United Launch Alliance


# GPS IIR-20 (M)


## U.S. Air Force

*Delta Launch Vehicle Programs*

# GPS IIR-20 (M)

The Delta team is proud to be the launch provider for the U.S. Air Force Global Positioning System (GPS) program by delivering replenishment satellites aboard the Delta II rocket. GPS satellites serve and protect our war fighters by providing navigational assistance for U.S. military operations on land, at sea, and in the air. Civilian users around the world also use and depend on GPS for directional assistance.

GPS IIR-20 (M) is the seventh of the modernized GPS satellites, incorporating various improvements to provide greater accuracy, increased resistance to interference, and enhanced performance for users. It will be launched aboard a Delta II 7925-9.5 launch vehicle from Space Launch Complex (SLC)-17A at Cape Canaveral Air Force Station (CCAFS), FL.

We wish to thank our team, which consists of the U.S. Air Force, The Aerospace Corporation, ULA, and major suppliers of ULA, for their continued hard work and commitment to mission success. We look forward to continuing our support of the U.S. Air Force aboard Delta II launch vehicles.

John Gerlitz
Director, USAF/MLV-III Program Delta II
ULA Customer Program Office

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Program Manager
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Launch & Range Systems Wing

# GPS Mission

The Navstar GPS is a constellation of orbiting satellites that provides navigation data to military and civilian users worldwide. The system is operated and controlled by the 50th Space Wing, located at Schriever Air Force Base, CO.

GPS satellites orbit the Earth every 12 hours, emitting continuous navigation signals. With the proper equipment, users can receive these signals to calculate time, location, and velocity. The signals are so accurate that time can be measured to within a millionth of a second, velocity within a fraction of a mile per hour, and location to within 100 feet. Receivers have been developed for use in aircraft, ships, land vehicles, and to hand carry.

GPS provides 24-hour navigation services including:

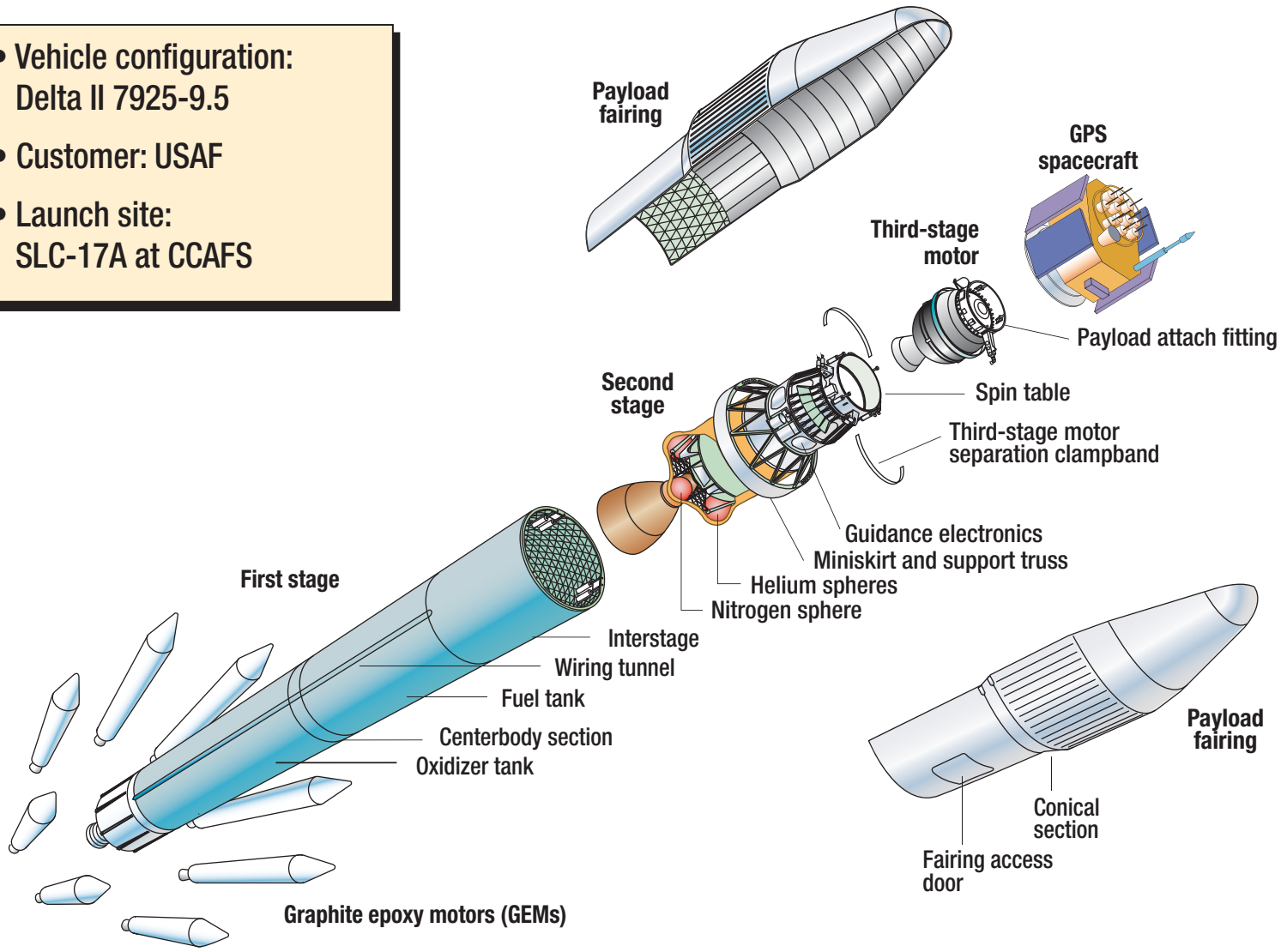
- Extremely accurate, three-dimensional location information (latitude, longitude, and altitude), velocity, and precise time
- Worldwide common grid that is easily converted to any local grid
- Passive all-weather operations
- Continuous real-time information
- Support to an unlimited number of users and areas
- Support to civilian users at a slightly less accurate level

The GPS constellation is designed and operated as a 24-satellite system, consisting of six planes with a minimum of four satellites per plane.

The GPS satellites are placed into nearly 11,000-mile circular orbits. While circling the Earth, the systems transmit signals on three different L-band frequencies. The satellites have a 10-year design life.

# Delta II 7925-9.5 Launch Vehicle

- Vehicle configuration: Delta II 7925-9.5
- Customer: USAF
- Launch site: SLC-17A at CCAFS



# GPS IIR-20 (M)
# Spacecraft Mission Requirements

- Transfer orbit criteria (defined at spacecraft separation)
  - – Apogee altitude: 10,998.00 nmi (integrated)
  - – Perigee altitude: 104.00 nmi
  - – Inclination: 40.00 deg
  - – Geodetic latitude: (at first apogee) -10.05 deg N
- Transfer orbit injection: Ascending node
- Payload weight: 4,540.0 lb (2,059.3 kg)
- Launch pad: SLC-17A
- Spin rate: 55 rpm
- Second-stage probability of command shutdown (PCS): ≥ 99.7%
- Free molecular heating rate at fairing separation: < 0.1 Btu/ft²-sec (1,135 W/m²)

# GPS IIR-20 (M)
# Flight Mode Description

- Delta II 7925-9.5 launch vehicle configuration
- Launch from CCAFS SLC-17A down-flight azimuth of 110 deg
- 6/3 graphite epoxy motor (GEM) firing sequence
- Common boost trajectory utilized for both descending and ascending node injections
- Boost trajectory designed to meet controllability, structural, and environmental constraints while maximizing vehicle performance
- Dogleg maneuver used to increase parking orbit inclination
  - Maneuver split between booster- and second-stage flight to meet Range Safety constraints
- Main engine cutoff (MECO) occurs at first-stage propellant depletion; approximately 263 sec after liftoff
- Second stage separates 8 sec after MECO; Stage II ignited 5.5 sec later
- Payload fairing jettisoned when free molecular heating rate is < 0.1 Btu/ft$^2$-sec (1,135 W/m$^2$)
- Second-stage first burn places vehicle in parking orbit at SECO-1
  - Ascending node: 94 x 111 nmi orbit at 37.50 deg inclination

# GPS IIR-20 (M)
# Flight Mode Description (concl'd)

- Following SECO-1, vehicle is reoriented to second-stage restart and third-stage burn attitude
- At end of reorientation maneuver, vehicle is rolled at 1 deg/sec for thermal conditioning
- Following coast period of 51.7 min, second-stage restart occurs at approximately 62.5 min after liftoff over the Guam Tracking Station
  - Restart burn duration of approximately 42.5 sec
  - At SECO-2, vehicle is in 103 x 670 nmi orbit at 37.95 deg inclination
- Spin-up and separation of third stage follows restart burn cutoff
- Third-stage burn and nutation control system (NCS) blowdown places spacecraft into the desired transfer orbit
- Spacecraft separation occurs approximately 68 min after liftoff; third stage yo deployed 2 sec after separation to tumble stage and preclude recontact with the spacecraft
- Guam Tracking Station provides telemetry coverage of second-stage restart through spacecraft separation

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# GPS IIR-20 (M)
# Mission Sequence of Events

| Event | Time (min:sec) |
|---|---|
| Liftoff | 00:00.0 |
| Mach 1 | 00:32.6 |
| Maximum dynamic pressure | 00:49.8 |
| Six ground-start GEMs burnout | 01:03.1 |
| Three air-lit GEMs ignition | 01:05.5 |
| Jettison three ground-start GEMs | 01:06.0 |
| Jettison three ground-start GEMs | 01:07.0 |
| Three air-lit GEMs burnout | 02:08.8 |
| Jettison three air-lit GEMs | 02:11.5 |
| First stage—begin dogleg maneuver | 02:20.0 |
| First stage—end dogleg maneuver | 02:40.0 |
| MECO | 04:23.4 |
| First-stage separation | 04:31.4 |
| Second-stage ignition | 04:36.9 |
| Second stage—begin dogleg maneuver | 04:43.0 |
| Second stage—end dogleg maneuver | 04:53.0 |

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# GPS IIR-20 (M)
# Mission Sequence of Events (concl'd)

| Event | Time (hr:min:sec) |
|---|---|
| Jettison fairing | 00:04:57.0 |
| First cutoff—second stage (SECO-1) | 00:10:48.1 |
| Begin reorientation maneuver | 00:12:30.0 |
| End reorientation maneuver | 00:17:10.0 |
| Begin coast roll maneuver | 00:17:20.0 |
| End coast roll maneuver | 00:56:25.0 |
| Restart second stage | 01:02:29.2 |
| Second cutoff—second stage (SECO-2) | 01:03:11.7 |
| Fire spin rockets | 01:04:01.7 |
| Second-stage separation | 01:04:04.7 |
| Third-stage ignition/NCS enable | 01:04:41.7 |
| Third-stage burnout (TECO) | 01:06:08.4 |
| Begin NCS blowdown | 01:06:51.7 |
| End NCS blowdown | 01:07:44.0 |
| Spacecraft separation | 01:08:01.7 |
| Third-stage yo deploy | 01:08:03.7 |
| First apogee of transfer orbit | 04:03:23.3 |

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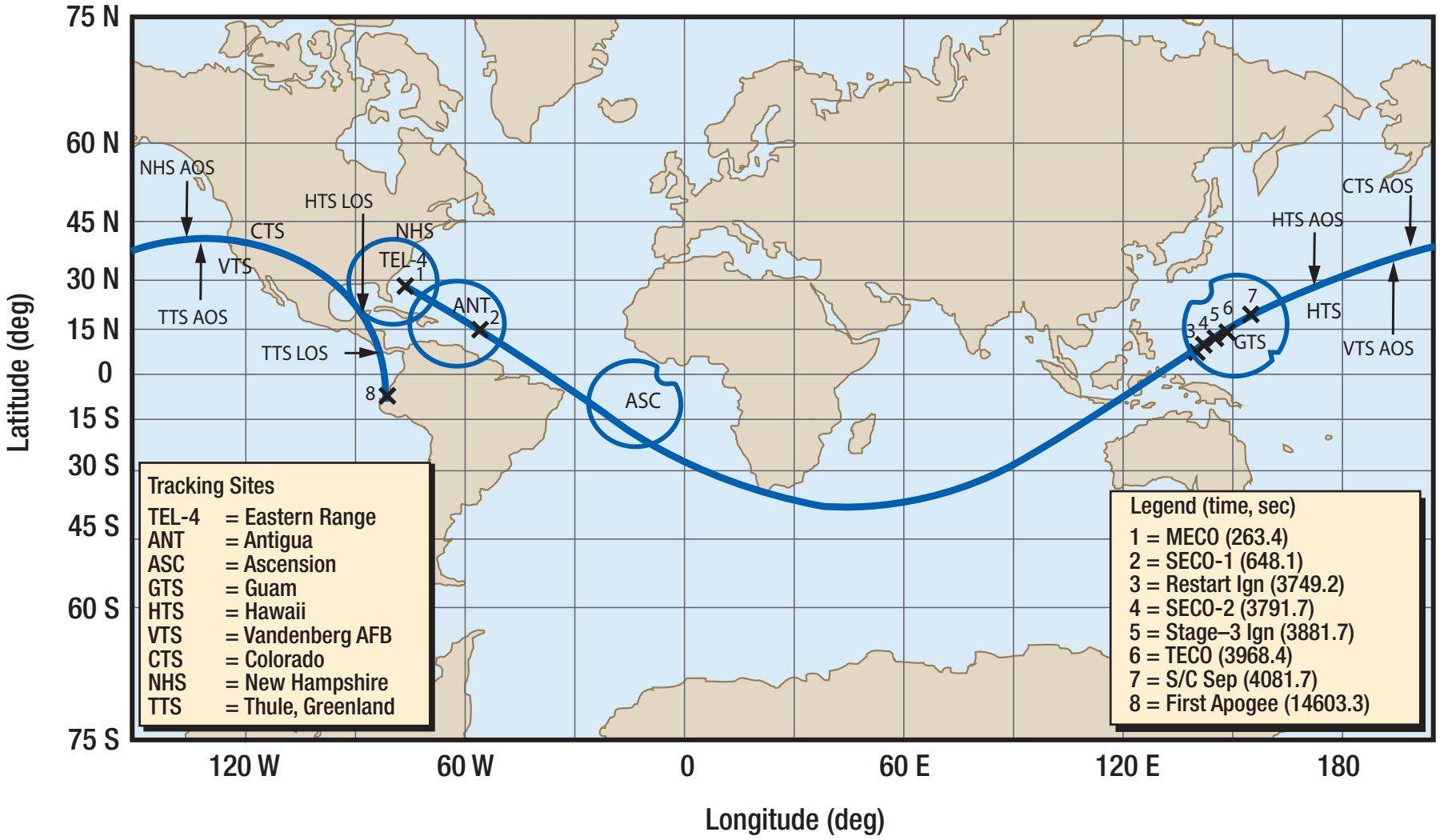
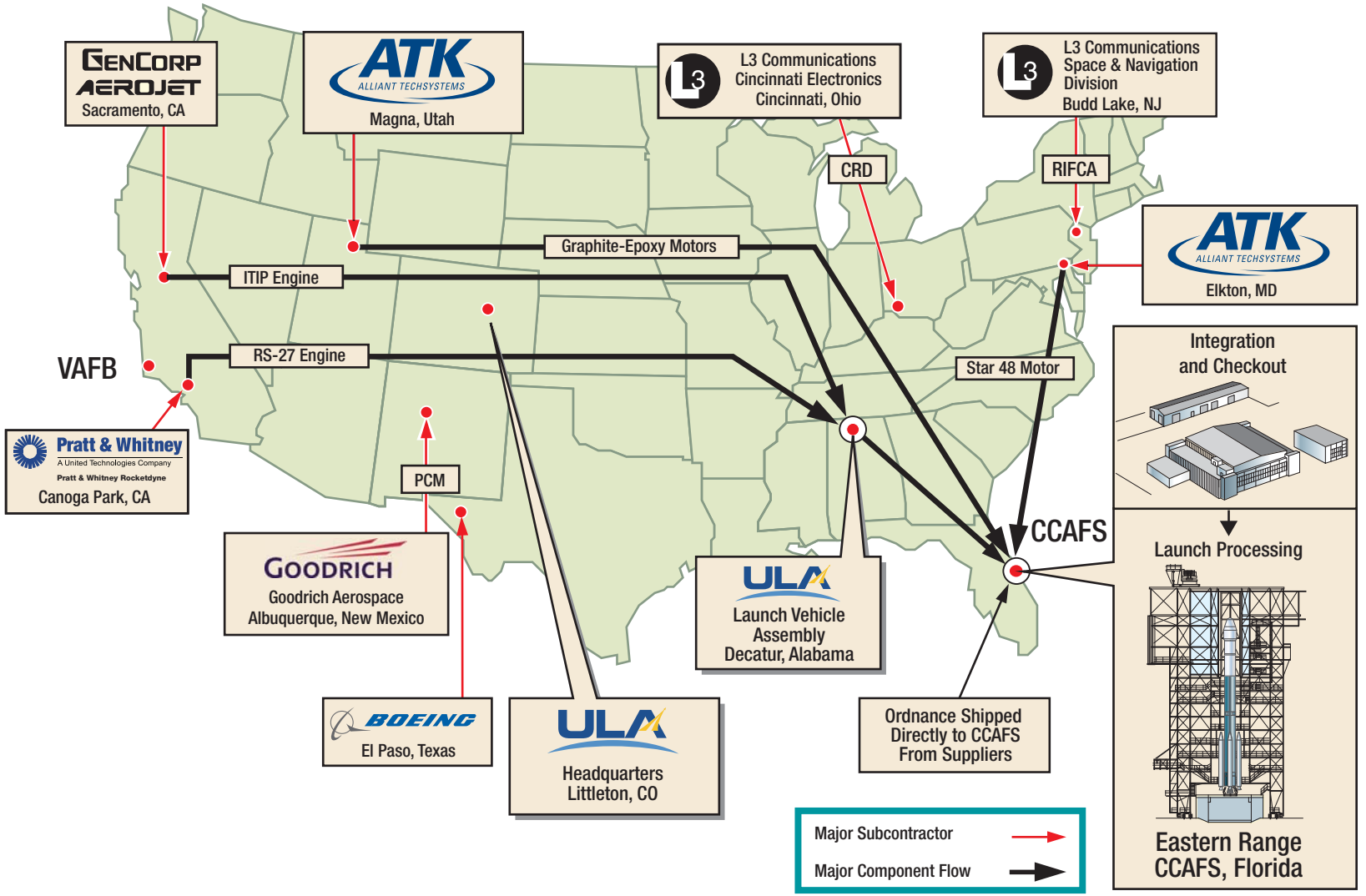
# Ascending Node Orbit Trace



# Depletion Burn Flight Mode Description

- Second-stage depletion burn follows primary mission to safe the stage and lower inclination to minimize casualty probability
- After second-stage separation, vehicle is reoriented to second-stage depletion burn attitude
- Depletion burn ignition for ascending node trajectory occurs at 1 hr, 46 min, 40 sec over Eastern Range Tel-4 and Antigua Tracking Stations
  - Nominal duration of 32 sec through mono-propellant blowdown
  - At end of nominal depletion burn, second stage is in a 110 x 661 nmi orbit with an inclination of 32.91 deg

# Operational Flow at Eastern Range



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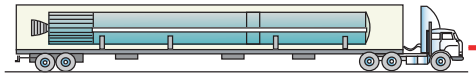
# Total Vehicle Integration & Checkout at the Launch Site



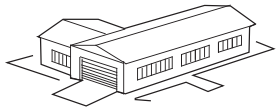
• First stage from assembly plant

• Second stage, fairing, interstage from assembly plant

**Delta Mission Checkout (Hangar AO)**

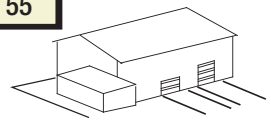
Delta II integration and checkout area
- Receive and inspect
- Mission integration and checkout
- Dual composite tests
- Storage
- Load on pad erection trailers

**Horizontal Processing Facility**

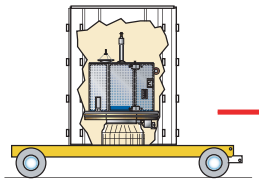


• Destruct installation

**Area 55**



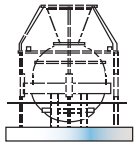
- Destruct installation
- Erection preparation
- Leak checks



• Spacecraft

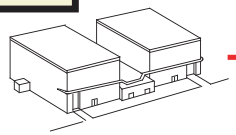
**Processing Facility**

• Mate to upper stage

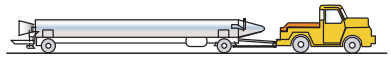


• Third-stage motor

**Area 59**

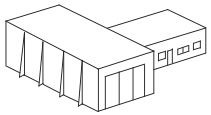


• Balance motor

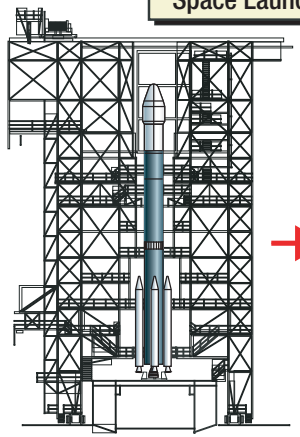


• Graphite-epoxy motors (GEMs)

**Area 57**

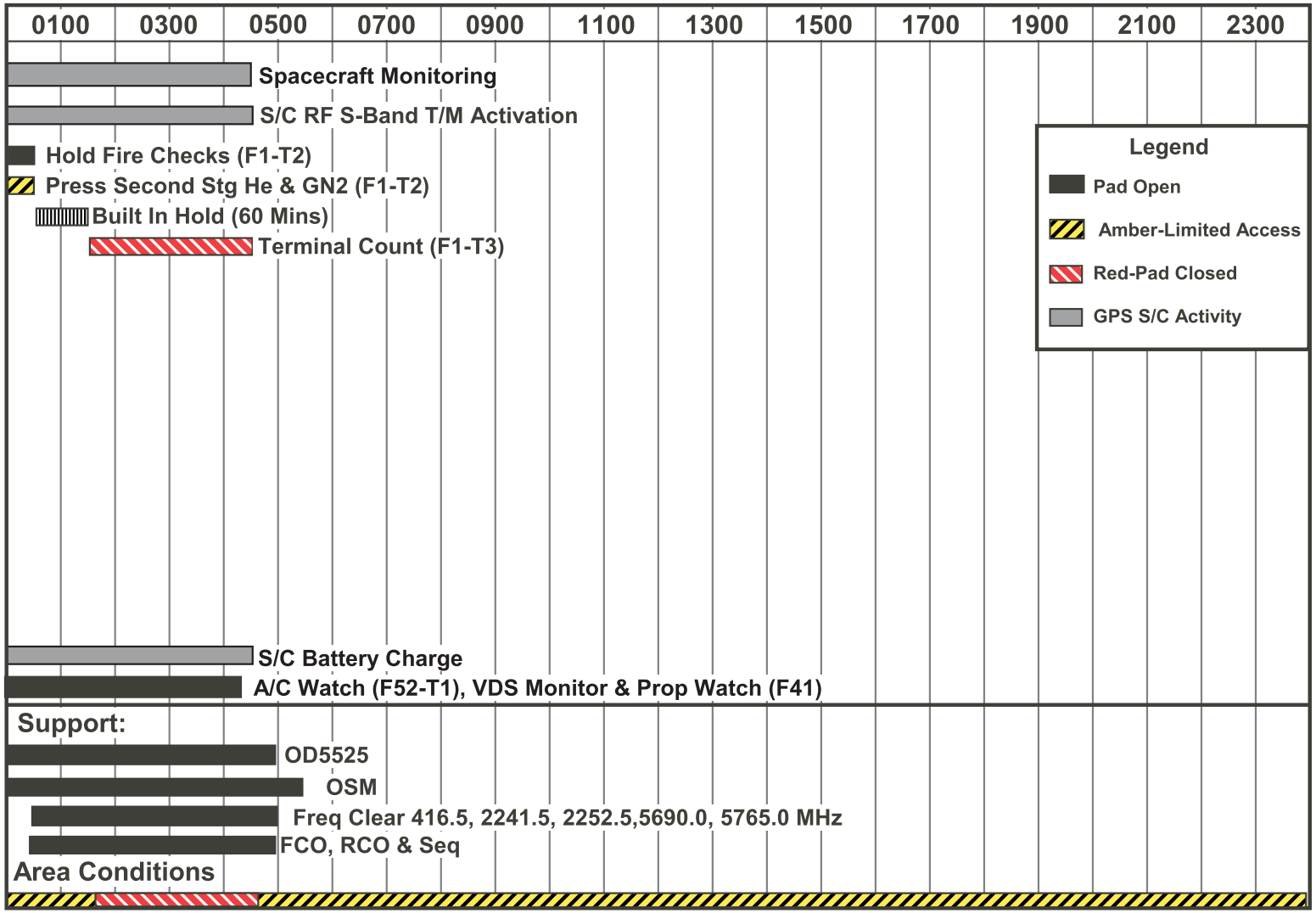


**Space Launch Complex 17**



- Erect and mate stages
- Install solid motors
- Check out subsystems
- Simulated flight test
- Preflight finalization

# Delta II Countdown (T-0 Day)



# Delta II Terminal Count (T-0 Day)