## ATLAS V OSIRIS-REx MISSION

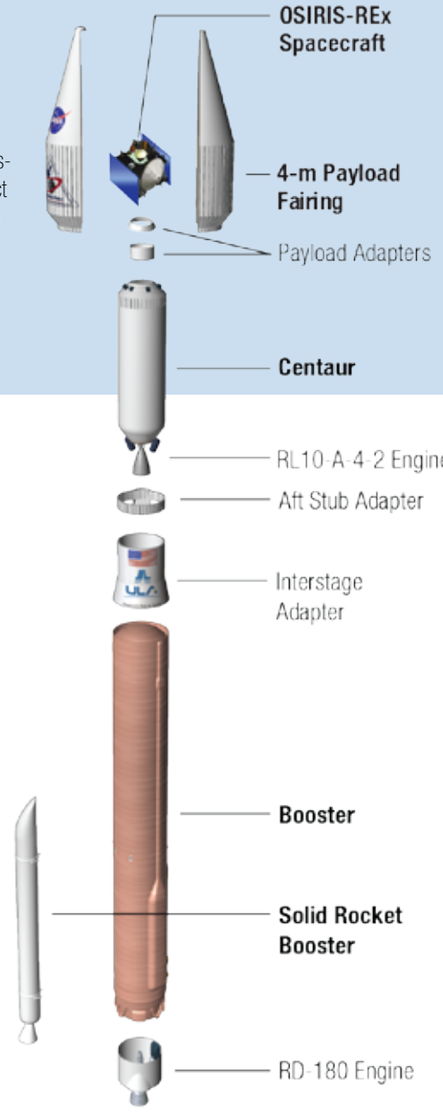
A United Launch Alliance (ULA) Atlas V 411 rocket will inject the OSIRIS-REx spacecraft into a hyperbolic trajectory away from Earth where it will begin a seven-year mission to return an asteroid sample. Liftoff will occur at Space Launch Complex-41 (SLC-41) at Cape Canaveral Air Force Station (CCAFS), Florida.

The OSIRIS-REx mission will help scientists investigate the origins of our solar system, how water and organic material traveled to Earth, and increase understanding of asteroids that could impact Earth. In addition, the sample returned to Earth will further our understanding of water, organics and precious metals on asteroids, which could fuel future exploration missions.

Image Credit: NASA/Goddard/Chris Meaney

Following separation, the OSIRIS-REx spacecraft will make precise maneuvers to modify its orbit around the sun to rendezvous, two years later, with the asteroid Bennu. Bennu, classified as a near-Earth asteroid, is roughly 0.3 miles in diameter and has an estimated mass of more than 65 million tons.

After arriving at Bennu, OSIRIS-REx will spend roughly two years scanning the chemical and physical properties of the asteroid. Laser ranging and optical instruments will map the surface to select its sample collection site. In 2020, OSIRIS-REx will approach Bennu and lightly touch the surface of the asteroid with a special boom-mounted instrument designed to collect material, or regolith, from the surface. The asteroid regolith will be stored in a sample return capsule for the two-year journey back to Earth, which will begin in 2021. As it approaches Earth, the spacecraft sample return capsule will separate from the main spacecraft and make a fiery plunge back to Earth for analysis, helping unlock the mysteries of our solar system's formation.




### Payload Fairing (PLF)

The OSIRIS-REx spacecraft is encapsulated in the 4-m (14-ft) diameter large payload fairing (LPF). The LPF 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.

### Centaur

The Centaur second 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 RL10-A-4-2 engine producing 22,330 lbf of thrust. The cryogenic tanks are insulated with a combination of helium-purged insulation blankets, radiation shields, and spray-on foam insulation (SOFI). The Centaur forward adapter (CFA) provides the structural mountings for the fault-tolerant avionics system and the structural and electrical interfaces with the spacecraft.

### Booster

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. One solid rocket booster (SRB) provides an additional 348,500 lb of thrust at liftoff.

## ATLAS V 411

The Atlas V 411 rocket, a unique configuration that includes just one solid rocket booster, provides the optimum performance to precisely deliver a range of mission types. In its more than 10 years of service, the 411 rocket has completed three flights.

**First Launch:** Apr. 20, 2006
**Launches to date:** 3

**Performance to GTO:** 5,950 kg (13,110 lb)
**Performance to LEO-Reference:** 12,030 kg (26,530 lb)

ATLAS®

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### America's Ride to Space

With more than a century of combined heritage, United Launch Alliance is the nation's most experienced and reliable launch service provider. ULA has successfully delivered more than 100 satellites to orbit that provide critical capabilities for troops in the field, aid meteorologists in tracking severe weather, enable personal device-based GPS navigation and unlock the mysteries of our solar system.

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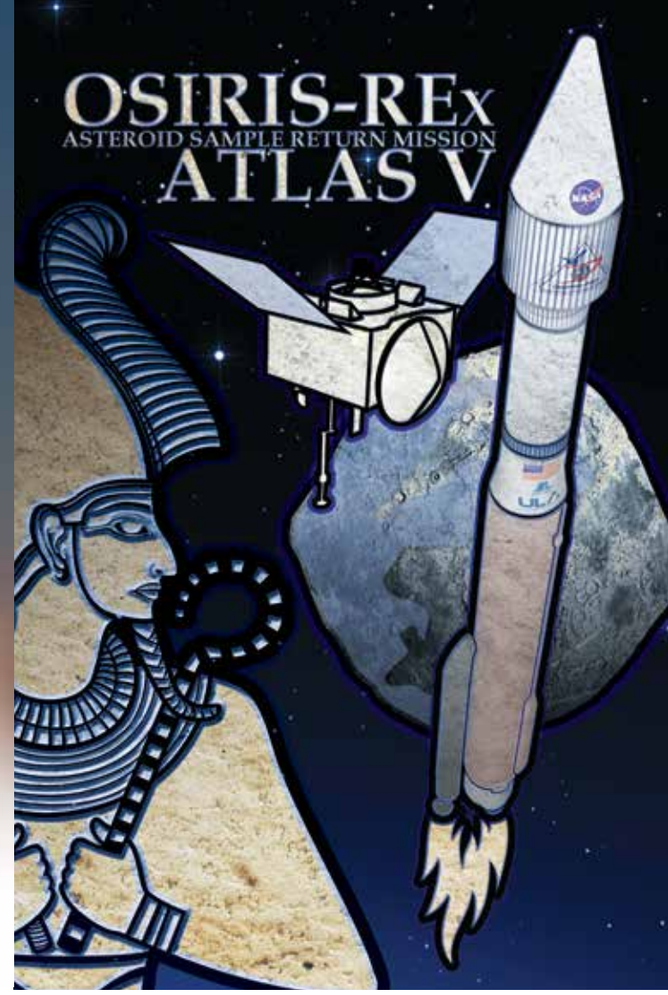


# MISSION OVERVIEW

– 65th Atlas V Launch

– 111th ULA Launch

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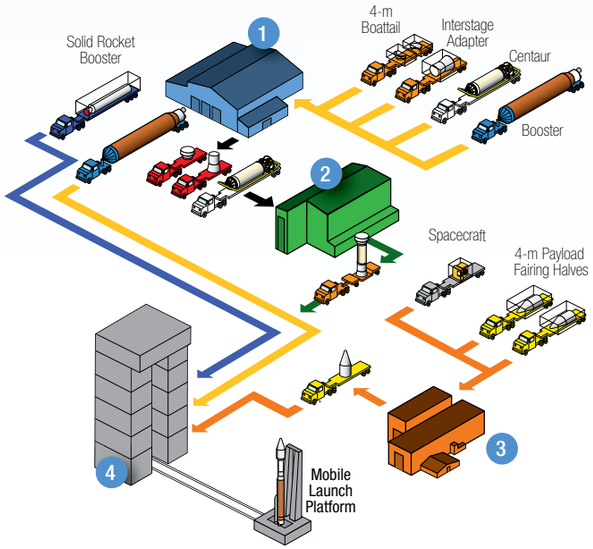
America's Ride to Space

## ATLAS V PRODUCTION AND LAUNCH

1. **Sacramento, CA**
   - Solid Rocket Booster Fabrication at Aerojet Rocketdyne
2. **Denver, CO**
   - ULA Headquarters & Design Center Engineering
3. **Harlingen, TX**
   - Payload Fairing, Adapter & Centaur Fabrication
4. **Decatur, AL**
   - Booster Fabrication & Final Assembly
   - Centaur Final Assembly
5. **West Palm Beach, FL**
   - RL10-A-4-2 Engine Fabrication at Aerojet Rocketdyne
6. **Khimki, Russia**
   - RD-180 Engine Fabrication at NPO Energomash

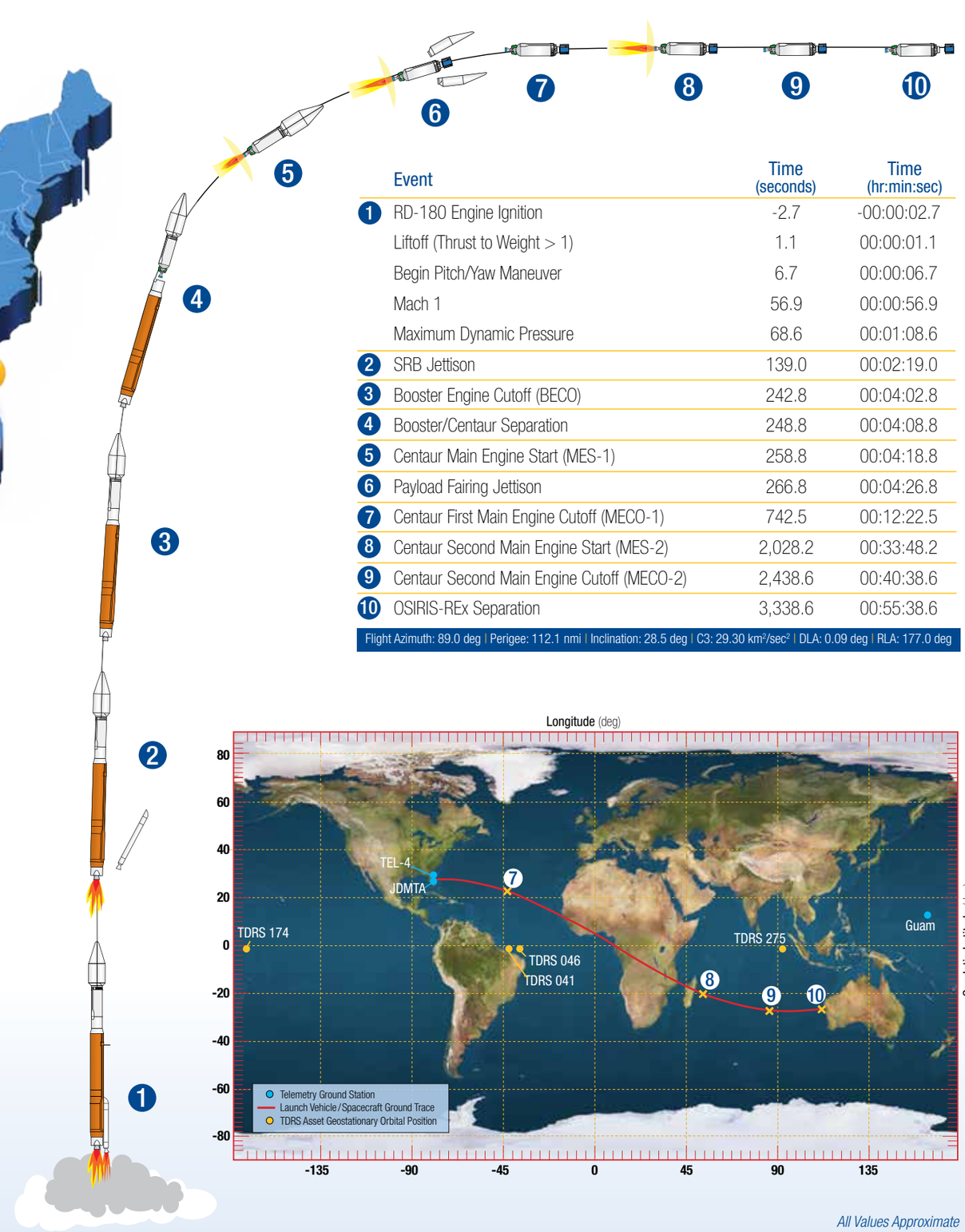

1. **Atlas Spaceflight Operations Center (ASOC)** | Launch Control Center and Mission Director's Center
2. **Delta Operations Center** | ISA, Centaur, Boattail Vertical Integration
3. **Spacecraft Processing Facility** | Spacecraft processing, testing and encapsulation
4. **Vertical Integration Facility** | Launch vehicle integration and testing, spacecraft mate and integrated operations




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



## MISSION PROFILE AND GROUND TRACE




| | Event | Time (seconds) | Time (hr:min:sec) |
|---|---|---|---|
| 1 | RD-180 Engine Ignition | -2.7 | -00:00:02.7 |
| | Liftoff (Thrust to Weight > 1) | 1.1 | 00:00:01.1 |
| | Begin Pitch/Yaw Maneuver | 6.7 | 00:00:06.7 |
| | Mach 1 | 56.9 | 00:00:56.9 |
| | Maximum Dynamic Pressure | 68.6 | 00:01:08.6 |
| 2 | SRB Jettison | 139.0 | 00:02:19.0 |
| 3 | Booster Engine Cutoff (BECO) | 242.8 | 00:04:02.8 |
| 4 | Booster/Centaur Separation | 248.8 | 00:04:08.8 |
| 5 | Centaur Main Engine Start (MES-1) | 258.8 | 00:04:18.8 |
| 6 | Payload Fairing Jettison | 266.8 | 00:04:26.8 |
| 7 | Centaur First Main Engine Cutoff (MECO-1) | 742.5 | 00:12:22.5 |
| 8 | Centaur Second Main Engine Start (MES-2) | 2,028.2 | 00:33:48.2 |
| 9 | Centaur Second Main Engine Cutoff (MECO-2) | 2,438.6 | 00:40:38.6 |
| 10 | OSIRIS-REx Separation | 3,338.6 | 00:55:38.6 |

Flight Azimuth: 89.0 deg | Perigee: 112.1 nmi | Inclination: 28.5 deg | C3: 29.30 $km^2/sec^2$ | DLA: 0.09 deg | RLA: 177.0 deg




*All Values Approximate*