MISSION OVERVIEW

SLC-41
CCAFS, FL

United Launch Alliance

ATLAS

The ULA team is proud to be the launch provider for the Radiation Belt Storm Probes mission. The two RBSP spacecraft will be launched into orbit around the Earth, sampling the harsh radiation belt environment where major space weather activity occurs.

The mission, part of NASA's Living With a Star Program, will provide unprecedented insight into the physical dynamics of the radiation belts and provide scientists data to predict change in this critical region of space.

The ULA team is focused on attaining Perfect Product Delivery for the RBSP mission, which includes a relentless focus on mission success (the perfect product) and also excellence and continuous improvement in meeting all of the needs of our customers (the perfect delivery).

My thanks to the entire ULA team and our mission partners for their dedication in bringing RBSP to launch and to NASA for making possible this fascinating mission.

Go Atlas, Go Centaur, Go RBSP!

Jim Sponnick
Vice President, Mission Operations

RBSP SPACECRAFT | Overview

The twin RBSP spacecraft are built and operated by the Applied Physics Laboratory (APL) of Johns Hopkins University (JHU). Weighing in at approximately 1,450 lbs each, the spacecraft will make dual measurements in the Earth's radiation belts to observe changes through both space and time.

The RBSP spacecraft have nearly identical elliptical orbits and will operate within the radiation belts throughout their 2-year primary mission. The orbits cover the entire radiation belt region and the spacecraft will lap each other several times over the course of the mission. The RBSP in situ measurements will discriminate between spatial and temporal effects, and compare the effects of various proposed mechanisms for charged particle acceleration and loss.

Each RBSP spacecraft carries a number of instruments in support of the mission's science objectives:

- **Energetic particle, Composition, and Thermal Plasma Suite (ECT)** will directly measure near-Earth space radiation particles to understand the physical processes that control the acceleration, global distribution and variability of radiation belt electrons and ions.

- **Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS)** will focus on the role played by magnetic fields and plasma waves in the processes of radiation belt particle acceleration and loss.

- **Electric Field and Waves Suite (EFW)** will study the electric fields in near-Earth space that energize radiation particles and modify the structure of the inner magnetosphere.

- **RBSP Ion Composition Experiment (RBSPICE)** will study how space weather creates the "storm-time ring current" around Earth and determine how that ring current supplies and supports the creation of radiation populations.

- **Relativistic Proton Spectrometer (RPS)** will measure inner Van Allen Belt protons with energies from 50 MeV to 2 GeV.

Image Courtesy JHU, APL and NASA

ATLAS V 401 LAUNCH VEHICLE | Overview

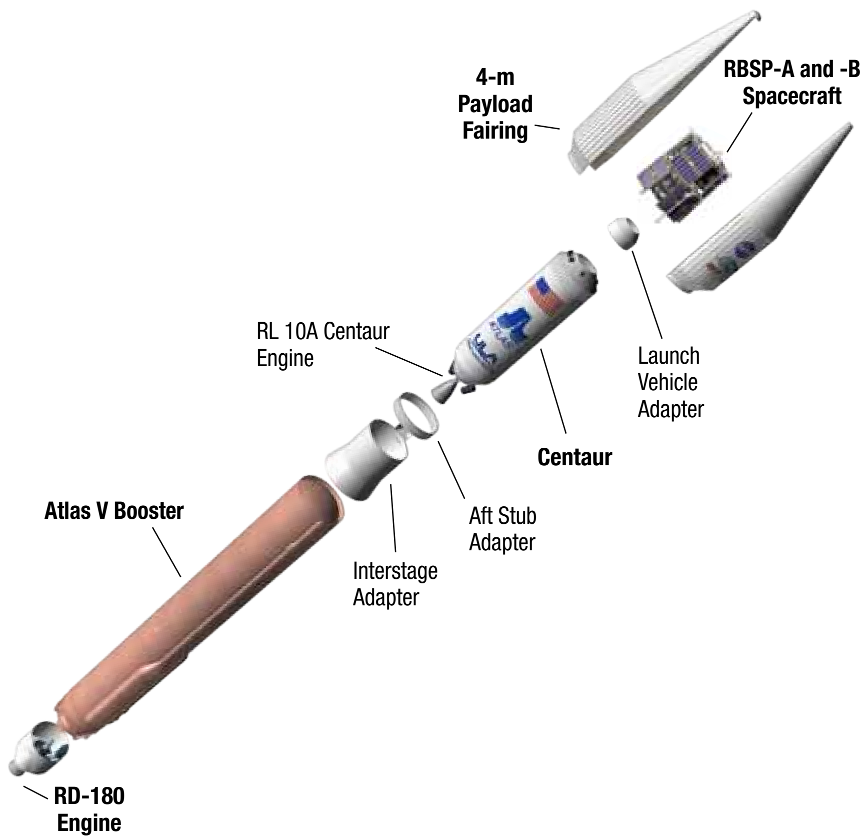
The Atlas V 401 consists of a single Atlas V booster stage, the Centaur upper stage, and a 4-m payload fairing (PLF).

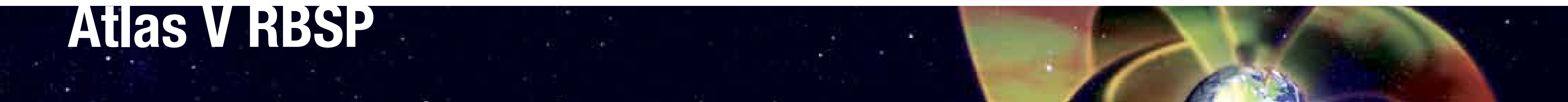
The Atlas V booster is 12.5 ft in diameter and 106.5 ft in length. The booster's tanks are structurally rigid and constructed of isogrid aluminum barrels, spun-formed aluminum domes, and intertank skirts. Atlas booster propulsion is provided by the RD-180 engine system (a single engine with two thrust chambers). The RD-180 burns RP-1 (Rocket Propellant-1 or highly purified kerosene) and liquid oxygen, and delivers 860,200 lb of thrust at sea level. The Atlas V booster is controlled by the Centaur avionics system, which provides guidance, flight control, and vehicle sequencing functions during the booster and Centaur phases of flight.

The Centaur upper stage is 10 ft in diameter and 41.5 ft in length. Its propellant tanks are constructed of pressure-stabilized, corrosion resistant stainless steel. Centaur is a liquid hydrogen/liquid oxygen- (cryogenic-) fueled vehicle. It uses a single RL10A-4-2 engine producing 22,300 lb of thrust. The cryogenic tanks are insulated with a combination of helium-purged insulation blankets, radiation shields, and closed-cell polyvinyl chloride (PVC) insulation. The Centaur forward adapter (CFA) provides the structural mountings for vehicle electronics and the structural and electronic interfaces with the spacecraft.

The RBSP mission is encapsulated in the 4-m (14-ft) diameter PLF. The PLF is a bisector (two-piece shell) fairing consisting of aluminum skin/stringer construction with vertical split-line longerons. The vehicle's height with the PLF is approximately 189 ft.

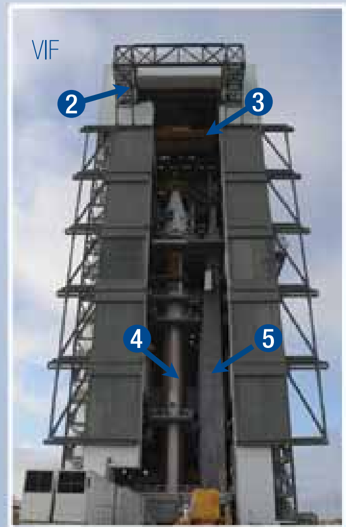
ATLAS V 401 LAUNCH VEHICLE | Expanded View





SPACE LAUNCH COMPLEX 41 (SLC-41) | Overview

1 Vertical Integration Facility (VIF) (See inset)
2 Bridge Crane Hammerhead
3 Bridge Crane
4 Launch Vehicle
5 Mobile Launch Platform (MLP)
6 Launch Vehicle
7 Centaur LO_2 Storage
8 High Pressure Gas Storage
9 Booster LO_2 Storage
10 Pad Equipment Building (PEB)
11 Pad ECS Shelter



ATLAS V RBSP | Mission Overview

The RBSP mission will be flown on an easterly trajectory from Space Launch Complex 41 (SLC-41) at Cape Canaveral Air Force Station (CCAFS), Florida. The RBSP-A and -B spacecraft will be released in nearly identical, highly elliptical orbits.

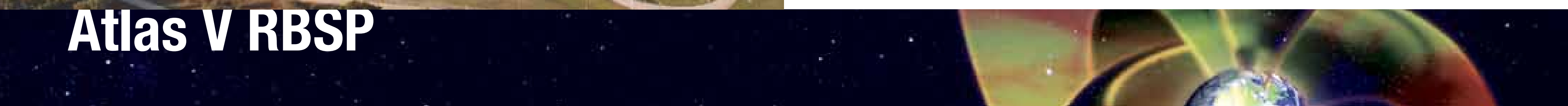
The mission begins with ignition of the RD-180 engine approximately 2.7 seconds prior to liftoff. Liftoff occurs at T+1.1 seconds. Shortly after the vehicle clears the pad, it performs its pitch/yaw/roll maneuvers.

Following maximum dynamic pressure, the RD-180 is throttled down to 95%. Guidance steering is enabled approximately 140 seconds into flight. At 210 seconds into flight, throttling is set to maintain a constant 5.0 G-level. At approximately 10 seconds prior to booster engine cutoff (BECO), throttling is set to a constant 4.6 G's. BECO occurs 243 seconds into flight followed by Centaur separation approximately 6 seconds later.

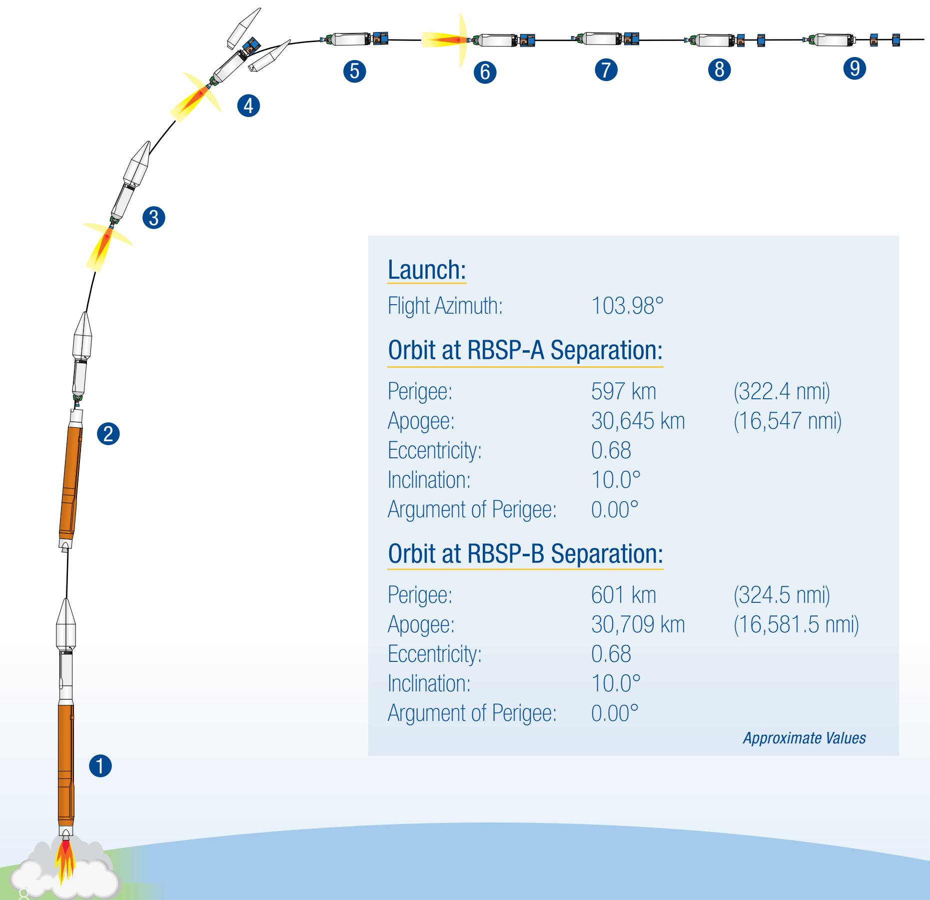
Approximately 259 seconds into flight, the Centaur stage ignites its main engine (MES-1) which begins a nine-minute burn to place the vehicle into a parking orbit. Eight seconds into the first Centaur burn, the payload fairing is jettisoned.

After a coast phase of nearly 56 minutes, the Centaur main engine is ignited for a 4½-minute second burn (MES-2). Two seconds after main engine cutoff (MECO-2), the Centaur begins a spacecraft separation attitude alignment and spins up to 5 RPM. RBSP-A is released approximately 79 minutes into flight.

Following release of RBSP-A, the Centaur de-spins and maneuvers to the positive velocity direction where it uses its thrusters to raise the apogee to the desired RBSP-B altitude. Centaur then re-aligns to the RBSP-B separation attitude followed by spinning up again to 5 RPM. Centaur releases RBSP-B approximately 91 minutes into flight.



FLIGHT PROFILE | Liftoff to Spacecraft Separation



Launch:

Flight Azimuth: 103.98°

Orbit at RBSP-A Separation:

Perigee:	597 km	(322.4 nmi)
Apogee:	30,645 km	(16,547 nmi)
Eccentricity:	0.68	
Inclination:	10.0°	
Argument of Perigee:	0.00°	

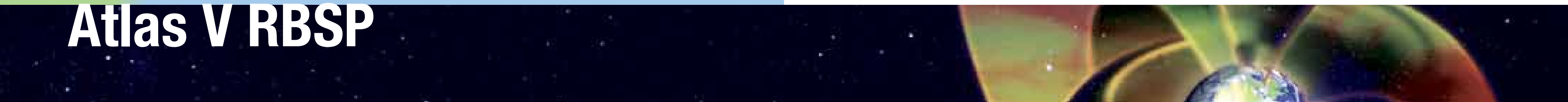
Orbit at RBSP-B Separation:

Perigee:	601 km	(324.5 nmi)
Apogee:	30,709 km	(16,581.5 nmi)
Eccentricity:	0.68	
Inclination:	10.0°	
Argument of Perigee:	0.00°	

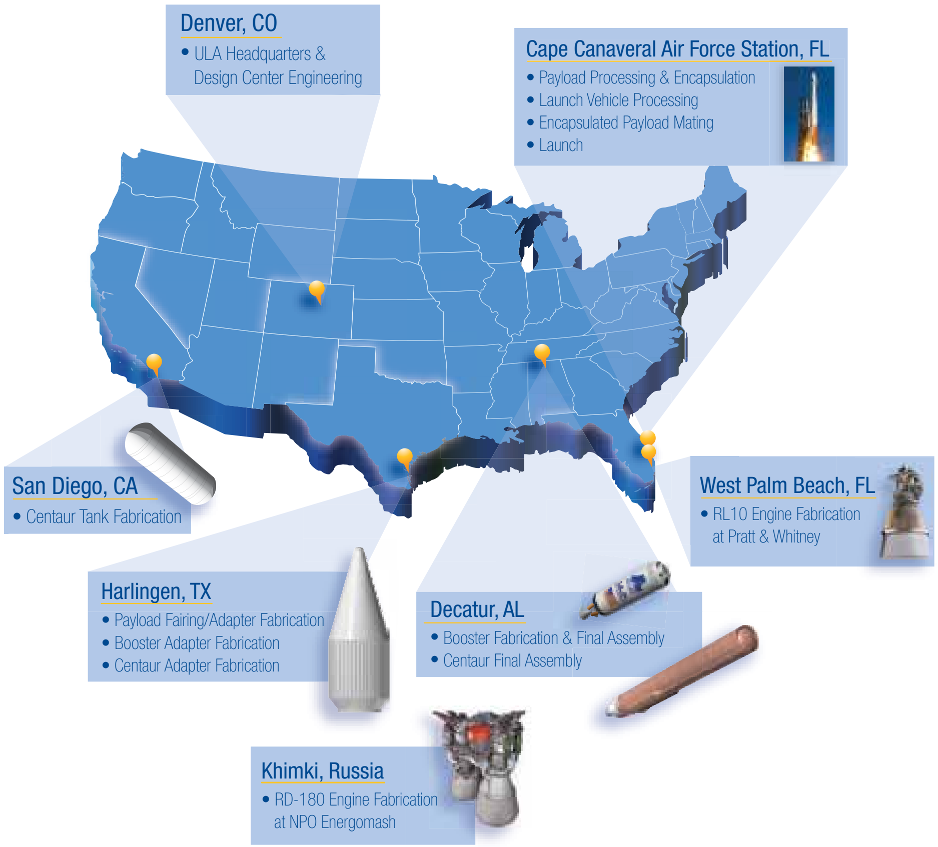
Approximate Values

SEQUENCE OF EVENTS | Liftoff to Spacecraft Separation

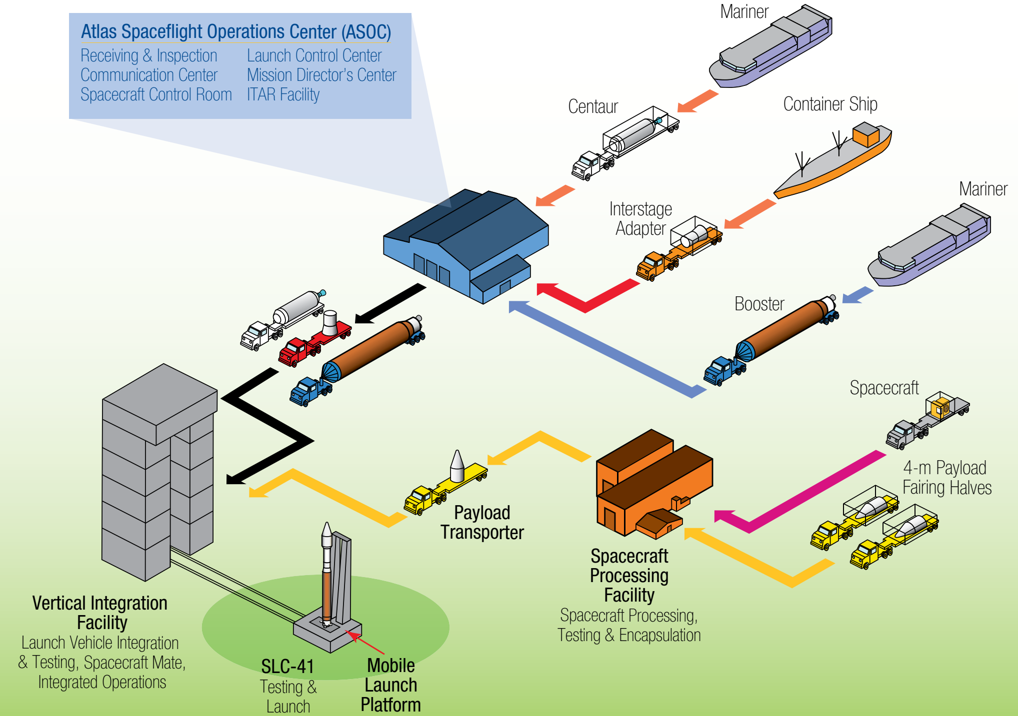
	Event	Time (seconds)	Time (hr:min:sec)
1	RD-180 Engine Ignition	-2.7	-00:00:02.7
	T=0 (Engine Ready)	0.0	00:00:00.0
	Liftoff (Thrust to Weight >1)	1.1	00:00:01.1
	Begin Pitch/Yaw/Roll Maneuver	17.3	00:00:17.3
	Maximum Dynamic Pressure	91.1	00:01:31.1
2	Atlas Booster Engine Cutoff (BECO)	243.4	00:04:03.4
	Atlas Booster/Centaur Separation	249.4	00:04:09.4
3	Centaur First Main Engine Start (MES-1)	259.4	00:04:19.4
4	Payload Fairing Jettison	267.4	00:04:27.4
5	Centaur First Main Engine Cutoff (MECO-1)	816.8	00:13:36.8
6	Centaur Second Main Engine Start (MES-2)	4,165.1	01:09:25.1
7	Centaur Second Main Engine Cutoff (MECO-2)	4,444.0	01:14:04.0
8	RBSP-A Separation	4,730.0	01:18:50.0
9	RBSP-B Separation	5,464.0	01:31:04.0

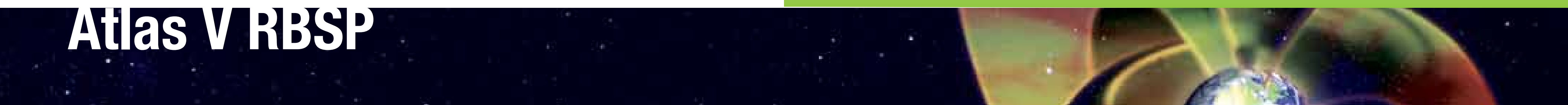


ATLAS V PRODUCTION & LAUNCH | Overview

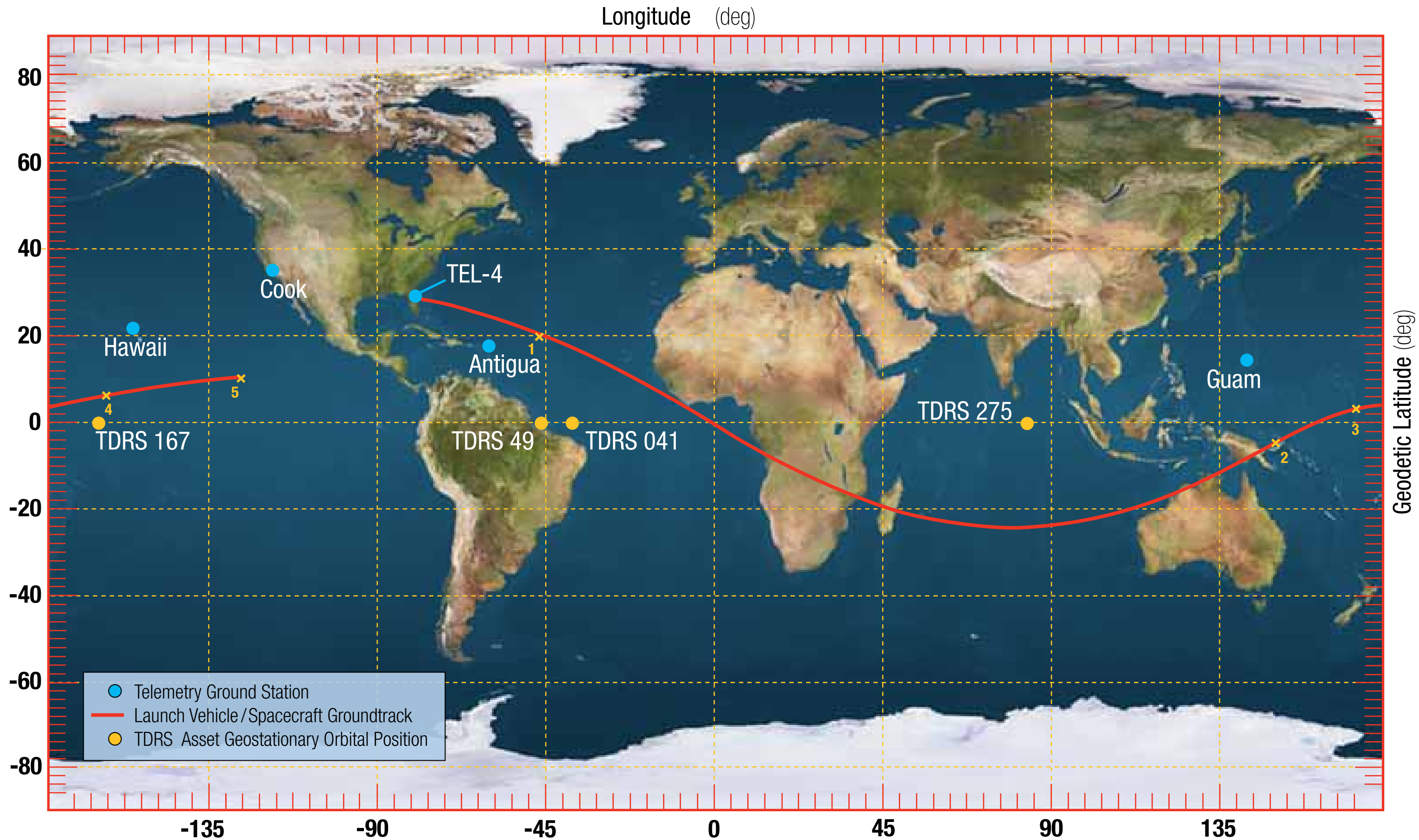


ATLAS V PROCESSING | Cape Canaveral

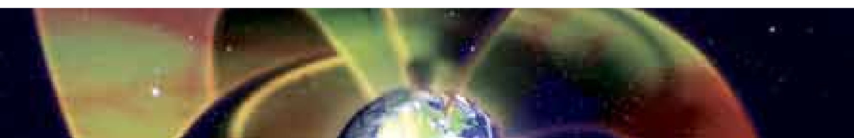


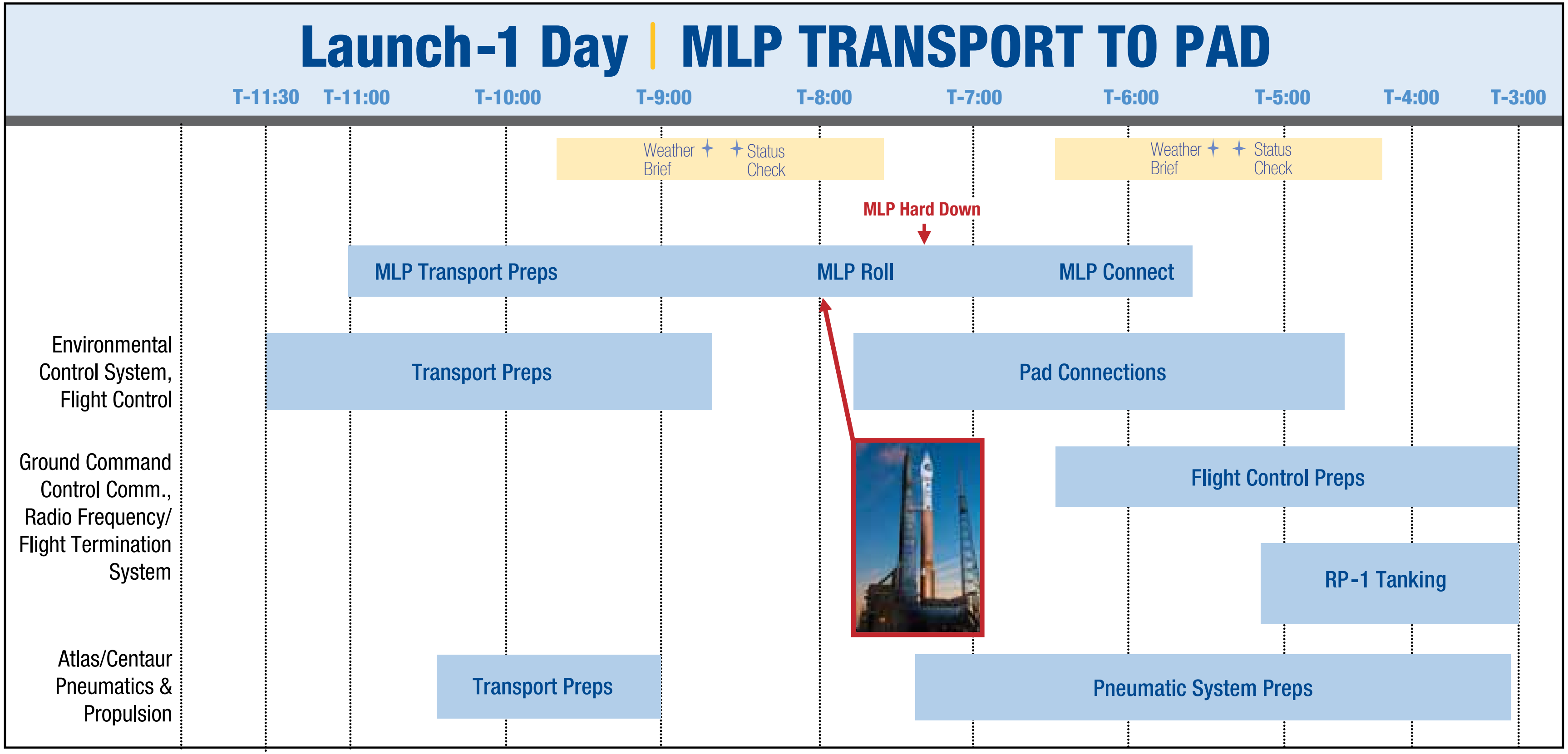


GROUND TRACE | Liftoff to Spacecraft Separation

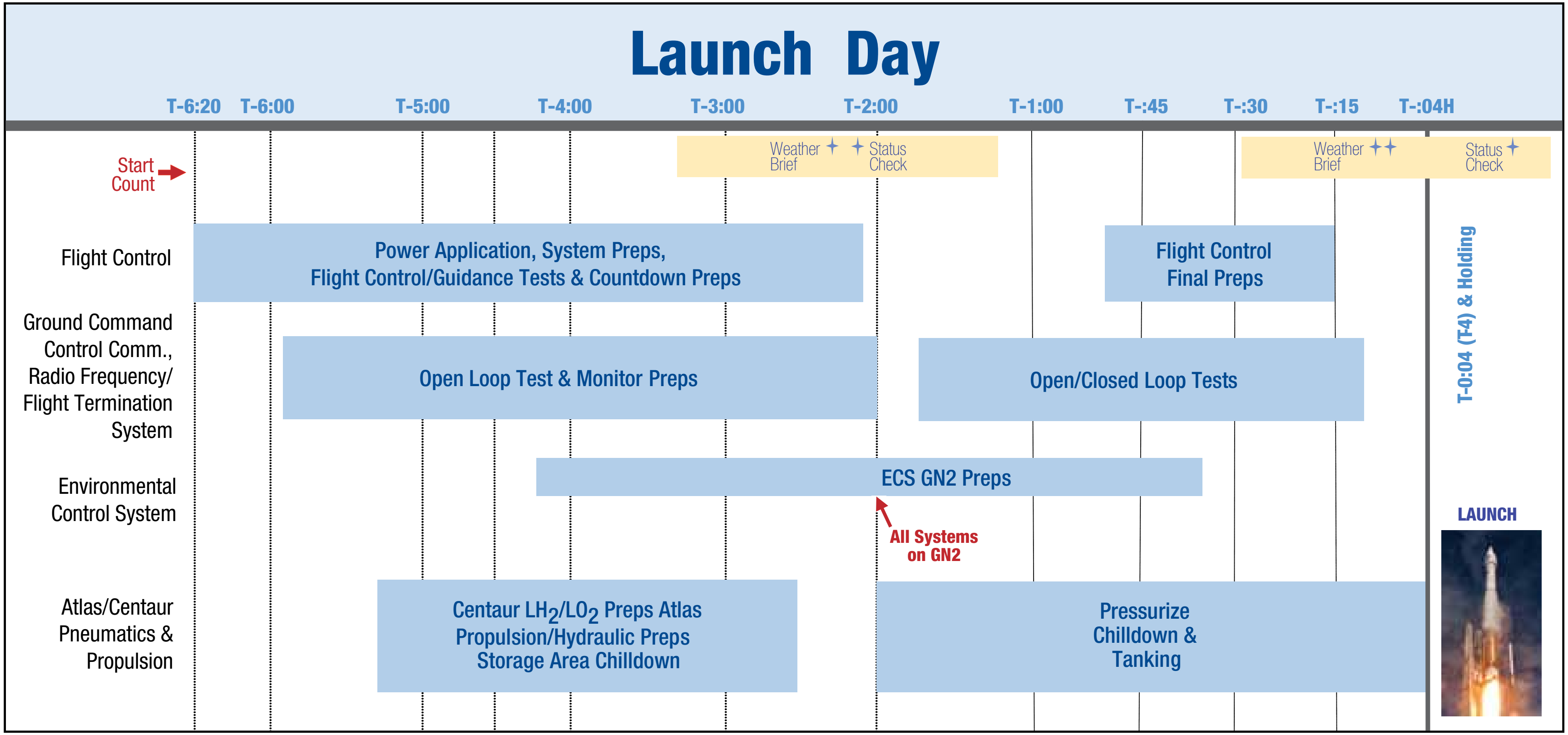


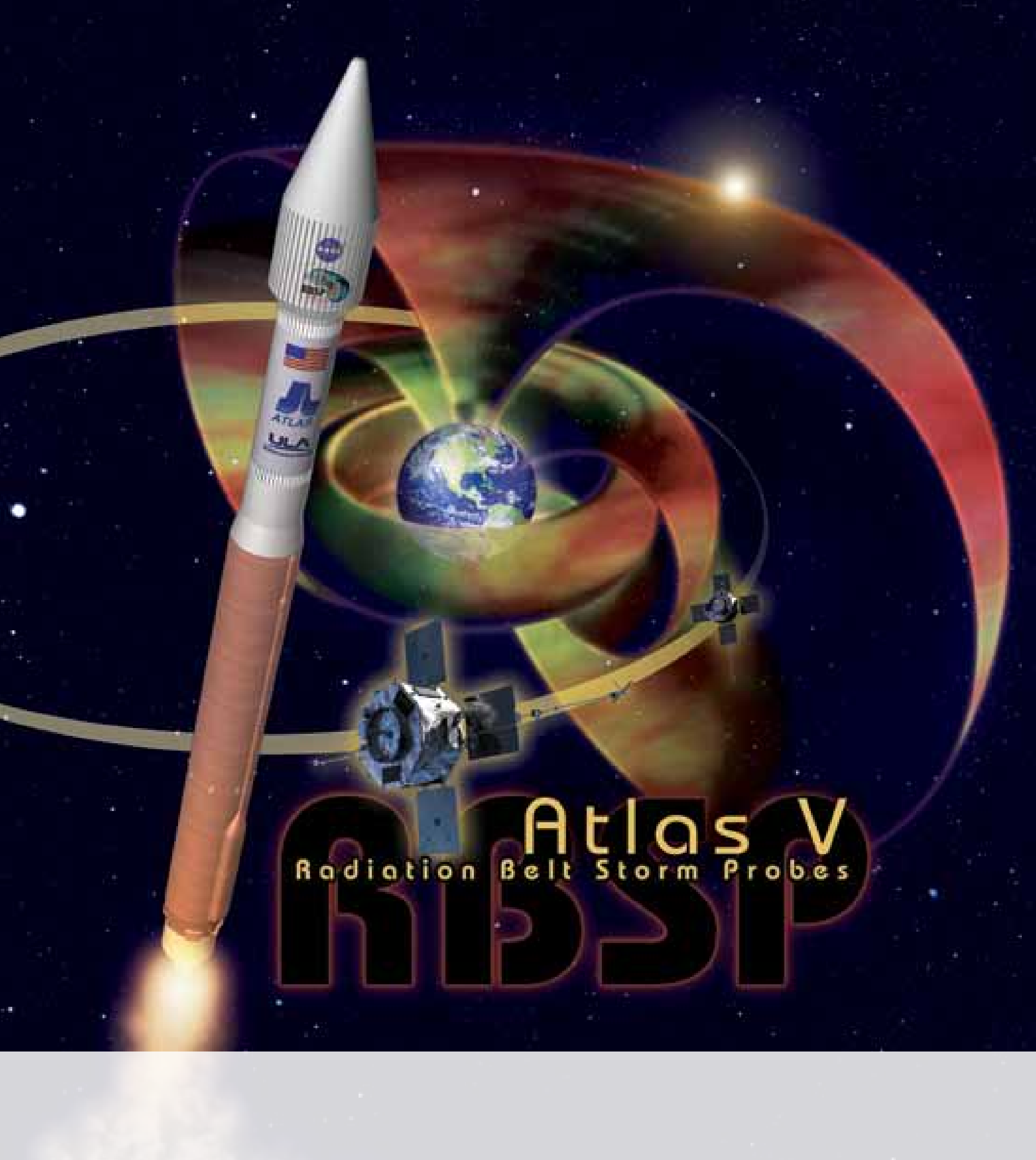
1 = MECO-1 (0:13:36) | **2 =** MES-2 (1:09:25) | **3 =** MECO-2 (1:14:04) | **4 =** RBSP-A Separation (1:18:50) | **5 =** RBSP-B Separation (1:31:04)





Launch-1 Day | MLP TRANSPORT TO PAD
T-11:30
T-11:00
T-10:00
T-9:00
T-8:00
T-7:00
T-6:00
T-5:00
T-4:00
T-3:00
Weather Brief
Status Check
Weather Brief
Status Check
MLP Hard Down
MLP Transport Preps
MLP Roll
MLP Connect
Environmental Control System, Flight Control
Transport Preps
Pad Connections
Ground Command Control Comm., Radio Frequency/ Flight Termination System
Flight Control Preps
RP-1 Tanking
Atlas/Centaur Pneumatics & Propulsion
Transport Preps
Pneumatic System Preps


Launch Day
T-6:20
T-6:00
T-5:00
T-4:00
T-3:00
T-2:00
T-1:00
T-:45
T-:30
T-:15
T-:04H
Start Count
Weather Brief
Status Check
Weather Brief
Status Check
Flight Control
Power Application, System Preps, Flight Control/Guidance Tests & Countdown Preps
Flight Control Final Preps
Ground Command Control Comm., Radio Frequency/ Flight Termination System
Open Loop Test & Monitor Preps
Open/Closed Loop Tests
T-0:04 (T4) & Holding
Environmental Control System
ECS GN2 Preps
All Systems on GN2
LAUNCH
Atlas/Centaur Pneumatics & Propulsion
Centaur LH2/LO2 Preps Atlas Propulsion/Hydraulic Preps Storage Area Childown
Pressurize Chilldown & Tanking



United Launch Alliance | P.O. Box 3788 Centennial, CO 80155 | www.ulalaunch.com