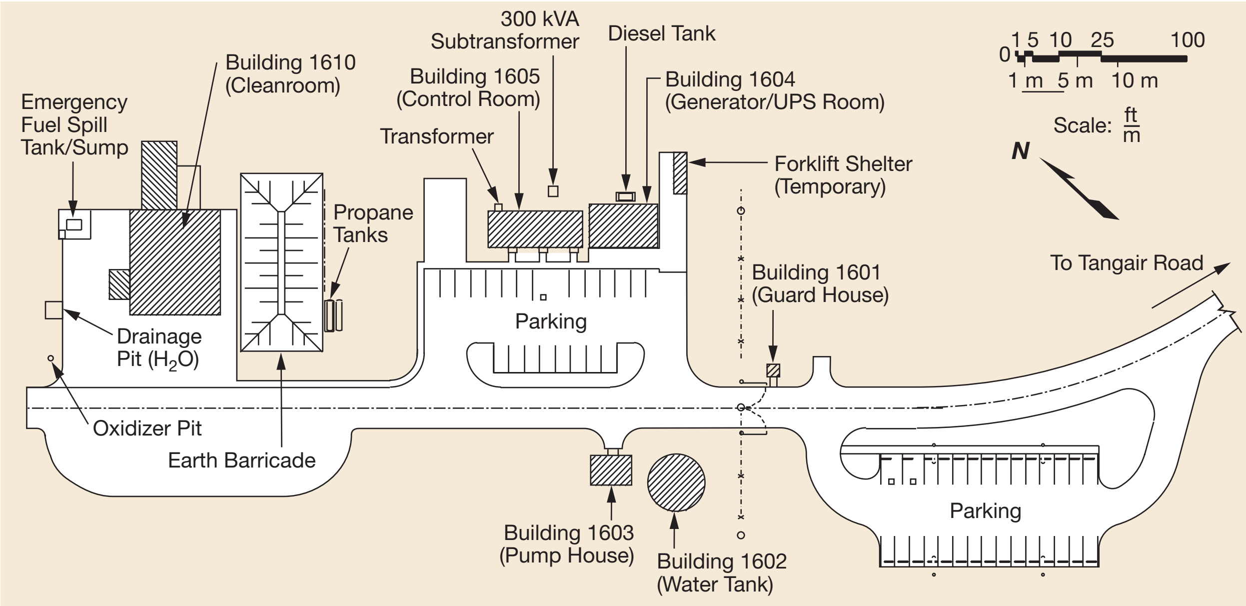


**Figure 7-10. NASA Hazardous Processing Facility**

The HPF (Figure 7-11), is an approved ordnance-handling facility and was constructed for dynamic balancing of spacecraft and solid rocket motors. It is 17.7 m (58 ft) long by 10.4 m (34 ft) wide by 13.7 m (45 ft) high with personnel access doors and a flight equipment entrance door opening that is 5.2 m (17 ft) wide and 9.1 m (29 ft 9 in.) high. The facility is equipped for safe handling of the hydrazine-type propellants used on many space vehicles for attitude control and supplemental propulsion. In the high bay, there is an overhead bridge crane with two 4545-kg (5-ton) capacity hoists. The working hook height is 10.7 m (35 ft). A spreader beam is available that allows use of both 5-ton hoists to lift up to 10 tons. This beam reduces the available hook height by 1 m (3 ft 2 in.) The HPF is a class 10,000 clean facility with positive pressure maintained in the room to minimize contamination from the exterior atmosphere. Positive-pressure clean air is provided by the air circulation and conditioning system located in a covered environmental equipment room at the rear of the building. Personnel gaining entry to the cleanroom from the entry room must wear appropriate apparel and must pass through an airlock. The airlock room has an access door to the exterior so that equipment can be moved into the cleanroom.

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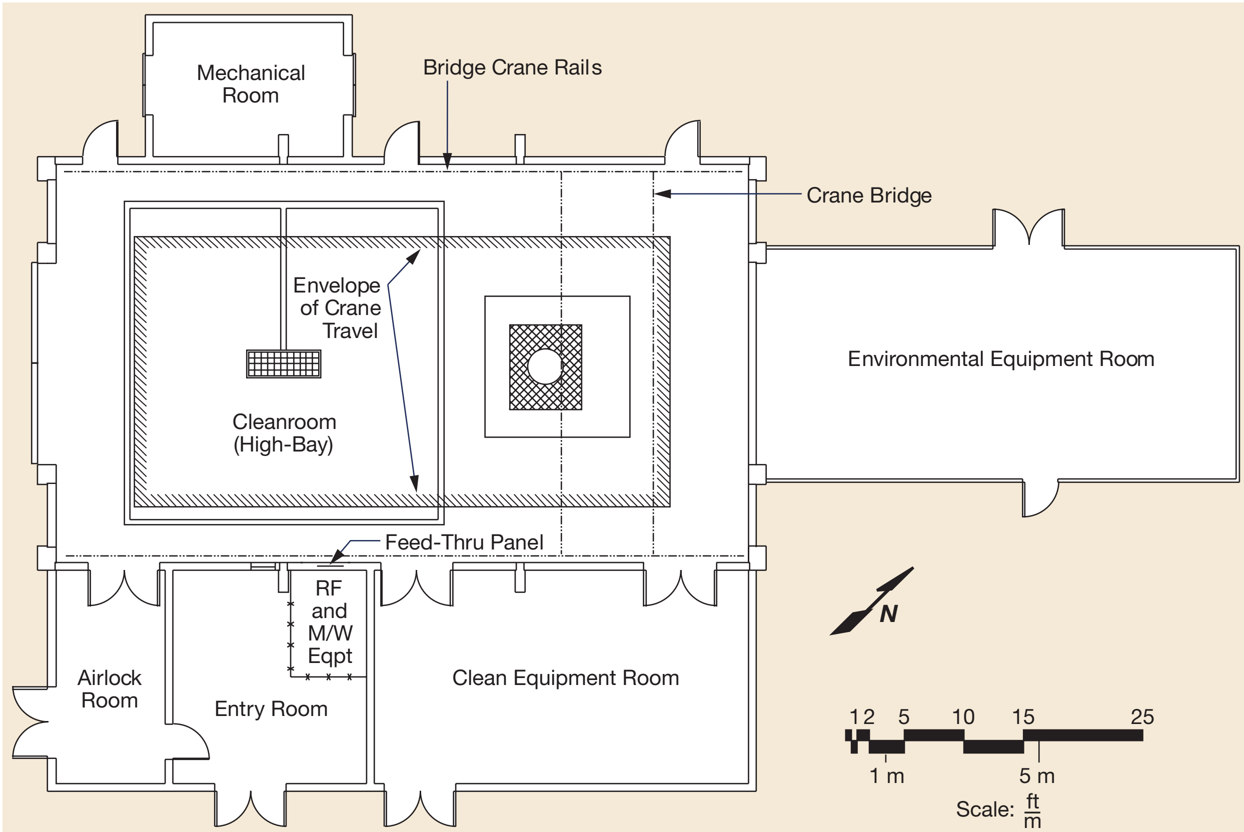


**Figure 7-11. Hazardous Processing Facility (Building 1610)**

7.2.2.2 Control Room Building. The control room building (Figure 7-12) contains a control room, an operations ready room, a fabrication room, and a mechanical/electrical room. The control console for the dynamic balancing system is located within the control room. Television monitors and a two-way intercommunications system provide continuous audio and visual monitoring of operations in the spin test building.

7.2.2.3 UPS/Generator Building. The UPS/generator building houses a 415-hp, autostart/autotransfer diesel generator. The generator produces 350 kVA, 240/208 VAC, 3-phase, 4-wire power. It is capable of carrying the entire facility power load approximately 8 hr after a loss of commercial power without a refueling operation. A 225-kVA uninterruptible power supply is also located in this building, which can carry all on-site power loads (except for HVAC) while the diesel is starting.

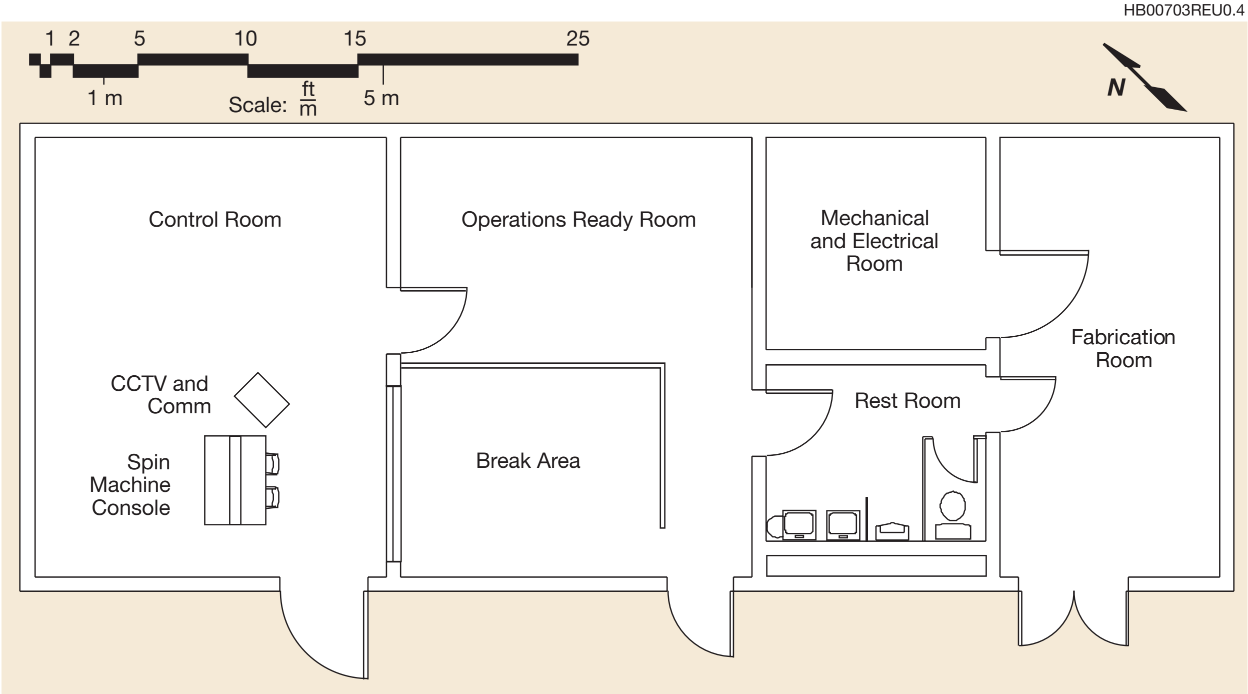


**Figure 7-12. Control Room (Building 1605)**

### 7.2.3 Astrotech Space Operations Facilities

The Astrotech facilities are located on 24.3 hectares (60 acres) of land at Vandenberg AFB approximately 3.7 km (2 mi) south of the Delta II launch complex (SLC-2) along Tangair Road. 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: www.spacehab.com/aso/reference. htm.

### 7.2.4 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 integrated processing facility (IPF) because both booster components and payloads (satellite vehicles) can be processed in the building at the same time. A complete description of the SSI facilities can be found on the Spaceport Systems Internationl Web site: www.calspace.com.

## 7.3 PAYLOAD ENCAPSULATION AND TRANSPORT TO LAUNCH SITE

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 fairing launch vehicles. For purposes of this document, discussions are limited to Astrotech and SSI facilities.

Prior to or after payload arrival, the fairing and PAF enter a high bay to be prepared for payload encapsulation. The fairing bisectors or trisectors 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 (a certified weight statement will suffice), the payload is mated to the PAF and integrated checkout is performed. The previously prepared fairing bisectors or trisectors are then moved into position for final mate, and the personnel access platforms are positioned for personnel access to the fairing mating plane. (These access platforms 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 transporter provided by the Delta Program and prepared for transport to the launch pad. Environmental controls are established, and a protective cover is installed. The basic sequence of operations is illustrated in Figure 7-13.

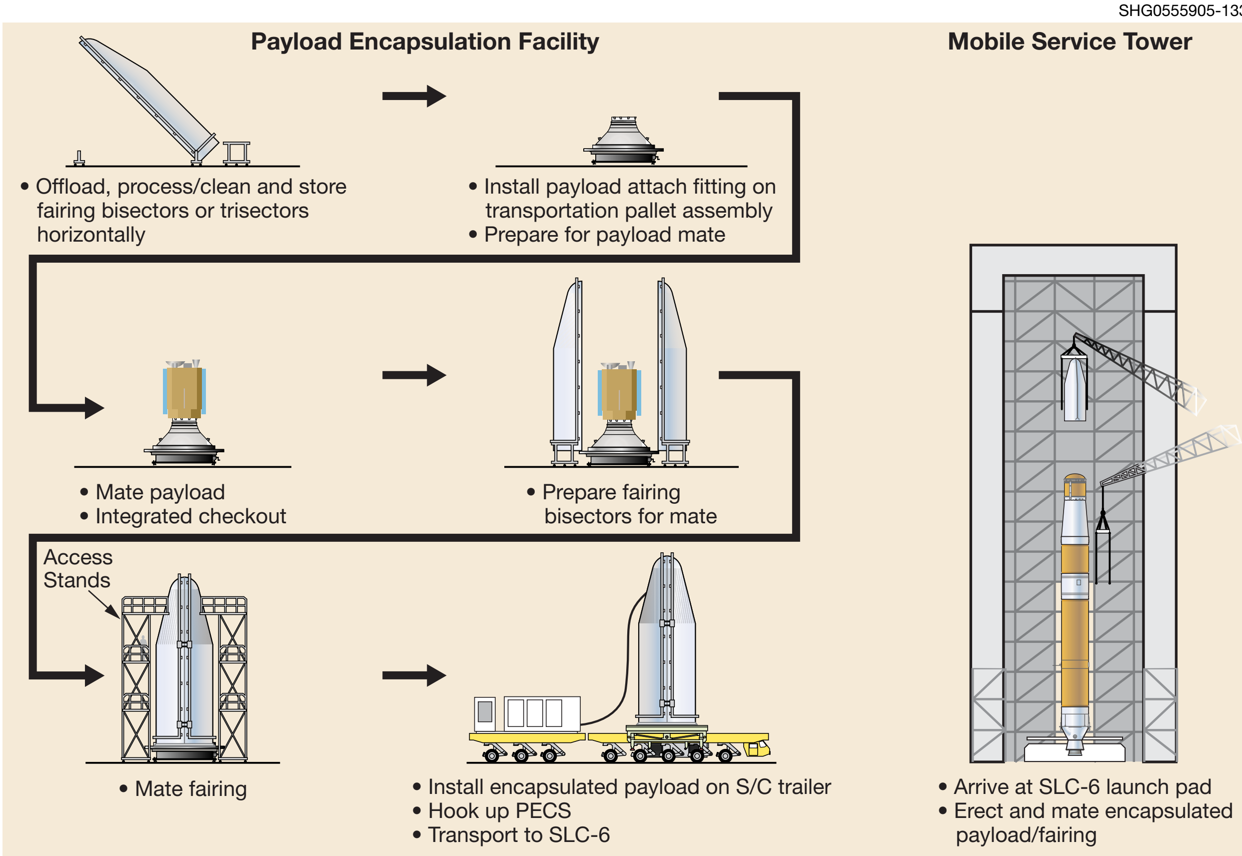


**Figure 7-13. Payload Encapsulation, Transport, and On-Pad Mate—4-m Fairing Example**

The payload is transported to the launch pad at a maximum speed of 8 km/hr (5 mph). The Delta Program uses PC-programmed monitors to measure and record the transport dynamic loads. The transport loads will be less than flight loads and will be verified by pathfinder tests (if required) prior to first use with the payload. 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 mobile service tower (MST) and immediately mated to the second stage. Environmental control is reestablished as soon as possible with class 5000 air. During payload hoist onto the launch vehicle, no environmental control system (ECS) services will be provided to the spacecraft. If ECS service is required during payload hoist operation, that service will be negotiated with the customer.

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

## 7.4 SPACE LAUNCH COMPLEX 6

Space Launch Complex 6 (SLC-6) (Figure 7-14) consists of one launch pad, the Delta Operations Center (DOC), a support equipment building (SEB), a horizontal integration facility (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 7-15.

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**Figure 7-14. Space Launch Complex 6**

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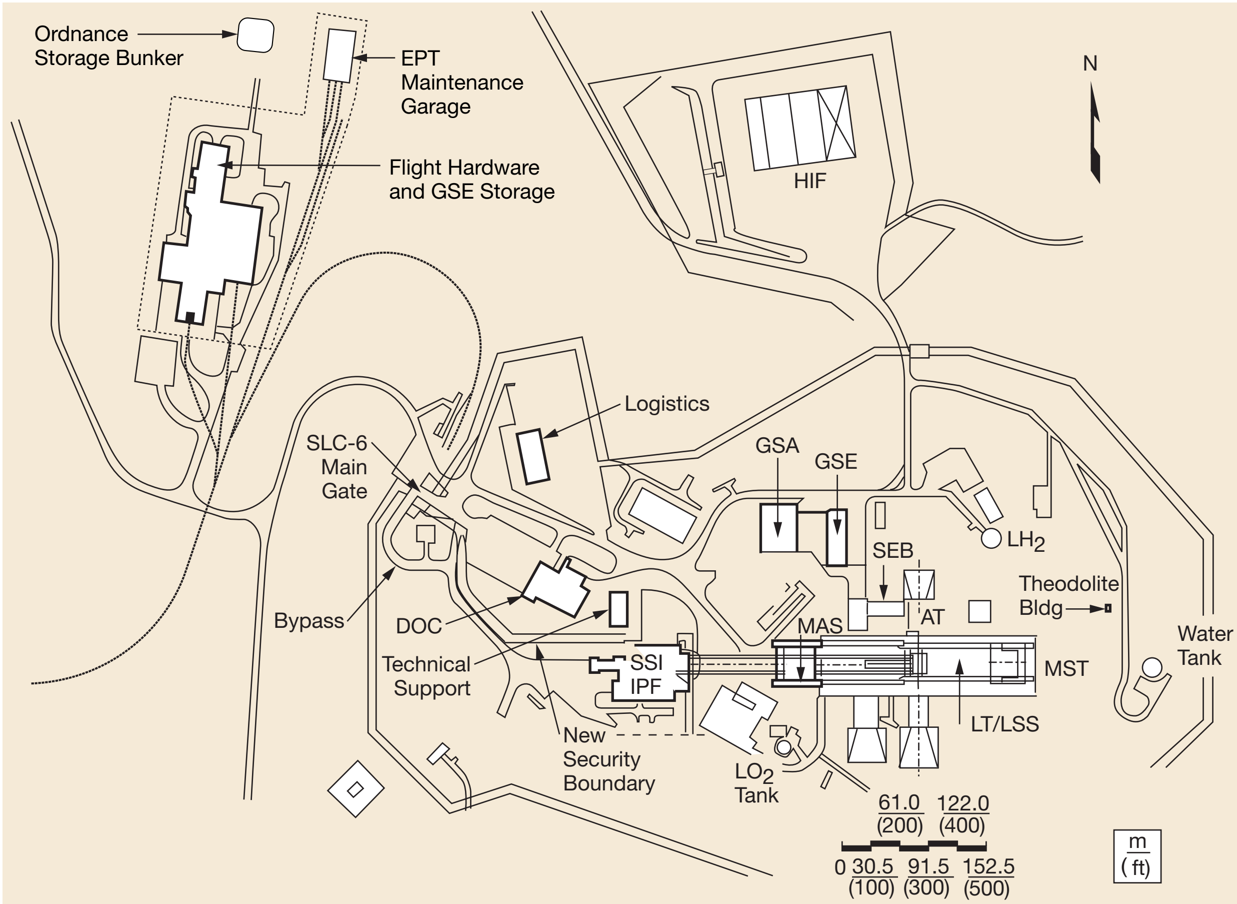


**Figure 7-15. Space Launch Complex 6, VAFB Site Plan**

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. Briefings on all these subjects are given to those required to work in the launch complex area.

### 7.4.1 Mobile Service Tower

The SLC-6 mobile service tower (MST) (Figure 7-16) provides a 79.2-m (260-ft) hook height with 11 working levels. An elevator provides access to the working levels. The payload area encompasses levels 8 through 12. Platform 8 (Figure 7-17) is the initial level through which all traffic to the upper levels is controlled. Figure 7-17 is a typical layout of all upper levels with a few exceptions. Limited space is available on levels 8 to 12 for spacecraft ground support equipment (GSE). Its placement must be coordinated with the Delta Progam, and appropriate seismic restraints provided by the spacecraft customer.

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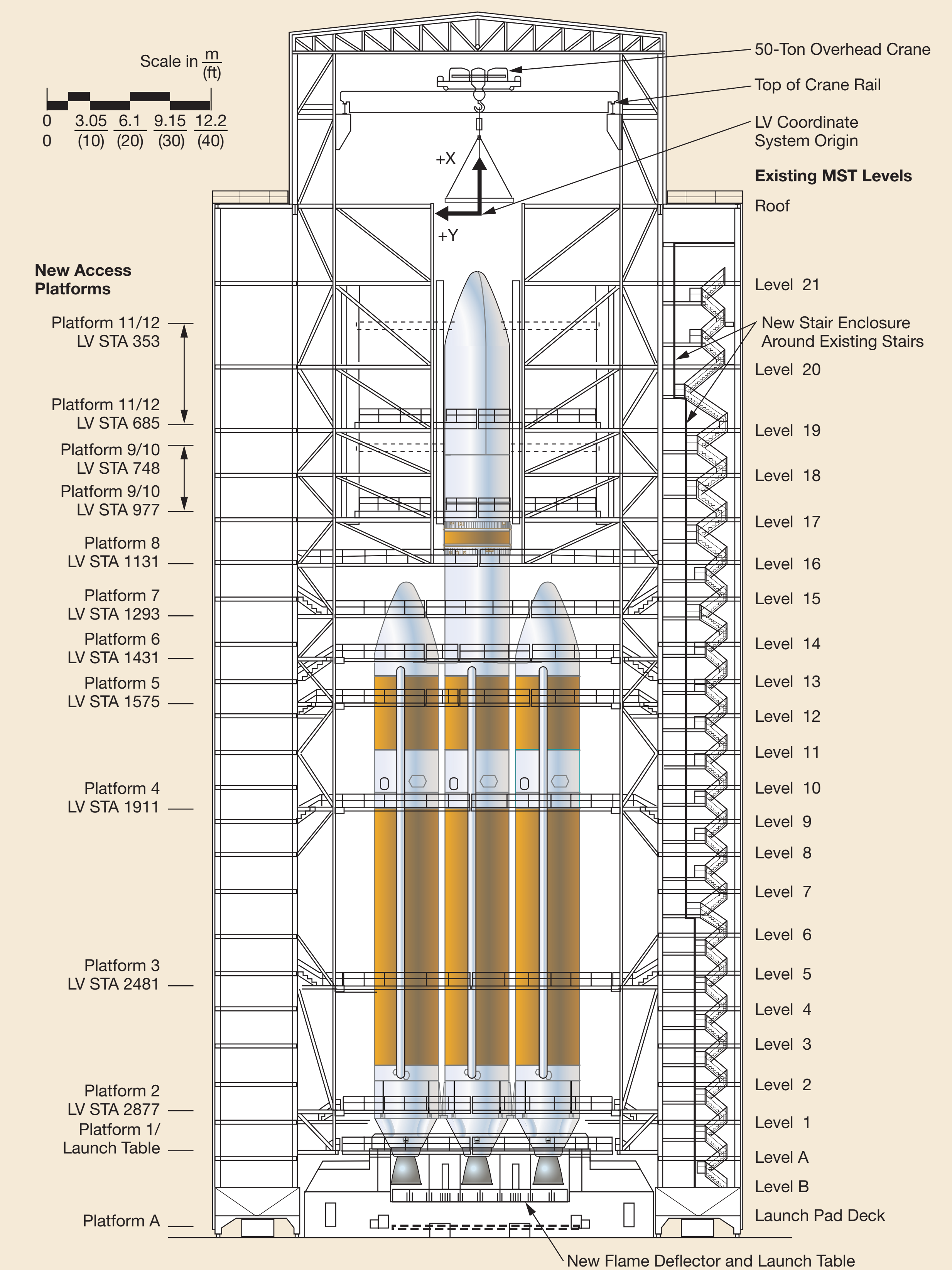


**Figure 7-16. Space Launch Complex 6 MST Elevation**

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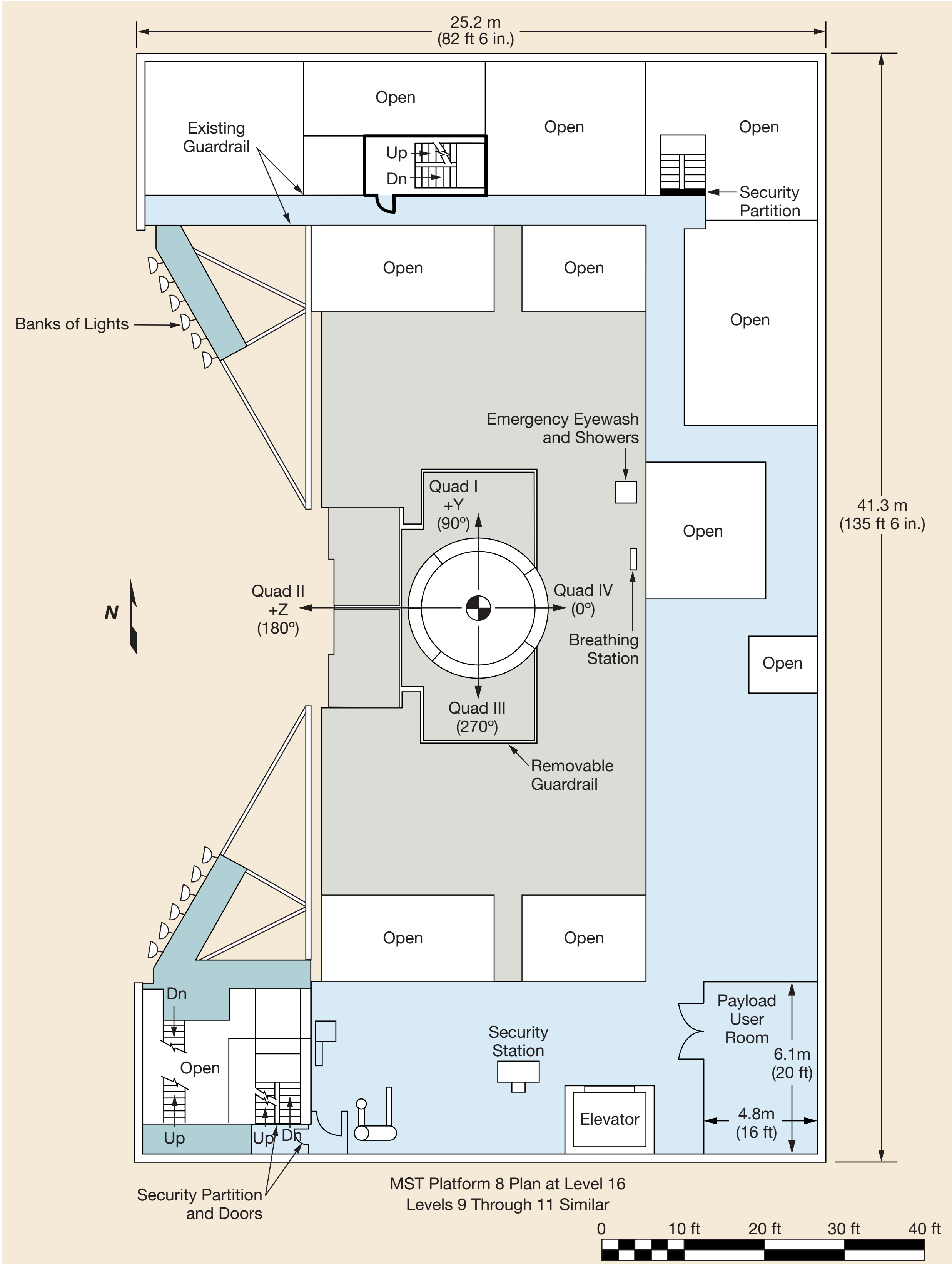


**Figure 7-17. Platform 8 of Space Launch Complex 6 Mobile Service Tower Plan View**

The entire MST is 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.

### 7.4.2 Common Support Buildings

The Delta Operations Center (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 7-18, 7-19, and 7-20 for a floor plan of these facilities.) These structures will not be occupied during launch.

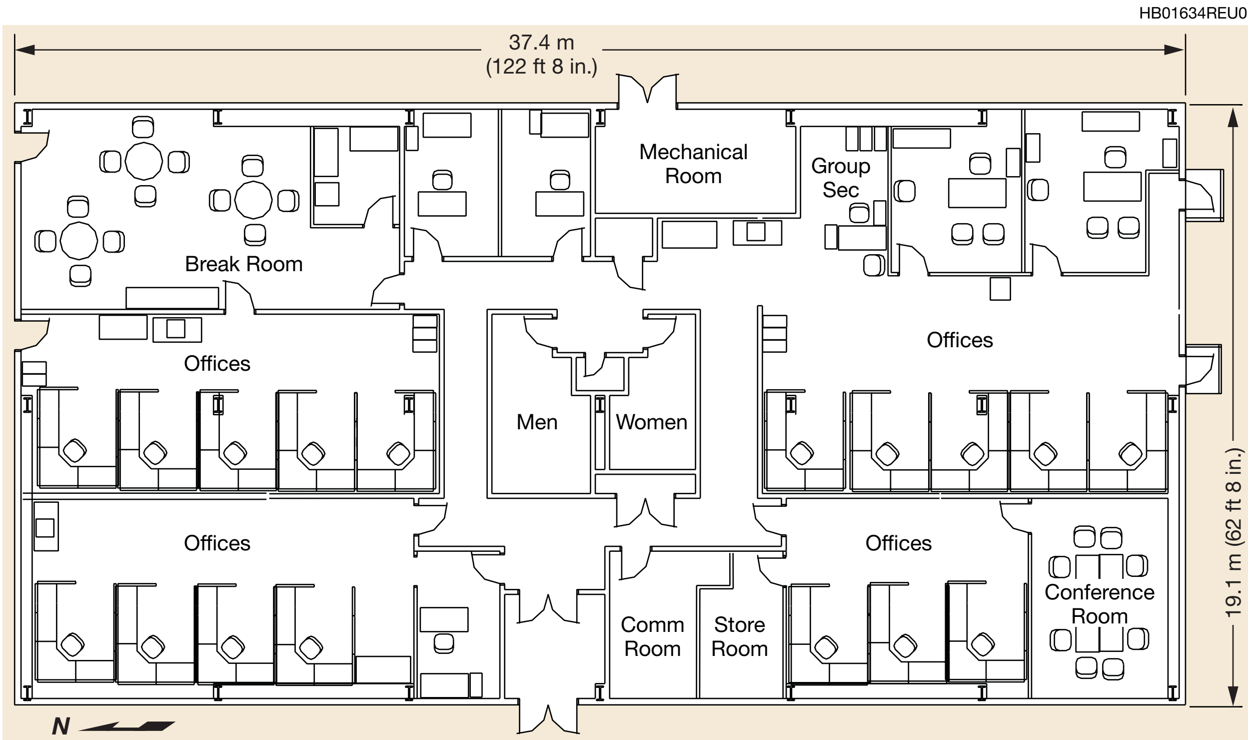


**Figure 7-18. Technical Support Building (TSB) (Building 384)**

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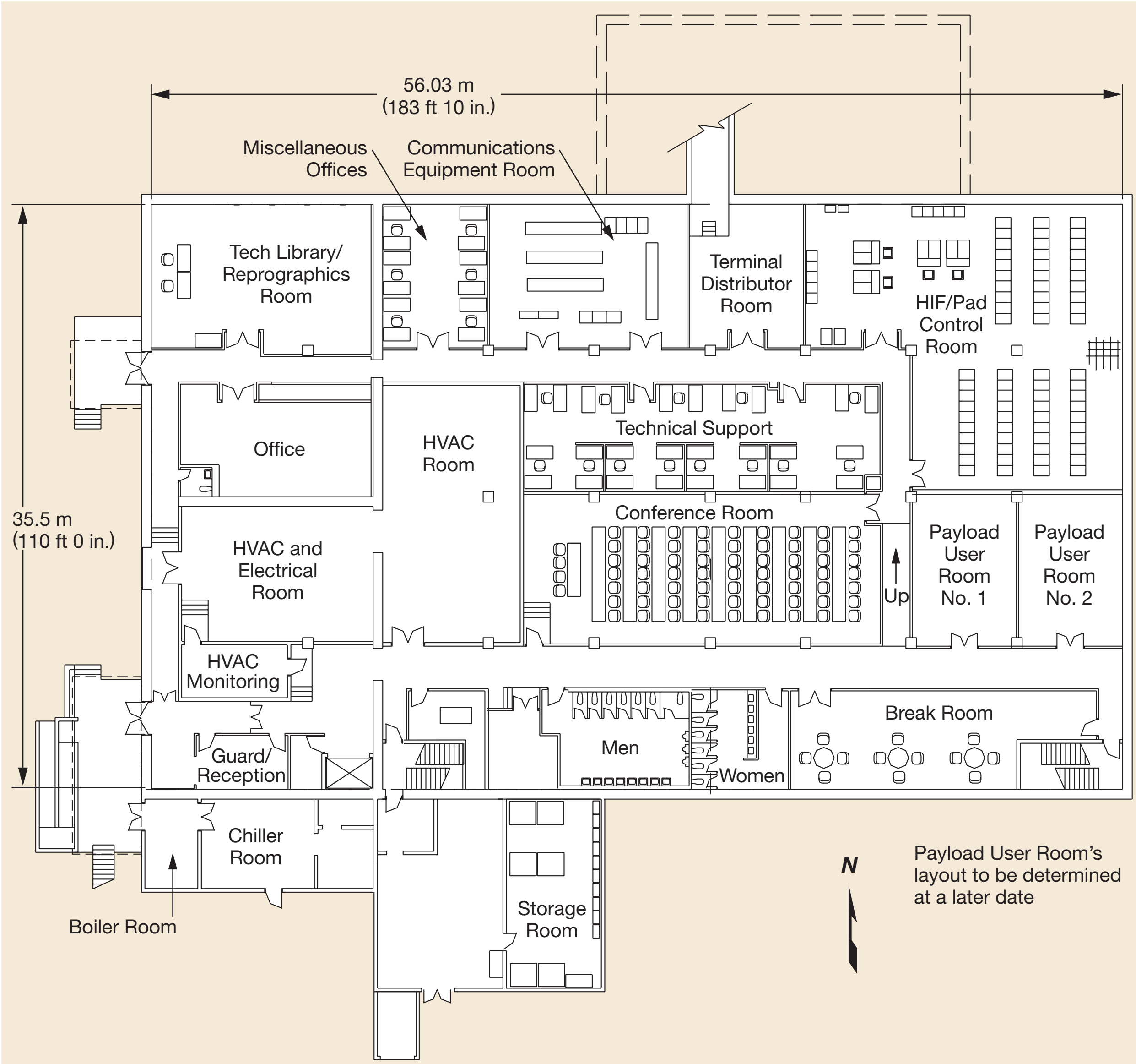


**Figure 7-19. Delta Operations Center (DOC) First Floor (Building 392)**

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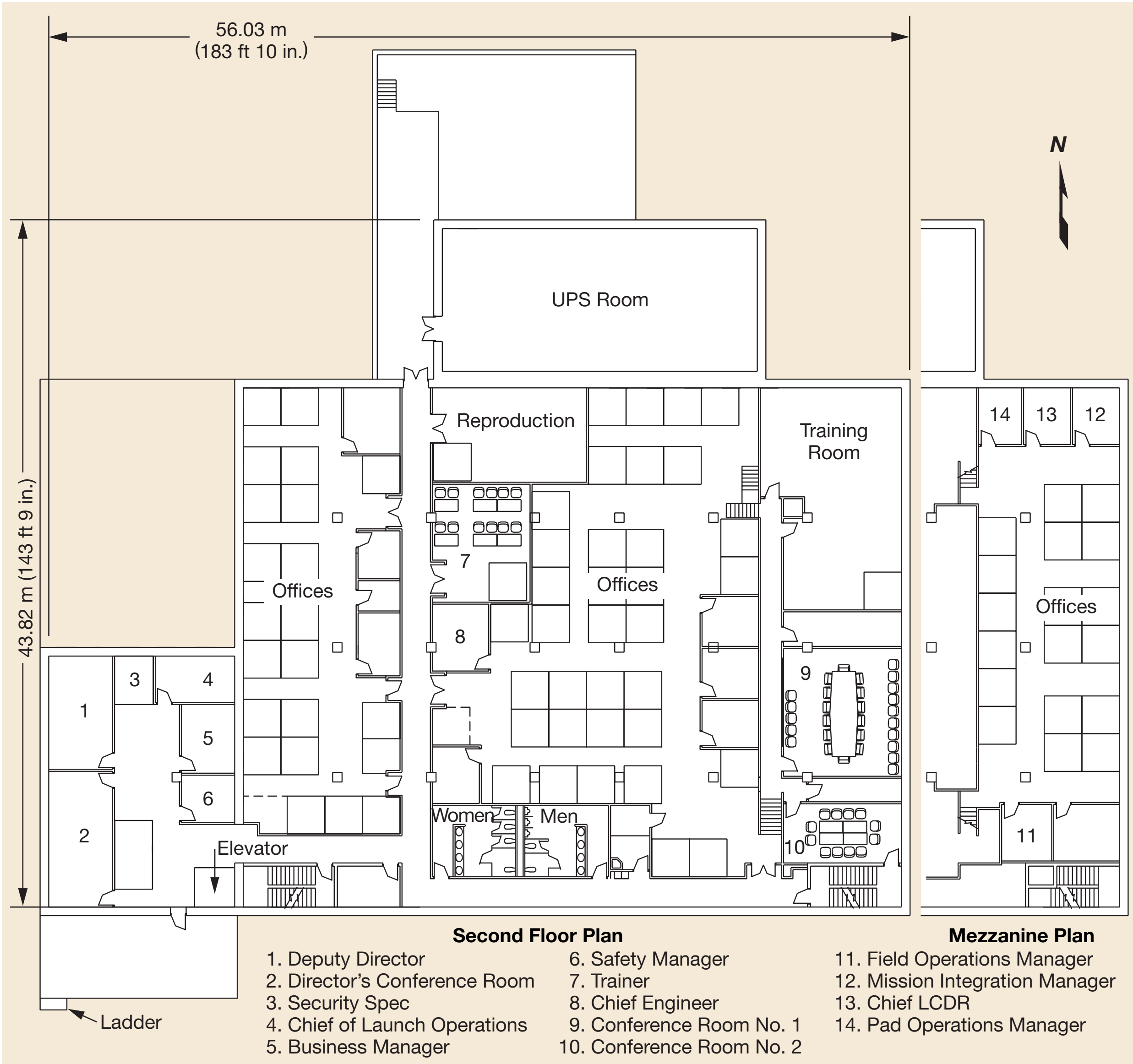


**Figure 7-20. Delta Operations Center (DOC) Second Floor (Building 392)**

## 7.4.3 Integrated Processing Facility

Payload processing may be accomplished in the facilities currently in use for this function. The payloads for the Delta IV program may also be encapsulated in these facilities. The facilities expected to be used are either the SSI integrated processing facility (IPF) or the commercial Astrotech facility.

### 7.4.4 Support Equipment Building

The existing support equipment buildings (SEB) and air-conditioning shelter (facilities 395 and 395A) will be used as the SEB (Figure 7-21.) The SEB will contain the payload air-conditioning equipment and electrical and data communications equipment needed in the near vicinity of the launch vehicle. The SEB will also include personnel support facilities such as toilet and locker rooms, break room/meeting area, and parts storage and tool issue (Figure 7-22). 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. Space is also allocated 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. This structure will not be occupied during launch.

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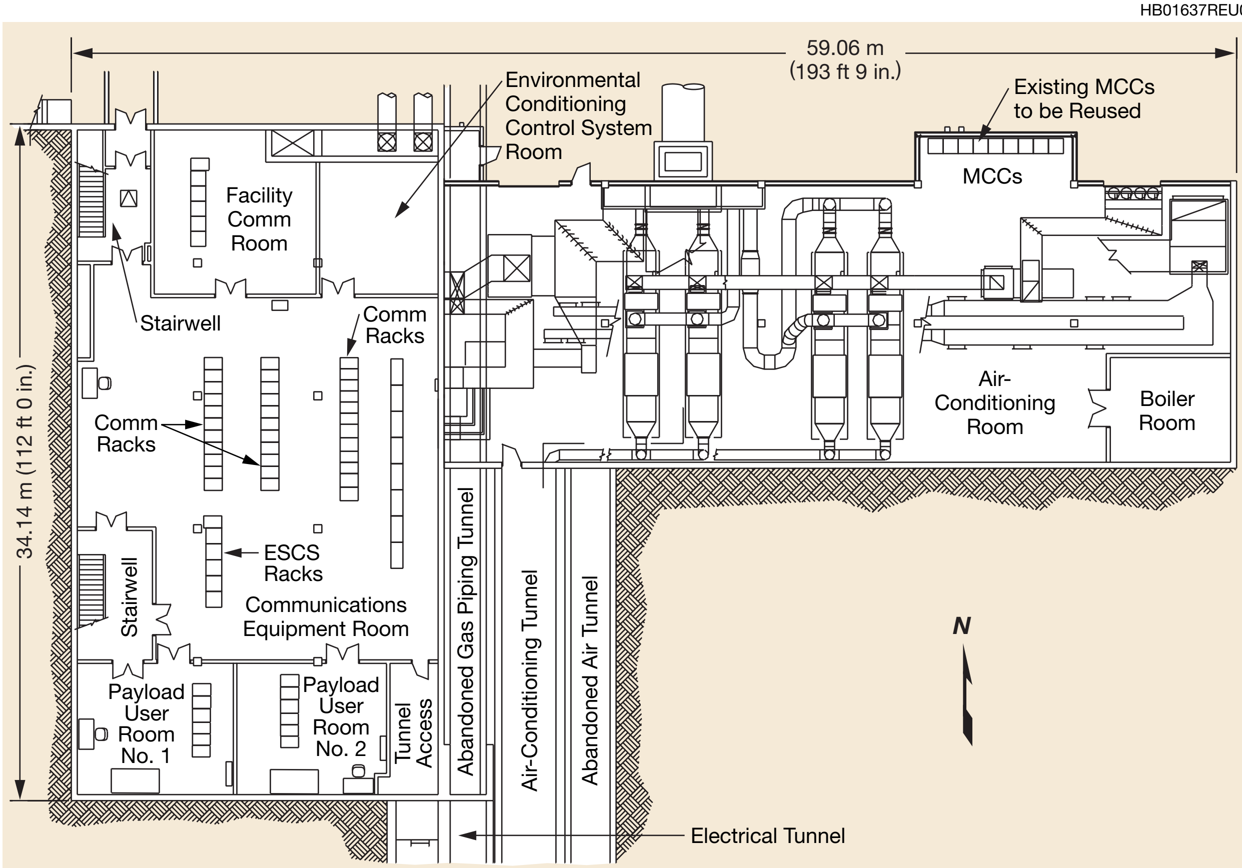


**Figure 7-21. Support Equipment Building (SEB) (Building 395) First-Floor Plan**

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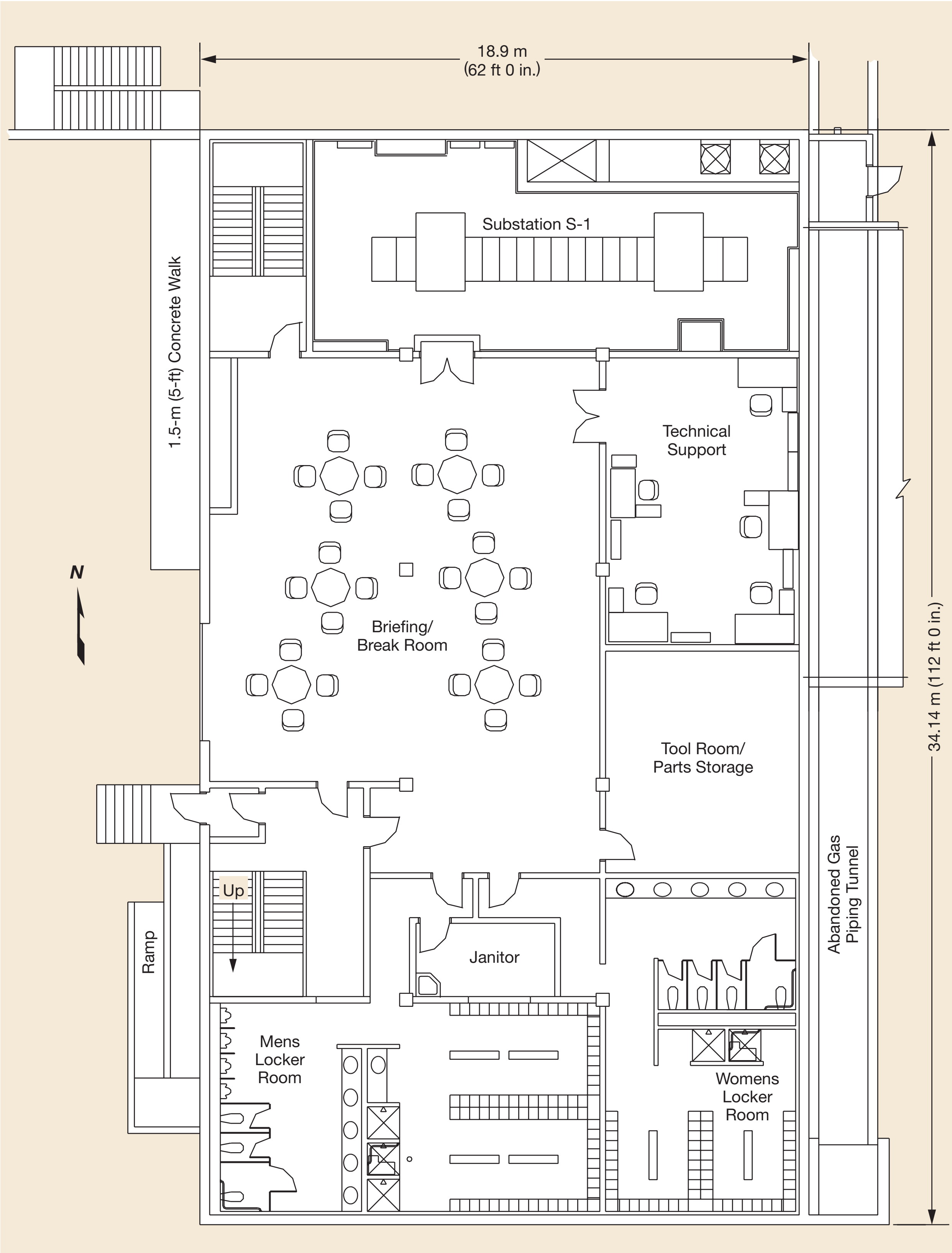


**Figure 7-22. Support Equipment Building (SEB) (Building 395) Second-Floor Plan**

### 7.4.5 Horizontal Integration Facility

Located at the north side of SLC-6 (Figure 7-22), the horizontal integration facility (HIF) 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 (Figures 7-23 and 7-24).

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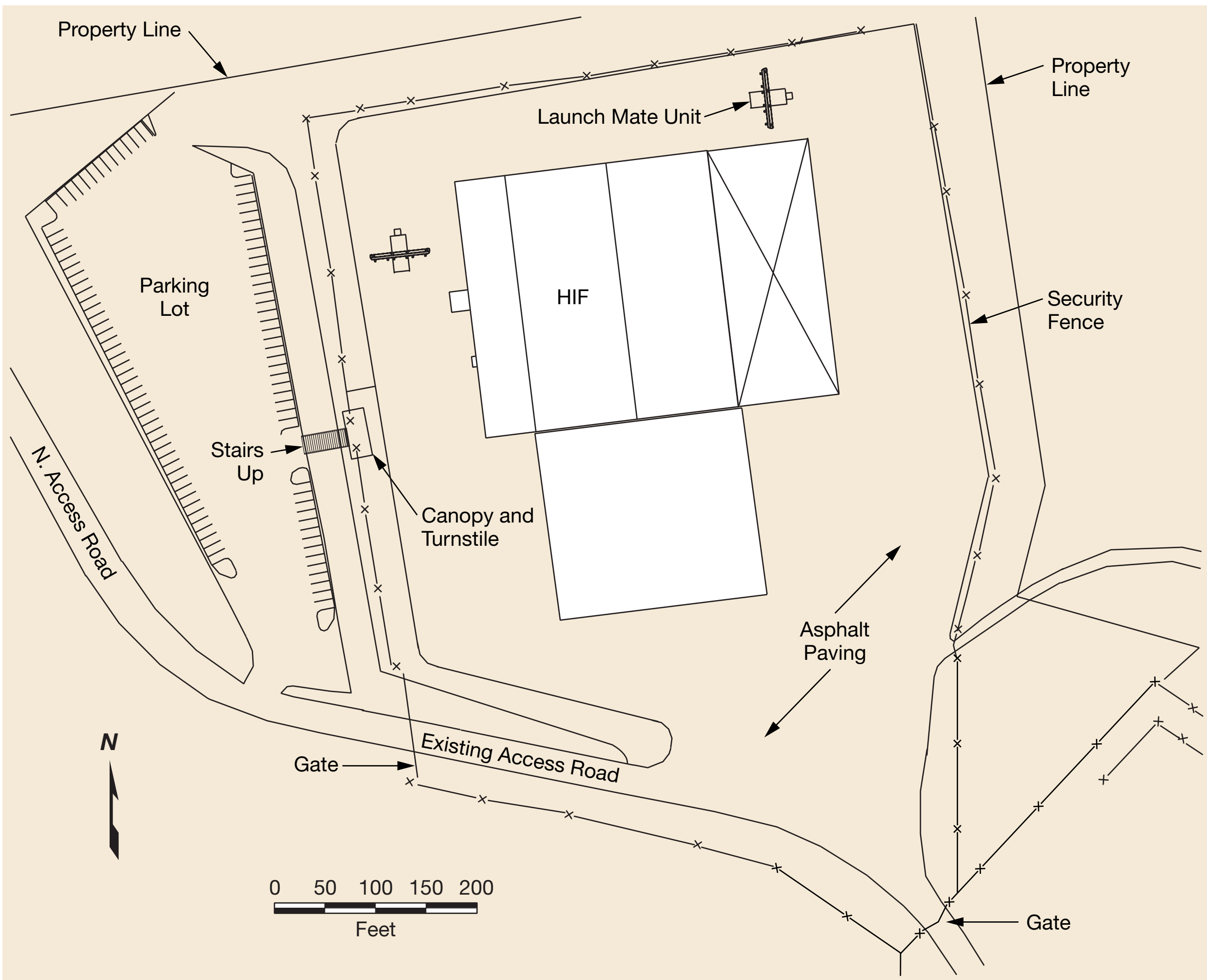


**Figure 7-23. Horizontal Integration Facility (HIF) Site Plan**

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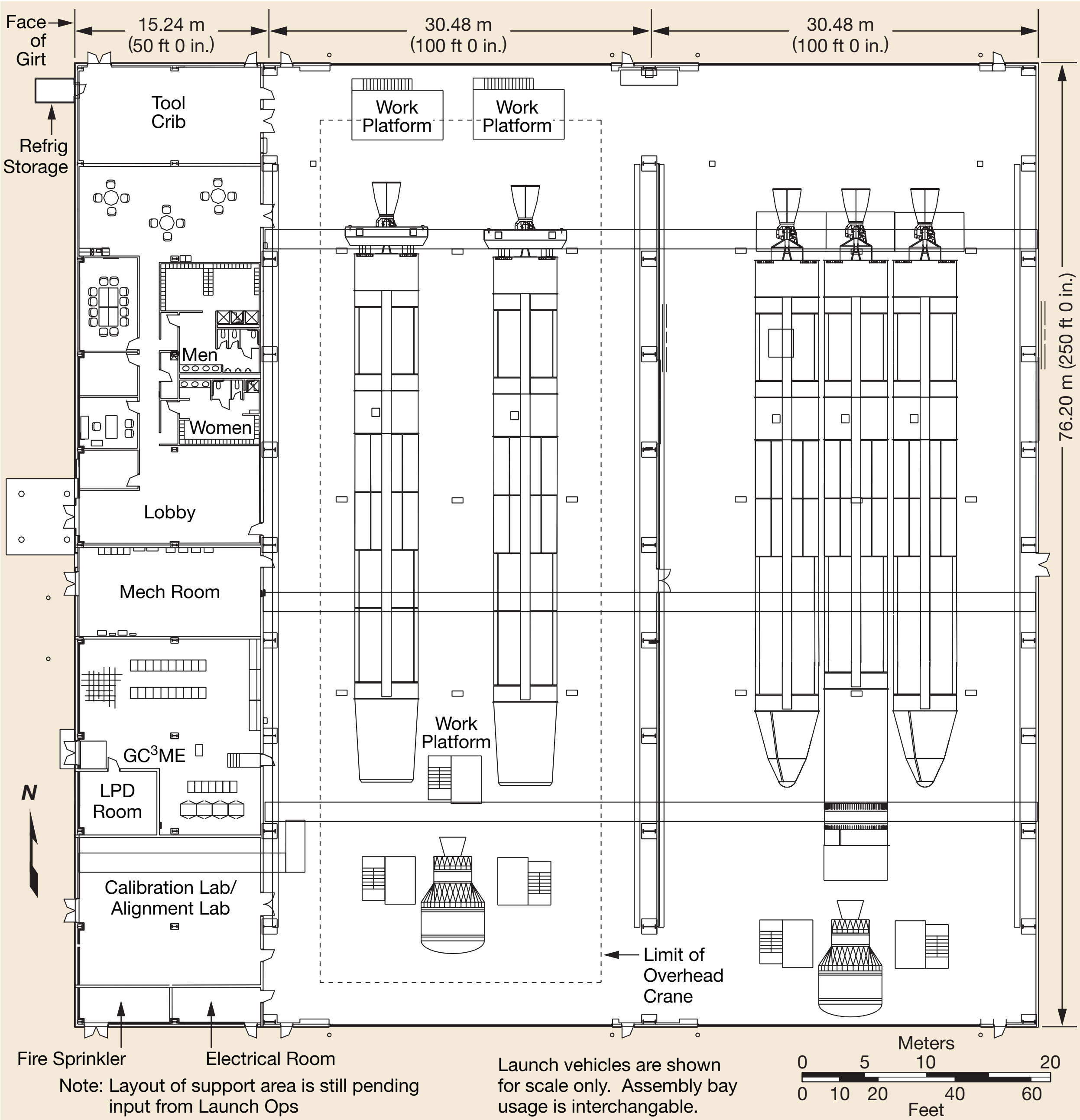


**Figure 7-24. Horizontal Integration Facility (HIF) Floor Plan**

### 7.4.6 Range Operations Control Center

The range operations control center (ROCC) will be used in its current function to control range safety and other range operations. No physical modifications are expected in the ROCC (building 7000) to facilitate support of the Delta IV program.

## 7.5 SUPPORT SERVICES

### 7.5.1 Launch Support

For countdown operations, the launch team is located in the RLCC in building 8510 and in the MDC and LVDC in building 836, with support from other base organizations.

7.5.1.1 Mission Director Center (Building 836). The Mission Director Center (MDC) described in Section 7.2.1.1, Figure 7-8, provides the necessary seating, data display, and communications to observe the launch process. Seating is provided for key personnel from the Delta Program, the Western Range, and the payload control team.

7.5.1.2 Building 8510 Remote Launch Control Center (RLCC). Launch operations are controlled from the remote launch control center (RLCC) building 8510, located on north base behind building 8500 in a secure area (Figure 7-25). 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.

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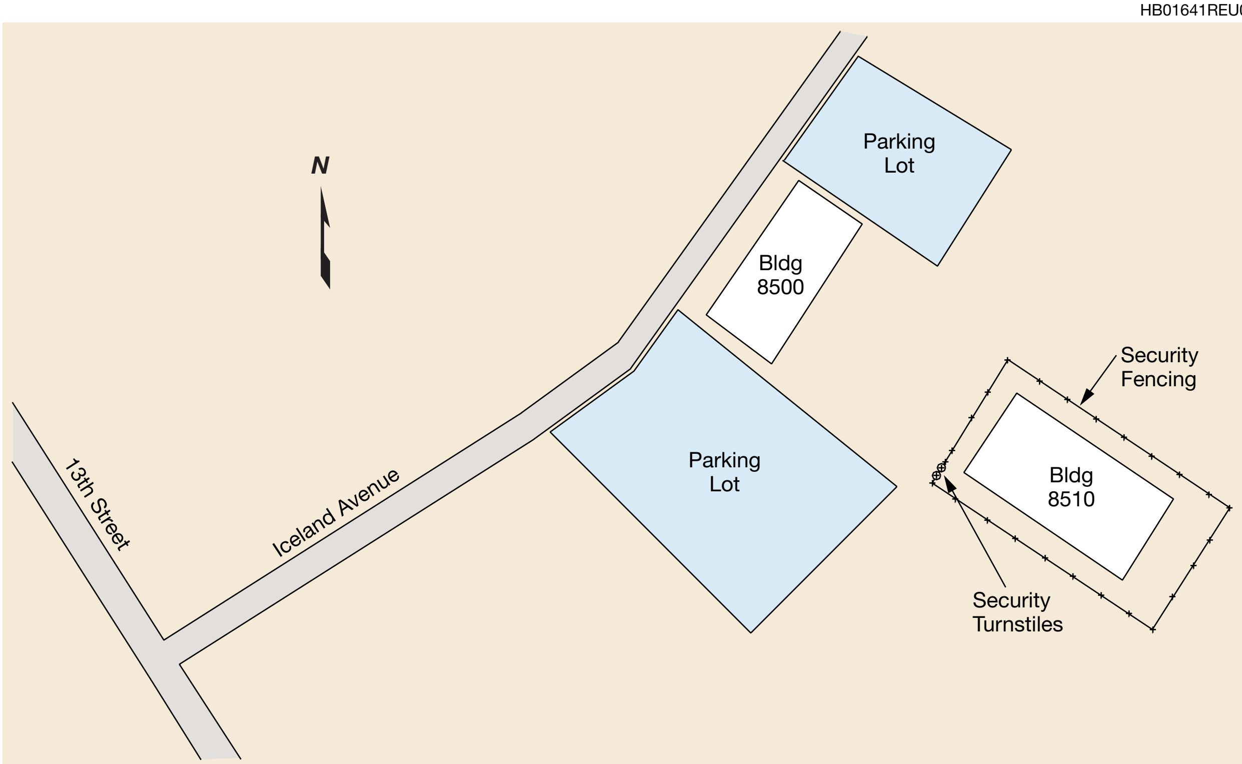


**Figure 7-25. Launch Control Center (Building 8510) Site Plan**

7.5.1.3 Launch-Decision Process. The launch-decision process is made by the appropriate management personnel representing the payload, launch vehicle, and range. Figure 7-26 shows the Delta IV communications flow required to make the launch decision.

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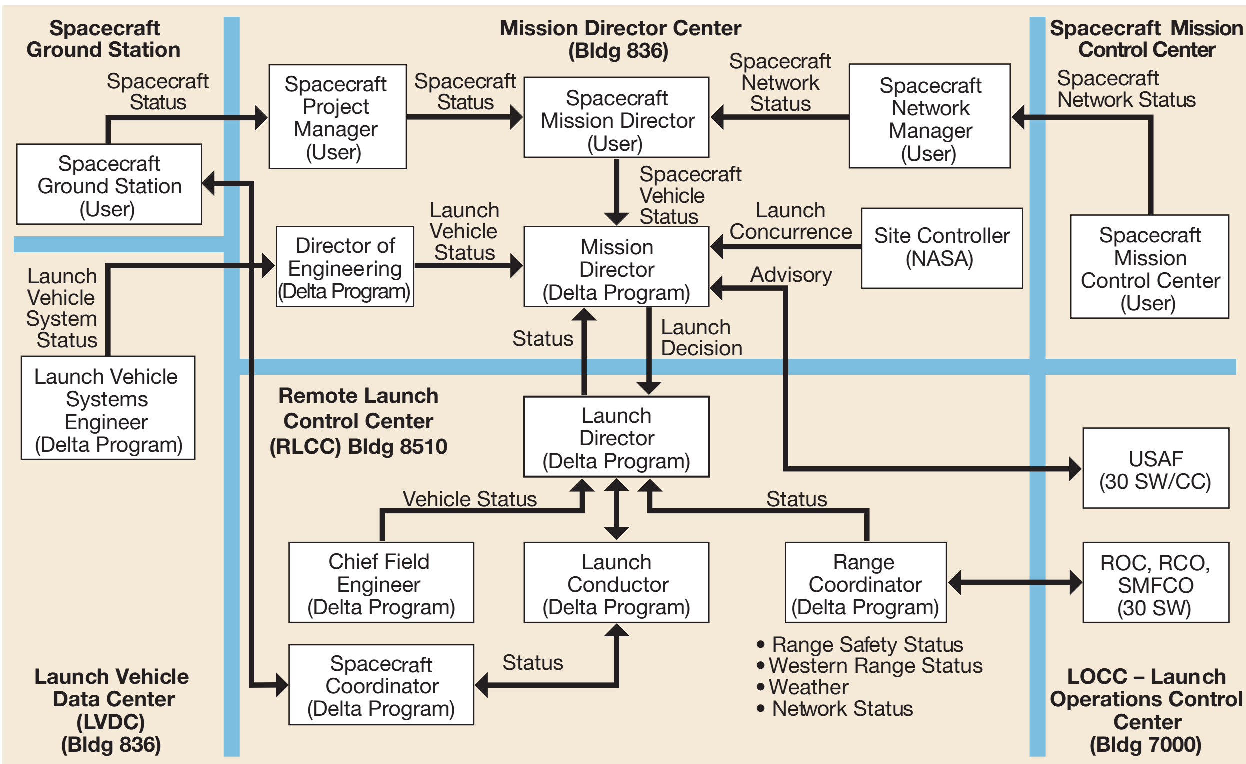


**Figure 7-26. Launch Decision Flow for Commercial Missions—Western Range**

## 7.5.2 Operational Safety

Safety requirements are covered in Section 9 of this document. In addition, it is the Delta Program Office 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 Delta Program spacecraft coordinator and presented by appropriate safety personnel.

## 7.5.3 Security

7.5.3.1 VAFB Security. For access to VAFB, U.S. citizens must provide to the Delta Program security coordinator NLT 7 days prior to arrival, full name with middle initial (if applicable), company name, company address and telephone number, and dates of arrival and expected departure. Delta Program security will arrange for entry authority for commercial missions or individuals sponsored by the Delta Program. Access by U.S. government-sponsored foreign nationals is coordinated by their sponsor directly with the USAF at VAFB. For non-U.S. 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 the Delta Program Office 2 months prior to the VAFB entry date. Government-sponsored individuals must follow U.S. government guidelines as appropriate. After Delta Program security obtains entry authority approval, entry to VAFB will be the same as for US citizens.

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

7.5.3.2 VAFB Security, Space Launch Complex 6. SLC-6 security is ensured by perimeter fencing, interior fencing, guards, and access badges. The MST is configured to support security for Priority-A resources.

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

7.5.3.3 Spacecraft Processing Laboratories. Physical security at the payload processing laboratories (building 836) is provided by door locks and guards. Details of the payload security requirements are arranged through the Delta Program spacecraft coordinator or appropriate payload processing facility.

### 7.5.4 Field-Related Services

The Delta Program employs certified propellant handlers wearing propellant handler's ensemble (PHE) 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. The Delta Program has access to a machine shop, metrology laboratory, $LO_2$ cleaning facility, and proof-loading facility. Delta Program operational team members are familiar with USAF, NASA, and commercial payload processing facilities at VAFB and can offer all of these skills and services to the payload project during the launch program.

## 7.6 DELTA IV PLANS AND SCHEDULES

### 7.6.1 Mission Plan

For each launch campaign, a mission plan is developed showing major tasks in a weekly timeline format. The plan includes launch vehicle activities, prelaunch reviews, and payload PPF occupancy times.

### 7.6.2 Integrated Schedules

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

Payload/launch vehicle schedules are similar from mission to mission from the time of payload weighing (if required) until launch.

Daily schedules are prepared on hourly timelines for these integrated activities. Daily schedules will typically cover the encapsulation effort in the PPF and all days-of-launch countdown activities. PPF tasks include payload weighing, if required, spacecraft-to-PAF mate and interface verification, and fairing encapsulation of the payload. Figures 7-27 and 7-28, show notional processing time lines for Delta IV M+(4,2), and Delta IV Heavy with a composite fairing.

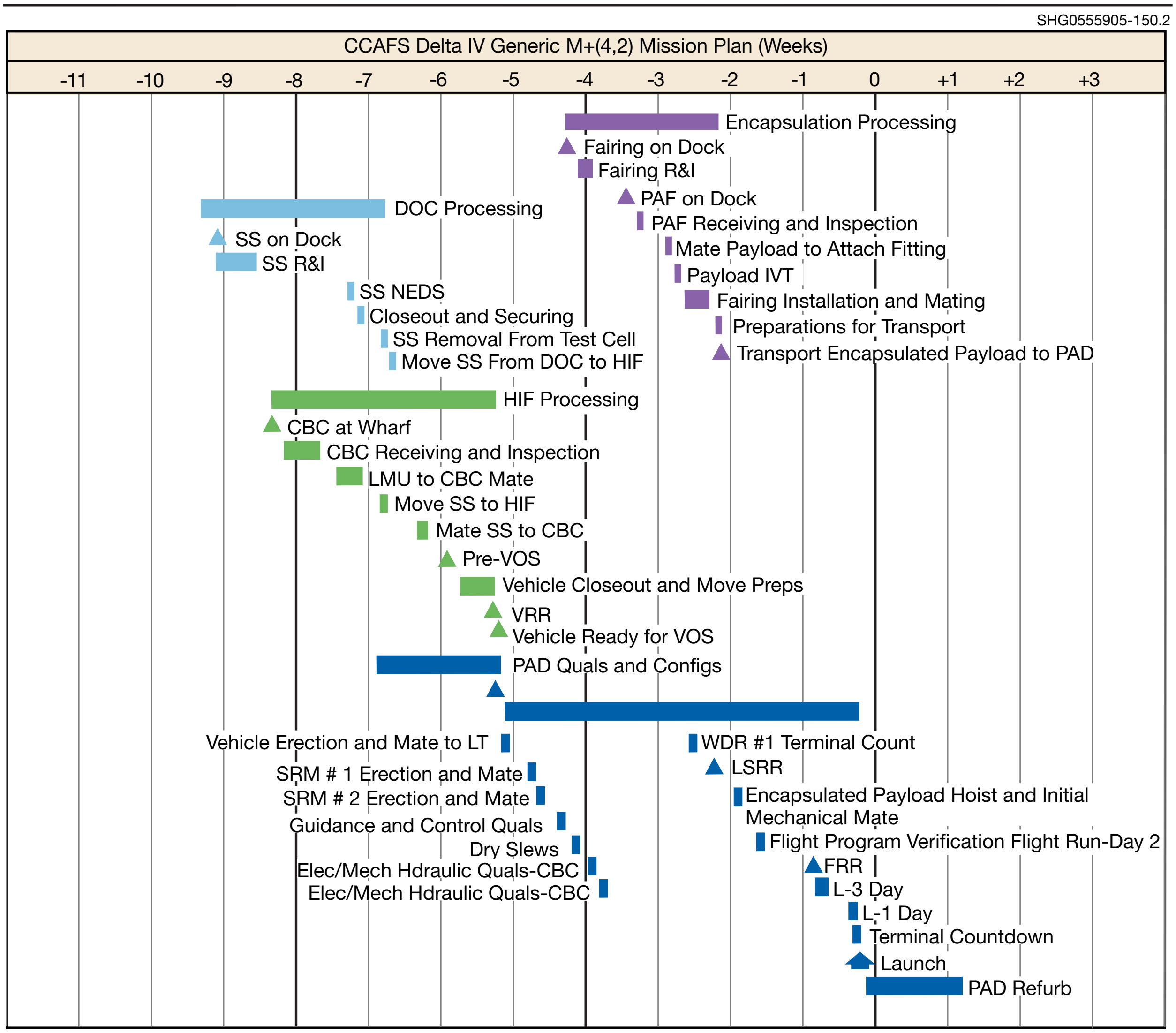


**Figure 7-27. Projected Processing Timeline—Delta IV M+(4,2) Launch Vehicle (rev. Q)**

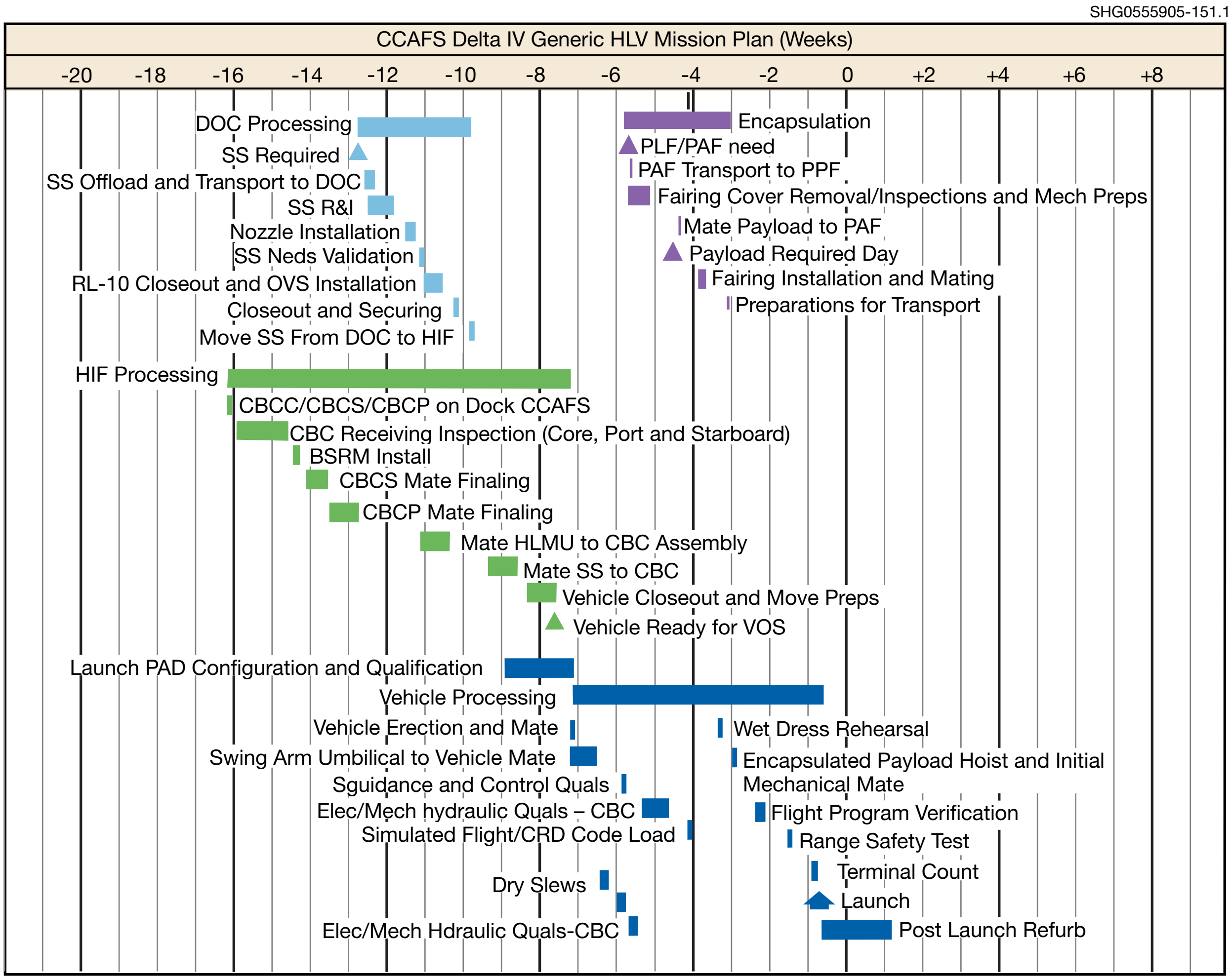


**Figure 7-28. Projected Processing Timeline—Delta IV Heavy Launch Vehicle (rev. Q)**

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 spacecraft contractor. 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. 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 countdown documents. The schedule of payload activities during that time is controlled by the Boeing launch operations manager.

### 7.6.3 Spacecraft Schedules

The customer will supply schedules to the Delta Program spacecraft coordinator, who will arrange support as required.

## 7.7 DELTA IV MEETINGS AND REVIEWS

During the launch scheduling preparation, various meetings and reviews occur. Some of these will require customer input while others allow the customer to monitor the progress of the overall mission. The Delta mission integration manager will ensure adequate customer participation.

### 7.7.1 Meetings

Delta status meetings are generally held once a week. They include a review of the activities scheduled and accomplished since the last meeting, a discussion of problems and their solutions, and a review of the mission schedule. Customers are encouraged to attend these meetings.

Daily schedule meetings are held to provide team members with their assignments and to summarize the previous or current day's accomplishments. These meetings are attended by the launch conductor, technicians, inspectors, engineers, supervisors, and the spacecraft coordinator. Depending on testing activities, these meetings are held at either the beginning or the end of the first shift.

### 7.7.2 Prelaunch Review Process

Periodic reviews are held to ensure that the payload and launch vehicle are ready for launch. The mission plan shows the relationship of the review to the program assembly and test flow.

The following paragraphs discuss the Delta IV readiness reviews.

**7.7.2.1 Postproduction Review.** A postproduction meeting is conducted at Decatur, Alabama, to review the flight hardware at the end of production and prior to shipment to VAFB.

**7.7.2.2 Mission Analysis Review.** A mission analysis review is held at Denver, Colorado, approximately 3 months prior to launch to review mission-specific drawings, studies, and analyses.

**7.7.2.3 Pre-Vehicle-On-Stand Review.** A pre-vehicle-on-stand (Pre-VOS) review is held approximately L-12 weeks at VAFB subsequent to the completion of HIF processing and prior to erection of the launch vehicle on the launch pad. It includes an update of the activities since manufacturing, the results of the HIF processing, and any hardware history changes. Launch facility readiness is also discussed.

**7.7.2.4 Flight Readiness Review.** A flight readiness review (FRR), typically held on L-5 day, is a status of the launch vehicle after initial pad processing and a mission analysis update. It is conducted to ensure that the launch vehicle and space vehicle are ready for countdown and launch. Upon completion of this meeting, authorization to proceed with the final phases of countdown preparation is given. This review also assesses the readiness of the range to support launch, and provides a predicted weather status.

7.7.2.5 Launch Readiness Review. Launch readiness review (LRR) is held on L-1 day. All agencies and contractors are required to provide a ready-to-launch statement. Upon completion of this meeting, authorization to enter terminal countdown is given.

# Section 8
# PAYLOAD INTEGRATION

This section describes the payload integration process (24-month baseline) and the supporting documentation requirements.

## 8.1 INTEGRATION PROCESS

The integration process (Figure 8-1) developed by the Delta Program is designed to support the payload requirements as well as the requirements of the launch vehicle. The Delta Program will work with customers to tailor the integration flow to meet their individual program requirements. The typical integration process encompasses the entire cycle of launch vehicle/payload integration activities; L-date is defined as calendar weeks, including workdays and scheduled non-workdays, such as holidays. At its core is a streamlined series of documents, reports, and meetings that are flexible and adaptable to the specific requirements of each program.

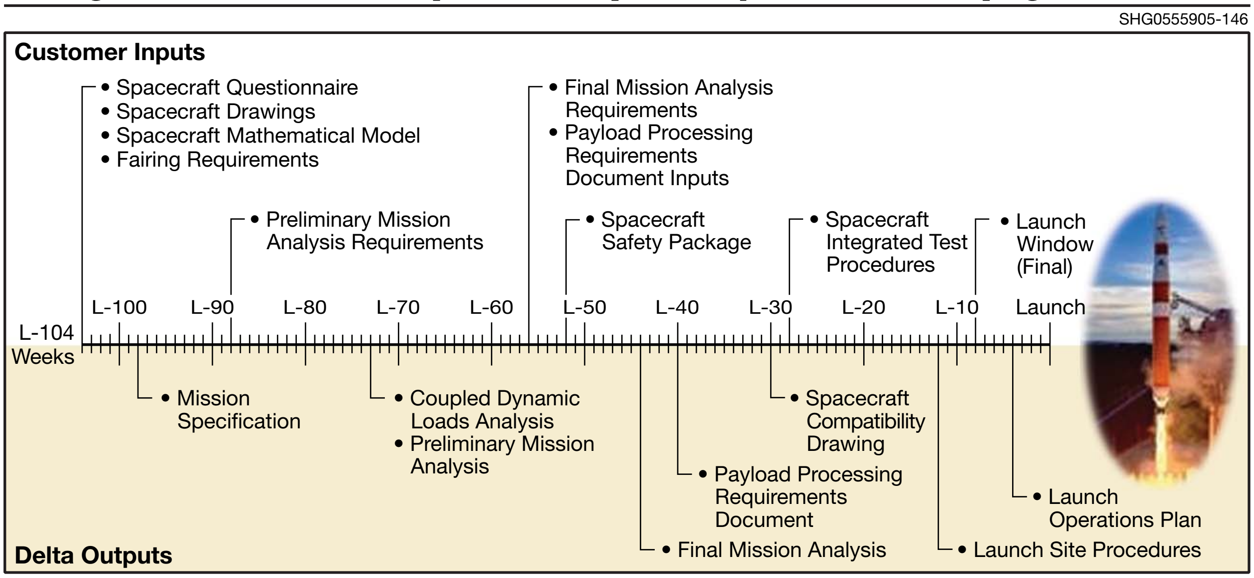


**Figure 8-1. Typical Mission Integration Process**

Mission integration for commercial and government missions is the responsibility of the Delta Program Office located in Denver, Colorado. The objective of mission integration is to coordinate all interface activities required for a successful launch, including the development of a mission specification, interface planning, coordination, and scheduling.

The Delta Program team assigns a mission integration manager to work with the customer and coordinate all mission-related interface activities. The mission integration manager develops a mission-specific integration planning schedule for both the launch vehicle and the payload by defining the documentation and analysis required. The mission integration manager also synthesizes payload requirements, engineering design, and launch environments into a controlled mission specification that establishes and documents all agreed-to interface requirements.

The mission integration manager ensures that all lines of communication function effectively. To this end, all pertinent communications, including technical/administrative documentation, technical interchange meetings (TIM), and formal integration meetings are coordinated by the mission integration manager. These lines of communication exist not only between the customer and the Delta Program, but also include other agencies involved in the Delta IV launch. Figure 8-2 illustrates the relationships among agencies involved in a typical Delta IV mission.

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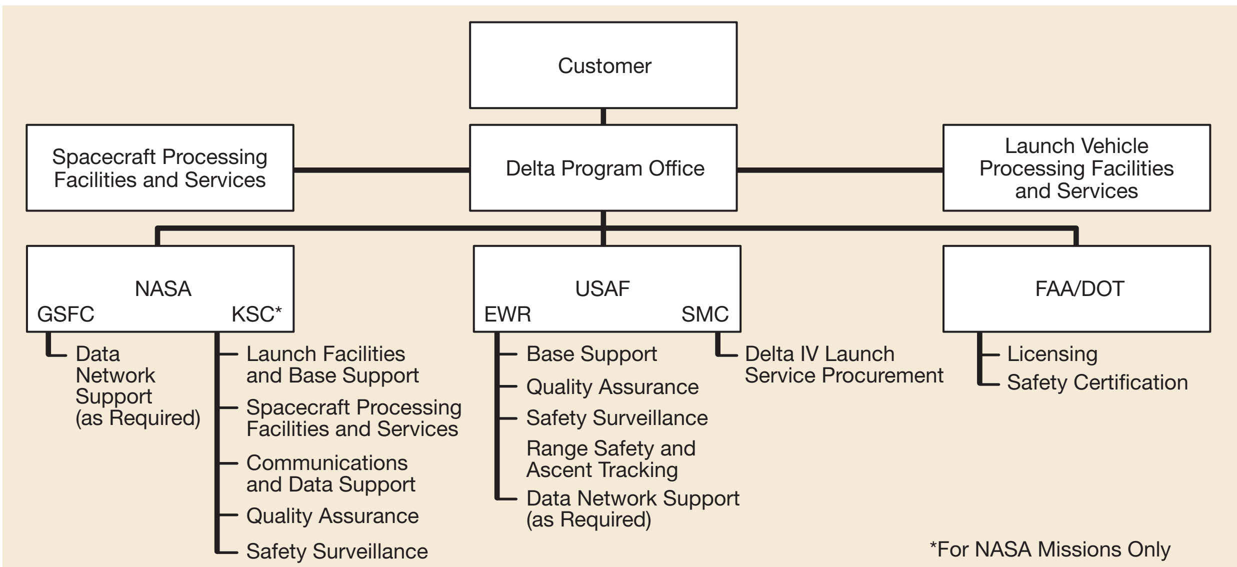


**Figure 8-2. Typical Delta IV Agency Interfaces**

## 8.2 DOCUMENTATION

Effective integration of the payload into the Delta IV launch system requires diligent, timely preparation and submittal of required documents. When submitted, these documents represent the primary communication of requirements, safety provisions, and system descriptions to each of the launch support agencies. The Delta Program Office acts as the administrative interface to assure proper documentation has been provided to the appropriate agencies. All formal and informal data are routed through this office. Relationships of the various categories of documentation are shown in Figure 8-3.

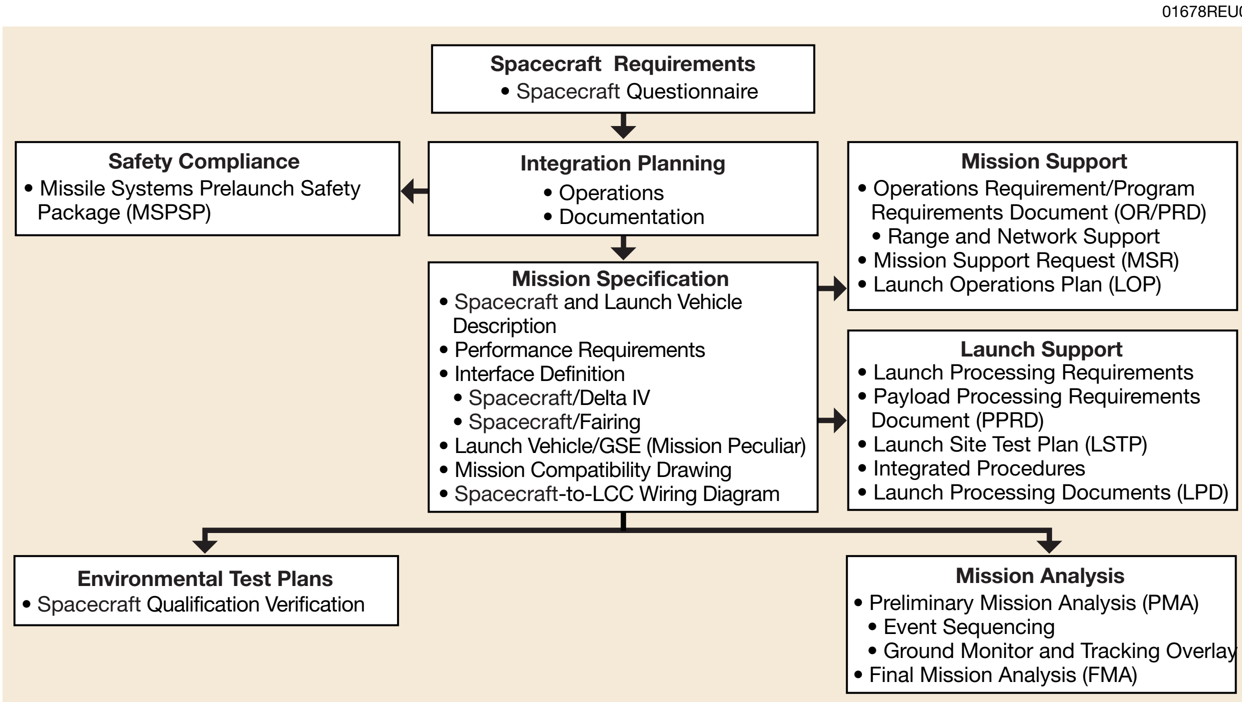


**Figure 8-3. Typical Document Interfaces**

A typical integration planning schedule is shown in Figure 8-4. Each data item listed in Figure 8-4 has an associated L-date (weeks before launch). The party responsible for each data item is identified. Close coordination with the Delta IV mission integration manager is required to achieve successful planning of integration documentation.

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| Task Name | OPR | Due Date (Weeks) |
|---|---|---|
| 1. SC Questionnaire/IRD | C | L-104 |
| 2. Fairing Requirements | C | L-104 |
| 3. Launch Vehicle Insignia Artwork | C | L-104 |
| 4. SC Drawings/3D CAD Model (Initial/Final) | C | L-104/L-54 |
| 5. SC Mathematical Model (Initial/Final) | C | L-104/L-54 |
| 6. MSPSP Inputs (Initial/Interim/Final) | C | L-104/L-52/L-26 |
| 7. Mission Specification (Initial/Final) | D | L-98/L-2 |
| 8. Mission Specification Comments | C | L-96 |
| 9. Preliminary Mission Analysis (PMA) Requirements | C | L-88 |
| 10. Integrated Management Plan (IMP) | D | L-85 |
| 11. SC Environmental Test Plan (Initial/Final) | C | L-82/L-24 |
| 12. SC-to-Control Center Wiring Requirements | C | L-80 |
| 13. SC Venting Model | C | L-78 |
| 14. SC Mass Properties Statement (Initial/Update/Final) | C | L-77/L-55/L-18 |
| 15. SC Thermal Model (Initial/Final) | C | L-76/L-35 |
| 16. Coupled Dynamic Loads Analysis (FDLC) | D | L-73 |
| 17. Preliminary Mission Analysis (PMA) | D | L-73 |
| 18. SC Compatibility Drawing (Draft/Initial/Final) | D | L-68/L-54/L-30 |
| 19. SC-to-Control Center Wiring Diagram (Initial/Final) | D | L-66/L-52 |
| 20. Fairing Venting Analysis (Initial/Final) | D | L-66/L-33 |
| 21. Radio Frequency Link Analysis (Initial/Final) | D | L-64/L-27 |
| 22. SC-to-Control Center Wiring Diagram Comments | C | L-62 |
| 23. Thermal Analysis Report (Initial/Final) | D | L-60/L-26 |
| 24. SC Separation Analysis (Initial/Final) | D | L-57/L-33 |
| 25. Launch Window (Initial/Final) | C | L-56/L-8 |
| 26. Final Mission Analysis (FMA) Requirements | C | L-56 |
| 27. Mission Operations and Support Requirements | C | L-56 |
| 28. Payload Processing Requirements Document Inputs | C | L-56 |
| 29. Acoustic and Shock Analysis (Initial/Final) | D | L-52/L-26 |
| 30. Program Requirements Document (PRD) SC Inputs | C | L-52 |
| 31. Radio Frequency Application (RFA) Inputs | C | L-52 |
| 32. SC Contamination Analysis (Initial/Final) | D | L-48/L-20 |
| 33. Final Mission Analysis (FMA) | D | L-44 |
| 34. PAF Fit Check | D | L-40 |
| 35. Payload Processing Requirements Document | D | L-40 |
| 36. SC Compatibility Drawing Comments | C | L-40 |
| 37. SC Environmental Test Report | C | L-33 |
| 38. Program/Operations Requirements Doc. (PRD/ORD) | D | L-29 |
| 39. Radio Frequency Application (RFA) | D | L-29 |
| 40. Coupled Dynamic Loads Analysis (VLC) | D | L-28 |
| 41. SC Integrated Test Procedure Inputs | C | L-28 |
| 42. SC Launch Site Procedures | C | L-28 |
| 43. SC Clearance Drawing | D | L-24 |
| 44. Integrated Countdown Schedule | D | L-16 |
| 45. MSPSP | D | L-15 |
| 46. Launch Site Integrated Procedures | D | L-12 |
| 47. Launch Operations Plan (LOP) | D | L-5 |
| 48. Best-Estimate Trajectory | D | L-4 |
| 49. Vehicle Information Memorandum (VIM) | D | L-4 |
| 50. Launch | D | L-0 |
| 51. Post-Launch Orbit Confirmation Data | C | L+0 |
| 52. Post-Launch Report (Final) | D | L+8 |

Months From Launch: -24 -23 -22 -21 -20 -19 -18 -17 -16 -15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1

D = Delta
C = Customer

**Figure 8-4. 24-Month Nominal Integration Planning Schedule**

The required documents for a typical mission are listed in Figures 8-5 and 8-6. Figure 8-7 describes the contents of the program documents identified. Mission-specific schedules are established by agreement with the customer. The Payload Questionnaire shown in Figure 8-8 is normally completed by the payload agency 104 weeks prior to launch to provide an initial definition of payload characteristics and requirements. A spacecraft interface requirements document (IRD) or launch services requirements document (LSRD) may be used instead of the questionnaire. Figure 8-9 is an outline of a typical payload launch-site test plan describing the launch site activities and operations expected in support of the mission. A set of orbital elements as described in Figure 8-10 is requested from the spacecraft customer to reconstruct the performance of the launch vehicle.

| Description | Figure 8-7 Reference | Nominal Due Weeks - or + Launch |
|---|---|---|
| Spacecraft Questionnaire | 2 | L-104 |
| Fairing Requirements | 8 | L-104 |
| Launch Vehicle Insignia | 15 | L-104 |
| DOT License Information | 2 | L-104 |
| SC Drawings (Initial/Final) | 18 | L-104/L-54 |
| SC Mathematical Model (Initial/Final) | 3 | L-104/L-54 |
| Missile System Prelaunch Safety Package SC Inputs (Initial/Update/Final) | 9 | L-104/L-52/L-26 |
| Mission Specification Comments | 4 | L-96 |
| Preliminary Mission Analysis (PMA) Inputs | 11 | L-88 |
| SC Environmental Test Documents (Initial/Final) | 5 | L-82/L-24 |
| Electrical Wiring Requirements | 7 | L-80 |
| SC Mass Properties Statement (Initial/Update/Final) | 22 | L-77/L-55/L-18 |
| SC-to-LCC Wiring Diagram Review | 28 | L-62 |
| Mission Operational and Support Requirements | 12 | L-56 |
| Payload Processing Requirements Document Inputs | 14 | L-56 |
| Final Mission Analysis (FMA) Inputs | 17 | L-56 |
| Launch Window (Initial/Final) | 16 | L-56/L-08 |
| Radio Frequency Applications Inputs | 10 | L-52 |
| Program Requirements Document Inputs | 13 | L-52 |
| SC Compatibility Drawing Comments | 18 | L-40 |
| Spacecraft Environments and Loads Test Report | 5 | L-33 |
| Spacecraft Launch Site Test Plan | 19 | L-28 |
| SC Integrated Test Procedure Inputs | 21 | L-28 |
| SC Launch-Site Procedures | 20 | L-28 |
| VIM Input | 26 | L-4 |
| Postlaunch Orbit Confirmation Data | 27 | L+1 day |

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**Figure 8-5. Customer Data Requirements**

| Description | Figure 8-7 Reference | Nominal Due Weeks - or + Launch |
|---|---|---|
| Mission Specification (Initial/Final) | 4 | L-98/L-02 |
| Coupled Dynamic Loads Analysis (FDLC/VLC) | 6 | L-73/L-28 |
| Preliminary Mission Analysis (PMA) | 11 | L-73 |
| SC Separation Analysis (Initial/Final) | 24 | L-57/L-33 |
| SC-to-LCC Wiring Diagram (Final) | 28 | L-52 |
| Final Mission Analysis (FMA) | 17 | L-44 |
| Payload Processing Requirements Document (PPRD) | 14 | L-40 |
| SC Compatibility Drawing (Final) | 18 | L-30 |
| Program Requirements Document /Operations Requirements Document | 14 | L-29 |
| RF Compatibility Analysis | 23 | L-27 |
| SC-Fairing Clearance Drawing | 18 | L-24 |
| Integrated Countdown Schedule | 30 | L-16 |
| MSPSP | 9 | L-15 |
| Launch Site Integrated Procedures | 29 | L-12 |
| Launch Operations Plan | 25 | L-5 |
| VIM | 26 | L-4 |

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**Figure 8-6. Delta Program Documents**

| | Item | Responsibility |
|---|---|---|
| **1.** | **Feasibility Study (Optional)**<br>A feasibility study may be necessary to define the launch vehicle's capabilities for a specific mission or to establish the overall feasibility of using the launch vehicle for performing the required mission. Typical items that may necessitate a feasibility study are (1) a new flight plan with unusual launch azimuth or orbital requirements, (2) a precise accuracy requirement or a performance requirement greater than that available with the standard launch vehicle, and (3) a payload that imposes uncertainties with respect to launch vehicle stability.<br>Specific tasks, schedules, and responsibilities are defined before study initiation, and a final report is prepared at the conclusion of the study. | Delta Program |
| **2.** | **Spacecraft Questionnaire**<br>The Spacecraft Questionnaire (Table 8-4) is the first step in the process. It is designed to provide the initial definition of spacecraft requirements, interface details, launch site facilities, and preliminary safety data for Delta's various agencies. It contains a set of questions whose answers define the requirements and inter faces as they are known at the time of preparation. The completed questionnaire is required not later than 18 months prior to launch. Additionally, the spacecraft's own IRD or LSRD may replace the questionnaire if the needed data is defined.<br>A specific response to some questions may not be possible because many items are defined at a later date. Of particular interest are answers that specify requirements in conflict with constraints specified herein. Normally, this document is not kept current; it will be used to create the initial issue of the mission specification (Item 4) and in support of our Federal Aviation Administration (FAA)/Department of Transportation (DOT) launch permit.<br>The specified items are typical of the data required for Delta IV missions. The spacecraft contractor is encouraged to include other pertinent information regarding mission requirements or constraints. | Customer |
| **3.** | **Spacecraft Mathematical Model for Dynamic Analysis**<br>A spacecraft mathematical model is required for use in a coupled loads analysis. Acceptable forms include (1) a discrete math model with associated mass and stiffness matrices or (2) a constrained normal mode model with modal mass and stiffness and the appropriate transformation matrices to recover internal responses. Required model information such as specific format, degrees-of-freedom requirements, and other necessary information will be supplied. | Customer |
| **4.** | **Mission Specification**<br>The Delta Mission Specification functions as the Delta launch vehicle interface control document and describes all mission-specific requirements. It contains the spacecraft description, spacecraft-to-opera tions-building wiring diagram interfaces, compatibility drawing, targeting criteria, special spacecraft requirements affecting the standard launch vehicle, description of the mission-specific launch vehicle interfaces, a description of special aerospace ground equipment (AGE) and facilities the Delta Program Office is required to furnish. The document is provided to spacecraft agencies for review and concurrence and is revised as required. The initial issue is based on data provided in the Spacecraft Questionnaire and is provided approximately 98 weeks before launch. Subsequent issues are published as requirements and data become available. The mission-specific requirements documented in the mission specification, along with the standard interfaces presented in this manual, define the spacecraft-to-launch vehicle interface. | Delta Program (input required from Customer) |
| **5.** | **Spacecraft Environmental Test Documents**<br>The environmental test plan documents the spacecraft contractor's approach for qualification and acceptance (preflight screening) tests. It is intended to provide a general test philosophy and an overview of the system-level environmental testing to be performed to demonstrate adequacy of the spacecraft for flight (e.g., static loads, vibration, acoustics, shock). The test plan should include test objectives, test specimen configuration, general test methods, and a schedule. It should not include detailed test procedures.<br>Following the system-level structural loads and dynamic environment testing, test reports documenting the results shall be provided to the Delta Program Office. These reports should summarize the testing performed to verify the adequacy of the spacecraft structure for the flight loads. For structural systems not verified by test, a structural loads analysis report documenting the analyses performed and resulting margins of safety should be provided to Boeing. | Customer |
| **6.** | **Coupled Dynamic Loads Analysis**<br>A coupled dynamic loads analysis is performed to define flight loads to major launch vehicle and space craft structures. The liftoff event, which generally causes the most severe lateral loads in the spacecraft, and the period of transonic flight and maximum dynamic pressure, causing the greatest relative deflections between the spacecraft and fairing, are generally included in this analysis. Output for each flight event includes tables of maximum acceleration at selected nodes of the spacecraft model as well as a summary of maximum interface loads. Worst-case spacecraft-fairing dynamic relative deflections are included. Close coordination between the user and the Delta IV mission integration is essential so that the output format and the actual work schedule for the analysis can be defined. | Delta Program (input required from Customer, item 3) |

**Figure 8-7. Required Documents**

| | Item | Responsibility |
|---|---|---|
| 7. | **Electrical Wiring Requirements**<br>The wiring requirements for the spacecraft to the launch control center (LCC) and the payload processing facilities are needed as early as possible. Section 5 lists the Delta capabilities and outlines details that must be supplied. The Delta Program Office will provide a spacecraft-to-operations-building wiring diagram based on the space craft requirements. It will define the hardware interface from the spacecraft to the LCC for control and monitoring of spacecraft functions after spacecraft installation in the launch vehicle. Close attention to the documentation schedule is required so that production checkout of the launch vehicle includes all of the mission-specific wiring. Any requirements for the payload processing facilities are to be furnished with the LCC information. | Customer |
| 8. | **Fairing Requirements**<br>Early spacecraft fairing requirements should be addressed in the questionnaire and updated in the mission specification. Final spacecraft requirements are needed to support the mission-specific fairing modi fica tions during production. Any in-flight requirements, ground requirements, critical spacecraft surfaces, surface sensitivities, mechanical attachments, RF transparent windows, and internal temperatures on the ground and in flight must be provided. | Customer |
| 9. | **Missile System Prelaunch Safety Package (MSPSP) (Refer to AFSPCMAN 91-710 for specific spacecraft safety regulations)**<br>To obtain approval to use the launch site facilities and resources for launch, an MSPSP must be prepared and submitted to Delta IV mission integration. The MSPSP includes a description of each hazardous system (with drawings, schematics, and assembly and handling procedures, as well as any other information that will aid in appraising the respective systems) and evidence of compliance with the safety require ments of each hazardous system. The major categories of hazardous systems are ordnance devices, radioactive material, propellants, pressurized systems, toxic materials and cryogenics, and RF radiation. The specific data required and suggested formats are discussed in Section 2 of AFSPCMAN 91-710. The Delta Program Office will provide this information to the appropriate government safety offices for their approval. | Customer and Delta Program |
| 10. | **Radio Frequency (RF) Applications**<br>The spacecraft contractor is required to specify the RF transmitted by the spacecraft during ground processing and launch intervals. An RF data sheet specifying individual frequencies will be provided. Names and qualifications are required covering spacecraft contractor personnel who will operate spacecraft RF systems. Data such as transmission frequency bandwidths, frequencies, radiated durations, and wattage will be provided. The Delta Program Office will provide these data to the appropriate range/government agencies for approval. | Customer and Delta Program |
| 11. | **Preliminary Mission Analysis (PMA)**<br>This analysis is normally the first step in the mission-planning process. It uses the best-available mission requirements (spacecraft 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 launch vehicle 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 varia tions of the critical orbit parameters as functions of probability level. A covariance matrix and a trajectory printout are also included.<br>The mission requirements and parameter ranges of interest for parametric studies are due as early as possible but in no case later than L-88 weeks. Comments to the PMA are needed no later than L-56 weeks for start of the FMA (Item 17). | Delta Program (input required from Customer) |
| 12. | **Mission Operational and Support Requirements**<br>To obtain unique range and network support, the spacecraft contractor must define any range or network requirements appropriate to the mission and submit them to the Delta Program Office. Spacecraft contractor operational con figuration, communication, tracking, and data flow are required to support document preparation and to arrange for required range support. | Customer |
| 13. | **Program Requirements Document (PRD)**<br>To obtain range and network support, a spacecraft PRD must be prepared. This document consists of a set of preprinted standard forms (with associated instructions) that must be completed. The spacecraft contractor will complete all forms appropriate to the mission and submit them to the Delta Program Office. The Delta Program Office will compile, review, provide comments, and, upon comment resolution, forward the spacecraft PRD to the appropriate support agency for formal acceptance. | Delta Program (input required from Customer) |
| 14. | **Payload Processing Requirements Document (PPRD)**<br>The PPRD is prepared if commercial facilities are to be used for spacecraft processing. The spacecraft contractor is required to provide data on all spacecraft activities to be performed at the commercial facility. This includes detailed information on all facilities, services, and support requested by the Delta Program Office to be provided by the commercial facility. Spacecraft hazardous systems descriptions shall include drawings, schematics, summary test data, and any other available data that will aid in appraising the respective hazardous sys tem. The commercial facility will accept spacecraft ground operations plans and/or MSPSP data for the PPRD. | Delta Program (input required from Customer) |

**Figure 8-7. Required Documents (Continued)**

| | Item | Responsibility |
|---|---|---|
| 15. | **Launch Vehicle Insignia**<br>The customer is entitled to have a mission-specific insignia placed on the launch vehicle. The customer will submit the proposed design to the Delta Program not later than 24 months before launch for review and approval. Following approval, the Delta Program will have the flight insignia prepared and placed on the launch vehicle. The maximum size of the insignia is 4.7 m by 4.7 m (15 ft by 15 ft). The insignia is placed on the uprange side of the launch vehicle. | Customer |
| 16. | **Launch Window**<br>The spacecraft contractor is required to specify the maximum launch window for any given day. Specifically, the window opening time (to the nearest minute) and the window closing time (to the nearest minute) are to be specified. This final window data should extend for at least 4 weeks beyond the scheduled launch date. Liftoff is targeted to the specified window opening. | Customer |
| 17. | **Final Mission Analysis (FMA) Report**<br>Boeing will issue an FMA trajectory report 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, spacecraft and launch vehicle tracking data, and other pertinent information. The trajectory is used to develop mission targeting constants and represents the flight trajectory. The FMA will be avail able at L-44 weeks. | Delta Program (input required from Customer) |
| 18. | **Spacecraft Drawings**<br>Spacecraft configuration drawings are required as early as possible. The drawings should show nominal and worst-case (maximum tolerance) dimensions and a tabulated definition of the physical location of all points on the spacecraft that are within 51 mm (2 in.) of the allowable spacecraft envelope for the compatibility drawing prepared by the Delta Program, clearance analysis, fairing compatibility, and other interface details. Spacecraft drawings are desired with the Spacecraft Questionnaire. The drawings should be 0.20 scale and transmitted via CAD media. Details should be worked out through Delta IV mission integration. | Customer |
| | The Delta Program will prepare and release the spacecraft compatibility drawing that will become part of the mission specification. This is a working drawing that identifies spacecraft-to-launch-vehicle interfaces. It defines electrical interfaces; mechanical interfaces, including spacecraft-to-PAF separation plane, separation springs and spring seats, and separation switch pads; definition of stay-out envelopes, both internal and external to the PAF; definition of stay-out envelopes within the fairing; and location and mechanical activa tion of spring seats. The spacecraft contractor reviews the drawing and provides comments, and upon comment resolution and incorporation of the final spacecraft drawings, the compatibility drawing is for mally accepted as a controlled interface between the Delta Program and the spacecraft agency. In addition, Boeing will provide a worst-case spacecraft-fairing clearance drawing. | Delta Program |
| 19. | **Spacecraft Launch Site Test Plan**<br>To provide all agencies with a detailed understanding of the launch site activities and operations planned for a particular mission, the spacecraft contractor is required to prepare a launch site test plan. The plan is intended to describe all aspects of the program while at the launch site. A suggested format is shown in Table 8-5. | Customer |
| 20. | **Spacecraft Launch Site Procedures**<br>Operating procedures must be prepared for all operations that are accomplished at the launch site. For operations that are hazardous (either to equipment or to personnel), special instructions must be followed in preparing the procedures. Refer to Section 9. | Customer |
| 21. | **Spacecraft Integrated Test Procedure Inputs**<br>On each mission, Boeing prepares launch site procedures for various operations that involve the space craft after it is mated with the Delta second stage. Included are requirements for operations such as spacecraft weighing, spacecraft installation to the third stage and encapsulation into the fairing, transportation to the launch complex, hoisting into the mobile service tower (MST) enclosure, spacecraft/third stage mating to the launch vehicle, flight program verification test, and launch countdown. The Delta Program requires inputs to these operations in the form of handling constraints, environmental constraints, person nel requirements, and equipment requirements. Of particular interest are spacecraft tasks/requirements during the final week before launch. (Refer to Section 6 or Section 7 for schedule constraints.) | Customer |
| 22. | **Spacecraft Mass Properties Statement**<br>The data from the spacecraft mass properties report represent the best current estimate of final space craft mass properties. The data should include any changes in mass properties while the spacecraft is attached to the Delta launch vehicle. Values quoted should include nominal and 3-σ uncertainties for mass, centers of gravity, moments of inertia, products of inertia, and principal axis misalignment. | Customer |
| 23. | **RF Compatibility Analysis**<br>A radio frequency interference (RFI) analysis is performed to verify that spacecraft RF sources are compatible with the launch vehicle telemetry and tracking beacon frequencies. Spacecraft frequencies defined in the mission specification are analyzed using a frequency-compatibility software program. The program provides a list of all intermodulation products that are then checked for image frequencies and intermodulation product interference. | Delta Program |

**Figure 8-7. Required Documents (Continued)**

| | Item | Responsibility |
|---|---|---|
| 24. | **Spacecraft/Launch Vehicle Separation Memorandum**<br>An analysis is performed to verify that there is adequate clearance and separation distance between the spacecraft and expended PAF/second stage. This analysis verifies adequate clearance between the spacecraft and second stage during separation and second-stage post-separation maneuvers. | Delta Program (input required from Customer) |
| 25. | **Launch Operations Plan (LOP)**<br>This plan is developed to define top-level requirements that flow down into detailed range requirements. The plan contains the launch operations configuration that identifies data and communication connectivity with all required support facilities. The plan also identifies organizational roles and responsibilities, the mission control team and its roles and responsibilities, mission rules supporting conduct of the launch operation, and go/no-go criteria. | Delta Program |
| 26. | **Vehicle Information Memorandum (VIM)**<br>The Delta Program Office is required to provide a vehicle information memorandum to the U.S. Space Command 15 calendar days prior to launch. The spacecraft agency will provide to the Delta Program the appropriate spacecraft on-orbit data required for this VIM. Data required are spacecraft on-orbit descriptions, descriptions of pieces and debris separated from the spacecraft, the orbital parameters for each piece of debris, payload spin rates, and orbital parameter information for each different orbit through final orbit. The Delta Program will incorporate these data into the overall VIM and transmit it to the appropriate U.S. government agency. | Delta Program (input required from Customer) |
| 27. | **Postlaunch Orbit Confirmation Data**<br>To reconstruct Delta performance, orbit data at burnout (stage II or III) are required from the spacecraft contractor. The spacecraft contractor should provide orbit conditions at the burnout epoch based on spacecraft tracking prior to any orbit-correction maneuvers. A complete set of orbital elements and asso ciated estimates of 3-σ accuracy is required (see Table 8-6). | Customer |
| 28. | **Spacecraft-to-Launch Control Center (LCC) Wiring Diagram**<br>For inclusion in the Mission Specification, the Delta Program will provide a spacecraft-to-LCC wiring diagram based on the spacecraft requirements. It will define the hardware interface from the spacecraft to the LCC for control and monitoring of spacecraft functions after spacecraft installation in the launch vehicle. | Delta Program |
| 29. | **Launch Site Integrated Procedures**<br>The Delta Program prepares procedures, called launch preparation documents (LPDs), that are used to authorize work on the flight hardware and related ground equipment. Most are applicable to the booster and second-stage operations, but a few are used to control and support stand-alone spacecraft and integrated activities at the payload processing facility and on the launch pad after encapsulated payload mate. These documents are prepared by the Delta Program based on Delta Program requirements; the inputs provided by the spacecraft contractor are listed in Item 21 and are available for review by the customer. LPDs are usually released a few weeks prior to use. | Delta Program |
| 30. | **Countdown Bar Charts**<br>Daily schedules are prepared on hourly timelines for integrated activities at the launch pad following encapsulated spacecraft mate to the second stage. These schedules are prepared by the Delta Program chief test conductor based on standard Delta Program launch operations, mission-specified requirements, and inputs provided by the spacecraft contractor as described in the mission specification. (Typical schedules are shown in Sections 6 and 7) A draft is prepared several months prior to launch and released to the customer for review. The final is normally released several weeks prior to encapsulated spacecraft mate at the pad. | Boeing |

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**Figure 8-7. Required Documents (Continued)**

## Delta IV Payload Questionnaire

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

1 Payload/Constellation Characteristics

1.1 Payload Description

1.2 Size and Space Envelope (Refer to Chapter 3)

1.2.1 Dimensioned Drawings/CAD Model of the Spacecraft in the Launch Configuration

1.2.2 Payload Components Within 50.8 mm/2.0 in. of Allowable Fairing Envelope Below Separation Plane (Identify Component and Location)

1.2.3 Payload Components Below Separation Plane (Identify Component and Location)

**Table 1.2.3.1. 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 1.2.3.2. 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).

1.2.4 On-Pad Configuration (Description and Drawing)

Figure 1.2.4-1. SC On-Pad Configuration

1.2.5 Orbit Configuration (Description and Drawing)

Figure 1.2.5-2. SC On-Orbit Configuration

Figure 1.2.5-3. Constellation On-Orbit Configuration (if applicable)

1.3 Payload Mass Properties

1.3.1 Weight, Moments and Products of Inertia, and CG Location

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 4 of the Payload Planners Guide?

**Table 1.3.4.1. Payload Stiffness Requirements**

| Spacecraft | Fundamental Frequency (Hz) | Axis |
|---|---|---|
| | | Lateral<br>Axial |

1.3.5 Description of Payload Dynamic Model

The Craig – Bampton format is the requested description of the payload dynamic model. If possible, use the Nastran OP4 BCD format for the following items. For SC with liquid tanks that are located off the centerline axis of the LV, the payload dynamic model must include the slosh characteristics.

1.3.5.1 Mass Matrix

1.3.5.2 Stiffness Matrix

1.3.5.3 Response Recovery Matrix

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

1.3.7 Spacecraft Coordinate System

**Figure 8-8. Delta IV Payload Questionnaire**

**Table 1.3.7.1. 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 1.3.7.2. 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) | $I_{XY}$ $I_{YZ}$ $I_{ZX}$ | | |

1.4 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 Delta Payload Planners Guide Section 9?

1.4.1.4 Location Where Pressure Vessels Are Loaded and Pressurized

**Table 1.4.1.5. Propulsion System Characteristics**

| Parameter | Value |
|---|---|
| Propellant Type | |
| 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 | |

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

**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 Boeing 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**

| Parameter | Antennas | | | |
|---|---|---|---|---|
| | **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 | | | | |

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

**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 |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

1.6 Spacecraft Systems Activated Prior to Spacecraft Separation

1.7 Spacecraft Volume (Ventable and Nonventable)

1.7.1 Spacecraft Venting (Volume, Rate, etc.)

1.7.2 Nonventable Volume

**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 | | |
| Probability of command shutdown | | |

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 Telemetry Constraint

2.4.6 Thermal Attitude Constraints

2.4.7 Contamination and Collision Avoidance Maneuver Constraints

2.4.8 Other

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

2.5 Trajectory and Spacecraft Separation Requirement

2.5.1 Special Trajectory Requirements

2.5.1.1 Thermal Maneuvers

2.5.1.2 Telemtry Maneuvers

2.5.1.3 Free Molecular Heating Restraints

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 Rate at Separation

2.5.2.6 Other

**Table 2.5.2.7. 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 Mission-Specific Configuration

3.1.1 Type of PAF

3.2 Fairing Mission-Specific Configuration

3.2.1 Access Doors and RF Windows in Fairing

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

**Table 3.2.1.1. Access Doors and RF Windows**

| 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

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

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 Multishift Operation Planned?

4.6.5 Additional Special Boeing Handling Requirements?

4.6.6 During Transport

4.6.7 On Stand

4.7 Special Equipment and Facilities Supplied by Boeing

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 AGE or Facilities Supplied by Boeing

4.8 Range Safety

4.8.1 Range Safety Console Interface

**5 Spacecraft/Launch Vehicle Interface Requirements**

5.1 Mechanical Interfaces

5.1.1 Fairing Envelope

5.1.1.1 Fairing Envelope Violations

**Table 5.1.1.1.1. Violations in the Fairing Envelope**

| Item | LV Vertical Station (unit) | Radial Dimension (unit) | Clocking from SC X-Axis | Clocking from LV Quadrant IV Axis | Clearance from Stay-out Zone |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

5.1.1.2 Separation Plane Envelope Violations

**Table 5.1.1.2.1. Violations in the Separation Plane**

| Item | LV vertical sta tion (unit) | Radial dimen sion (unit) | Clocking from SC X-Axis | Clocking from LV Quadrant IV Axis | Clearance from stay-out Zone |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

5.1.2 Separation System

5.1.2.1 Clampband/Attachment System Desired and Interface Diameter

**Table 5.1.2.1.1. Spacecraft Mechanical Interface Definition**

| SC Bus | Size of S/C Interface to LV (unit) | Type of SC Interface to LV Desired |
|---|---|---|
| | | |
| | | |
| | | |

5.1.2.2 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

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

5.2.1.2 Connector Pin Assignments in the Spacecraft Umbilical Connector(s)

5.2.1.3 Spacecraft Separation Indication

5.2.1.4 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?

5.3 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 interface

5.3.2.1 Equipment Consoles (Sizes, Weight, etc.)

5.3.2.2 Interface Ground Cables

5.3.2.3 Auxiliary Boxes (Sizes, Weight, etc.)

5.3.2.4 Other Equipment

**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

**Figure 8-8. Delta IV Spacecraft Questionnaire (Continued)**

**7 Identify Any Additional Spacecraft or Mission Requirements That Are Outside of the Boundary of the Constraints Defined in the Payload Planners Guide**

1 General
- 1.1 Plan Organization
- 1.2 Plan Scope
- 1.3 Applicable Documents
- 1.4 Spacecraft Hazardous Systems Summary

2 Prelaunch/Launch Test Operations Summary
- 2.1 Schedule
- 2.2 Layout of Equipment (Each Facility) (Including Test Equipment)
- 2.3 Description of Event at Launch Site
  - 2.3.1 Spacecraft Delivery Operations
    - 2.3.1.1 Spacecraft Removal and Transport to Spacecraft Processing Facility
    - 2.3.1.2 Handling and Transport of Miscellaneous Items (Ordnance, Motors, Batteries, Test Equipment, Handling and Transportation Equipment)
  - 2.3.2 Payload Processing Facility Operations
    - 2.3.2.1 Spacecraft Receiving Inspection
    - 2.3.2.2 Battery Inspection
    - 2.3.2.3 Reaction Control System (RCS) Leak Test
    - 2.3.2.4 Battery Installation
    - 2.3.2.5 Battery Charging
    - 2.3.2.6 Spacecraft Validation
    - 2.3.2.7 Solar Array Validation
    - 2.3.2.8 Spacecraft/Data Network Compatibility Test Operations
    - 2.3.2.9 Spacecraft Readiness Review
    - 2.3.2.10 Preparation for Transport, Spacecraft Encapsulation, and Transport to Hazardous Processing Facility (HPF)
  - 2.3.3 Solid Fuel Storage Area
    - 2.3.3.1 Apogee Kick Motor (AKM) Receiving, Preparation, and X-Ray
    - 2.3.3.2 Safe and Arm (S&A) Device Receiving, Inspection, and Electrical Test
    - 2.3.3.3 Igniter Receiving and Test
    - 2.3.3.4 AKM/S&A Assembly and Leak Test
  - 2.3.4 HPF
    - 2.3.4.1 Spacecraft Receiving Inspection
    - 2.3.4.2 Preparation for AKM Installation
    - 2.3.4.3 Mate AKM to Spacecraft
    - 2.3.4.4 Spacecraft Weighing (Include Configuration Sketch and Approximate Weights of Handling Equipment)
    - 2.3.4.5 Spacecraft/Fairing Mating
    - 2.3.4.6 Preparation for Transport
    - 2.3.4.7 Transport to Launch Complex
  - 2.3.5 Launch Complex Operations
    - 2.3.5.1 Spacecraft/Fairing Hoisting
    - 2.3.5.2 Spacecraft/Fairing Mate to Launch Vehicle
    - 2.3.5.3 Hydrazine Leak Test
    - 2.3.5.4 Telemetry, Tracking, and Command (TT&C) Checkout
    - 2.3.5.5 Preflight Preparations
    - 2.3.5.6 Launch Countdown
- 2.4 Launch/Hold Criteria
- 2.5 Environmental Requirement for Facilities During Transport

3 Test Facility Activation
- 3.1 Activation Schedule
- 3.2 Logistics Requirements
- 3.3 Equipment Handling
  - 3.3.1 Receiving
  - 3.3.2 Installation
  - 3.3.3 Validation
  - 3.3.4 Calibration
- 3.4 Maintenance
  - 3.4.1 Spacecraft
  - 3.4.2 Launch-Critical Mechanical Aerospace Ground Equipment (AGE) and Electrical AGE

4 Administration
- 4.1 Test Operations Organizational Relationships and Interfaces (Personnel Accommodations, Communications)

5 Security Provisions for Hardware

6 Special Range-Support Requirements
- 6.1 Real-Time Tracking Data Relay Requirements
- 6.2 Voice Communications
- 6.3 Mission Control Operations

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**Figure 8-9. Typical Spacecraft Launch-Site Test Plan**

1. Epoch: Spacecraft Separation (prior to propulsive maneuvers)
2. Position and velocity components velocity components ( $X, Y, X, \dot{X}, \dot{Y}\ \dot{Z}$ ) in equatorial inertial Cartesian coordinates.* specify mean-of-date or true-of-date, etc.
3. Keplerian elements* at the above epoch:
   Semimajor axis, a
   Eccentricity, e
   Inclination, I
   Argument of perigee, w
   Mean anomaly, M
   Right ascension of ascending node, W
4. Polar elements* at the above epoch:
   Inertial velocity, V
   Inertial flight path angle, g1
   Inertial flight path angle, g2
   Radius, R
   Geocentric latitude, r
   Longitude, m
5. Estimated accuracies of elements and a discussion of quality of tracking data and difficulties such as reorientation maneuvers within 6 hr of separation, etc.
6. Constants used:
   Gravitational constant, m
   Equatorial radius, RE
   J2 or Earth model assumed
7. Estimate of spacecraft attitude and coning angle at separation (if available).

*Note: At least one set of orbit elements in Items 2, 3, or 4 is required.

0000580.3

**Figure 8-10. Data Required for Orbit Parameter Statement**

## 8.3 LAUNCH OPERATIONS PLANNING

Development of launch operations, range support, and other support requirements is an evolutionary process that requires timely inputs and continued support from the customer.

## 8.4 PAYLOAD PROCESSING REQUIREMENTS

The checklist shown in Figure 8-11 is provided to assist the customer in identifying the requirements at each processing facility. The requirements identified are submitted to the Delta Program for the program requirements document (PRD) and payload processing requirements document (PPRD). The Delta Program coordinates with the range and payload processing facility, and implements the requirements through the PRD/PPRD. The customer may add items to the list.

**1. General**

A. Transportation of spacecraft elements/ground support equipment (GSE) to processing facility
  (1) Mode of transportation________________________
  (2) Arriving at (gate, skid strip) ____________________
  (date) ____________________________________
B. Data-hand ling
  (1) Send data to (name and address) ______________
  (2) Time needed (real time versus after the fact) ______
C. Training and medical examinations for
  ________________________________ crane operators
D. Radiation data
  (1) Ionizing radiation materials ____________________
  (2) Nonionizing radiation materials/systems __________

**2. Spacecraft Processing Facility (for nonhazardous work)**

A. Does payload require a cleanroom?
  (yes) _____ (no) ____
  (1) Class of cleanroom required ___________________
  (2) Special sampling techniques __________________
B. Area required
  (1) For spacecraft ______________________________
  (2) For ground station ___________________________
  (3) For office space______________________________
  (4) For other GSE _______________________________
  (5) For storage _________________________________
C. Largest door size
  (1) For spacecraft/GSE __________________________
  (high) ________________(wide) _______________
  (2) For ground station ___________________________
D. Material-handling equipment
  (1) Cranes
    a. Capacity _________________________________
    b. Minimum hook height _____________________
    c. Travel ___________________________________
  (2) Other ____________________________________
E. Environmental controls for spacecraft/ground station
  (1) Temperature/humidity and tolerance limits ________
  __________________________________________
  (2) Frequency of monitoring _____________________
  (3) Downtime allowable in the event of a system failure
  __________________________________________
  (4) Is a backup (portable) air-conditioning system required? (yes) ______ (no) ______
  (5) Other ____________________________________
F. Electrical power for payload and ground station
  (1) kVA required _______________________________
  (2) Any special requirements such as clean/quiet power, or special phasing? Explain __________________
  __________________________________________
  (3) Backup power (diesel generator) _______________
G. Communications (list)
  (1) Administrative telephone _____________________
  (2) Commercial telephone _______________________
  (3) Commercial data phones _____________________
  (4) Fax machines _______________________________
  (5) Operational intercom system _________________
  (6) Closed-circuit television _____________________
  (7) Countdown clocks __________________________
  (8) Timing ____________________________________
  (9) Antennas ___________________________________
  (10) Data lines (from/to where) ___________________
  (11) Type (wideband/narrowband) _________________
H. Services general
  (1) Gases
    a. Specification___________________________
    Procured by user? _________ KSC?________
    b. Quantity ______________________________
    c. Sampling (yes)______ (no)_______
  (2) Photographs/Video _______ (qty/B&W/color) ____
  (3) Janitorial (yes) _____________ (no) ___________
  (4) Reproduction services (yes) _______ (no) ______
I. Security (yes) _______________ (no) ____________
  (1) Safes ______________________ (number/type)
J. Storage ____________________________ (size area)
  ________________________________ (environment)
K. Other _____________________________________
L. Spacecraft payload processing facility (PPF) activities calendar
  (1) Assembly and testing _______________________
  (2) Hazardous operations_______________________
    a. Initial turn-on of a high-power RF system_____
    b. Category B ordnance installation ___________
    c. Initial pressurization _____________________
    d. Other ________________________________
M. Transportation of payloads/GSE from PPF to HPF
  (1) Will spacecraft agency supply transportation canister? _____________________________
  If no, explain ____________________________
  (2) Equipment support, (e.g., mobile crane, flatbed)
  ______________________________________
  (3) Weather forecast (yes) __________ (no) ________
  (4) Security escort (yes) __________ (no) _________
  (5) Other ____________________________________

**3. Hazardous Processing Facility**

A .Does spacecraft require a cleanroom? (yes)__ (no) __
  (1) Class of clean room required _______________
  (2) Special sampling techniques (e.g., hydrocarbon monitoring) _______________________________
B. Area required
  (1) For spacecraft ____________________________
  (2) For GSE _________________________________
    a. Continuous ___________________________
    b. During critical tests ____________________
C. Largest door size
  (1) For payload ___________high ___________wide
  (2) For GSE ______________high __________wide
D. Material handling equipment
  (1) Cranes
    a. Capacity _______________________________
    b. Hook height_____________________________
    c. Travel ________________________________
  (2) Other ___________________________________
E. Environmental controls spacecraft/GSE
  (1) Temperature/humidity and tolerance limits _______
  ______________________________________
  (2) Frequency of monitoring ____________________
  (3) Down-time allowable in the event of a system failure
  ______________________________________
  (4) Is a backup (portable) system required?
  (yes) _____ (no) ____
  (5) Other ____________________________________
F. Power for spacecraft and GSE
  (1) kVA required _______________________________

Note: Please specify units as applicable

**Figure 8-11. Spacecraft Checklist**

G. Communications (list)
  (1) Administrative telephone ______________________
  (2) Commercial telephone ______________________
  (3) Completed data phones ______________________
  (4) Fax machines ______________________
  (5) Operational intercom system ______________________
  (6) Closed-circuit television ______________________
  (7) Countdown clocks ______________________
  (8) Timing ______________________
  (9) Antennas ______________________
  (10) Data lines (from/to where) ______________________
H. Services general
  (1) Gases
    a. Specification ______________________
       Procured by user __________ KSC? _________
    b. Quantity ______________________
    c. Sampling (yes) __________ (no) ___________
  (2) Photographs/Video ______ (qty/B&W/color) ______
  (3) Janitorial (yes) ___________ (no) ______________
  (4) Reproduction services (yes) _______ (no) ________
I. Security (yes) _______________ (no) ______________
  (1) Safes ______________________ (number/type)
J. Storage ______________________ (size area)
  ______________________ (environment)
K. Other ______________________
L. Spacecraft PPF activities calendar ______________________
  (1) Assembly and testing ______________________
  (2) Hazardous operations ______________________
    a. Category A ordnance installation ____________
    b. Fuel loading ______________________
    c. Mating operations (hoisting) ______________
M. Transportation of encapsulated payloads to launch pad
  (1) Security escort (yes) __________ (no) __________
  (2) Other ______________________

**4. Launch Complex Mobile Service Tower (MST) Enclosure**

A. Environmental controls payload/GSE
  (1) Temperature/humidity and tolerance limits
    ______________________
  (2) Any special requirements such as clean/quiet power? Please detail requirements ______________________
  (3) Backup power (diesel generator)
    a. Continuous ______________________
    b. During critical tests ______________________
  (4) Hydrocarbon monitoring required ______________
  (5) Frequency of monitoring ______________________
  (6) Down-time allowable in the event of a system failure
    ______________________
  (7) Other ______________________
B. Power for payload and GSE
  (1) kVA required ______________________
  (2) Any special requirements such as clean/quiet power/phasing? Explain ______________________
  (3) Backup power (diesel generator)
    a. Continuous ______________________
    b. During critical tests ______________________
C. Communications (list)
  (1) Operational intercom system ______________________
  (2) Closed-circuit television ______________________
  (3) Countdown clocks ______________________
  (4) Timing ______________________
  (5) Antennas ______________________
  (6) Data lines (from/to where) ______________________
D. Services general
  (1) Gases
    a. Specification ______________________
       Procured by user _________ KSC? _________
    b. Quantity ______________________
    c. Sampling (yes) _________ (no) ____________
  (2) Photographs/Video ______ (qty/B&W/color) _____
E. Security (yes) ____________ (no) ________________
F. Other ______________________
G. Stand-alone testing (does not include tests involving the Delta IV launch vehicle)
  (1) Tests required ______________________
    (e.g., RF system checkout, encrypter checkout)
  (2) Communications required for__________________
    (e.g., antennas, data lines)
  (3) Spacecraft servicing required__________________
    (e.g., cryogenics refill)

Note: Please specify units as applicable

0000581.8

**Figure 8-11. Spacecraft Checklist (Continued)**

# Section 9
# SAFETY

This section discusses the safety requirements that govern a payload to be launched by a Delta IV launch vehicle from Cape Canaveral Air Force Station (CCAFS), Florida, or Vandenberg Air Force Base (VAFB), California. This section provides safety requirements guidance for payload processing operations conducted at Space Launch Complex 37B (CCAFS) or Space Launch Complex 6 (VAFB).

Payload prelaunch operations may be conducted at Kennedy Space Center (KSC), Florida; Cape Canaveral Air Force Station, Florida; Astrotech in Titusville, Florida; Astrotech in Vandenberg Air Force Base, California; or Spaceport Systems International in Vandenberg Air Force Base, California, by arrangement with the appropriate agencies. Payload operations conducted at Astrotech facilities shall be conducted in accordance with Astrotech ground safety polices. Payload operations conducted at Spaceport Systems International facilities shall be conducted in accordance with Spaceport Systems International ground safety polices. Payload operation conducted at U.S. government facilities shall be conducted in accordance with the government facilities ground safety requirements.

Payload transportation operations conducted on public highways shall be conducted in accordance with Code of Federal Regulations (CFR), Title 49, Department of Transportation, Transportation of Hazardous Materials.

The USAF 45th and 30th Space Wings are responsible for overall range (ground/flight) safety at CCAFS and VAFB, respectively, and are primarily concerned with payload flight and public safety concerns associated with cryogenic, solid fuel, hypergolic fuel, or early flight termination system (FTS) action catastrophic hazards. Payload operations conducted under the jurisdiction of the Eastern and Western Range shall be in accordance with the Air Force Space Command Manual (AFSPCMAN) 91-710, Range Safety User Requirements, 1 July 2004.

The Federal Aviation Administration (FAA)/Associate Administrator for Commercial Space Transportation (AST) is responsible for the licensing of commercial space launches and permitting the operations of commercial launch sites. Mission-specific launch license processing shall be the responsibility of the Delta Program Office in accordance with Code of Federal Regulations, Title 14, Aeronautics and Space, Parts 400-499, Commercial Space Transportation.

Delta IV payload launch complex operations are conducted at Space Launch Complex 37B (CCAFS) and Space Launch Complex 6 (VAFB) in accordance with the applicable Operations Safety Plan and the Delta IV EWR 127-1 Range Safety Requirements (Tailored), MDC 99H1112.

## 9.1 REQUIREMENTS

The payload organization shall have a system safety program to effectively:

A. Identify and adequately describe all hazardous systems, assess associated mishap risks/mitigation measures, reduce mishap risks to acceptable levels, verify/document/track identified risks using a risk-management-process to support preparation of a mission-unique missile system prelaunch safety package (MSPSP) and payload safety review process in accordance with Attachment 1 of AFSPCMAN 91-710, and Section 9.2 of this guide.

B. Support an assessment to determine if a flight termination system is required.

C. Identify to the Delta program any potential requests to tailor the requirements of AFSPCMAN 91-710, prior to the mission orientation briefing.

D. Identify to the Delta program any potential noncompliances with AFSPCMAN 91-710, prior to the mission orientation briefing.

## 9.2 PAYLOAD SAFETY REQUIREMENTS

The interactive process between the payload manufacturers, Delta IV system safety, and range safety or other government agencies described in this section will ensure minimum impact to payload programs and reduce the cost and time required for the approval process.

Many payload systems are generic, meaning that they are built to a common bus structure, using a common launch vehicle and common range processing prelaunch and launch procedures. As a result, these generic payloads contain few changes to the baseline system, and the safety data can remain the same from one mission to the next.

To take advantage of previously approved payload systems and generic safety data, the requirements described below shall be followed; however, they may be modified to meet individual program requirements:

A. Delta IV system safety and the payload manufacturer, in conjunction with range safety or other government agency, shall conduct initial planning meetings to establish a payload approval process.

B. Once a baseline system has been approved, efforts will focus on specific changes for each new program or mission. NOTE: Existing and ongoing previously (range-safety) approved components, systems, and subsystems need not be resubmitted as part of data packages for review but referenced for traceability.

C. Delta IV system safety, the payload manufacturer, and range safety or other government agencies shall conduct a safety assessment of each new program or mission to define changes and/or additions that create new, uncontrolled hazards or that increase risks significantly.

D. Based on the joint safety assessment, the parties shall agree on the minimum required mission-unique documentation to be submitted for review and approval.

E. Data submittal and response times shall be established based on the joint safety assessment and modified only upon agreement of all parties.

F. The goal of the generic payload approval process is to achieve final range safety or other government agency approval at least 60 calendar days prior to payload arrival at Space Launch Complex 37B, (CCAFS) or 6 (VAFB).

### 9.2.1 Approval Process for Existing Payload Buses

For currently (range-safety) approved payload buses, the goal is to grant baseline approvals for generic buses during the first mission after implementation of this approach. Subsequent flights would use the joint assessment process to review and approve changes to the generic bus and/or payload additions for specific missions. Key to the approach is the safety assessment that is used to determine whether changes or additions have created any new uncontrolled hazards or have increased the risks significantly. The assessment results will be used to determine data required for review and approval requirements. The approval process for existing payload buses is shown in Figure 9-1 and described below.

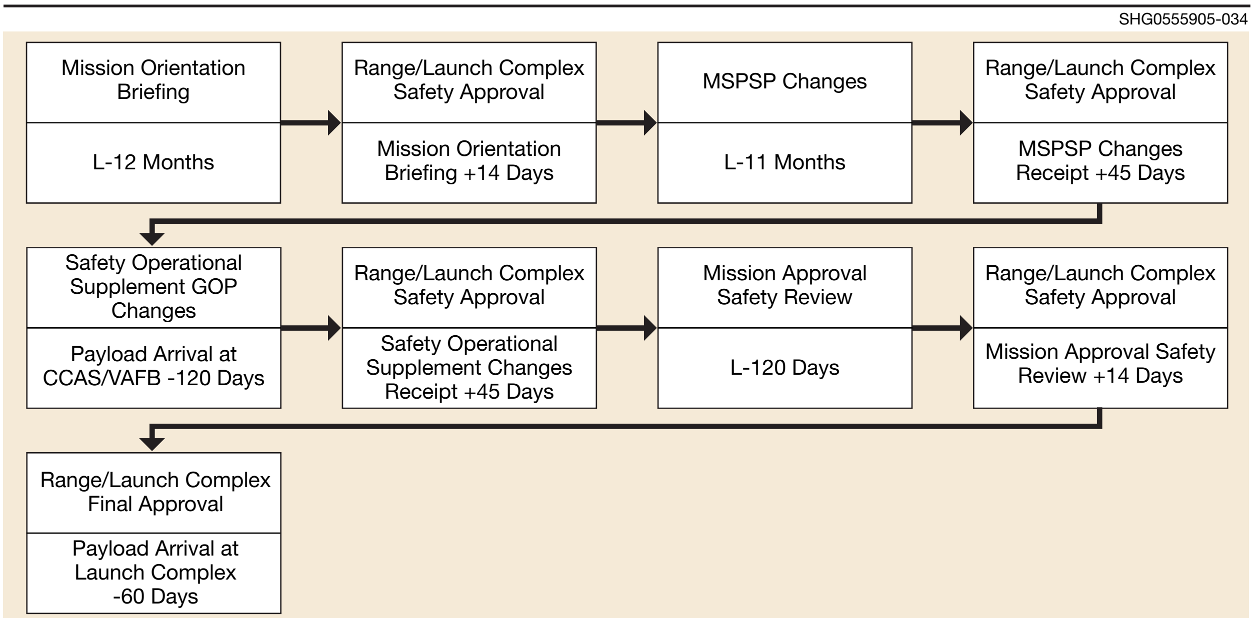


**Figure 9-1. Approval Process for Existing Payload Buses**

9.2.1.1 Mission Orientation Briefing. A mission orientation safety briefing shall be conducted for Delta IV system safety, range safety, and/or other government agencies for the mission. The briefing shall cover the following topics.

1. Changes to the payload bus.
2. Planned payload additions for the mission.

3. Changes to hazardous systems and operations (the focus of this review).
4. Changes to the launch vehicle.

Concurrence for both the mission concept and schedule for the remaining milestones shall be provided during the mission orientation safety briefing.

#### 9.2.1.2 Data Review and Approval

**9.2.1.2.1 Mission-Unique Missile System Prelaunch Safety Package.** An approved Delta IV system safety-prepared mission-unique missile system prelaunch safety package (MSPSP) must be delivered to range safety and/or other government agencies 45 days prior to hardware delivery to the range or the start of operations. It must contain the payload data identified during the mission orientation safety briefing on the changes unique for the mission.

Delta IV system safety will coordinate with range safety and/or other government agencies to disposition responses after they receive this MSPSP.

**9.2.1.2.2 Ground Operations Plan (GOP) and Hazardous and Safety-Critical Procedures.** A Space Launch Complex 37B or 6 GOP supplement describing changes to approved operations and/or new or modified safety critical or hazardous procedures shall be delivered to range safety and other government agencies approximately 120 days prior to payload arrival on the range. NOTE: This supplement is required only if changes have been made to operations and procedures that affect hazardous levels or risks.

Delta IV launch operations will coordinate with range safety and/or other government agencies to disposition responses after receipt of the data package.

**9.2.1.2.3 Mission Approval Safety Review.** A mission approval safety review shall be conducted approximately L-120 days to obtain range safety or other government agency approval for the launch vehicle and payload processing, transport of the payload to the launch complex, payload launch vehicle mating, and launch complex payload processing.

Delta IV system safety will coordinate resolution of any significant safety issues with range safety and/or other government agencies after the mission approval safety review.

**9.2.1.2.4 Final Launch Approval.** Final approval to proceed with launch vehicle and payload processing up to beginning the final countdown shall be provided by range safety and/or other government agencies at least 60 days prior to payload arrival at the launch complex. NOTE: Flight plan approval for a mission that involves public safety may not be granted until just prior to the launch readiness review (LRR) depending on the complexity of the public safety issue encountered.

### 9.2.2 Approval Process for New Payload Buses

For new payload buses, the goal is to grant baseline approvals for generic buses during the first mission after implementation of this approach. Subsequent flights would use the joint assessment process to review and approve changes to the generic bus and/or payload additions for specific missions. Key to the approach is the safety assessment that is used to determine whether changes or additions have created any new uncontrolled hazards or have increased the risks significantly. The assessment results will be used to determine data required for review and approval requirements.

The approval process for new payload buses is shown in Figure 9-2 and described below.

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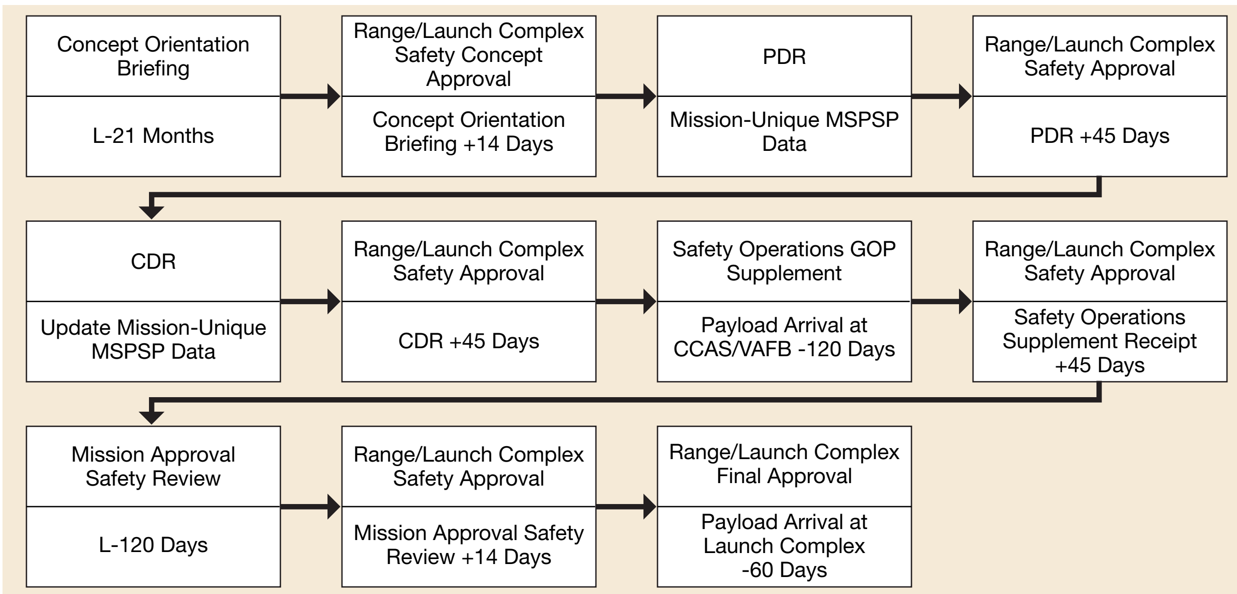



**Figure 9-2. Approval Process for New Payload Buses**

9.2.2.1 Concept Orientation Briefing and Safety Review. A payload concept orientation briefing shall be provided to Delta IV system safety, range safety, and other government agencies early in the conceptual phase of payload design development.

The approval process shall be documented so that an audit trail can be established.

A payload concept orientation safety review shall be held in conjunction with this briefing, and approval of design concepts, schedule of safety submittals, and responses shall be documented.

9.2.2.2 Preliminary Design Review. A payload preliminary design review (PDR) shall be held with Delta IV system safety to provide necessary mission-unique MSPSP data for initial submittal before the final payload design is completed and prelaunch processing is initiated. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and other government agencies.

**9.2.2.3 Critical Design and Data Review.** A payload critical design review (CDR) shall be held with Delta IV system safety to provide the necessary mission-unique MSPSP data to grant final design approval and prelaunch processing initial procedure review. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and/or other government agencies

A mission-unique ground operations plan describing operations and containing safety-critical and hazardous procedures shall be delivered to range safety approximately 120 days prior to payload arrival on the range. Delta IV system safety will coordinate resolution of any significant ground operations plan issues with range safety and other government agencies.

**9.2.2.4 Mission Approval Safety Review.** Mission approval safety reviews are conducted to obtain range safety approval for launch vehicle and payload processing, transport to the payload launch pad, payload launch vehicle mating, and launch pad payload processing. The payload customer shall support these reviews as required. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and other government agencies

**9.2.2.5 Final Launch Approval.** Final approval to proceed with launch vehicle and payload processing up to beginning the final countdown shall be provided by range safety and/or other government agencies at least 60 days prior to payload arrival at the launch complex. NOTE: Flight plan approval for a mission that involves public safety may not be granted until just prior to the LRR, depending on the complexity of the public safety issue encountered. Typically, easterly launch azimuths from CCAFS can be approved at least 120 days prior to launch. Alternatively, high-inclination launches may require additional risk analyses that can lengthen the final flight plan approval process.

### 9.2.3 Incidental Range Safety Issues

Incidental range safety/launch complex issues such as component failures, test failures, and the discovery of unforeseen hazards occurring after baseline approvals shall be worked in real time as part of the final approval process for an individual launch. Typically, these issues involve the launch vehicle and not the payload.

# Section 10
# 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 Delta program commitment to continuous improvement to the Delta IV vehicle.

## 10.1 PAYLOAD ACCOMMODATIONS

The Delta program is continuously striving to develop additional capability. This allows the Delta program 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.

### 10.1.1 Payload Attach Fittings

The Delta PAF design philosophy and long heritage of launch vehicle experience allows the Delta program to work with customers to either modify existing hardware or develop new "clean sheet" designs to incorporate mission-unique requirements. Figure 10-1 shows examples of future PAFs currently in various stages of development.

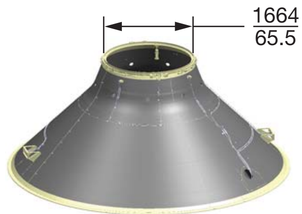
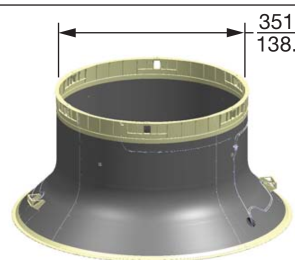
| Model | Note: All dimensions are in $\frac{mm}{in.}$ | Separation Mechanism | Features |
|---|---|---|---|
| **Delta IV 937-4/-5 PAFs** |  $\frac{937}{37}$ dia | $\frac{937}{37}$ dia clampband | Two calibrated spacers verify the clampband preload, while a retention system prevents re-contact. Four matched springs, or differential spring actuators are able to provide various tip-off rates. |
| **Delta IV 1664-4/-5 PAFs** |  $\frac{1664}{65.5}$ dia | Four separation bolts in a $\frac{1664}{65.5}$ dia bolt circle | Four hard-point attachments, released by four redundantly initiated explosive nuts. Four differential springs to provide a tip-off rate. |
| **Delta IV 3518-5 PAF** |  $\frac{3518}{138.5}$ dia | Six separation bolts | The spacecraft interface consist of six equally spaced separation bolts. SHG0555905-113 |

**Figure 10-1. Future Delta IV Payload Attach Fittings**

### 10.1.1.1 937 PAFs

The 937-mm (37-in.) PAFs provide a Marmon-type clampband separation system with separation spring actuators similar to the 3712A clampband system developed on the Delta II program. Payload umbilical disconnects and separation spring assemblies are similar to what is used on other Delta IV PAFs. The 4-m composite fairing version, or 937-4 PAF, is shown in Figure 10-2. The 5-m composite fairing version, or 937-5 PAF, is shown in Figure 10-3.

SGF0555905-114

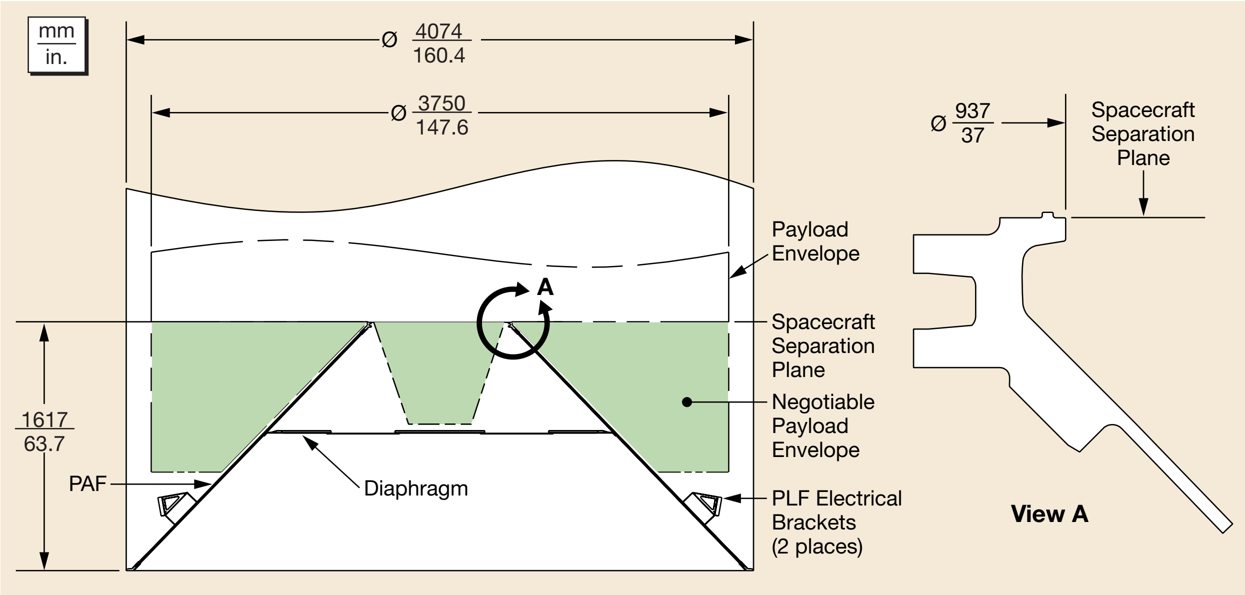



**Figure 10-2. Delta IV 937-4 PAF**

SGF0555905-115

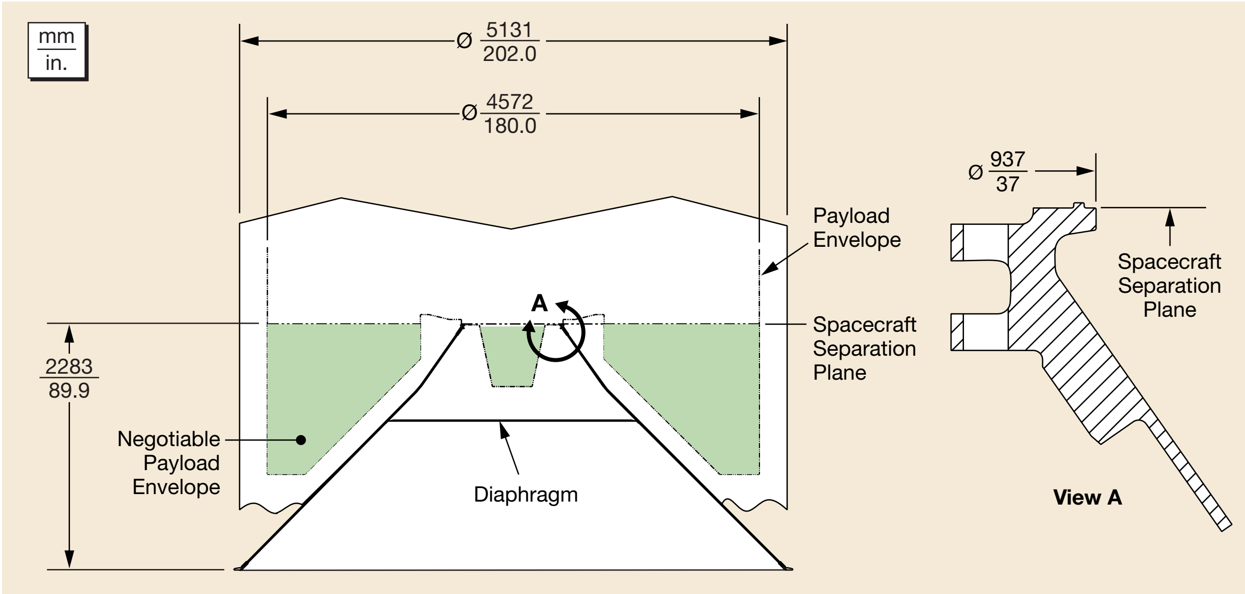



**Figure 10-3. Delta IV 937-5 PAF**

### 10.1.1.2 1664 PAFs

The 1664-mm (65.5-in.) PAFs provide a four-point, bolted separation system similar to what has been flown successfully on the Delta II program. The PAF uses umbilical disconnects and separation spring assemblies similar to that of the 1666-mm interface. The 1664-4 PAF and 1664-5 PAF are shown in Figures 10-4 and 10-5, respectively.

SGF0555905-116

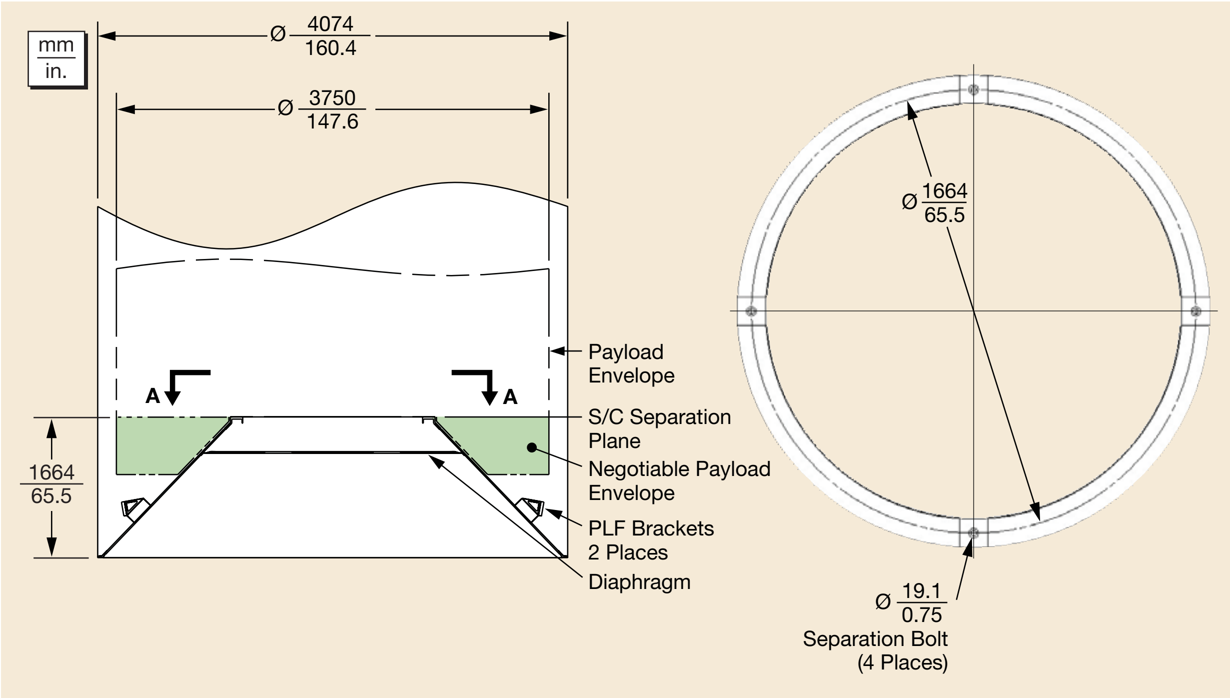



**Figure 10-4. Delta IV 1664-4 PAF**

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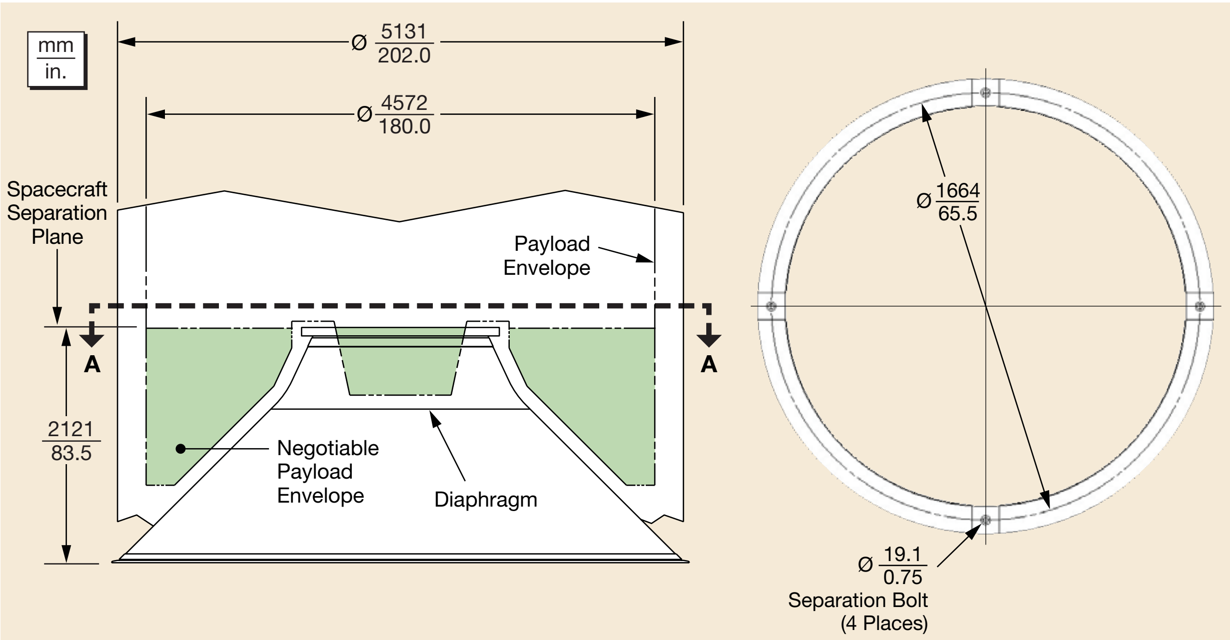


**Figure 10-5. Delta IV 1664-5 PAF**

#### 10.1.1.3 3518-5 PAF

The 3518-5 PAF provides a six-point, bolted separation system along a 3518-mm interface, and uses a 5-m composite fairing (Figure 10-6).

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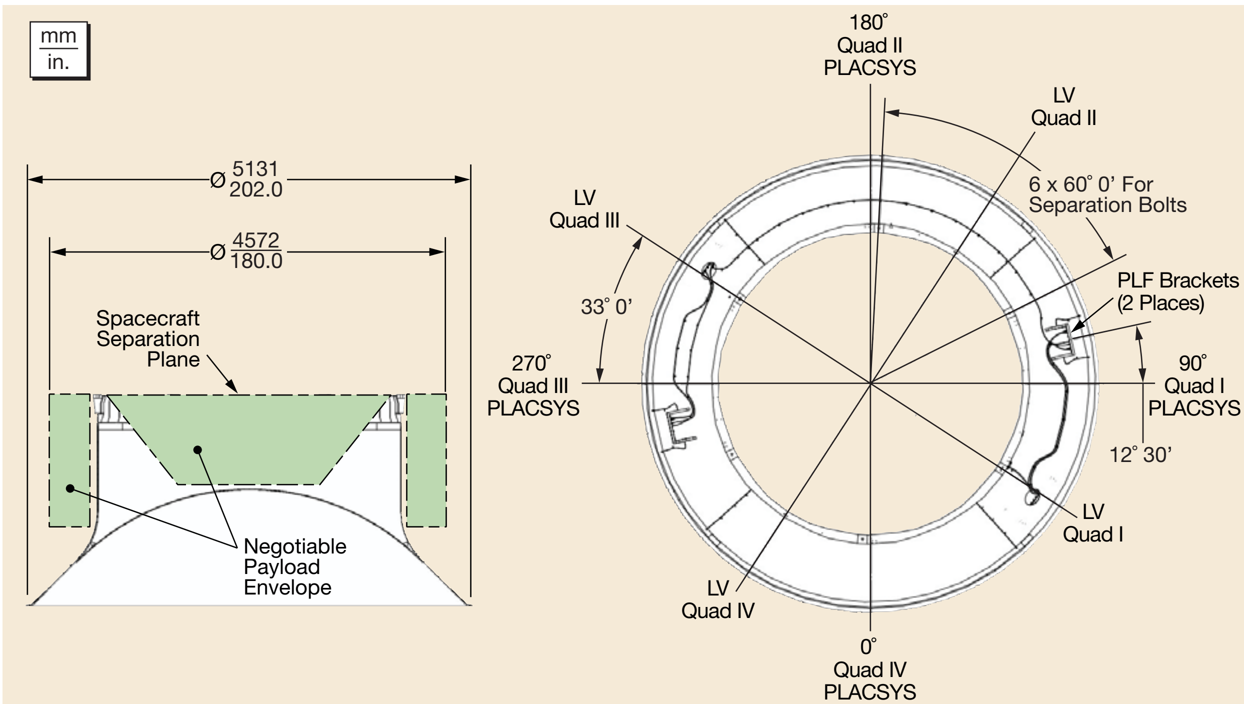


**Figure 10-6. Delta IV 3518-5 PAF**

### 10.1.2 Dual-Payload Attach Fitting (DPAF-5)

The Delta IV dual-manifest capability would utilize the Delta IV Heavy configuration. The Delta IV Heavy dual-manifest launch system would have the capability to launch two spacecraft totaling up to 9860 kg (21,840 lb) separated mass to a transfer orbit of 271-km perigee by 71,572-km apogee at 23.3 deg of inclination, using a 5-m composite fairing that is 19.1 m (62.7 ft) long.

The Delta IV Heavy dual-manifest system would use the dual-payload attach fitting (DPAF-5) hardware shown in Figure 10-7. This dual-manifest system is evolved from the Astrium-built, flight-proven DPAF system used on Delta II. We are continuing to work on the DPAF-5 design, which will be a slightly modified version of the flight-proven SYLDA-5 dual-manifest system.

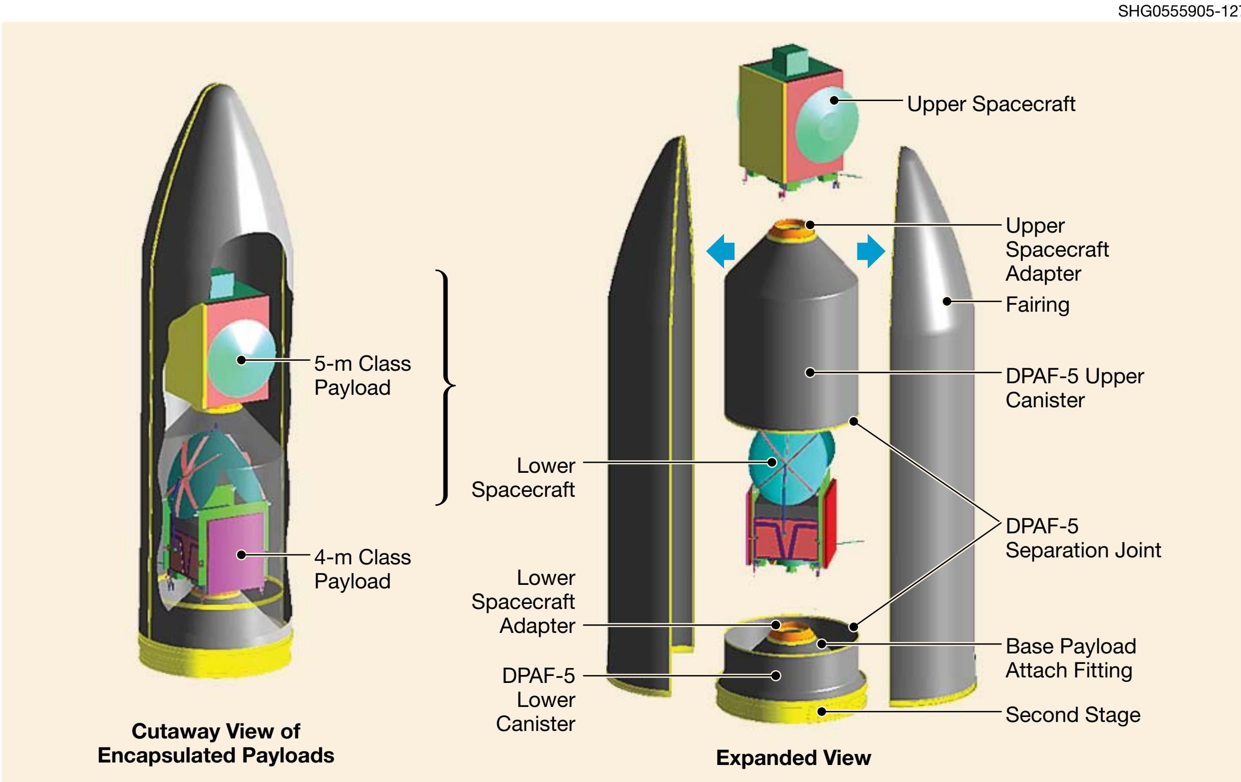


**Figure 10-7. Delta IV Heavy Dual-Payload Attach Fitting**

The Delta IV Heavy will support two standard versions of DPAF-5, which have been designed to meet a broad spectrum of mission requirements. The DPAF-5 Long, which uses the 8-m (26.2-ft)-long DPAF-5, can accommodate medium-class payloads in both the upper and lower bays. The DPAF-5 Short, which uses the 6.8-m (22.3-ft)-long DPAF-5, can accommodate a large-class payload in the upper bay, with a small- to medium-class payload in the lower bay. When matching co-passengers, Delta IV Heavy dual-manifest payload classes are defined as follows:

- Small class: less than ~2500 kg
- Medium class: between ~2500 kg and ~5500 kg
- Large class: greater than ~5500 kg

For operational purposes, the interface between both payloads and the launch vehicle will use an established spacecraft adapter design. The spacecraft adapters will mate to the DPAF-5 structure and extend upward to the required payload interface (i.e., 937-mm clampband, 1194-mm clampband, 1666-mm clampband, or 1664-mm bolted interface). The standard spacecraft adapter interface allows considerable flexibility in accommodating payloads in either the upper or lower payload position.

During the mission integration process, the Delta Program will analyze requirements for each payload to determine optimum positioning for a dual-manifested launch. The upper and lower payload bays can individually accommodate satellites up to 7000 kg in mass with a center of gravity of up to 2.0 m above the separation plane. Some of the primary technical requirements that will be evaluated in determining the optimum positioning are payload size and mass, center of gravity, electrical and RF signal requirements/compatibility, etc.

#### 10.1.2.2 DPAF-5 Fairing Envelopes

The dual-manifest payload accommodations, shown in Figures 10-8 and 10-9 feature a DPAF that encapsulates the lower payload and then serves as structure support for the upper payload. The payload is then encapsulated by the 19.1-m fairing that also is used by the Delta IV Heavy. Both payloads are mounted within these bays to Delta IV separation interfaces, dependent on payload needs.

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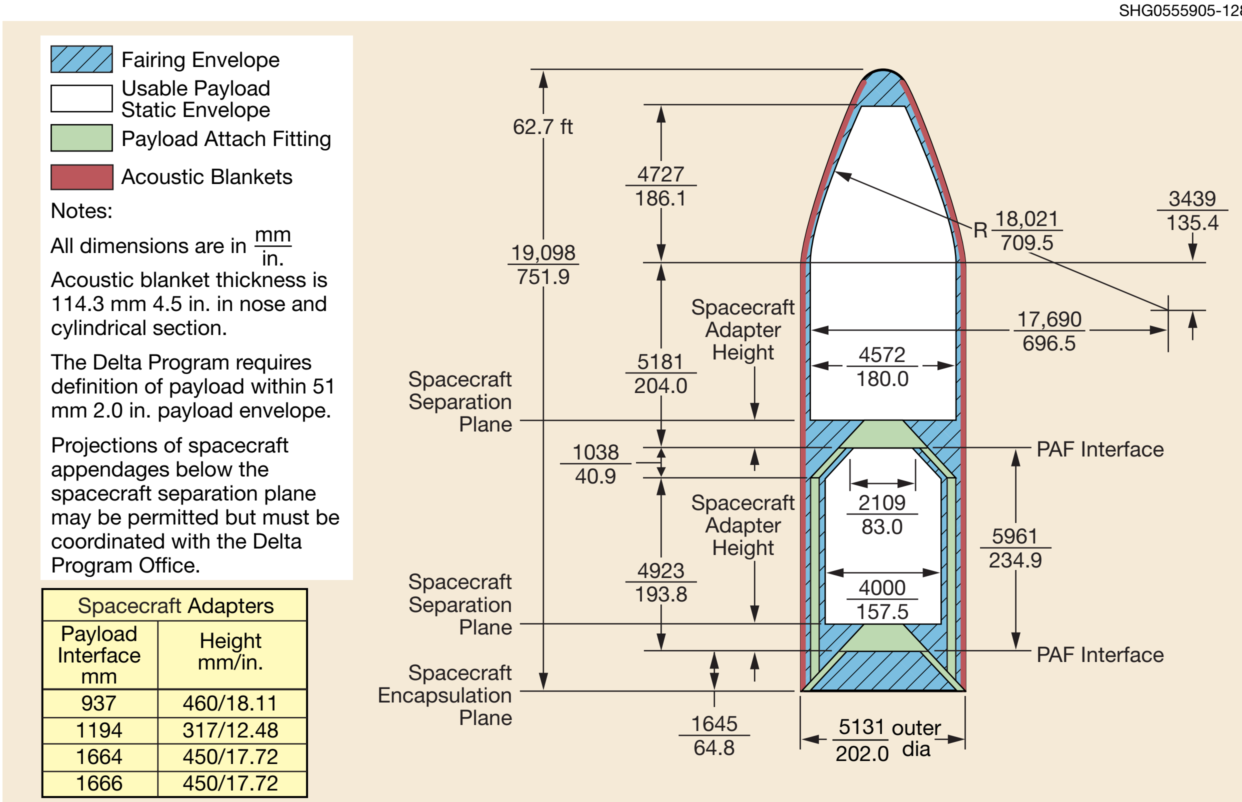
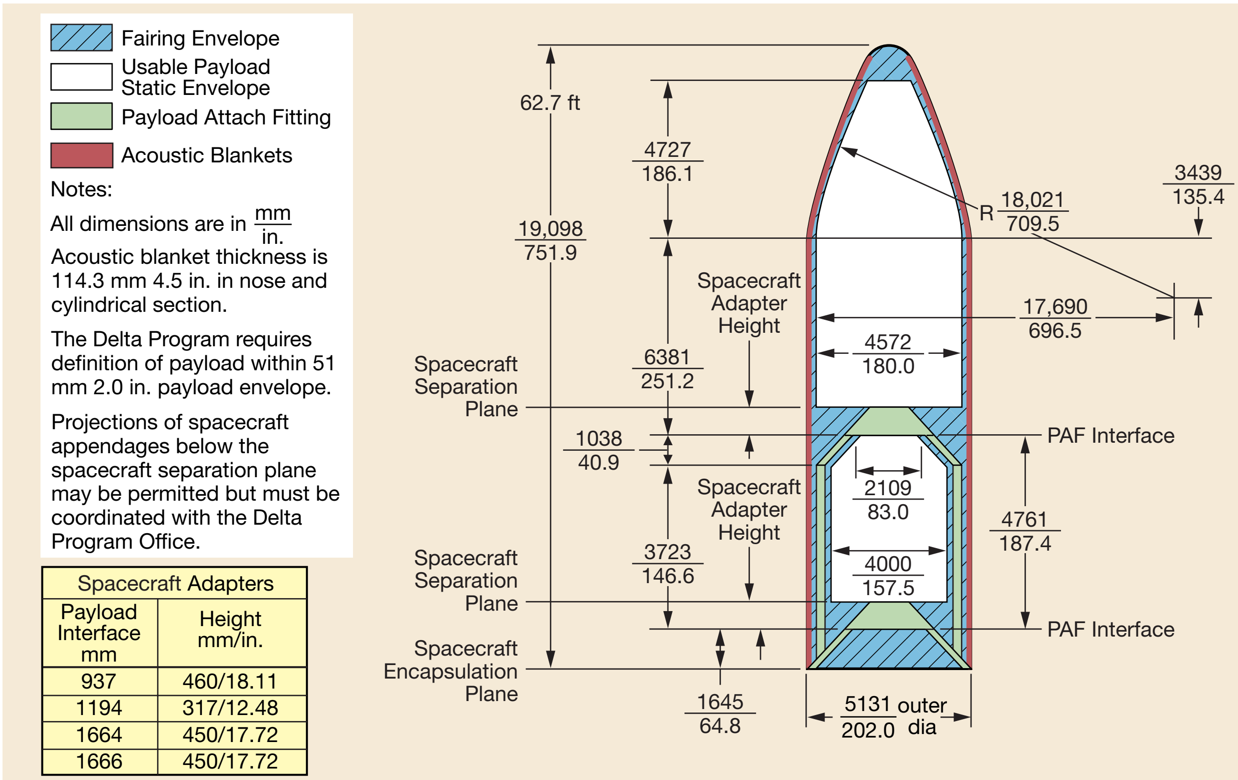



**Figure 10-8. Delta IV Heavy Dual Manifest (DPAF-5 Long)**

SHG0555905-129




| Spacecraft Adapters | |
|---|---|
| Payload Interface mm | Height mm/in. |
| 937 | 460/18.11 |
| 1194 | 317/12.48 |
| 1664 | 450/17.72 |
| 1666 | 450/17.72 |

**Figure 10-9. Delta IV Heavy Dual Manifest (DPAF-5 Short)**

### 10.1.2.3 DPAF-5 Launch Operations

Once a satellite has completed its preparations within the processing facility, each payload will be mated to its assigned spacecraft adapter for spacecraft checkout (Figure 10-10). Payload “stack-up” begins by mounting the lower spacecraft and spacecraft adapter combination to the base payload attach fitting. A verification test will be performed to assure that all connections are properly mated and all systems are functioning. When these tests are completed, the DPAF-5 canister is placed over the lower payload and mated to the base payload attach fitting. In parallel to the lower payload encapsulation, the upper payload is mated to its assigned spacecraft adapter. Once the lower payload is encapsulated within DPAF-5, the upper payload and its spacecraft adapter are transferred into the high bay and mated to the top of DPAF-5. A verification test is then performed for the upper payload to assure that all connections are properly mated and all systems are functioning properly.

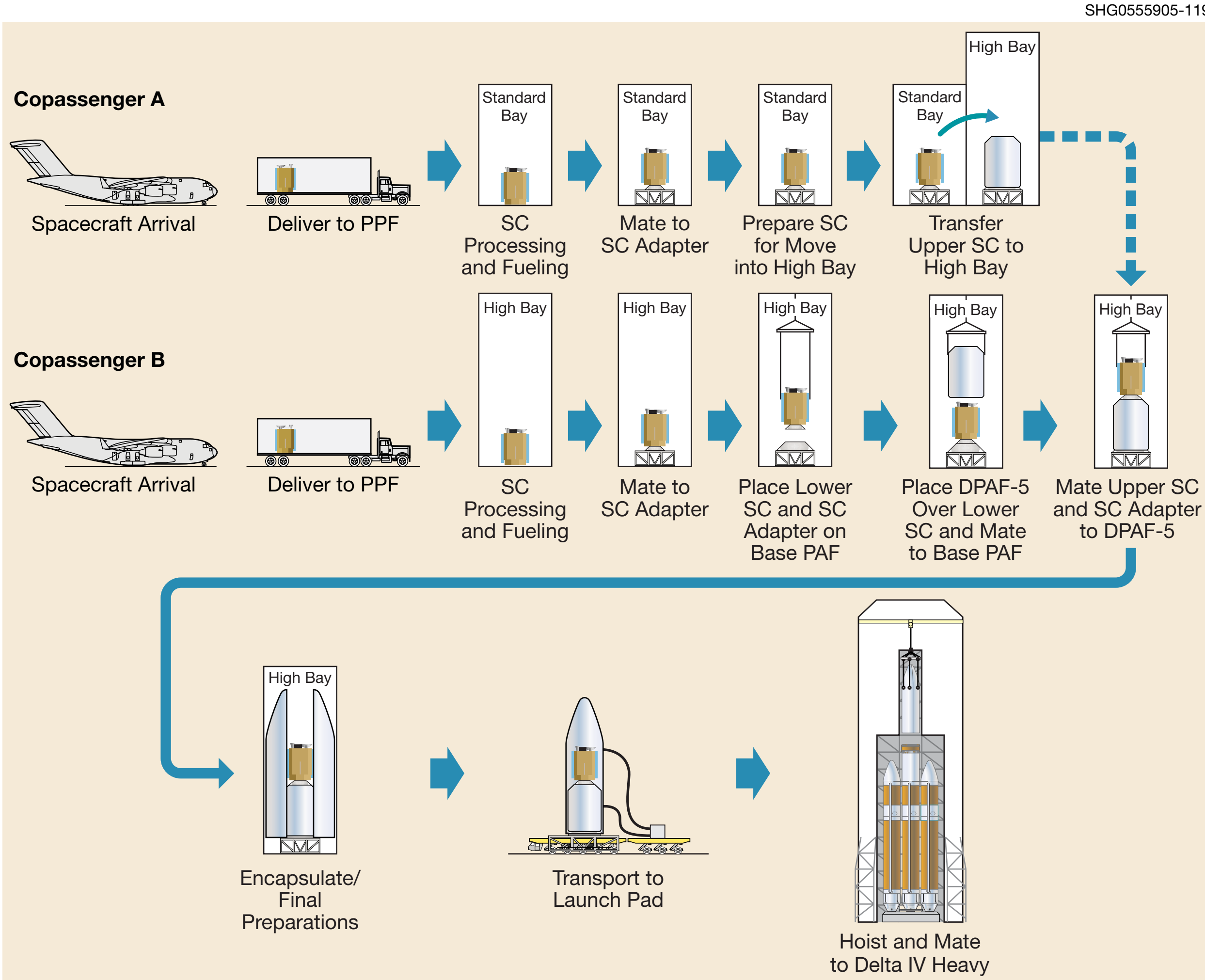



**Figure 10-10. Dual-Manifest Payload Processing and Encapsulation**

Once the stack-up is completed, the dual-manifested payloads will be encapsulated within the 5-m-dia, 19.1-m (62.7-ft)-long composite fairing. After encapsulation is completed, conditioned air is provided through two ports in the fairing, one to each payload compartment, to assure a contamination-free and thermally stabilized environment. Conditioned air is provided as the encapsulated payloads are transported to the launch pad approximately five days before launch. At the Delta IV launch pad, the encapsulated satellites are hoisted by the mobile service tower (MST) crane and mated to the top of the Delta IV Heavy second stage. Final connections are verified, and preparations are made for final countdown and launch. Conditioned air is provided to each payload bay on pad through the same two ports in the fairing until launch.

Physical access to dual-manifested payloads is possible until approximately 24 hours before launch. Access doors will be provided at agreed-to locations in the fairing and DPAF-5 to allow customers access to their satellite systems after encapsulation.

### 10.1.2.4 Delta IV Heavy/DPAF-5 GTO Mission Profile

The sequence of events through upper spacecraft separation for the dual-manifest Delta IV Heavy is shown in Figure 10-11. The standard two-burn dual-manifest delivery orbit is 271-km perigee by 71,572-km apogee at 23.3 deg of inclination to geosynchronous transfer orbit (GTO). This baseline drop-off orbit, with an apogee altitude capped at twice-synchronous altitude, will deploy both satellites into an orbit that requires a satellite ΔV to GEO of approximately 1550 m/sec. The total mission duration for satellite deployment into the proposed standard delivery orbit is approximately 1.5 hours from liftoff through final spacecraft separation.

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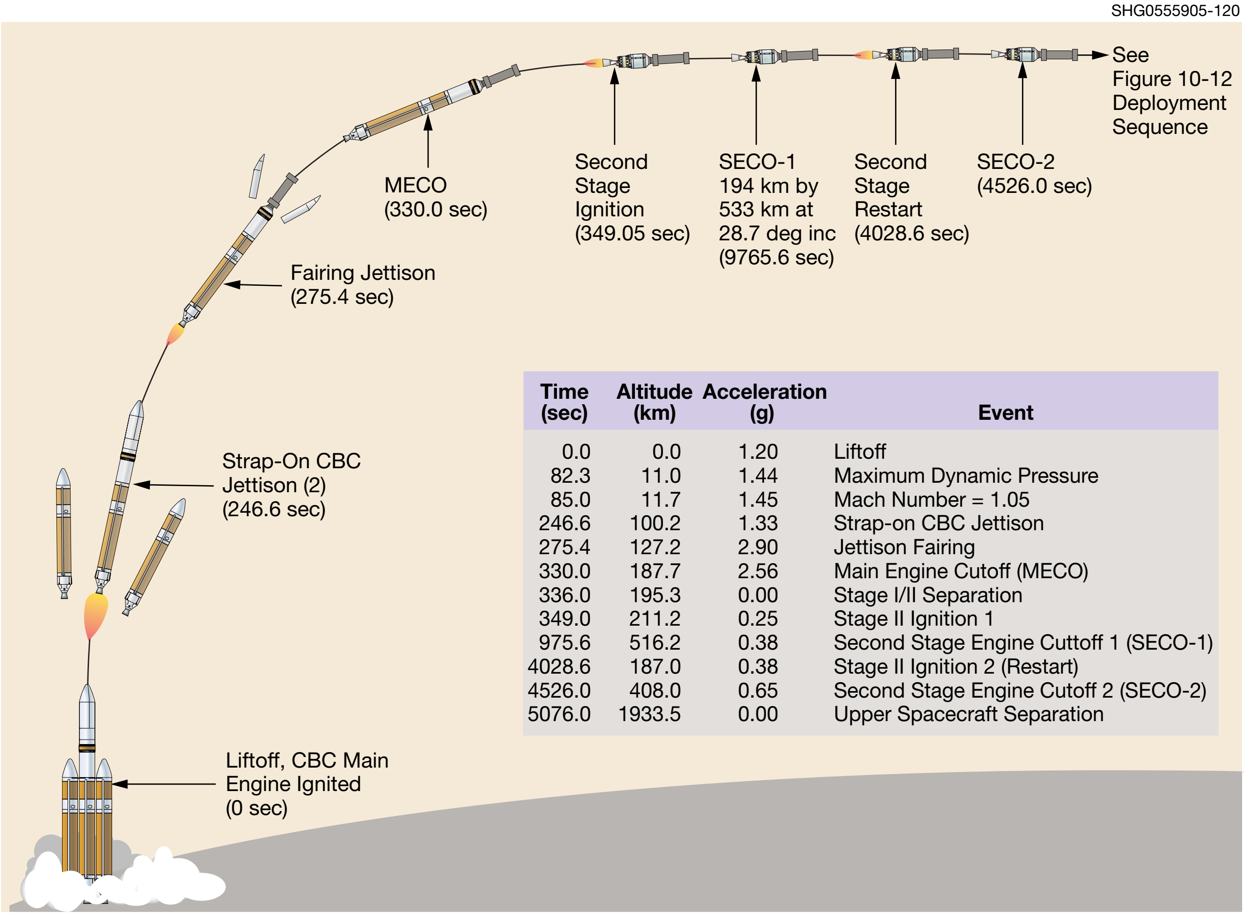


| Time (sec) | Altitude (km) | Acceleration (g) | Event |
|---|---|---|---|
| 0.0 | 0.0 | 1.20 | Liftoff |
| 82.3 | 11.0 | 1.44 | Maximum Dynamic Pressure |
| 85.0 | 11.7 | 1.45 | Mach Number = 1.05 |
| 246.6 | 100.2 | 1.33 | Strap-on CBC Jettison |
| 275.4 | 127.2 | 2.90 | Jettison Fairing |
| 330.0 | 187.7 | 2.56 | Main Engine Cutoff (MECO) |
| 336.0 | 195.3 | 0.00 | Stage I/II Separation |
| 349.0 | 211.2 | 0.25 | Stage II Ignition 1 |
| 975.6 | 516.2 | 0.38 | Second Stage Engine Cuttoff 1 (SECO-1) |
| 4028.6 | 187.0 | 0.38 | Stage II Ignition 2 (Restart) |
| 4526.0 | 408.0 | 0.65 | Second Stage Engine Cutoff 2 (SECO-2) |
| 5076.0 | 1933.5 | 0.00 | Upper Spacecraft Separation |

**Figure 10-11. Delta IV Heavy Dual-Manifest Sequence of Events for a GTO Mission (Eastern Range)**

Figure 10-12 shows the dual-manifest deployment sequence. During the ascent phase, the 5-m-dia fairing is jettisoned once the free-molecular heating rate has reached a specified level. This exposes the satellite in the upper bay, while the satellite in the lower bay remains encapsulated within DPAF-5. The Delta IV second stage then maneuvers into the intended delivery orbit at the attitude required for separation of the upper payload. Following the events of the second stage, the upper payload is released, and then the second stage performs a reorientation maneuver. Once this maneuver is completed, the DPAF-5 canister is deployed over the top of the lower

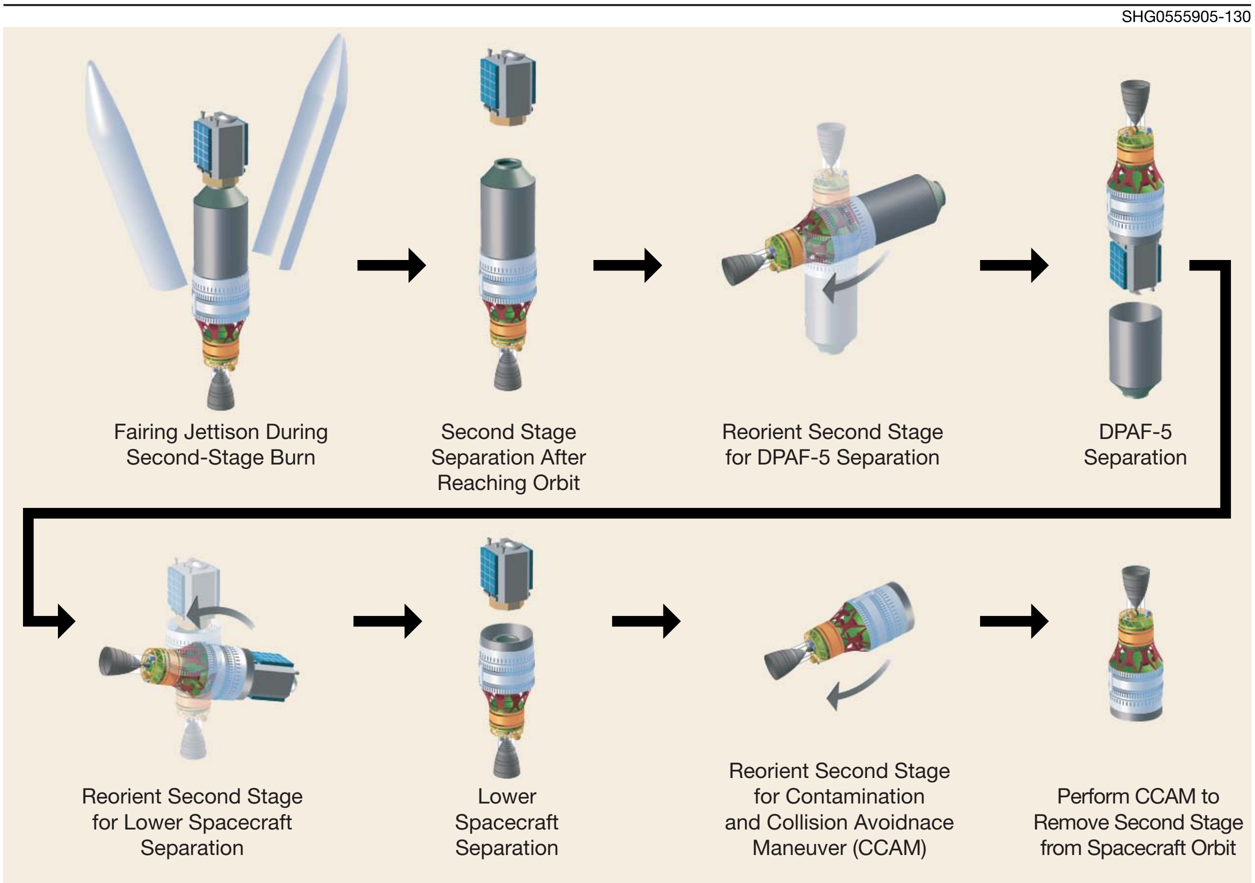


**Figure 10-12. Delta IV Heavy Dual-Manifest Spacecraft Deployment Sequence**

payload, in a direction that will assure no contact with the lower satellite and no interference with the upper satellite that was already deployed.

After the DPAF-5 structure has been released, the second stage reorients itself again into the attitude required for separation of the lower spacecraft. Once the lower satellite has been deployed successfully, the second stage performs an additional reorientation maneuver, and executes a contamination and collision avoidance maneuver (CCAM). This assures that the second stage will not contaminate or interfere with the released satellites.

Satellite separation can be accomplished using three-axis stabilization, spin stabilization, or transverse tip-off modes. A separation analysis is conducted to assure proper payload separation with no contamination or interference as a result of the other satellite, DPAF-5 structure, or launch vehicle second stage. Please contact the Delta Program Office for specific mission analysis.

### 10.1.3 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 3. 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 10-13, 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 the Delta Program Office.

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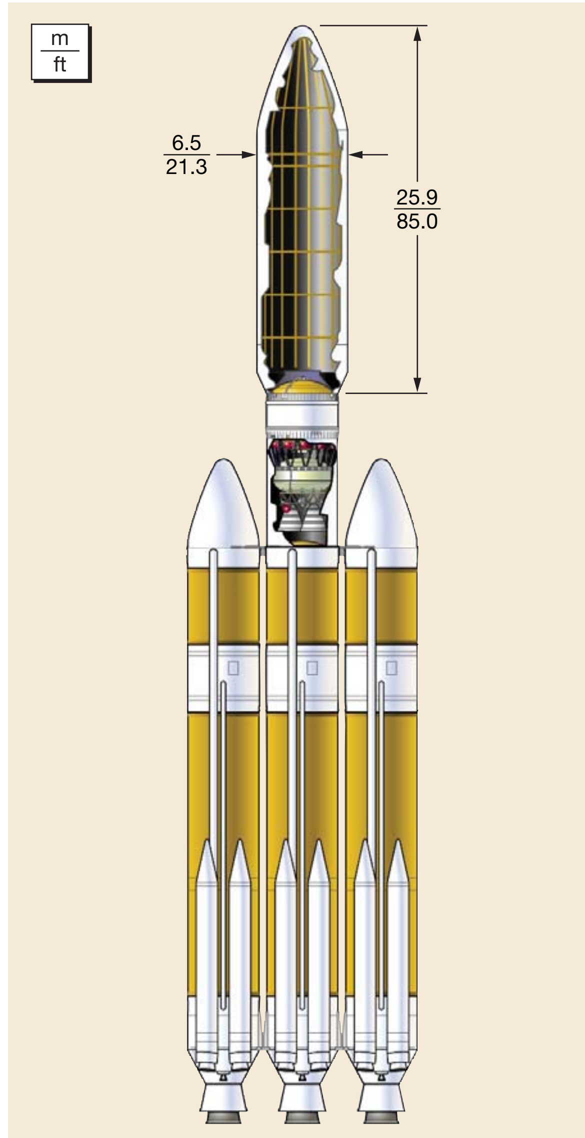


Figure 10-13. Delta IV Heavy with 6.5-m-dia. x 25.9-m-long PLF

### 10.1.4 Secondary Payloads

Since 1967, the Delta family of launch vehicles has launched 27 auxiliary payloads on 24 missions. These rideshares have ranged in mass from 15-lb to 265-lb; have been manifested on USAF, NASA, and commercial missions; and have launched payloads for different nations such as the United States, the United Kingdom, Japan, Spain, Sweden, Denmark, and South Africa. The following capabilities are under consideration in support of future secondary payloads missions

#### 10.1.4.1 Cubesat/P-Pod

In 1999, the California Polytechnic State University, San Luis Obispo (Cal Poly) and Stanford University developed Cubesat, a small secondary payload platform weighing 1 kg (2.2 lb) with a volume of 10 cm x 10 cm x 10 cm (3.9-in. x 3.9-in. x 3.9 in.), for use by universities across the world to launch small payloads to orbit. To assist with the deployment of these Cubesats from the launch vehicle, Cal Poly designed the Poly Picosatellite Orbital Deployer (P-Pod), a small structure capable of holding up to three Cubesats during launch and dispensing them into space (Figure 10-14). Due to its small size and mass, a P-Pod can be placed almost anywhere on the launch vehicle. The Delta Program is assessing the possibility of mounting multiple P-Pods on

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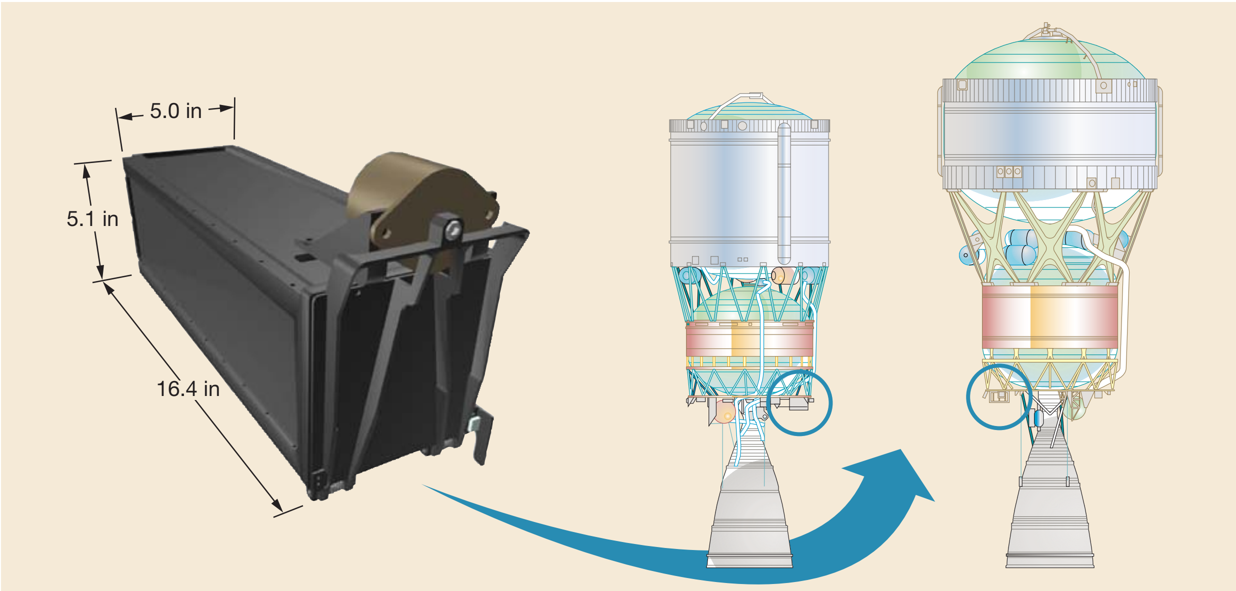


**Figure 10-14. Delta IV Second-Stage Equipment Shelf Mounting Locations for Cubesat P-Pods**

the Delta IV second-stage equipment shelf, at a location that is normally used for additional batteries and equipment to support the extended times to orbit for GEO missions. For non-GEO missions, this volume is not normally used and could be made available to P-Pods. Such a location would have limited access prior to launch, and would require the Cubesat payloads to be ejected well after primary payload separation.

Further information on Cubesat and P-Pod can be found at the Cubesat Web site: http://cubesat.calpoly.edu/

### 10.1.4.2 Secondary Attach Mounting (SAM)

The Delta IV Secondary Attach Mounting (SAM) is a one-piece machined aluminum ring structure that is bolted to the side of the 1575-4 composite PAF (Figure 10-15). SAM can accommodate a single payload up to 400-lb in mass, with a 15-in. center of gravity, and a nominal volume of 30-in. x 30-in. x 30-in. The placement of SAM on the forward section of the PAF maximizes the available volume of the secondary payload within the payload fairing without impacting the primary payload in any way. The 15-in.-diameter payload interface and the 24-bolt hole locations on SAM is the same as that on ESPA to maintain standardization between all ESPA-class payloads (see Section 5.2.9).

At a minimum, the electrical interface to the secondary payload will consist of 4 connectors mounted on a bracket at the SAM/secondary payload interface. Two of these connectors will be for primary and redundant separation signals. The other two connectors will be for primary and redundant discretes for secondary payload power-up and a break wire for separation indication. Further capabilities such as trickle-charge and onboard telemetry are under consideration.

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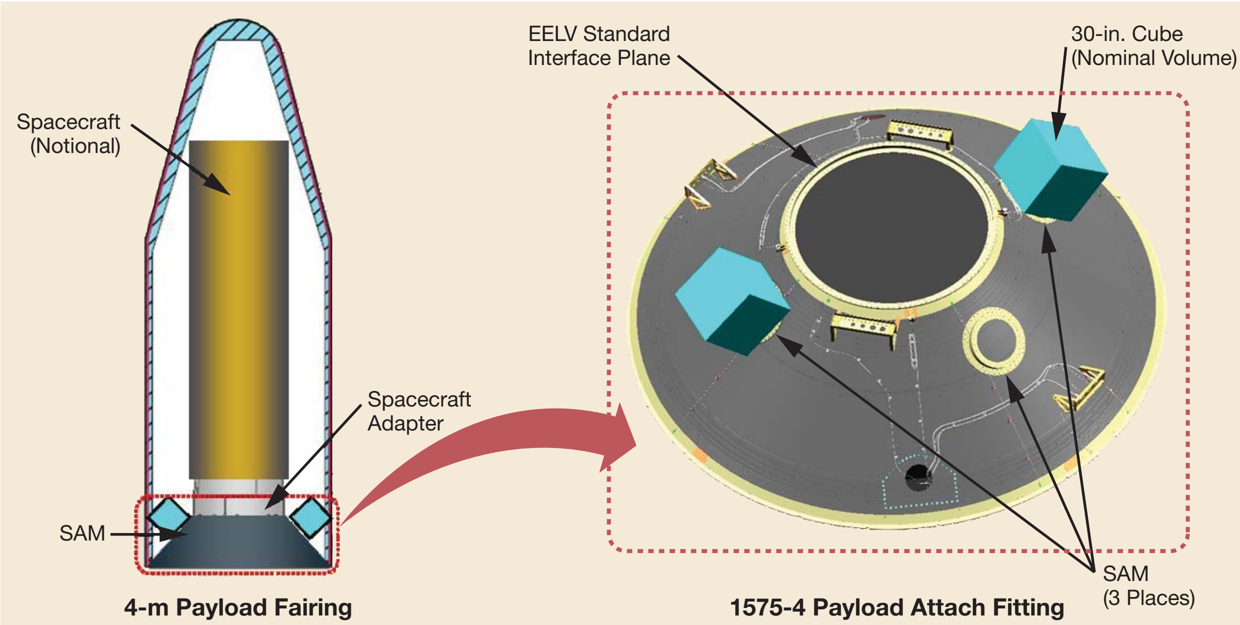


**Figure 10-15. Delta IV Secondary Attach Mounting (SAM)**

The Delta Program expects to be able to attach from one to three SAMs per PAF, depending on the primary mission performance margin and available volume envelope. These parameters will be determined on a case-by-case basis, as they will be affected by the height of the primary spacecraft adapter and the characteristics of the primary payload, such as spacecraft mass, dimensions, and envelope requirements below the separation plane.

## 10.2 PERFORMANCE UPGRADES

Delta IV enhancement options range across the availability timeline from ongoing performance upgrades to the RS-68, 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 Saturn V. Each section below describes the potential upgrades in greater detail. For additional information, please contact the Delta Program Office.

### 10.2.1 RS-68A Main Engine Upgrade

The Delta Program is currently upgrading the Delta IV Heavy with an improved version of the main engine (Figure 10-16), designated the RS-68A. The RS-68A will provide increased thrust and improved Isp for an approximately 13%

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**Figure 10-16. RS-68A Engine**

improvement in payload mass delivered to orbit (Figure 10-17). The upgraded Heavy with RS-68A is expected be available in early 2011. The remaining Delta IV Medium and Medium+ configurations are also expected to incorporate the RS-68A upgrade, with availability sometime after implementation on the Heavy configuration. The higher performance associated with use of the 106% throttle setting may require some structural modifications or requalification, while use of the RS-68A at the current 102% throttle level involves a minimum amount of vehicle modification. The associated performance gains for the Medium and Medium+ configurations are shown in Figure 10-17.

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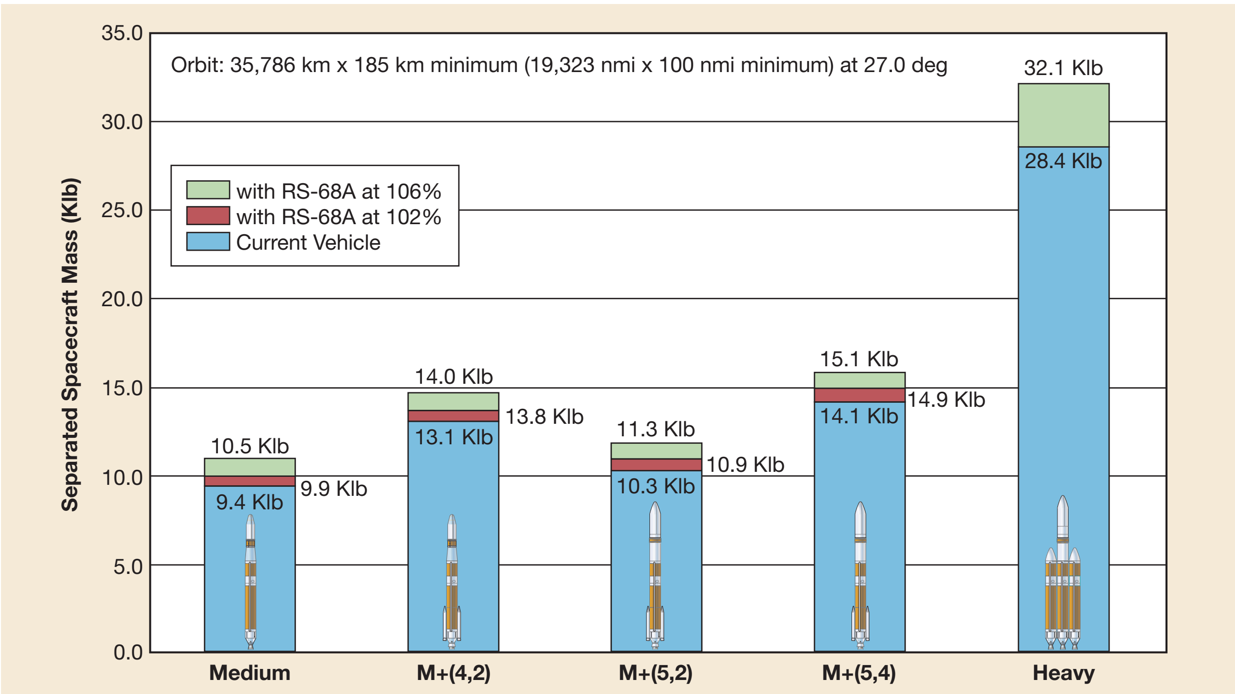


**Figure 10-17. Delta IV Performance Improvement with RS-68A Engine**

### 10.2.2 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+(5,4) 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 10-18, and discussed in additional detail below.

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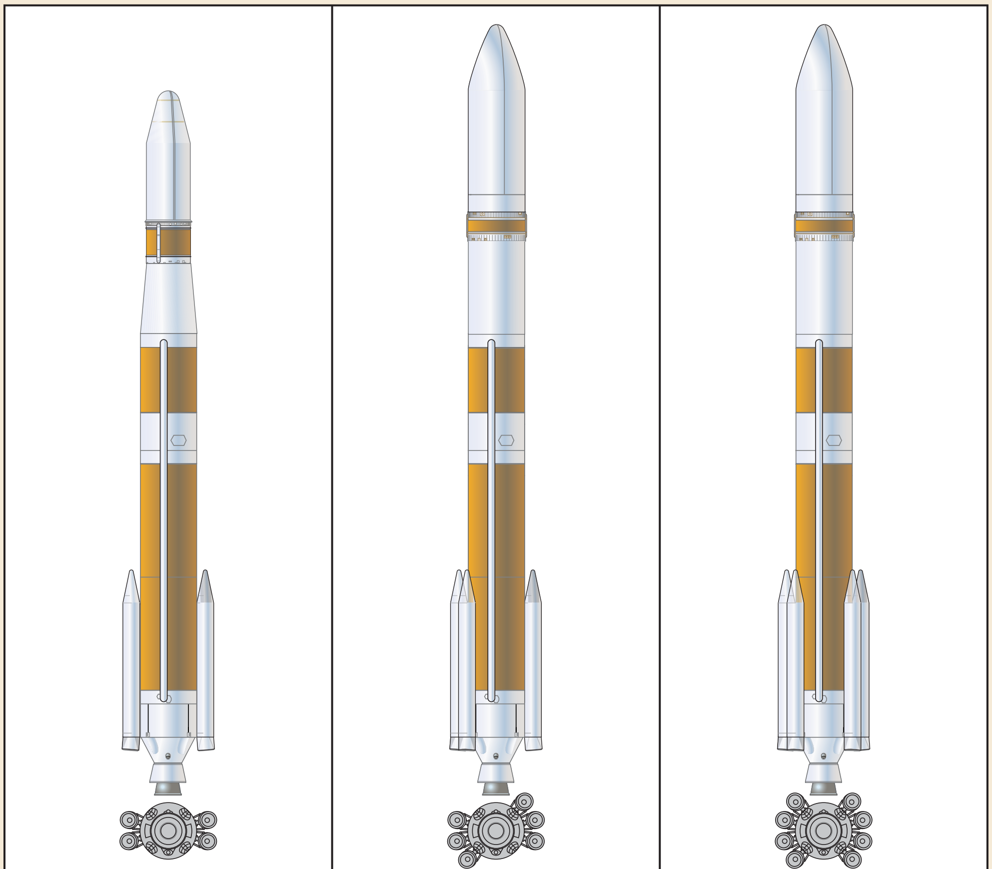


| | M+(4,4) | M+(5,6) | M+(5,8) |
|---|---|---|---|
| GTO | 7,500 kg (16,600 lb) | 7,700 kg (17,000 lb) | 9,200 kg (20,200 lb) |
| LEO | 14,800 kg (32,700 lb) | 15,000 kg (33,000 lb) | 17,200 kg (38,100 lb) |

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

**Figure 10-18. Delta IV M+ Improved Vehicle Configurations**

### 10.2.2.1 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 upper 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.

### 10.2.2.2 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.

### 10.2.3 DIV Heavy Upgrades

There are a considerable number of upgrades available for improving performance of the Delta IV family beyond the current Heavy capabilities or the RS-68A upgrade. A selection of possible upgrades is shown in Figure 10-19. This figure does not include the RS-68A upgrade discussed in Section 10.2.1.

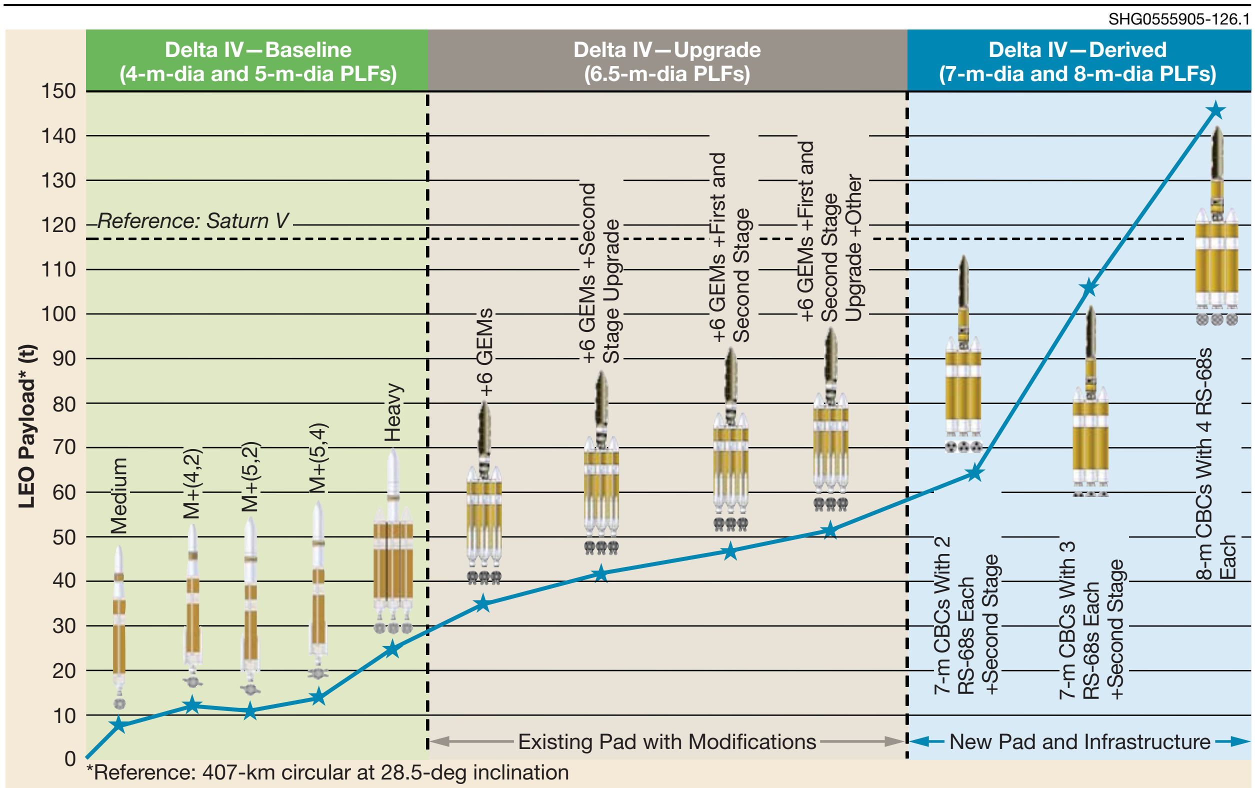


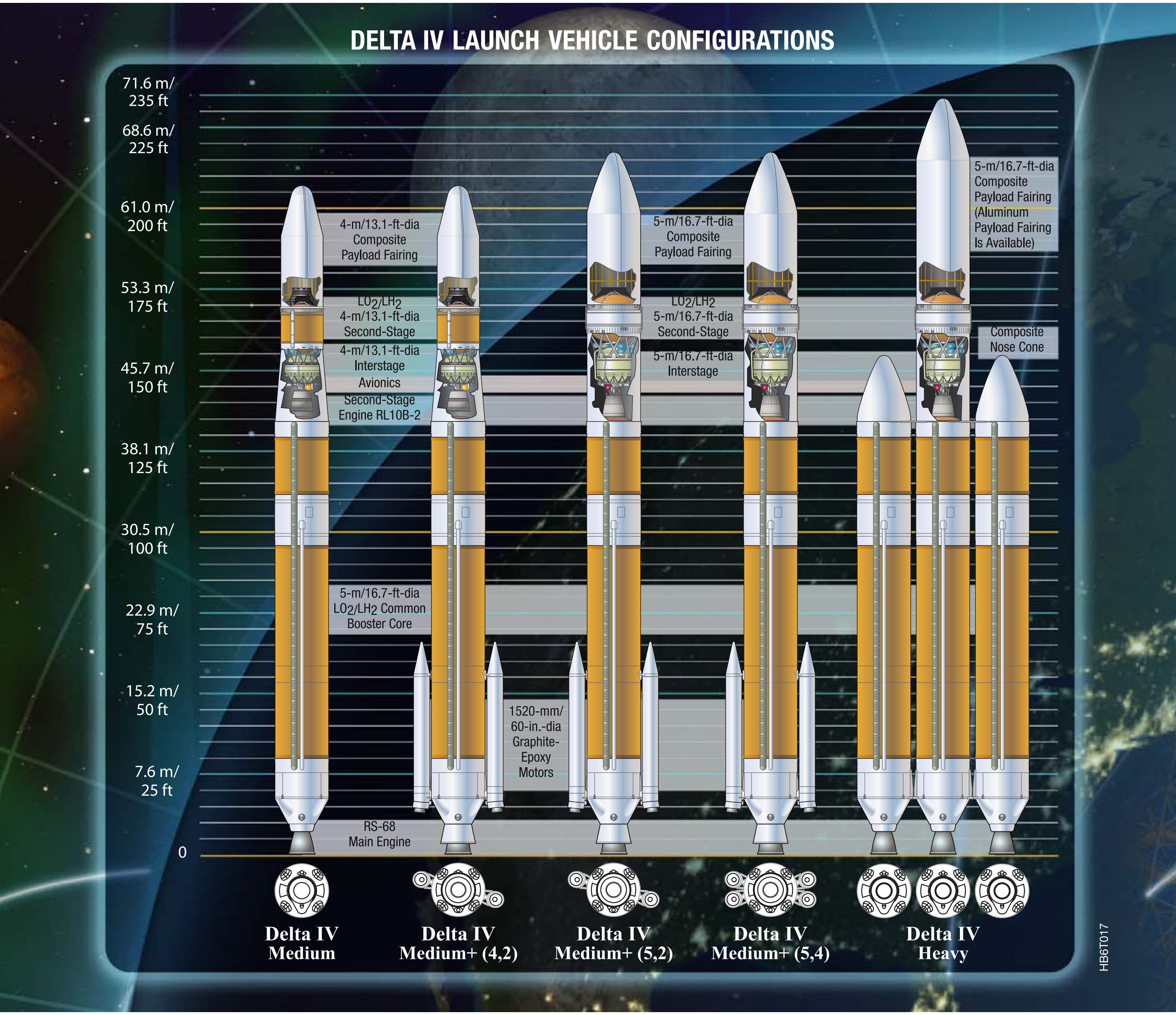

**Figure 10-19. Range of Upgrade Options Available to Improve Performance of the Delta IV Heavy**

The lowest cost options for upgrading the Heavy are shown in Figure 10-19. 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 cross-feed. 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 10-19. 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-68 engines per CBC. The upper 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 the Delta Program Office.

United Launch Alliance

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