

# Atlas V ★★★★★

MOBILE USER OBJECTIVE SYSTEM

# ML105-2



## MISSION OVERVIEW | SLC-41 CCAFS, FL



United Launch Alliance (ULA) is proud to be a part of the deployment of the U.S. Navy's Mobile User Objective System (MUOS) satellite constellation.

MUOS-2 is the second of a five-satellite constellation to be launched and operated by PMW 146, the Navy's Communications Satellite Program Office. MUOS is a next-generation narrowband tactical satellite communications system designed to significantly improve ground communications to U.S. forces on the move around the globe.

The MUOS-2 satellite will be the heaviest payload to ride into space atop any of ULA's Atlas V launch vehicles. The Atlas V will generate more than two and half million pounds of thrust at liftoff in order to meet the demands of lifting the nearly 7.5-ton satellite.

The ULA team is focused on attaining Perfect Product Delivery for the MUOS-2 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).

Thank you to the entire ULA team and to our mission partners. Your dedication has made this game-changing mission possible.

Go Atlas, Go Centaur, Go MUOS!

A handwritten signature in black ink that reads "J. Spornick".

**Jim Spornick**

Vice President, Atlas and Delta Programs



## MUOS-2 SATELLITE | Overview

The MUOS-2 satellite will ensure continued mission capability of the existing Ultra-High Frequency Satellite Communications (UHF SATCOM) system, and represents deployment of the second satellite in the next-generation narrowband tactical satellite communications system that will provide significantly improved and assured communications for the mobile warfighter. The MUOS constellation will ultimately replace the current UHF SATCOM system, providing military users with 10 times more communications capacity over existing systems, including simultaneous voice (full-duplex) and data, leveraging 3G mobile communications technology.

From its vantage point in geostationary orbit, the MUOS-2 satellite will cover approximately a third of the Earth's surface and uses its 14-meter diameter reflecting mesh antenna to communicate with ground-based users. Lockheed Martin Space Systems is the MUOS prime contractor and system integrator.

The Mobile User Objective System will provide netcentric use of UHF SATCOM as well as the following enabling capabilities:

- Beyond-line-of-site communication for mobile warfighters with focus on usability.
- Global communications to connect any set of users, regardless of location with the exception of polar regions.
- Improved connectivity in stressed environments including urban canyons, mountains, jungle, weather and scintillation.
- "Bandwidth on Demand" architecture that is future upgradeable with "smarts" on the ground and accessibility to Global Information Grid (GIG), Non-secure Internet Protocol Router Network (NIPRNet), Secure Internet Protocol Router Network (SIPRNet), and Defense Information Systems Network (DISN).



## ATLAS V 551 LAUNCH VEHICLE | Overview

The Atlas V 551 consists of a single Atlas V booster stage, the Centaur upper stage, five solid rocket boosters (SRB), and a 5-m diameter payload fairing (PLF).

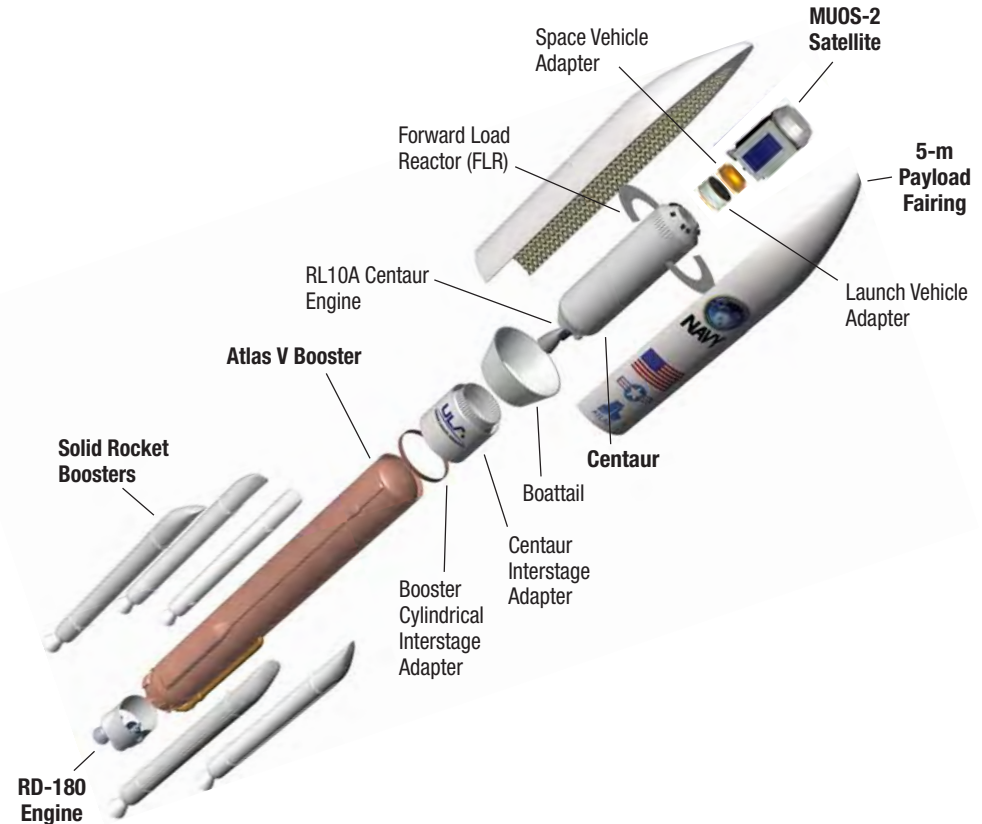
The Atlas V booster is 12.5 ft in diameter and 106.5 ft in length. The booster's tanks are structurally rigid and constructed of isogrid aluminum barrels, spun-formed aluminum domes, and intertank skirts. Atlas booster propulsion is provided by the RD-180 engine system (a single engine with two thrust 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 SRBs are approximately 61 in. in diameter, 67 ft in length, and constructed of a graphite-epoxy composite with the throttle profile designed into the propellant grain. The SRBs are jettisoned by structural thrusters following a 92-second burn.

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 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.

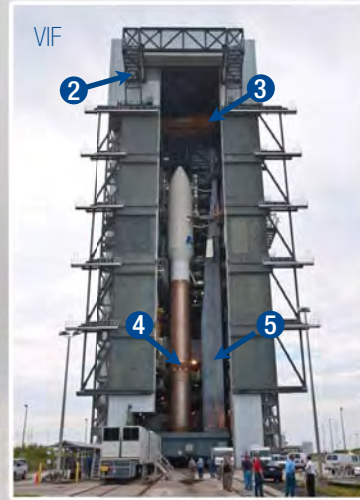
MUOS-2 is encapsulated in a 5-m diameter medium PLF. The 5-m PLF is a sandwich composite structure made with a vented aluminum-honeycomb core and graphite-epoxy face sheets. The bisector (two-piece shell) PLF encapsulates both the Centaur and the spacecraft, which separates using a debris-free pyrotechnic actuating system. Payload clearance and vehicle structural stability are enhanced by the all-aluminum forward load reactor (FLR), which centers the PLF around the Centaur upper stage and shares payload shear loading. The vehicle's height with the 5-m medium PLF is approximately 206 ft.

## ATLAS V 551 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 Centaur LO<sub>2</sub> Storage
- 7 High Pressure Gas Storage
- 8 Booster LO<sub>2</sub> Storage
- 9 Pad Equipment Building (PEB)
- 10 Pad ECS Shelter



# Atlas V MUOS-2

## ATLAS V MUOS-2 | Mission Overview

The MUOS-2 mission is based on an Atlas V 551 ascent profile to geosynchronous transfer orbit (GTO). The mission begins with ignition of the RD-180 engine at approximately 2.7 seconds prior to liftoff. The flight begins with a vertical rise of 85 feet, after which the vehicle begins its initial pitch-over phase, a roll, pitch, and yaw maneuver to achieve the desired flight azimuth. The vehicle then throttles down and begins a nominal zero pitch and zero yaw angle-of-attack phase to minimize aerodynamic loads. Following maximum dynamic pressure and SRB burnout, the RD-180 is throttled back up to 100 percent. Zero pitch and yaw angle-of-attack flight continues until closed-loop guidance takes over at approximately 110 seconds into flight.

Booster flight continues in this guidance-steered phase until propellant depletion. Payload fairing jettison occurs at approximately 192 seconds, based on thermal constraints. When the vehicle reaches 4.6 Gs the RD-180 engine is throttled to maintain this G-level. The boost phase of flight ends with Atlas/Centaur separation at a nominal time of 6.0 seconds after Booster Engine Cutoff (BECO).

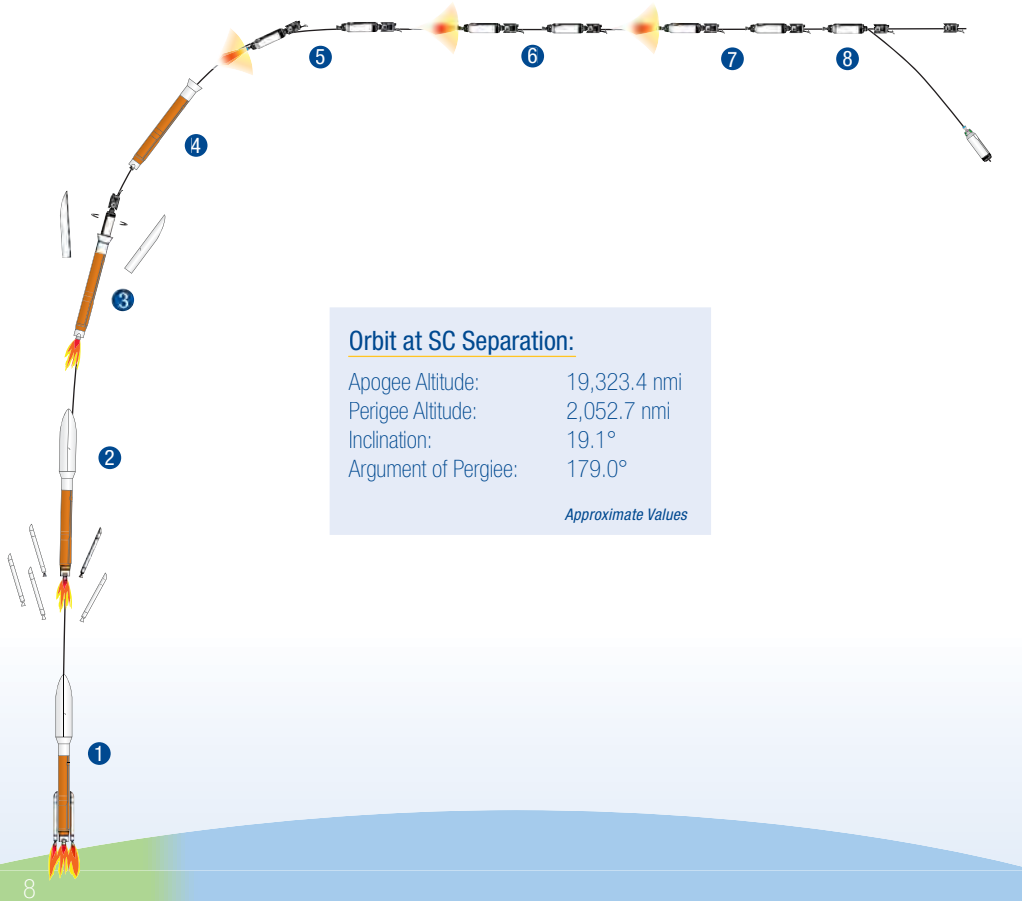
Following Atlas/Centaur separation, the Centaur main engine is started (MES-1). The 467-second Centaur first burn concludes with main engine cutoff (MECO-1), injecting the vehicle into a low-Earth parking orbit.

Following MECO-1, the Centaur and spacecraft (SC) enter an 8-minute coast period. Based on a guidance-calculated start time, the Centaur main engine is re-started (MES-2) then steered into an intermediate transfer orbit. The second Centaur burn duration is 356 seconds and concludes with main engine cutoff (MECO-2), initiated by guidance command once the targeted orbital parameters are achieved.

The Centaur and spacecraft next enter a 2.4-hour coast period. Based on a guidance-calculated start time, the Centaur main engine is re-started (MES-3) and steered into the spacecraft separation transfer orbit. The third Centaur burn duration is 59 seconds and concludes with main engine cutoff (MECO-3), initiated by guidance command once the targeted orbital parameters are achieved.

Spacecraft separation is initiated 219 seconds after MECO-3, at nearly 2 hours, 54 minutes after liftoff.

## FLIGHT PROFILE | Liftoff to Separation



## SEQUENCE OF EVENTS | Liftoff to Separation

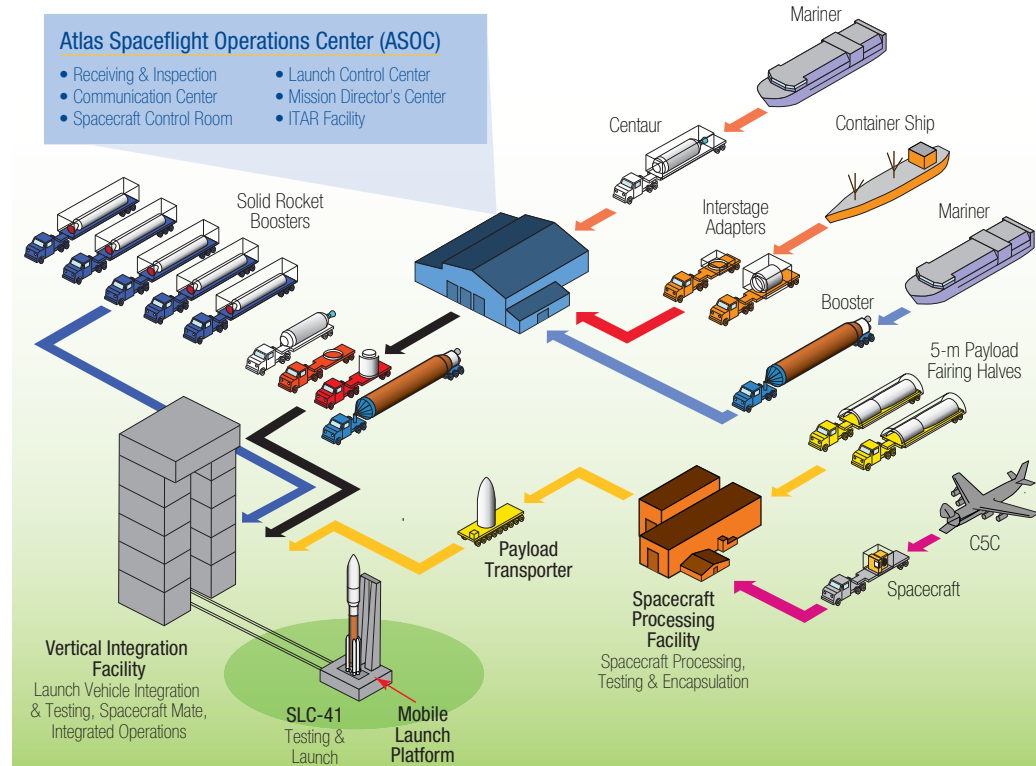
	Event	Time (seconds)	Time (hr:min:sec)
1	RD-180 Engine Ignition	-2.7	-0:00:02.7
	T=0 (Engine Ready)	0.0	0:00:00
	Liftoff (Thrust to Weight > 1)	1.1	0:00:01.1
	Begin Pitch/Yaw/Roll Maneuver	3.9	0:00:03.9
	Maximum Dynamic Pressure	44.6	0:00:44.6
2	Solid Rocket Booster 1,2 Jettison	103.3	0:01:43.3
	Solid Rocket Booster 3,4,5 Jettison	104.8	0:01:44.8
3	Payload Fairing Jettison	191.5	0:03:11.5
	Centaur Forward Load Reactor Jettison	196.5	0:03:16.5
4	Atlas Booster Engine Cutoff (BECO)	261.0	0:04:21.0
	Atlas Booster/Centaur Separation	267.0	0:04:27.0
5	Centaur First Main Engine Start (MES-1)	276.9	0:04:36.9
	Centaur First Main Engine Cutoff (MECO-1)	743.8	0:12:23.8
6	Centaur Second Main Engine Start (MES-2)	1,222.8	0:20:22.8
	Centaur Second Main Engine Cutoff (MECO-2)	1,578.5	0:26:18.5
7	Centaur Third Main Engine Start (MES-3)	10,134.6	2:48:54.6
	Centaur Third Main Engine Cutoff (MECO-3)	10,193.7	2:49:53.7
8	MUOS-2 Separation	10,412.7	2:53:32.7

# Atlas V MUOS-2

## ATLAS V PRODUCTION & LAUNCH | Overview



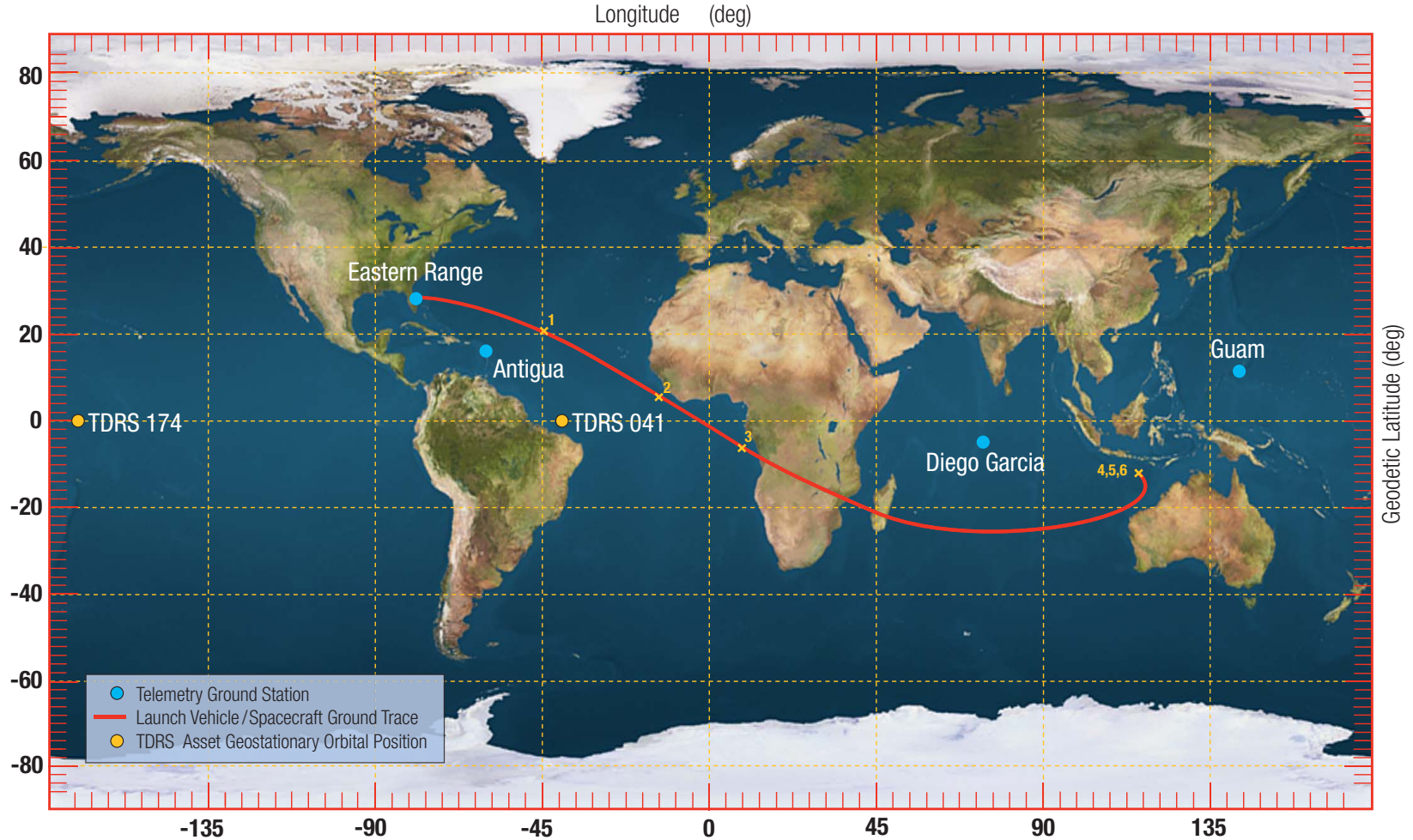
## ATLAS V PROCESSING | Cape Canaveral



# Atlas V MUOS-2



GROUND TRACE | Liftoff to Separation

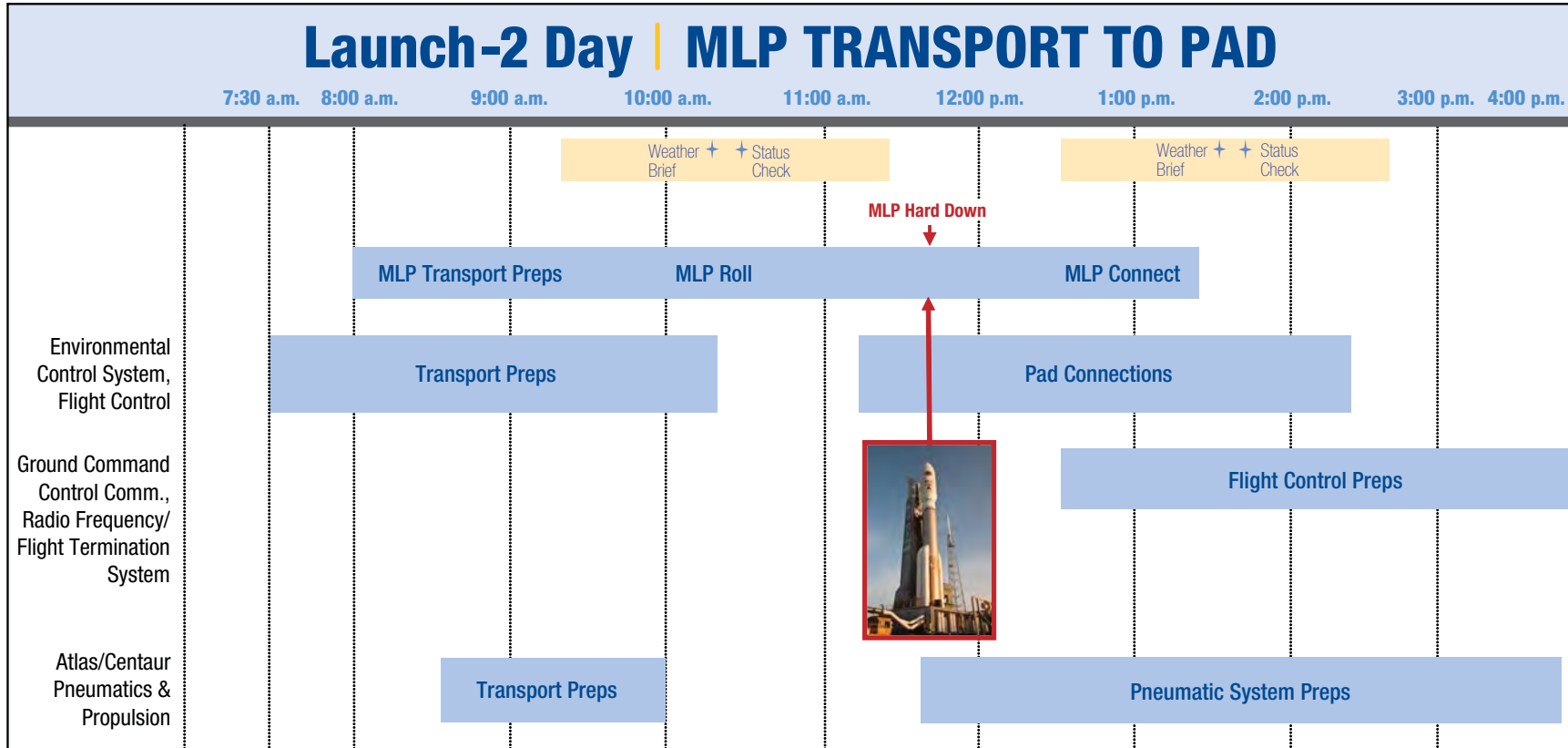


1 = MECO-1 (0:12:23.8) | 2 = MES-2 (0:20:22.8) | 3 = MECO-2 (0:26:18.5) | 4 = MES-3 (2:48:54.6) | 5 = MECO-3 (2:49:53.7) | 6 = MUOS-2 Sep (2:53:32.7)

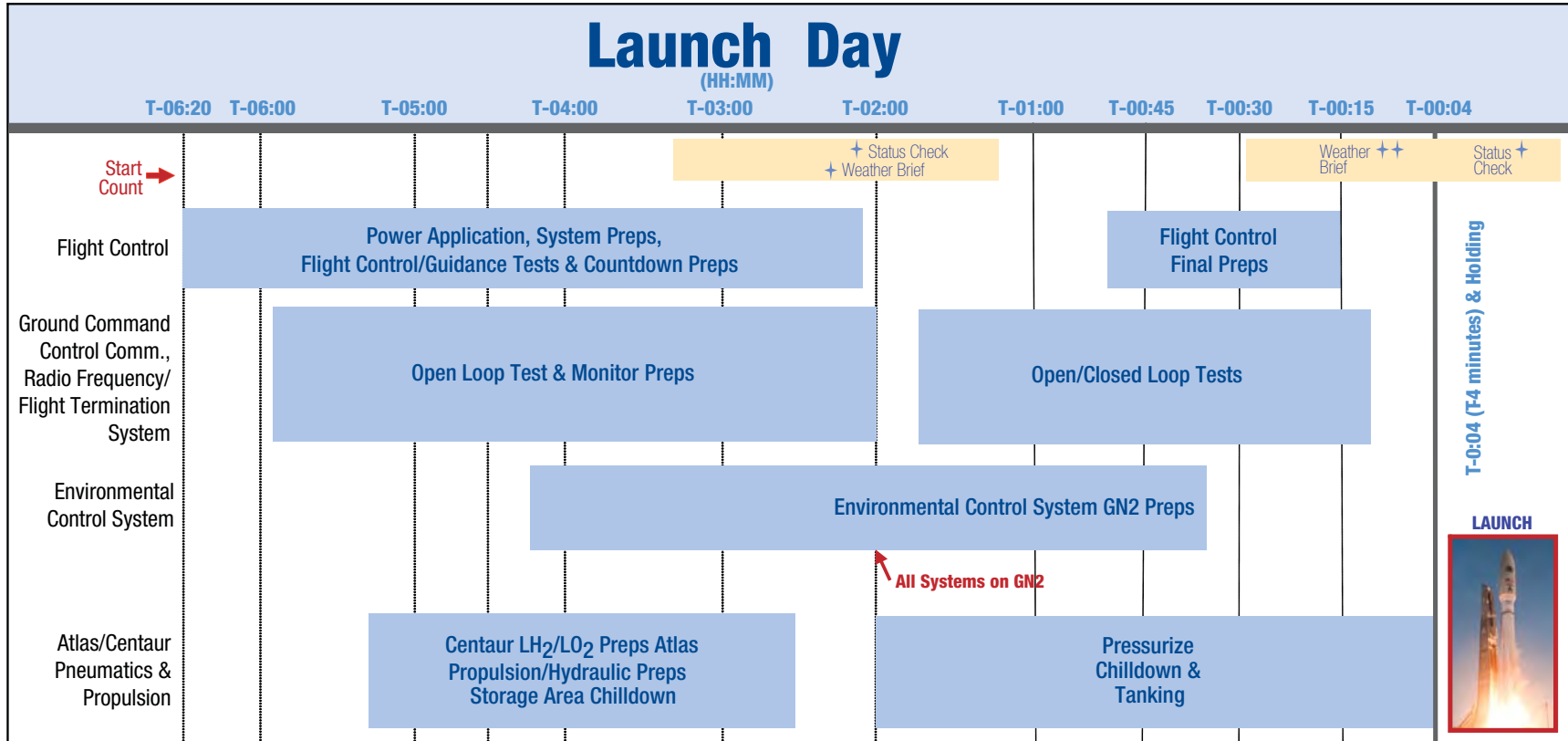
# Atlas V MUOS-2







# COUNTDOWN TIMELINE | Launch Day



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