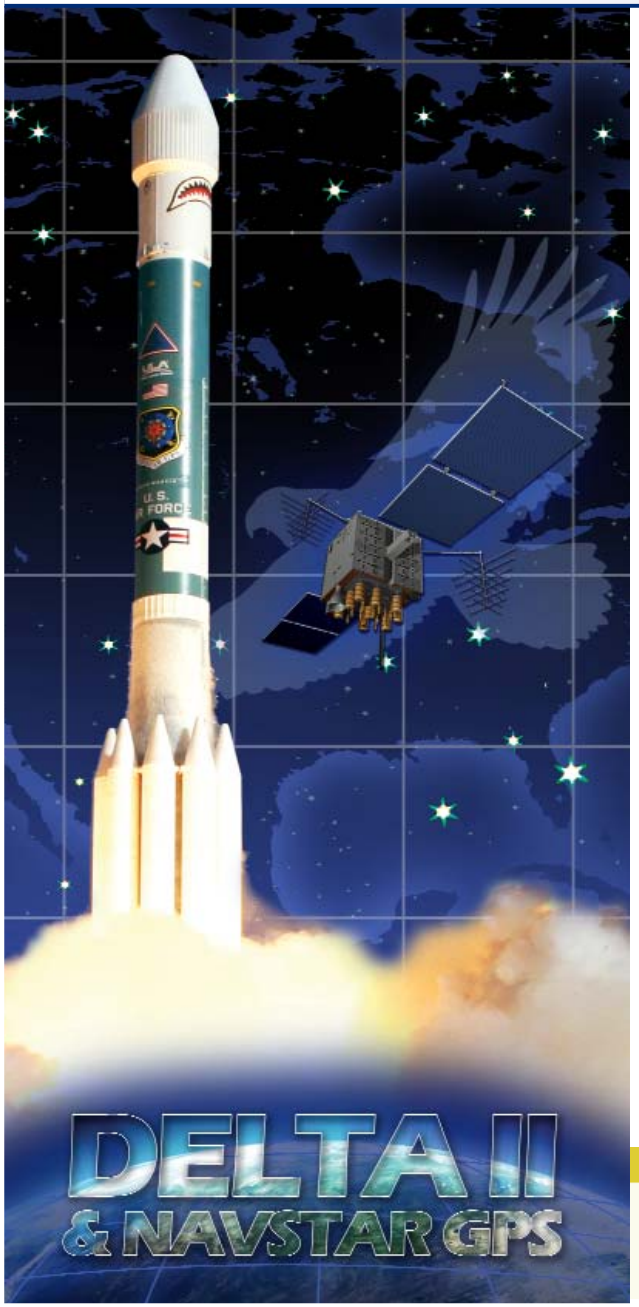
United Launch Alliance

DELTA



GPS IIR-21 (M)

U.S. Air Force

Delta Launch Vehicle Programs

20 Years of Launching Change Around the World

GPS IIR-21 (M)

The Delta team is proud to provide the 21st and final NAVSTAR Global Positioning System (GPS) IIR launch aboard a Delta II rocket for the U.S. Air Force (USAF), ending an era and partnership that began on February 14, 1989 with the debut of the first Delta II.

GPS IIR-21 (M) is the eighth of the modernized GPS satellites and it incorporates several improvements to provide greater accuracy, increase resistance to interference, and enhanced performance for its users. It will be launched aboard a Delta II 7925-9.5 from Space Launch Complex 17A (SLC-17A) at Cape Canaveral Air Force Station (CCAFS), FL.

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.

We wish to thank our team, which consists of the USAF, The Aerospace Corporation, ULA, and its multiple suppliers for their continued hard work and commitment to mission success. We also thank all our GPS and Delta II partners over the past two decades.

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

Lt Col Mark Cinnamon
Program Manager
Delta Launch Group
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 and emit 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.

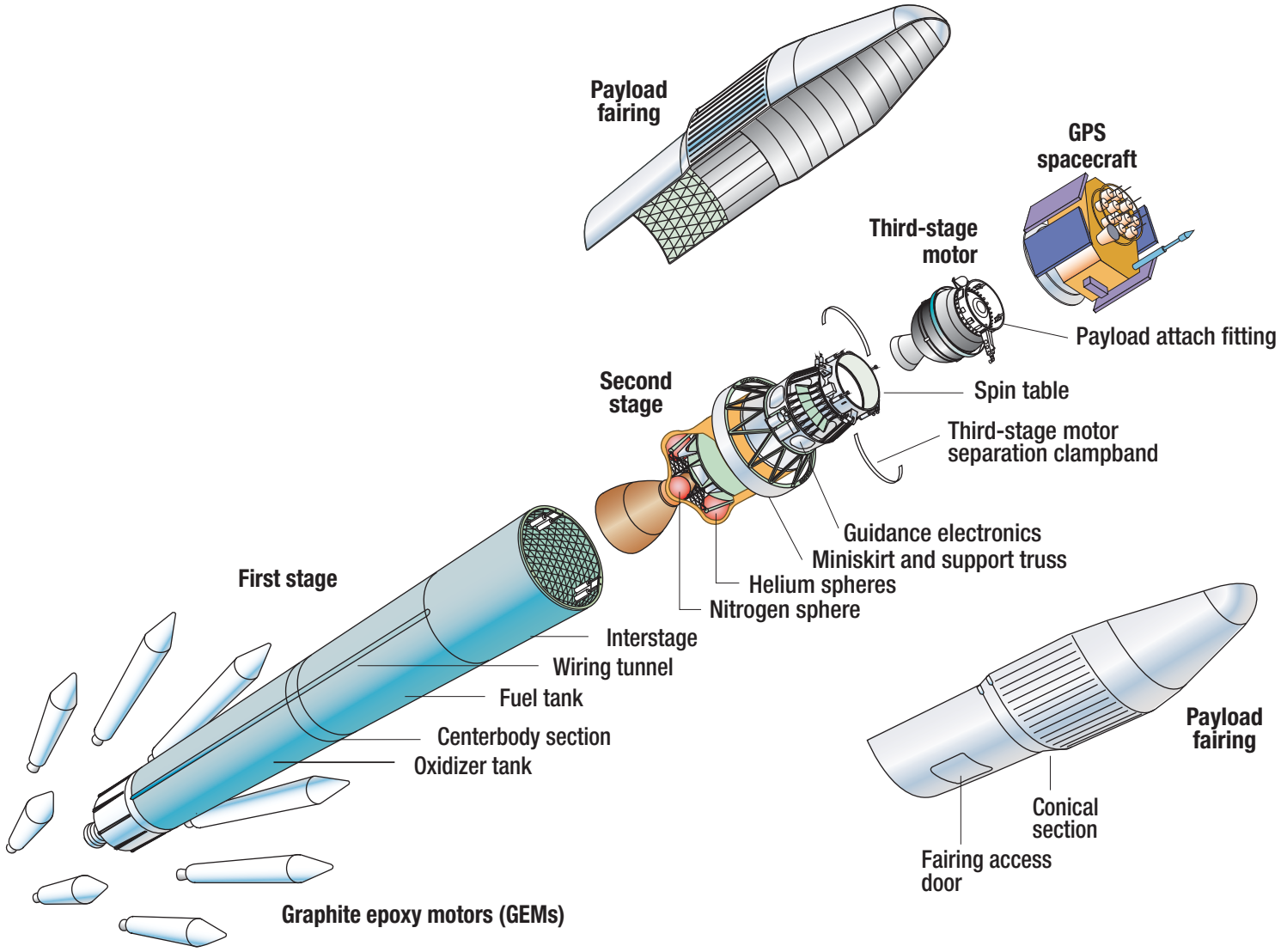
GPS provides 24-hour navigation services including:

- 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



GPS IIR-21 (M)
Spacecraft Mission Requirements

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- 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-21 (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 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; second stage 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-21 (M)
Flight Mode Description

- 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 over the Guam Tracking Station at approximately 62.5 min after liftoff
  - 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

GPS IIR-21 (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-21 (M)
Mission Sequence of Events

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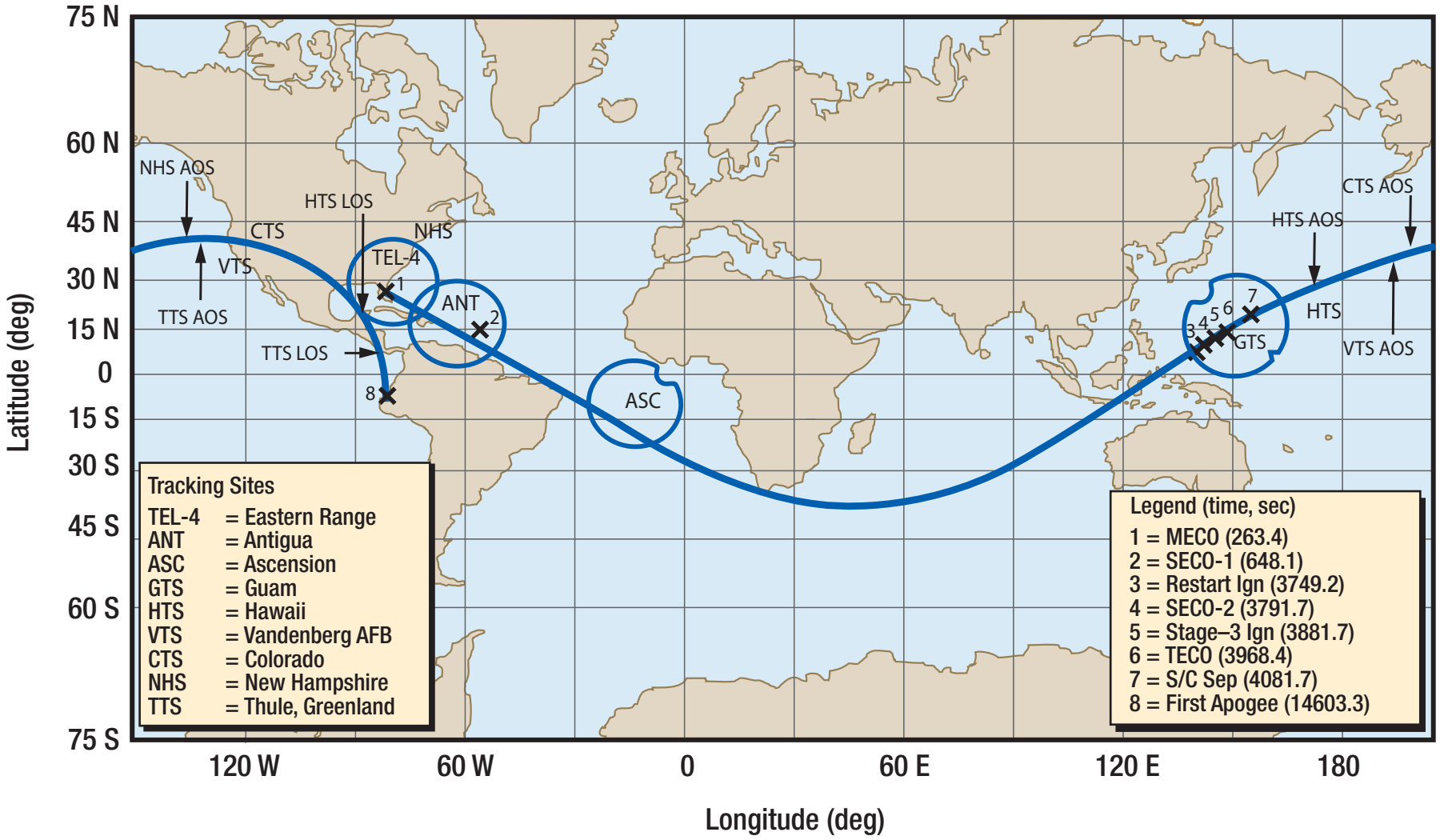
Event	Time (hr:min:sec)
Jettison fairing	00:04:57.0
First cutoff—second stage (SECO-1)	00:10:48.1
Begin reorientation maneuver	00:12:30.0
End reorientation maneuver	00:17:10.0
Begin coast roll maneuver	00:17:20.0
End coast roll maneuver	00:56:25.0
Restart second stage	01:02:29.2
Second cutoff—second 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 cutoff (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

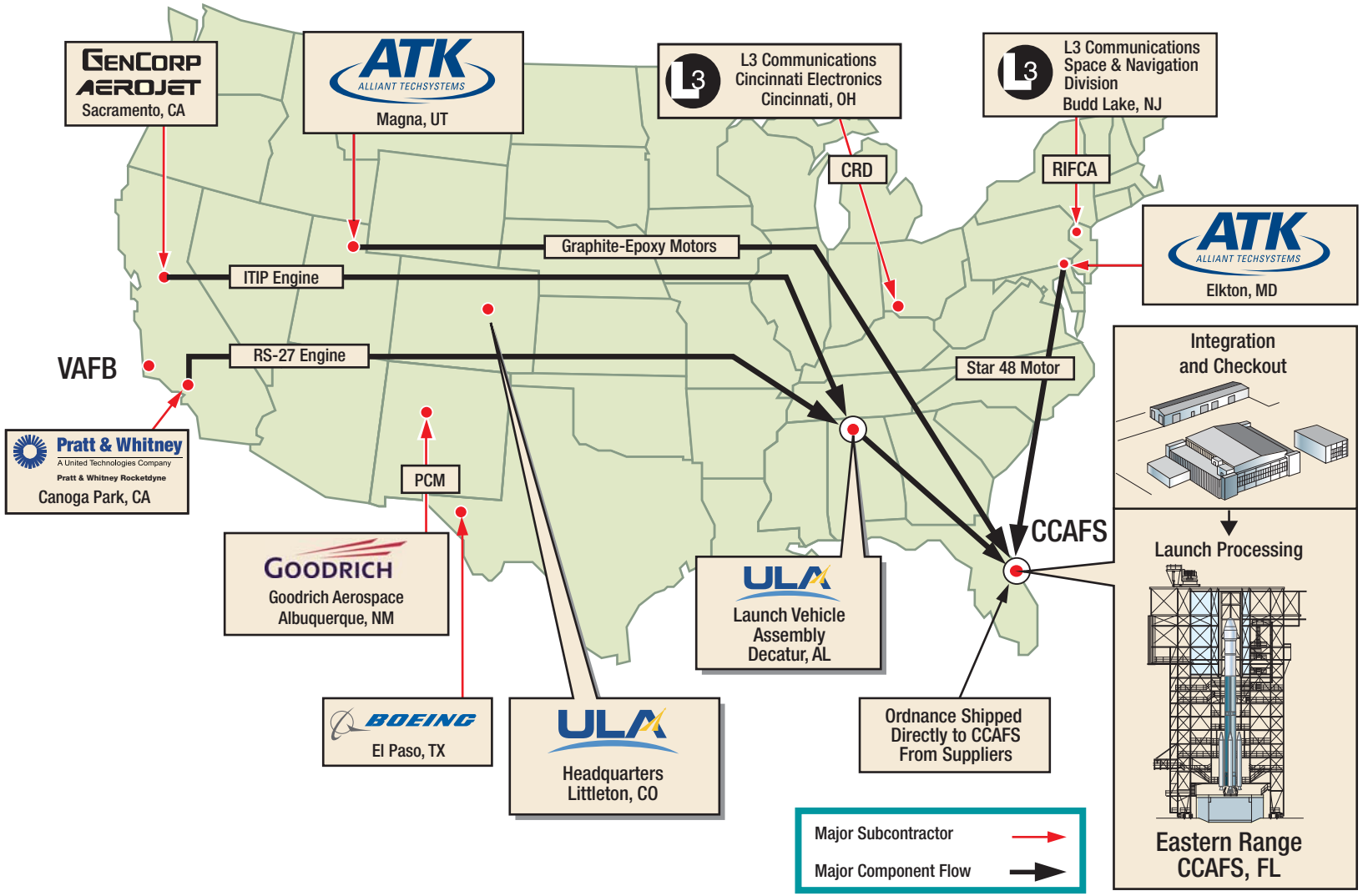
Ascending Node Orbit Trace



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



Total Vehicle Integration & Checkout at the Launch Site

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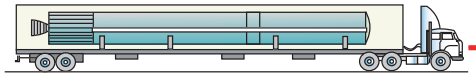


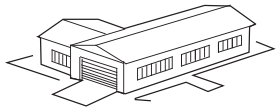
• First stage from assembly plant

• Second stage, fairing, interstage from assembly plant

Delta Mission Checkout (Hangar AO)

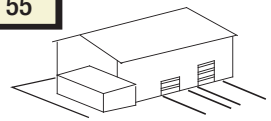
Delta II integration and checkout area
- Receive and inspect
- Mission integration and checkout
- Dual composite tests
- Storage
- Load on pad erection trailers

Horizontal Processing Facility

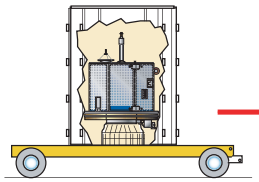


• Ordnance installation

Area 55



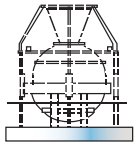
- Ordnance installation
- Erection preparation
- Leak checks



• Spacecraft

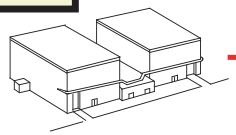
Processing Facility

• Mate to upper stage

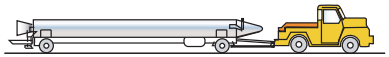


• Third-stage motor

Area 59

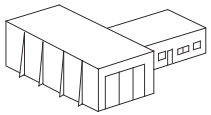


• Balance motor

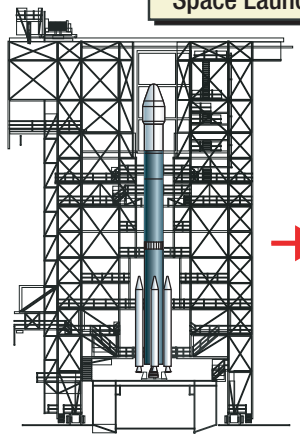


• Graphite-epoxy motors (GEMs)

Area 57

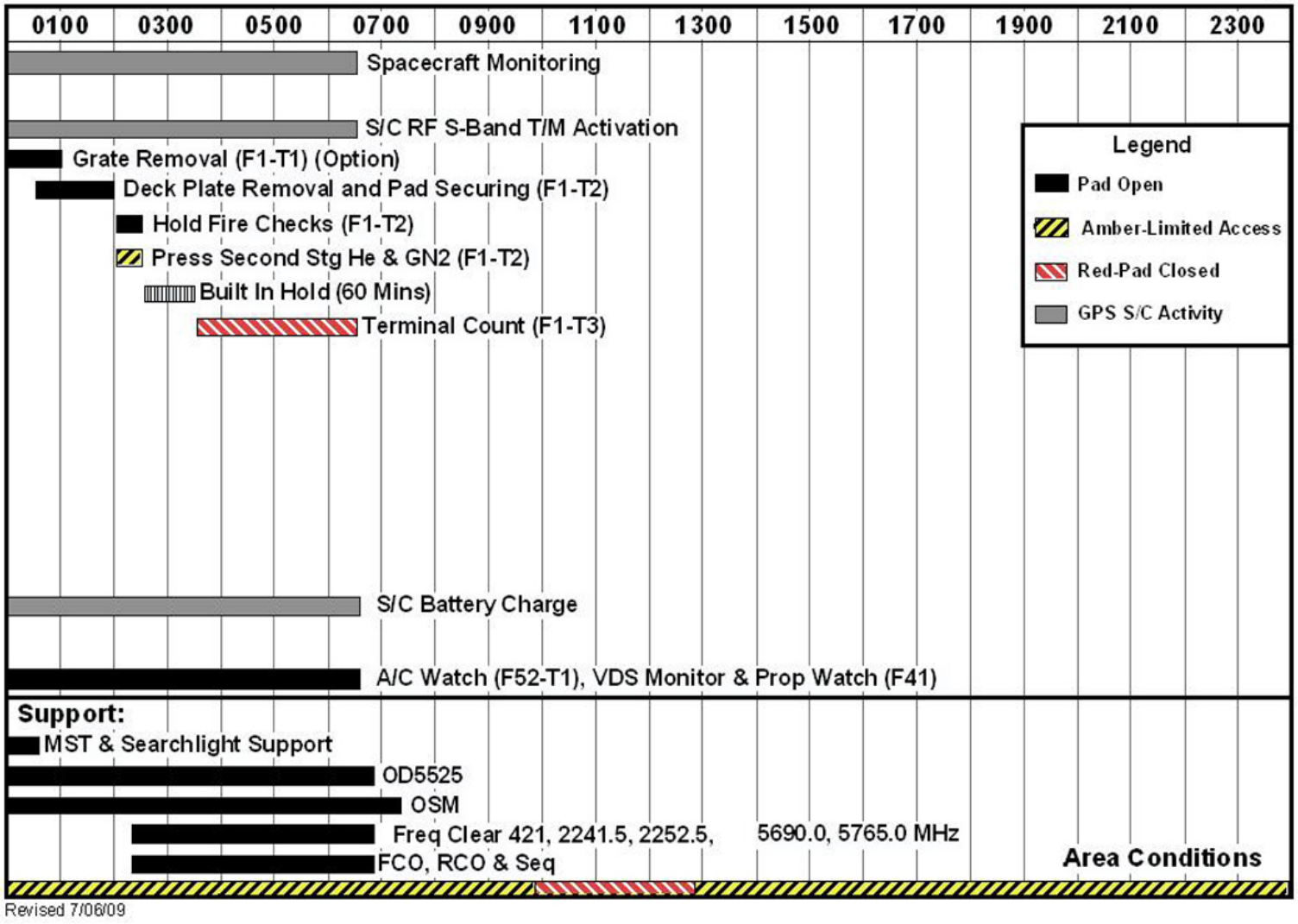


Space Launch Complex 17



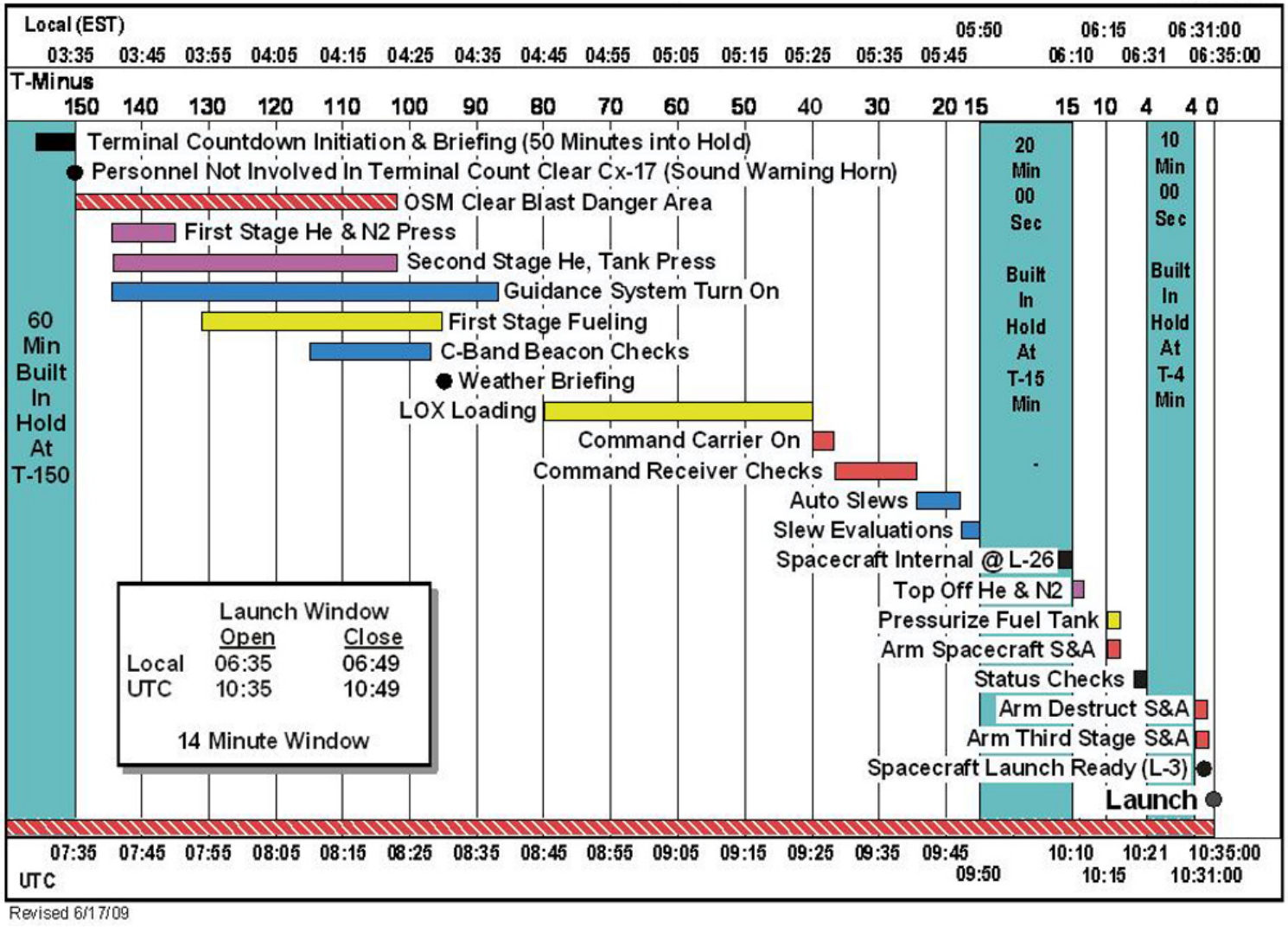
- Erect and mate stages
- Install solid motors
- Check out subsystems
- Simulated flight test
- Preflight finalization

Delta II Countdown (T-0 Day)



Revised 7/06/09

Delta II Terminal Count (T-0 Day)



Revised 6/17/09