Mars Atmosphere and Volatile Evolution

MAVEN

MISSION OVERVIEW | SLC-41 CCAFS, FL

ULA® United Launch Alliance

ATLAS®

The ULA team is proud to be the launch provider for the Mars Atmosphere and Volatile Evolution (MAVEN) mission.

While the MAVEN spacecraft continues a long line of Mars missions launched by ULA's vehicles, it will be the first devoted to directly analyzing the tenuous upper atmosphere of Mars. After a 10-month cruise to Mars, MAVEN will spend an Earth-year in its primary scientific mission. Numerous "deep dips" into the upper atmosphere will allow MAVEN to assess the complex interaction with the Sun and other factors to understand the present and past rates of water and carbon dioxide loss to space. This knowledge will help scientists understand the mechanisms for the loss of atmosphere on Mars and on planets being discovered around other stars. Following its primary mission, MAVEN will remain in orbit for many years continuing to make science measurements and to serve as a data-relay for surface rovers and future spacecraft in our continuing quest to reveal the secrets of the red planet.

The ULA team is focused on attaining Perfect Product Delivery for the MAVEN 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 team for its dedication in bringing MAVEN to launch and to NASA for trusting ULA to deliver this essential mission.

Go Atlas, Go Centaur, Go MAVEN!

Jim Sponnick
Vice President, Atlas and Delta Programs

MAVEN SPACECRAFT | Overview

The MAVEN spacecraft will be the first probe to directly assess the mysteries of the atmosphere of Mars. Previous missions clearly show the past presence of water, but how it and the other gas components were lost is uncertain. Some may have been stripped away by the Sun, while others may still be on Mars – absorbed into its crust. MAVEN will determine the present state of the upper atmosphere and today's rates of loss to space, which will enable determination of the net integrated loss to space through time.

Weighing more than 5,600 lbs at launch, the spacecraft will generate 1,135 watts of power when it arrives in orbit via its solar panels. The solar panels have been designed in a 'gull wing' configuration to help stabilize the spacecraft as it dives through the Martian atmosphere as well as to carry magnetic field instruments at each tip. The fixed main antenna will not only return global data from the primary atmospheric mission, but will also serve as a data relay for future missions.

Manufactured by Lockheed Martin Space Systems for NASA's Goddard Spaceflight Center (GSFC), the spacecraft carries instruments provided by GSFC, the Colorado University Laboratory for Atmospheric and Space Physics, and the Space Sciences Laboratory at UC Berkeley. The spacecraft includes an Articulated Payload Platform (APP), which is a deployable boom with a wide range of attitude capability. The APP will precisely point three instrument packages on its tip to sample the Mars atmosphere. This suite of instruments includes the Neutral Gas and Ion Mass Spectrometer, the Imaging Ultraviolet Spectrometer, and the Suprathermal and Thermal Ion Composition instruments. A separate deployed boom provides standoff from the spacecraft for the Solar Wind Electron Analyzer. Instruments mounted on the spacecraft body provide detailed measurements of the Sun's electrons, ions, particles, and radiation. Two additional booms measure electron temperature and density.

Together, these instruments will provide unprecedented insight into Mars as it exists today, and how it was in the past.

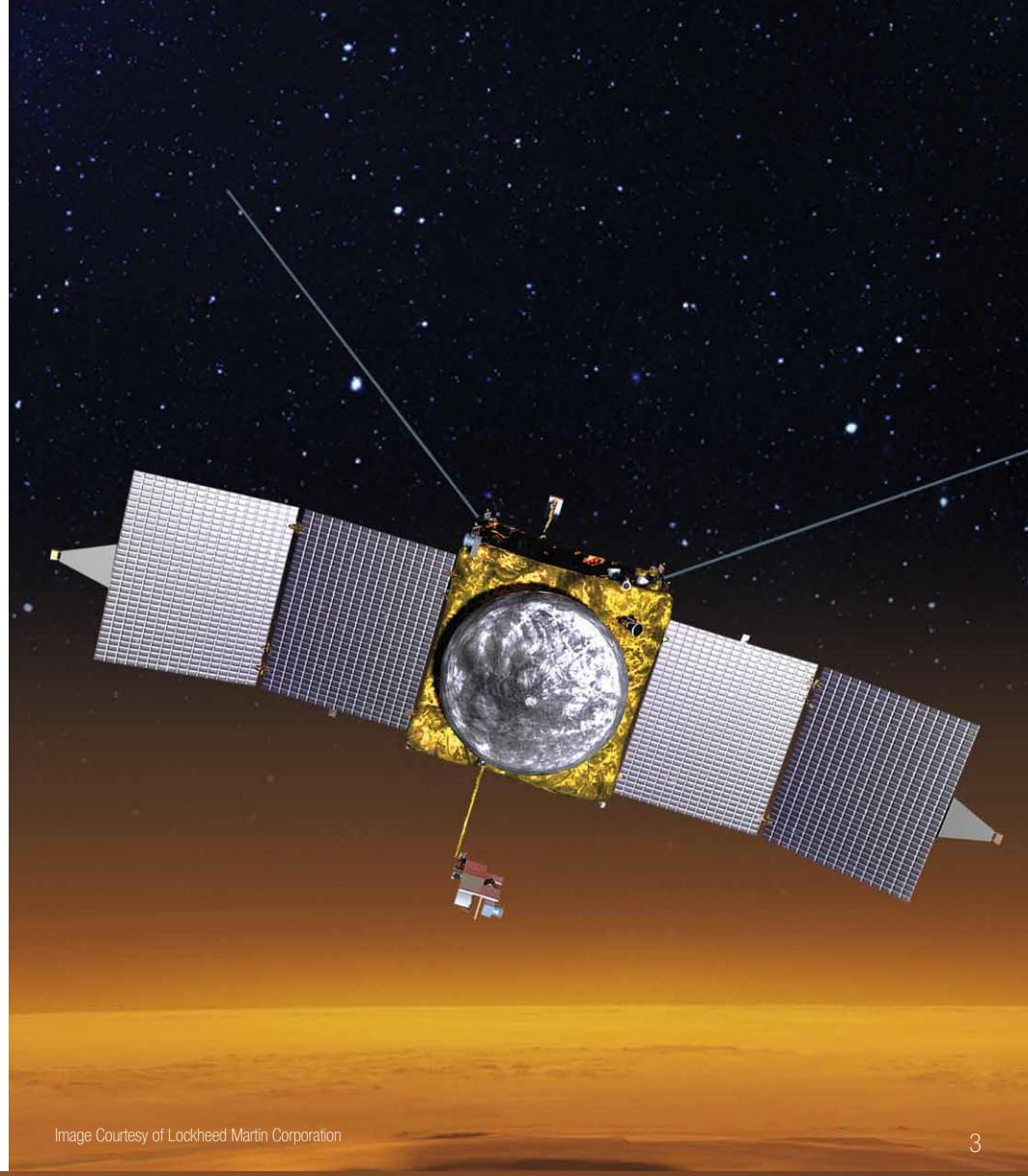


Image Courtesy of Lockheed Martin Corporation

ATLAS V 401 LAUNCH VEHICLE | Overview

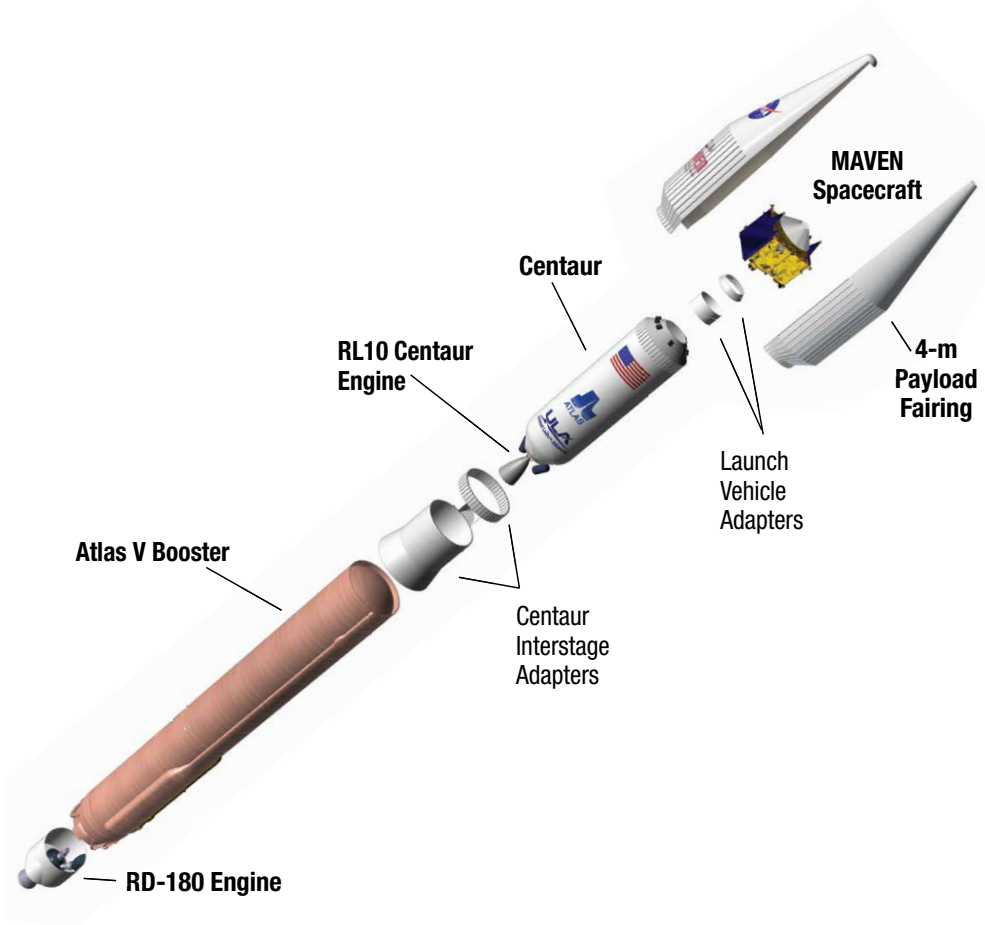
The Atlas V 401 launch vehicle consists of a single Atlas V booster stage, the Centaur second stage, and a 4-m diameter payload fairing (PLF).

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 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-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 spray-on foam insulation. The Centaur forward adapter provides the structural mountings for the fault-tolerant avionics system and the structural and electrical interfaces with the spacecraft.

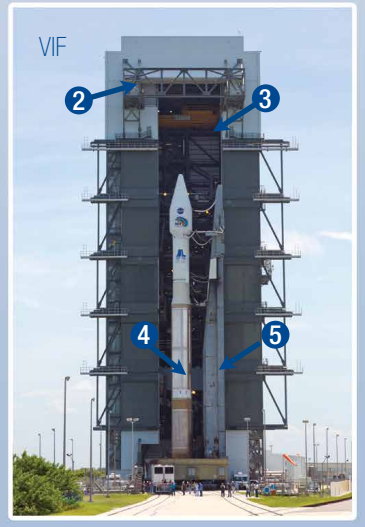
The MAVEN spacecraft is encapsulated in the 4-m (14-ft) diameter large payload fairing (LPF). The 39.3-ft long LPF is a bisector (two-piece shell) fairing consisting of aluminum skin/stringer construction with vertical split-line longerons. The vehicle's height with the PLF is approximately 188 ft.

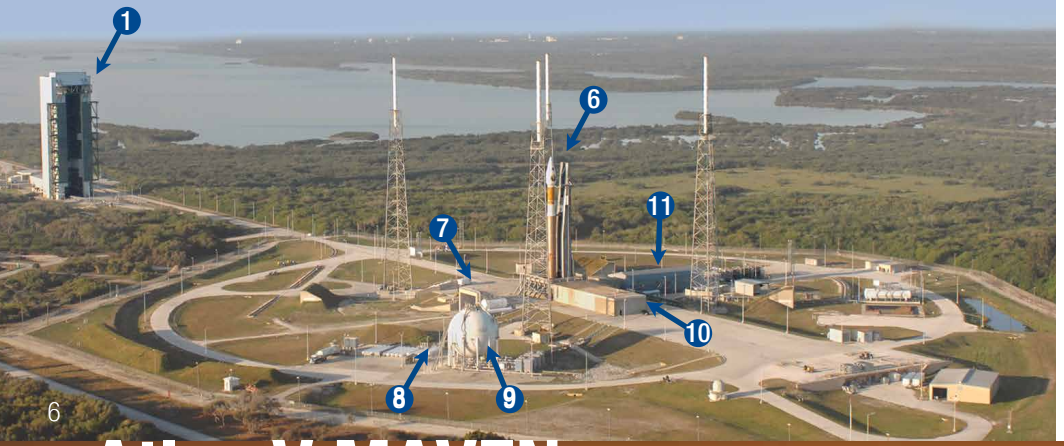
ATLAS V 401 LAUNCH VEHICLE | Expanded View



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





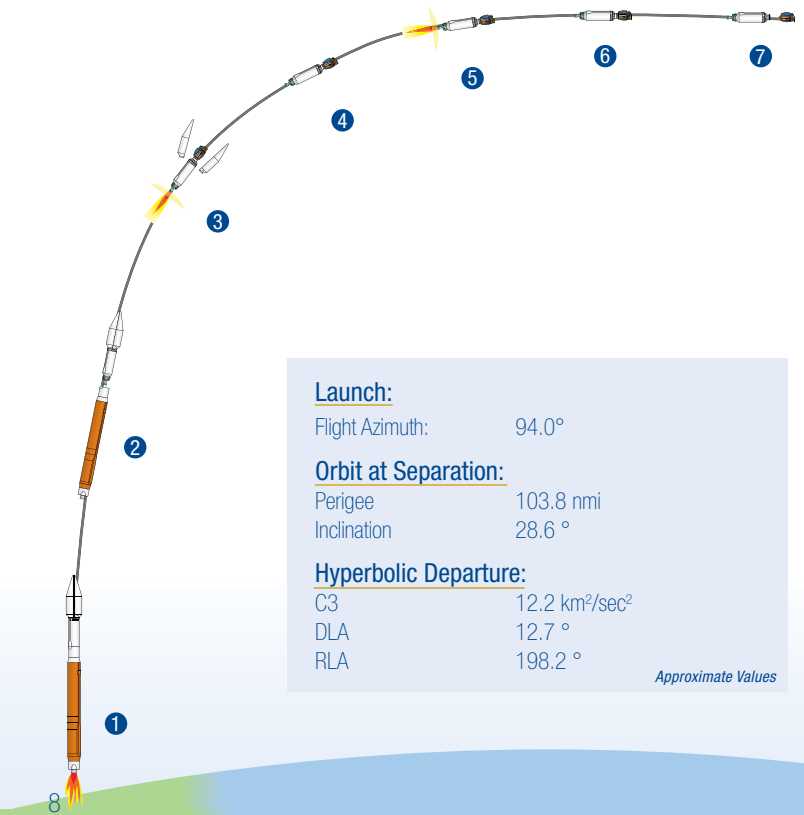
ATLAS V MAVEN | Mission Overview

The MAVEN mission will be flown on an easterly trajectory from Space Launch Complex 41 at Cape Canaveral Air Force Station (CCAFS), FL. The MAVEN spacecraft will be released into a hyperbolic Earth escape orbit to Mars.

The mission begins with ignition of the RD-180 engine approximately 3.8 seconds prior to liftoff. 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. Booster engine cutoff (BECO) occurs 242.4 seconds into flight followed by Centaur separation 6 seconds later.

Approximately 4 minutes into flight, the Centaur stage ignites its main engine (MES1). Eight seconds into the burn, the payload fairing is jettisoned. Over the Atlantic Ocean the burn lasts 9.5 minutes, and uses a special steering profile. This profile optimizes the trajectory for the interplanetary target, placing the vehicle into a unique parking orbit tailored for the day and time of launch. Following a 24-minute coast, the Centaur main engine is ignited for a second burn (MES2), lasting 5.5 minutes. Following Centaur engine shutdown (MECO2), the vehicle turns to the separation attitude and delays separation for approximately 3 minutes to ensure that the down range Deep Space Network stations will have contact with MAVEN during the separation event. Separation occurs over Australia at approximately 53 minutes after launch.

FLIGHT PROFILE | Liftoff to Separation



Launch:

Flight Azimuth: 94.0°

Orbit at Separation:

Perigee 103.8 nmi
Inclination 28.6 °

Hyperbolic Departure:

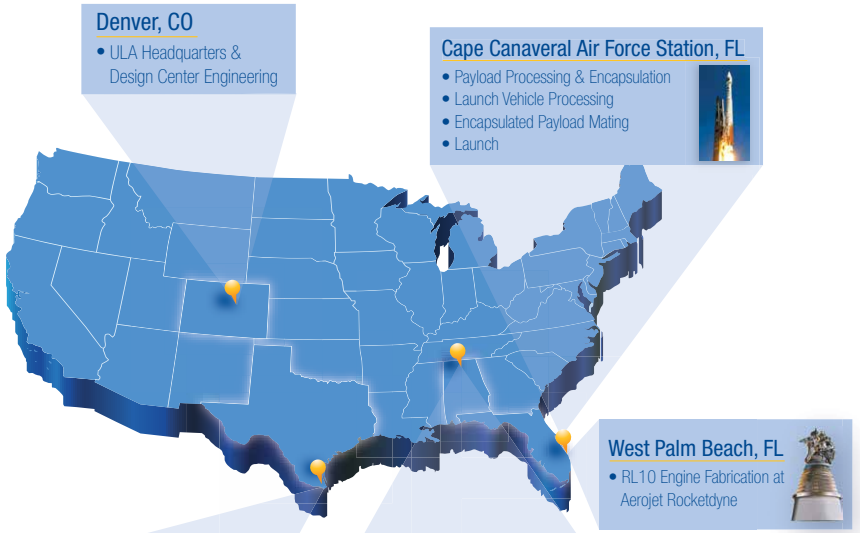
C3 12.2 km^2/sec^2
DLA 12.7 °
RLA 198.2 °

Approximate Values

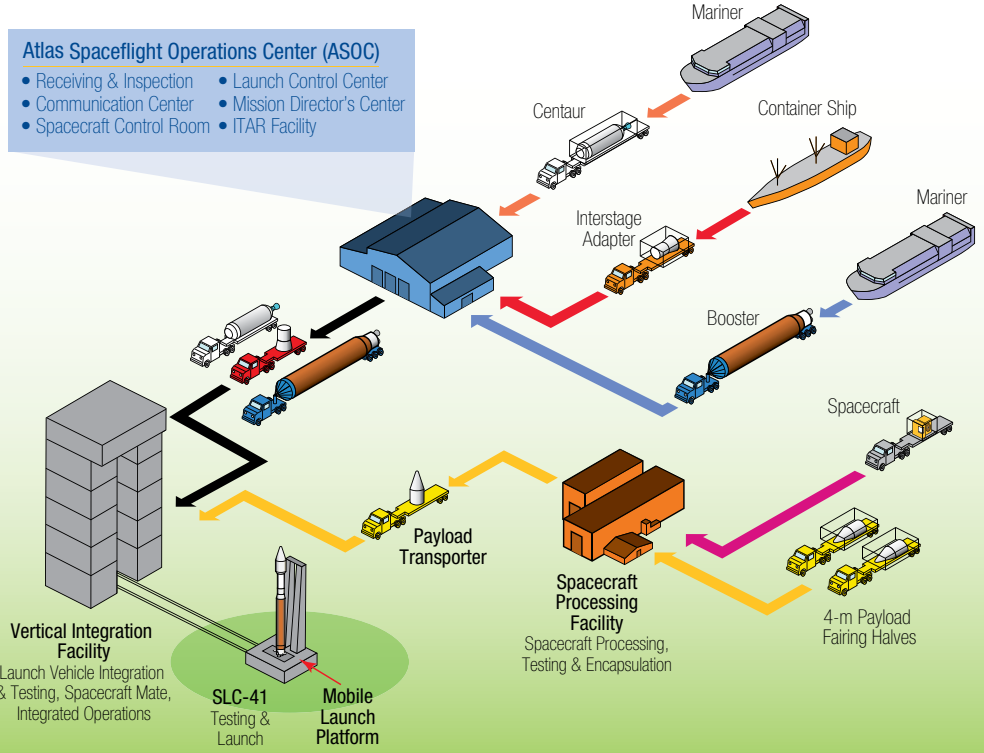
SEQUENCE OF EVENTS | Liftoff to Separation

	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/Roll Maneuver	17.3	00:00:17.3
	Maximum Dynamic Pressure	90.9	00:01:30.9
2	Atlas Booster Engine Cutoff (BECO)	242.4	00:04:02.4
	Atlas Booster/Centaur Separation	248.4	00:04:08.4
3	Centaur First Main Engine Start (MES1)	258.3	00:04:18.3
	Payload Fairing Jettison	266.4	00:04:26.4
4	Centaur First Main Engine Cutoff (MECO1)	828.3	00:13:48.3
5	Centaur Second Main Engine Start (MES2)	2,484.3	00:41:24.3
6	Centaur Second Main Engine Cutoff (MECO2)	2,813.2	00:46:53.2
7	MAVEN Separation	3,162.2	00:52:42.2

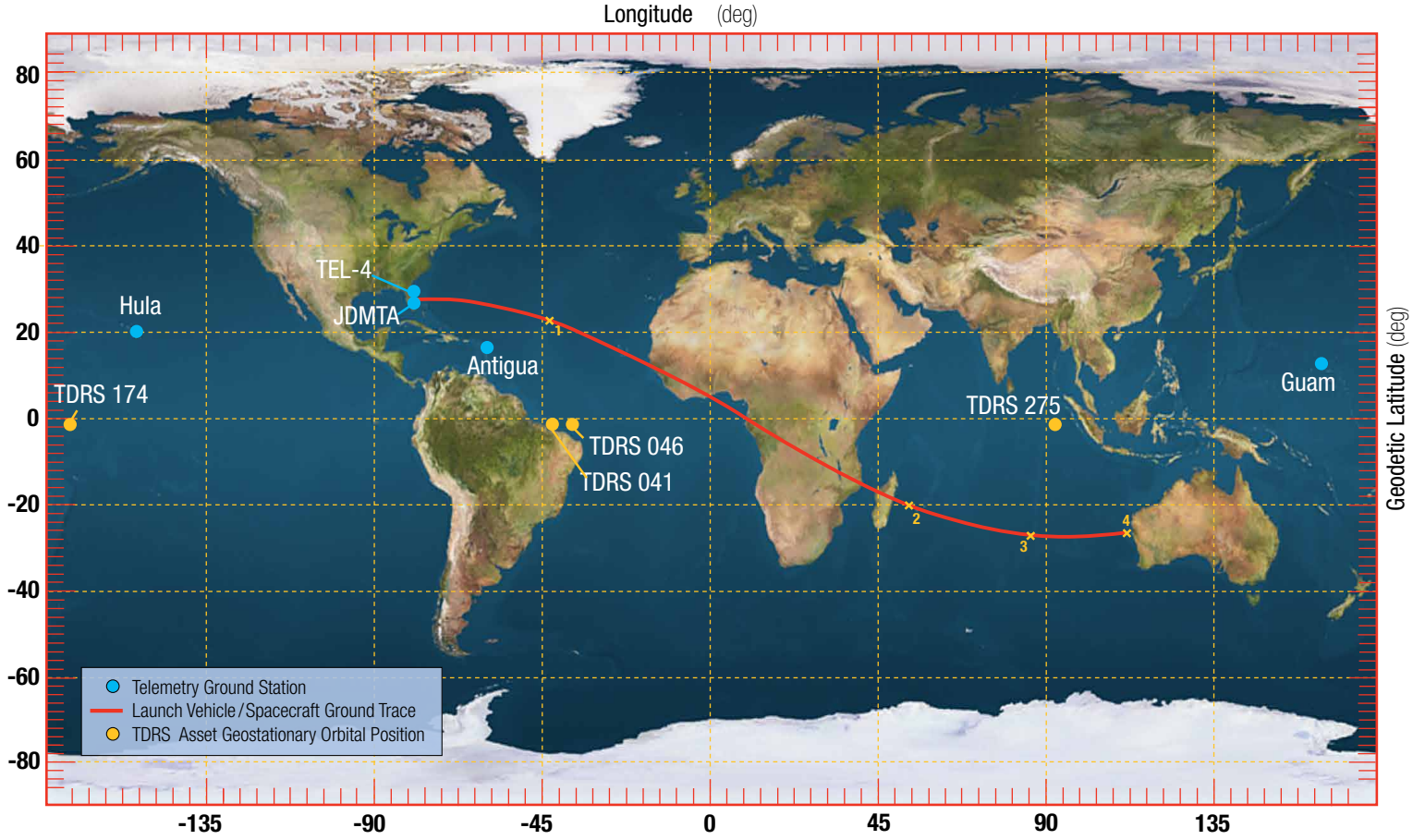
ATLAS V PRODUCTION & LAUNCH | Overview



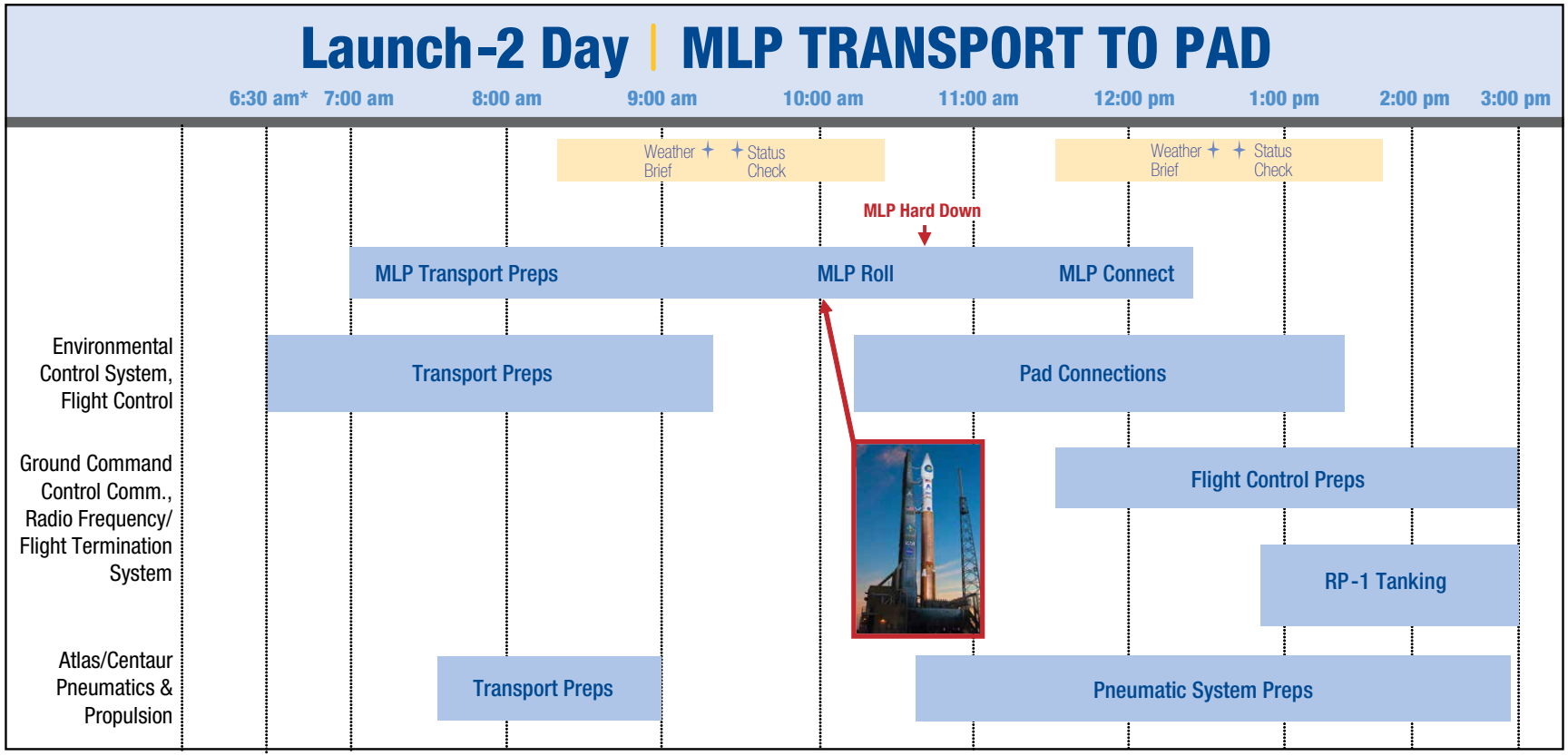
ATLAS V PROCESSING | Cape Canaveral



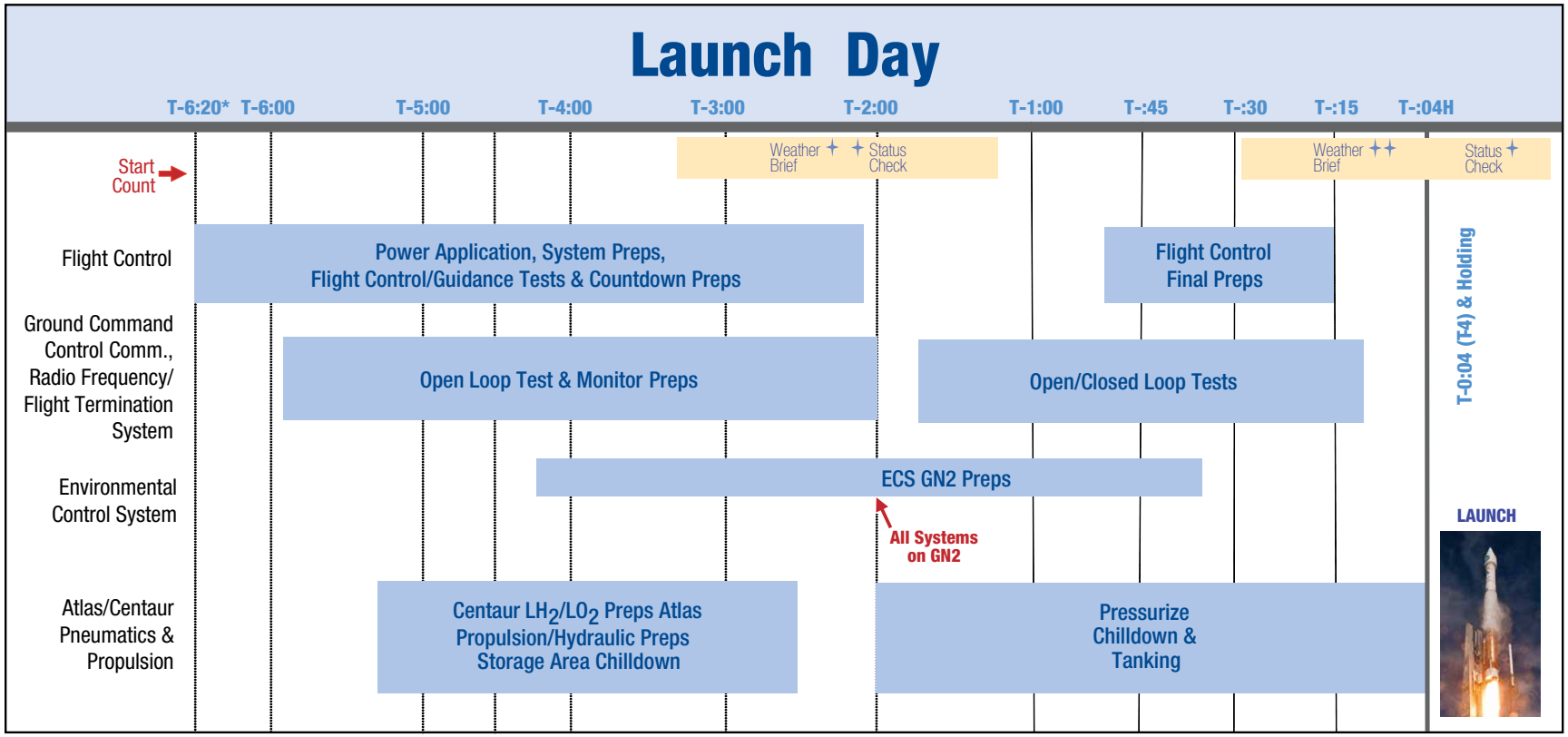
GROUND TRACE | Liftoff to Separation



1 = MECO1 (0:13:48.3) | **2 =** MES2 (0:41:24.3) | **3 =** MECO2 (0:46:53.2) | **4 =** MAVEN Separation (0:52:42.2)



*Approximate times based on process time



*Times based on countdown to launch

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