October 1999

MDC 99H0068

DELTA III

PAYLOAD PLANNERS GUIDE

BOEING

DELTA III
PAYLOAD PLANNERS GUIDE

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02717REU9.1

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PREFACE

This Delta III Payload Planners Guide (PPG) is issued to the spacecraft user community to provide information regarding the Delta III launch vehicle and its related systems and launch services.

This document contains current information on The Boeing Company plans for Delta III launch services including a brief description of the Delta III vehicle, design vehicle performance figures, anticipated spacecraft environments, mechanical and electrical interfaces, payload processing, and other related information of interest to customers.

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GLOSSARY

1SLS OB	1st Space Launch Squadron Operations Building
ACS	attitude control system
ACS	auxiliary control system (backup to ALCS)
AGE	aerospace ground equipment
AKM	apogee kick motor
ALCS	advanced launch control system
ANSI	American Standard National Institute
ARIA	advanced range instrumentation aircraft
ASO	Astrotech Space Operations
ATP	authority to proceed
AWG	American wire gauge
B/H	blockhouse
CAD	computer-aided design
CCAM	contamination and collision avoidance maneuver
CCAS	Cape Canaveral Air Station
CCW	counterclockwise
CG	center of gravity
CRD	command receiver/decoder
DBL	dynamic balance laboratory
DIGS	Delta inertial guidance system
DLS	Delta Launch Services
DMCO	Delta mission checkout
DOT	Department of Transportation
DTO	detailed test objective
E&O	engineering and operations
E/W	east/west
EMA	electromechanical actuator
EED	electro-explosive device
EMI	electromagnetic interference
EMTF	electrical-mechanical testing facility
ER	Eastern Range
EWR	Eastern/Western Range
FAA	Federal Aviation Administration
FO	fiber optic
FRR	flight readiness review
FS	first stage
FUT	fixed umbilical tower
GC&NS	guidance, control, and navigation system
GCR	ground control rack
GEM	graphite epoxy motor
GEO	geosynchronous Earth orbit
GMT	Greenwich mean time
GN_2	gaseous nitrogen
GN&C	guidance, navigation, and control
GSFC	Goddard Space Flight Center
GSE	ground support equipment
GTO	geosynchronous transfer orbit
HPF	hazardous processing facility
HPTF	hazardous processing testing facility
I/F	interface
ICD	interface control drawing
ICE	interface control electronics
IIP	instantaneous impact point
IPA	isopropyl alcohol
IPF	integrated processing facility

IPT	integrated product team
I_{SP}	specific impulse
J-box	junction box
KBPS	kilobits per second
KMI	KSC Management Instruction
KSC	Kennedy Space Center
LCC	launch control center
LEO	low-Earth orbit
LH_2	liquid hydrogen
LO_2	liquid oxygen
LOCC	launch operations control center
LOP	launch operations plan
LPD	launch processing document
LRR	launch readiness review
LSRR	launch site readiness review
LSTP	launch site test plan
LV	launch vehicle
LVC	launch vehicle contractor
LVDC	launch vehicle data center
MD	Mission Director
MDA	McDonnell Douglas Aerospace
MDC	Mission Director Center
MECO	main-engine cutoff
MIC	meets-intent certification
MOI	moment of inertia
MSPSP	missile system prelaunch safety package
MSR	mission support request
MST	mobile service tower
N/S	north/south
NASA	National Aeronautics and Space Administration
OASPL	overall sound pressure level
OB	operations building
OR	operations requirement
P&C	power and control
P/N	part number
PA	payload adapter
PAA	payload attach assembly
PAF	payload attach fitting
PAM	payload assist module
PCC	payload checkout cell
PCM	pulse code modulation
PCS	probability of command shutdown
PDS	propellant-depletion shutdown
PHE	propellant handler’s ensemble
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
PSA	power switching assembly
PSM	program support manager
PSSC	pad safety supervisor’s console
QD	quick disconnect
RCS	reaction control system
RF	radio frequency
RFA	radio frequency application
RFI	radio frequency interference
RIFCA	redundant inertial flight control assembly
S&A	safe and arm

SC	spacecraft
SECO	second-stage engine cutoff
SLC	Space Launch Complex
SLS	Space Launch Squadron
SOB	squadron operations building
SOP	standard operating procedure
SR&QA	safety requirements and quality assurance
SRM	solid rocket motor
SS	second stage
SSRM	strap-on solid rocket motor
SVC	space vehicle contractor
SW	Space Wing
TBD	to be determined
TIM	technical interchange meeting
TM, T/M	telemetry
TMS	telemetry system
TT&C	telemetry, tracking, and command
TVC	thrust vector control
USAF	United States Air Force
UV	ultraviolet
VAC	volts alternating current
VDC	volts direct current
VAFB	Vandenberg Air Force Base
VC	visible cleanliness
VCR	video cassette recorder
VIM	vehicle information memorandum
VDL	voice direct line
VOS	vehicle on stand
VRR	vehicle readiness review
W/O	without
WR	Western Range

INTRODUCTION

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

The Delta III design evolved from our reliable Delta family, developed to provide the international user community with an efficient and low-cost launch system. In four decades of use, success of the Delta launch vehicle stems from its evolutionary design, which has been steadily upgraded to meet the needs of the user community while maintaining the highest reliability of any Western launch vehicle.

The launch complex at Cape Canaveral Air Station (CCAS) in Florida has been regularly upgraded to meet the increasingly rigorous spacecraft support requirements of Boeing customers. The complex is open to both commercial and government customers. The Delta III will be launched from Space Launch Complex 17 (SLC-17) at CCAS for missions requiring low- and medium-inclination orbits. Currently, Boeing has no requirements that would necessitate a Delta III launch from South Vandenberg Air Force Base, California. Vehicle performance data from the CCAS range 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), National Aeronautics and Space Administration (NASA), Federal Aviation Administration (FAA), the payload processing facility, and any other relevant agency when commercial or government facilities are engaged for spacecraft processing. Commercialization agreements with the USAF and NASA provide to Boeing the use of the launch facilities and services in support of Delta III 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

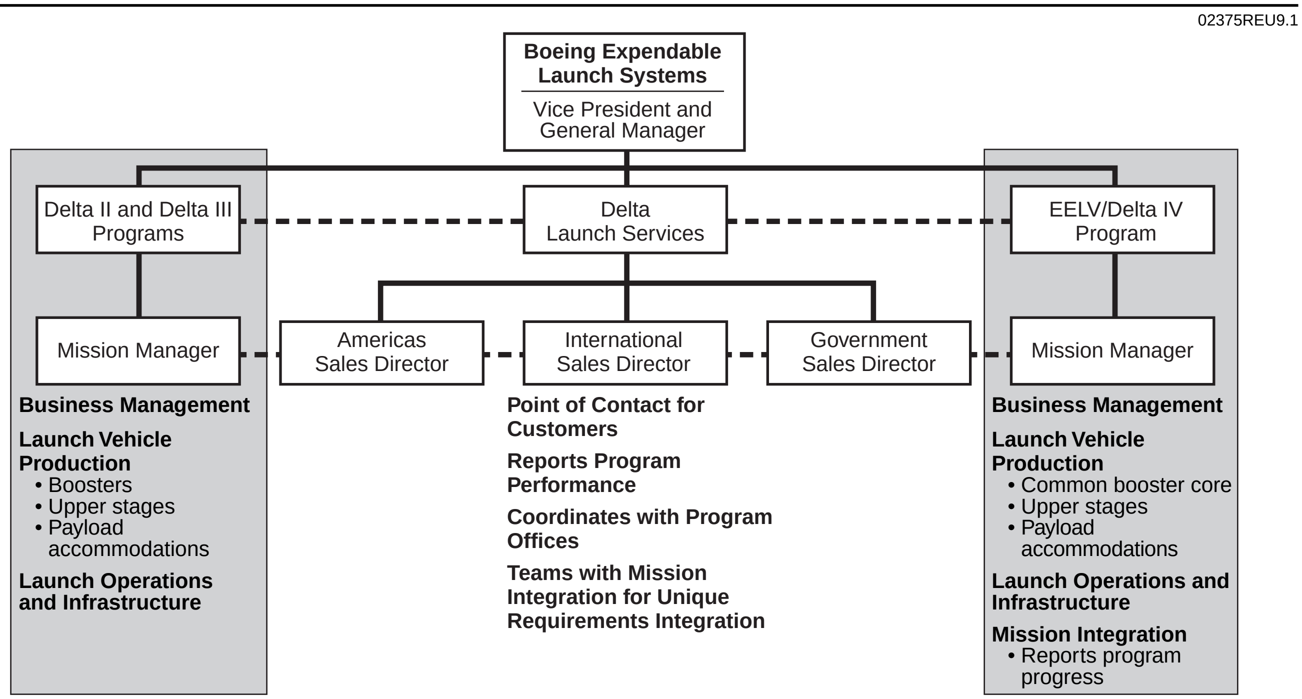

Figure 1. Delta Launch Services Organizational Relationships

launch solutions to meet customer needs as well as providing customers with a launch service agreement for the selected launch services. It is through the DLS organization that dedicated focal points of contacts 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 III program to ensure that high-level technical customer requirements are coordinated. The Delta III program is responsible for the development, production, integration, test, mission integration, and launch of the Delta III system.

For contracted launch services, a dedicated mission integration manager is appointed from within the Delta III program to support the customer. The mission integration 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' 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 III; 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.

Section 1
LAUNCH VEHICLE DESCRIPTION

This section provides an overall description of the Delta III launch vehicle and its major components. In addition, the 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 with Boeing (then Douglas Aircraft Company and later as McDonnell Douglas Corporation) as 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 geostationary transfer orbit (GTO) and 181 kg (400 lb) to low-Earth orbit (LEO). The Boeing dedication to vehicle improvement in meeting customer needs led to the Delta II vehicle, which now provides a capability as much as 2109 kg (4650 lb) to GTO (Figure 1-1).

The Delta III launch vehicle continues the Boeing tradition of Delta growth by providing a LEO capability of 8292 kg (18,280 lb) and a GTO capability of 3810 kg (8400 lb).

The Delta launch systems will continue to strive toward increased performance at lower costs and faster cycle times. Boeing will work with our customers through Delta Launch Services (DLS) to

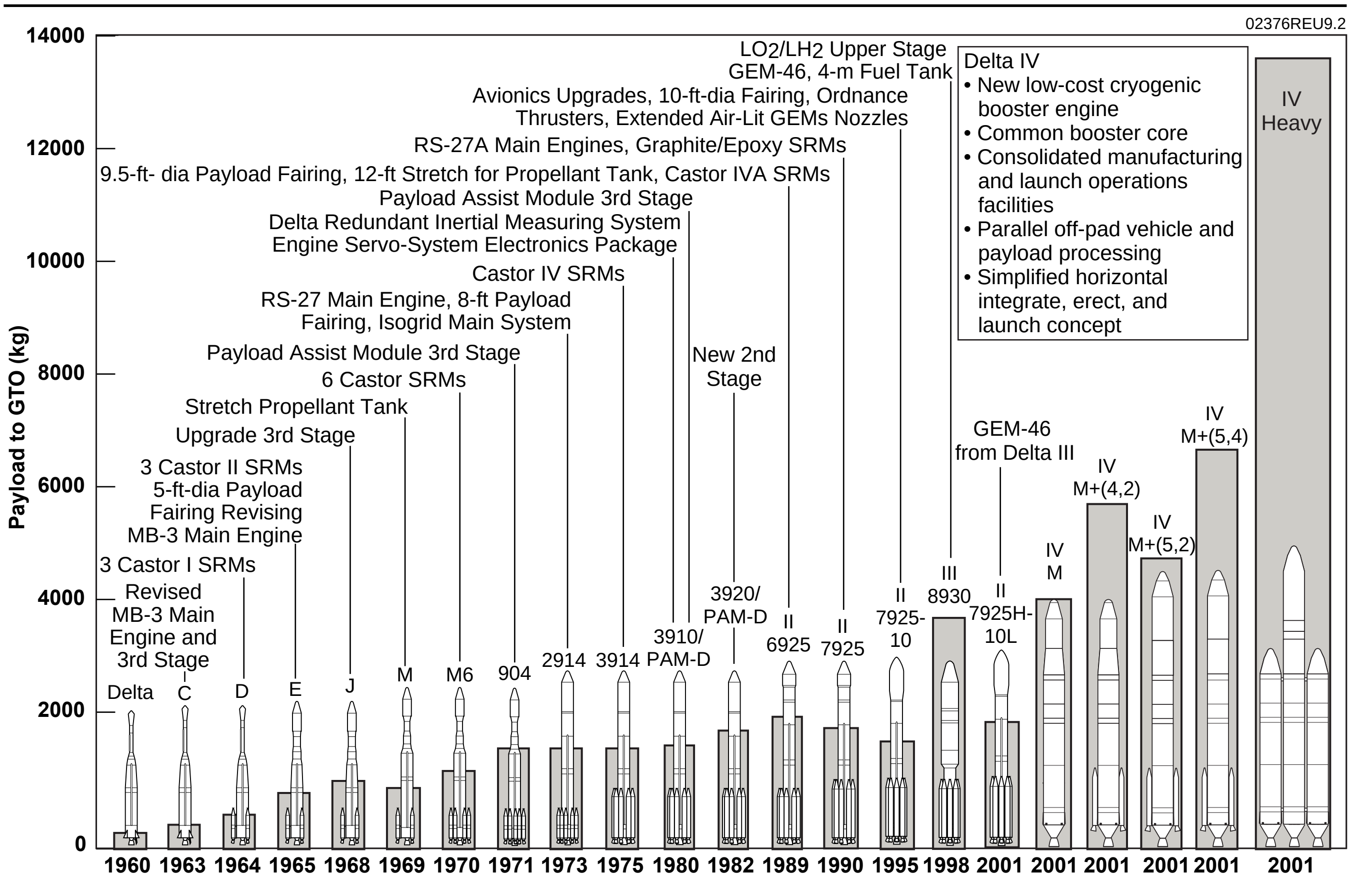

Figure 1-1. Delta/Delta II/Delta III/Delta IV Growth To Meet Customer Needs

satisfy all customer needs and provide the best-value launch services package across the entire Delta fleet.

1.2 DELTA III LAUNCH VEHICLE DESCRIPTION

The Delta III uses flight-proven Delta II components and processes, as well as enhancements evolved from existing aerospace systems. Its major elements are the first stage and its nine thrust-augmentation solid motors, the cryogenic second stage, and a 4-m composite bisector payload fairing (PLF). The major components associated with the Delta III vehicle are illustrated in Figure 1-2, which also lists Delta-heritage and aerospace-enhanced components used on Delta III.

1.2.1 First Stage

The first stage of the Delta III is powered by a Rocketdyne RS-27A main engine, which has a 12:1 expansion ratio and employs a turbine/turbopump, a regeneratively cooled thrust chamber and nozzle, and a hydraulically gimbaled thrust chamber and nozzle that provides pitch and yaw control. Two Rocketdyne vernier engines provide roll control during main-engine burn, and attitude control between main-engine cutoff (MECO) and second-stage separation. High repeatability of mixture ratio ensures very accurate propellant usage for the engines. The Rocketdyne RS-27A main and vernier engines are both unchanged from Delta II. Nine 1168-mm (46-in.)-dia Alliant

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Delta III System	Similarity to Existing Systems: New	Unchanged	Enhanced
Fairing			
• Separation system			X
• Composite structure		X	
Second Stage			
• RL10B-2 engine			X
• Thermal protection system	X		
• Structure	X		
First Stage			
• RS-27A main engine		X	
• Vernier engines		X	
• GEM-46 SSRMs			X
Avionics			
• RIFCA		X	
• Data buses		X	
• Telemetry system			X

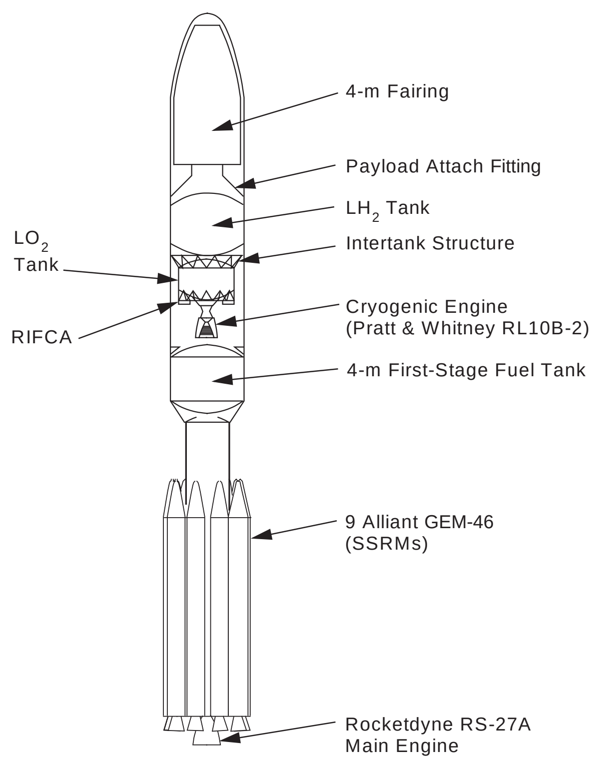

Figure 1-2. Delta III Launch Vehicle Description

Techsystems graphite epoxy motors, GEM-46 (strap-on solid rocket motors [SSRM]) augment the first-stage performance and are a direct evolution from the GEMs currently used on Delta II. Three of the six ground-ignited SSRMs have thrust vector control (TVC) to increase control authority. Ordnance for motor ignition and separation systems is completely redundant. Solid-motor separation is accomplished using redundantly initiated ordnance thrusters that provide the radial thrust to separate the expended solid motors from the booster.

1.2.2 Second Stage

The upgraded cryogenic second-stage Pratt & Whitney RL10B-2 engine is based on the 30-year heritage of the reliable RL10 engine. It incorporates an extendable exit cone for increased specific impulse (I_{sp}) and payload capability. The basic engine and turbopump are unchanged relative to the RL10. The engine gimbal system uses electromechanical actuators that increase reliability while reducing both cost and weight. The propulsion system and attitude control system (ACS) use flight-proven off-the-shelf components. The second-stage propulsion system produces a thrust of 24,750 lb with a total propellant load of 37,000 lb, providing a total burn time of approximately 700 sec. Propellants are managed during coast by directing hydrogen boiloff through an aft-facing continuous vent system to provide settling thrust. Propellant tank pressurization during burn is accomplished using hydrogen bleed from the engine for the LH_2 tank and helium for the LO_2 tank. After spacecraft separation, the stage is safed by dumping propellants followed by venting of the tanks.

1.2.3 Third Stage

Depending on mission needs, a third stage is employed to increase capability and can be coordinated through DLS. The third stage consists of a STAR 48B solid rocket motor, a payload attach fitting (PAF) with nutation control system (NCS), and a spin table containing small rockets for spin-up of the third stage 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 that is prepressurized with helium. This simple system has inherent reliability with only one functioning component and 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.

1.2.4 Payload Attach Fitting

The spacecraft mates to the launch vehicle using a payload attach fitting (PAF), which can also be referred to as a payload attach assembly (PAA), provided by Boeing. A variety of PAFs are available to meet the customer requirements. The spacecraft separation systems are typically incorporated into the launch vehicle PAF and include clampband-separation systems or attach-bolt systems as required. The PAFs and separation systems are discussed in greater detail in Section 5.

1.2.5 Payload Fairing

The Delta III 4-m-dia composite payload fairing (PLF) protects the spacecraft from the aerodynamic, acoustic, and thermal environments through the launch and ascent phases of flight. The 4-m fairing is derived from the Delta II 3-m (10-ft) composite fairing. Mission-specific access doors can be incorporated into the fairing as required. The spacecraft is further protected by acoustic and radio frequency (RF) absorption blankets, installed within the fairing interior, that reduce the vibro-acoustic, RF, and thermal environments. Figure 1-3 illustrates the Delta III 4-m fairing. Delta III will incorporate off-pad payload encapsulation within the fairing (Section 6.3) to enhance payload safety, security, and contamination control.

1.2.6 Avionics and Flight Software

The Delta III launch vehicle incorporates the fault-tolerant avionics system that was flight-proven on Delta II. The major element of the avionics system is the redundant inertial flight control assembly (RIFCA), which is a modernized fault-tolerant guidance system. RIFCA uses six Allied Signal RL20 ring laser gyros and six Sundstrand model QA3000 accelerometers to provide redundant three-axis attitude and velocity data. The RIFCA also uses three MIL-STD-1750A processors to provide triple modular redundant data processing for the Delta III guidance, navigation, and control (GN&C) functions. The RIFCA is a common element to both the Delta III and the Delta II

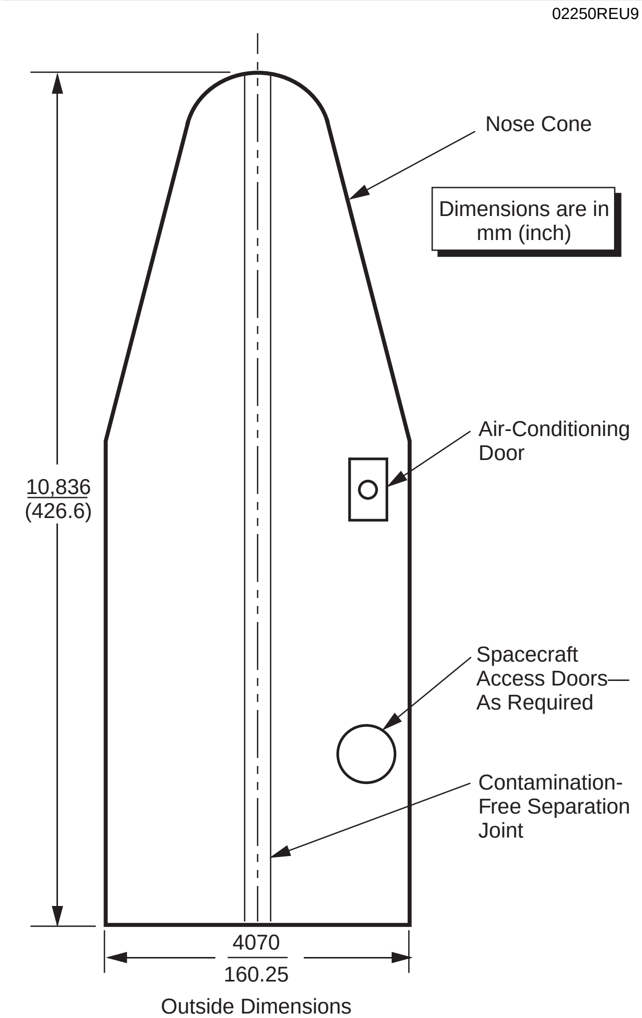

Figure 1-3. Delta III 4-m Composite Fairing

launch vehicles. It contains the control logic that processes rate and accelerometer data to form the proportional and discrete control output commands needed to drive the engine actuators and/or attitude control system (ACS) thrusters.

Position and velocity data are explicitly computed to derive guidance steering commands. Early in flight, a load relief mode reorients the vehicle 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.

In addition to the RIFCA, the avionics suite includes (1) a first-stage power and control (P&C) box and a second-stage power-switching assembly (PSA) to support power distribution, (2) ordnance boxes to issue ordnance commands, (3) electronics packages (E-packages) and an electromechanical actuator (EMA) and controller for thrust vector control, and (4) a pulse code modulation (PCM) telemetry system that provides real-time vehicle system performance data.

The Delta III launch vehicle flight software is composed of the reusable flight program and a mission-constants database designed specifically to meet the mission requirements. Mission requirements will be implemented through configuring the mission-constants database, which will be designed to fly the mission trajectory and to separate the spacecraft 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 resulting mission flight software package, which includes the flight program (unchanged for each mission) and mission constants, effectively captures all benefits and successes of existing software, while adding robustness and fault-tolerance capability through the avionics upgrade.

Delta III uses an upgraded Delta II 640 KBps PCM telemetry system to provide extensive telemetry for vehicle health management. Spacecraft telemetry can also be interleaved with vehicle telemetry during ascent. Spacecraft ground control is provided through a dedicated 122-pin umbilical (JU3) at the vehicle/launch pad interface.

1.3 LAUNCH VEHICLE AXES/ATTITUDE DEFINITIONS

The vehicle axes are defined in Figure 1-4; the vehicle centerline is the longitudinal axis of the vehicle. Axis II is on the downrange (bottom) side of the vehicle, and axis IV is on the uprange (top) side. The vehicle pitches about axes I and III. Positive pitch rotates the nose of the vehicle up, toward axis IV. The vehicle

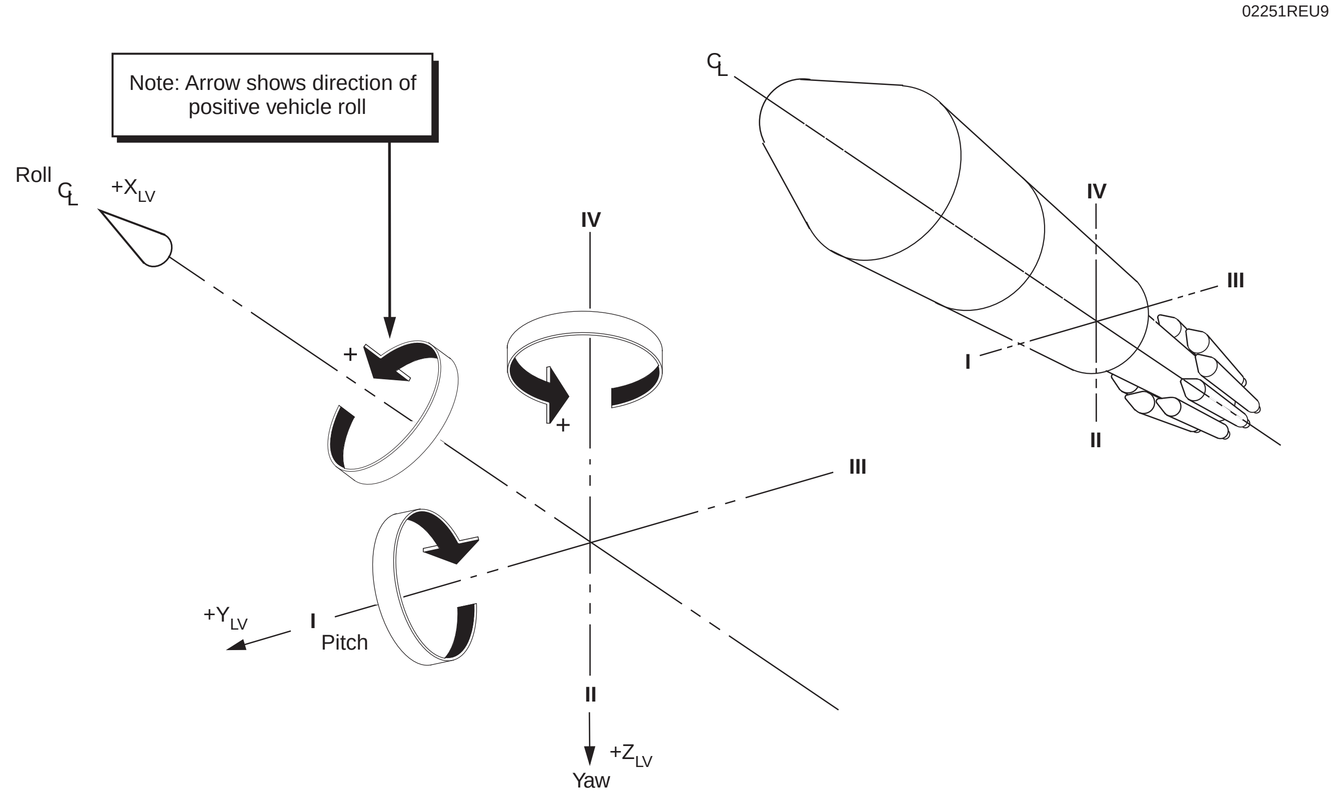

Figure 1-4. Vehicle Axes

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.

1.4 LAUNCH VEHICLE INSIGNIA

Delta III 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 to the Delta Program Office, no later than 9 months prior to launch, for review and approval. The maximum size of the insignia is 2.4 m by 2.4 m (8 ft by 8 ft). Following approval, the Delta Program Office will have the flight insignia prepared and placed on the uprange side of the launch vehicle.

Section 2
GENERAL PERFORMANCE CAPABILITY

The Delta III can accommodate a wide range of spacecraft requirements. The following sections detail specific performance capabilities of the Delta III launch vehicle. In addition to the capabilities shown herein, our mission designers can provide innovative performance trades to meet the particular requirements of our payload customers.

2.1 LAUNCH SITE

The Delta III launch site is Space Launch Complex 17 (SLC-17) at Cape Canaveral Air Station (CCAS), Florida. This site can accommodate flight azimuths in the range of 65 to 110 deg, with 98.2 deg being the most commonly flown.

2.2 MISSION PROFILES

Mission profiles for two-stage low-Earth orbit (LEO) and geosynchronous transfer orbit (GTO) missions are shown in Figures 2-1 and 2-2.

The first-stage RS-27A main engine and six of the nine strap-on solid rocket motors are ignited at liftoff. Following burnout of the six solids, the

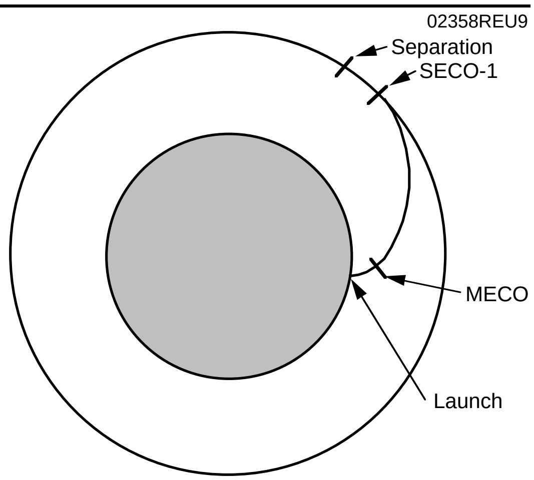

Figure 2-1. Typical LEO Two-Stage Mission Profile

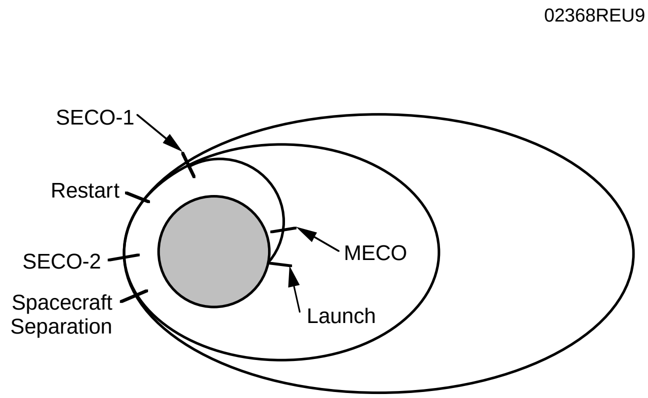

Figure 2-2. Typical GTO Two-Stage Mission Profile

remaining three extended-nozzle graphite epoxy motors (GEM-46) are ignited. The six spent cases are then jettisoned in two sets of three after vehicle and range safety constraints have been met. Jettisoning of the second set occurs 1 sec following the first set. The remaining three solids are jettisoned about 3 sec after they burn out. Payload fairing separation occurs when an acceptable free molecular heating rate has been achieved. The main engine then continues to burn until main-engine cutoff (MECO). Following a short coast period of 8 sec, the first stage is separated from the Delta III second stage and, approximately 13 sec later, the second-stage engine is ignited. For a LEO mission, the desired orbit is achieved by employing either the direct insertion or the Hohmann transfer flight mode. The specific requirements of the LEO mission and the payload weight will determine which of these flight modes is optimum for the mission. For the direct-insertion flight mode, the first (and only) burn of the second-stage engine continues until the desired low-Earth orbit is achieved. The direct-insertion flight mode is depicted in Figures 2-1 and 2-3. Two

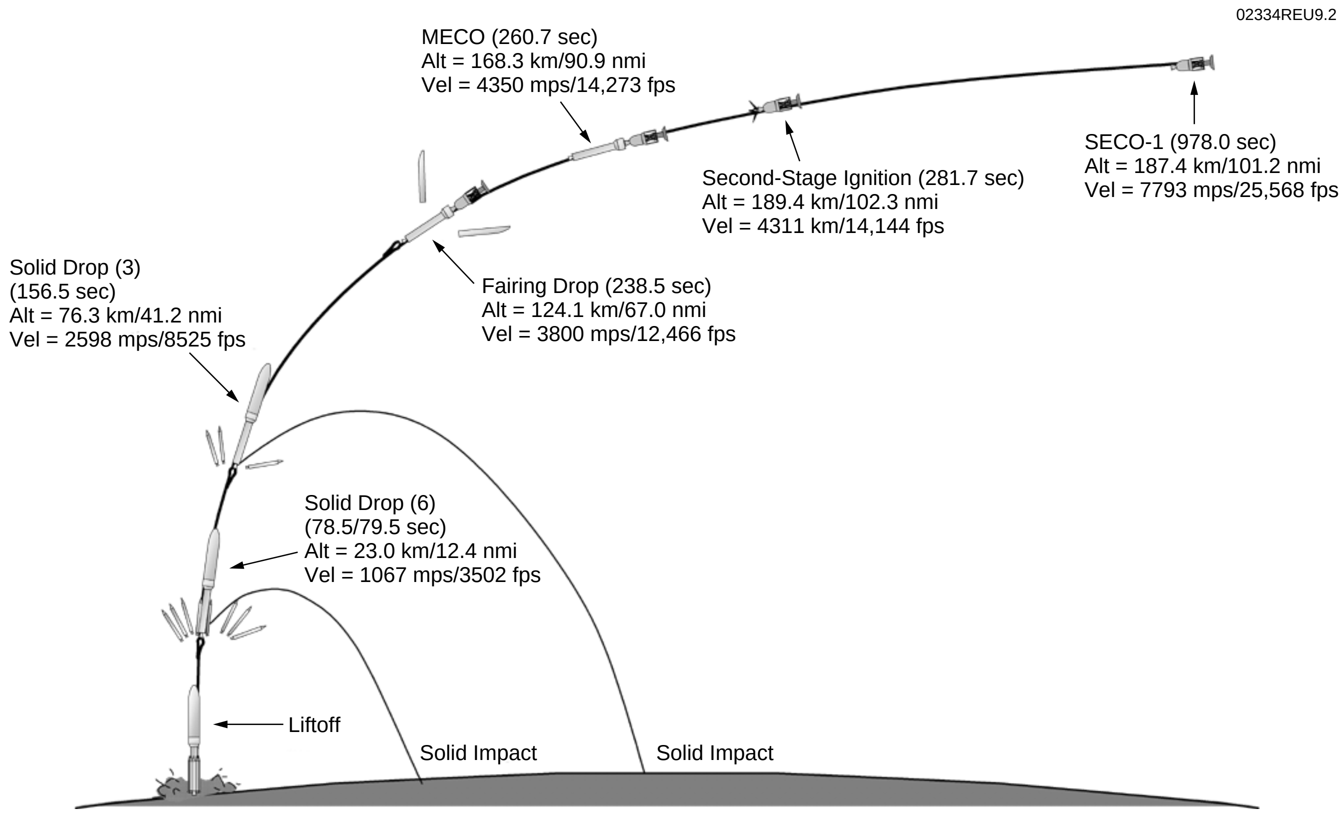

Figure 2-3. Typical Delta III LEO Mission Profile

burns of the second-stage engine are required when the Hohmann transfer flight mode is employed. The second stage is injected near perigee of the Hohmann transfer orbit at the cutoff of its first burn. After coasting to a point near apogee of the transfer orbit, a restart burn of the second-stage engine is employed to inject the second stage and its payload into the desired low-Earth orbit. Due to the characteristics of the second-stage engine restart, the Hohmann transfer flight mode may be unusable in some cases because the minimum allowable restart burn duration is approximately 12 sec. Regardless of the flight mode employed for a LEO mission, spacecraft separation would occur approximately 250 sec after the final cutoff of the second-stage engine. In a typical GTO mission, the second-stage engine would burn for approximately 500 sec on its first burn to second-stage engine cutoff 1 (SECO-1). The vehicle would then coast to near the equator at either a descending node or ascending node of the transfer orbit, at which point the second-stage engine would restart and burn for approximately 200 sec, injecting the vehicle into the desired geosynchronous transfer orbit at SECO-2. Spacecraft separation would then occur up to 700 sec following SECO-2. After payload separation, the Delta second stage is safed by expelling any remaining propellants.

A typical sequence for a Delta III LEO mission is shown in Figure 2-3 and a typical sequence for a GTO mission is shown in Figure 2-4. Typical event times are presented in Tables 2-1 and 2-2. Figures 2-5 and 2-6 show ground traces for the

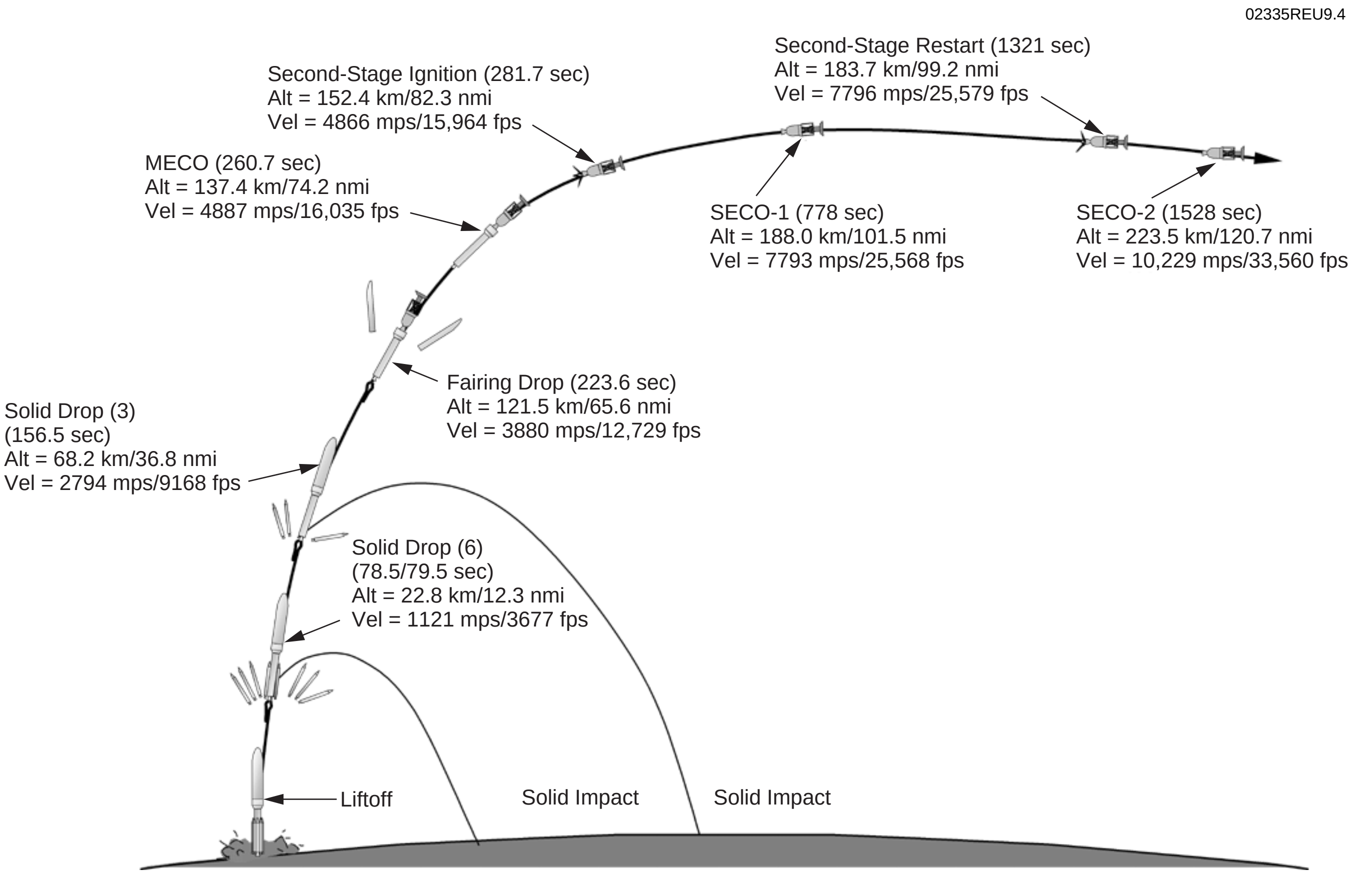

Figure 2-4. Typical Delta III GTO Mission Profile

Table 2-1. Delta III Typical LEO Event Times*

Event	First Stage
Main-engine ignition	T + 0
Solid-motor ignition (6 solids)	T + 0
Solid-motor burnout (6 solids)	T + 75.2
Solid-motor ignition (3 solids)	T + 78
Solid-motor separation (3/3 solids)	T + 78.5/79.5
Solid-motor burnout (3 solids)	T + 153.4
Solid-motor separation (3 solids)	T + 156.5
Fairing separation	T + 238.5
MECO	T + 260.7
Second Stage	
Activate stage I/II separation bolts	M + 8
Stage II ignition	M + 21
SECO-1	M + 717.3
Spacecraft	
Spacecraft separation	S1 + 250
*All times shown in seconds.	

T1.3

Table 2-2. Delta III Typical GTO Event Times*

Event	First Stage
Main-engine ignition	T + 0
Solid-motor ignition (6 solids)	T + 0
Solid-motor burnout (6 solids)	T + 75.2
Solid-motor ignition (3 solids)	T + 78
Solid-motor separation (3/3 solids)	T + 78.5/79.5
Solid-motor burnout (3 solids)	T + 153.4
Solid-motor separation (3 solids)	T + 156.5
Fairing separation	T + 223.6
MECO (M)	T + 260.7
Second Stage	
Activate stage I/II separation bolts	M + 8
Stage II ignition	M + 21
SECO-1	M + 517.3
Stage II engine restart	S1 + 543
SECO-2	S1 + 750
Spacecraft	
Spacecraft separation	S2 + 700
*All times shown in seconds.	

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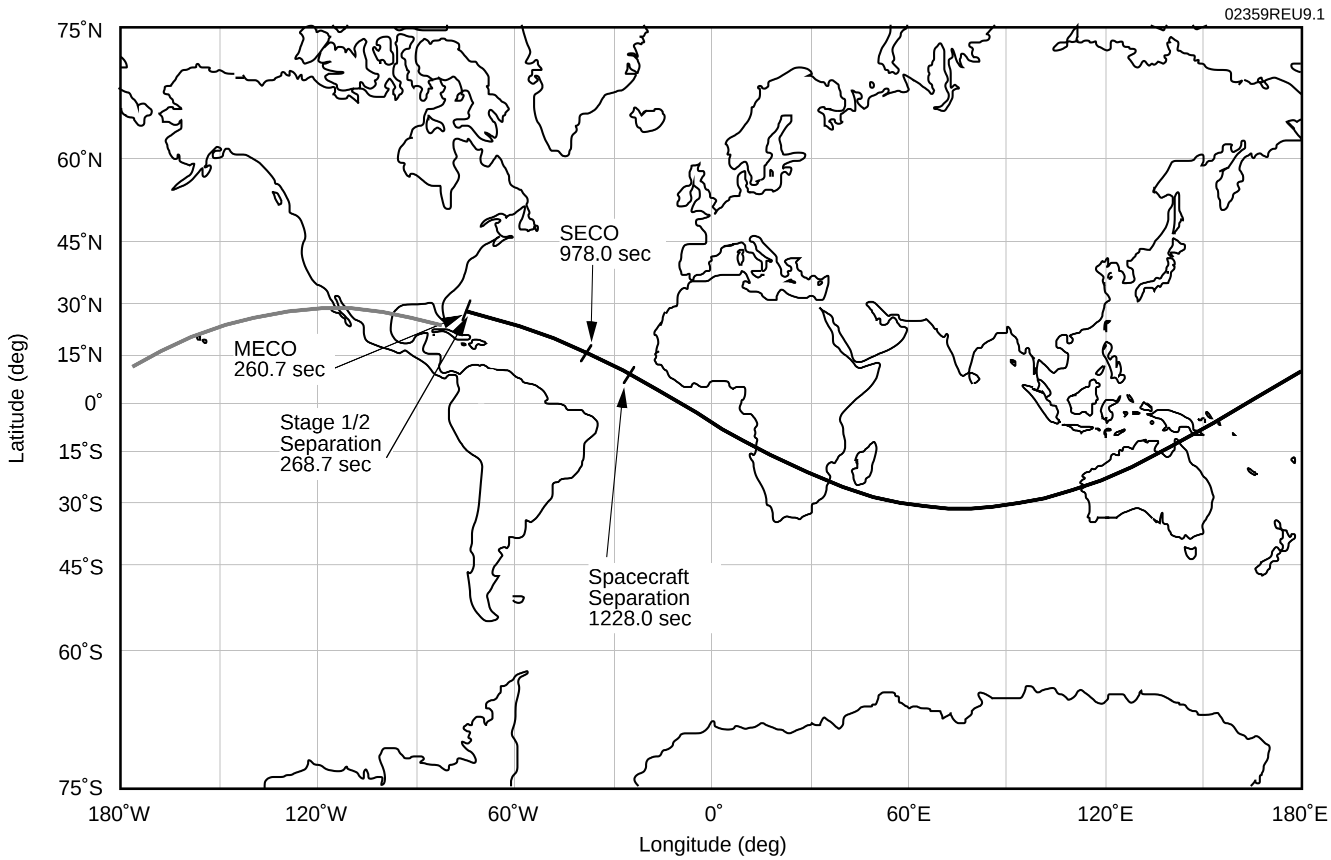

Figure 2-5. Typical Delta III LEO Mission Ground Trace

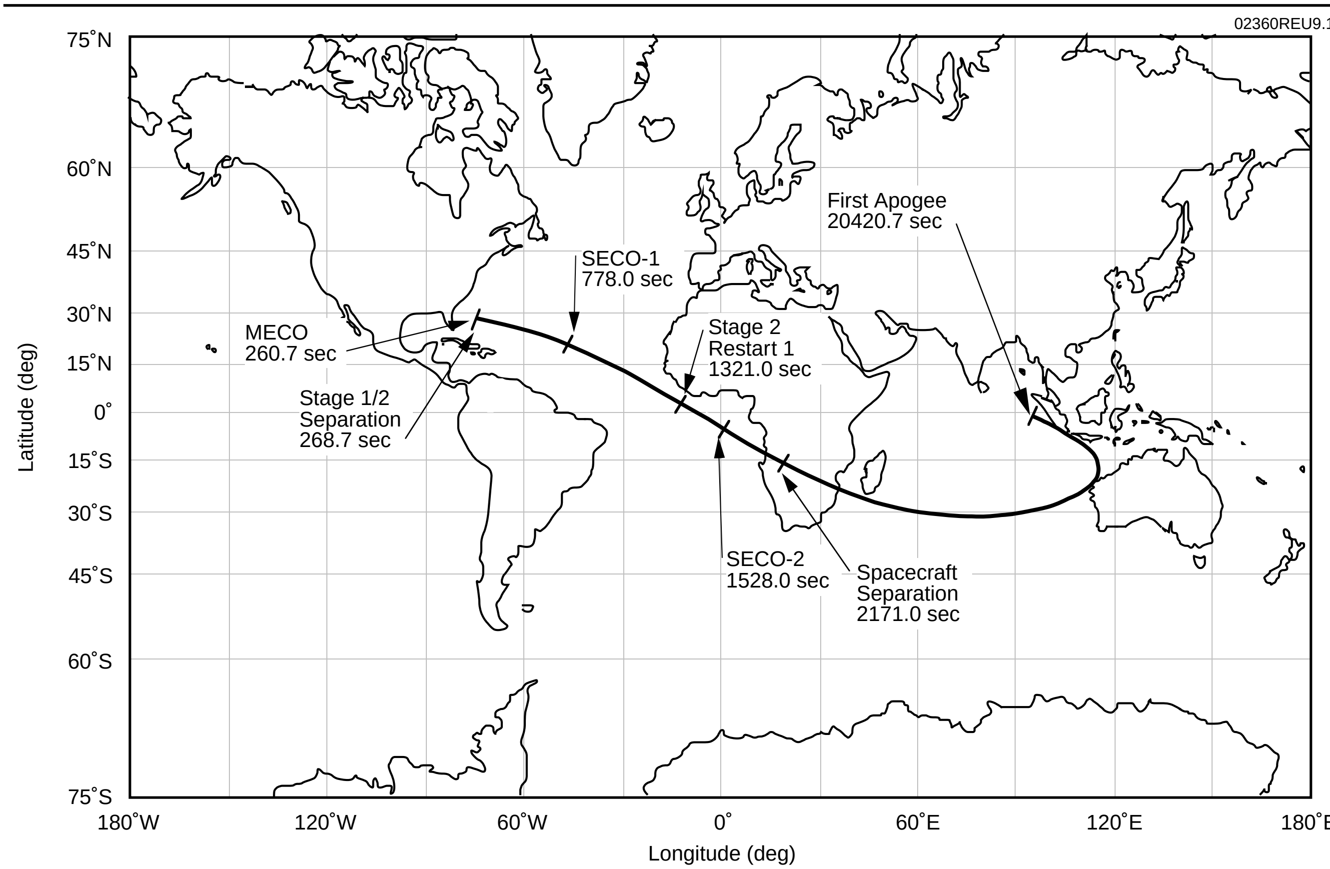

Figure 2-6. Typical Delta III GTO Mission Ground Trace

LEO and GTO missions discussed.

2.3 PERFORMANCE CAPABILITY

The performance estimates discussed in this section were computed based on the following:

- Nominal propulsion system and weight models were used on all stages.
- The first stage is burned to propellant depletion.
- Second-stage propellant consumption is constrained to ensure a 99.7% probability of a command shutdown (PCS) by the guidance system.
- Payload fairing (PLF) separation occurs at a time when the free molecular heating rate range is equal to or less than 1135 W/m^2 (0.1 Btu/ft^2-sec).
- Perigee velocity is the vehicle burnout velocity at 185 km (100 nmi) altitude and zero deg flight path angle.
- The initial flight azimuth is 98.2 deg.
- Payload attach fittings (PAF) range in weight from 204 kg (450 lb) for the 1666-4 PAF used for lighter payloads to an estimated 272 kg (600 lb) for heavier payloads. Table 2-3 notes the estimated PAF weight for each mission for the maximum payload quoted.
- The standard 4-m PLF is used.
- Propellant loading and boiloff are based on a one-restart mission. These values will be different for multiple-restart missions.

A summary of performance for the typical missions is presented in Table 2-3.

Performance data are presented in the following pages for both two- and an assumed three-stage Delta III vehicle launched from the Eastern Range. Spacecraft weight capability is presented as a function of the parameters listed below.

Table 2-3. Typical Delta III Mission Capabilities

	Spacecraft weight (kg/lb)[1]
■ Geosynchronous transfer orbit (GTO) [2]	3810/8400
● i = 28.7 deg	
● 185 by 35,786 km/100 by 19,323 nmi	
■ Low-Earth orbit (LEO)	
● i = 28.7 deg	
● 185 km/100 nmi circular	8292/18,280
■ Earth escape mission (C3 = 0.0 km^2/sec^2)	
● i = 28.7 deg	
● 185 km/100 nmi injection	2722/6000

(1) The spacecraft weights shown represent on-orbit payload weights above the Delta III separation interface plane. The following adapter weights are booked under the second-stage weight.
Light spacecraft missions (less than 4300 kg [9480 lb]) use a 204-kg/(450-lb) 1666-4 PAF
Heavy spacecraft missions use a 272-kg/(600-lb) PAF
For missions where the spacecraft weight is greater than 4300 kg (9480 lb), the PAF would have to be enhanced structurally up to an estimated 272 kg/(600 lb), an increase of 150 lb, for the maximum spacecraft weight expected to be carried, 8292 kg (18,280 lb) for LEO capability for CCAS. A mission-unique analysis using spacecraft mass properties must be performed to confirm acceptability.
(2) The payload capability can be increased by approximately 340 lb by burning the second stage to propellant depletion.

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- Two-stage Delta III.
  - Perigee velocity (Figure 2-7).
  - Apogee altitude (Figure 2-8).
  - GTO inclination (Figure 2-9).
  - Circular orbit altitude (Figure 2-10).
  - Launch energy (Figure 2-11).
- Three-stage Delta III.
  - Launch energy (Figure 2-12).

For any given mission, performance capability depends on quantitative analyses of known mission requirements and range safety restrictions. Allowable spacecraft weight should be coordinated as early as possible in the basic mission planning. Preliminary error analysis, performance optimization, and tradeoff studies will be performed, as required, to arrive at an early commitment of allowable spacecraft weight for each

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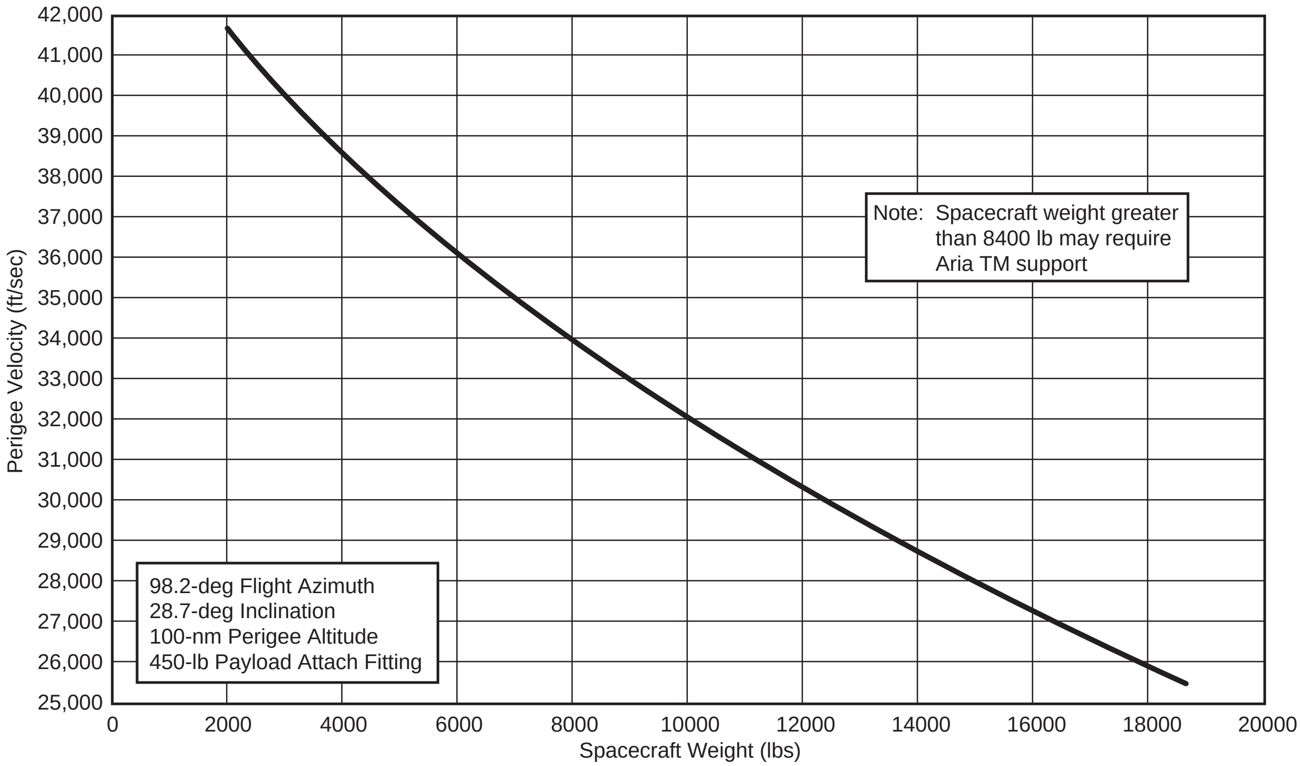

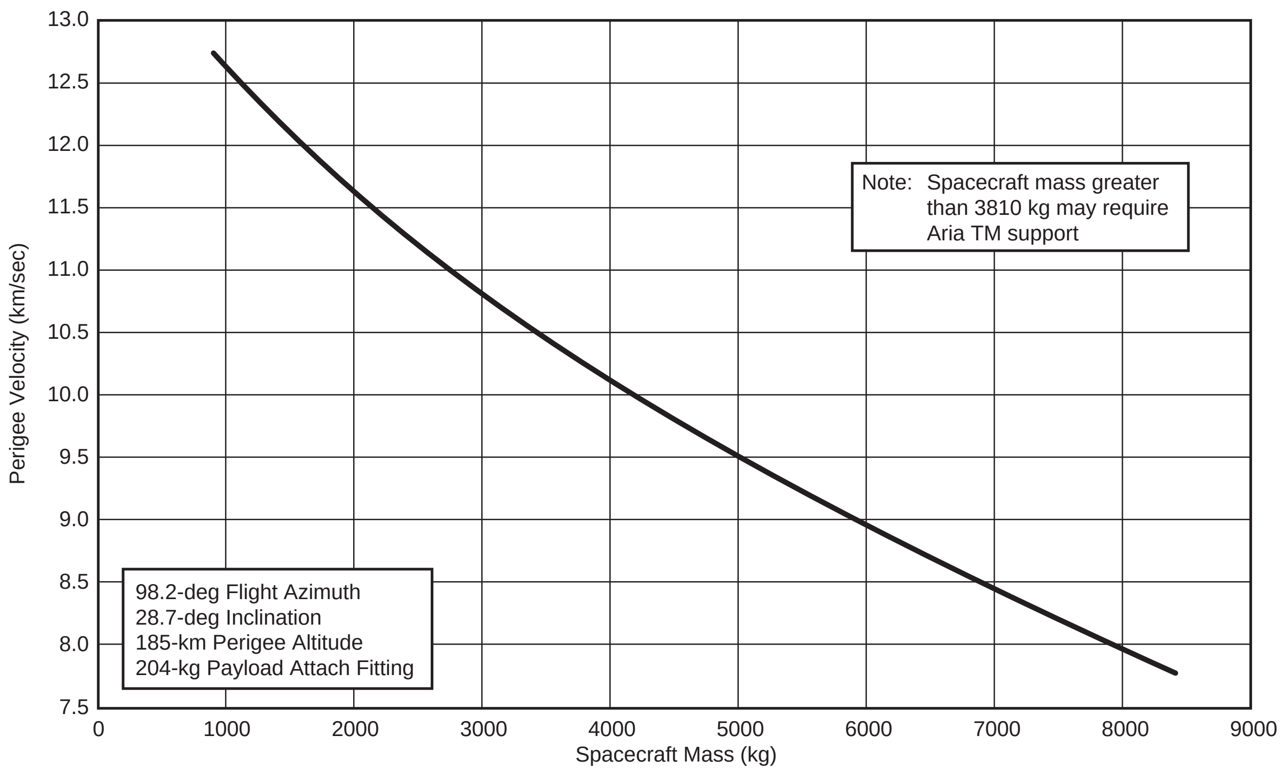

Figure 2-7. Delta III Vehicle, Two-Stage Velocity Capability

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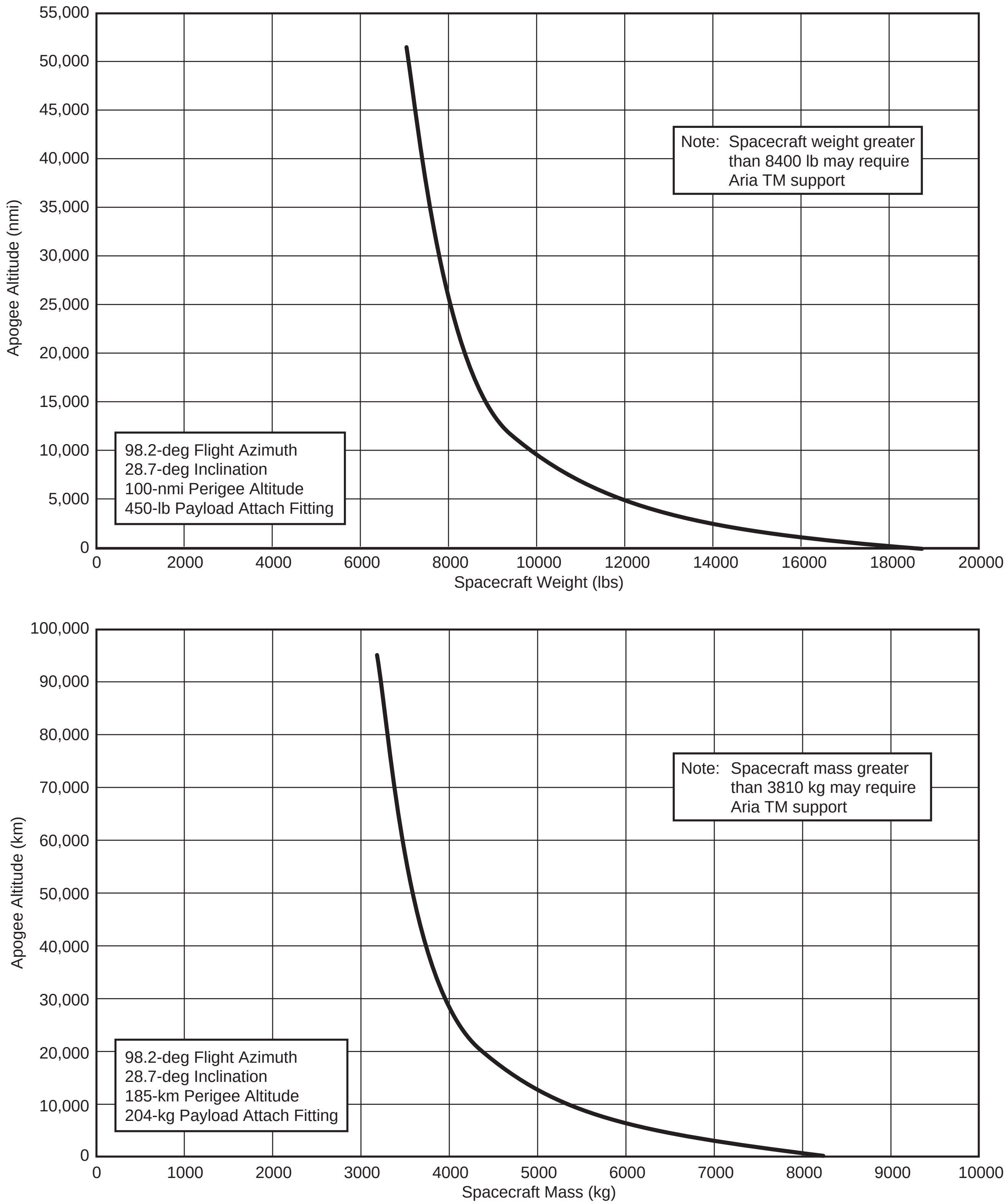
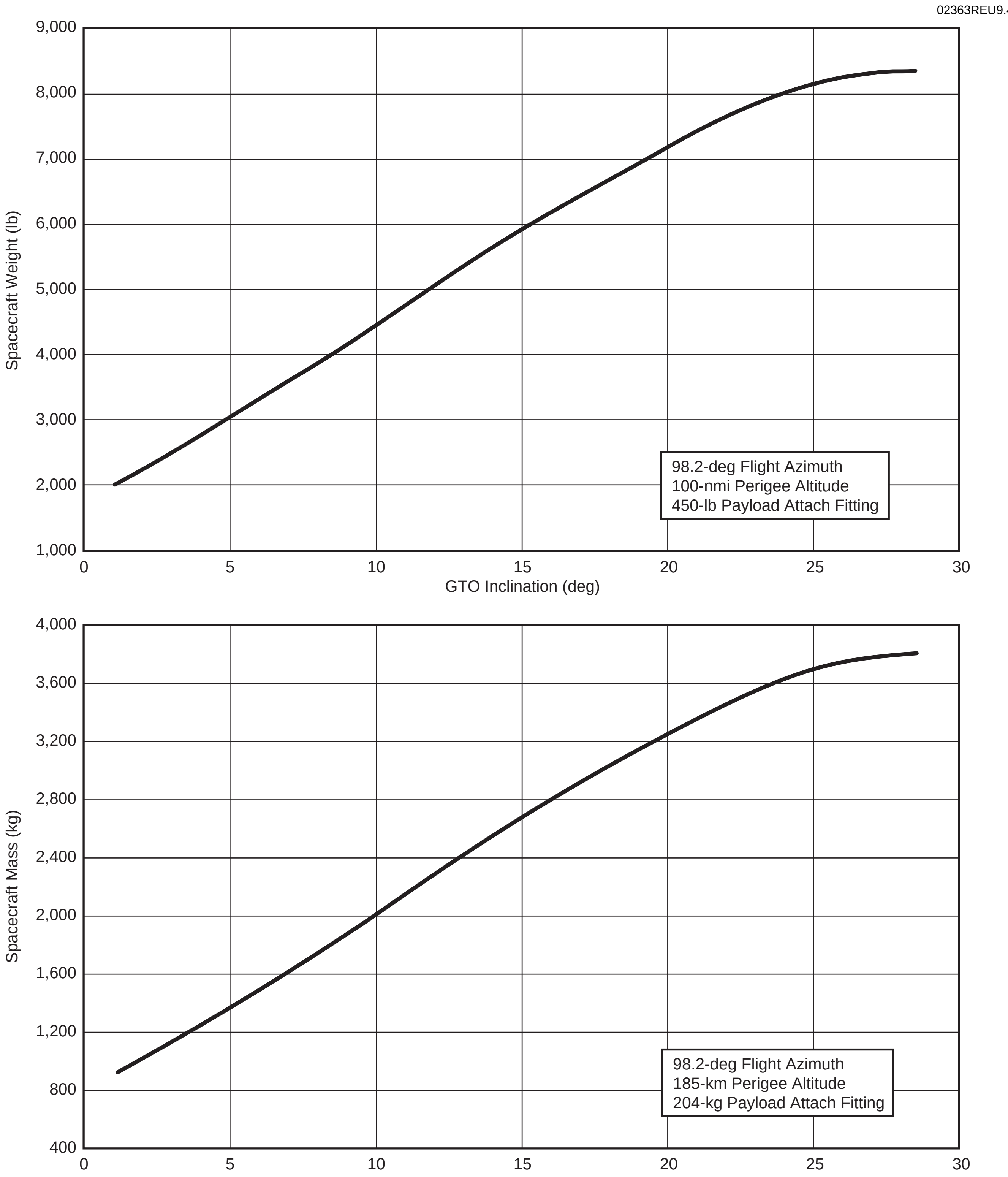


Figure 2-8. Delta III Vehicle, Two-Stage Apogee Altitude



A propellant-depletion shutdown (PDS) mission increases performance capability by 154 kg (340 lb) at 28.7-deg inclination. When flying a PDS mission, apogee altitude dispersions will increase.

Figure 2-9. Delta III Vehicle, Two-Stage GTO Inclination

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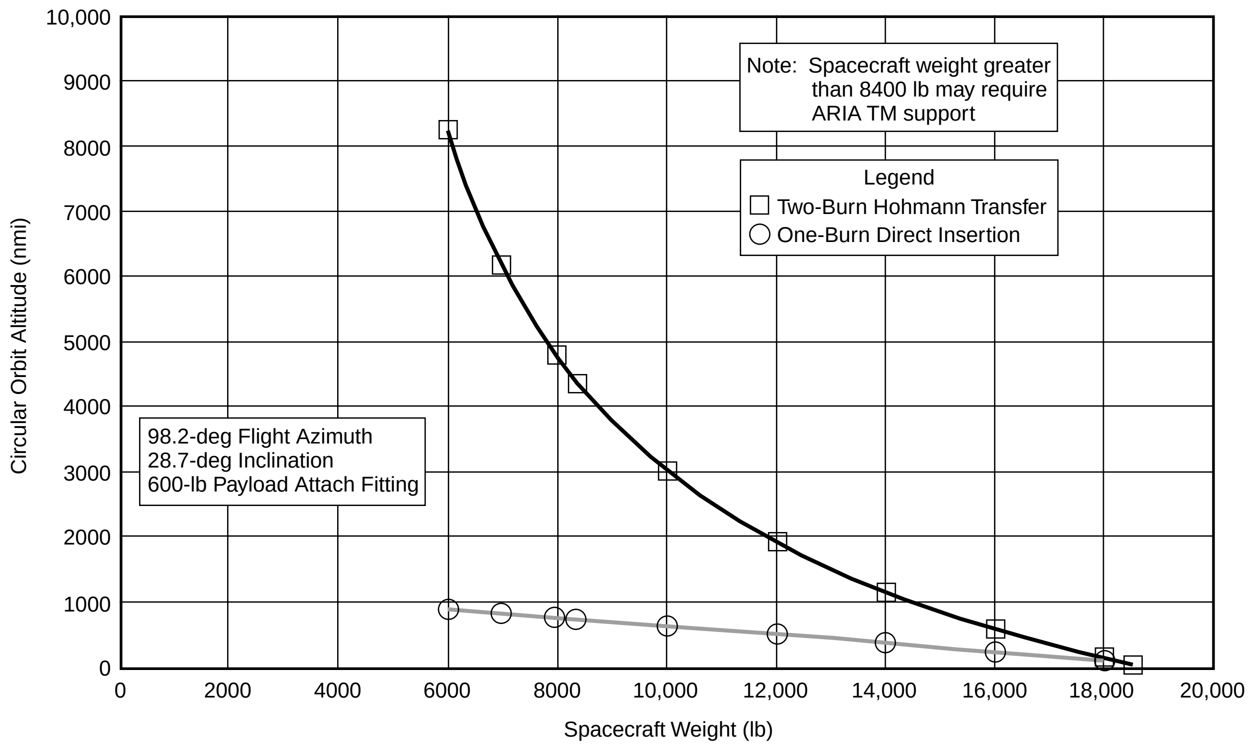


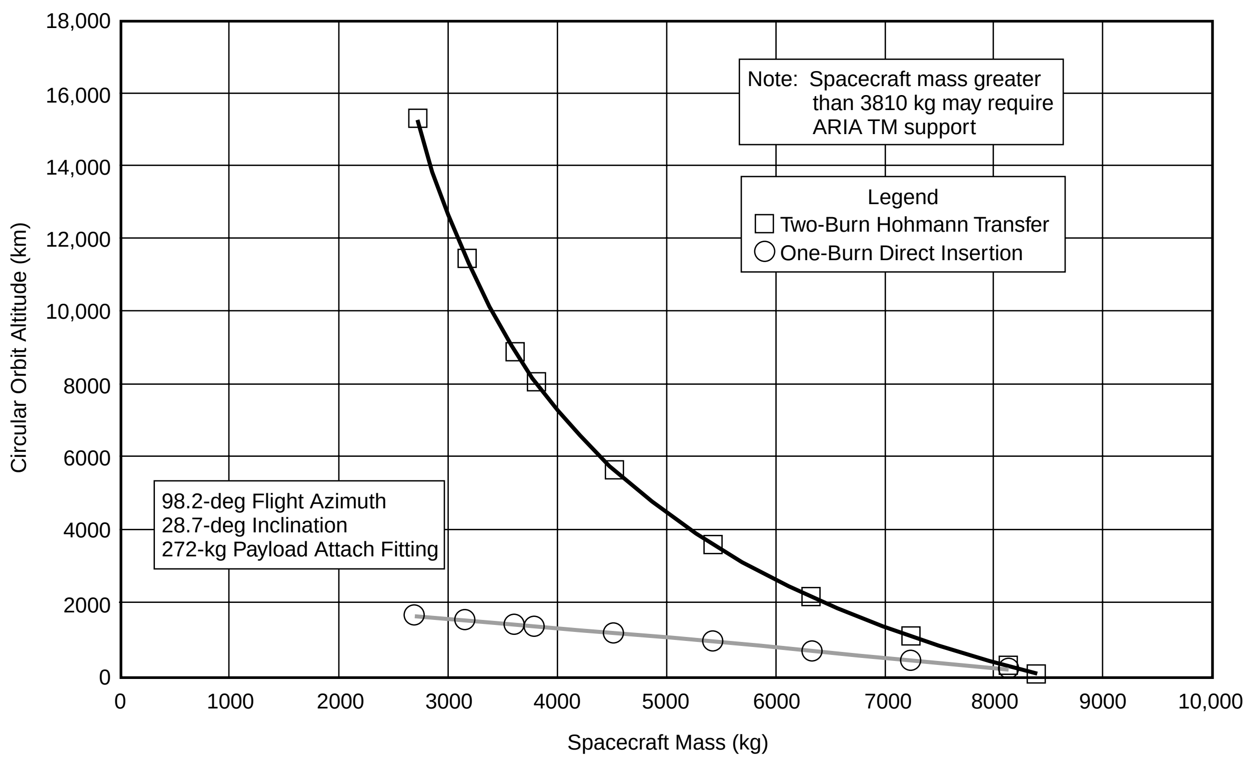
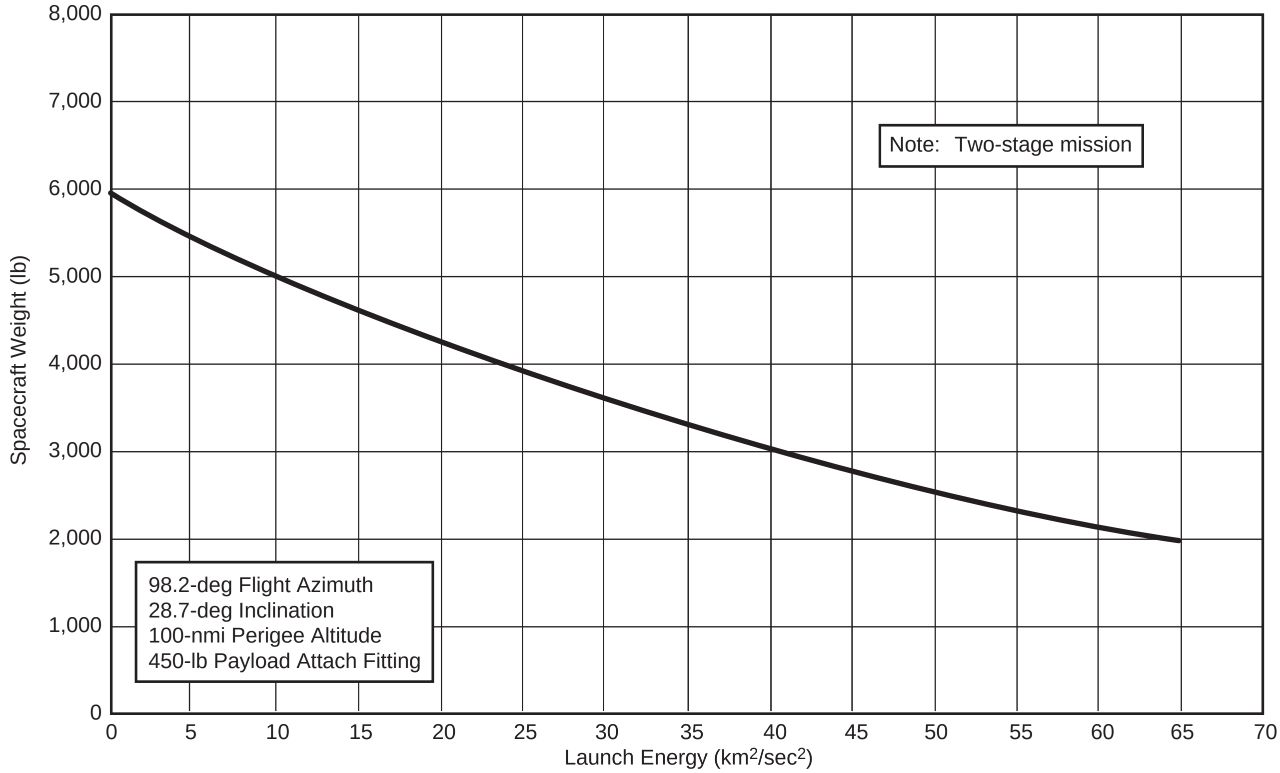


Figure 2-10. Delta III Vehicle, Two-Stage Circular Orbit Altitude Capability



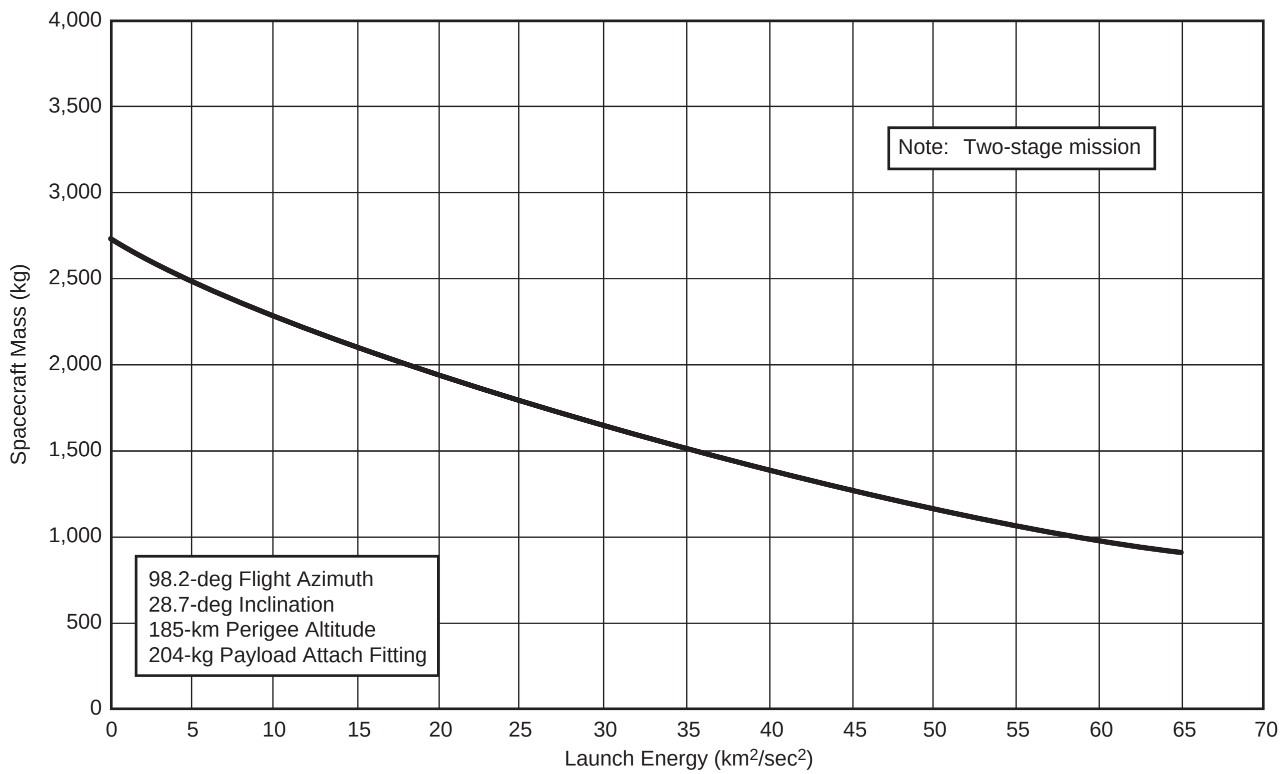


Figure 2-11. Delta III Vehicle, Two-Stage Planetary Mission Capability

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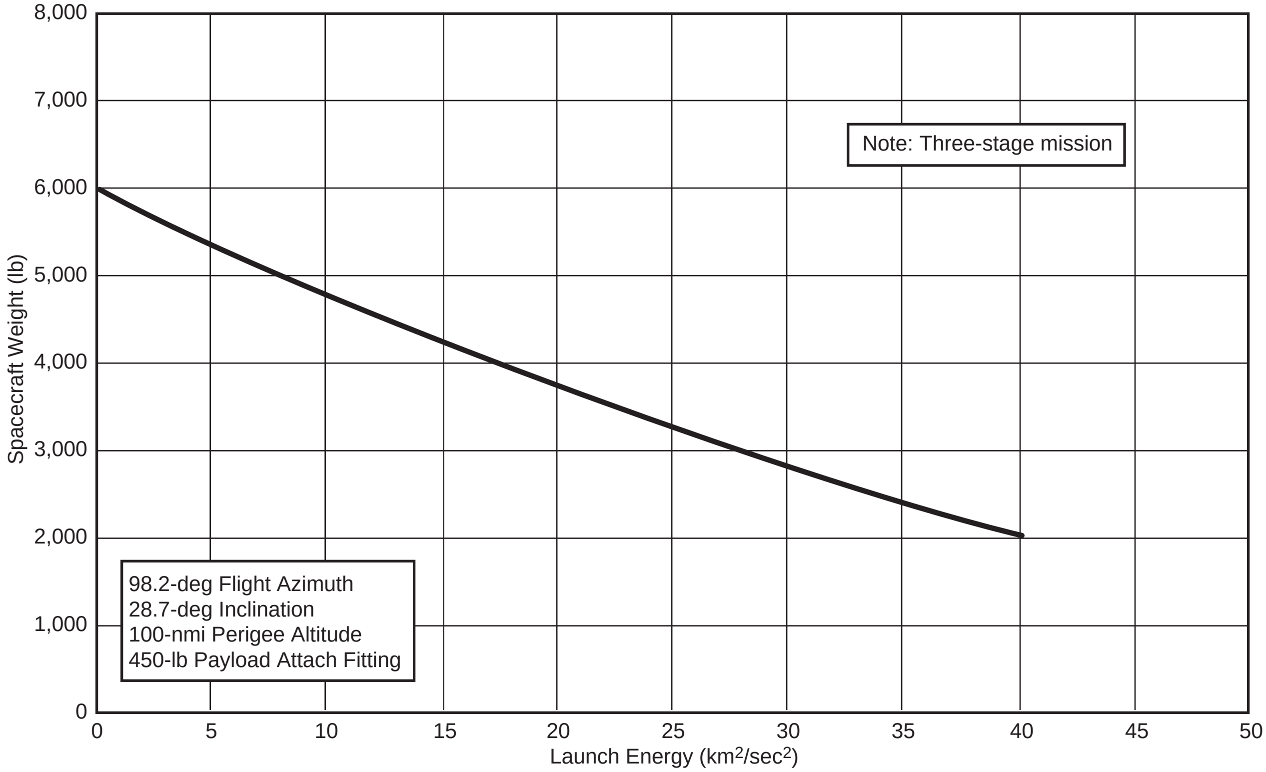

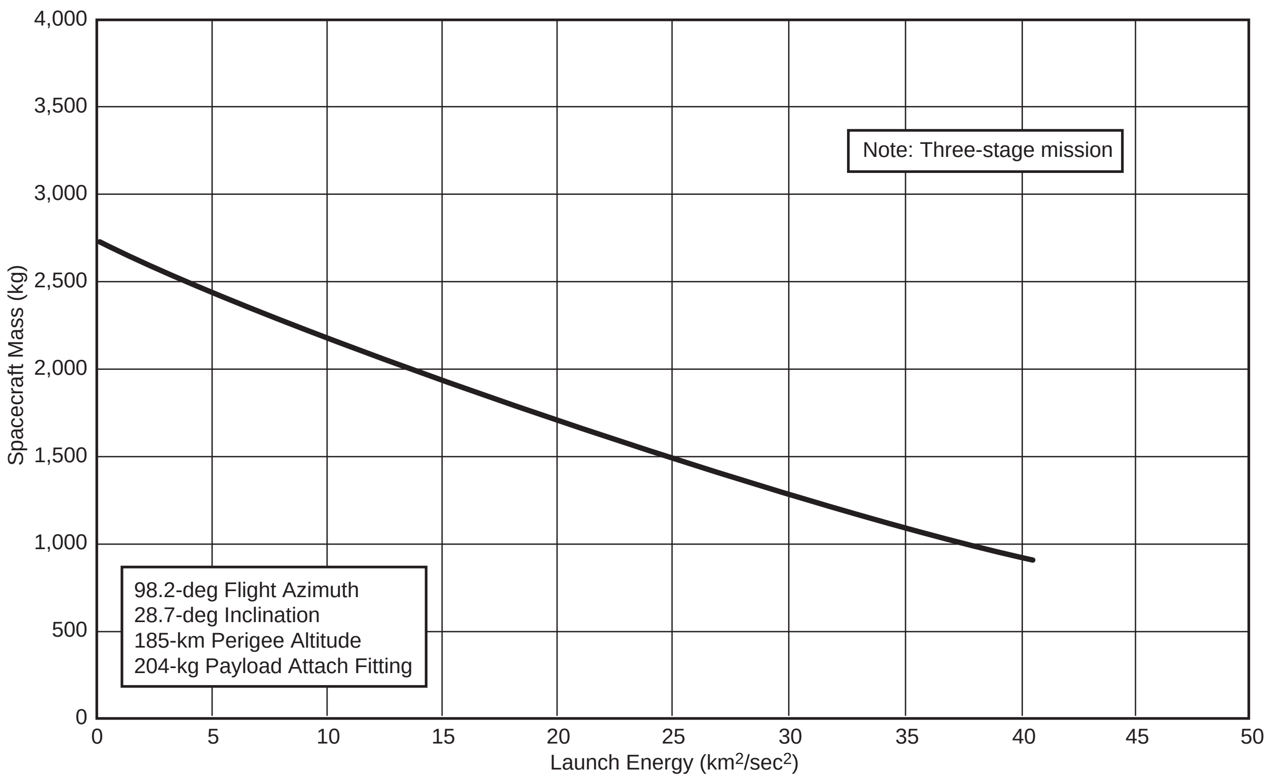

Figure 2-12. Delta III Vehicle, Three-Stage Planetary Mission Capability

specific mission. As pointed out in the footnote to Table 2-3, the PAF would need to be structurally enhanced for a spacecraft weight greater than 4300 kg (9480 lb). Boeing has therefore made an estimate of the weight increase to accommodate the maximum expected spacecraft weight for the Delta III vehicle of 8292 kg (18,280 lb). This structural enhancement would increase the existing 1666-4 PAF weight by 68 kg (150 lb), raising the total estimated weight to 272 kg (600 lb). The performance curves shown in Figures 2-7 and 2-8 would have to be adjusted accordingly for spacecraft weights greater than 4300 kg (9480 lb) because the data presented are based on a 1666-4 PAF weight of 204 kg (450 lb). A mission-unique analysis will be performed using the specific spacecraft mass properties to confirm capabilities.

2.4 MISSION ACCURACY DATA

Delta III employs the redundant inertial flight control assembly (RIFCA) mounted on the second-stage equipment shelf. This system provides precise pointing and orbit accuracy for all missions.

The spacecraft injection orbit accuracy delivered by the Delta III launch vehicle will satisfy the user's requirements for key orbit parameters including perigee and apogee altitude (or circular orbit altitude) and inclination. Delta III accuracy is achieved by (1) accurately predicting vehicle performance, (2) providing closed-loop guidance during booster and second-stage burns, and (3) providing adequate second-stage propellant margin (velocity reserve) to ensure a high probability of command shutdown (PCS). The predicted three-sigma orbit accuracy for the two-stage GTO and LEO missions is presented in Table 2-4.

Table 2-4. Delta III Two-Stage Orbit Insertion Accuracy

	Perigee altitude (km)	Apogee altitude (km)	Orbit inclination (deg)
LEO mission			
Nominal value	185	185	28.7
3-sigma dispersion at PCS = 99.865%	±4	±4	±0.03
GTO mission			
Nominal value	185	35786	28.7
3-sigma dispersion at PCS = 99.865%	±4	±167	±0.03
3-sigma dispersion at PCS = 99.7%	±4	-600/+167	±0.03
3-sigma dispersion at PCS = 0% (PDS)*	±4	-6500/+8000	±0.08

*0% PCS means spacecraft orbit insertion at second stage cutoff always occurs due to a propellant depletion shutdown (PDS) and is never commanded by guidance.

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Delta has consistently demonstrated the capability to place a spacecraft into orbit well within the preflight predicted accuracy. Figure 2-13 provides a comparison of the achieved orbit deviations with those predicted three-sigma deviations for 24 two-stage missions flown on the current Delta II vehicle.

These data are presented as general indicators only. Individual mission requirements and specifications will be used as the basis for detailed analyses for specific missions. The customer is invited to contact the Delta team for further information.

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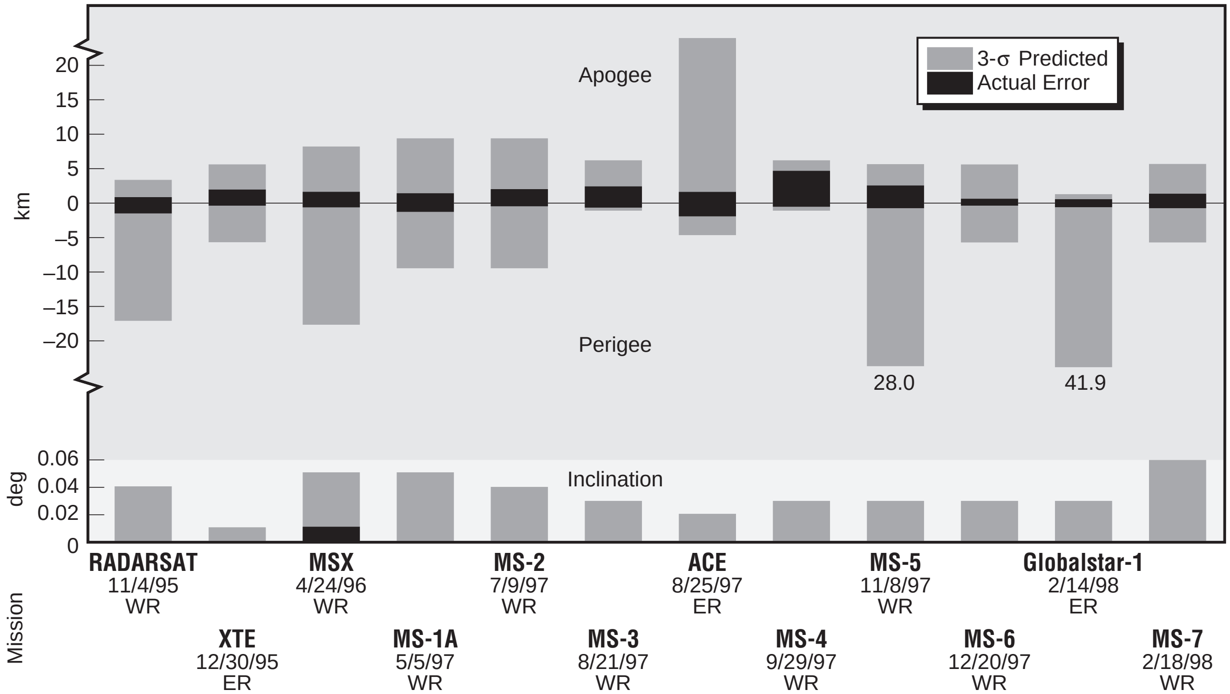
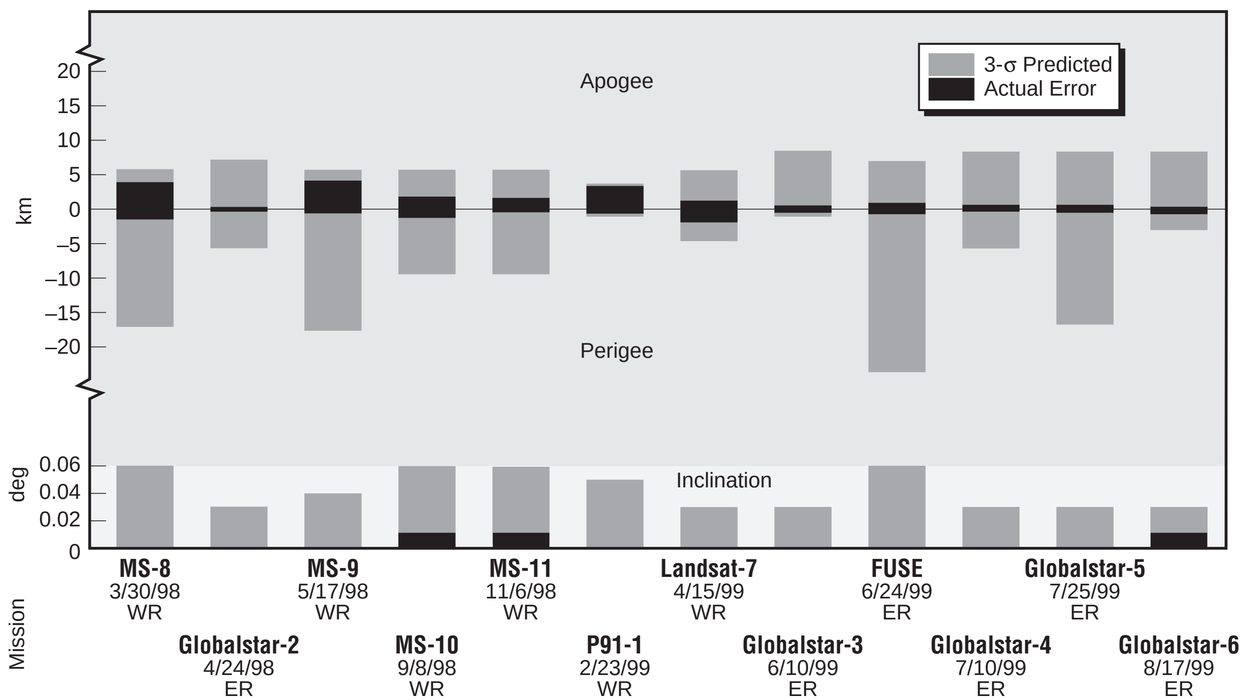


(a)



(b)

Figure 2-13. Demonstrated Delta Orbit Accuracy for Two-Stage Missions

Section 3
SPACECRAFT FAIRINGS

The spacecraft is protected by a fairing that shields it from external environments and contamination during the prelaunch and ascent phases. Typically, the fairing is jettisoned during first-stage powered flight at an acceptable free molecular heating rate. A general discussion of the Delta III fairing is presented in Section 3.1. Detailed descriptions and envelopes for the 4.0-m (13.1-ft) fairing are presented in Section 3.2.

3.1 GENERAL DESCRIPTION

The envelopes presented in the following sections define the preliminary maximum allowable static dimensions of the spacecraft (including manufacturing tolerances) relative to the spacecraft/payload attach fitting (PAF) interface. If dimensions are maintained within these envelopes, there will be no contact of the spacecraft with the fairing during flight, provided that the frequency and structural stiffness characteristics of the spacecraft are in accordance with the guidelines specified in Section 4.2.3. These envelopes include allowances for relative static/dynamic deflections between the launch vehicle and spacecraft. Also included are the manufacturing tolerances of the launch vehicle as well as the thickness of the acoustic blankets installed on the fairing interior. The blanket configurations available 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 accomplish this, it is important that the spacecraft description (refer to Section 8) includes an accurate definition of the physical location of all points on the spacecraft that are within 51 mm (2 in.) of the allowable envelope. The dimensions must include the maximum manufacturing tolerances.

Table 3-1. Typical Acoustic Blanket Configurations

Fairing	Location
4.0 m (13.1 ft)	The existing baseline configuration for acoustic blankets is 76.2-mm (3-in.)-thick blankets running from the nose cap to the base of the fairing.

■ Blankets for the Delta III composite fairing are constructed of acoustic material. The blankets are vented through the aft section of the fairing. The acoustic blankets are being designed to meet the intent of the criteria of 1.0% maximum total weight loss and 0.10% maximum volatile condensable material

T6.1

An air-conditioning inlet umbilical door on the fairing provides a controlled environment to the spacecraft while on the launch stand.

Electrical disconnect is accomplished at fairing separation by quick-disconnect connectors.

Contamination of the spacecraft is minimized by factory cleaning of the fairing prior to shipment to the field site. After cleaning, the fairing is double-bagged to maintain cleanliness during transport to the payload processing facility.

Mission-unique features can also be incorporated into the basic fairing construction. Electrical umbilical cabling to the spacecraft may be attached to the inside surface of the fairing shell. Special cleaning of the fairing in the field in a clean-room environment using “black light” is available upon request. Access doors are offered in two standard sizes, either 457-mm (18-in.) or 610-mm (24-in.) dia, depending on location. Specific door sizes, locations and mission-unique items should be coordinated with Boeing. It is understood that customers will have various requirements such as fill-and-drain valves, spacecraft arming devices, and/or electrical connectors. An RF-transparent window can be incorporated into the fairing.

3.2 THE 4.0-M (13-1-FT)-DIA COMPOSITE SPACECRAFT FAIRING

The 4-m (13.1-ft)-dia fairing (Figure 3-1) is a composite sandwich structure that separates into bisectors. Each bisector is constructed in a single co-cured lay-up, eliminating the need for module-to-module manufacturing joints and intermediate ring stiffeners. The resulting smooth inner skin provides the flexibility to install mission-unique access doors almost anywhere in the cylindrical portion of the fairing.

The bisectors are joined by a contamination-free linear piston/cylinder thrusting separation system that runs longitudinally the full length of the fairing.

The fairing bisectors are jettisoned by the detonating fuse in the thrusting joint cylinder rail cavity. A bellows assembly within each cylinder rail retains the detonating-fuse gases

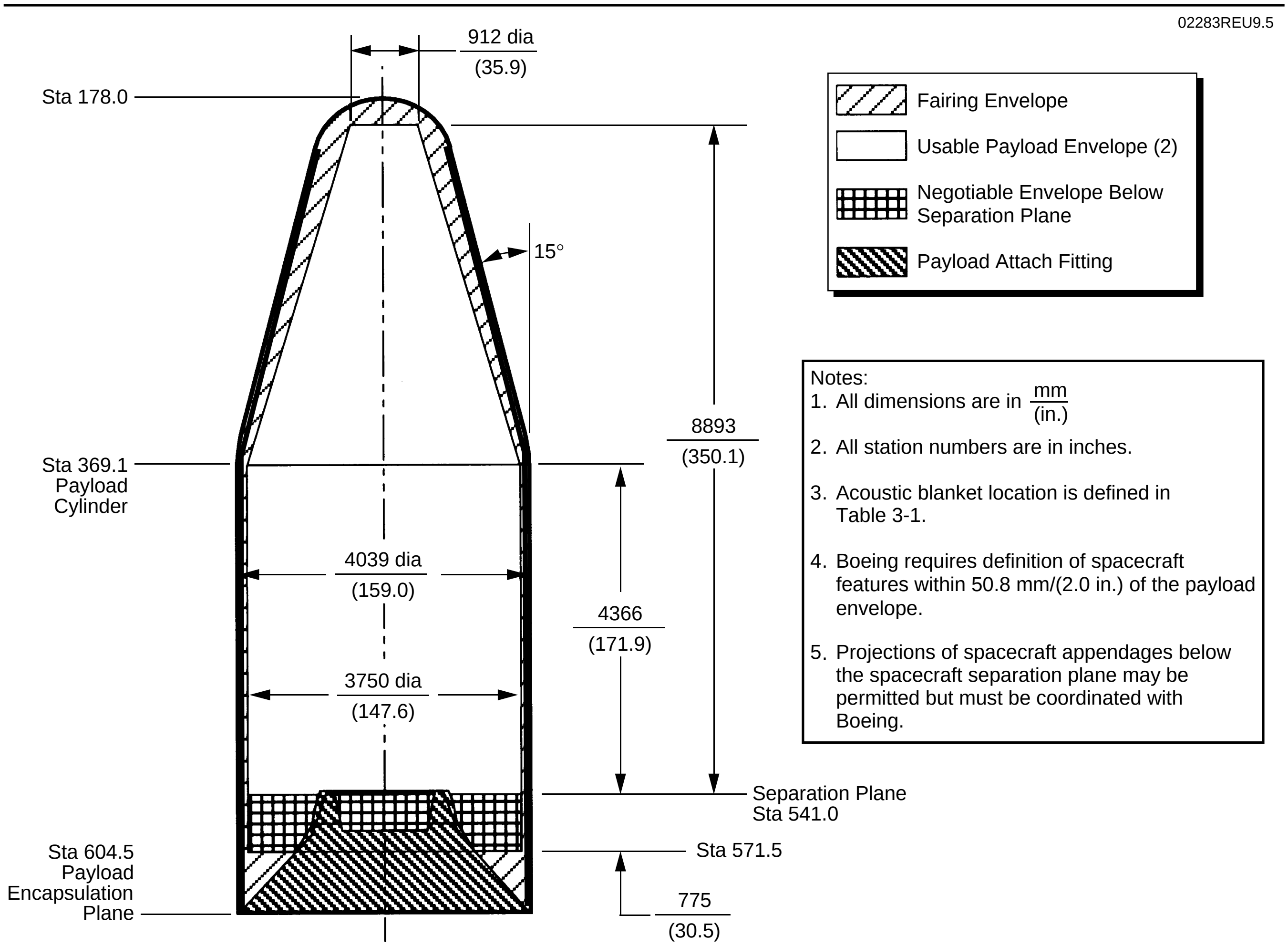


Figure 3-1. Spacecraft Envelope, 4.0-m (13.1-ft)-dia Fairing, Two-Stage Configuration (1666-4 PAF)

to prevent contamination of the spacecraft during the fairing separation event.

Acoustic and RF absorption blankets are provided on the fairing interior. It should be noted that access doors in the cylindrical section do not contain blankets. The baseline blanket configuration is described in Table 3-1. The allowable static spacecraft envelope within the fairing is shown in Figure 3-1 for the Delta III vehicle. This figure reflects an envelope for the 1666-4 payload attach fitting. The static envelope allows adequate dynamic clearance during launch provided that the spacecraft stiffness guidelines in Section 4.2.3.2 are observed. Use of the portion of the envelope shown in Figure 3-1 that is below the separation plane and local protuberances outside the envelopes presented require coordination and approval of the Delta Program Office.

Section 4
SPACECRAFT ENVIRONMENTS

Launch-vehicle-to-payload compatibility and mission-unique analyses are conducted to ensure the success of each mission. These analyses include prediction of spacecraft environments, vehicle control and stability analyses, and calculation of clearances between the spacecraft and Delta III fairing. To support these analyses, Boeing will require customer data such as structural and dynamic characteristics associated with the spacecraft.

4.1 PRELAUNCH ENVIRONMENTS

4.1.1 Eastern Range Spacecraft Air-Conditioning

Air-conditioning is supplied to the spacecraft through an umbilical after the encapsulated spacecraft and fairing are mated to the Delta III second stage. The spacecraft air-distribution system provides air at the required temperature, relative humidity, and flow rate. The spacecraft air-distribution system utilizes a diffuser on the inlet air-conditioning duct at the fairing interface, as shown in Figure 4-1. If required, a deflector can be installed on the inlet to direct the airflow away from sensitive spacecraft components. 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 setpoint of 2100 cfm. The air flows downward and around the spacecraft. It is discharged through vents in the aft ring of the payload fairing.

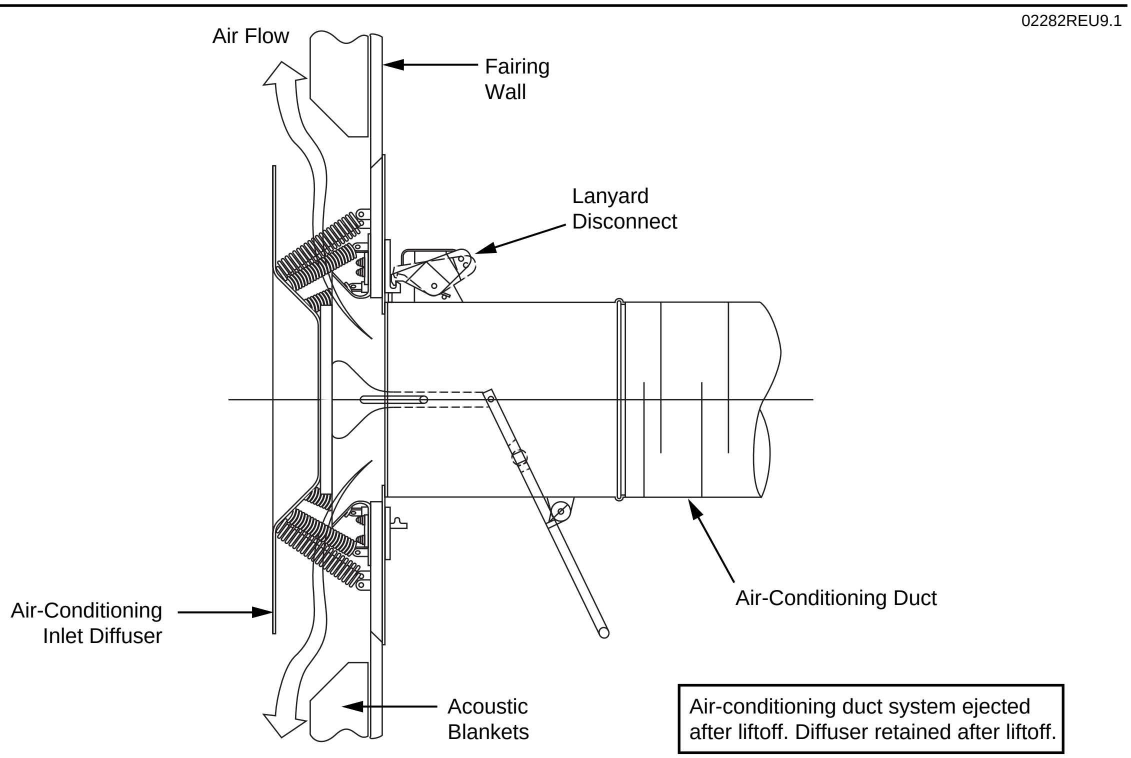


Figure 4-1. Payload Air Distribution System

Quality of the fairing air is measured in the hardline duct downstream of the high efficiency particulate air (HEPA) filter located on level 15 of the fixed umbilical tower. The duct contains an inline particle counter allowing for continuous particle-count sampling. The temperature, flow rate, and humidity are also measured at this point. The fairing air is redundant. A backup environmental control unit is operated in a hot standby mode for automatic transfer. Both fairing air environmental control units are connected to a diesel generator in the event of loss of commercial power. If auxiliary air-conditioning is required in addition to the fairing air, a small cooling unit is available. This unit, located on the mobile service tower (MST) on level 9B, provides low-temperature air with limited humidity control through a 152-mm (6-in.) interface.

4.1.2 Mobile Service Tower White Room

The white room is an environmentally controlled room located in the upper levels of the mobile service tower at Complex 17B. The payload levels are 9B and 9C. The floor plans of these levels are shown in Figure 4-2 and Figure 4-3. Services available to the customer (power, communications, and commodities) are shown for each level. The white room is rated as a class 100,00 facility. Capabilities of the environmental system are shown in Table 4-1. Movable work platforms are available to allow access to customer-requested door openings in the payload fairing.

4.1.3 RF and EMI Environments

4.1.3.1 Radio Frequency Compatibility. At the Eastern Range, the electromagnetic environment to which the spacecraft is exposed

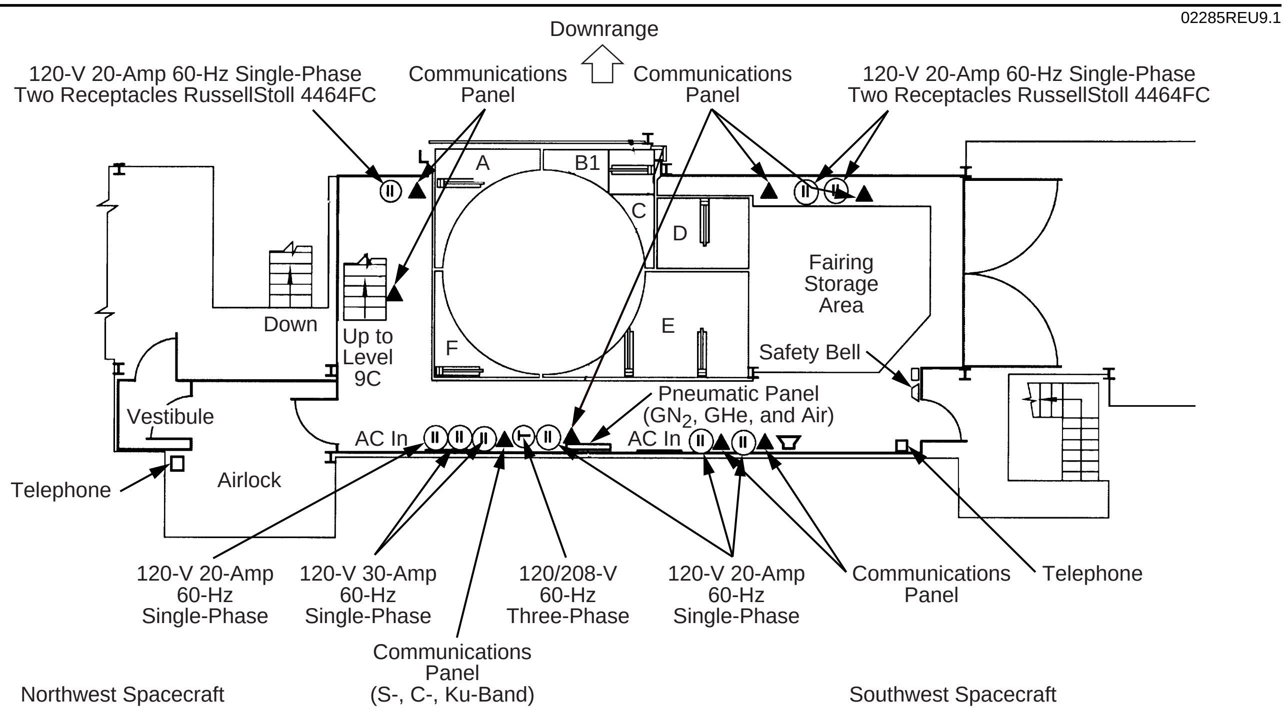


Figure 4-2. Level 9B, Pad B, Delta III

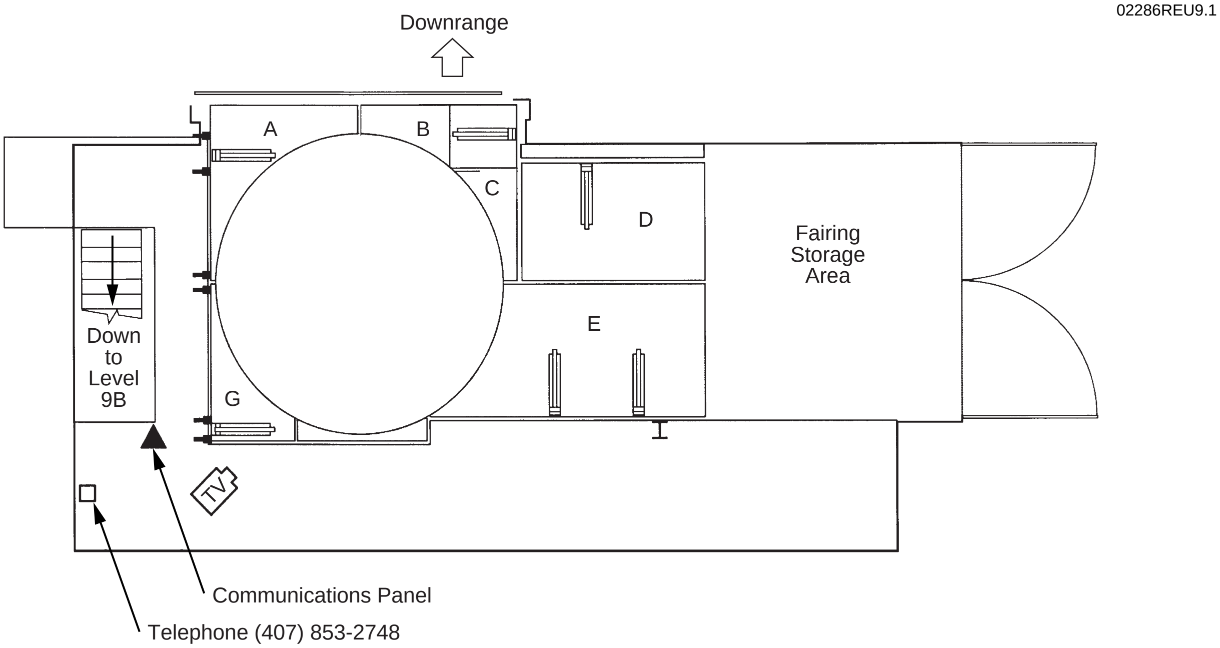


Figure 4-3. Level 9C, Pad B, Delta III

Table 4-1. Eastern Range Facility Environments

Facility Environmental Control System				
Location		**Temperature**	**Relative humidity**	**Filtration**
Encapsulated spacecraft	Mobile	Note(1)	Not controlled(2)	Not controlled(2)
MST	SLC-17B white room	65˚ to 75˚F	35 to 50%	Class 100,000(3)
Astrotech	Buildings 1 and 2: Airlock High Bay	 75˚ ± 5˚F 70˚ to 78˚F	 50 ± 5% 55% max	 Class 100,000(3) 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) Passive temperature control provided by operational constraints.
(2) Dry gaseous nitrogen purge per MIL-P-27401C, Type 1, Grade B.
(3) Classification of air cleanliness is defined by FED-STD-209D.

Vehicle Environmental Control Systems						
Location		**Temperature**	**Relative humidity**	**Flow rate**	**Filtration**	**Hydrocarbons**
Launch Complex SLC-17B	Payload fairing air(1)	45˚ to 80˚F ± 2˚F(2)(3)	35 to 50 ± 5%(2)	700 to 2100 ± 50 cfm(2)	Class 5,000(5)	15 ppm max(4)
	Supplemental cooling air(1)	50˚ to 80˚F ± 5˚F(2)	90% max (not selectable)	0 to 600 cfm(2)	Class 5,000(3)	5 ppm max(4)

(1)All conditions are specified as inlet conditions.
(2)Specific setpoint is selectable within the specified range and the system controls within the specified control tolerance.
(3)Fairing air temperature requirements over 75˚F and under 55˚F should be coordinated with Boeing.
(4)Air is filtered by an activated carbon charcoal filter and non-DOP tested HEPA filter.
(5)Classification of air cleanliness is defined by FED-STD-209D.

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results primarily from the operation of 45th Space Wing radars and the launch vehicle transmitters and antennas. The maximum RF environment at the launch site is controlled through coordination with the range. With protective masking of Cape Canaveral 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 Delta III launch vehicle transmits on several frequencies to provide launch vehicle telemetry and beacon signals to the appropriate range tracking stations. It also has uplink capability for command destruct. On the second stage there are an S-band telemetry system, two command receiver decoder (CRD) systems on the second stage, and a C-band transponder (beacon). The maximum Delta III launch vehicle emissions measured at the spacecraft/launch vehicle separation plane are shown in Figure 4-4. The radio frequency (RF) systems are switched on prior to launch and remain on until mission completion.

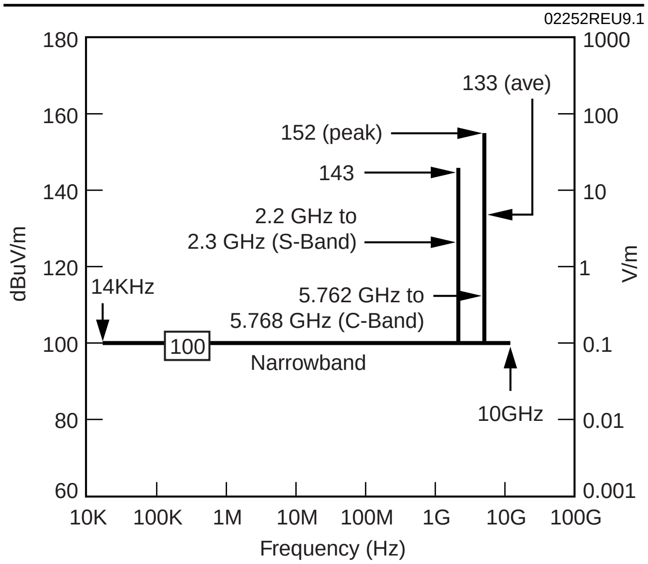


Figure 4-4. Delta III Maximum Allowable Launch-Vehicle-Radiated Emissions

An RF hazard analysis is performed to ensure that the spacecraft transmitters are compatible with the vehicle avionics and ordnance systems. An RF compatibility analysis is also performed to verify that the vehicle and satellite transmitter frequencies do not have interfering intermodulation products or image rejection problems.

The maximum allowable spacecraft emissions measured at the spacecraft/launch vehicle separation plane are shown in Figure 4-5. Figure 4-6 can

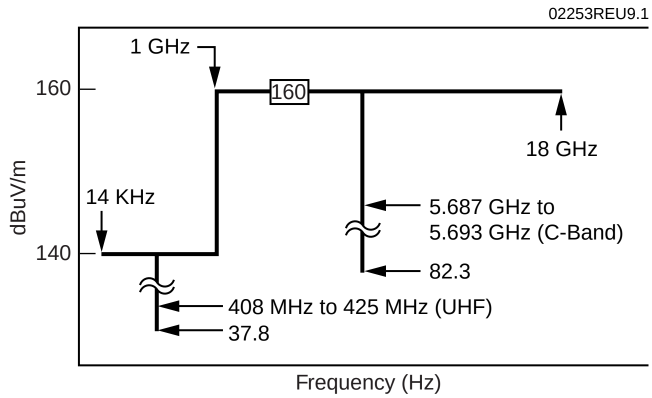
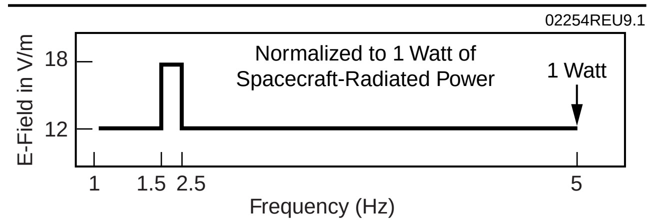


Figure 4-5. Delta III Maximum Allowable Spacecraft-Radiated Emissions



$E_{max} = 12\ V/m \bullet \sqrt{P}$ — Frequency 1 GHz to 1.5 GHz, 2.5 GHz to 18 GHz

$E_{max} = 18\ V/m \bullet \sqrt{P}$ — Frequency 1.5 GHz to 2.5 GHz

Where

E_{max} = The maximum electric field level in the fairing enclosure

P = The power level to the base of the transmitting antenna (if the antenna's main beam is pointed to allow the energy to disperse within the fairing cavity)

= The EIRP of the antenna (if the main beam of the antenna is pointed in a direction so that the radiated energy is confined to and reflected inside of a local area

Figure 4-6. E-Field vs Power Inside Payload Fairing

be used to estimate the E-field level inside the Delta III fairing enclosure due to an antenna radiating inside the fairing enclosure.

4.1.3.2 Electromagnetic Interference.

Payload agencies should identify any susceptibility to EMI including lightning. The Eastern Range has the capability of locating and quantifying (peak current amplitude) lightning strikes. The MST provides protection to the flight hardware as long as it is located around the vehicle. The launch team is responsible for determining whether predicted weather conditions violate requirements. The team also provides an approval to move the encapsulated spacecraft from the payload processing facility to the launch pad. The encapsulated spacecraft, on a Boeing transporter, does not have lightning protection. Transporting is not allowed if the predicted weather conditions violate requirements.

4.1.4 Electrostatic Potential

The spacecraft 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 spacecraft, at least 31.8 mm (1.25 in.) above the separation plane. The vehicle/spacecraft interface provides the conductive path for grounding the spacecraft to the launch vehicle. Therefore, a dielectric coating should not be applied to the spacecraft interface. The electrical resistance of the spacecraft-to-payload-attach-fitting (PAF) interface as measured across the mechanical mated interface shall be 0.010 Ω or less and is verified during spacecraft-to-PAF mating.

4.1.5 Contamination and Cleanliness

Cleanliness conditions discussed below for the Delta III payloads represent the minimum available. The following guidelines and practices from prelaunch through spacecraft separation provide the minimum class 100,000 cleanliness conditions (per Federal Standard 209B):

- Precautions are taken during manufacture, assembly, test, and shipment to prevent contaminant accumulations in the Delta III payload accommodations processing area, composite fairing, and PAF.
- Encapsulation of the payload into the payload 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 and include SLC-17. The fairing is used to transport the encapsulated payload to the white room and provides environmental protection for the payload.
- The composite fairing is cleaned at the manufacturing facility using alcohol and then inspected for cleanliness prior to shipment to the field. The PLF is double-bagged prior to installation into a shipping container and not unbagged until ready for spacecraft encapsulation. Table 4-2 provides Boeing STP0407 visible cleanliness (VC) levels. The standard Boeing cleanliness provided to payload customers is visible clean (VC) level 3, as shown below and defined in Boeing specification STP0407. Other cleanliness levels must be negotiated with Delta Launch Services.

Table 4-2. Cleanliness Level Definitions

VC 1	Shop lights at 3 ft
VC 2	50 fc at 5 to 10 ft
VC 3	100 to 200 fc at 18 in.
VC 4	300 W drop light at 5 ft
VC 5	100 to 200 fc at 6 to 18 in.
VC 6	100 to 200 fc + long wavelength UV at 6 to 18 in.

T4-2

Cleanliness Level Definitions

VC 1. All surfaces shall be free of all particulates and nonparticulates visible to the normal unaided (or corrected-vision) eye. A particulate is defined as matter of miniature size with observable length, width, and thickness. A nonparticulate is film matter without definite dimension. Inspection operations shall be performed under normal shop lighting conditions at a maximum distance of 3 ft.

VC 2. All surfaces shall be free of all particulates and nonparticulates visible to the normal unaided (or corrected-vision) eye. A particulate is identified as matter of miniature size with observable length, width, and thickness. A nonparticulate is film matter without definite dimension. Inspection operations shall be performed at incident light levels of 50 fc and observation distances of 5 to 10 ft.

VC 3. All surfaces shall be free of all particulates and nonparticulates visible to the normal unaided (or corrected-vision) eye. A particulate is identified as matter of miniature size with observable length, width, and thickness. A nonparticulate is film matter without definite dimension. Inspections shall be performed at incident light levels of 100 to 200 fc at an observation distance of 18 in. or less.

VC 4. All surfaces shall be free of all particulates and nonparticulates visible to the normal unaided (or corrected-vision) eye. A particulate is identified as matter of miniature size with observable length, width, and thickness. A nonparticulate is film matter without definite dimension. This level requires no particulate count. The source of incident light shall be a 300 W drop light (explosion proof) held at a distance of 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 free of all particulates and nonparticulates visible to the normal unaided (or corrected-vision) eye. A particulate is identified as matter of miniature size with observable length, width, and thickness. A nonparticulate is film matter without definite dimension. This level requires no particulate count. Inspections shall be performed at incident light levels of 100 to 200 fc at observation distances of 6 to 18 in. Cleaning must be done in a class 100,000 cleanroom or better.

VC 6. All surfaces shall be visibly free of all particulates and nonparticulates visible to the normal unaided (or corrected-vision) eye. A particulate is identified as matter of miniature size with observable length, width, and thickness. A nonparticulate is film matter without definite dimension. This level requires no particulate count. Inspections shall be performed at incident light levels of 100 to 200 fc at observation distances of 6 to 18 in. Additional incident light requirements are 8 W minimum of long-wave ultraviolet light at 6 to 18 in. observation distance in a darkened work area. Protective eyeware may be used as required with UV lamps. Cleaning must be done in a class 100,000 cleanroom or better.

- Personnel and operational controls are employed during spacecraft encapsulation to maintain spacecraft cleanliness.
- The payload agency may provide a protective barrier (bag) around the spacecraft optical instruments that can be removed on pad through an access door prior to launch vehicle closeout.

4.2 LAUNCH AND FLIGHT ENVIRONMENTS

4.2.1 Fairing Internal Pressure Environment

As the Delta III vehicle ascends through the atmosphere, air flows out of the payload compartment through vent holes in the aft section of the fairing. Venting also occurs through additional leak paths in the fairing. The expected extremes of internal pressure and maximum internal pressure decay rate during ascent are presented in Figure 4-7 and Figure 4-8, respectively, for the 4-m (13.1-ft)-dia composite fairing.

4.2.2 Thermal Environment

The thermal environments encountered prior to launch, during boost, and during the orbital phases of the mission are controlled by appropriate thermal management, based on the satellite and launch vehicle thermal requirements.

Fairing aerodynamic heating is predicted using a maximum aerodynamic heating trajectory. The aerodynamic heating prediction methods have been verified to be conservative based on Delta II/III flight temperature measurements. Maximum temperature histories for the inner surface of the

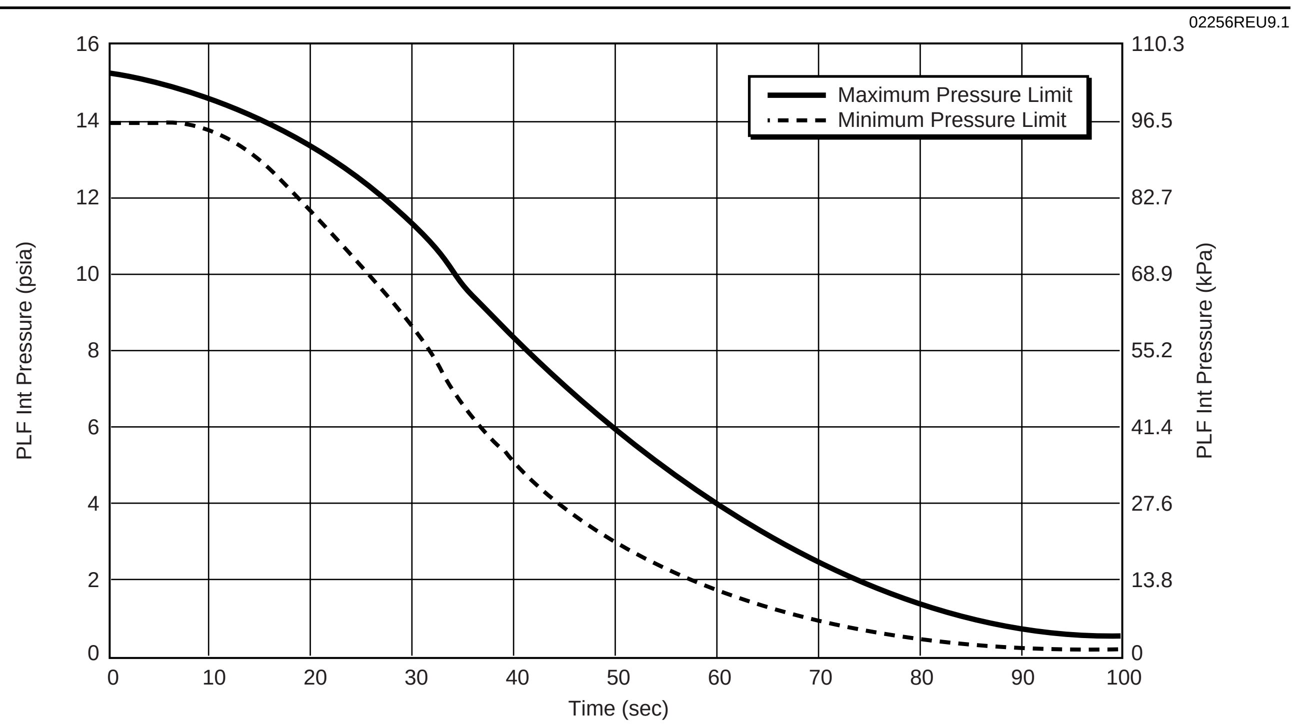


Figure 4-7. Delta III Payload Fairing Compartment Absolute Pressure Envelope

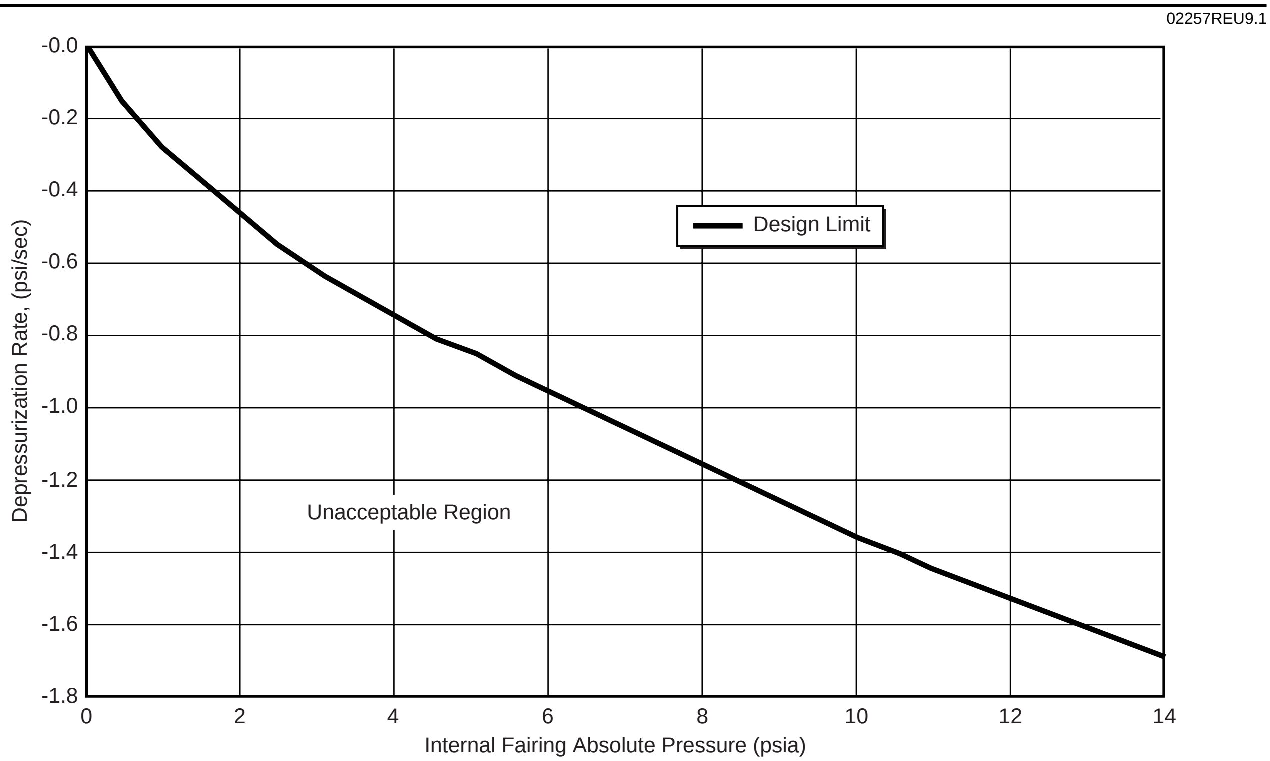


Figure 4-8. Delta III Payload Fairing Depressurization Limit

fairing separation rail, acoustic blankets and graphite epoxy skin (where there is no blanket) are shown in Figure 4-9. The regions without acoustic blankets include the nose cap and various fairing access doors.

Fairing jettison will be constrained such that the worst-case (including dispersions) theoretical free molecular heating for a flat plate normal to the free stream will be below 1135 W/m^2 (0.1 Btu/ft^2-sec).

The thermal parameters at the interface between the vehicle payload attach fitting and the spacecraft include:

- Thermal conductance at PAF interface.
- Effective emittance of PAF interior.
- Absorbance/emittance of exterior surfaces of PAF.

Temperature histories of the PAF structure can be provided after sun angles have been defined.

During on-orbit coast periods, the Delta III second stage can be oriented to meet parking orbit thermal requirements. A slow roll can also be used to moderate orbital heating or cooling during coast periods to maintain the spacecraft-launch vehicle interface temperatures.

Launch vehicle engine exhaust plumes will not impinge on the spacecraft during powered flight. Evasive burns following spacecraft separation can be tailored to minimize contamination to the spacecraft.

4.2.3 Flight Dynamic Environment

4.2.3.1 Steady-State Acceleration. For the Delta III vehicle, the maximum axial acceleration occurs at the end of the first-stage burn main

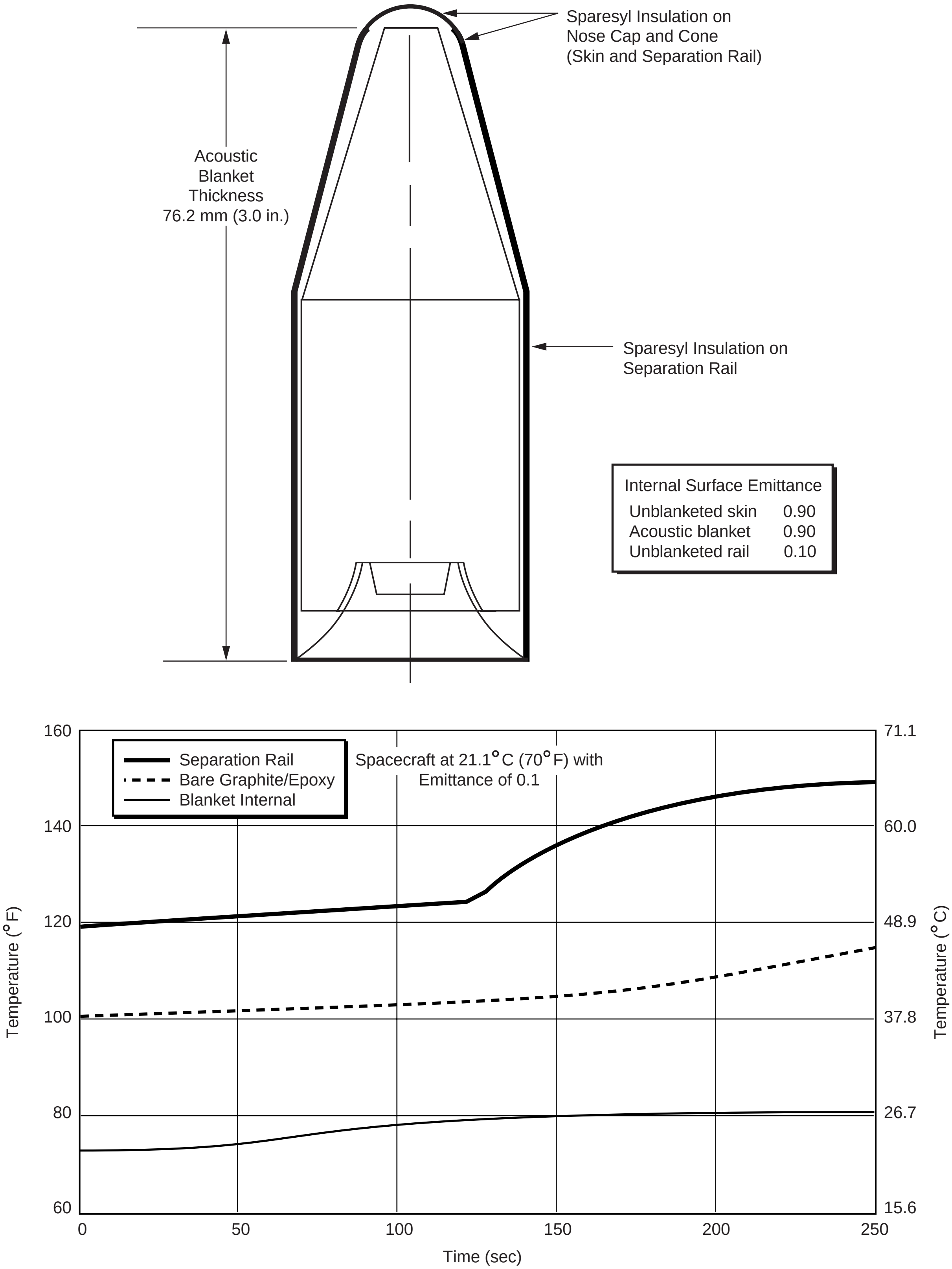


Figure 4-9. Delta III Payload Fairing Internal Surface Maximum Temperatures

engine cutoff (MECO). A plot of steady-state axial acceleration at MECO vs spacecraft weight is shown in Figure 4-10. For an assumed Star 48B three-stage Delta III vehicle, the maximum steady-state acceleration occurs at the end of third-stage flight for spacecraft less than approximately 1905 kg (4200 lb). Above this weight the maximum acceleration occurs at the end of first-stage burn. Steady-state axial acceleration vs spacecraft weight at third-stage motor burnout is shown in Figure 4-11.

4.2.3.2 Combined Loads. Dynamic excitations, which occur predominantly during liftoff, transonic, maximum dynamic pressure, and MECO flight events, are superimposed on steady-state accelerations to produce combined accelerations that must be used in the spacecraft structural design. The combined spacecraft accelerations are a function of spacecraft dynamic characteristics and mass properties. To minimize dynamic coupling between low-frequency vehicle and spacecraft modes, it is desirable for the stiffness of the spacecraft structure for a two-stage Delta III mission to produce fundamental frequencies above 27 Hz in the thrust axis and 10 Hz in the lateral axis for a spacecraft hard-mounted at the spacecraft separation plane (without PAF and separation clamp). In addition, secondary structure mode frequencies above 35 Hz will prevent coupling with launch vehicle modes and/or large fairing-to-spacecraft relative dynamic deflections. The spacecraft design limit load factors presented in Table 4-3

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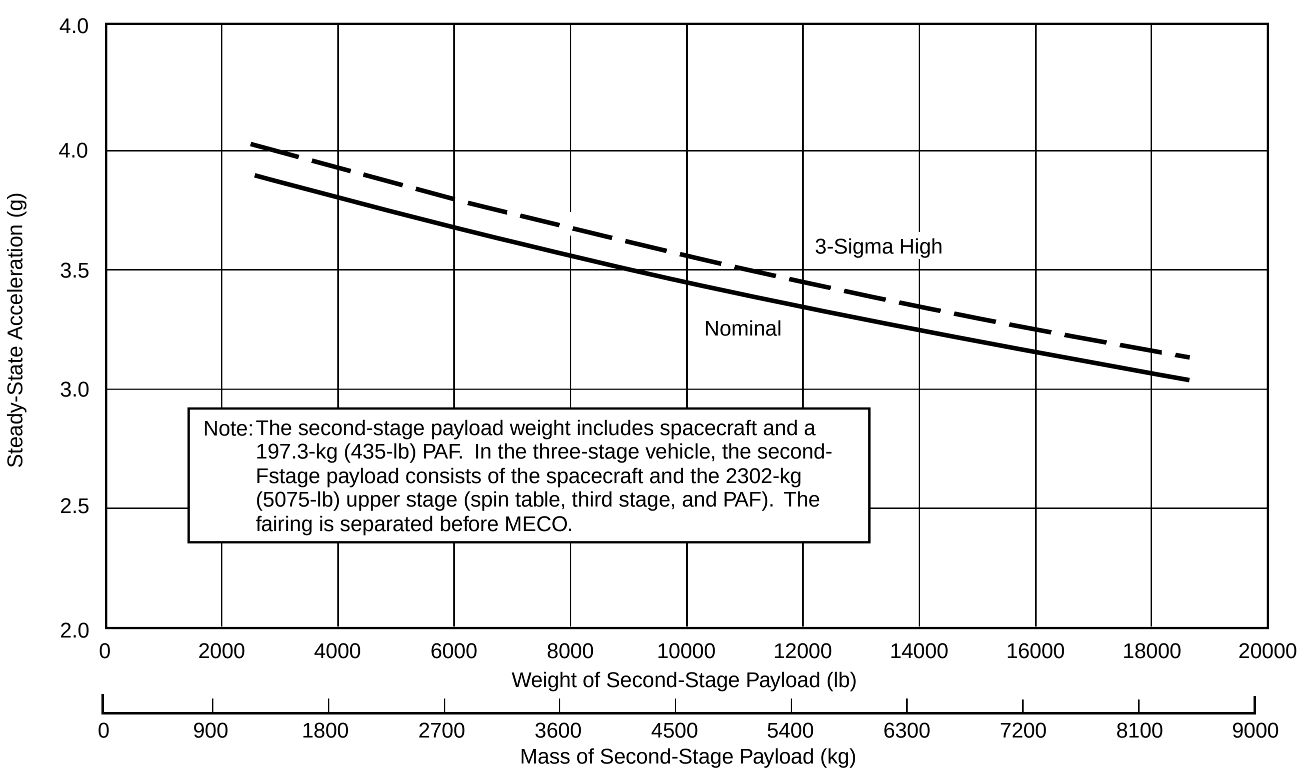

Figure 4-10. Axial Steady-State Acceleration vs Second-Stage Payload Weight

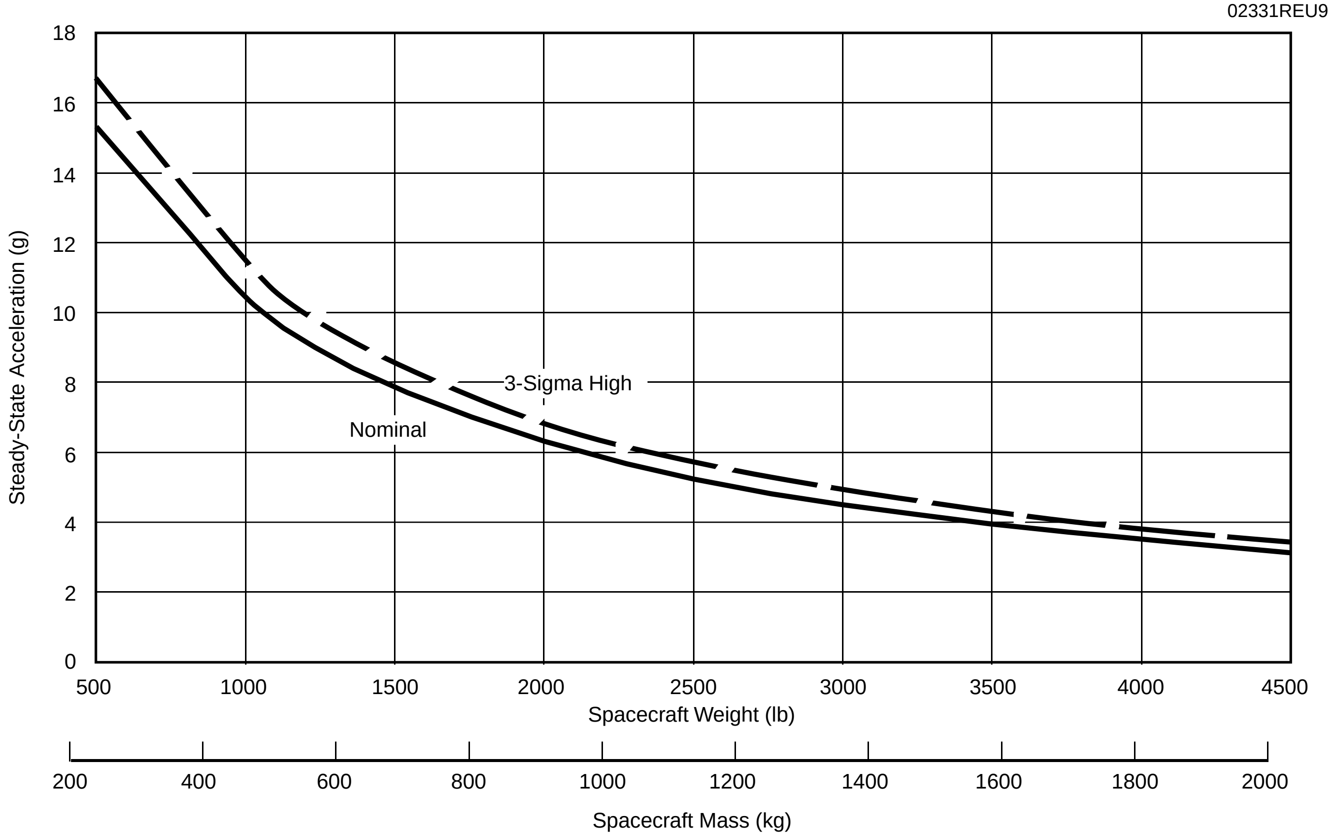

Figure 4-11. Axial Steady-State Acceleration at Third-Stage Burnout

Table 4-3. Preliminary Design Load Factors

	Limit load factors (g)(1)(2)	
Load condition	**Liftoff, Max Aero**	**MECO**
■ Lateral axes	± 2.0 [± 2.5](3)	± 0.5
■ Thrust axis + Compression – Tension	+ 2.7/– 0.2(4)	3.7 ± 1.5(5)

(1)Loads are applicable at spacecraft center of gravity.
(2)Limit load factors should be multiplied by a 1.25 factor to obtain ultimate loads, if tested.
(3)Lateral load factor of ± 2.0 g provides correct bending moment at spacecraft separation plane for a two-stage vehicle; ± 2.5 g is specified for a three-stage vehicle.
(4)The liftoff axial load factor will increase for stiff spacecraft with a high fundamental axial mode frequency; e.g., for a spacecraft with a 45-Hz axial mode frequency, these load factors will be +3.3/-0.5g.
(5)Axial load factor at MECO consists of a static component that is a function of spacecraft weight (Figure 4-10) and a dynamic component at a frequency between 16 and 23 Hz. The 3.7-g static value is based on a two-stage spacecraft weight of 3630 kg (8000 lb). The 1.5-g dynamic component applies to spacecraft with weights less than 5443 kg (12,000 lb) and fundamental axial mode greater than 27 Hz. For spacecraft outside these weight and frequency limits, dynamic acceleration could be higher.

T4-3.2

are applicable for spacecraft meeting the above guidelines. For spacecraft not meeting these guidelines, the combined accelerations and subsequent design-limit load factors may not be applicable and the user should coordinate with Boeing so that an appropriate evaluation can be performed to better define loading conditions.

Detailed spacecraft dynamic responses are determined by vehicle/spacecraft coupled dynamic loads analyses performed by Boeing. The user-provided spacecraft dynamic model is coupled to the Delta III vehicle dynamic model for these analyses. Liftoff, transonic, maximum dynamic pressure, and, if appropriate, MECO flight events that are significant to the spacecraft dynamic loading are included in the analyses. Outputs for each flight event are summarized in reports and available in electronic computer media to the user.

4.2.3.3 Acoustic Environment.

The maximum acoustic environment experienced by the spacecraft occurs during liftoff and the transonic/maximum dynamic pressure flight regime. The duration of the maximum environment is less than 10 sec.

Typical spacecraft acoustic levels are shown in Figure 4-12 and are presented as one-third octave band sound pressure levels (dB, ref: 2×10^{-5} N/m^2) vs one-third octave band center frequency. These levels apply to the blanketed section of the fairing and represent a 95th percentile space average environment for a typical spacecraft with an equivalent cross-sectional area fill of 60 percent, which equates to an equivalent spacecraft diameter of 3150 mm (124 in.). For a larger spacecraft with an equivalent cross-sectional area fill of 80 percent, which equates to an equivalent spacecraft diameter of 3635 mm (143 in.), the acoustic environment is approximately 3 dB higher. When the size, shape, and overall dimensions of a spacecraft are defined, a mission-specific acoustic analysis can be performed to determine the acoustic environment for the spacecraft. The acoustic levels shown in Figure 4-12 have been adjusted to represent the equivalent sound pressure levels consistent with the typical acoustic test practice of locating control microphones approximately 508 mm (20 in.) from the spacecraft surface. The acoustic levels shown in Figure 4-12 are defined for launches from the Eastern Range (LC-17).

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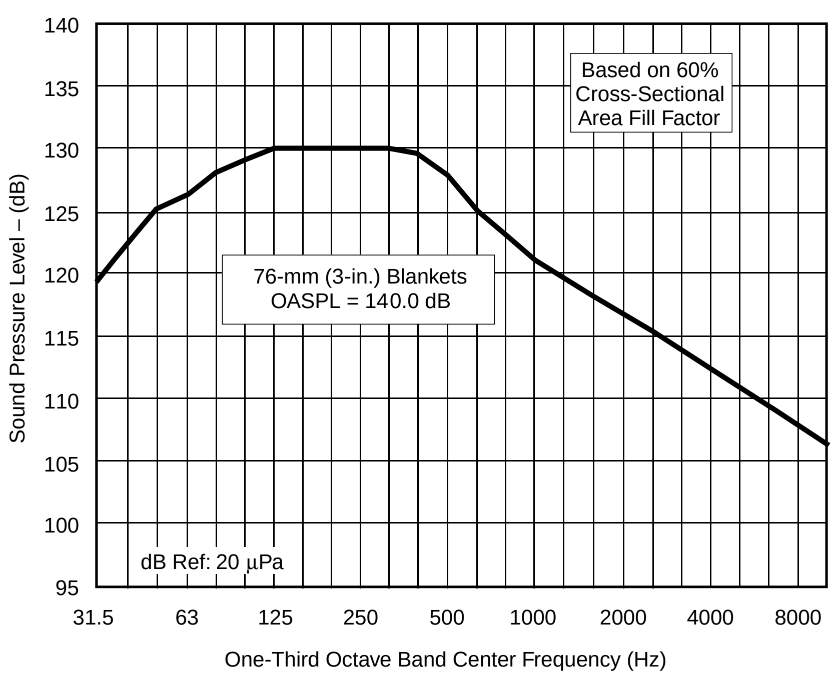

One-Third Octave Band Center Frequency (Hz)	Maximum Flight Sound Pressure Level 95th Percentile Space Average (dB)
31.5	119.5
40	122.5
50	125.2
63	126.3
80	128.0
100	129.0
125	130.0
160	130.0
200	130.0
250	130.0
315	130.0
400	129.5
500	128.0
630	125.0
800	123.0
1000	121.0
1250	119.5
1600	118.0
2000	116.5
2500	115.0
3150	113.5
4000	112.0
5000	110.5
6300	109.0
8000	107.5
10000	106.0
OASPL	140.0

Figure 4-12. Typical Spacecraft Acoustic Levels

The acoustic environment produces the dominant high-frequency random vibration responses in the spacecraft, and a properly performed acoustic test is the best simulation of the acoustically-induced random vibration environment (see Section 4.2.4.2). There are no significant high-frequency random vibration inputs at the payload attach fitting/spacecraft interface that are generated by the Delta III launch vehicle; consequently, an interface random vibration environment is not specified. For a spacecraft that has components mounted near the payload attach fitting/spacecraft interface that are sensitive to low-level random vibration, Boeing should be contacted if more information is required.

4.2.3.4 Sinusoidal Vibration Environment. The spacecraft will experience sinusoidal vibration inputs during flight as a result of Delta III launch and ascent transients and oscillatory flight events. The maximum flight sinusoidal vibration inputs at the payload attach fitting/spacecraft interface are defined in Table 4-4. These sinusoidal vibration levels provide a general envelope of low-frequency flight dynamic events such as liftoff transients, transonic/maximum dynamic pressure oscillations, pre-MECO sinusoidal oscillations, MECO transients, and second-stage events.

Table 4-4. Sinusoidal Vibration Levels

Axis	Frequency range (Hz)	Maximum flight level
Thrust	5 to 6.2 6.2 to 100	12.7 mm (0.5 in.) double amplitude 1.0 g (zero to peak)
Lateral	5 to 100	0.7 g (zero to peak)

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The sinusoidal vibration levels in Table 4-4 are not intended for use in the design of spacecraft primary structure. Limit load factors for spacecraft primary structure design are specified in Table 4-3. The sinusoidal vibration levels should be used in conjunction with the results of the spacecraft coupled dynamic loads analysis 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 III 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 spacecraft coupled dynamic loads analysis results (see Section 4.2.4.3).

4.2.3.5 Shock Environment. The maximum shock environment at the payload attach fitting/spacecraft interface occurs during spacecraft separation from the Delta III launch vehicle and is a function of the spacecraft separation system configuration. High-frequency shock levels at the payload attach fitting/spacecraft interface due to other flight shock events, such as Stage I-II separation and fairing separation, are typically not significant compared to the spacecraft separation shock environment.

The maximum flight shock environments at the payload attach fitting/spacecraft interface are defined in Figure 4-13 and Figure 4-14 for the 1666-mm (66-in.) dia and 1194-mm (47-in.)-dia clamp separation systems, respectively. Both

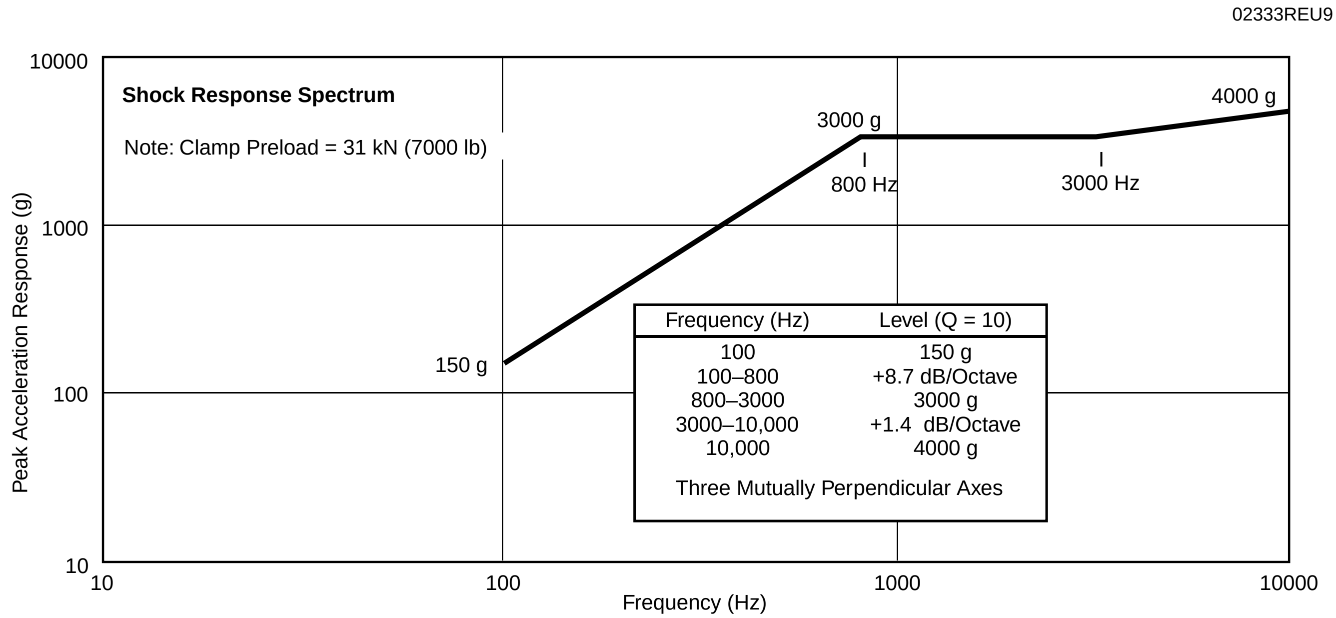

Figure 4-13. Spacecraft Interface Shock Environment—1666-4 Payload Attach Fitting

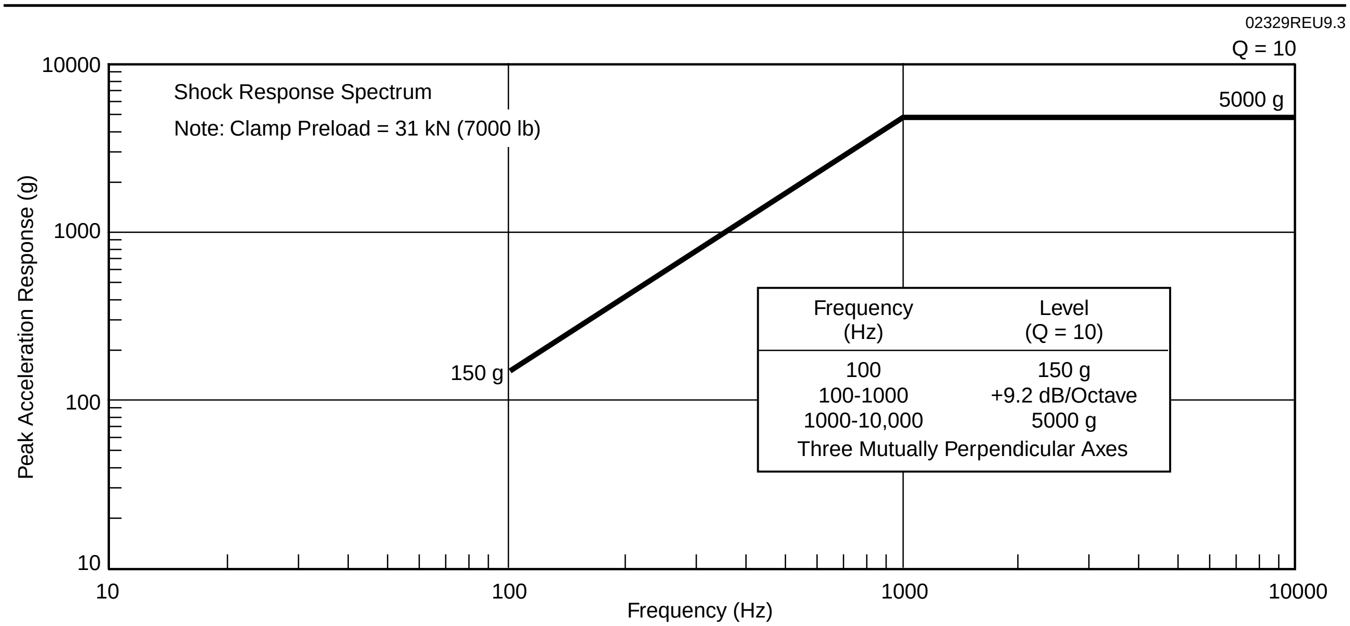

Figure 4-14. Spacecraft Interface Shock Environment—1194-4 Payload Attach Fitting

clamp systems use a maximum 31.147-kN (7000-lb) clampband preload. Definition of the shock environment for the four-point bolted separation system is being evaluated. These spacecraft interface shock environments are intended to aid in the design of spacecraft components and secondary structure that may be sensitive to high-frequency pyrotechnic shock. Typical of this type of shock, the shock 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 (see Section 4.2.4.4).

4.2.4 Spacecraft Qualification and Acceptance Testing

This section outlines a series of environmental system-level qualification, acceptance, and protoflight test recommendations for spacecraft launched on Delta III 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. The tests presented here are, by necessity, generalized in order to encompass numerous spacecraft configurations. For this reason, each spacecraft project should critically evaluate its own specific requirements and develop detailed test specifications tailored to its particular spacecraft. Coordination with the Delta Program Office during the development of spacecraft test specifications is encouraged to ensure the adequacy of the spacecraft test approach. (See 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 III dynamic environmental loads, even with minor weight and design variations. The acceptance test levels presented in this section are intended to verify adequate spacecraft manufacturing workmanship by subjecting the flight spacecraft to maximum expected flight environments. The protoflight test approach presented in this section is intended to combine verification of adequate design margin and adequacy of spacecraft manufacturing workmanship by subjecting the flight spacecraft to protoflight test levels, which 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 (or simulation) is required to provide proper load distribution at the spacecraft interface. The spacecraft user should coordinate with the Delta Program Office before developing the structural load test plan and should obtain concurrence for the test load magnitude to ensure that the PAF will not be stressed beyond its load-carrying capability.

When the maximum axial load is controlled by the third stage (which is a candidate Delta III configuration), radial accelerations due to spin must be included.

Spacecraft combined-loading qualification testing is accomplished by a static load test or on a centrifuge. Generally, static load tests can be readily performed on structures with easily defined load paths, whereas for complex spacecraft assemblies, centrifuge testing may be the most economical.

Test duration should be 30 sec. Test tolerances and mounting of the spacecraft for centrifuge testing should be accomplished per Paragraph 4, Method 513, Military Standard 810E, Environmental Test Methods, dated 14 July 1989, which states:

"After the test item is properly oriented and mounted on the centrifuge, measurements and calculations must be made to assure that the end of the test item nearest to the center of the centrifuge will be subjected to no less than 90 percent of the g level established for the test. If the g level is found to be less than 90 percent of the established g level, the test item must be mounted further out on the centrifuge arm and the rotational speed adjusted accordingly or a larger centrifuge used so that the end of the test item nearest to the center of the centrifuge is subjected to at least 90 percent of the established g level. However, the opposite end of the test item (the end farthest from the center of the centrifuge) should not be subjected to over 110 percent of the established g level. For large test items, exceptions should be made for load gradients based on the existing availability of large centrifuges in commercial or government test facilities."

4.2.4.2 Acoustic Testing. The 95th percentile acoustic environment is increased by 3.0 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 level is equal to the 95th percentile acoustic environment. The acoustic acceptance test duration is 60 sec.

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.

4.2.4.3 Sinusoidal Vibration Testing. The maximum flight sinusoidal vibration environments defined in Section 4.2.3.4 are increased by 3.0 dB (a factor of 1.4) for spacecraft qualification and protoflight testing. For spacecraft acceptance testing, the sinusoidal vibration test levels are equal to the maximum flight sinusoidal vibration environments defined in Section 4.2.3.4.

The spacecraft sinusoidal vibration qualification test consists of one sweep through the specified frequency range using a logarithmic sweep rate of 2 octaves per minute. For spacecraft acceptance and protoflight testing, the test consists of one sweep through the specified frequency range using a logarithmic sweep rate of 4 octaves per minute. The sinusoidal vibration test input levels should be maintained within ±10% of the nominal test levels throughout the test frequency range.

When testing a spacecraft with a shaker in the laboratory, it is not within the current state of the art to duplicate the boundary conditions at the shaker input 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 spacecraft/launch vehicle dynamic coupling.

Where it can be shown by a spacecraft /launch vehicle coupled dynamic loads analysis that the spacecraft or payload attach fitting would experience unrealistic response levels during test, the sinusoidal vibration input level can be reduced (notched) at the fundamental resonances of the hard-mounted spacecraft or payload attach fitting to more realistically simulate flight loading conditions. This has been accomplished on many previous spacecraft in the lateral axis by correlating one or several accelerometers mounted on the spacecraft to the bending moment at the payload attach fitting separation plane. The bending moment is then limited by (1) introducing a narrow-band notch into the sinusoidal vibration input program or (2) controlling the input by a servo-system using a selected accelerometer on the spacecraft as the limiting monitor. A redundant accelerometer is usually used as a backup monitor to prevent shaker runaway.

The Delta III program normally conducts a spacecraft/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 payload attach fitting, which is designed for a wide range of spacecraft configurations and weights. The spacecraft user should coordinate with the Delta Program Office for information on the spacecraft/launch vehicle coupled dynamic loads analysis for that specific mission or similar missions before developing the sinusoidal vibration test plan. 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 spacecraft system-level shock testing is to use a Delta III flight configuration spacecraft separation system and payload attach assembly with functional ordnance devices. Spacecraft qualification and protoflight shock testing are performed by installing the spacecraft separation system in flight configuration and activating the separation system twice. Spacecraft shock acceptance testing is performed in a similar manner by activating the 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 roll, final spacecraft orientation, and separation.

Spin-Balance Requirements. There are no specific static and dynamic balance constraints for the spacecraft. However, for both nonspinning and spinning spacecraft, the static imbalance directly influences the spacecraft angular rates at separation. When there is a separation tip-off rate constraint, the spacecraft center of gravity (CG) offset must be coordinated with Boeing for evaluation. For spinning spacecraft, the dynamic balance directly influences the angular momentum vector pointing and centerline pointing. When there are spacecraft constraints on these parameters, the dynamic balance must be coordinated with Boeing for evaluation.

Second-Stage Roll Rate Capability. For some two-stage missions, the spacecraft may require a low roll rate at separation. The Delta III second stage can command roll rates up to 5 rpm (0.52 rad/s) using control jets. Higher roll rates are also possible; however, roll rates higher than 5 rpm (0.52 rad/s) must be coordinated with Boeing and be assessed relative to specific spacecraft requirements.

4.2.5.2 Three-Stage Missions. A Delta III third-stage configuration is being investigated and the assumed motor would be a spin-stabilized Star 48B, which is being successfully used on Delta II. For a complete description of spacecraft balance requirements, spin-rate capabilities, spin-up angular acceleration, and nutation control system function, please refer to the Delta II Payload Planners Guide.

Section 5
SPACECRAFT INTERFACES

This section presents the detailed descriptions and requirements of the mechanical and electrical interfaces of the launch vehicle with the spacecraft.

Because of the development time and cost associated with a custom payload attach fitting (PAF), it is to the advantage of the spacecraft agency to use existing PAF designs. As early as possible in the design phase, selection of an appropriate PAF should be coordinated with Delta Launch Services.

5.1 STRUCTURE AND MECHANICAL DESIGN

The launch-vehicle-to-spacecraft interface can be tailored to suit the user's spacecraft. The Delta III PAF uses a structural design evolved from demand for a lighter weight structure with a minimal part count. Some of the key features follow.

- High-modulus graphite epoxy/foam core sandwich construction for the conic shell.
- One-piece aluminum rings at each end for interface to the upper stage and payload.
- Efficient double-splice lap joints to join end rings to the conic shell.
- High-modulus graphite epoxy/foam core sandwich diaphragm structure that provides a barrier to the upper 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. Boeing offers several PAF configurations for use on Delta III two-stage missions, as shown in Figure 5-1. PAFs compatible with the Star 48B third-stage motor are currently being studied for use on Delta III.

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 III PAF.

The PAF for two-stage missions has a separation system that is activated by a power signal from the Delta III second stage. The spacecraft is separated by activation of explosive nuts or by the release of a V-block-type band clamp assembly followed by action of the spring separation system. The Delta III spring separation system can be tailored to suit each customer's needs.

PAF components are mounted on its surface. All hardware necessary for mating and separation (e.g., PAF, clamp assembly, studs, separation springs) remains with the PAF upon spacecraft separation.

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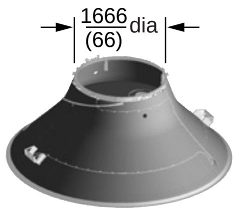
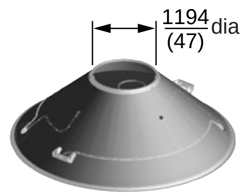
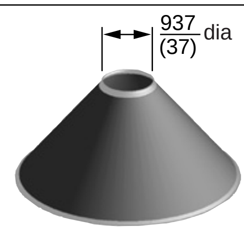
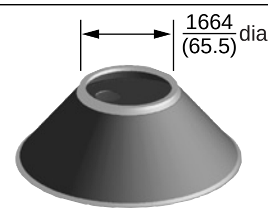
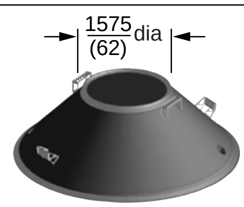
Delta 1666-4 PAF		1666 (66) dia clampband	Two calibrated spacers to verify clampband preload. Four matched springs to provide tip-off rate <2.0 deg/sec or differential springs to provide different tip-off rate. Retention system prevents clampband recontact.
Delta 1194-4 PAF		1194 (47) dia clampband	Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact.
Delta 937-4 PAF		937 (37) dia clampband	Two calibrated spacers to verify clampband preload. Four matched spring or differential spring actuators to provide different tip-off rate. Retention system prevents clampband recontact.
Delta 1664-4 PAF		Four separation bolts in a 1664 (65.5) dia bolt circle	Four hard-point attachments, released by four pairs of redundantly initiated explosive nuts. Four differential springs to provide a tip-off rate.
Delta 1575-4 PAF		121 bolts in a 1575 (62) dia bolt circle	62.010-in. bolted interface

mm
(in.)

Figure 5-1. Delta III 4-m Payload Attachment Fittings

5.1.1 Payload Attach Fitting 1666-4

The 1666-4 PAF uses 1666-mm (66-in.) V-block-type clampband interface. The PAF is a 1613-mm (63.5-in.) high one-piece conical composite structure with a 1666-mm (66-in.)-dia spacecraft clampband interface (Figures 5-2, 5-3, and 5-4). The spacecraft is fastened to the PAF by a two-piece V-block-type clamp assembly secured by two studs. Calibrated spacers are used to preload the clamp assembly to 30,000N (6744 lb). Spacecraft separation is initiated by actuation of cutters that sever the two studs. Clamp assembly design is such that cutting either stud will permit spacecraft separation. Springs assist in retracting the clamp assembly into retainers after release. A relative separation velocity is imparted to the spacecraft by four spring actuators (Figures 5-5 and 5-6). The

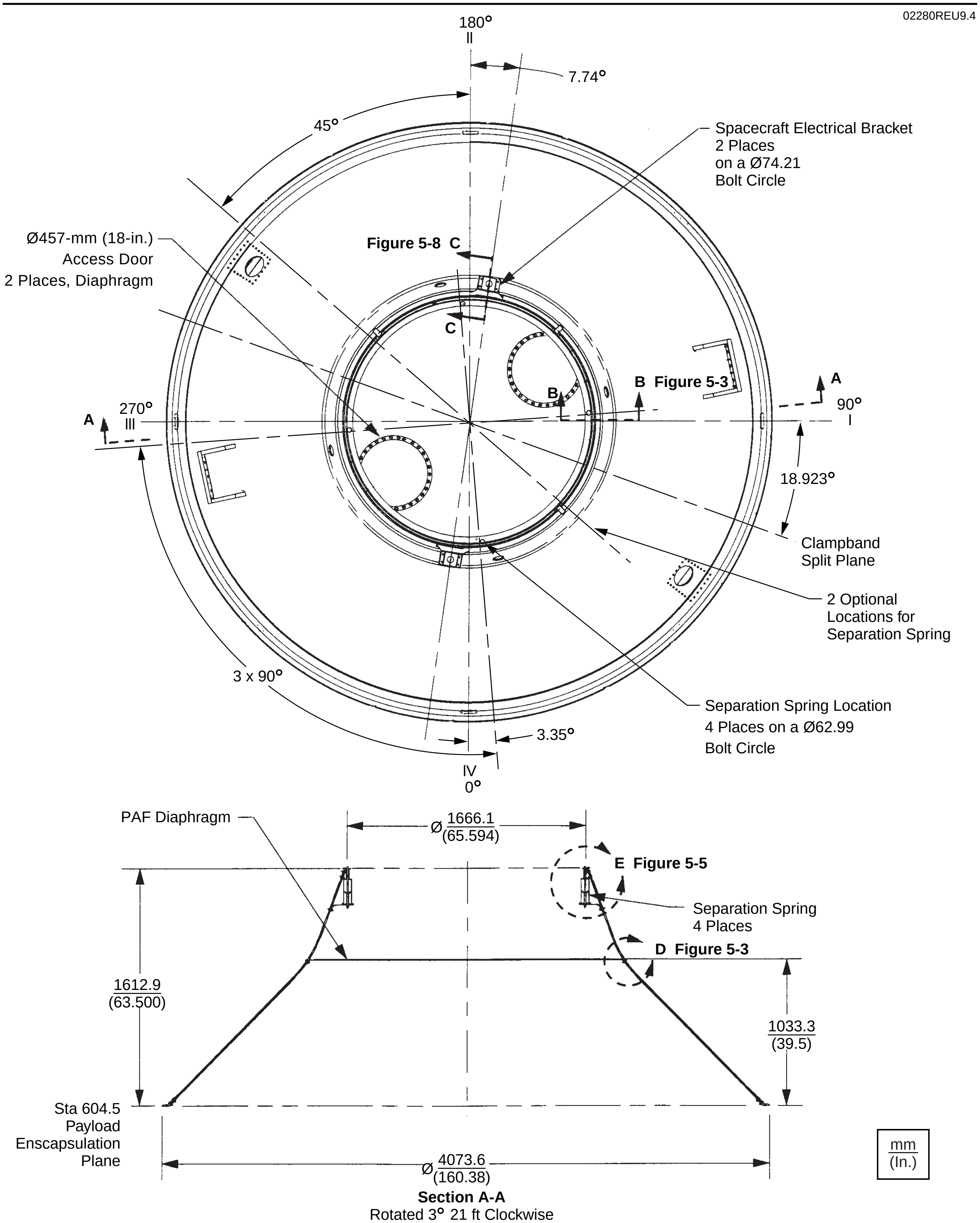


Figure 5-2. Delta III 1666-4 PAF Detailed Assembly

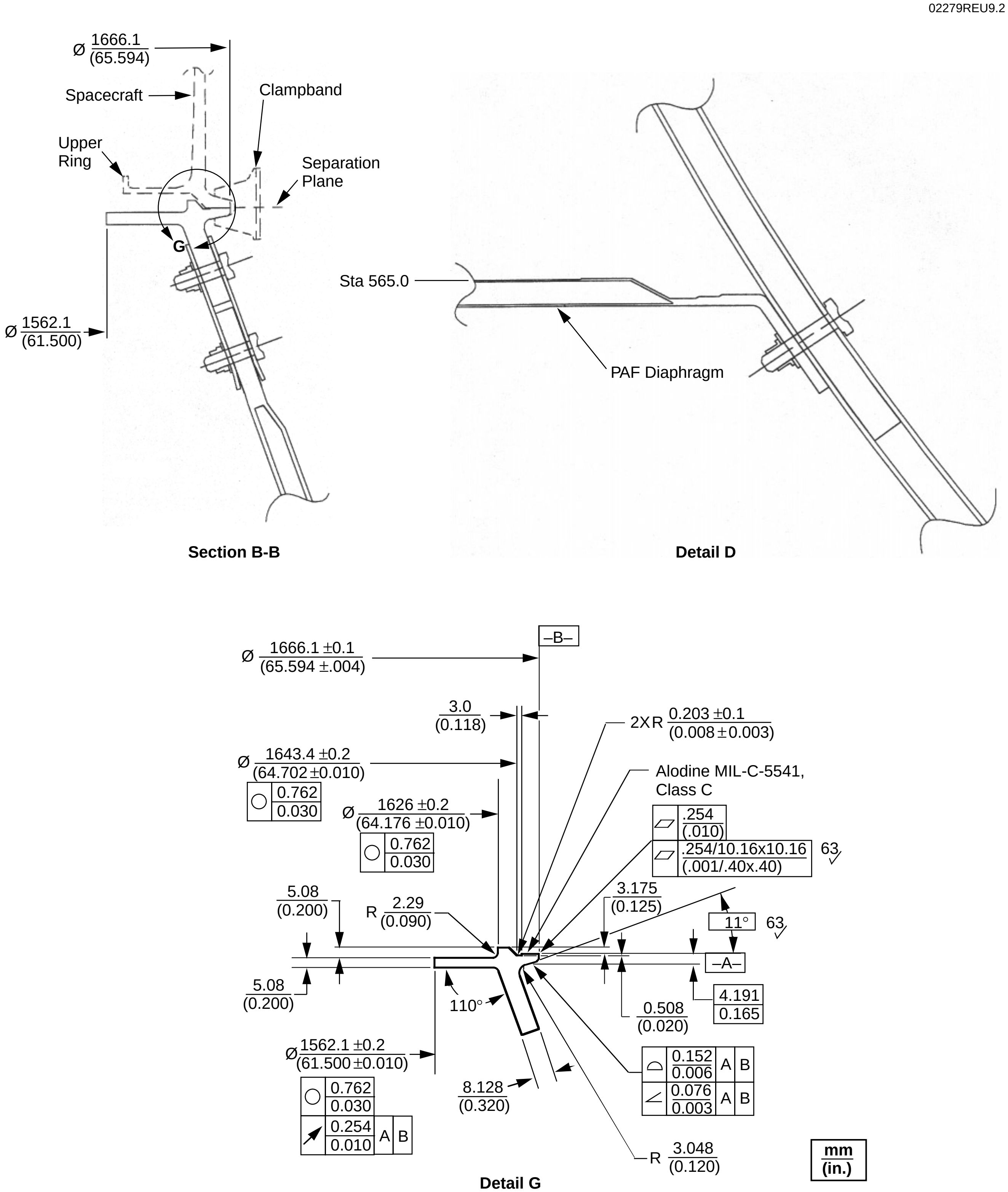


Figure 5-3. Delta III 1666-4 PAF Assembly

clampband installation and release envelope is shown in Figure 5-7.

Two electrical umbilical disconnects between the spacecraft and PAF will be provided for spacecraft servicing requirements (Figure 5-8).

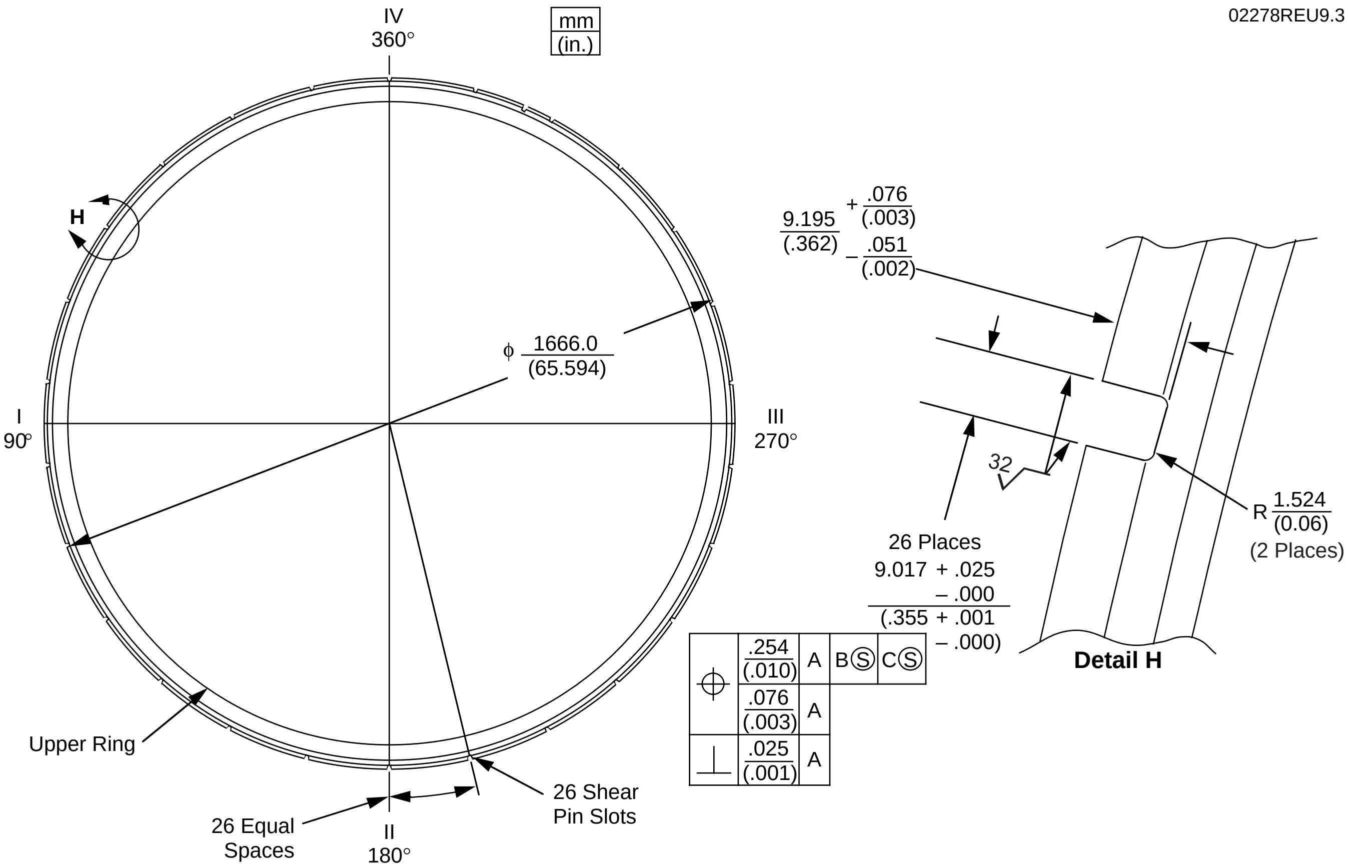


Figure 5-4. Delta III 1666-4 PAF Upper Ring Detail

A T-0 GN_2 purge system across the spacecraft separation plane is offer as a nonstandard service option (Figure 5-9). The GN_2 purge can be supplied from facility MIL-P-27401C, Type 1, Grade B nitrogen or from customer-supplied K-bottles or dewars.

5.1.2 Payload Attach Fitting 1194-4

The 1194-mm (47-in.) interfaces are derivatives of the 1666-4 payload attach fitting, providing a Marmon-type clampband separation system with separation spring actuators. Details of the 1194-4 PAF are shown in Figure 5-10 and 5-11.

5.1.3 Payload Attach Fitting 937-4

The 937-mm (37-in) PAF provides a Marmon-type clampband separation system with separation spring actuators similar to those developed on the Delta II program. Payload umbilical disconnects and separation spring assemblies are similar to those used on other Delta III PAFs. Details of the 937-4 PAF are shown in Figure 5-12.

5.1.4 Payload Attach Fitting 1664-4

The 1664-mm (65-in.) PAF provides a four-point, bolted separation system similar to that which has successfully flown on the Delta II program. The PAF also uses umbilical disconnects and separation spring assemblies similar to that of

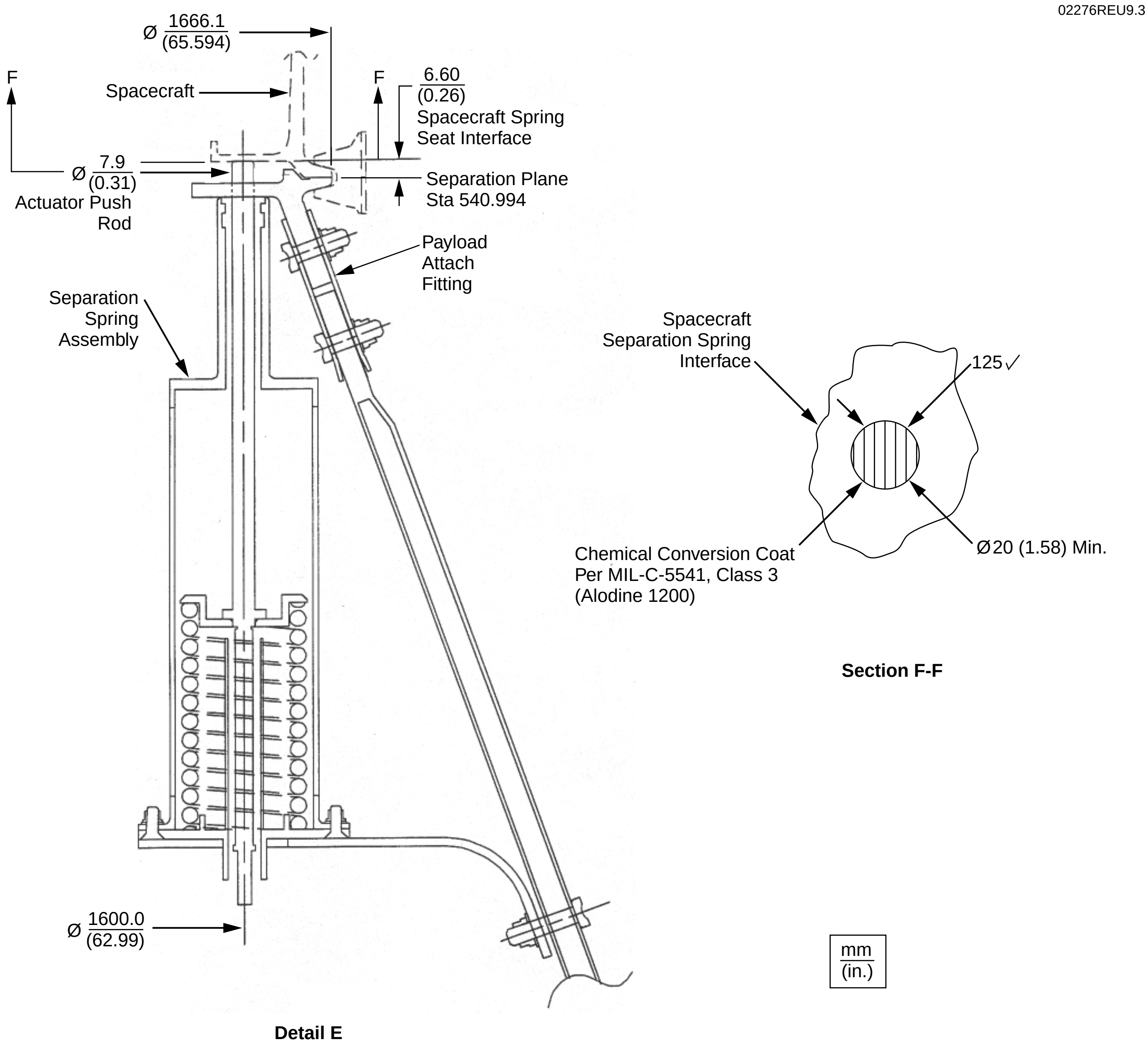


Figure 5-5. Delta III 1666-4 PAF Separation Spring Interface

the 1666-mm (66-in.) interface. Details of the 1664-4 PAF are shown in Figure 5-13.

5.1.5 Payload Attach Fitting 1575-4

The 1575-mm (62-in.) PAF provides a standard 121-bolt mating interface, at a 1575-mm (62.01-in.) dia. Details of the 1575-4 PAF are shown in Figures 5-14 and 5-15. 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.

5.1.6 Test Payload Attach Fittings and Fit-Check Policy

A fit-check, using the flight PAF, is typically performed at the spacecraft manufacturing facility. The fit check is performed with the assigned PAF for that mission. The separation

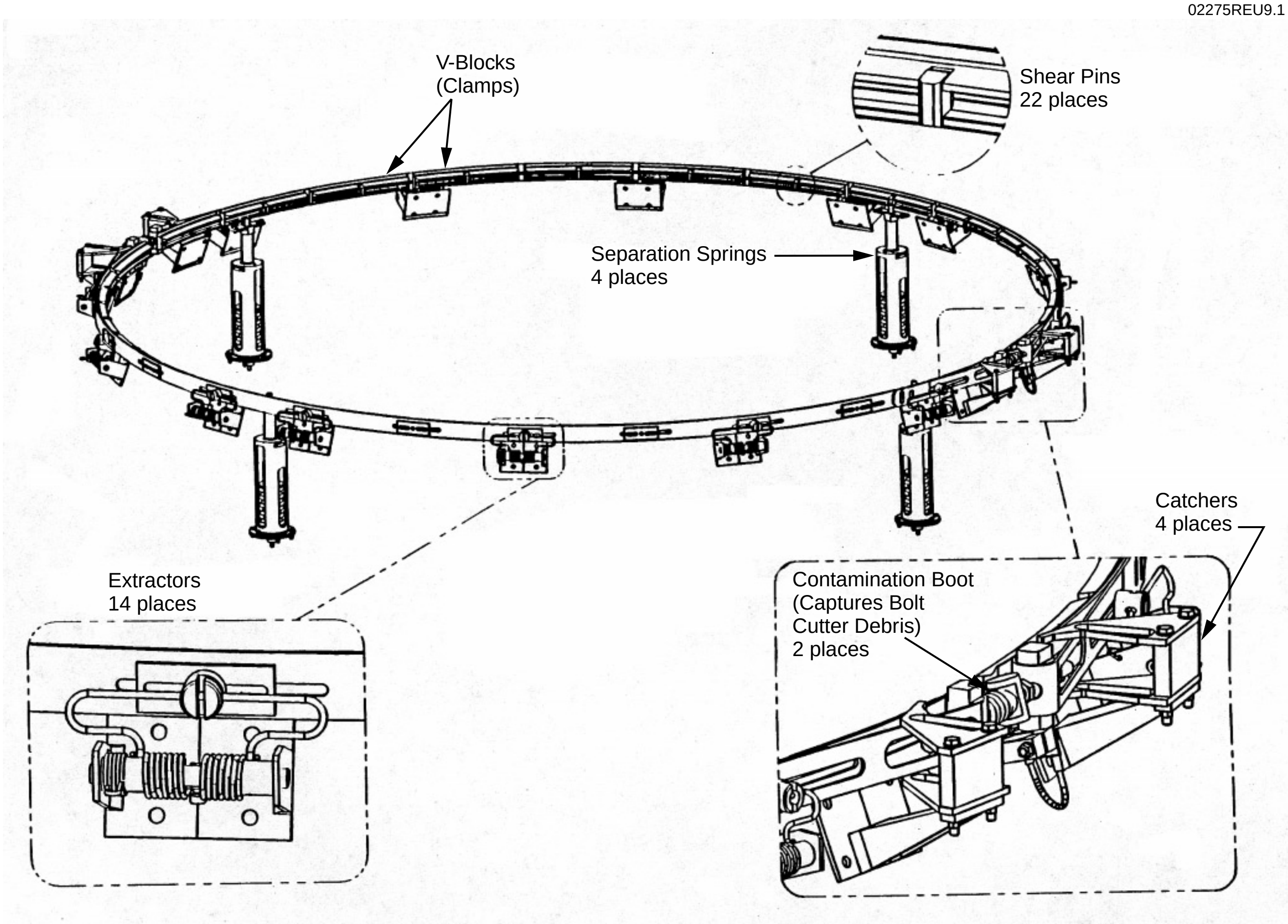


Figure 5-6. Delta III 1666-4 PAF SS66D Clampband Separation System

system clampband is also installed at this time to validate proper fit prior to shipment to the launch site.

5.2 DELTA III THIRD-STAGE INTERFACE

A Delta III third-stage configuration is being investigated. The assumed Delta III third-stage motor would be a Star 48B, which is being successfully used on Delta II. For a complete description of payload attach fittings compatible with the Star 48B third-stage motor, please refer to the Delta II Payload Planners Guide (MDC H3224D, April 1996). (See Section 6.2.3.)

5.3 ELECTRICAL INTERFACES

Descriptions of the spacecraft/vehicle electrical interface design constraints are presented in the following paragraphs.

5.3.1 Blockhouse-to-Spacecraft Wiring

Boeing provides wiring between the blockhouse and the white room to enable the customer to communicate with the encapsulated spacecraft. Wiring is routed from a remotely operated, customer-supplied payload console in the blockhouse through a second-stage umbilical connector to the spacecraft, through payload attach fitting interface connectors. The remote operation is controlled

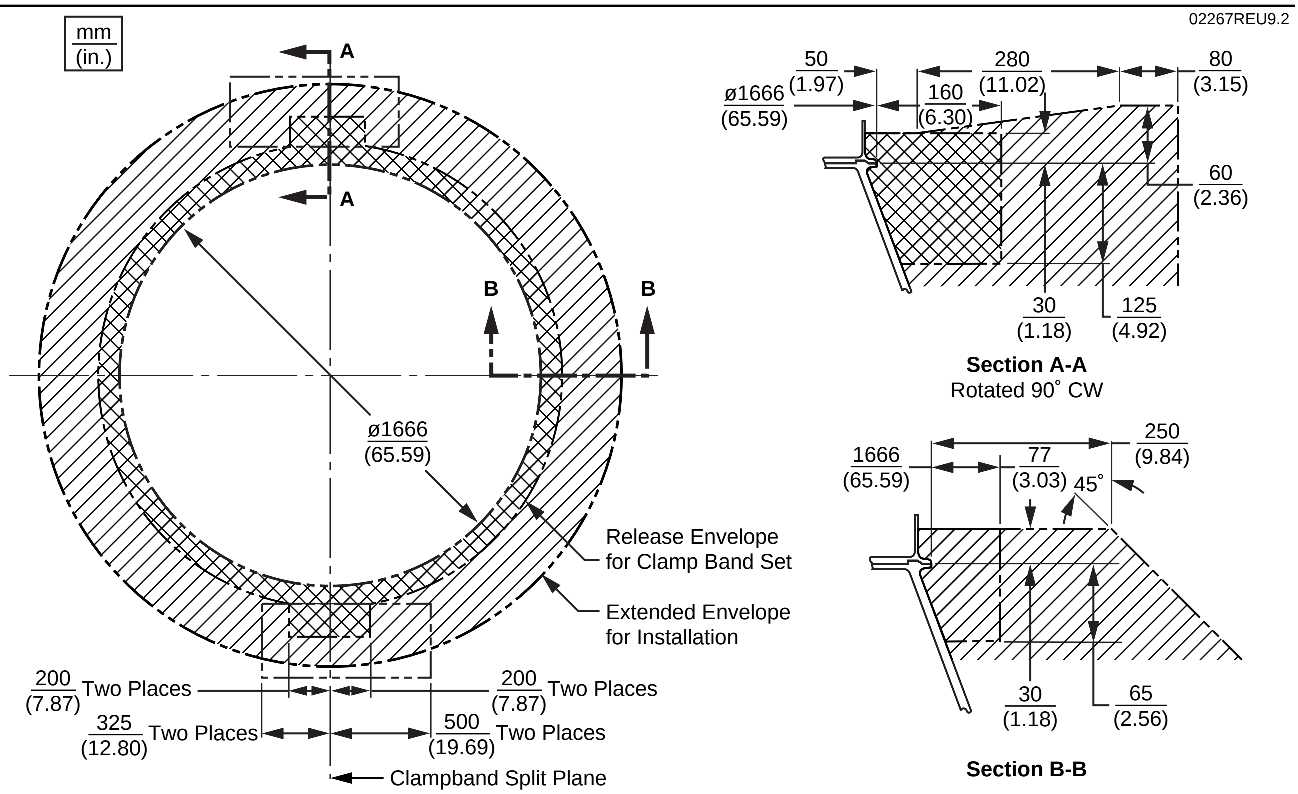


Figure 5-7. Clampband Assembly Envelope

from the spacecraft ground station, normally located at Astrotech. Provisions have also been made for monitoring the spacecraft from the 1st Space Launch Squadron Operations Building (1SLS OB). (See Section 6.2.3.) The customer may use the blockhouse console directly until the launch pad is evacuated several hours prior to launch. Safety regulations may also prevent the customer from using the blockhouse console directly during certain hazardous Delta prelaunch operations.

A second-stage umbilical connector (JU3) is provided for spacecraft servicing. A typical baseline wiring configuration provides up to 61 wires through each of the two payload attach assembly interface connectors and 122 wires through the JU3. Alternatively, wiring can be routed along each fairing sector to connect directly to the spacecraft. Additional wiring can be provided by special modifications. Available wire types are twisted/shielded pairs, single shielded, or unshielded single conductors and coaxial conductor.

The baseline wiring configuration between the fixed umbilical tower (FUT) (refer to Section 6 for further discussion on Cape Canaveral Air Station (CCAS) facilities) and the blockhouse follows.

At CCAS, the configuration at Space Launch Complex 17 (SLC-17) consists of 60 twisted and shielded pairs (120 wires, No. 14 AWG), 12 twisted and shielded pairs (24 wires, No. 16 AWG), and 14 twisted pairs (28 wires, No. 8 AWG).

Space is available in the blockhouse for installation of the ground support equipment (GSE) required for spacecraft checkout. The

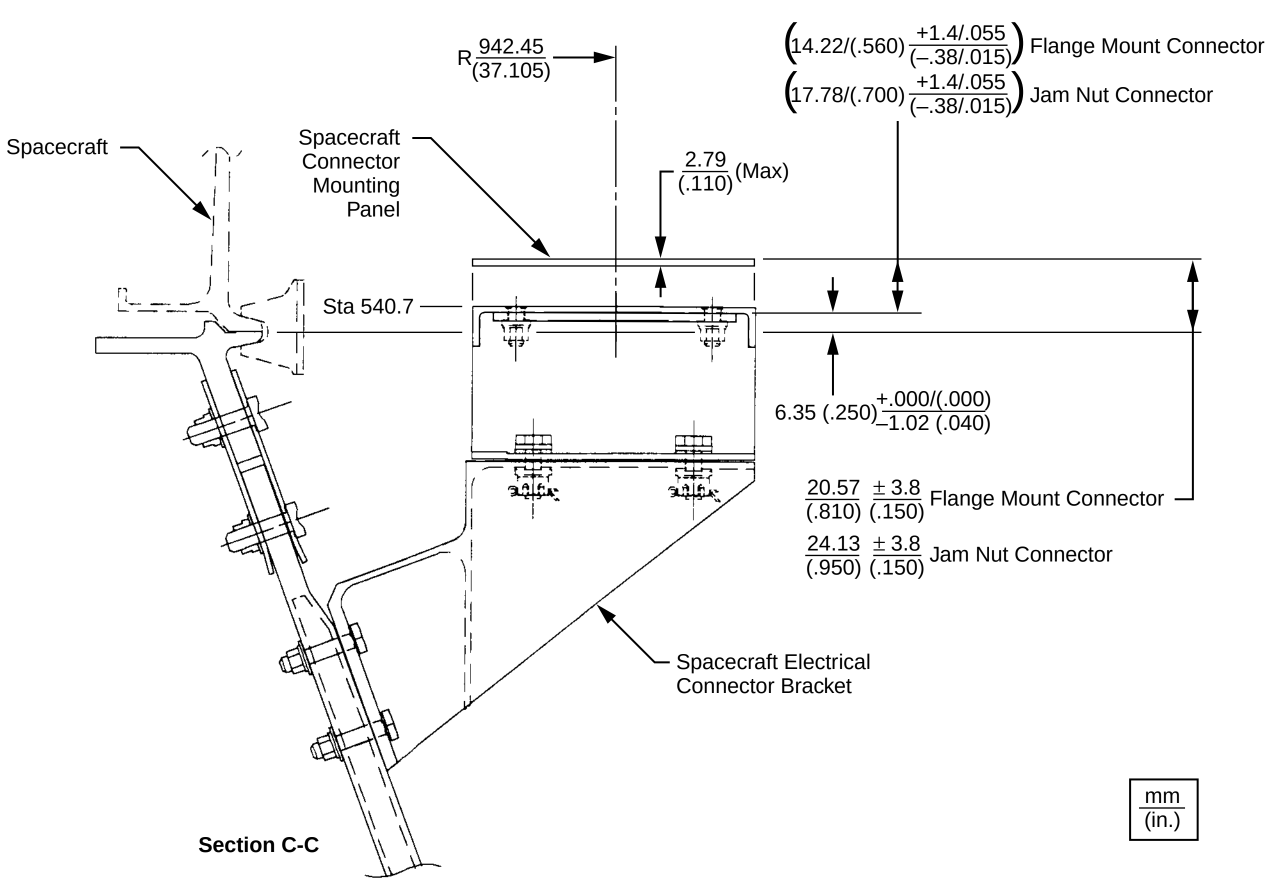


Figure 5-8. Delta III 1666-4 PAF Spacecraft Electrical Connector Interface

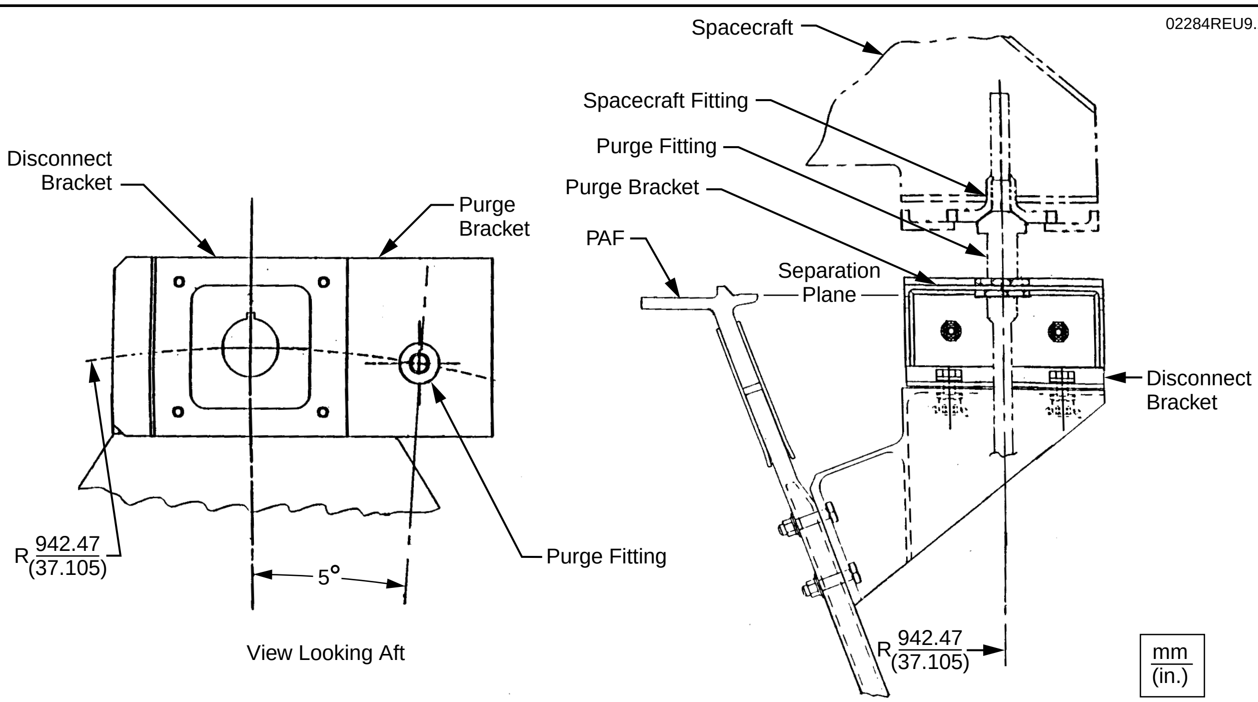


Figure 5-9. Delta III 1666-4 PAF Optional GN_2 Purge Interface

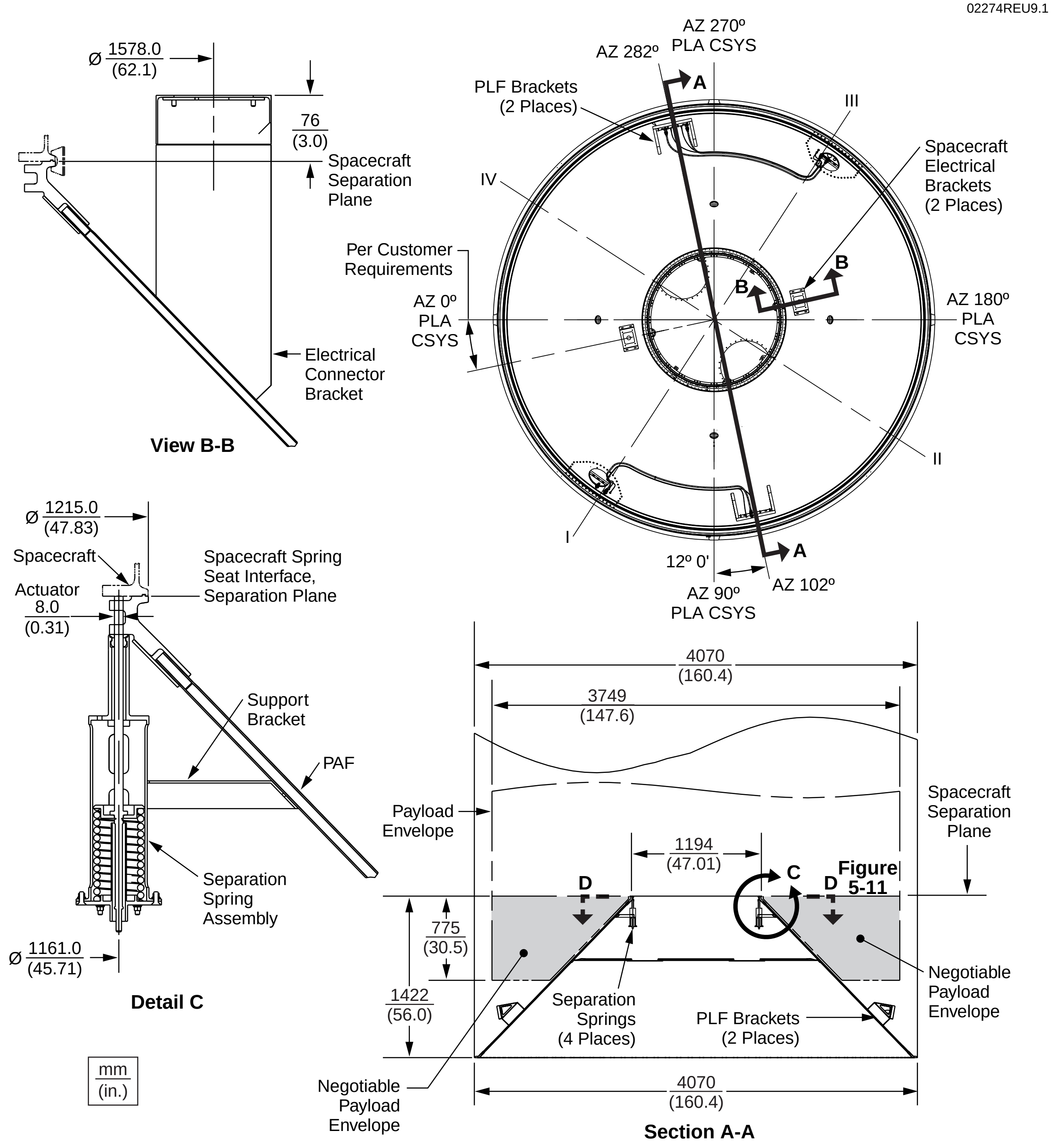


Figure 5-10. Delta III 4-m 1194-4 PAF

space allocated for the spacecraft GSE is described in Section 6 for SLC-17. There is also limited space in the umbilical J-box for a buffer amplifier or other data line conditioning modules required for data transfer to the blockhouse. The space allocated in the J-box for this equipment has dimensions of approximately 303 mm by 305 mm by 203 mm (12 in. by 12 in. by 8 in.) at SLC-17.

The standard electrical interface method is as follows.

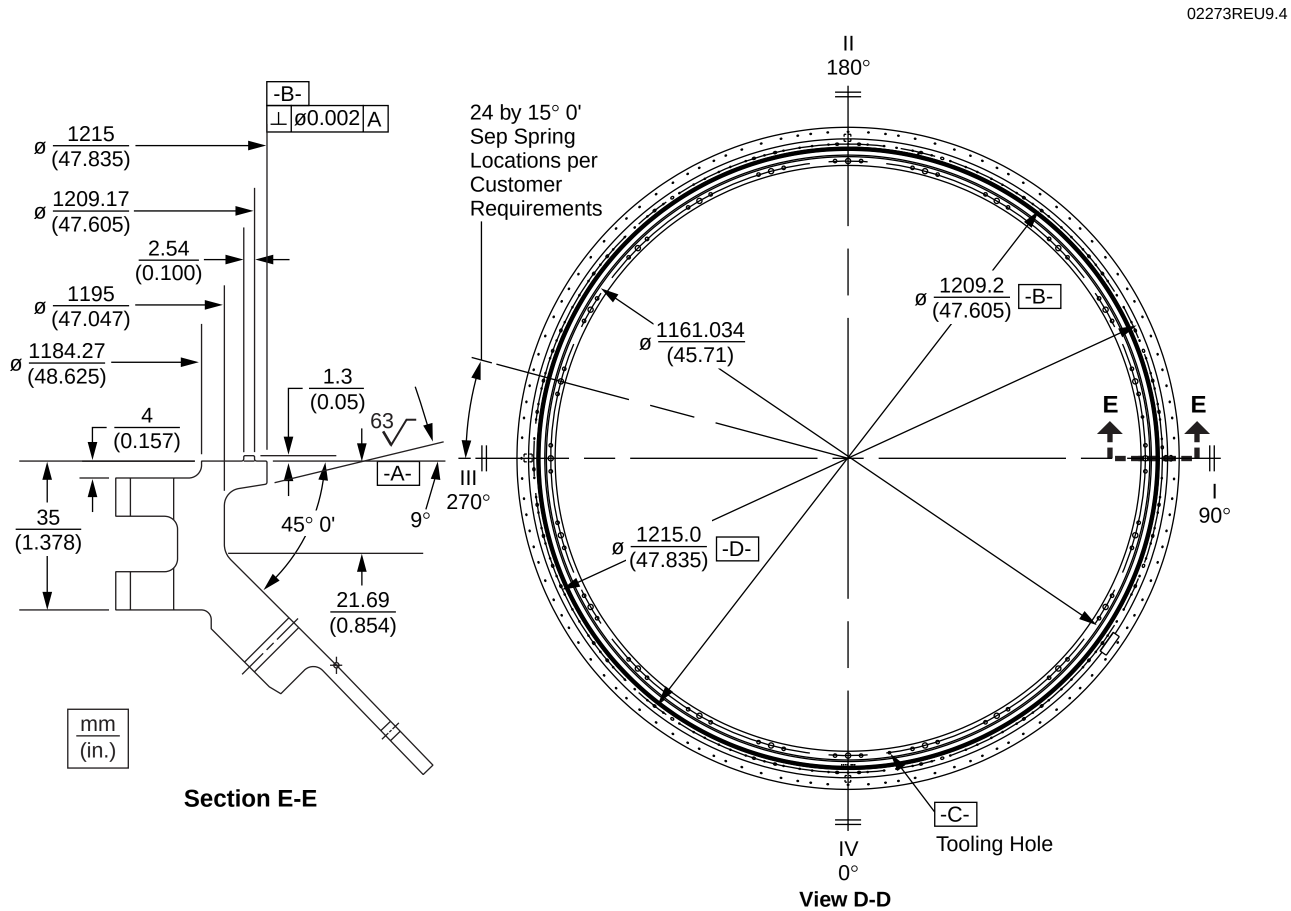


Figure 5-11. Delta III 4-m 1194-4 PAF Mechanical Interface

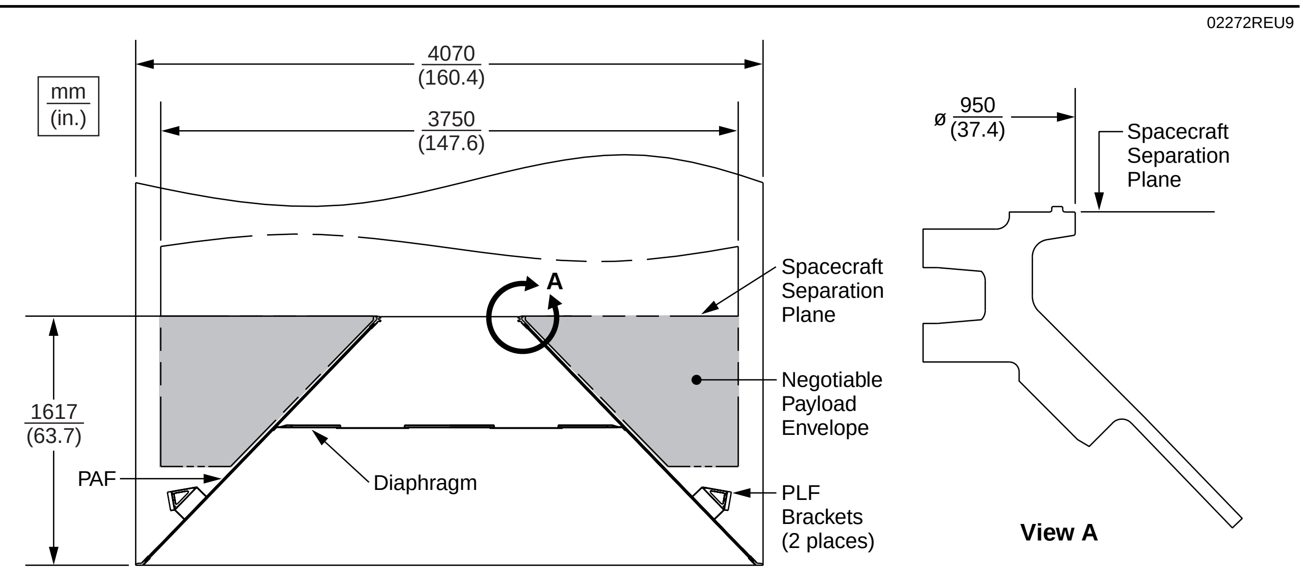


Figure 5-12. Delta III 4-m 937-4 PAF

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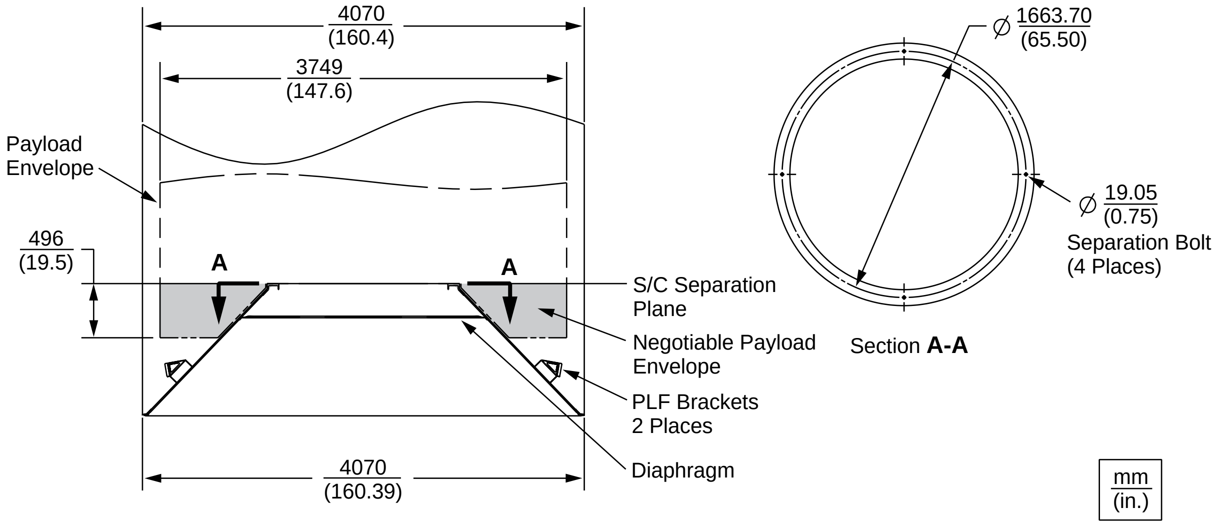


Figure 5-13 Delta III 4-m 1664-4 Four-Point-Bolted PAF

- The spacecraft contractor typically provides a console and a 12.2-m (40-ft.) cable to interface with the spacecraft junction box in the blockhouse. Boeing will provide the interfacing cable if requested by the customer.
- The spacecraft apogee motor safe-and-arm circuit (if applicable) must interconnect with the pad safety supervisor's console (PSSC).
- A spacecraft-to-blockhouse wiring schematic is prepared for each mission from requirements provided by the spacecraft contractor.
- To ensure proper design of the spacecraft-to-blockhouse wiring, the following information, in addition to the above requirements, shall be furnished by the spacecraft contractor:

  – Number of wires required.

  – Pin assignments in the spacecraft umbilical connector(s).

  – Function of each wire including voltage, current, frequency, load type, magnitude, polarity, and maximum resistance or voltage drop requirements.

  – Shielding requirements for RF protection or signal noise rejection.

  – Voltage of the spacecraft battery and polarity of the battery ground.

  – Part number and item number of the spacecraft umbilical connector(s) (compliance required with the standardized spacecraft umbilical connectors listed in Section 5.3.2).

  – Physical location of the spacecraft umbilical connector including (1) angular location in relation to the quadrant system, (2) station location, and (3) radial distance of the outboard face of the connector from the vehicle centerline for a fairing disconnect or connector centerline for PAF disconnect.

  – Periods (checkout or countdown) during which hardline controlled/monitored systems will be operated.

A typical harness arrangement for on-pad checkout with the fairing installed is shown in Figure 5-16.

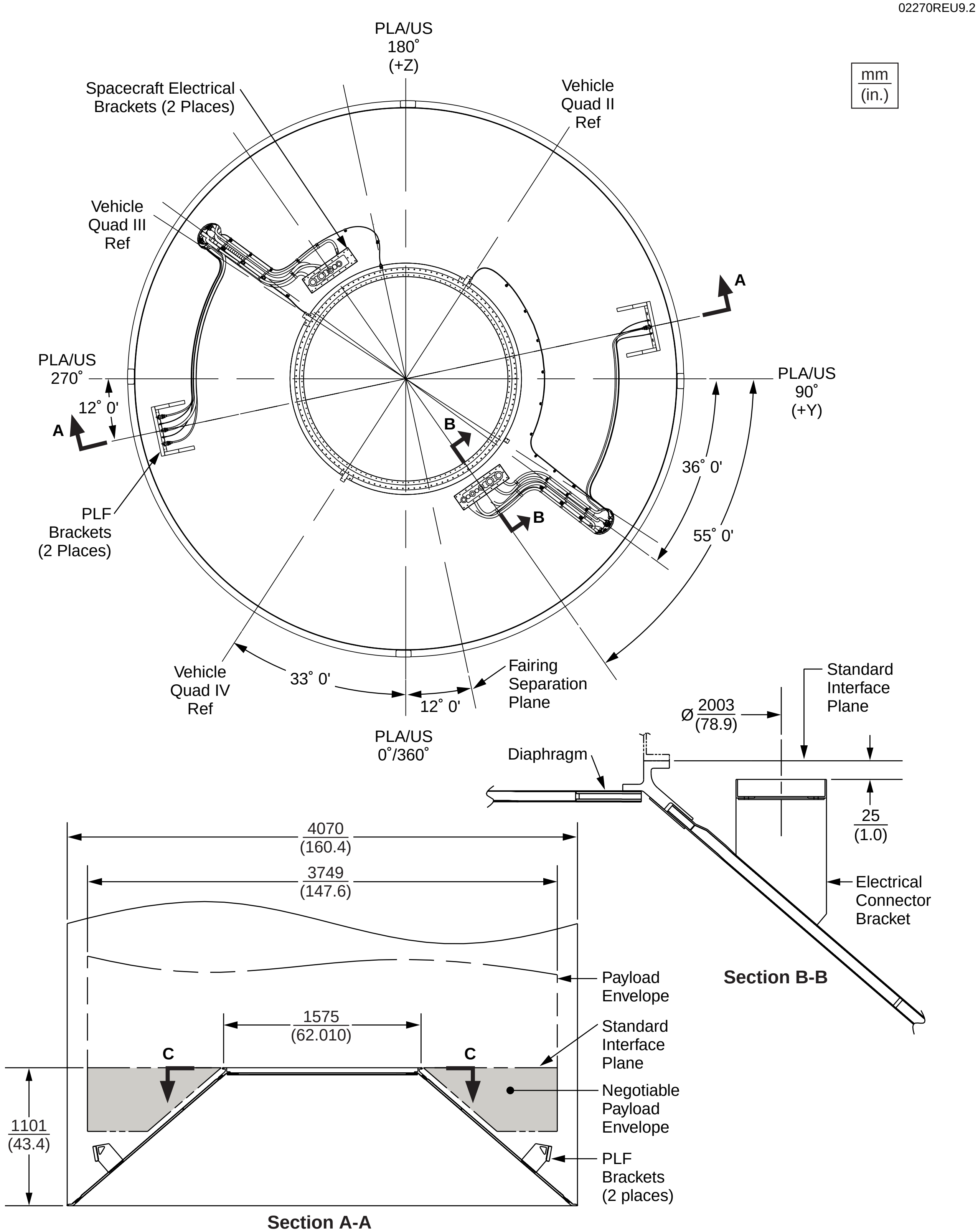


Figure 5-14. Delta III 4-m 1575-4 PAF Mechanical Interface

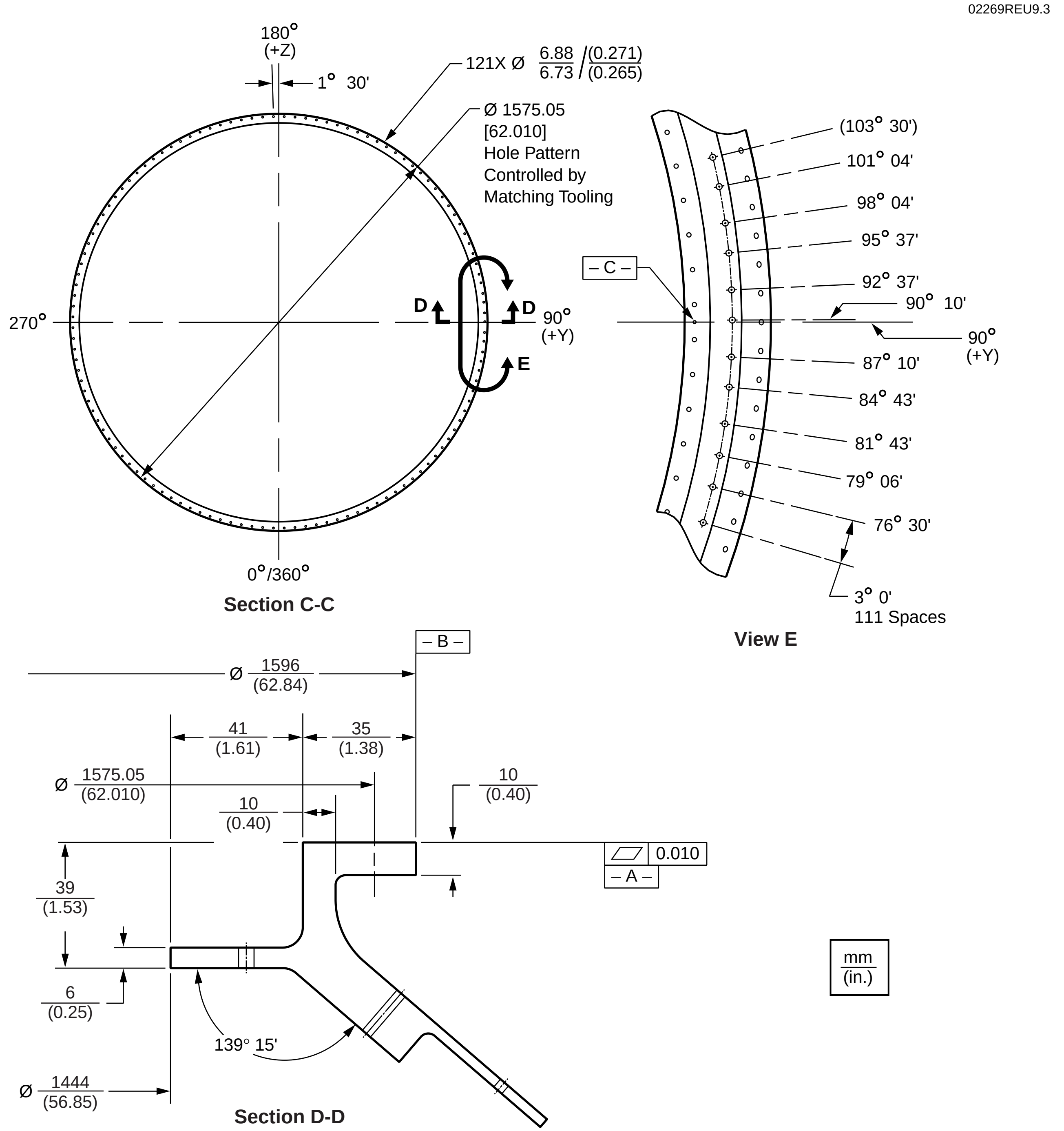


Figure 5-15. Delta III 4-m 1575-4 PAF Mechanical Interface—Detail

Each wire in the baseline spacecraft-to-blockhouse wiring configuration has a current-carrying capacity of 6 A, wire-to-wire isolation of 50 MΩ, and voltage rating of 600 VDC.

Typical one-way line resistance for any wire is shown in Table 5-1.

5.3.2 Spacecraft Umbilical Connectors

For spacecraft configurations in which the umbilical connectors interface directly to the payload attach fitting, the following connectors (conforming to MIL-C-26482) are recommended:

- MS3424E61-50S (flange-mount receptacle).
- MS3464E61-50S (jam nut-mount receptacle).

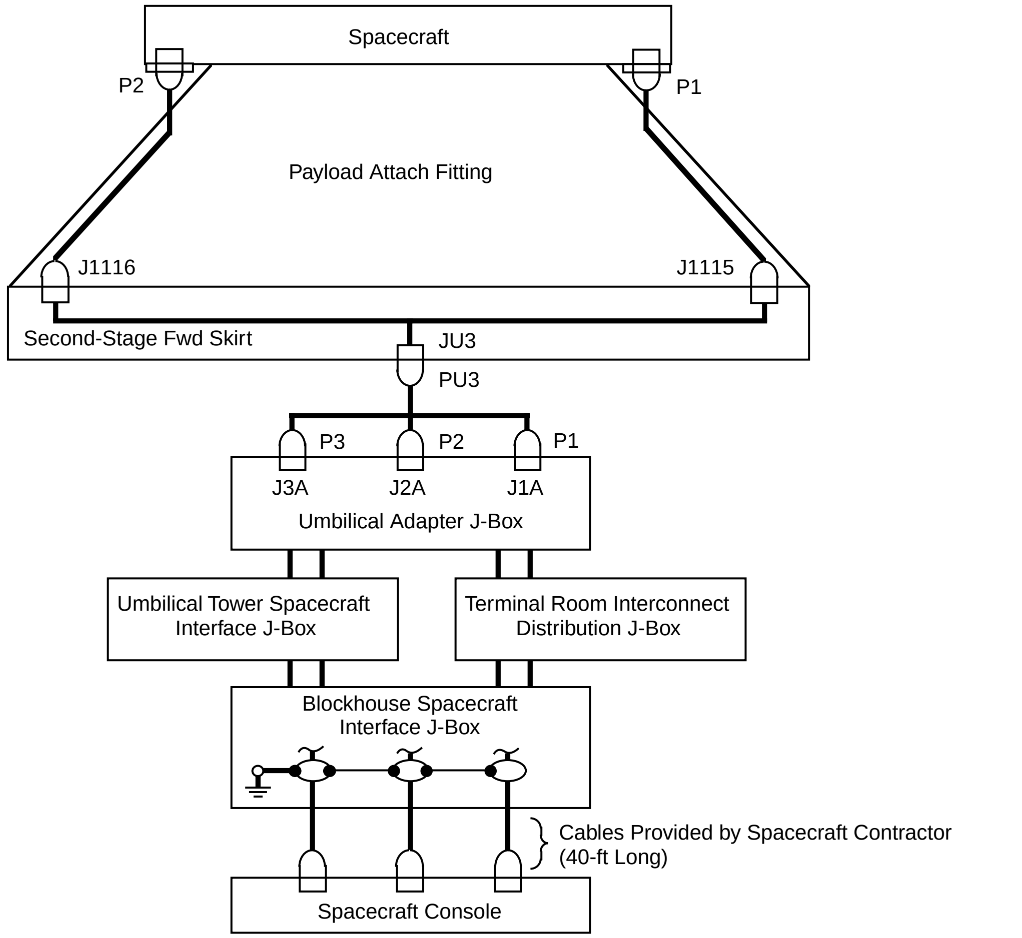


Figure 5-16. Typical Payload-to-Blockhouse Wiring Diagram for Delta III Missions at SLC-17

These connectors mate to a 61-pin MS3446E61-50P rack-and-panel mount interface connector on the payload attach fitting.

For spacecraft configurations in which the umbilical connectors interface directly with the fairing-wire harness, the following connectors (conforming to MIL-C-26482) are recommended:

- MS3470L18-32A (flange-mount receptacle).
- MS3474L18-32S (jam nut-mount receptacle).

These connectors mate to a 32-pin lanyard disconnect plug (Boeing part number ST290G18N32PN) in the fairing.

Table 5-1. One-Way Line Resistance

Location	Function	Number of wires	Fairing on* Length (m/ft)	Fairing on* Resistance (ohms)
CCAS	Data/control	60	348/1142	2.5
CCAS	Power	28	354/1160	1.3
CCAS	Data/control	24	354/1160	6.2
VAFB	**	**	**	**

*Resistance values are for two parallel wires between the fixed umbilical tower and the blockhouse.
**Being defined.

T5-1

Alternatively, the following connectors (conforming to MIL-C-81703) may be used when spacecraft umbilical connectors interface with the fairing-mounted wire harnesses or to the payload attach fitting (these connectors are manufactured by Deutsch):

- D817*E61-OSN.

- D817*E37-OSN.
- D817*E27-OSN.
- D817*E19-OSN.
- D817*E12-OSN.
- D817*E7-OSN.

If “*” is 0, the receptacle is flange-mounted; if 4, the receptacle is jam nut-mounted.

These connectors mate to a D817*E-series lanyard disconnect plug in the fairing or MS3446EXX series rack-and-panel plug on the PAF. The connector shell size numbers (i.e., 37, 27, etc.) also correspond to the number of contacts.

For spacecraft using the option with umbilical connectors that interface directly to the fairing wire harnesses, the spacecraft connector shall be installed so that the polarizing key is in line with the vehicle longitudinal axis and facing forward (upward). The connector shall be within 5 deg of the fairing sector centerline. The face of the connector shall be within 2 deg of being perpendicular to the centerline. A typical spacecraft umbilical connector is shown in Figure 5-17. There should be no surrounding spacecraft intrusion within a 30-deg half-cone angle separation clearance envelope at the mated fairing umbilical connector (Figure 5-18). Pull forces for the lanyard disconnect plugs are shown in Table 5-2. For spacecraft umbilical connectors interfacing with the PAF, the connector shall be installed so that the polarizing key is oriented radially outward. Spring compression and pin retention forces for the rack-and-panel connectors are shown in Table 5-3. Separation forces for the bayonet-mate lanyard disconnect connectors are shown in Table 5-4.

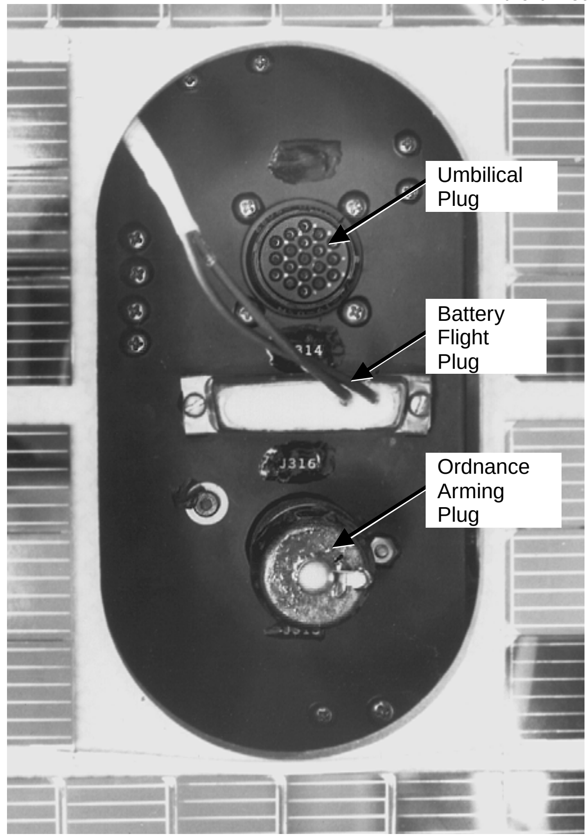


Figure 5-17. Typical Spacecraft Umbilical Connector

5.3.3 Spacecraft Separation Switch

To monitor vehicle/spacecraft separation, a separation switch can be installed in the spacecraft. The configuration must be coordinated with Boeing. This switch should be located to interface with the vehicle at the separation plane. The switch design should provide for at least 6.4 mm (0.25 in.) overtravel in the mated condition.A typical spacecraft separation switch configuration is shown in Figure 5-19. An alternative for obtaining a spacecraft separation indication is through the vehicle telemetry system.

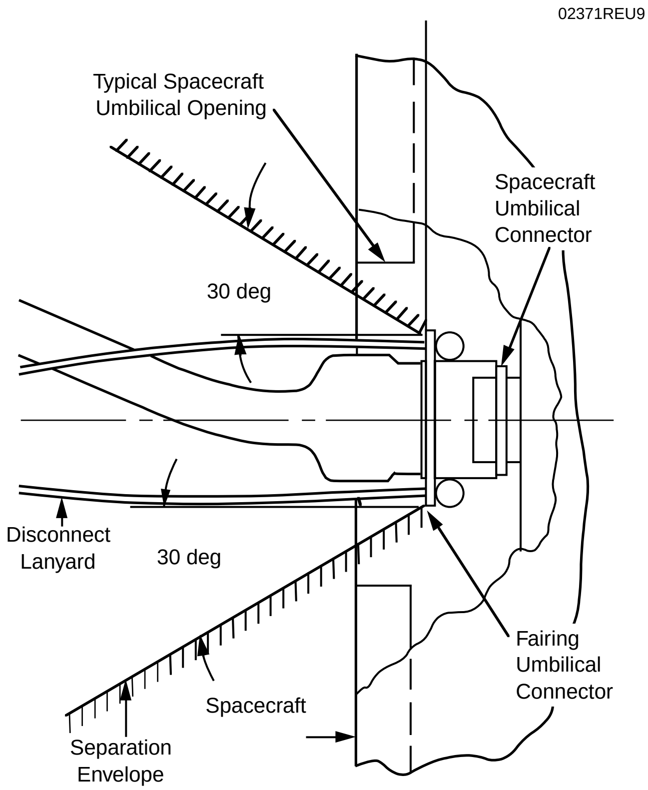


Figure 5-18. Spacecraft/Fairing Umbilical Clearance Envelope

Table 5-2. Disconnect Pull Forces (Lanyard Plugs)

Connector type	Shell size	Minimum force for disengagement		Maximum engagement and disengagement force	
		(lb)	(kg)	(lb)	(kg)
MS347X	18	8.0	3.63	35.0	15.88
D817X	61	7.0	3.17	49.0	22.21
D817X	37	6.0	2.72	44.0	19.96
D817X	27	4.0	1.81	40.0	18.14
D817X	19	3.0	1.36	38.0	17.24
D817X	12	2.0	0.91	34.0	15.42
D817X	7	1.5	0.68	20.0	9.07

T5-2

5.3.4 Spacecraft Safe and Arm Circuit

The spacecraft apogee motor safe-and-arm circuit (if applicable) must interconnect with the pad

Table 5-3. Disconnect Forces (Rack-and-Panel Connectors)

Connector type	Shell size	Maximum spring compression		Maximum pin retention	
		(lb)	(kg)	(lb)	(kg)
D817X	61	77	34.93	68	30.84
	37	48	21.77	50	22.68
	27	46	20.86	46	20.86
	19	45	20.41	46	20.86
	12	36	16.33	38	17.24
	7	18	8.16	20	9.07

T5-3.1

Table 5-4. Disconnect Forces (Bayonet-Mate Lanyards)

Connector type	Shell size	Min		Max	
		(lb)	(kg)	(lb)	(kg)
ST290X	12 14 16	8 8 8	3.63 3.63 3.63	20 30 30	9.07 13.61 13.61
	18 20 22	8 8 8	3.63 3.63 3.63	35 35 40	15.88 15.88 18.14
	24	8	3.63	40	18.14

T5-4

safety supervisor's console in the 1SLS OB. An interface diagram for the spacecraft blockhouse console and the pad safety supervisor's console is provided in Figure 5-20 for the 1SLS OB configuration. Circuits for the safe-and-arm (S&A) mechanism "arm permission" and the S&A talk-back lights are provided.

5.3.5 Special Interfaces

Additional functional interfaces such as redundant in-flight relay closures, 28-V commands or access to the launch vehicle telemetry system (to downlink spacecraft data) can be provided as optional services. Requests for these special interfaces should be made as early as possible through technical discussions with Delta Launch Services.

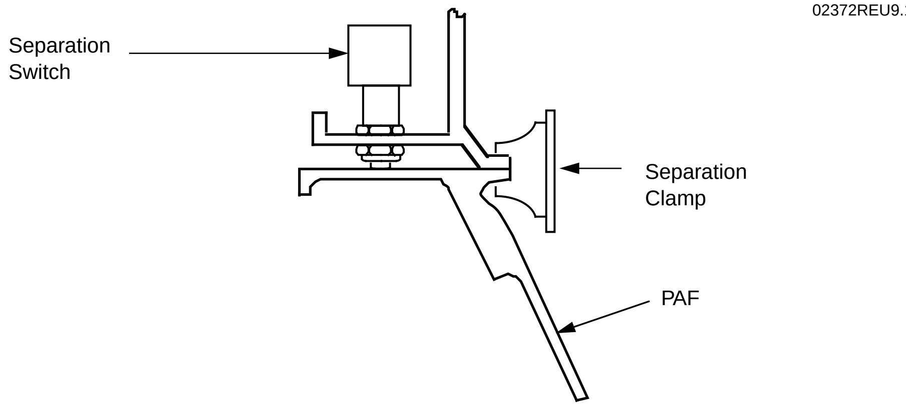


Figure 5-19. Typical Spacecraft Separation Switch and PAF Interface

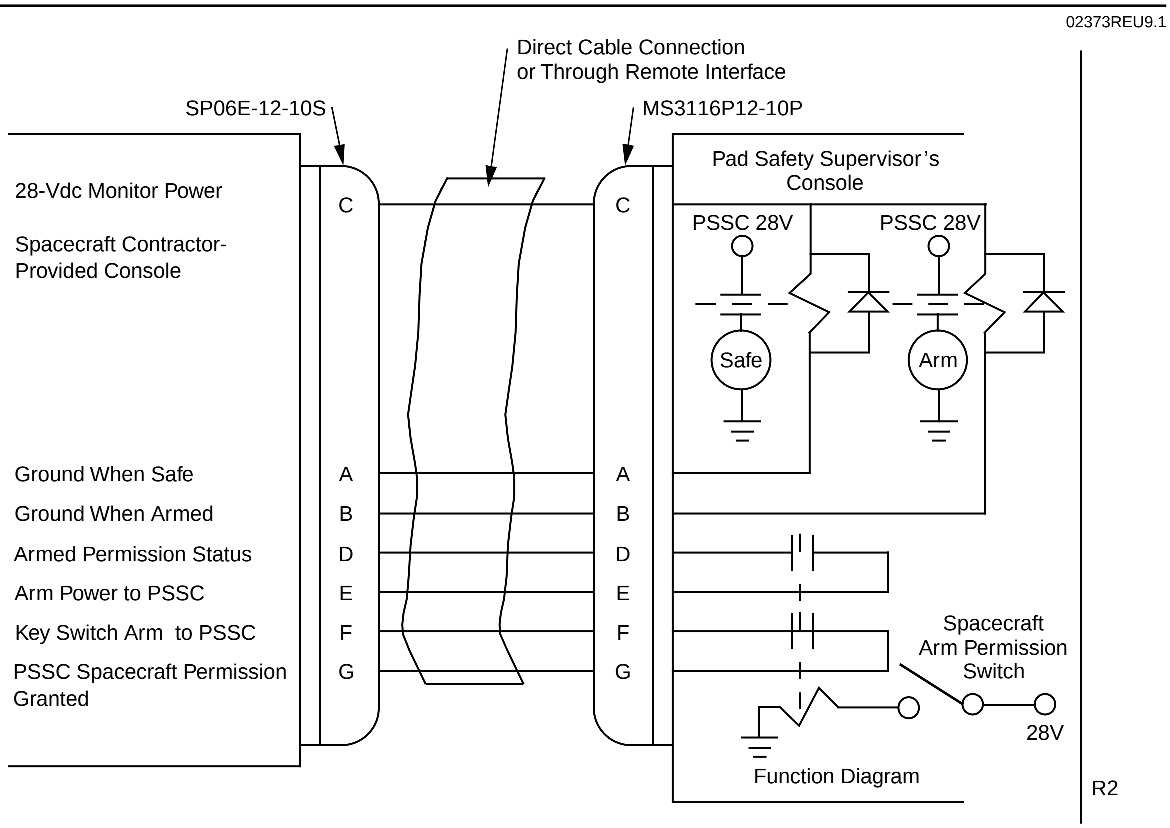


Figure 5-20. PSSC-to-Spacecraft Interface Diagram

Section 6
LAUNCH OPERATIONS AT EASTERN RANGE

This section presents a description of Delta launch vehicle operations associated with Space Launch Complex 17 (SLC-17) at the Cape Canaveral Air Station, (CCAS) Florida. Delta III 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 NASA, USAF, and commercial customers at CCAS. Boeing provides the interface to the Federal Aviation Administration (FAA) for the licensing and certification needed to launch commercial spacecraft using the Delta III. Boeing also has an established working relationship with Astrotech Space Operations (ASO). Astrotech owns and operates a processing facility for commercial spacecraft in Titusville, Florida, in support of Delta missions. Use of these facilities and services is arranged by Boeing for the customer.

Boeing interfaces with NASA at Kennedy Space Center (KSC) through the Expendable Launch Vehicles and Payload Carriers Program Office. NASA designates a launch site integration manager who arranges all of the support requested from NASA for a launch from CCAS. Boeing has an established interface with the 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, as well as 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 agency using the government's universal documentation system format (see Section 8, Spacecraft Integration). The organizations that support a launch are shown in Figure 6-1. A spacecraft coordinator from the Boeing CCAS launch team is assigned for each mission to assist the spacecraft team during the launch campaign by helping to obtain safety approval of the spacecraft test procedures and operations, integrating the spacecraft operations into the launch vehicle activities, and serving as the interface between the spacecraft personnel and test conductor in the launch control center during the countdown and launch.

6.2 FACILITIES

In addition to those facilities required for the Delta III launch vehicle, specialized facilities are provided for checkout and preparation of the spacecraft. Laboratories, clean rooms, receiving and shipping areas, hazardous-operations areas, offices, etc., are provided for use by spacecraft project personnel.

Commercial spacecraft will normally be processed through the Astrotech facilities. Other payload processing facilities, controlled by

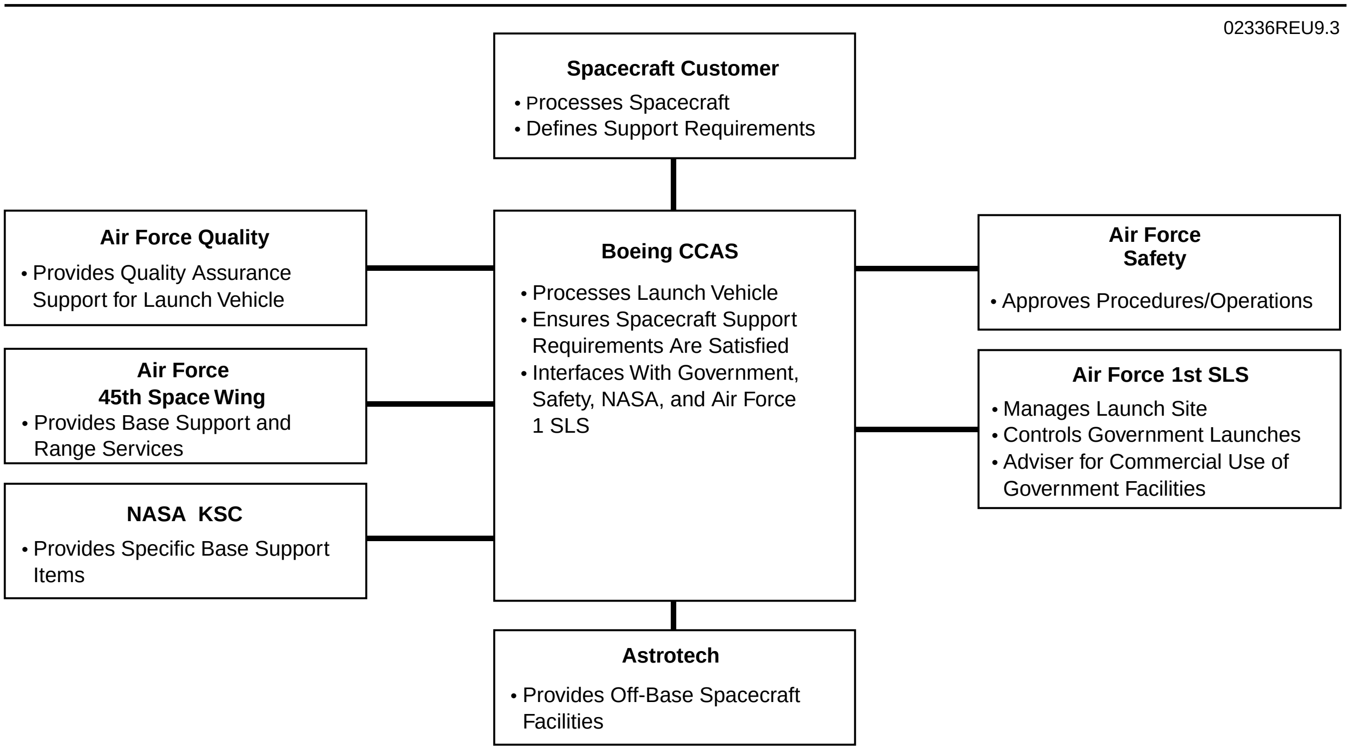


Figure 6-1. Organizational Interfaces for Commercial Users

NASA and the USAF, will be used only under special circumstances.

- Spacecraft nonhazardous payload processing facilities (PPF): Astrotech Space Operations Buildings 1 and 1A.
- Hazardous processing facilities (HPF): Astrotech Space Operations Building 2.

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 are services provided by Boeing from any of the local airports to the spacecraft processing facilities, and from there to the launch site. 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 (EED), radioactive sources, etc., must be in accordance with applicable regulations. It is the responsibility of the spacecraft agency to identify these items and become familiar with such regulations. These regulations include those 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

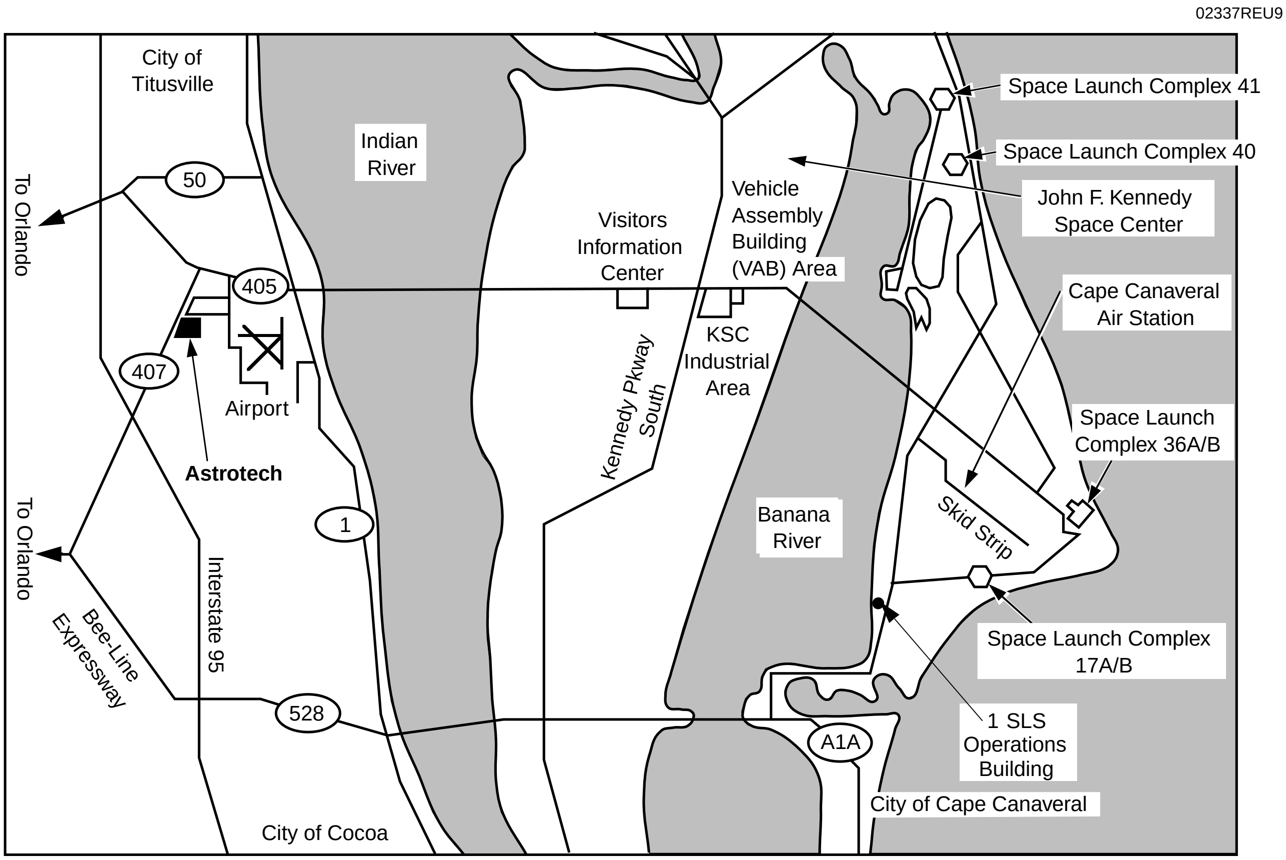


Figure 6-2. Astrotech Payload Processing Site Location

Titusville, Florida, (Figures 6-2 and 6-3). This facility includes 7,400 m^2 (80,000 ft^2) of industrial space that is constructed on 15.2 hectares (37.5 acres) of land.

There are six 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 Processing Facility, is used for spacecraft final assembly and checkout. It houses spacecraft clean-room high bays, control rooms, and offices. Antennas mounted on the building provide line-of-sight

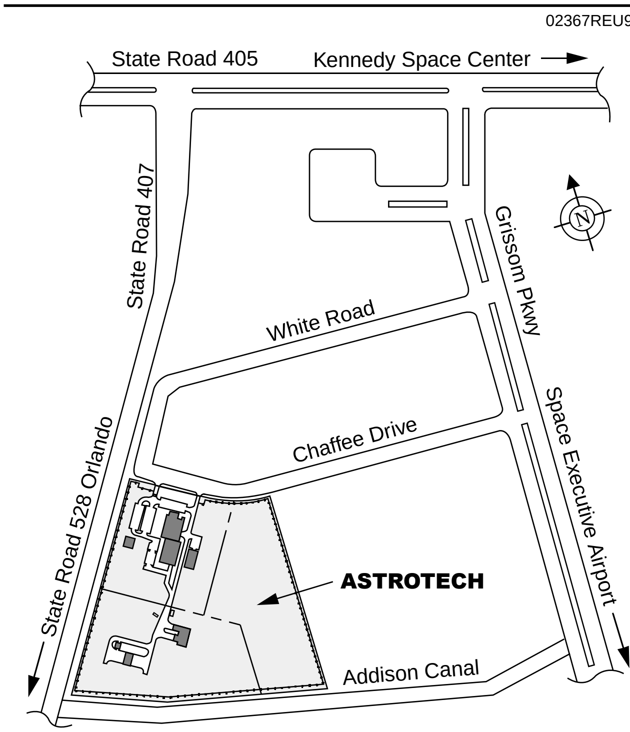


Figure 6-3. Astrotech Complex Location

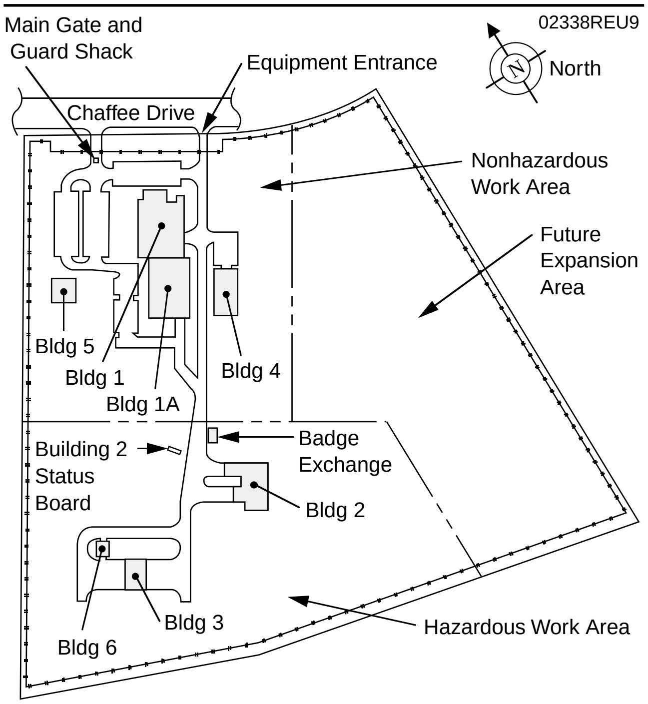


Figure 6-4. Astrotech Building Locations

communication with SLC-17 and Building AE at CCAS.

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

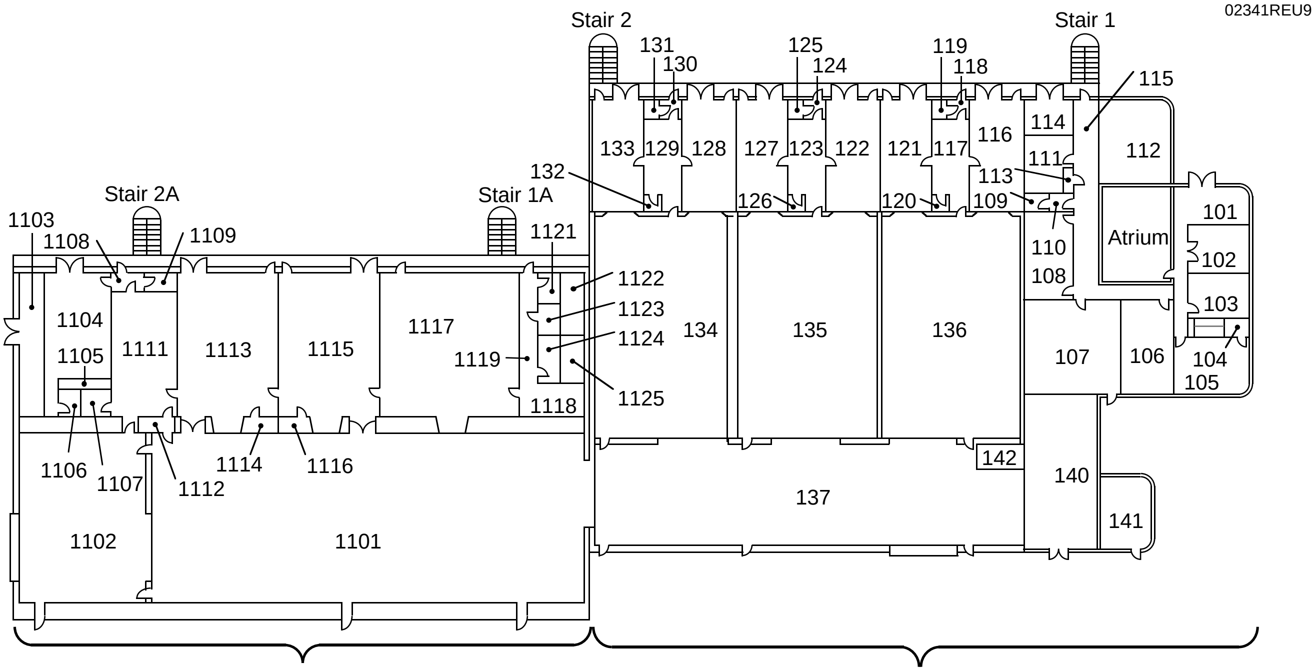
Building 4, the Warehouse Storage Facility, provides covered storage space for shipping containers, hoisting and handling equipment, and other articles not requiring environmental control.

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

Building 6, the Fairing Support Facility, provides covered storage space for launch vehicle hardware and equipment, and other articles not requiring environmental control.

6.2.1.1 Astrotech Building 1/1A. 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.

Building 1. 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 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. The three high bays in Building 1 each have



Building 1A

- 1101 Large High Bay D
- 1102 Large Airlock
- 1103 Mechanical Room
- 1104 Soundproof Conference Room D1
- 1105 Closet
- 1106 Restroom
- 1107 Restroom
- 1108 Vestibule
- 1109 Janitor Storage
- 1110 Not Used
- 1111 Change Room D
- 1112 Air Shower
- 1113 Control Room D2
- 1114 Equipment Room
- 1115 Control Room D1
- 1116 Equipment Room
- 1117 Office Area D1
- 1118 Break Room
- 1119 Corridor
- 1120 Not Used
- 1121 Mens Washroom
- 1122 Mens Restroom
- 1123 Janitor Closet
- 1124 Womens Washroom
- 1125 Womens Restroom

Building 1

- 101 ASO Reception Area
- 102 ASO Repro/Fax
- 103 ASO Staff Office
- 104 ASO Office Restroom
- 105 ASO Staff Office
- 106 ASO Staff Office
- 107 ASO Staff Office
- 108 Conference Room
- 109 Womens Restroom
- 110 Womens Lounge
- 111 Mens Restroom
- 112 Break/Lunch Room
- 113 Janitor Closet
- 114 ASO Machine Shop
- 115 Corridor
- 116 Control Room A1
- 117 Change Room A
- 118 Vestibule A
- 119 Storage A
- 120 Restroom A
- 121 Control Room A2
- 122 Control Room B1
- 123 Change Room B
- 124 Vestibule B
- 125 Storage B
- 126 Restroom B
- 127 Control Room B2
- 128 Control Room C1
- 129 Change Room C
- 130 Vestibule C
- 131 Storage C
- 132 Restroom C
- 133 Control Room C2
- 134 High Bay C
- 135 High Bay B
- 136 High Bay A
- 137 Common Airlock
- 138 Not Used
- 139 Not Used
- 140 Mechanical Room
- 141 Electrical Vault
- 142 Telephone Room

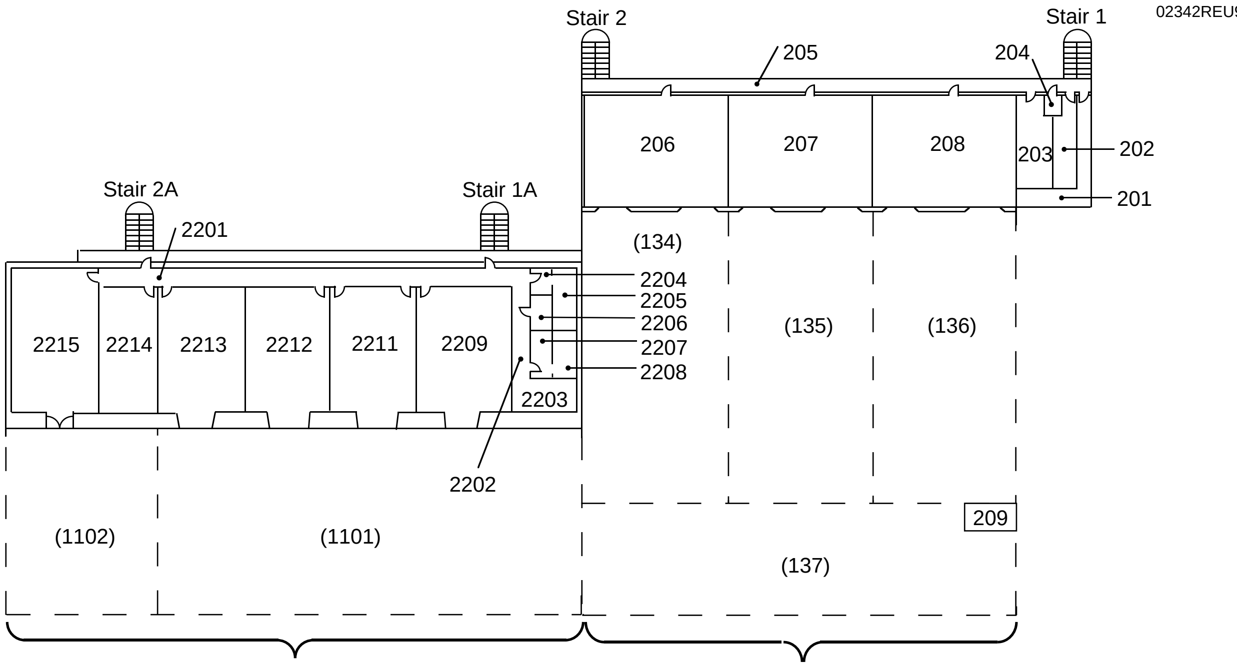
Figure 6-5. First-Level Floor Plan, Building 1/1A Astrotech

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 of 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 1A

2201 Corridor
2202 Corridor
2203 Break Room
2204 Mens Washroom
2205 Mens Restroom
2206 Janitor Closet
2207 Womens Washroom
2208 Womens restroom
2209 Office Area D2
2210 Not Used
2211 Office Area D3
2212 Office Area D4
2213 Office Area D5
2214 Conference Room D2
2215 Office Area D6

Building 1

201 Telephone Room
202 Womens Restroom
203 Mens Restroom
204 Janitor Closet
205 Corridor
206 Office Area C
207 Office Area B
208 Office Area A
209 Communications Room

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

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.

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, which 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 a class 100,000 clean room.

There are two control rooms adjacent to the high bay. Each control room 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 secure conference room designed for the discussion and handling of classified material).

6.2.1.2 Astrotech Building 2. Building 2 has overall plan dimensions of approximately 48.5 m by 34.1 m (159 ft by 112 ft) and a height of 14.9 m (49 ft). Major features are one airlock, two spacecraft processing high bays, two encapsulation high bays, and two control rooms. The airlock 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. It also provides access to the south encapsulation 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). The overhead monorail crane in the south airlock has a hook height of 11.3 m (37 ft) and an 8800-kg (2-ton) capacity. Direct access is available to the south encapsulation bay. It has a floor area of 13.7 m x 21.3 m (45 x 70 ft) and a clear vertical ceiling height of 18.8 m (65 ft). The bay also has a 27,215-kg (30-ton) overhead traveling bridge crane with a maximum hook height of 16.8 m (55 ft).

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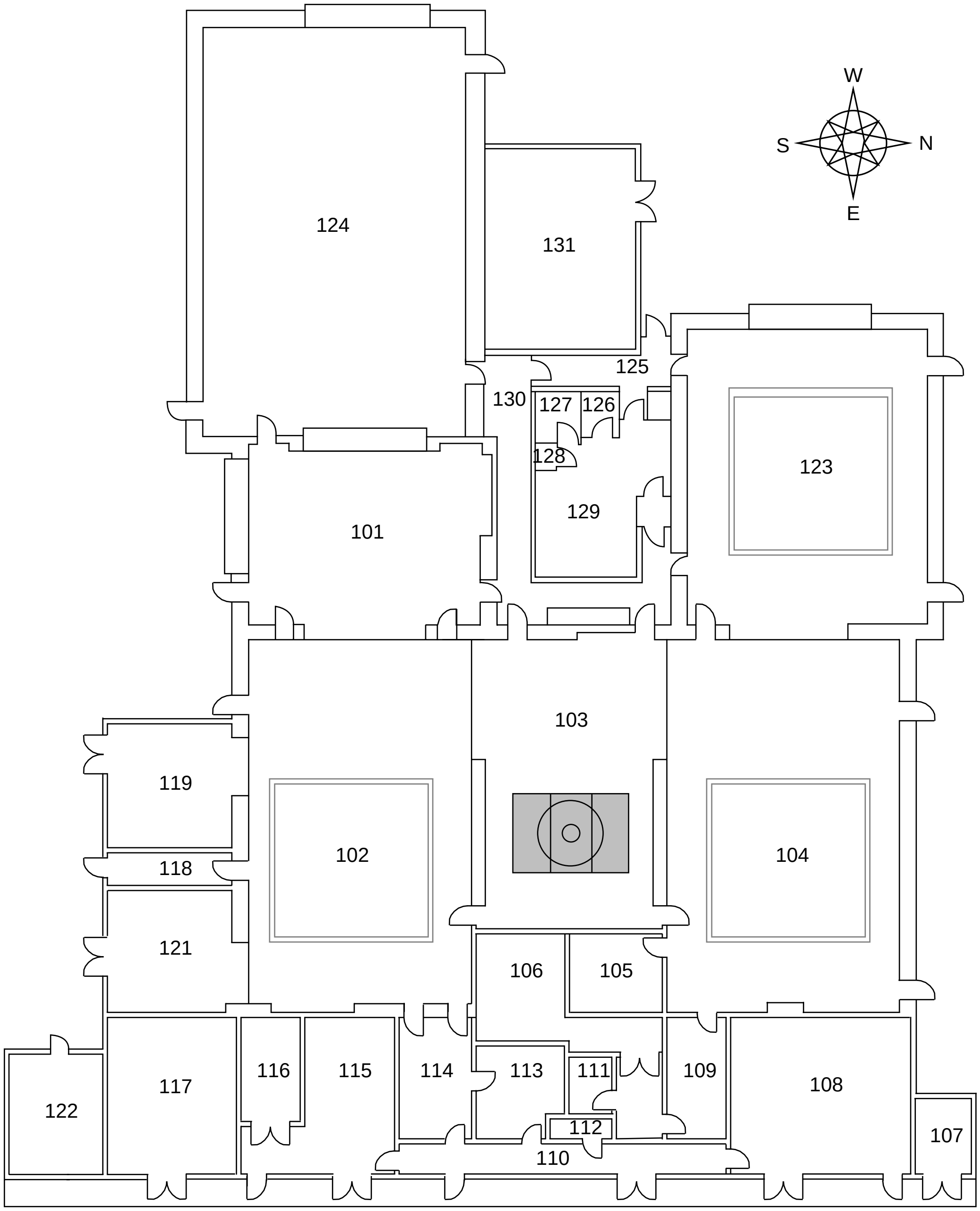


Room	Function	Room	Function	Room	Function
101	Airlock	111	Womens Restroom	122	Mechanical Room
102	South High Bay	112	Janitor	123	North Encapaulation Bay
103	Spin-Balance HIgh Bay	113	Mens Restroom	124	South Encapaulation Bay
104	North High Bay	114	South Change Room	129	Garment Change Room
105	Equipment Storage	115	South Control Room	125	Entry
106	Mechanical Room	116	Balance Control Room	128	Janitor
107	Mechanical Room	117	Mechanical Room	126	Womens Restroom
108	North Control Room	118	Corridor	127	Mens Restroom
109	North Change Room	119	Prop. Cart Room	130	Corridor
110	Corridor	121	Prop. Cart Room		

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

The north encapsulation bay 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 encapsulation bay 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 spacecraft processing bays are designed to support spacecraft solid-propellant motor assembly and liquid-bipropellant transfer operations. Both the north and south high bays have floor areas measuring 11.3 m by 18.3 m (37 ft by 60 ft) and a clear vertical ceiling height of 13.1 m (43 ft). 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. The trench system is sloped so that any major spill of hazardous propellants drains into the emergency spill-retention system. The north encapsulation bay is also configured for propellant loading. The spin-balance bay has a floor area measuring 8.2 m by 18.3 m (27 ft by 48 ft) and a clear vertical ceiling height of 13.1 m (43 ft). The spin-balance bay contains an 8391-kg (18,500-lb) capacity dynamic balance machine that is designed to balance solid rocket motor upper stages and spacecraft. Rooms 102, 103, and 104 share two 9071-kg (10-ton) overhead bridge cranes having a maximum hook height of 11.3 m (37 ft). Both cranes cannot be used in the same room. Equipment access to the spin-balance bay is from either the north or south spacecraft processing bays through 6.1-m wide by 13.1-m high (20-ft by 43-ft) roll-up doors.

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. Personnel access to all the high bay areas is through the garment change rooms (109, 114, or 129) while spacecraft processing operations are being conducted.

Because the spin balance table equipment located in the center high bay 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 considerations. Television cameras are used for remote monitoring of spin-room activities.

Adjacent to the south high bay, fuel and oxidizer cart storage rooms are provided with 3-m wide by 5-m high (10-ft by 8-ft) roll-up access doors to the high bay and exterior doors for easy equipment access. These two rooms measure 6.1 m by 6.1 m (20 ft by 20 ft) with a vertical ceiling height of 2.7 m (9 ft). The rooms feature a floor drain to the emergency spill-retention system.

6.2.1.3 Astrotech Building 3. The dimensions of Building 3 (Figure 6-8) are approximately 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 about 8.5 m (28 ft). The bays have individual environmental control

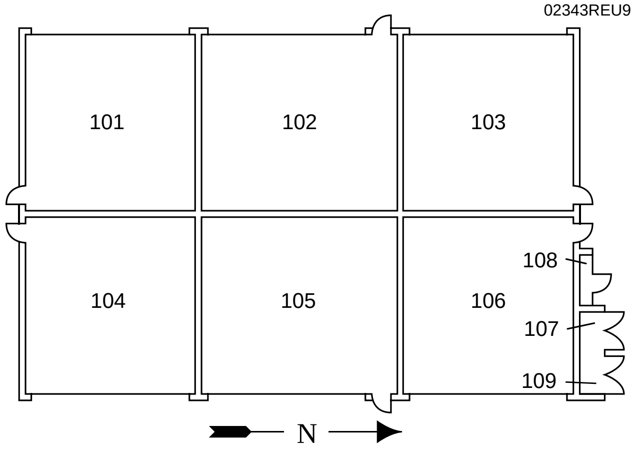


Figure 6-8. Building 3 Detailed Floor Plan, Astrotech

but are not clean rooms, which mandates that payloads be stored in suitable containers.

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

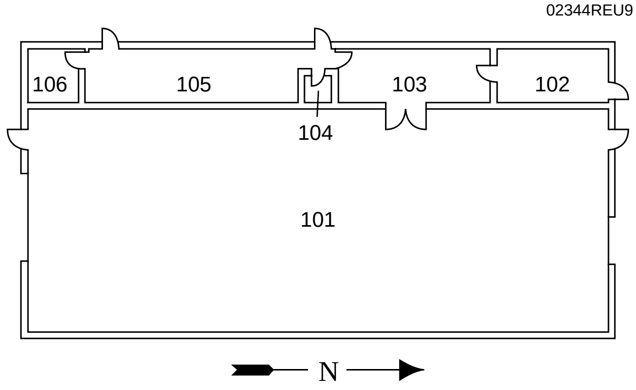


Figure 6-9. Building 4 Detailed Floor Plan, Astrotech

Building 4 are the warehouse storage area, bonded storage area, and the Astrotech staff office area.

The large warehouse storage area has a floor area measuring 15.2 m by 38.1 m (50 ft by 125 ft) and a clear vertical height which 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. Building 5 (Figure 6-10) provides office and conference rooms for the spacecraft project.

6.2.1.6 Astrotech Building 6. Building 6 (Figure 6-11) consists of a warehouse storage 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).

6.2.2 CCAS Operations and Facilities

Prelaunch operations and testing of Delta III spacecraft at CCAS take place in the following areas:

- Cape Canaveral industrial area.
- SLC-17.

6.2.2.1 Cape Canaveral Industrial Area. Delta III spacecraft support facilities are located in the CCAS support and industrial area (Figures 6-12 and 6-13). USAF-shared facilities or work areas at

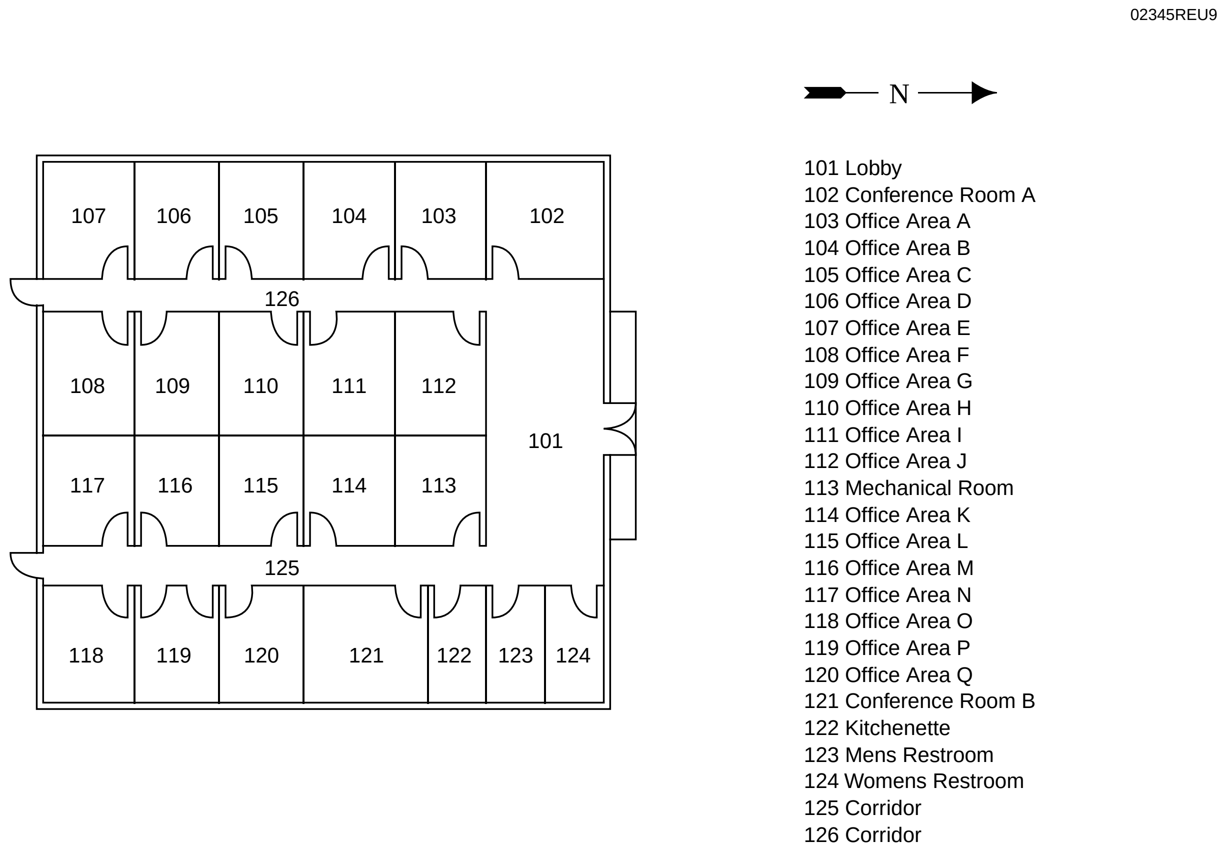
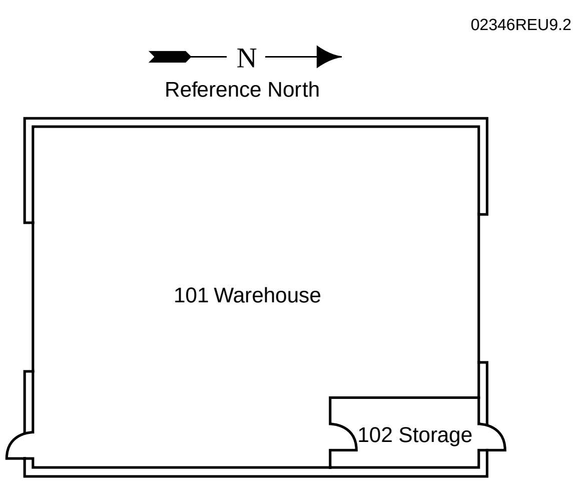


Figure 6-10. Building 5 Detailed Floor Plan, Astrotech



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

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

CCAS are available for supporting spacecraft projects and the spacecraft contractors. These areas include the following:

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

6.2.2.2 Building AE. Located in Building AE (Figure 6-14) is the Mission Director Center (MDC), and the Launch Vehicle Data Center (LVDC). This building also houses the communications equipment that links the Astrotech facility with NASA and USAF voice and data networks at KSC and CCAS.

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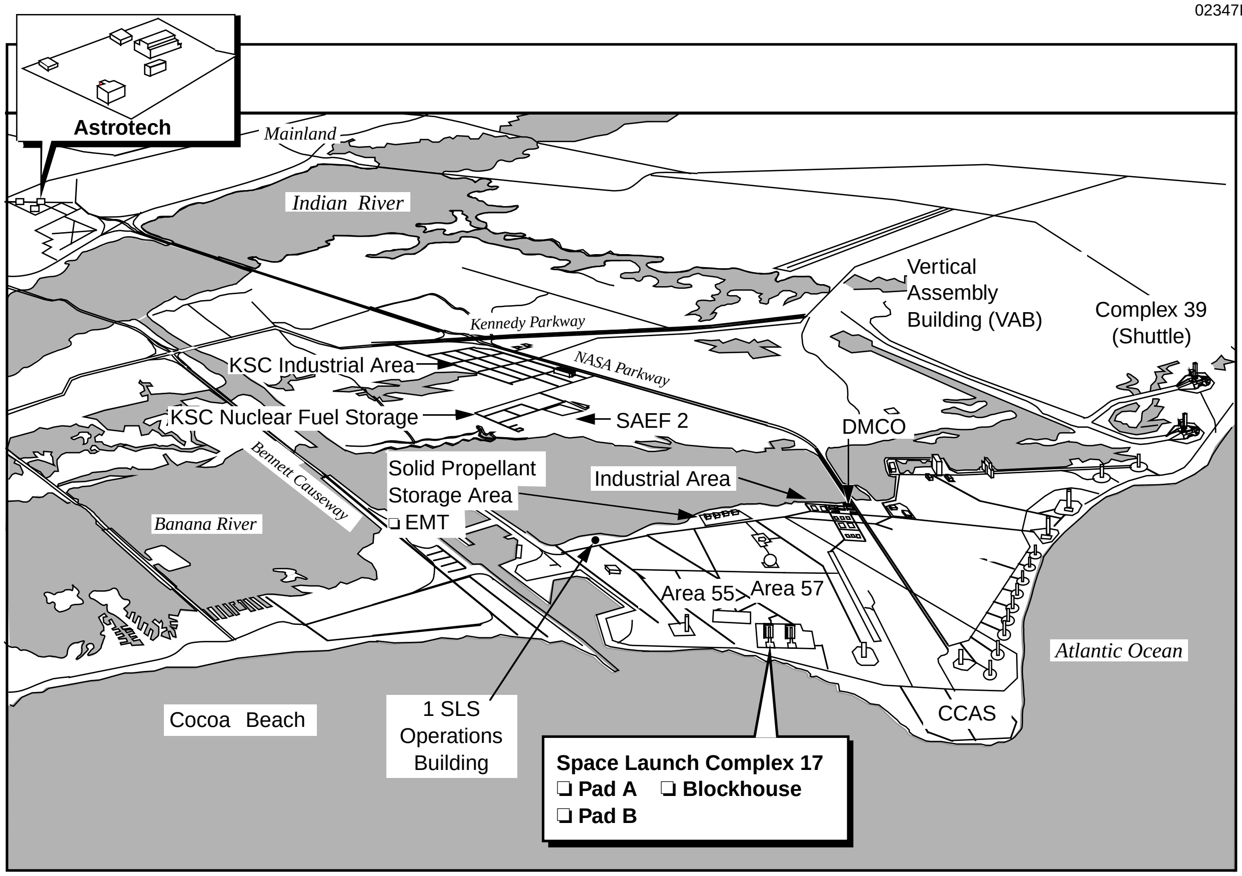

Figure 6-12. CCAS Delta Support Areas

Launch operations and overall mission activities are monitored by the mission director (MD) and the supporting mission management team in the Mission Director Center (Figure 6-15) where the team is informed of launch vehicle, spacecraft, and tracking network flight readiness. Appropriate real-time prelaunch and launch data are displayed to provide a presentation of vehicle launch and flight progress. During launch operations, the Mission Director Center also functions as an operational communications center from which all communication emanates to tracking and control stations. Across the hall from the Mission Director Center is the Launch Vehicle Data Center, where Boeing Delta management and technical support personnel are stationed to provide assistance to the launch team and the MD.

At the front of the Mission Director Center are large illuminated displays that list the tracking stations and range stations in use and the sequence of events after liftoff. These displays are used to show present position and instantaneous impact point (IIP) plots. When compared with the theoretical plots, these displays give an overall representation of launch vehicle performance.

6.2.3 First Space Launch Squadron Operations Building (1SLS OB)

Launch operations are conducted from the launch control center (LCC) located on the second floor of the 1st Space Launch Squadron

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Figure 6-13. Cape Canaveral Industrial Area

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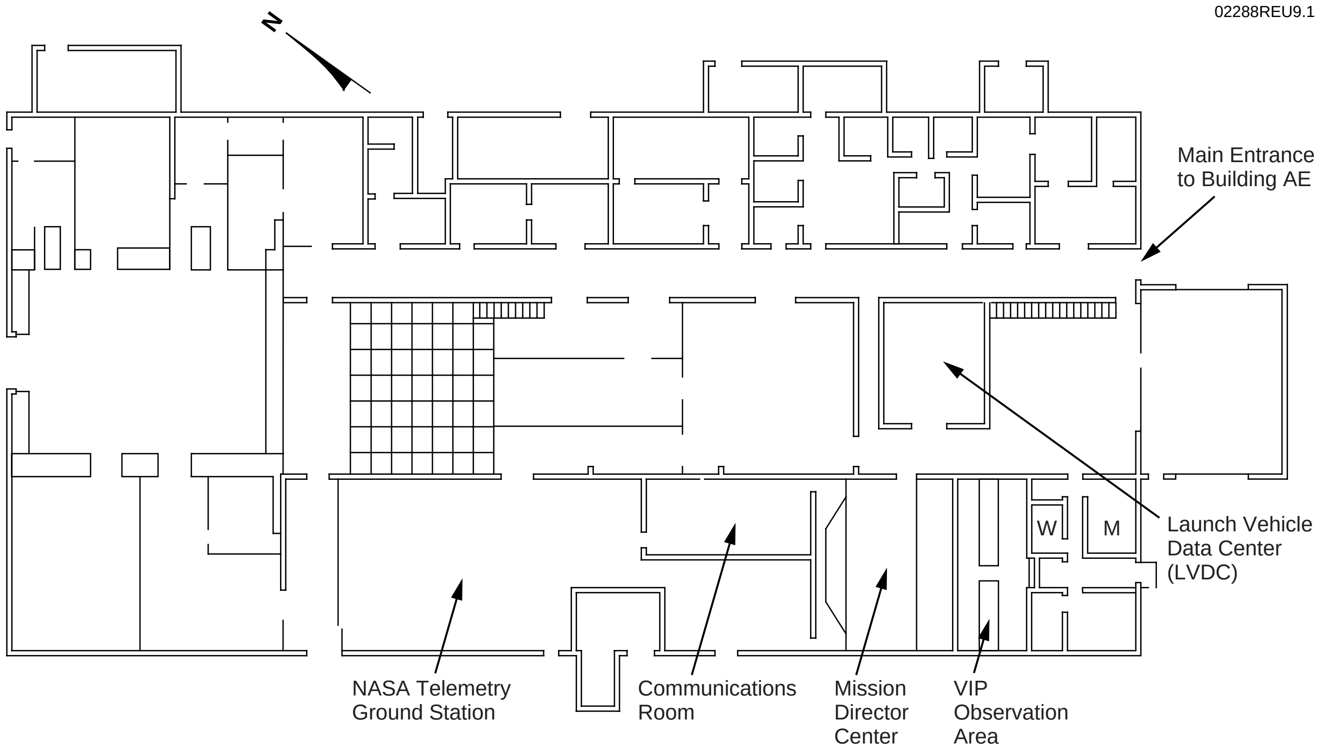

Figure 6-14. Building AE Floor Plan

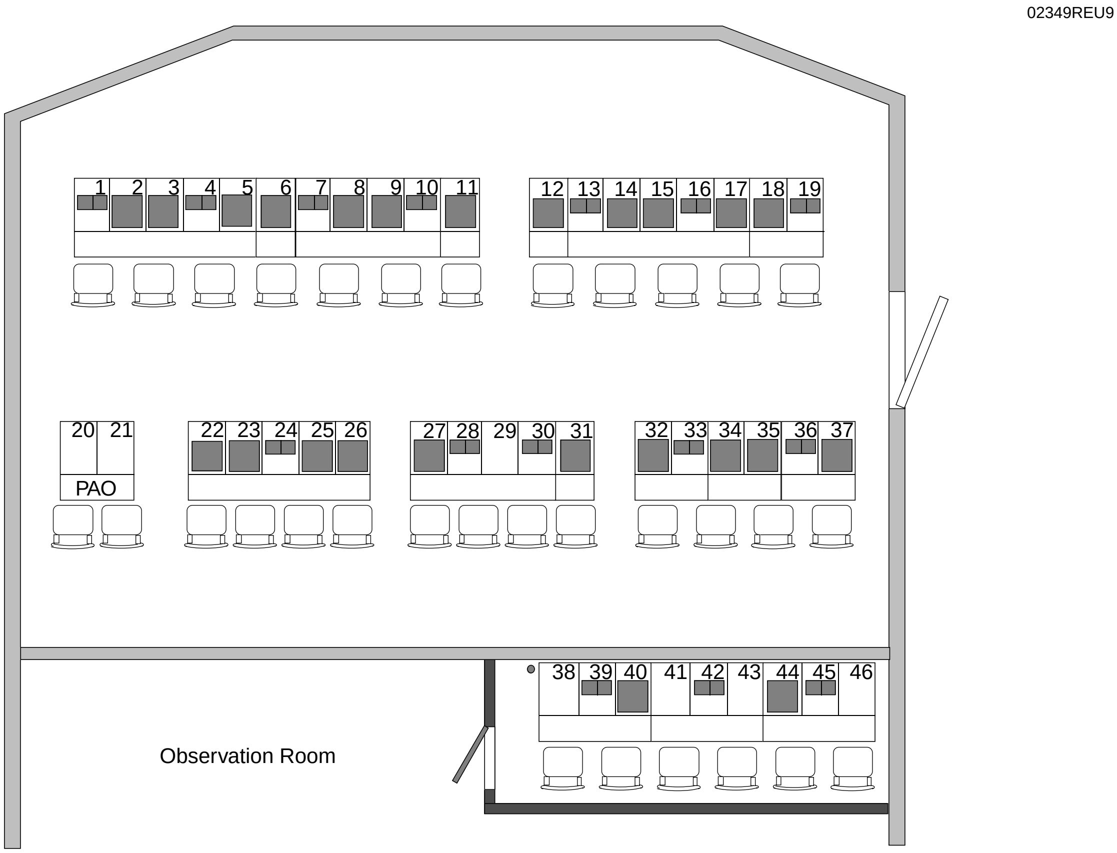

Figure 6-15. Building AE Mission Director Center

(1SLS) Operations Building (OB) (Figure 6-16). The launch vehicle and its associated ground support equipment (GSE) are controlled and monitored from the LCC by the advanced launch control system (ALCS), a work-station-based system. The ALCS provides all command and control signals required to conduct launch vehicle test, certification, and launch. The ALCS additionally provides the capability to remotely control and monitor payload functions from the OB.

Adjacent to the LCC are two spacecraft control rooms. These rooms are reserved for payload support activities and are connected to the blockhouse and launch pads through a subset of ALCS channels. This subset has the ability to provide EIA RS-232, RS-422, and RS-485 full-duplex digital circuits; bidirectional analog transmission, up to 1 KHz; and discrete remote relay closure (simulating switch contacts) (Figure 6-17).

Available in the control rooms is the ability to display a color video image of the payload GSE area of the blockhouse. This feature allows for remote visual monitoring of indicators that are not otherwise easily remoted, such as analog power supply meters.

Access is provided to all required voice nets used to support both test and launch operations along with standard commercial telephone and fax machine services.

The spacecraft safe and arm (S&A) control console may be located in either the blockhouse or in the spacecraft control room. Regardless of

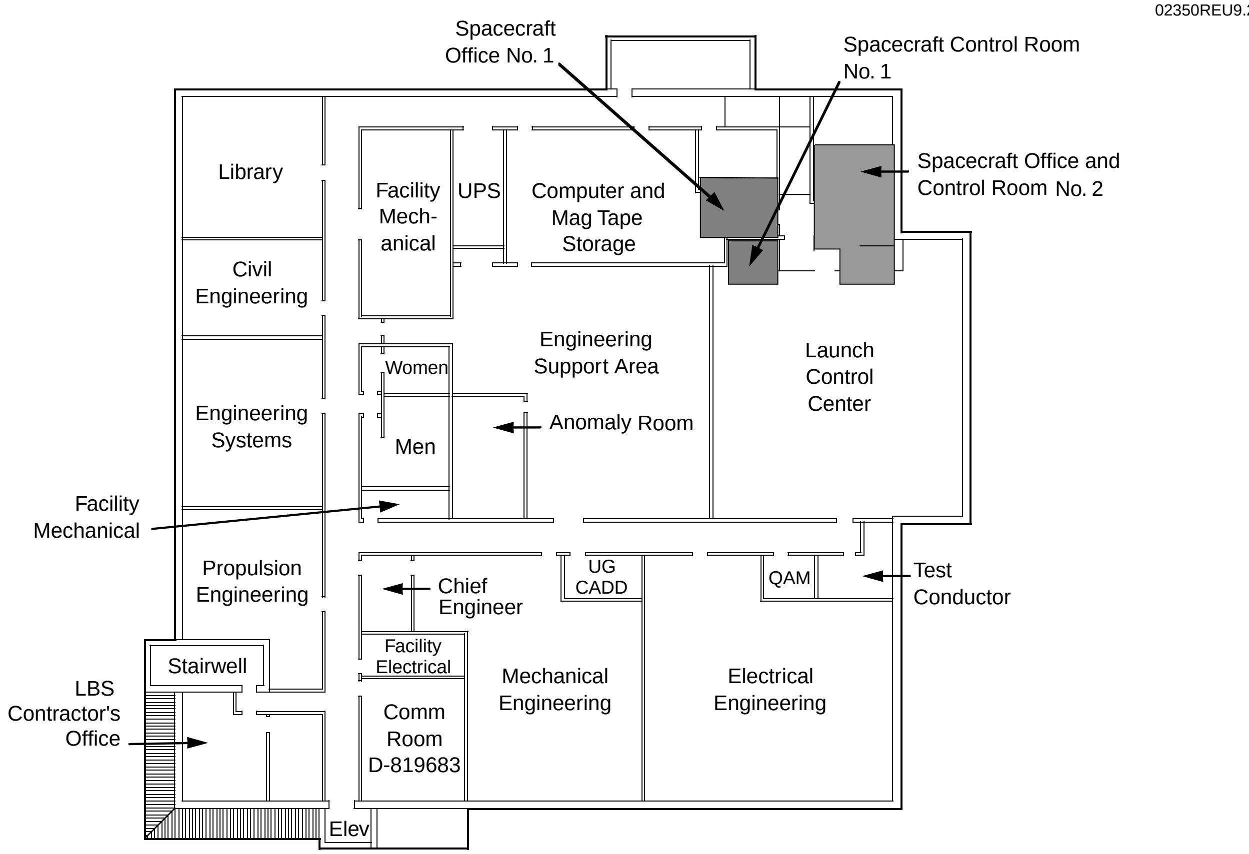

Figure 6-16. 1 SLS Operations Building, Second Floor

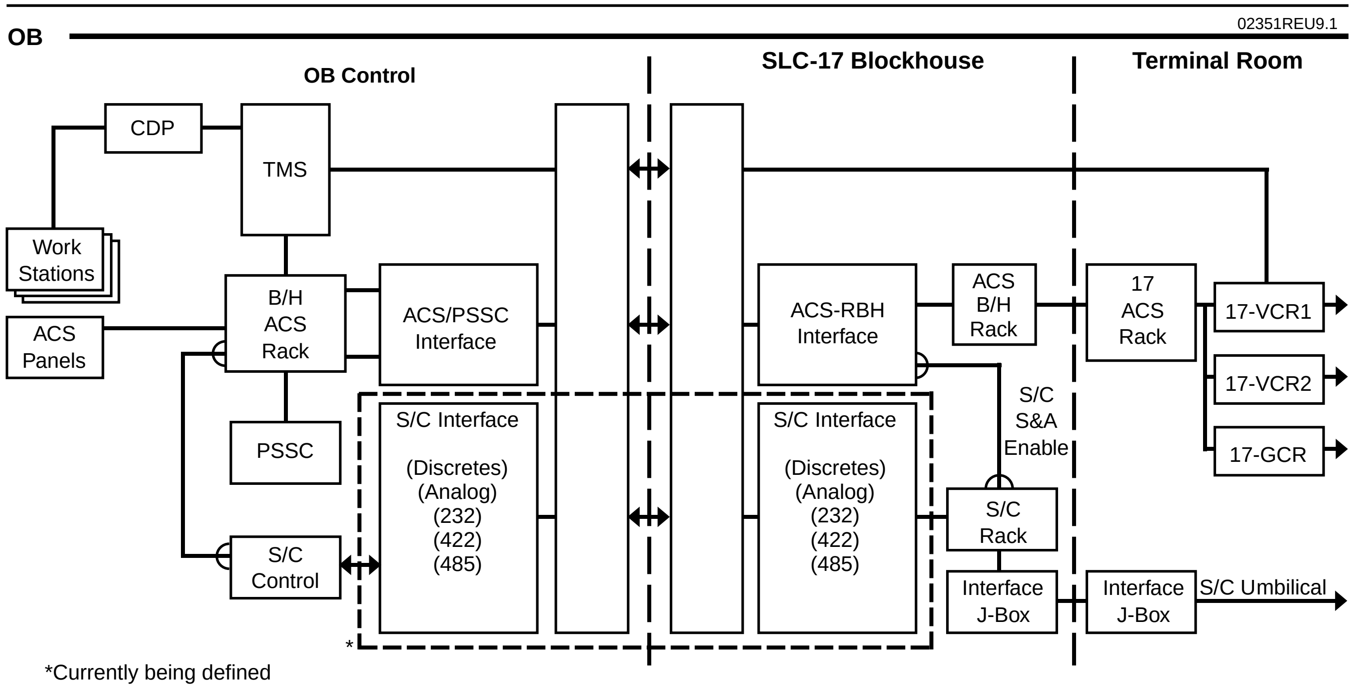

Figure 6-17. Interface Overview—Spacecraft Control Rack in Squadron Operations Building

the location, the enable interface is through the OB and uses the same pin connector interface as was previously defined by the spacecraft/pad safety supervisor's console (PSSC) interface.

6.2.4 Solid Propellant Storage Area, Cape Canaveral Air Station

The facilities and support equipment in this area are maintained and operated by the USAF range contractor personnel. They also provide ordnance item transport. Preparation of ordnance items for flight (i.e., safe and arm devices, EEDs, etc.) is performed by spacecraft contractor personnel using spacecraft contractor-prepared, range-safety-approved procedures.

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

The second magazine is used for the storage of solid-propellant motors. It is environmentally controlled to 29.4° ± 2.8°C (85° ± 5°F) with a maximum relative humidity of 65%.

6.2.4.2 Electrical-Mechanical Testing Facility. The Electrical-Mechanical Testing Facility (EMTF) at CCAS (Figure 6-18), operated by range contractor personnel, can be used for such functions as ordnance item bridgewire resistance checks and S&A device functional tests, as well as for test-firing small self-contained ordnance items.

Electrical cables that provide the interface between the ordnance items and the test equipment already exist 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. A 6-week lead time is required for cable fabrication. Range contractor-supplied test consoles contain the items listed in Table 6-1. The tests are conducted according to spacecraft contractor procedures, approved by range safety personnel.

6.3 SPACECRAFT ENCAPSULATION AND TRANSPORT TO THE LAUNCH SITE

Delta III provides spacecraft encapsulation within the fairing at the payload processing facility, normally Astrotech. This capability enhances payload safety and security, prevents contamination, and greatly reduces launch pad operations in the vicinity of the spacecraft.

Payload integration with the PAF and encapsulation within the fairing is planned in Astrotech Building 2. Details of the high bay areas, air locks, and adjacent control and equipment rooms are provided in Section 6.2.1.1. The basic sequence of operations at Astrotech is illustrated in Figure 6-19.

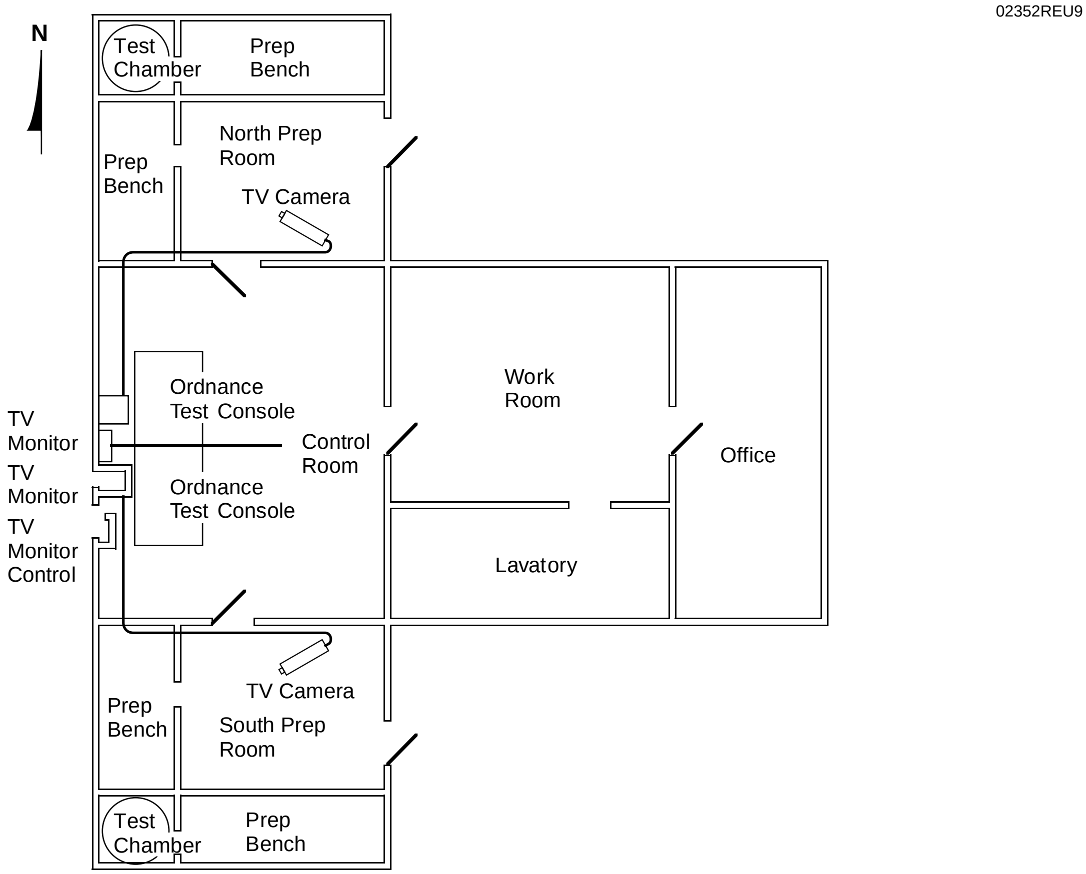

Figure 6-18. Electrical-Mechanical Testing Building Floor Plan

Table 6-1. Test Console Items

Resistant 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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Prior to spacecraft arrival, the fairing bisectors and PAF enter the high bay to be prepared for payload encapsulation. The fairing bisectors are erected and stored on vertical storage 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, the payload is mated to the PAF, and integrated checkout is performed. The Boeing buildup stand has air bearings to enable movement into an adjacent bay to receive the payload, and subsequent return to the encapsulation bay without the need for an overhead crane. The previously prepared fairing bisectors are then moved into position for final mate, and the personnel access stands are positioned for personnel access to the fairing mating plane. These access stands can also be used for payload access prior to fairing mate. The fairing is joined and mated to the PAF. A final payload telemetry test, through the fairing, can be accommodated at this time. The encapsulated payload is lifted, and the aft end of the payload attach fitting is bagged.

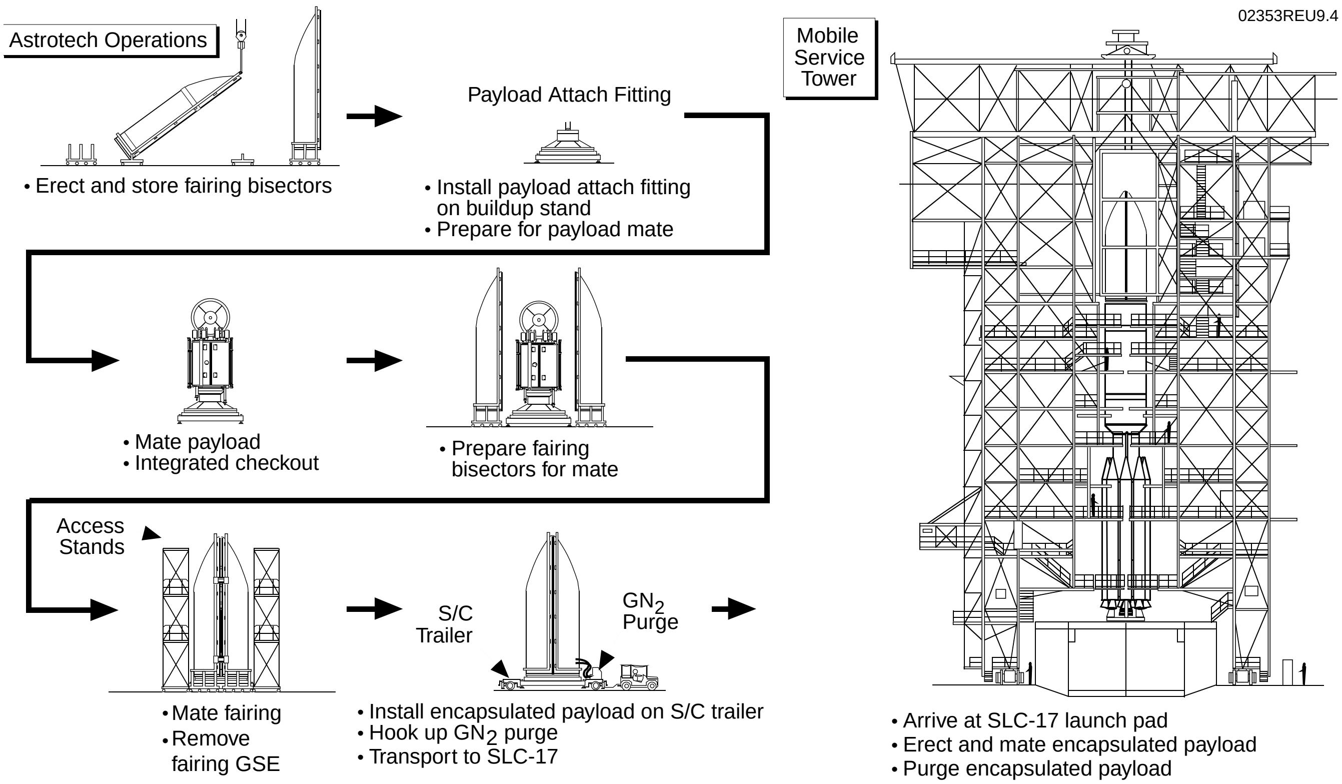

Figure 6-19. Payload Encapsulation, Transport, and On-Pad Mate

The entire assembly is then transferred to the trailer provided by Boeing and prepared for transport to the launch pad. A GN_2 purge of the fairing envelope is installed.

The spacecraft trailer is a rubber-tired transporter with spring/air bag suspension; it is towed to the launch pad by a Boeing tractor at 5 to 10 mph. The temperature within the fairing is not actively controlled, but is maintained at acceptable levels by selecting the time of day when transport occurs and by the passive insulation the flight fairing provides. Boeing uses PC-programmed monitors to measure and record the transport dynamic loads as well as temperatures and humidities.

After arrival at SLC-17, the encapsulated payload is lifted into the mobile service tower (MST), the PAF aft baggie is removed, and the encapsulated payload is immediately mated to the second stage. The clean room is then closed and the clean-room air is sampled for acceptable levels prior to subsequent operations, including removal of fairing access doors. The fairing air-conditioning is immediately installed to provide a class 5,000 air shower over the payload for all operations through liftoff.

6.4 SPACE LAUNCH COMPLEX 17

SLC-17 is located in the southeastern section of CCAS (Figure 6-12). It consists of two launch pads (17A and 17B), a blockhouse, ready room, shops, and other facilities needed to prepare, service, and launch the Delta vehicles. Only one pad, 17B, is configured to launch the Delta III. However, Delta II can be launched from 17A or 17B.

The arrangement of SLC-17 is shown in Figure 6-20, and an aerial view is given in Figure 6-21.

Because all operations in the launch complex area involve or are conducted in the vicinity of liquid or solid propellants and 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 specified in Section 9 is required. Boeing will provide for mandatory safety briefings on these subjects for those required to work in the launch complex area.

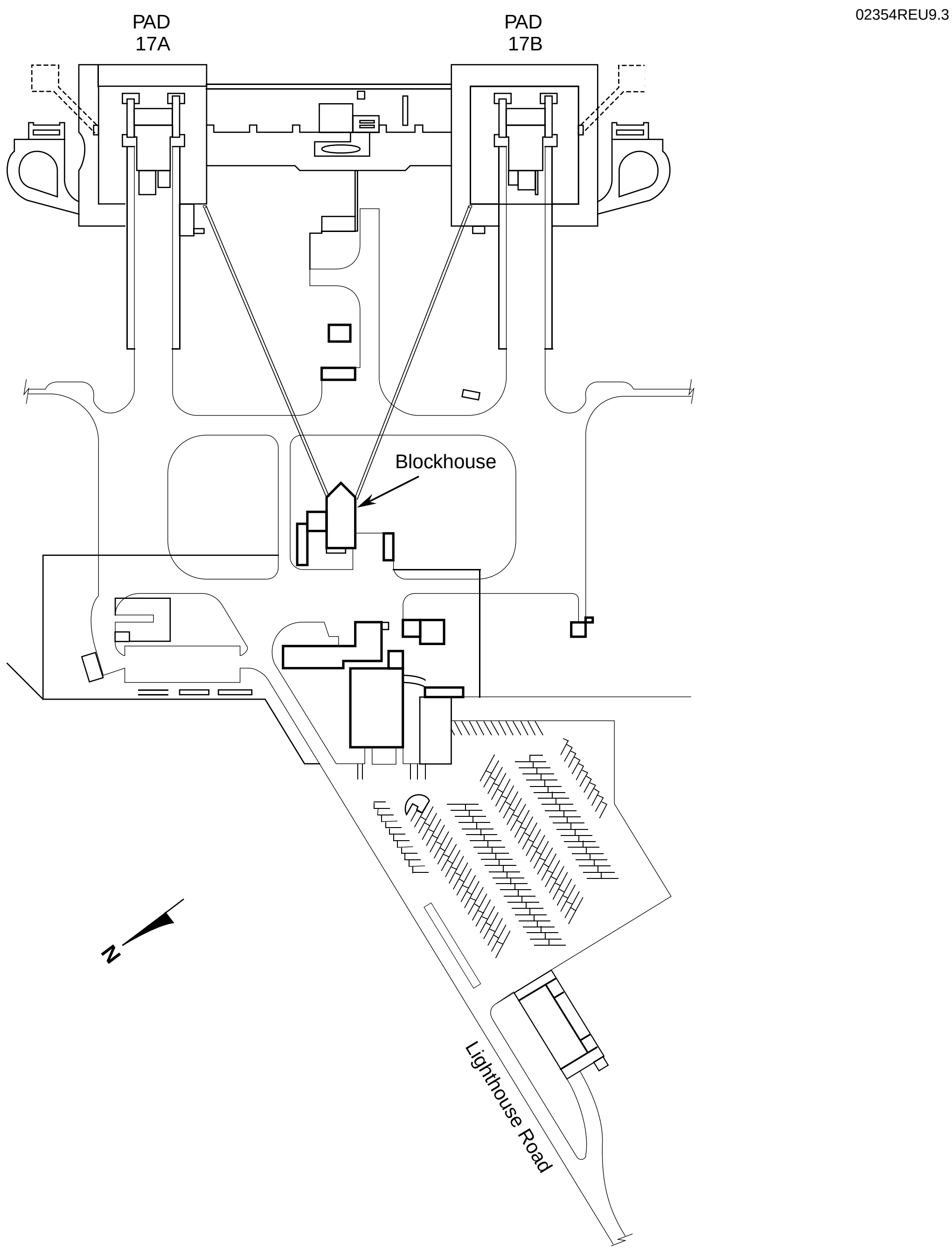

Figure 6-20. Space Launch Complex 17, Cape Canaveral Air Station

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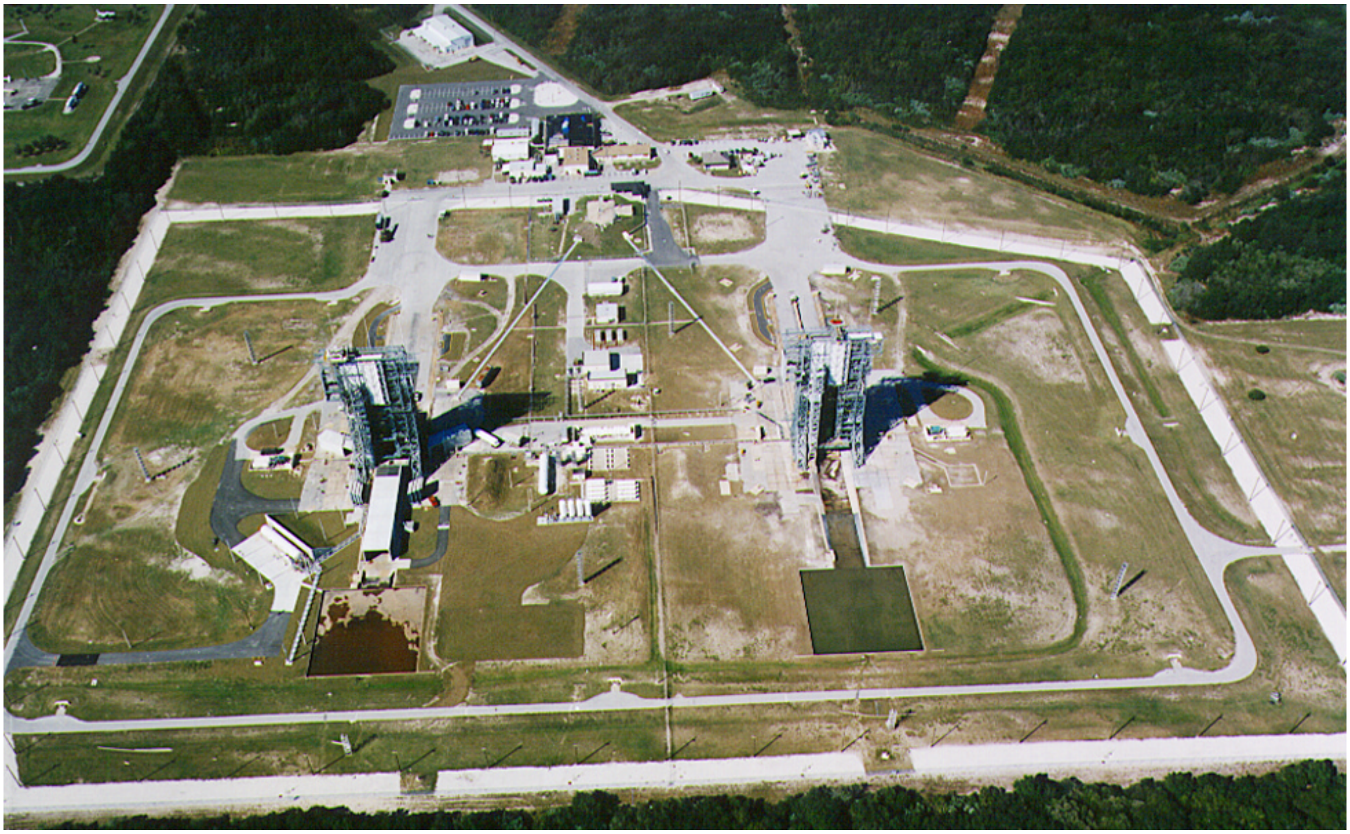

Figure 6-21. Cape Canaveral Launch Site SLC-17

A changeout room is provided on MST level 9 for use by spacecraft programs requiring this service.

6.4.1 Mobile Service Tower Spacecraft Work Levels

The number of personnel admitted to the MST is governed by safety requirements and by the limited amount of work space on the spacecraft levels. Outlets for electrical power, helium, nitrogen, and breathing air are provided on the MST levels. Communications equipment provided on the MST includes telephones and operational communications stations for test support.

6.4.2 Space Launch Complex 17 Blockhouse

Most hazardous operations including launch are no longer controlled from the SLC-17 Blockhouse, but are controlled from the 1st Space Launch Squadron Operations Building (1 SLS OB). The SLC-17 blockhouse remains and has floor space allocated for remotely controlled spacecraft consoles and battery-charging equipment. Terminal board connections in the spacecraft-to-blockhouse junction box (Figure 6-22) provide electrical connection to the spacecraft umbilical wires. Boeing will terminate the cable for the customer. Spacecraft umbilical wires should be tagged with the terminal board wires,

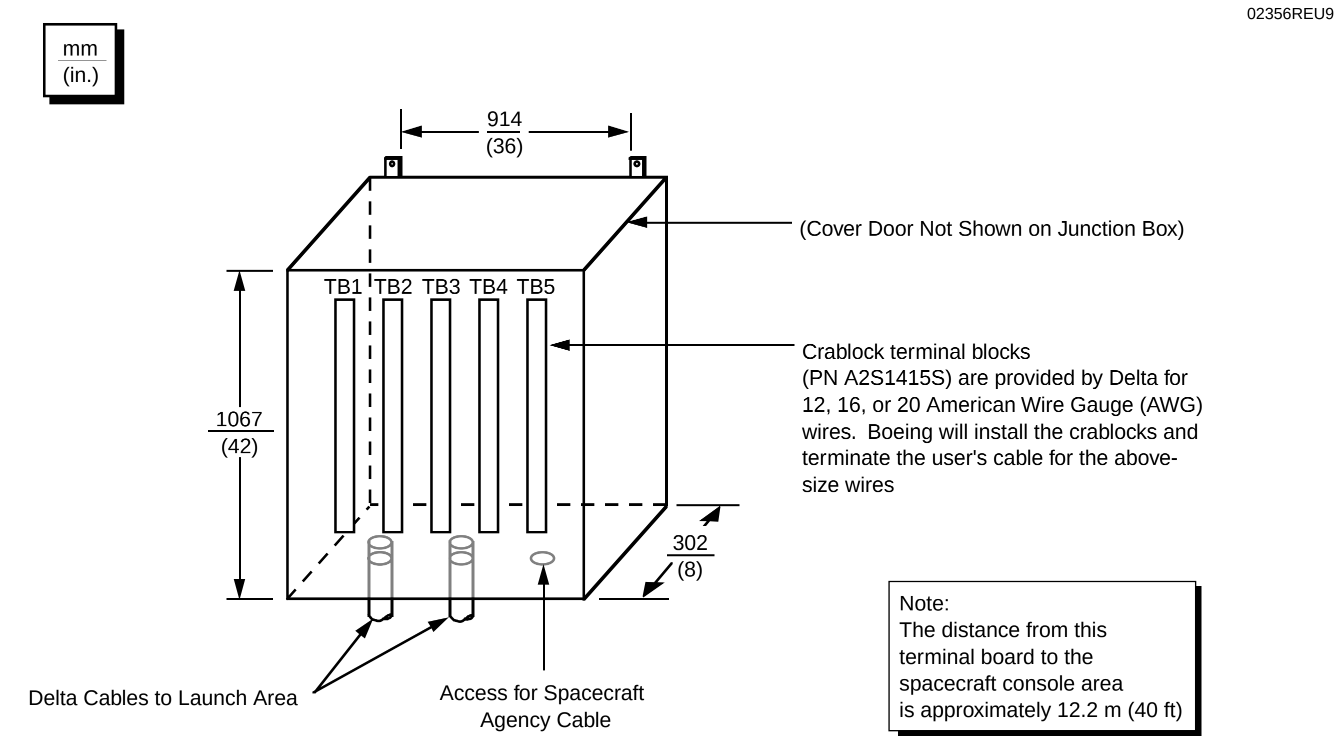

Figure 6-22. Spacecraft-to-Blockhouse Junction Box

as indicated in the payload-to-blockhouse wiring diagram provided by Boeing.

6.5 SUPPORT SERVICES

6.5.1 Launch Support

For countdown operations, the launch team is normally located in the 1 SLS OB and Hangar AE with support from many other organizations. Spacecraft command and control equipment can also be located at Astrotech, if desired. Communications to the spacecraft can be provided from that location.

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

6.5.1.1 Mission Director Center (Hangar AE). The Mission Director Center provides the necessary seating, data display, and communication to control the launch process. Seating is provided for key personnel from Boeing, the Eastern Range, and the spacecraft control team.

6.5.1.2 Launch-Decision Process. The launch-decision process is conducted by the appropriate management personnel representing the spacecraft, the launch vehicle, and the range. Figure 6-23 shows the typical communications flow required to make the launch decision.

6.5.2 Weather Constraints

6.5.2.1 Ground-Wind Constraints. The Delta III vehicle is enclosed in the MST until approximately L-7 hr. The tower protects the vehicle from ground winds. The winds are

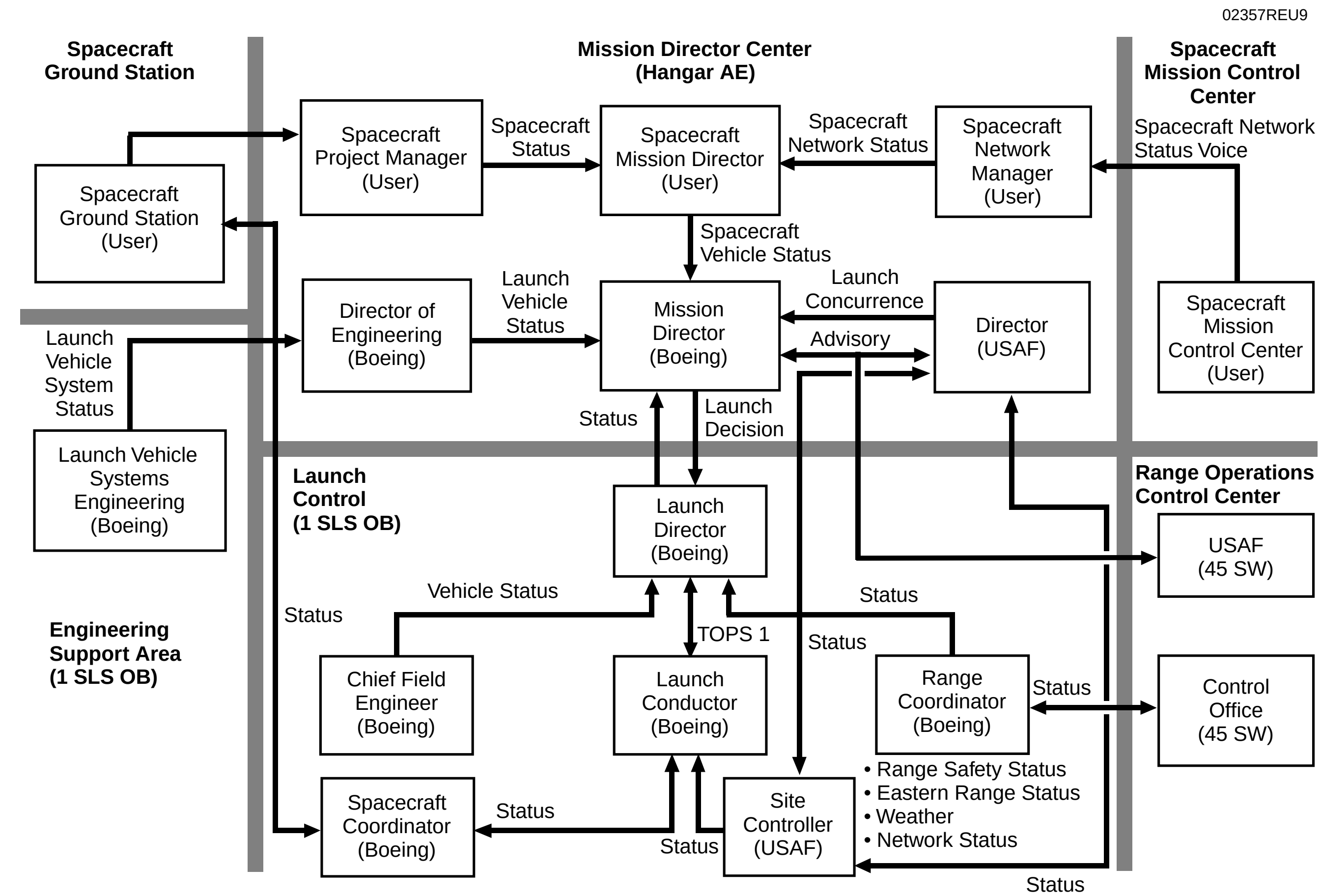

Figure 6-23. Launch Decision Flow for Commercial Missions—Eastern Range

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. The Delta III controls and loads 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 analyses. 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 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).

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

  – Within 18.5 km (10 nmi) of a cumulo-nimbus (thunderstorm) cloud, whether convective or in layers, where precipitation (or virga) is observed.

  – Through any cloud, whether convective or in layers, where precipitation or virga is observed.

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

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

– Through any cloud if a plus-or-minus 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.

– 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).

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

■ 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.

■ 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 the current atmospheric conditions.

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

■ Evacuation of the MST and fixed umbilical tower (FUT) is accomplished at the direction of the launch conductor (reference: Delta Launch Complex Safety Plan).

■ Instrumentation may be operated during an electrical storm.

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

■ If an electrical storm passes through after a simulated flight test, all electrical systems are turned on in 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.

■ If data from the quiescent turn-on reveal 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 Cape Canaveral Air Station Security. For access to CCAS, US citizens must provide full name with middle initial if applicable, social security number, company name, and dates of arrival and expected departure to the Boeing spacecraft coordinator or Boeing and CCAS security. 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, clearance 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) must be furnished to Boeing two weeks prior to the CCAS entry date; or, for government-sponsored individuals, follow NASA or US government guidelines as appropriate. The spacecraft coordinator will furnish visitor identification documentation to the appropriate agencies. After Boeing security receives clearance approval, entry to CCAS will be the same as for US citizens.

6.5.4.2 Launch Complex Security. SLC-17 physical security is ensured by perimeter fencing, guards, and access badges. The MST white room is a closed area with cipher locks on entry-controlled doors. Access can also be controlled by a security guard on the MST eighth level. A special badge is required for unescorted entry into the fenced area at SLC-17. Arrangements must be made 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 the spacecraft security requirements will be arranged through the Boeing spacecraft coordinator.

6.5.5 Field-Related Services

Boeing employs certified propellant handler's ensemble (PHE) suits, propellant handlers, 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 under its control a machine shop, metrology laboratory, LO_2 cleaning facility, proof-load facility, and hydrostatic proof test equipment. The Boeing operational team members are familiar with the payload processing facilities and can offer all of these skills and services to the spacecraft project during the launch program.

6.6 DELTA III PLANS AND SCHEDULES

The following plans and schedules are under development and subject to change.

6.6.1 Mission Plan

A mission plan (Figure 6-24) is developed at least 12 months prior to each launch campaign, showing major tasks on a weekly timeline format. The plan includes launch vehicle activities,

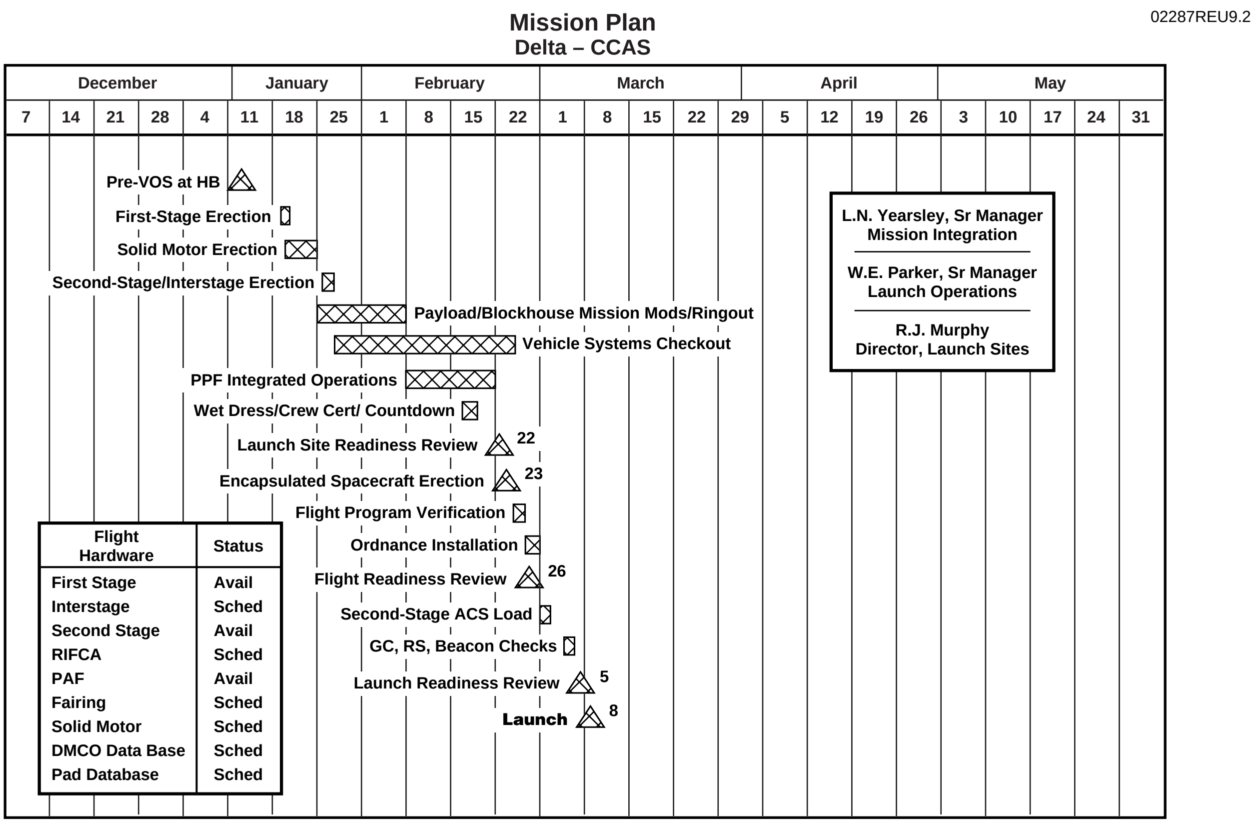

Figure 6-24. Typical Delta III Mission Plan

prelaunch reviews, and spacecraft PPF and HPF occupancy time.

6.6.2 Integrated Schedules

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

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

Daily schedules are prepared on hourly time lines for these integrated activities. These schedules typically cover the encapsulation effort in Astrotech Building 2 and all days-of-launch countdown activities. Tasks include spacecraft weighing, spacecraft-to-payload attach fitting mate, encapsulation, and interface verification. 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, reflecting inputs from the spacecraft project. These schedules comprise the integrating document to ensure timely launch pad operations.

Typical schedules of integrated activities from spacecraft weighing until launch are indicated as launch minus (T-) workdays. Saturdays, Sundays, and holidays are not normally scheduled workdays and therefore are not T-days. The T-days, from spacecraft mate through launch, are coordinated with each spacecraft contractor to optimize on-pad testing. Examples of typical integrated schedules, from T-8 encapsulated spacecraft mate through terminal count, are provided in Figures 6-25, 6-26, 6-27, 6-28, 6-29, 6-30, and 6-31. All operations are formally conducted and controlled using approved procedures. The schedule of spacecraft activities during that time is controlled by the Boeing chief launch conductor. Tasks involving the spacecraft or tasks requiring that spacecraft personnel be present are shaded for easy identification.

A description of preparations for a typical mission from CCAS follows; spacecraft and Boeing hardware checkout is completed before T-12 day.

T-12. Tasks include equipment verification, precision weighing of spacecraft, and securing.

T-11. Spacecraft is lifted, weighed (optional), and mated to the payload attach assembly, the clampband installed, and clamp band tension established. An electrical interface test may be performed at this time prior to encapsulation at the request of the payload contractor. Preparation for encapsulation begins.

T-10. Tasks include encapsulation of the spacecraft/payload attach fitting inside the payload fairing and interface verification, if required.

T-9. Transportation covers are installed, the encapsulated spacecraft is placed on its trailer, and a dry nitrogen purge is set up.

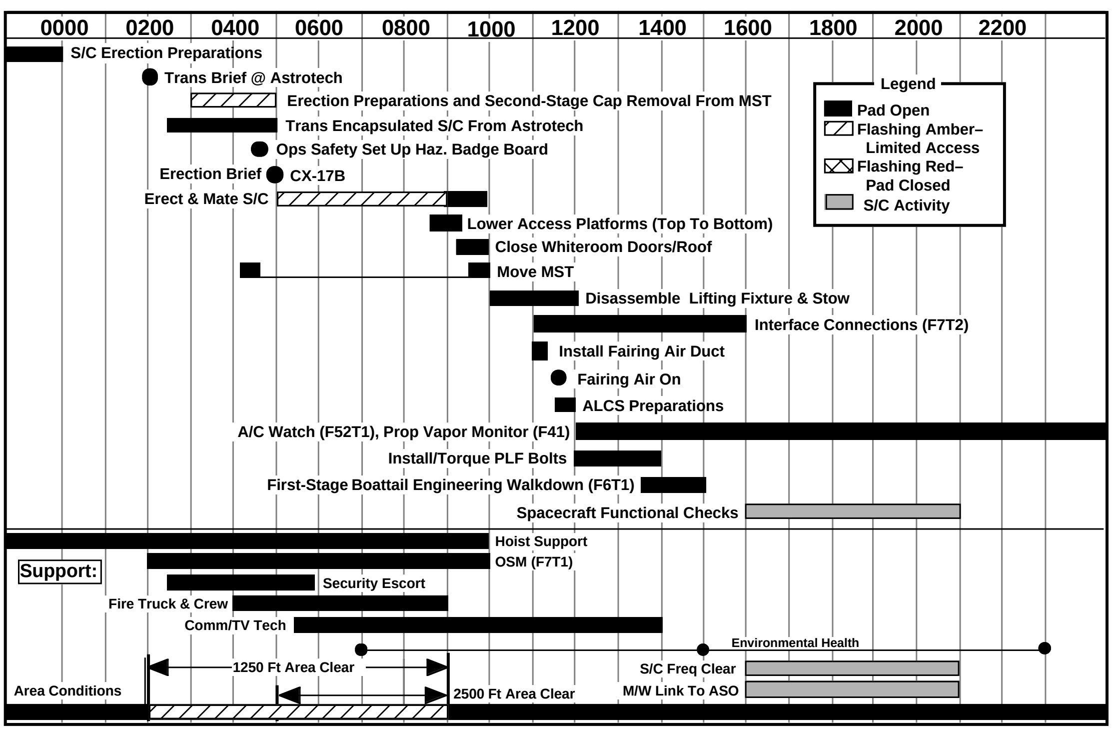

Figure 6-25. Typical Spacecraft Erection (F7T1), T-8 Day

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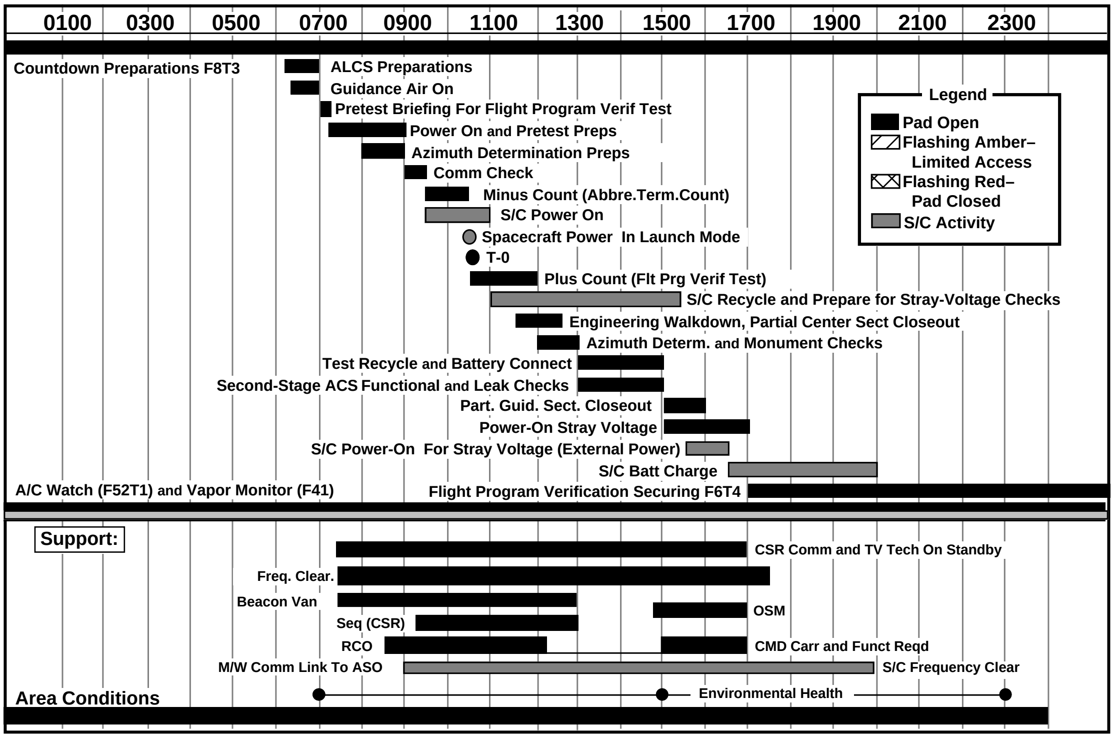

Figure 6-26. Typical Flight Program Verification and Power-On Stray Voltage (F6T2), T-7 Day

02236REU9.2

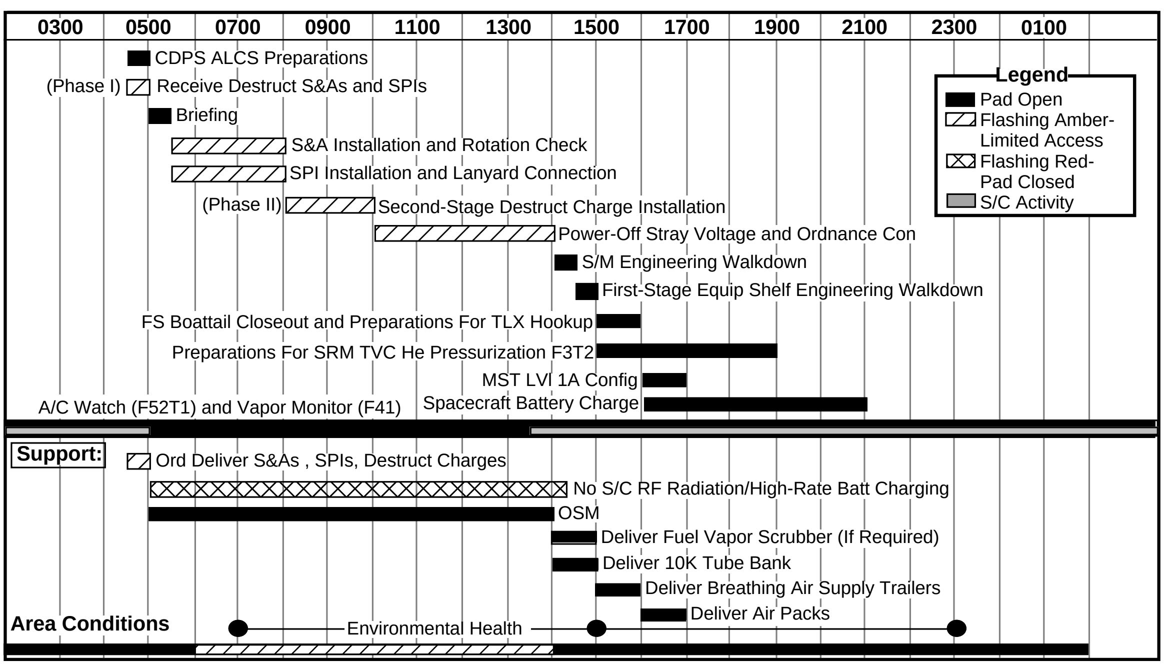

Figure 6-27. Typical Power-Off Stray Voltage, Ordnance Installation, and Hookup (Class B), (F5), T-6 Day

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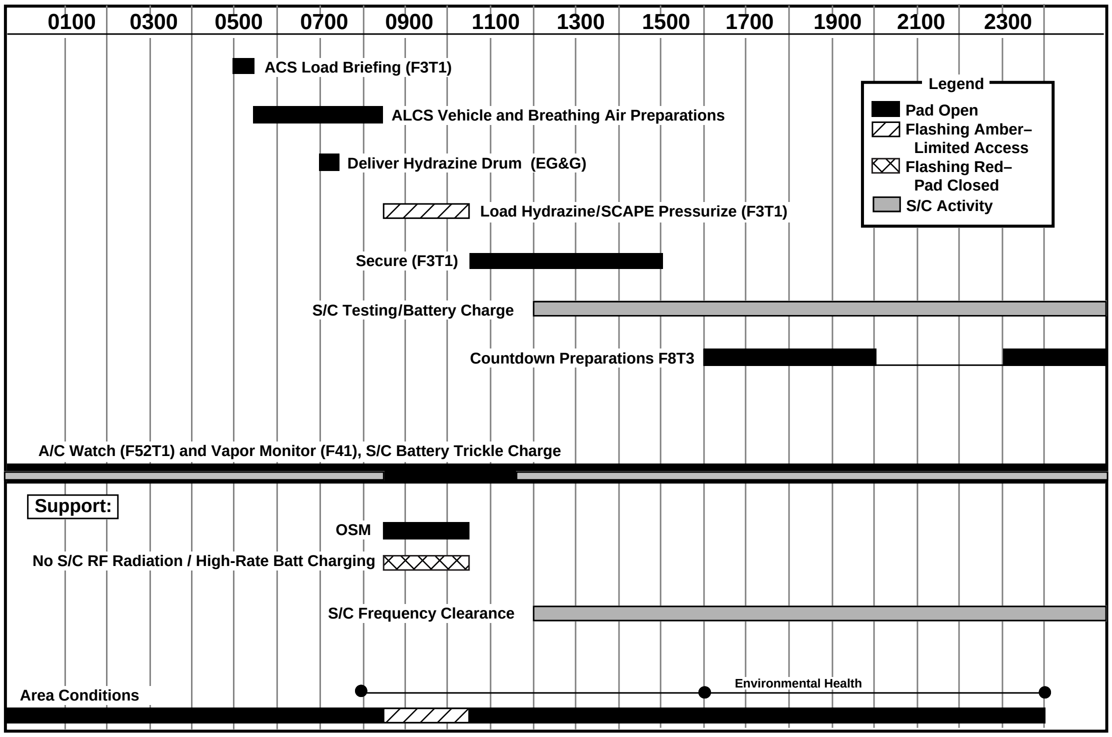

Figure 6-28. Typical Second-Stage ACS Propulsion Load (F3T1), T-5 Day

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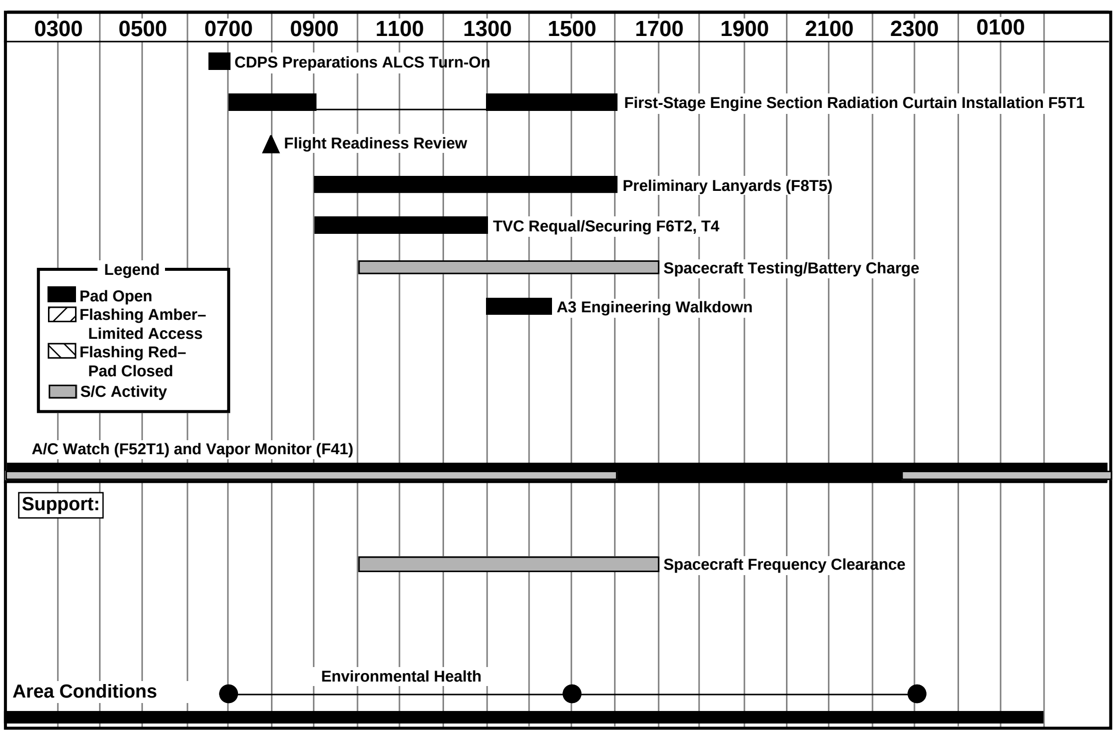

Figure 6-29. Typical Second-Stage Closeouts (F2T2), T-4 Day

02239REU9.2

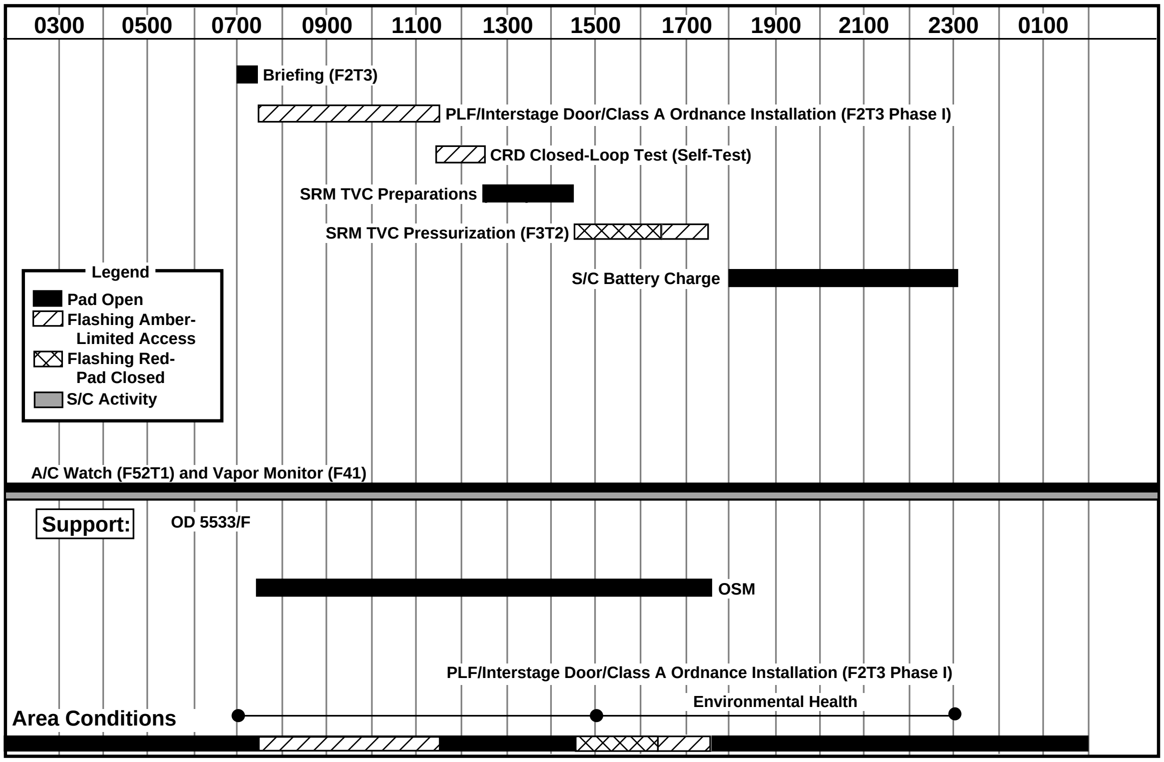

Figure 6-30. Typical Class A Ordnance (F2T3) SRM TVC Preparations and Pressurization (F3T2), T-3 Day

02240REU9.2

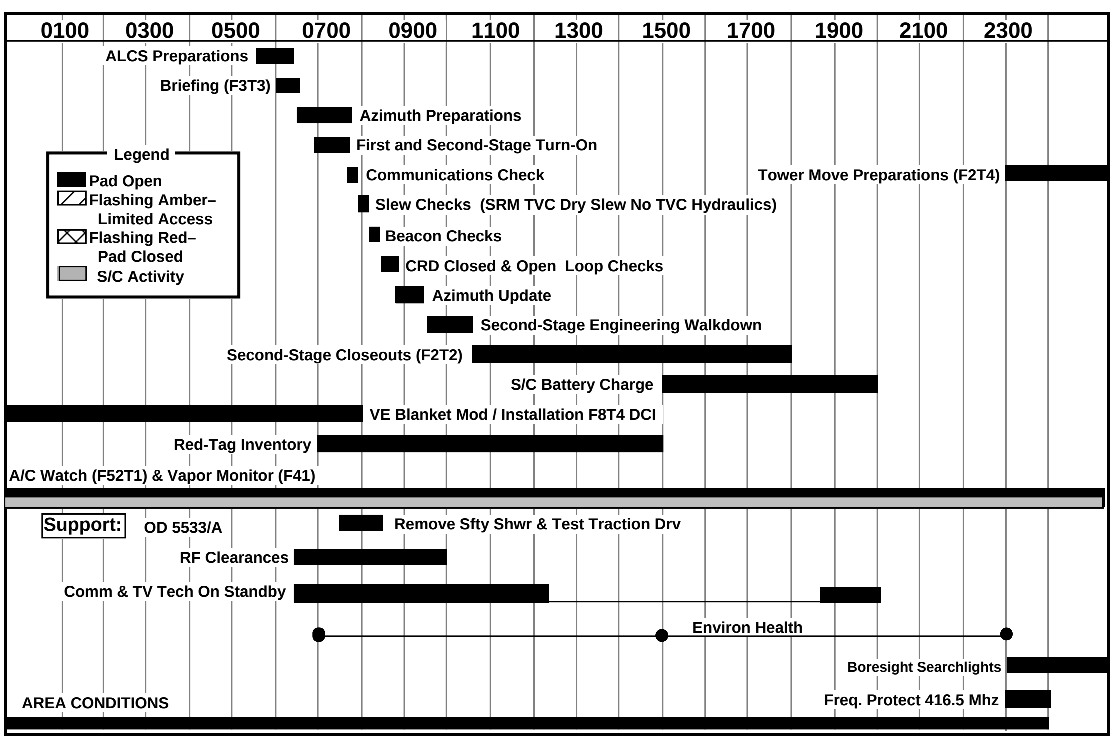

Figure 6-31. Typical Beacon, Range Safety, and Class A Ordnance (F3F2), T-2 Day

T-8. Tasks include transportation to the launch site, erection, and mating of the encapsulated payload to the Delta III second stage in the MST white room. Preparations are made for the launch vehicle flight program verification test. Spacecraft battery-charging can begin at this time and can continue through launch except for a brief period of time during second-stage attitude control system hydrazine loading on T-5. Time is available on this day for spacecraft system testing, if required. However, the spacecraft is required to support the power-on, stray-voltage testing on T-7 (Figure 6-25).

T-7. The launch vehicle flight program verification test is performed, followed by the vehicle power-on stray-voltage test. Spacecraft systems to be powered at liftoff are turned on during the flight program verification test, and all data are monitored for electromagnetic interference (EMI) and radio frequency interference (RFI). Spacecraft systems to be turned on at any time between T-7 day and spacecraft separation are turned on in support of the vehicle power-on stray-voltage test. Spacecraft support of these two vehicle system tests is critical to meeting the scheduled launch date (Figure 6-26).

T-6. Power-off stray voltage is performed and all data are monitored for EMI and RFI. Class B ordnance is installed and hooked up at this time. The Delta III vehicle ordnance installation/connection and spacecraft close-out operations (if required) are performed. Preparations begin for SRM thrust vector assembly (TVA) system pressurization (Figure 6-27).

T-5. The second-stage attitude control system propellant system is loaded for flight. The countdown simulation/mission rehearsal is normally conducted on this day (Figure 6-28).

T-4. Second-stage/interstage close-out activities begin, and launch vehicle final preparations for MST movement begin. Spacecraft testing/battery charge can be performed at this time (Figure 6-29).

T-3. Class A ordnance installation and SRM TVC preparations and pressurization is performed after the hazardous operations. Spacecraft batteries can be charged (Figure 6-30).

T-2. Tasks include C-band beacon readout, and azimuth update (Figure 6-31).

T-1. Tasks include vehicle Class A ordnance connection, spacecraft ordnance arming, and final fairing preparations for MST removal, second-stage engine section close-out, and launch vehicle final preparations (Figure 6-32).

T-0. Launch day preparations include a variety of mechanical tasks leading up to mobile service tower removal, final arming, and terminal sequences. The spacecraft should be in launch configuration immediately prior to T-4 minutes and standing by for liftoff. The nominal hold

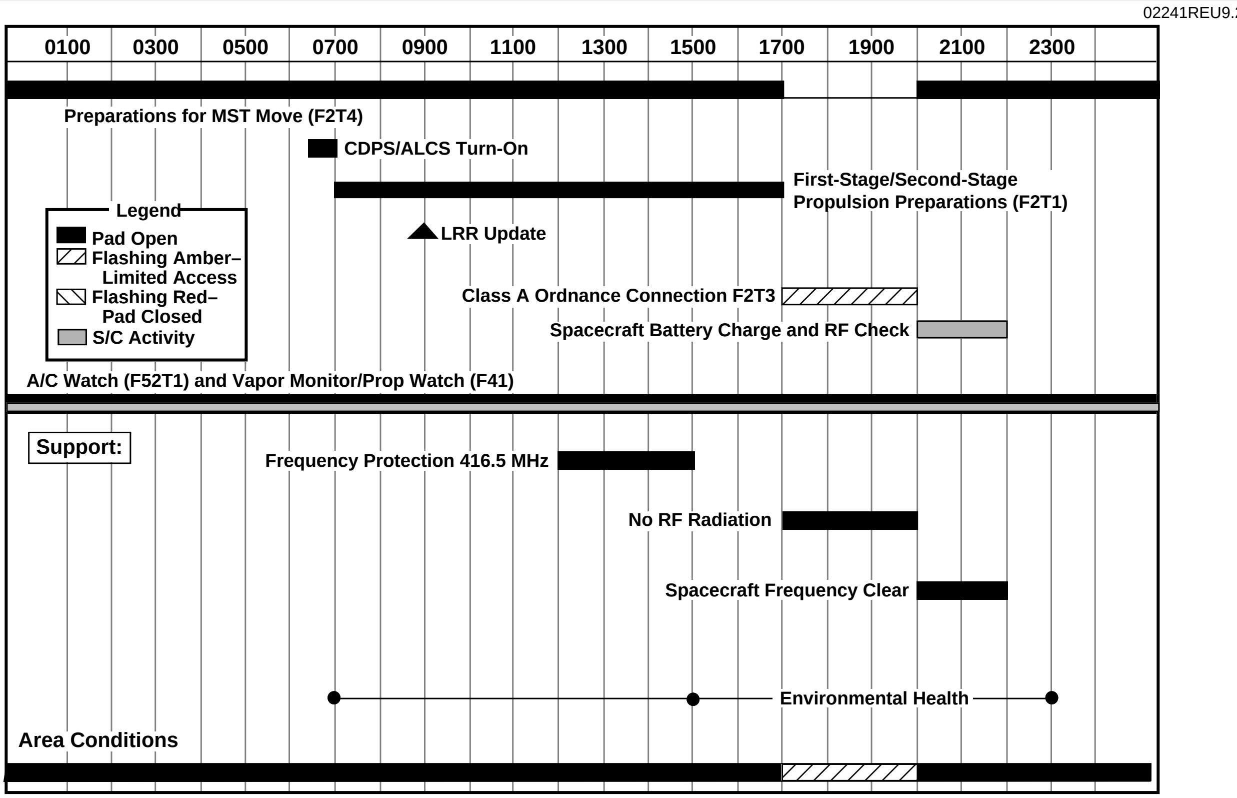

Figure 6-32. Typical First-Stage/Second-Stage Propulsion Preparations, Preparations for Tower Move, T-1 Day

and recycle point, if required, is T-4 minutes (Figure 6-33).

Terminal Count. Terminal count is initiated at L-255 (T-180)-min terminal countdown. The bar chart provides a detailed breakdown of preparation activities for launch (Figure 6-34).

Launch Scrub. Figures 6-35, 6-36, and 6-37 show typical scrub turnaround options depending on at what part of the countdown the scrub occurred. The options are when cryogens are not loaded, when cryogens are loaded; and if TVC has been actuated.

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 both launch pads, Delta mission checkout (DMCO), Hangar M, solid-motor area, and PPFs as required. These schedules are revised daily and reviewed at the twice-weekly Delta status meetings. Another set of launch-vehicle-specific schedules is generated, on a daily timeline, covering a two- or three-month period to show the complete processing of each launch vehicle component. An individual schedule is made for DMCO, HPF, and the launch pad.

6.6.4 Spacecraft Schedules

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

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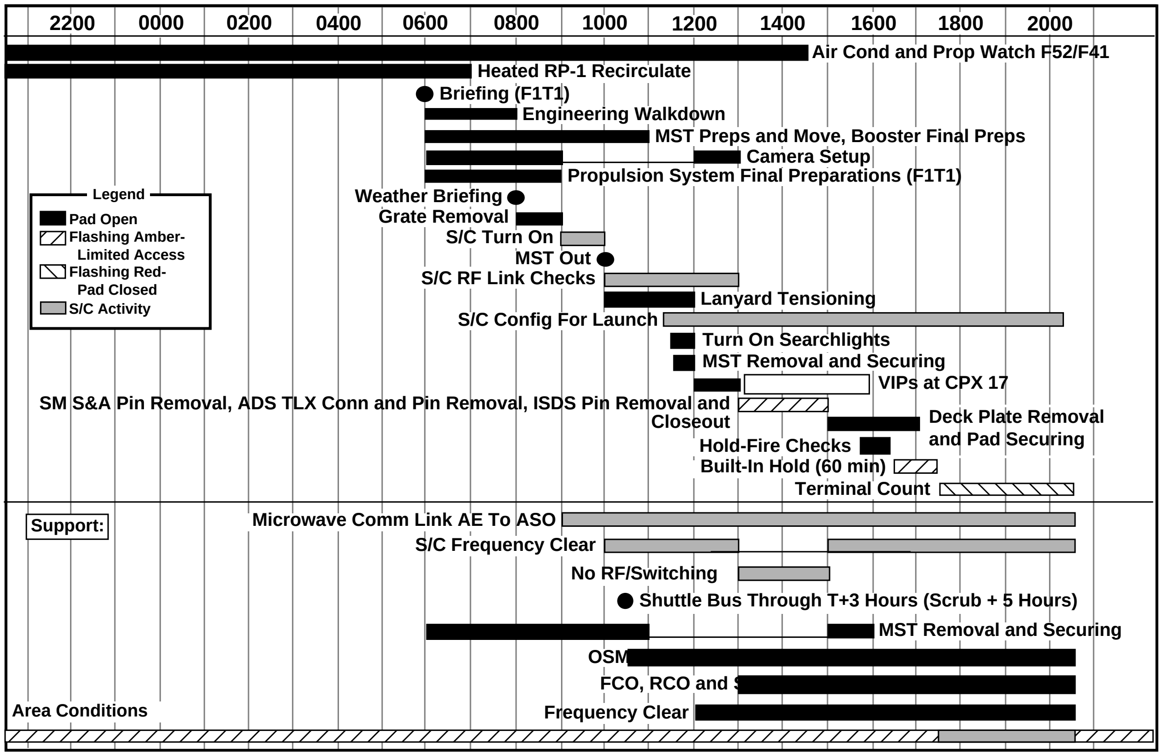

Figure 6-33. Typical Delta Countdown (F1T1), T-0 Day

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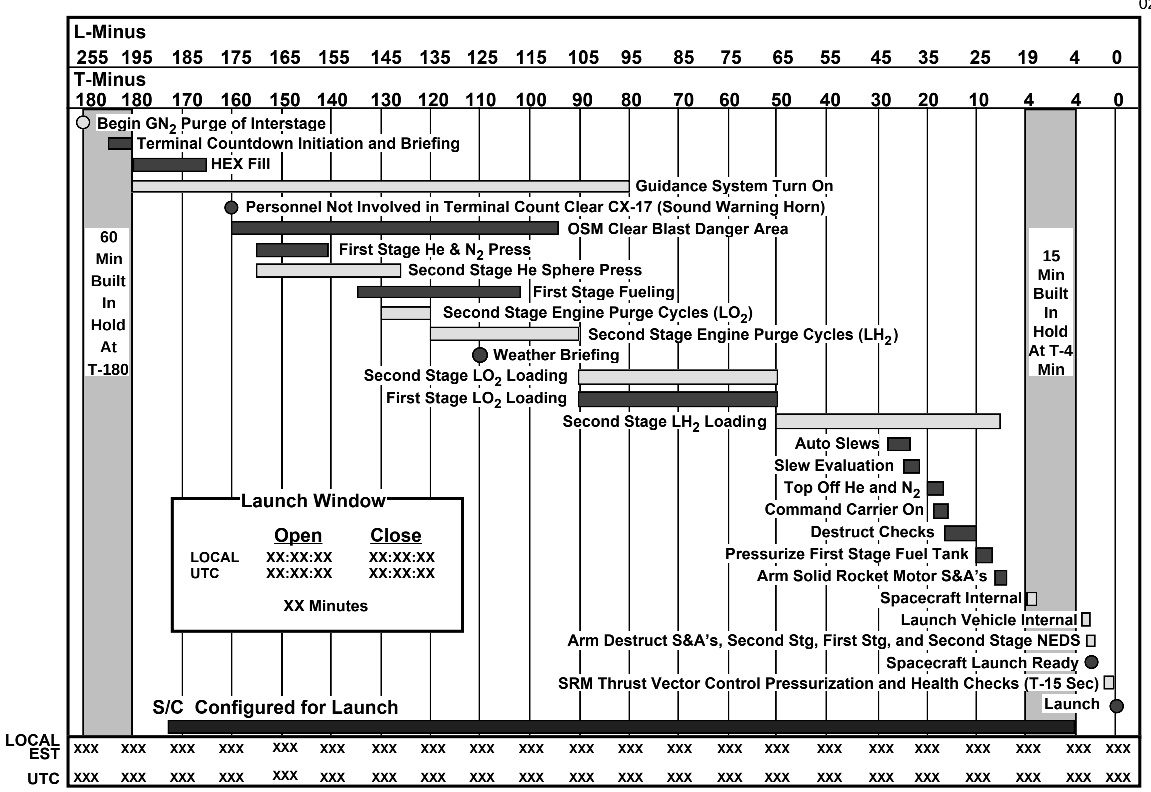

Figure 6-34. Typical Terminal Countdown Bar Charts (F1T3), T-0 Day

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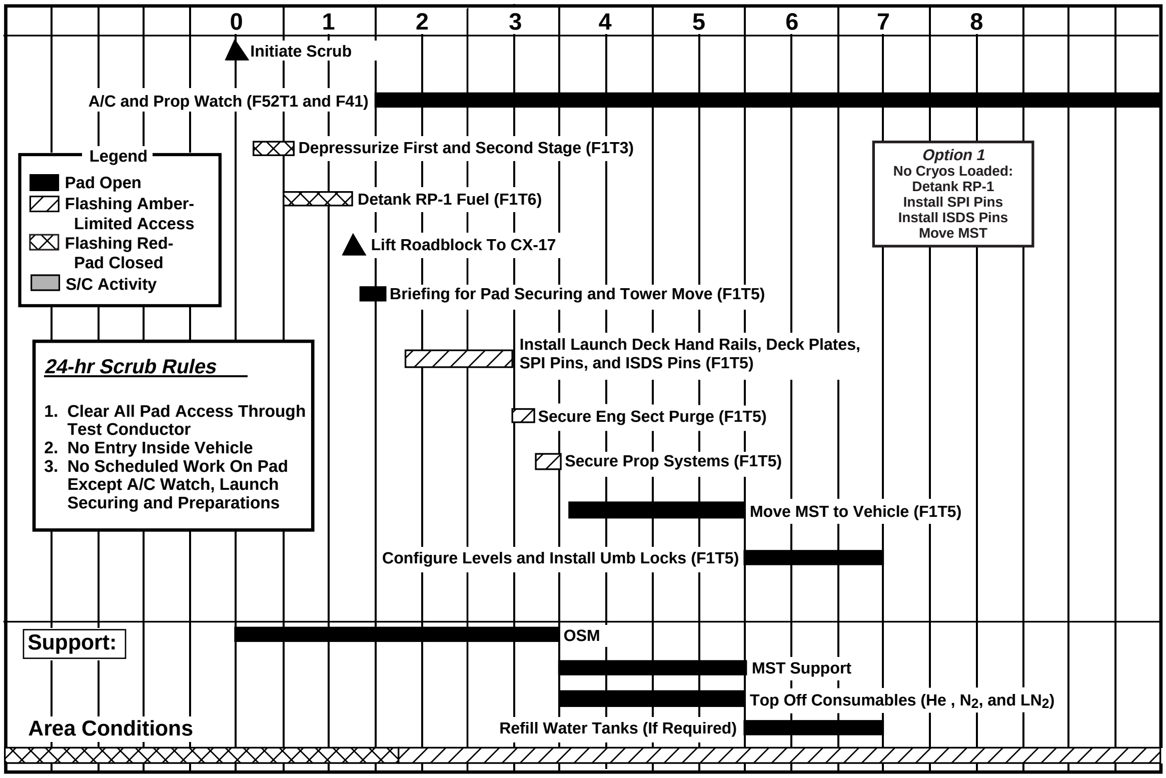

Figure 6-35. Typical Scrub Turnaround, No Cryogens Loaded During Countdown—Option 1

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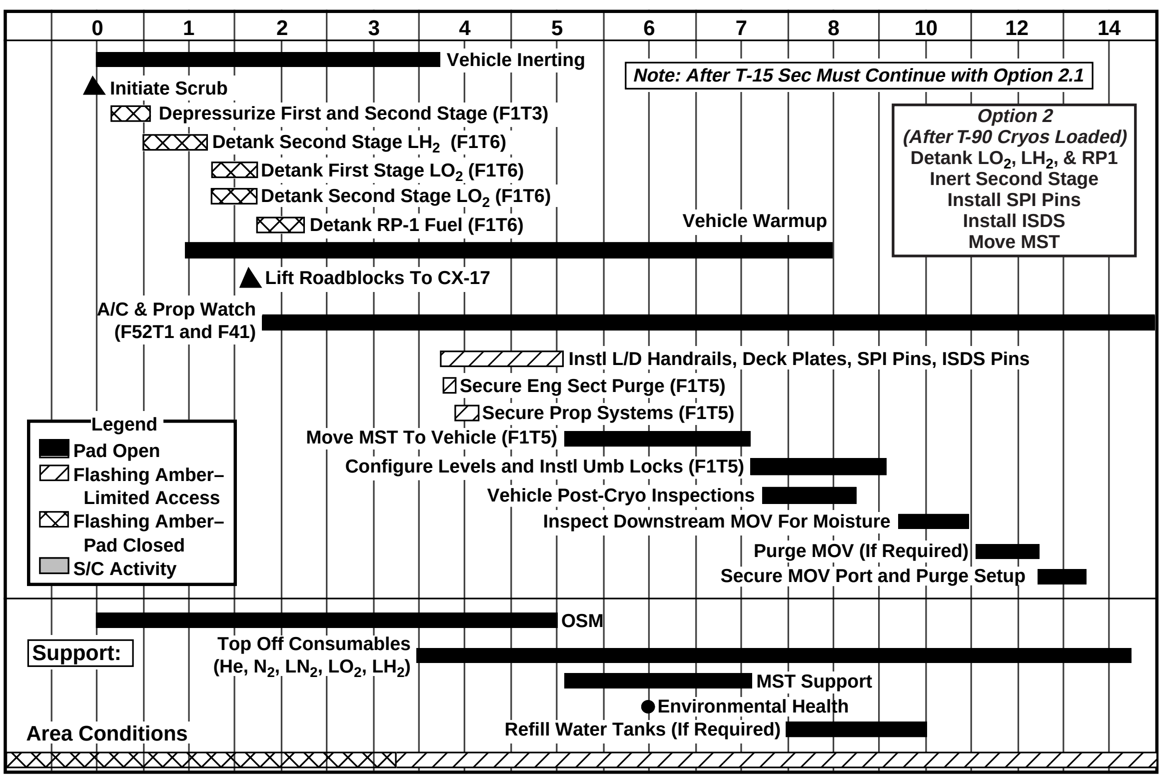

Figure 6-36. Typical Scrub Turnaround, Cryogens Loaded During Countdown—Option 2

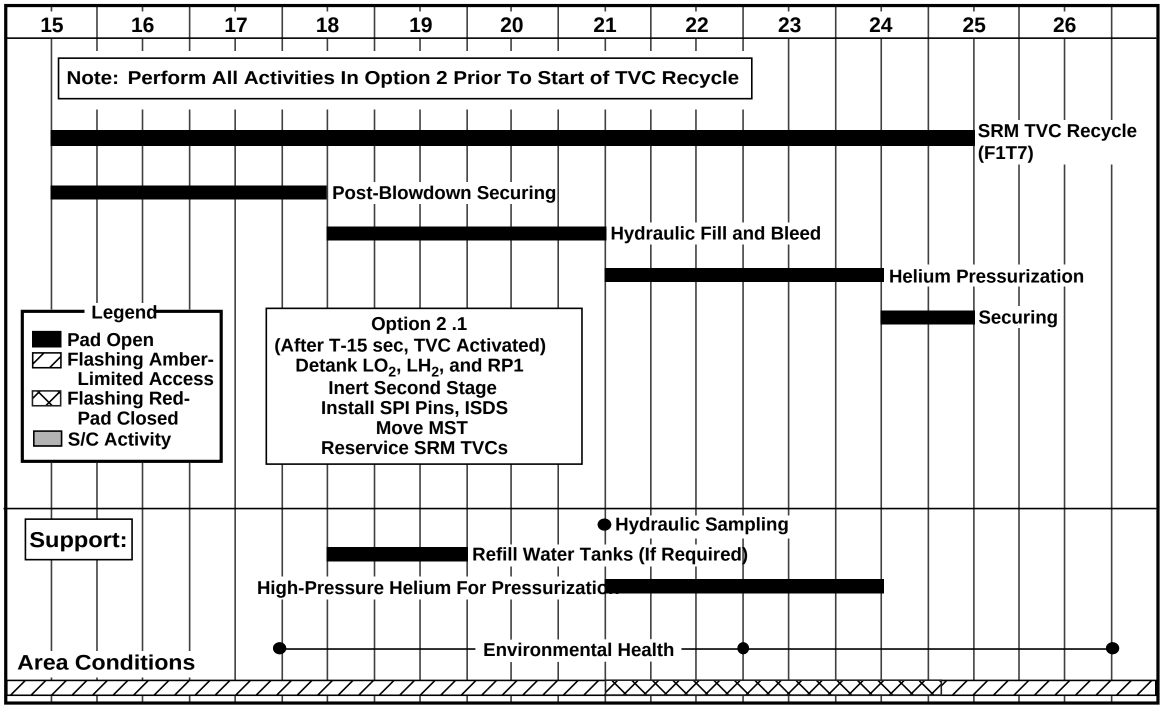

Figure 6-37. Typical Scrub Turnaround, Cryogens Loaded and TVC Activated—Option 2.1

6.7 DELTA III MEETINGS AND REVIEWS

During launch preparation, various meetings and reviews take place. Some of these will require spacecraft customer input while others allow the customer to monitor the progress of the overall mission. The Boeing spacecraft coordinator will ensure adequate spacecraft user participation.

6.7.1 Meetings

6.7.1.1 Delta Status Meetings. Status meetings are generally held twice a week at the launch site when a booster is on the pad. 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. Spacecraft user representatives are encouraged to attend these meetings.

6.7.1.2 Daily Schedule Meetings. Daily schedule meetings are held at SLC-17 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. A daily meeting, usually at the end of first shift, with the Boeing launch conductor, Boeing spacecraft coordinator, and spacecraft customer representatives attending is held starting approximately three days prior to arrival of the encapsulated payload at the launch pad. Status of the day's activities, discussion of work remaining, problems, and the next day's schedule are discussed. This meeting can be conducted via telephone if required.

6.7.2 Reviews

Periodic reviews are held to ensure that the spacecraft and launch vehicle are ready for launch. The Mission Plan (Figure 6-24) shows the relationship of the reviews to the program assembly and test flow.

The following paragraphs discuss the Delta III readiness reviews.

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

6.7.2.2 Mission Analysis Review. This review is held at Huntington Beach, California, approximately three months prior to launch, to review mission-specific drawings, studies, and analyses.

6.7.2.3 Vehicle Readiness Review. The vehicle readiness review (VRR) is held at CCAS subsequent to the completion of DMCO. It includes an update of the activities since Pueblo, the results of the DMCO processing, and hardware history changes. Launch facility readiness is also discussed.

6.7.2.4 Launch Site Readiness Review. The launch site readiness review (LSRR) is held prior to erection and mate of the encapsulated spacecraft. It includes an update of the activities since the VRR and verifies the readiness of the launch vehicle, launch facilities, and spacecraft for transfer of the encapsulated spacecraft to the pad.

6.7.2.5 Flight Readiness Review. The flight readiness review (FRR), typically held on T-4 day, is an update of actuals since the LSRR and is conducted to determine that checkout has shown that the launch vehicle and spacecraft are ready for countdown and launch. Upon completion of this meeting, authorization to proceed with the final phases of countdown preparation is given. This review also assesses the readiness of the range to support launch and provides a predicted weather status.

6.7.2.6 Launch Readiness Review. The launch readiness review (LRR) is typically held on T-1 day (Figure 6-32), and 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

Currently, Boeing customers do not require Delta III launch services at the Western Range; however, customers are encouraged to contact Delta Launch Services for launch options.

Section 8
SPACECRAFT INTEGRATION

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

8.1 INTEGRATION PROCESS

The integration process developed by Boeing is designed to support the requirements of both the launch vehicle and the payload. We work closely with our customers to tailor the integration flow to meet their individual requirements. The integration process (Figure 8-1) encompasses the entire life of the launch vehicle/spacecraft 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.

Mission integration is the responsibility of the Delta Program Office, which is located at the Boeing facility in Huntington Beach, California. The objective of mission integration is to coordinate all interface activities required for the launch. This objective includes reaching an interface agreement between the customer and Boeing and accomplishing interface planning, coordinating, scheduling, control, and targeting.

The Delta Program Office assigns a mission integration manager to direct interface activities. The mission integration manager develops a tailored integration planning schedule for the Delta III launch vehicle/spacecraft by defining the documentation and analysis required. The mission integration manager also synthesizes the spacecraft requirements and engineering design and analysis

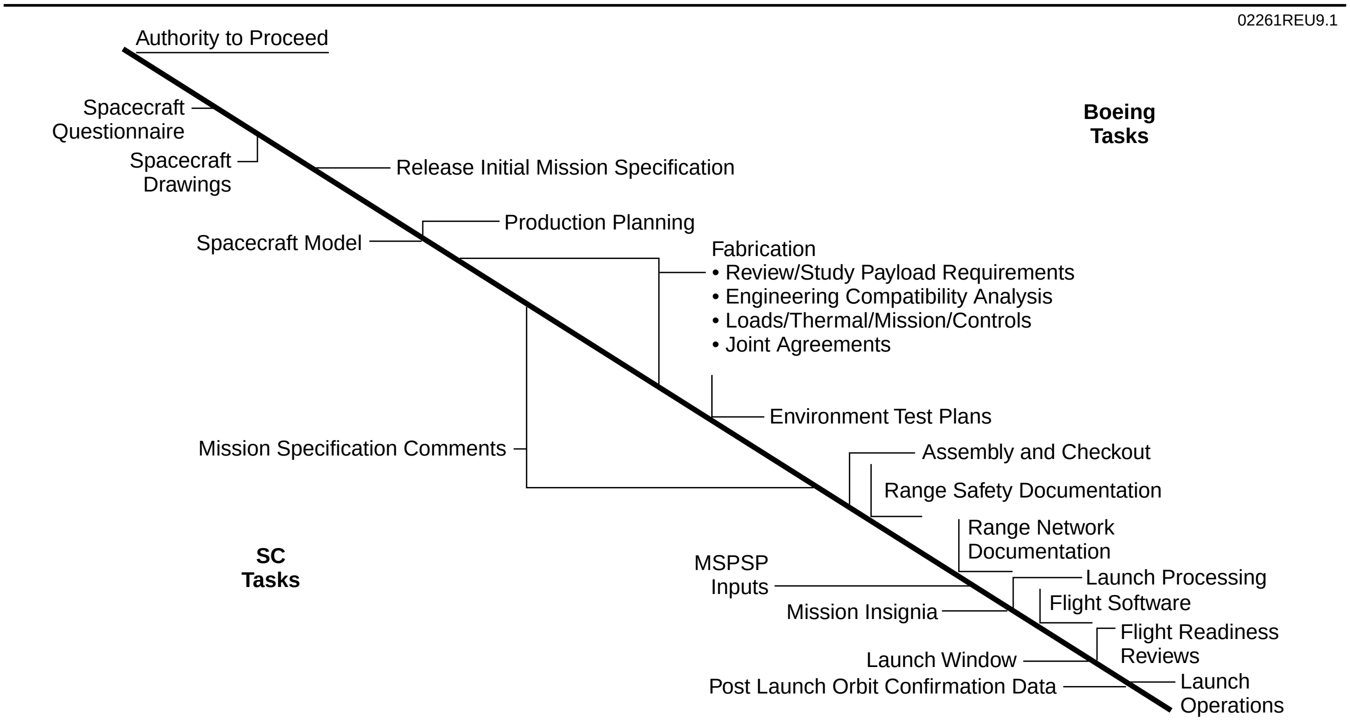

Figure 8-1. Mission Integration Process

into a controlled mission specification that establishes agreed-to interfaces.

The integration manager ensures that all lines of communication function effectively. To this end, all pertinent communications, including technical/administrative documentation, technical interchange meetings (TIM), and formal integration meetings are coordinated through the Delta Program Office 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 III launches. Figure 8-2 shows the typical relationships among agencies involved in a Delta mission.

8.2 DOCUMENTATION

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

The typically required documents and need dates are listed in Tables 8-1 and 8-2. The document

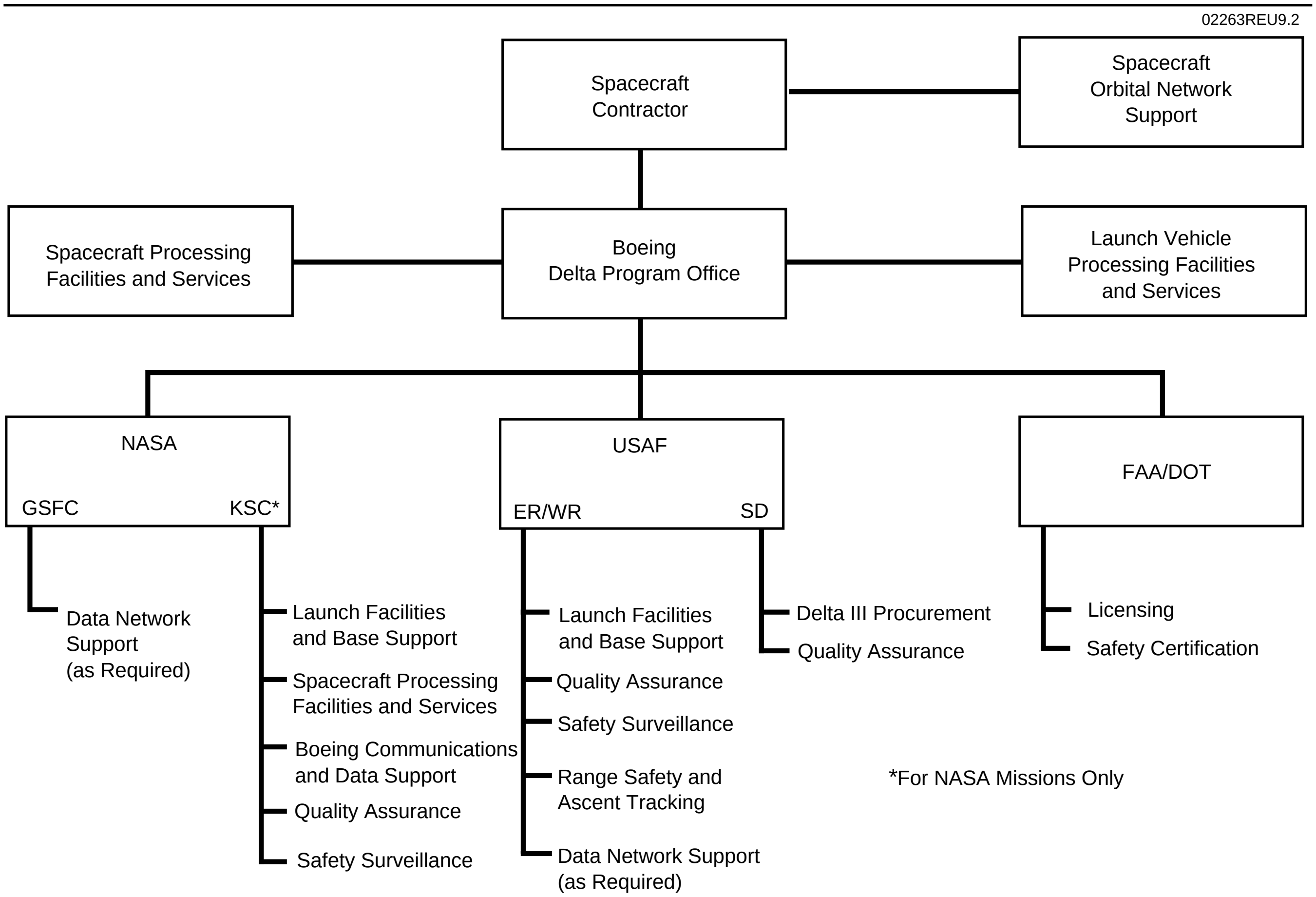

Figure 8-2. Typical Delta III Agency Interfaces

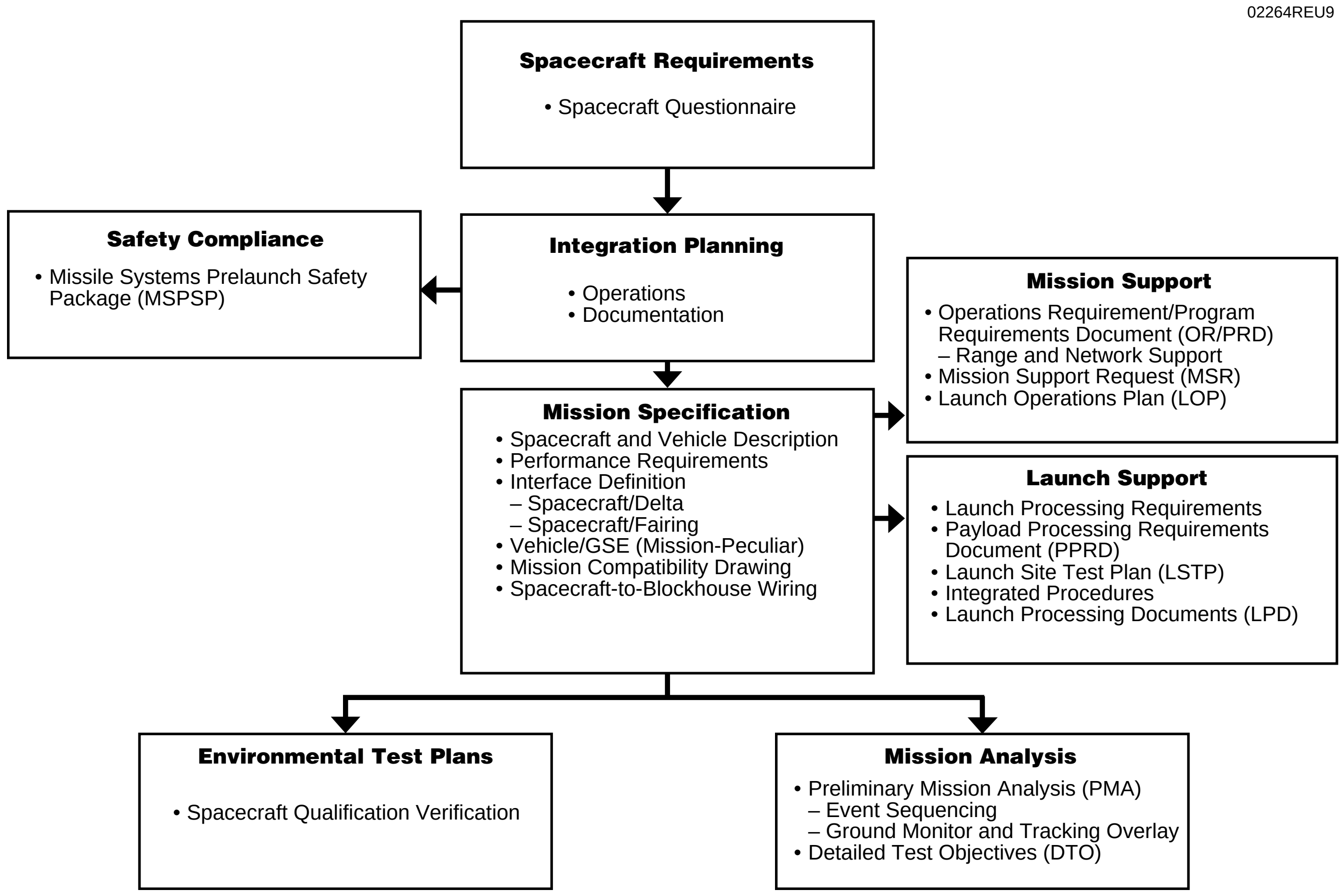

Figure 8-3. Typical Document Interfaces

description is identified in Table 8-3. Specific schedules can be established by coordinating with the mission manager. The spacecraft questionnaire shown in Table 8-4 is to be completed by the spacecraft contractor at least two years prior to launch to provide an initial definition of spacecraft characteristics. Table 8-5 is an outline of a typical spacecraft launch site test plan that describes the launch site activities and operations expected in support of the mission. Orbit data at final stage burnout are needed to reconstruct Delta performance following the mission. A complete set of orbital elements and associated estimates of 3-sigma accuracy required to reconstruct this performance are presented in Table 8-6.

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 mission integration manager is required to provide proper planning of the integration documentation.

8.3 LAUNCH OPERATIONS PLANNING

The 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. The relationship and submittal schedules of key controlling documents are shown in Figure 8-5.

8.4 SPACECRAFT 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 Cape Canaveral Air Station/Kennedy Space Center (CCAS/KSC) or Astrotech Space Operations (ASO), as appropriate and implements the requirements through the program requirements document/payload processing requirements document (PRD/PPRD). The user may add items to the list. Note that most requirements for assembly and checkout of commercial spacecraft will be met at the Astrotech facility.

Table 8-1. Spacecraft Contractor Data Requirements

Description	Table 8-3 reference	Nominal due weeks
Spacecraft Questionnaire	2	L-104
Federal Aviation Administration (FAA) License Information	2	L-104
Spacecraft Mathematical Model	3	L-90
Spacecraft Environmental Test Documents	5	L-84
Mission Specification Comments	4	30 days after receipt
Electrical Wiring Requirements	7	L-60
Spacecraft Drawings (Initial/Final)	18	L-78/L-44
Fairing Requirements	8	L-68
Radio Frequency Applications Inputs	10	L-58
Spacecraft Missile System Prelaunch Safety Package (MSPSP)	9	L-26
Preliminary Mission Analysis (PMA) Requirements	11	L-54/L-39
Mission Operational and Support Requirements for Spacecraft	12, 13	L-52
Payload Processing Requirements Document Inputs	14	L-52
Spacecraft-to-Blockhouse Wiring Diagram Review	29	L-40
Detailed Test Objective (DTO)	17	L-39
Launch Window (Initial/Final)	16	L-39, L-4
Vehicle Launch Insignia	15	L-39
Spacecraft Launch Site Test Plan	19	L-34
Spacecraft Compatibility Drawing Comments	18	L-29
Spacecraft Mass Properties Statement (Initial/Final)	22	L-54/L-20
Spacecraft Integrated Test Procedure Inputs	21	L-15
Spacecraft Launch Site Test Procedure	20	L-18
Spacecraft Environments and Loads Test Report	5	L-18
Mission Operational and Support Requirements	12	L-12
Postlaunch Orbit Confirmation Data	28	L+1

M067, t14.3

Table 8-2. Boeing Program Documents

Description	Table 8-3 reference	Nominal due weeks
Mission Specification (Initial)	4	L-84
Coupled Dynamic Loads Analysis	6	L-68
Spacecraft-to-Blockhouse Wiring Diagram (Preliminary/Final)	29	L-50, L-24
Preliminary Mission Analysis (PMA)	11	L-44
Payload Processing Requirements Document (PPRD)	14	L-39
Spacecraft Compatibility Drawing	18	L-36, L-17
Detailed Test Objective (DTO)	17	L-28
Spacecraft-Fairing Clearance Drawing	18	L-27
Spacecraft Separation Analysis	25	L-12
Launch Site Procedures	30	L-10
Countdown Bar Charts	31	L-4
Launch Operations Plan (LOP)	26	L-4
Vehicle Information Memorandum (VIM)	27	L-3

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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 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 vehicle; and (3) spacecraft that impose uncertainties with regard to 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 and is designed to provide the initial definition of spacecraft requirements, interface details, launch site facilities, and preliminary safety data to 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 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 III missions. The spacecraft contractor is encouraged to include other pertinent information regarding mission requirements or constraints.	Spacecraft Contractor (SC)
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, degree 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 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 upon data provided in the spacecraft questionnaire and is provided approximately 84 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 Spacecraft Contractor)
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 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 vehicle and spacecraft structure. 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 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 spacecraft contractor and the Delta Program Office is essential to decide on the output format and the actual work schedule for the analysis.	Boeing (input required from Spacecraft Contractor, item 3)
7.	**Electrical Wiring Requirements** The wiring requirements for the spacecraft to the operations building 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 operations building 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 operations building information.	Spacecraft Contractor

Table 8-3. Required Documents (Continued)

	Item	Responsibility
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, radio frequency (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, a MSPSP must be prepared and submitted to the Delta Program Office. 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 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 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 54 weeks before launch. Comments to the PMA are needed no later than launch minus 39 weeks for start of the detailed test objective (DTO) (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 the Delta Program Office. 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 Documents (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 the Delta Program Office. The Delta Program Office will compile, review, provide comments, and, upon comment resolution, forward the spacecraft PRD to the appropriate support agency for formal acceptance.	Boeing (input required from user)
14.	**Payload Processing Requirements Documents (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 of 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
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 the Delta Program Office not later than 9 months before launch for review and approval. Following approval, the Delta Progam Office will have the flight insignia prepared and placed on the launch vehicle. The maximum size of the insignia is 2.4 m by 2.4 m (8 ft by 8 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 date should extend for at least 2 weeks beyond the scheduled launch date. Liftoff is targeted to the specified window opening.	Spacecraft Contractor

Table 8-3. Required Documents (Continued)

	Item	Responsibility
17.	**Detailed Test Objectives (DTO) Report** Boeing will issue a DTO trajectory report that provides the mission reference trajectory. The DTO contains a description of the flight objectives, the nominal trajectory printout, a sequence of events, vehicle attitude rates, spacecraft and vehicle tracking data, and other pertinent information. The trajectory is used to develop mission targeting constants and represents the flight trajectory. The DTO will be available at launch minus 28 weeks.	Boeing (input required from Spacecraft Contractor)
18.	**Spacecraft Drawings** Spacecraft configuration drawings are required as early as possible. The drawings should show nominal and worst-case (maximum tolerance) dimensions for the compatibility drawing prepared by Boeing, clearance analysis, fairing compatibility, and other interface details. Preliminary drawings are desired with the spacecraft questionnaire but no later than 78 weeks prior to launch. The drawings should be 0.20 scale and transmitted through the computer-aided design (CAD) medium. However, rolled vellum or mylar is acceptable. Details should be worked through the Delta Program Office.	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-payload attach fitting (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 contractor. In addition, Boeing will provide a worst-case spacecraft-fairing clearance drawing.	Boeing
19.	**Spacecraft Launch Site Test 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 test plan. The plan is intended to describe all aspects of the program while at the launch site. A suggested format is shown in Table 8-5.	Spacecraft Contractor
20.	**Spacecraft Launch Site Test Procedures** Operating procedures must be prepared for all operations that are accomplished at the launch site. For those operations that are hazardous in nature (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 upper 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 represent 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 vehicle. Values quoted should include nominal and 3-sigma uncertainties for mass, centers of gravity, moments of inertia, products of inertia, and principal axis misalignment.	Spacecraft Contractor
23.	**Reserved**	
24.	**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 listing of all intermodulation products, which are then checked for image frequencies and intermodulation product interference.	Boeing
25.	**Spacecraft/Launch Vehicle Separation Memorandum** An analysis is performed to verify that there is adequate clearance and separation distance between the spacecraft and 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 Spacecraft Contractor)
26.	**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

Table 8-3. Required Documents (Continued)

	Item	Responsibility
27.	**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 contractor 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, S/C spin rates, and orbital parameter information for each different orbit through final orbit. Boeing will incorporate these data into the overall VIM and transmit to the appropriate US government agency.	Boeing
28.	**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 data prior to any orbit correction maneuvers. A complete set of orbital elements and associated estimates of 3-sigma accuracy is required (see Table 8-6).	Spacecraft Contractor
29.	**Spacecraft-to-Operations Building Wiring Diagram** Boeing will provide, for inclusion into the mission specification, a spacecraft-to-operations building wiring diagram based on the spacecraft requirements. It will define the hardware interface from the spacecraft to the operations building for control and monitoring of spacecraft functions after spacecraft installation in the launch vehicle.	Boeing
30.	**Launch Site Procedures** Boeing prepares procedures, called launch preparation documents (LPD), that are used to authorize work on the flight hardware and related ground equipment. Most are applicable to the booster and second-stage operations, but a few are used to control and support the stand-alone spacecraft and integrated activities at the payload processing facility and on the launch pad after encapsulated payload mate. These documents are prepared by Boeing based on Boeing requirements; the inputs provided by the spacecraft contractor are listed in item 21 and are available for review by the customer. LPDs are usually released a few weeks prior to use.	Boeing
31.	**Countdown Bar Charts** Daily schedules are prepared on hourly timelines for integrated activities at the launch pad following encapsulated spacecraft mate to the second stage. These schedules are prepared by the Boeing chief test conductor based on standard Boeing launch operations, mission-specific requirements, and inputs provided by the spacecraft contractor as described in the mission specification. (Typical schedules are shown in Figures 6-25, 6-26, 6-27, 6-28, 6-29, 6-30, and 6-31.) A draft is prepared several months prior to launch and released to the customer for review. The final is normally released several weeks prior to encapsulated spacecraft mate at the pad.	Boeing

M067, t16.6

Table 8-4. Delta III 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 1.2.5-1. SC On-Orbit Configuration

Figure 1.2.5-2. Constellation On-Orbit Configuration (if applicable)

1.3 Spacecraft Mass Properties

1.3.1 Weight, Moments and Products of Inertia, Table 1.3.8-1 and 1.3.8-2

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 III 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 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 1.4.4.1-1. 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 1.4.4.1-2. 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 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 Requirements
- 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 Tip-Off 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 (0/360º) toward Quadrant I (90º).

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)				

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

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 5.2.2.1-1. Spacecraft Mechanical Interface Definition

SC bus	Size of SC 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 (SC coordinates or LV coordinates)		
Radial Distance of Connector Centerline from Vehicle Centerline[1] (unit)		
Polarizing Key		
Maximum Connector Force (+Compression, –Tension) (unit)		
Note: 1. Positional tolerance defined in Payload Planners Guide.		

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 Clampband 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

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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, and $\dot{X}$, $\dot{Y}$, $\dot{Z}$) 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, γ_1
   Inertial flight path angle, γ_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 6 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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Agency	Milestones	Weeks (100 90 80 70 60 50 40 30 20 10 0 — Launch)
SC	Spacecraft Questionnaire	L-104
SC	Spacecraft Mathematical Model	L-90
SC	Spacecraft Environment Test Document	L-84
Boeing	Mission Specification	L-84 Initial
SC	Spacecraft Drawings	L-78 Initial; L-44 Final
SC	Mission Specification Comments	L-80
Boeing	Coupled Dynamic Loads Analysis	L-68
SC	Fairing Requirements	L-68
SC	Electrical Wiring Requirements	L-80
SC	Spacecraft Missile System Prelaunch Safety Package (MSPSP)	L-58
SC	Radio Frequency Application (RFA)	L-58
SC	Preliminary Mission Analysis (PMA) Requirements	L-54
SC	Payload Processing Requirements Doc (PPRD) Input	L-52
SC	Mission Operations and Support Requirements	L-52
Boeing	Spacecraft-to-Blockhouse Wiring Diagram	Preliminary L-50; Final L-24
Boeing	Preliminary Mission Analysis	L-44
SC	Spacecraft-to-Blockhouse Wiring Diagram Comments	L-40
SC	Launch Vehicle Insignia	L-39
SC	Launch Window	L-39 Initial; Final L-4
SC	Detailed Test Objective (DTO) Requirements	L-39
Boeing	Payload Processing Requirements Document	L-39
Boeing	Spacecraft Compatibility Drawing	L-36; L-17 Final
SC	Spacecraft Launch Site Test Plan	L-34
SC	Spacecraft Compatibility Drawing Comments	L-29
Boeing	Detailed Test Objective	L-28
Boeing	Spacecraft Fairing Clearance Drawing	L-27
Boeing	Program Requirements Document	L-26
SC	Combined Spacecraft/ Mass Properties Statement	L-54 Initial; L-20 Final
SC	Spacecraft Integrated Test Procedure Input	L-20
SC	Spacecraft Launch Site Procedures	L-18
SC	Spacecraft Environments and Loads Test Report	L-18
Boeing	Launch Site Procedures	L-15
Boeing	RF Compatibility Study Results	L-12
Boeing	Spacecraft Separation Analysis	L-12
Boeing	Launch Operations Plan	L-12; Final L-4
Boeing	Countdown Bar Charts	L-4
Boeing	Vehicle Information Memo (VIM)	L-3
SC	Postlaunch Orbit Confirm. Data (Orbital Tracking Data)	L+1 Day
Boeing	Postlaunch Flight Report	L+8

Launch

Figure 8-4. Typical Integration Planning Schedule

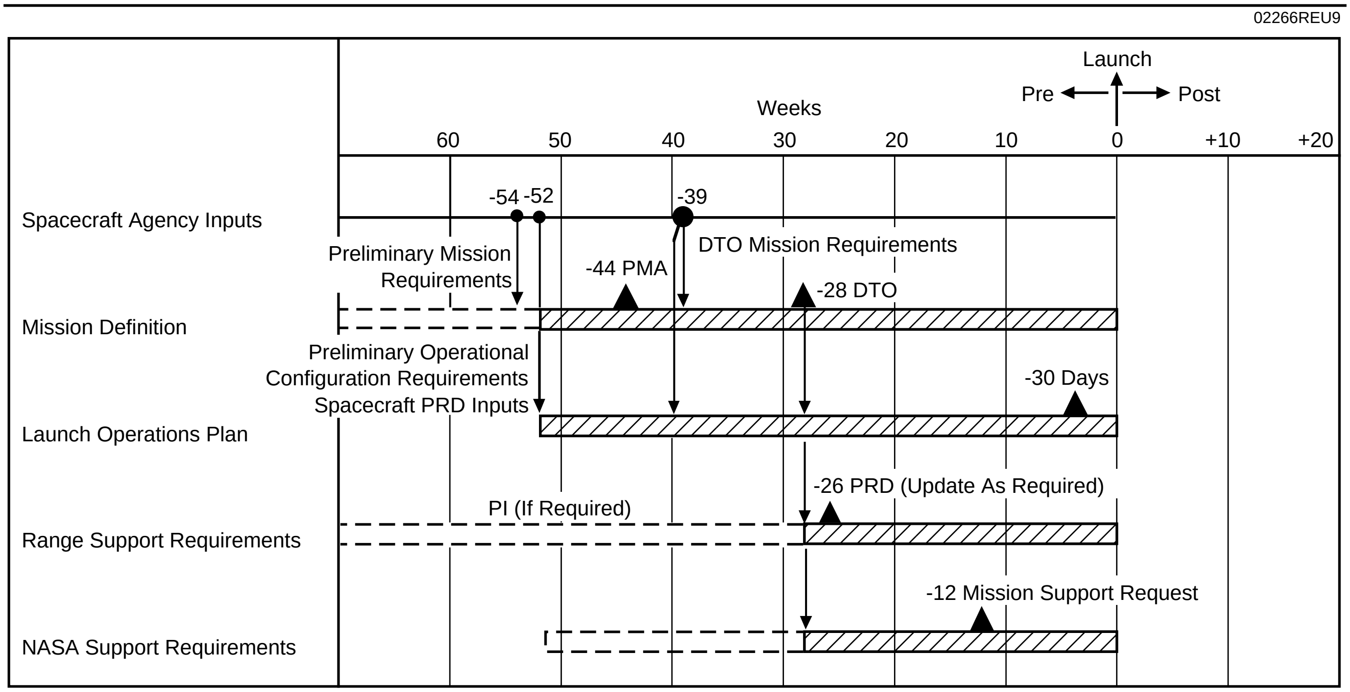

Figure 8-5. Launch Operational Configuration Development

Table 8-7. Spacecraft Checklist

1. General

A. Transportation of spacecraft elements/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) ____________________________________
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)
    a.Continuous:
    b.During critical tests:
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 _____ (quantity/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. ____
L. Spacecraft 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

Table 8-7. Spacecraft Checklist (Continued)

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) Downtime 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:
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) _______________
H. Services general
  (1) Gases
    a. Specification _______________________
      Procured by user? _____ KSC? ________
    b. Quantity ___________________________
    c. Sampling? (yes) _____ (no) ___________
  (2) Photographs/video ___ (quantity/B&W/color)
  (3) Janitorial (yes) _________ (no) ___________
  (4) Reproduction services (yes) ____ (no) _____
I. Security (yes) ________ (no) __________
J. Storage _______________ (size area) (environment) ________________________
K. Other _____
L. Spacecraft HPF 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-17
  (1) Security escort (yes) _____ (no) ___________
  (2) Other ______________________________

4. Launch Complex White Room (MST)

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) Downtime 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 _________ (quantity/B&W/color)
E. Security (yes) _____ (no) ____________________
F. Other ____________________________________
G. Stand-alone testing (does not include tests involving the Delta III 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 regulations and requirements that govern a payload to be launched by a Delta III launch vehicle. Regulations and instructions that apply to spacecraft design and processing procedures are reviewed. Boeing acts as the coordinating agent for the customer in interfacing with all federal, state, and local safety agencies.

9.1 SAFETY REQUIREMENTS

Delta III prelaunch operations are conducted in Florida at Cape Canaveral Air Station (CCAS), Astrotech in Titusville, and Kennedy Space Center (KSC). The USAF is responsible for overall safety (ground/flight) at CCAS and has established safety requirements accordingly. Operations at the Astrotech facility are covered by their safety policies. NASA safety regulations govern spacecraft processing in NASA facilities and for all NASA spacecraft wherever they may be processed. The following documents specify the safety requirements applicable to Delta III users at the respective location.

A. EWR 127-1, Range Safety Requirements, 31 October 1997.

B. KHB 1710.2C, Kennedy Space Center Safety Practices Handbook, February 27, 1997.

C. Astrotech Space Operations, Safety, Standard Operating Procedure (SOP), 1988.

Document applicability is determined by mission type and launch site as shown in Table 9-1.

The Space Wing safety organization encourages payload contractors to coordinate with them to generate a tailored version of the EWR 127-1 document specific to each program. This process can greatly simplify the safety process at the range. Boeing provides coordination and assistance to the spacecraft agency in this process.

9.2 DOCUMENTATION REQUIREMENTS

Both USAF and NASA require formal submittal of safety documentation containing detailed information on all hazardous systems and associated operations. Before a spacecraft moves onto USAF property, the 45th Space Wing (45 SW) at the Eastern Range requires preparation and submittal of a missile system prelaunch safety package (MSPSP). Document content and format requirements are found in EWR 127-1, Range Safety Requirements, and should be included in the tailoring process. Data requirements include design, test, and operational considerations. NASA requirements in almost every instance are covered by the USAF requirements; however, the

Table 9-1. Safety Document Applicability

		Safety document		
Launch site	Payload type	EWR 127-1 Reference A	KHB 1710.2C Reference B	Astrotech SOP 1988 Reference C
CCAS	NASA	X	X	
	Commercial	X		X

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spacecraft contractor can refer to KHB 1710.2C for details and/or additional requirements.

A ground operations plan (GOP) must be submitted describing hazardous and safety-critical operations for processing spacecraft systems and associated ground support equipment (GSE).

Test and inspection plans are required for the use of hoisting equipment and pressure vessels at the ranges. These plans describe testing methods, analyses, and maintenance procedures used to ensure compliance with EWR 127-1 requirements.

The payload organization is also required to support an assessment to determine if a flight termination system (FTS) is required on the payload. The purpose of the FTS would be to prevent the spacecraft's propulsion system from igniting and causing an increase in crossrange hazard beyond that achievable by the launch vehicle. An FTS system on the spacecraft is not usually required if it can be demonstrated that there should be no increase in capability to hazard-protected areas over that associated with impacting debris resulting from a command destruct.

Diligent and conscientious preparation of the required safety documentation cannot be overemphasized. Each of the USAF launch range support organizations retains final approval authority over all hazardous operations that take place within its jurisdiction. Therefore, the spacecraft contractor should consider the requirements of the EWR 127-1 and KHB 1710.2C from the outset of a program, use them for design guidance, and submit the required data as early as possible. Document applicability is determined by mission type and launch site as shown in Table 9-1.

The safety document is submitted to the appropriate government agency, or to Boeing for commercial missions, for review and further distribution. Sufficient copies of the original and all revisions must be submitted by the originator to enable a review by all concerned agencies. The review process usually requires several iterations until the system design and its intended use are considered to be final and in compliance with all safety requirements. The flow of spacecraft safety information is dependent on the range, the customer, and contractual arrangements. Contact Boeing for specific details.

Each Air Force and NASA safety agency has a requirement for submittal of documentation for emitters of ionizing and nonionizing radiation. Required submittals depend on the location, use, and type of emitter and may consist of forms and/or analyses specified in the pertinent regulations and instructions.

A radio frequency (RF) ordnance hazard analysis must be performed, documented, and submitted to confirm that the spacecraft systems and the local RF environment present no hazards to ordnance on the spacecraft or launch vehicle.

Each processing procedure that includes hazardous operations must have a written procedure approved by Space Wing safety (and NASA safety for NASA facilities). Those that involve Boeing personnel or integrated operations with the launch vehicle must also be approved by Boeing Test and Operational Safety.

9.3 HAZARDOUS SYSTEMS AND OPERATIONS

The requirements cited in the Space Wing safety regulations apply for hazardous systems and operations. However, Boeing safety requirements are, in some cases, more stringent than those of the launch range. The design and operations requirements governing activities involving Boeing participation are discussed in the following paragraphs.

9.3.1 Operations Involving Pressure Vessels (Tanks)

For Boeing personnel to be safely exposed to pressurized vessels, the vessels must be designed, built, and tested to meet the minimum factor of safety requirements (ratio between operating pressure and design burst pressure). All-metal tanks with a 4-to-1 factor of safety are preferred; however, it is understood that weight constraints make this type of design impractical for many spacecraft applications. For other designs, detailed data must be provided to Boeing to assure that any spacecraft pressure vessel has been designed, manufactured, and tested in accordance with the requirements of EWR 127-1, Appendix 3C. Boeing desires a minimum factor of safety of 2-to-1 for all pressure vessels that will be pressurized in the vicinity of Boeing personnel. In some cases, Boeing data, analysis, and operational requirements may also be more stringent than those imposed by range safety.

Even with approval of the basic design, pressurization operations will, in general, be required to be performed remotely (with no personnel exposure).

Additionally, special requirements are imposed for the processing of spacecraft containing composite overwrapped pressure vessels (COPV). Hazard-clear areas are imposed for transport and erection at CCAS. Contact Boeing for specific details.

9.3.2 Nonionizing Radiation

The spacecraft nonionizing radiation systems are subject to the design criteria in the USAF and KSC manuals and the special Delta-imposed criteria as follows.

- Systems producing nonionizing radiation will be designed and operated so that the hazards to personnel are at the lowest practical level.
- Boeing employees are not to be exposed to nonionizing radiation above 10 mW/cm^2 averaged over any 1-min interval. Safety documentation shall include the calculated distances at which a level of 10 mW/cm^2 (194 V/m) occurs (to meet the USAF requirement) and the distances at which a level of 1 mW/cm^2 (61 V/m) occurs (to meet the Boeing requirement) for each emitter of nonionizing radiation.

9.3.3 Liquid Propellant Offloading

Range safety regulations require that spacecraft are designed with the capability to offload liquid propellants from tank(s) during any stage of prelaunch processing. Any tank, piping, or other components containing propellants must be capable of being drained and then flushed and purged with inert fluids should a leak or other contingency require propellant offloading to reach a safe state. Spacecraft designs should consider the number and placement of drain valves to maintain accessibility by technicians in propellant handler's ensemble (PHE) or self-contained atmospheric ensemble (SCAPE), throughout processing. Close coordination with Boeing is needed to ensure that access can be accomplished while the payload fairing is in place and that proper interfaces can be made with Delta equipment and facilities.

9.3.4 Safing of Ordnance

If used, manual ordnance safing devices (S&A or safing/arming plugs) for Range Category A ordnance are also required to be accessible with the payload fairing installed. Consideration should be given to placing such devices so that they can be reached through fairing openings and armed as late in the countdown as possible and safed in the event of an aborted/scrubbed launch, if required. Early coordination with Boeing is needed to ensure that the required fairing access door(s) can be provided.

9.4 WAIVERS

Space Wing safety organizations discourage the use of waivers. They are normally granted only for spacecraft designs that have a history of proven safety. After a complete review of all safety requirements, the spacecraft agency should determine if waivers are necessary. A waiver or meets-intent certification (MIC) request is required for any safety-related requirement that cannot be met. If a noncompliant condition is suspected, coordination with the appropriate Space Wing safety organization is needed to determine whether a waiver or meets-intent certification will be required. Requests for waivers shall be submitted prior to implementation of the safety-related design or practice in question. Waiver/MIC requests must be accompanied by sufficient substantiating data to warrant consideration and approval. It should be noted that the USAF Space Wing safety organizations determine when a waiver or MIC is required and have final approval of all requests. No guarantees can be made that approval will be granted.

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
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

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
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
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

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
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
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

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
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
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

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
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
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

ER–Eastern Range WR–Western Range

Delta	Mission	Vehicle	Launch date	Results	Launch site
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

Appendix B
NATURAL AND TRIGGERED LIGHTNING LAUNCH COMMIT CRITERIA

The Delta launch vehicle will not be launched if any of the following criteria are not met. Even when these constraints are not violated, if any other hazardous weather conditions exist, the launch weather officer will report the threat to the launch director. The launch director may hold at any time based on weather instability.

■ Lightning

A. Do not launch for 30 min after any type of lightning occurs in a thunderstorm if the flight path will carry the vehicle within 10 nmi of that thunderstorm.

B. Do not launch for 30 min after any type of lightning occurs within 10 nmi of the flight path;

-UNLESS-

(1) The cloud that produced the lighting is not within 10 nmi of the flight path;

-AND-

(2) There is at least one working field mill within 5 nmi of each such lightning flash; and

(3) The absolute values of all electric field measurements at the surface within 5 nmi of the flight path and at the mill(s) specified in (2) above have been less than 1000 V/m for 15 min.

■ Cumulus Clouds

A. Do not launch if the flight path will carry the vehicle within 10 nmi of any cumulus cloud with its cloud top higher than the –20ºC level.

B. Do not launch if the flight path will carry the vehicle within 5 nmi of any cumulus cloud with its cloud top higher than the –10ºC level.

C. Do not launch if the flight path will carry the vehicle through any cumulus cloud with its cloud top higher than the –5ºC level.

D. Do not launch if the flight path will carry the vehicle through any cumulus cloud with its cloud top between +5ºC and –5ºC levels;

-UNLESS-

(1) The cloud is not producing precipitation;

-AND-

(2) The horizontal distance from the center of the cloud top to at least one working field mill is less than 2 nmi;

-AND-

(3) All electric field measurements at the surface within 5 nmi of the flight path and at the mill(s) specified in (2) above have been between –100 V/m and +500 V/m for 15 min.

Note: Cumulus clouds in this criterion do not include altocumulus, cirrocumulus, or stratocumulus.

■ Anvil Clouds

A. Attached Anvils.

(1) Do not launch if the flight path will carry the vehicle through nontransparent parts of attached anvil clouds.

(2) Do not launch if the flight path will carry the vehicle within 5 nmi of nontransparent parts of attached anvil clouds for the first 3 hr

after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud.

(3) Do not launch if the flight path will carry the vehicle within 10 nmi of nontransparent parts of attached anvil clouds for the first 30 min after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud.

B. Detached Anvils.

(1) Do not launch if the flight path will carry the vehicle through nontransparent parts of a detached anvil cloud for the first 3 hr after the time that the anvil cloud is observed to have detached from the parent cloud.

(2) Do not launch if the flight path will carry the vehicle through nontransparent parts of a detached anvil cloud for the first 4 hr after the time of the last lightning discharge that occurs in the detached anvil cloud.

(3) Do not launch if the flight path will carry the vehicle within 5 nmi of nontransparent parts of a detached anvil cloud for the first 3 hr after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud before detachment or in the detached anvil cloud after detachment;

-UNLESS-

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

-AND-

(b) The absolute values of all electric field measurements at the surface within 5 nmi of the flight path and at the mill(s) specified in (a) above have been less than 1000 V/m for 15 min;

-AND-

(c) The maximum radar return from any part of the detached anvil cloud within 5 nmi of the flight path has been less than 10 dBZ for 15 min.

(4) Do not launch if the flight path will carry the vehicle within 10 nmi of nontransparent parts of a detached anvil cloud for the first 30 min after the time of the last lightning discharge that occurs in the parent cloud or anvil cloud before detachment or in the detached anvil cloud after detachment.

Note: Detached anvil clouds are never considered debris clouds, nor are they covered by debris cloud criterion.

■ Debris Cloud

A. Do not launch if the flight path will carry the vehicle through any nontransparent parts of a debris cloud during the 3-hr period defined below.

B. Do not launch if the flight path will carry the vehicle within 5 nmi of any nontransparent parts of a debris cloud during the 3-hr period defined below;

-UNLESS-

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

-AND-

(2) The absolute values of all electric field measurements at the surface within 5 nmi of the flight path and at the mill(s) specified in (1) above have been less than 1000 V/m for 15 min;

-AND-

(3) The maximum radar return from any part of the debris cloud within 5 nmi of the flight path has been less than 10 dBZ for 15 min. The 3-hr period in A and B above begins at the time when the debris cloud is observed to have detached from the parent cloud or when the debris cloud is observed to have formed from the decay of the parent cloud top below the altitude of the –10ºC level. The 3-hr period begins anew at the time of any lightning discharge that occurs in the debris cloud.

■ Disturbed Weather

Do not launch if the flight will carry the vehicle through any nontransparent clouds that are associated with a weather disturbance having clouds that extend to altitudes at or above the 0ºC level and contain moderate or greater precipitation or a radar bright band or other evidence of melting precipitation within 5 nmi of the flight path.

■ Thick Cloud Layers

Do not launch if the flight path will carry the vehicle through nontransparent parts of a cloud layer that is:

A. Greater than 4500-ft thick and any part of the cloud layer along the flight path is located between the 0ºC and the –20ºC levels;

-OR-

B. Connected to a cloud layer that, within 5 nmi of the flight path, is greater than 4500-ft thick and has any part located between the 0ºC and the –20ºC levels;

-UNLESS-

(1) The cloud layer is a cirriform cloud that has never been associated with convective clouds, is located entirely at temperatures of –15ºC or colder;

-AND-

(2) The cloud layer shows no evidence of containing liquid water (e.g., aircraft icing).

■ Smoke Plumes

Do not launch if the flight path will carry the vehicle through any cumulus cloud that developed from a smoke plume while the cloud is attached to the smoke plume, or for the first 60 min after the cumulus cloud is observed to have detached from the smoke plume.

Note: Cumulus clouds that have formed above a fire but have been detached from the smoke plume for more than 60 min are considered cumulus clouds and are covered in Cumulus Clouds Criterion .

■ Surface Electric Fields

A. Do not launch for 15 min after the absolute value of any electric field measurements at the surface within 5 nmi of the flight path has been greater than 1500 V/m.

B. Do not launch for 15 min after the absolute value of any electric field measurements at the surface within 5 nmi of the flight path has been greater than 1000 V/m;

-UNLESS-

(1) All clouds within 10 nmi of the flight path are transparent;

-OR-

(2) All nontransparent clouds within 10 nmi of the flight path have cloud tops below the +5ºC level and have not been part of convective clouds with cloud tops above the –10ºC level within the last 3 hr.

Notes:

(i) Electric field measurements at the surface are used to increase safety by detecting electric fields due to unforeseen or unrecognized hazards.

(ii) For confirmed failure of one or more field mill sensors, the countdown and launch may continue.

■ **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 hold at any time based on the weather threat.

■ **Definitions/Explanations**

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

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

– **Cloud Layer:** An array of clouds, not necessarily all of the same type, whose bases are approximately at the same level.

– **Cloud Top:** The visible cloud top is preferred. If this is not possible, then the 10-dBz radar cloud top is acceptable.

– **Cumulonimbus Cloud:** Any convective cloud with any part above the –20.0°C temperature level.

– **Debris Cloud:** Any cloud, except an anvil 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.

– **Documented:** “Documented” means that sufficient data have been gathered on benign phenomena to both understand them and to develop evaluation procedures; and that 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 benign phenomena during launch countdowns shall be documented and implemented by the 45th Weather Squadron.

– **Electric Field (for Surface-Based Electric Field Mill Measurements):** This is a 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 dominant charge overhead.

– **Flight Path:** The planned flight trajectory including its uncertainties (“error bounds”).

– **Precipitation:** Detectable rain, snow, sleet, etc. at the ground, or virga, or a radar reflectivity greater than 18 dBZ.

– **Thunderstorm:** Any convective cloud that produces lightning.

– **Transparent:** Synonymous with optically thin. Sky cover is transparent if higher clouds, blue sky, stars, etc., can be distinctly seen from below, or if the sun casts distinct shadows of the objects on the ground, or if terrain, buildings, lights on the ground, etc., can be distinctly seen from above.

DELTA III

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