## ATLAS V MMS MISSION

A ULA Atlas V 421 will deliver the MMS constellation to a highly elliptical orbit (HEO). Liftoff will occur from Space Launch Complex 41 at Cape Canaveral Air Force Station, FL.

The Magnetospheric Multiscale mission, or MMS, is a NASA Solar Terrestrial Probes mission consisting of four identical science observatories whose objective is to understand the microphysics of magnetic reconnection. The four MMS observatories are designed, built, and operated by NASA's Goddard Space Flight Center (GSFC) in Greenbelt, MD and a science and instrument team led by Southwest Research Institute (SwRI) in San Antonio, TX.

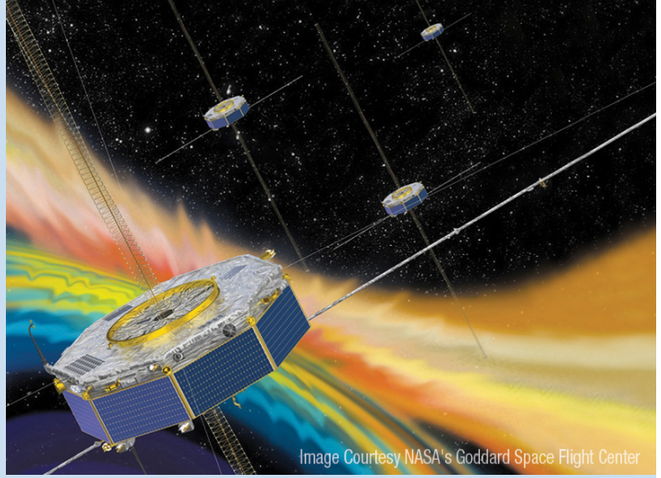
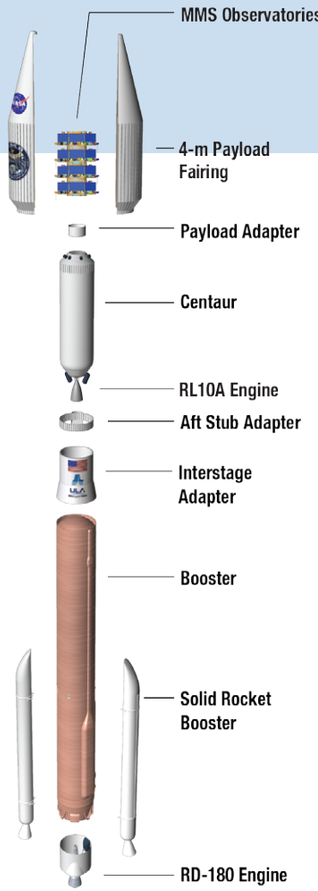


Image Courtesy NASA's Goddard Space Flight Center

Magnetic reconnection is a universal process that happens when magnetic fields in two adjacent regions of space interconnect across their boundary converting magnetic energy into heat and high energy charged particles. This process lies at the heart of giant explosions on the sun, such as solar flares and coronal mass ejections, which can fling radiation and particles across the solar system. Because it's so difficult to see this process on the sun, and it's also a difficult process to re-create and study in the lab, researchers plan to take a closer look at magnetic reconnection in space.

The four identically instrumented MMS observatories will fly in an adjustable pyramid-like tetrahedron formation. By observing magnetic reconnection in nature, MMS provides access to predictive knowledge of a universal process that is the final governor of space weather, affecting modern technological systems such as communications networks, GPS navigation, and electrical power grids. Magnetic reconnection also limits the performance of fusion reactors on Earth. Solving magnetic reconnection has the potential to unlock understanding of a fundamental energy process present throughout the universe that also affects and limits our use of technologies on Earth.




### Payload Fairing (PLF)

The MMS observatories are encapsulated in the 4-m (14-ft) diameter Extra Extended Payload Fairing (XEPF). The XEPF 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 195 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 RL10A engine producing 22,300 lb 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. Two solid rocket boosters (SRB) generate the additional power required at liftoff, with each SRB providing 348,500 lb of thrust. 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 ULA team is proud to be the launch provider for the Magnetospheric Multiscale (MMS) mission for the National Aeronautics and Space Administration (NASA). MMS will study the microphysics of magnetic reconnection. This fundamental energy process is the ultimate driver of space weather which affects communication networks, GPS navigation, and electrical power grids on and near the Earth.

The MMS Project Office at NASA's Goddard Space Flight Center manages the spacecraft and our direct customer for this launch is the NASA Launch Services Program (LSP).

The ULA team is focused on attaining Perfect Product Delivery for the MMS 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).

We sincerely thank the entire team, which consists of NASA, Southwest Research Institute, ULA, and major suppliers of ULA.

Go Atlas, Go Centaur, Go MMS!

Jim Sponnick
Vice President, Atlas and Delta Programs

**America's Ride to Space**

With more than a century of combined heritage, ULA is the nation's most experienced and reliable launch service provider. ULA has successfully delivered more than 90 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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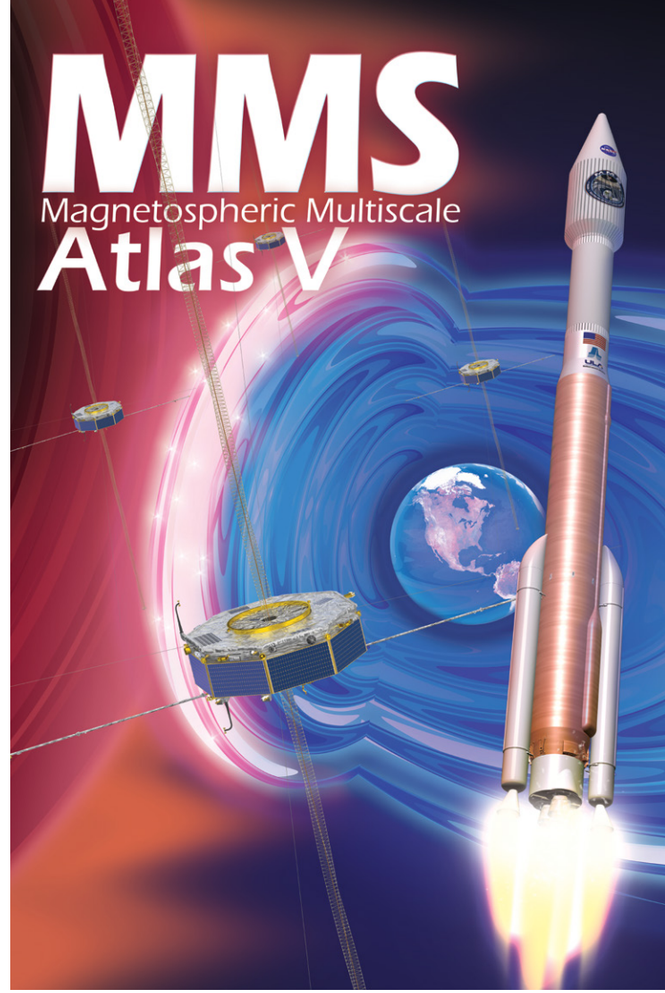
# MMS
## Magnetospheric Multiscale
## Atlas V



# MISSION OVERVIEW

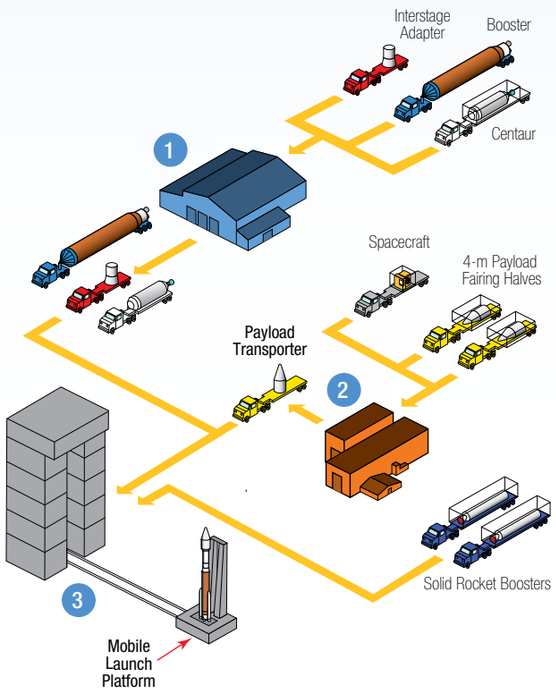
– 4th Atlas V 421 Launch
– 12th NASA Atlas V Mission
– 53rd Atlas V Launch

America's Ride to Space

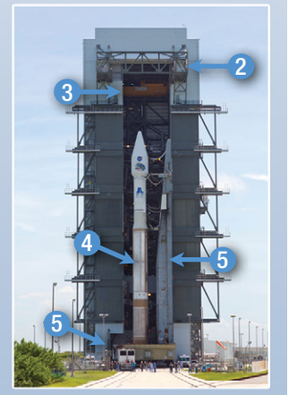
## ATLAS V PRODUCTION AND LAUNCH

1. **Sacramento, CA**
   – Solid Rocket Booster Fabrication at Aerojet Rocketdyne
2. **Denver, CO**
   – ULA Headquarters & Design Center Engineering
3. **Harlingen, TX**
   – Payload Fairing, Payload Fairing Adapter, Booster Adapter & Centaur Adapter Fabrication
4. **Decatur, AL**
   – Booster Fabrication & Final Assembly, Centaur Tank Fabrication & Centaur Final Assembly
5. **West Palm Beach, FL**
   – RL10A 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. **Spacecraft Processing Facility** | Spacecraft processing, testing and encapsulation
3. **Vertical Integration Facility** | Launch vehicle Integration and testing, spacecraft mate and integrated operations

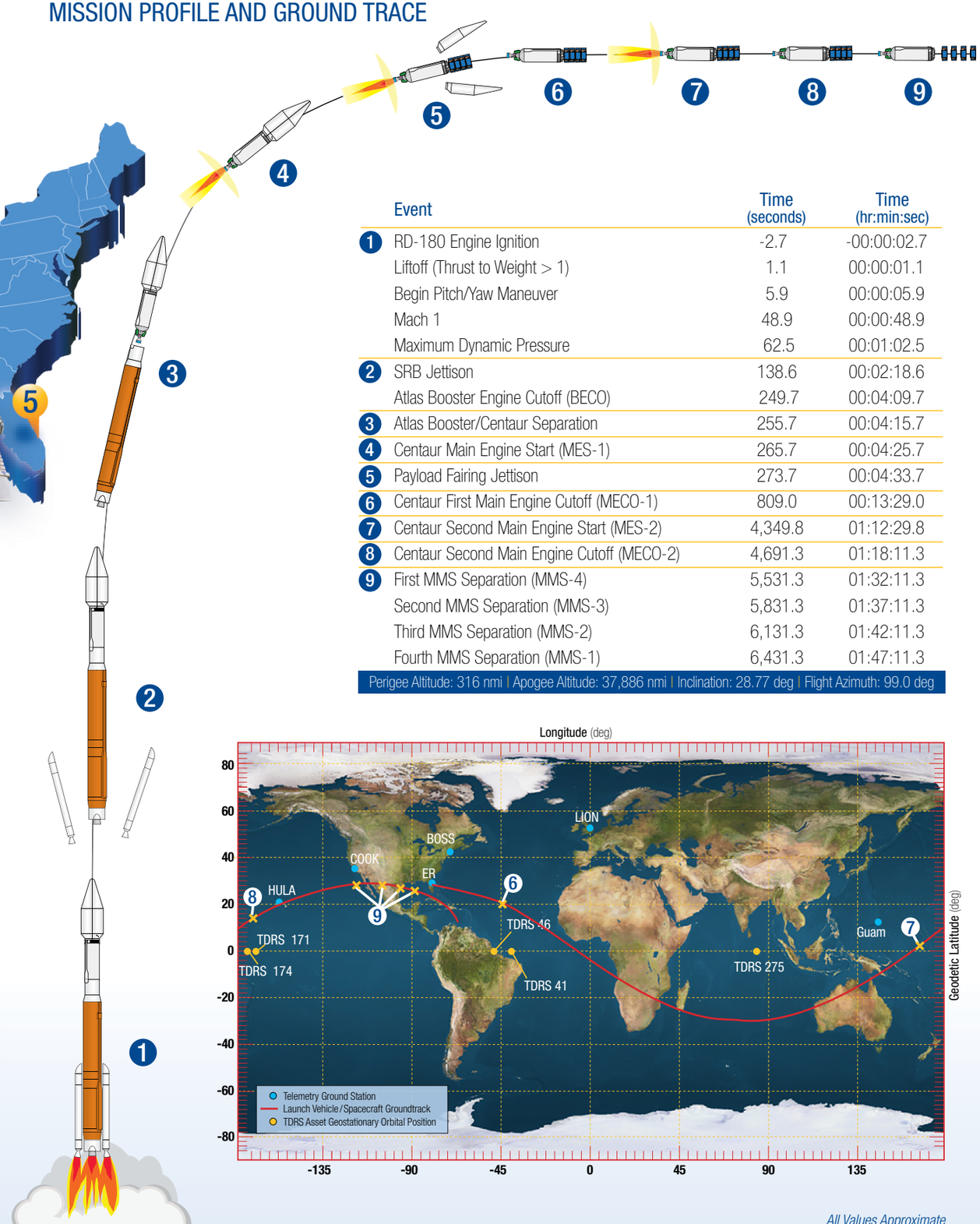



1. **Vertical Integration Facility** (VIF) (See inset)
2. **Bridge Crane Hammerhead**
3. **Bridge Crane**
4. **Launch Vehicle**
5. **Mobile Launch Platform** (MLP)
6. **Centaur $LO_2$ Storage**
7. **High Pressure Gas Storage**
8. **Booster $LO_2$ Storage**
9. **Pad Equipment Building** (PEB)
10. **Pad 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 | 5.9 | 00:00:05.9 |
| | Mach 1 | 48.9 | 00:00:48.9 |
| | Maximum Dynamic Pressure | 62.5 | 00:01:02.5 |
| 2 | SRB Jettison | 138.6 | 00:02:18.6 |
| | Atlas Booster Engine Cutoff (BECO) | 249.7 | 00:04:09.7 |
| 3 | Atlas Booster/Centaur Separation | 255.7 | 00:04:15.7 |
| 4 | Centaur Main Engine Start (MES-1) | 265.7 | 00:04:25.7 |
| 5 | Payload Fairing Jettison | 273.7 | 00:04:33.7 |
| 6 | Centaur First Main Engine Cutoff (MECO-1) | 809.0 | 00:13:29.0 |
| 7 | Centaur Second Main Engine Start (MES-2) | 4,349.8 | 01:12:29.8 |
| 8 | Centaur Second Main Engine Cutoff (MECO-2) | 4,691.3 | 01:18:11.3 |
| 9 | First MMS Separation (MMS-4) | 5,531.3 | 01:32:11.3 |
| | Second MMS Separation (MMS-3) | 5,831.3 | 01:37:11.3 |
| | Third MMS Separation (MMS-2) | 6,131.3 | 01:42:11.3 |
| | Fourth MMS Separation (MMS-1) | 6,431.3 | 01:47:11.3 |

Perigee Altitude: 316 nmi | Apogee Altitude: 37,886 nmi | Inclination: 28.77 deg | Flight Azimuth: 99.0 deg




*All Values Approximate*