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Delta IV Payload Planners Guide

DELTA IV
PAYLOAD PLANNERS GUIDE

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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 their related systems and launch services.

This document contains current information on Boeing plans for Delta IV launch services in addition to current projections related to the Delta 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.

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FIGURES

TABLES

1SLS OB	1st Space Launch Squadron Operations Building
30SW	30th Space Wing
45SW	45th Space Wing
A/C	air-conditioning
AASHTO	American Association of State Highway and Transportation Officials
ACS	attitude control system
AFB	Air Force Base
AGE	aerospace ground equipment
AKM	apogee kick motor
ANSI	American National Standards Institute
ASO	Astrotech Space Operations, LP
AT	access tower
ATP	authority to proceed
AWG	American Wire Gauge
AZ	azimuth
BAS	breathing air supply
B/H	blockhouse
B&W	black and white
BPS	bits per second
CAD	computer-aided design
CBC	common booster core
CCAM	contamination and collision avoidance maneuver
CCAS	Cape Canaveral Air Station
CCW	counter-clockwise
CFR	Code of Federal Regulations
CG	center of gravity
C/O	checkout
COMSTAC	Commercial Space Transportation Advisory Committee

CPF ______ Centaur processing facility
CRD ______ command receiver decoder
CSB ______ common support building
DBL ______ dynamic balance laboratory
DID ______ data item description
DIV-H ______ Delta IV Heavy
DIV-M ______ Delta IV Medium
DIV-M+ ______ Delta IV Medium-Plus
DLPS ______ Delta launch processing system
DLS ______ Delta Launch Services
DMCO ______ Delta Mission Checkout
DOC ______ Delta Operations Center
DOD ______ Department of Defense
DOF ______ degrees of freedom
DOT ______ Department of Transportation
DPC ______ dual-payload canister
DPF ______ DSCS Processing Facility
DSCS ______ Defense Satellite Communications System
DTO ______ detailed test objectives
EAL ______ entry authority list
E&O ______ engineering and operations
E/W ______ east/west
ECS ______ environmental control system
EED ______ electro-explosive device
EELV ______ evolved expendable launch vehicle
EGSE ______ electrical ground support equipment
EHD ______ engineering hardware description
EIRP ______ effective isotropic radiated power
ELS ______ expendable launch system

ELV — expendable launch vehicle

EMC — electromagnetic compatibility

EMI — electromagnetic interference

EMT — electrical-mechanical testing

EPT — elevating platform transporter

ER — Eastern Range

ESA — explosive safe area

ESM — erectable service mast

EWR — Eastern and Western Ranges

FAA — Federal Aviation Administration

FDLC — final design loads cycle

FMA — final mission analysis

FO — fiber-optic

FOTS — fiber-optic transmission system

FPE — fixed platform erector

FRR — flight readiness review

FS — first stage

FSAA — fairing storage and assembly area

FTS — flight termination system

FUT — fixed umbilical tower

GC — guidance computer

GC&NS — guidance control & navigation system

GC^3ME — ground command, control, communication, and mission equipment

GEM — graphite epoxy motor

GEO — geosynchronous Earth orbit

GMT — Greenwich mean time

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
GTO	geosynchronous transfer orbit
H	heavy
H_2	hydrogen
H/H	hook height
HB	Huntington Beach (California)
HEPA	high-efficiency particulate air
HIF	horizontal integration facility
HIP	hot isostatic pressing
HLV	heavy launch vehicle
HPF	hazardous processing facility; hydrogen processing facility
HPTF	hazardous processing testing facility
HVAC	heating, ventilating, and air conditioning
I/F	interface
IACO	integration and checkout
IBD	inhabited building distance
ICD	interface control drawing
IIP	instantaneous impact point
IL	interline distance
IPA	isopropyl alcohol
IPF	integrated processing facility
IPT	integrated product team
I_{SP}	specific impulse
J-box	junction box
KMI	KSC Management Instruction
KSC	Kennedy Space Center
LCC	launch control center

LEA	linear explosive assembly
LDXL	large diameter extra long
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 documents
LPT	lightning protection tower
LRB	liquid rocket booster
LRR	launch readiness review
LSIM	launch services integration manager
LSRR	launch site readiness review
LSS	launch site support
LSSM	launch site support manager
LSTP	launch site test plan
LT/LSS	launch table/launch support shelter
LV	launch vehicle
LVC	launch vehicle contractor
LVCS	launch vehicle coordinate system
LVDC	launch vehicle data center
M	medium
MAS	mobile assembly structure
MCC-1	Marshall convergent coating
MD	mission director
MDA	McDonnell Douglas Aerospace
MDC	McDonnell Douglas Corporation; Mission Director Center
MECO	main-engine cutoff

MEOP	mean expected operating pressure
MIC	meets-intent certification
MLV	medium launch vehicle
MOI	moment of inertia
MPPF	multi-payload processing facility
MSL	mean sea level
MSPSP	missile system prelaunch safety package
MSR	mission support request
MST	mobile service tower
N/S	north/south
NASA	National Aeronautics and Space Administration
NCS	nutation control system
NMM	national mission model
NPF	Navstar processing facility
NUS	no upper stage
NOAA	National Oceanographic and Atmospheric Administration
OASPL	overall sound pressure level
OB	operations building
OH	overhead
OR	operations requirement
OSB	operations support building
OVS	operational voice system
P&C	power and control
P/N	part number
PA	payload adapter
PACS	payload accommodations coordinate system
PAF	payload attach fitting
PAM	payload assist module
PCC	payload checkout cell

PCES ____ portable clean environmental shelter
PCM ____ pulse code modulation
PCS ____ probability of command shutdown
PDD ____ payload database document
PDR ____ preliminary design review
PEA ____ payload encapsulation area
PEF ____ payload encapsulation facility
PGOC ____ payload ground operations contract
PHE ____ propellant handler's ensemble
PHPF ____ payload hazardous processing facility
PL ____ payload
PLF ____ payload fairing
PMA ____ preliminary mission analysis
PPF ____ payload processing facility
PPG ____ payload planners guide
PPR ____ payload processing room
PPRD ____ payload processing requirements document
PRD ____ program requirements document
PSM ____ program support manager
PSP ____ program support plan
PSSC ____ pad safety supervisor's console
PTR ____ public transportation route
PWU ____ portable weight unit
QD ____ quick disconnect
RACS ____ redundant attitude control system
RCO ____ range control officer
RCS ____ reaction control system
RF ____ radio frequency
RFA ____ radio frequency application

RFI ______ radio frequency interference

RGA ______ rate gyro assembly

RIFCA ______ redundant inertial flight control assembly

RLCC ______ range launch control center; remote launch control center

ROC ______ range operations commander

ROCC ______ range operations control center

ROS ______ range operations specialist

S&A ______ safe and arm

S&G ______ Sargent and Greenleaf

S/C ______ spacecraft

SAB ______ satellite assembly building

SAEF ______ spacecraft assembly and encapsulation facility

SCAPE ______ self-contained atmosphere protection ensemble

SE ______ support equipment

SEB ______ support equipment building

SECO ______ second-stage engine cutoff

SEIP ______ standard electric interface panel

SIP ______ standard interface plane

SLC ______ Space Launch Complex

SLC-37 ______ Space Launch Complex 37 (CCAS)

SLC-6 ______ Space Launch Complex 6 (VAFB)

SLS ______ Space Launch Squadron

SMC ______ Space and Missile Systems Center

SOB ______ squadron operations building

SOP ______ standard operating procedure

SPIF ______ Shuttle payload integration facility

SR&QA ______ safety, reliability, and quality assurance; safety requirements and quality assurance

SRM ______ solid rocket motor

SSI ______ Spaceport Systems International

SSME ____ Space Shuttle main engine

STD ____ standard

STG ____ stage

STS ____ Space Transportation System

SV ____ space vehicle

SVC ____ space vehicle contractor

SVAFB ____ South Vandenberg Air Force Base

SVIP ____ space vehicle interface panel

SW ____ Space Wing

SW/CC ____ Space Wing Control Center

T/M ____ telemetry

TBD ____ to be determined

TBR ____ to be revised

TDRSS ____ tracking and data relay satellite system

THD ____ total harmonic distortion

TIM ____ technical interchange meeting

TMR ____ telemetry control rack

TMS ____ telemetry system

TOPS ____ transistorized operational phone system

TT&C ____ telemetry, tracking, and command

TVC ____ thrust vector control

TWX ____ telex

UDS ____ universal document system

UPS ____ uninterruptable power supply

USAF ____ United States Air Force

UV ____ ultraviolet

VAB ____ vertical assembly building

VAC ____ volts alternating current

VAFB ____ Vandenberg Air Force Base

VC	visible cleanliness
VCA	vehicle checkout area
VCF	vehicle checkout facility
VCR	vehicle control rack
VDC	volts direct current
VDL	voice direct line
VIM	vehicle information memorandum
VLC	verification loads cycle
VM	video monitor
VOS	vehicle on stand
VPF	vertical processing facility
VRR	vehicle readiness review
W/D	walkdown
W/O	without
WR	Western Range

INTRODUCTION

This Delta IV Payload Planners Guide (PPG) is provided by The Boeing Company to familiarize customers with Delta IV launch services. Delta background and heritage, Delta IV launch vehicle configurations, their performance capabilities, and correlated launch services are described in this guide. Payload interfaces and the environments that the spacecraft will experience during launch are also defined. Facilities, operations, and payload processing procedures are described, as well as the documentation, integration, and procedural requirements associated with preparing for and conducting a launch.

The Delta IV configurations described herein are the latest evolution of our reliable Delta family, developed to provide the international user community with efficient, low-cost access to space. In four decades of use, Delta launch vehicle success stems from its evolutionary design, which has been steadily upgraded to meet the needs of the user community while maintaining high reliability.

A new launch complex, Space Launch Complex 37 (SLC-37), is being constructed at Cape Canaveral Air Station (CCAS) in Florida to support our commercial and government customers. The Delta IV will be launched from SLC-37 for geosynchronous transfer orbit (GTO) missions as well as missions requiring low- and medium-inclination orbits. Boeing will provide launches from SLC-6 at South Vandenberg Air Force Base, California, for high-inclination missions. Specific vehicle performance data are presented in Section 2.

As a commercial launch services provider, Boeing acts as the coordinating agent for the user in interfacing with the United States Air Force (USAF), the Federal Aviation Administration (FAA), the designated payload processing facility, and any other relevant agency when other commercial or government facilities are engaged for spacecraft processing. Commercialization agreements with the USAF provide Boeing the use of launch facilities and services in support of Delta IV launch services.

During the first quarter of 1999, the transition of McDonnell Douglas Commercial Delta, Inc., to Delta Launch Services, Inc., was completed. As part of this reorganization, we have designed Delta Launch Services (DLS) to improve customer satisfaction, provide a single point of contact, and increase responsiveness. Delta Launch Services offers full-service launch solutions using the Delta II, Delta III, and Delta IV family of launch vehicles. The customer is supported by an integrated product team (IPT)-based organization consisting of highly knowledgeable technical and managerial personnel who are dedicated to open communication and responsive to all customer needs (Figure 1).

Delta Launch Services has the ultimate responsibility, authority, and accountability for all Delta customer opportunities. This includes developing launch solutions to meet customer needs as well as providing customers with a launch service agreement for the selected launch services. It is

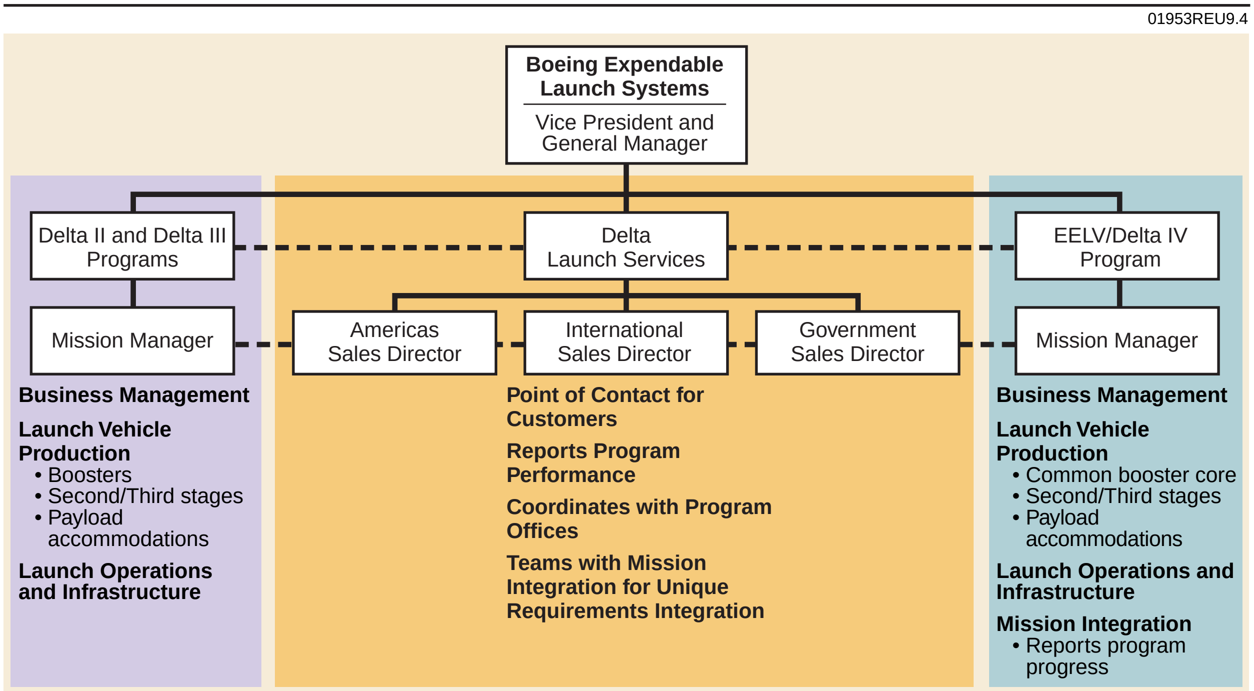

Figure 1. Delta Launch Services Functional Organization

through the DLS organization that dedicated focal points of contact are assigned to customers to ensure that all the launch service needs are coordinated with the appropriate sales, marketing, contracts, and technical personnel within DLS.

Delta Launch Services works closely with the Delta IV program to ensure that high-level customer technical requirements are coordinated. The Delta IV program is responsible for the development, production, integration, test, mission integration, and launch of the Delta IV system.

For contracted launch services, a dedicated mission integration manager is appointed from within the Delta IV program to support the customer. The mission manager works with DLS 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 before 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 postflight analysis.

The Delta team works closely with its customers to define optimum performance for mission payload(s). In many cases, we can provide innovative performance trades to augment the performance shown in Section 2. Our Delta team also has extensive experience in supporting customers around the world. This 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.

Delta IV offers dedicated as well as dual-manifest launch services, the benefits of a launch team committed to each user's payload, and a mission profile and launch window designed for individual mission orbits. Delta's manifesting, whether dedicated or dual-manifest, provides exceptional cost control and overall efficiency, simplified integration processes, on-time launch assurance, and efficient flight operations and control. Further, our dual-manifest system provides the payload community autonomy similar to a dedicated launch with price economies of a shared launch. Coupled with these launch service attributes is the Boeing commitment to excellence and proven dependability which, for more than three decades, has given our customers the highest assurance of a successful launch campaign.

Section 1
LAUNCH VEHICLE DESCRIPTION

This section provides an overall description of the Delta IV launch system and its major components. In addition, Delta 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 Boeing Company, then McDonnell Douglas (previously Douglas Aircraft Missiles and Space Systems), was the prime contractor. Boeing developed an interim space launch vehicle using a modified Thor 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 Boeing commitment to vehicle improvement to meet customer needs led to the Delta II vehicle, which now provides a capability of as much as 2109 kg (4650 lb) to GTO (Figure 1-1).

The Boeing commitment to continued vehicle improvement to meet customer needs is evident in the many configurations, as shown in Figure 1-1. Delta II has provided customers with a demonstrated world-class success rate of 97.6%, and processing times on the launch pad have been reduced from 40 to 24 days. The Delta III launch vehicle continues the Boeing tradition of Delta growth by providing a GTO capability of 3810 kg (8400 lb) and a LEO capability of 8292 kg (18,280 lb). The Delta IV launch system is a continuation of this 40-year evolution, and provides a GTO capability of 4060 kg (8950 lb) to 10840 kg (23,900 lb). By incorporating heritage hardware, proven processes, and lessons learned, Delta IV will provide a broad spectrum of performance capabilities at a lower cost, while providing even greater reliability and operability (Figure 1-2). Boeing 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. It consists of a family of five launch vehicles (LV) (Figures 1-3 and 1-4): 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). Each has a newly developed first-stage common booster core (CBC) using a cryogenic propulsion system (liquid oxygen, LO_2/liquid hydrogen, LH_2). Figure 1-3 displays the evolution of the Delta IV launch vehicle system from our heritage Delta II and Delta III programs, and presents the nomenclature used to describe the Delta IV launch vehicle family.

The Delta IV-M uses one CBC, a Delta III-derived cryogenic propellant (LO_2/LH_2) 4-m (157.5-in.)-dia second stage (which hereinafter may be referred to as the 4-m second stage), and a modified

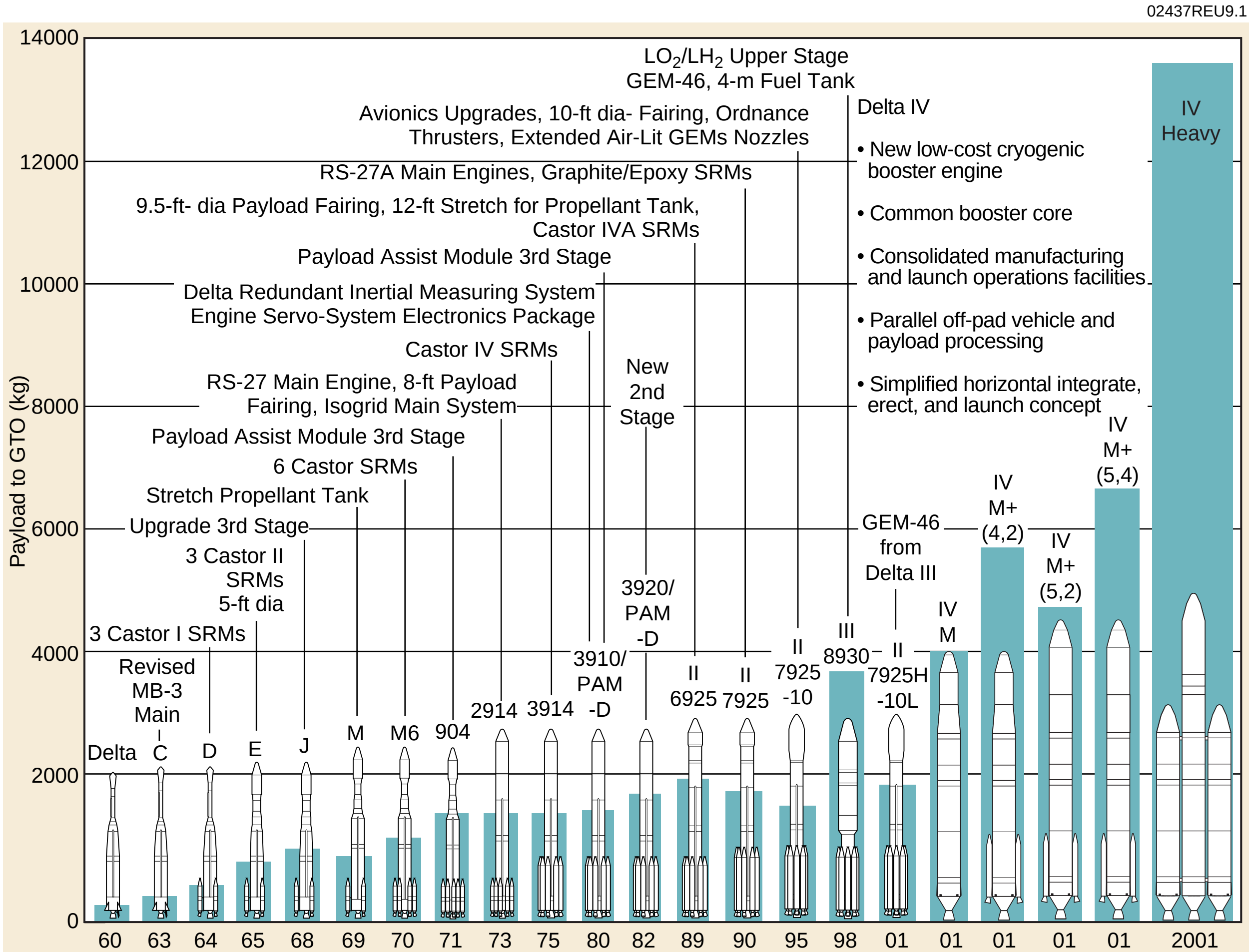

Figure 1-1. Delta/Delta II/Delta III/Delta IV Growth to Meet Customer Needs

Delta III 4-m (160.3-in.)-dia composite payload fairing (PLF) (which hereinafter may be referred to as the 4-m composite fairing).

The Delta IV-M+ vehicles accommodate payload classes between the Delta IV-M and Delta IV-H-class vehicles, using three versatile configurations. One configuration, the Delta IV-M+ (4,2), uses two solid-rocket motors (SRM) derived from the Delta III graphite-epoxy motors (GEM) attached to a central common booster core; a modified Delta III cryogenic 4-m second stage; and a 4-m composite fairing derived from the Delta III. The other configurations use either two SRMs (Delta IV-M+ [5,2]) or four SRMs (Delta IV-M+ [5,4]) attached to a central CBC; a 5-m (200-in.)-dia cryogenic second stage (which hereinafter may be referred to as the 5-m second stage); and the latest addition to our fairing family, a 5.13-m (202-in)-dia by 14.3-m (47-ft)-long composite bisector fairing (which hereinafter may be referred to as a 5-m composite fairing), also derived from our Delta III 4-m composite fairing. The SRMs of the Delta IV-M+ vehicles are increased in size, and provide more thrust than the Delta II and Delta III SRMs.

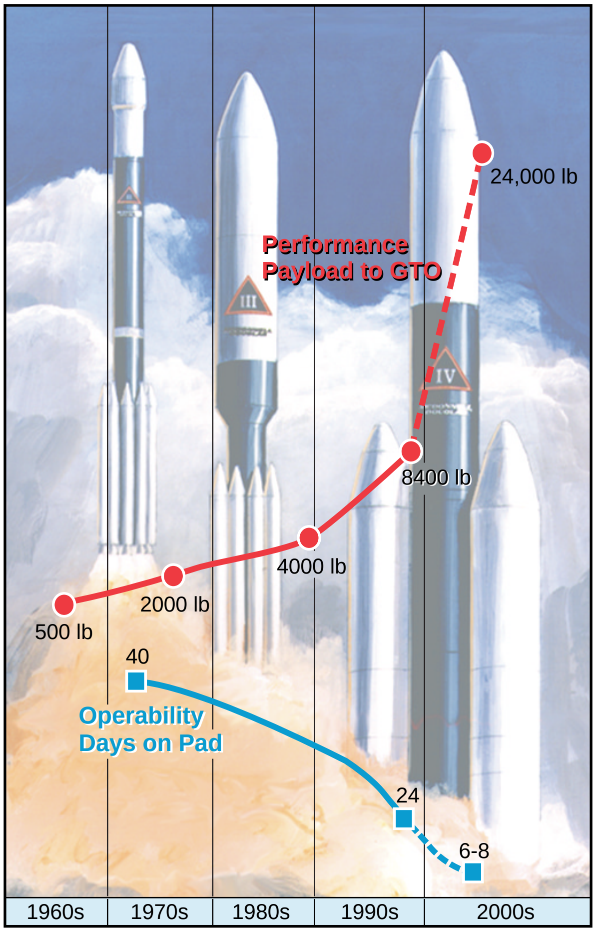

Figure 1-2. Performance and Operability of the Delta Family

The Delta IV-H vehicle uses a central CBC with two strap-on CBC boosters and the 5-m cryogenic second-stage configuration. The 5-m second stage uses the same engine as the 4-m configuration, but with a stretched, same-diameter LO_2 tank and an LH_2 tank that has been increased in diameter to 5 m to optimize performance. The Delta IV-H accommodates heavy-class dedicated payloads as well as dual-manifested payloads. The Delta IV-H uses the Boeing 5-m 19.1-m (63-ft)-long composite bisector payload fairing (PLF). The 5-m (200-in.)-dia Boeing-built Titan IV metallic (aluminum isogrid trisector) fairing (which hereinafter may be referred to as the 5-m metallic fairing) is the baseline for the US government heavy-class payloads.

Delta IV is designed to place payloads into various orbits by launching from either the Eastern Range (ER) at Cape Canaveral Air Station (CCAS), Florida, or Western Range (WR) at Vandenberg Air Force Base (VAFB), California, as 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

All configurations of the Delta IV launch system employ a CBC. The CBC subassemblies include the interstage, liquid oxygen (LO_2) tank, liquid hydrogen (LH_2) tank, centerbody, engine section, and nose cones for strap-on boosters on the Delta IV-H. For 4-m second-stage configurations (Delta IV-M, Delta IV-M+ [4,2]), the interstage narrows from a 5-m (200-in.) dia to a 4-m (157.5-in.) dia. For 5-m (200-in.) second-stage configurations (Delta IV-M+ [5,2], Delta IV-M+ [5,4], and Delta IV-H]) the interstage is a cylinder with a 5-m (200-in.) dia.

Powering each Delta IV CBC for all missions is the new Rocketdyne RS-68 engine (Figure 1-5). The RS-68 is a state-of-the-art, low-cost engine, derived from the Space Shuttle main engine (SSME), that burns LO_2 and LH_2 cryogens. The RS-68 features moderate chamber pressures and

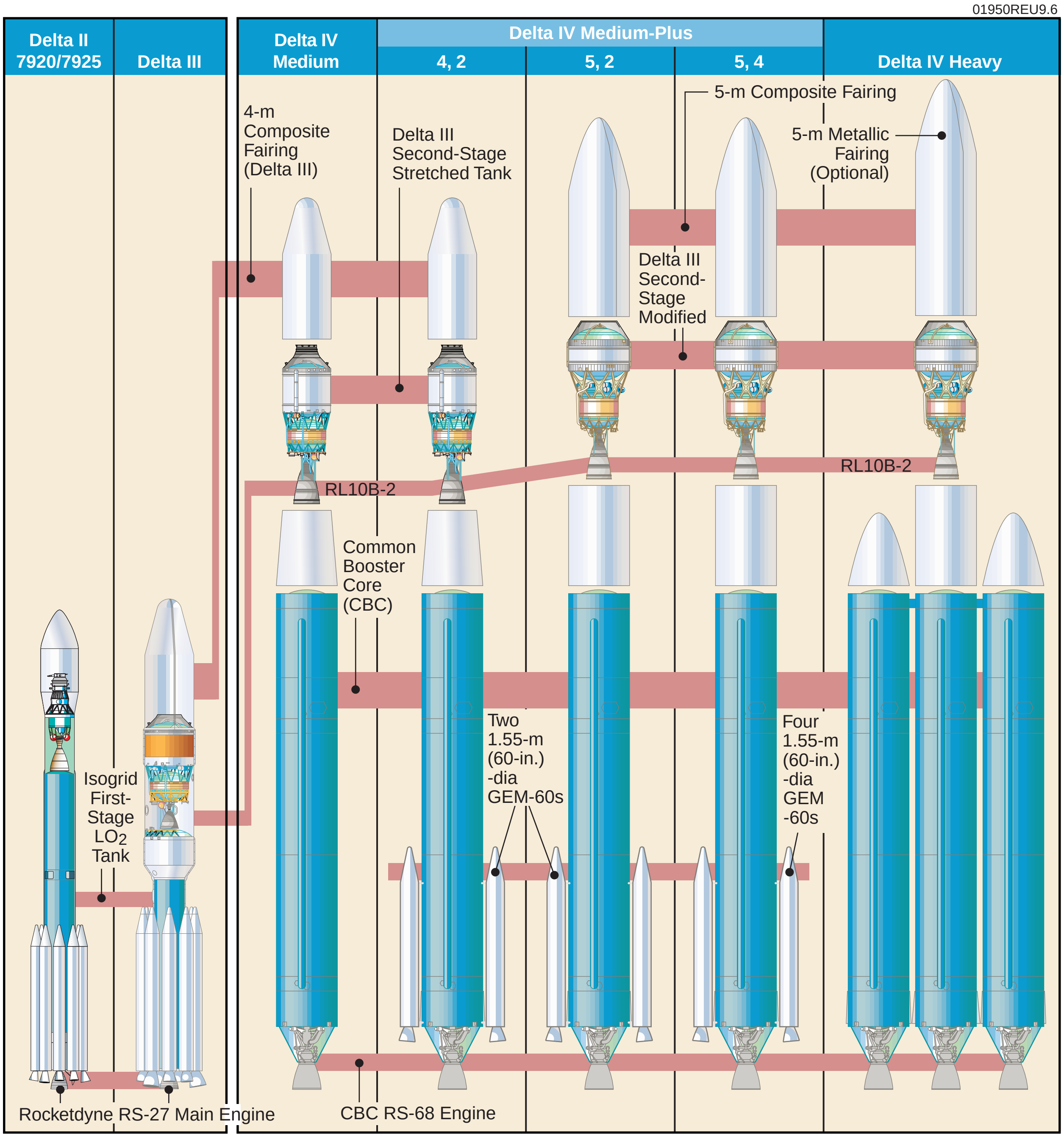

Figure 1-3. Delta Launch Vehicle Family

uses a simple gas generator cycle. It features proven, well-understood technologies. The coaxial injector is derived from the SSME and uses low-cost materials and advanced fabrication techniques. The thrust chamber is an innovative hot isostatic press (HIP)-bonded evolution of the SSME design. It has been designed for minimum part count and relies on the use of standard materials. The RS-68 has a 21:5 expansion ratio and employs a gas generator, a turbopump, and a regeneratively cooled thrust chamber. The thrust chamber and nozzle are hydraulically gimbaled to provide pitch and yaw

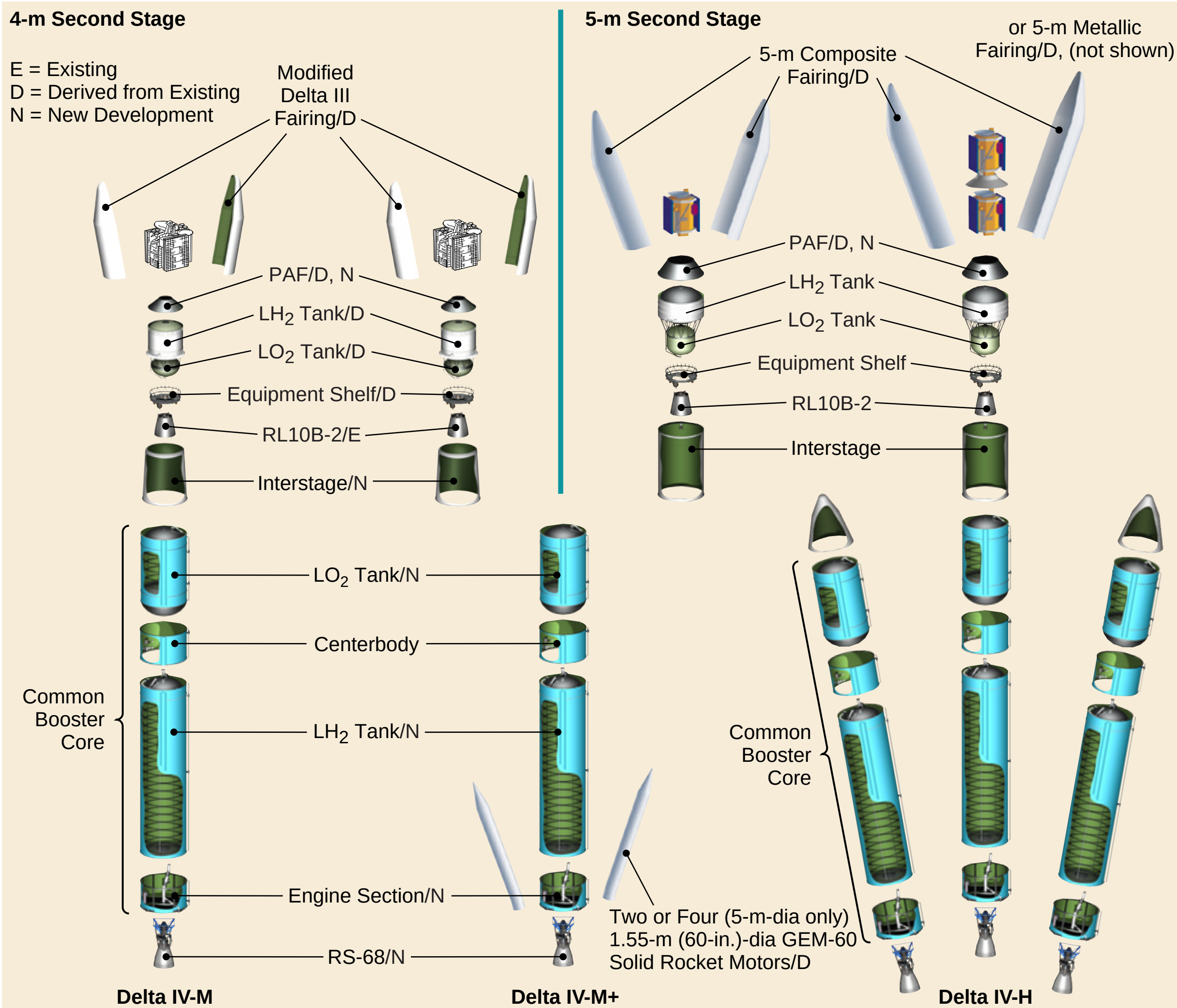

Figure 1-4. Delta IV Launch Vehicle Description

control. Vehicle roll control for single-core 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 CBC boosters.

The Delta IV-M+ configurations use either two or four 1.55-m (60-in.)-dia Alliant graphite-epoxy motors (GEM-60). These motors are derived from the smaller GEM-46 used on Delta III. Ordnance for motor ignition and separation systems is completely redundant. Separation is accomplished using redundantly initiated ordnance thrusters that provide a radial thrust to jettison the expended SRMs away from the CBC. The Delta IV-H uses two additional CBCs as strap-on liquid rocket boosters (LRB) with nose cones and separation motors.

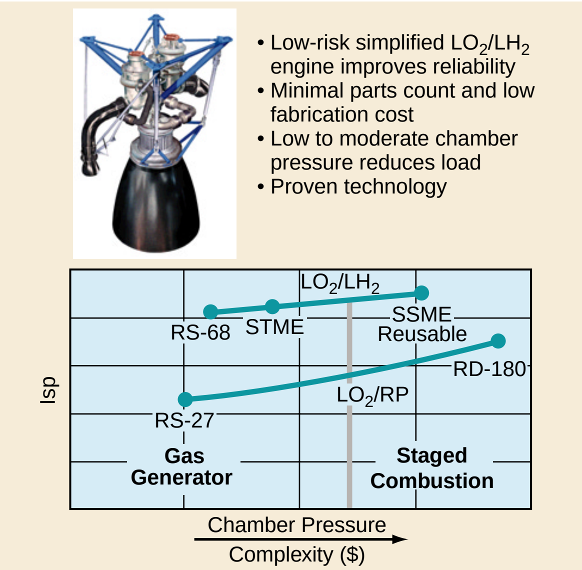

Figure 1-5. The RS-68 Engine

1.2.2 Second Stage

Two second stage configurations, 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, accommodate all Delta IV variations (Figure 1-6).

Both second stages use the Delta III cryogenic Pratt & Whitney RL10B-2 engine, derived from the 36-year heritage of the flight-proven RL10 family. Like the Delta III, the engine has an extendible nozzle for increased specific impulse (I_{sp}) and thrust. 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 propulsion system produces a thrust of 11 225 kg (24,750 lb). The 4-m configuration has a total propellant load of 20 410 kg (45,000 lb), providing a total burn time of approximately 850 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 attitude control system (ACS), as required. Propellant tank pressurization during burn is accomplished using hydrogen bleed from

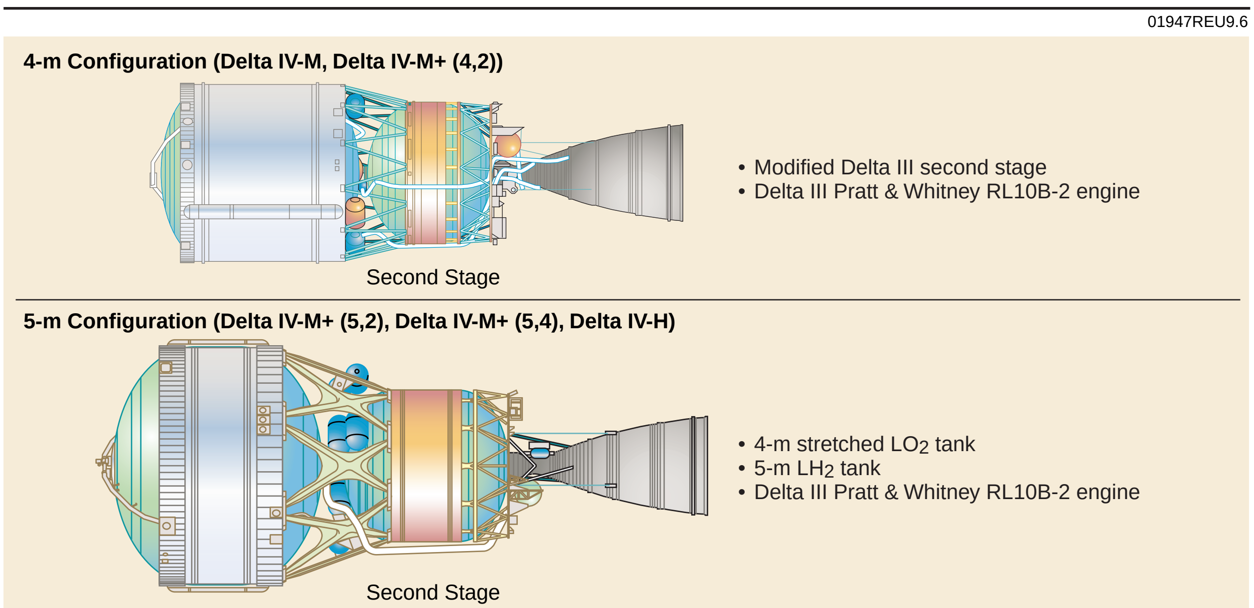

Figure 1-6. Delta IV Second-Stage Configurations

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. After payload separation a contamination and collision avoidance maneuver (CCAM) is conducted. After CCAM, the vehicle is safed from explosion by burning/venting all remaining propellant and pressurants.

The 5-m configuration of the Delta IV second stage uses the same engine and subsystems as the 4-m configuration. The LO_2 tank is the same diameter as the 4-m configuration, lengthened for additional propellant. The 5-m configuration has a total propellant load of 27 200 kg (60,000 lb), providing a total burn time of over 1125 sec.

1.2.3 Third Stage

Delta IV is evaluating the use of a third stage for the Delta IV Medium-Plus and Heavy launch vehicles for interplanetary missions. The third-stage design would be based on the proven Delta II design. Because this configuration is not currently baselined in the Delta IV program, no other reference to the third stage will be made in the Delta IV Payload Planners Guide at this time.

The heritage Delta II third stage, upon which the Delta IV would be based, 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 and spacecraft. This stack mates to the top of the second stage.

The flight-proven STAR 48B SRM is produced by the Thiokol Corporation. The motor was developed from a family of high-performance apogee and perigee kick motors made by Thiokol.

Our flight-proven NCS maintains orientation of the spin-axis of the SRM/spacecraft during third-stage flight until just prior to spacecraft separation. The NCS uses monopropellant hydrazine prepressurized with helium. This simple system has inherent reliability, with only one moving component and a leak-free design.

An ordnance sequence system is used to release the third stage after spin-up, to fire the STAR-48B motor, and to separate the spacecraft following motor burn.

Additional information about the heritage third-stage design is available in the Delta II Payload Planners Guide. For more information regarding a Delta IV configuration using the third stage, contact Delta Launch Services.

1.2.4 Payload Attach Fittings

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 Boeing, or Boeing can supply the separation system. Payload separation systems typically incorporated on the PAF include clampband separation systems or explosive attach-bolt systems as required. The PAFs and separation systems are discussed in greater detail in Section 5.

In addition, Boeing 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 Delta Launch Services.

1.2.5 Payload Fairings

The Delta IV launch system offers the PLFs shown in Figure 1-7. These fairings provide protection to the satellite vehicle from the aerodynamic, acoustic, and thermal environments through the launch and ascent phases of flight. The 4-m fairing is a stretched Delta III 4-m composite bisector fairing.

The 5-m composite fairing is based on the Delta III 4-m composite fairing and comes in two standard lengths: 14.3 m (47 ft) and 19.1 m (62.7 ft). The dual-manifest fairing consists of two sections, a 5-m composite bisector fairing and a lower 5-m composite dual-payload canister (DPC). The dual-manifest configurations come in two lengths: 19.1-m (62.7 ft)-long, and 22.4-m (73.5-ft)-long. This construction is described in greater detail in Section 1.2.6.

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

All PLFs are configured for off-pad payload encapsulation (see Sections 6.3 and 7.3) to enhance payload safety and security, and to minimize on-pad time. All fairings incorporate interior acoustic absorption materials as well as flight-proven contamination-free separation joints. Boeing provides mission-specific modifications to the fairings as required by the customer. These include access doors, additional acoustic materials, and radio frequency (RF) windows. Fairings are discussed in greater detail in Section 3.

1.2.6 Dual-Manifest Capability

The Delta IV launch system offers the capability of dual-manifesting payloads on our Delta IV-H launch vehicle (see Section 2 for dual-manifest payload capability), beginning in 2002. The Delta IV-H dual-manifest system provides payload autonomy similar to a dedicated launch with the price economy of a shared launch, or the capability of launching multiple payloads in a single launch at a significant cost reduction compared to a dedicated launch. Our Delta IV-H dual-manifest approach has the capability to launch two spacecraft totaling up to 10 800 kg (23,900 lb) to our standard 27-deg GTO orbit using a 5-m composite fairing with a total length of 22.4 m (73.5 ft).

Our 5-m-dia 19.1-m (62.7-ft)-long Delta IV-H dual-manifest system consists of a 12.3-m (40.3-ft)-long composite fairing and a 6.8-m (22.4-ft)-long DPC. Our 5-m-dia 22.4-m (73.5-ft)-long Delta IV-H dual-manifest system consists of a 14.3-m (47-ft)-long composite bisector fairing and an 8.1-m (26.5-ft)-long DPC. The dual-manifest system consists of two independent payload bays, similar in volume, which are vented separately. Both spacecraft are

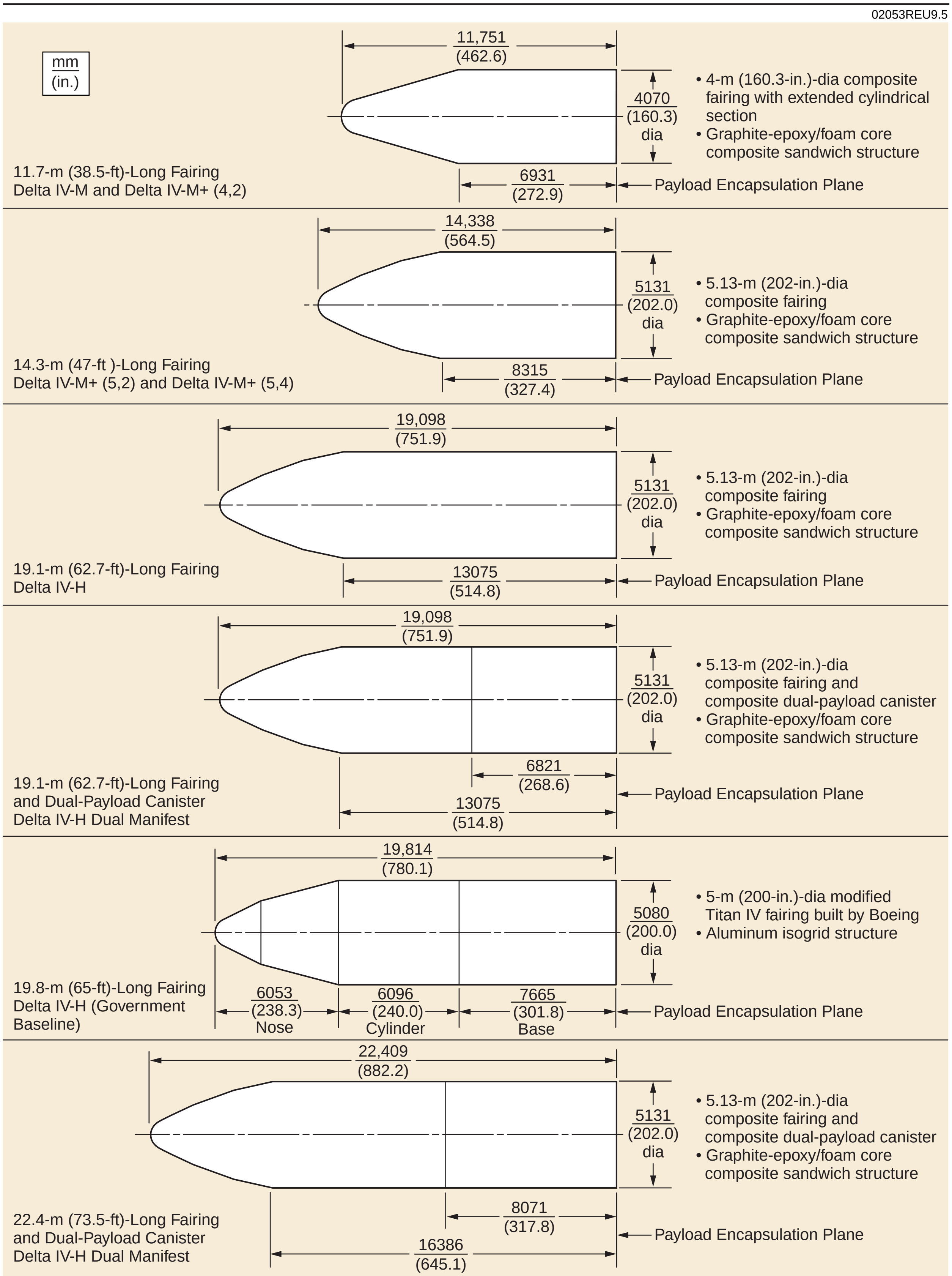

Figure 1-7. Delta IV Fairing Configurations

mounted within these bays to standard Delta IV PAF separation interfaces, dependent on spacecraft needs. For dual-manifest launches, two standard fairing access doors are provided in the cylindrical section of each payload bay. As with the Delta IV single-manifest composite fairing, existing acoustic blankets are provided from the aft end of the fairing to the nose cone.

For fairing separation, the same noncontaminating thrusting joint system designed and patented by Boeing (presented in Section 3.2) is used for bisector separation of the composite fairing. For the lower payload bay, a circumferential sure-sep system (patented by Boeing) with spring actuators is used to deploy the DPC over the spacecraft.

The dual-manifest capability is currently being evaluated for use on other Delta IV vehicle configurations. For further details on the Delta IV Heavy dual-manifest system, as well as dual-manifest launches on other Delta IV vehicles, contact Delta Launch Services.

1.2.7 Avionics and Flight Software

The Delta IV launch system uses a modified advanced 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 a modified advanced launch control system.

The RIFCA, supplied by AlliedSignal, uses six RL20 ring laser gyros and six QA3000 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; an ordnance box to issue ordnance commands; and a pulse code modulation (PCM) telemetry (T/M) system with switchable formats that provide real-time vehicle system performance data to ground stations either directly or through the tracking and data relay satellite system (TDRSS). TDRSS is used to relay post-boost telemetry information when ground coverage is not available, and provides improved mission flexibility with global telemetry coverage. A C-band (beacon) transponder is provided for vehicle tracking to support the flight termination system (FTS).

The flight software comprises a standard flight program and a mission-constants database specifically designed to meet each customer’s mission requirements. Mission requirements are implemented by configuring the mission-constants database, which will be 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, the systems integration tests, and the final software validation test.

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 cold gas jet 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 load relief 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 axes of the vehicle are defined in Figure 1-8. 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 downrange side of the vehicle, and axis IV (-Z) is on the up-range side. The vehicle pitches about axes I (+Y) and III (-Y). Positive pitch rotates the nose of the vehicle up, toward axis IV. The vehicle yaws about axes II and IV. Positive yaw rotates the nose to the right, toward axis I. The vehicle rolls about the centerline. Positive roll is clockwise rotation, looking forward from the aft end of the vehicle (i.e., from axis I toward axis II).

1.3.1 Orientation

Two distinct coordinate systems are of interest to the spacecraft customer. First is the launch vehicle coordinate system, which has already been discussed. The second system is the payload accommodations (PLA) coordinate system. Figure 1-9 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. In Figure 1-9, the +X direction is up out of the page.

1.3.2 Station Number

Station number units are in inches and measured along the X-axis of the vehicle coordinate system (see Section 1.3.1 for coordinate system orientation). The origin of the launch vehicle coordinate system is near the top of the mobile service tower. See Section 3 (Figures 3-2, 3-3, 3-4, 3-5, 3-6, 3-7, and 3-8) for launch vehicle station locations at the payload encapsulation plane.

1.4 LAUNCH VEHICLE INSIGNIA

Delta IV customers are invited to create a mission-peculiar insignia to be placed on their launch vehicles. The customer is invited to submit the proposed design no later than nine months prior to launch 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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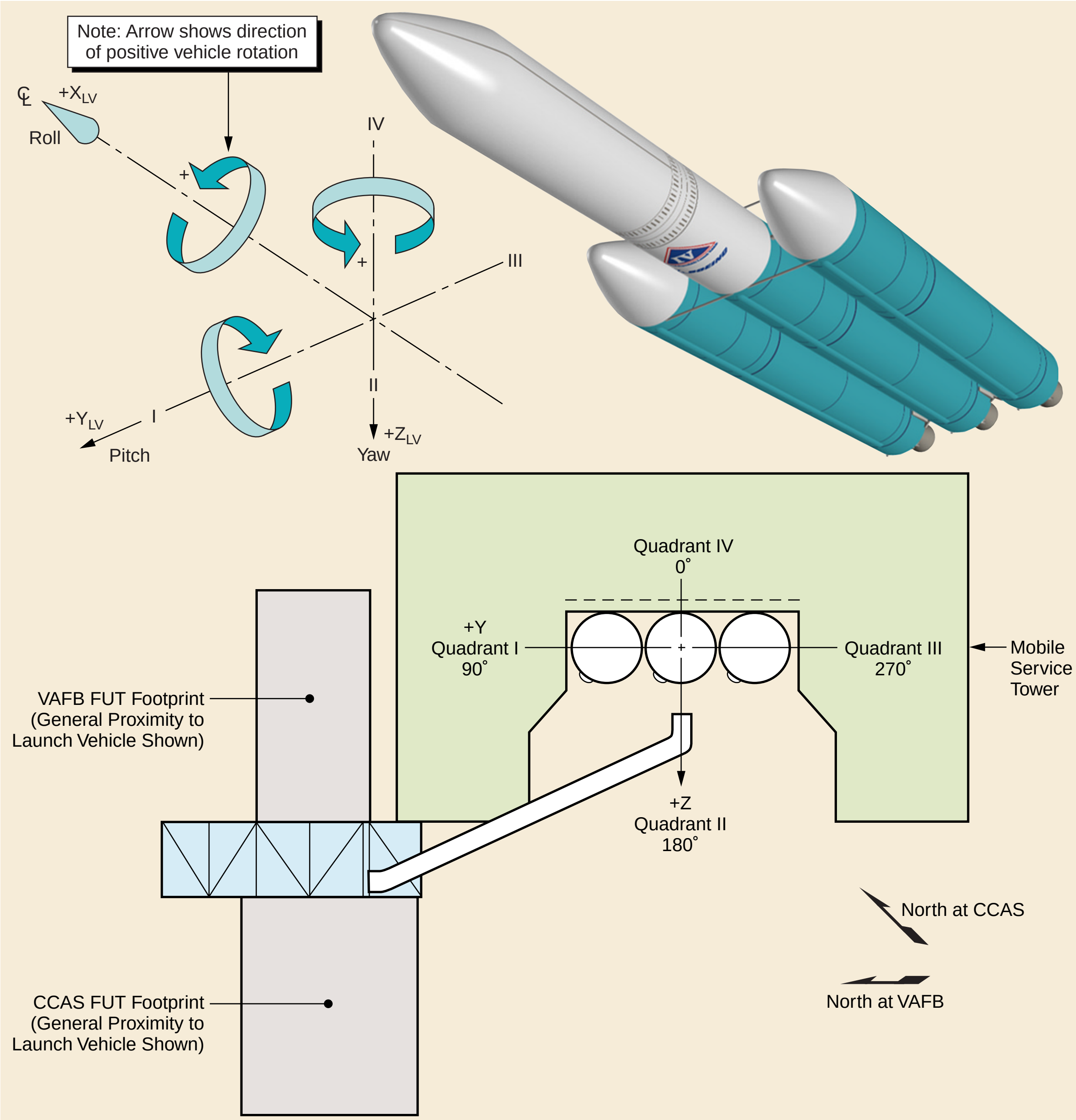

Figure 1-8. Vehicle Axes

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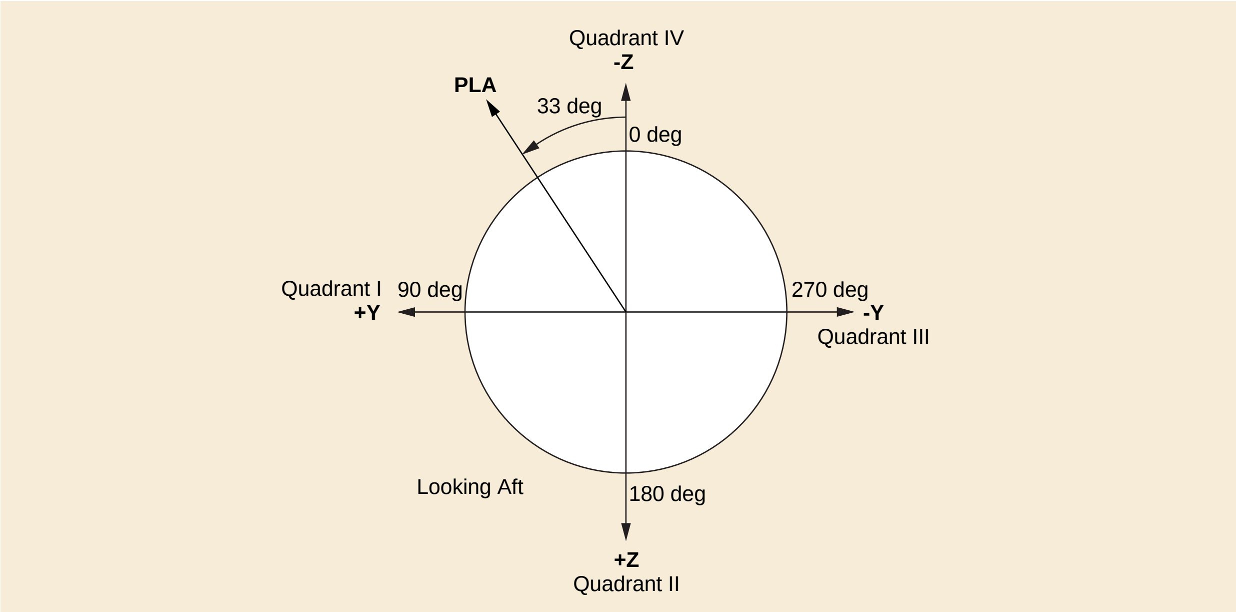

Figure 1-9. Launch Vehicle vs Payload Accommodations Coordinate System

Section 2
GENERAL PERFORMANCE CAPABILITY

The Delta IV launch system can accommodate a wide variety of mission requirements from the Eastern and Western launch ranges. The following sections are presented as general indicators of 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. Boeing mission designers can provide innovative performance trades to meet specific requirements. Our customers are encouraged to contact Delta Launch Services 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 an East Coast or West Coast launch site.

2.1.1 East Coast Launch Site

The Delta IV eastern launch site is Space Launch Complex 37 (SLC-37) at Cape Canaveral Air Station (CCAS), 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 West Coast 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 highly accurate redundant inertial flight control assembly (RIFCA) inserts payloads into orbits with significantly better-than-predicted accuracy (Section 2.4), 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 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.

After separation of the spacecraft, with launch vehicle attitude control thrusters deactivated, a coast period is allowed to provide the required launch-vehicle-to-spacecraft separation distance prior to reactivating the control thrusters. Following spacecraft separation, a contamination and collision avoidance maneuver (CCAM) is performed to remove the second stage from the spacecraft's orbit, followed by vehicle safing. 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 (burning or venting of propellants). 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 3-DOF simulations will verify that the guidance can steer the launch vehicle and perform Delta IV maneuvers properly. For payloads requiring spin prior to separation (Delta IV can achieve spin rates up to 5 rpm), 6-DOF simulations will be used to verify control system adequacy during spinup, separation, launch vehicle coast, and despin. Our experience, capability, and accuracy assure that all customer requirements are met to ensure mission success. A typical two-stage mission profile is shown in Figure 2-1.

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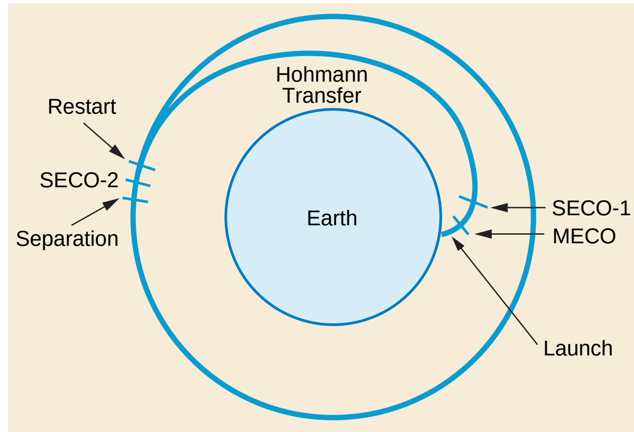


Figure 2-1. Typical Two-Stage Mission Profile

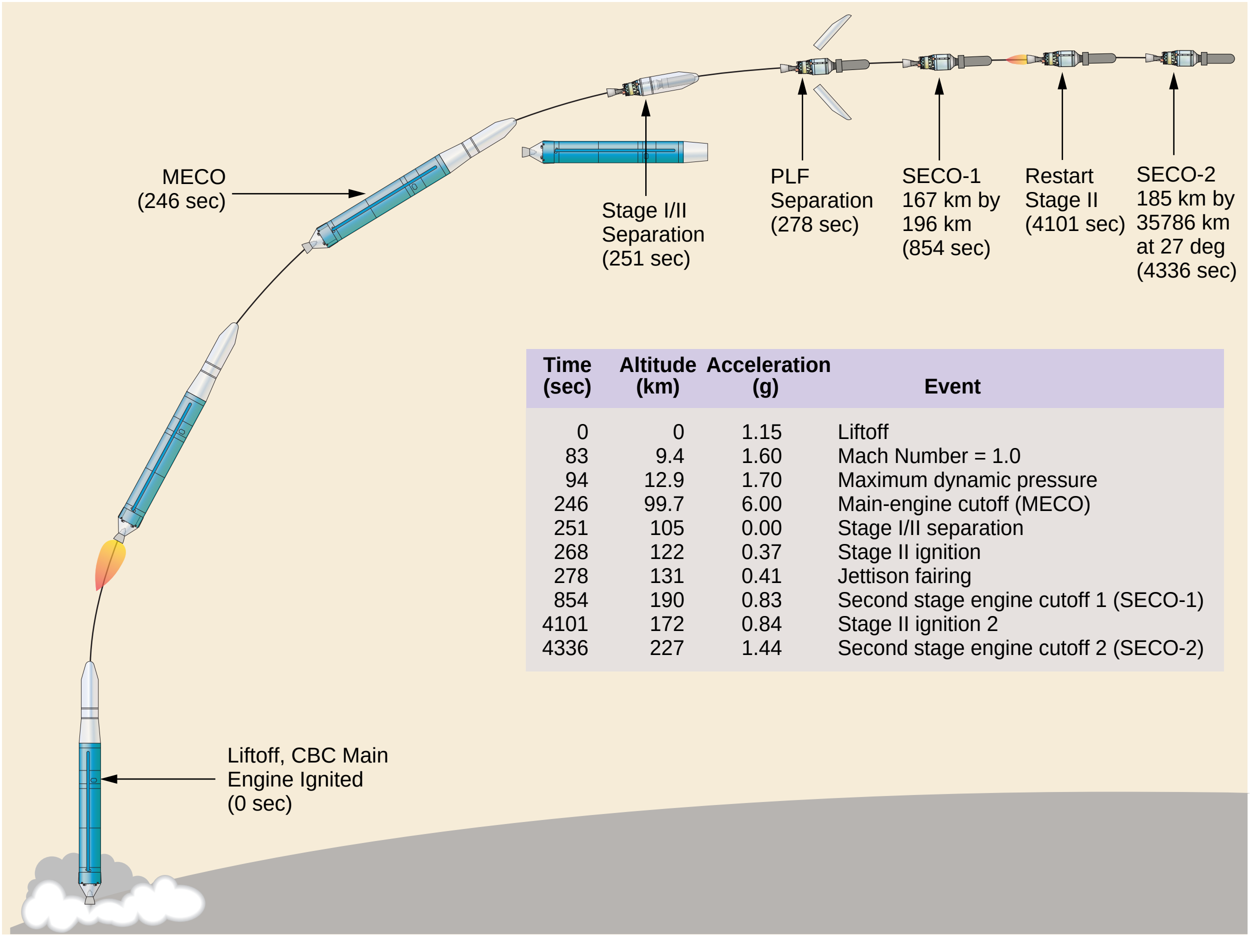
2.2.1 GTO Mission Profile

The typical sequence of events for the Delta IV family of launch vehicles to a geosynchronous transfer orbit (GTO) mission 185 km by 35 786 km at 27.0 deg inclination (100 nmi by 19,323 nmi at 27.0 deg) is shown in Figures 2-2, 2-3, and 2-4. The profile follows a sequence similar to the Delta II and Delta III 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, but may be increased up to 7 hr with minor modifications.

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 (633 km by 7604 km at 116.6 deg,



Time (sec)	Altitude (km)	Acceleration (g)	Event
0	0	1.15	Liftoff
83	9.4	1.60	Mach Number = 1.0
94	12.9	1.70	Maximum dynamic pressure
246	99.7	6.00	Main-engine cutoff (MECO)
251	105	0.00	Stage I/II separation
268	122	0.37	Stage II ignition
278	131	0.41	Jettison fairing
854	190	0.83	Second stage engine cutoff 1 (SECO-1)
4101	172	0.84	Stage II ignition 2
4336	227	1.44	Second stage engine cutoff 2 (SECO-2)

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

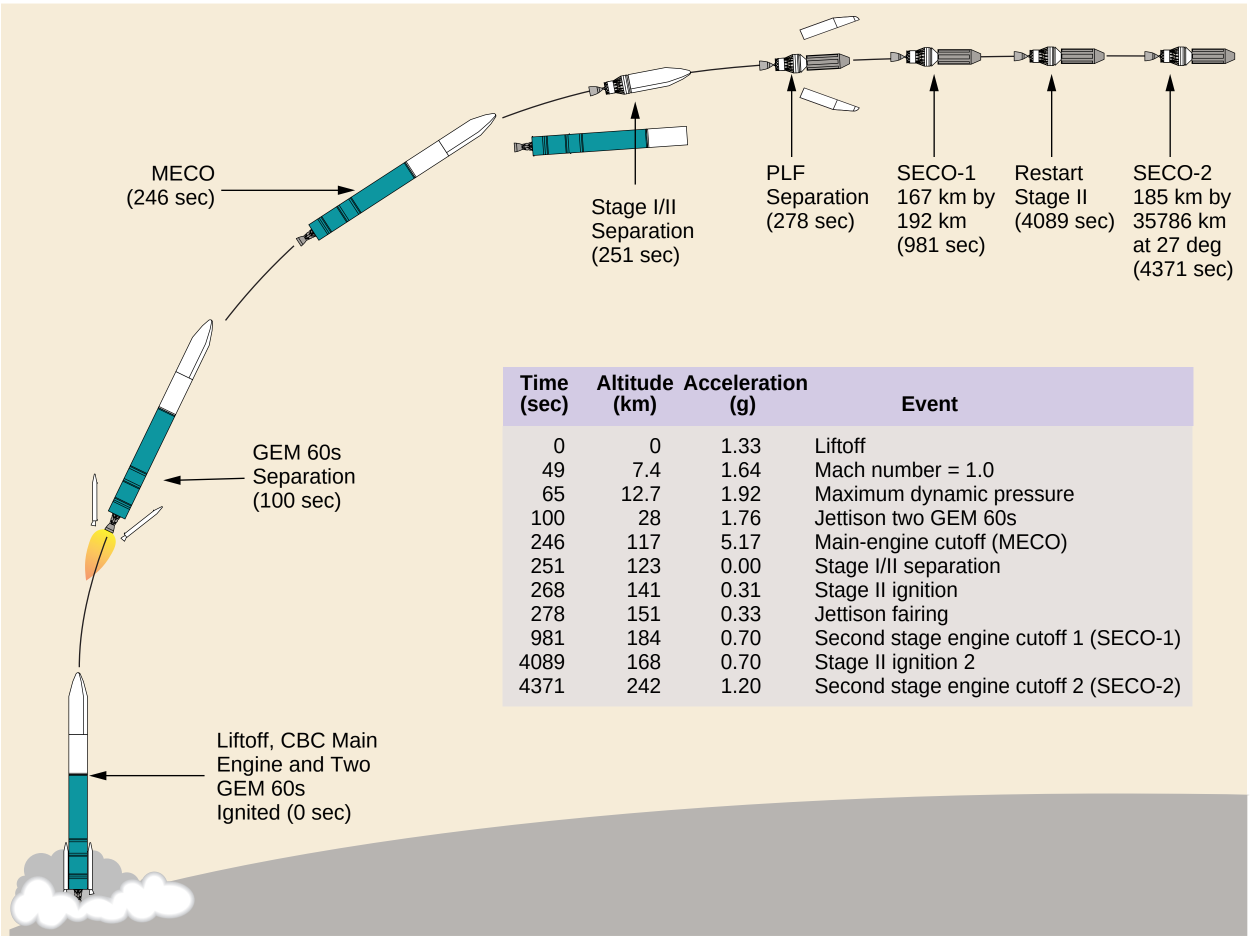
and 780 km circular at 96 deg) while maximizing payload lift capability. The second stage is capable of deploying multiple spacecraft simultaneously or singly, with reorientation and hold periods between each separation event (see Section 2.2.5). The mission operation time is less than 2.3 hr nominally, but may be increased up to 7 hr with minor modifications.

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 kit, the Delta IV-M+ (5,4), and Delta IV-H can carry the spacecraft directly to its desired GEO orbit or anywhere in between. Maximum mission operation time is 7.2 hr.

2.2.4 Delta IV Heavy Dual-Manifest GTO Mission Profile

The baseline dual-manifesting approach allows the customer to launch into GTO two payloads on a single Delta IV-H vehicle, at significant cost savings over two separate launches.

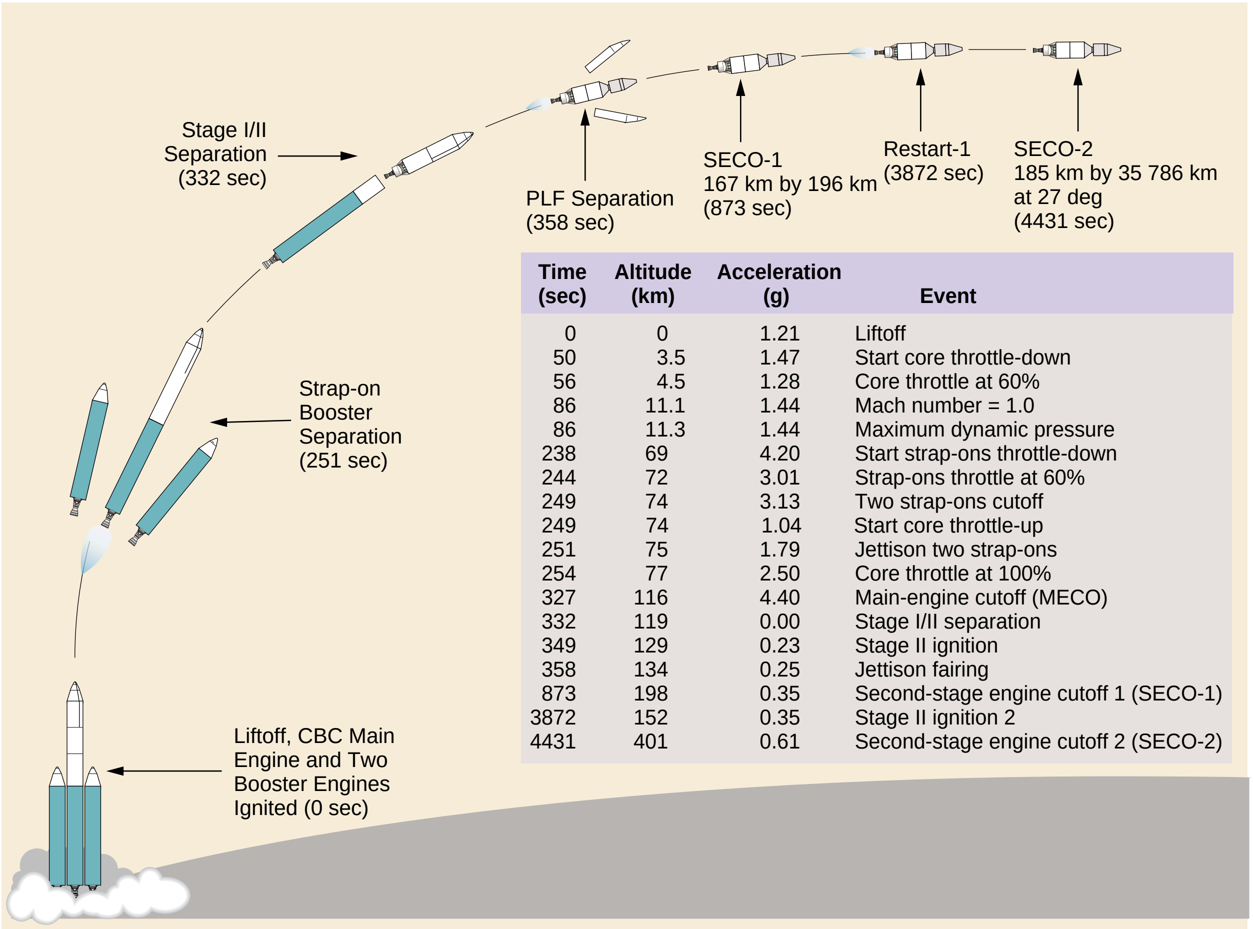


Time (sec)	Altitude (km)	Acceleration (g)	Event
0	0	1.33	Liftoff
49	7.4	1.64	Mach number = 1.0
65	12.7	1.92	Maximum dynamic pressure
100	28	1.76	Jettison two GEM 60s
246	117	5.17	Main-engine cutoff (MECO)
251	123	0.00	Stage I/II separation
268	141	0.31	Stage II ignition
278	151	0.33	Jettison fairing
981	184	0.70	Second stage engine cutoff 1 (SECO-1)
4089	168	0.70	Stage II ignition 2
4371	242	1.20	Second stage engine cutoff 2 (SECO-2)

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

The sequence of events through second stage engine cutoff 2 (SECO-2) for the dual-manifest Delta IV-H is shown in Figure 2-4. This places the second stage and payloads into the desired orbits.

Figure 2-8 shows the deployment sequence. During the second stage burn, fairing jettison occurs and reveals the upper spacecraft on the payload attach fitting. Upon reaching the target orbit, upper spacecraft deployment occurs. After the first payload reaches an acceptable distance from the launch vehicle, the second stage reorients to a new position. The combined upper payload attach fitting and dual-payload canister then separate from the second stage, revealing the lower spacecraft section. After reorienting to the target attitude, final spacecraft deployment occurs. The launch vehicle, which is now the second stage and lower payload attach fitting, reorients and performs the CCAM maneuver to remove itself from the spacecraft orbit. Boeing will coordinate with the customer to ensure that adequate separation distances are maintained through all separation events.



Time (sec)	Altitude (km)	Acceleration (g)	Event
0	0	1.21	Liftoff
50	3.5	1.47	Start core throttle-down
56	4.5	1.28	Core throttle at 60%
86	11.1	1.44	Mach number = 1.0
86	11.3	1.44	Maximum dynamic pressure
238	69	4.20	Start strap-ons throttle-down
244	72	3.01	Strap-ons throttle at 60%
249	74	3.13	Two strap-ons cutoff
249	74	1.04	Start core throttle-up
251	75	1.79	Jettison two strap-ons
254	77	2.50	Core throttle at 100%
327	116	4.40	Main-engine cutoff (MECO)
332	119	0.00	Stage I/II separation
349	129	0.23	Stage II ignition
358	134	0.25	Jettison fairing
873	198	0.35	Second-stage engine cutoff 1 (SECO-1)
3872	152	0.35	Stage II ignition 2
4431	401	0.61	Second-stage engine cutoff 2 (SECO-2)

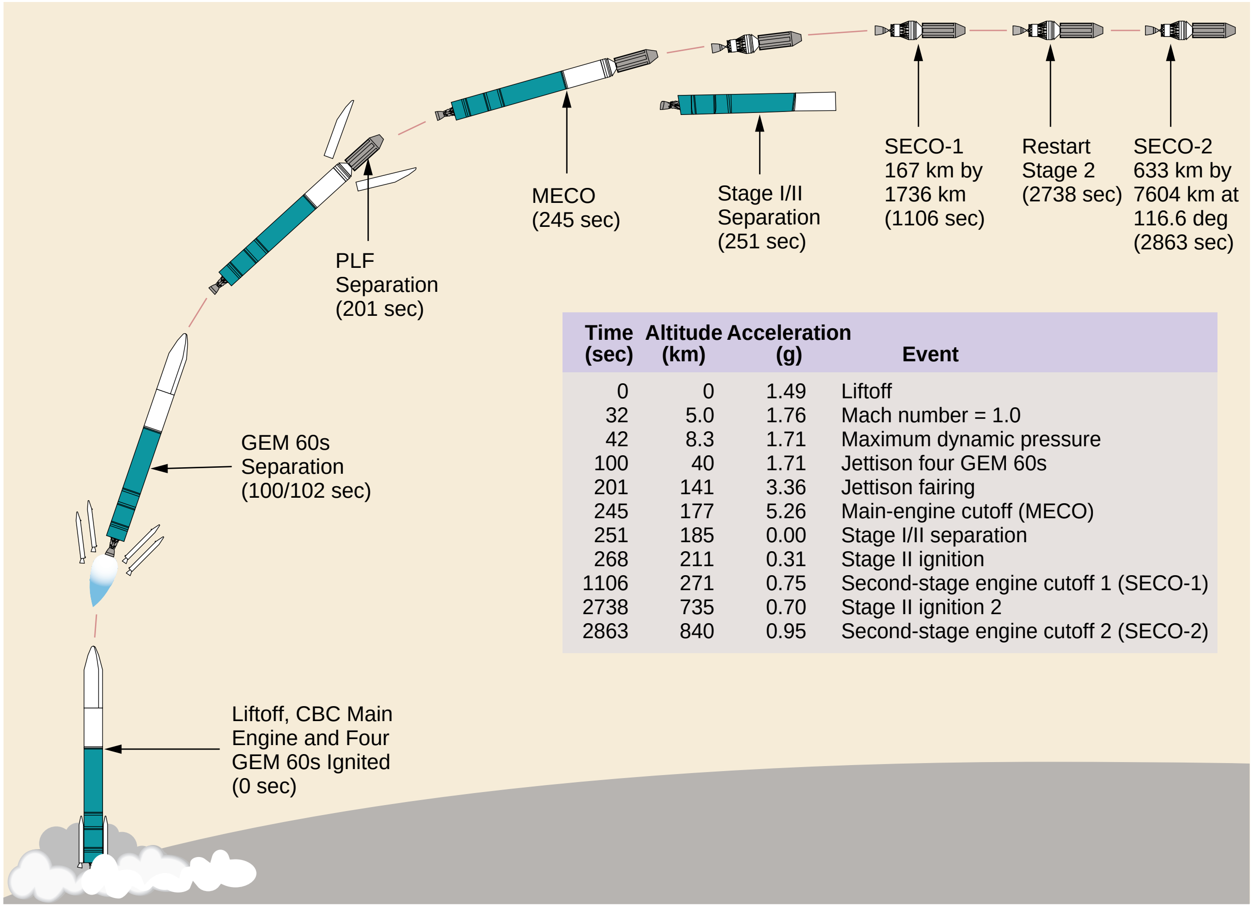
Figure 2-4. Delta IV Heavy Sequence of Events for a GTO Mission (Eastern Range)

2.2.5 Multiple-Manifest Mission Profile

Boeing has extensive experience with multiple-manifest spacecraft and special on-orbit operations. 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.

A typical sequence of events for a multiple-spacecraft mission would proceed as follows. After second-stage engine cutoff, the launch vehicle, which is now the second stage, dispenser, and spacecraft, is in the desired target orbit. 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.

Following each deployment sequence, the launch vehicle waits to obtain sufficient separation distance between the launch vehicle and the spacecraft before initiating the next deployment



Time (sec)	Altitude (km)	Acceleration (g)	Event
0	0	1.49	Liftoff
32	5.0	1.76	Mach number = 1.0
42	8.3	1.71	Maximum dynamic pressure
100	40	1.71	Jettison four GEM 60s
201	141	3.36	Jettison fairing
245	177	5.26	Main-engine cutoff (MECO)
251	185	0.00	Stage I/II separation
268	211	0.31	Stage II ignition
1106	271	0.75	Second-stage engine cutoff 1 (SECO-1)
2738	735	0.70	Stage II ignition 2
2863	840	0.95	Second-stage engine cutoff 2 (SECO-2)

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

sequence, or until ground coverage is available, if necessary. The launch vehicle can be reoriented to a different position, such as a relative position that follows the velocity vector, for the next deployment.

Alternating deployment and reorient/wait periods are repeated as necessary until all spacecraft are deployed. For simultaneous deployment of multiple spacecraft, the total time to deploy all spacecraft is not expected to exceed 1 hr. However, if the individual spacecraft are separated one at a time, more on-orbit time is needed. Our launch vehicle is nominally sized for total mission durations up to 2.3 hr, but may be increased with minor modifications.

2.3 PERFORMANCE SUMMARIES

Performance data are presented in the following pages for the Delta IV launch vehicle family. Descriptions of the performance curves for both Eastern and Western Range launches are listed below. Orbit capability is presented as “Separated Spacecraft Weight” for near-synchronous orbits and as “Useful Load Weight” for LEO orbits. The near-synchronous orbit “Separated Spacecraft Weight” is defined as the spacecraft weight above the standard Delta IV payload attach fitting (PAF) (PAF-1194-4 for 4-m second stages and PAF-1194-5 for 5-m second stages).

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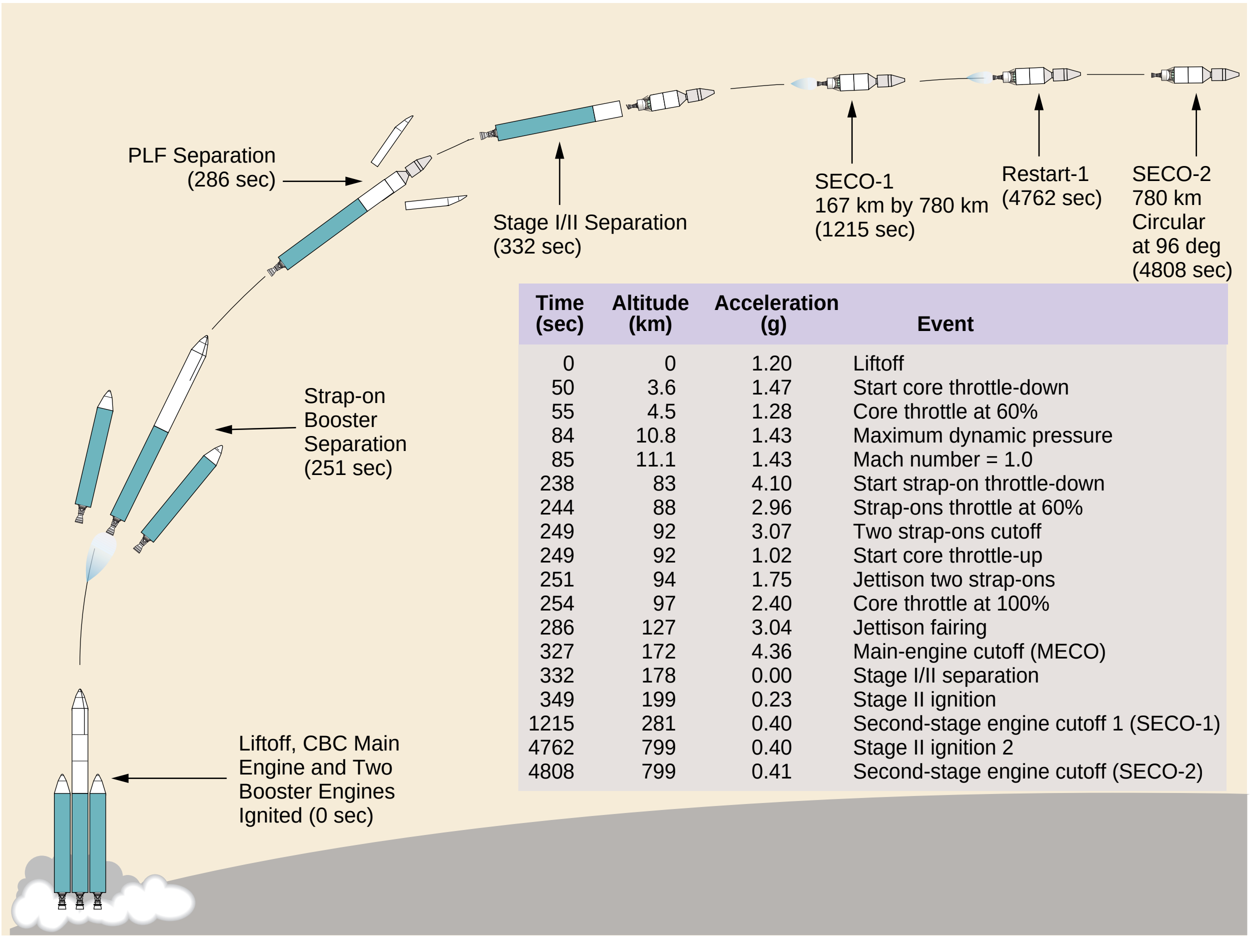

Time (sec)	Altitude (km)	Acceleration (g)	Event
0	0	1.20	Liftoff
50	3.6	1.47	Start core throttle-down
55	4.5	1.28	Core throttle at 60%
84	10.8	1.43	Maximum dynamic pressure
85	11.1	1.43	Mach number = 1.0
238	83	4.10	Start strap-on throttle-down
244	88	2.96	Strap-ons throttle at 60%
249	92	3.07	Two strap-ons cutoff
249	92	1.02	Start core throttle-up
251	94	1.75	Jettison two strap-ons
254	97	2.40	Core throttle at 100%
286	127	3.04	Jettison fairing
327	172	4.36	Main-engine cutoff (MECO)
332	178	0.00	Stage I/II separation
349	199	0.23	Stage II ignition
1215	281	0.40	Second-stage engine cutoff 1 (SECO-1)
4762	799	0.40	Stage II ignition 2
4808	799	0.41	Second-stage engine cutoff (SECO-2)

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

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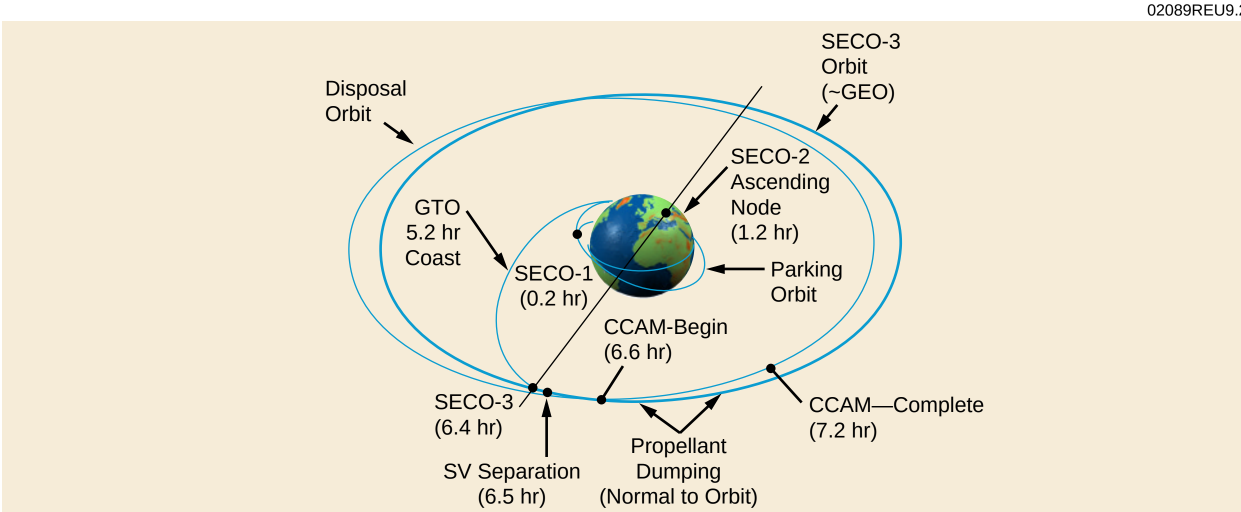

Figure 2-7. Ascending Node GEO Mission Profile

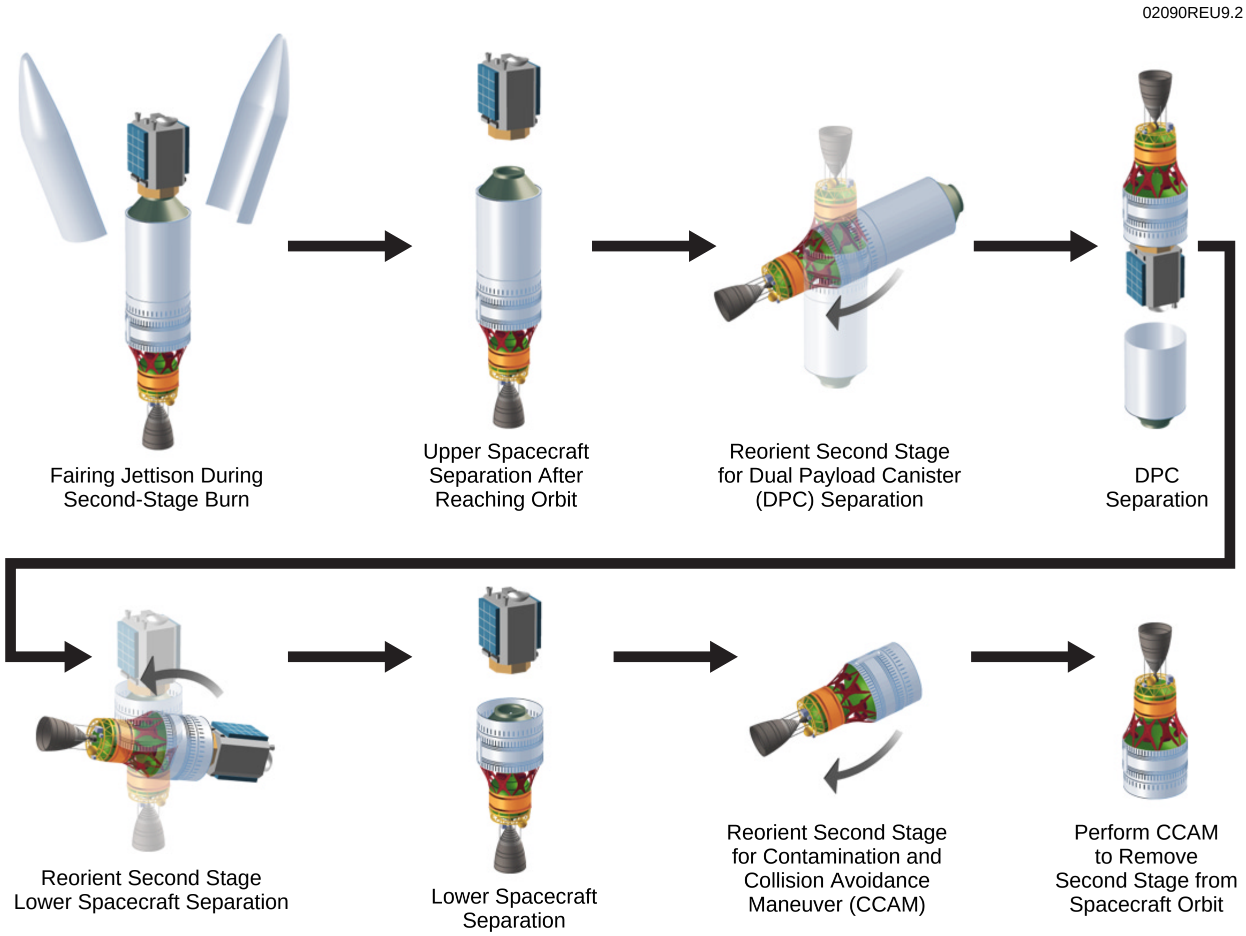

Figure 2-8. Baseline Dual-Manifest Separation Sequence of Events

The LEO "Useful Load Weight" is the total payload weight available to be distributed between the spacecraft and the PAF/dispenser (i.e., the PAF/dispenser weight is included as part of the payload weight, not as part of the Delta IV second-stage weight). Note that in Figures 2-33a, b, and 2-34, which present the Delta IV Heavy dual-manifest capability, the "Separated Spacecraft Weight" illustrated in the orbit capability curves represents the combined weight of both separated spacecraft.

For the "excess ΔV" figures, the "excess ΔV" is defined as the second-stage impulsive velocity (ΔV) capability remaining (excess) after achieving the initial parking orbit, that could be used to further change the orbit. Note that the "excess ΔV" is the impulsive velocity in excess of that required for the flight performance reserve.

2.3.1 Delta IV Medium Vehicle

- Eastern Range.
  - GTO apogee altitude capability—28.5-, 27-, and 25-deg inclinations (Figures 2-9a and b).
  - GTO excess ΔV capability—28.9-deg inclination (Figure 2-10).
  - LEO circular orbit capability—45- and 55-deg inclinations (Figure 2-11).

– LEO excess ΔV capability—45- and 55-deg inclinations (Figure 2-12).

- Western Range.
  - LEO circular orbit capability—63.4-deg inclination and sun-synchronous (Figure 2-13).
  - LEO excess ΔV capability—63.4-deg inclination and sun-synchronous (Figure 2-14).

2.3.2 Delta IV Medium-Plus (4,2) Vehicle

- Eastern Range.
  - GTO apogee altitude capability—28.5-, 27-, and 25-deg inclinations (Figure 2-15a and b).
  - GTO excess ΔV capability—28.9-deg inclination (Figure 2-16).
  - LEO circular orbit capability—45- and 55-deg inclinations (Figure 2-17).
  - LEO excess ΔV capability—45- and 55-deg inclinations (Figure 2-18).
- Western Range.
  - LEO circular orbit capability—63.4-deg inclination and sun-synchronous (Figure 2-19).
  - LEO excess ΔV capability—63.4-deg inclination and sun-synchronous (Figure 2-20).

2.3.3 Delta IV Medium-Plus (5,2) Vehicle

- Eastern Range.
  - GTO apogee altitude capability—28.5-, 27-, and 25-deg inclinations (Figures 2-21a and b).
  - GTO excess ΔV capability—28.9-deg inclination (Figure 2-22).
  - LEO circular orbit capability—45- and 55-deg inclinations (Figure 2-23).
  - LEO excess ΔV capability—45- and 55-deg inclinations (Figure 2-24).
- Western Range.
  - LEO circular orbit capability—63.4-deg inclination and sun-synchronous (Figure 2-25).
  - LEO excess ΔV capability—63.4-deg inclination and sun-synchronous (Figure 2-26).

2.3.4 Delta IV Medium-Plus (5,4) Vehicle

- Eastern Range.
  - GTO apogee altitude capability—28.5-, 27-, and 25-deg inclinations (Figures 2-27a and b).
  - GTO excess ΔV capability—28.9-deg inclination (Figure 2-28).
  - LEO circular orbit capability—45- and 55-deg inclinations (Figure 2-29).
  - LEO excess ΔV capability—45- and 55-deg inclinations (Figure 2-30).
- Western Range.
  - LEO circular orbit capability—63.4-deg inclination and sun-synchronous (Figure 2-31).
  - LEO excess ΔV capability—63.4-deg inclination and sun-synchronous (Figure 2-32).

2.3.5 Delta IV Heavy Vehicle

- Eastern Range.
  - GTO apogee altitude dual manifest—28.5-, 27-, and 25-deg inclinations (Figures 2-33a and b).
  - GTO excess ΔV capability dual manifest—28.9-deg inclination (Figure 2-34).

- LEO circular orbit capability—45- and 55-deg inclinations (Figure 2-35).
- LEO excess ΔV capability—45- and 55-deg inclinations (Figure 2-36).

- Western Range.
  - LEO circular orbit capability—63.4-deg inclination and sun-synchronous (Figure 2-37).
  - LEO excess ΔV capability—63.4-deg inclination and sun-synchronous (Figure 2-38).

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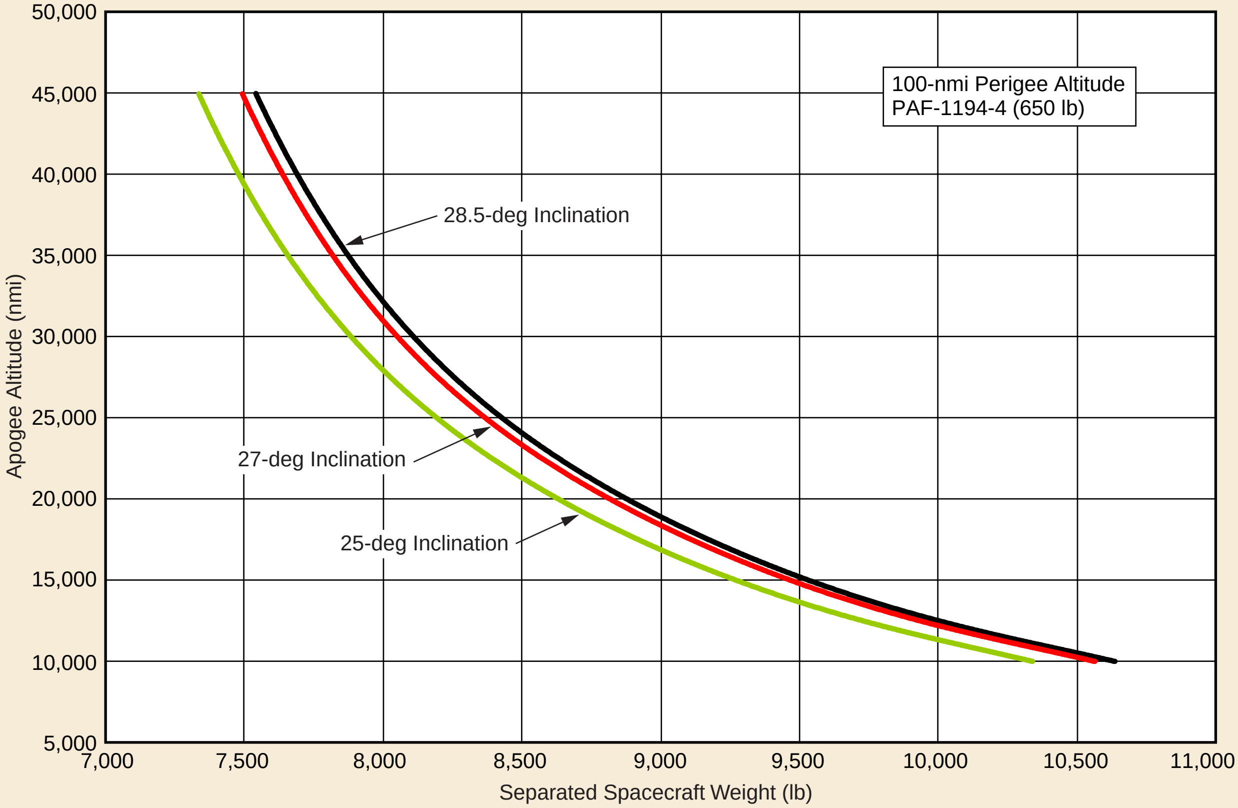
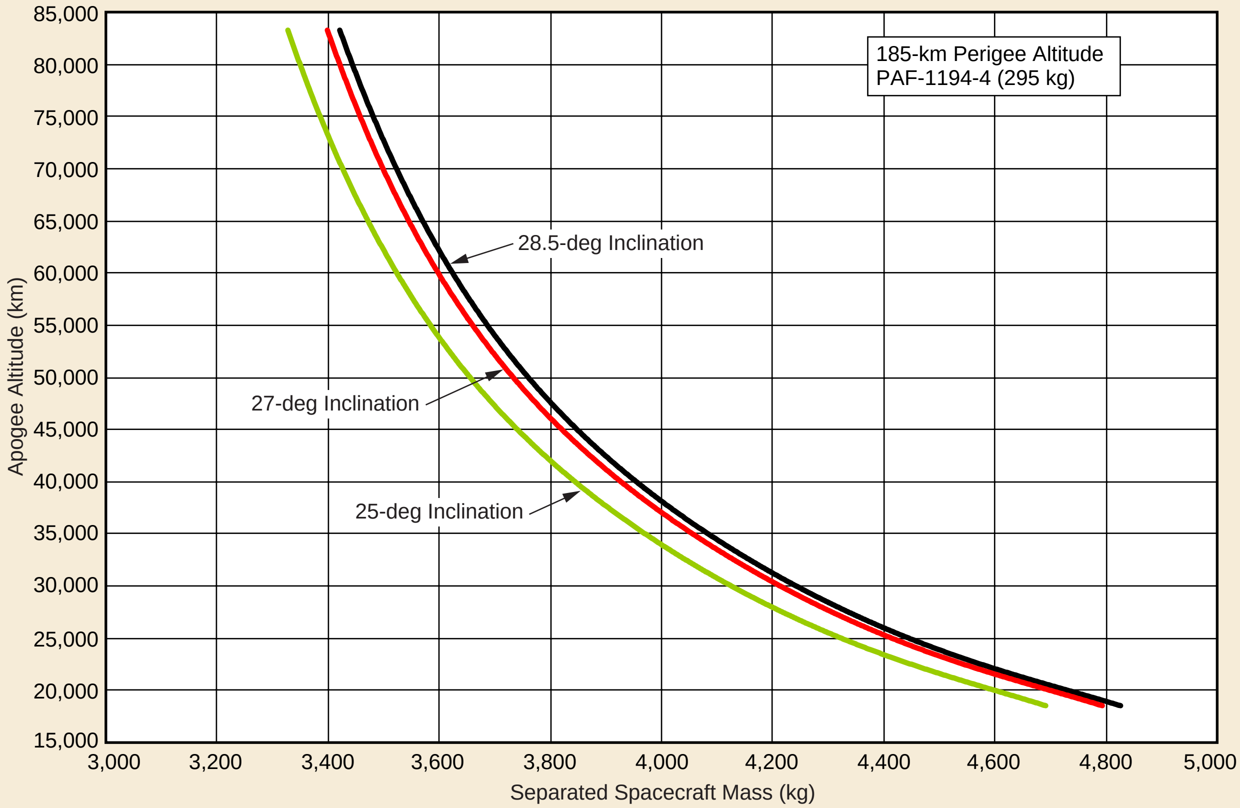


Apogee Altitude (nmi)*	Separated Spacecraft Weight (lb) 25 deg	27 deg	28.5 deg
GTO - 9,000	10,252	10,473	10,545
GTO - 8,000	9,997	10,210	10,281
GTO - 6,000	9,570	9,772	9,839
GTO - 4,000	9,226	9,422	9,486
GTO - 2,000	8,942	9,134	9,196
GTO (19,323)	8,704	8,891	8,952
GTO + 2,000	8,499	8,682	8,743
GTO + 4,000	8,323	8,501	8,562
GTO + 6,000	8,170	8,344	8,405
GTO + 8,000	8,037	8,208	8,268
GTO + 10,00	7,922	8,090	8,149
GTO + 12,000	7,822	7,987	8,045
GTO + 14,000	7,733	7,897	7,953
GTO + 16,000	7,653	7,816	7,870
GTO + 18,000	7,578	7,740	7,793
2 x GTO (38,646)	7,531	7,691	7,744
GTO + 20,000	7,507	7,667	7,719
GTO + 22,000	7,439	7,597	7,649
GTO + 24,000	7,377	7,534	7,585
GTO + 25,000	7,351	7,508	7,558

*Note: Trajectories have a perigee altitude of 100 nmi

Figure 2-9a. Delta IV-M GTO Apogee Altitude Capability (nmi)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

02137REU9.2



Apogee Altitude (km)*	Separated Spacecraft Mass (kg) 25 deg	27 deg	28.5 deg
GTO - 17,000	4,673	4,774	4,807
GTO - 15,000	4,546	4,642	4,675
GTO - 10,000	4,290	4,381	4,411
GTO - 5,000	4,099	4,186	4,215
GTO (35,786)	3,948	4,033	4,061
GTO + 5,000	3,826	3,908	3,936
GTO + 10,000	3,726	3,805	3,833
GTO + 15,000	3,643	3,720	3,747
GTO + 20,000	3,575	3,650	3,677
GTO + 25,000	3,517	3,592	3,617
GTO + 30,000	3,468	3,542	3,566
GTO + 35,000	3,423	3,496	3,520
2 x GTO (71,752)	3,416	3,489	3,512
GTO + 40,000	3,380	3,452	3,476
GTO + 45,000	3,342	3,414	3,436
GTO + 47,000	3,330	3,402	3,424

*Note: Trajectories have a perigee altitude of 185 km

Figure 2-9b. Delta IV-M GTO Apogee Altitude Capability (km)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

02138REU9.1

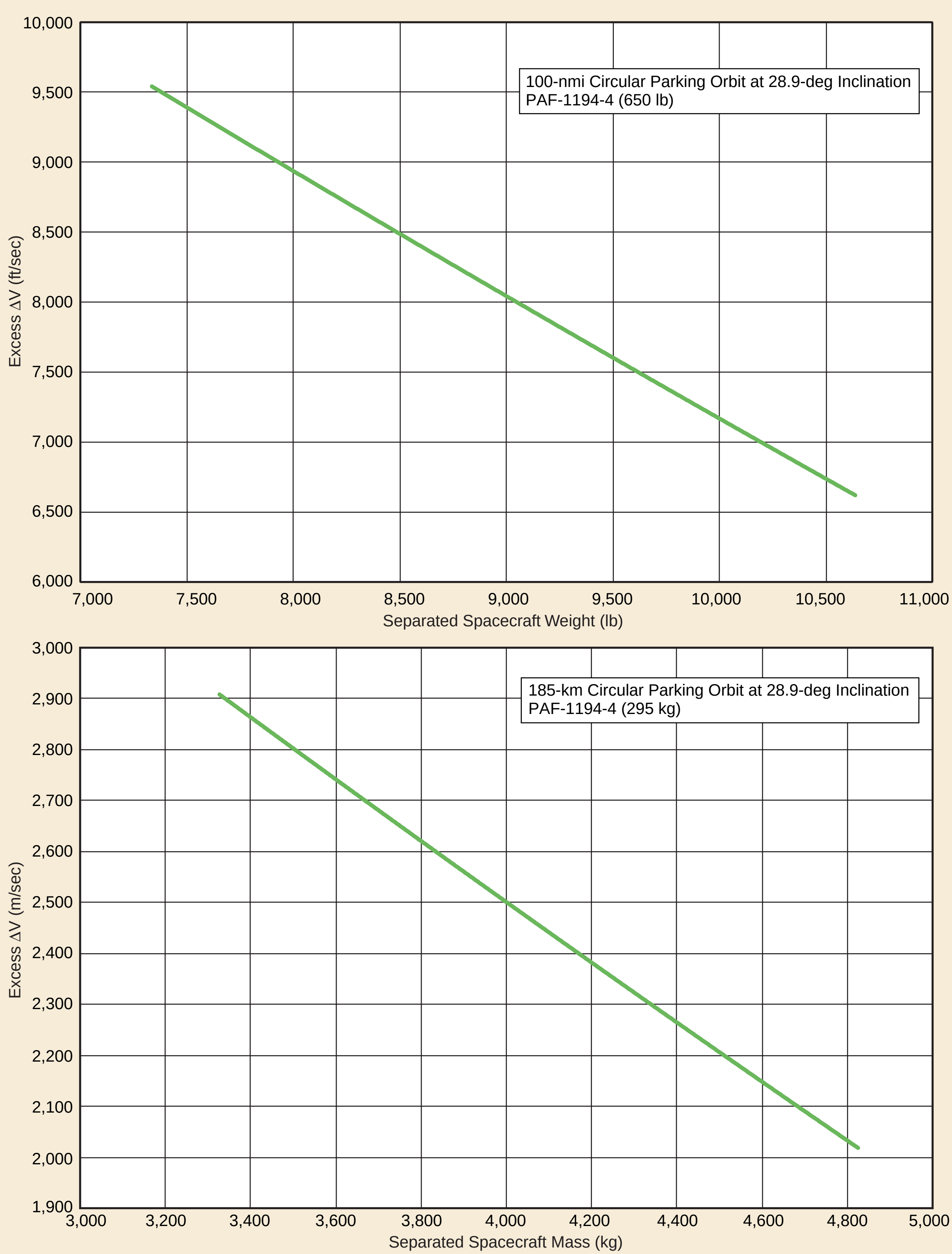


Figure 2-10. Delta IV-M GTO Excess ΔV Capability—28.9-deg Inclination (Eastern Range)

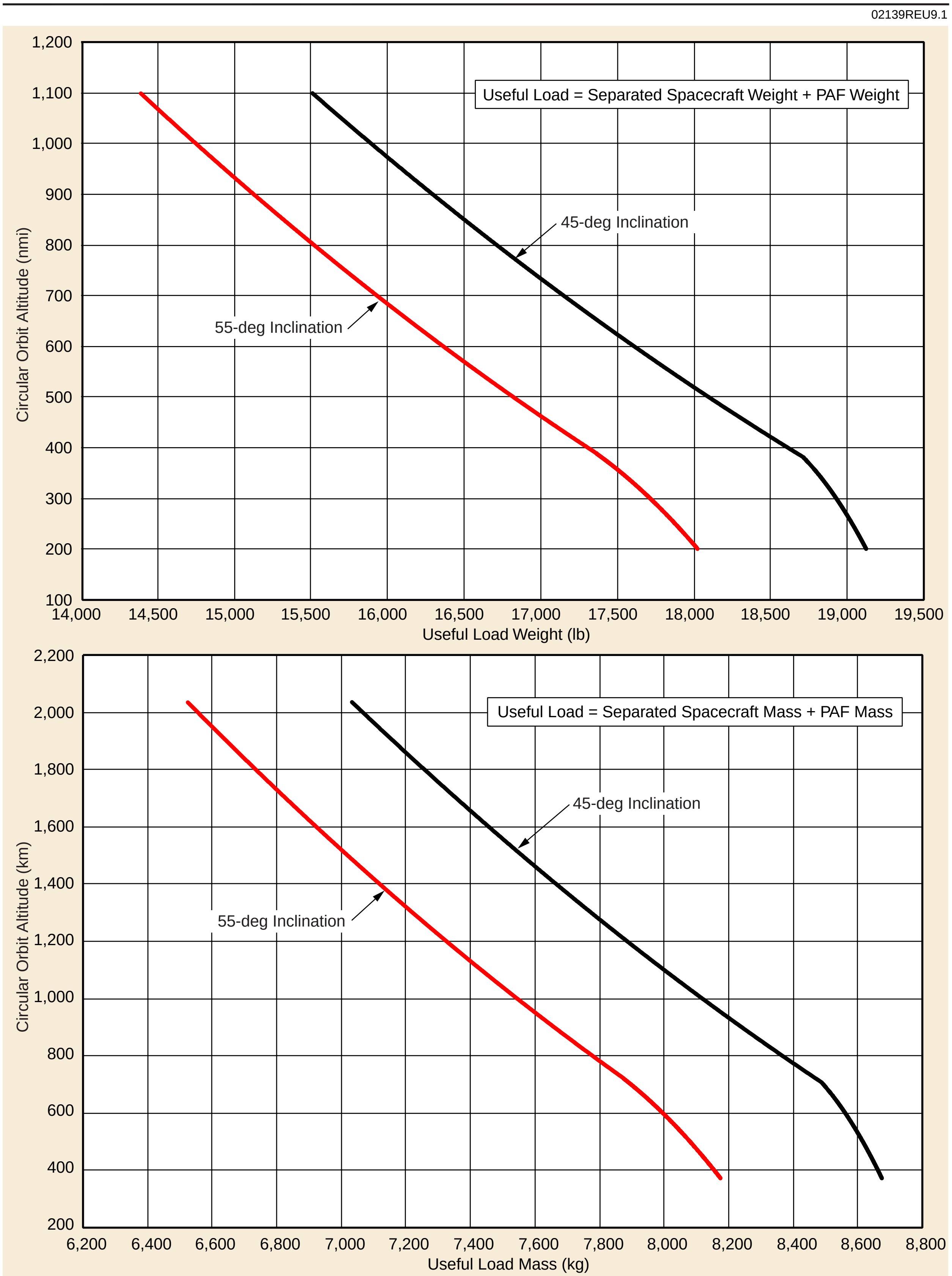


Figure 2-11. Delta IV-M LEO Circular Orbit Capability—45- and 55-deg Inclinations (Eastern Range)

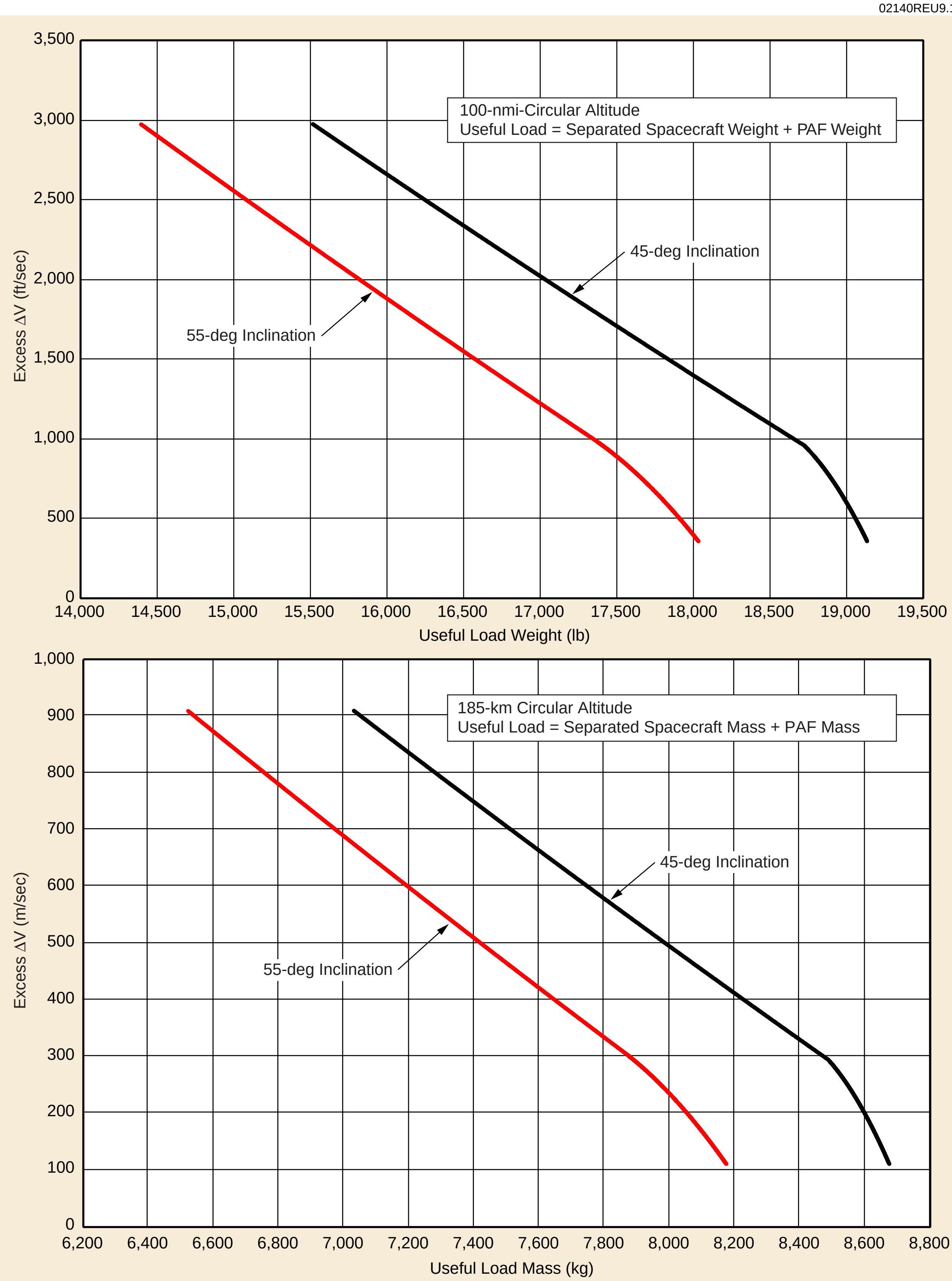


Figure 2-12. Delta IV-M LEO Excess ΔV Capability—45- and 55-deg Inclinations (Eastern Range)

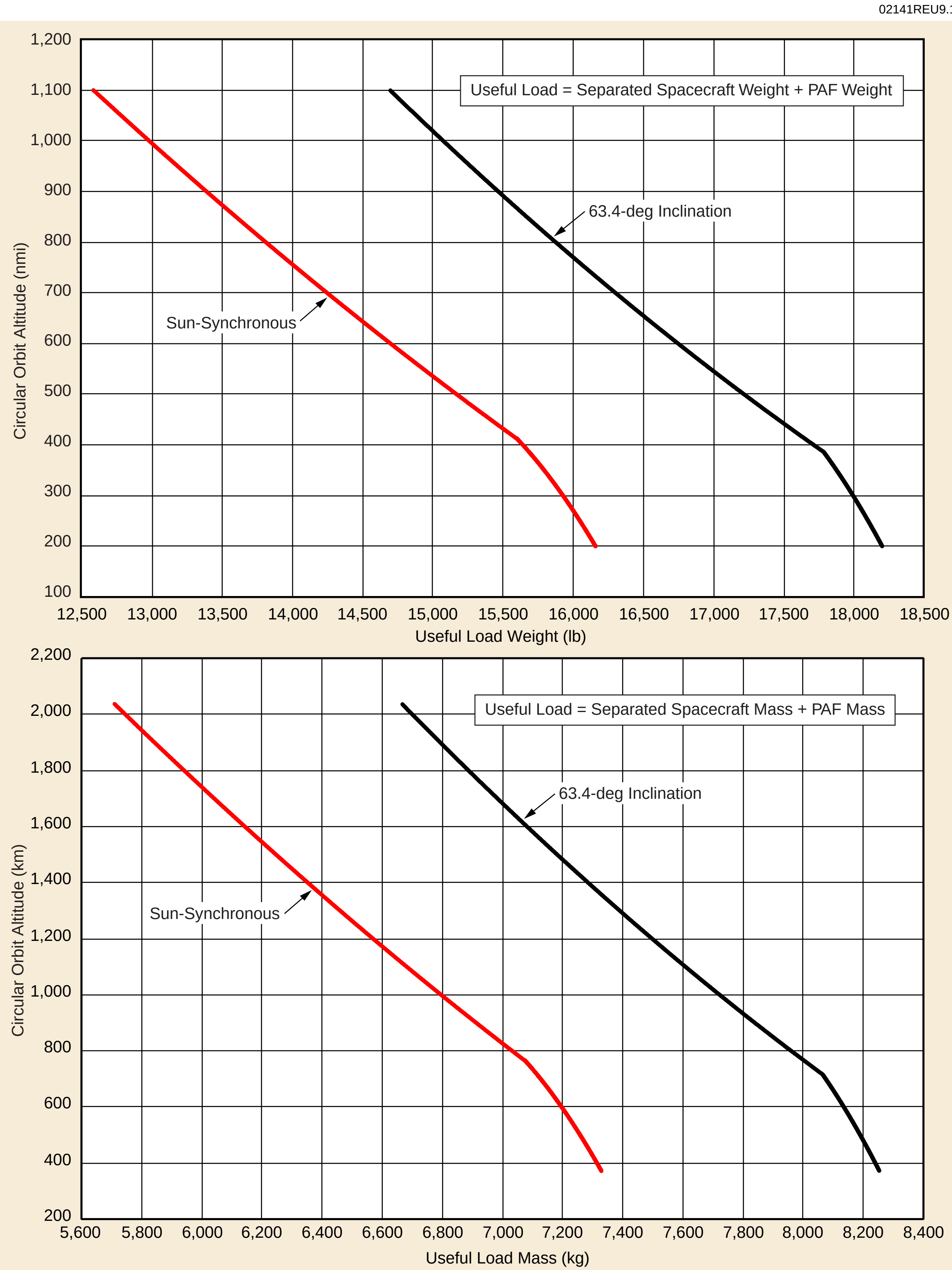


Figure 2-13. Delta IV-M LEO Circular Orbit Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

02142REU9.1

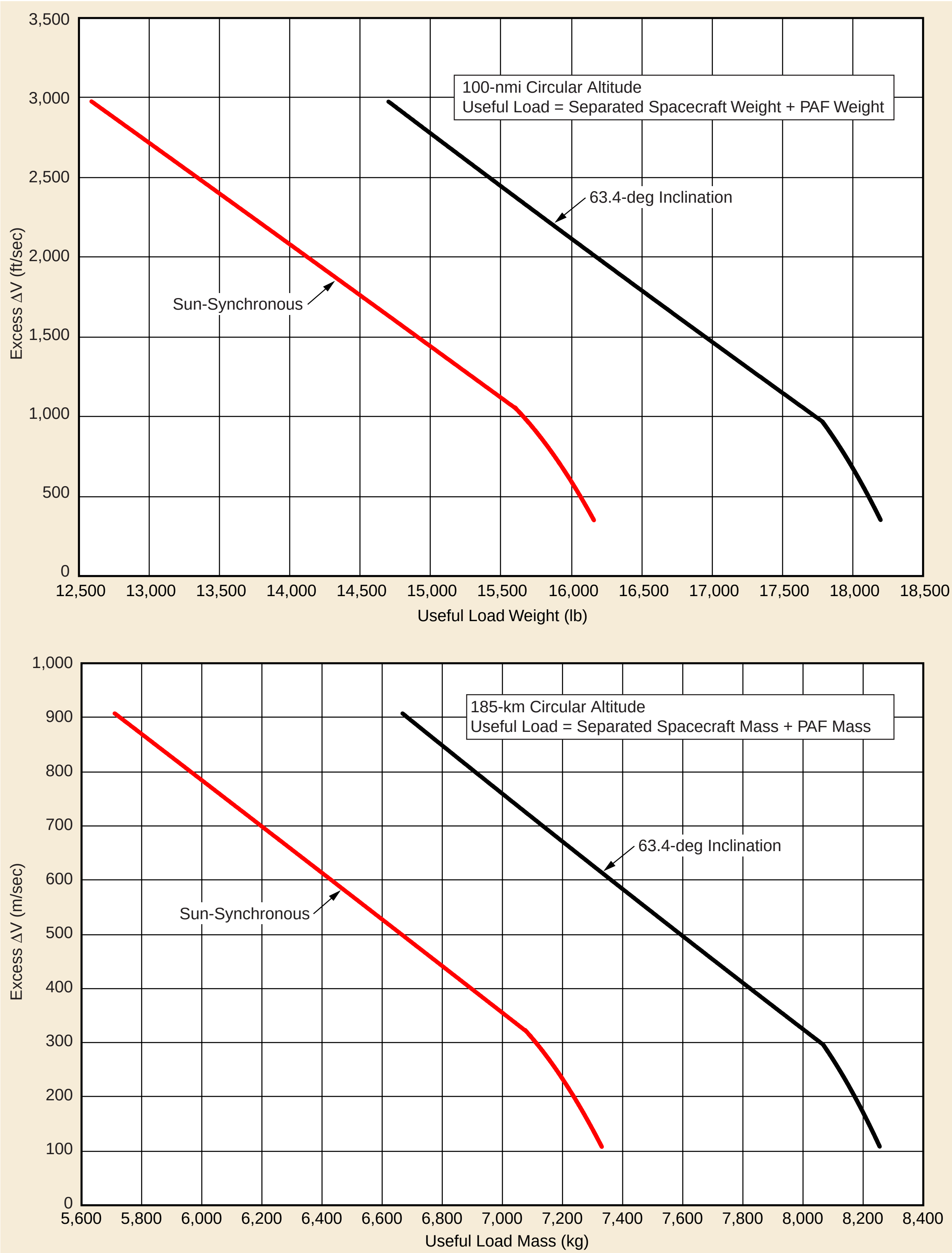
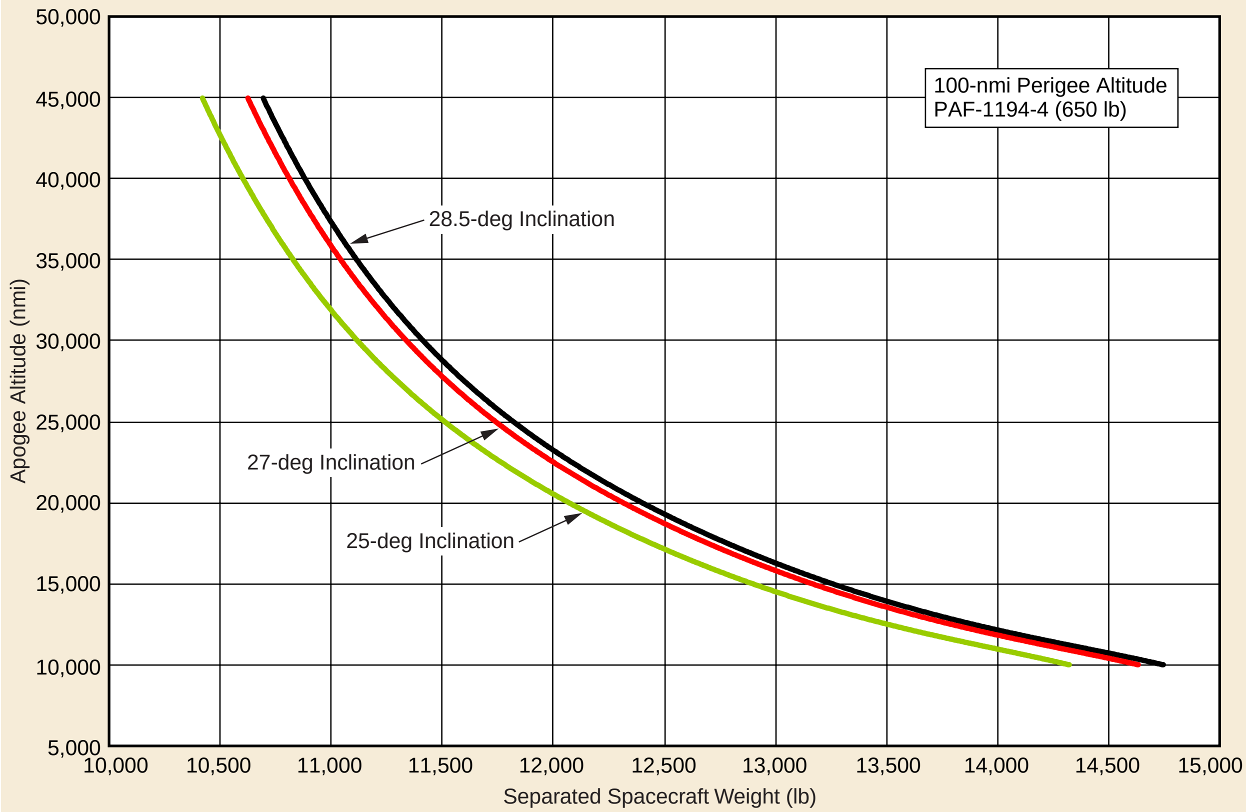


Figure 2-14. Delta IV-M LEO Excess ΔV Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

02143REU9.1

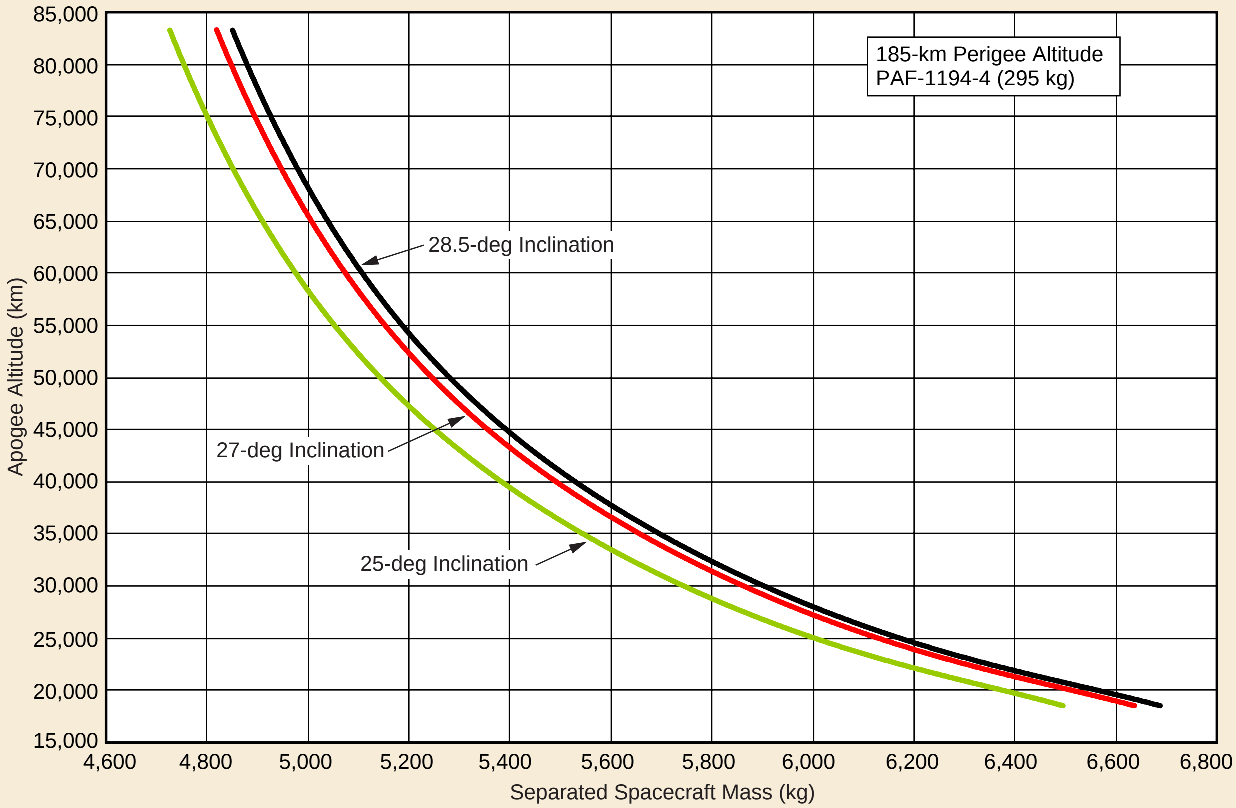


Apogee Altitude (nmi)*	Separated Spacecraft Weight (lb) 25 deg	27 deg	28.5 deg
GTO - 9,000	14,203	14,510	14,621
GTO - 8,000	13,862	14,159	14,264
GTO - 6,000	13,293	13,572	13,669
GTO - 4,000	12,838	13,104	13,196
GTO - 2,000	12,468	12,723	12,811
GTO (19,323)	12,160	12,407	12,492
GTO + 2,000	11,900	12,140	12,223
GTO + 4,000	11,676	11,910	11,991
GTO + 6,000	11,482	11,711	11,791
GTO + 8,000	11,313	11,538	11,616
GTO + 10,000	11,165	11,387	11,462
GTO + 12,000	11,036	11,254	11,327
GTO + 14,000	10,920	11,136	11,208
GTO + 16,000	10,817	11,030	11,100
GTO + 18,000	10,722	10,933	11,002
2 x GTO (38,646)	10,663	10,873	10,942
GTO + 20,000	10,633	10,843	10,912
GTO + 22,000	10,550	10,758	10,827
GTO + 24,000	10,474	10,681	10,750
GTO + 25,000	10,441	10,646	10,715

*Note: Trajectories have a perigee altitude of 100 nmi

Figure 2-15a. Delta IV-M+ (4,2) GTO Apogee Altitude Capability (nmi)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

02144REU9.2



Apogee Altitude (km)*	Separated Spacecraft Mass (kg) 25 deg	27 deg	28.5 deg
GTO - 17,000	6,472	6,612	6,663
GTO - 15,000	6,302	6,437	6,485
GTO - 10,000	5,963	6,087	6,131
GTO - 5,000	5,710	5,828	5,868
GTO (35,786)	5,516	5,628	5,666
GTO + 5,000	5,360	5,468	5,506
GTO + 10,000	5,233	5,338	5,374
GTO + 15,000	5,128	5,230	5,265
GTO + 20,000	5,040	5,140	5,174
GTO + 25,000	4,966	5,064	5,097
GTO + 30,000	4,902	4,999	5,030
GTO + 35,000	4,845	4,941	4,972
2 x GTO (71,752)	4,836	4,932	4,963
GTO + 40,000	4,793	4,887	4,919
GTO + 45,000	4,746	4,840	4,871
GTO + 47,000	4,731	4,823	4,855

*Note: Trajectories have a perigee altitude of 185 km

Figure 2-15b. Delta IV-M+ (4,2) GTO Apogee Altitude Capability (km)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

02145REU9.1

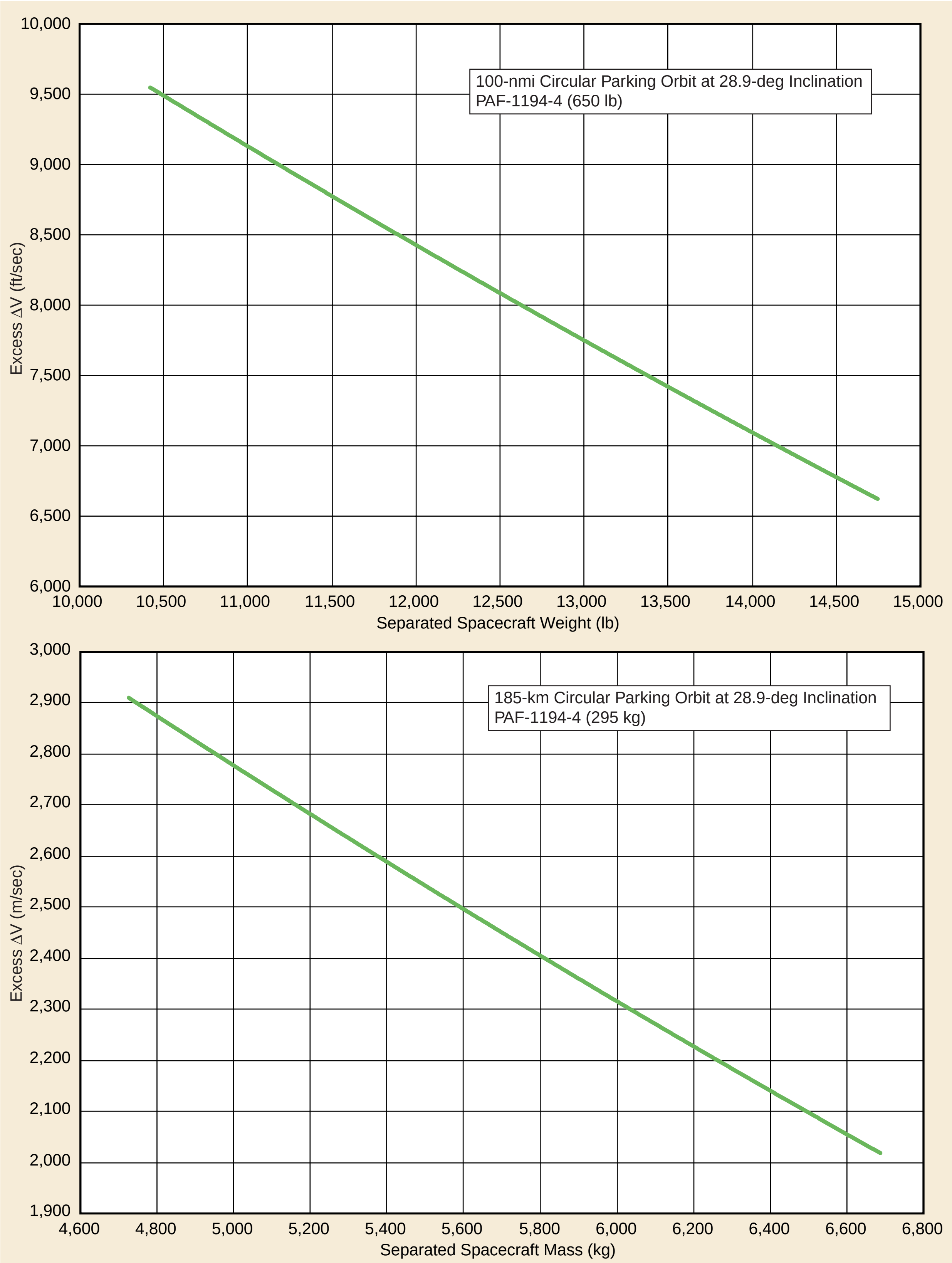


Figure 2-16. Delta IV-M+ (4,2) GTO Excess ΔV Capability—28.9-deg Inclination (Eastern Range)

02146REU9.1

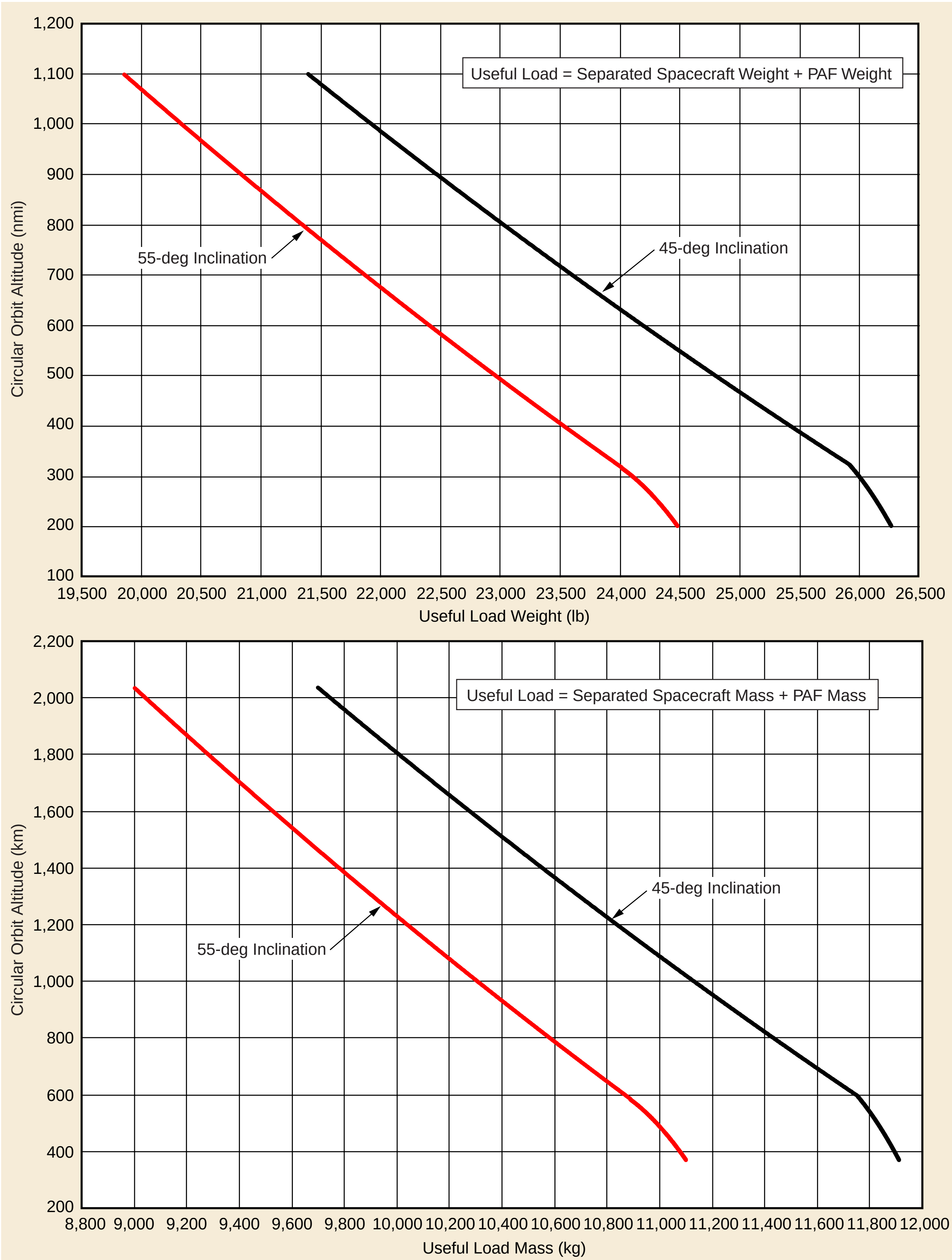


Figure 2-17. Delta IV-M+ (4,2) LEO Circular Capability—45- and 55-deg Inclinations (Eastern Range)

02147REU9.1

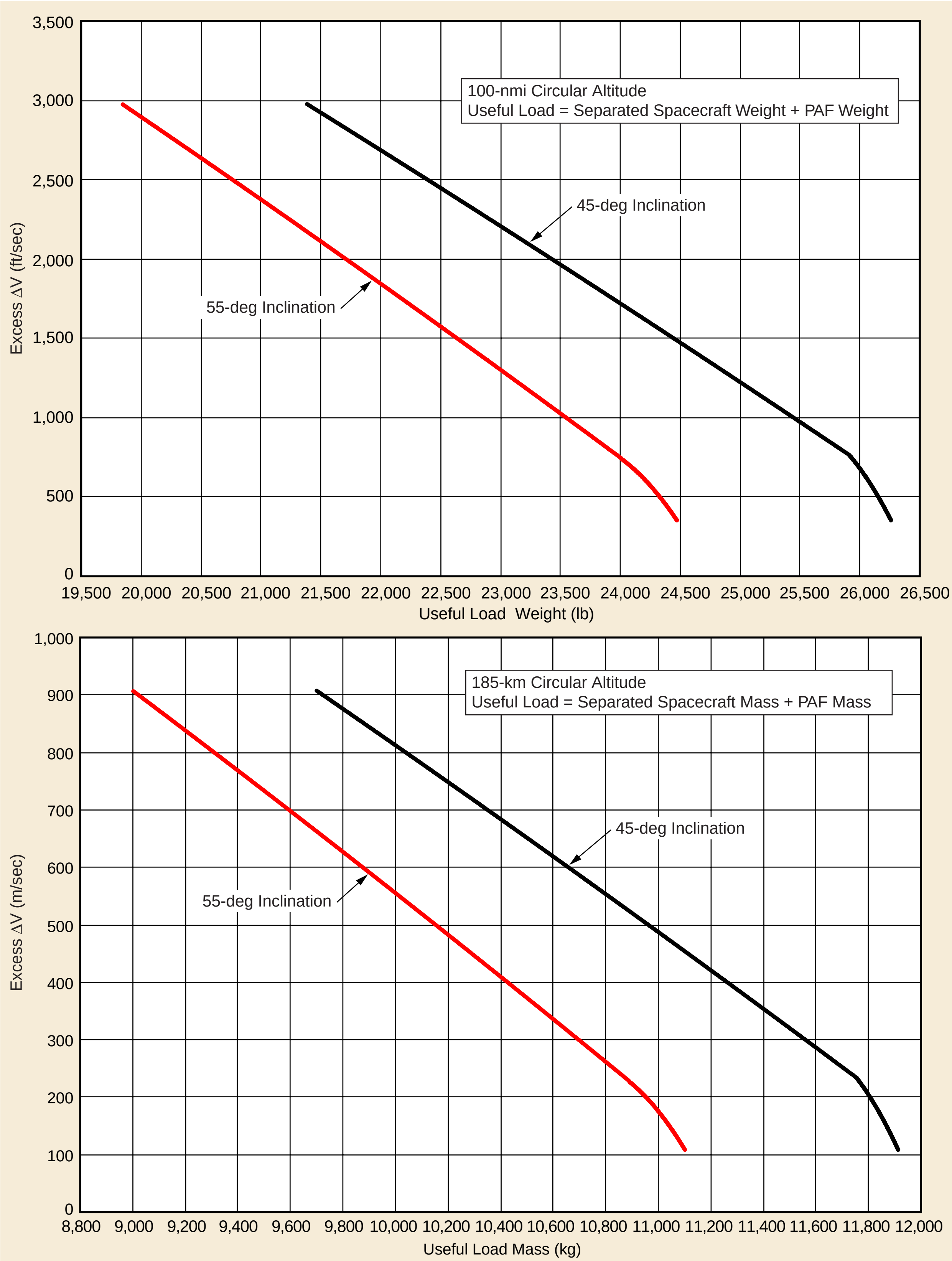


Figure 2-18. Delta IV-M+ (4,2) LEO Excess ΔV Capability—45- and 55-deg Inclinations (Eastern Range)

02148REU9.1

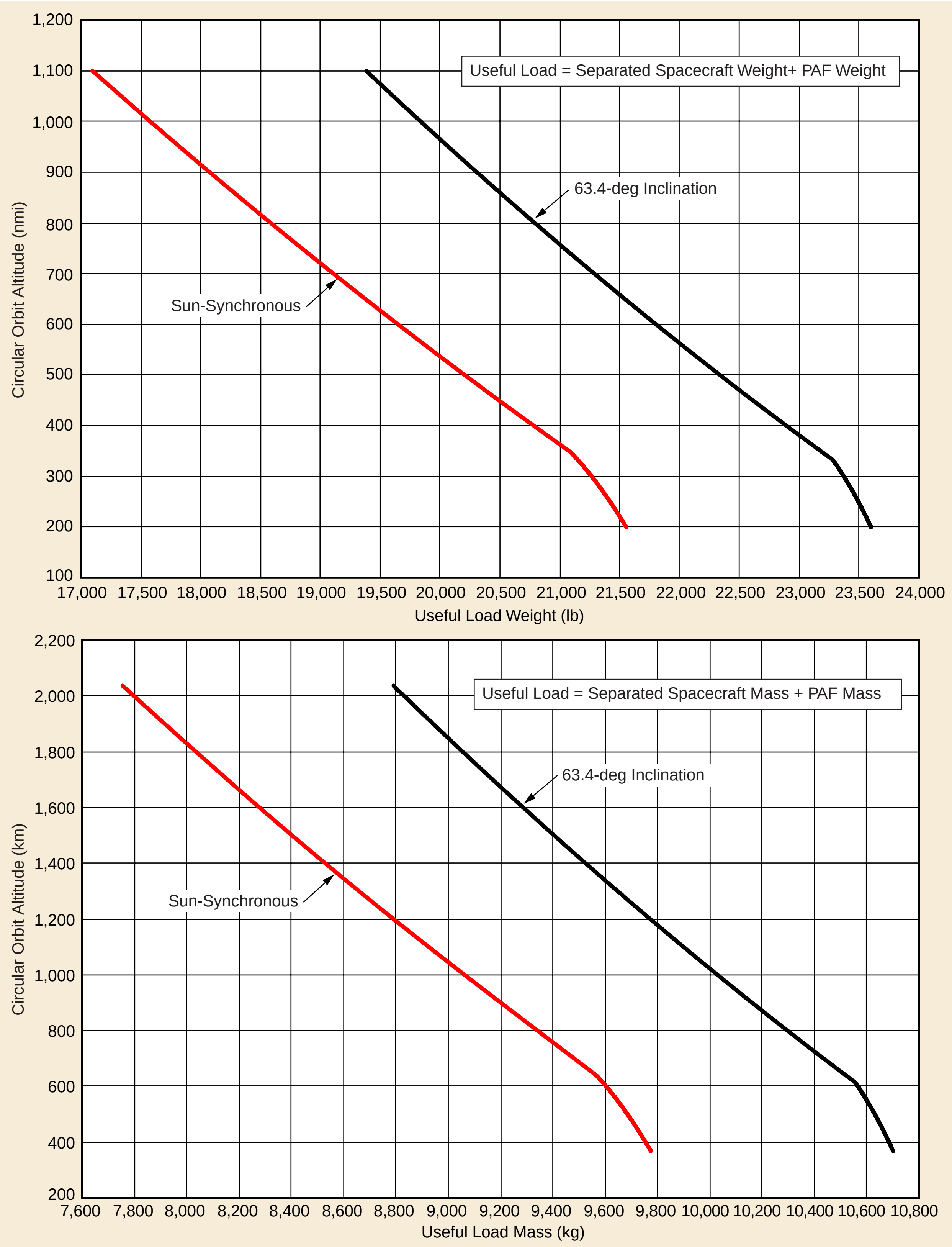


Figure 2-19. Delta IV-M+ (4,2) LEO Circular Orbit Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

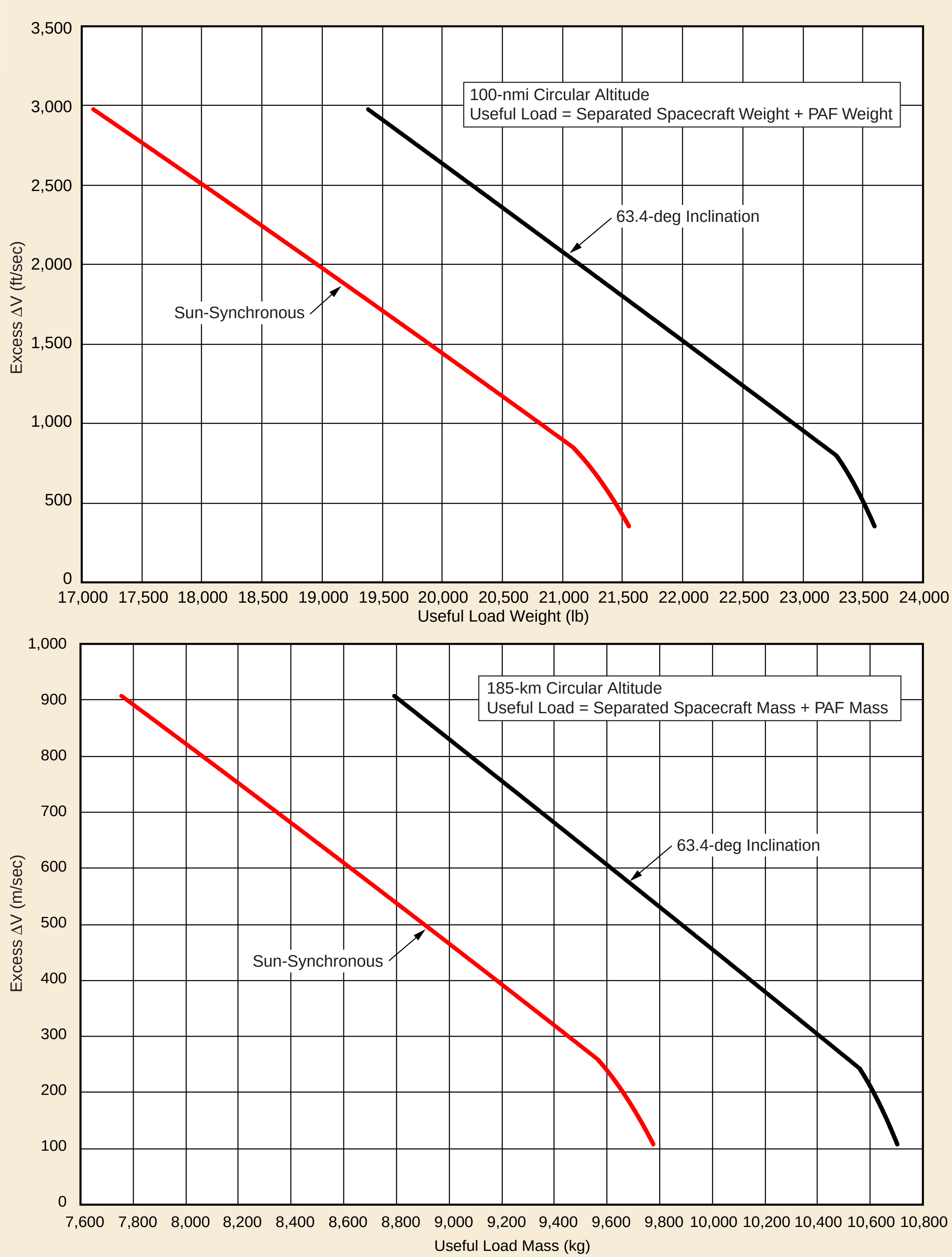
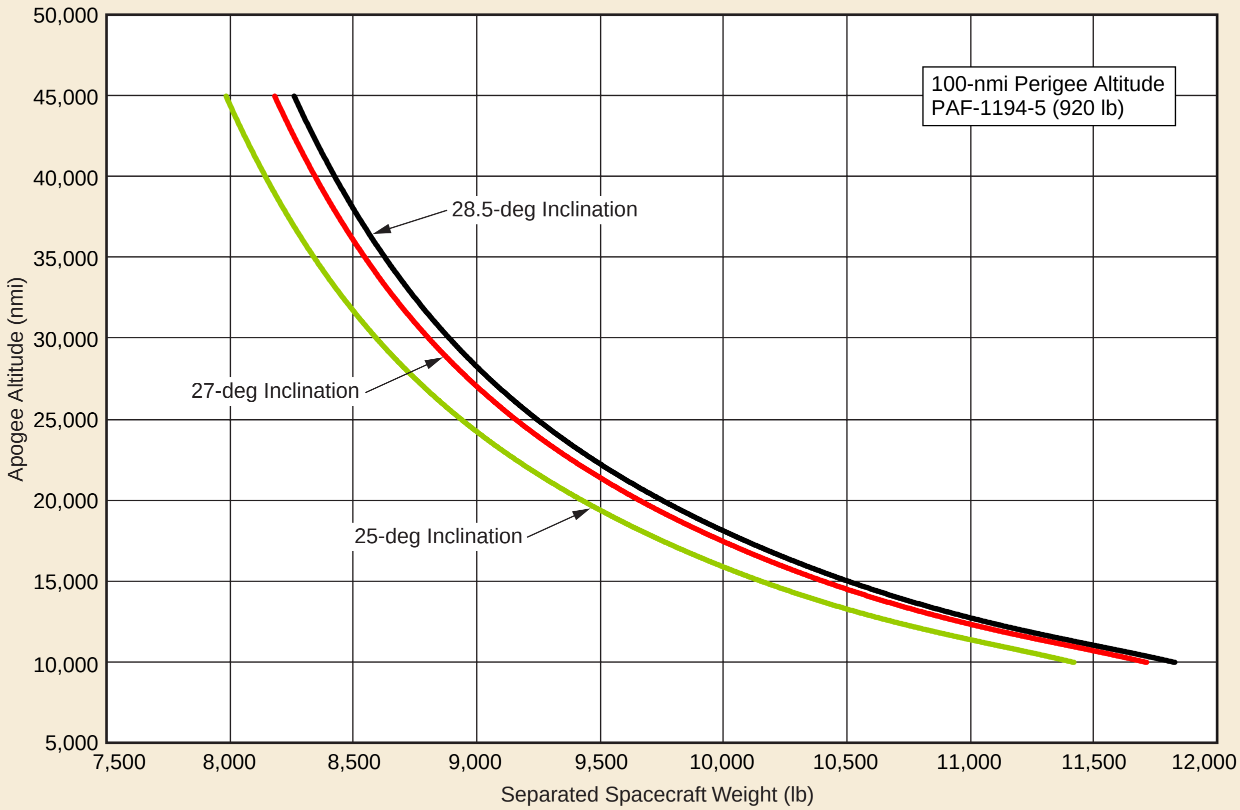


Figure 2-20. Delta IV-M+ (4,2) LEO Excess ΔV Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

02150REU9.1

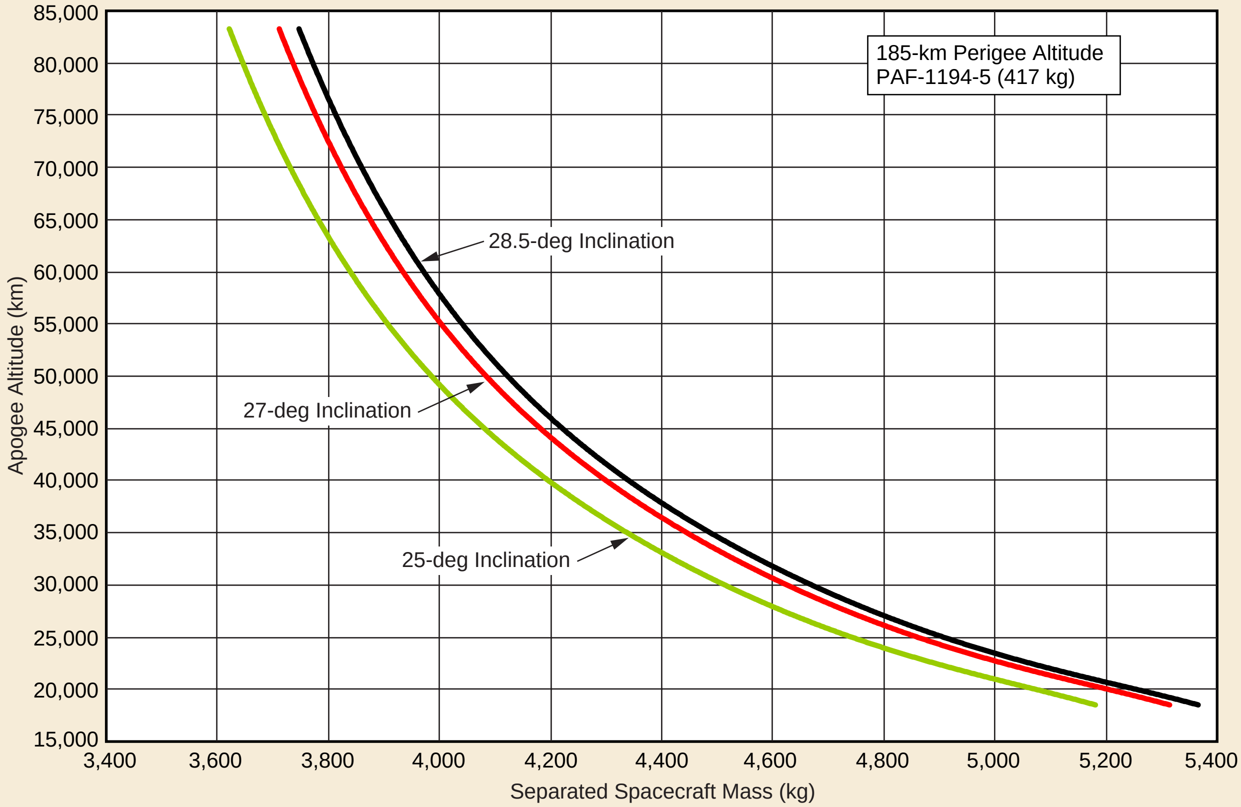


Apogee Altitude (nmi)*	Separated Spacecraft Weight (lb) 25 deg	27 deg	28.5 deg
GTO - 9,000	11,315	11,606	11,719
GTO - 8,000	11,012	11,292	11,401
GTO - 6,000	10,506	10,770	10,873
GTO - 4,000	10,104	10,355	10,455
GTO - 2,000	9,778	10,020	10,116
GTO (19,323)	9,508	9,743	9,836
GTO + 2,000	9,279	9,508	9,599
GTO + 4,000	9,083	9,308	9,396
GTO + 6,000	8,913	9,134	9,220
GTO + 8,000	8,766	8,982	9,067
GTO + 10,000	8,636	8,849	8,933
GTO + 12,000	8,523	8,733	8,816
GTO + 14,000	8,423	8,629	8,711
GTO + 16,000	8,332	8,537	8,618
GTO + 18,000	8,249	8,452	8,532
2 x GTO (38,646)	8,197	8,399	8,479
GTO + 20,000	8,172	8,373	8,453
GTO + 22,000	8,098	8,299	8,378
GTO + 24,000	8,032	8,231	8,310
GTO + 25,000	8,002	8,201	8,280

*Note: Trajectories have a perigee altitude of 100 nmi

Figure 2-21a. Delta IV-M+ (5,2) GTO Apogee Altitude Capability (nmi)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

02151REU9.1



Apogee Altitude (km)*	Separated Spacecraft Mass (kg) 25 deg	27 deg	28.5 deg
GTO - 17,000	5,159	5,292	5,343
GTO - 15,000	5,008	5,135	5,185
GTO - 10,000	4,706	4,824	4,871
GTO - 5,000	4,484	4,595	4,639
GTO (35,786)	4,313	4,419	4,461
GTO + 5,000	4,176	4,280	4,320
GTO + 10,000	4,065	4,166	4,205
GTO + 15,000	3,973	4,071	4,110
GTO + 20,000	3,896	3,992	4,030
GTO + 25,000	3,831	3,926	3,963
GTO + 30,000	3,776	3,868	3,905
GTO + 35,000	3,726	3,817	3,854
2 x GTO (71,752)	3,718	3,810	3,846
GTO + 40,000	3,680	3,771	3,807
GTO + 45,000	3,639	3,729	3,765
GTO + 47,000	3,625	3,715	3,751

*Note: Trajectories have a perigee altitude of 185 km

Figure 2-21b. Delta IV-M+ (5,2) GTO Apogee Altitude Capability (km)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

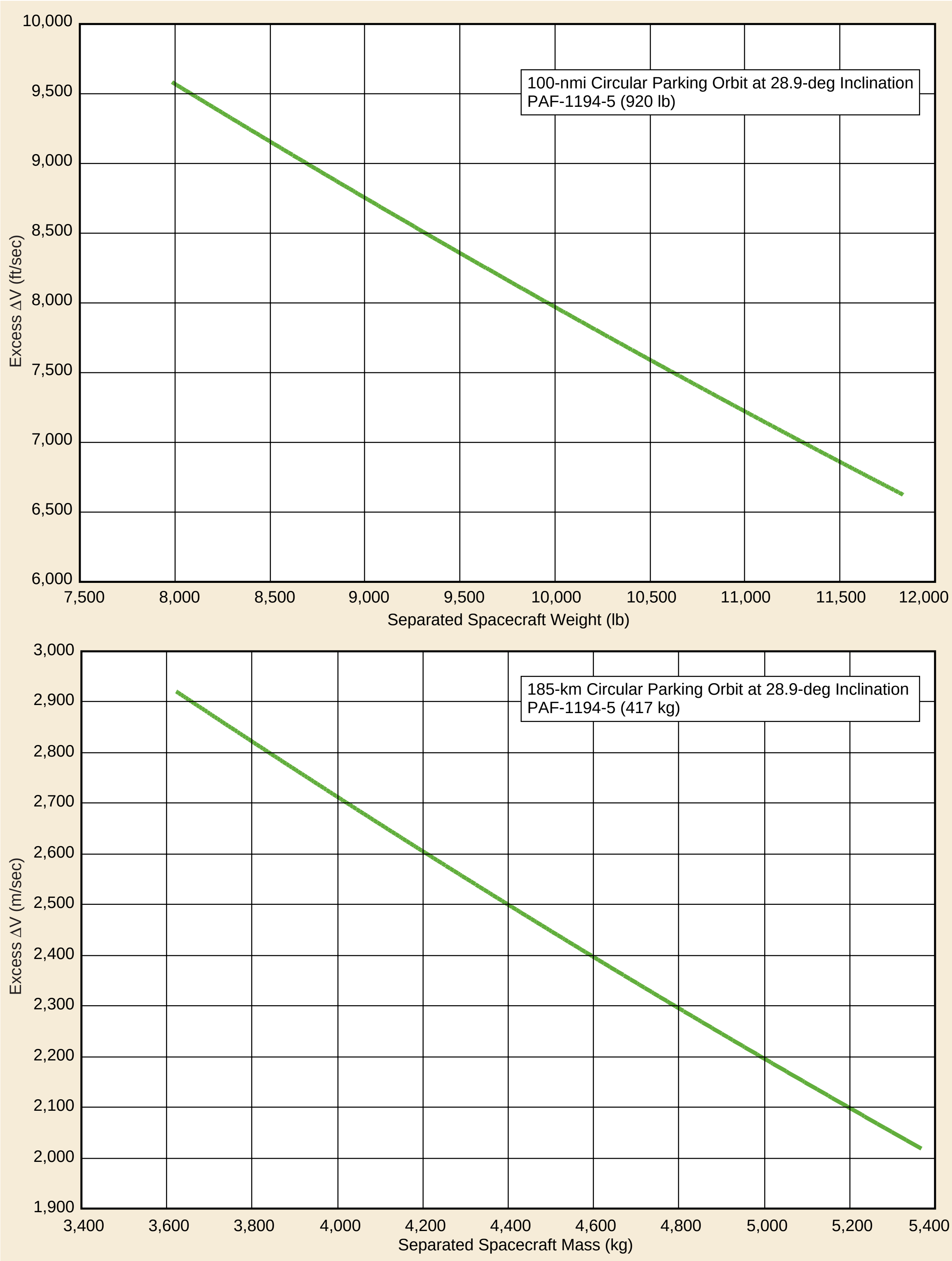


Figure 2-22. Delta IV-M+ (5,2) GTO Excess ΔV Capability—28.9-deg Inclination (Eastern Range)

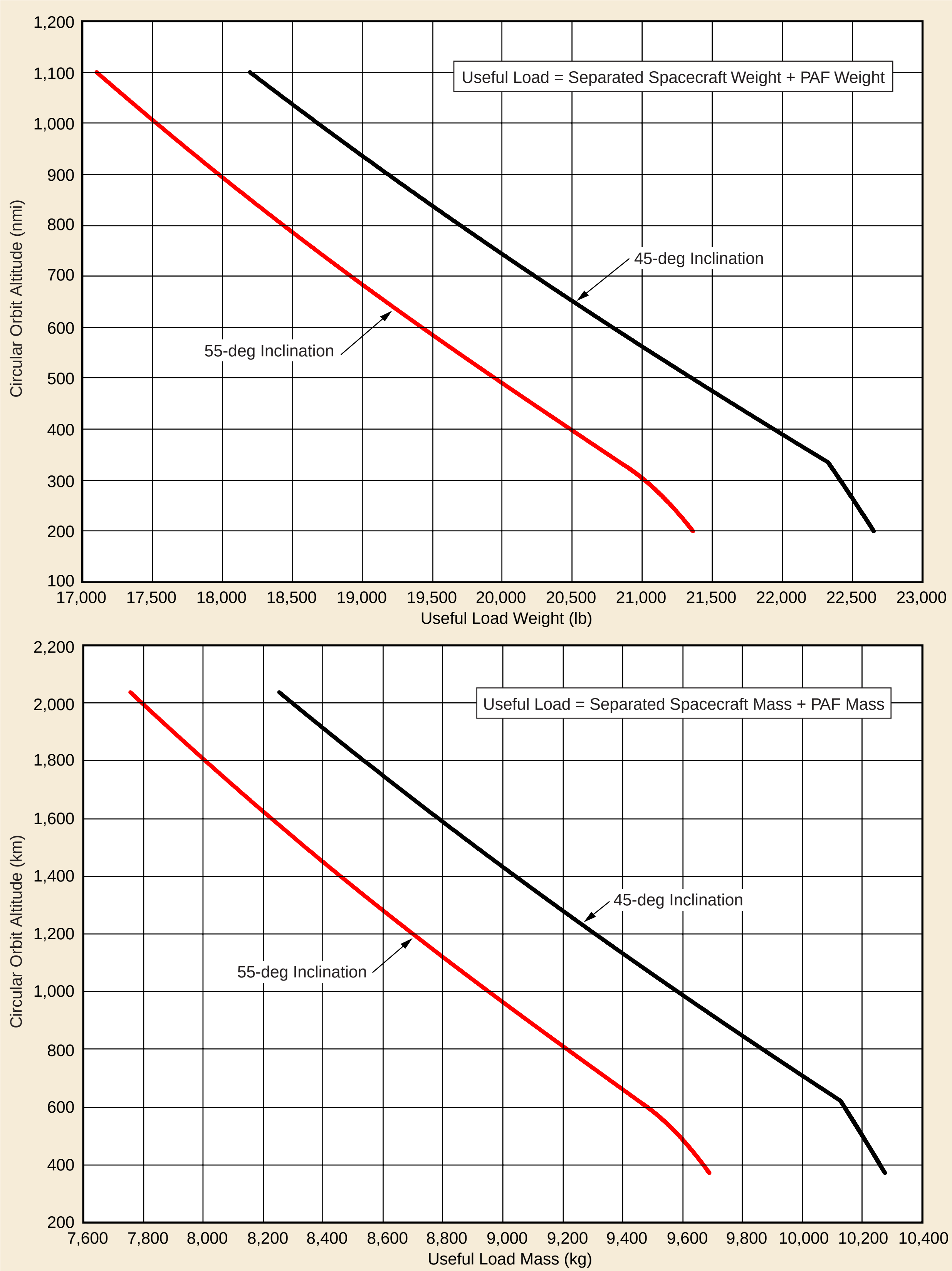


Figure 2-23. Delta IV-M+ (5,2) LEO Circular Orbit Capability—45- and 55-deg Inclinations (Eastern Range)

02154REU9.1

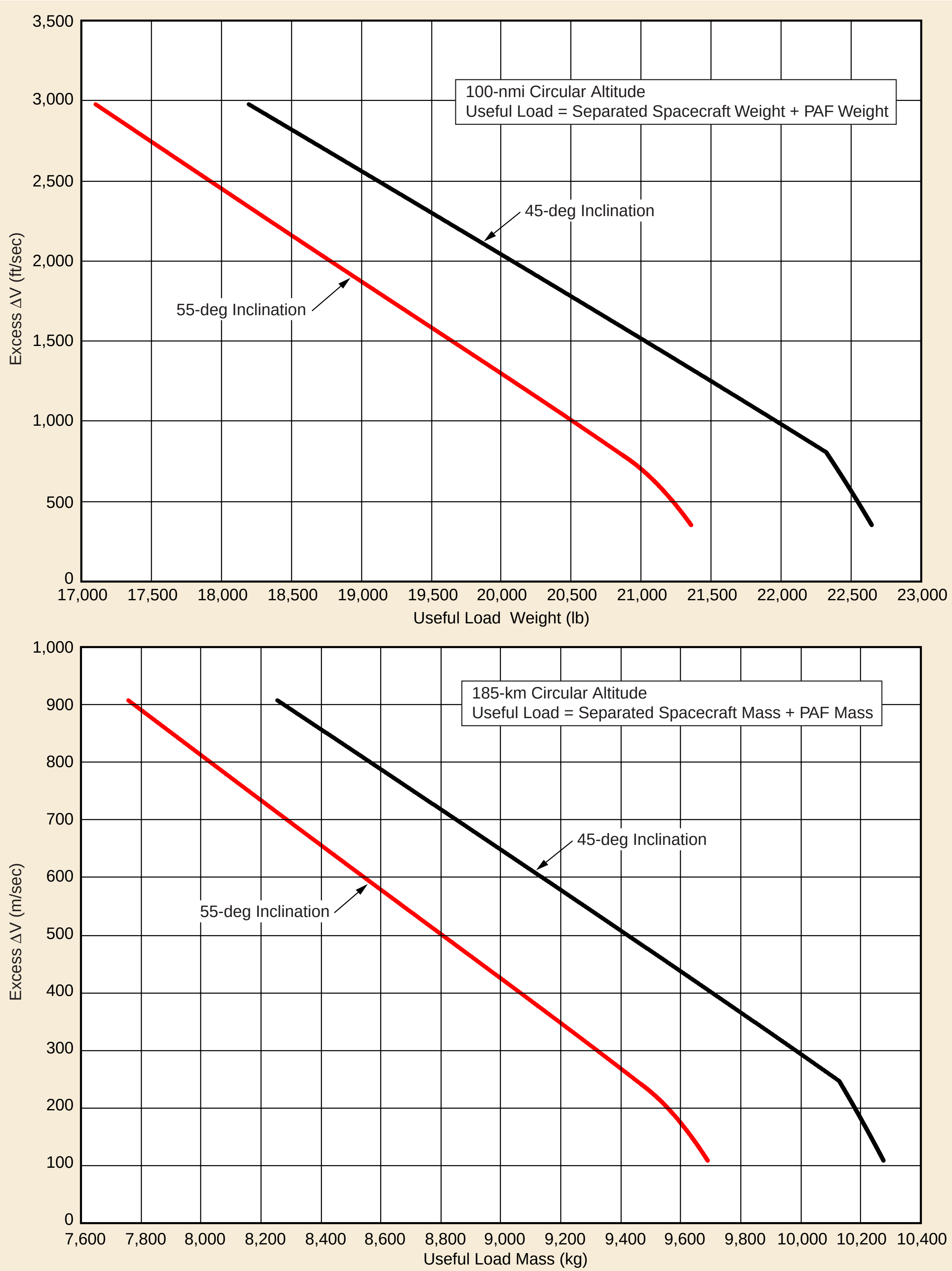


Figure 2-24. Delta IV-M+ (5,2) LEO Excess ΔV Capability—45- and 55-deg Inclinations (Eastern Range)

02155REU9.1

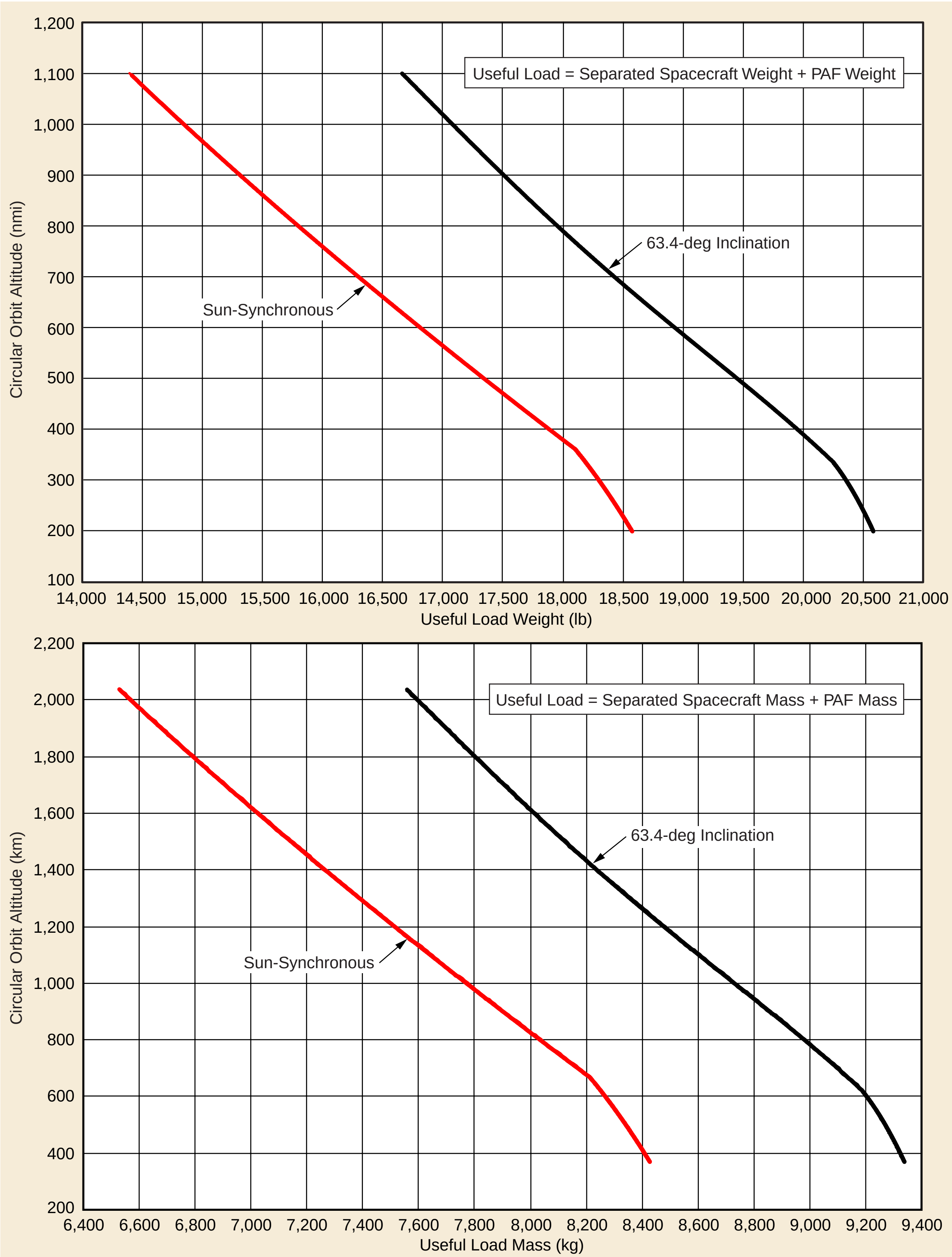


Figure 2-25. Delta IV-M+ (5,2) LEO Circular Orbit Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

02156REU9.1

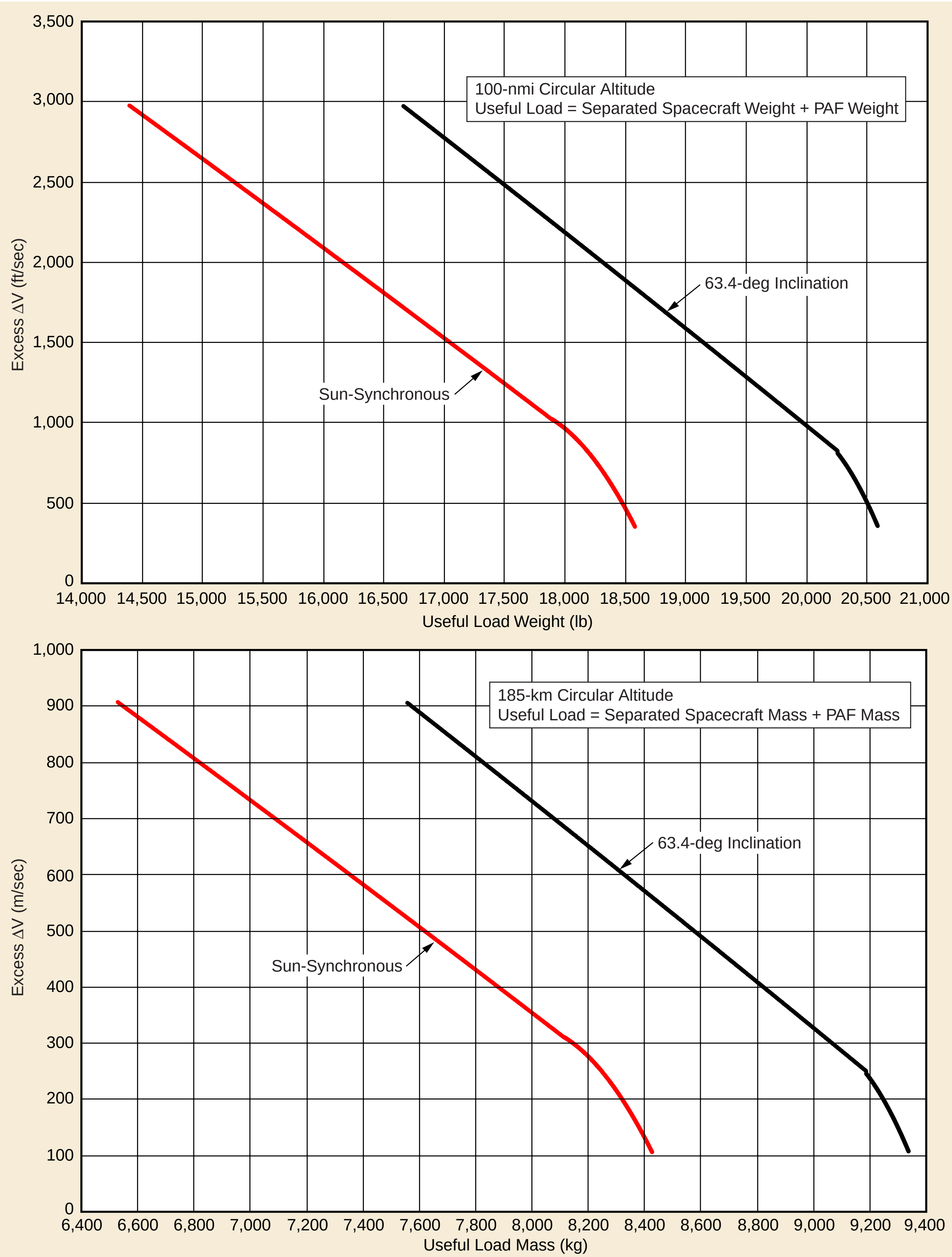
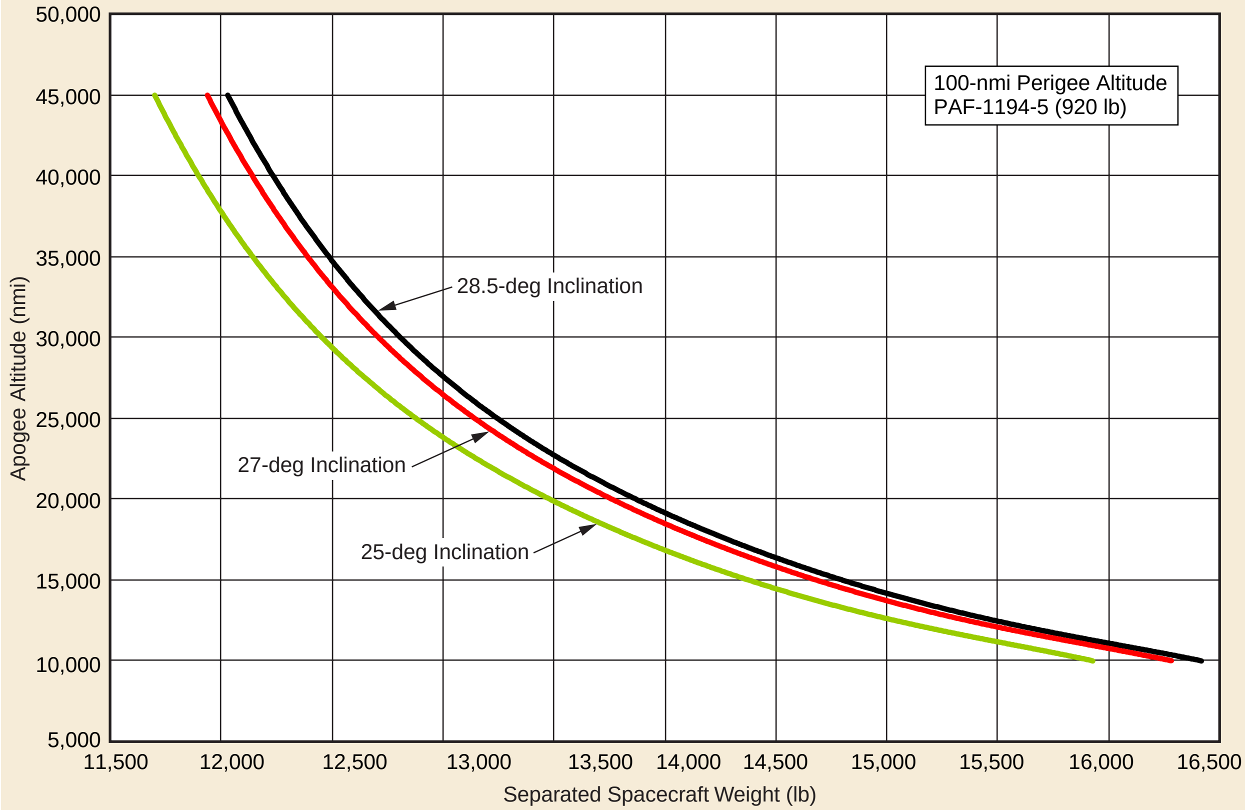


Figure 2-26. Delta IV-M+ (5,2) LEO Excess ΔV Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

02157REU9.1

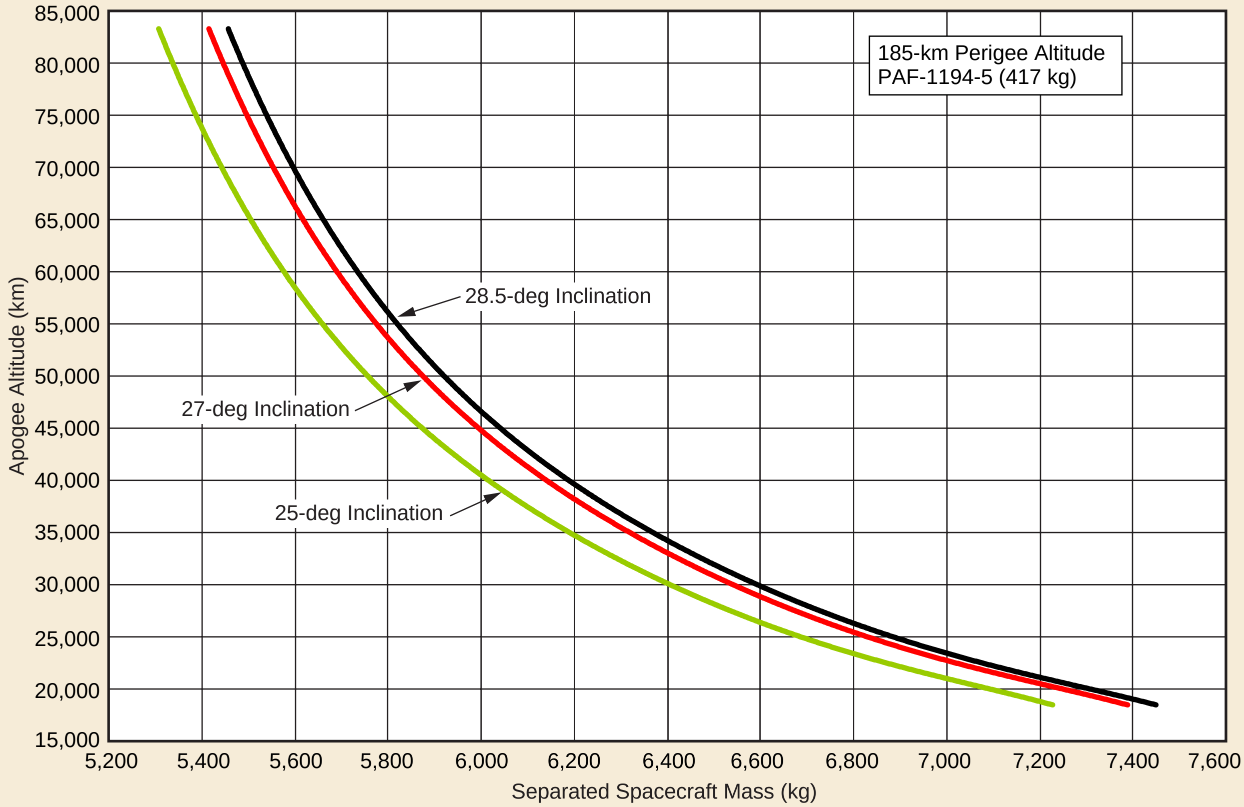


Apogee Altitude (nmi)*	Separated Spacecraft Weight (lb) 25 deg	27 deg	28.5 deg
GTO - 9,000	15,800	16,150	16,283
GTO - 8,000	15,427	15,765	15,893
GTO - 6,000	14,806	15,124	15,245
GTO - 4,000	14,312	14,615	14,731
GTO - 2,000	13,911	14,203	14,315
GTO (19,323)	13,578	13,861	13,970
GTO + 2,000	13,297	13,573	13,679
GTO + 4,000	13,056	13,326	13,429
GTO + 6,000	12,847	13,111	13,213
GTO + 8,000	12,665	12,925	13,025
GTO + 10,000	12,505	12,761	12,860
GTO + 12,000	12,365	12,618	12,716
GTO + 14,000	12,241	12,491	12,589
GTO + 16,000	12,129	12,376	12,474
GTO + 18,000	12,027	12,272	12,368
2 x GTO (38,646)	11,963	12,206	12,302
GTO + 20,000	11,932	12,174	12,269
GTO + 22,000	11,842	12,083	12,176
GTO + 24,000	11,760	11,999	12,091
GTO + 25,000	11,724	11,961	12,053

*Note: Trajectories have a perigee altitude of 100 nmi

Figure 2-27a. Delta IV-M+ (5,4) GTO Apogee Altitude Capability (nmi)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

02158REU9.1



Apogee Altitude (km)*	Separated Spacecraft Mass (kg) 25 deg	27 deg	28.5 deg
GTO - 17,000	7,199	7,359	7,420
GTO - 15,000	7,014	7,167	7,226
GTO - 10,000	6,643	6,785	6,840
GTO - 5,000	6,370	6,504	6,555
GTO (35,786)	6,159	6,287	6,337
GTO + 5,000	5,991	6,115	6,163
GTO + 10,000	5,854	5,975	6,021
GTO + 15,000	5,741	5,859	5,904
GTO + 20,000	5,646	5,761	5,806
GTO + 25,000	5,566	5,679	5,724
GTO + 30,000	5,497	5,609	5,653
GTO + 35,000	5,436	5,546	5,590
2 x GTO (71,752)	5,426	5,537	5,580
GTO + 40,000	5,379	5,489	5,531
GTO + 45,000	5,329	5,437	5,479
GTO + 47,000	5,312	5,420	5,461

*Note: Trajectories have a perigee altitude of 185 km

Figure 2-27b. Delta IV-M+ (5,4) GTO Apogee Altitude Capability (km)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

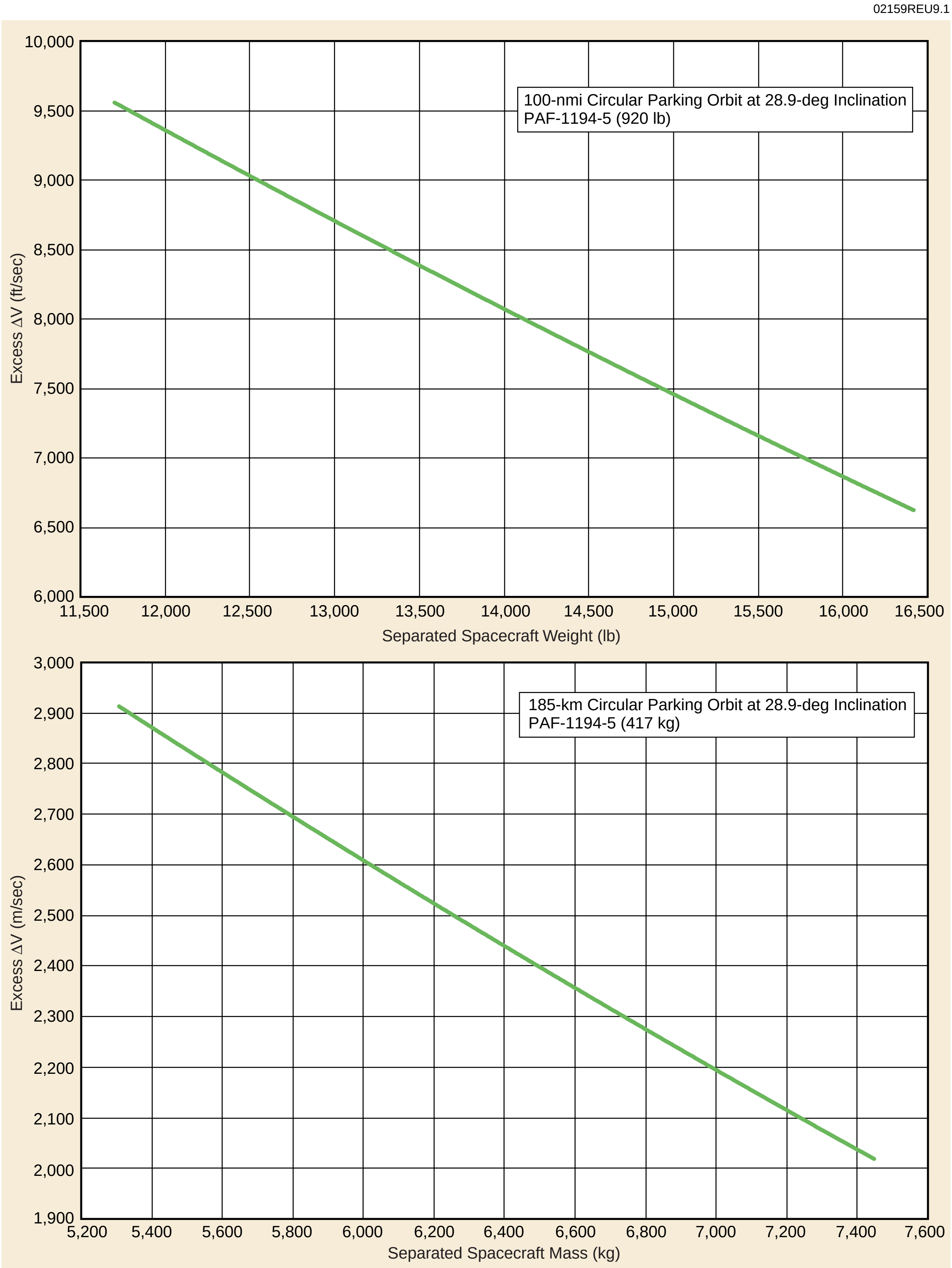


Figure 2-28. Delta IV-M+ (5,4) GTO Excess ΔV Capability—28.9-deg Inclination (Eastern Range)

02160REU9.1

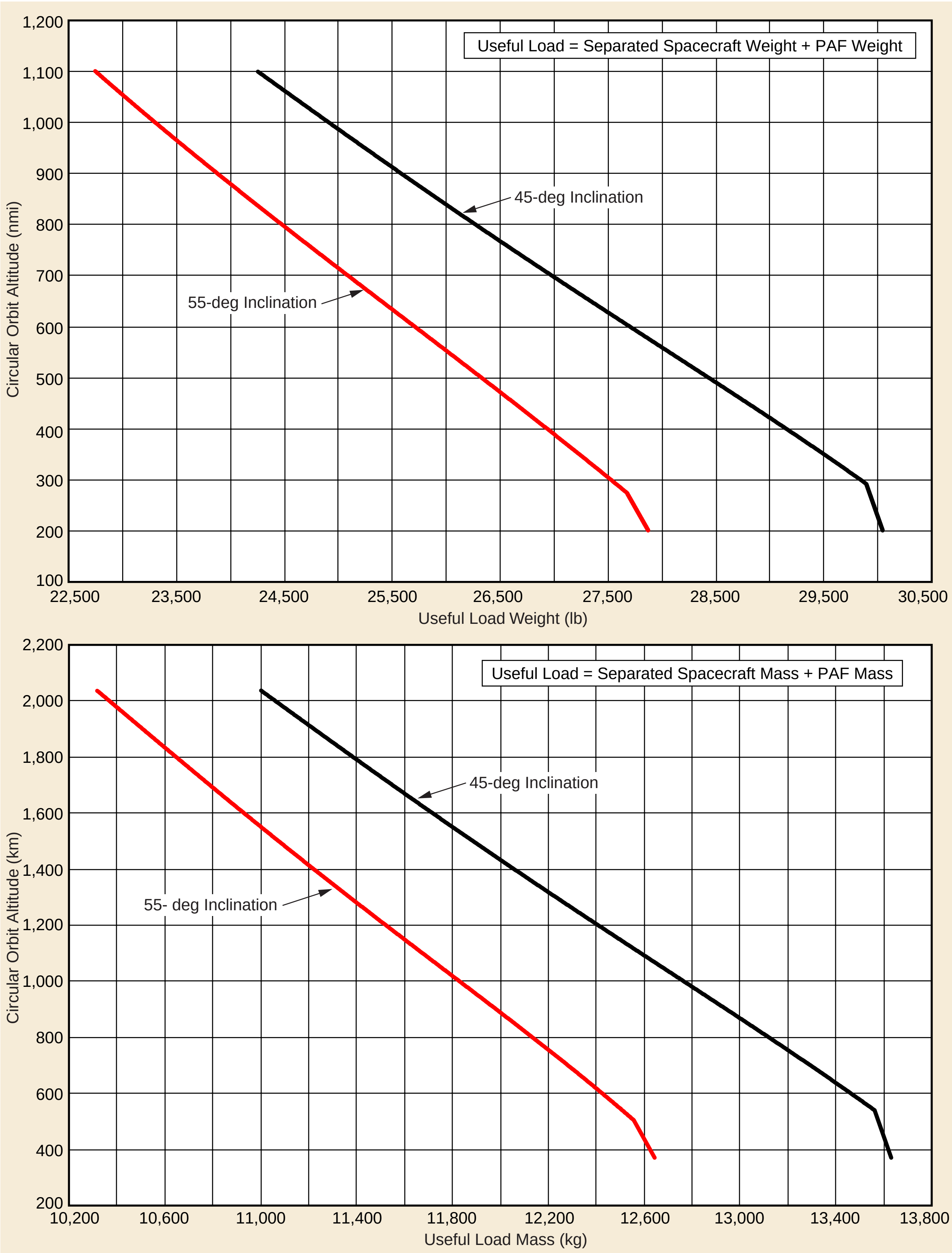


Figure 2-29. Delta IV-M+ (5,4) LEO Circular Orbit Capability—45- and 55-deg Inclinations (Eastern Range)

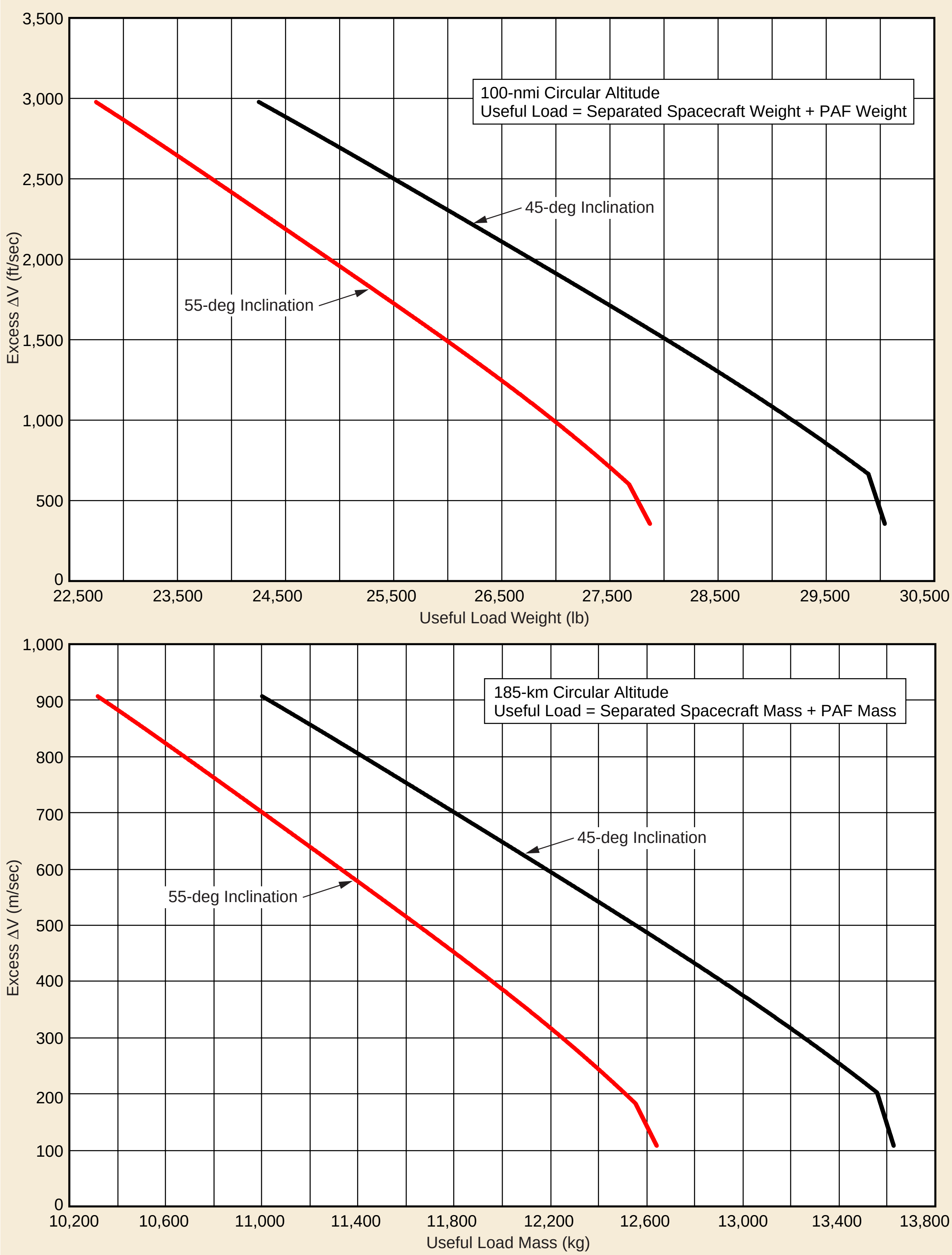


Figure 2-30. Delta IV-M+ (5,4) LEO Excess ΔV Capability—45- and 55-deg Inclinations (Eastern Range)

02176REU9.1

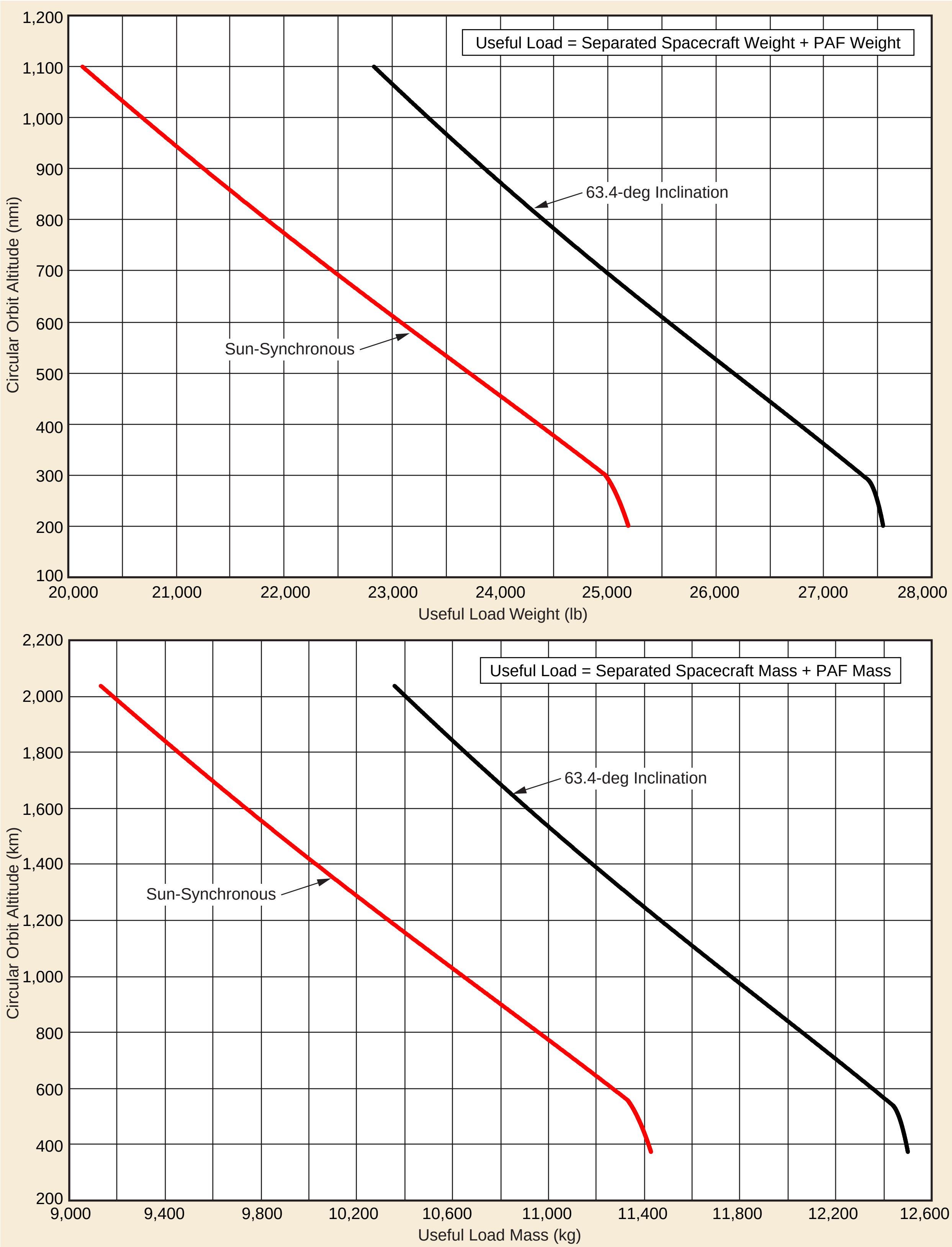


Figure 2-31. Delta IV-M+ (5,4) LEO Circular Orbit Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

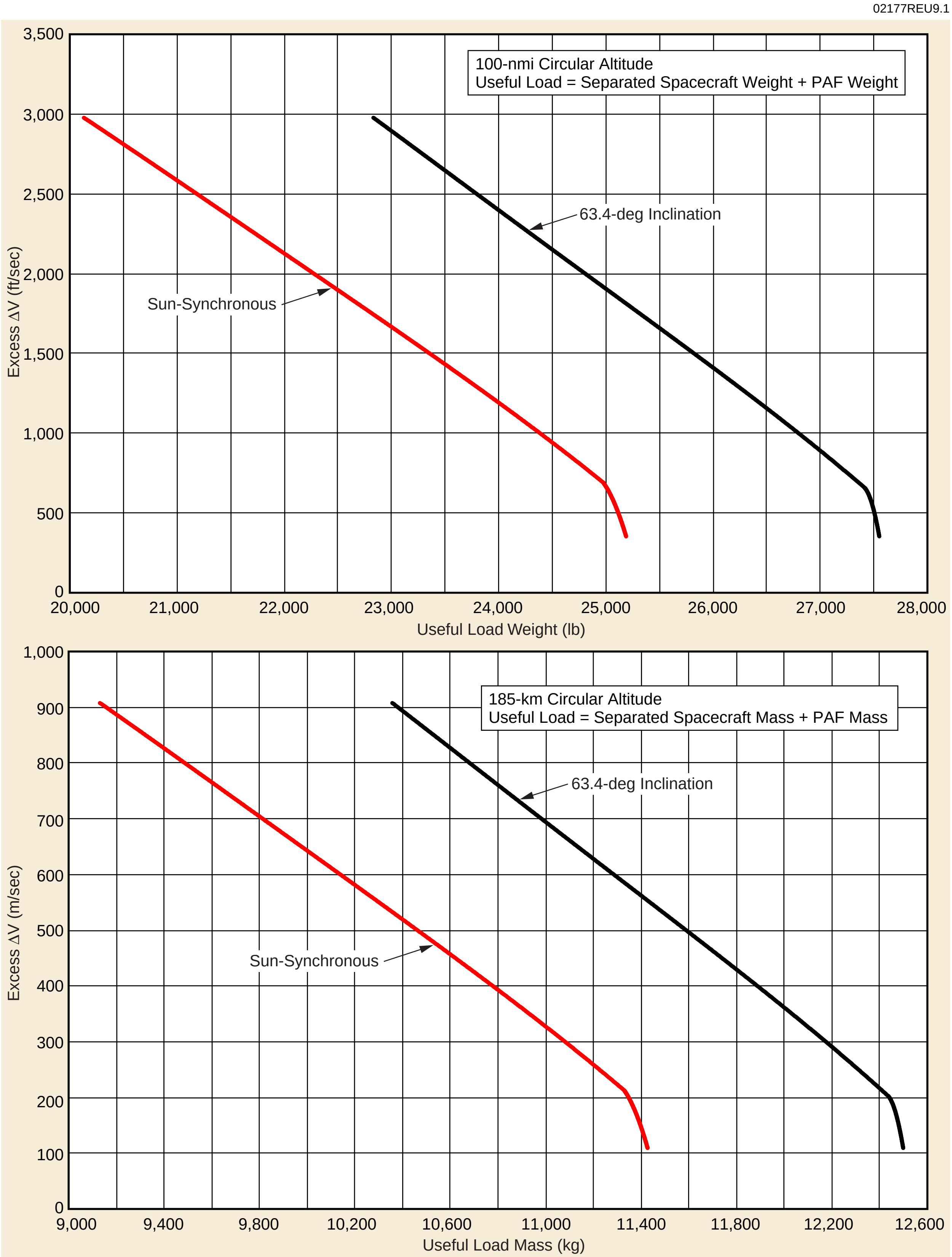
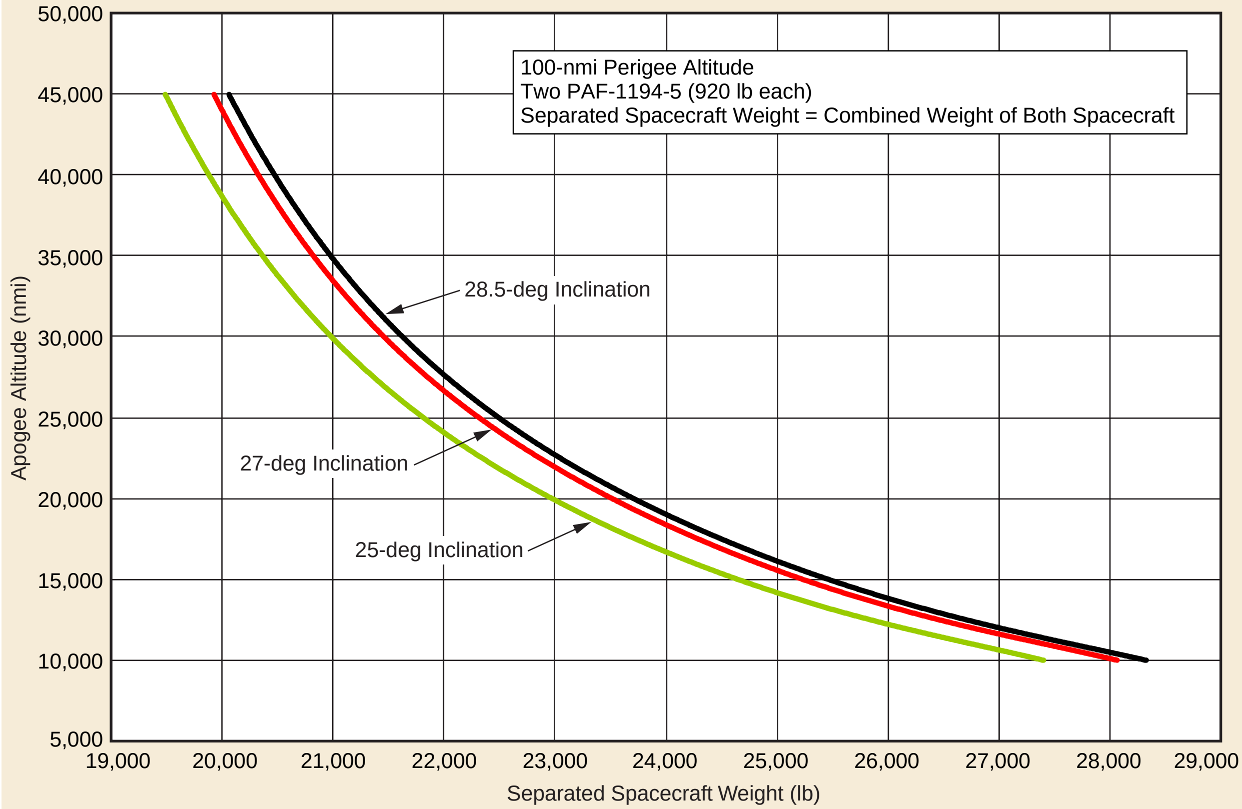


Figure 2-32. Delta IV-M+ (5,4) LEO Excess ΔV Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

02178REU9.1

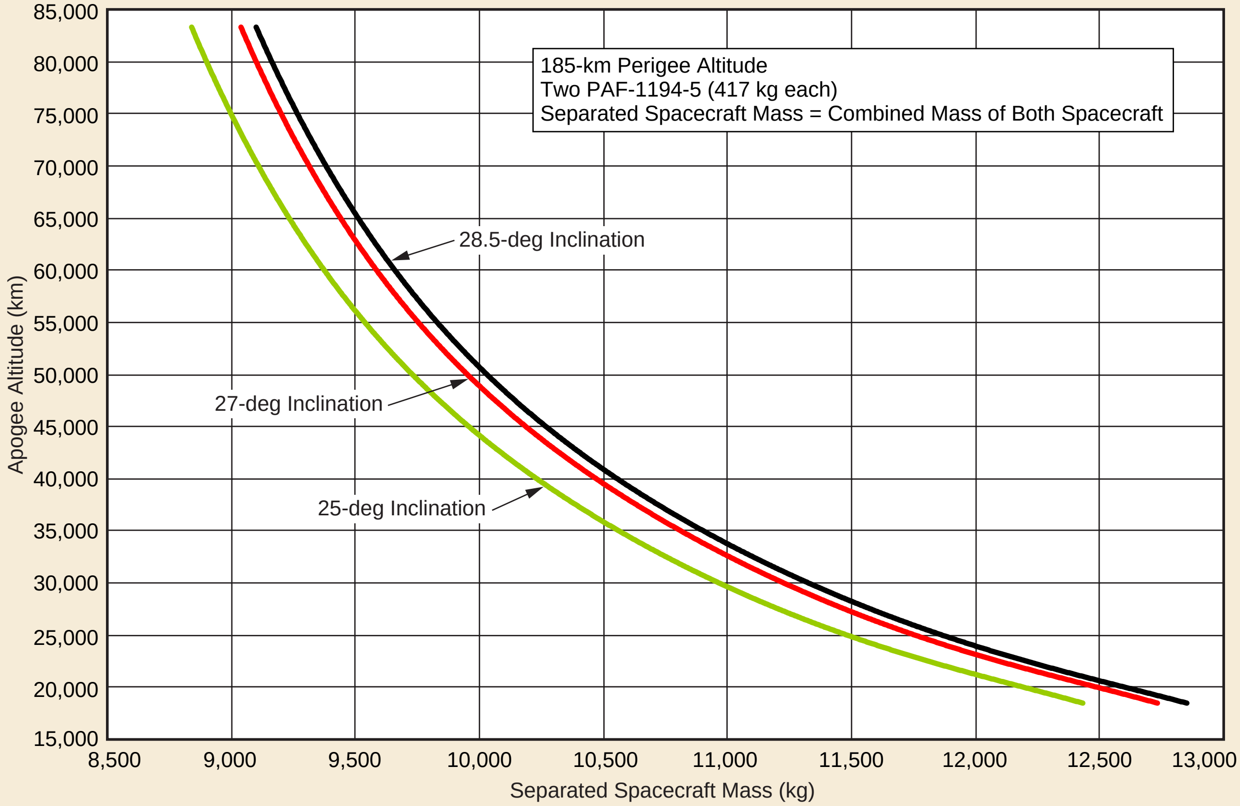


	Separated Spacecraft Weight (lb)		
Apogee Altitude (nmi)*	**25 deg**	**27 deg**	**28.5 deg**
GTO - 9,000	27,182	27,839	28,098
GTO - 8,000	26,534	27,174	27,424
GTO - 6,000	25,430	26,040	26,277
GTO - 4,000	24,531	25,114	25,340
GTO - 2,000	23,786	24,349	24,561
GTO (19,323)	23,159	23,704	23,904
GTO + 2,000	22,623	23,154	23,342
GTO + 4,000	22,159	22,677	22,855
GTO + 6,000	21,754	22,258	22,430
GTO + 8,000	21,399	21,889	22,058
GTO + 10,000	21,085	21,561	21,731
GTO + 12,000	20,807	21,269	21,442
GTO + 14,000	20,559	21,010	21,184
GTO + 16,000	20,335	20,778	20,952
GTO + 18,000	20,132	20,570	20,739
2 x GTO (38,646)	20,005	20,444	20,606
GTO + 20,000	19,943	20,383	20,541
GTO + 22,000	19,769	20,211	20,356
GTO + 24,000	19,608	20,053	20,187
GTO + 25,000	19,536	19,977	20,111

*Note: Trajectories have a perigee altitude of 100 nmi

Figure 2-33a. Delta IV-H Dual-Manifest GTO Apogee Altitude Capability (nmi)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

02179REU9.1



Apogee Altitude (km)*	Separated Spacecraft Mass (kg) 25 deg	27 deg	28.5 deg
GTO - 17,000	12,386	12,685	12,804
GTO - 15,000	12,063	12,354	12,468
GTO - 10,000	11,404	11,677	11,783
GTO - 5,000	10,901	11,159	11,257
GTO (35,786)	10,505	10,752	10,843
GTO + 5,000	10,185	10,423	10,507
GTO + 10,000	9,920	10,151	10,229
GTO + 15,000	9,699	9,921	9,998
GTO + 20,000	9,512	9,725	9,803
GTO + 25,000	9,352	9,558	9,637
GTO + 30,000	9,214	9,415	9,494
GTO + 35,000	9,092	9,291	9,366
2 x GTO (71,752)	9,074	9,273	9,347
GTO + 40,000	8,982	9,183	9,250
GTO + 45,000	8,884	9,085	9,146
GTO + 47,000	8,849	9,049	9,110

*Note: Trajectories have a perigee altitude of 185 km

Figure 2-33b. Delta IV-H Dual-Manifest GTO Apogee Altitude Capability (km)—28.5-, 27-, and 25-deg Inclinations (Eastern Range)

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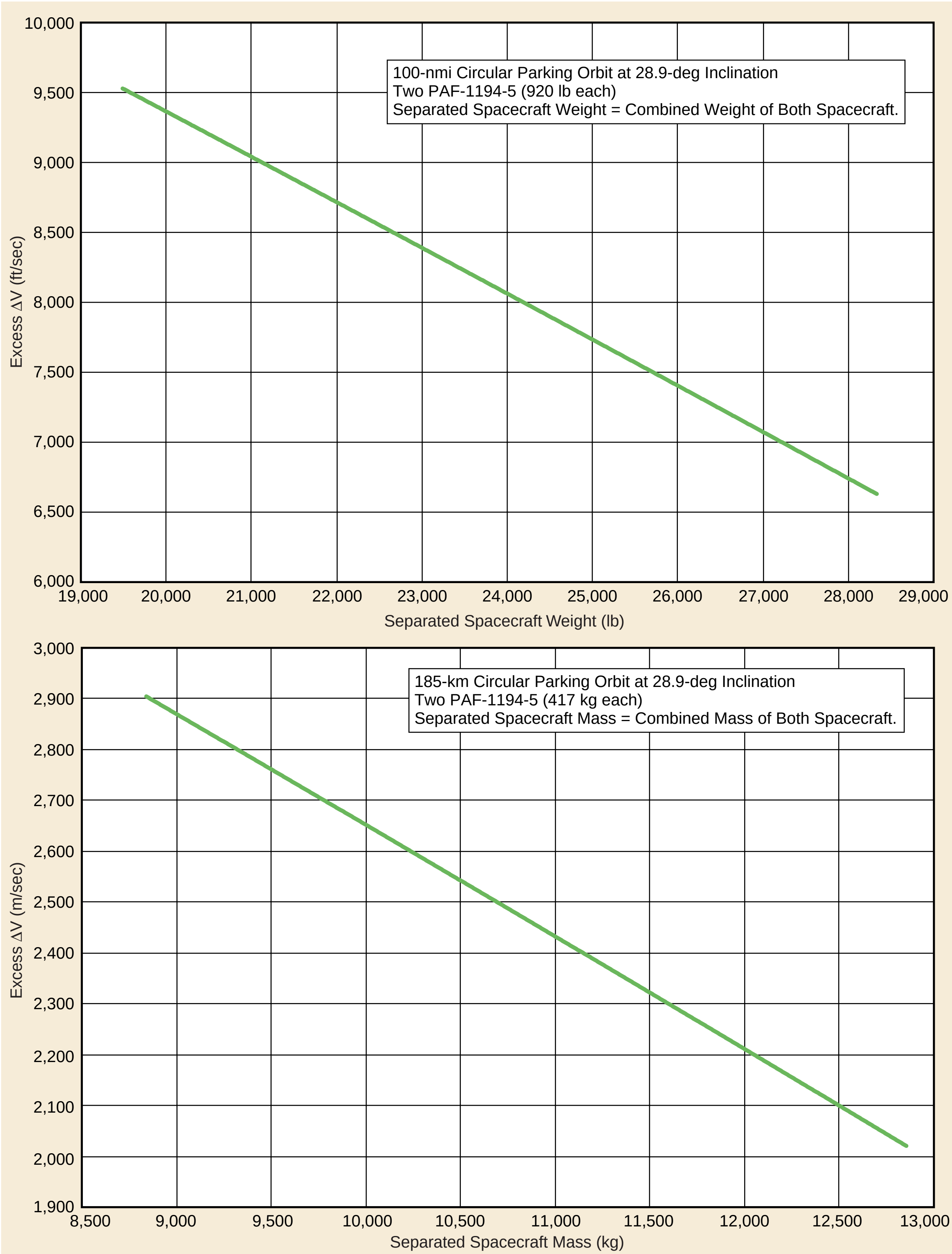

Figure 2-34. Delta IV-H Dual-Manifest Excess ΔV Capability—28.9-deg Inclination (Eastern Range)

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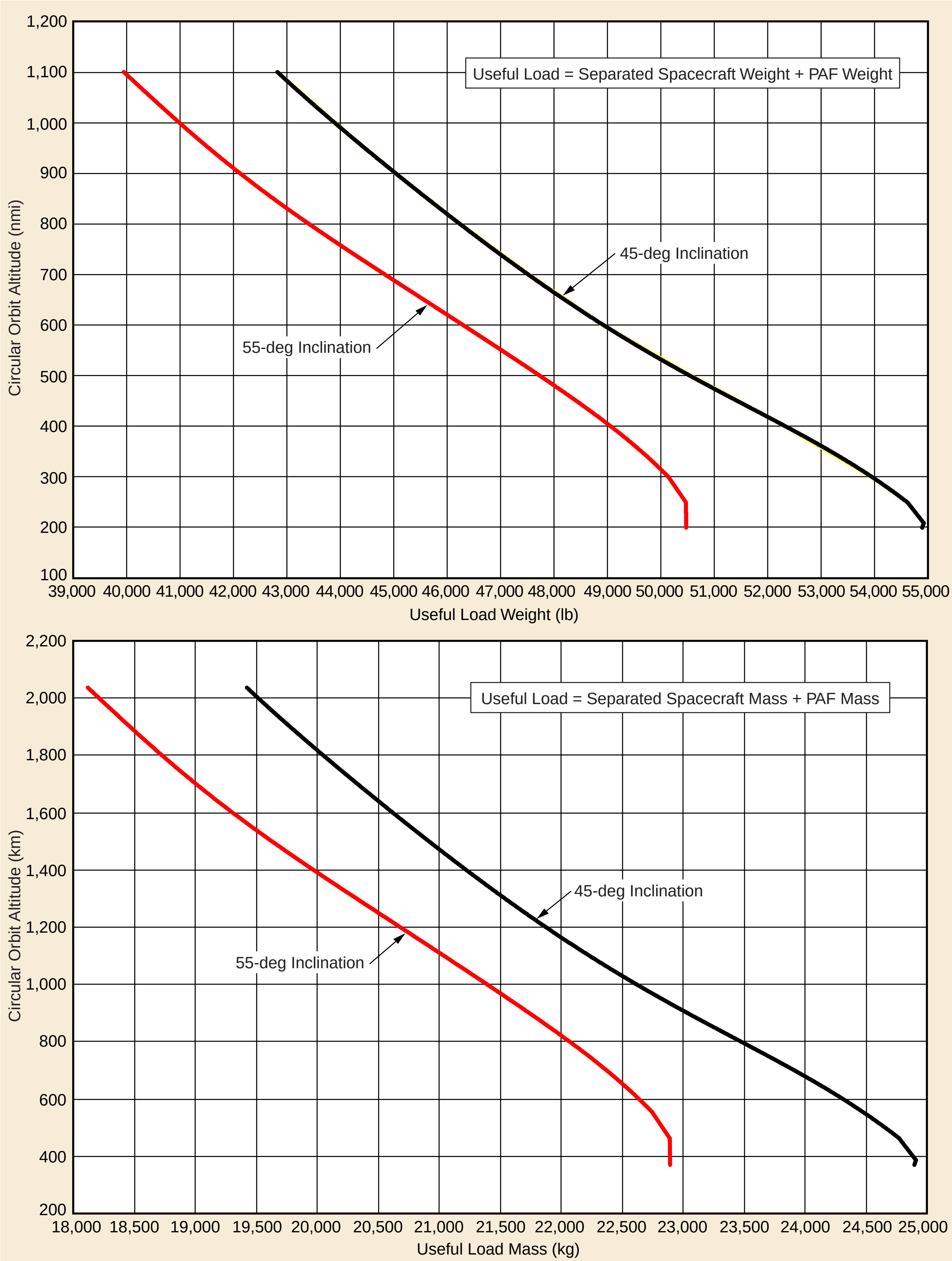

Figure 2-35. Delta IV-H LEO Circular Orbit Capability—45- and 55-deg Inclinations (Eastern Range)

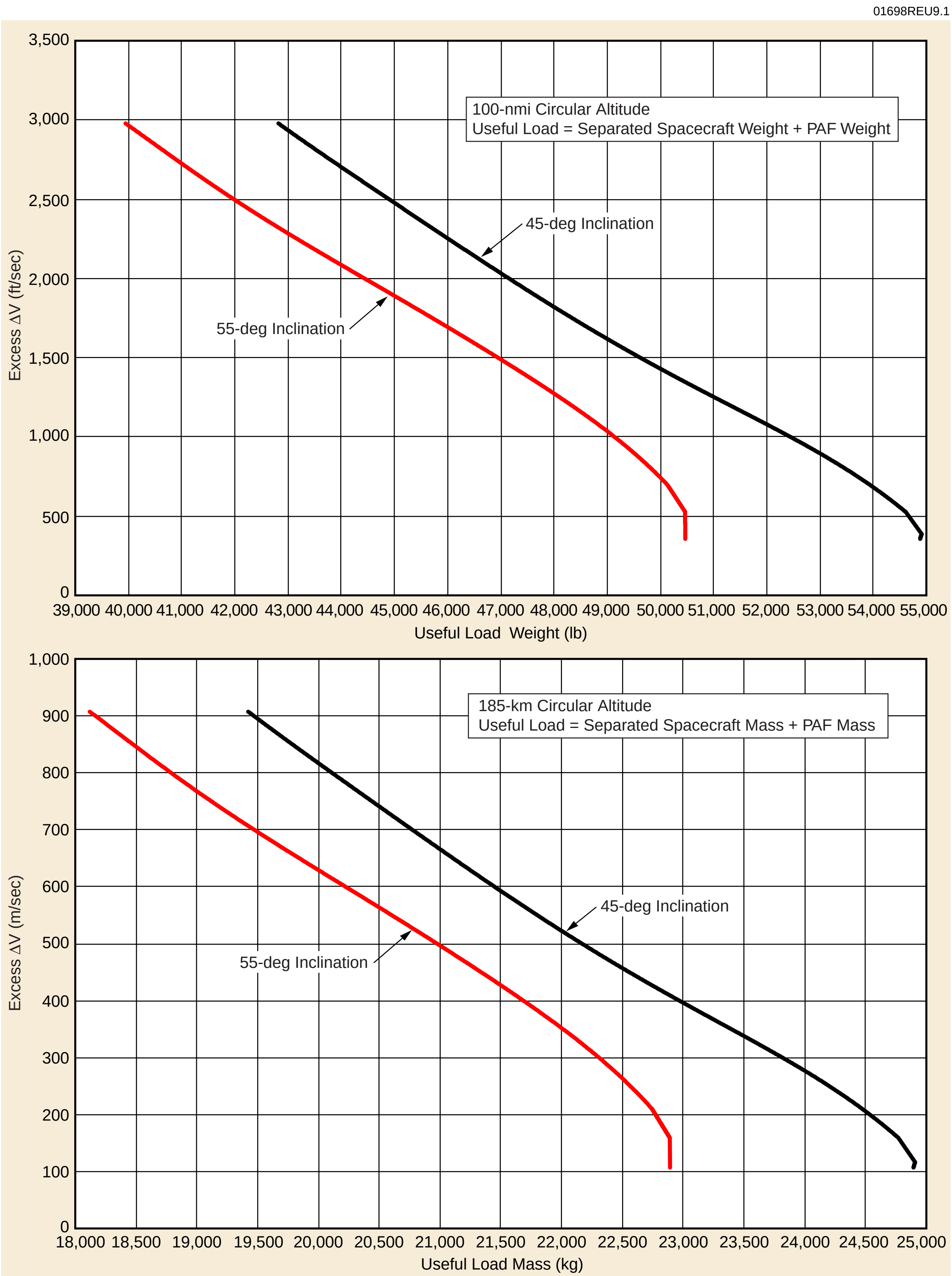

Figure 2-36. Delta IV-H LEO Excess ΔV Capability—45- and 55-deg Inclinations (Eastern Range)

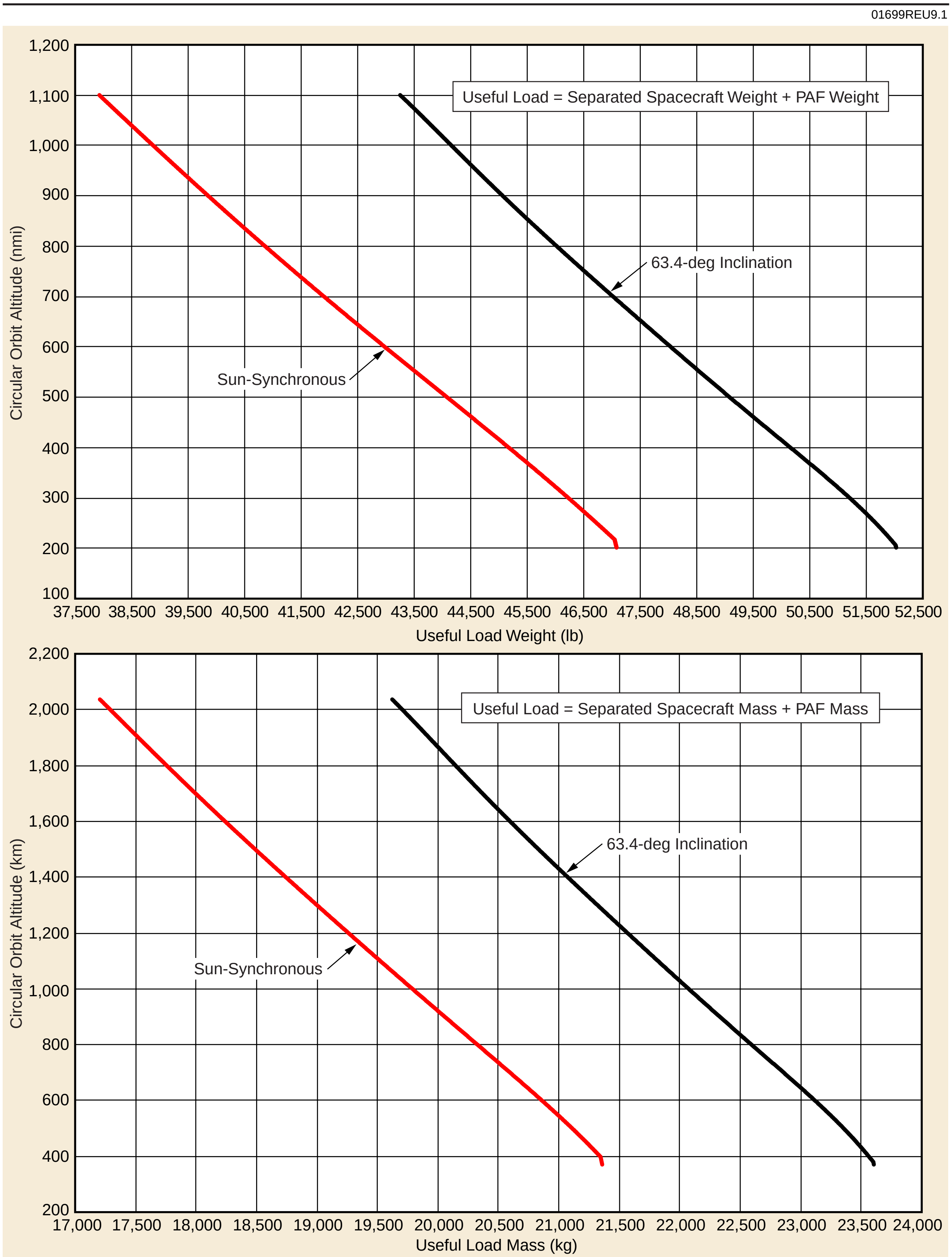

Figure 2-37. Delta IV-H LEO Circular Orbit Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

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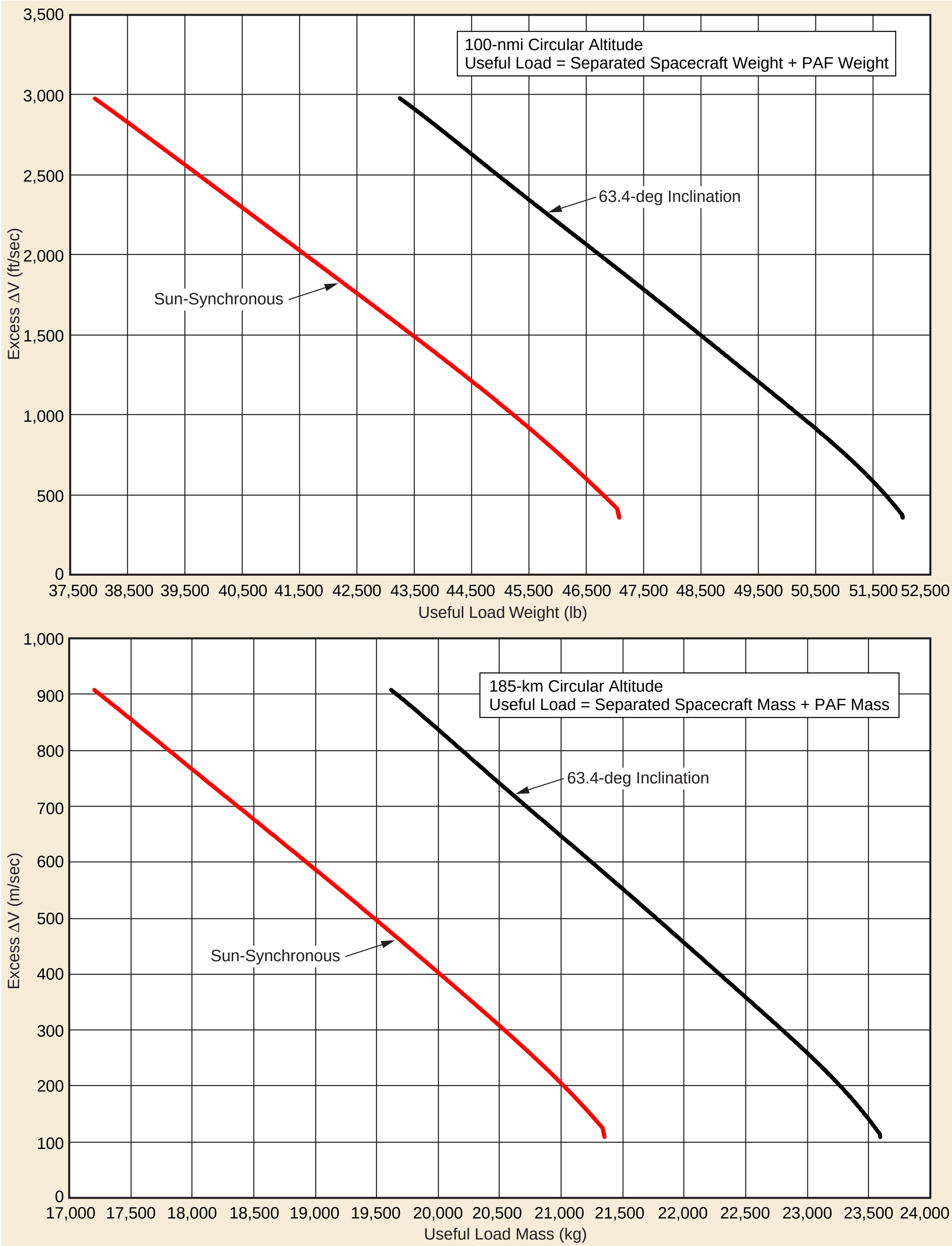

Figure 2-38. Delta IV-H LEO Excess ΔV Capability—63.4-deg Inclination and Sun-Synchronous (Western Range)

2.4 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 orbits with significantly better-than-predicted accuracy is well documented. While all successful RIFCA missions have inserted payloads well within the 3-σ orbit requirements, we present ten recent Delta II RIFCA missions orbit accuracies in Table 2-1 as a sampling of the effectiveness of our highly accurate avionics system.

Table 2-1. RIFCA 3-σ Orbit Accuracy—Ten Recent Delta II Missions Through July 1999

	Predicted orbit accuracy (3σ)	Achieved orbit accuracy
Bonum-1—launched 11-22-98		
Perigee (nmi)	+3.0/–3.0	–0.7
Apogee (nmi)	+562/–581	–93
Inclination (deg)	+0.25/–0.24	–0.04
Argument of perigee (deg)	+0.74/–0.74	–0.04
MSP ’98 Orbiter—launched 12-11-98		
Perigee (nmi)	+2.3/–2.4	0.3
Perigee velocity (fps)	+33.9/–125.1	2.8
Inclination (deg)	+0.18/–0.17	–0.07
Argument of perigee (deg)	+1.04/–1.05	0.50
MSP ’98 Lander—launched 1-3-99		
Perigee (nmi)	+6.0/–6.6	–3.0
Perigee velocity (fps)	+49.4/–56.3	23.2
Inclination (deg)	+0.36/–0.35	0.13
Argument of perigee (deg)	+1.15/–1.16	–0.36
Stardust—launched 2-7-99		
Perigee (nmi)	+3.4/–4.0	0.4
Perigee velocity (fps)	+74.1/–168.0	7.2
Inclination (deg)	+0.59/–0.58	0.03
Argument of perigee (deg)	+1.01/–1.02	0.11
P91-1—launched 2-23-99		
Perigee (nmi)	+2.0/–3.8	1.4
Apogee (nmi)	+3.4/–2.0	1.8
Inclination (deg)	+0.03/–0.03	0.00
LANDSAT-7—launched 4-15-99		
Perigee (nmi)	+0.5/–11.8	0.0
Apogee (nmi)	+3.0/–2.9	0.6
Inclination (deg)	+0.03/–0.03	0.00
Argument of perigee (deg)	+14.09/–16.10	0.60
Globalstar-3—launched 6-10-99		
Perigee (nmi)	+0.8/–19.6	–0.3
Apogee (nmi)	+4.5/–0.8	0.2
Inclination (deg)	+0.03/–0.03	0.00
FUSE—launched 6-24-99		
Perigee (nmi)	+1.8/–6.2	–0.6
Apogee (nmi)	+3.7/–1.6	0.5
Inclination (deg)	+0.06/–0.01	0.00

Table 2-1. RIFCA 3-σ Orbit Accuracy—Ten Recent Delta II Missions Through July 1999 (Continued)

	Predicted orbit accuracy (3σ)	Achieved orbit accuracy
Globalstar-4—launched 7-10-99		
Perigee (nmi)	+0.8/–19.6	0.1
Apogee (nmi)	+4.5/–0.8	0.6
Inclination (deg)	+0.03/–0.03	0.00
Globalstar-5—launched 7-25-99		
Perigee (nmi)	+0.8/–19.6	0.1
Apogee (nmi)	+4.5/–0.8	0.4
Inclination (deg)	+0.03/–0.03	0.00

0000703.8

Table 2-2 summarizes currently predicted 3-σ orbit accuracy for the Delta IV family to typical LEO and GTO 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 Delta Launch Services for further information.

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

Orbit	Parameter	Accuracy
GTO 185 km by 35 786 km at 27 deg (100 nmi by 19,323 nmi at 27 deg)	Perigee (km/nmi)	5.6/3.0
	Apogee (km/nmi)	93/50
	Inclination (deg)	0.03
LEO 500 km circular at 90-deg (270 nmi circular at 90-deg)	Perigee (km/nmi)	7.4/4.0
	Apogee (km/nmi)	7.4/4.0
	Inclination (deg)	0.04

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The payload launched on a Delta IV Medium, Delta IV Medium-Plus, or Delta IV Heavy launch vehicle is protected by fairings 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 early during either first- or second-stage powered flight when an acceptable free molecular heating rate is reached (Section 2.3). 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.

3.1 GENERAL DESCRIPTION

The envelopes presented in the following text and illustrations for composite fairings define the maximum allowable static dimensions (see Section 4) of the payload (including manufacturing tolerances) relative to the payload/attach fitting interface. If 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 in accordance with the guidelines specified in Section 4.2.3. 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. The available blanket configurations are described in Table 3-1.

Clearance layouts and analyses are performed and, if necessary, critical clearances 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, 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 GN_2 purge system can be incorporated to provide continuous dry nitrogen to the payload until liftoff.

Payload contamination is minimized by cleaning the fairing in a class 100,000 clean room prior to shipment to the field site. Special cleaning of the fairing with inspection using an ultraviolet (UV) light is available on request. (See Table 4-4 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 the standard fairing 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

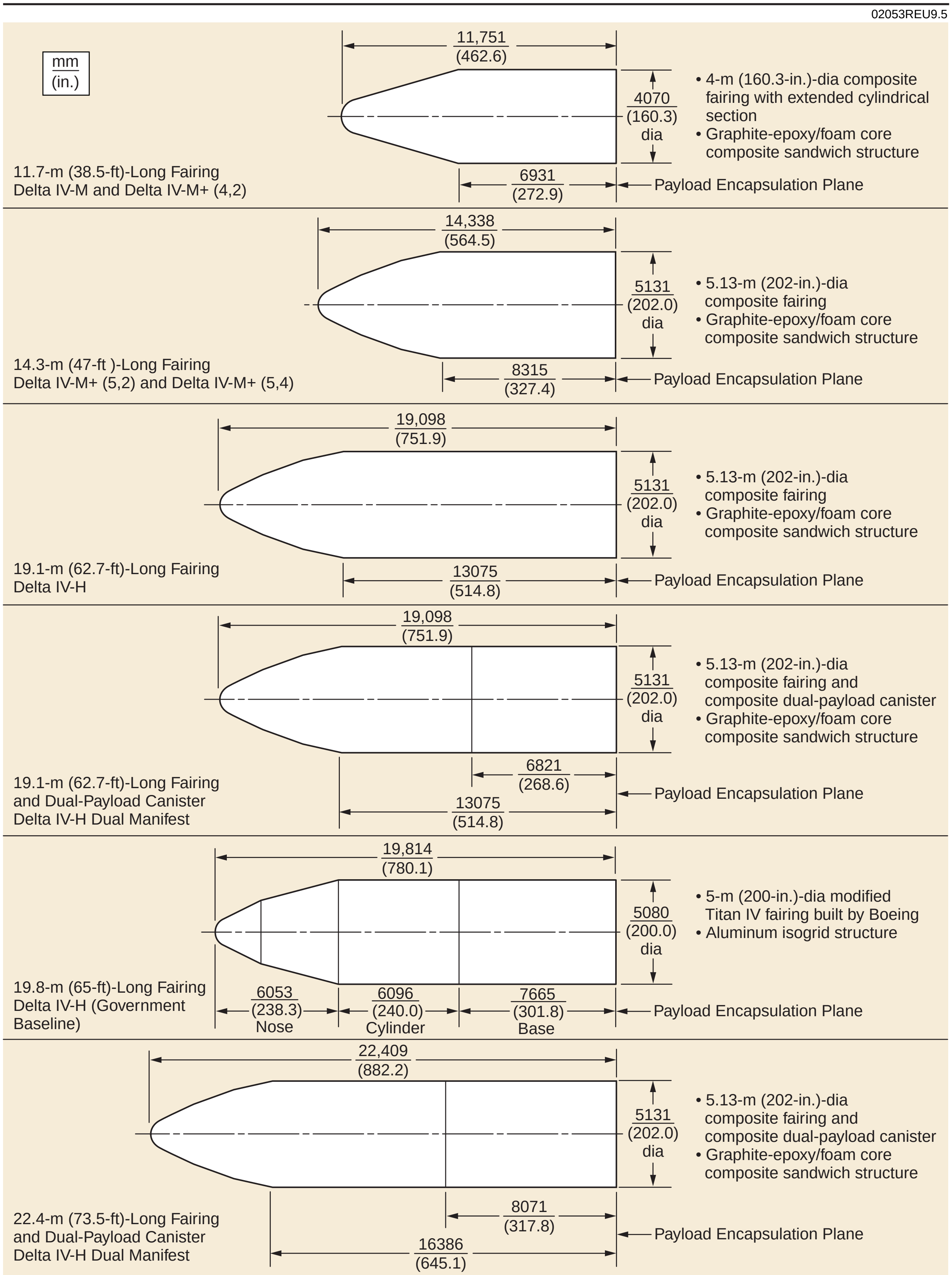

Figure 3-1. Delta IV Fairing Configurations

Table 3-1. Typical Acoustic Blanket Configurations

Fairing	Location
4-m Delta IV-M and Delta IV-M+ (4,2) 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 76-mm (3-in.)-thick blankets 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 blankets 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.	

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composite fairing is the standard fairing 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 the standard fairing for the Delta IV-H commercial launch vehicle. Dual-manifest missions may utilize either a 5-m-dia by 19.1-m (62.7-ft)-long or 5-m-dia by 22.4-m (73.5-ft)-long fairing and dual-payload canister (DPC) for the Delta IV-H commercial launch vehicle.

The 4-m composite fairing (Figures 3-2 and 3-3), and the 5-m composite fairing (Figures 3-4 and 3-5) are composite sandwich structures that separate into two sectors. 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). 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 will need access to items such as payload arming devices, electrical connectors, and fill-and-drain valves for payloads using liquid propellants, additional access doors can be negotiated on a mission-unique basis. Also, differing diameters or shapes to the two standard access doors can be negotiated on a mission-unique basis. Standard access doors are not blanketed, while mission-unique doors will be specified as to the usage of blankets, with typical blanket configurations described in Table 3-1. Access door locations and sizes should be coordinated with Delta Launch Services. Radio frequency (RF) windows can be accommodated by co-curing during the shell layup or by post-curing later in the manufacturing cycle. RF window requirements should be coordinated with Delta Launch Services.

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 first and then by detonating the linear explosive strands in the thrusting joint cylinder rail cavity. Separation

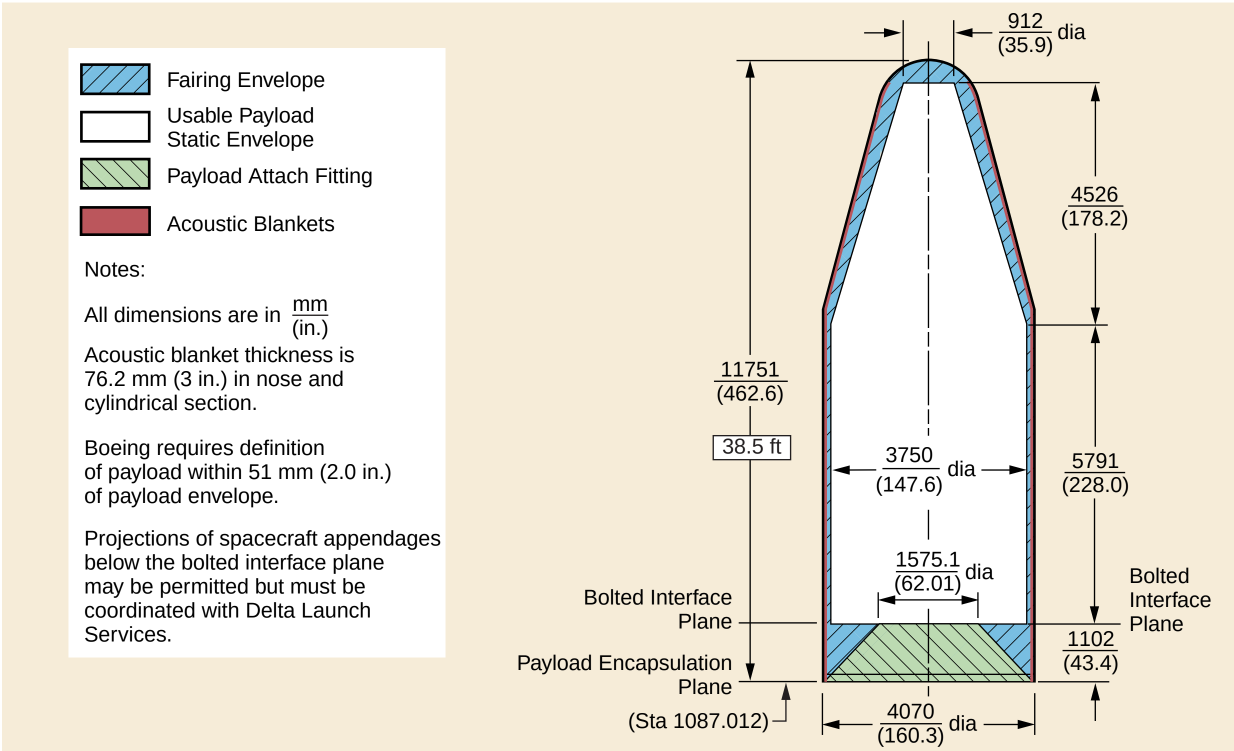
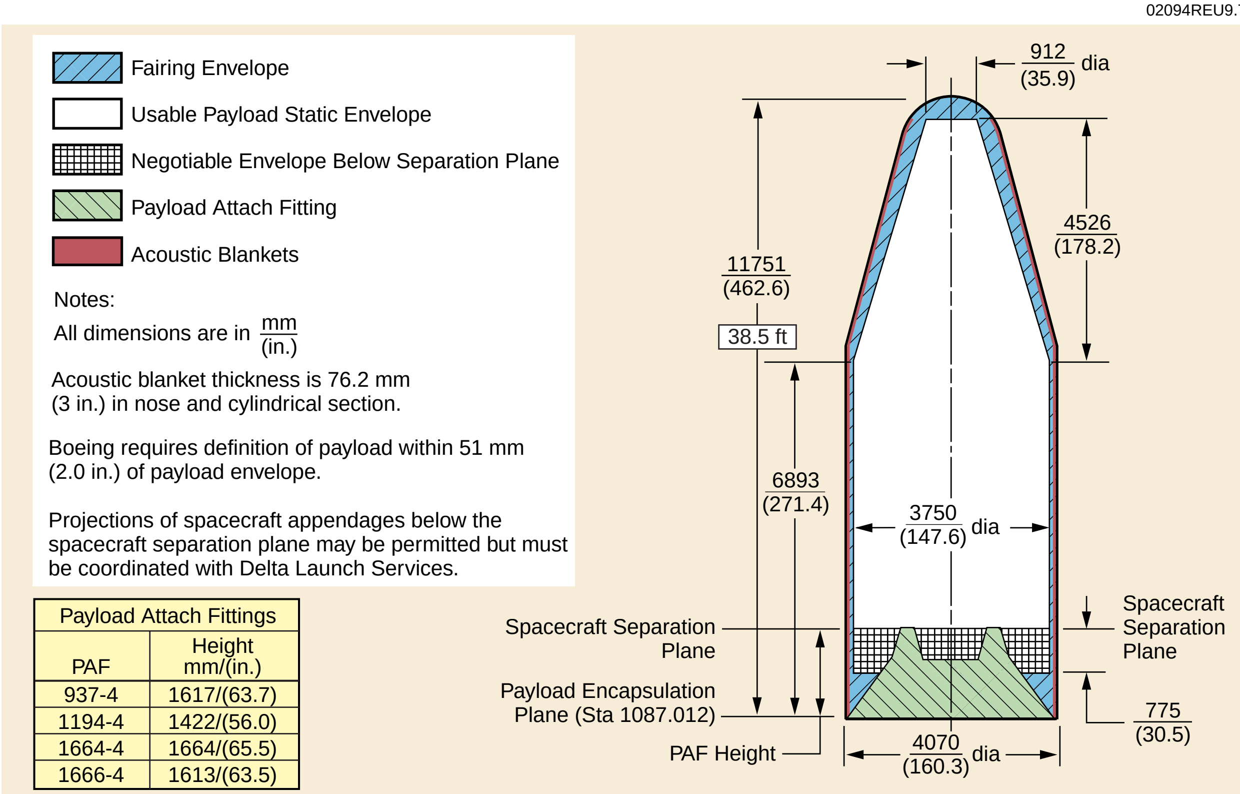


Figure 3-2. Payload Envelope, 4-m-dia Composite Fairing—1575-4 PAF



Payload Attach Fittings	
PAF	Height mm/(in.)
937-4	1617/(63.7)
1194-4	1422/(56.0)
1664-4	1664/(65.5)
1666-4	1613/(63.5)

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

02027REU9.6

- Fairing Envelope
- Usable Payload Static Envelope
- Negotiable Envelope Below Separation Plane
- Acoustic Blankets

Notes:

All dimensions are in mm/(in.)

Acoustic blanket thickness is 76.2 mm (3 in.) in nose and cylindrical section.

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

Projections of spacecraft appendages below the spacecraft separation plane may be permitted but must be coordinated with Delta Launch Services.

Payload Attach Fittings	
PAF	Height mm/(in.)
937-5	2283/(89.9)
1194-5	2088/(82.2)
1664-5	2121/(83.5)
1666-5	2134/(84.0)

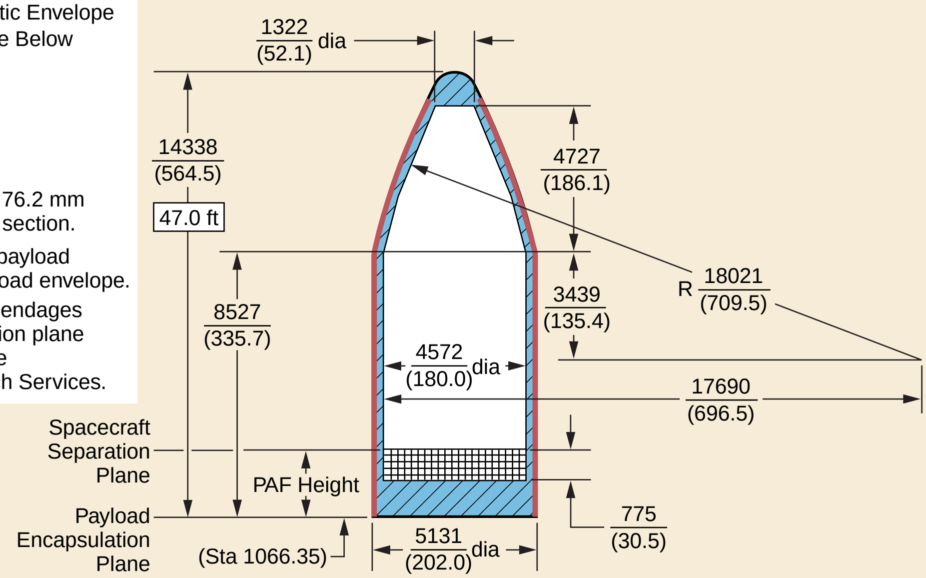


Figure 3-4. Delta IV Medium-Plus 5-m-dia by 14.3-m-Long Composite Fairing Payload Envelope

02051REU9.7

- Fairing Envelope
- Usable Payload Static Envelope
- Negotiable Envelope Below Separation Plane
- Acoustic Blankets

Notes:

All dimensions are in mm/(in.)

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

Acoustic blanket thickness is 76.2 mm (3 in.) in nose and cylindrical section.

Projections of spacecraft appendages below the payload separation plane may be permitted but must be coordinated with Delta Launch Services.

Payload Attach Fittings	
PAF	Height mm/(in.)
937-5	2283/(89.9)
1194-5	2088/(82.2)
1664-5	2121/(83.5)
1666-5	2134/(84.0)

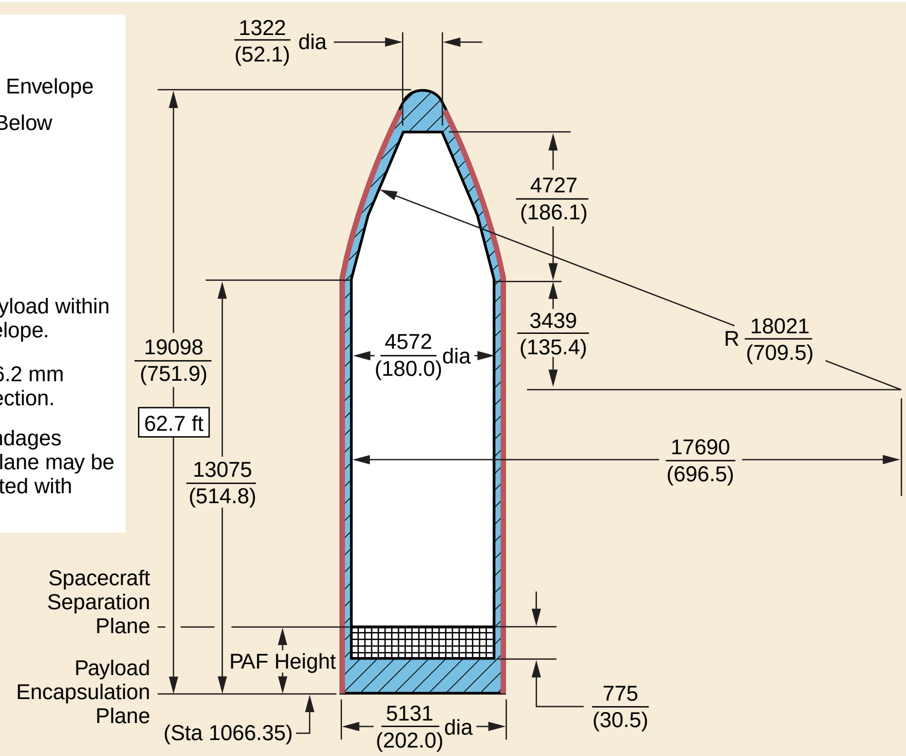


Figure 3-5. Delta IV Heavy 5-m-dia by 19.1-m Composite Fairing Payload Envelope

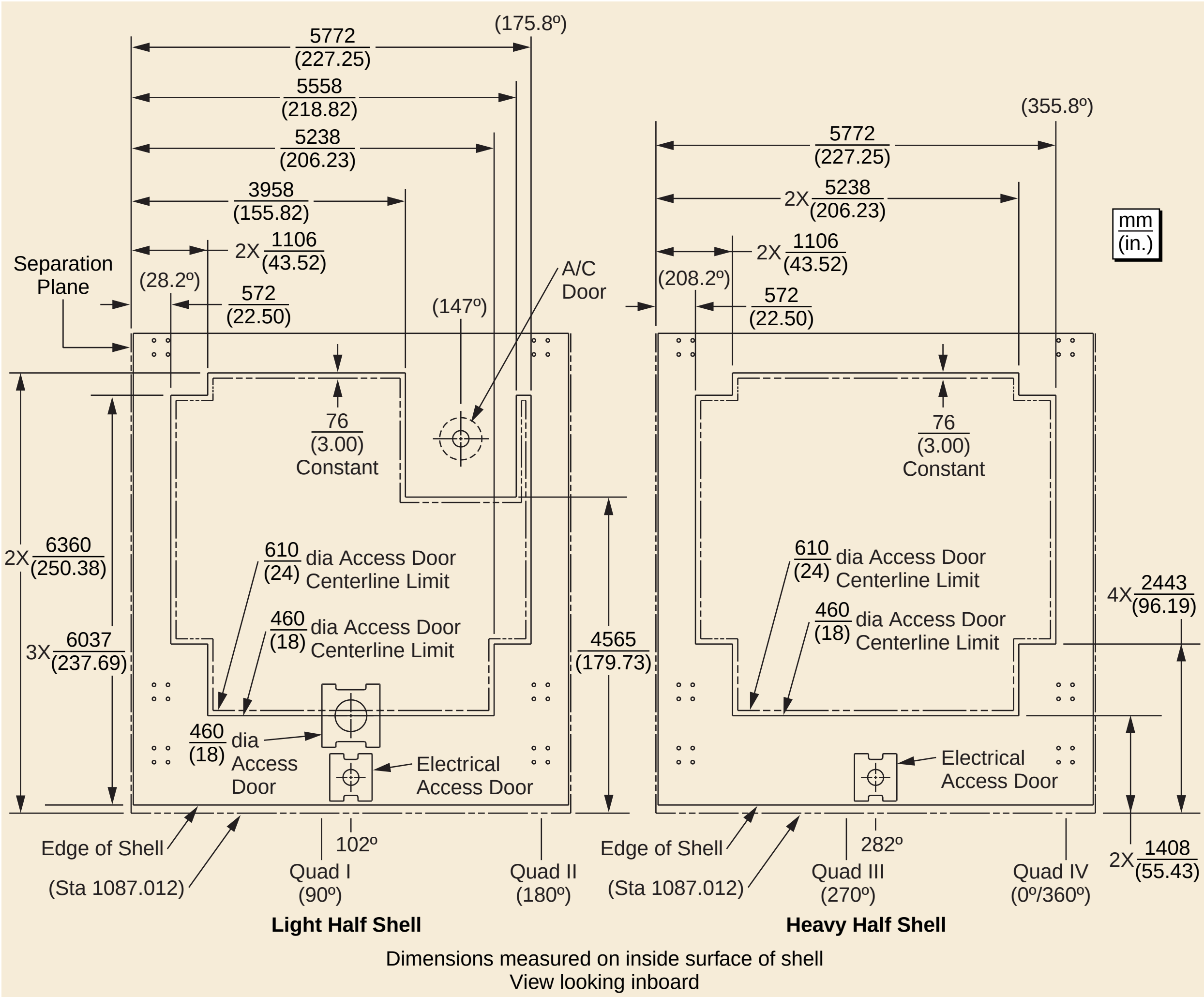


Figure 3-6. Allowable Access Door Locations for 4-m-dia by 11.7-m-Long Composite Fairing

augmentation springs are provided to ensure positive separation clearance. A bellows assembly in each cylinder rail retains the product gases and thereby prevents contamination of the payload during the fairing separation event.

The allowable static payload envelope in the fairing is shown in Figure 3-2 for the 4-m composite fairing with the 1575-4 payload attach fitting (PAF) interface. Figure 3-3 defines the envelopes for the 4-m fairing with the 937-4, 1194-4, 1664-4, 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 937-5, 1194-5, 1664-5, and 1666-5 payload attach fittings.

These figures assume that the payload stiffness guidelines in Section 4.2.3 are observed. Intrusion into any portion of the fairing envelopes that is below the separation plane or local protuberances outside the envelope requires coordination with and approval of Delta Launch Services.

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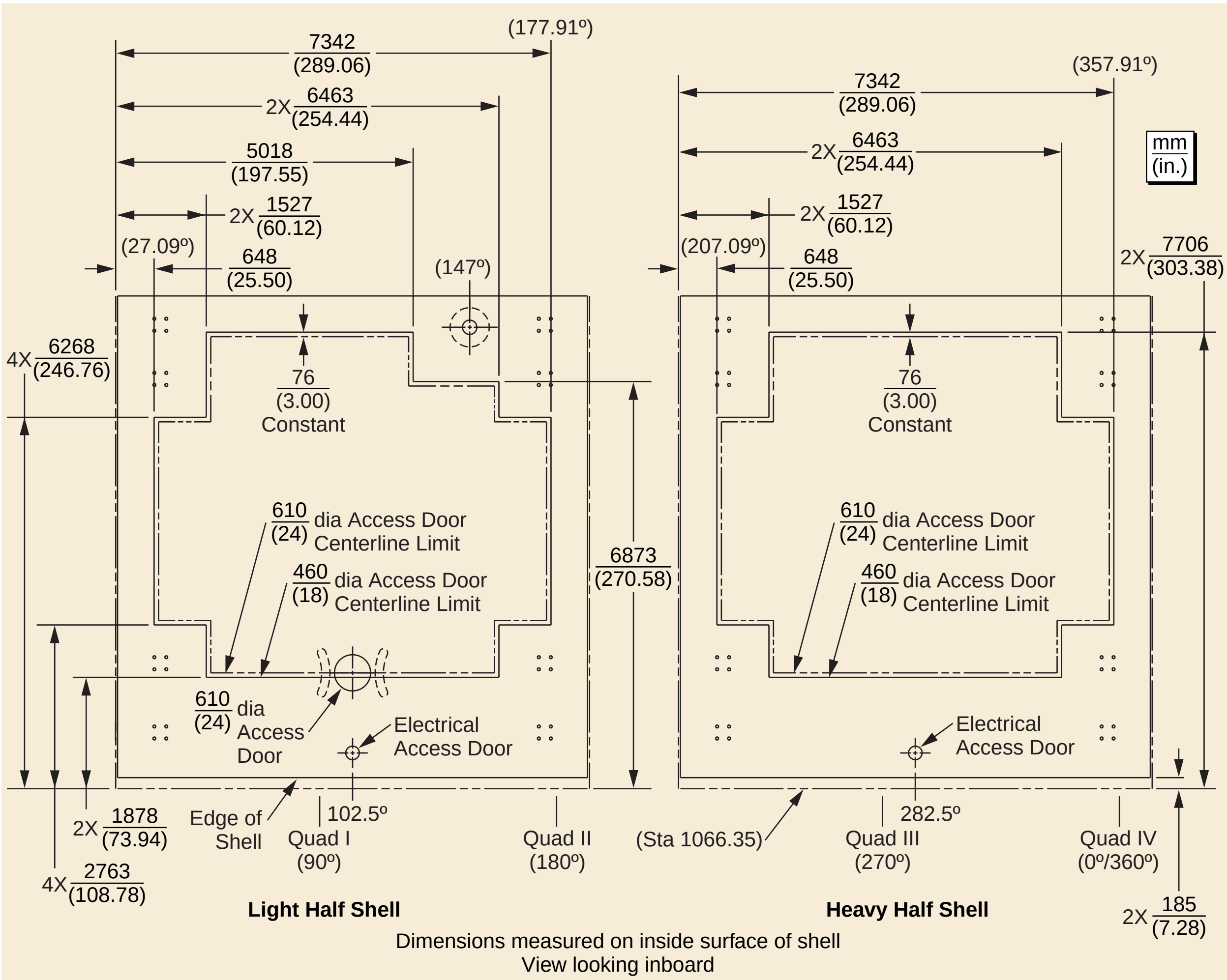

Figure 3-7. Allowable Access Door Locations for 5-m-dia by 14.3-m-Long Composite Fairing

Our dual-manifest concepts shown in Figures 3-9 and 3-10 feature (1) a cylindrical composite DPC that encapsulates the lower payload and (2) a composite bisector fairing that encapsulates the upper payload. Both payloads are mounted within these bays to standard Delta IV separation interfaces, dependent on payload needs. The payload envelope assumes that the payload stiffness guidelines in Section 4.2.3 are observed. Intrusion into any portion of the envelope below the interface plane or local protuberances outside the envelope requires coordination with and approval of Delta Launch Services.

3.3 5-M-DIA METALLIC PAYLOAD FAIRING

The 5-m (200-in.)-dia modified Titan IV metallic fairing built by Boeing (Figure 3-11) 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 government Delta IV-H launch vehicles.

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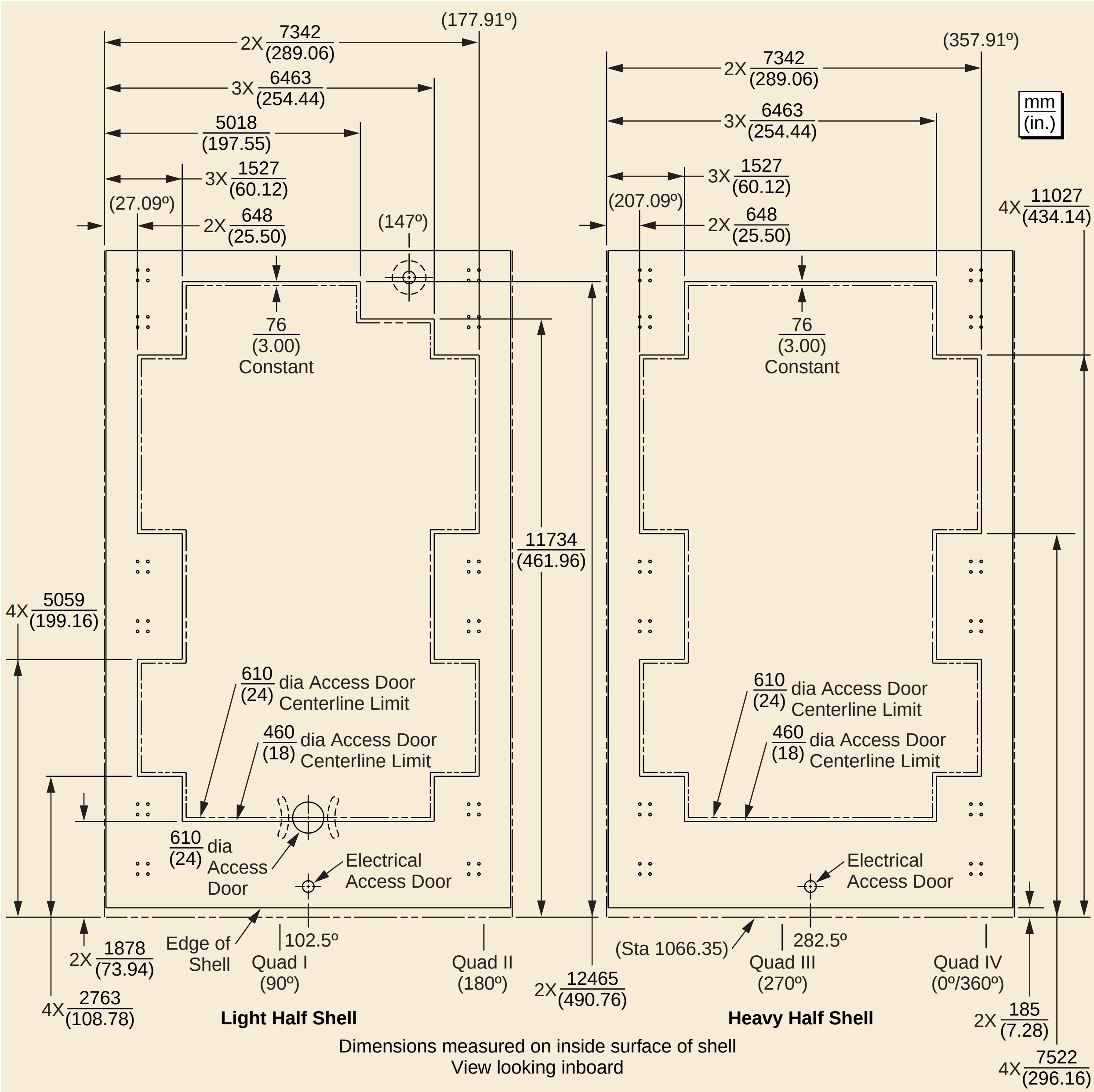

Figure 3-8. Allowable Access Door Locations for 5-m-dia by 19.1-m-Long Composite Fairing

The PLF 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 base of the fairing. 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 product gases and thereby prevents contamination of the payload during the fairing separation event.

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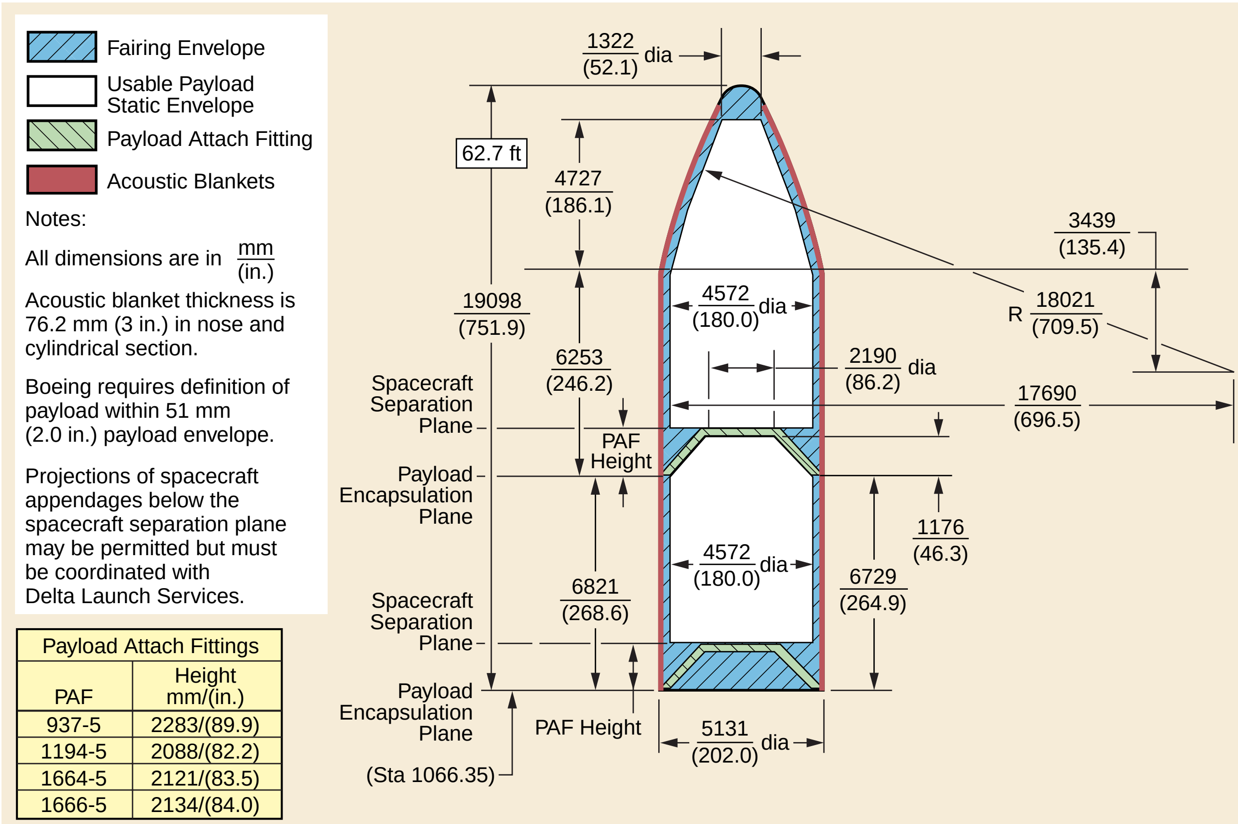

Payload Attach Fittings	
PAF	Height mm/(in.)
937-5	2283/(89.9)
1194-5	2088/(82.2)
1664-5	2121/(83.5)
1666-5	2134/(84.0)

Figure 3-9. Delta IV Heavy 5-m-dia by 19.1-m-Long Dual-Manifest Fairing Payload Envelope

The baseline acoustic blanket configuration is described in Table 3-1. Boeing can provide acoustic blankets varying in thicknesses of 38 mm (1.5 in.) every 13 mm (0.5 in.) up to 152 mm (6 in.), 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 Delta Launch Services.

Figure 3-11 assumes that the payload stiffness guidelines in Section 4.2.3 are observed. Intrusion into any portion of the fairing envelope that is below the separation plane or local protuberances outside the envelope requires coordination with and approval by Delta Launch Services.

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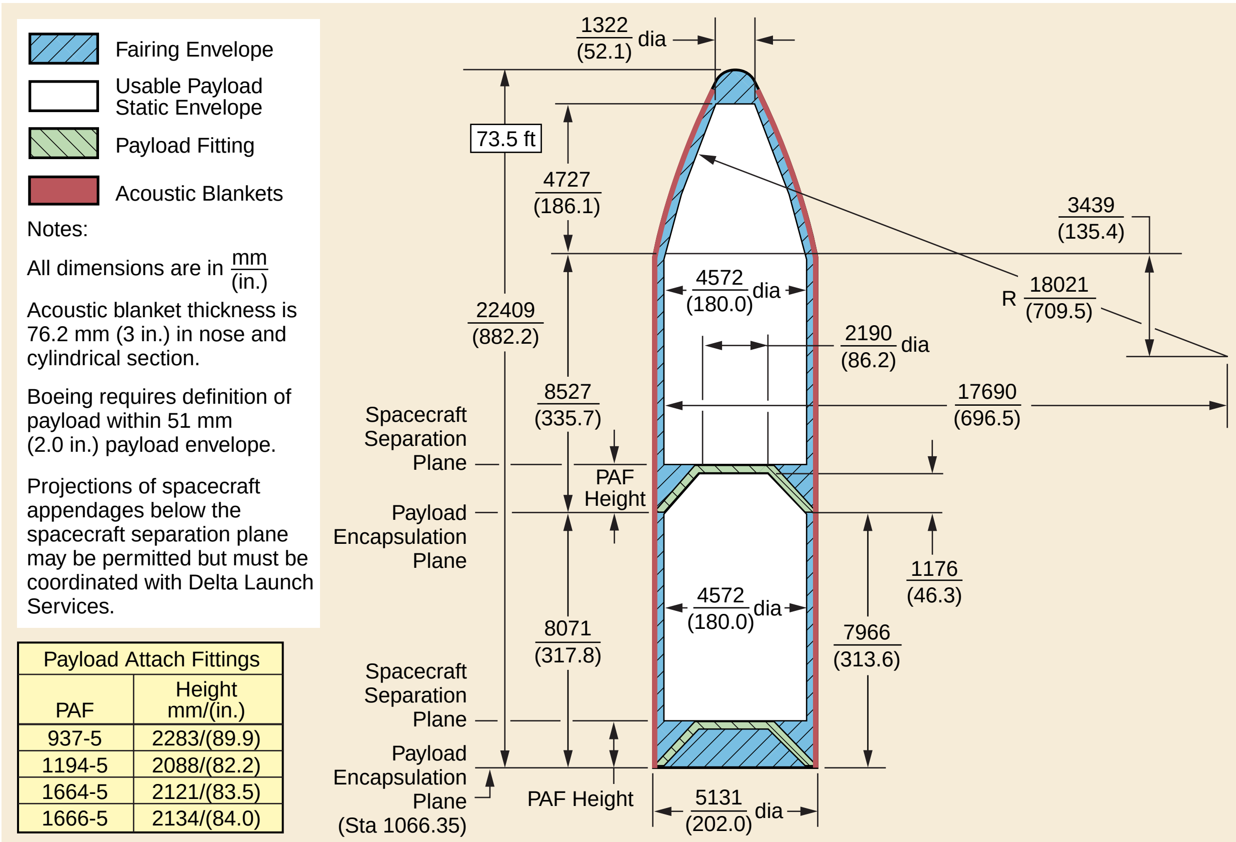

Payload Attach Fittings	
PAF	Height mm/(in.)
937-5	2283/(89.9)
1194-5	2088/(82.2)
1664-5	2121/(83.5)
1666-5	2134/(84.0)

Figure 3-10. Delta IV Heavy 5-m-dia by 22.4-m-Long Dual-Manifest Fairing Payload Envelope

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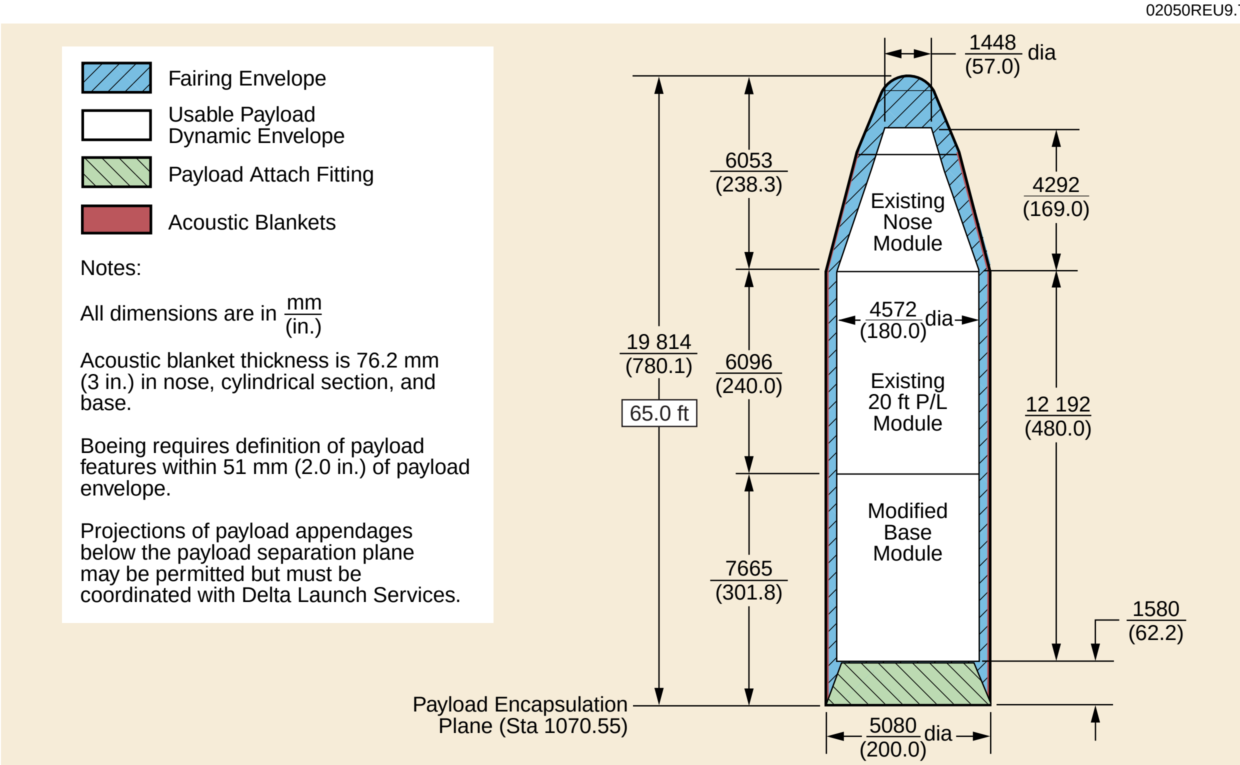

Figure 3-11. Delta IV Heavy 5-m-dia by 19.8-m-Long Metallic Fairing Payload Envelope—4394-5 PAF

Section 4
PAYLOAD ENVIRONMENTS

This section describes the launch vehicle environments to which the payload is exposed during prelaunch and launch. Section 4.1 discusses 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

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 mobile service tower (MST) enclosure, and mounted on any of the Delta IV launch vehicles on the pad. During transportation, air-conditioning is supplied through a portable environmental control system (ECS). 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 standard 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 standard payload air-distribution system uses a diffuser on the inlet air-conditioning duct at the fairing interface. The metallic

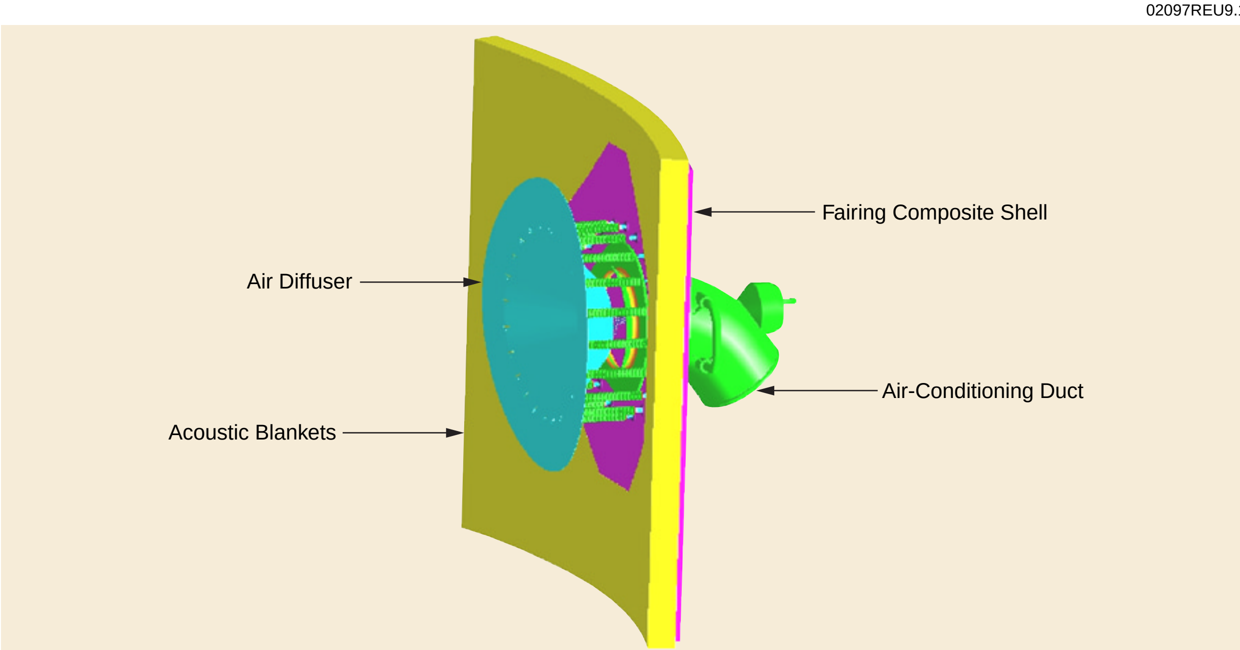

Figure 4-1. Standard 4-m Composite Fairing and 5-m Composite Fairing Air-Conditioning Duct Inlet Configuration

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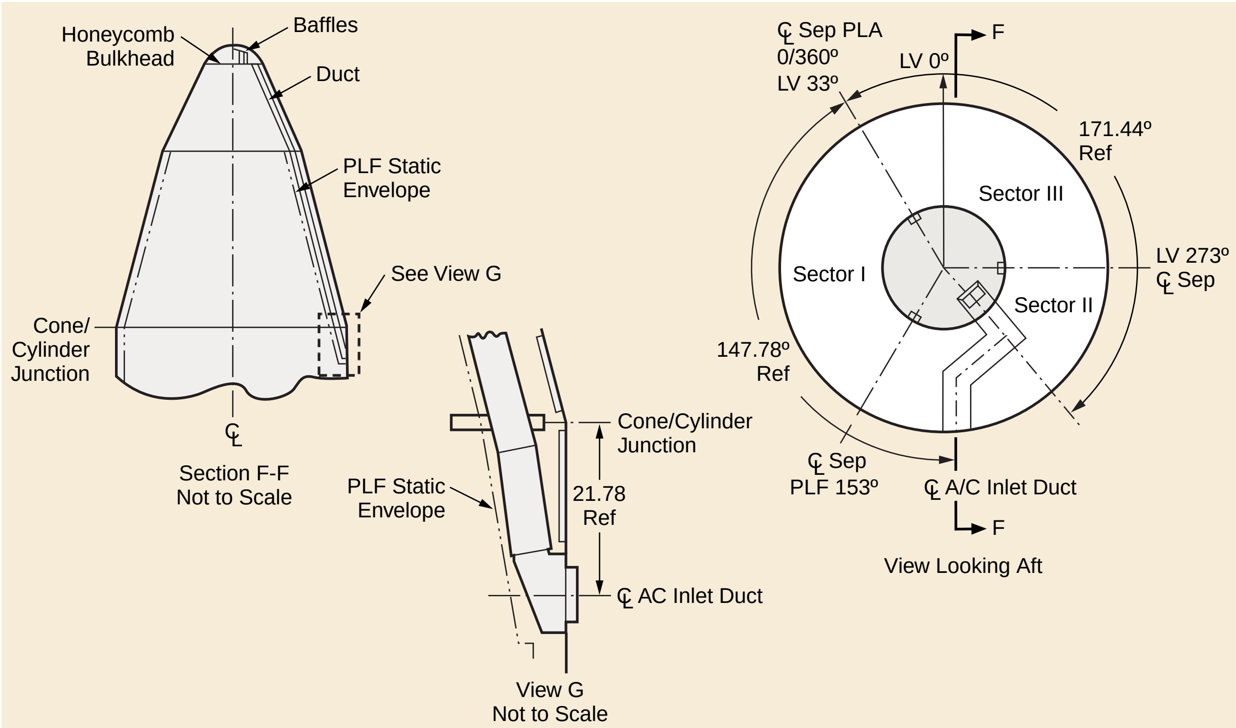

Figure 4-2. 5-m Metallic Fairing Payload Air-Distribution System

fairing payload air-distribution system is ducted up to the nose and enters the payload envelope through a diffuser to distribute the air within the fairing. The air-conditioning umbilical is pulled away at liftoff by lanyard disconnects, and the access door on the fairing automatically closes.

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 flows around the payload and is discharged through vents in the aft end of the fairing. At Space Launch Complex 37 (SLC-37) and SLC-6, the launch pads will have a backup system for fairing air-conditioning. 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 trisector II for the 5-m metallic fairing. Unique mission requirements or equipment and mission-specific options should be coordinated with Delta Launch Services.

Various payload processing facilities are available at the launch site for use by the payload agency. Environmental control specifications for these facilities are listed in Tables 4-1 and 4-2 for the Eastern and Western ranges, respectively. The facilities used depend on payload program requirements.

4.1.2 MST Enclosure

The enclosure will be environmentally controlled for personnel comfort on the East Coast and uncontrolled on the West Coast. This enclosure is located at the upper levels in the MST

Table 4-1. Eastern Range Facility Environments

Location		Temperature	Relative humidity[3]	Particulate class[4]
Encapsulated payload	Mobile	10° to 29.4° ±2.8°C (50° to 85°±5°F)	35 to 50% ±5%	Class 5000[2]
MST[1]	Environmental enclosure Fairing	20° to 25.6°C (68° to 78°F) Any specified between 10° and 29.4° ±2.8°C (50° and 85° ±5°F)	50% 20 to 50%	Not controlled Class 5000 inlet
Astrotech	Buildings 1 and 2: airlock, high bays, storage bays	23.9° ±2.8°C (75° ±5°F) 21°C to 25.5°C (70°F to 78°F)	50 ±5% 55% max	Class 100,000[2] Commercial standard

Note: The facilities listed can only lower the outside humidity level. The facilities do not have the capability to raise outside humidity levels.
These numbers are provided for planning purposes only. Specific values should be obtained from the controlling agency.
[1]A backup system exists for the mobile service tower (MST) air-conditioning.
[2]FED-STD-209D.
[3]50% relative humidity can be maintained at a temperature of 16.7°C (62°F). At higher temperatures, the relative humidity can be reduced by drying the conditioned air to a minimum specific humidity of 40 grains of moisture per 0.45 kg (1 lb) of dry air.
[4]Verified/sampled at duct outlet.

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Table 4-2. Western Range Facility Environments

Location		Temperature	Relative humidity	Particulate Class
Encapsulated payload	Mobile	10° to 29.4° ±2.8°C (50° to 85° ±5°F)	35 to 50% ±5%	Class 5000[2]
Spaceport Systems International	Payload Checkout Cells	21.1° ±2.8°C (70° ±5°)	30 to 50%	Class 100,000[2] HEPA filtered, Class 5000 at inlet
Astrotech	Payload Processing Rooms	15.5° to 26.6° ±1.2°C[1] (60° to 80° ±2°F)	35 to 60% ±10[1]	Class 100,000[1] functional 10,000
MST	SLC-6 MST/MAS Fairing	Not controlled Any specified between 10° and 29.4° ±2.8°C (50° and 85° ±5°F)	Not controlled 20 to 50%	Not controlled Class 5000 inlet[1]

[1]Controlled to customer requirement within range.
[2]FED-STD-209D.

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to provide weather protection. A portable clean environmental shelter (PCES) can be provided that allows environmentally controlled access through multiple payload fairing (PLF) doors within the MST operational constraints while the encapsulated payload is housed within the MST. The PCES comprises three major components: (1) the shelter structure, (2) the shelter enclosure, and (3) the PLF interface. This interface provides shielding/sealing around the PLF access doors and protects the payload-encapsulated environment from contamination from the MST ambient environment. The PCES is shown in Figure 4-3.

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

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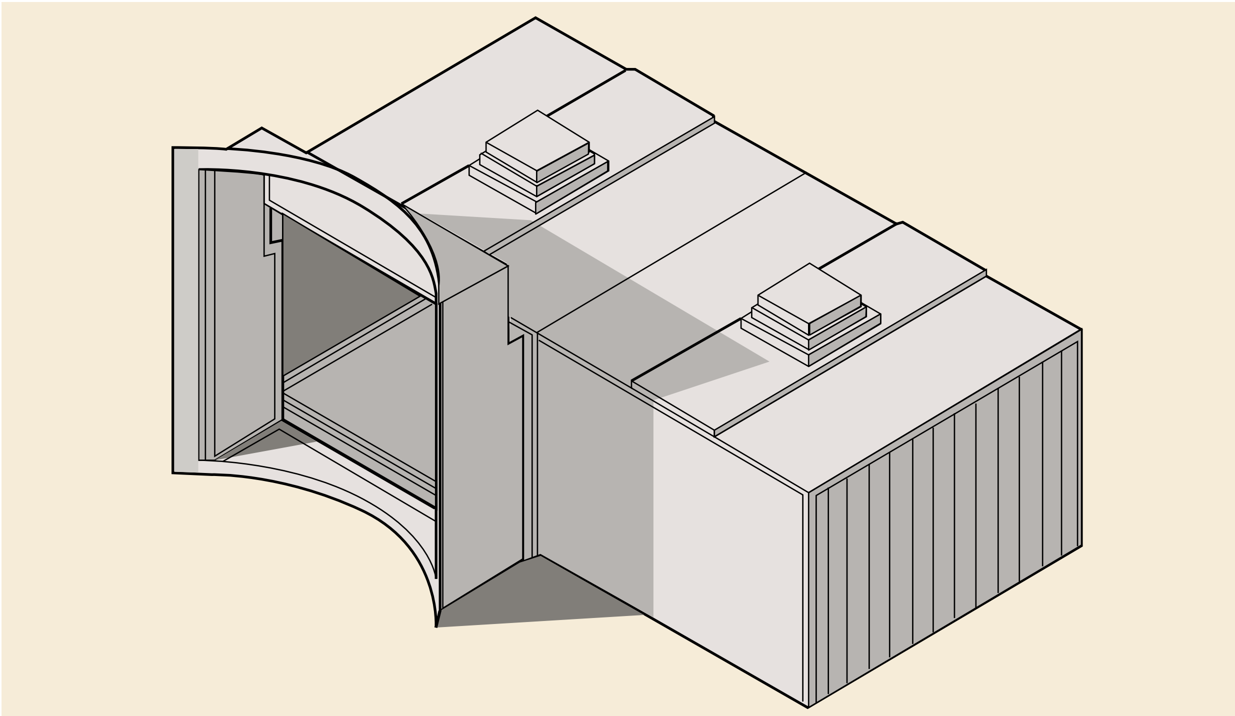

Figure 4-3. Portable Clean Environmental Shelter (PCES)

(TDRSS). It 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 radiation characteristics of these systems are listed in Table 4-3. The radio frequency (RF) systems are switched on prior to launch and remain on until mission completion.

At the Eastern and Western ranges, the electromagnetic environment to which the satellite 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

Table 4-3. Delta IV Transmitter Characteristics

	Second-stage telemetry radiation characteristics	Second-stage C-band beacon characteristics
■ Transmitter – Nominal frequency – Power output – Modulation data rate	 2241.5 MHz 30.0 W min 1.92 Mbps (Heavy) or 1.28 Mbps (Medium) from launch to conclusion of range safety authority and 192 Kbps via TDRSS until the contamination and collision avoidance maneuver (CCAM)	 5765 MHz (transmit) 5690 MHz (receive) 400 W min peak, 0.52 W min average 6 MHz at 6 dB
■ Antenna – Type – Polarization	S-Band Patch Right-hand circular	C-Band Spiral Right-hand circular
■ Location	5-m second stage – Sta 1172.88 4-m second stage – Sta 1232.36	5-m Sta 1172.88 4-m Sta 1232.36
■ Pattern coverage	■ Launch to 2 deg above radar horizon = 95% ■ From 2 deg above radar horizon to CCAM = 95% ±60 deg boresight via one of four selected antennas around the circumference of the launch vehicle	Launch to 2 deg horizon

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range and with protective masking of radars. The launch pads are protected to an environment of 10 V/m at frequencies from 14 kHz to 40 GHz and 20 V/m in the C-band frequency of the range tracking radars.

The RF environment is analyzed to ensure that the satellite transmitters are compatible with the launch vehicle avionics and ordnance systems. RF compatibility is also analyzed to verify that the launch vehicle and satellite transmitter frequencies do not have interfering intermodulation products or image-rejection problems. For dual-manifested missions, RF co-passenger compatibility is also required.

Spacecraft contractors should contact Delta Launch Services 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/MIL-STD-464, 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.

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

B. The fairing and PAF are cleaned using isopropyl alcohol (IPA) at the manufacturing site, then inspected for cleanliness prior to double-bagging for shipment to the launch site. Table 4-4 provides Boeing 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 utilizing a composite fairing is VC 3. Other cleanliness levels must be negotiated with Delta Launch Services.

Table 4-4. Cleanliness-Level Definitions

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

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Cleanliness 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 foot-candles [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 2152.8 lux (100 fc to 200 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 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 2152.8 lux (100 fc to 200 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 clean room.

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 2152.8 lux (100 fc to 200 fc) at an observation distance of 15.2 cm to 45.7 cm (6 in. to 18 in.). Additional incident light requirements are 8 W 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 clean room.

VC 7—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 2152.8 lux (100 fc to 200 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 clean room. 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.

C. 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 clean-room 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 Boeing is used to transport the encapsulated payload to the MST and a portable environmental control system is used to provide environmental protection for the payload during transport.

D. 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.

E. The payload agency may provide a protective barrier (bag) around the payload prior to encapsulation in the fairing.

F. The portable environmental control system will provide temperature and air-flow control during transport to the launch site. The humidity control is operationally constrained.

4.2 LAUNCH AND FLIGHT ENVIRONMENTS

Payload launch environment data, such as low- and high-frequency vibration, acceleration transients, shock, velocity increments, and payload status, will be obtained from the launch vehicle telemetry system for in-flight environment 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 4-4, 4-5, 4-6, 4-7, 4-8, and 4-9 for the Delta IV family of launch vehicles.

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 Medium, Delta IV Medium-Plus, and Delta IV Heavy launch vehicles will generally be constrained to a sustained

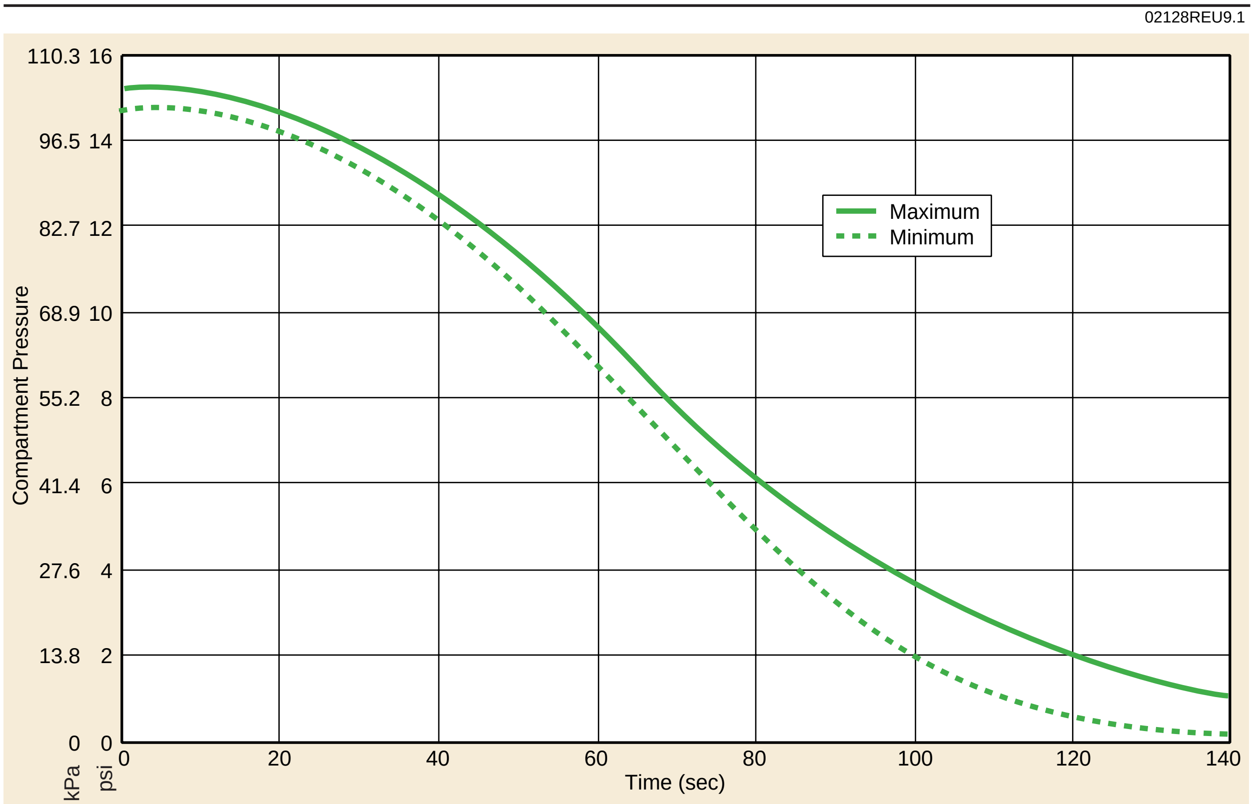

Figure 4-4. Delta IV Medium Absolute Pressure Envelope

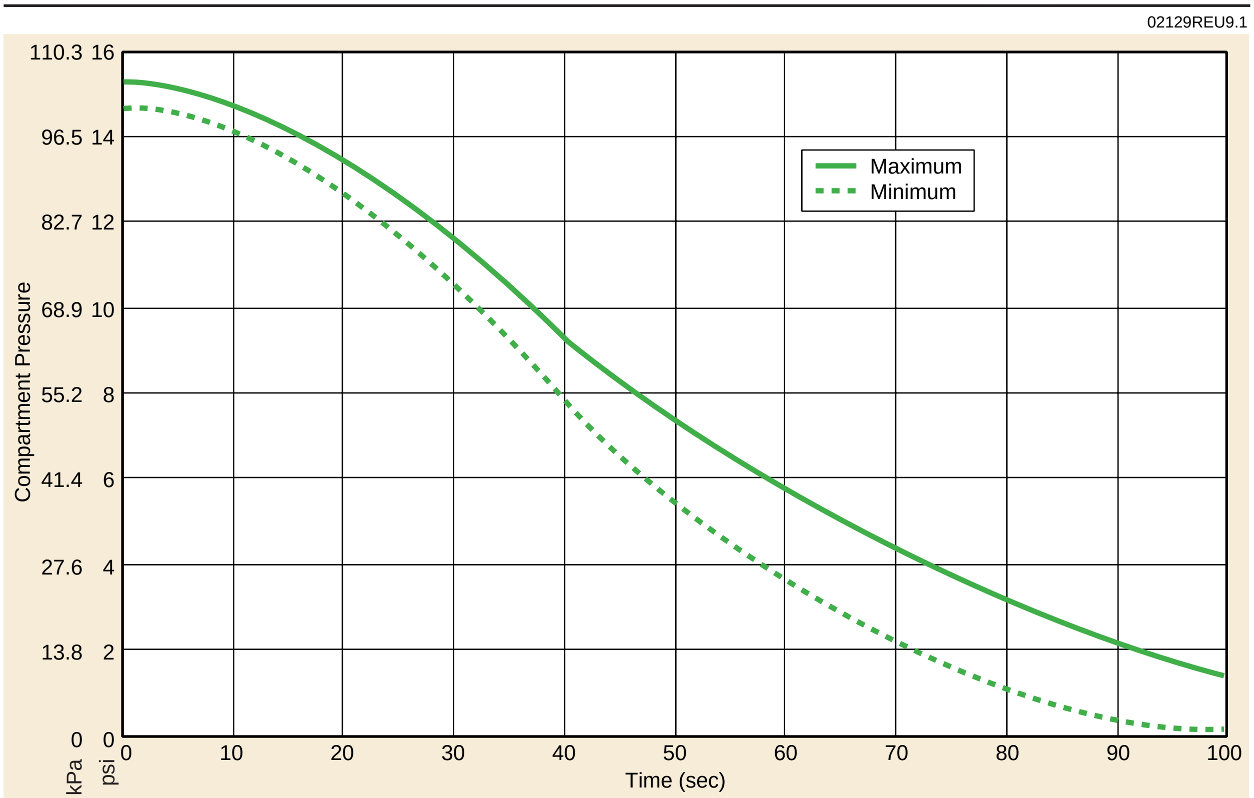

Figure 4-5. Delta IV Medium-Plus (4,2) Absolute Pressure Envelope

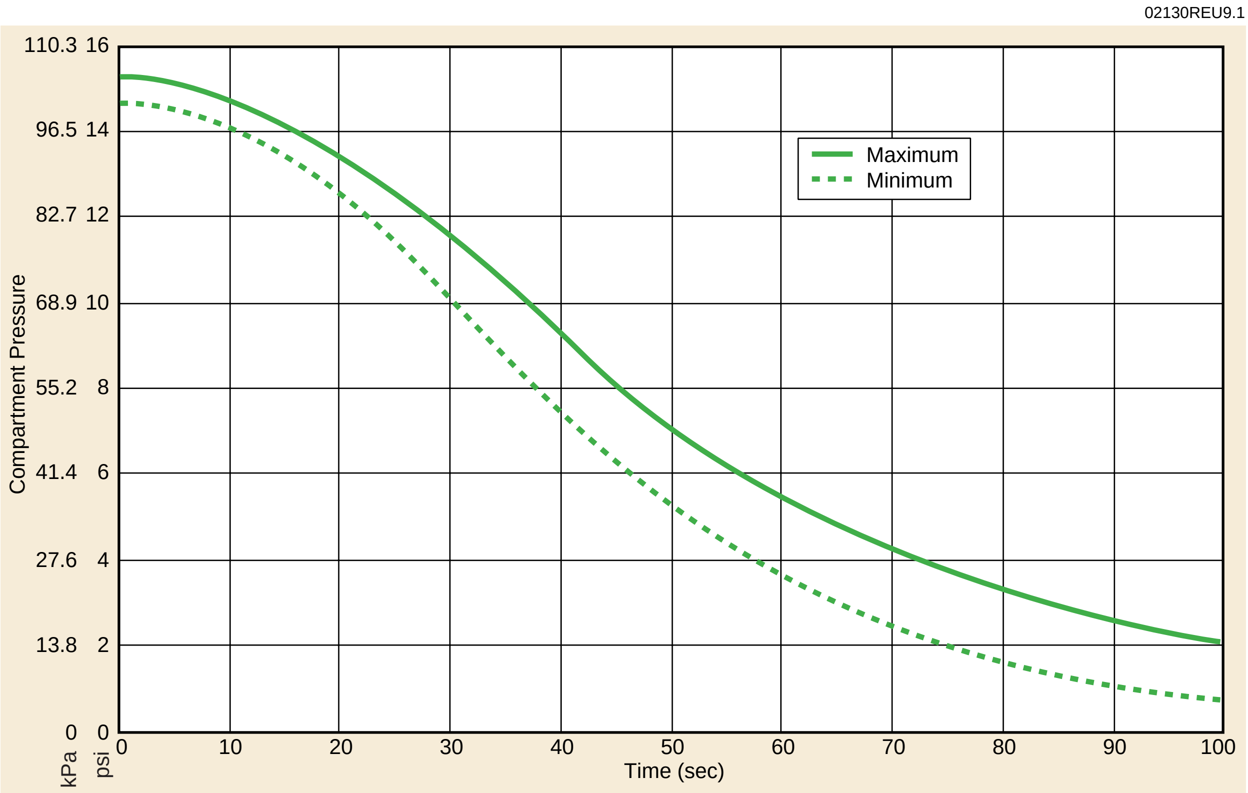

Figure 4-6. Delta IV Medium-Plus (5,2) Absolute Pressure Envelope

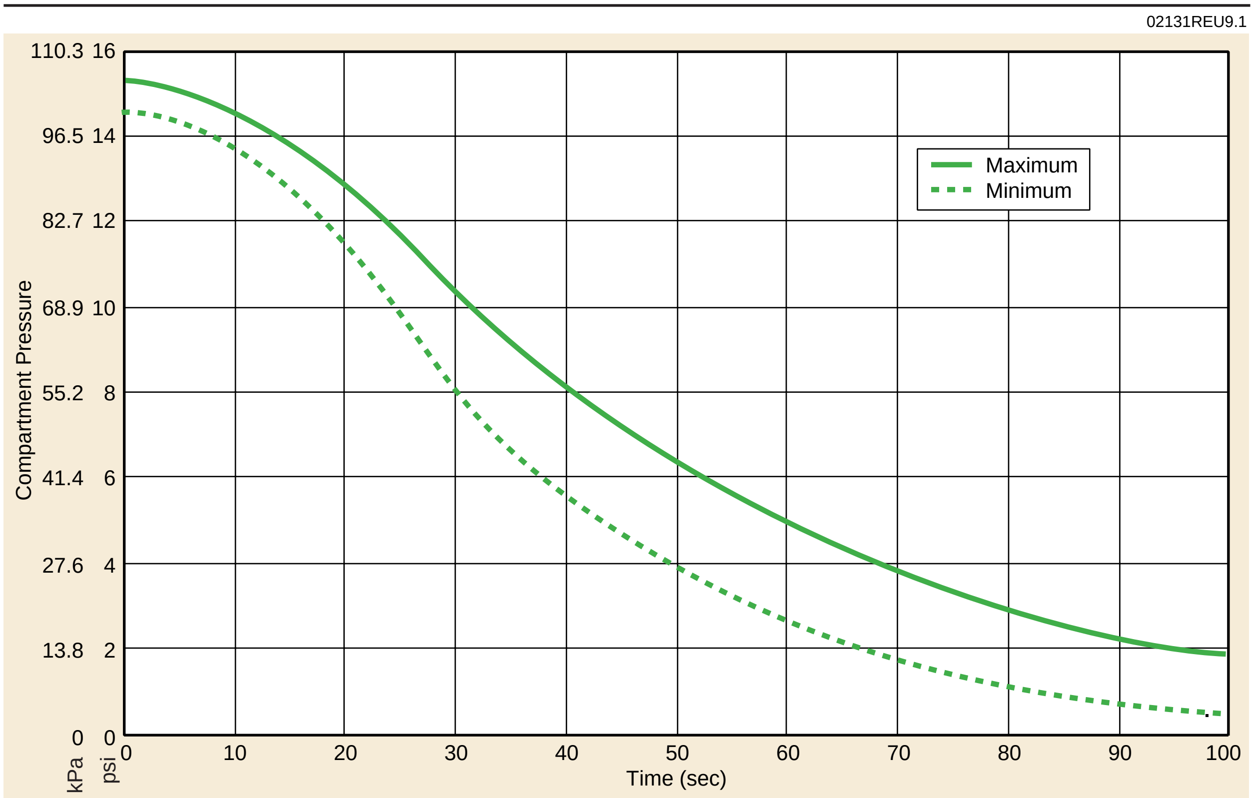

Figure 4-7. Delta IV Medium-Plus (5,4) Absolute Pressure Envelope

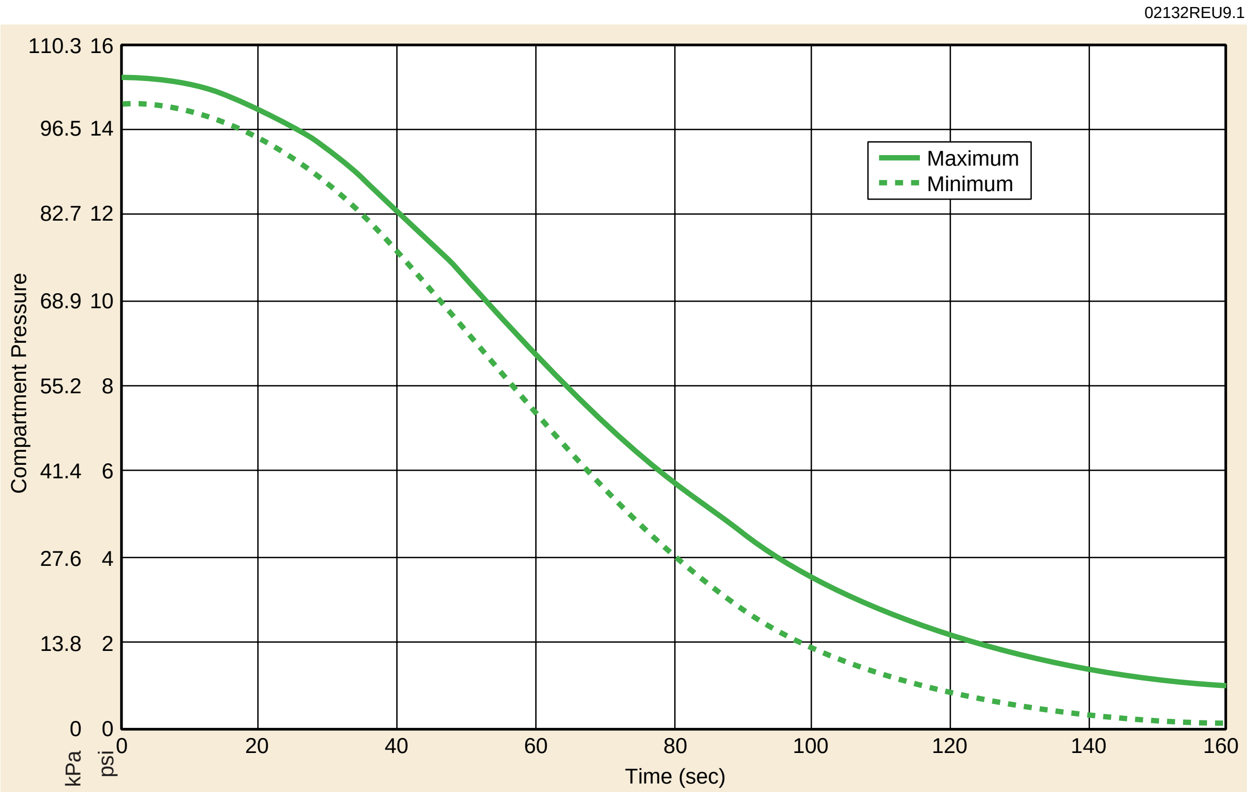

Figure 4-8. Delta IV Heavy (Composite PLF) Absolute Pressure Envelope

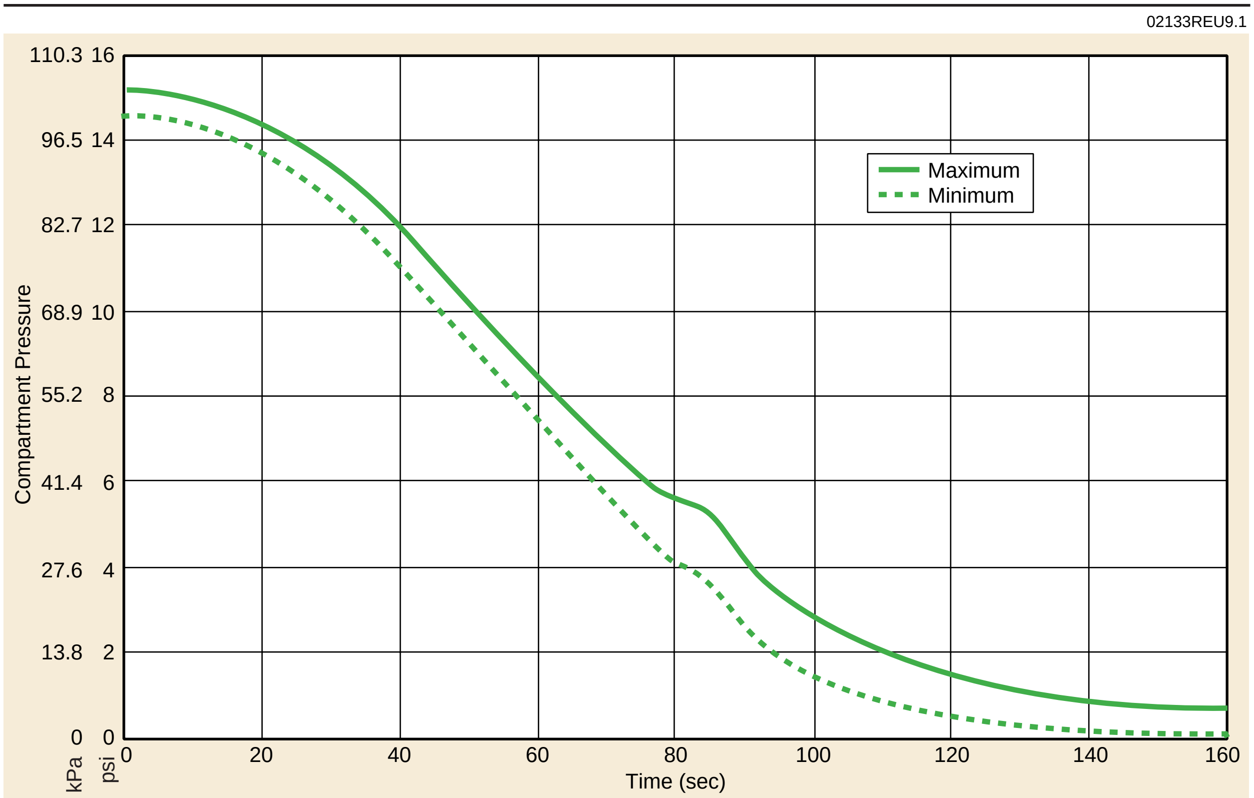

Figure 4-9. Delta IV Heavy (Metallic PLF) Absolute Pressure Envelope

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 Delta IV payload fairings and second stages 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 4-10 for the 4-m composite fairings, Figure 4-11 for the 5-m composite fairings, and Figure 4-12 for the 5-m metallic fairing. Temperatures are provided for both the PLF conical section and the cylindrical section facing the payload. PLF inboard-facing surface emissivity values are also provided. All temperature histories presented are based on depressed (worst-case) versions of the trajectory and hot-day launch conditions. Cooler days would have cooler starting temperatures.

The acoustic blankets provide a relatively cool radiation environment by effectively shielding the payload from ascent heating in blanketed areas. This is particularly the case for the 4-m and 5-m composite fairings, which satisfy the COMSTAC limit for maximum heat flux from the fairing to the payload of 500 W/m² (Section 3.2) by a large margin as a result of low blanket temperatures. Delta IV 5-m metallic fairings also satisfy this limit. Figures 4-10, 4-11, and 4-12 depict the areas of the various Delta IV fairings that are typically blanketed. There may be slight variations in blanket coverage areas based on mission requirements.

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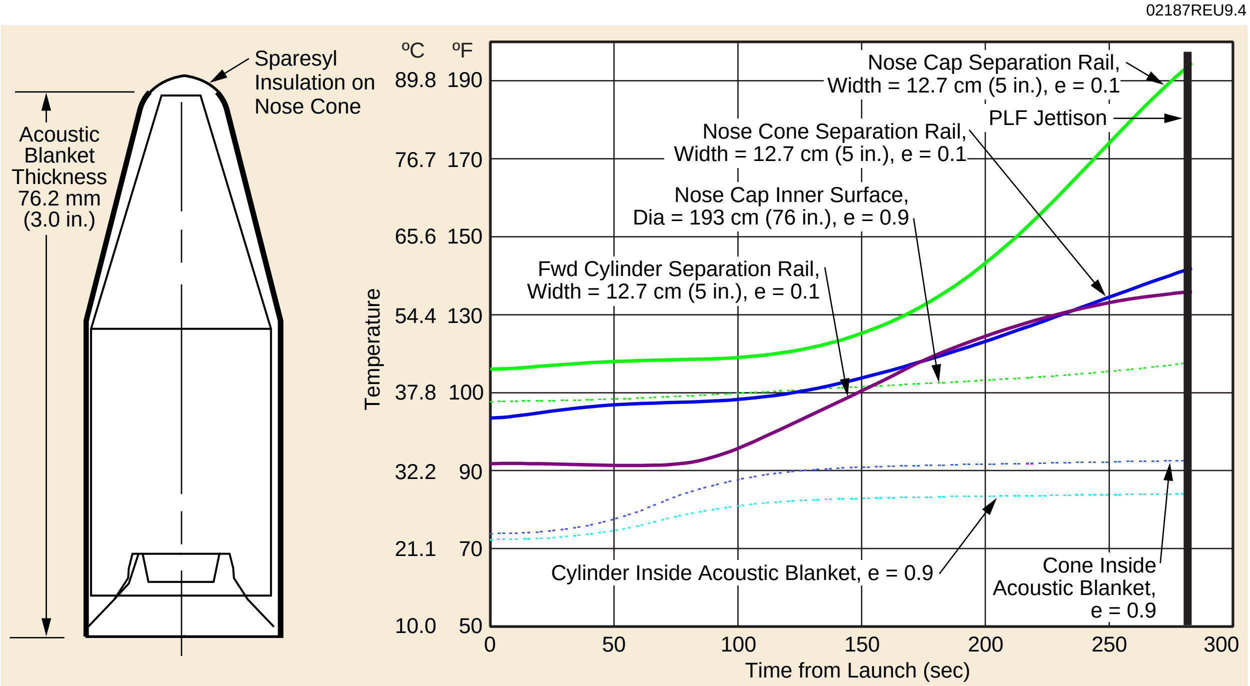

Figure 4-10. Inside Surface Temperature Visible to Payload, 4-m Composite Fairings

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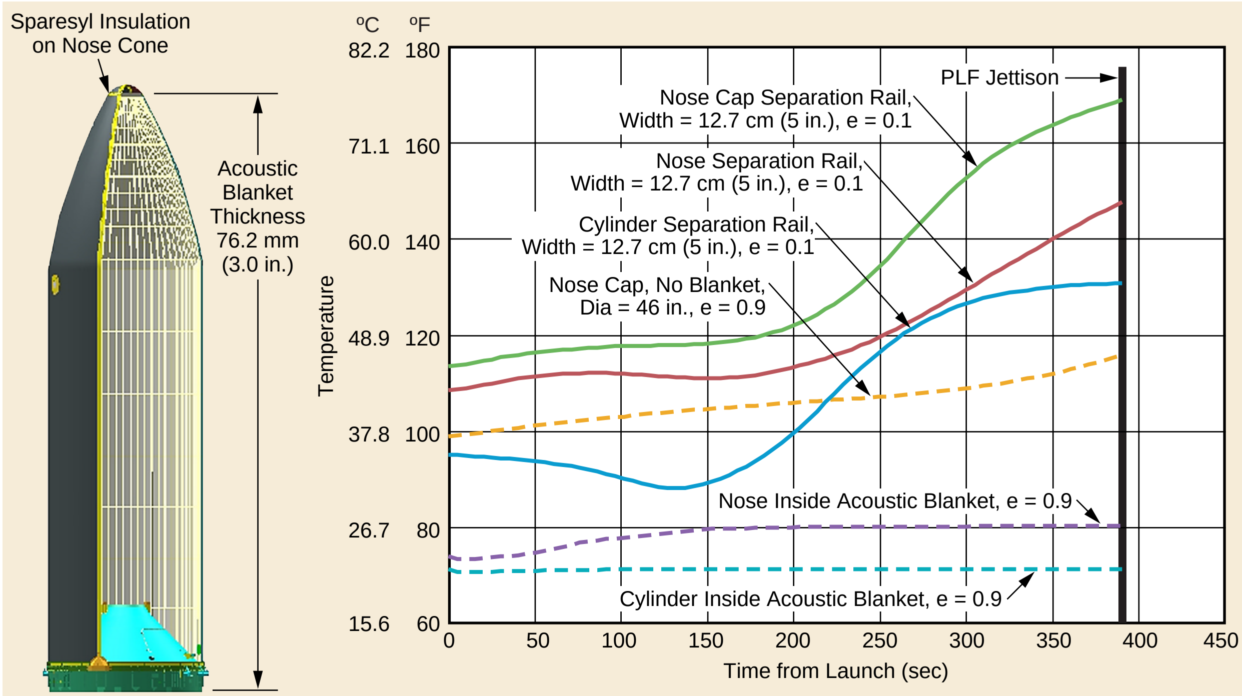

Figure 4-11. Inside Surface Temperature Visible to Payload, 5-m Composite Fairings

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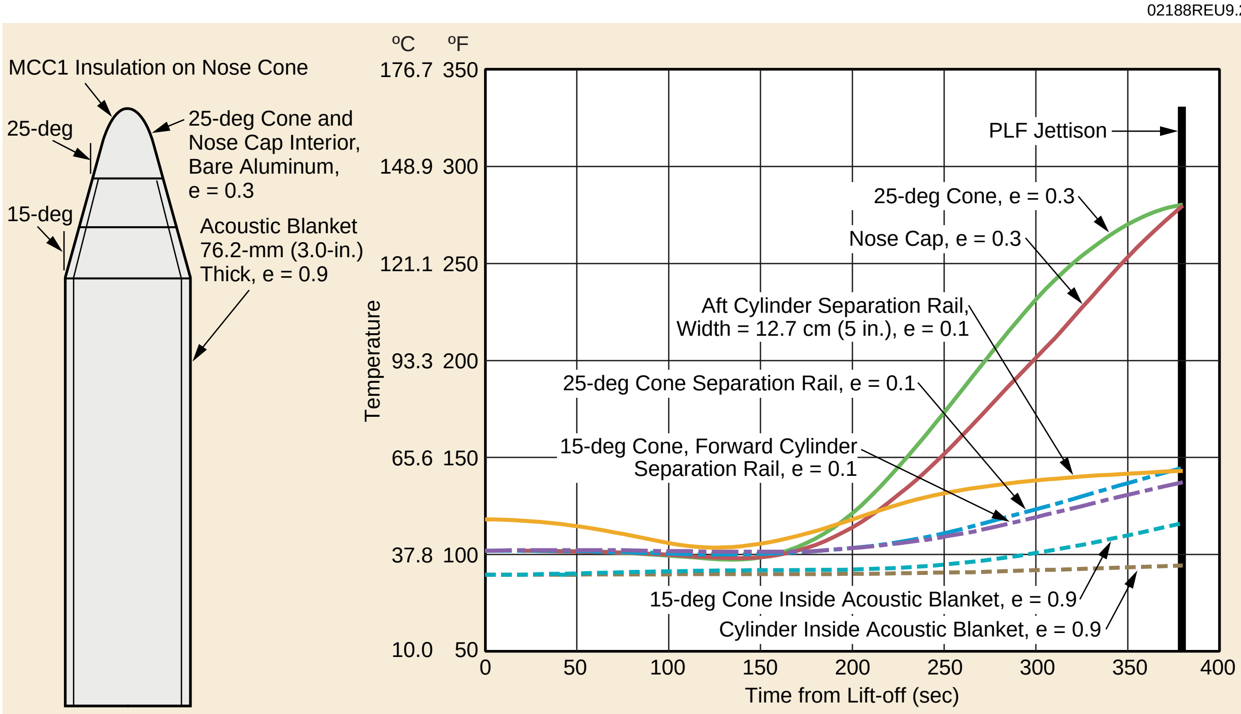

Figure 4-12. Inside Surface Temperature Visible to Payload, 5-m Metallic Fairings

Unless otherwise requested, fairing jettison for standard 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/m2 (360 Btu/hr ft2) based on the 1962 US Standard Atmosphere. Additional theoretical free molecular heating rates at fairing jettison (e.g., 1009 W/m2 (320 Btu/hr ft^2)) can be accommodated by the Delta IV family through coordination with Delta Launch Services.

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 slow roll during a long coast period can also be used to moderate orbital heating and cooling. The Delta IV roll rate for thermal control is typically 1.5 deg/sec for the 4-m second stage and 1.0 deg/sec for the 5-m second stage, based on existing Delta launch vehicles.

4.2.2.3 Payload/Launch Vehicle Interface. Boeing will perform a thermodynamic analysis using a customer-provided payload thermal model to define payload temperatures during ground and flight operations until payload jettison.

4.2.2.4 Stage-Induced Thermal Environments. The plume of the RL10B-2 engine does not impinge on the payload. Hydrazine thrusters, which are used for attitude control, are located on the equipment deck, aft of the main propellant tanks. Nozzles are pointed circumferentially and aft.

4.2.2.5 In-Flight Contamination Environments. Contamination environments from second-stage propulsive systems and 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 contamination of the payload. The blankets are made of Melamine foam and are attached to the fairing with hook-and-loop fasteners. They are then covered with carbon-filled kapton face sheets, with all seams 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 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; both species are quite volatile and evaporate in a reasonable time. 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 in Sections 4.2.3.3, 4.2.3.4, and 4.2.3.5 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 4-13, 4-14, 4-15, 4-16, and 4-17 for the Delta IV-M, -M+ (4,2), -M+ (5,2), -M+ (5,4), and -H 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 Delta Launch Services for details. Typical steady-state axial accelerations versus space vehicle weight at second-stage burnout are shown in Figures 4-18, 4-19, 4-20, 4-21, and 4-22 for the Delta IV-M, -M+ (4,2), -M+ (5,2), -M+ (5,4), and -H vehicles, respectively.

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.

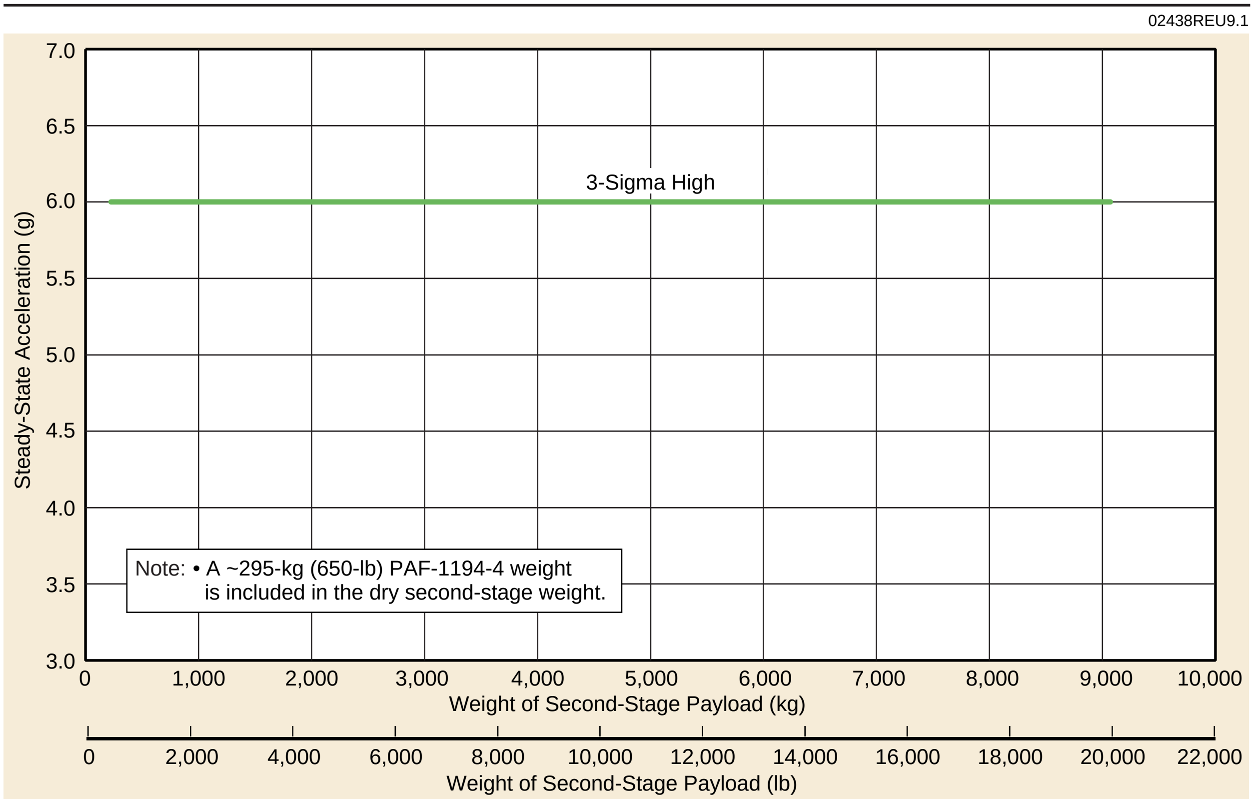

Figure 4-13. Delta IV Medium Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second-Stage Payload Weight

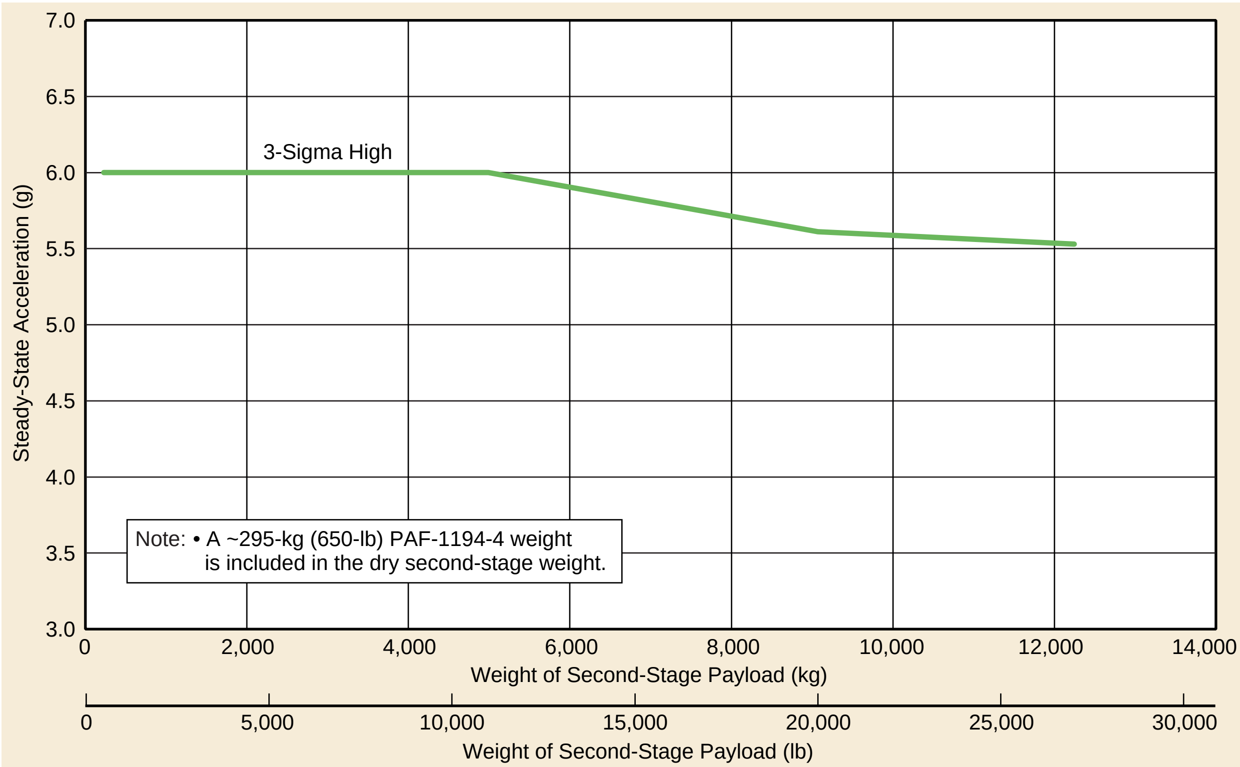

Figure 4-14. Delta IV Medium-Plus (4,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second-Stage Payload Weight

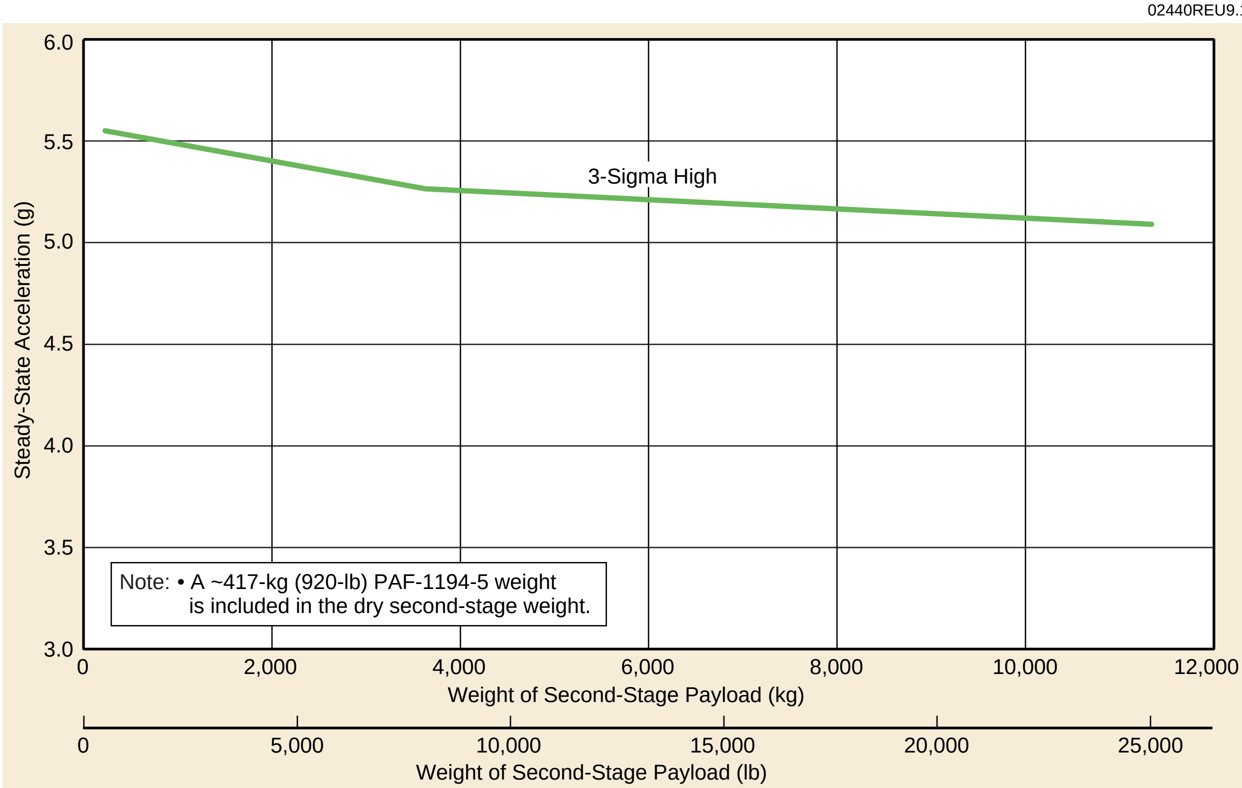

Figure 4-15. Delta IV Medium-Plus (5,2) Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second-Stage Payload Weight

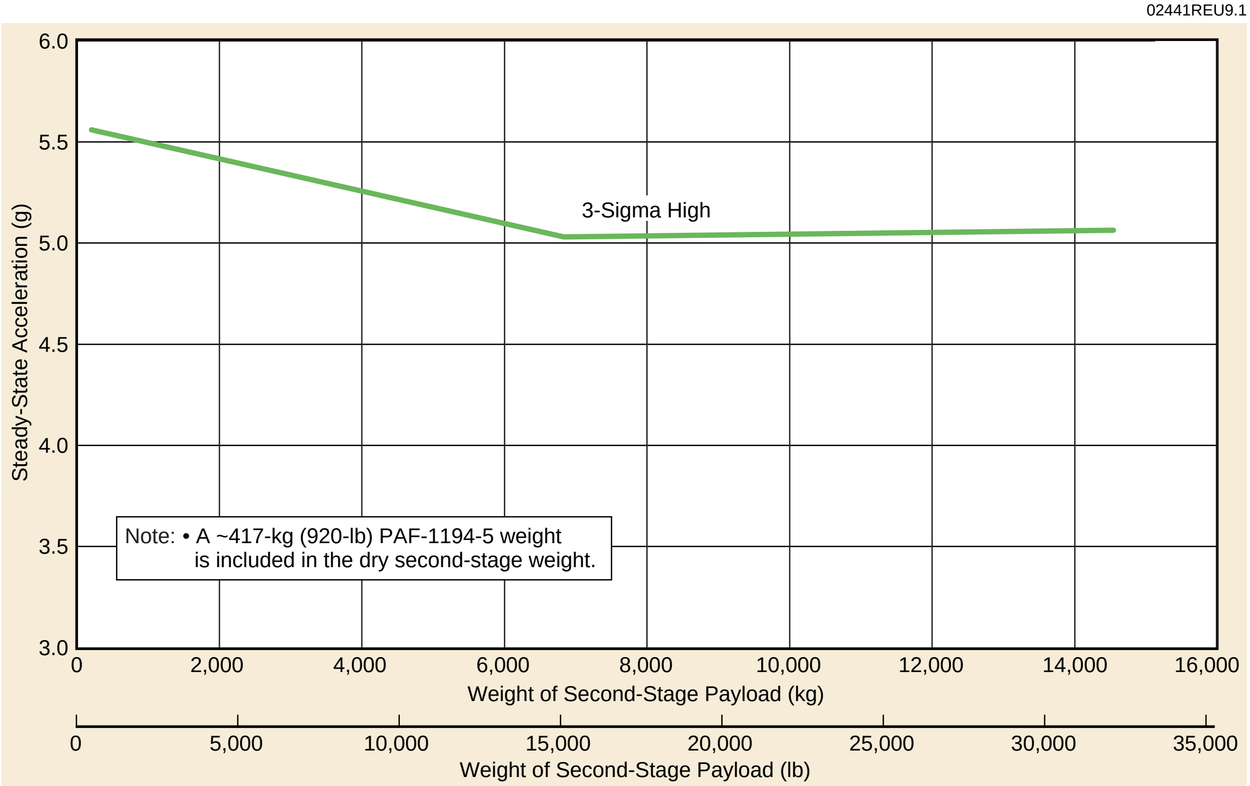

Figure 4-16. Delta IV Medium-Plus (5,4) Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second-Stage Payload Weight

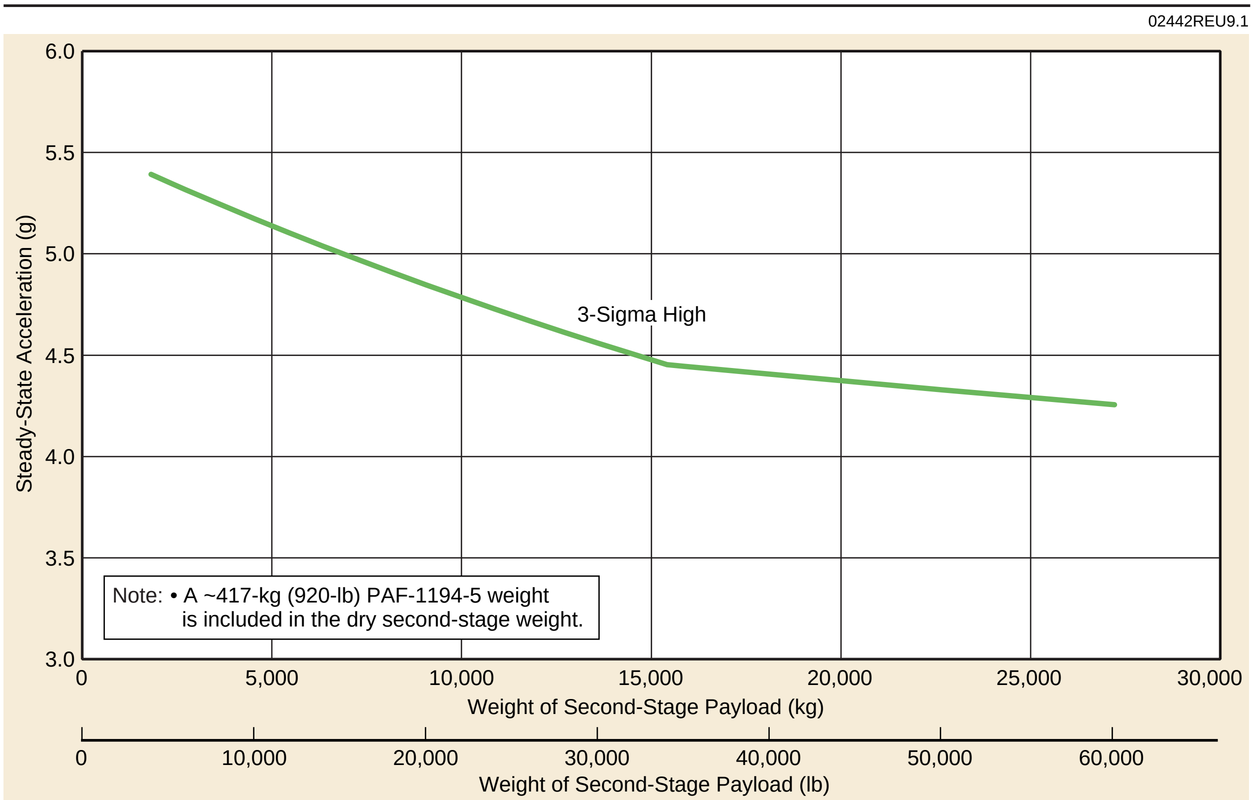

Figure 4-17. Delta IV Heavy Maximum Axial Steady-State Acceleration During First-Stage Burn vs Second-Stage Payload Weight

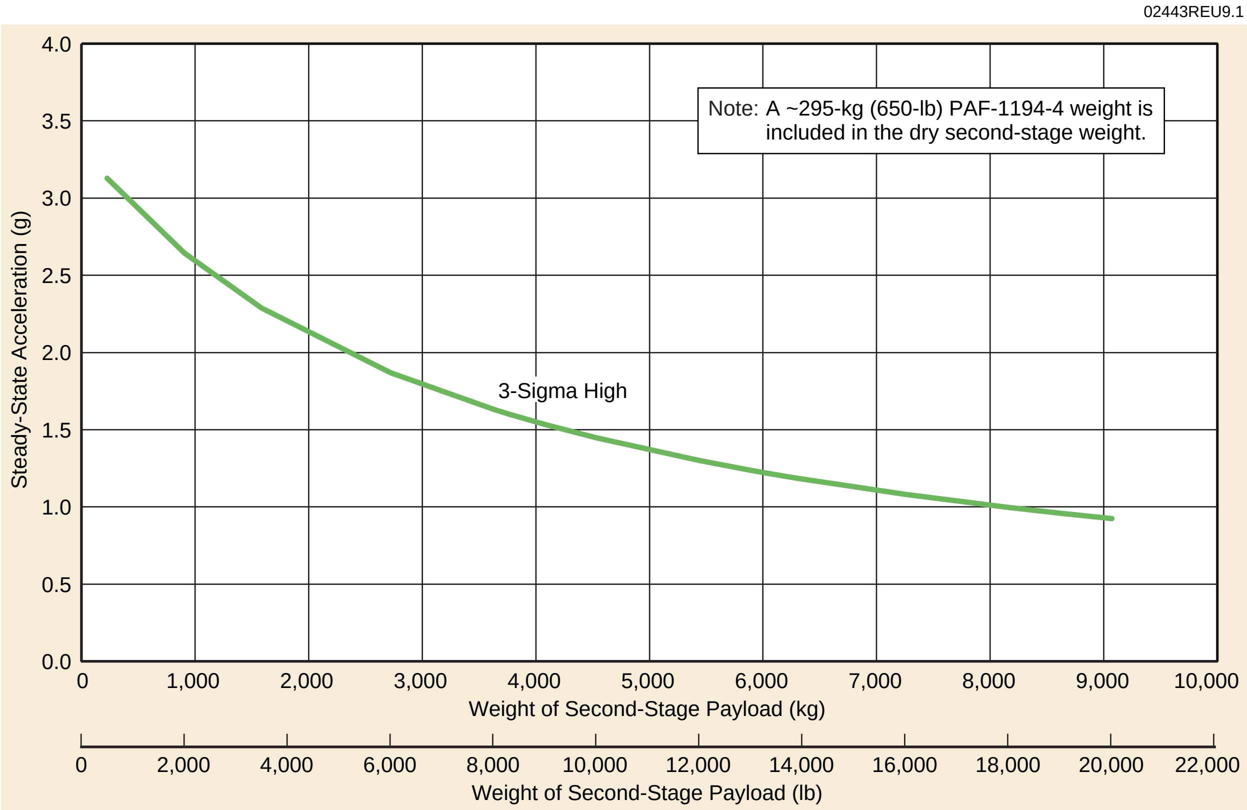

Figure 4-18. Delta IV Medium Axial Steady-State Acceleration at Second-Stage Cutoff

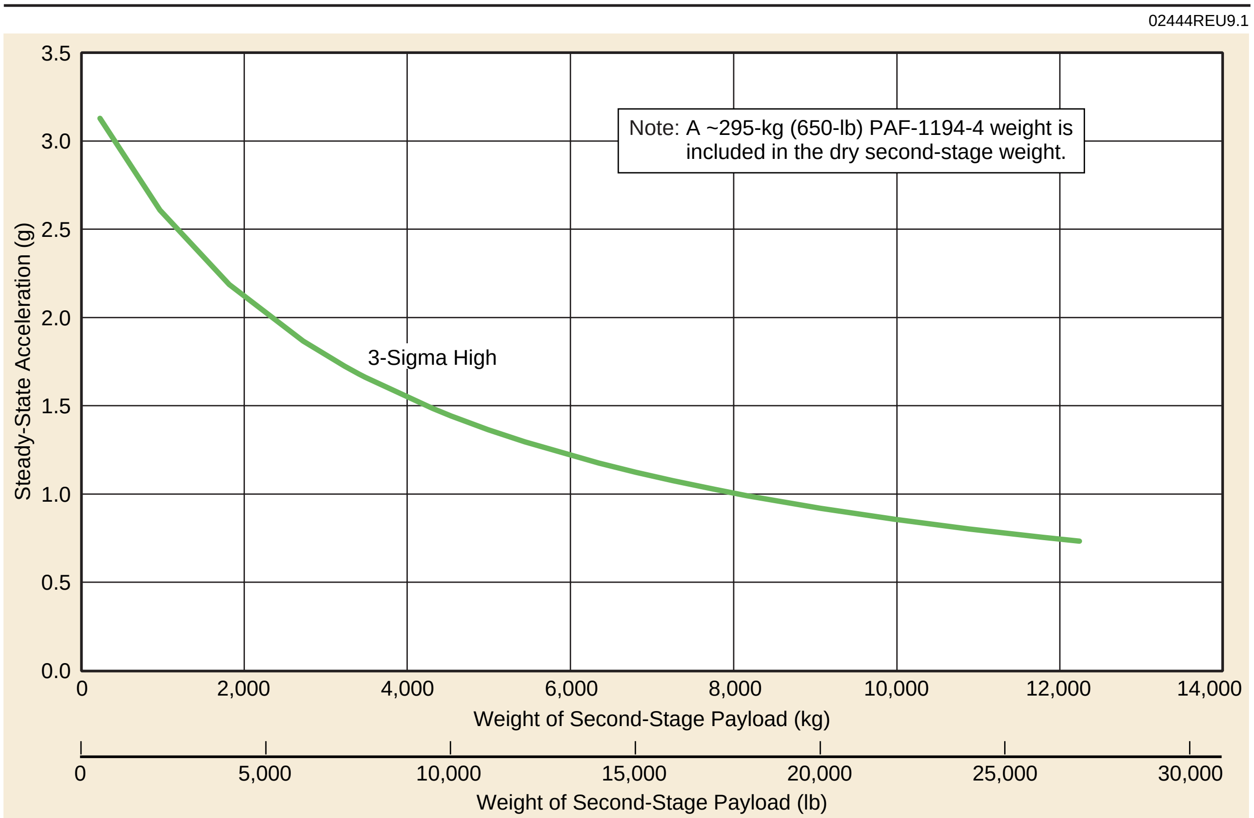

Figure 4-19. Delta IV Medium-Plus (4,2) Axial Steady-Stage Acceleration at Second-Stage Cutoff

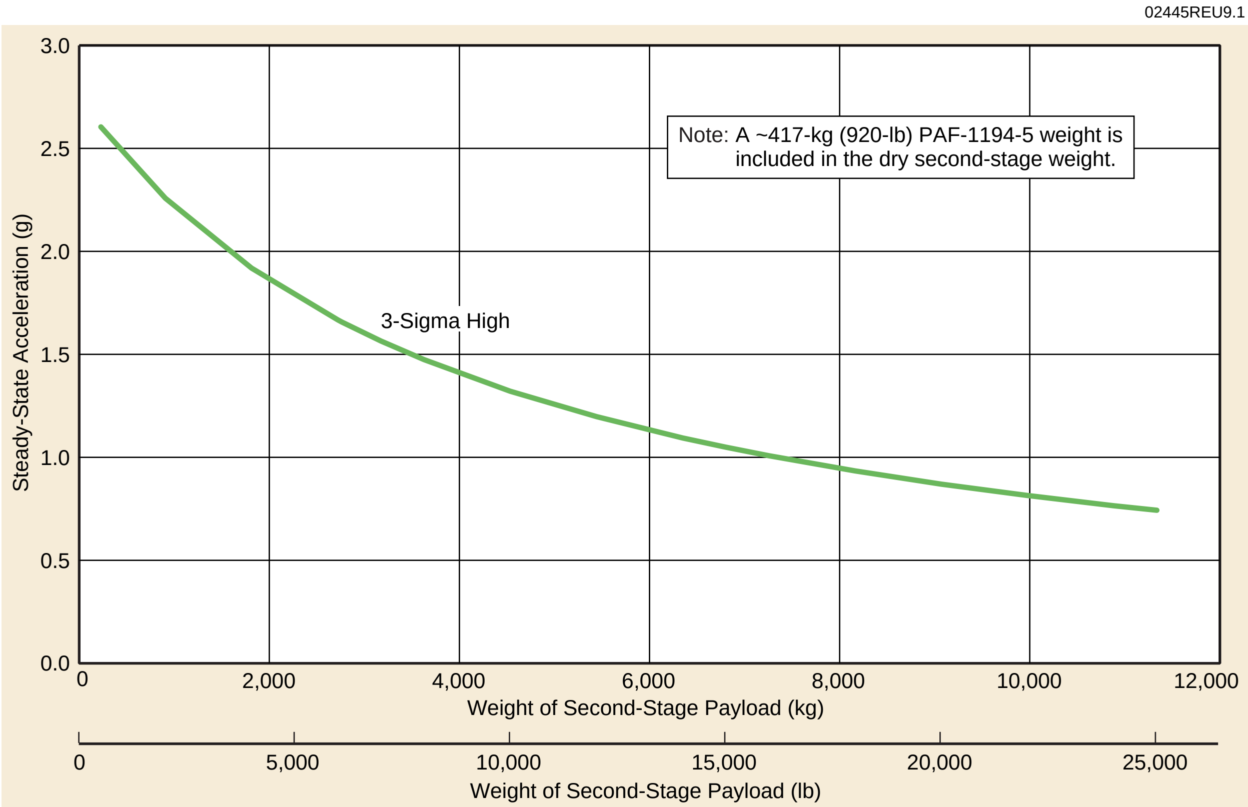

Figure 4-20. Delta IV Medium-Plus (5,2) Axial Steady-State Acceleration at Second-Stage Cutoff

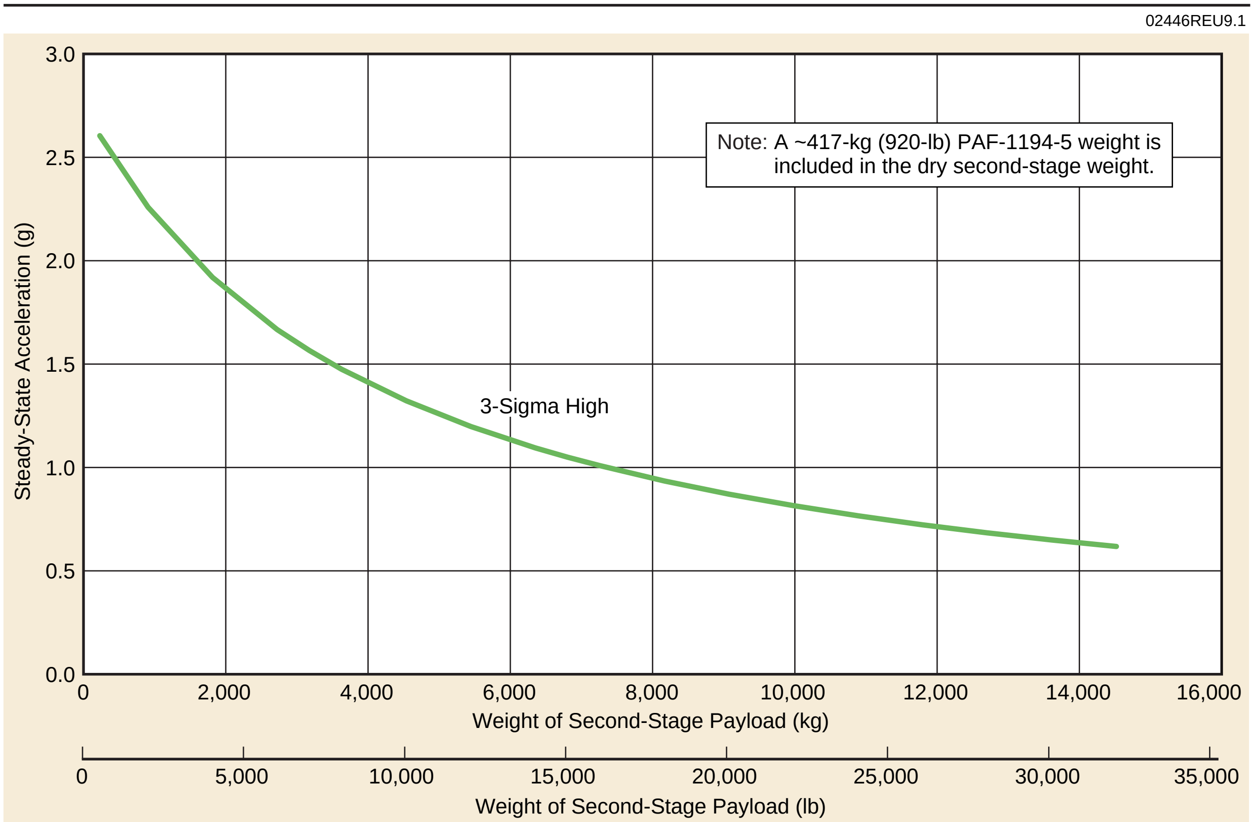

Figure 4-21. Delta IV Medium-Plus (5,4) Axial Steady-State Acceleration at Second-Stage Cutoff

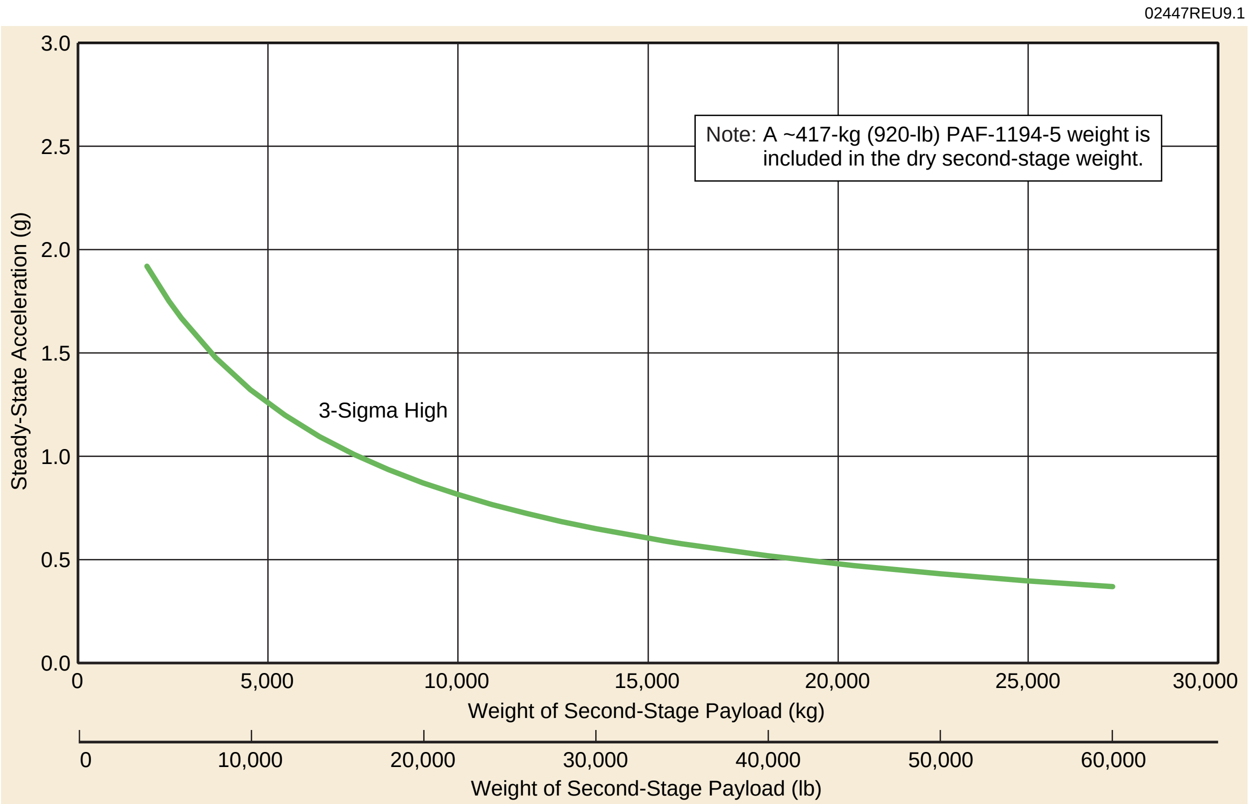

Figure 4-22. Delta IV Heavy Axial Steady-Stage Acceleration at Second-Stage Cutoff

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 Tables 4-5 and 4-6 for the static/dynamic fairing envelopes shown in Section 3. The payload dynamic envelope is defined by calculating the maximum deflected shape using the combined axial and lateral limit load factors, shown in Figures 4-23 and 4-24.

For payloads utilizing the static envelope requirements, 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 Tables 4-5 and 4-6 for the corresponding launch vehicles. These frequencies are for a payload hard-mounted at the payload separation plane 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

Table 4-5. Static Envelope Requirements

Static envelope requirements					Maximum lateral		Maximum axial	
LV type	Overall payload fairing length (m/ft)	Minimum axial frequency (Hz)	Minimum lateral frequency (Hz)	Static diameter (barrel section) (m/in.)	Maximum axial (g)	Maximum lateral (g)	Maximum axial (g)	Maximum lateral (g)
Delta IV Medium	11.7/38.5	27	10	3.75/147.6	+2.4/-0.2	±2.0	6.5*	±0.5
Delta IV Medium-Plus (4,2)	11.7/38.5	27	10	3.75/147.6	+2.5/-0.2	±2.0	6.5*	±0.5
Delta IV Medium-Plus (5,2)	14.3/47	27	10	4.57/180.0	+2.4/-0.2	±2.0	6.5*	±0.5
Delta IV Medium-Plus (5,4)	14.3/47	27	10	4.57/180.0	+2.5/-0.2	±2.0	6.5*	±0.5
Delta IV Heavy**	19.8/62.7	30	8	4.57/180.0	+2.3/-0.2	±2.5	6.0	±0.5
Delta IV Heavy Dual-Manifest	22.4/73.5	30	8	4.57/180.0	+2.3/-0.2	±2.5‡	6.0	±0.5

*Current projection; lower customer axial requirements may be accommodated through coordination with Delta Launch Services.
**Payloads greater than 12,250-kg (27,000 lb).
‡Current analysis indicates lateral acceleration levels approaching dedicated launch vehicle levels (2 g).

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Table 4-6. Dynamic Envelope Requirements

Dynamic envelope requirements					Maximum lateral		Maximum axial	
LV type	Overall payload fairing length (m/ft)	Minimum axial frequency (Hz)	Minimum lateral frequency (Hz)	Static diameter (barrel section) (m/in.)	Maximum axial (g)	Maximum lateral (g)	Maximum axial (g)	Maximum lateral (g)
Delta IV Medium	11.7/38.5	15	8	3.75/147.6	See Figure 4-23			
Delta IV Heavy*	19.8/65.0	15	2.5	4.57/180.0	See Figure 4-24			

*5-m metallic fairing.

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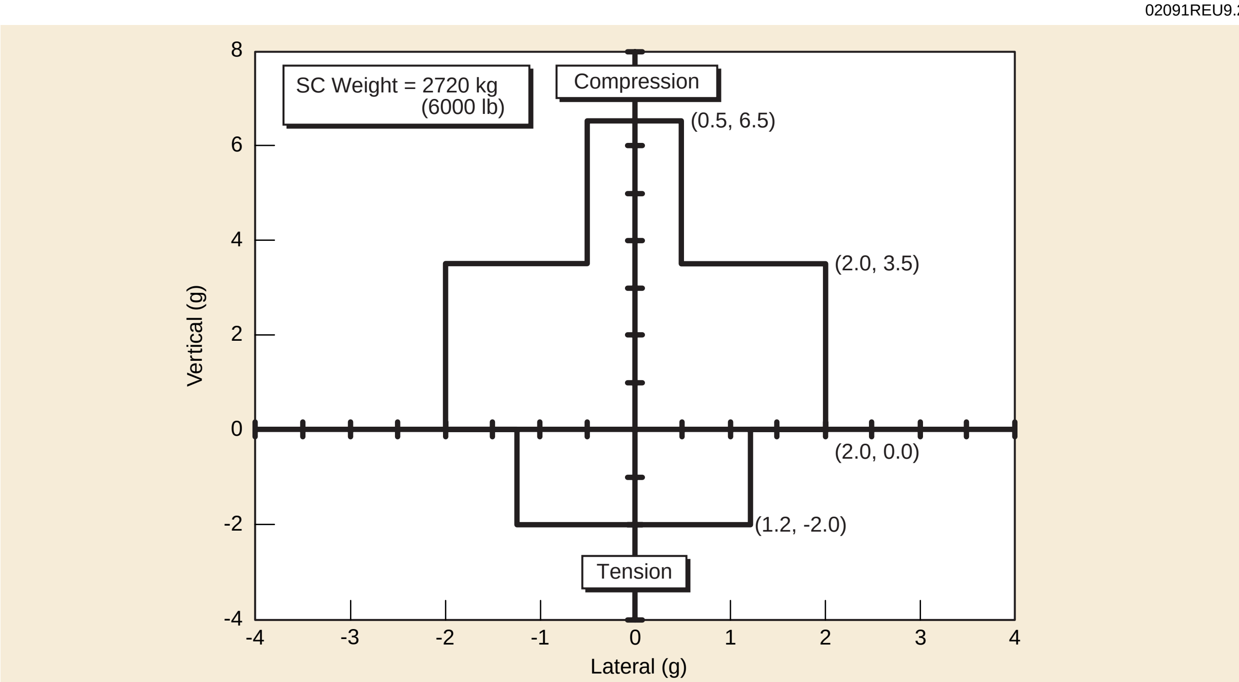

Figure 4-23. Delta IV Medium Design Load Factors for Dynamic Envelope Requirements

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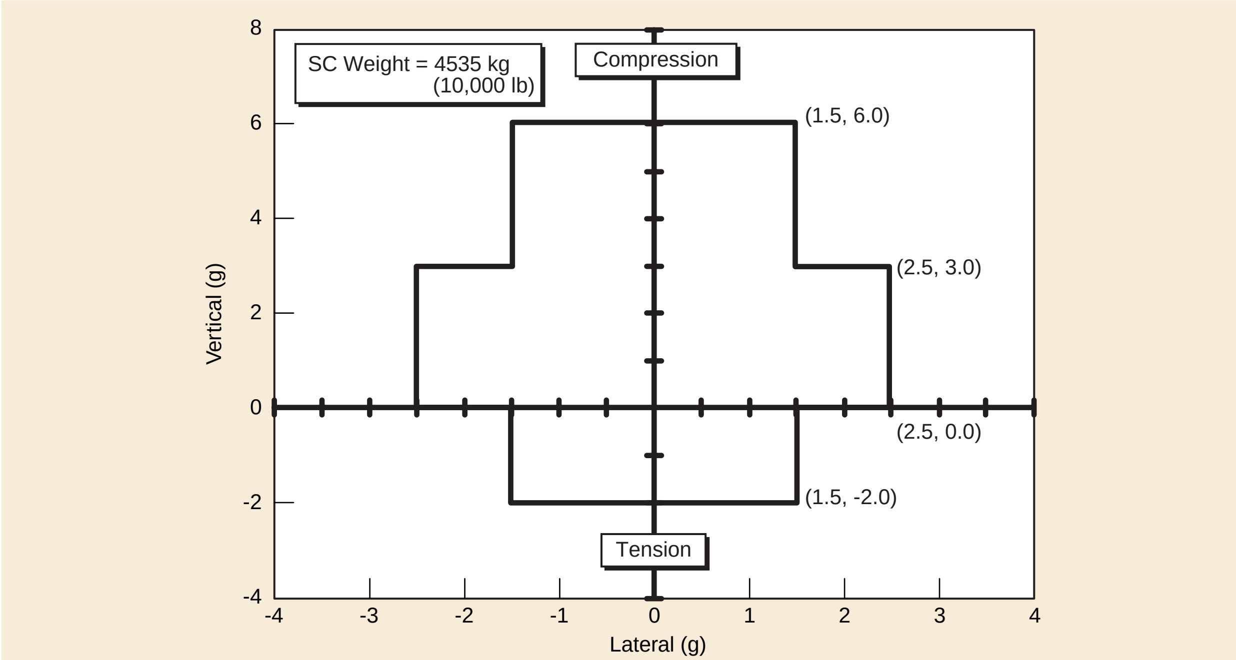

Figure 4-24. Delta IV Heavy Design Load Factors for Dynamic Envelope Requirements

design limit-load factors could be higher than shown; users should consult the Delta Launch Services 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 duration of the maximum environment is less than 10 sec. The payload acoustic environment is a function of the configuration of the launch vehicle, the fairing, the fairing acoustic blankets, and the payload. Section 3 defines the fairing blanket configurations. Table 4-7 identifies the figures that define the payload acoustic environment for the five versions 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 large payload may increase the acoustic environments shown in Figures 4-25, 4-26, 4-27, and 4-28. Users should contact Delta Launch Services to coordinate any payload acoustic requirements below the levels shown in Figures 4-25, 4-26, 4-27, and 4-28.

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

Table 4-7. Spacecraft Acoustic Environment Figure Reference

Delta IV launch vehicle configuration	Mission type	Fairing configuration	Fairing acoustic blanket configuration	Space vehicle acoustic environment
Delta IV Medium, Medium-Plus	2-stage	4-m composite	3-in. configuration	See Figure 4-25
Delta IV Medium-Plus	2-stage	5-m composite	3-in configuration	See Figure 4-26
Delta IV Heavy	2-stage	5-m composite	3-in. configuration	See Figure 4-27
Delta IV Heavy	2-stage	5-m metallic	3-in configuration	See Figure 4-28

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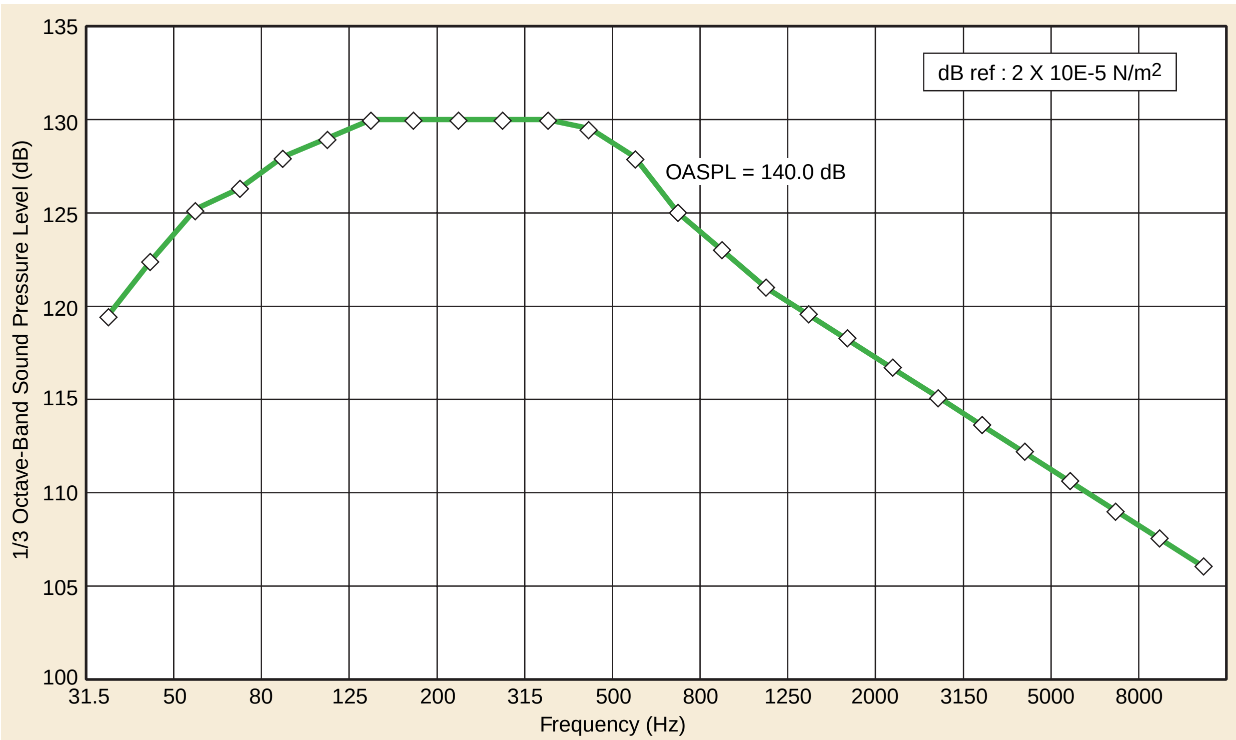

Figure 4-25. Delta IV-M and Delta IV-M+ (4-m Composite Fairing) Internal Payload Acoustics Typical 95 Percentile, 50% Confidence Predictions, 60% Fill Effect Included

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. During flight, the payload will experience sinusoidal vibration inputs as a result of Delta IV launch and ascent transients and oscillatory flight events. The maximum predicted flight level sinusoidal vibration inputs, which are the same for all Delta IV launch vehicle configurations, are defined in Table 4-8 at the spacecraft separation plane. These predicted sinusoidal vibration levels provide general envelope low-frequency flight dynamic events such as liftoff transients, transonic/maximum Q oscillations, main engine cutoff (MECO) transients, pre-MECO sinusoidal oscillations, and second-stage events.

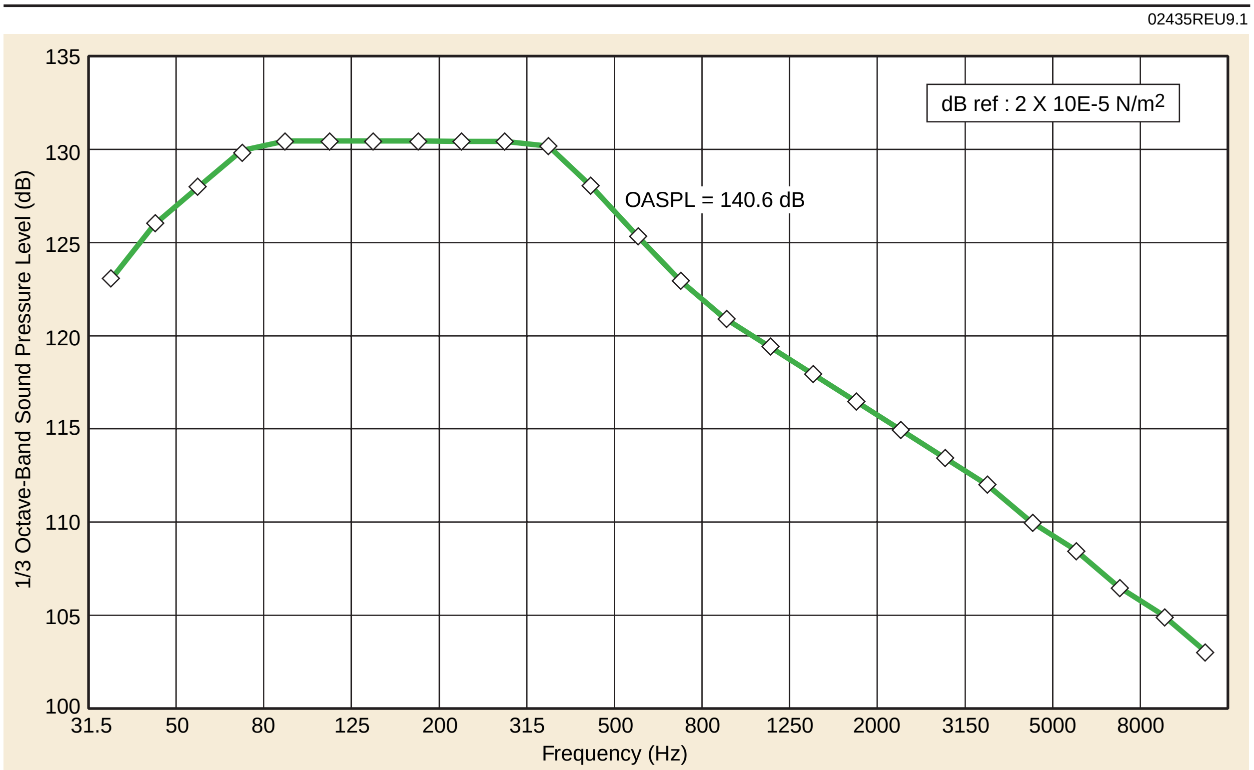

Figure 4-26. Delta IV-M+ (5-m Composite Fairing) Internal Payload Acoustics Typical 95 Percentile, 50% Confidence Predictions, 60% Fill Effect Included

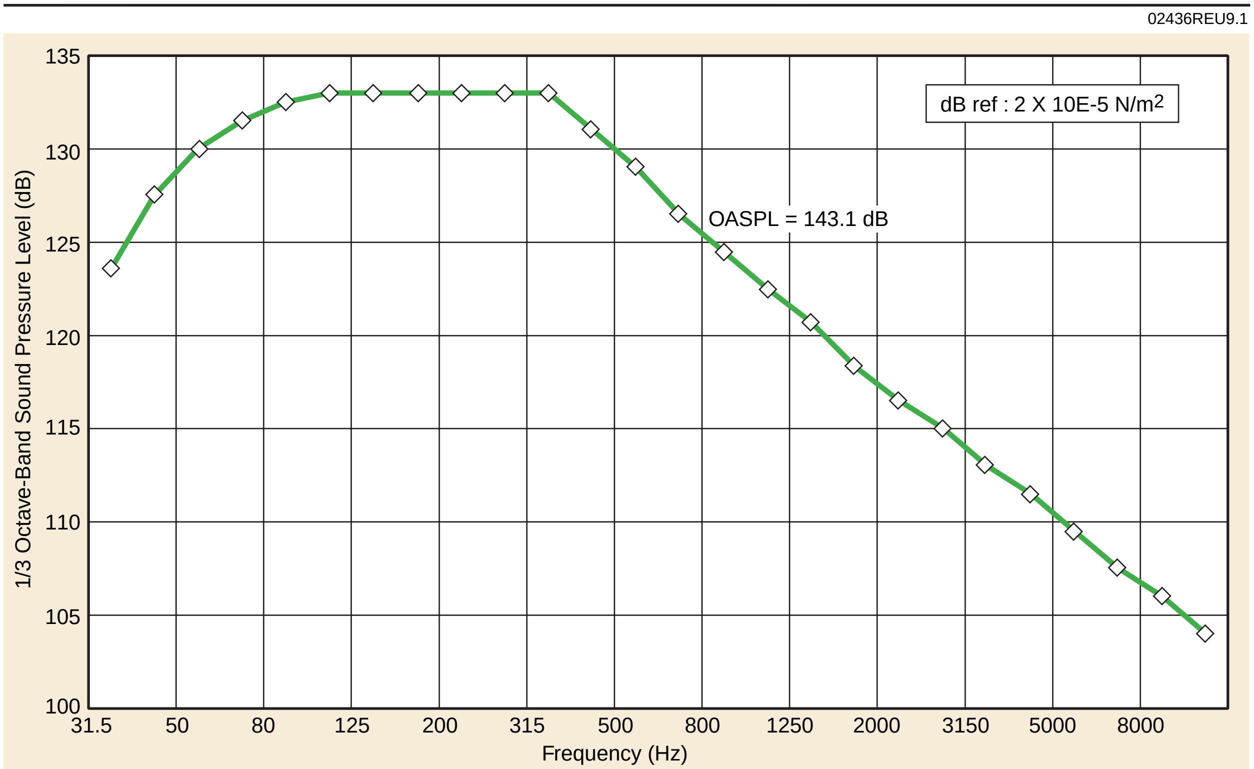

Figure 4-27. Delta IV-Heavy (5-m Composite Fairing) Internal Payload Acoustics Typical 95 Percentile, 50% Confidence Predictions, 60% Fill Effect Included

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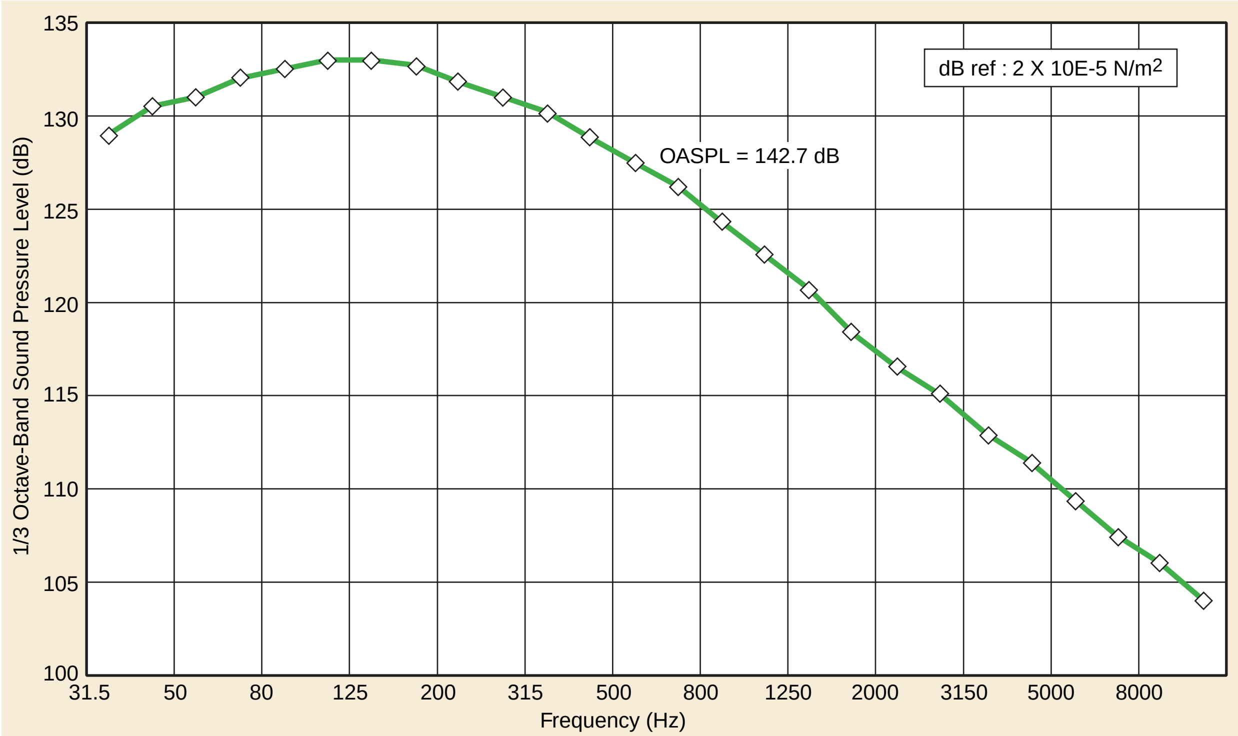

Figure 4-28. Delta IV-Heavy (5-m Metallic Fairing) Internal Payload Acoustics Typical 95 Percentile, 50% Confidence Predictions, 60% Fill Effect Included

Table 4-8. Sinusoidal Vibration Levels

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

0000589

The sinusoidal vibration levels in Table 4-8 are not intended for use in the design of spacecraft primary structure. Limit load factors for spacecraft primary structure design are specified in Figures 4-23 and 4-24.

The sinusoidal vibration levels should be used in conjunction with the results of the coupled dynamic loads analysis (Table 8-3, item 6) to aid in the design of spacecraft secondary structure (e.g., solar arrays, antennae, appendages, etc.) 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 use a Delta IV PAF with or without a 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 provided data 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 the PAF-bolted interface, the maximum allowable payload-induced shock transmitted to the launch vehicle is shown in Figure 4-29 for all launch vehicle configurations.

For the 1575-4 PAF interface, the maximum launch-vehicle-induced shock environment is defined in Figure 4-30. For the 4394-5 PAF interface, the maximum launch-vehicle-induced shock environment is defined in Figure 4-31. The maximum clamp-separation-system-induced shock environment at the payload attach fitting/payload interface is defined in Figure 4-32 for the 1666-mm (66-in.)-dia clamp separation system (1666-4 PAF) with a 31.147-kN (7000-lb) clampband preload. Definition of the shock environments for the 937-mm (37-in.), and the

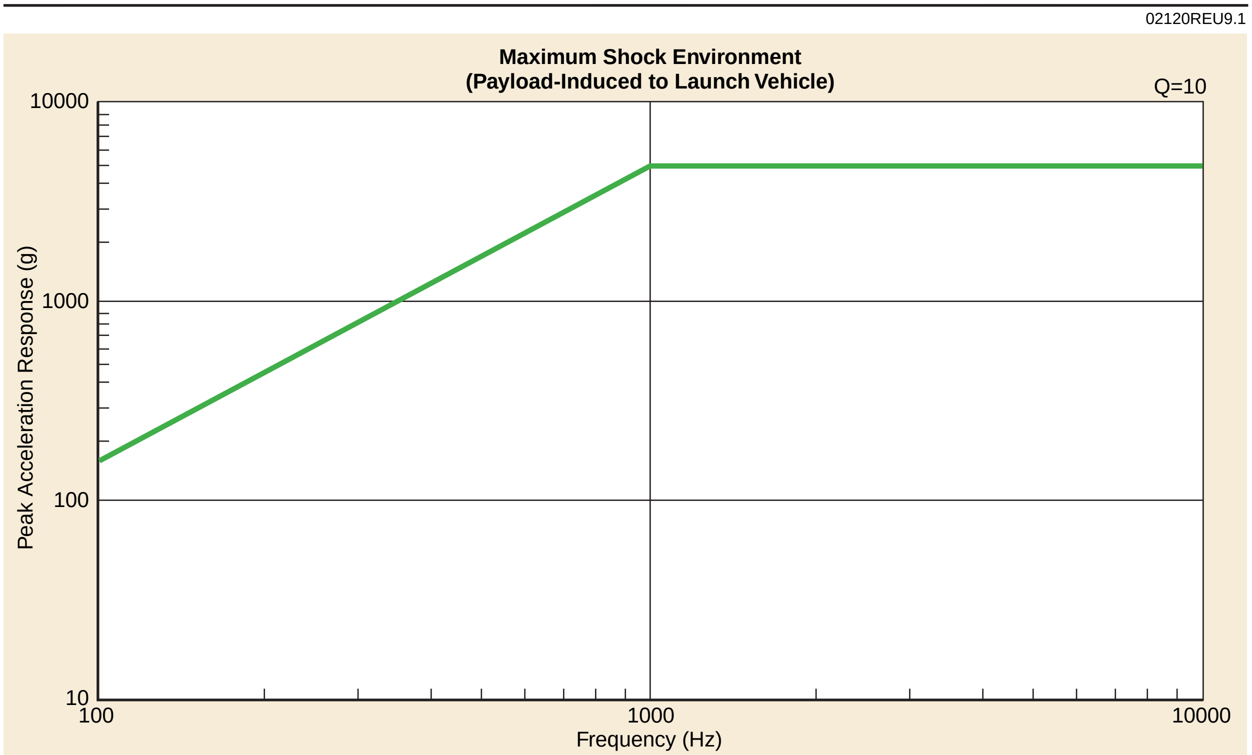

Figure 4-29. Maximum Allowable Payload-Induced Shock Levels at Bolted Payload Attach Fitting Interface

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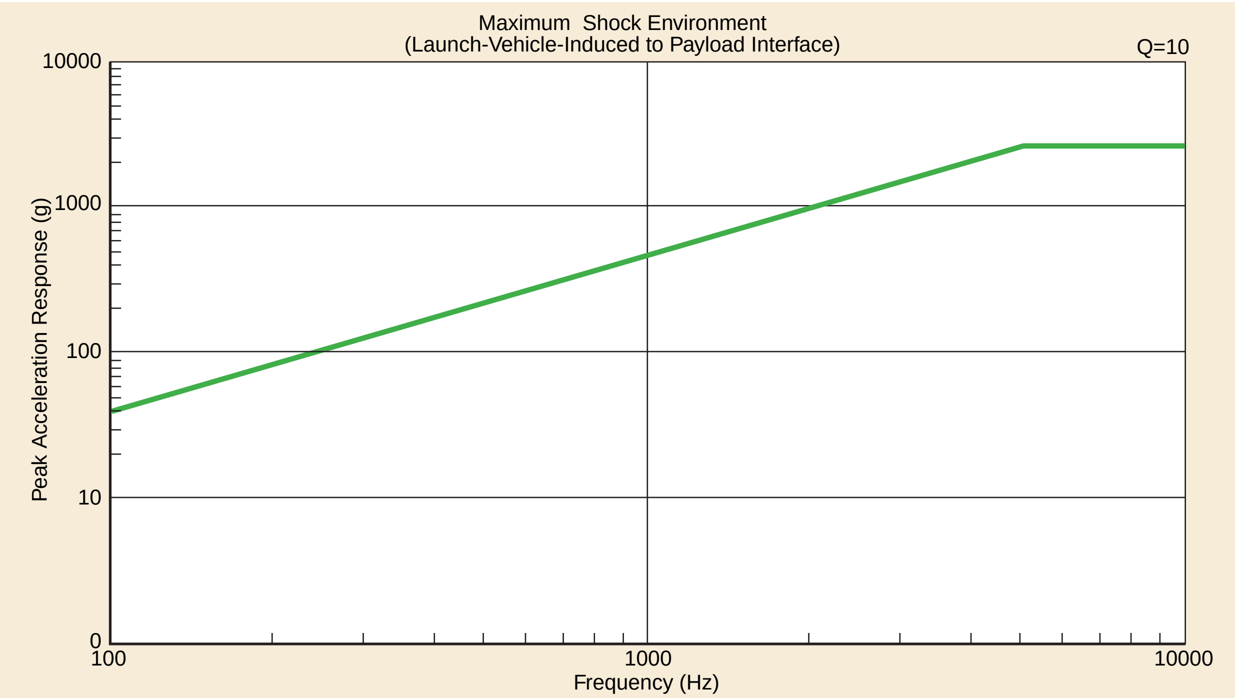

Figure 4-30. Payload Interface Shock Environment—1575-4 Payload Attach Fitting

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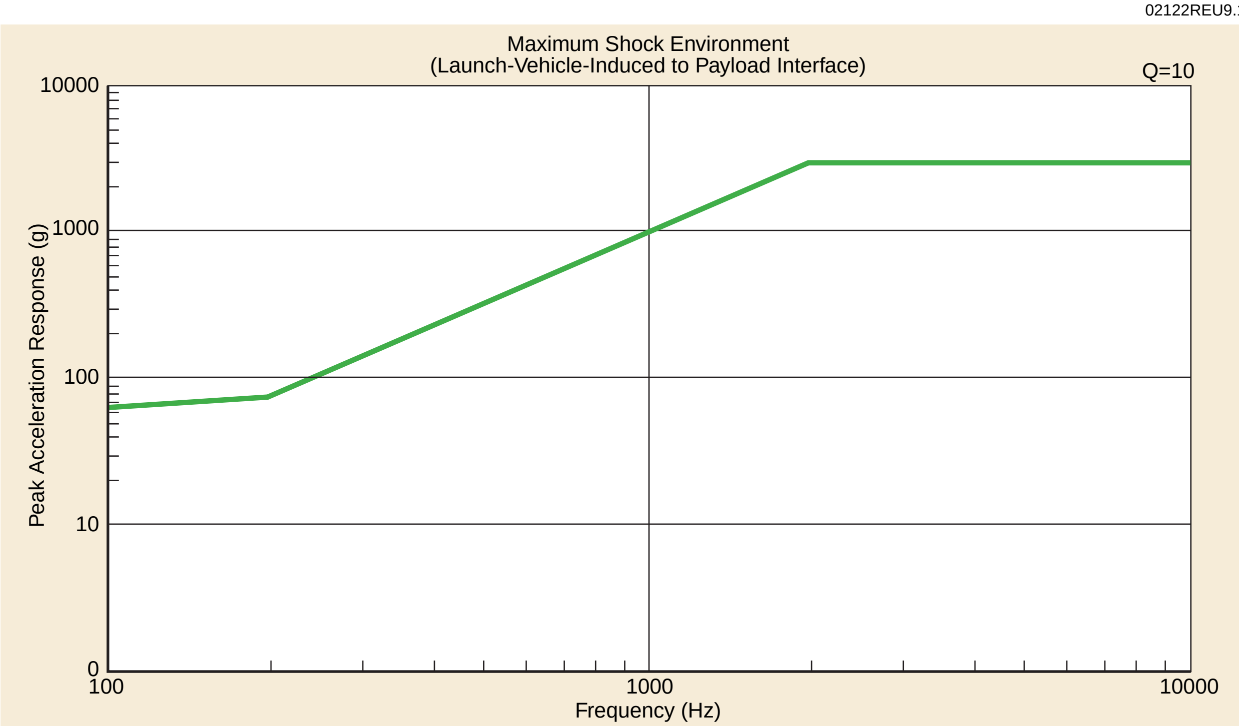

Figure 4-31. Payload Interface Shock Environment—4394-5 Payload Attach Fitting

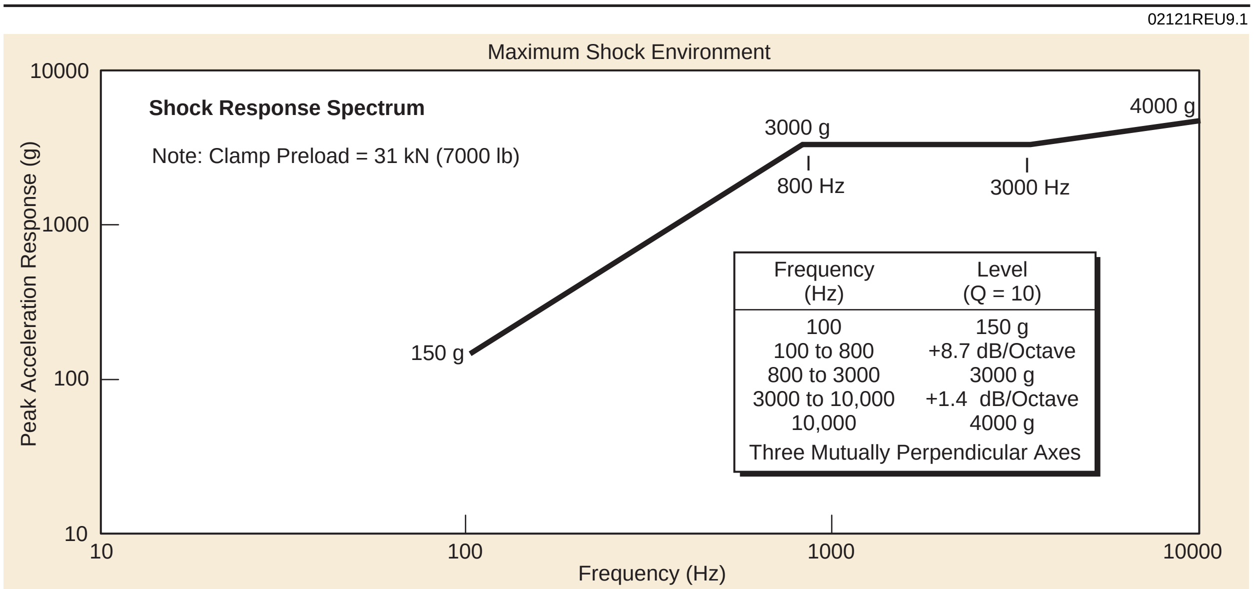

Figure 4-32. Payload Interface Shock Environment—1666-4 Payload Attach Fitting

1194-mm (47-in.)-dia clamp separation systems and the four-point bolted separation system (1664-4 PAF) are being evaluated.

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 structural capability of the spacecraft primary structure is to be demonstrated by test, this section becomes a requirement. If the spacecraft primary structure 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 Launch Services during the development of spacecraft test specifications is encouraged to ensure the adequacy of the spacecraft test approach (Table 8-3, item 5).

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 flight spacecraft to maximum expected flight environments. The protoflight test approach is intended to combine verification of adequate design margin and adequacy of spacecraft manufacture and workmanship by subjecting the flight spacecraft 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 user to demonstrate the design integrity of the primary structural elements of the spacecraft. These loads are based on worst-case conditions as defined in Sections 4.2.3.1 and 4.2.3.2. 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 Delta Launch Services 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 Table 4-9.

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. Spacecraft users should contact Delta Launch Services to coordinate any spacecraft acoustic requirements below the test levels provided in Table 4-9.

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 qualification, acceptance, and protoflight test levels for all Delta IV launch vehicle configurations are defined in Tables 4-10, 4-11, and 4-12 at the spacecraft separation plane.

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.

Table 4-9. Spacecraft Acoustic Test Levels

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 isogrid 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 isogrid 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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Table 4-10. Sinusoidal Vibration Acceptance Test Levels

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

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Table 4-11. Sinusoidal Vibration Qualification Test Levels

Axis	Frequency (Hz)	Acceptance test levels	Sweep rate
Thrust	5 to 7.4 7.4 to 100	1.27 cm (0.5 in.) double amplitude 1.4 g (zero to peak)	2 octaves/min
Lateral	5 to 6.2 6.2 to 100	1.27 cm (0.5 in) double amplitude 1.0 g (zero to peak)	2 octaves/min

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Table 4-12. Sinusoidal Vibration Protoflight Test Levels

Axis	Frequency (Hz)	Acceptance test levels	Sweep rate
Thrust	5 to 7.4 7.4 to 100	1.27 cm (0.5 in.) double amplitude 1.4 g (zero to peak)	4 octaves/min
Lateral	5 to 6.2 6.2 to 100	1.27 cm (0.5 in) double amplitude 1.0 g (zero to peak)	4 octaves/min

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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.

Boeing normally will 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 Delta Launch Services before developing the sinusoidal vibration test plan for information on the payload/launch vehicle coupled dynamic loads analysis for that special mission or similar missions. 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

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 Spin Balance Requirements. For nonspinning spacecraft, no dynamic balance constraint exists, but the static imbalance directly influences the spacecraft angular rates at separation. When a separation tip-off constraint exists, the spacecraft center-of-gravity offset must be coordinated with Delta Launch Services 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/s) 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/s) must be assessed relative to specific spacecraft requirements.

Section 5
PAYLOAD INTERFACES

This section presents the detailed description of the mechanical interfaces between the payload and the Delta IV launch vehicle family. Our Delta IV payload interfaces are designed to meet the present and future demands of the global satellite market. Boeing utilizes a heritage design approach for its payload attach fittings (PAFs); hence, unique interface requirements can be accommodated through a natural extension of a developed structure. Multiple payload dispenser systems are also available; for further details coordinate directly with Delta Launch Services (DLS).

5.1 HERITAGE DESIGN PHILOSOPHY

Delta IV payload attach fittings are based on heritage designs that have been developed and qualified by Boeing. 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 Delta III program. This heritage design evolved out of demand for a lighter weight structure with minimal part count. Some of the key features include:

- 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 conic shell.
- 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/contracting 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 adapted 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

Boeing has extensive flight experience with both Marmon-type clampband and discrete bolted interface separation systems. Delta II and Delta III 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; location and quantity 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 the 4-m and 5-m payload fairings, as shown in Figures 5-1 and 5-2, respectively. Each PAF is designated by its payload interface diameter in millimeters, followed by a dash and the corresponding fairing diameter in meters. The associated payload envelopes for the following PAFs are shown in Figures 3-2, 3-3, 3-4, 3-5, 3-9, 3-10 and 3-11. All PAFs are designed such that payload electrical interfaces and separation

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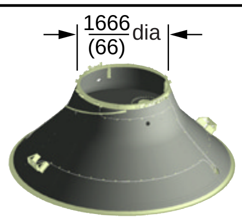
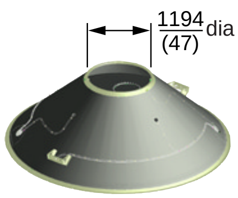
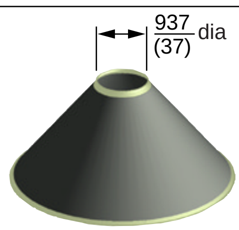
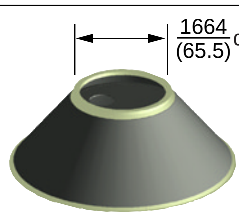
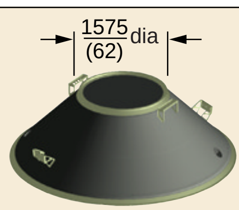
Delta IV 1666-4 PAF		1666 dia (66) clampband	Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact
Delta IV 1194-4 PAF		1194 dia (47) clampband	Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact
Delta IV 937-4 PAF		937 dia (37) 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 1664-4 PAF		Four separation bolts in a 1664 dia (65.5) bolt circle	Four hard-point attachments, released by four redundantly initiated explosive nuts. Four differential springs to provide a tip-off rate
Delta IV 1575-4 PAF		121 bolts in a 1575 dia (62) bolt circle	1575-mm (62.010-in.) bolted interface

mm (in.)

EELV Standard Interface

Figure 5-1. Delta IV 4-m Second-Stage Payload Attachment Configurations

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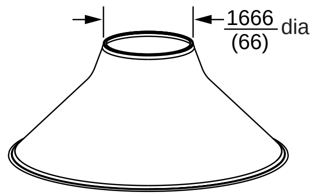
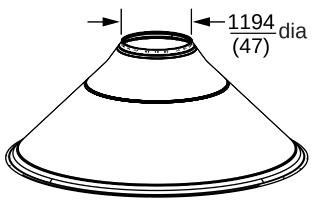
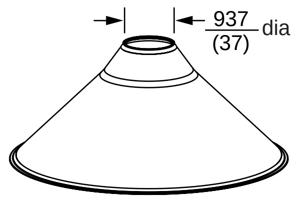
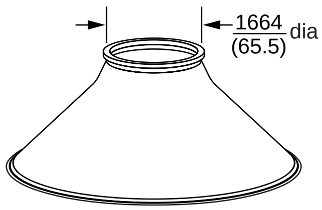
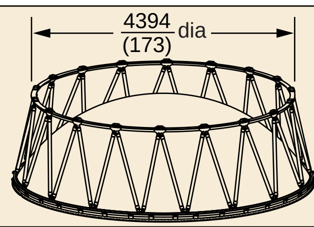
Delta IV 1666-5 PAF		1666 dia (66) clampband	Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact
Delta IV 1194-5 PAF		1194 dia (47) clampband	Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact
Delta IV 937-5 PAF		937 dia (37) 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 1664-5 PAF		Four separation bolts 1664 dia (65.5) bolt circle	Four hard-point attachments, released by four redundantly initiated explosive nuts. Four differential springs to provide a tip-off rate
Delta IV 4394-5 PAF		72 bolts in a 4394 dia (173) bolt circle	4394 (173-in.) bolted interface. Standard only for 5-m metallic fairing

mm (in.)

EELV Standard Interface

Figure 5-2. Delta IV 5-m Second-Stage Payload Attachment Configurations

springs can be located to accommodate specific customer requirements. Selection of an appropriate PAF should be coordinated with Delta Launch Services as early as possible.

5.2.1 1666-mm (66-in.) Payload Interface—1666-4 and 1666-5 PAFs

The Delta IV 1666-mm (66-in.) PAF for both the 4-m and 5-m composite fairings are derivatives of the Delta III 1666-4 payload attach fitting and provide a Marmon-type clampband separation system with separation spring actuators. The Delta IV 1666-4 PAF is shown in Figures 5-3 and 5-4, and the 1666-5 PAF is shown in Figure 5-5.

5.2.2 1194-mm (47-in.) Payload Interface—1194-4 and 1194-5 PAFs

Like the Delta IV 1666-4 and 1666-5 PAFs, the 1194-mm (47-in.) PAFs are derivatives of the Delta III 1194-4 payload attach fitting, providing a Marmon-type clampband separation system

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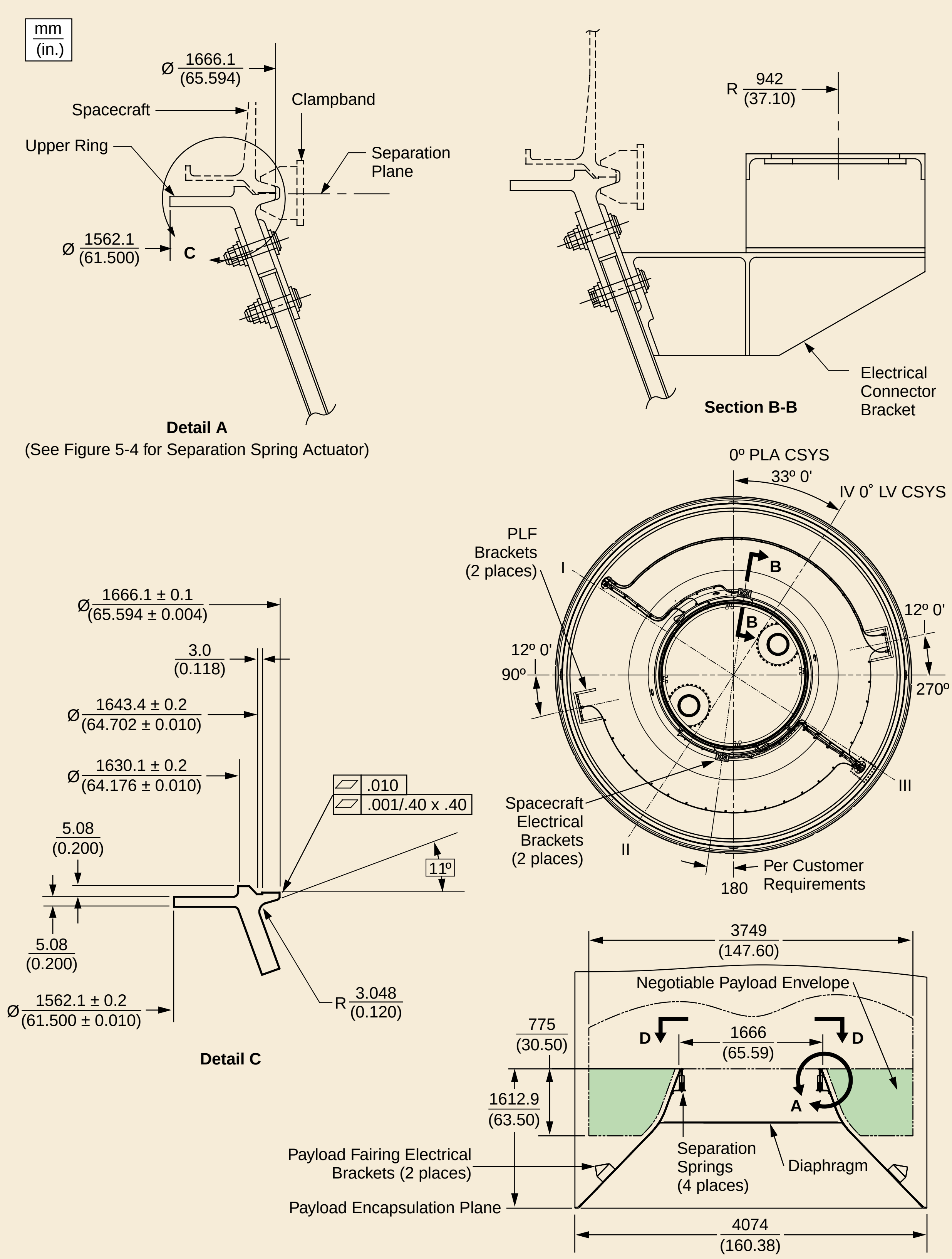

Figure 5-3. Delta IV 1666-4 PAF

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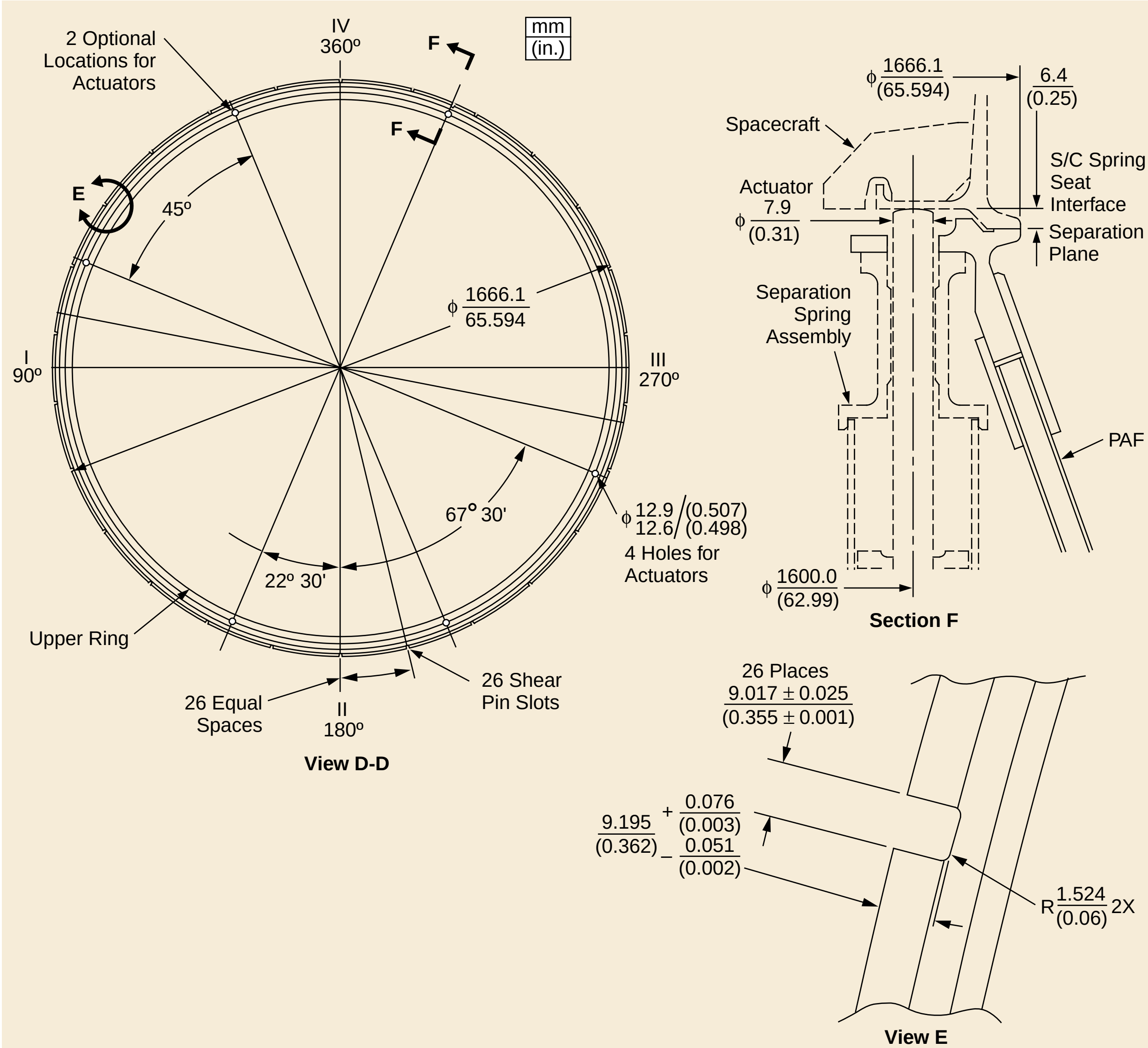

Figure 5-4. 1666-4 PAF Separation Spring Assembly and Shear Slot Detail

with separation spring actuators. Details of the 1194-4 PAF are provided in Figures 5-6 and 5-7, and details of the 1194-5 PAF are shown in Figure 5-8.

5.2.3 937-mm (37-in.) Payload Interface—937-4 and 937-5 PAFs

The 937-mm (37-in.) PAFs provide a Marmon-type clampband separation system with separation spring actuators similar to what has been 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 5-9, and the 5-m composite fairing version, or 937-5 PAF, is shown in Figure 5-10.

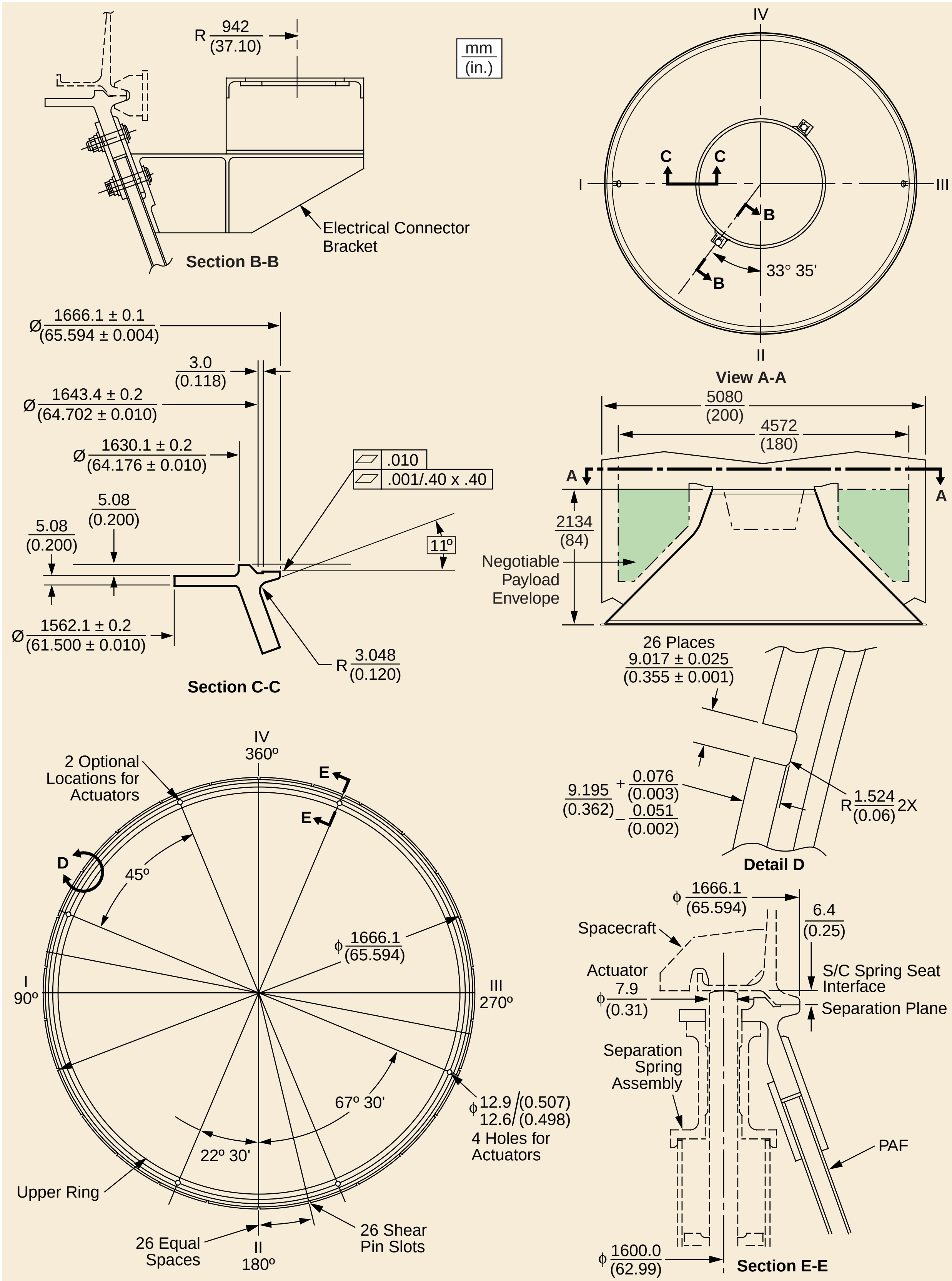

Figure 5-5. Delta IV 1666-5 PAF

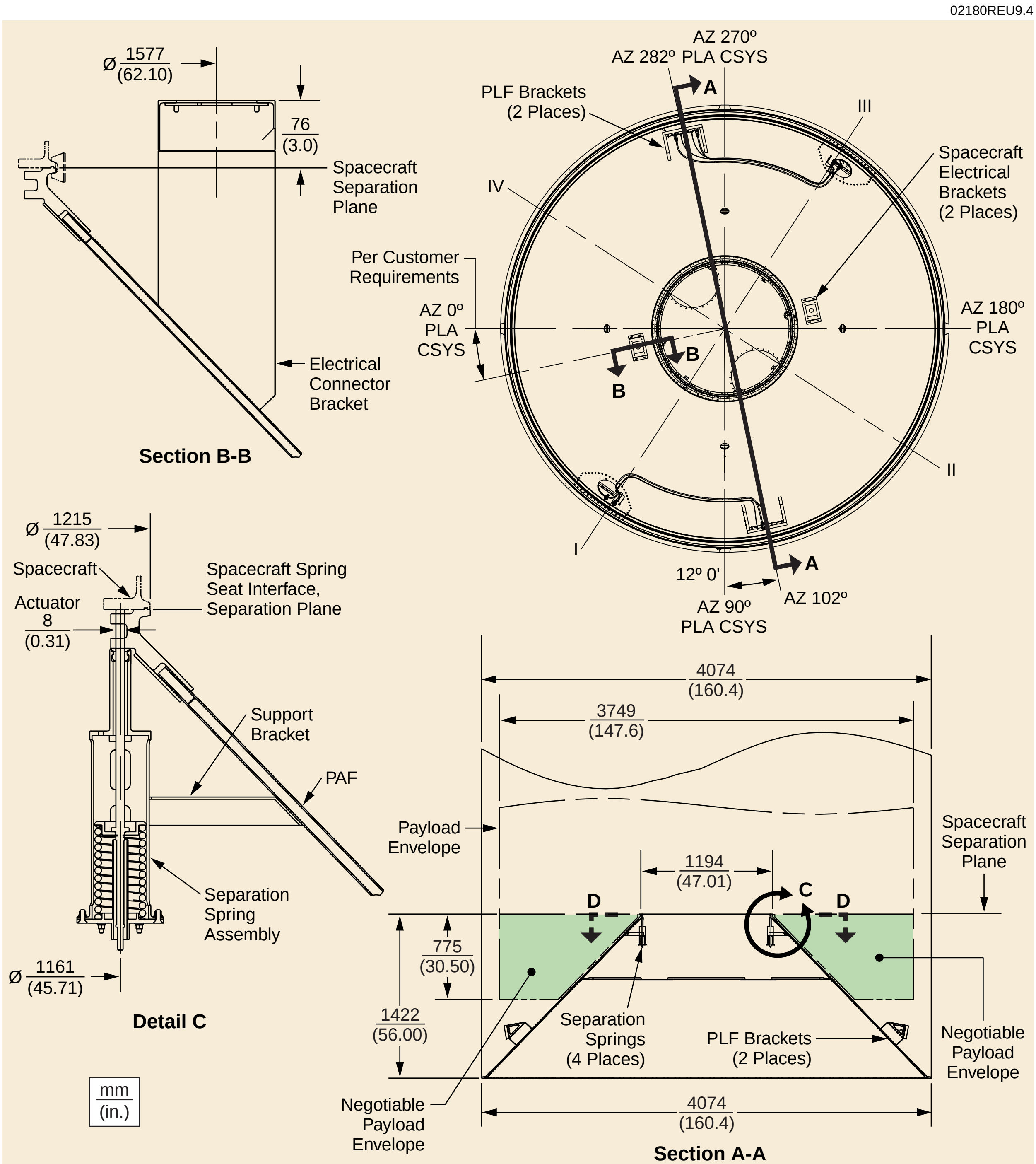

Figure 5-6. Delta IV 1194-4 PAF

5.2.4 1664-mm (66-in.) Payload Interface—1664-4 and 1664-5 PAFs

The 1664-mm PAFs provide a four-point, bolted separation system similar to what has been successfully flown on the Delta II program. The PAF also 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 5-11 and 5-12, respectively.

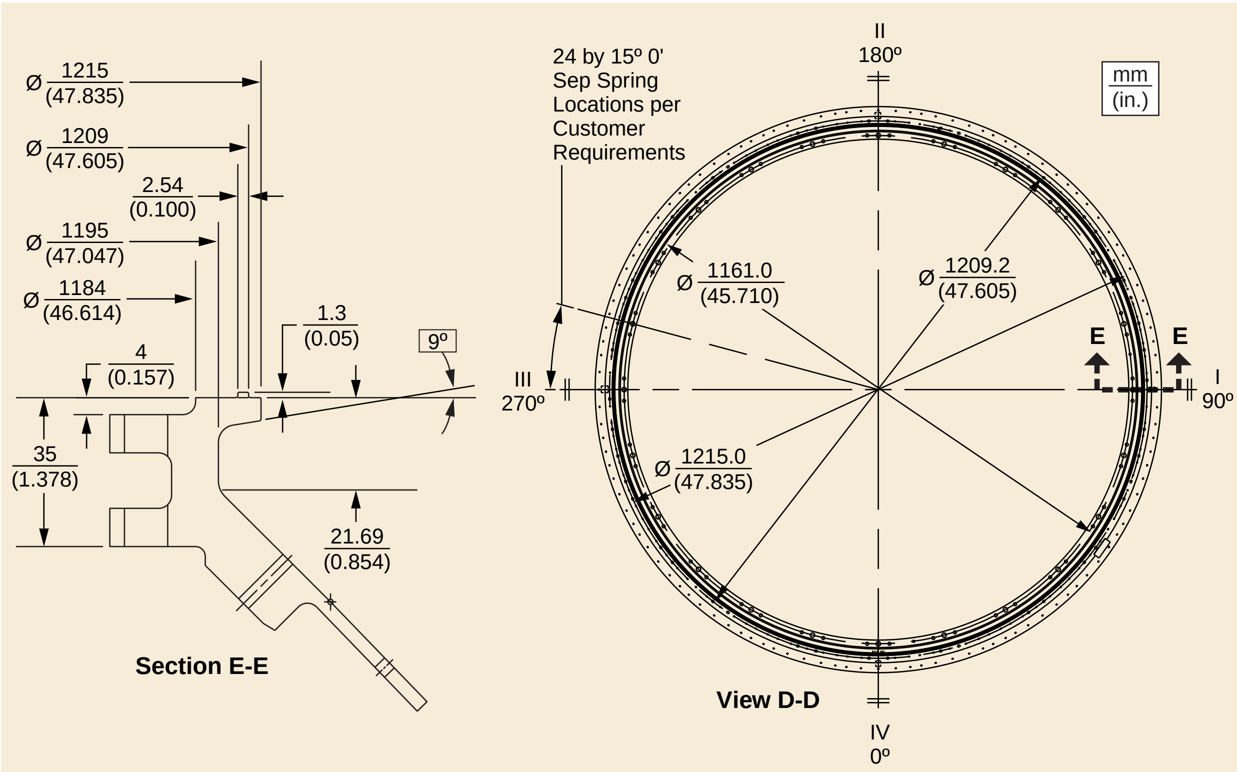

Figure 5-7. Delta IV 1194-4 PAF

The bolted payload interfaces for the Delta IV launch vehicle provide different payload interface diameters for the 4-m and 5-m PAFs. The 4-m offers a 1575-mm interface and the 5-m offers a larger 4394-mm interface dia. These fixed interfaces are intended to mate with a customer-provided separation system and/or payload adapter. Should the customer require Boeing to supply a separation system and/or mating adapter, this can be arranged by contacting Delta Launch Services.

5.2.5 1575-4 PAF

For the 4-m composite fairing, the 1575-4 PAF provides a standard 121-bolt mating interface to the payload at a 1575-mm (62.01 in.) dia. See Figures 5-13 and 5-14 for details.

5.2.6 4394-5 PAF

For the 5-m metallic fairing, the 4394-5 PAF uses an 18-point, 72-bolt interface pattern with a 4394-mm (173-in.) dia. Unlike other Delta IV PAFs, the 4394-5 PAF uses a heritage truss structure design that offers a higher stiffness-to-weight ratio for the larger interface diameter than the conic shell design. See Figure 5-15 for details.

5.2.7 Payload Mass vs Center-of-Gravity Location Capabilities

Figures 5-16 and 5-17 provide the estimated capabilities for certain 4-m and 5-m PAFs. The capabilities are plotted in terms of payload mass and center-of-gravity (CG) location above the

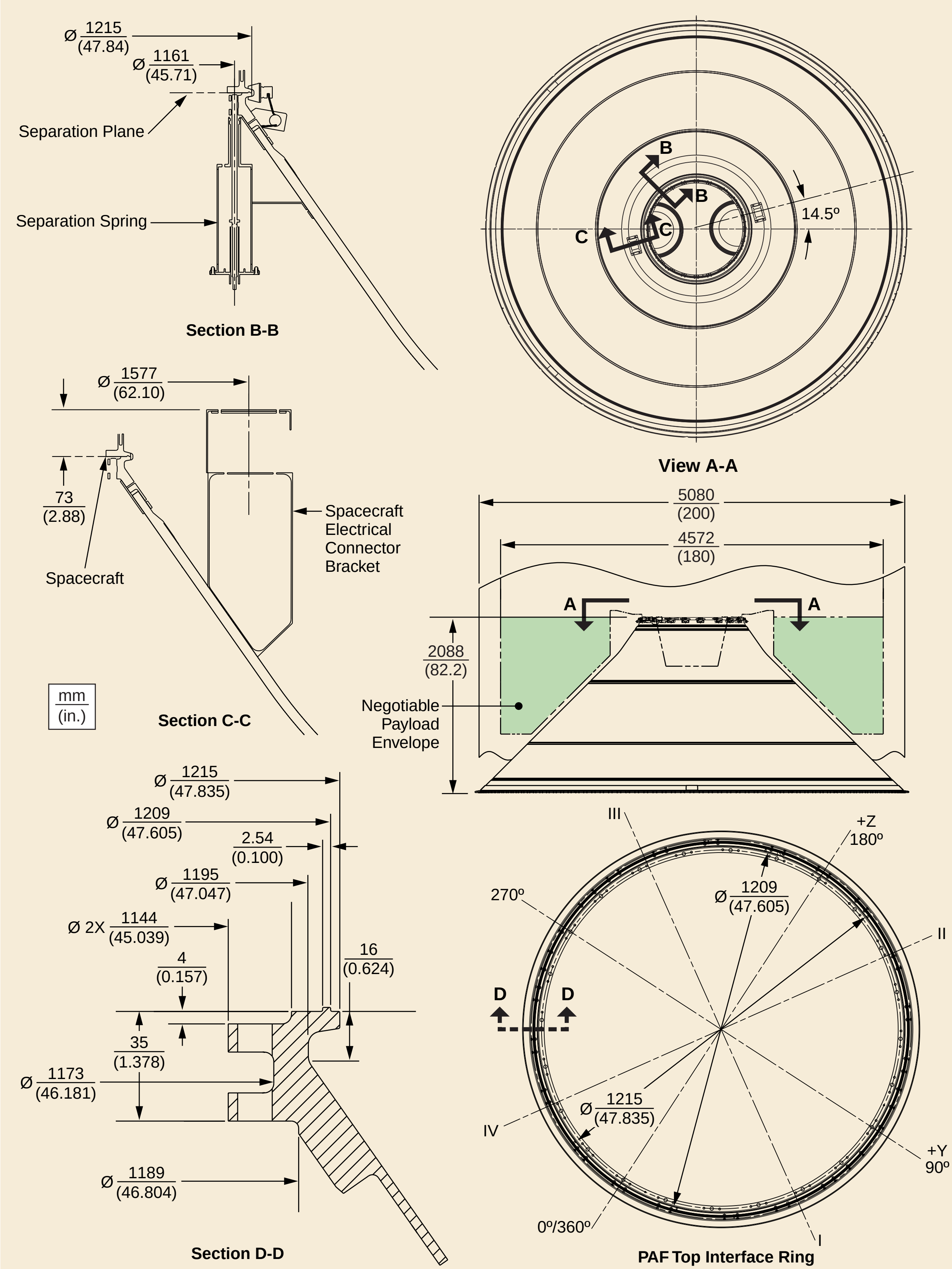

Figure 5-8. Delta IV 1194-5 PAF

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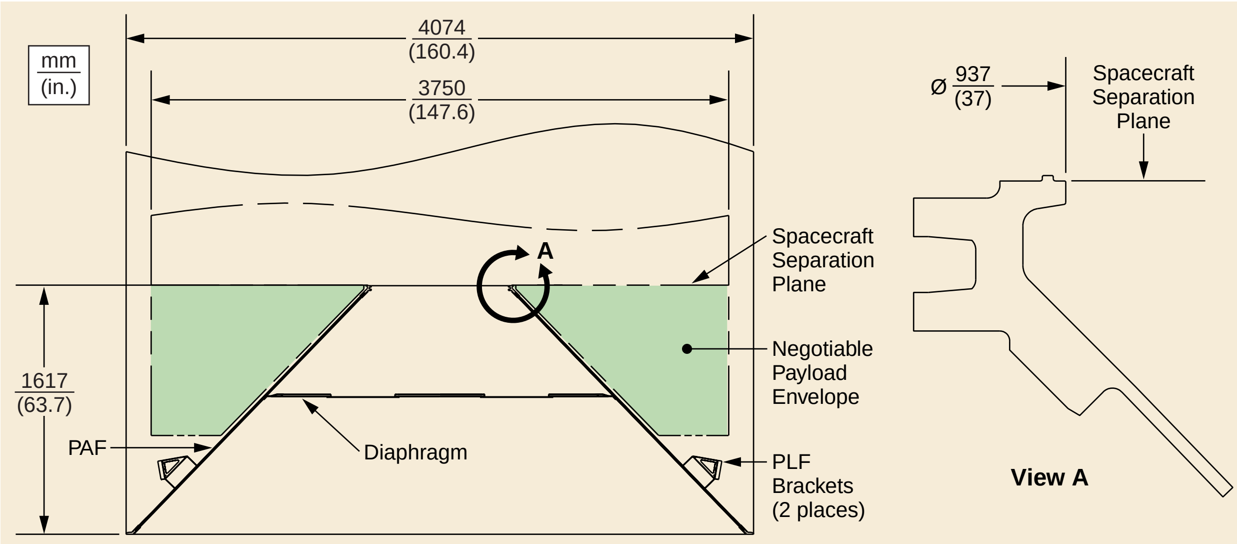

Figure 5-9. Delta IV 937-4 PAF

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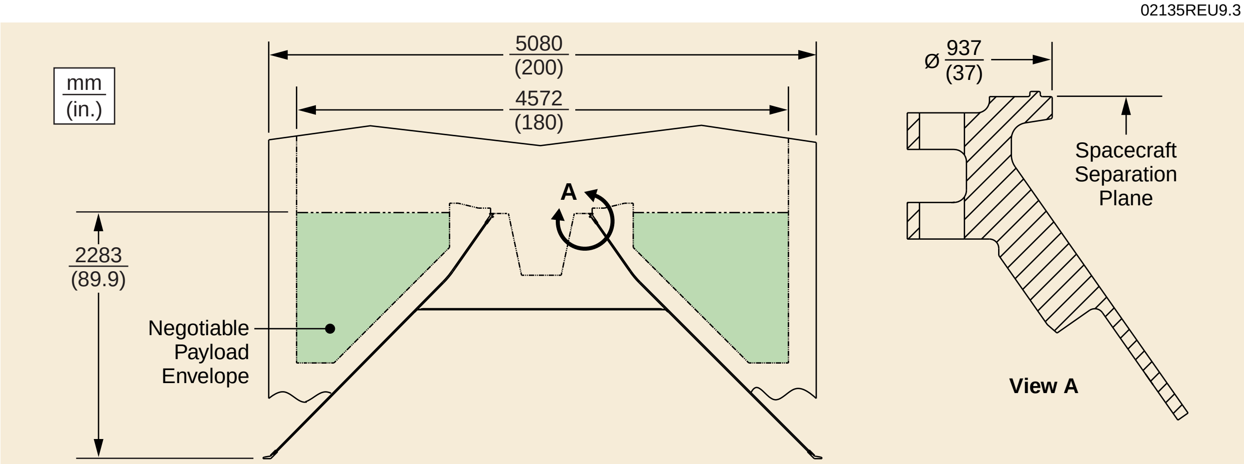

Figure 5-10. Delta IV 937-5 PAF

payload interface plane and are based upon extrapolation of analytical results for generic payloads. Therefore, when the payload configuration is determined, The mission integration manager will initiate a coupled loads analysis to verify that the structural capability of both the payload and launch vehicle is not exceeded.

5.2.8 Other Payload Attach Fittings

Any user having a unique interface incompatible with the Delta IV 5-m PAFs discussed in this section should contact Delta Launch Services for more options. Other requirements may also be accommodated through coordination with Delta Launch Services.

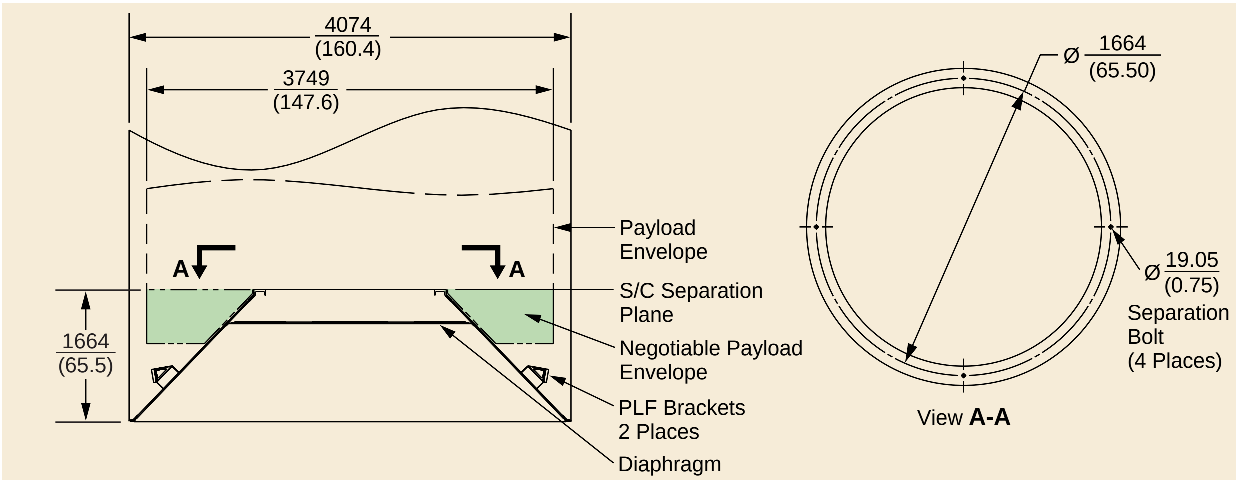

Figure 5-11. Delta IV 1664-4 PAF

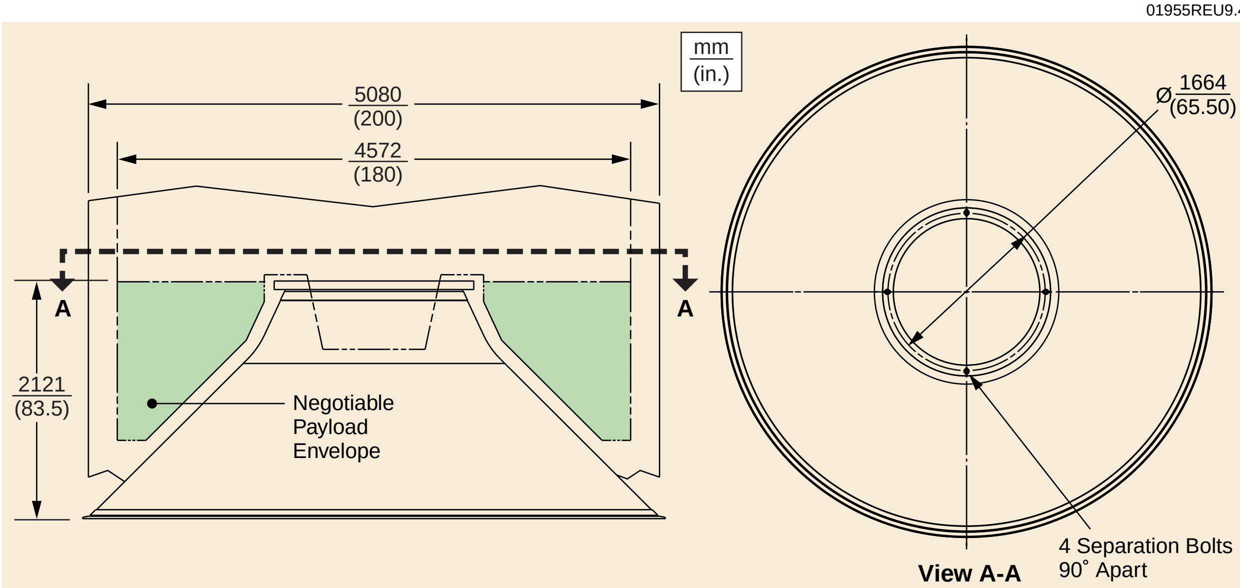

Figure 5-12. Delta IV 1664-5 PAF

5.3 DELTA IV ELECTRICAL INTERFACES

The standard electrical interfaces with the payload are identical for all Delta IV configurations and for either launch site. The interface is defined at the standard electric interface panel (SEIP) on the PAF. 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.

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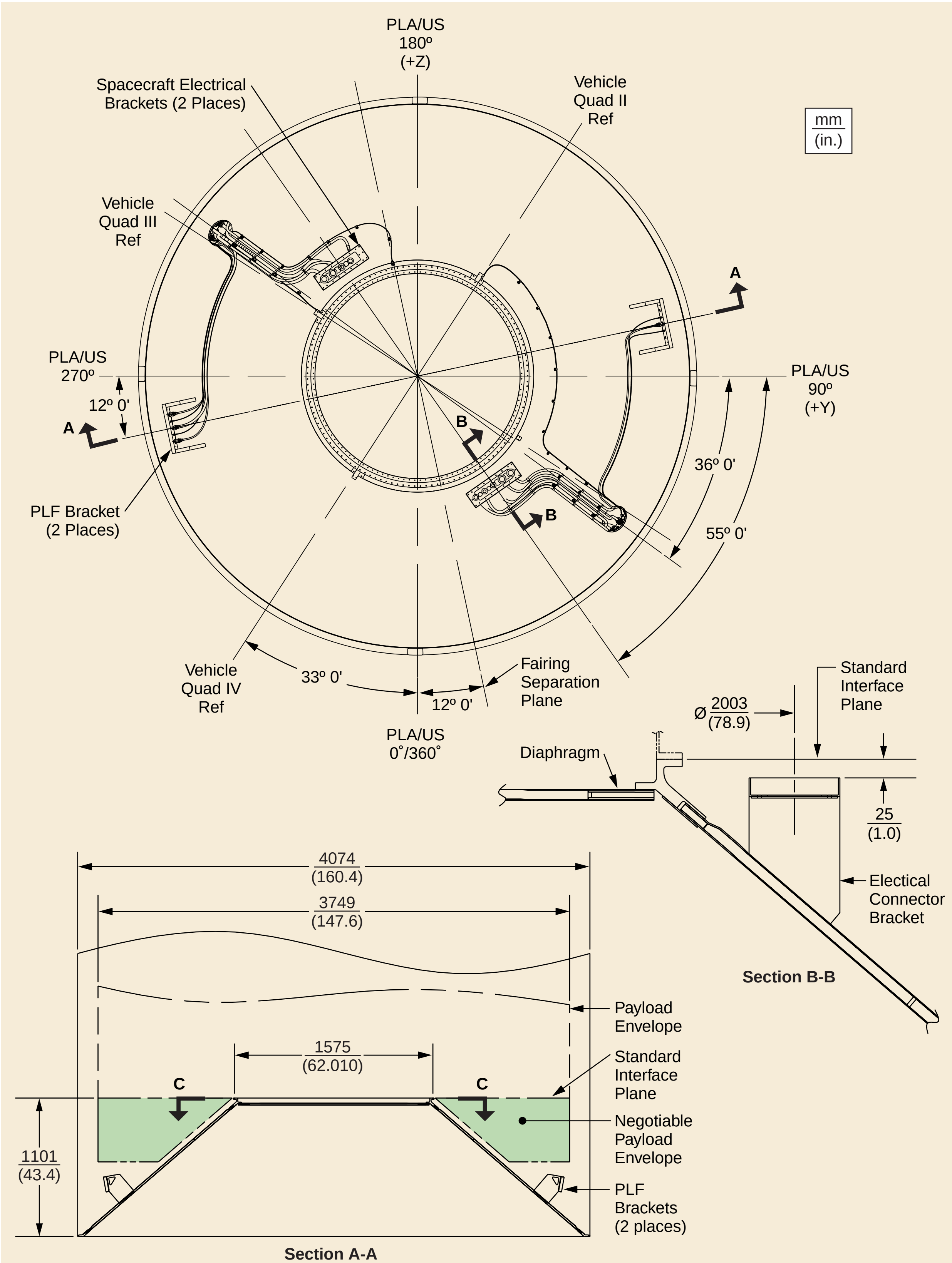

Figure 5-13. Delta IV Evolved Expendable Launch Vehicle 1575-4 PAF

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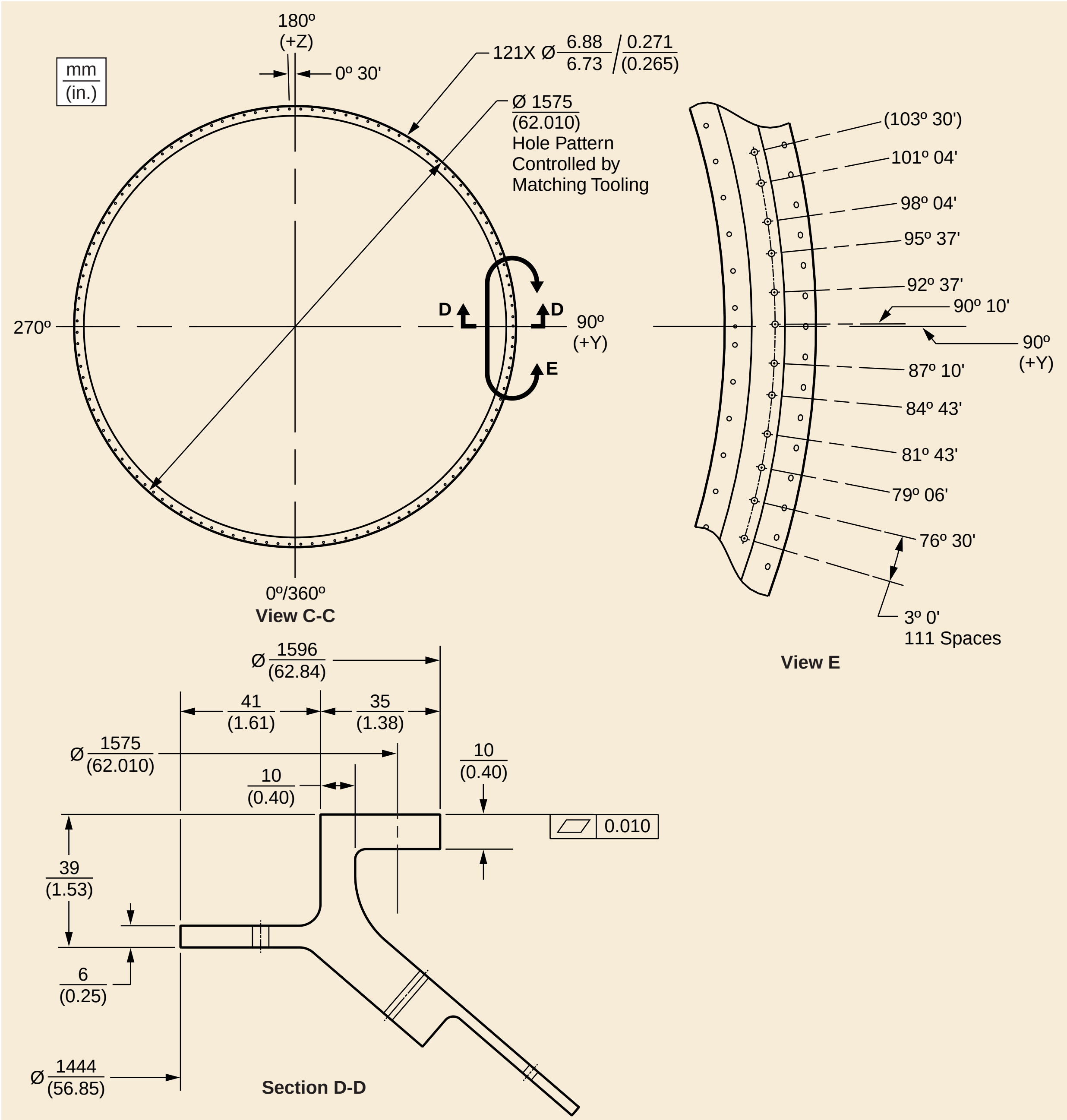

Figure 5-14. Delta IV EELV 1575-4 PAF

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 Table 5-1.

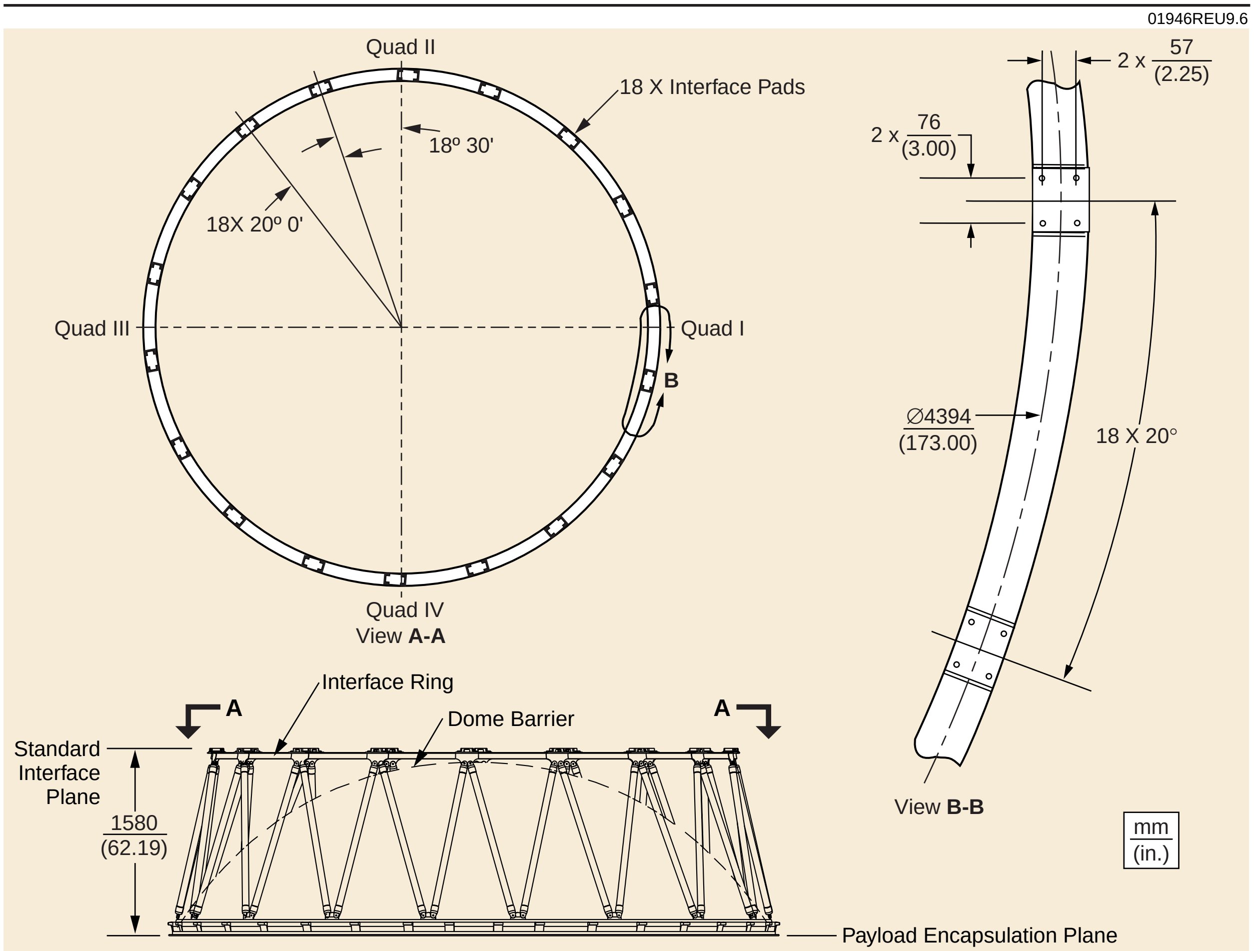

Figure 5-15. Delta IV EELV 4394-5 PAF

(Note that it is not the intent of this document to identify all electrical interface requirements. For example, applicable grounding and isolation requirements have not been included.)

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 Boeing 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, 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. Twelve 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 11 A per pair (at 126 VDC maximum). Another 60 twisted pairs of data/control/monitoring

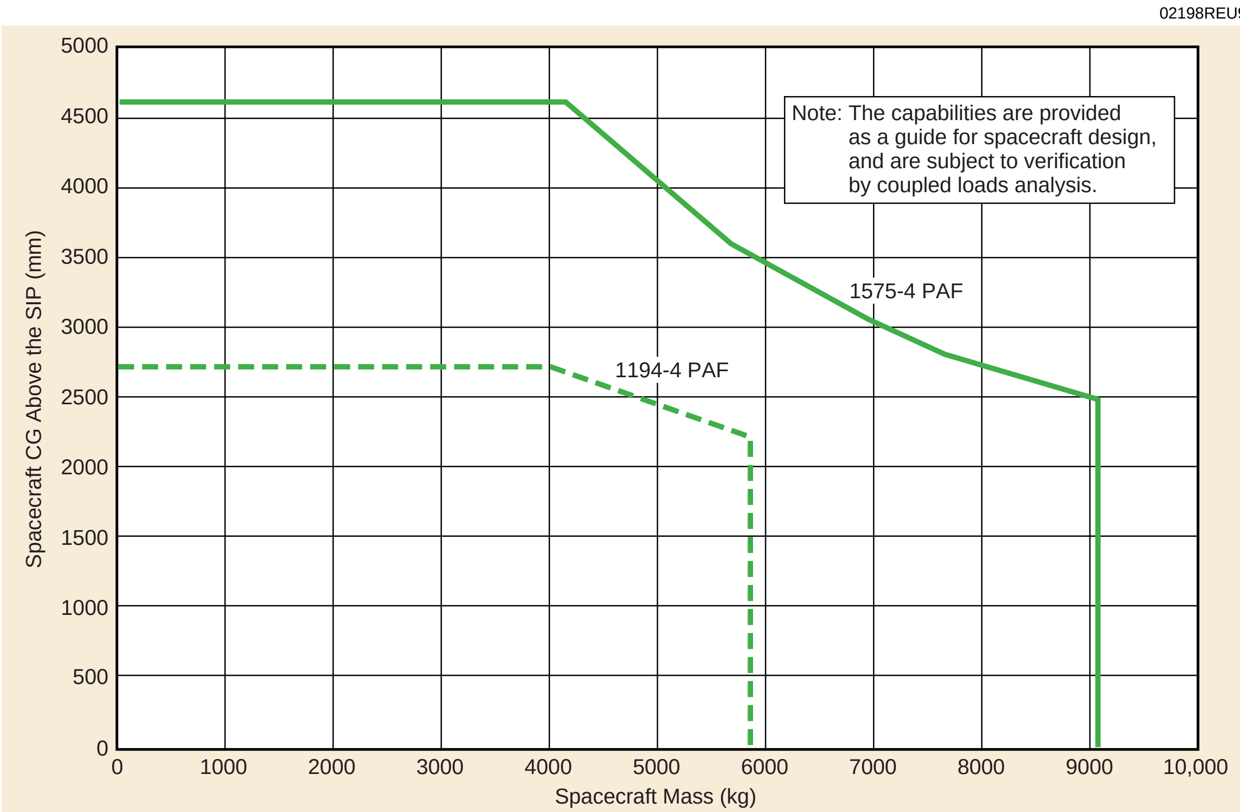

Figure 5-16. 4-m PAF Spacecraft Center of Gravity vs Mass Capability

Table 5-1. Electrical Interface Signal Functions

Signal function	Signal quantity	Wire count	Max current	Max voltage
Ground-to-spacecraft functions				
Ground power	12 pairs	24	11 A	126 VDC
Data/command/monitoring	60 pairs	120	3 A	126 VDC
Launch-vehicle-to-spacecraft functions				
Ordnance discretes	8 redundant pairs	32	18 A	36 VDC
28 VDC command discretes or switch closures	8 redundant pairs	32	500 mA 100 mA	33 VDC 32 VDC
Breakwire separation monitors	1 redundant pair	4	--	--
Telemetry channels (data and clock)	2	8	--	--

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, monitoring self-test, etc.

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 µs
Maximum load current:	20 kVA

Note: 50-Hz power can be provided through coordination with Delta Launch Services.

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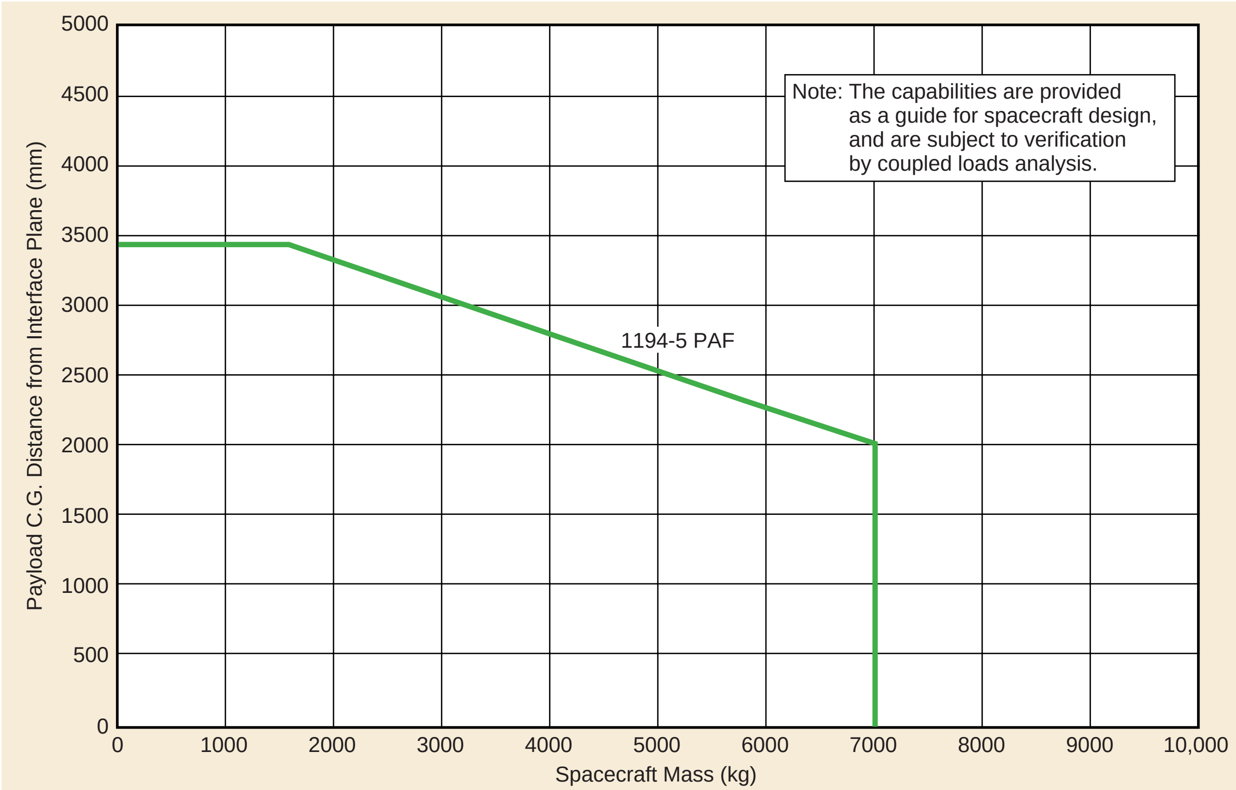

Figure 5-17. 5-m PAF Spacecraft Center of Gravity vs Mass Capability

5.3.2 Launch-Vehicle-to-Payload Functions

The standard electrical interface provides for four functions while in flight as described in Sections 5.3.2.1, 5.3.2.2, 5.3.2.3, and 5.3.2.4.

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 (EED) provided by the payload (or dispenser system).

Each circuit will provide (one time only) a minimum of 5 A into a 0.9- to 2.0-Ω load (wiring and one EED) with a duration of 40 ± 10 ms and is current-limited to 18 A. Each pair of circuits (the primary and the redundant) will be turned ON either within 5 ms of each other or within 80 ± 10 ms, 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 to be either 28-VDC command discretes or switch closures, depending on customer needs (all circuits must be configured in the same way).

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, but each commanded duration must be between 20 ms and 10 sec. Hence, each circuit may not be ON for a cumulative time of greater than 50 sec.

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 2 kBps of data, but not both at the same time.

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. TBD

5.3.4 Customer Wiring Documentation

To ensure proper attention to the customer's needs, information regarding customer wiring documentation, which is contained in Section 8, Table 8-4, Delta IV Spacecraft Questionnaire, 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 Station, (CCAS) Florida. Delta IV prelaunch processing and spacecraft operations conducted prior to launch are presented.

6.1 ORGANIZATIONS

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

Boeing has an established interface with the USAF 45th Space Wing 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 Boeing, based on inputs from the spacecraft contractor, 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 coordinator from the Boeing CCAS 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 and test conductor in the launch control center during the countdown and launch. Boeing interfaces with NASA at Kennedy Space Center (KSC) through the Expendable Launch Vehicle and Payload Carriers Program Office. NASA designates a launch service integration manager who arranges all of the support requested from NASA for a launch from CCAS.

Boeing also has an established working relationship with Astrotech Space Operations. 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 by Boeing for the customer.

6.2 FACILITIES

In addition to the facilities required for the Delta IV launch vehicles, specialized payload processing facilities (PPFs) listed below are provided for checkout and preparation of government

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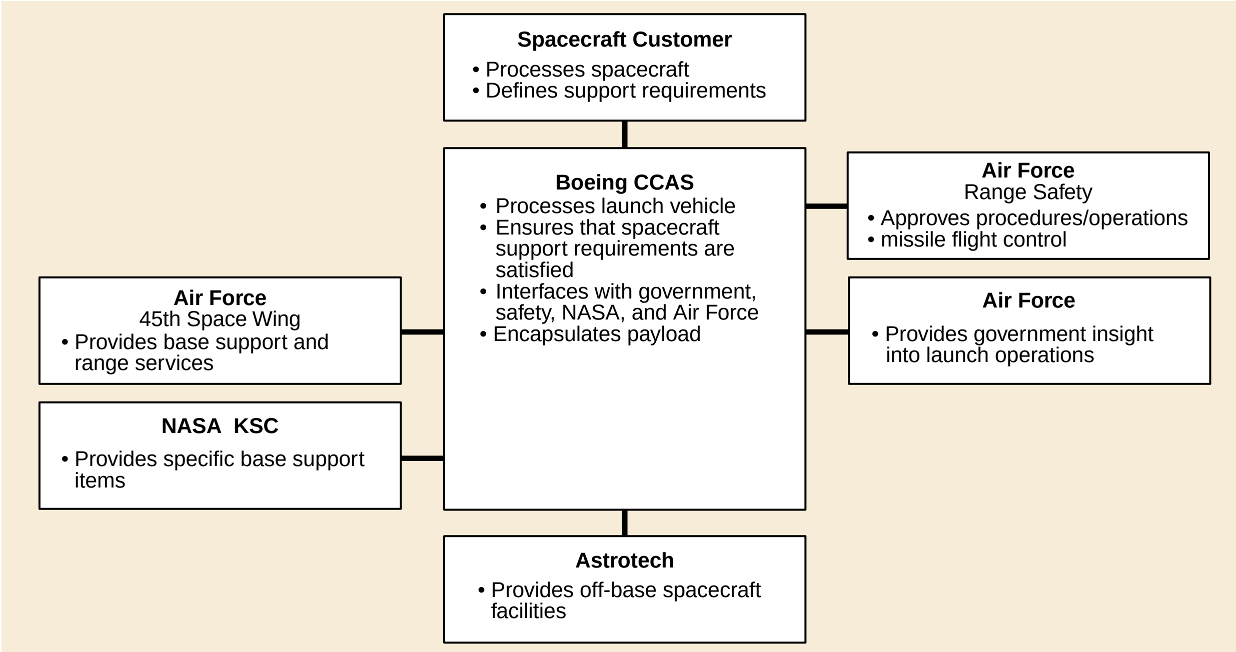

Figure 6-1. Organizational Interfaces for Commercial Users

and commercial spacecraft. Laboratories, clean rooms, receiving and shipping areas, hazardous operations areas, offices, etc., are provided for use by payload project personnel.

Offline encapsulation of fueled payloads is a key element of the Delta IV program. Boeing conducted a study to define existing USAF, NASA, and commercial facilities where this could be accomplished without a facility modification. Details of this study are presented in Section 6.2.1. The Boeing study revealed the following at the Eastern Range:

USAF Facilities

- Defense Satellite Communications 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).

In the following paragraphs, detailed information is presented on the NASA SAEF-2 and commercial ASO facilities. Users guides for the other PPFs listed can be provided upon request.

Commercial spacecraft will normally be processed through the Astrotech facilities. Other 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 is provided by the spacecraft contractor-selected processing facility with assistance from Boeing. 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 and 6-3). This facility includes 7,400 m^2 (80,000 ft^2) of industrial space constructed on 15.2 hectares (37.5 acres) of land.

There are eight major buildings on the site, as shown in Figure 6-4.

A general description of each facility is given below. For additional details, a copy of the Astrotech Facility Accommodation Handbook is available.

Building 1/1A, the nonhazardous payload processing facility (PPF), is used for final assembly and checkout of the payload. It houses payload clean-room high bays, control rooms, and offices.

Building 2, the hazardous processing facility (HPF), houses three explosion-proof high bays for hazardous operations including liquid propellant and solid rocket motor handling, and spin balancing, and two bays for payload attach fitting (PAF)/payload fairing preparations, and payload encapsulation.

Building 3, the environmental storage facility, provides six secure, air-conditioned, masonry-constructed bays for storage of high-value hardware or hazardous materials.

Building 4, the warehouse storage facility, provides covered storage space for shipping containers, hoisting and handling equipment, and other articles not requiring environmental control.

Building 5, the owner/operator office area, is an executive office building that provides spacecraft project officials with office space for conducting business during their stay at Astrotech and the Eastern Range.

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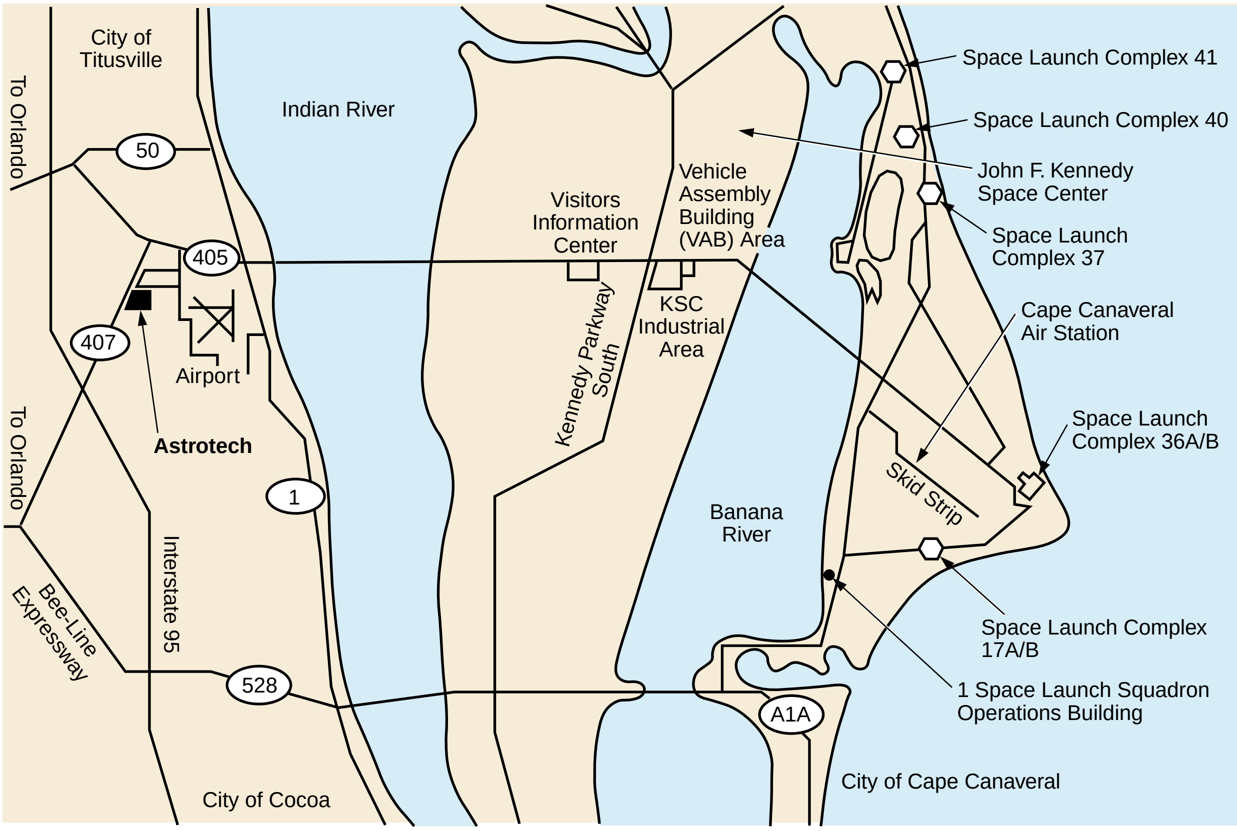

Figure 6-2. Astrotech Site Location

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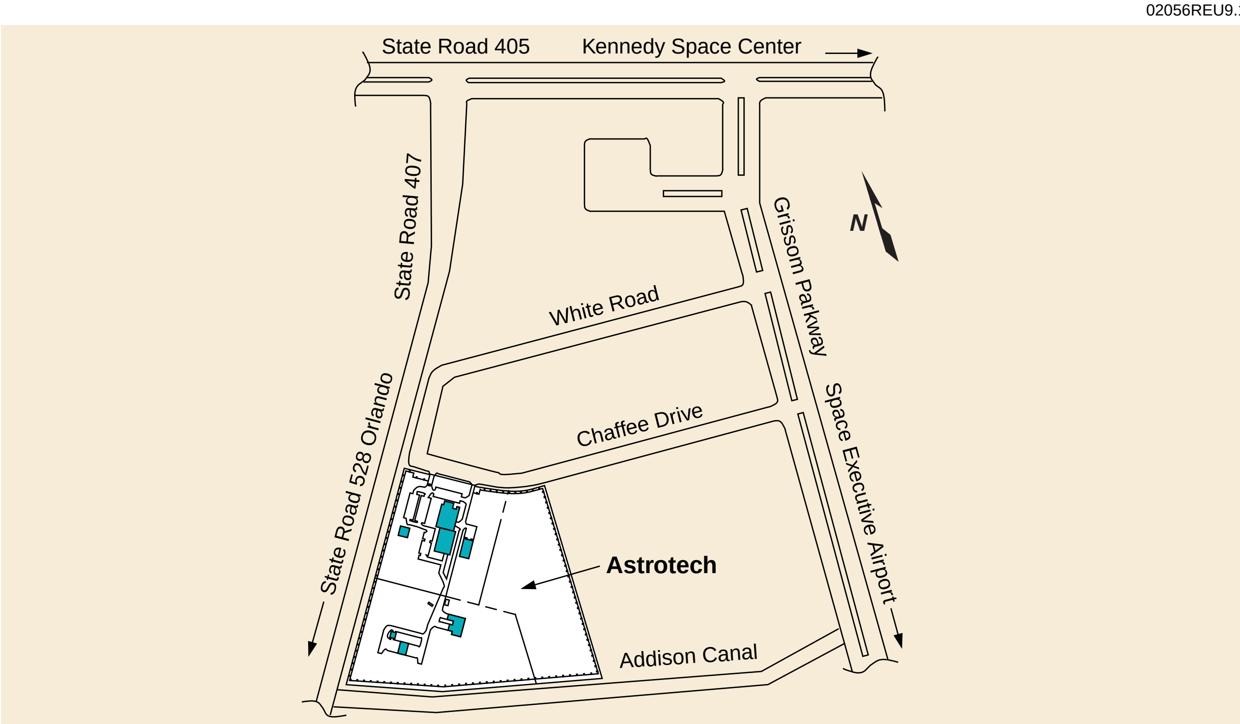

Figure 6-3. Astrotech Complex Location

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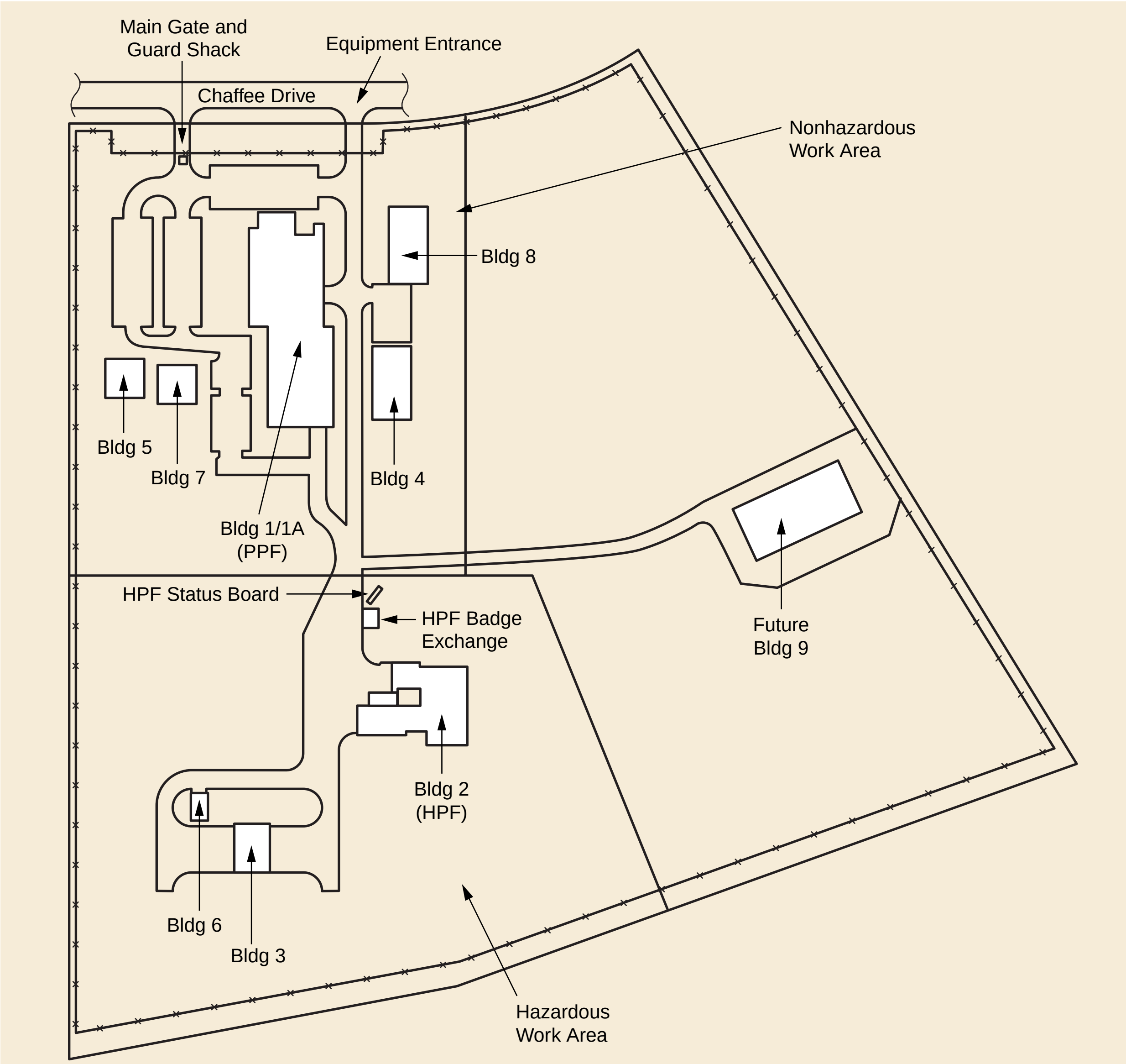

Figure 6-4. Astrotech Building Locations

Building 6, the fairing support facility, provides covered storage space for launch vehicle hardware and equipment, and other articles not requiring environmental control.

Building 7, the Boeing office area, provides Delta IV personnel with office space during the term of contract.

Building 8, the launch operations storage building.

Building 9, the Delta IV payload processing facility, is a dedicated satellite-preparation and -encapsulation facility being built by ASO to support Delta IV satellite customers.

6.2.1.1 Astrotech Building 1/1A (PPF). Building 1/1A has overall plan dimensions of approximately 113 m by 34 m (370 ft by 110 ft) and a maximum height of approximately 18 m

(60 ft). Major features are two airlocks, four high bays with control rooms, and an office complex. The airlocks and high bays are class 100,000 clean rooms, with the ability to achieve class 10,000 or better cleanliness levels using strict operational controls. They have floor coverings made of an electrostatic-dissipating (high-impedance) epoxy-based material. The ground-level floor plan of building 1/1A is shown in Figure 6-5, and the upper-level floor plan is shown in Figure 6-6.

6.2.1.1.1 Building 1 (PPF). The airlock in building 1 has a floor area measuring 9.1 m by 36.6 m (30 ft by 120 ft) and a clear vertical ceiling height of 7.0 m (23 ft). It provides

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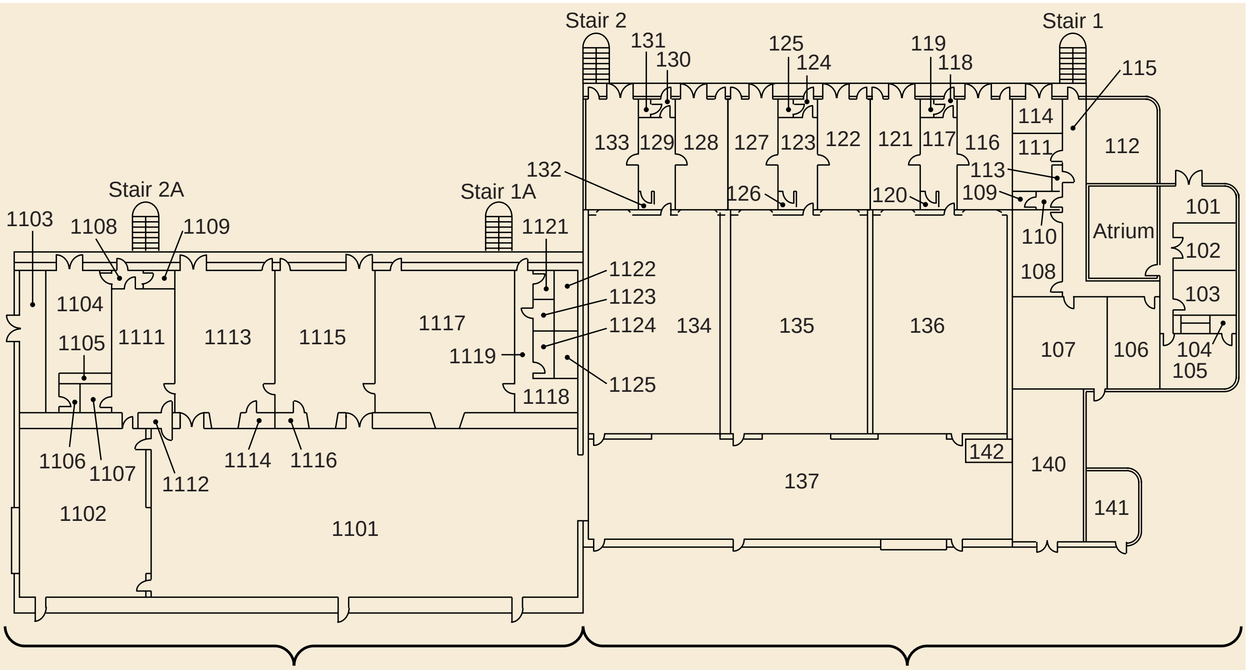

Building 1A		Building 1	
1101 Large High Bay D	1113 Control Room D2	101 ASO Reception Area	122 Control Room B1
1102 Large Airlock	1114 Equipment Room	102 ASO Repro/Fax	123 Change Room B
1103 Mechanical Room	1115 Control Room D1	103 ASO Staff Office	124 Vestibule B
1104 Soundproof Conference Room D1	1116 Equipment Room	104 ASO Office Restroom	125 Storage B
1105 Closet	1117 Office Area D1	105 ASO Staff Office	126 Restroom B
1106 Restroom	1118 Break Room	106 ASO Staff Office	127 Control Room B2
1107 Restroom	1119 Corridor	107 ASO Staff Office	128 Control Room C1
1108 Vestibule	1120 Not Used	108 Conference Room	129 Change Room C
1109 Janitor Storage	1121 Mens Washroom	109 Womens Restroom	130 Vestibule C
1110 Not Used	1122 Mens Restroom	110 Womens Lounge	131 Storage C
1111 Change Room D	1123 Janitor Closet	111 Mens Restroom	132 Restroom C
1112 Air Shower	1124 Womens Washroom	112 Break/Lunch Room	133 Control Room C2
	1125 Womens Restroom	113 Janitor Closet	134 High Bay C
		114 ASO Machine Shop	135 High Bay B
		115 Corridor	136 High Bay A
		116 Control Room A1	137 Common Airlock
		117 Control Room A	138 Not Used
		118 Vestibule A	139 Not Used
		119 Storage A	140 Mechancial Room
		120 Restroom A	141 Electrical Vault
		121 Control Room A2	142 Telephone Room

Figure 6-5. First-Level Floor Plan, Building 1/1A (PPF), Astrotech

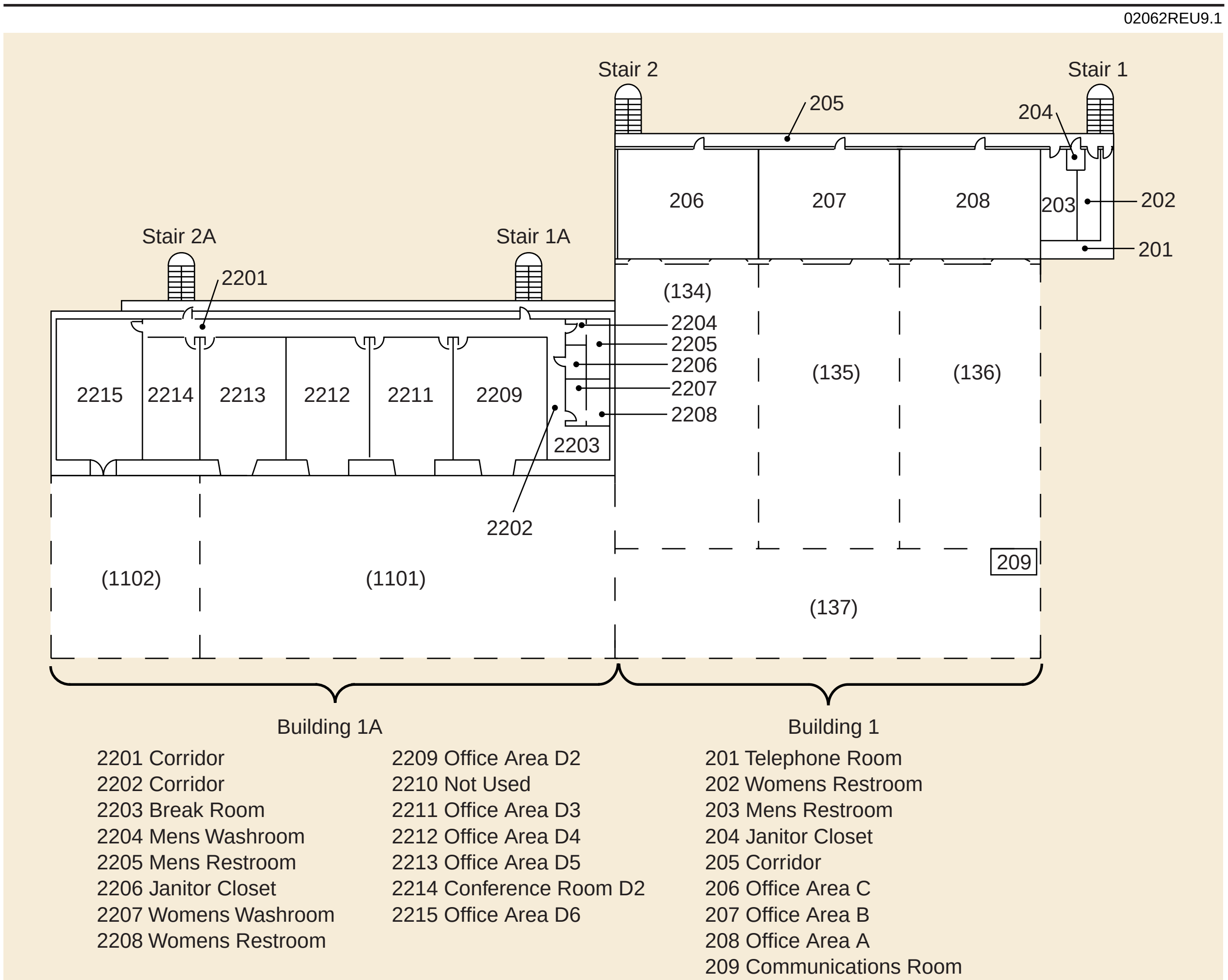

Figure 6-6. Second-Level Floor Plan, Building 1/1A (PPF), Astrotech

environmentally controlled external access to the three high bays, and interconnects with building 1A. There is no overhead crane in the airlock. Three radio frequency (RF) antenna towers are located on the roof of the airlock. Each of the three high bays in building 1 has a floor area measuring 12.2 m by 18.3 m (40 ft by 60 ft) and a clear vertical ceiling height of 13.2 m (43.5 ft). Each high bay has a 9072-kg (10-ton) overhead traveling bridge crane with a maximum hook height of 11.3 m (37 ft).

There are two adjacent control rooms for each high bay. Each control room has a floor area measuring 4.3 m by 9.1 m (14 ft by 30 ft) with a 2.7-m (8.9-ft) ceiling height. A large exterior door is provided in each control room to facilitate installation and removal of equipment. Each control room has a large window for viewing activities in the high bay.

Garment rooms provide personnel access to, and support, the high-bay areas. Limiting access to the high bays through these rooms helps control personnel traffic and maintains a clean-room environment.

Office accommodations for spacecraft project personnel are provided on the upper floor of building 1 (Figure 6-6). This space is conveniently located near the spacecraft processing area and contains windows for viewing activities in the high bay.

The remaining areas of building 1 contain the Astrotech offices and shared support areas including break room, supply/photocopy room, restroom facilities, and a 24-person conference room.

6.2.1.1.2 Building 1A. In addition to providing access through the building 1 airlock, building 1A contains a separate airlock that is an extension of the high bay and provides environmentally controlled external access. The airlock has a floor area measuring 12.2 m by 15.5 m (40 ft by 51 ft) and a clear vertical ceiling height of 18.3 m (60 ft). The airlock is a class 100,000 clean room. External access for payloads and equipment is provided through a large exterior door.

The exterior wall of the airlock adjacent to the exterior overhead door contains a 4.3-m by 4.3-m (14-ft by 14-ft) RF-transparent window that looks out onto a far-field antenna range that has a 30.5-m (100-ft)-high target tower located approximately 91.4 m (300 ft) downrange. The center of the window is 5.8 m (19 ft) above the floor.

The high bay has a floor area measuring 15.5 m by 38.1 m (51 ft by 125 ft) and a clear vertical ceiling height of 18.3 m (60 ft). The high bay and airlock share a common 27 215-kg (30-ton) overhead traveling bridge crane with a maximum hook height of 15.2 m (50 ft). Personnel normally enter the high bay through the garment change room to maintain clean-room standards. The high bay is class 100,000.

Adjacent to the high bay are two control rooms. Each has a floor area measuring 9.1 m by 10.7 m (30 ft by 35 ft) with a 2.8-m (9.3-ft) ceiling height. Each control room has a large interior door to permit the direct transfer of equipment between the high bay and the control room; a large exterior door to facilitate installation and removal of equipment; and a large window for viewing activities in the high bay.

A garment room provides access for personnel and supports the high bay. Limiting access to the high bay through this room helps control personnel traffic and maintains a clean-room environment. Office accommodations for spacecraft project personnel are provided on the ground floor and upper floor of building 1A. This space is conveniently located near the spacecraft processing area and contains windows for viewing activities in the high bay.

The remaining areas of building 1A contain shared support areas, including break rooms, restroom facilities, and two 24-person conference rooms (one of which is a secured conference room designed for the discussion and handling of classified material).

6.2.1.2 Astrotech Building 2 (HPF). Building 2 has overall plan dimensions of 36.6 m by 36.6 m (120 ft by 120 ft) and a height of 14.0 m (46 ft). Major features are two airlocks, three high bays, and two control rooms. The airlocks and high bays have floor coverings made of electrostatic-dissipating (high-impedance) epoxy-based material. They are class 100,000 clean rooms, with the ability to achieve class 10,000 or better cleanliness levels using strict operational controls. The ground-level floor plan of building 2 is shown in Figure 6-7.

The south airlock provides environmentally controlled access to building 2 through the south high bay. The south airlock has a floor area measuring 8.8 m by 11.6 m (29 ft by 38 ft) and a clear vertical ceiling height of 13.1 m (43 ft). There is no overhead crane in the south airlock.

The north airlock provides environmentally controlled access to building 2 through the north high bay and, if external building 2 access is restricted to the south airlock, it can be used as a fourth high bay. The north airlock has a floor area measuring 12.2 m by 15.2 m (40 ft by 50 ft) and a clear vertical ceiling height of 19.8 m (65 ft). The north airlock has a 27 215-kg (30-ton) overhead traveling bridge crane with a maximum hook height of 16.8 m (55 ft).

The north and south high bays are designed to support payload solid-propellant motor assembly and liquid monopropellant and bipropellant transfer operations. All liquid-propellant transfer operations take place within a 7.6 m by 7.6 m (25 ft by 25 ft) floor area surrounded by a trench system. It is sloped so that any major spill of hazardous propellants would drain into the emergency spill retention system. The north airlock is also configured for propellant loading. The center high bay contains an 8391-kg (18,500-lb) capacity dynamic balance machine designed to balance solid rocket motor upper stages and payload. Because the spin balance table equipment is below the floor level, other uses can be made of this bay. The spin balance machine control room is separate from the spin room for safety reasons. Television cameras are used for remote monitoring of spin room activities.

A control room is located next to each processing high bay to facilitate monitoring and control of hazardous operations. Visual contact with the high bay is through an explosion-proof glass window in the separating wall. Access to the high bay area from the control room is through the garment room while spacecraft processing operations are being conducted.

Adjacent to the south high bay, fuel and oxidizer cart storage rooms are provided with access doors to the high bay and exterior doors for easy equipment access. Garment rooms provide personnel access to, and support, the high bay areas. Limiting access to the high bays through these rooms helps control personnel traffic and maintains a clean-room environment.

6.2.1.3 Astrotech Building 3 (Environmental Storage Facility). The dimensions of building 3 (Figure 6-8) are 15.8 m by 21.6 m (52 ft by 71 ft). The building is divided into six storage bays, each with a clear vertical height of 8.5 m (28 ft). The bays have individual environmental control but are not clean rooms, which mandates that payloads be stored in suitable containers.

6.2.1.4 Astrotech Building 4 (Warehouse Storage Facility). Building 4 (Figure 6-9) is 18.9 m by 38.1 m (62 ft by 125 ft), with a maximum roof height of 9.1 m (30 ft). The major

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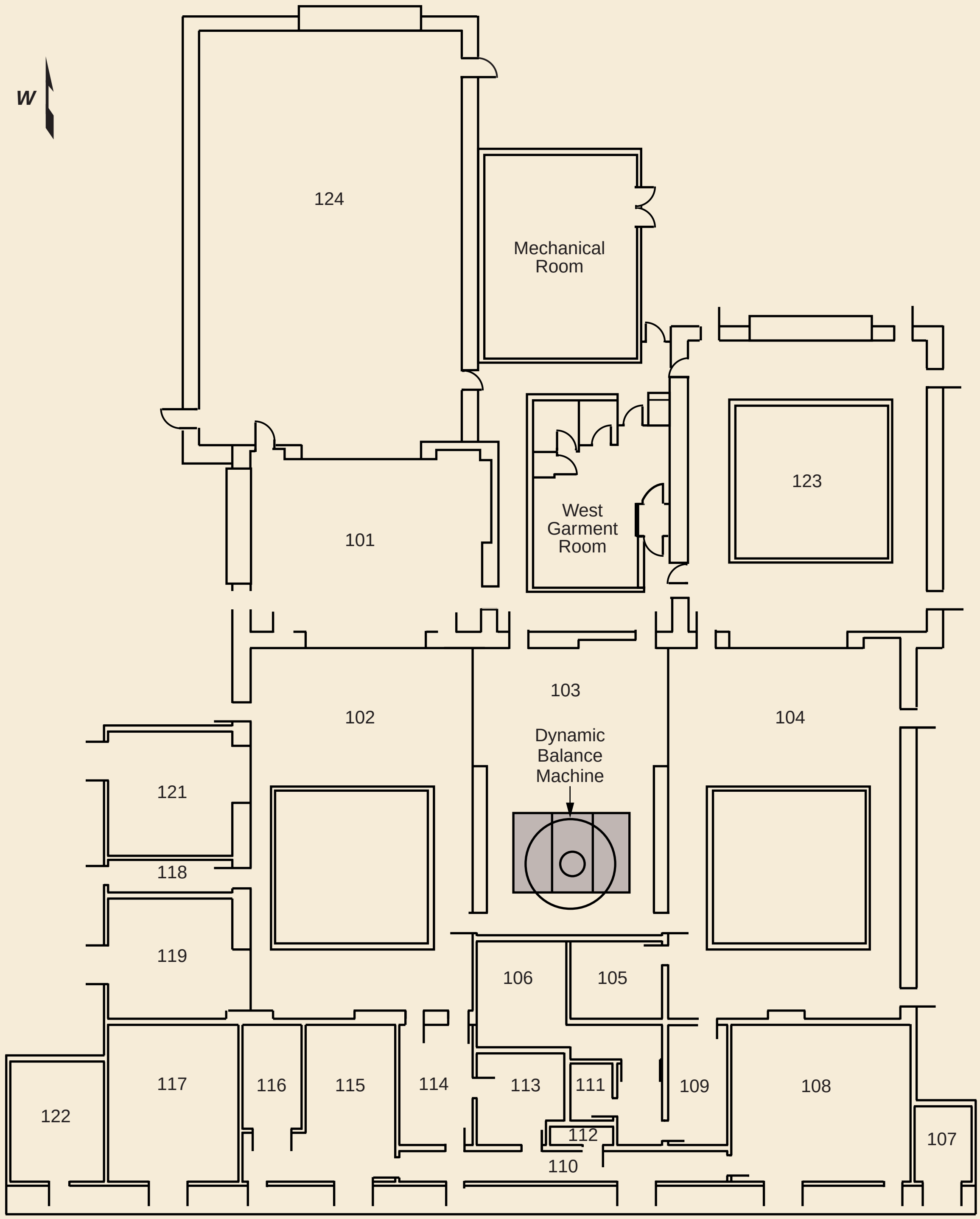

101 South Airlock	108 North Control Room	115 South Control Room	120 Not Used
102 South High Bay	109 North Change Room	116 Balance Machine Control Room	121 Fuel Cart Storage Room
103 Center High Bay	110 Corridor	117 Mechanical Room 1	122 Electrical Vault
104 North High Bay	111 Womens Restroom	118 Corridor	123 Building 2A – North Airlock High Bay
105 Office	112 Janitor	119 Oxidizer Cart Storage Room	124 South Encapsulation Bay
106 Mechanical Room 2	113 Mens Restroom		
107 Motor Generator Room	114 South Change Room		

Figure 6-7. Building 2 (HPF) Detailed Floor Plan, Astrotech

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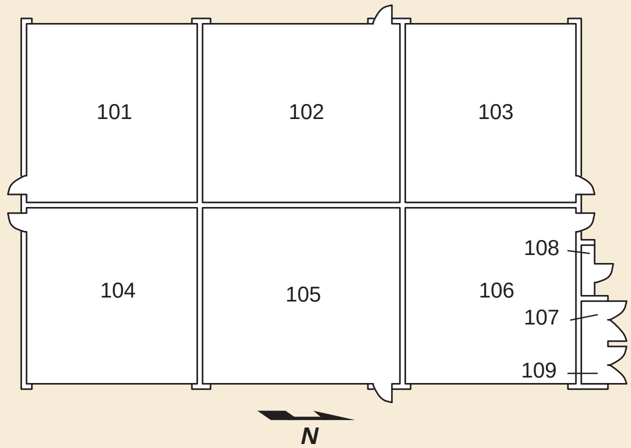

Figure 6-8. Building 3 Detailed Floor Plan, Astrotech

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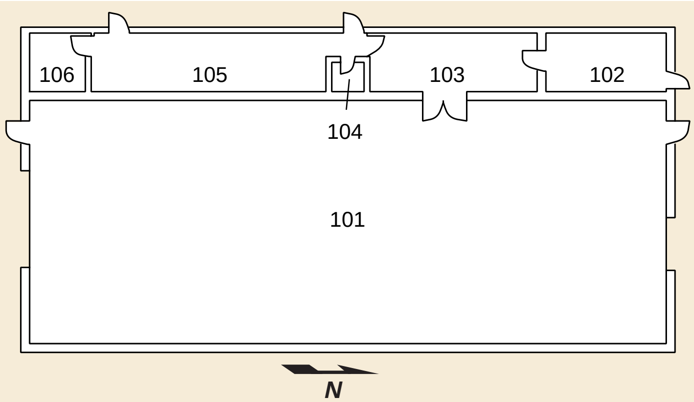

Figure 6-9. Building 4 Detailed Floor Plan, Astrotech

areas of building 4 are the warehouse storage area, bonded storage area, and Astrotech staff office area.

The main warehouse storage area measures 15.2 m by 38.1 m (50 ft by 125 ft) and has a clear vertical height that varies from 8.5 m (28 ft) along either sidewall to 9.7 m (32 ft) along the lengthwise centerline of the room. While the storage area is protected from the outside weather, there is no environmental control.

The bonded storage area is environmentally controlled and has a floor area measuring 3.6 m by 9.7 m (12 ft by 32 ft).

6.2.1.5 Astrotech Building 5 (Owner/Operator Office Area). Building 5 (Figure 6-10) provides office and conference rooms for the spacecraft project.

6.2.1.6 Astrotech Building 6 (Fairing Support Facility). Building 6 (Figure 6-11) consists of a warehouse area and a bonded storage area. The overall plan dimensions of building 6 are 15.2 m by 18.3 m (50 ft by 60 ft), with maximum roof height of 12.2 m (40 ft).

6.2.1.7 Astrotech Building 7 (Boeing Office Area). This area provides the Boeing launch team with office space during their activities at Astrotech.

6.2.1.8 Astrotech Building 8 (Launch Operations Storage Building). This building provides storage space for customers to prepare for launch campaigns.

6.2.1.9 Astrotech Building 9 (Delta IV Payload Processing Facility). This building will be a new satellite preparation and encapsulation facility for Delta IV customers. Details of this facility will be included in subsequent revisions to this document as the design is finalized.

6.2.1.10 Spacecraft Long-Term Storage. Astrotech can provide long-term environmentally controlled storage for spacecraft contractors. For further information, contact Delta Launch Services.

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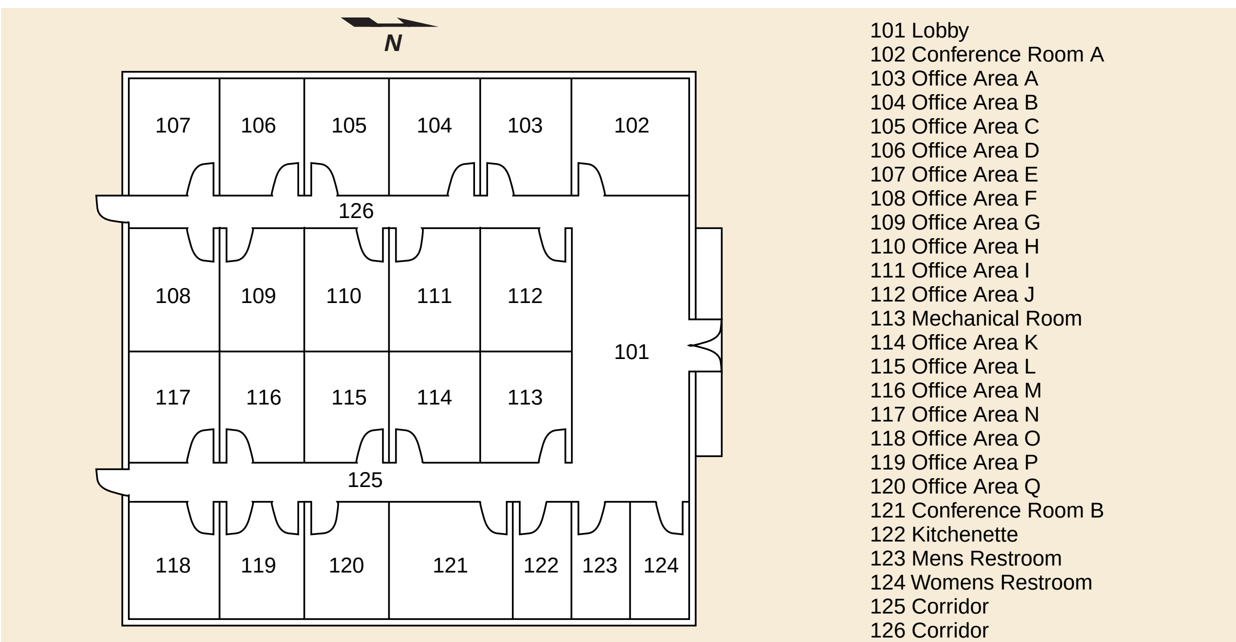

Figure 6-10. Building 5 Detailed Floor Plan, Astrotech

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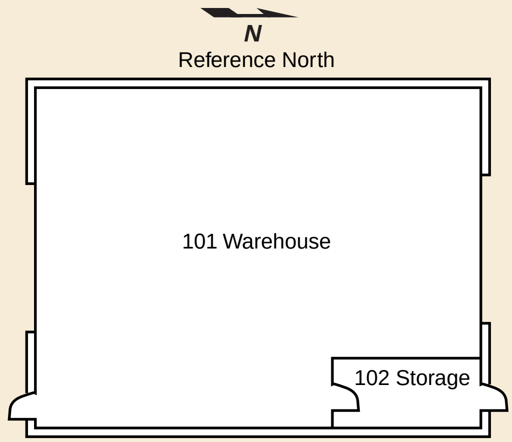

Room	Function	Length	Width	Height	Doorway
101	Warehouse	18.3 m (60 ft)	15.2 m (50 ft)	12.2 m (40 ft)	6.1 m by 12.2 m (20 ft by 40 ft)
102	Storage	6.1 m (20 ft)	3.1 m (10 ft)	2.4 m (8 ft)	0.9 m by 2.0 m (3.0 ft by 6.8 ft)

Notes:
1. All dimensions are approximate and shown as meters (feet).
2. The walls and ceilings in the warehouse are made of poly-covered insulation. The floor is made of concrete.

Figure 6-11. Building 6 Detailed Floor Plan, Astrotech

6.2.2 CCAS Operations and Facilities

Prelaunch operations and testing of Delta IV payloads at CCAS 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 CCAS industrial and support area (Figure 6-12). USAF-shared facilities or work areas at CCAS 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.

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.

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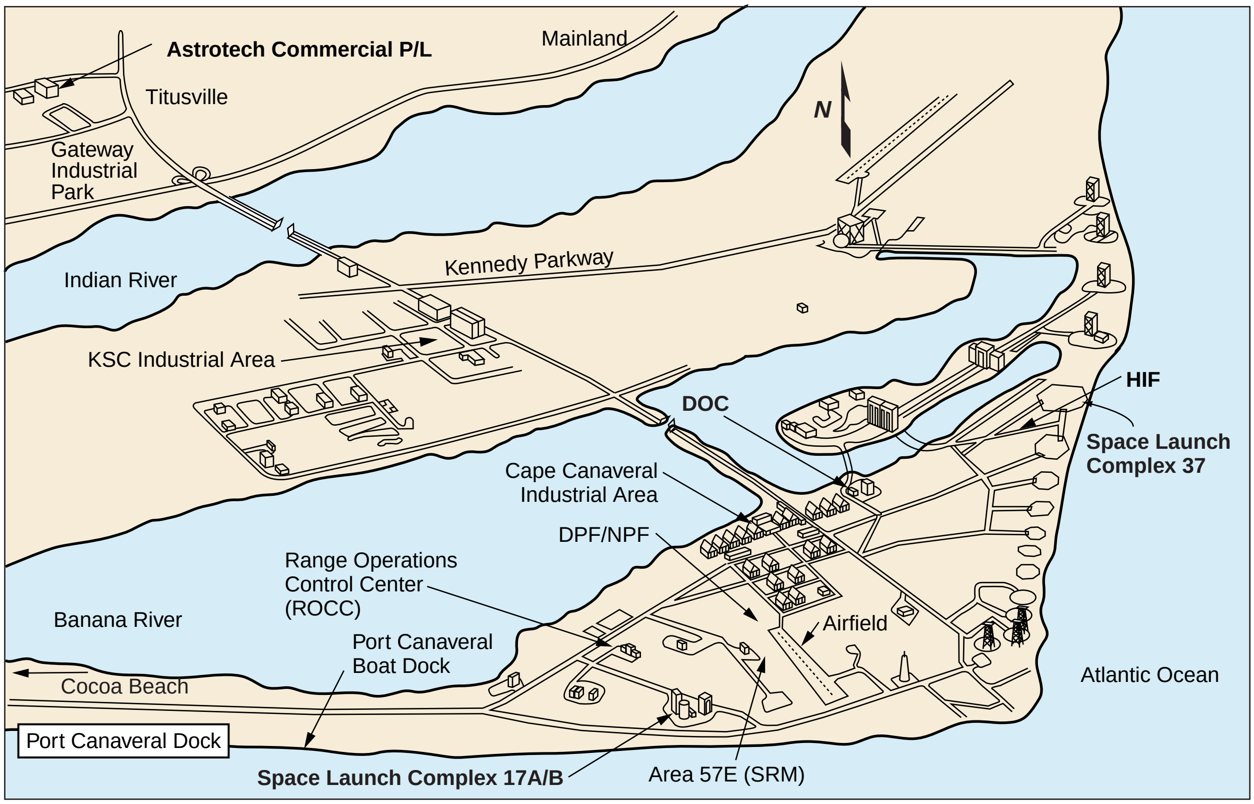

Figure 6-12. Cape Canaveral Air Station (CCAS) Facilities

6.2.4 Solid-Propellant Storage Area, CCAS

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, EEDs, etc.) is performed by spacecraft contractor personnel using spacecraft-contractor-prepared, range-safety-approved procedures. Range-contractor-supplied test consoles contain the items listed in Table 6-1. Tests are conducted according to spacecraft contractor procedures, approved by range safety personnel.

Table 6-1. Test Console Items

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	Relay power supply
High-current test controls	Test power supply
Power supply (5 V)	Power control panel
High-current test power supply	Blower

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6.2.4.1 Storage Magazines, CCAS. 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, CCAS. The electrical-mechanical testing (EMT) facility (Figure 6-13), 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.

Existing electrical cables provide the interface between the ordnance items and the test equipment for most devices commonly used at CCAS. These cables are tested before each use, and the 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 CCAS industrial area for USAF

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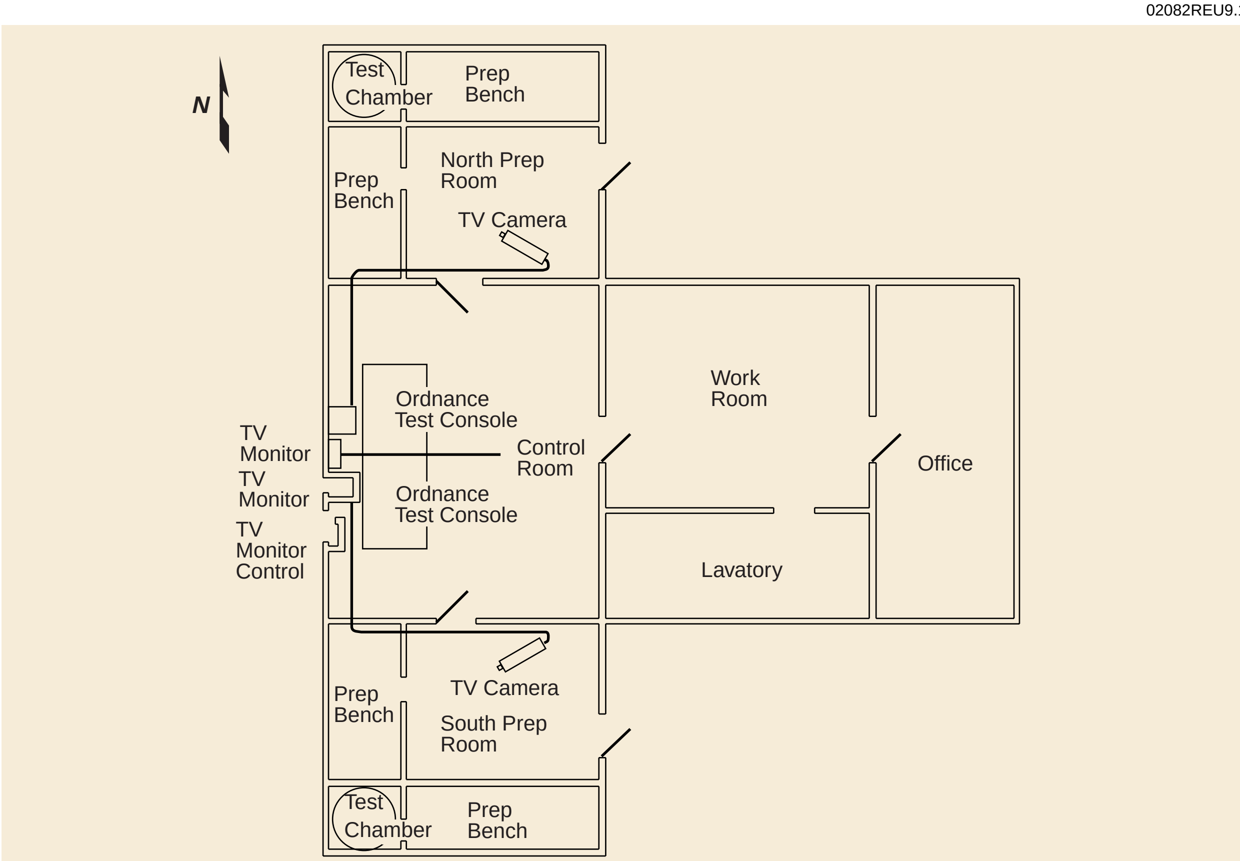

Figure 6-13. Electrical-Mechanical Testing Building Floor Plan

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. Details of the high bay, airlock, and adjacent control and equipment rooms are given in Section 6.2.1.1. The basic sequence of operations at Astrotech is illustrated in Figure 6-14.

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 roll transfer dollies. The PAF is installed on the Boeing 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

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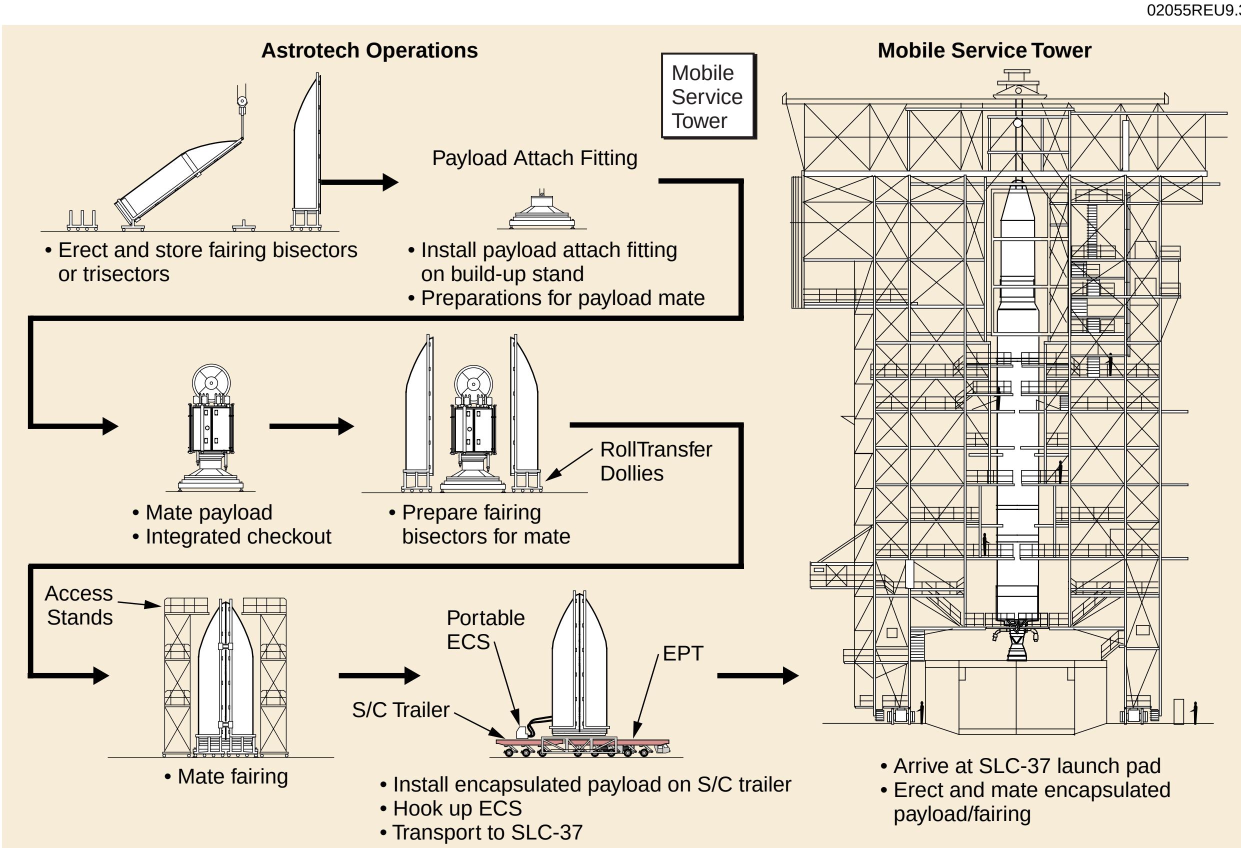

Figure 6-14. Payload Encapsulation, Transport, and On-Pad Mate

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 Boeing and prepared for transport to the launch pad. Environmental controls are established, and a protective road barrier is installed.

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 Table 6-2.

Potential PPFs and their facility specifications are outlined in the Payload Processing Facility Matrix (Table 6-3).

6.4 SPACE LAUNCH COMPLEX 37

SLC-37 is located in the northeastern section of CCAS (Figure 6-12) between SLC 36 and SLC 41. It consists of one launch pad (pad B), a mobile service tower (MST), 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. Arrangement of SLC-37 is shown in Figure 6-15.

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. Boeing provides mandatory safety briefings on these subjects for persons required to work in the launch complex area.

Table 6-2. Eastern Range Payload Processing Facilities

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 Station, FL	4-m fairings
Shuttle payload integration facility (SPIF)	Cape Canaveral Air Station, FL	4-m and 5-m fairings
Astrotech Space Operations	Titusville, FL	4-m fairings

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Table 6-3. Payload Processing Facility Matrix

Facility	Location	No. payload (cap.)	Work area/bay cleanliness classification size (W by L by H)	Bay access opening (W by H)	Bay hoist equipment max. hook height	Airlock size (W by L by H)	Airlock access opening (W by H)	Airlock hoist equip. max. hook height	Other information	Encap. compatibility
Vertical processing facility (VPF) <u>Note</u> Deactivated: Use of this facility requires notice to NASA for activation.	KSC, FL	2	Class 100,000 22.9 m x 45.7 m x 29.6 m (75 ft by 150 ft by 97 ft)	11.6 m by 21.7 m (38 ft by 71 ft 4 in.)	22 675-kg (25-ton) bridge 28.7-m (94 ft) hook height 10 884-kg (12-ton) bridge 28.4-m (93 ft) hook height	12.8 m by 22.9 m by 22.6 m (42 ft by 75 ft by 74 ft)	7.5 m by 21.6 m (24 ft 9 in. by 71 ft)	9070-kg (10-ton) monorail 20-m (65-ft 8-in.) hook height		4-m fairings 5-m fairings (limited)
Multi-payload processing facility (MPPF)	KSC, FL	Multiple	Class 100,000 low bay: 10.4 m by 10.4 m by 9.1 m (34 ft by 34 ft by 30 ft) High bay: 40.2 m by 18.3 m by 18.9 m (132 ft by 60 ft by 62 ft)	High bay door (external entry door): 8.5 m by 12.8 m (28 ft by 42 ft) Low bay door: 6.1 m by 4.6 m (20 ft by 15 ft)	18 140-kg (20-ton) bridge 14.9-m (49 ft) hook height	Class 300,000 11.9 m by 8.5 m by 6.1 m (39 ft by 28 ft by 20 ft)	6.1 m by 4.6 m (20 ft by 15 ft)	None	6.1 m by 5.5 m by 3.7 m (20 ft by 18 ft by 12 ft) horiz. laminar flow 100k CWA	4-m fairings
Payload hazardous processing facility (PHPF)	KSC, FL	1	Class 100,000 32.6 m by 18.4 m by 28.9 m (107 ft by 60 ft 4 in. by 94 ft 10 in.)	10.8 m by 22.9 m (35 ft 5 in. by 75 ft)	45 380-kg (50-ton) bridge 25.3-m (83-ft) hook height	Class 300,000 25.9 m by 15.3 m by 27.4 m (85 ft by 50 ft 4 in. by 89 ft 10 in.)	10.8 m by 22.9 m (35 ft 5 in. by 75 ft)	13 600-kg (15-ton) bridge 22.9-m (75-ft) hook height		4-m fairings 5-m fairings
DSCS processing facility (DPF)	CCAS, FL	TBD (2)	Class 100,000 Main bay: 15.2 m by 30.5 m by 7.6 m (50 ft by 100 ft by 25 ft) Encapsulation bay: 15.2 m by 15.2 m by 19.8 m (50 ft by 50 ft by 65 ft) Fueling bay: 15.2 m by 15.2 m by 19.8 m (50 ft by 50 ft by 65 ft)	Main bay: 6.1 m by 6.1 m (20 ft by 20 ft) Encapsulation bay: 6.1 m by 15.2 m (20 ft by 50 ft) Fueling bay: 6.1 m by 15.2 m (20 ft by 50 ft)	Main bay: 4535-kg (5-ton) bridge 6.1-m (20-ft) hook height Encapsulation bay: (TBD) Fueling bay: 13 600-kg (15-ton) bridge 16.8-m (55-ft) hook height	Class 100,000 15.2 m by 15.2 m by 19.8 m (50 ft by 50 ft by 65 ft)	6.1 m by 15.2 m (20 ft by 50 ft)	13 600-kg (15-ton) bridge 16.8-m (55-ft) hook height		4-m fairings

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Table 6-3. Payload Processing Facility Matrix (Continued)

Facility	Location	No. payload (cap.)	Work area/bay cleanliness classification size (W by L by H)	Bay access opening (W by H)	Bay hoist equipment max. hook height	Airlock size: (W by L by H)	Airlock access opening (W by H)	Airlock hoist equip. max. hook height	Other information	Encap. compatibility
Shuttle payload integration facility (SPIF)	CCAS, FL	2	Class 100,000 Integration cells: 9.32 m by 11.2 m by 23.2 m (30 ft 7 in. by 36 ft 9 in. by 76 ft) Transfer aisle: 11.6 m by 23.5 m (38 ft by 77 ft by 119 ft)	Integration cells: 6.1 m by 23 m (20 ft by 75 ft 6 in.) Transfer aisle: 7 m by 22.3 m (23 ft by 73 ft)	Transfer aisle/ integration cells: 45 360-kg (50-ton) bridge w/9070-kg (10-ton) aux. 30.4-m (100-ft) hook height	Class 100,000 Canister airlock 7 m by 12.2 m by 24.4 (23 ft by 40 ft by 80 ft)	7 m by 22.3 m (23 ft by 73 ft)	None		4-m fairings 5-m fairings (limited)
Astrotech Space Operations	Titusville, FL	Multiple	Class 100,000 N. high bay: 11.3 m by 18.3 m by 13.1 m (37 ft by 60 ft by 43 ft) S. high bay: 11.3 m by 18.3 m by 13.1 m (37 ft by 60 ft by 43 ft)	Both bays: 6.1 m by 12.2 m (20 ft by 40 ft)	19 070-kg (10-ton) bridge common to north/south and spin bays 11.3-m (37-ft) hook height	N. airlock 12.2 m by 16.8 m by 19.8 m (40 ft by 55 ft by 65 ft)	6.1 m by 15.2 m (20 ft by 50 ft)	27 220-kg (30-ton) bridge 16.8-m (55-ft) hook height	4-m fairing encapsulation in airlock	4-m fairings

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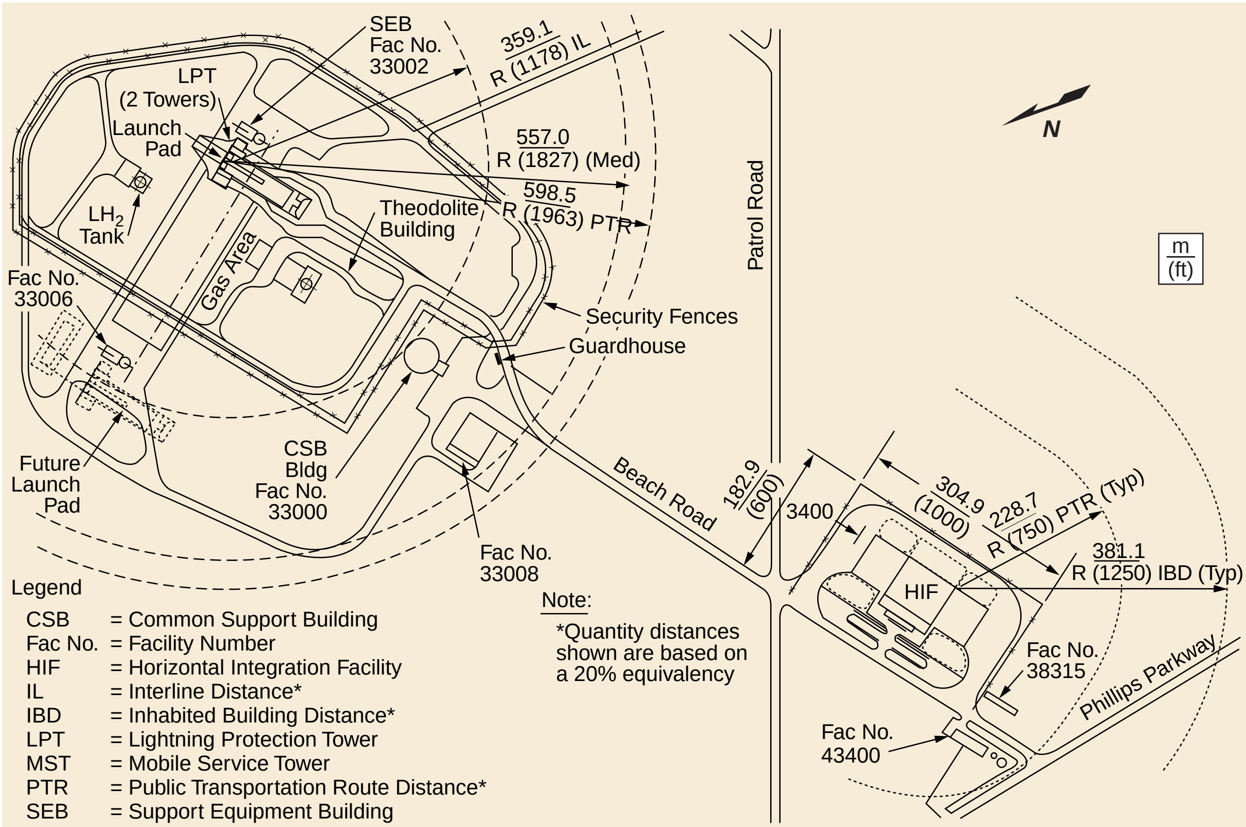

Figure 6-15. Space Launch Complex 37, CCAS

6.4.1 Mobile Service Tower

The mobile service tower (MST, Figure 6-16) is used to provide protection for and access to the launch vehicle after it is installed in the vertical position on the launch table. The MST contains the crane used to lift the payload and install it on the launch vehicle.

The MST is moved on rails up to the launch vehicle (service position) using a hydraulic drive system, after the vehicle is installed on the launch table. Pneumatically and hydraulically operated platforms are used for accessing the launch vehicle and payload for integration assembly and final checkout. The platforms are moved to clear the launch vehicle, and the MSTs are moved to the park position and unoccupied during launch operations. Work platform levels 5 through 7 provide a weather-protected enclosure for launch vehicle innerstage access. Work platform levels 8 through 12 provide climate-controlled space for installation and final payload protection. This enclosure contains a 45 350-kg (50-ton) bridge crane with a 91.5-m (300-ft) hook height. The platform floor plan for the fixed platform (Level 8) is shown in Figure 6-17. The platform floor plans for adjustable levels 9 through 12 are shown in Figures 6-18 and 6-19.

6.4.2 Common Support Building

The CSB will contain 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

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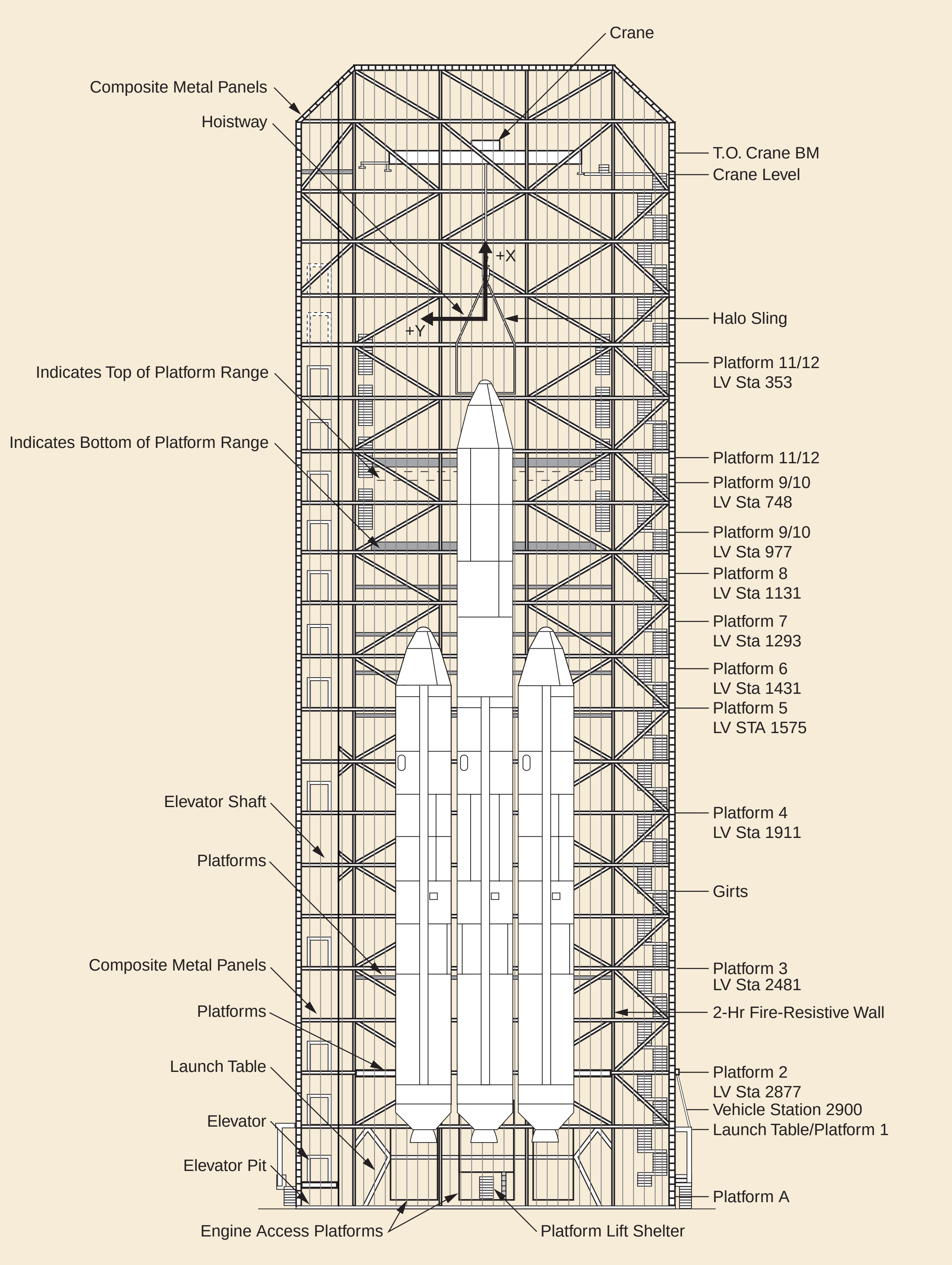

Figure 6-16. Space Launch Complex 37 Mobile Service Tower (MST)

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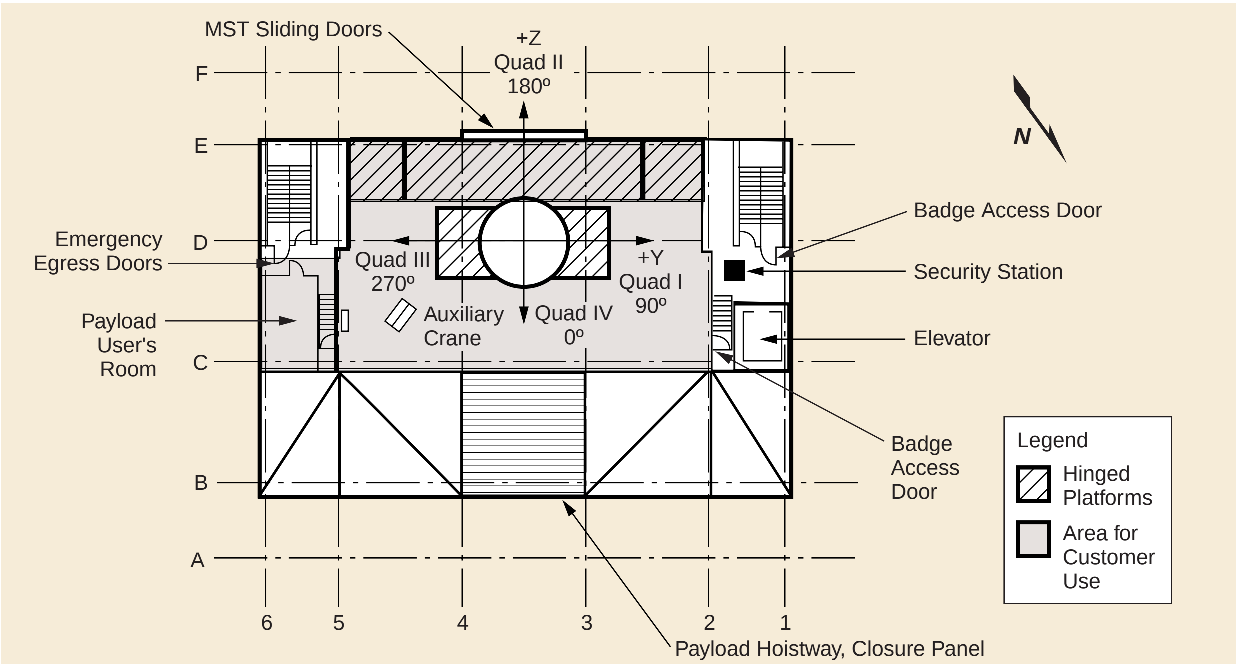

Figure 6-17. Fixed Platform (Level 8)

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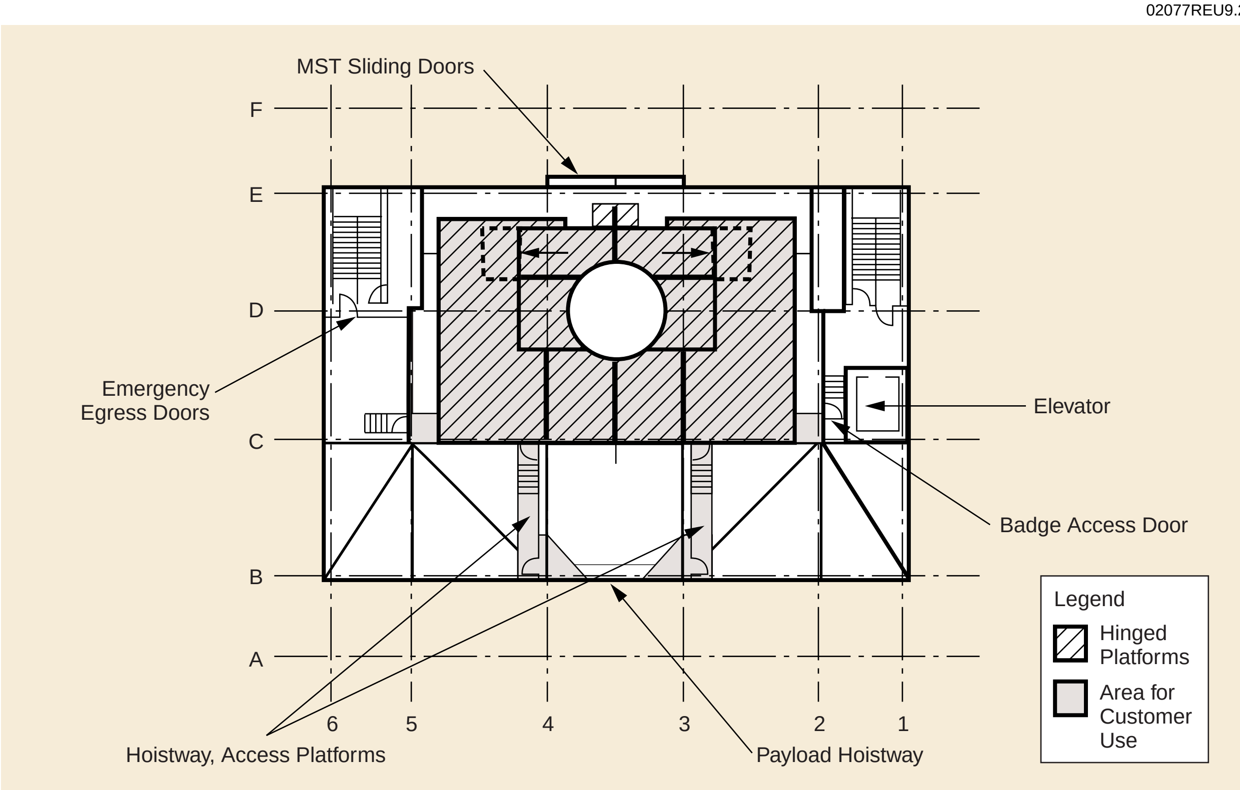

Figure 6-18. Adjustable Platform (Levels 9 and 10)

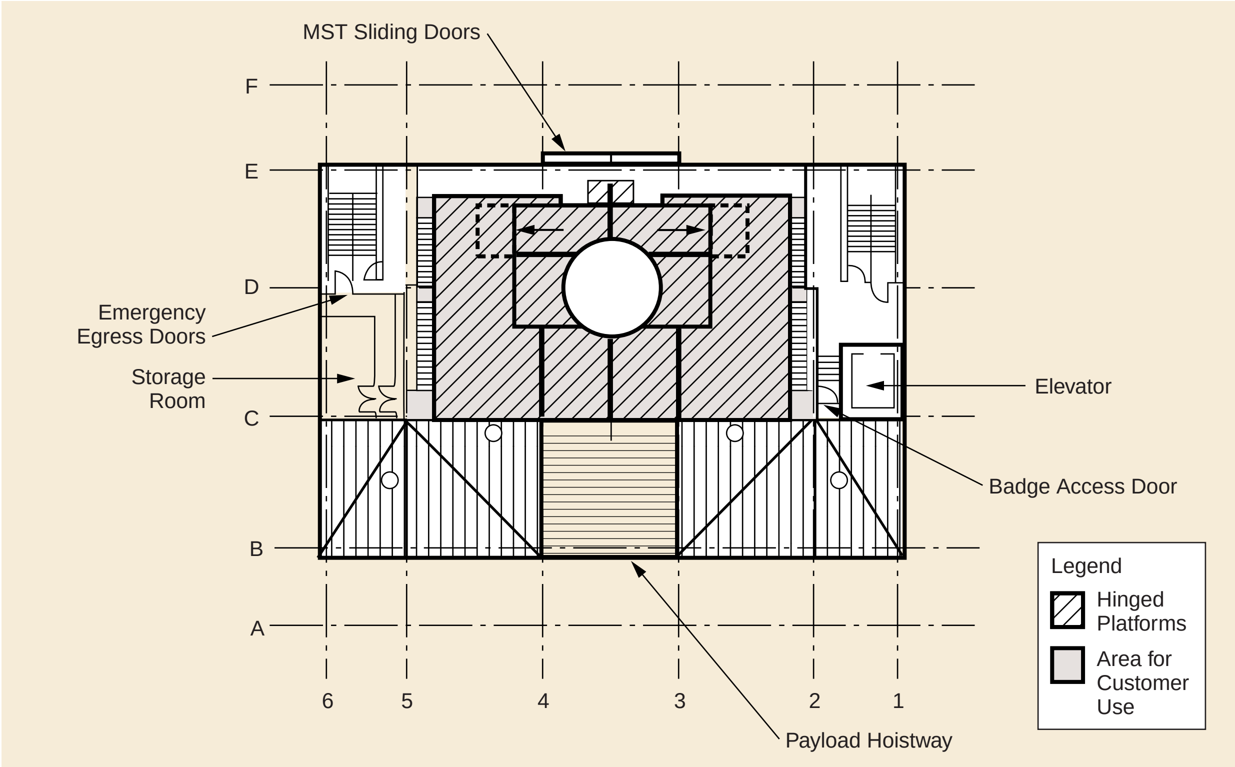

Figure 6-19. Adjustable Platform (Levels 11 and 12)

33000, which served as the launch control center for SLC-37, will be modified to provide space for these activities. This structure will not be occupied during launch (Figure 6-20).

6.4.3 Support Equipment Building

Facility 33002, the existing building at complex 37B, will be used as the support equipment building (SEB) (Figures 6-15 and 6-21). The SEB will contain the payload, launch vehicle and facility air-conditioning equipment, and electrical and data communications equipment needed near the launch vehicle. All equipment will be new. The SEB will also include minimal personnel support areas such as small rest rooms 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 will be provided. This structure will not be occupied during launch.

6.4.4 Horizontal Integration Facility

Although not part of the SLC-37 complex, the horizontal integration facility (HIF) (Figures 6-15 and 6-22) will be 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 will have two bays to accommodate four single-core Delta IV-M and Delta IV-M+ process areas or two single-core Delta IV-M and Delta IV-M+ process areas and a Delta IV-H process area. Each bay

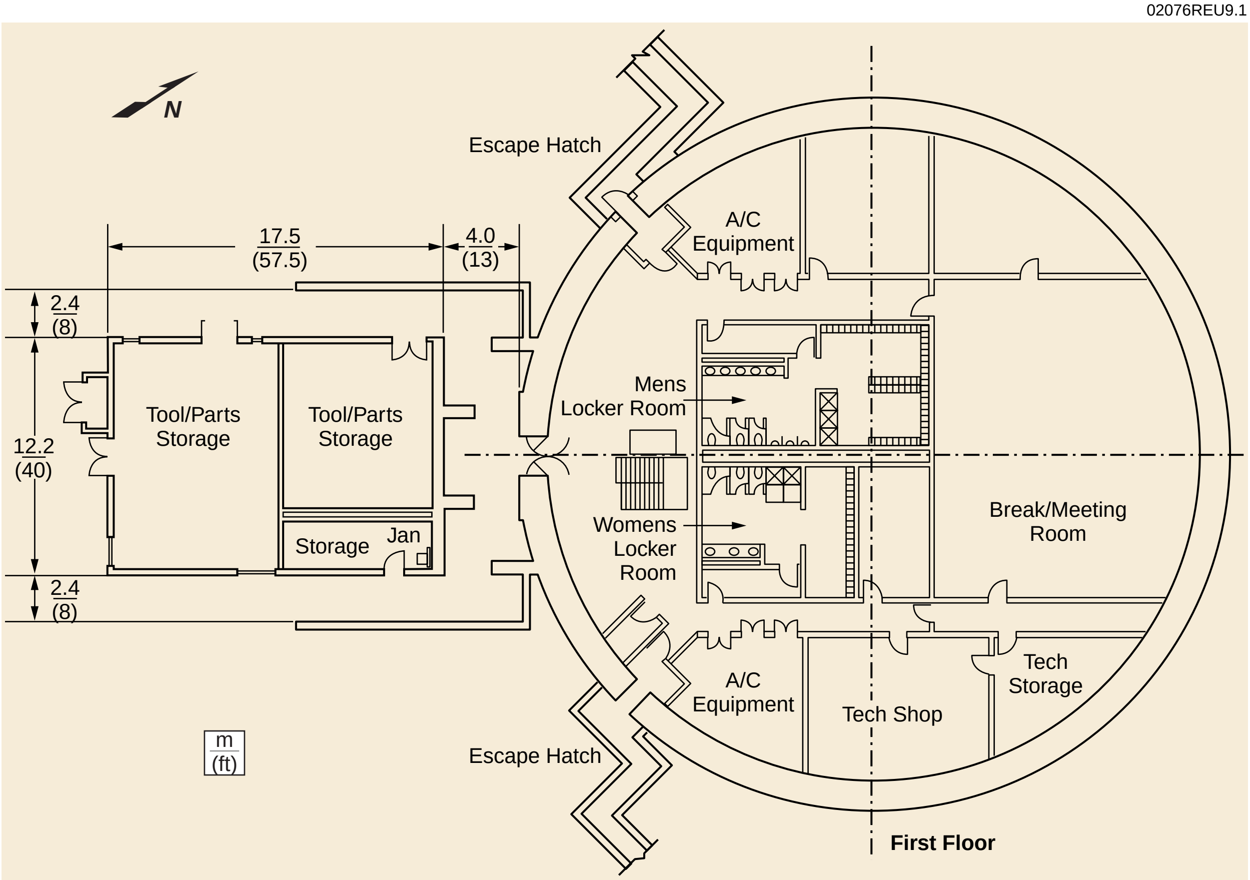

Figure 6-20. Space Launch Complex 37 Common Support Building (CSB) Sample Layout

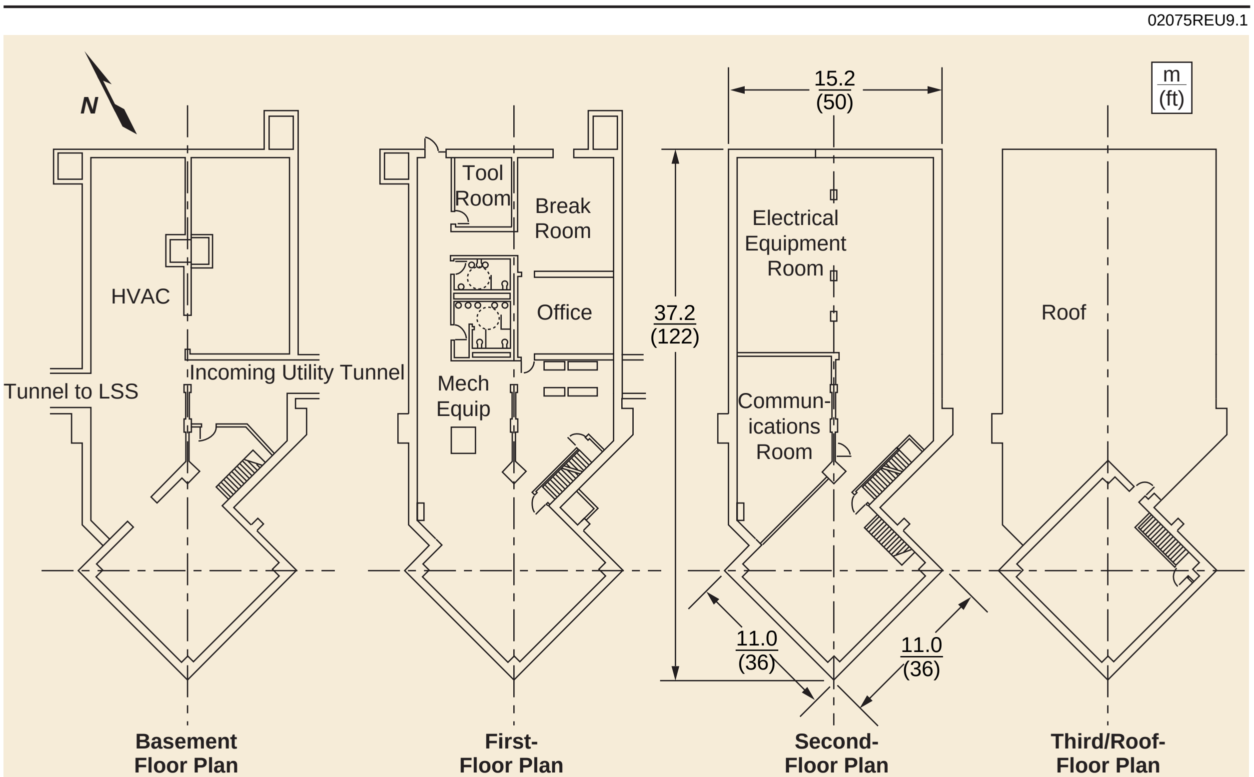

Figure 6-21. Space Launch Complex 37 Support Equipment Building (SEB)

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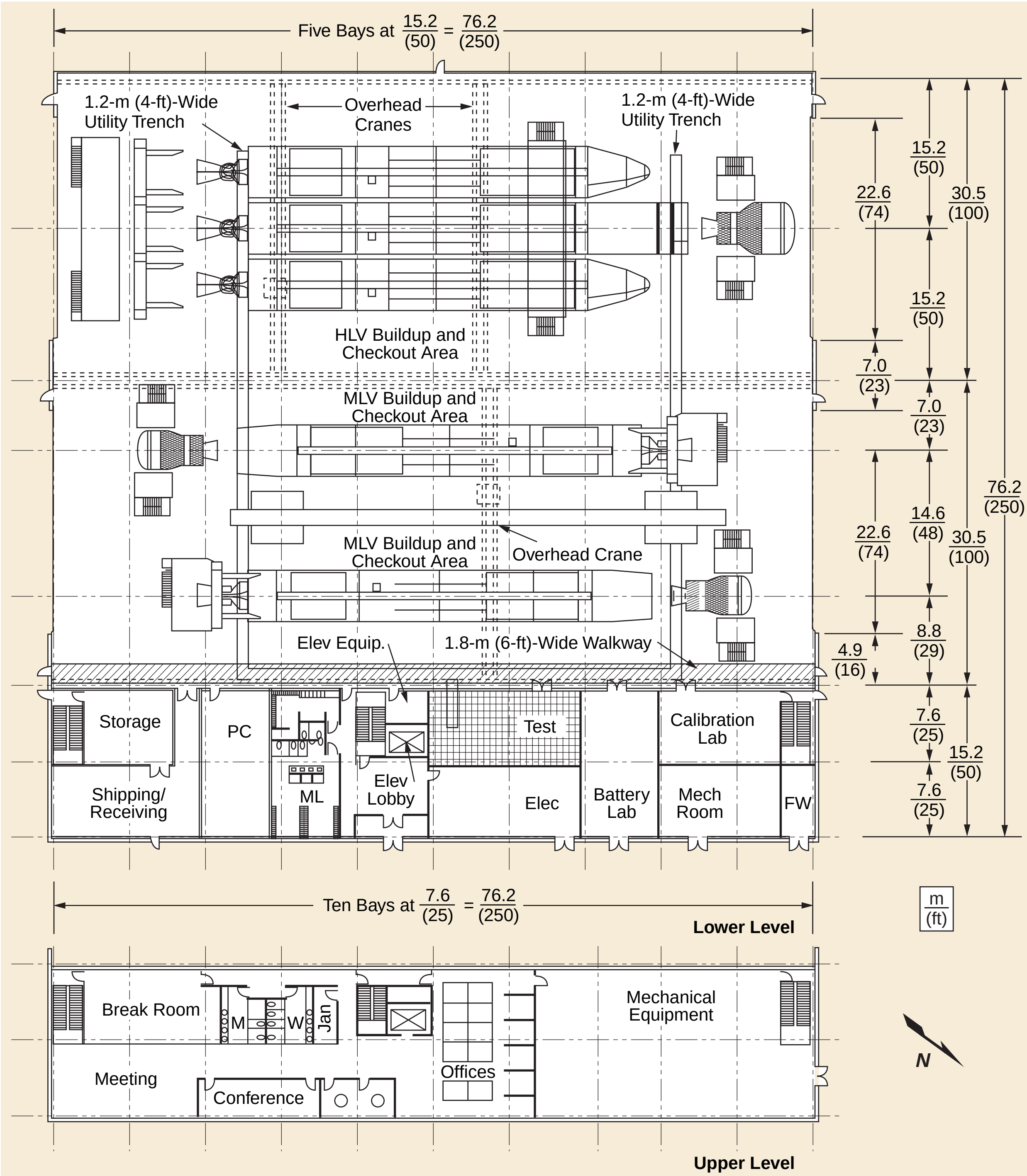

Figure 6-22. Space Launch Complex 37 Horizontal Integration Facility (HIF)

will be 76.2 m by 30.5 m (250 ft by 100 ft). Each bay will have one 22 675-kg (25-ton) utility bridge crane. Both bays will have a 22.6-m (74-ft) door on each end.

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 will provide an additional staging and LMU refurbishment area.

HIF offices will be used by administrative and technical personnel. A conference room is also provided. Employee support facilities include a training room, breakroom, locker rooms, and restrooms (Figure 6-23).

6.4.5 Launch Control

The Range operations control center (ROCC) will be used to control range safety and other range operations. No physical modifications are expected to be needed in the ROCC (facility 81900) for support of the Delta IV program. The launch control center (LCC) for launch complex 37 will be located in the Delta Operations Center (DOC), building 38835.

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 provides the necessary seating, data display, and communication to observe the launch process. Seating is provided for key personnel from the spacecraft control team.

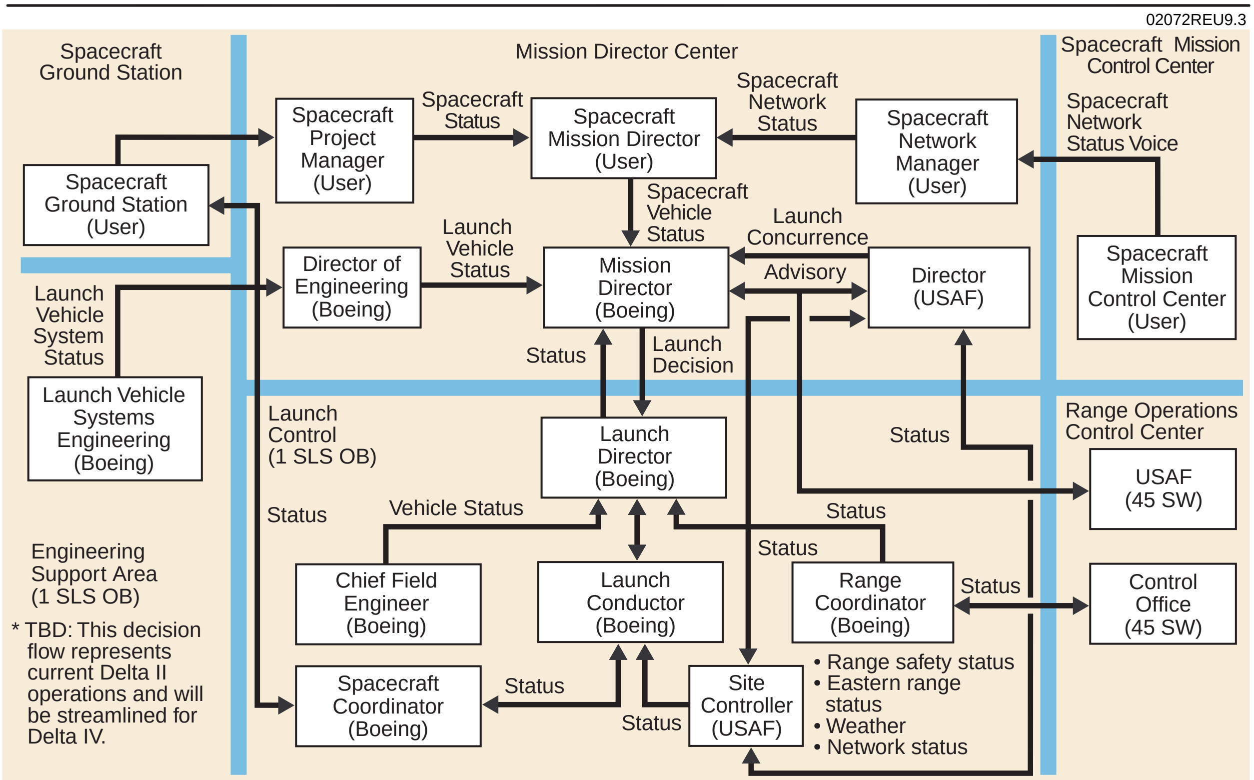

Figure 6-23. Launch Decision Flow for Commercial Missions—Eastern Range

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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 6-23 shows the typical communication flow required to make the launch decision for Delta II/III. The Delta IV process is currently evolving but will generally follow the same decision paths as Delta II/III.

6.5.2 Weather Constraints

6.5.2.1 Ground-Wind Constraints. The Delta IV launch vehicles will be enclosed in the MST until approximately launch- (L-) 7 hr. The tower protects the launch vehicle from ground winds (measured using anemometers at several levels of the tower).

6.5.2.2 Winds-Aloft Constraints. Measurements of winds aloft are taken at the launch pad. On launch day, Delta IV launch vehicle controls and load constraints for winds aloft are evaluated by conducting a trajectory analysis using the measured wind. A curve fit to the wind data provides load relief in the trajectory analysis. The curve fit and other load-relief parameters are used to reset the mission constants just prior to launch.

6.5.2.3 Weather Constraints. Weather constraints are imposed by range safety to assure safe passage of the Delta IV launch vehicle through the atmosphere. The following condensed set of constraints is evaluated just prior to liftoff. (The complete set of constraints is contained in Appendix B.)

A. The launch will not take place if the normal flight path will carry the launch vehicle:

1. Within 18.5 km (10 nmi) of a cumulo-nimbus (thunderstorm) cloud, whether convective or in layers, where precipitation (or virga) is observed.
2. Through any cloud, whether convective or in layers, where precipitation or virga is observed.
3. Through any frontal or squall-line clouds which extend above 3048 m (10,000 ft).
4. Through cloud layers or through cumulus clouds where the freeze level is in the clouds.
5. Through any cloud if a ±1 kV/m or greater level electric field contour passes within 9.3 km (5 nmi) of the launch site at any time within 15 min prior to liftoff.
6. Through previously electrified clouds not monitored by an electrical field mill network if the dissipating state was short-lived (less than 15 min after observed electrical activity).

B. The launch will not take place if there is precipitation over the launch site or along the flight path.

C. A weather observation aircraft is mandatory to augment meteorological capabilities for real-time evaluation of local conditions unless a cloud-free line of sight exists to the launch vehicle flight path. Rawinsonde will not be used to determine cloud buildup.

D. Even though the above criteria are observed or forecast to be satisfied at the predicted launch time, the launch director may elect to delay the launch based on the instability of atmospheric conditions.

6.5.2.4 Lightning Activity. The following are procedures for test status during lightning activity:

A. Evacuation of the MST is accomplished at the direction of the launch conductor (Reference: Delta Launch Complex Safety Plan).

B. Instrumentation may be operated during an electrical storm.

C. If other electrical systems are powered when an electrical storm approaches, these systems may remain powered.

D. If an electrical storm passes through after vehicle automated interface tests are performed, all electrical systems are turned on to a quiescent state, and all data sources are evaluated for evidence of damage. This turn-on is done remotely (pad clear) if any Category-A ordnance circuits are connected for flight. Ordnance circuits are disconnected and safed prior to turn-on with personnel exposed to the vehicle.

E. If data from the health monitoring turn-on reveals equipment discrepancies that can be attributed to the electrical storm, a flight program requalification test must be run subsequent to the storm and prior to a launch attempt.

6.5.3 Operational Safety

Safety requirements are covered in Section 9 of this document. In addition, it is the operating policy at both CCAS and Astrotech that all personnel will be given safety orientation briefings prior to entrance to hazardous areas. These briefings will be scheduled by the Boeing spacecraft coordinator and presented by the appropriate safety personnel.

6.5.4 Security

6.5.4.1 CCAS Security. For access to CCAS, US citizens must provide to Boeing security their full name with middle initial (if applicable), social security number, company name, company address, company telephone, and dates of arrival and expected departure by seven days prior to arrival. Boeing security will arrange for entry authority for commercial missions or individuals sponsored by Boeing. Access by NASA personnel or NASA-sponsored foreign nationals is coordinated by NASA KSC with the USAF at CCAS. Access by other US government-sponsored foreign nationals is coordinated by their sponsor directly with the USAF at CCAS. For non-US 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, organization, company address, home address) must be furnished to Boeing security two months prior to the CCAS entry date. Government-sponsored individuals follow NASA or US government guidelines, as appropriate. After Boeing security gets entry authority approval, entry to CCAS 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.

6.5.4.2 Launch Complex Security. SLC-37 physical security is ensured by perimeter fencing, guards, and access badges. The MST is configured to provide security for Priority-A resources. Unique badging is required for unescorted entry into the fenced area at SLC-37. Arrangements must be made through Boeing security at least 30 days prior to need to begin badging arrangements for personnel requiring such access. Boeing personnel are also available 24 hr a day to provide escort to others requiring access.

6.5.4.3 Astrotech Security. Physical security at the Astrotech facilities is provided by chain-link perimeter fencing, door locks, and guards. Details of payload security requirements will be arranged through the Boeing spacecraft coordinator.

6.5.5 Field-Related Services

Boeing 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. Boeing has access to a machine shop, metrology laboratory, LO_2 cleaning facility, proof-load facility, and hydrostatic proof test equipment. Boeing 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 spacecraft payload processing facility (PPF) and boost vehicles 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 spacecraft contractor.

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 days-of-launch countdown activities. Tasks include payload weighing, spacecraft-to-PAF mate, encapsulation, and interface verification. Figures 6-24, 6-25, 6-26, 6-27, 6-28, and 6-29 show the integrated processing time lines for the Delta IV-M, Delta IV-M+(4,2), Delta IV-M+ (5,2), Delta IV-M+(5,4), Delta IV-H, and Delta IV-H dual-manifest, respectively. The countdown schedules provide a detailed, hour-by-hour breakdown of launch pad operations, illustrating the flow of activities from spacecraft erection through terminal countdown and reflecting inputs from the

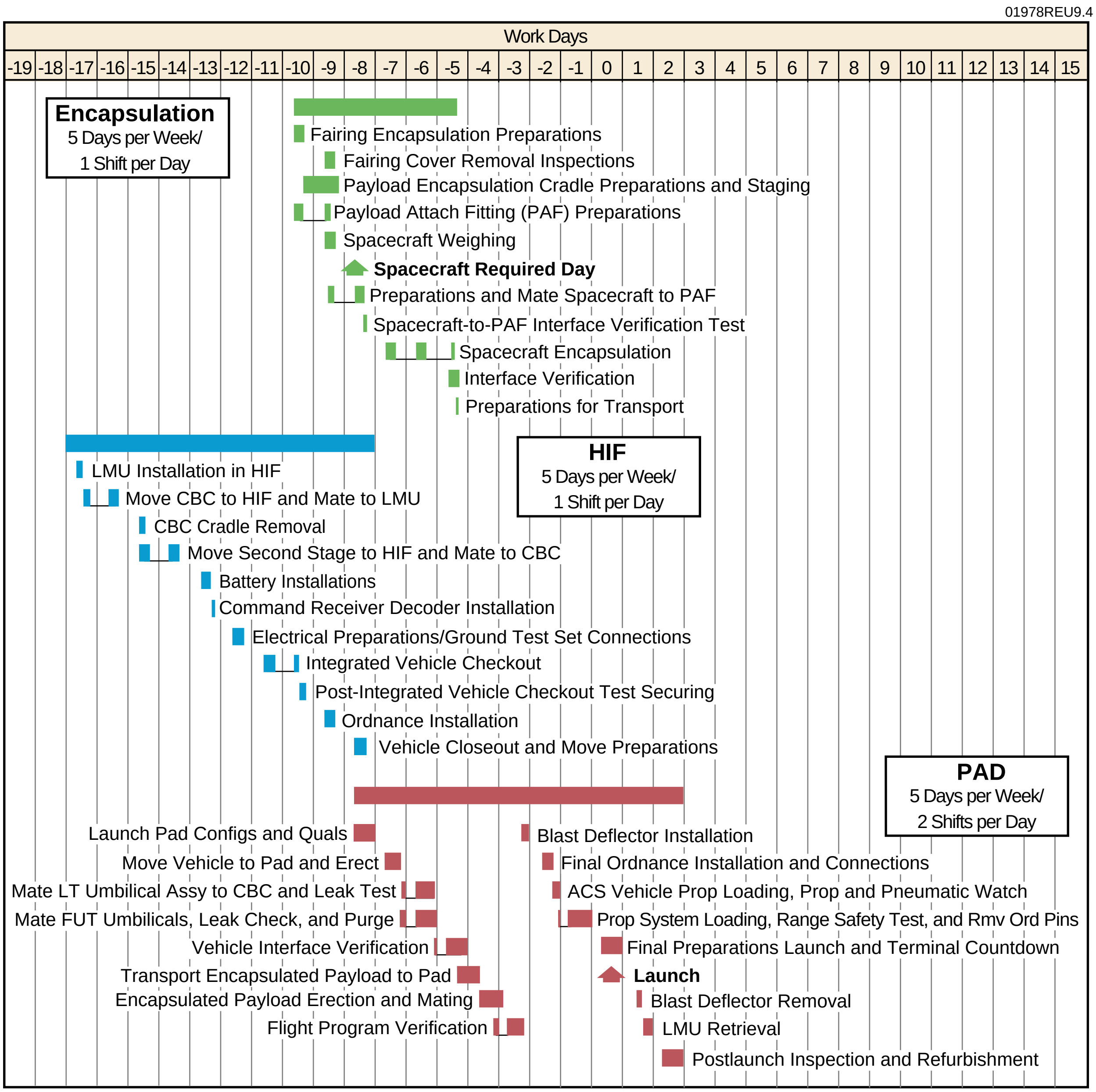

Figure 6-24. Projected Processing Time Line—Delta IV Medium Launch Vehicle (rev. K)

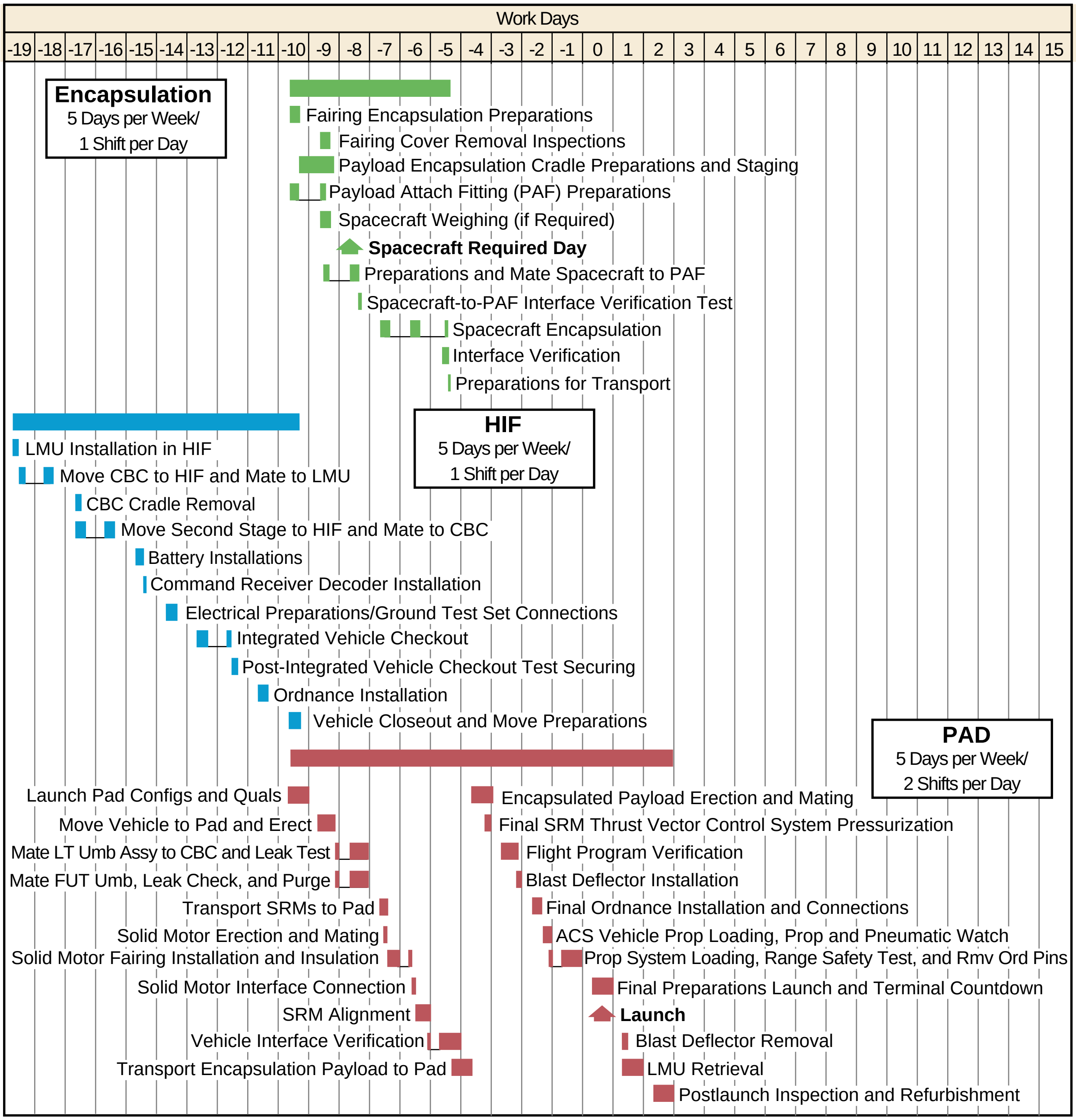

Figure 6-25. Projected Processing Time Line—Delta IV Medium-Plus (4,2) Launch Vehicle (rev. K)

spacecraft contractor. Daily schedules comprise the integrating document to ensure timely launch pad operations.

The integrated processing timelines do not normally include Saturdays, Sundays, or holidays. The schedules, from spacecraft mate through launch, are coordinated with each spacecraft contractor 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.

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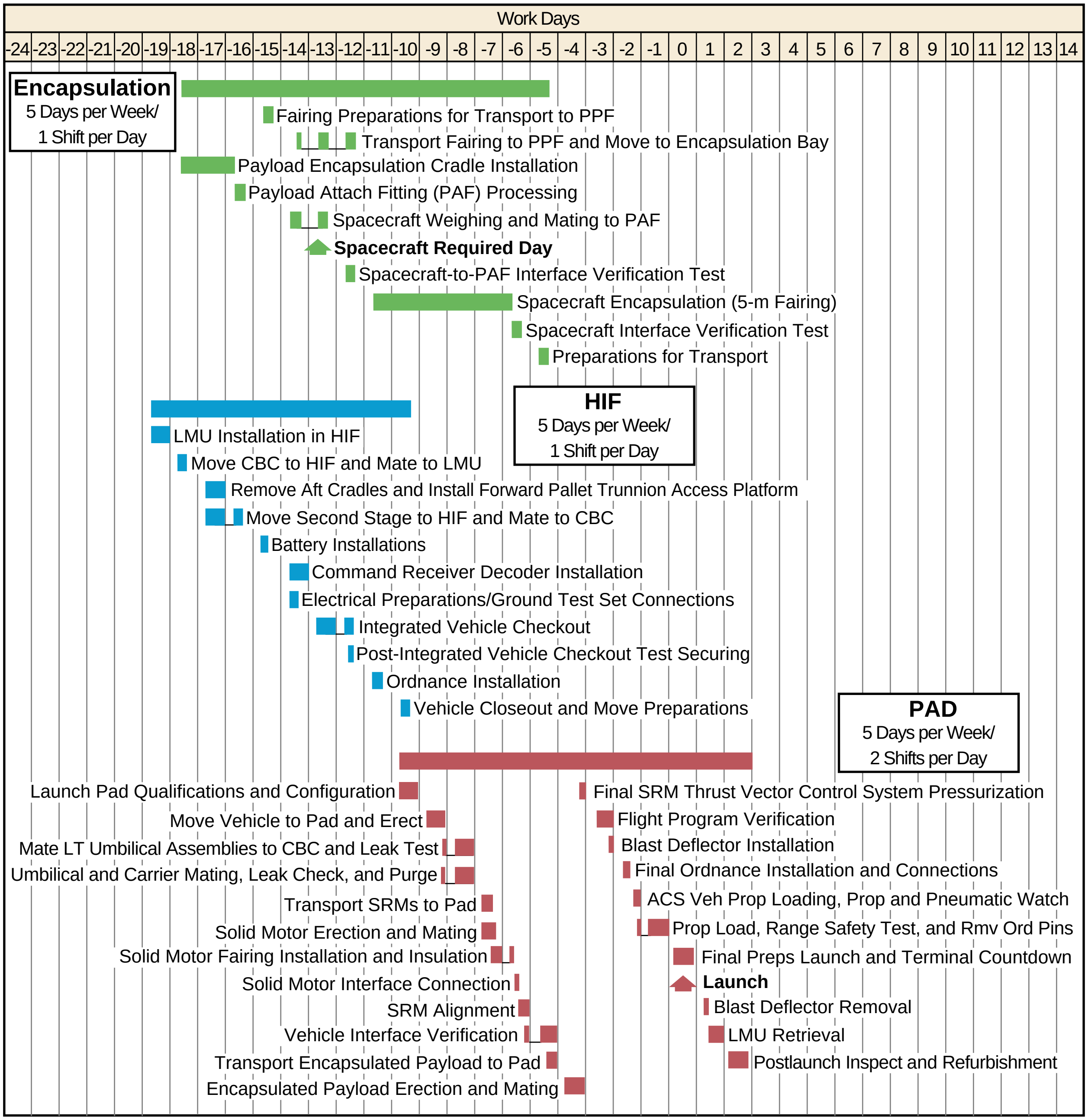

Figure 6-26. Projected Processing Time Line—Delta IV Medium-Plus (5,2) Launch Vehicle (rev. L)

6.6.3 Launch Vehicle Schedules

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

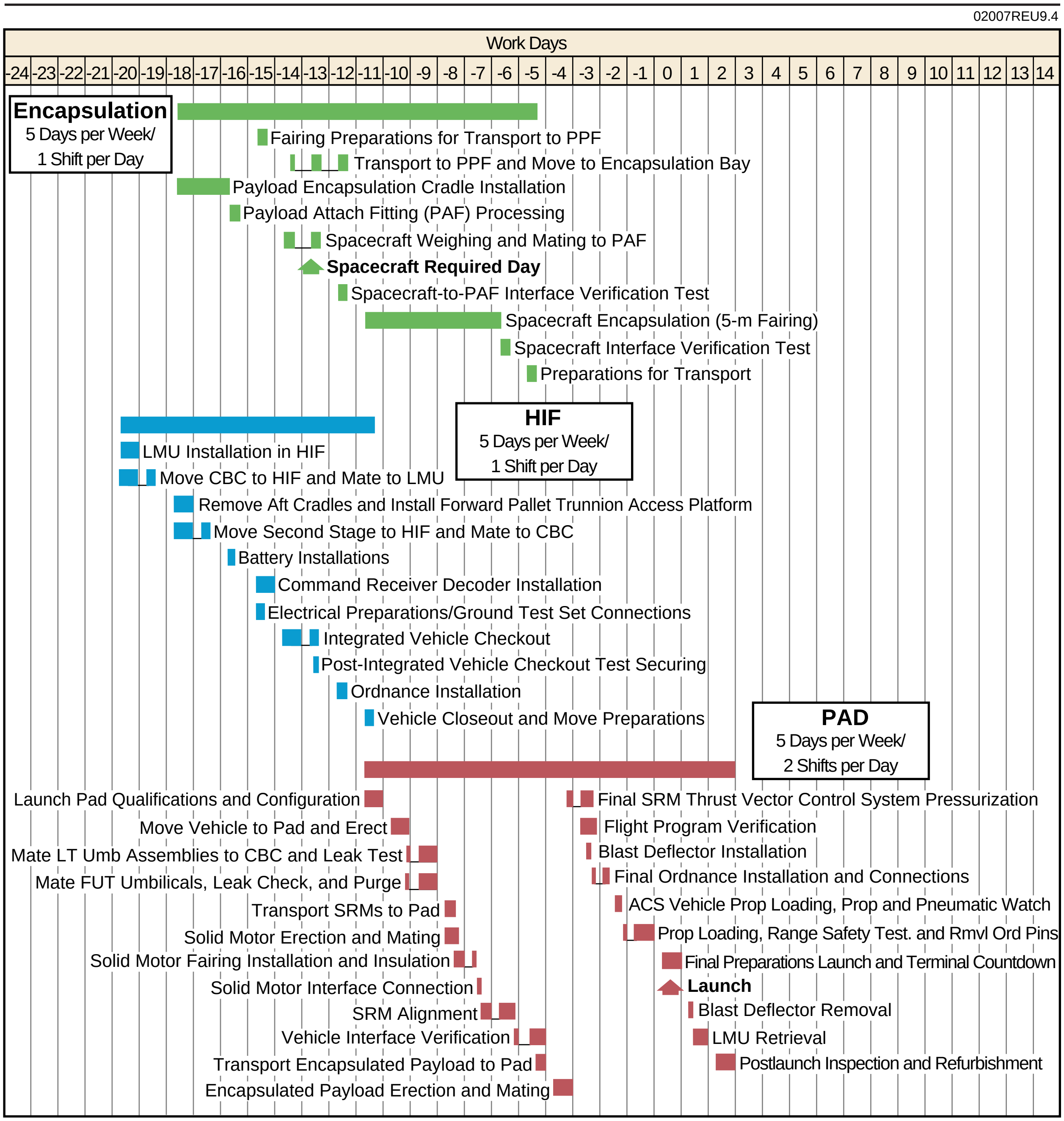

Figure 6-27. Projected Processing Time Line—Delta IV Medium-Plus (5,4) Launch Vehicle (rev. L)

6.6.4 Spacecraft Schedules

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

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

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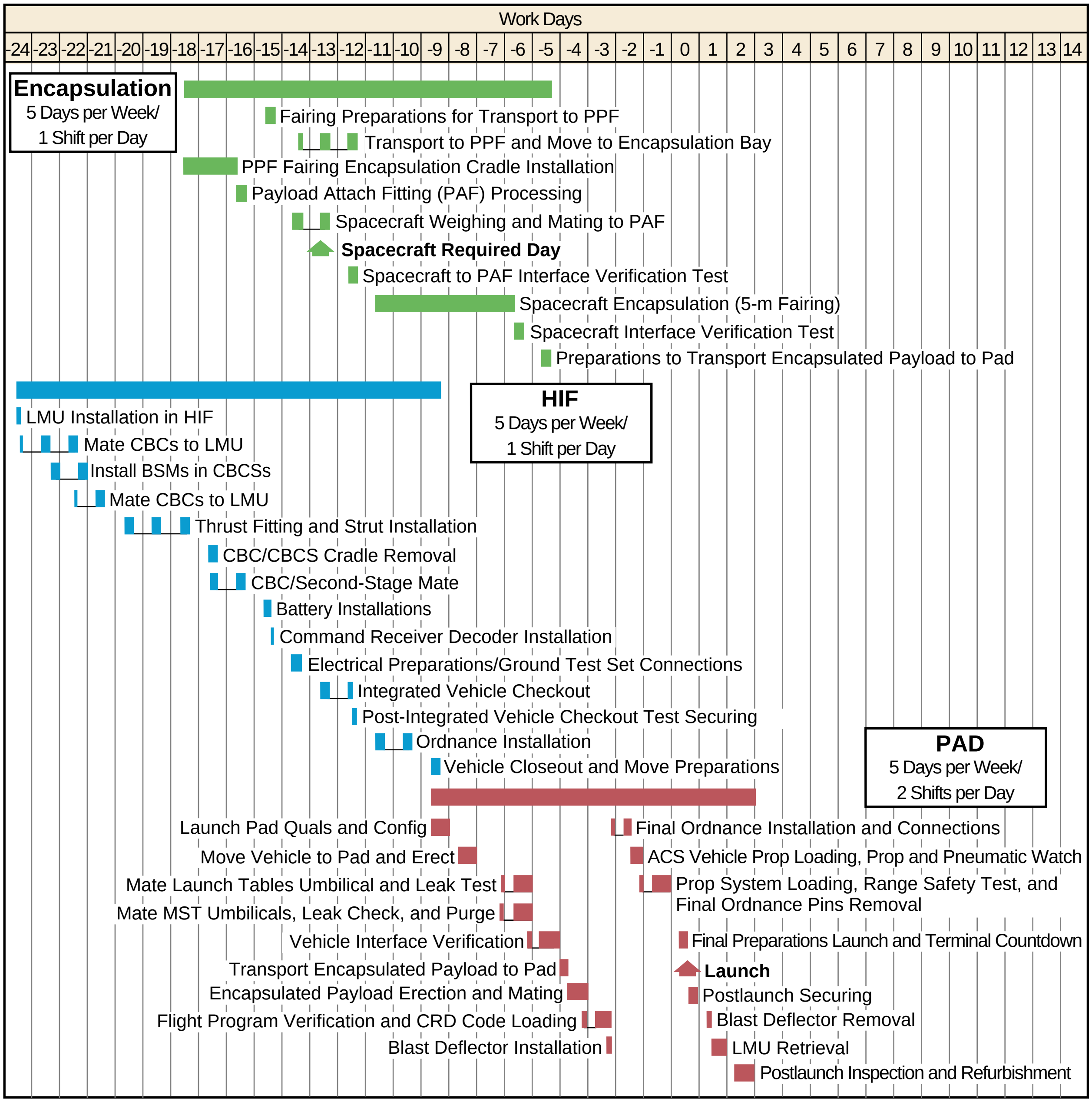

Figure 6-28. Projected Processing Time Line—Delta IV Heavy Launch Vehicle (rev. L)

monitor the progress of the overall mission. The Boeing mission integration manager will ensure adequate customer participation.

6.7.1 Meetings

Delta status meetings are generally held twice 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.

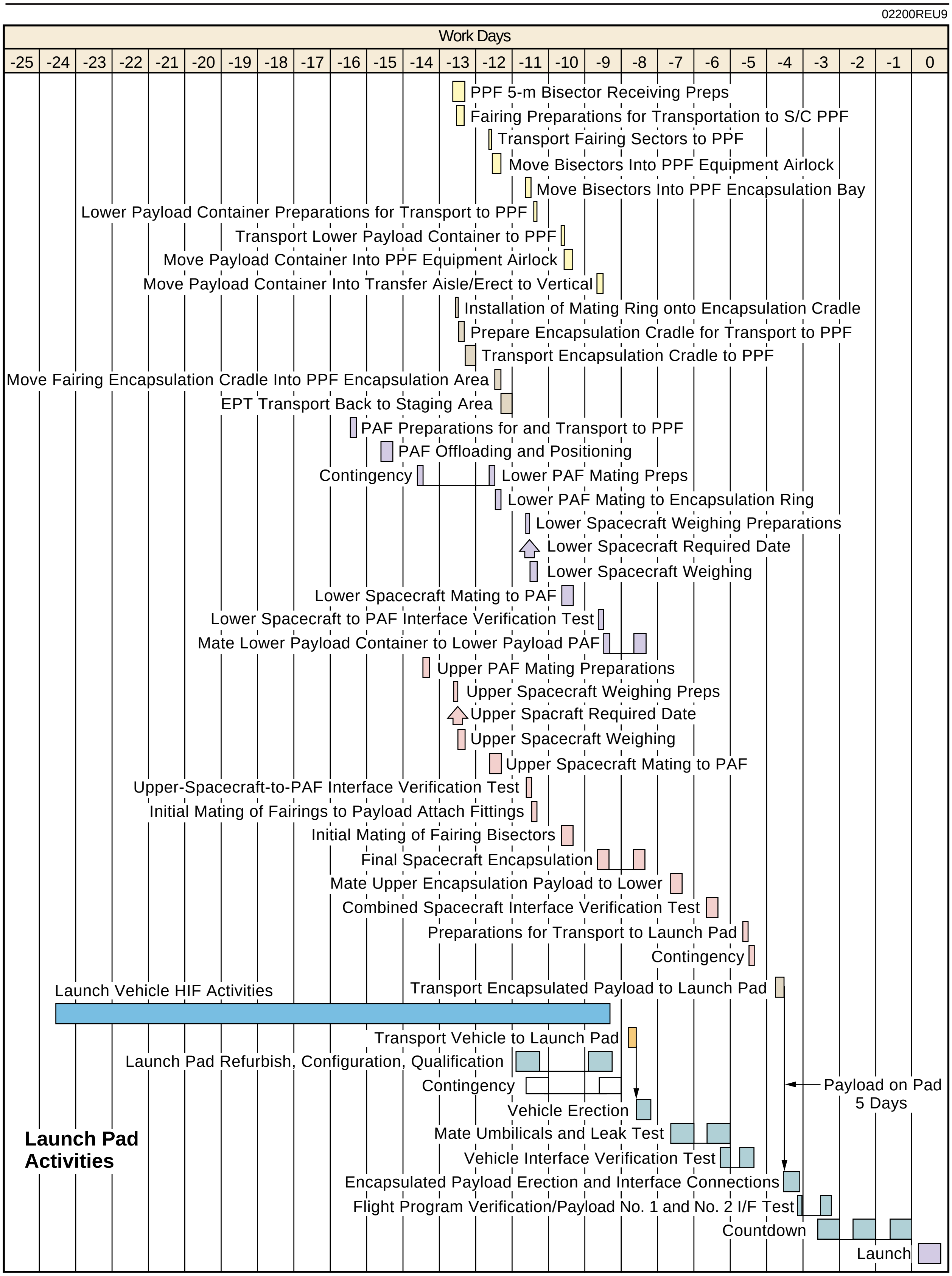

Figure 6-29. Projected Processing Time Line for Delta IV Heavy Launch Vehicle Dual-Manifest Missions (Prelim)

Daily schedule meetings are held to provide the 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 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 discuss the Delta IV readiness reviews.

6.7.2.1 Postproduction Review. This meeting, conducted at Decatur, Alabama, reviews the flight hardware at the end of production and prior to shipment to CCAS.

6.7.2.2 Mission Analysis Review. This meeting is held at Huntington Beach, California, approximately three 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 at CCAS subsequent to the 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. (Pre-VOS occurs approximately at L-12.)

6.7.2.4 Flight Readiness Review. Flight readiness review (FRR) is a status of the launch vehicle after HIF 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 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 predicted weather data. (FRR occurs at L-2 days.)

6.7.2.5 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 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, Boeing 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. Boeing 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.

Boeing 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 Boeing, based on inputs from the spacecraft contractor (the launch vehicle builder), using the government's universal documentation system (UDS) format (see Section 8, Payload Integration). Boeing and the spacecraft contractor generate the program requirements document (PRD). Formal submittal of these documents to the government agencies is arranged by Boeing.

For commercial launches, Boeing 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 Boeing 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). Boeing interfaces with NASA at VAFB through the VAFB Kennedy Space Center (KSC) resident office.

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, clean rooms, receiving and shipping areas, hazardous operations areas, and offices are provided for payload project personnel.

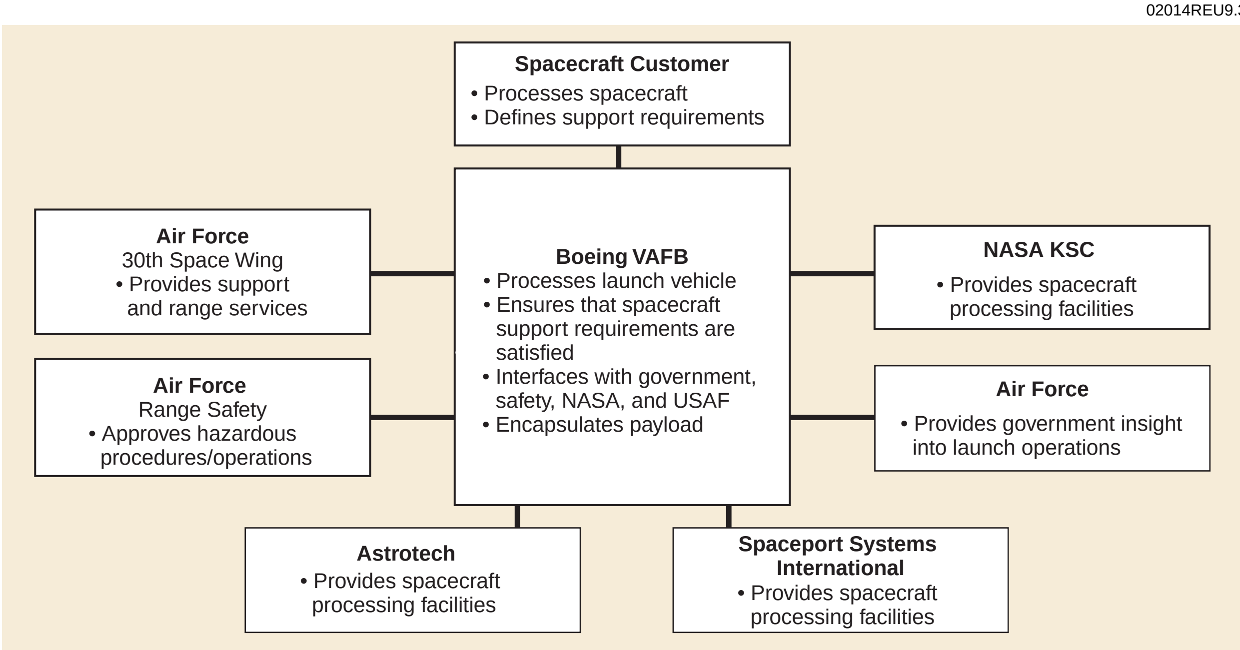

Figure 7-1. Launch Base Organization at VAFB for Commercial Launches

As discussed in Section 6.2, offline encapsulation of fueled payloads is a key element of the Delta IV program. The Boeing study conducted for existing encapsulation facilities revealed that there are no government-owned or -operated PPFs at VAFB capable of supporting Delta IV encapsulation operations. The study revealed that only the Astrotech Space Operations (ASO) facilities are capable of supporting Delta IV 4-m fairings without modifications. The study also showed that, with some modifications, the integrated processing facility (IPF) operated by Spaceport Systems International (SSI), near Space Launch Complex 6 (SLC-6), can accommodate the Delta IV 4-m and 5-m fairings. Details of this study are discussed in Section 7.3.1.

A map of VAFB is shown in Figure 7-2, showing 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.

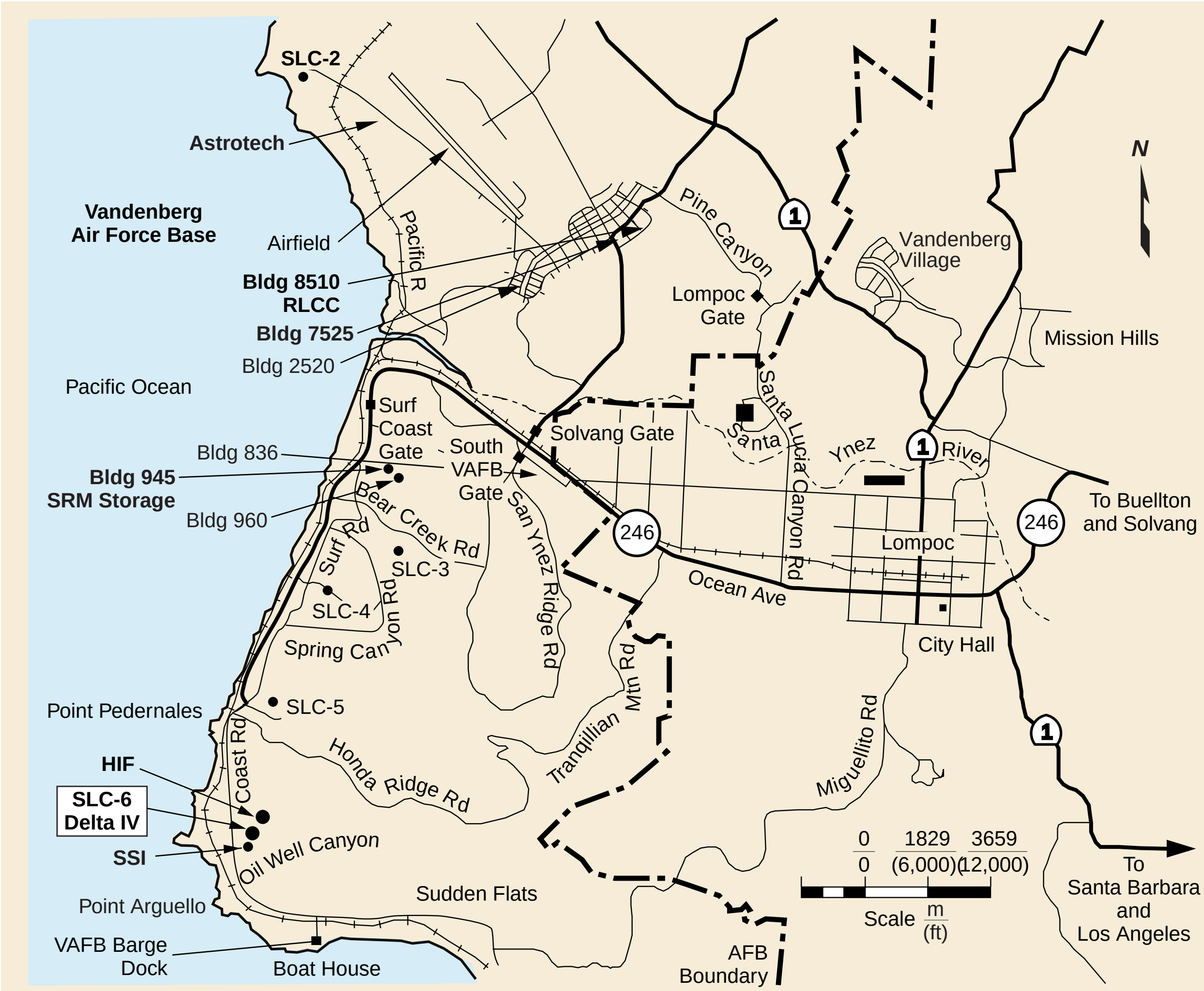

Figure 7-2. Vandenberg Air Force Base (VAFB) Facilities

4. (Building 945 will be used for Delta IV Medium-Plus (Delta IV-M+) graphite-epoxy motor (GEM) processing.

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 Boeing, the spacecraft contractor, and USAF or NASA). For spacecraft preparations, the spacecraft contractor must provide its own test equipment including telemetry receivers and telemetry ground stations.

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 spacecraft contractor-selected processing facility with assistance from Boeing. 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 spacecraft contractor.

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 spacecraft contractor 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

The NASA spacecraft facilities are located in the NASA support area on South VAFB (SVAFB) (Figure 7-3). The spacecraft support area is adjacent to State Highway 246 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).

7.2.1.1 Spacecraft Laboratory. The spacecraft laboratory in building 836 (Figure 7-4) is divided into work and laboratory areas and includes spacecraft assembly areas, laboratory areas, clean rooms, a computer facility, office space, a conference room, and the telemetry station.

Spacecraft laboratory 1 consists of a high bay 20.4 m (67 ft) long, 9.8 m (32 ft) wide, and 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 by 3.7 m (12 ft by 12 ft) connect the two portions of this laboratory. The outside cargo entrance door to the space vehicle assembly room in laboratory 1 is 6.1 m (20 ft) wide by 7.8 m

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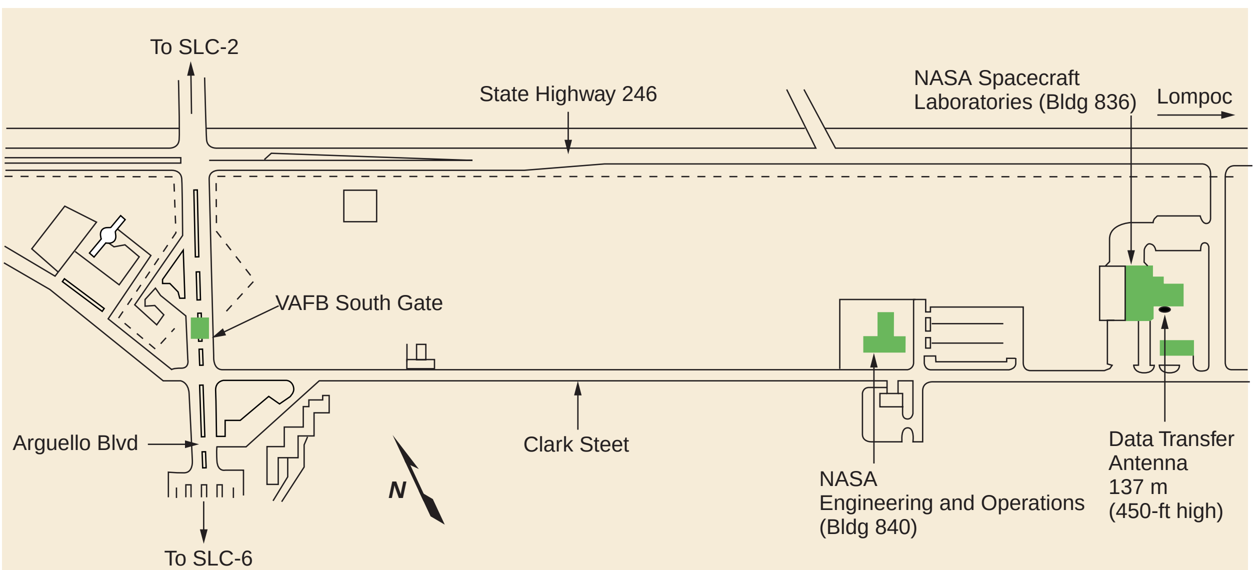

Figure 7-3. Spacecraft Support Area

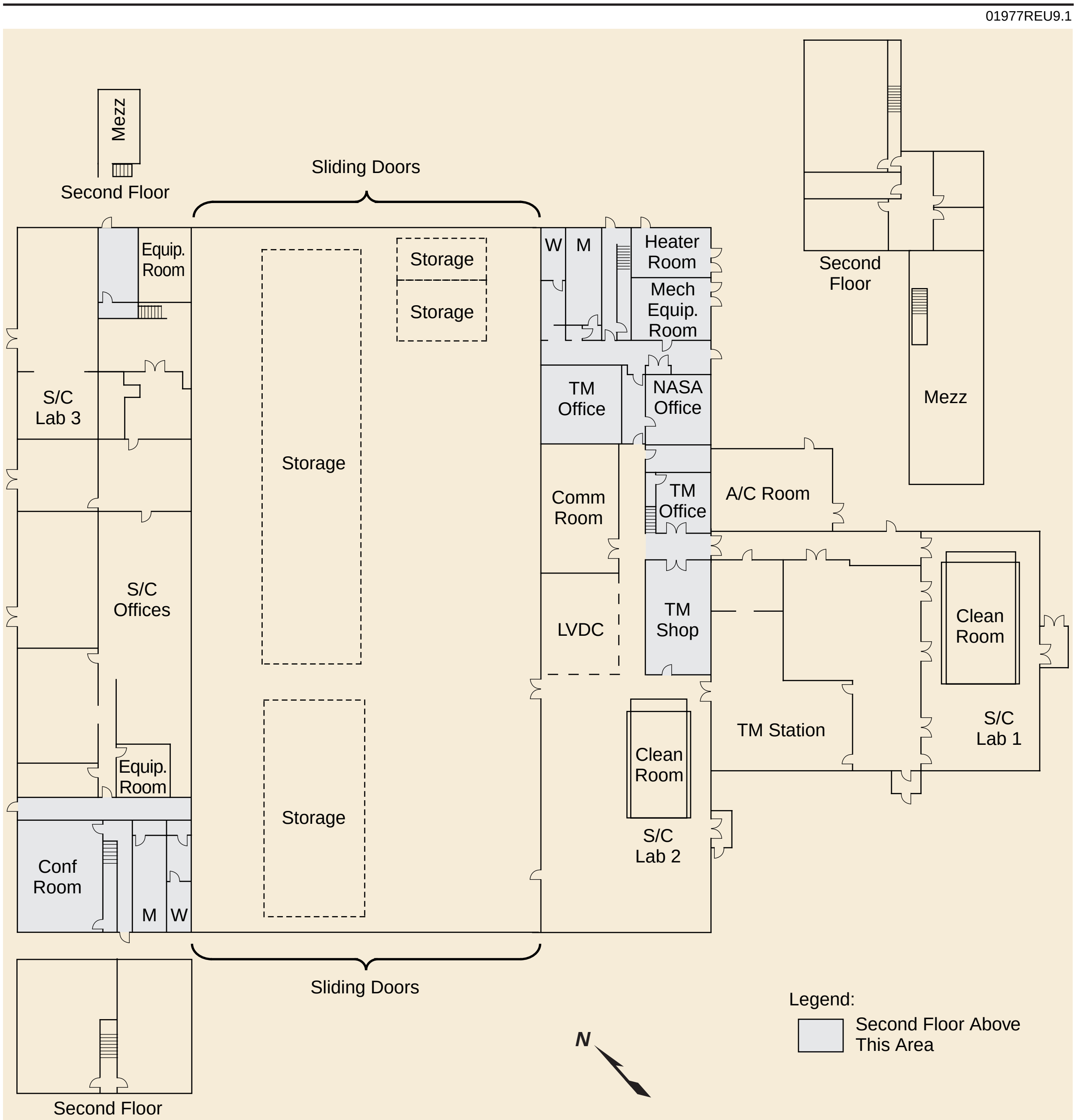

Figure 7-4. NASA Space Vehicle Laboratory (Building 836)

(25 ft, 7 in.) high. A bridge crane, with an 8.8-m (29-ft) hook height and a 4535-kg (5-ton) capacity, is available for handling payloads and associated equipment. This assembly room contains a class 100,000 horizontal laminar flow clean room, 10.4 m (34 ft) long by 6.6 m (21.5 ft) wide by 7.6 m (25 ft) high with temperature control of 15.6° to 26.7° ± 1.1°C (60° to 80° ± 2°F). The front of the clean room opens to allow free entry of the payloads and handling equipment.

The clean room 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 clean-room divider. Spacecraft laboratory 1 also supports 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). Temperature control in this area is 21.1° ± 2.8°C (70° ±5°F).

Spacecraft laboratory 2 has a 527-m^2 (5670-ft^2) work area. Access to this area from the high bay service area is provided by a 3.7-m by 5.2-m (12-ft by 17-ft) roll-up door. Three electric overhead cranes are available: a fixed 909-kg (1-ton) hoist with a 7-m (23-ft) hook height and two 909-kg (1-ton) monorail hoists with 5.5-m (18-ft) hook heights. A horizontal laminar flow class 100,000 clean room, 9.1 m by 5.2 m by 5.2 m (30 ft by 17 ft by 17 ft), is located in this laboratory for spacecraft use. One end of the clean room is open to allow access.

Spacecraft laboratory 3 has three work areas with a total of 2323 m^2 (25,000 ft^2). This laboratory is permanently assigned to the National Oceanographic and Atmospheric Administration (NOAA) Environmental Monitoring Satellite Program.

The high bay is a 30.5-m by 61-m (100-ft by 200-ft) area serviced by a 22 727-kg (25-ton) crane with a 7.6-m (25-ft) hook height. This area is ideal for handling heavy equipment and loading or unloading trucks. The high bay is heated and has 30.5-m (100-ft)-wide by 9.1-m (30-ft)-high sliding doors on both ends.

7.2.2 Astrotech Space Operations Facilities

Astrotech's VAFB facility is located on 24.3 hectares (60 acres) of land approximately 33.3 km (18 mi) north of the Delta IV launch complex (SLC-6) along Tangair Road at Red Road (Figures 7-2 and 7-5). The initial phase of this facility includes approximately 1000 m^2 (10,600 ft^2) of industrial space. Since completion of the Phase II expansion in 1996, this facility includes an additional ~500 m^2 (~5,400 ft^2) of industrial space.

With Phase II completion there will be three major buildings on the site, as shown in Figure 7-5. A brief description of each building is given below. For further details, a copy of the Astrotech Facility Accommodation Handbook is available on request.

Building 1032, the payload processing facility (PPF), houses two explosion-proof high bays and an explosion-proof airlock/high bay for nonhazardous and hazardous operations. The PPF is used for final assembly and checkout of the payload, liquid propellant and solid rocket motor handling operations, third-stage preparations, and payload final assembly. The Astrotech and SSI facilities are on the VAFB fiber-optic network, providing basewide communications capability.

Technical support building M1030 provides administrative facilities for payload project officials, with office space for conducting business during their stay at Astrotech and the western launch site.

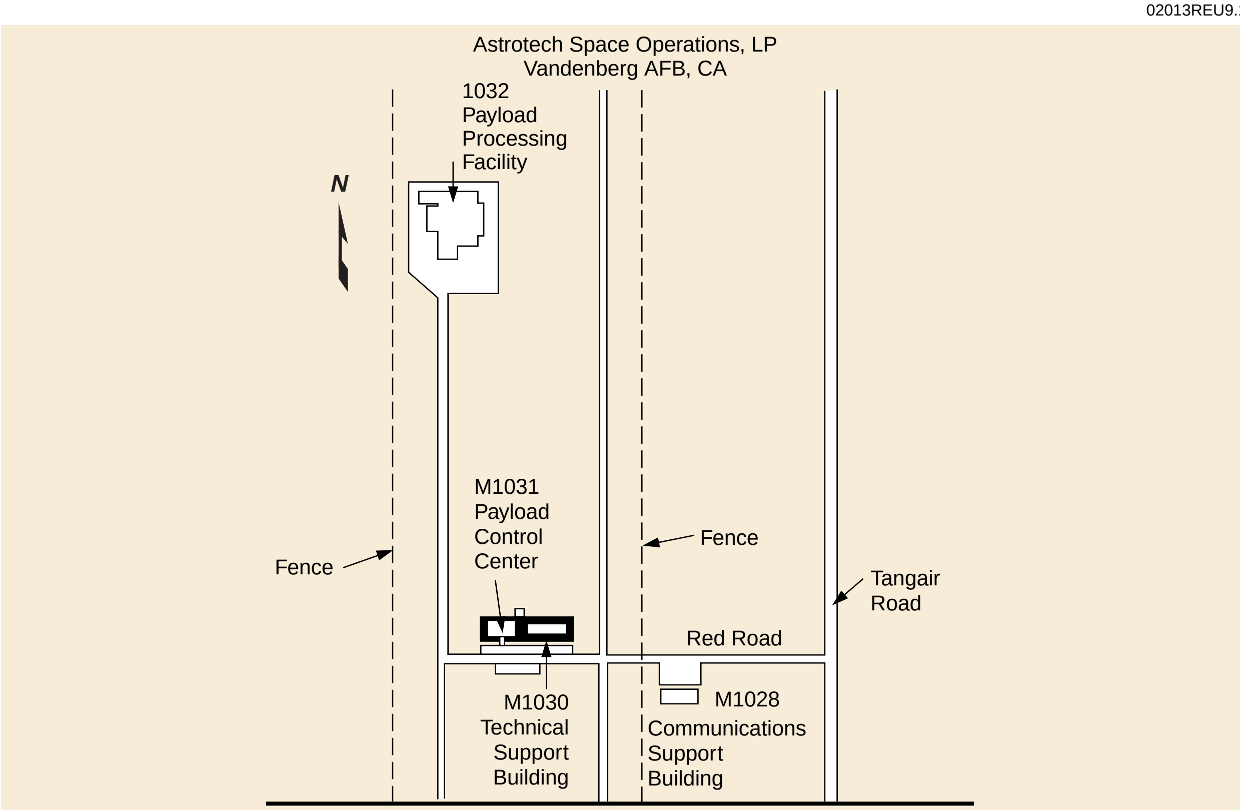

Figure 7-5. Astrotech Payload Processing Area

Communications support building 1028 contains the fiber termination unit that is the communications interface between the Astrotech facility and the VAFB communications network. This building also includes additional administrative facilities for payload project officials.

7.2.2.1 Astrotech Building 1032 (Payload Processing Facility). Building 1032 has overall plan dimensions of approximately 46 by 27 m (150 by 90 ft) and a maximum height of approximately 20 m (65 ft). Major features are an airlock/high bay, two high bays with control rooms, and three airlocks/low bays. The airlocks and high bays have class 100,000 clean rooms demonstrated capability, with the ability to achieve class 10,000 or better levels. The floor coverings in these areas are made of an electrostatic dissipating (high impedance) epoxy-based material. The ground-level floor plan of building 1032 is shown in Figure 7-6. The airlock/high bay in building 1032 has a floor area measuring 12.2 m by 18.3 m (40 ft by 60 ft) and a clear vertical ceiling height of 13.7 m (45 ft). It provides environmentally controlled external access for large equipment entry into the high bays. The airlock/high bay contains a 9072-kg (10-ton) overhead crane with an 11.3-m (37-ft) hook height that serves both the airlock/high bay and the adjoining high bay. The two high bays in building 1032 differ in size. The smaller high bay, which adjoins and is an extension of the airlock/high bay, has a floor area measuring 12.2 m by 18.3 m (40 ft by 60 ft) and a clear vertical ceiling height of 13.7 m (45 ft). As noted above, the 9072-kg (10-ton) overhead crane in the airlock/high bay also serves the smaller high bay. The adjoining larger high bay has a floor area measuring 15.3 m by 21.4 m (50 ft by 70 ft) and a clear vertical ceiling height of 20 m (65 ft). The larger high bay has a 27 200-kg (30-ton) overhead traveling bridge crane with a maximum hook height of 16.8 m (55 ft).

Each high bay has an adjacent control room with floor areas as shown in Figure 7-6. A large exterior door is provided in each control room to facilitate installation and removal of equipment. Each control room has a large window for viewing activities in the high bay. Garment rooms support the high bay areas and provide personnel access to them. Limiting access to the high bays through these rooms helps control personnel traffic and maintains a clean-room environment. There are three airlocks/low bays—two adjoining the smaller high bay and one adjoining the larger high bay. Each airlock/low bay has a floor area measuring 6.1 m by 6.1 m (20 ft by 20 ft) and a clear vertical ceiling height of 3.7 m (12 ft). A large exterior door is provided in each airlock/low bay, and a roll-up door is located in the wall between the airlock/low bay and the adjoining high bay to provide environmentally controlled external access for small equipment entry into the high bays. The airlocks/low bays are also suitable for staging of liquid propellants.

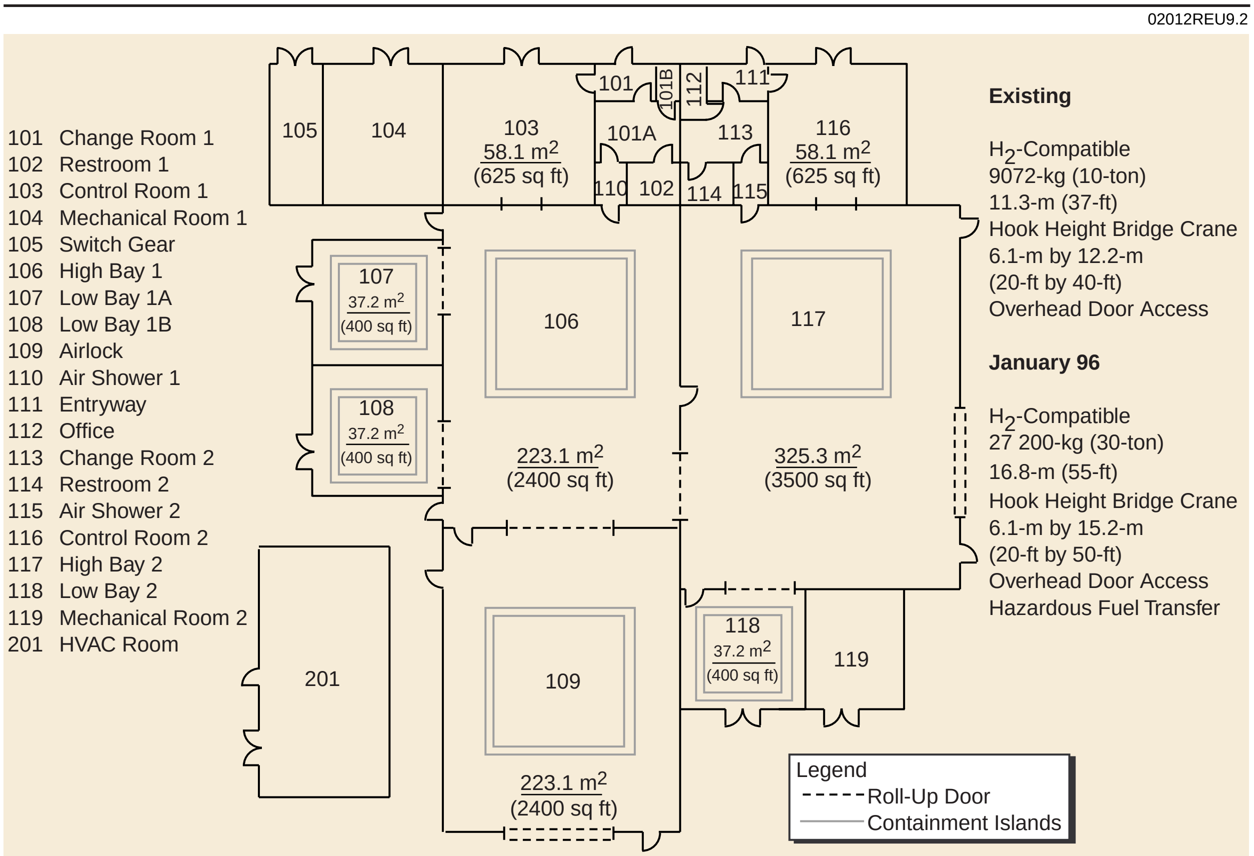

Figure 7-6. Astrotech Payload Processing Facility (Building 1032)

7.2.2.2 Astrotech Building M1030 (Technical Support Building). Building M1030 provides 223 m² (2400 ft²) of office and conference room space for the spacecraft project.

7.2.2.3 Astrotech Building 1028 (Communications Support Building). Building 1028 provides 111 m² (1200 ft²) of office area for the spacecraft project.

7.2.3 Spaceport Systems International

Spaceport Systems International (SSI) is located immediately south of and adjacent to SLC-6 (Figure 7-2). The PPF associated with the California spaceport is located on South Vandenberg adjacent to the spaceport. This PPF is called the integrated processing facility (IPF) because booster components and payloads (satellites) can be processed at the same time. Originally built to process classified Space Shuttle payloads, this facility is now a part of SSI's facilities. It has two basic areas: processing, and technical support (Figure 7-7). The processing areas are on the north side of the building, and the technical support areas are on the south side.

The cross-sectional view of the IPF shown in Figure 7-8 illustrates the relationships between the technical support area and the processing area level numbers. Level numbers are defined in feet in reference to the SLC-6 launch mount. Rooms on two levels (89 and 101) provide office space and technical support rooms ranging from 14 m² to 150 m² (150 ft² to 1620 ft²). These floors

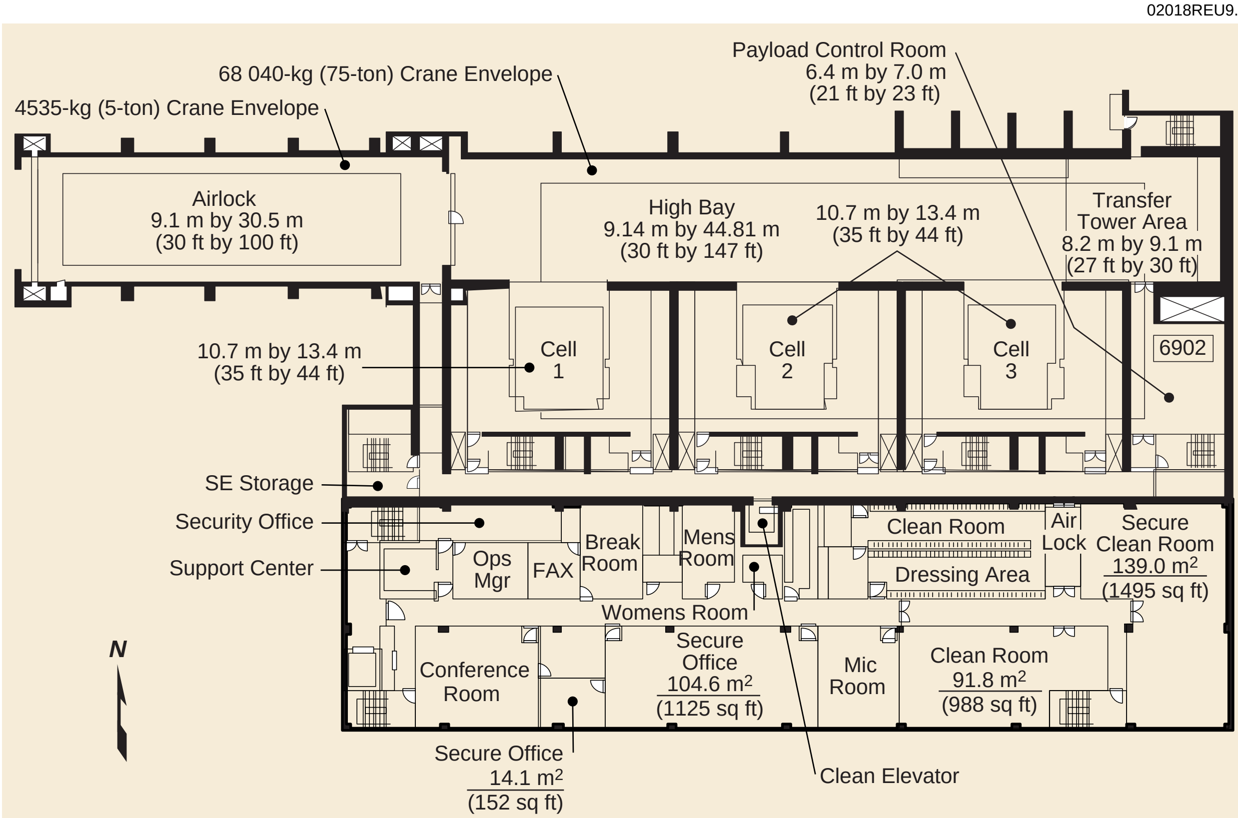

Figure 7-7. California Spaceport—Plan View of the Integrated Processing Facility

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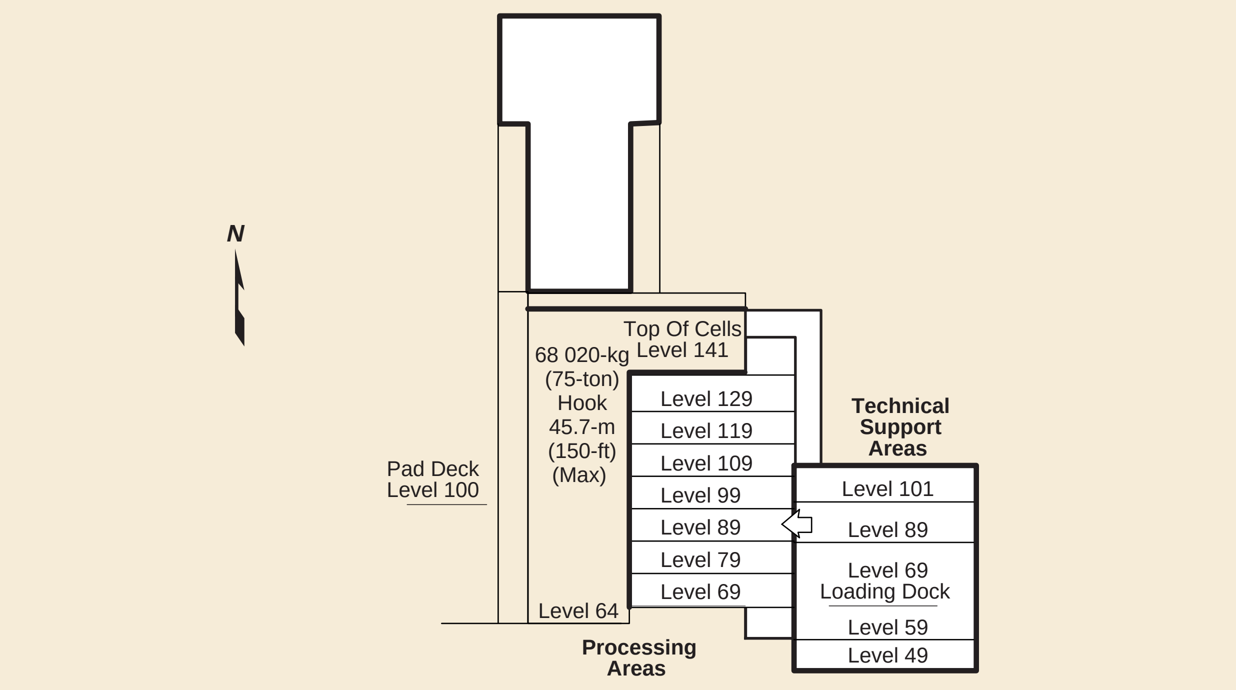

Figure 7-8. California Spaceport—Integrated Processing Facility Cross-Sectional View

contain both “dirty” and clean elevators, clean dressing areas, tool-cleaning areas, a propellant handler’s ensemble (PHE) change room, dressing rooms, showers, break room, conference room, and restrooms. An airlock on level 89 separates the technical support area from the processing areas.

7.2.3.1 Processing Areas. There are six major processing areas within the IPF:

1. Airlock (9.1 m x 30.5 m [30 ft by 100 ft]).
2. High bay (9.1 m by 44.8 m [30 ft by 147 ft]).
3. Three payload checkout cells (PCC) (10.7 m by 13.4 m [35 ft by 44 ft]).
4. Transfer tower area (8.2 m by 9.1 m [27 ft by 30 ft]).
5. Fairing storage and assembly area (FSAA).
6. Miscellaneous payload processing rooms (PPR).
7. Payload Encapsulation Facility (PEF).

Some dimensions of the processing areas are summarized in Figure 7-7. Also shown are the crane envelopes for the 4535-kg (5-ton) cranes in the airlock; the 68 040-kg (75-ton) cranes servicing the high bay, the checkout cells, and the transfer tower area; and the checkout cell 4535-kg (5-ton) cranes. Vehicles and equipment enter through the main entry door in the west end of the airlock. Personnel and support equipment access to the checkout cells is provided through the airlock on level 89 of the technical support area. There is also a personnel airlock entry door on the south side of the airlock. The level 69 payload processing room (6902) is shown in Figure 7-7;

rooms are also available on levels 79, 89, 99, 109, 119, and 129. The rooms are 4.9 m by 7.0 m (16 ft by 23 ft).

There are seven levels on the processing side; six can be seen in Figure 7-8. The seventh (fairing storage and assembly area) is shown in Figure 7-9. The airlock and the high bay are on level 64. The payload checkout cells floor and the transfer tower area are on level 69. In addition to the cell floor at level 69, there are six platform levels (79, 89, 99, 109, 119, and 129) in each of the three processing cells. There are payload processing rooms on each level, providing a total of seven rooms, similar to the payload processing room shown in Figure 7-7, for small payload processing or processing support. Access is provided to the processing area through the airlock on level 89 of the technical support area.

Figure 7-9 illustrates the IPF as viewed in cutaway looking south, and shows the location of the fairing storage and assembly area. This class 100,000 clean room provides the option for fairing storage and build-up prior to encapsulating the payload in the transfer tower area.

Access to the IPF is through the 7.3-m (24-ft)-wide, 8.5-m (28-ft)-high main door on the west side of the airlock. The 9.1-m by 30.5-m (30-ft by 100-ft) Class 100,000 clean airlock has two 4535-kg (5-ton) overhead bridge cranes with a hook height of 10.8 m (35 ft, 5 in.). The class 100,000 clean room, 9.1-m by 44.8-m (30-ft by 147-ft) high bay is serviced by a 68 040-kg (75-ton) bridge

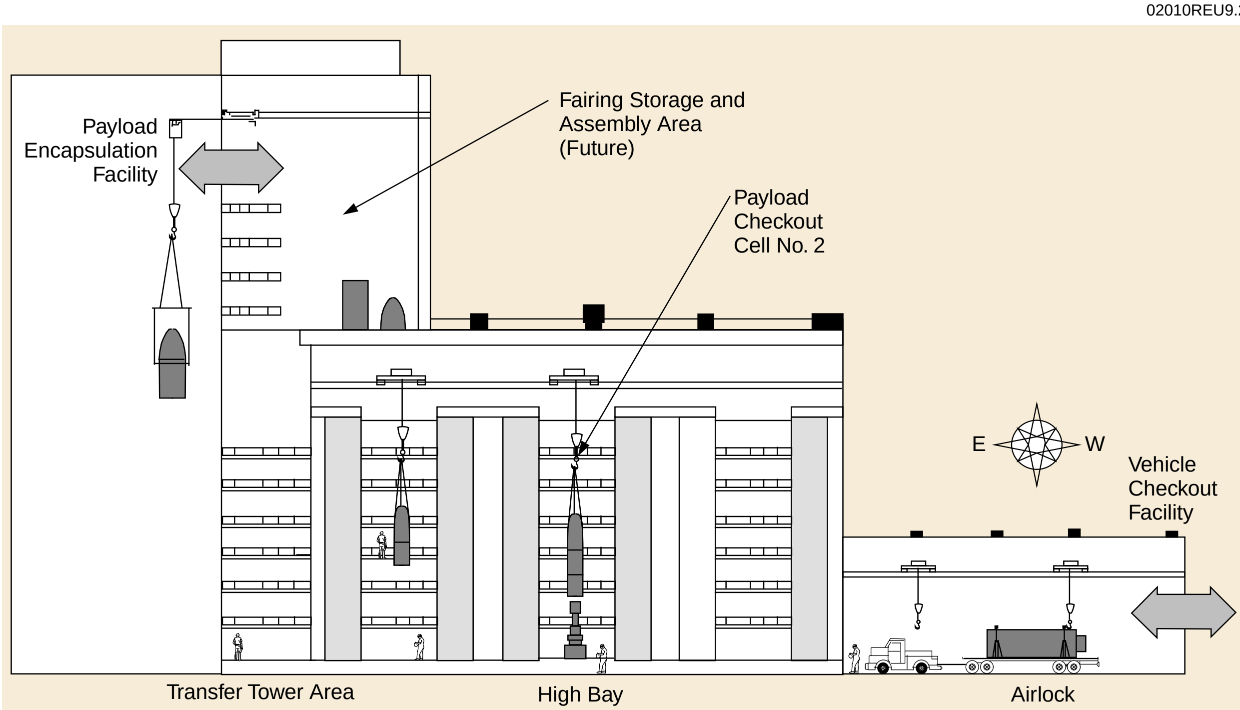

Figure 7-9. Spaceport Systems International—Cutaway View of the Integrated Processing Facility (Looking South)

crane. The hook height in the high bay is 26.3 m (86 ft, 4 in.). Access to the high bay is through the 7.3-m-(24-ft)-wide, 8.5-m (28-ft) door from the airlock.

The three class 100,000 clean-room (10.7-m by 13.4-m [35-ft by 44-ft]) payload checkout cells (PCCs) are serviced by a 68 040-kg (75-ton) bridge crane with a 24.8-m (81-ft, 4-in.) hook height. Each cell also has 4535-kg (5-ton) crane support with a hook height of 21.9 m (71 ft, 11 in.). Access to each cell is through doors from the high bay with a total opening of 6.4 m (21 ft, 2 in.).

Tables 7-1, 7-2, 7-3, 7-4, 7-5, 7-6, and 7-7 detail some of the capabilities in each of the processing areas. They define constraints, customer-provided equipment, and technical capability summaries in nine categories: space/access, handling, electrical, liquids, pneumatics, environmental control, safety, security, and communications.

7.2.3.2 Technical Support Areas. Figures 7-10 and 7-11 are plan views of the IPF, showing levels 89 and 101 of the technical support side. (Level numbers are defined in feet, with the SLC-6 launch mount defined as level 100.) These figures show room sizes as well as potential functions. Note that the clean elevator can be accessed only from the technical support side on level 89 through the airlock (for support equipment) or the clean change room. From the elevator, any level on the processing side can be accessed.

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. The Astrotech facilities can accommodate payload encapsulation for 4-m fairing (Delta IV-M, Delta IV-M+[4,2]) launch vehicles, and with modifications, can accommodate all Delta IV launch vehicle configurations. With modifications, the SSI facilities can also accommodate all Delta IV launch vehicle configurations. For purposes of this document, discussions are limited to Astrotech and SSI facilities.

Prior to or after payload arrival, the fairing and PAF(s) enter a high bay to be prepared for payload encapsulation. The fairing bisectors or trisectors are erected and stored on roll transfer dollies. The PAF is installed on the Boeing 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 rolled 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

Table 7-1. Spacecraft Checkout Facility

Constraints	Contractor-provided support
■ No secure communications ■ No installed propellant loading system ■ No installed propellant disposal system ■ No installed microwave or infrared intrusion detection system	■ GN_2 and He pressure carts ■ Spill aspirators
Capability type	**Capability**
1. Space/access	■ Floor loading for mobile equipment; meets AASHTO H-20 ■ 9.144-m by 30.48-m (30-ft by 100-ft) internal floor space ■ 8.53-m by 7.32-m (28-ft-h by 24-ft-w) door openings ■ Adjacent to washdown area outside ■ Accept tow vehicle/transporter of 6.10 by 27.43 m (20 by 90 ft)
2. Handling	■ Two 4535-kg (5-ton) overhead bridge cranes ■ Crane maximum hook height of 10.8 m (35 ft 5 in.) ■ Speeds – Hoist 0.08 m/s (16 fpm) – Bridge 0.07 m/s (14 fpm) – Trolley 0.07 m/s (14 fpm) ■ Pendant control at elevation 19.51 m (64 ft) (floor)
3. Electrical	■ Utility and technical power 120/208 VAC ■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500-516 ■ Multipoint grounding per MIL-STD-1542
4. Liquids	■ Cleaning water supply – 378.5 l/m at 0.55 MPa (100 gpm at 80 psig) – 38.1-mm (1.5-in.) male hose thread
5. Pneumatics	■ Compressed air 0.862 MPa (125 psig) – 9.53-mm (3/8-in.) quick-disconnect (QD) interface
6. Environment	■ Buffer for operations between external environment and high bay area ■ 100,000 clean-room capability – Inlet air Class 5000 – Temp 21°±2.8°C (70°±5°F) – RH 30–50% – Dif 1.27-mm (0.05-in.) Wg – Air chg 10–12 changes/hr min ■ Central vacuum system
7. Safety	■ All electrical equipment is hazard-proof as defined in National Electrical Code, Articles 500-516 ■ Fire detection and suppression system
8. Security	■ Access control – KeyCard/cipher system – Intrusion detection system (BMS switches) – Vault doors with S&G 3-position tumbler – Lockable personnel and hardware access doors
9. Communications	■ Administrative phone ■ Operational Voice System (OVS) ■ Area warning system ■ Paging system

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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 Boeing 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 7-12.

The payload is transported to the launch pad at 8 km/hr (5 mph). The encapsulated fueled payload is environmentally controlled during transportation. During payload hoist onto the launch vehicle, interruptions in environmental control system (ECS) services will be negotiated with the spacecraft contractor. Boeing uses PC-programmed monitors to measure and record the transport dynamic

Table 7-2. Spacecraft Checkout Area

Constraints	Contractor-provided support
■ No secure communications ■ No installed propellant loading system ■ No installed propellant disposal system ■ No installed microwave or infrared intrusion detection system	■ GN_2 and He pressure carts ■ Spill aspirators

Capability type	Capability
1. Space/access	■ Floor loading for mobile equipment; meets AASHTO H-20 ■ Work space approximately 9.14 m by 44.73 m (30 ft by 146 ft 9 in.) ■ Adjacent to transfer tower area and payload checkout cells
2. Handling	■ 68 040-kg (75-ton) overhead bridge main crane (currently proofloaded to 26 310 kg (29 tons) ■ Hook height – Vehicle checkout area (VCA) 26.31 m (86 ft 4 in.) above floor at elev 19.5 m (64 ft) – Checkout cells 24.79 m (81 ft 4 in.) maximum above floor (floor at elev 21.03 m [69 ft]) – Transfer tower 24.79 m (81 ft 4 in.) maximum above floor (floor at elev 21.03 m [69 ft]) ■ Speeds – Hoist 0.05 m/s (10 fpm) – Bridge E/W 0.076 and 0.15 m/s (15 and 30 fpm) – Trolley N/S 0.076 and 0.05 m/s (15 and 10 fpm) ■ Micro drive – Hoist 0.0025 m/s (0.5 fpm) and .0076 m/s (1.5 fpm) – Bridge 0.0025 m/s (0.5 fpm) – Trolley 0.0025 m/s (0.5 fpm) ■ Two portable pushbutton stations with 18.3-m (60-ft) flex cable ■ Connected to junction boxes on north wall
3. Electrical	■ Utility and technical power 120/208 VAC ■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500-516 ■ Multipoint grounding per MIL-STD-1542
4. Liquids	■ None
5. Pneumatics	■ Gaseous nitrogen (GN_2)
6. Environment	■ 100,000 clean-room capability – Inlet air Class 5000 – Temp 21°±2.8°C (70°±5°F) – RH 30–50% – Dif 1.27-mm (0.05-in.) Wg – Air chg 10–12 changes/hr min ■ Central vacuum system
7. Safety	■ All electrical equipment is hazard-proof as defined in National Electrical Code, Articles 500-516 ■ Fire detection and suppression system (suppression system currently inactivated)
8. Security	■ Access control – KeyCard/cipher system – Intrusion detection system (BMS switches) – Lockable personnel and hardware access doors
9. Communications	■ Administrative phone ■ Operational Voice System (OVS) ■ Area warning system ■ Paging system

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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.

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 re-established 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 environmental shelter will be erected over the immediate area to prevent payload contamination.

Table 7-3. Payload Checkout Cells Capabilities

Constraints	Contractor-provided support
■ No installed GN_2 or GHe systems ■ Hypergolic propellant loading system in Cell 2 not activated ■ No installed propellant disposal system	■ GN_2 and He pressure carts ■ Spill aspirators

Capability type	Capability
1. Space/access	■ Design floor loading – 4788 Pa (100 psf) on checkout cell floor – 3591 Pa (75 psf) plus a 1814-kg (4000-lb) load on four casters (1.22 m by 1.83 m) (4 by 6 ft) on fixed platforms – 2394 Pa (50 psf) plus a 544-kg (1200-lb) load on folding platforms ■ Work space approximately 10.7 m by 13.4 m (35 ft by 44 ft) ■ Cell door opening 6.45 m by 21.64 m (21 ft 2 in. by 71 ft high) ■ Adjacent to transfer tower area and high bay ■ Six working platform levels (fixed and fold-down plus finger planks in Cells 2 and 3) spaced 3.05 m (10 ft) apart
2. Handling	■ 4535-kg (5-ton) overhead bridge main crane ■ Hook height (floor at elev 21.03 m [69 ft]) – Cell 1 21.79 m (71 ft 6 in.) above floor – Cell 2 21.92 m (71 ft 11 in.) above floor – Cell 3 21.76 m (71 ft 4.5 in.) above floor ■ Speeds – Hoist 0.08 m/s (16 fpm) (Cells 2/3) 0.05 m/s (10 fpm) (Cell 1) – Bridge E/W 0.05 m/s (10 fpm) – Trolley N/S 0.05 m/s (10 fpm) (Cell 1) 0.025 m/s (5 fpm) (Cell 2) 0.086 m/s (17 fpm) (Cell 3) ■ Micro drive – Hoist 0.0025 m/s (0.5 fpm) – Bridge 0.0025 m/s (0.5 fpm) – Trolley 0.0025 m/s (0.5 fpm) ■ Portable pushbutton station with 13.72-m (45-ft) flex cable connected to receptacle on northeast corner of cell on any level
3. Electrical	■ Utility and technical power 120/208, 408 VAC ■ Multipoint grounding per MIL-STD-1542
4. Liquids	■ Cleaning water supply – 189.3 l/m at 0.55 MPa (50 gpm at 80 psig) – 25.4-mm (1-in.) hose bib with 25.4-mm (1-in.) male hose thread on south wall of each level ■ Hypergolic
5. Pneumatics	■ Compressed air 0.862 MPa (125 psig) 9.53-mm (3/8-in.) quick disconnect (QD) at two locations per cell
6. Environment	■ 100,000 clean-room capability (class 5000 high-efficiency particulate air [HEPA]) – Inlet air Class 5000 – Temp 12.8° to 23.9°±2.8°C (55° to 75°±5°F) selectable – RH 30–50% – Dif 1.27-mm (0.05-in.) Wg – Air chg 15–17 changes/hr min ■ Central vacuum system
7. Safety	■ All electrical equipment is hazard-proof as defined in National Electrical Code ■ Fire detection and suppression system (dry pipe, manual valve)
8. Security	■ Access control – KeyCard/cipher system – Intrusion detection system (BMS switches) – Vault doors with S&G 3-position tumbler – Lockable personnel and hardware access doors
9. Communications	■ Administrative phone ■ Operational Voice System (OVS) Cell 2 (Cells 1 and 3 planned) ■ Area warning system ■ Paging system

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Table 7-4. Transfer Tower Area

Capability type	Capability
1. Space/access	■ 8.23 m by 9.14-m (27-ft by 30-ft) clear floor access ■ Design floor loading is 4788 Pa (100 psf) ■ Seven platforms on three sides (north, east, and south) – 3591 Pa (75 psf) loading on platforms
2. Handling	■ 68 040-kg (75-ton) stationary hoist ■ Hook height of 50.78 m (166 ft 6 in.) above floor elevation 1753 mm (69 in.) ■ Speeds – Hoist 0.0025, 0.025, and 0.05 m/s (0.5, 5.0, and 10 fpm) ■ Pendant control at elevation 42.37 m and 50.47 m (139 ft 0 in. and 165 ft 7 in.)
3. Electrical	■ Utility power – 110 VAC ■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500-516 ■ Static grounding reel
4. Liquids	■ None
5. Pneumatics	■ Compressed air 0.862 MPa (125 psig) – 9.53-mm (3/8-in.) quick-disconnect (QD) interface
6. Environment	■ 100,000 clean-room capability – Inlet air Class 5000 – Temp 21°±2.8°C (70°±5°F) – RH 30–50% – Dif 1.27-mm (0.05-in.) Wg – Air chg 10–12 changes/hr min ■ Central vacuum system
7. Safety	■ All electrical equipment is hazard-proof as defined in National Electrical Code, Articles 500-516 ■ Fire detection and suppression system
8. Security	■ Access control – KeyCard/cipher system – Intrusion detection system (BMS switches) – Vault doors with S&G 3-position tumbler – Lockable personnel and hardware access doors
9. Communications	■ Administrative phone ■ Operational Voice System (OVS) ■ Area warning system ■ Paging system

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Table 7-5. Fairing Storage and Assembly Area

Capability type	Capability
1. Space/access	■ Floor loading 3591 Pa (75 psf) on platforms ■ 9.75-m by 19.2-m (32-ft by 63-ft) internal floor space ■ 20.88-m by 6.71-m (68-ft 6-in.-h by 22-ft-w) breechload door opening
2. Handling	■ 68 040-kg (75-ton) stationary hoist ■ Hook height of 50.78 m (166 ft 6 in.) above floor elevation 1753 mm (69 in.) ■ Speeds – Hoist 0.0025, 0.025, and 0.05 m/s (0.5, 5.0, and 10 fpm) ■ Pendant control at elevation 42.37 m (139 ft 0 in.) and 50.47 m (165 ft 7 in.)
3. Electrical	■ 100 VAC, utility power ■ Hazard-proof electrical equipment as defined in the National Electrical Code, Articles 500-516 ■ Multipoint grounding per MIL-STD-1542
4. Liquids	■ None
5. Pneumatics	■ Compressed air 0.862 MPa (125 psig) – 9.53-mm (3/8-in.) quick disconnect (QD) interface
6. Environment	■ 100,000 clean-room capability – Inlet air Class 500-0 – Temp 21°±2.8°C (70°±5°F) – RH 30–50% – Dif 1.27-mm (0.05-in.) Wg – Air chg 10–12 changes/hr min ■ Central vacuum system
7. Safety	■ All electrical equipment is hazard-proof as defined in National Electrical Code, Articles 500-516 ■ Fire detection and suppression system
8. Security	■ Access control – KeyCard/cipher system – Intrusion detection system (BMS switches) – Lockable personnel and hardware access doors
9. Communications	■ Paging system

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Table 7-6. Payload Processing Room (PPR) 6902

Capability type	Capability
1. Space/access	■ Processing/storage room 6902: – 6.53 m by 7.01 m (21 ft 5 in. by 23 ft) – 46 m^2 (495 sq ft) ■ Door openings shall accommodate an envelope of 1.22 by 1.83 by 2.13 m (4 by 6 by 7 ft)
2. Handling	■ None
3. Electrical	■ 110 VAC, utility power ■ 20/208 VAC 3 phase ■ Multipoint grounding per MIL-STD-1542 ■ Hazard-proof electrical equipment as defined in the National Electrical Code
4. Liquids	■ None
5. Pneumatics	■ None
6. Environment	■ 100,000 clean-room capability – Inlet air Class 5000 – Temp 21°±2.8°C (70°±5°F) – RH 30–50% – Dif 1.27-mm (0.05-in.) Wg – Air chg 15 changes/hr min
7. Safety	■ Fire detection and suppression system
8. Security	■ Access control – KeyCard/cipher system – Intrusion detection system (BMS switches) – Lockable personnel and hardware access doors
9. Communications	■ None

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Table 7-7. Payload Processing Room (PPR) 8910

Capability type	Capability
1. Space/access	■ Processing/storage room 10.82 m by 9.14 m (35 ft 6 in. by 30 ft 0 in.) and 7.16 m by 7.16 m (23 ft 6 in. by 23 ft 6 in.) 139 m^2 (1495 sq ft) total ■ Door openings shall accommodate an envelope of 1.22 m by 1.83 m by 2.13 m (4 ft by 6 ft by 7 ft)
2. Handling	■ None
3. Electrical	■ 110 VAC, utility power ■ 120/208 VAC 3 phase ■ Multipoint grounding per MIL-STD-1542 ■ Hazard-proof electrical equipment as defined in the National Electrical Code
4. Liquids	■ None
5. Pneumatics	■ None
6. Environment	■ Temp 18.3° to 26.7°C (65° to 80°F) RH N/A Dif 12.7-mm (0.5-in. Wg) Air Chgs 15 changes/hr min (goal) ■ Central vacuum system
7. Safety	■ Fire detection and suppression system
8. Security	■ Keycard/cipher access control ■ Intrusion detection system (BMS switches) ■ Lockable personnel and hardware access doors
9. Communications	■ None

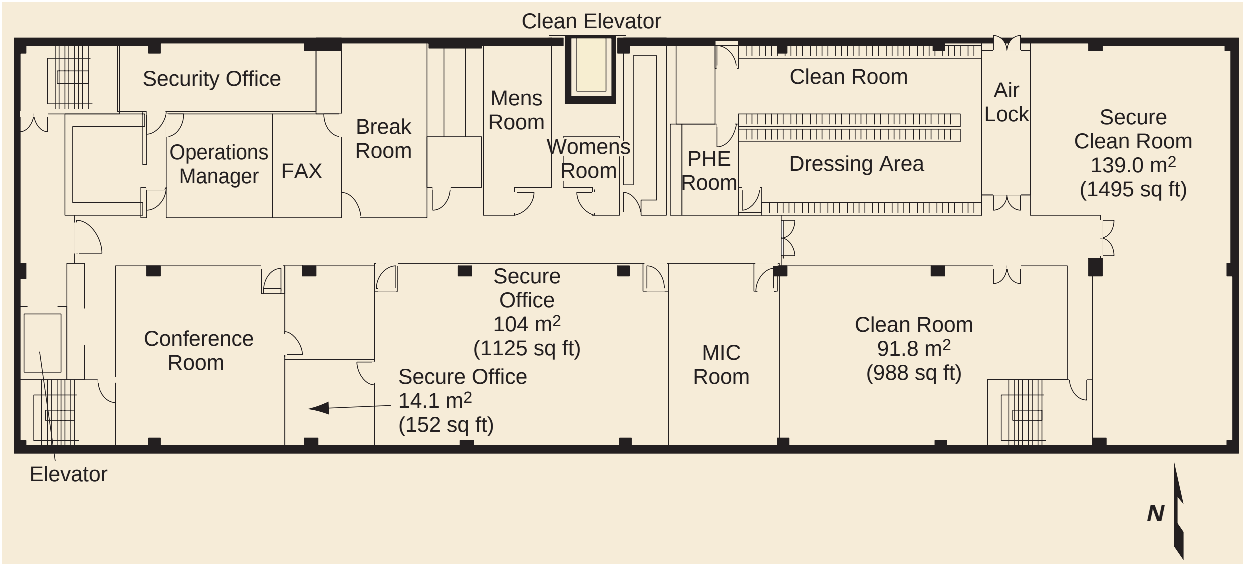

Figure 7-10. California Spaceport—Level 89 Technical Support Area

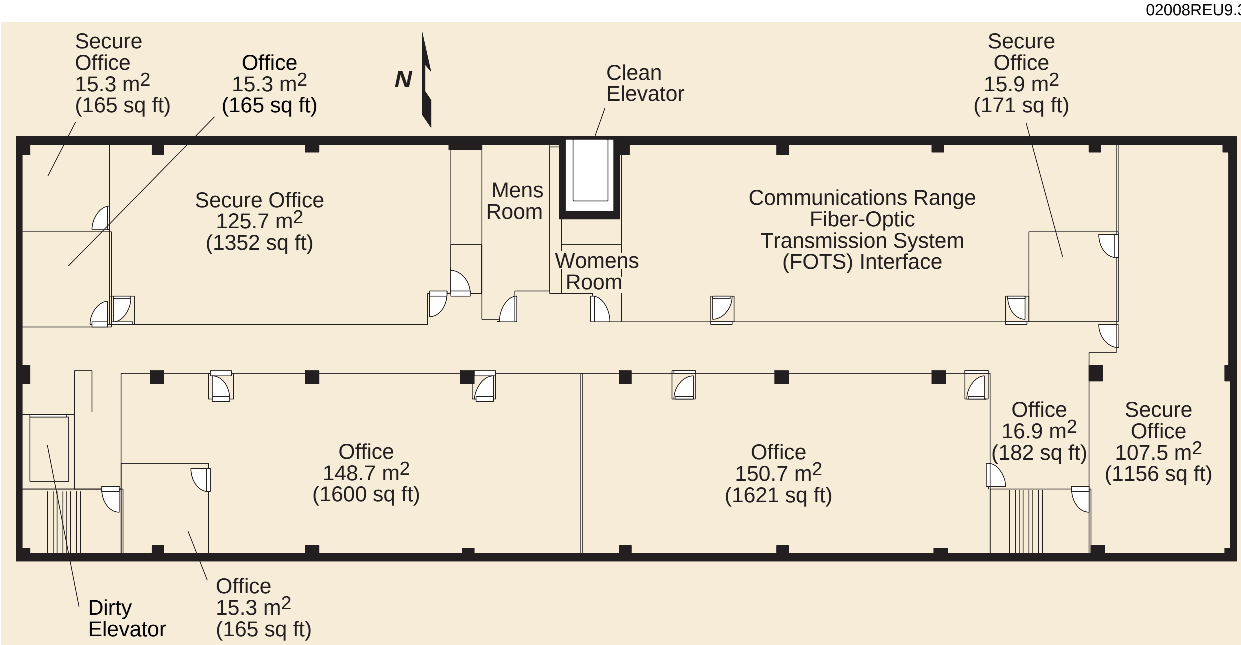

Figure 7-11. California Spaceport—Level 101 Technical Support Area

7.3.1 Payload Processing Facility Analysis for Delta IV Encapsulation

This analysis provides an overview of the PPFs located at both the ER and WR and identifies those that are suitable for Delta IV encapsulation operations without modification. With the exception of the IPF at VAFB, only those facilities thought to be possible candidates for payload encapsulation were evaluated. The facility dimensions, door openings, and crane/hoist ratings and hook heights were evaluated and compared to the esti-

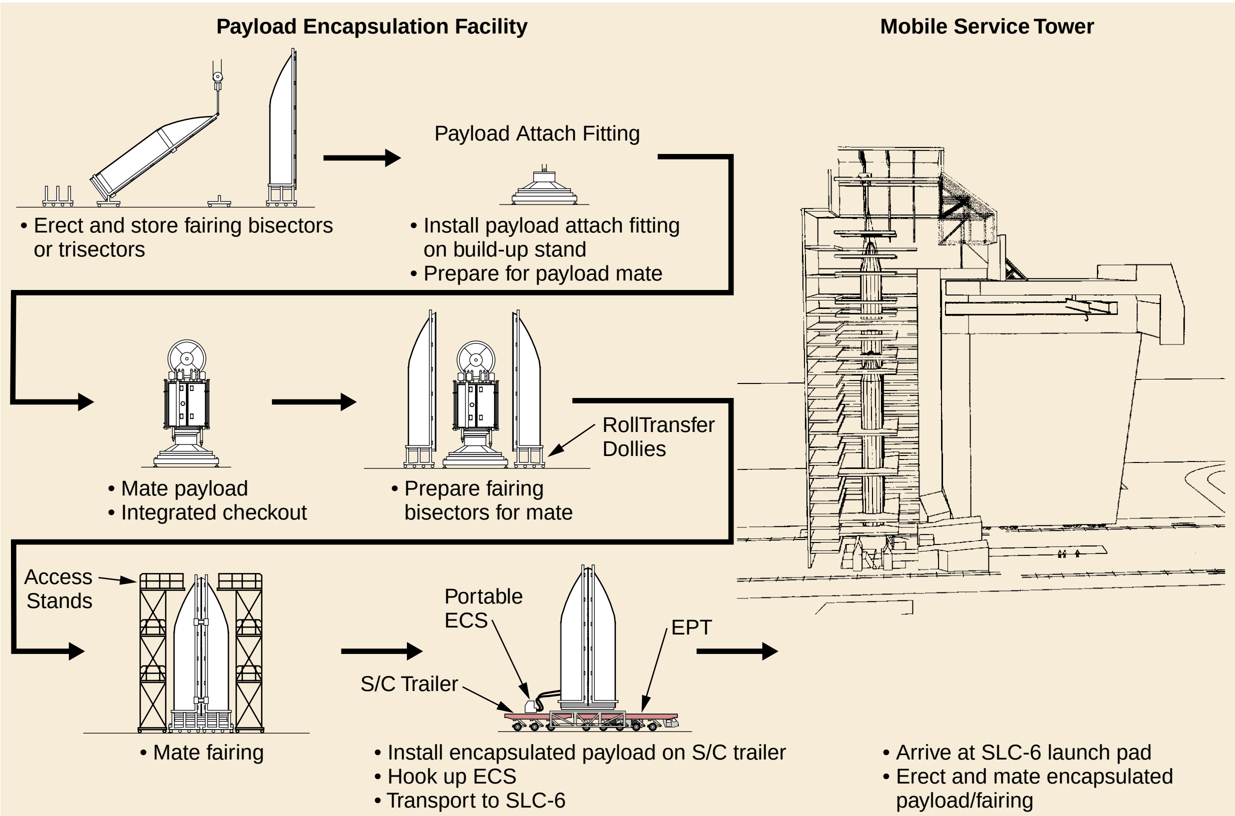

Figure 7-12. Payload Encapsulation, Transport, and On-Pad Mate—4-m Fairing Example

mated requirements for encapsulating the Delta IV-M, Delta IV-M+, and Delta IV-H payloads (Table 7-8). The facility specifications are outlined in the payload processing facility matrix (Table 7-9).

At VAFB, two payload processing facilities exist that are adequate for encapsulation operations with modifications. There are no government-owned or -operated PPFs at VAFB capable of supporting encapsulation operations. The facilities capable of supporting encapsulation operations with modification are:

Facility	Encapsulation capability
Astrotech Space Operations (requires modification)	4-m fairings 5-m fairings (with modifications)
Integrated Processing Facility (requires modification)	4-m fairings 5-m fairings (with modifications)

7.4 SPACE LAUNCH COMPLEX 6

Space Launch Complex 6 (SLC-6) (Figure 7-13) consists of one launch pad, the Delta Operations Center (DOC), an integrated processing facility (IPF), 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 7-14.

Table 7-8. Delta IV Payload Encapsulation Facility Requirements

Vehicle fairing	Floor space	Crane hook height	Door opening	Fairing lay-down area
4-m fairings	12.2-m by 18.3-m; 223.1 m^2 (40 ft by 60 ft; 2400 ft^2)	14.6 m (48 ft)	12.5-m h by 5.5-m w (41 ft h by 18 ft w)	8.5-m by 10.7-m (28 ft by 35 ft)
5-m fairings	11.6-m by 22.3-m; 257.8 m^2 (38 ft by 73 ft; 2774 ft^2)	25 m (82 ft)	22.3-m h by 6.1-m w (73 ft h by 20 ft w)	9.1-m by 20.1-m (30 ft by 66 ft)

These facility requirements are preliminary, based on operations analysis. A design analysis of encapsulation processes and facility needs has not yet been accomplished. It is assumed that the floor space requirements can be adjusted to fit facility floor plans, within reason, through operational modifications to the standard process.

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Table 7-9. Payload Processing Facility Matrix

Facility	Location	Number of payloads (cap.)	Work area/bay cleanliness classification Size: WxLxH	Bay access opening WxH	Bay hoist equipment max. hook height (ft)	Airlock size: WxLxH	Airlock access opening WxH	Airlock hoist equip. max. hook height ft	Other information	Encap compatibility
Astrotech Space Operations	VAFB	Multiple	Class 100,000 Room 106 12.2 m by 18.3 m by 14.3 m (40 ft by 60 ft by 47 ft) Room 117 15.2 m by 21.3 m by 19.8 m (50 ft by 70 ft by 65 ft)	Room 106 6.1 m by 12.2 m (20 ft by 40 ft) Room 117 6.1 m by 13.4 m (20 ft by 44 ft) External door 6.1 m by 15.2 m (20 ft by 50 ft)	Room 106 One 9070-kg (10-ton) bridge 11.3-m (37-ft) hook height Room 117 One 27 210-kg (30-ton) bridge 16.8-m (55-ft) hook height	12.2 m by 18.3 m (40 ft by 60 ft)	6.1 m by 12.2 m (20 ft by 40 ft)	One 9070-kg (10-ton) bridge 11.3-m (37-ft) hook height		4-m dia
California Spaceport (IPF)	VAFB	3	Class 100,000 High bay: 9.1 m by 44.8 m (3 ft by 147 ft) Payload check-out cells: 10.7 m by 13.4 m (35 ft by 44 ft) payload transfer	High bay: 7.3 m by 8.5 m (24 ft by 28 ft) Payload check-out cells: 6.5 m by 21.3 m (21 ft-2 in. by 70 ft) transfer	Vehicle check-out area: 68 040-kg (75-ton) bridge (proof load to 26 300 kg [29 tons]) 26.3-m (86 ft-4 in.) hook height	Class 100,000 9.1m by 30.5 m (30 ft by 100 ft)	Vehicle check-out facility: 7.3 m by 30.5 m (24 ft by 100 ft)	Two 4535-kg (5-ton) bridges 10.8-m (35 ft-5-in.) hook height	SSI is under contract to design a payload encapsulation facility	No (due to configuration and access issues this facility will not meet minimum encapsulation requirements)

Facility data based on a variety of sources including interface control drawings (ICDs), facility drawings, and verbal responses to questions. The facility ICD will supersede information contained in this matrix.

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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 7-15) provides a 79.2-m (260-ft) hook height with 11 working levels. An elevator provides access to the working levels. The payload area encloses levels 8 through 12. Platform 8 (Figure 7-16) is the initial secured level through which all traffic to the upper levels is controlled. This figure 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 Boeing, and appropriate seismic restraints provided.

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

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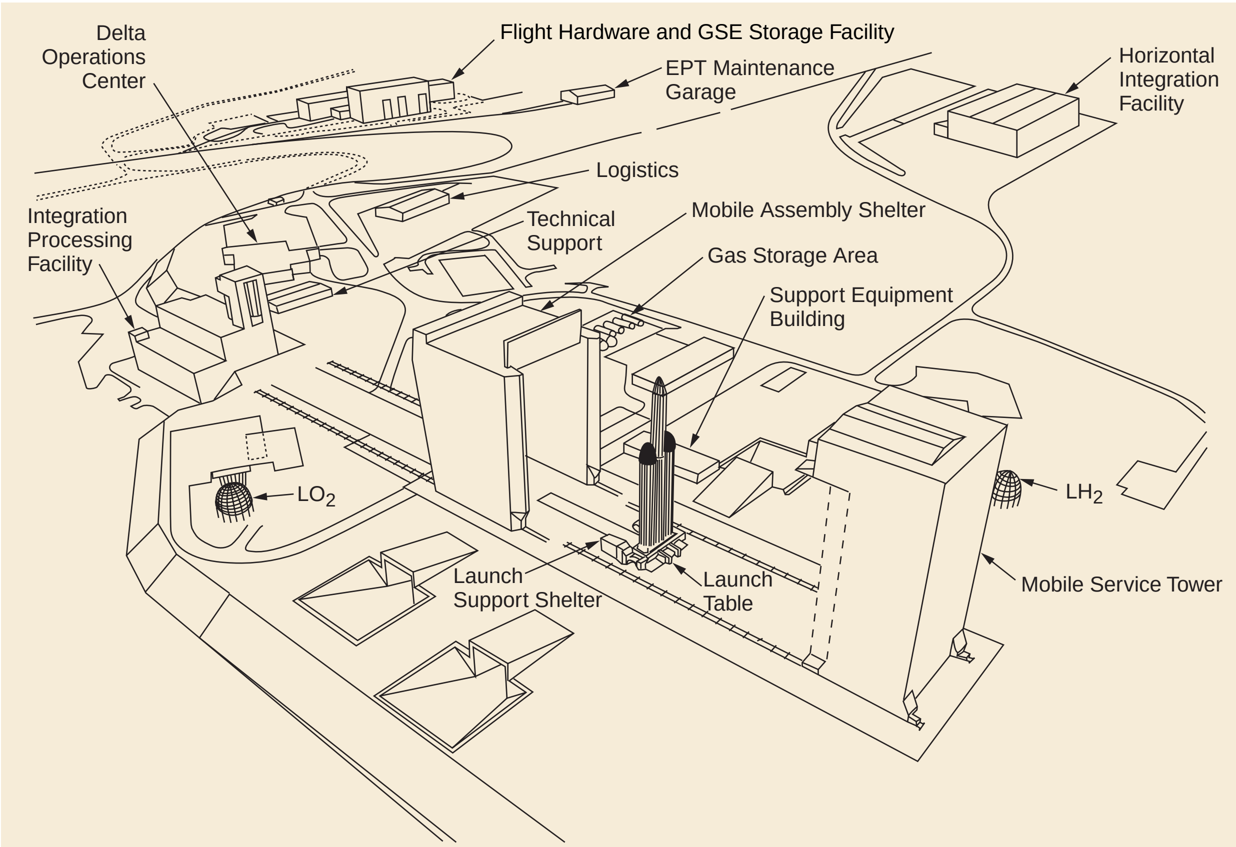

Figure 7-13. Space Launch Complex 6

by the limited amount of work space. Clean-room access to the payload is provided by portable clean-room enclosures.

7.4.2 Common Support Building

The existing structures (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 7-17, 7-18 and 7-19 for a floor plan of these facilities.) These structures will not be occupied during launch.

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. The IPF was discussed at length in Section 7.2.3.

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 7-20.) The SEB will contain the payload air-conditioning

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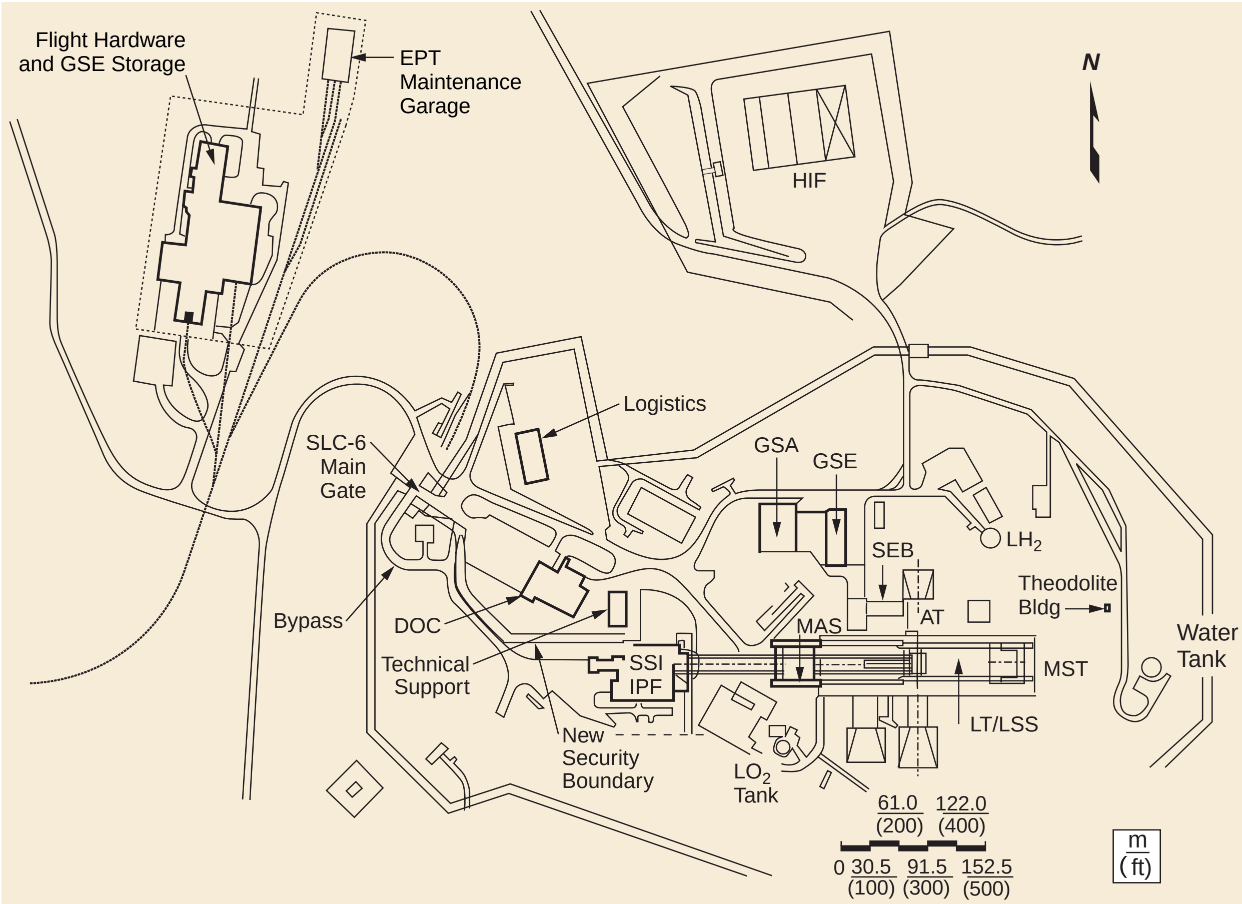

Figure 7-14. Space Launch Complex 6, VAFB Site Plan

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 7-21). 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.

7.4.5 Horizontal Integration Facility

Located at the north site of SLC-6, (Figure 7-14) 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 will have two bays for four single-core (Delta IV-M and Delta IV-M+) process areas or two single-core (Delta IV-M and Delta IV-M+) process areas and a Delta IV-H process area (Figures 7-22 and 7-23).

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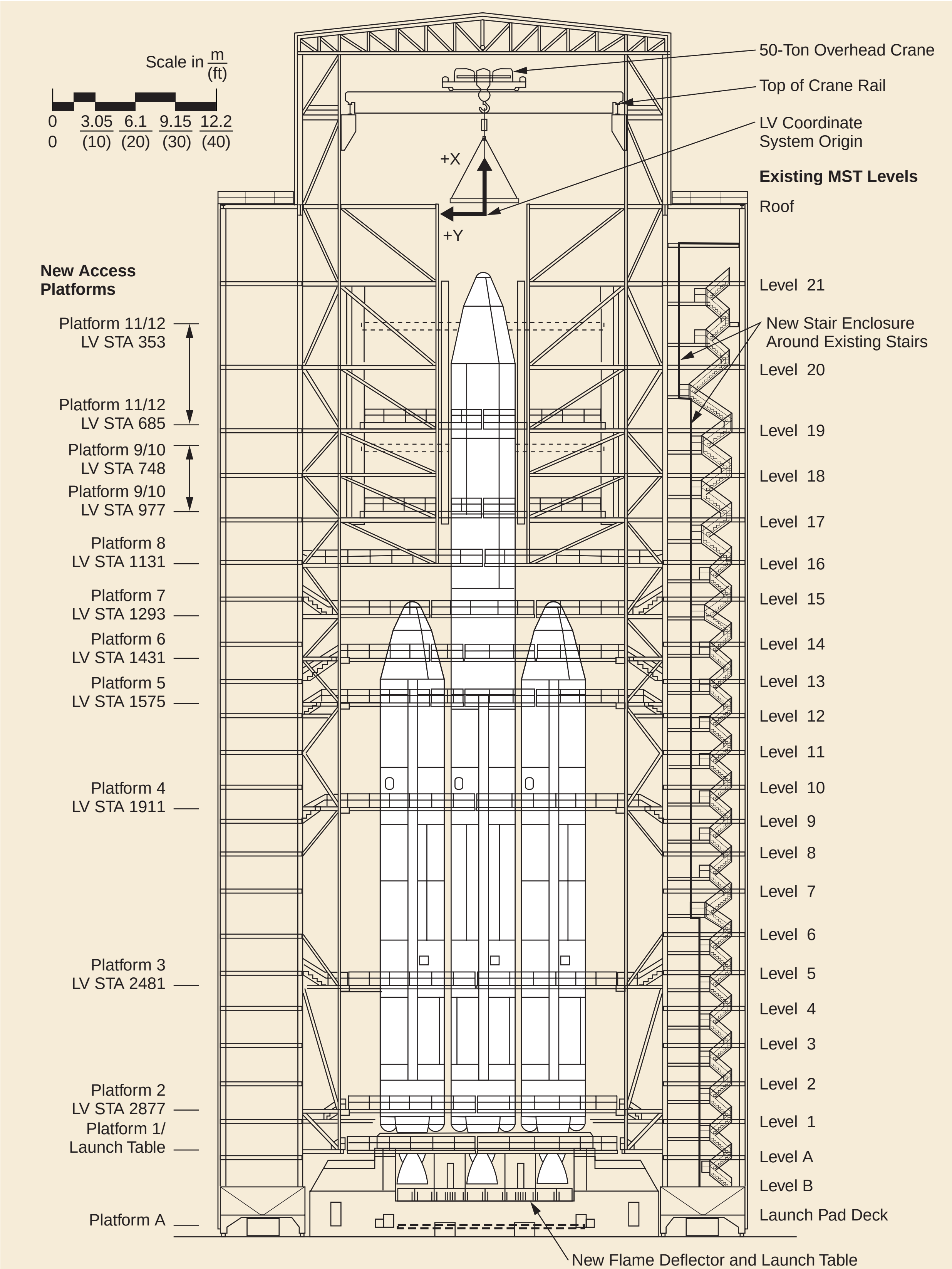

Figure 7-15. Space Launch Complex 6 MST Elevation

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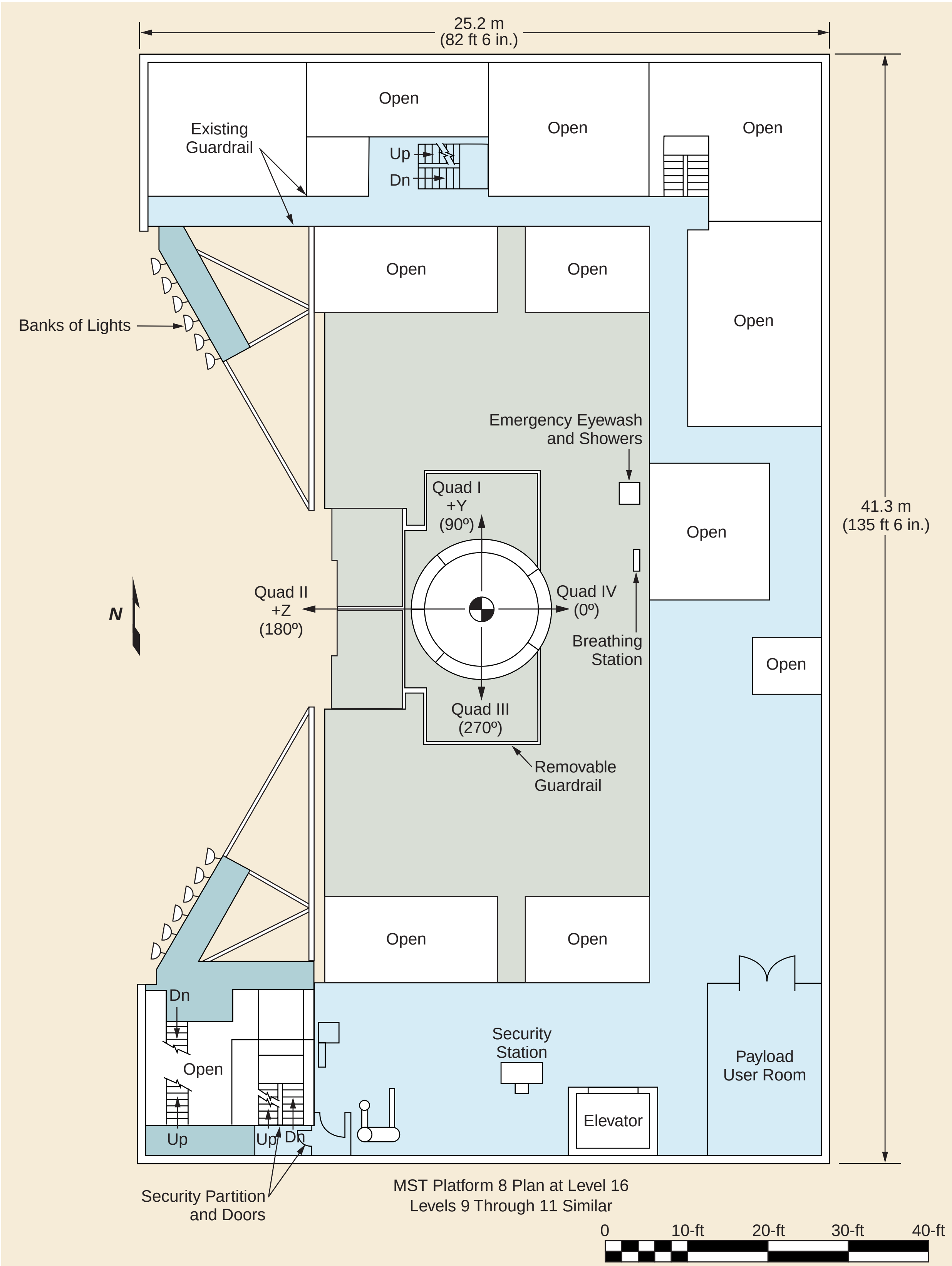

Figure 7-16. Platform 8 of Space Launch Complex 6 Mobile Service Tower Plan View

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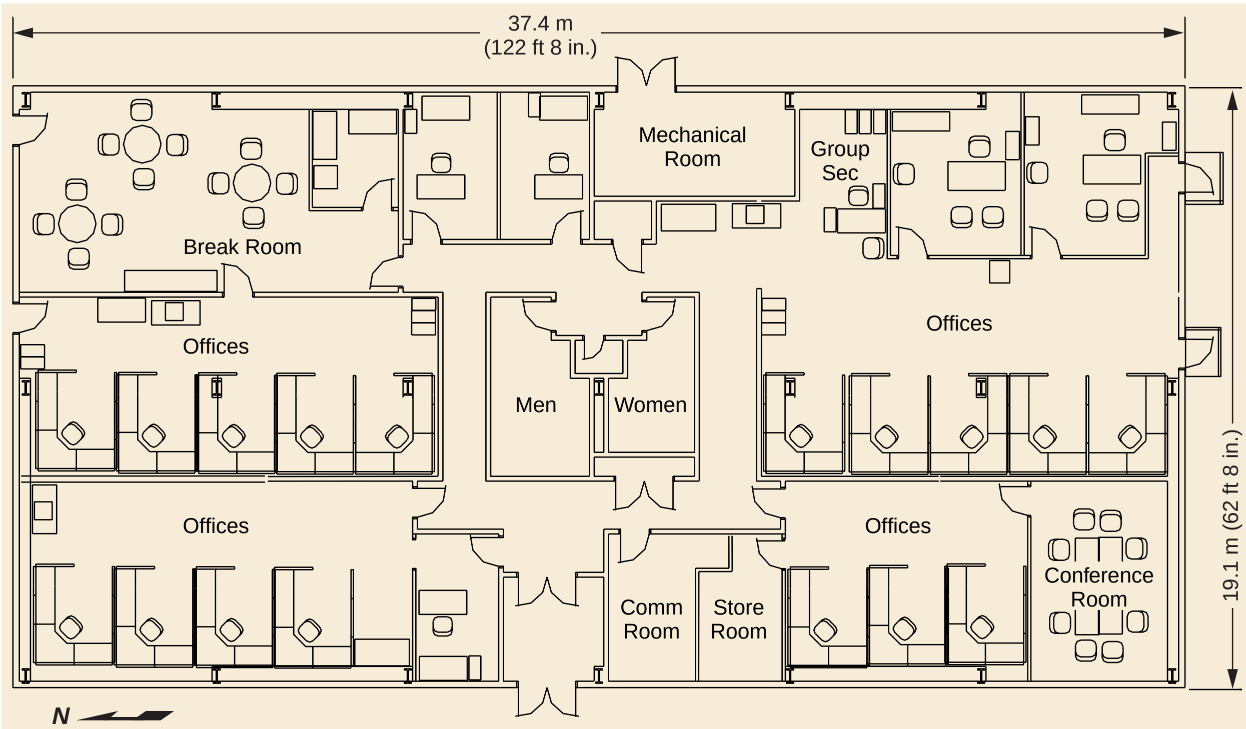

Figure 7-17. Technical Support (Building 384)

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 to be needed in the ROCC (facility 7000) to facilitate support of the Delta IV program. The remote launch control center (RLCC) for SLC-6 will be located in building 8510 on north VAFB. A new RLCC will be assembled using space in the existing building.

The RLCC will be used to conduct launch operations at SLC-6 and will serve as the oversight and range control center for Delta IV operations. Figure 7-2 shows the facility locations at VAFB.

7.5 SUPPORT SERVICES

7.5.1 Launch Support

For countdown operations, the launch team is located in the RLCC in building 8510 (Figure 7-24), with support from other base organizations.

7.5.1.1 Mission Director Center (Building 840). The mission director center (MDC) provides the necessary seating, data display, and communications to observe the launch process. Seating is provided for key personnel from Boeing, the Western Range, and the payload control team.

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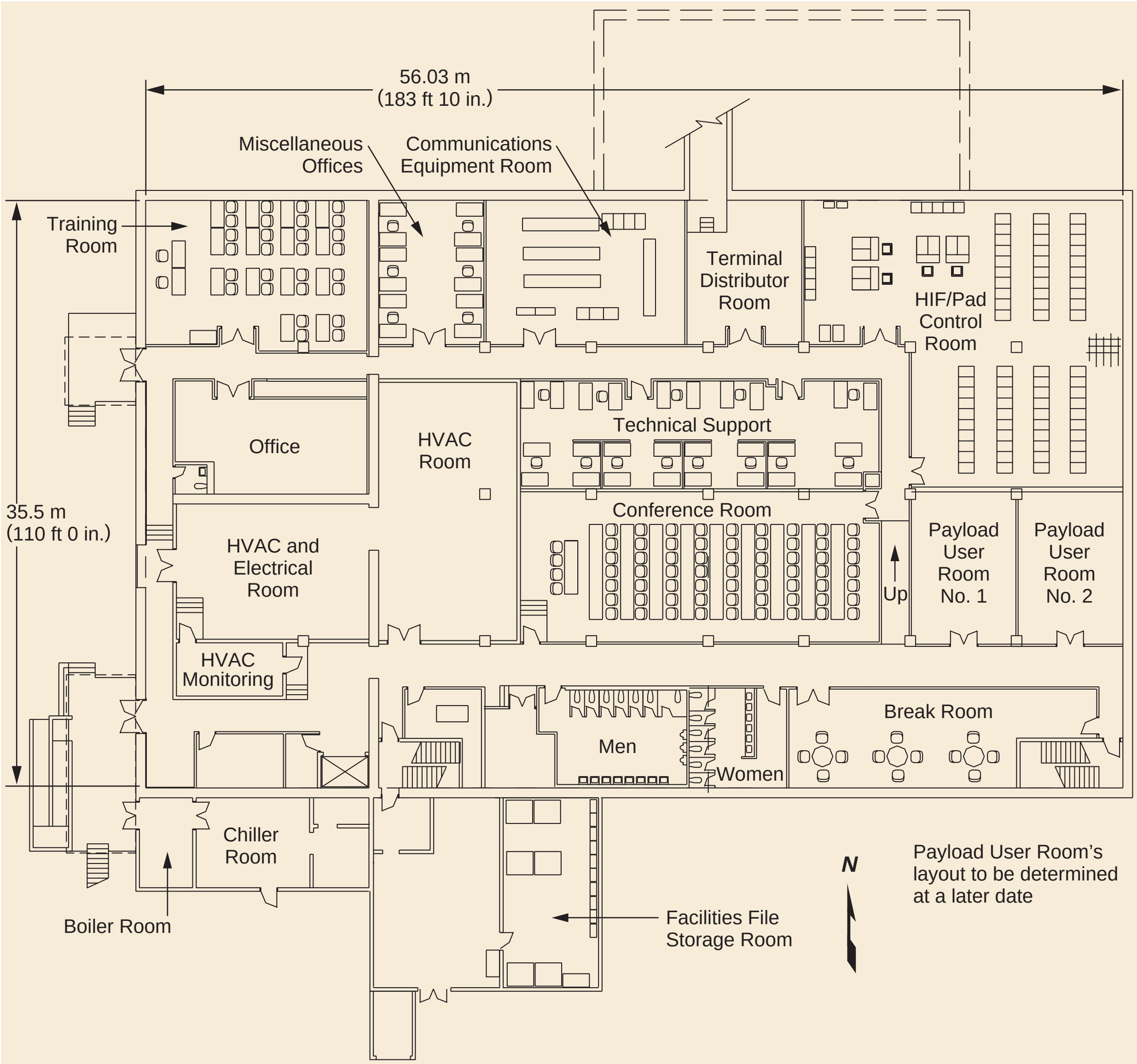

Figure 7-18. Delta Operations Center First Floor (Building 392)

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 also 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 wires.

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 II communications flow required to make the launch decision.

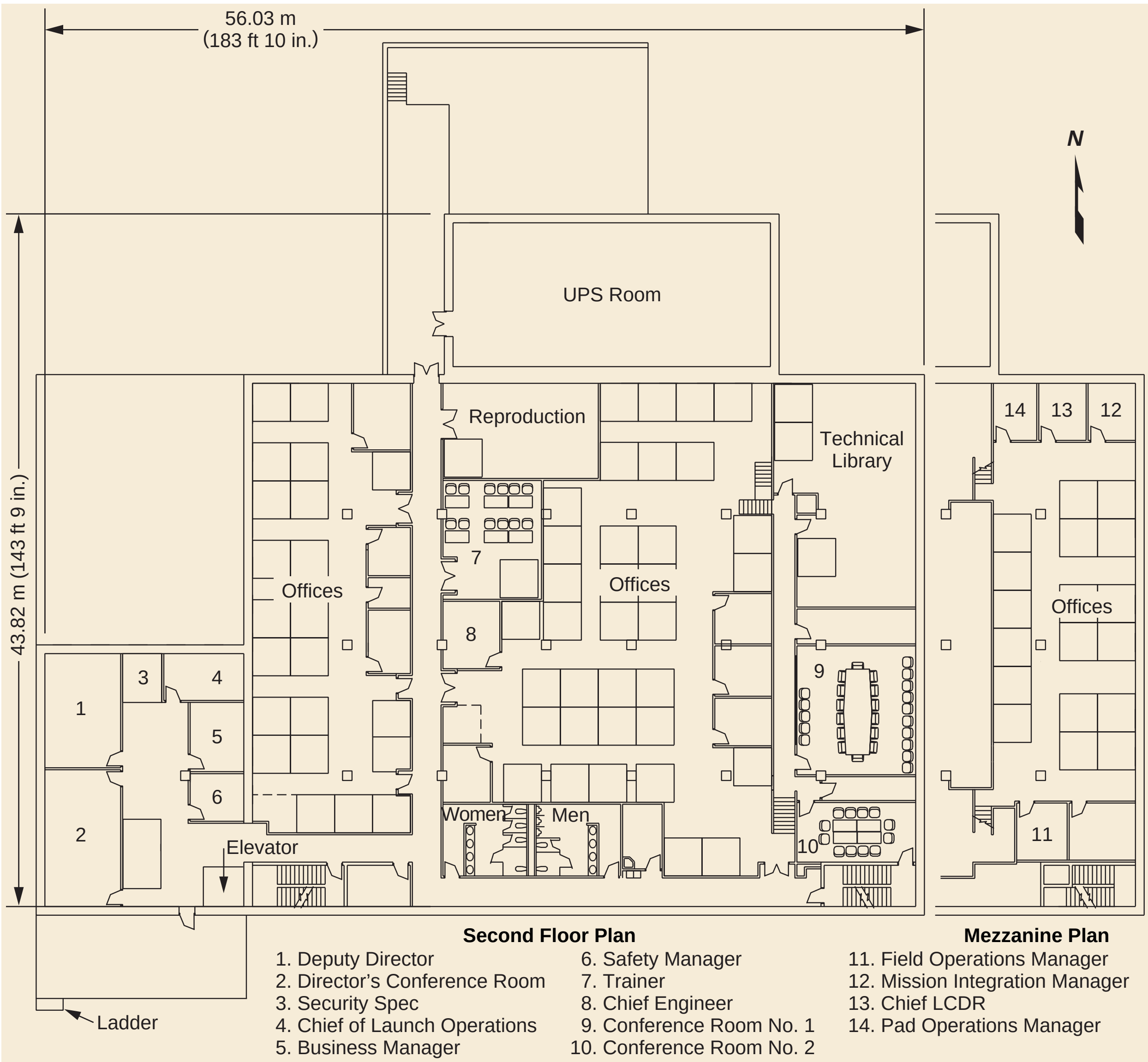

Figure 7-19. Delta Operations Center Second Floor (Building 392)

7.5.2 Weather Constraints

7.5.2.1 Ground-Wind Constraints. The MST/MAS encloses the Delta IV launch vehicle until approximately L-7 hours and provides protection from ground winds. The winds are measured using an anemometer at the 16.5-m (54-ft) level of the MST.

7.5.2.2 Winds-Aloft Constraints. Measurements of winds aloft are taken in the vicinity of the launch pad. The Delta IV launch vehicle controls and load constraints for winds aloft are evaluated on launch day by conducting a trajectory analysis using the measured wind. A curve fit to the wind data provides load relief in the trajectory analysis. The curve fit and other load-relief parameters are used to set the mission constants just prior to launch.

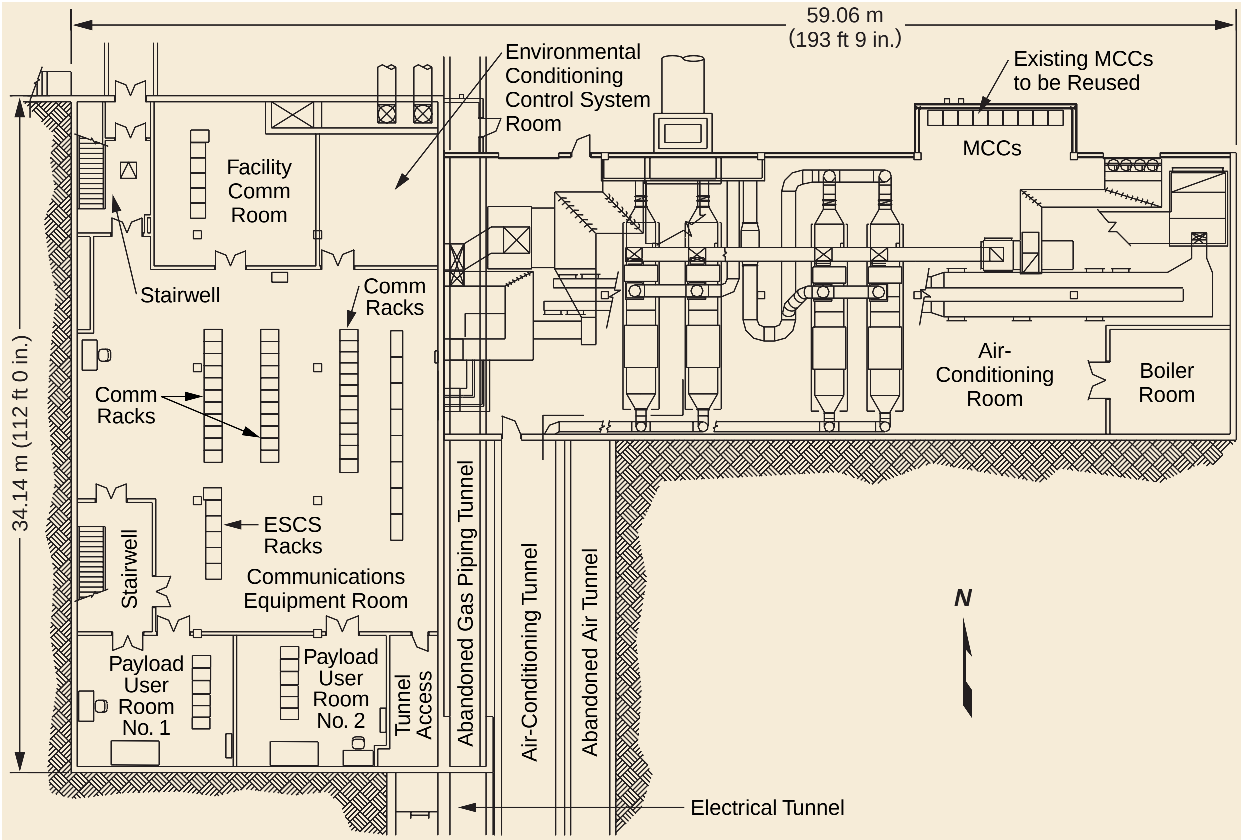

Figure 7-20. Support Equipment Building (SEB) (Building 395) First-Floor Plan

7.5.2.3 Weather Constraints. Weather constraints are imposed to ensure safe passage of the Delta IV launch vehicle through the atmosphere. The following is a general overview of the constraints evaluated prior to liftoff. Appendix B lists the detailed weather constraints.

A. The launch will not take place if the normal flight path will carry the launch vehicle:

1. Within 18.5 km (10 nmi) of a cumulonimbus (thunderstorm) cloud, whether convective or in layers, where precipitation or virga is observed.

2. Through any cloud, whether convective or in layers, where precipitation or virga is present.

3. Through any frontal or squall-line clouds extending above 3048 m (10,000 ft).

4. Through cloud layers or through cumulus clouds where the freeze level is in the clouds.

5. Through previously electrified clouds not monitored by an electrical field mill network if the dissipating state was short-lived (less than 15 min after observed electrical activity).

B. The launch will not take place if there is precipitation over the launch site or along the flight path.

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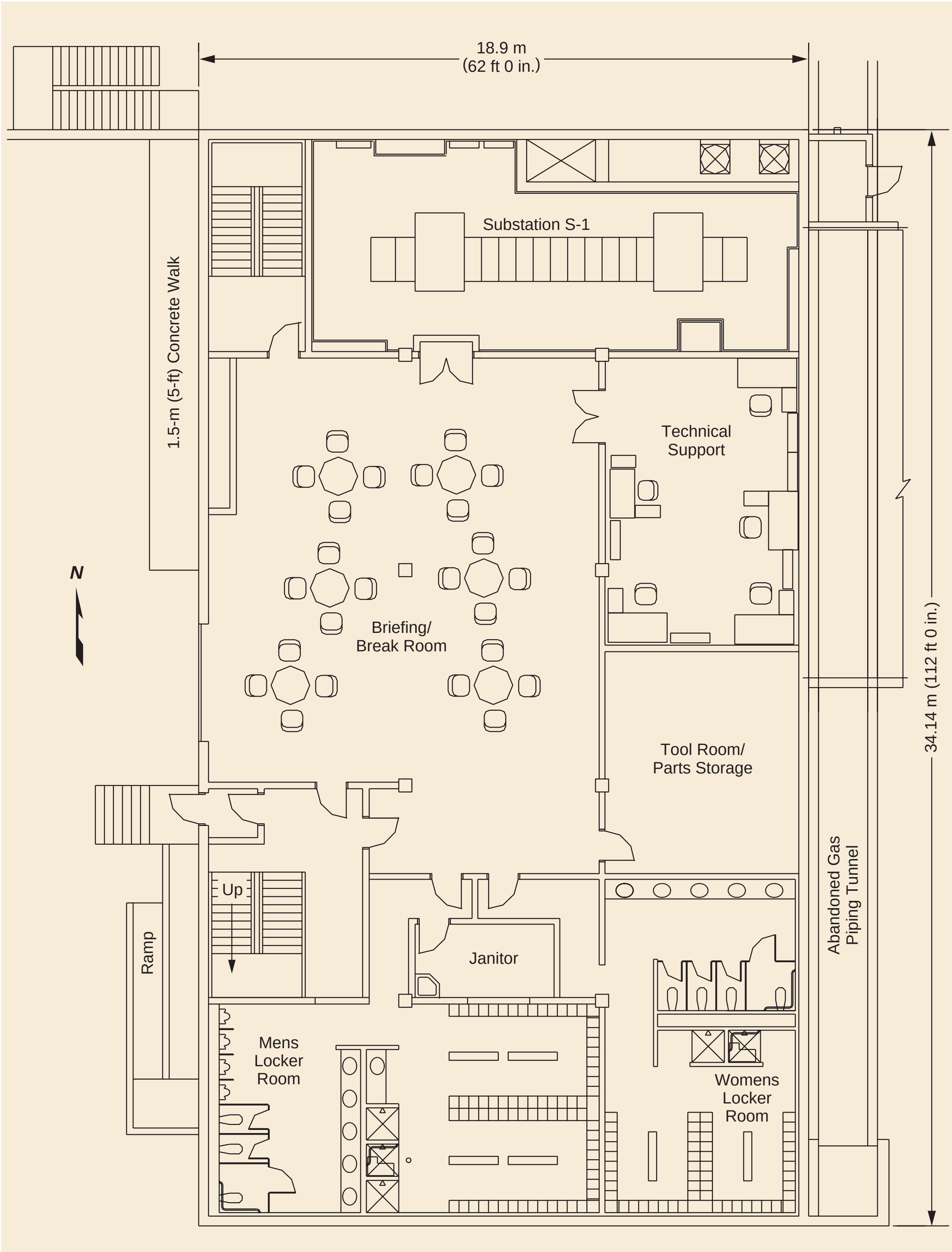

Figure 7-21. Support Equipment Building (SEB) (Building 395) Second-Floor Plan

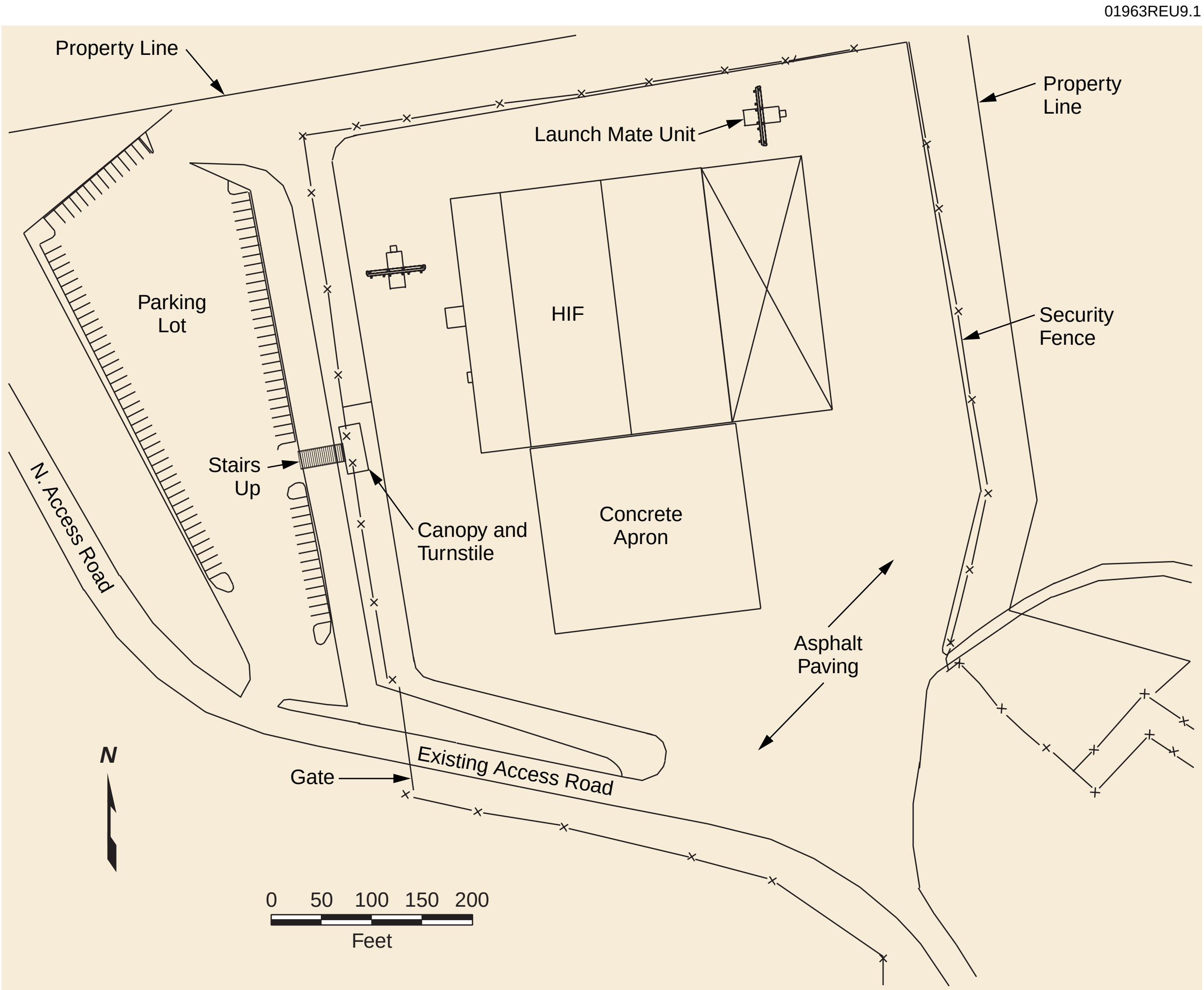

Figure 7-22. Horizontal Integration Facility (HIF) Site Plan

C. A weather observation aircraft is mandatory to augment meteorological capabilities for real-time evaluation of local conditions unless a cloud-free line of sight exists to the vehicle flight path. Rawinsonde will not be used to determine cloud buildup.

D. Even though the above criteria are observed or forecast to be satisfied at the predicted launch time, the launch director may elect to delay the launch based on the instability of atmospheric conditions.

7.5.2.4 Lightning Activities. The following are procedures for test status during lightning activity:

A. Evacuation of the MST is accomplished at the direction of the Launch Conductor (Reference: Delta Launch Complex Safety Plan).

B. First- and second-stage instrumentation may be operated during an electrical storm.

C. If other launch vehicle electrical systems are powered when an electrical storm approaches, these systems may also remain powered. If Category-A electro-explosive device (EED) circuits

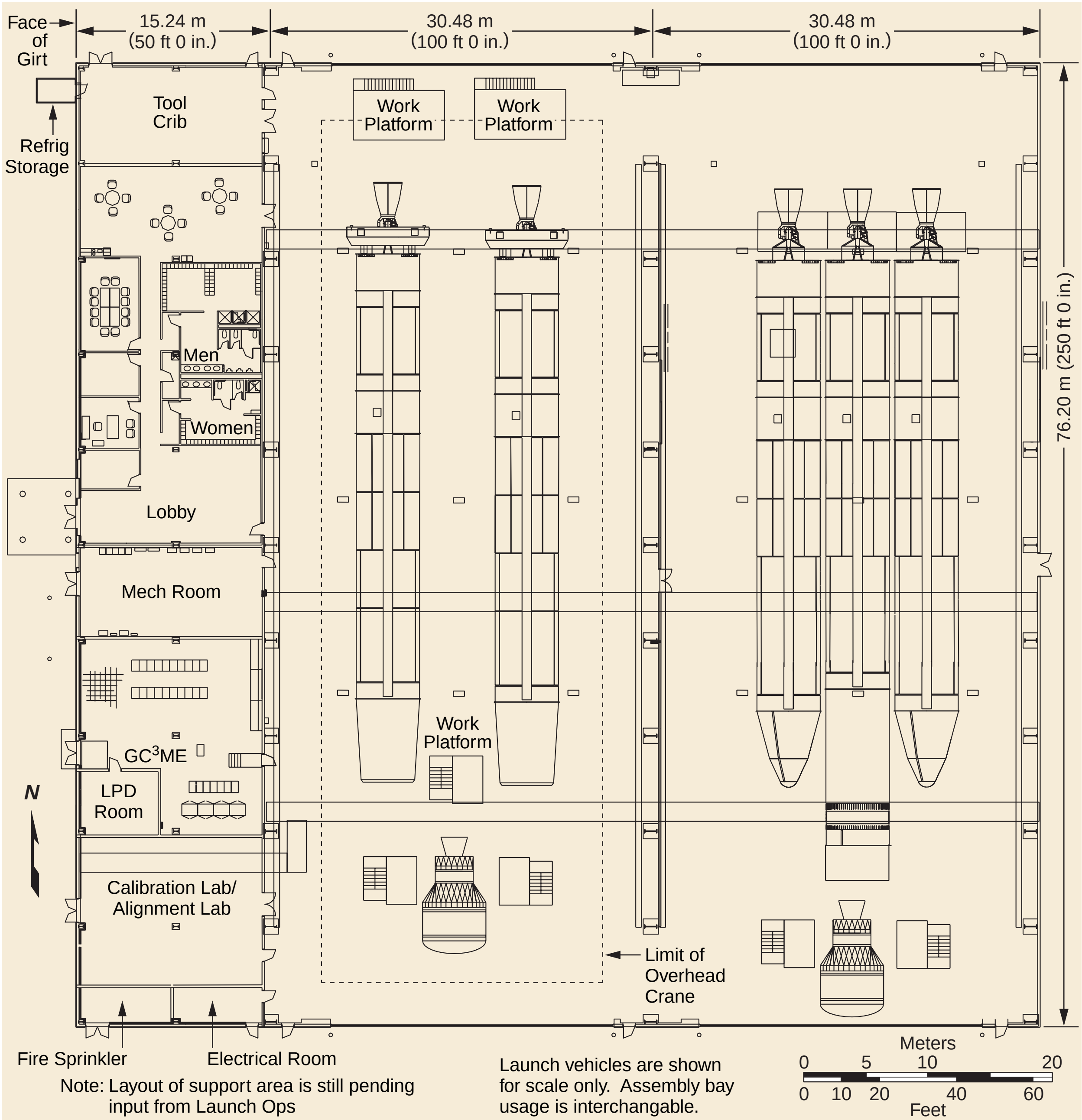

Figure 7-23. Horizontal Integration Facility (HIF) Floor Plan

are electrically connected in the launch configurations, the guidance computer (GC) must be turned off.

D. If an electrical storm passes through after launch vehicle automated interface tests, all electrical systems are turned to a quiescent state, and all data sources are evaluated for evidence of damage. This turn-on is done remotely (pad clear) if any Category-A ordnance circuits are connected for flight. Ordnance circuits are disconnected and safed prior to turn-on with personnel exposed to the launch vehicle.

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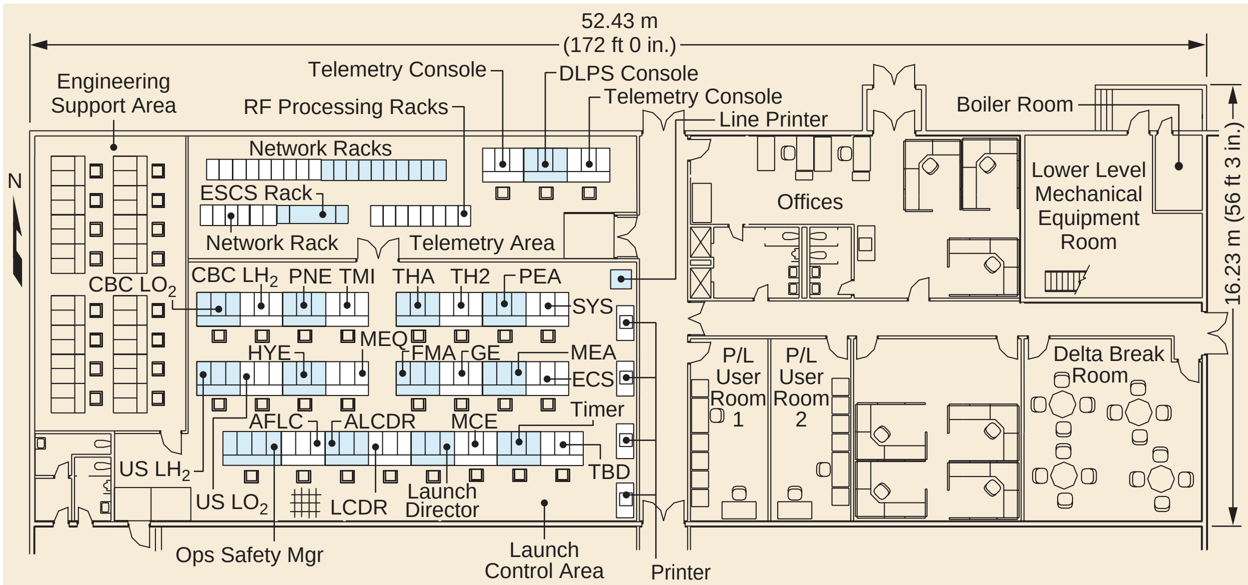

Figure 7-24. VAFB Launch Control Center (Building 8510)

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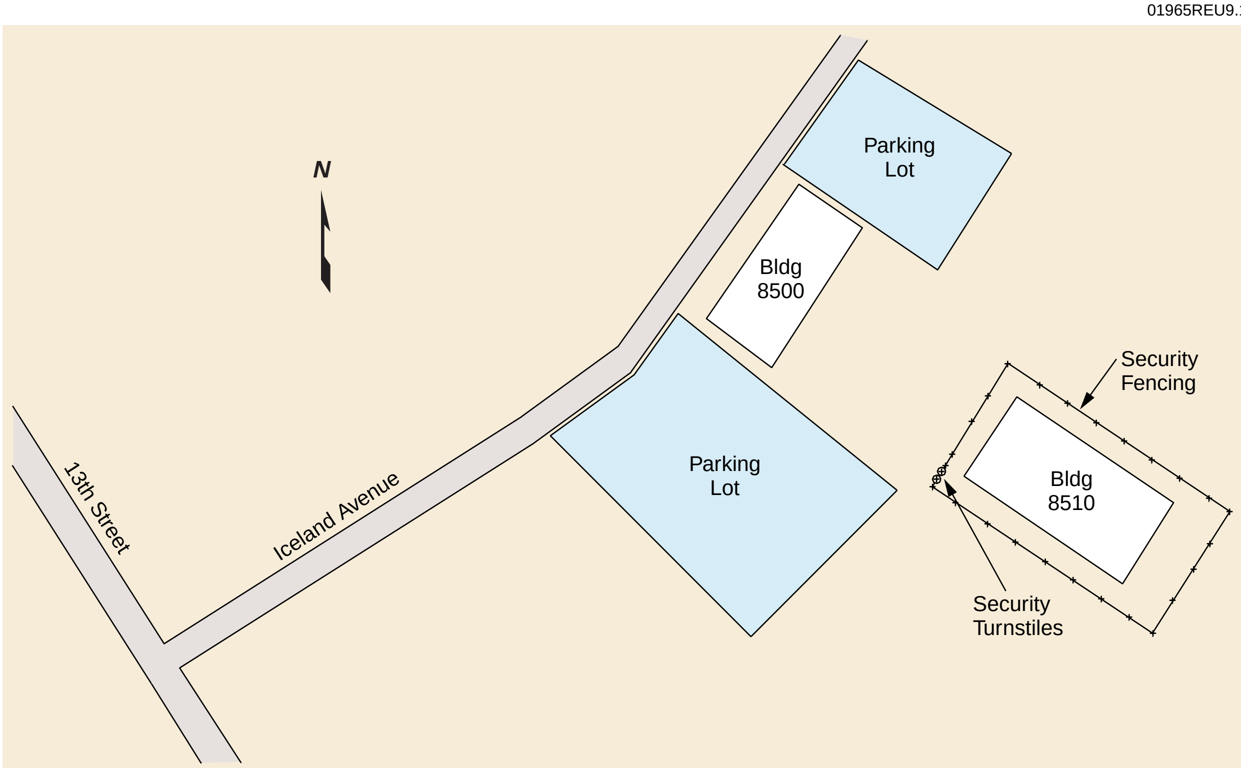

Figure 7-25. Launch Control Center (Building 8510) Site Plan

E. If data from the health monitoring reveals equipment discrepancies that can be attributed to the electrical storm, a requalification test must be run subsequent to the storm and prior to a launch attempt.

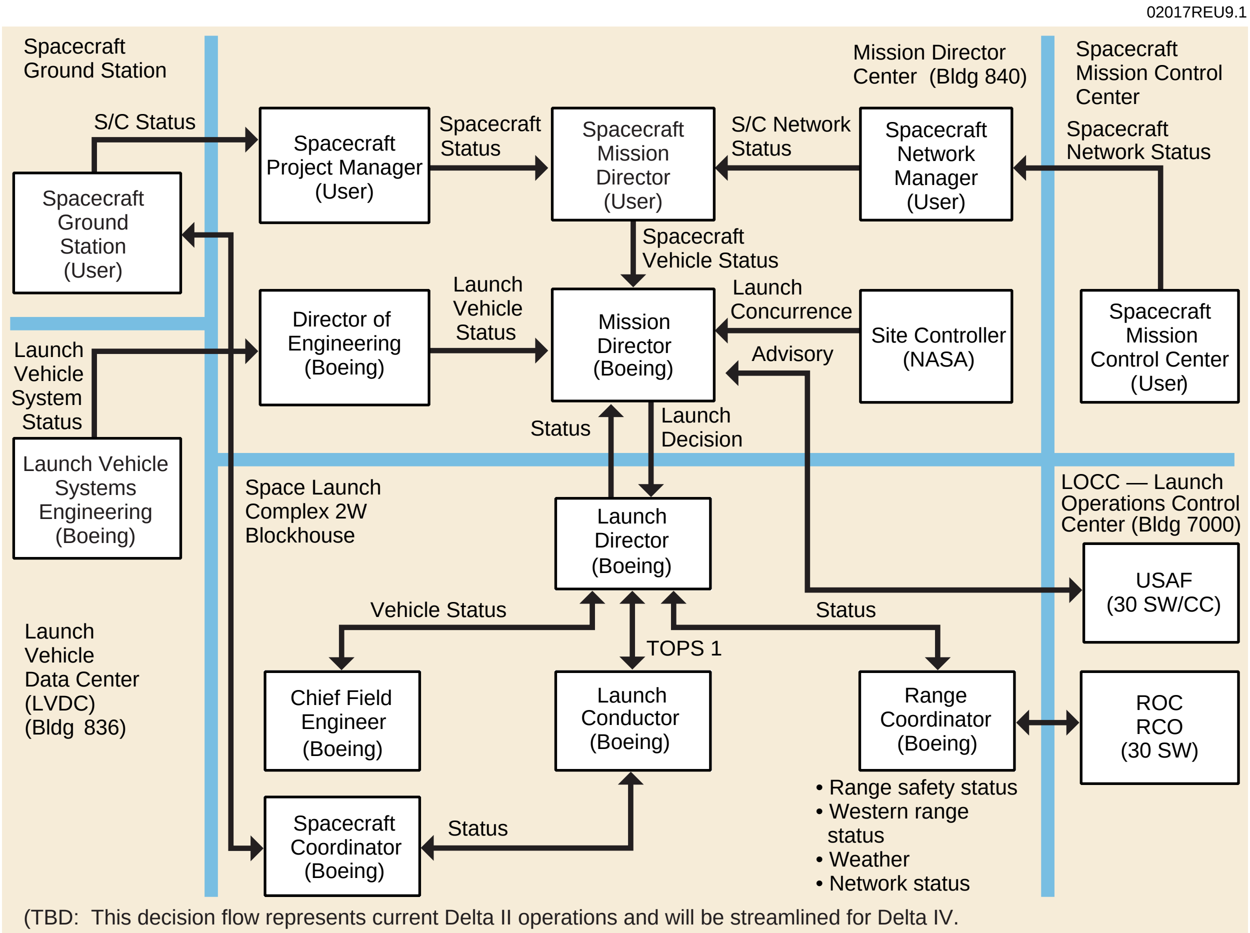

Figure 7-26. Launch Decision Flow for Commercial Missions—Western Range

F. During terminal countdown, the launch director is responsible for initiating and ending an alert. Upon initiation of an alert, the GC is turned off. When the alert is lifted, the GC is turned on and its memory is verified.

7.5.3 Operational Safety

Safety requirements are covered in Section 9 of this manual. In addition, it is Boeing 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 Boeing spacecraft coordinator and presented by appropriate safety personnel.

7.5.4 Security

7.5.4.1 VAFB Security. For access to VAFB, US citizens must provide to Boeing security by seven days prior to arrival, full name with middle initial (if applicable), social security number, company name, company address and telephone number, and dates of arrival and expected departure. Boeing security will arrange for entry authority for commercial missions or individuals sponsored by Boeing. Access by US government-sponsored foreign nationals is coordinated by their sponsor directly with the USAF at VAFB. For non-US 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 Boeing security two months prior to the VAFB entry date. Government-sponsored individuals must follow US government guidelines as appropriate. After Boeing 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.

7.5.4.2 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 provide security for Priority-A resources.

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

7.5.4.3 Hazardous Processing Facility. (TBD).

7.5.4.4 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 Boeing spacecraft coordinator or appropriate payload processing facility.

7.5.5 Field-Related Services

Boeing 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. Boeing has access to a machine shop, metrology laboratory, LO_2 cleaning facility, and proof-loading facility. Boeing 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 and HIF occupancy times.

7.6.2 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 payload contractor.

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. 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 around the combined payload. Figures 7-27, 7-28, 7-29, 7-30, 7-31, and 7-32 show the processing time lines for Delta IV-M, Delta IV-M+ (4,2), Delta IV-M+ (5,2), Delta IV-M+ (5,4), Delta IV-H and Delta IV-H dual manifest, respectively.

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 spacecraft contractor 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 spacecraft contractor will supply schedules to the Boeing 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 Boeing mission integration manager will ensure adequate customer participation.

7.7.1 Meetings

Delta status meetings are generally held twice 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.

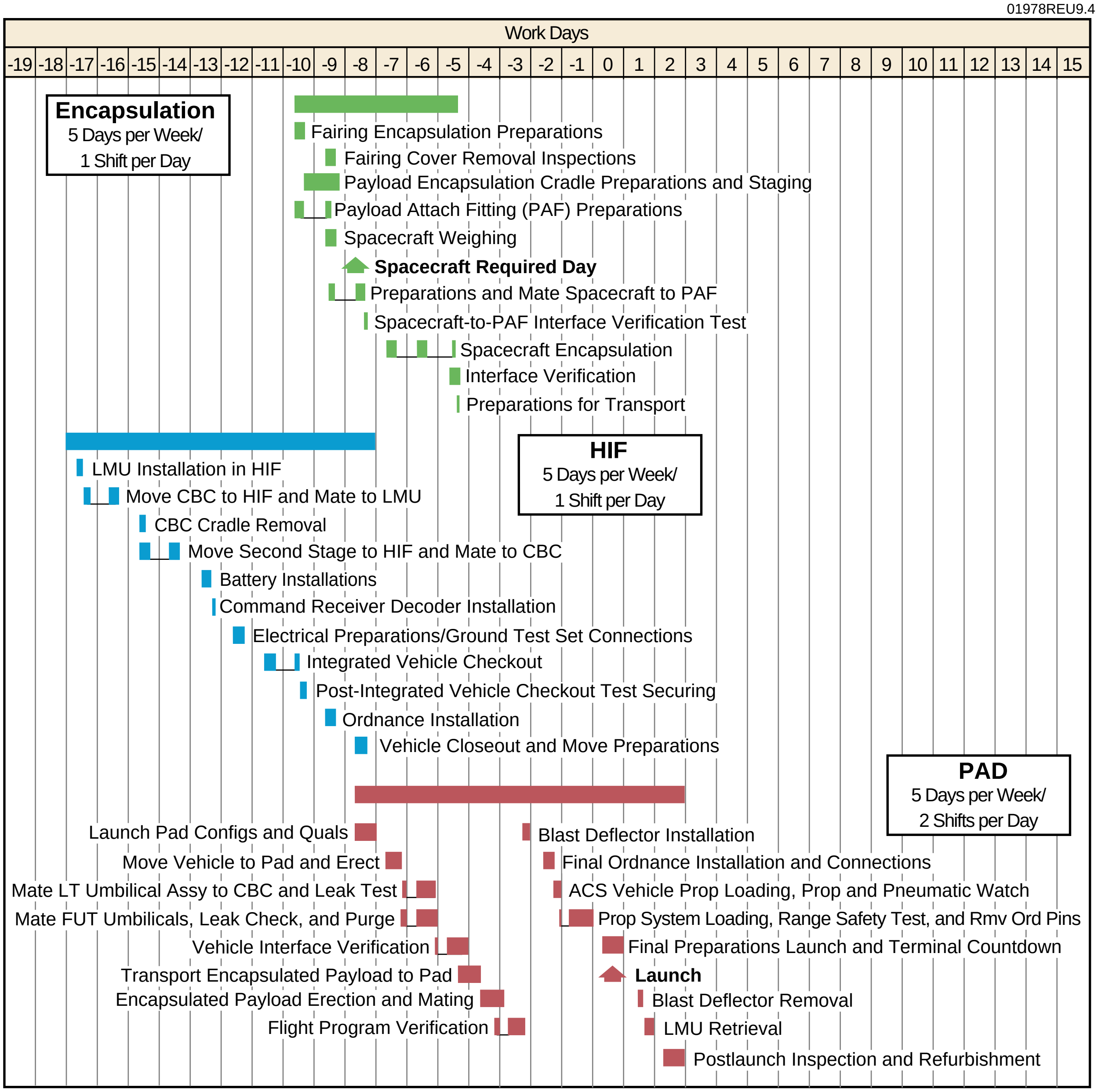

Figure 7-27. Projected Processing Time Line—Delta IV Medium Launch Vehicle (rev. K)

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.

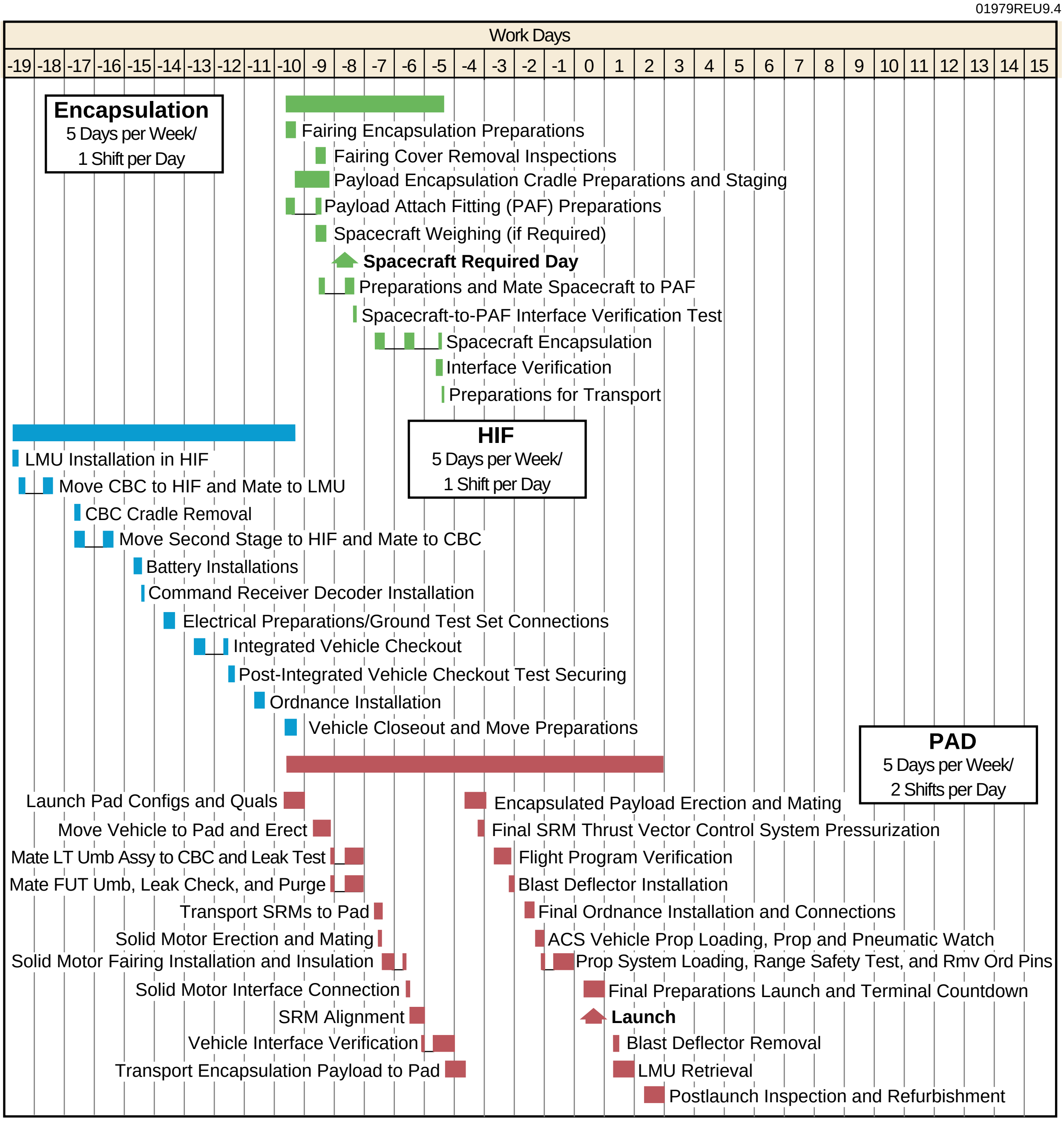

Figure 7-28. Projected Processing Time Line—Delta IV Medium-Plus (4,2) Launch Vehicle (rev. K)

7.7.2.2 Mission Analysis Review. A mission analysis review is held at Huntington Beach, California, approximately three 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 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

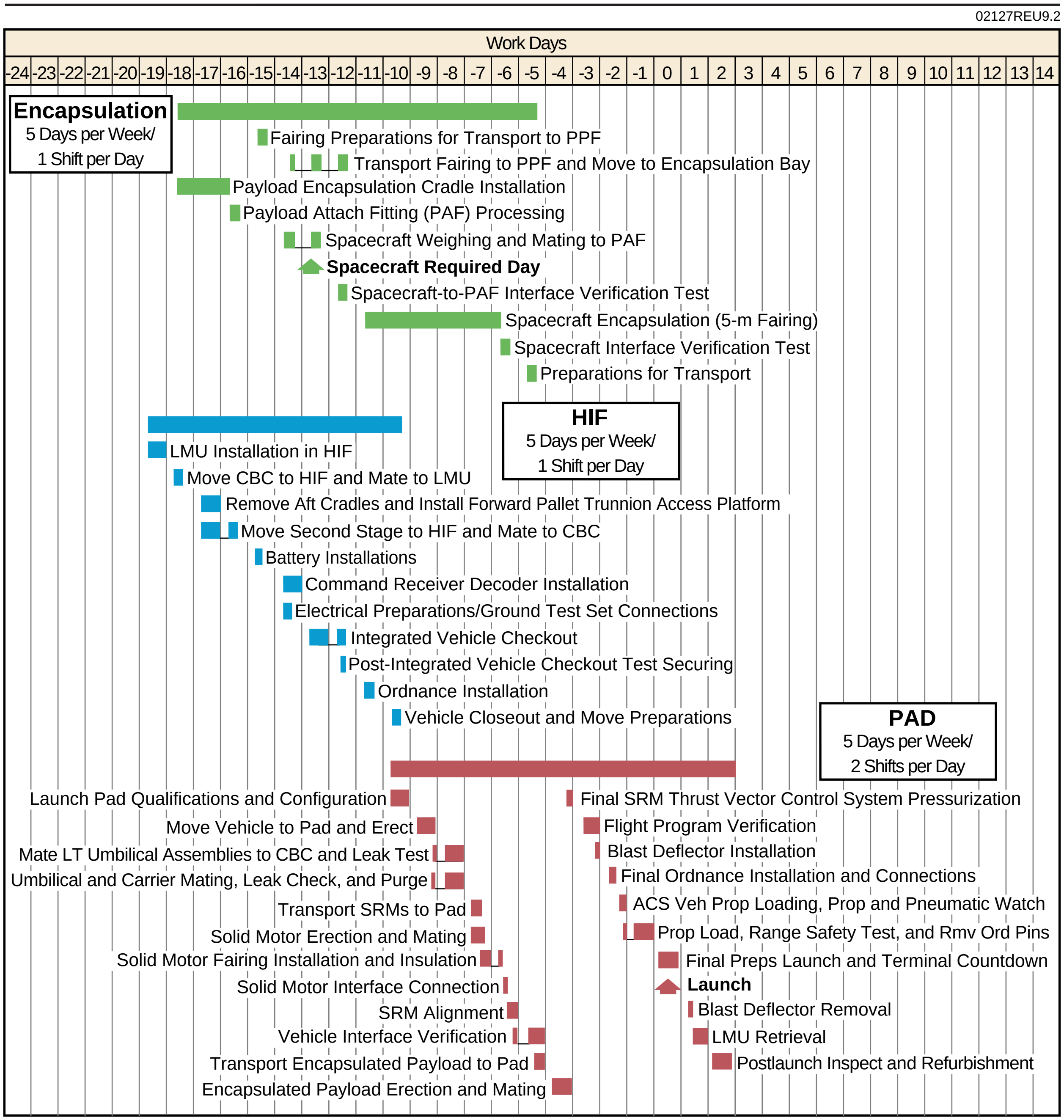

Figure 7-29. Projected Processing Time Line—Delta IV Medium-Plus (5,2) Launch Vehicle (rev. L)

of the HIF processing, and any hardware history changes. Launch facility readiness is also discussed. (Pre-VOS occurs approximately at L-12 days.)

7.7.2.4 Flight Readiness Review. A flight readiness review (FRR) is a status of the launch vehicle after HIF 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 loading of second-stage propellants is given. This

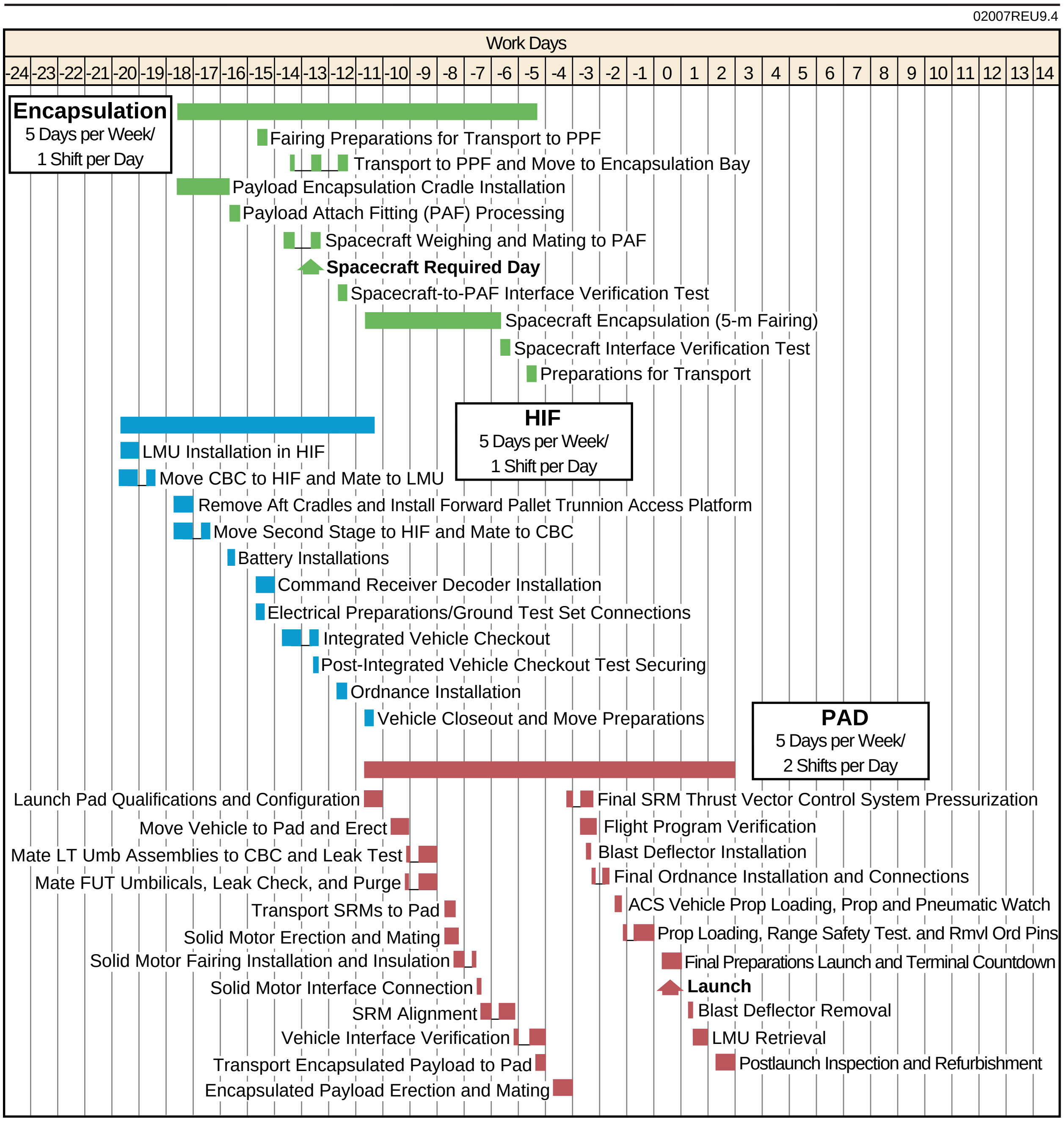

Figure 7-30. Projected Processing Time Line—Delta IV Medium-Plus (5,4) Launch Vehicle (rev. L)

review also assesses the readiness of the range to support launch, and provides a predicted weather status (FRR occurs at L-2 days).

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.

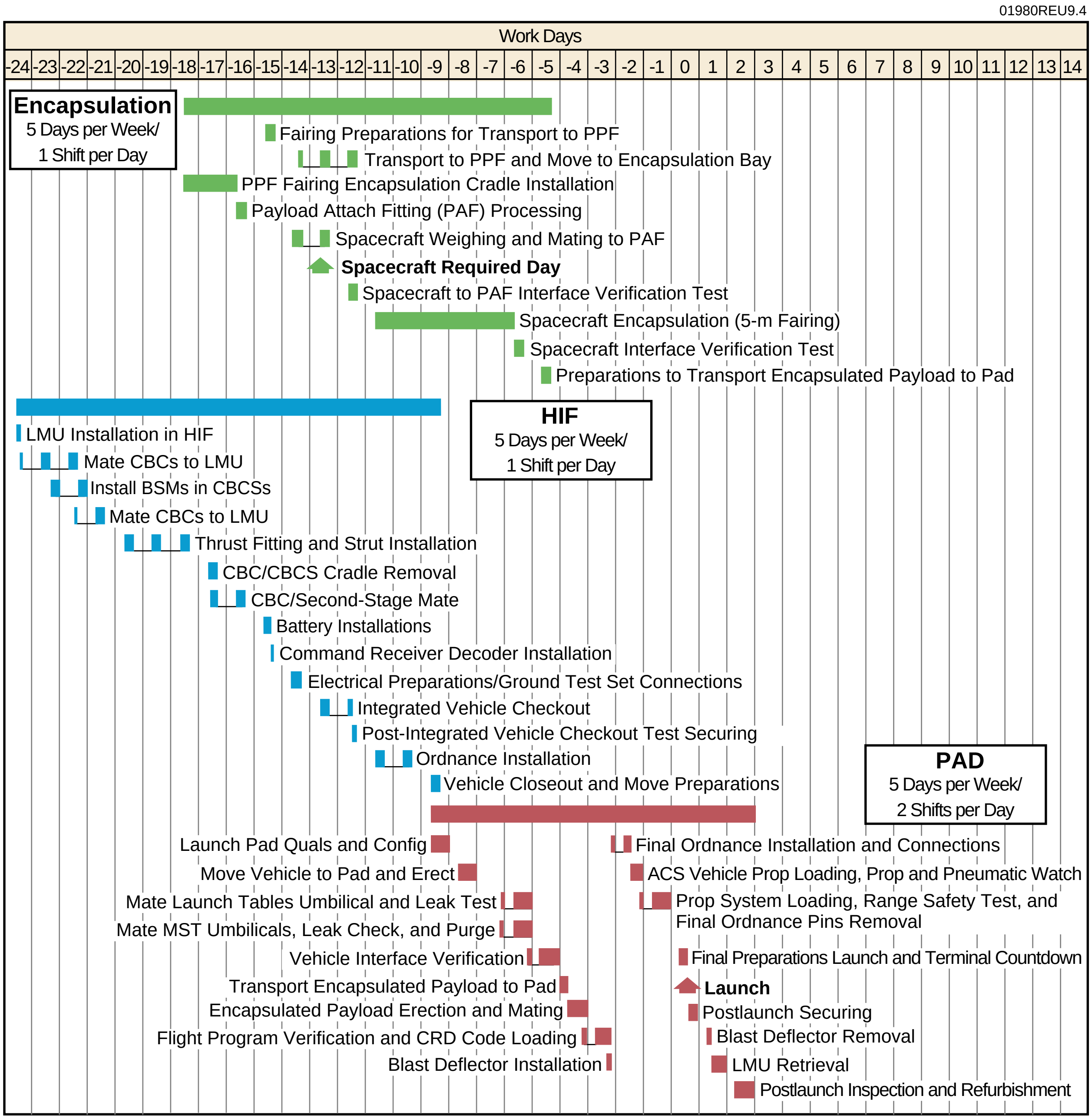

Figure 7-31. Projected Processing Time Line—Delta IV Heavy Launch Vehicle (rev. L)

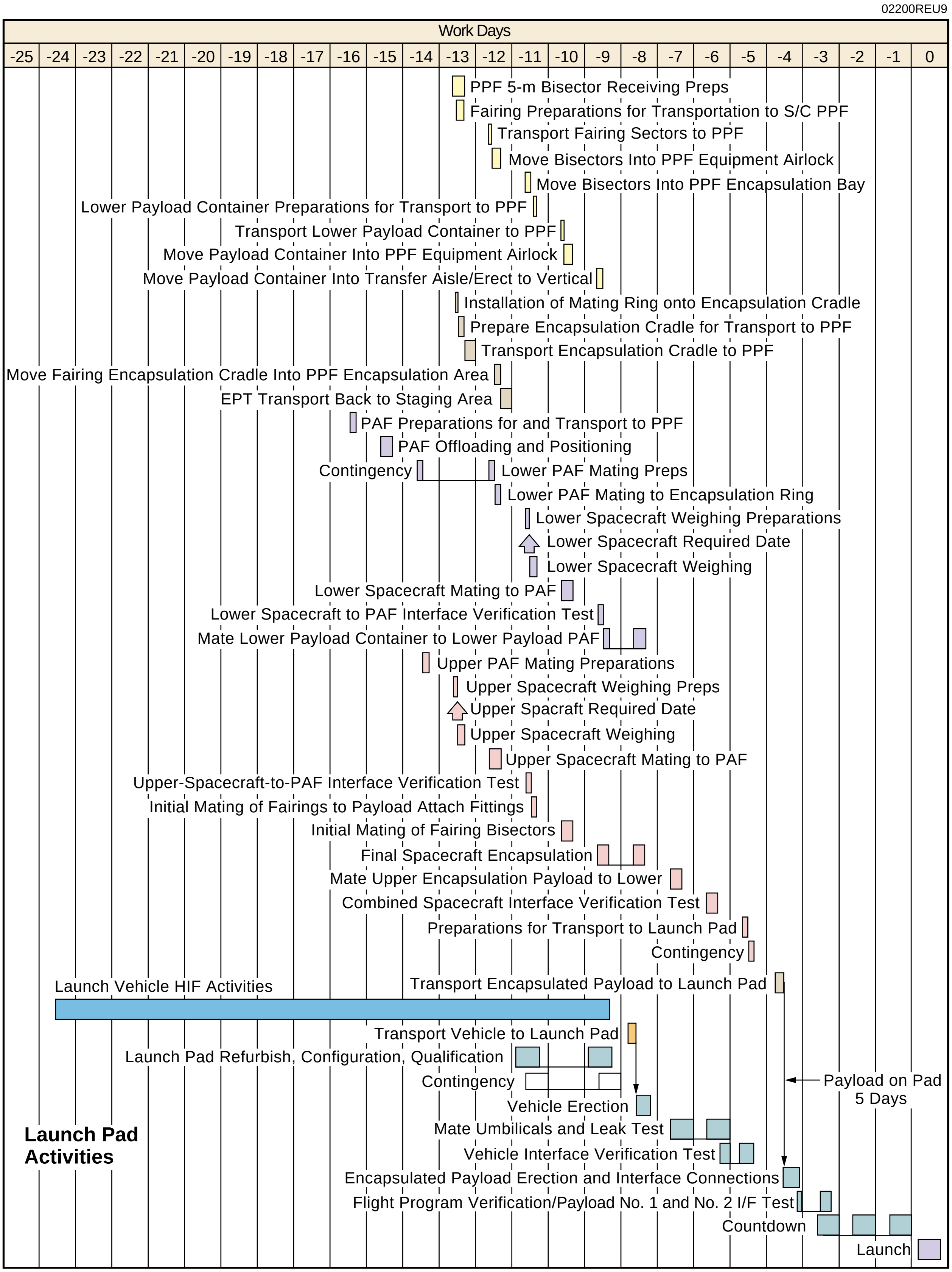

Figure 7-32. Projected Processing Time Line for Delta IV Heavy Launch Vehicle Dual-Manifest Missions (Preliminary)

Section 8
PAYLOAD INTEGRATION

This section describes the payload integration process, the supporting documentation required from the spacecraft contractor, and the resulting analyses provided by Boeing.

8.1 INTEGRATION PROCESS

The integration process (Figure 8-1) developed by Boeing is designed to support the requirements of both the launch vehicle and the payload. The tasks below the line are completed by the spacecraft contractor and those above by Boeing. Boeing works closely with customers to tailor the integration flow to meet their individual requirements. The integration process encompasses the entire life of launch vehicle/payload integration activities. At its core is a streamlined series of documents, reports, and meetings that are flexible and adaptable to the specific requirements of each program.

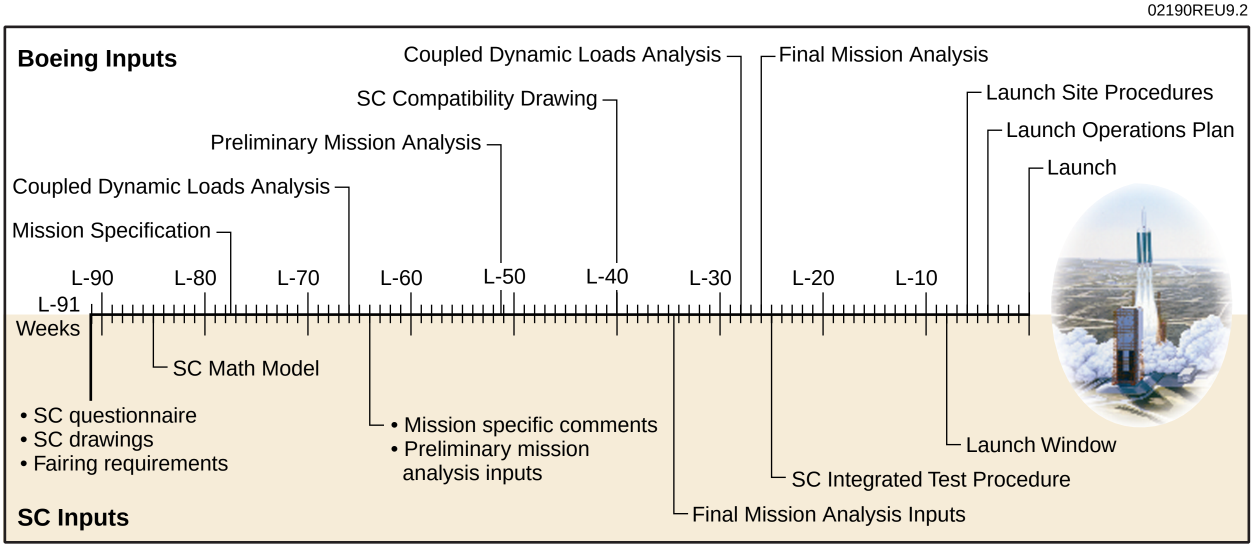

Figure 8-1. Mission Integration Process

Mission integration for commercial and government missions is the responsibility of the mission integration team located at the Boeing facility in Huntington Beach, California. The prime objective of mission integration is to coordinate all interface activities required to launch commercial and government payloads using Delta IV launch vehicles. This objective includes reaching a customer-Boeing interface agreement and accomplishing interface planning, coordinating, scheduling, control, and targeting.

The mission integration manager assigns a mission manager to carry out interface activities. The mission manager also develops a tailored integration planning schedule for the Delta IV and the payload by defining the documentation and analysis required. The mission manager incorporates payload requirements plus engineering design and analysis into a controlled mission specification that defines agreed-to interfaces.

The mission 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 through the mission manager and executed in a timely manner. These data-exchange lines exist not only between the user and Boeing, but also include other agencies involved in Delta IV launches. Figure 8-2 shows the typical relationships among agencies involved in a Delta IV mission.

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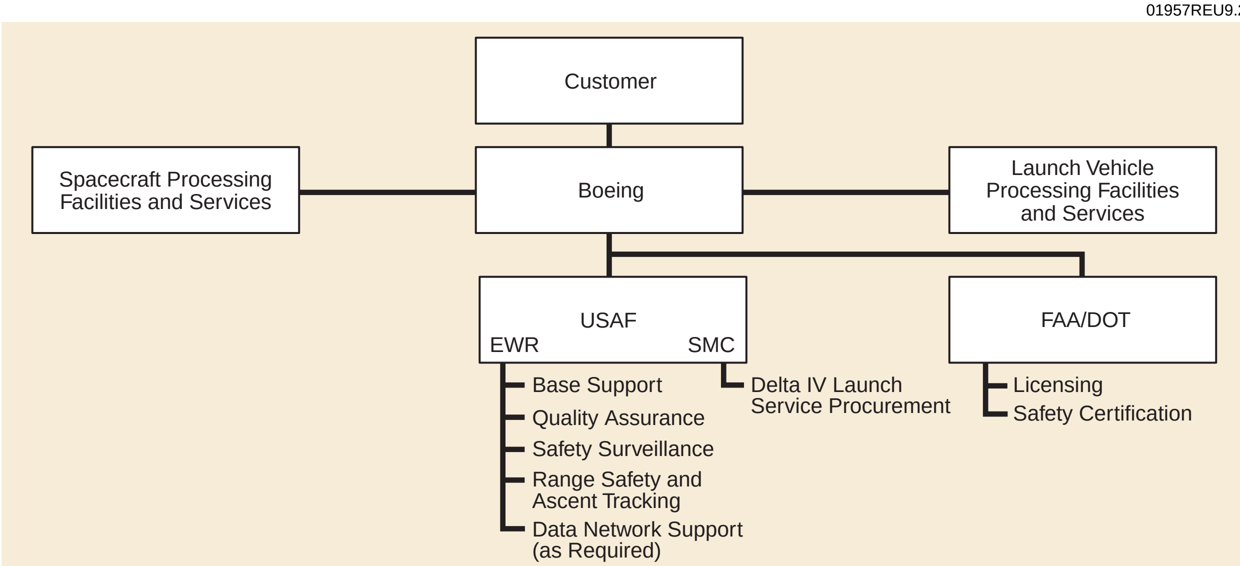

Figure 8-2. Typical Delta IV Agency Interfaces

8.2 DOCUMENTATION

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

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

A general model for the Delta IV launch vehicle and payload documentation requirements is shown in Tables 8-1 and 8-2. Table 8-3 describes the documents identified. Specific schedules are established by agreement with each customer. The Spacecraft Questionnaire shown in Table 8-4

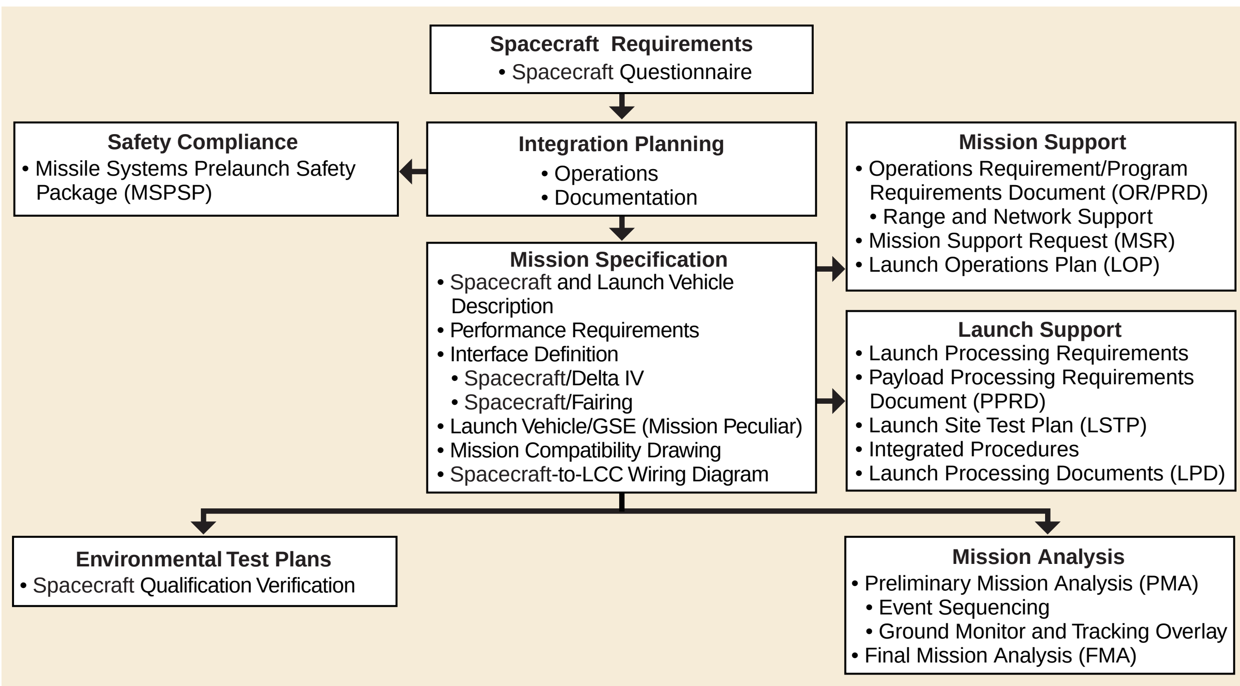

Figure 8-3. Typical Document Interfaces

is to be completed by the payload agency at least 91 weeks prior to launch to provide an initial definition of payload characteristics. Table 8-5 is an outline of a typical payload launch-site test plan that describes the launch site activities and operations expected in support of the mission. Orbit data at burnout of the final stage are needed to reconstruct the performance of the Delta IV following the mission. Presented in Table 8-6 are a complete set of orbital elements and associated estimates of 3-σ accuracy required to reconstruct this performance.

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 spacecraft contractor.

8.4 PAYLOAD PROCESSING REQUIREMENTS

The checklist shown in Table 8-7 is provided to assist the user in identifying the requirements at each processing facility. The requirements identified are submitted to Boeing for the program requirements document (PRD). Boeing coordinates with the payload processing facility, as appropriate, and implements the requirements through the PRD/payload processing requirements document (PPRD). The user may add items to the list. Note that most requirements for assembly and checkout of commercial spacecraft will be met at Astrotech Space Operations Company.

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Task Name	OPR	Due Date (Wks)
1. Spacecraft Questionnaire	S	L-91
2. Fairing Requirements	S	L-91
3. SC Drawings	S	L-91
4. SC Mass Properties Statement	S	L-91
5. SC Environmental Test Document (Test Plan)	S	L-91
6. MSPSP Inputs	S	L-91
7. Preliminary Mission Analysis (PMA) Rqmts	S	L-91
8. Program Requirements Document - SC Inputs	S	L-91
9. Mission Operations and Support Requirements	S	L-91
10. P/L Processing Requirements Document Inputs	S	L-91
11. SC Mathematical Model	S	L-85
12. Separation Analysis	B	L-81
13. Mission Specification (Initial)	B	L-78
14. Program Requirements Document (PRD)	B	L-74
15. SC Launch Site Operations Plan (Initial)	S	L-72
16. Plume/Contamination Analysis Report	B	L-70
17. Payload Compatibility Drawing (Initial)	B	L-68
18. SC-to-Control Center Wiring Diagram (Initial)	B	L-68
19. Coupled Dynamic Loads Analysis (FDLC)	B	L-66
20. Radio Frequency Applications Inputs	S	L-65
21. Mission Specification Review (Initial)	S	L-64
22. SC Compatibility Drawing Comments (Initial)	S	L-64
23. Radio Frequency Applications (RFA)	B	L-52
24. DOT License Information	S	L-52
25. SC-to-Control Ctr Wiring Requirements (Initial)	S	L-51
26. Preliminary Mission Analysis	B	L-51
27. SC Ctrl Ctr Wiring Diagram Comments (Initial)	S	L-47
28. DOT License Application	B	L-45
29. SC Compatibility Drawing	B	L-40
30. Mission Specification (Final)	B	L-39
31. SC Mass Properties Statement (Update)	S	L-36
32. Real-Time Tracking Data Requirements	S	L-36
33. SC-to-Control Ctr Wiring Diagram Comm (Final)	B	L-36
34. Mission Specification Review (Review)	S	L-36
35. SC Clearance Drawing	S	L-36
36. SC-to-Control Center Wiring Diagram (Final)	B	L-35
37. Launch Vehicle Insignia	S	L-35
38. Final Mission Analysis (FMA) Requirements	S	L-35
39. Launch Window (Initial)	S	L-35
40. Spacecraft Thermal Model	S	L-29
41. Coupled Dynamic Loads Analysis (LVC)	B	L-28
42. Delta IV/SC Combined Ops Reqmts Doc (OR)	B	L-26
43. SC Integrated Test Procedure	S	L-26
44. SC Launch Site Procedures	S	L-26
45. Final Mission Analysis (FMA)	B	L-25
46. Thermal Analysis Report	S	L-22
47. SC/Fairing Clearance Analysis (Initial)	B	L-16
48. MSPSP (Final)	B	L-10
49. Launch Window (Final)	S	L-08
50. SC Mass Properties Statement (Final)	S	L-08
51. Launch Site Procedures	B	L-06
52. SC Launch Site Operations Plan (Final)	S	L-06
53. Launch Operations Plan (LOP)	B	L-05
54. Best-Estimate Trajectory	B	L-04
55. Vehicle Information Memorandum (VIM) Data	B	L-04
56. SC/Fairing Clearance Analysis	B	L-03
57. RF Compatibility Analysis Report	B	L-01
58. Vehicle Information Memorandum (VIM)	B	L-4d
59. Launch Readiness Review Data Package	B	L-1d
60. Launch	B	L-0
61. Post-Launch Report	S	L+2hr
62. Post-Launch Orbit Confirmation Data	B	L+7d

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

B = Boeing
S = Spacecraft
d = Days

Figure 8-4. Typical Integration Planning Schedule

Table 8-1. Spacecraft Contractor Data Requirements

Description	Table 8-3 reference	Nominal due weeks - or + launch
Spacecraft Questionnaire	2	L-91
Fairing Requirements	8	L-91
SC Drawings	18	L-91
SC Mathematical Model	3	L-91
Preliminary Mission Analysis (PMA) Inputs	11	L-91
Missile System Prelaunch Safety Package SC Inputs	9	L-91
SC Mass Properties Statement (Initial/Update)	22	L-91/L-36
SC Environmental Test Documents	5	L-85
Mission Specification Comments	4	L-64
SC Compatibility Drawing Comments	18	L-64
SC-to-LCC Wiring Diagram Review	28	L-64
Mission Operational and Support Requirements	12, 13	L-52
Payload Processing Requirements Document	14	L-52
FAA License Information	2	L-52
Radio Frequency Applications Inputs	10	L-52
Electrical Wiring Requirements	7	L-51
Launch Vehicle Insignia	15	L-35
Final Mission Analysis (FMA) Inputs	17	L-35
SC Integrated Test Procedure	21	L-26
SC Launch-Site Procedures	20	L-26
Launch Window (Initial/Final)	16	L-08
Postlaunch Orbit Confirmation Data	27	L+2 hr

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Table 8-2. Boeing Program Documents

Description	Table 8-3 reference	Nominal due weeks - or + launch
SC Separation Analysis	24	L-81
Program Requirements Document	14	L-74
Coupled Dynamic Loads Analysis (FDLC/VLC)	6	L-66/L-28
Preliminary Mission Analysis (PMA)	11	L-51
SC Compatibility Drawing (Final)	18	L-40
SC-to-LCC Wiring Diagram (Final)	28	L-40
Mission Specification (Final)	4	L-39
SC-Fairing Clearance Drawing	18	L-36
Final Mission Analysis (FMA)	17	L-25
Integrated Countdown Schedule		L-15
Launch Site Procedures		L-6
Launch Operations Plan	25	L-5
VIM	26	L-5 days

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Table 8-3. Required Documents

	Item	Responsibility
1.	**Feasibility Study (Optional)** 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. Specific tasks, schedules, and responsibilities are defined before study initiation, and a final report is prepared at the conclusion of the study.	Boeing
2.	**Spacecraft Questionnaire** 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 interfaces as they are known at the time of preparation. The completed questionnaire is required not later than two years prior to launch. A definitive 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 would not be 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. 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.	Spacecraft contractor
3.	**Spacecraft Mathematical Model for Dynamic Analysis** 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.	Spacecraft contractor
4.	**Mission Specification** The Boeing mission specification functions as the Delta launch vehicle interface control document and describes all mission-specific requirements. It contains the spacecraft description, spacecraft-to-operations building wiring diagram, compatibility drawing, targeting criteria, special spacecraft requirements affecting the standard launch vehicle, description of the mission-specific launch vehicle, a description of special aerospace ground equipment (AGE) and facilities Boeing is required to furnish, etc. 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 68 weeks before launch. Subsequent issues are published as requirements and data become available. The mission-peculiar requirements documented in the mission specification, along with the standard interfaces presented in this manual, define the spacecraft-to-launch vehicle interface.	Boeing (input required from user)
5.	**Spacecraft Environmental Test Documents** 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. Following the system-level structural loads and dynamic environment testing, test reports documenting the results shall be provided to Boeing. These reports should summarize the testing performed to verify the adequacy of 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.	Spacecraft contractor
6.	**Coupled Dynamic Loads Analysis** A coupled dynamic loads analysis is performed to define flight loads to major launch vehicle and spacecraft 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.	Boeing (input required from user, item 3)

Table 8-3. Required Documents (Continued)

	Item	Responsibility
7.	**Electrical Wiring Requirements** 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 the necessary details to be supplied. Boeing will provide a spacecraft-to-operations building 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. 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.	Spacecraft contractor
8.	**Fairing Requirements** 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 modifications 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.	Spacecraft contractor
9.	**Missile System Prelaunch Safety Package (MSPSP) (Refer to EWR 127-1 for specific spacecraft safety regulations)** To obtain approval to use the launch site facilities and resources and for launch, an MSPSP must be prepared and submitted to the 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 requirements 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 EWR 127-1. Boeing will provide this information to the appropriate government safety offices for their approval.	Spacecraft contractor
10.	**Radio Frequency (RF) Applications** 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. Transmission frequency bandwidths, frequencies, radiated durations, wattage, etc., will be provided. Boeing will provide these data to the appropriate range/government agencies for approval.	Spacecraft contractor
11.	**Preliminary Mission Analysis (PMA)** 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 variations of the critical orbit parameters as functions of probability level. A covariance matrix and a trajectory printout are also included. The mission requirements and parameter ranges of interest for parametric studies are due as early as possible but in no case later than L-64 weeks. Comments to the PMA are needed no later than L-36 weeks for start of the FMA (Item 17).	Boeing (input required from user)
12.	**Mission Operational and Support Requirements** To obtain unique range and network support, the spacecraft contractor must define any range or network requirements appropriate to its mission and then submit them to Boeing. Spacecraft contractor operational configuration, communication, tracking, and data flow requirements are required to support document preparation and arrange required range support.	Spacecraft contractor
13.	**Program Requirements Document (PRD)** 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 its mission and then submit them to Boeing. Boeing will compile, review, provide comments, and, upon comment resolution, forward the spacecraft PRD to the appropriate support agency for formal acceptance.	Boeing (input required from user)
14.	**Payload Processing Requirements Document (PPRD)** 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 Boeing 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 system. The commercial facility will accept spacecraft ground operations plans and/or MSPSP data for the PPRD.	Spacecraft contractor

Table 8-3. Required Documents (Continued)

	Item	Responsibility
15.	**Launch Vehicle Insignia** The customer is entitled to have a mission-specific insignia placed on the launch vehicle. The customer will submit the proposed design to Boeing not later than 9 months before launch for review and approval. Following approval, Boeing 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.	Spacecraft contractor
16.	**Launch Window** 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 2 weeks beyond the scheduled launch date. Liftoff is targeted to the specified window opening.	Spacecraft contractor
17.	**Final Mission Analysis (FMA) Report** Boeing will issue a 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 available at L-26 weeks.	Boeing (input required from user)
18.	**Spacecraft Drawings** 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 Boeing, 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 the Delta IV mission integration.	Spacecraft contractor
	Boeing 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 activation 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 formally accepted as a controlled interface between Boeing and the spacecraft agency. In addition, Boeing will provide a worst-case spacecraft-fairing clearance drawing.	Boeing
19.	**Spacecraft Launch Site Operations Plan** 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 operations 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.	Spacecraft contractor
20.	**Spacecraft Launch Site Procedures** 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.	Spacecraft contractor
21.	**Spacecraft Integrated Test Procedure Inputs** On each mission, Boeing prepares launch site procedures for various operations that involve the spacecraft after it is mated with the Delta second stage. Included are requirements for operations such as spacecraft weighing, spacecraft installation to 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 launch vehicle, flight program verification test, and launch countdown. Boeing requires inputs to these operations in the form of handling constraints, environmental constraints, personnel requirements, equipment requirements, etc. Of particular interest are spacecraft tasks/requirements during the final week before launch. (Refer to Section 6 for schedule constraints.)	Spacecraft contractor
22.	**Spacecraft Mass Properties Statement** The data from the spacecraft mass properties report represents the best current estimate of final spacecraft 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.	Spacecraft contractor
23.	**RF Compatibility Analysis** 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.	Boeing
24.	**Spacecraft/Launch Vehicle Separation Memorandum** 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.	Boeing (input required from user)

Table 8-3. Required Documents (Continued)

	Item	Responsibility
25.	**Launch Operations Plan (LOP)** This plan is developed to define top-level requirements that flow down into detailed range requirements. The plan contains the launch operations configuration, which 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.	Boeing
26.	**Vehicle Information Memorandum (VIM)** Boeing is required to provide a vehicle information memorandum to the US Space Command 15 calendar days prior to launch. The spacecraft agency will provide to Boeing the appropriate spacecraft on-orbit data required for this VIM. Data required are spacecraft on-orbit descriptions, description 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. Boeing will incorporate these data into the overall VIM and transmit it to the appropriate US government agency.	Boeing
27.	**Postlaunch Orbit Confirmation Data** 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 associated estimates of 3-σaccuracy is required (see Table 8-6).	Spacecraft contractor
28.	**Spacecraft-to-Launch Control Center (LCC) Wiring Diagram** Boeing will provide, for inclusion into the Mission Specification, 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.	Boeing

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Table 8-4. Delta IV Spacecraft Questionnaire

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

1 Spacecraft/Constellation Characteristics

1.1 Spacecraft Description

1.2 Size and Space Envelope

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

1.2.2 Protuberances Within 76 mm/3.0 in. of Allowable Fairing Envelope Below Separation Plane (Identify Component and Location)

1.2.3 Appendages Below Separation Plane (Identify Component and Location)

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 Spacecraft Mass Properties

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

1.3.2 CG Location

1.3.3 Principal Axis Misalignment

1.3.4 Fundamental Frequencies (Thrust Axis/Lateral Axis)

1.3.5 Are All Significant Vibration Modes Above 27 Hz in Thrust and 10 Hz in Lateral Axes?

Table 1.3.5-1. SC Stiffness Requirements

Spacecraft	Fundamental frequency (Hz)	Axis
		Lateral Axial

1.3.6 Description of Spacecraft Dynamic Model

Mass Matrix

Stiffness Matrix

Response-Recovery Matrix

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

1.3.8 Spacecraft Coordinate System

Table 1.3.8-1. Individual SC 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 1.3.8-2. Entire Payload Mass Properties (All SCs and Dispenser Combined)

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 8-4. Delta IV Spacecraft Questionnaire (Continued)

1.4 Spacecraft Hazardous Systems
- 1.4.1 Propulsion System
  - 1.4.1.1 Apogee Motor (Solid or Liquid)
  - 1.4.1.2 Attitude Control System
  - 1.4.1.3 Hydrazine (Quantity, Spec, etc.)
  - 1.4.1.4 Do Pressure Vessels Conform to Safety Requirements of Delta Payload Planners Guide Section 9?
  - 1.4.1.5 Location Where Pressure Vessels Are Loaded and Pressurized

Table 1.4.1.5-1. Propulsion System 1 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—Ground (unit)	
Design Burst Pressure—Calculated (unit)	
FS (Design Burst/Ground MEOP)	
Actual Burst Pressure—Test (unit)	
Proof Pressure—Test (unit)	
Vessel Contents	
Capacity—Launch (unit)	
Quantity—Launch (unit)	
Purpose	
Pressurized at (unit)	
Pressure When Boeing Personnel Are Exposed (unit)	
Tank Material	
Number of Vessels Used	

Table 8-4. Delta IV Spacecraft Questionnaire (Continued)

Table 1.4.1.5-2. Pressurized Tank-1 Characteristics

Parameter	Value
Operating Pressure—Flight (unit)	
Operating Pressure—Ground (unit)	
Design Burst Pressure—Calculated (unit)	
FS (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 (unit)	
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 1

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)	
Cell Pressure Vessel Material (unit)	
Cell Pressure Vessel Material (unit)	

1.4.4 RF Systems

1.4.4.1 System

1.4.4.2 Frequency (MHz)

1.4.4.3 Maximum Power (EIRP) (dBm)

1.4.4.4 Average Power (W)

1.4.4.5 Type of Transmitter

1.4.4.6 Antenna Gain (dBi)

1.4.4.7 Antenna Location

1.4.4.8 Distance at Which RF Radiation Flux Density Equals 1 mW/cm^2

1.4.4.9 When Is RF Transmitter Operated?

1.4.4.10 RF Checkout Requirements (Location and Duration, to What Facility, Support Requirements, etc.)

1.4.4.11 RF Radiation Levels (Personnel Safety)

Table 1.4.4-1. 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 building ________ Prelaunch: Pre - Fairing Inspection Postlaunch: Before SC Separation				

Table 1.4.4-2. Radio Frequency Environment

Frequency	E-field

1.4.5 Deployable Systems
- 1.4.5.1 Antennas
- 1.4.5.2 Solar Panels

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

Table 1.4.7-1. 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

Table 1.4.8-1. 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 Surface Sensitivity (e.g., Susceptibility to Propellants, Gases and Exhaust Products, and Other Contaminants)

Table 1.5-1. Contamination-Sensitive Surfaces

Component	Sensitive to	NVR	Particulate	Level

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

2.1.2 Number of Launches required

2.1.3 Frequency of Launches required

2.2 Orbit Characteristics

2.2.1 Apogee (Integrated)

2.2.2 Perigee (Integrated)

2.2.3 Inclination

2.2.4 Argument of Perigee at Insertion

2.2.5 Other

Table 2.2-1. Orbit Characteristics

LV and launch site	Mass	Apogee	Perigee	Inclination	Argument of perigee at insertion	RAAN	Eccentricity	Period

2.3 Launch Site

2.4 Launch Dates and Times

2.4.1 Launch Windows (over 1-year span)

2.4.2 Launch Exclusion Dates

Table 8-4. Delta IV Spacecraft Questionnaire (Continued)

Table 2.4.1-1. 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 2.4.2-1. Launch Exclusion Dates

Month	Exclusion dates

2.5 Spacecraft Constraints on Mission Parameters
- 2.5.1 Sun-Angle Constraints
- 2.5.2 Eclipse
- 2.5.3 Ascending Node
- 2.5.4 Inclination
- 2.5.5 Telemetry Constraint
- 2.5.6 Thermal Attitude Constraints
- 2.5.7 Other

2.6 Trajectory and Spacecraft Separation Requirement
- 2.6.1 Special Trajectory Requirements
  - 2.6.1.1 Thermal Maneuvers
  - 2.6.1.2 T/M Maneuvers
  - 2.6.1.3 Free Molecular Heating Restraints
- 2.6.2 Spacecraft Separation Requirements
  - 2.6.2.1 Position
  - 2.6.2.2 Attitude
  - 2.6.2.3 Sequence and Timing
  - 2.6.2.4 Tipoff and Coning
  - 2.6.2.5 Spin Rate at Separation
  - 2.6.2.6 Other

Table 2.6.2-1. Separation Requirements

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

2.7 Launch And Flight Operation Requirements
- 2.7.1 Operations—Prelaunch
  - 2.7.1.1 Location of Spacecraft Operations Control Center
  - 2.7.1.2 Spacecraft Ground Station Interface Requirements
  - 2.7.1.3 Mission-Critical Interface Requirements
- 2.7.2 Operations—Launch Through Spacecraft Separation
  - 2.7.2.1 Spacecraft Uplink Requirement
  - 2.7.2.2 Spacecraft Downlink Requirement
  - 2.7.2.3 Launch Vehicle Tracking Stations
  - 2.7.2.4 Coverage by Instrumented Aircraft
  - 2.7.2.5 TDRSS Coverage

Table 2.7.2-1. Events During Launch Phase

Event	Time from liftoff	Constraints/comments

2.7.3 Operations—Post-Spacecraft Separation
2.7.3.1 Spacecraft Tracking Station
2.7.3.2 Spacecraft Acquisition Assistance Requirements

3 Launch Vehicle Configuration

3.1 Dispenser/Payload Attach Fitting Mission-Specific Configuration
3.1.1 Nutation Control System
3.1.2 Despin System
3.1.3 Retro System
3.1.4 Ballast
3.1.5 Insulation
3.2 Fairing Mission-Specific Configuration
3.2.1 Access Doors and RF Windows in Fairing

Table 3.2.1-1. Access Doors

Size (unit)	LV station (unit)[1]	Clocking (degrees)[2]	Purpose

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

3.2.2 External Fairing Insulation
3.2.3 Acoustic Blanket Modifications
3.2.3.1 Cylindrical Section
3.2.3.2 Nose Section
3.2.3.3 Aft Canister Section (for Dual-Manifest configuration)
3.2.4 Special Instrumentation
3.2.5 Mission Support Equipment
3.2.6 Air-Conditioning Distribution
3.2.6.1 Spacecraft In-Flight Requirements
3.2.6.2 Spacecraft Ground Requirements (Fairing Installed)
3.2.6.3 Critical Surfaces (i.e., Type, Size, Location)
3.3 Mission-Specific Reliability Requirements
3.4 Second-Stage Mission-Specific Configuration
3.4.1 Extended-Mission Modifications
3.4.2 Retro System
3.5 Interstage Mission-Specific Configuration
3.6 First-Stage Mission-Specific Configuration

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
  Figure 4.2.4-1. GN_2 Purge Interface Design
4.3 Contamination/Cleanliness Requirements
 4.3.1 Contamination and Collision Avoidance Maneuver (CCAM)
4.4 Spacecraft Weighing and Balancing
 4.4.1 Spacecraft Balancing
 4.4.3 Spacecraft Weighing
4.5 Security
 4.5.1 PPF Security
 4.5.2 Transportation Security
 4.5.3 Pad Security
4.6 Special Handling Requirements
 4.6.1 Payload Processing Facility Preference and Priority
 4.6.2 List the Hazardous Processing Facilities the Spacecraft Project Desires to Use
 4.6.3 What Are the Expected Dwell Times the Spacecraft Project Would Spend in the Payload Processing Facilities?
 4.6.4 Do Spacecraft Contamination Requirements Conform With Capabilities of Existing Facilities?
 4.6.5 During Transport
 4.6.6 On Stand
 4.6.7 In Support Equipment Support Building
 4.6.8 Is a Multishift Operation Planned?
 4.6.9 Additional Special Boeing Handling Requirements?
  4.6.9.1 In Payload Processing Facility (PPF)
  4.6.9.2 In Fairing Encapsulation
  4.6.9.3 On Stand
  4.6.9.4 In Operations Building
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
4.9 Other Spacecraft Handling and Processing Requirements

5 Spacecraft/Launch Vehicle Interface Requirements

5.1 Responsibility
5.2 Mechanical Interfaces
 5.2.1 Fairing Envelope
  5.2.1.1 Fairing Envelope Violations

Table 5.2.1.1-1. 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

  5.2.1.2 Separation Plane Envelope Violations

Table 5.2.1.2-1. Violations in the Separation Plane

Item	LV vertical station (unit)	Radial dimension (unit)	Clocking from SC X-axis	Clocking from LV Quadrant IV axis	Clearance from stay-out zone

 5.2.2 Separation System
  5.2.2.1 Clampband/Attachment System Desired

Table 8-4. Delta IV Spacecraft Questionnaire (Continued)

Table 5.2.2.1-1. Spacecraft Mechanical Interface Definition

SC bus	Size of S/C interface to LV (unit)	Type of SC interface to LV desired

5.2.2.2 Separation Springs

5.3 Electrical Interfaces

5.3.1 Spacecraft/Payload Attach Fitting Electrical Connectors

5.3.1.1 Connector Types, Location, Orientation, and Part Number

Figure 5.3.1.1-1. Electrical Connector Configuration

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

5.3.1.3 Spacecraft Separation Indication

5.3.1.4 Spacecraft Data Requirements

Table 5.3.1-1. Interface Connectors

Item	P1	P2
Vehicle Connector		
SC Mating Connectors (J1 and J2)		
Distance Forward of SC Mating Plane (unit)		
Launch Vehicle Station		
Clocking[1] (deg)		
Radial Distance of Connector Centerline from Vehicle Centerline (unit)		
Polarizing Key		
Maximum Connector Force (+Compression, –Tension) (unit)		
Note: 1. Positional tolerance defined in Payload Planners Guide (reference launch vehicle coordinates).		

5.3.2 Separation Switches

5.3.2.1 Separation Switch Pads (Launch Vehicle)

5.3.2.2 Separation Switches (Spacecraft)

5.3.2.3 Spacecraft/Fairing Electrical Connectors

5.3.2.4 Does Spacecraft Require Discrete Signals From Delta?

5.4 Ground Electrical Interfaces

5.4.1 Spacecraft-to-Blockhouse Wiring Requirements

5.4.1.1 Number of Wires Required

5.4.1.2 Pin Assignments in the Spacecraft Umbilical Connector(s)

5.4.1.3 Purpose and Nomenclature of Each Wire Including Voltage, Current, Polarity Requirements, and Maximum Resistance

5.4.1.4 Shielding Requirements

5.4.1.5 Voltage of the Spacecraft Battery and Polarity of the Battery Ground

Table 5.4.1.5-1. Pin Assignments

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

5.5 Spacecraft Environments

5.5.1 Steady-State Acceleration

5.5.2 Quasi-Static Load Factors

Table 5.5.2-1. Quasi-Static Load Factors

	G-Loads (+ is tension, – is compression)					
	Lateral			Axial		
Load event	Static	Dynamic	Total	Static	Dynamic	Total
Ground Transport to Pad						
Liftoff						
Max. Dynamic Pressure						
Max. Flight Winds (gust and buffet)						
Max. Longitudinal Load						
Max. Axial Load						
Stage 1 Engine Cutoff						
Stage 2 Flight						
Stage 2 Engine Cutoff						
Pre-Strap-on Nonsymmetric Burnout						

5.5.3 Dynamic Environments
5.5.3.1 Acoustic Environment
Figure 5.5.3.1-1. Spacecraft Acoustic Environment Maximum Flight Levels
5.5.3.2 Vibration

Table 5.5.3.2-1. Maximum Flight Sinusoidal Vibration Levels

	Frequency (Hz)	Level
Thrust Axis		
Lateral Axes		
Note: Accelerations apply at payload attach fitting base during testing. Responses at fundamental frequencies should be limited based on vehicle coupled loads analysis.		

5.5.3.3 Spacecraft Interface Shock Environment

Table 5.5.3.3-1. Maximum Flight Level Interface Environment

Frequency (Hz)	Shock response spectrum level (Q = 10)
100	
100 to 1500	
1500 to 10,000	

5.5.3.4 Spacecraft Stiffness
5.5.4 Thermal Environment
5.5.4.1 Fairing Temperature and Emissivities
5.5.4.2 Free Molecular Heating Rate
5.5.4.3 Second-Stage Thermal Sources
5.5.4.4 Electromagnetic Compatibility (EMC)
Figure 5.5.4.4-1 Ascent Thermal Environment
5.5.5 RF Environment
5.5.6 Electrical Bonding
5.5.7 Power to the SCs
5.5.8 Fairing Internal Pressure Environment
5.5.9 Humidity Requirements

6 Spacecraft Development and Test Programs

6.1 Test Schedule at Launch Site
6.1.1 Operations Flow Chart (Flow Chart Should Be a Detailed Sequence of Operations Referencing Days and Shifts and Location)
6.2 Spacecraft Development and Test Schedules
6.2.1 Flow Chart and Test Schedule
6.2.2 Is a Test PAF Required? When?
6.2.3 Is Clamp Band Ordnance Required? When?
6.3 Special Test Requirements
6.3.1 Spacecraft Spin Balancing
6.3.2 Other

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

001931.3

Table 8-5. Typical Spacecraft Launch-Site Test Plan

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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Table 8-6. Data Required for Orbit Parameter Statement

1. Epoch: Second-stage burnout

2. Position and velocity components $(X, Y, Z, \dot{X}, \dot{Y}, \dot{Z})$ 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, ω
   Mean anomaly, M
   Right ascension of ascending node, Ω

4. Polar elements* at the above epoch:
   Inertial velocity, V
   Inertial flight path angle, $\gamma 1$
   Inertial flight path angle, $\gamma 2$
   Radius, R
   Geocentric latitude, ρ
   Longitude, μ

5. Estimated accuracies of elements and a discussion of quality of tracking data and difficulties such as reorientation maneuvers within six hr of separation, etc.

6. Constants used:
   Gravitational constant, μ
   Equatorial radius, R_E
   J_2 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.

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Table 8-7. Spacecraft Checklist

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-handling
  - (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 clean room?
  (yes) _____ (no) ____
  - (1) Class of clean room required _________________
  - (2) Special sampling techniques __________________
- B. Area required
  - (1) For spacecraft __________________________sq ft
  - (2) For ground station _______________________sq ft
  - (3) For office space _________________________sq ft
  - (4) For other GSE ___________________________sq ft
  - (5) For storage _____________________________sq ft
- 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 clean room? (yes)__ (no) __
  - (1) Class of clean room required __________________
  - (2) Special sampling techniques (e.g., hydrocarbon monitoring) ______________________________
- B. Area required
  - (1) For spacecraft ________________________ sq ft
  - (2) For GSE ____________________________ sq ft
    - 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 ______________________________

Table 8-7. Spacecraft Checklist (Continued)

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 SLC-37/SLC-6
  (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? Explain ____________
  (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)

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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 Station (CCAS), Florida, or Vandenberg Air Force Base (VAFB), California. This section provides safety requirements guidance for payload processing operations conducted at Space Launch Complex 37 A/B (CCAS) or Space Launch Complex 6 (VAFB).

Payload prelaunch operations may be conducted at Cape Canaveral Air Station, Florida; at Astrotech in Titusville, Florida; Astrotech, Vandenberg Air Force Base, California; or at Spaceport Systems International, 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 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 30th and 45th Space Wings are responsible for overall range (ground/flight) safety at CCAS 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 Eastern and Western Range (EWR) 127-1 Range Safety Requirements.

The Federal Aviation Administration (FAA)/Associate Administrator for Commercial Safety 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 Boeing Delta Launch Services 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 37 A/B (CCAS) 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 pre-launch safety package (MSPSP) and payload safety review process in accordance with Delta IV EWR 127-1 (T), Appendix 3A and Appendix C “Payload Safety Requirements.”

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

C. Identify to Delta Launch Services any potential Delta IV EWR 127-1 (T)—MDC 99H1112, tailoring requests prior to the mission orientation briefing.

D. Identify to Delta Launch Services any potential Delta IV EWR 127-1 (T)—MDC 99H1112, noncompliance requests prior to the mission orientation briefing.

Appendix A
DELTA MISSIONS CHRONOLOGY

Delta	Mission	Vehicle	Launch date	Results	Launch site
274	Globalstar-6 (4 satellites)	DELTA II	08/17/99	Successful	ER
273	Globalstar-5 (4 satellites)	DELTA II	07/25/99	Successful	ER
272	Globalstar-4 (4 satellites)	DELTA II	07/10/99	Successful	ER
271	FUSE	DELTA II	06/24/99	Successful	ER
270	Globalstar-3 (4 satellites)	DELTA II	06/10/99	Successful	ER
269	Orion-3	DELTA III	05/04/99	Failed	ER
268	Landsat-7	DELTA II	04/15/99	Successful	WR
267	P91 Argos, Orsted, and Sunsat	DELTA II	02/23/99	Successful	WR
266	Stardust	DELTA II	02/07/99	Successful	ER
265	Mars Polar Lander	DELTA II	01/03/99	Successful	ER
264	Mars Climate Orbiter	DELTA II	12/11/98	Successful	ER
263	Bonum-1	DELTA II	11/22/98	Successful	ER
262	MS-11 Iridium (5 satellites)	DELTA II	11/06/98	Successful	WR
261	Deep Space 1 and SEDSAT	DELTA II	10/24/98	Successful	ER
260	MS-10 Iridium (5 satellites)	DELTA II	09/08/98	Successful	WR
259	GALAXY X	DELTA III	08/26/98	Failed	ER
258	THOR III	DELTA II	06/09/98	Successful	ER
257	MS-9 Iridium (5 satellites)	DELTA II	05/17/98	Successful	WR
256	Globalstar-2 (4 satellites)	DELTA II	04/24/98	Successful	ER
255	MS-8 Iridium (5 satellites)	DELTA II	03/29/98	Successful	WR
254	MS-7 Iridium (5 satellites)	DELTA II	02/18/98	Successful	WR
253	Globalstar-1 (4 satellites)	DELTA II	02/14/98	Successful	ER
252	SKYNET 4D	DELTA II	01/09/98	Successful	ER
251	MS-6 Iridium (5 satellites)	DELTA II	12/20/97	Successful	WR
250	MS-5 Iridium (5 satellites)	DELTA II	11/08/97	Successful	WR
249	GPS II-28	DELTA II	11/05/97	Successful	ER
248	MS-4 Iridium (5 satellites)	DELTA II	09/26/97	Successful	WR
247	ACE	DELTA II	08/25/97	Successful	ER
246	MS-3 Iridium (5 satellites)	DELTA II	08/20/97	Successful	WR
245	GPS IIR-2	DELTA II	07/22/97	Successful	ER
244	MS-2 Iridium (5 satellites)	DELTA II	07/09/97	Successful	WR
243	THOR IIA	DELTA II	05/20/97	Successful	ER
242	MS-1A Iridium (5 satellites)	DELTA II	05/05/97	Successful	WR
241	GPS IIR-1	DELTA II	01/17/97	Failed	ER
240	Mars Pathfinder	DELTA II	12/04/96	Successful	ER
239	Mars Global Surveyor	DELTA II	11/07/96	Successful	ER
238	GPS II-27	DELTA II	09/12/96	Successful	ER
237	GPS II-26	DELTA II	07/15/96	Successful	ER
236	GALAXY IX	DELTA II	05/23/96	Successful	ER
235	MSX	DELTA II	04/24/96	Successful	WR
234	GPS II-25	DELTA II	03/27/96	Successful	ER
233	POLAR	DELTA II	02/24/96	Successful	WR
232	NEAR	DELTA II	02/17/96	Successful	ER

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
231	KOREASAT-2	DELTA II	01/14/96	Successful	ER
230	XTE	DELTA II	12/30/95	Successful	ER
229	RADARSAT and SURFSAT	DELTA II	11/04/95	Successful	WR
228	KOREASAT-1	DELTA II	08/05/95	Failed (lower than desired orbit)	ER
227	WIND	DELTA II	11/01/94	Successful	ER
226	NAVSTAR II-24 and SEDS-2	DELTA II	03/09/94	Successful	ER
225	GALAXY I-R	DELTA II	02/19/94	Successful	ER
224	NATO IVB	DELTA II	12/07/93	Successful	ER
223	NAVSTAR II-23	DELTA II	10/26/93	Successful	ER
222	NAVSTAR II-22	DELTA II	08/30/93	Successful	ER
221	NAVSTAR II-21 and PMG	DELTA II	06/26/93	Successful	ER
220	NAVSTAR II-20	DELTA II	05/12/93	Successful	ER
219	NAVSTAR II-19 and SEDS-1	DELTA II	03/29/93	Successful	ER
218	NAVSTAR II-18	DELTA II	02/02/93	Successful	ER
217	NAVSTAR II-17	DELTA II	12/18/92	Successful	ER
216	NAVSTAR II-16	DELTA II	11/22/92	Successful	ER
215	DFS-3 KOPERNIKUS	DELTA II	10/12/92	Successful	ER
214	NAVSTAR II-15	DELTA II	09/09/92	Successful	ER
213	SATCOM C-4	DELTA II	08/31/92	Successful	ER
212	GEOTAIL and DUVE	DELTA II	07/24/92	Successful	ER
211	NAVSTAR II-14	DELTA II	07/07/92	Successful	ER
210	EUVE	DELTA II	06/07/92	Successful	ER
209	PALAPA B4	DELTA II	05/13/92	Successful	ER
208	NAVSTAR I-13	DELTA II	04/09/92	Successful	ER
207	NAVSTAR II-12R	DELTA II	02/23/92	Successful	ER
206	NAVSTAR II-11R and LOSAT-X	DELTA II	07/03/91	Successful	ER
205	AURORA II	DELTA II	05/29/91	Successful	ER
204	ASC-2	DELTA II	04/12/91	Successful	ER
203	INMARSAT 2 (F2)	DELTA II	03/08/91	Successful	ER
202	NATO-IVA	DELTA II	01/07/91	Successful	ER
201	NAVSTAR II-10	DELTA II	11/26/90	Successful	ER
200	INMARSAT 2 (F2)	DELTA II	10/30/90	Successful	ER
199	NAVSTAR II-9	DELTA II	10/01/90	Successful	ER
198	BSB-R2	DELTA II	08/17/90	Successful	ER
197	NAVSTAR II-8	DELTA II	08/02/90	Successful	ER
196	INSAT-1D	DELTA	06/12/90	Successful	ER
195	ROSAT	DELTA II	06/01/90	Successful	ER
194	PALAPA B2-R	DELTA II	04/13/90	Successful	ER
193	NAVSTAR II-7	DELTA II	03/25/90	Successful	ER
192	LOSAT (LACE/RME)	DELTA II	02/14/90	Successful	ER
191	NAVSTAR II-6	DELTA II	01/24/90	Successful	ER
190	NAVSTAR II-5	DELTA II	12/11/89	Successful	ER
189	COBE	DELTA	11/18/89	Successful	WR
188	NAVSTAR II-4	DELTA II	10/21/89	Successful	ER
187	BSB-R1	DELTA	08/27/89	Successful	ER
186	NAVSTAR II-3	DELTA II	08/18/89	Successful	ER
185	NAVSTAR II-2	DELTA II	06/10/89	Successful	ER

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
184	NAVSTAR II-1	DELTA II	02/14/89	Successful	ER
183	DELTA STAR	DELTA	03/24/89	Successful	ER
182	PALAPA B2-P	DELTA	03/20/87	Successful	ER
181	DOD#2	DELTA	02/08/88	Successful	ER
180	DM-43 (DOD)	DELTA	09/05/86	Successful	ER
179	GOES-H	DELTA	02/26/87	Successful	ER
178	GOES-G	DELTA	05/03/86	Failed	ER
177	NATO-IIID	DELTA	11/13/84	Successful	ER
176	GALAXY-C	DELTA	09/21/84	Successful	ER
175	AMPTE	DELTA	08/16/84	Successful	ER
174	LANDSAT-D and UOSAT	DELTA	03/01/84	Successful	WR
173	GALAXY-B	DELTA	09/22/83	Successful	ER
172	RCA-G	DELTA	09/08/83	Successful	ER
171	TELSTAR-3A	DELTA	07/28/83	Successful	ER
170	GALAXY-A	DELTA	06/28/83	Successful	ER
169	EXOSAT	DELTA	05/26/83	Successful	WR
168	GOES-F	DELTA	04/28/83	Successful	ER
167	RCA-F	DELTA	04/11/83	Successful	ER
166	IRAS and PIX-B	DELTA	01/25/83	Successful	WR
165	RCA-E	DELTA	10/27/82	Successful	ER
164	TELESAT-F	DELTA	08/26/82	Successful	ER
163	LANDSAT-D	DELTA	07/16/82	Successful	WR
162	WESTAR-V	DELTA	06/08/82	Successful	ER
161	INSAT-1A	DELTA	04/10/82	Successful	ER
160	WESTAR-IV	DELTA	02/25/82	Successful	ER
159	RCA-C	DELTA	01/15/82	Successful	ER
158	RCA-D	DELTA	11/19/81	Successful	ER
157	SME and UOSAT	DELTA	10/06/81	Successful	WR
156	SBS-B	DELTA	09/24/81	Successful	ER
155	Dynamic Explorer DE-A and DE-B	DELTA	08/03/81	Successful	WR
154	GOES-E	DELTA	05/22/81	Successful	ER
153	SBS-A	DELTA	11/15/80	Successful	ER
152	GOES-D	DELTA	09/09/80	Successful	ER
151	SMM	DELTA	02/14/80	Successful	ER
150	RCA-C	DELTA	12/06/79	Successful	ER
149	WESTAR-C	DELTA	08/09/79	Successful	ER
148	SCATHA	DELTA	01/30/79	Successful	ER
147	TELESAT-D	DELTA	12/15/78	Successful	ER
146	NATO-IIIC	DELTA	11/18/78	Successful	ER
145	NIMBUS-G and CAMEO	DELTA	10/24/78	Successful	WR
144	ISEE-C	DELTA	08/12/78	Successful	ER
143	ESA-GEOS-2	DELTA	07/14/78	Successful	ER
142	GOES-C	DELTA	06/16/78	Successful	ER
141	OTS-2	DELTA	05/11/78	Successful	ER
140	BSE	DELTA	04/07/78	Successful	ER
139	LANDSAT-C, OSCAR, and PIX-A	DELTA	03/05/78	Successful	WR
138	IUE	DELTA	01/26/78	Successful	ER

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
137	CS	DELTA	12/14/77	Successful	ER
136	METEOSAT	DELTA	11/22/77	Successful	ER
135	ISEE-A and ISEE-B	DELTA	10/22/77	Successful	ER
134	OTS	DELTA	09/13/77	Failed	ER
133	SIRIO	DELTA	08/25/77	Successful	ER
132	GMS	DELTA	07/14/77	Successful	ER
131	GOES-B	DELTA	06/16/77	Successful	ER
130	ESRO-GEOS	DELTA	04/20/77	Failed	ER
129	PALAPA-B	DELTA	03/10/77	Successful	ER
128	NATO -IIIB	DELTA	01/27/77	Successful	ER
127	MARISAT-C	DELTA	10/14/76	Successful	ER
126	ITOS-E2	DELTA	07/29/76	Successful	WR
125	PALAPA-A	DELTA	07/08/76	Successful	ER
124	MARISAT-B	DELTA	06/09/76	Successful	ER
123	LAGEOS	DELTA	05/04/76	Successful	WR
122	NATO-IIIA	DELTA	04/22/76	Successful	ER
121	RCA-B	DELTA	03/26/76	Successful	ER
120	MARISAT-A	DELTA	02/19/76	Successful	ER
119	CTS	DELTA	01/17/76	Successful	ER
118	RCA-A	DELTA	12/12/75	Successful	ER
117	AE-E	DELTA	11/19/75	Successful	ER
116	GOES-A	DELTA	10/16/75	Successful	ER
115	AE-D	DELTA	10/06/75	Successful	WR
114	SYMPHONIE-B	DELTA	08/26/75	Successful	ER
113	COS-B	DELTA	08/08/75	Successful	WR
112	OSO-I	DELTA	06/21/75	Successful	ER
111	NIMBUS-F	DELTA	06/12/75	Successful	WR
110	TELESAT-C	DELTA	05/07/75	Successful	ER
109	GEOS-C	DELTA	04/09/75	Successful	WR
108	SMS-B	DELTA	02/06/75	Successful	ER
107	ERTS-B	DELTA	01/22/75	Successful	WR
106	SYMPHONIE-A	DELTA	12/18/74	Successful	ER
105	SKYNET IIB	DELTA	11/22/74	Successful	ER
104	ITOS-G, OSCAR-7, and INTASAT	DELTA	11/15/74	Successful	WR
103	WESTAR-B	DELTA	10/10/74	Successful	ER
102	SMS-A	DELTA	05/17/74	Successful	ER
101	WESTAR-A	DELTA	04/13/74	Successful	ER
100	SKYNET IIA	DELTA	01/18/74	Failed	ER
99	AE-C	DELTA	12/15/73	Successful	WR
98	ITOS-F	DELTA	11/06/73	Successful	WR
97	IMP-J	DELTA	10/25/73	Successful	ER
96	ITOS-E	DELTA	07/16/73	Failed	WR
95	RAE-B	DELTA	06/10/73	Successful	ER
94	TELESAT-B	DELTA	04/20/73	Successful	ER
93	NIMBUS-E	DELTA	12/10/72	Successful	WR
92	TELESAT-A	DELTA	11/09/72	Successful	ER
91	ITOS-D and AMSAT-OSCAR-6	DELTA	10/15/72	Successful	WR

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
90	IMP-H	DELTA	09/22/72	Successful	ER
89	ERTS-A	DELTA	07/23/72	Successful	WR
88	TD-1	DELTA	03/11/72	Successful	WR
87	HEOS-A2	DELTA	01/31/72	Successful	WR
86	ITOS-B	DELTA	10/21/71	Failed	WR
85	OSO-H and TERS-4	DELTA		Successful	ER
84	ISIS-B	DELTA	03/31/71	Successful	WR
83	IMP-1	DELTA	03/13/71	Successful	ER
82	NATO-B	DELTA	02/02/71	Successful	ER
81	ITOS-A	DELTA	12/11/70	Successful	WR
80	IDCPS/A-B	DELTA	08/19/70	Successful	ER
79	INTELSAT III-H	DELTA	07/23/70	Successful	ER
78	INTELSAT III-G	DELTA	04/22/70	Successful	ER
77	NATO-A	DELTA	03/20/70	Successful	ER
76	TIROS-M and OSCAR-5	DELTA	01/23/70	Successful	WR
75	INTELSAT III-F	DELTA	01/14/70	Successful	ER
74	IDCSP/A	DELTA	11/21/69	Successful	ER
73	PIONEER E and TERS-3	DELTA	08/27/69	Failed	ER
72	OSO-G and PAC	DELTA	08/09/69	Successful	ER
71	INTELSAT III-E	DELTA	07/25/69	Failed	ER
70	BIOS-D	DELTA	06/28/69	Successful	ER
69	EXPLORER 41 (IMP-G)	DELTA	06/21/69	Successful	WR
68	INTELSAT III-D	DELTA	05/21/69	Successful	ER
67	TOS-G	DELTA	02/26/69	Successful	ER
66	INTELSAT III-B	DELTA	02/05/69	Successful	ER
65	ISIS-A	DELTA	01/29/69	Successful	WR
64	OSO-F	DELTA	01/22/69	Successful	ER
63	INTELSAT III-C	DELTA	12/18/68	Successful	ER
62	TOS-E2/F	DELTA	12/15/68	Successful	WR
61	HEOS-A	DELTA	12/05/68	Successful	ER
60	PIONEER D and TERS-2 (Test & Training Satellite)	DELTA	11/08/68	Successful	ER
59	INTELSAT III-A	DELTA	09/18/68	Failed	ER
58	TOS-E	DELTA	08/16/68	Successful	WR
57	EXPLORER XXXVII (RAE-A)	DELTA	07/14/68	Successful	WR
56	EXPLORER XXXVI (GEOS-B)	DELTA	01/11/68	Successful	WR
55	PIONEER C and TTS-1 (piggyback satellite)	DELTA	12/13/67	Successful	ER
54	TOS-C	DELTA	11/10/67	Successful	WR
53	OSO-D	DELTA	10/18/67	Successful	ER
52	INTELSAT II F4	DELTA	09/27/67	Successful	ER
51	BIOS-B	DELTA	09/07/67	Successful	ER
50	EXPLORER XXXV (IMP-E)	DELTA	07/19/67	Successful	ER
49	EXPLORER XXXIV (IMP-F)	DELTA	05/24/67	Successful	WR
48	TOS-D	DELTA	04/20/67	Successful	WR
47	INTELSAT II F3	DELTA	03/22/67	Successful	ER
46	OSO-E1	DELTA	03/08/67	Successful	ER
45	TOS-B	DELTA	01/26/67	Successful	WR
44	INTELSAT II F2	DELTA	01/11/67	Successful	ER

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
43	BIOS-A	DELTA	12/14/66	Successful	ER
42	INTELSAT II F1	DELTA	10/26/66	Successful	ER
41	TOS-A	DELTA	10/02/66	Successful	WR
40	PIONEER B	DELTA	08/17/66	Successful	ER
39	EXPLORER XXXIII (IMP-D)	DELTA	07/01/66	Successful	ER
38	EXPLORER XXXII (AE-B)	DELTA	05/25/66	Successful	ER
37	ESSA II (TIROS OT-2)	DELTA	02/28/66	Successful	ER
36	ESSA I (TIROS OT-3)	DELTA	02/03/66	Successful	ER
35	PIONEER A	DELTA	12/16/65	Successful	ER
34	EXPLORER XXIX (GEOS-A)	DELTA	11/06/65	Successful	ER
33	OSO-C	DELTA	08/25/65	Failed	ER
32	TIROS X	DELTA	07/01/65	Successful	ER
31	EXPLORER XXVIII (IMP-C)	DELTA	05/29/65	Successful	ER
30	COMSAT-1	DELTA	04/06/65	Successful	ER
29	OSO-B2	DELTA	02/03/65	Successful	ER
28	TIROS-I	DELTA	01/22/65	Successful	ER
27	EXPLORER XXVI	DELTA	12/21/64	Successful	ER
26	EXPLORER XXI (IMP-B)	DELTA	10/03/64	Successful	ER
25	SYNCOM-C	DELTA	08/19/64	Successful	ER
24	S-66	DELTA	03/19/64	Failed	ER
23	RELAY	DELTA	01/21/64	Successful	ER
22	TIROS-H	DELTA	12/21/63	Successful	ER
21	EXPLORER XVIII (IMP-A)	DELTA	11/26/63	Successful	ER
20	SYNCOM A-26	DELTA	07/26/63	Successful	ER
19	TIROS-G	DELTA	06/19/63	Successful	ER
18	TELSTAR-2	DELTA	05/07/63	Successful	ER
17	EXPLORER XVII	DELTA	04/02/63	Successful	ER
16	SYNCOM-A-25	DELTA	02/14/63	Successful	ER
15	RELAY A-15	DELTA	12/13/62	Successful	ER
14	EXPLORER XV (S-3B)	DELTA	10/27/62	Successful	ER
13	EXPLORER XIV (S-3A)	DELTA	10/02/62	Successful	ER
12	TIROS-F	DELTA	09/18/62	Successful	ER
11	TELSTAR I	DELTA	07/10/62	Successful	ER
10	TIROS-E	DELTA	06/19/62	Successful	ER
9	ARIEL (UK)	DELTA	04/26/62	Successful	ER
8	OSO A	DELTA	03/07/62	Successful	ER
7	TIROS-D	DELTA	02/08/62	Successful	ER
6	EXPLORER XII (S-C)	DELTA	08/15/61	Successful	ER
5	TIROS-A3	DELTA	07/12/61	Successful	ER
4	EXPLORER X (P-14)	DELTA	03/25/61	Successful	ER
3	TIROS-2	DELTA	11/23/60	Successful	ER
2	ECHO 1A	DELTA	08/12/60	Successful	ER
1	ECHO 1	DELTA	05/13/60	Failed	ER

ER–Eastern Range WR–Western Range

The Delta launch vehicle will not be launched even if only one of the following criteria is not met. If these constraints are not violated, yet other hazardous weather conditions exist, the launch weather officer will report the threat to the launch director. The launch director may order a hold at any time based on weather instability.

A. Do not launch if any type of lightning is detected within 10 nmi of the planned flight path within 30 min prior to launch, unless the meteorological condition that produced the lightning has moved more than 10 nmi away from the planned flight path.

B. Do not launch if the planned flight path will carry the vehicle:

(1) Through a cumulus* cloud with its top between the +5.0°C and -5.0°C level unless:

(a) The cloud is not producing precipitation;

-AND-

(b) The horizontal distance from the farthest edge of the cloud top to at least one working field mill is less than the altitude of the -5.0°C level, or 3 nmi, whichever is smaller;

-AND-

(c) All field mill readings within 5 nmi of the flight path are between -100 V/m and +1000 V/m for the preceding 15 minutes.

(2) Through cumulus clouds with tops higher than the -5.0°C level.

(3) Through or within 5 nmi (horizontal or vertical) of the nearest edge of cumulus clouds with tops higher than the -10.0°C level.

(4) Through or within 10 nmi (horizontal or vertical) of the nearest edge of any cumulonimbus or thunderstorm cloud, including nontransparent parts of its anvil.

(5) Through or within 10 nmi (horizontal or vertical) of the nearest edge of a nontransparent detached anvil for the first hour after detachment from the parent thunderstorm or cumulonimbus cloud.

C. Do not launch if, for ranges equipped with a surface electric field mill network, at any time during the 15 min prior to launch time, the absolute value of any electric field intensity measurement at the ground is greater than 1000 V/m within 5 nmi of the flight path unless:

(1) There are no clouds within 10 nmi of the flight path except:

(a) Transparent clouds,

-OR-

(b) Clouds with tops below the +5.0°C level that have not been associated with convective clouds with tops above the -10.0°C level within the past 3 hr,

-AND-

(2) A known source of electric field (such as ground fog) that is occurring near the sensor, and that has been previously determined and documented to be benign, is clearly causing the elevated readings.

Note: For confirmed failure of the surface field mill system, the countdown and launch may continue, because *the other lightning launch commit criteria completely describe unsafe meteorological conditions.*

D. Do not launch if the flight path is through a vertically continuous layer of clouds with an overall depth of 4,500 ft or greater where any part of the clouds is located between the 0.0°C and -20.0°C levels.

E. Do not launch if the flight path is through any clouds that:

(1) Extend to altitudes at or above the 0.0°C level,

-AND-

(2) Are associated with disturbed weather that is producing moderate (29 dBz) or greater precipitation within 5 nmi of the flight path.

F. Do not launch if the flight path will carry the vehicle:

(1) Through any nontransparent thunderstorm or cumulonimbus debris cloud during the first 3 hr after the debris cloud formed from the parent cloud.

(2) Within 5 nmi (horizontal or vertical) of the nearest edge of a nontransparent thunderstorm or cumulonimbus debris cloud during the first 3 hr after the debris cloud formed from a parent cloud unless:

(a) There is at least one working field mill within 5 nmi of the debris cloud;

-AND-

(b) All electric field intensity measurements at the ground are between +1000 V/m and -1000 V/m within 5 nmi of the flight path during the 15 min preceding the launch time;

(c) The maximum radar return from the entire debris cloud is less than 10 dBz during the 15 minutes preceding launch time;

-AND-

(3) The start of the 3-hr period is determined as follows:

(a) **DETACHMENT**. If the cloud detaches from the parent cloud, the 3-hr period begins at the time when cloud detachment is observed or at the time of the last detected lightning discharge (if any) from the detached debris cloud, whichever is later.

(b) **DECAY OR DETACHMENT UNCERTAIN.** If it is not known whether the cloud is detached or the debris cloud forms from the decay of the parent cloud, the 3-hr period begins at the time when the parent cloud top decays to below the altitude of the -10°C level, or at the time of the last detected lightning discharge (if any) from the parent cloud or debris cloud, whichever is later.

G. Good Sense Rule: Even when constraints are not violated, if hazardous conditions exist, the launch weather officer will report the threat to the launch director. The launch director may order a hold at any time based on the weather threat.

H. Definitions/Explanations

(1) **Anvil:** Stratiform or fibrous cloud produced by the upper level outflow or blow-off from thunderstorms or convective clouds.

(2) **Cloud Edge:** The visible cloud edge is preferred. If this is not possible, then the 10 dBz radar cloud edge is acceptable.

(3) **Cloud Layer:** An array of clouds, not necessarily all of the same type, whose bases are approximately at the same level. Also, multiple arrays of clouds at different altitudes that are connected vertically by cloud element; e.g., turrets from one cloud to another. Convective clouds (e.g., clouds under Rule B above) are excluded from this definition unless they are imbedded with other cloud types.

(4) **Cloud Top:** The visible cloud top is preferred. If this is not possible, then the 13 dBz radar cloud top is acceptable.

(5) **Cumulonimbus Cloud:** Any convective cloud with any part above the -20.0°C temperature level.

(6) **Debris Cloud:** Any nontransparent cloud that has become detached from a parent cumulonimbus cloud or thunderstorm, or that results from the decay of a parent cumulonimbus cloud or thunderstorm.

(7) **Documented:** With respect to Rule C (2), "documented" means that sufficient data have been gathered on the benign phenomenon to both understand it and to develop procedures to evaluate it, and that the supporting data and evaluation have been reported in a technical report, journal article, or equivalent publication. For launches at the Eastern Range, copies of the documentation shall be maintained by the 45th Weather Squadron and KSC Weather Projects Office. The procedures used to assess the phenomenon during launch countdowns shall be documented and implemented by the 45th Weather Squadron.

(8) **Electric Field (for surface-based electric field mill measurements):** The 1-min arithmetic average of the vertical electric field (Ez) at the ground such as is measured by a ground-based field mill. The polarity of the electric field is the same as that of the potential gradient; that is, the polarity of the field at the ground is the same as that of the charge overhead.

(9) **Flight Path:** The planned flight trajectory including its uncertainties ("error bounds").

(10) **Precipitating Cloud:** Any cloud containing precipitation, producing virga, or having radar reflectivity greater than 13 dBz.

(11) **Thunderstorm:** Any cloud that produces lightning.

(12) **Transparent:** Synonymous with visually transparent. Sky cover through which higher clouds, blue sky, stars, etc., may be clearly observed from below. Also, sky cover through which terrain, buildings, etc., may be clearly observed from above. Sky cover through which forms are blurred, indistinct, or obscured is not transparent.

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 37 A/B (CCAS) or 6 (VAFB).

C.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 and review and approval requirements.

The approval process for existing payload buses is shown in Figure C-1 and described below.

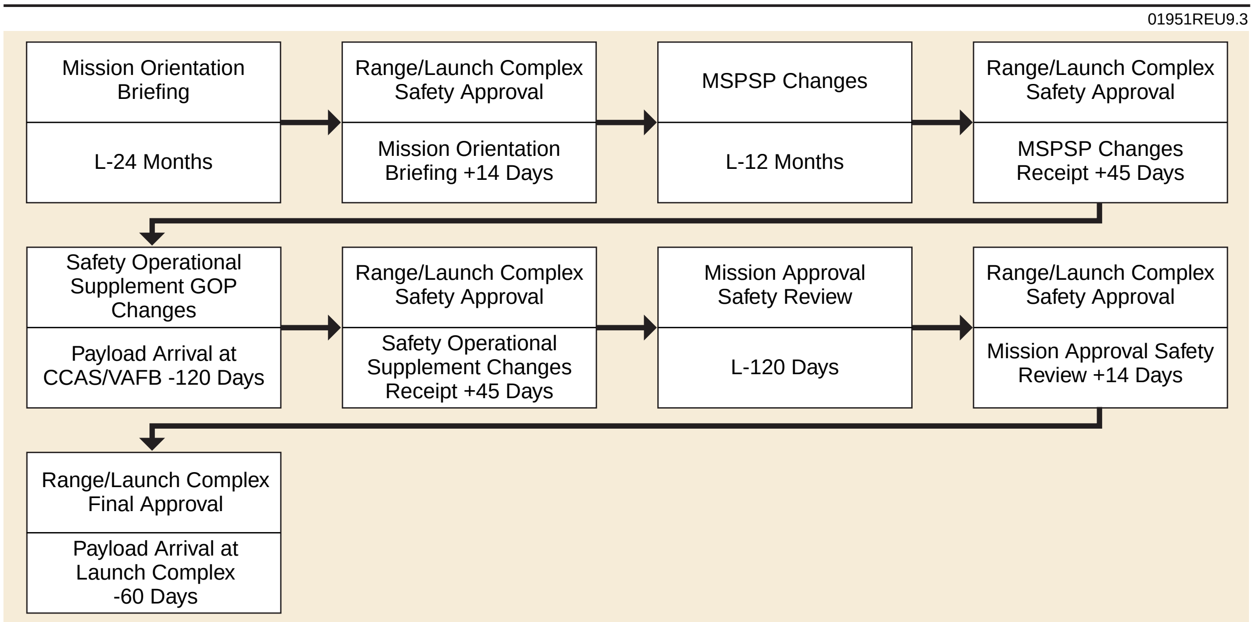


Figure C-1. Approval Process for Existing Payload Buses

C.1.1 Mission Orientation Briefing

A. 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.

B. Concurrence for both the mission concept and schedule for the remaining milestones shall be provided during the mission orientation safety briefing.

C.1.2 Data Review and Approval

C1.2.1 Mission-Unique Missile System Prelaunch Safety Package

A. A Delta IV system safety-prepared mission-unique missile system prelaunch safety package (MSPSP) shall be delivered to range safety and/or other government agencies approximately 12 months prior to launch and contain the payload data identified during the mission orientation safety briefing on the changes unique for the mission.

B. Delta IV system safety will coordinate with range safety and/or other government agencies to disposition responses after receipt of the data package.

C.1.2.2 Ground Operations Plan (GOP) and Hazardous and Safety-Critical Procedures

A. A Space Launch Complex 37 A/B 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.

B. Delta IV system safety will coordinate with range safety and/or other government agencies to disposition responses after receipt of the data package.

C.1.2.3 Mission Approval Safety Review

A. 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.

B. 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.

C1.2.4 Final Launch Approval

A. 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.

C.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 and review and approval requirements.

The approval process for new payload buses is shown in Figure C-2 and described below.

C.2.1 Concept Orientation Briefing and Safety Review

A. 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.

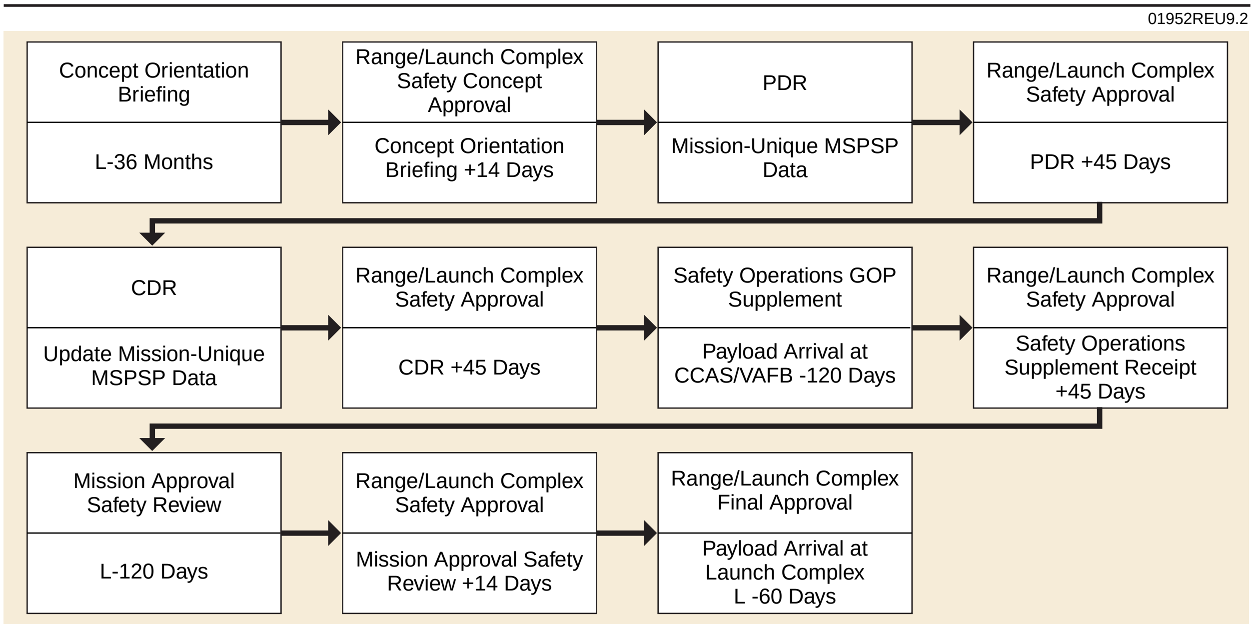


Figure C-2. Approval Process for New Payload Buses

B. The approval process shall be documented so that an audit trail can be established.

C. 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.

C.2.2 Preliminary Design Review

A. 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.

B. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and other government agencies.

C.2.3 Critical Design and Data Review

A. 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.

B. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and/or other government agencies

C. 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.

D. Delta IV system safety will coordinate resolution of any significant ground operations plan issues with range safety and other government agencies

C.2.4 Mission Approval Safety Review

A. A mission approval safety review shall be conducted by Delta IV system safety approximately L-120 days 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.

B. Delta IV system safety will coordinate resolution of any significant safety issues with range safety and other government agencies

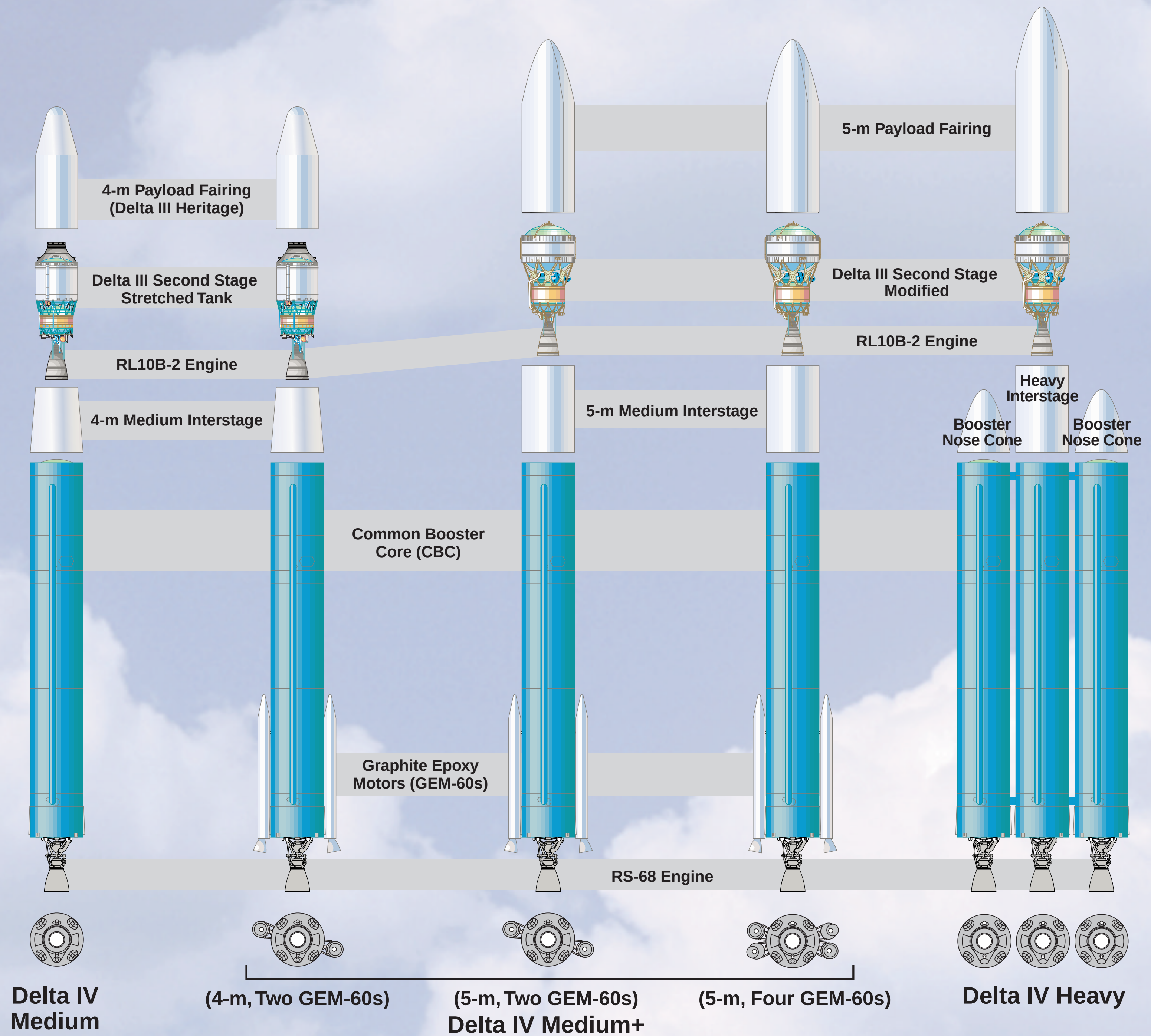
C.2.5 Final Launch Approval

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 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.

C.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.

THE DELTA IV FAMILY



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