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Partnering for Success: New and Traditional Space Collaborate on Future Launch Vehicle

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1. Technical paper

A partnership between Northrop Grumman (NG) and Firefly Aerospace that formed in 2022 to develop a new medium-class launch vehicle (MLV) is now bearing fruit, as engine testing advances and test, manufacturing, integration, and launch facilities are built new or improved. This technical paper describes how this partnership between a traditional aerospace and defense prime and an agile new space company benefits the nation by enabling greater access to space as activity increases in Low-Earth Orbit (LEO) and beyond.

2. MEDIUM LAUNCH VEHICLE

The NG/Firefly collaboration emerged after the conflict between Russia and Ukraine prevented further supply of propulsions components for the NG Antares 230+ vehicle. NG sought a new US propulsion supplier and Firefly sought an experienced partner to move into the medium-class launch segment. The companies are working together under two agreements – one for the Antares 330, which will be powered by a new Firefly liquid first stage, and another for the eventual Antares successor, the MLV – which will have a liquid first and second stage and a larger payload fairing.

The scale of this collaboration has driven both companies to make investments in their development, manufacturing, integration, and launch capabilities. Testing of the Firefly Miranda first stage engine is occurring at Firefly's Rocket Ranch in Briggs, TX, using a new multi-bay test stand. Meanwhile, a new manufacturing facility has been stood up in Briggs with an automated fiber placement machine for composites. NG is working with Virginia Space on pad and vehicle integration facility enhancements at NASA's Wallops Flight Facility.

The Antares 330 will launch Cygnus on its destination to the International Space Station (ISS) and is an interim step to the MLV – which is designed to meet the growing demand for commercial, civil and national security space launch. MLV is powered by Firefly's innovative first and second stage propulsion systems, which feature lightweight composite sandwich structures and Miranda tap-off cycle engines – seven on Stage 1 for a combined vacuum thrust of 7,162 kN, and a vacuum-optimized version on Stage 2 with a vacuum thrust of 890 kN. NG is developing the new 5 m payload fairing and is incorporating many of its flight-proven systems, such as the modular avionics and autonomous flight safety system. The baseline two-stage vehicle will put more than 16,000 kg of payload into LEO.

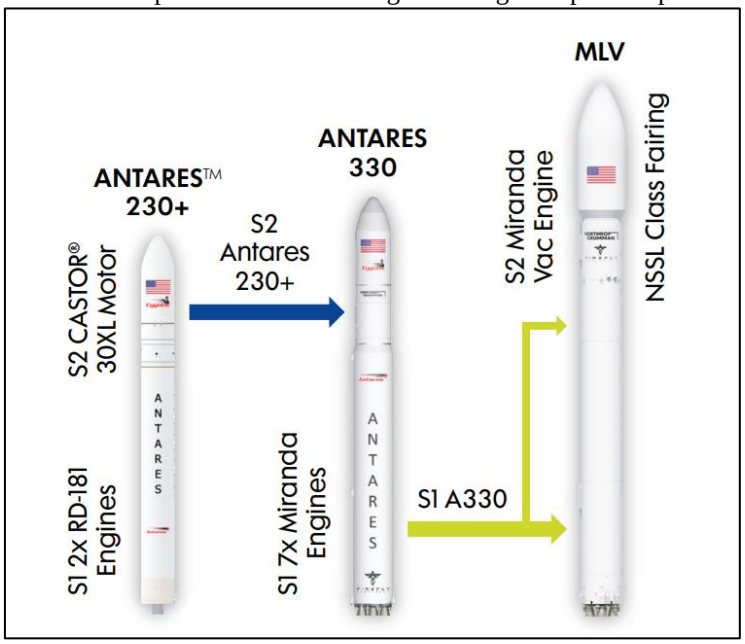

Figure 2-1. Antares to MLV Transition

	Antares 230+	Antares 330	MLV
Mass-to-Orbit CRS Cygnus LEO	8,120 kg (17,902 lb.)	10,500 kg (23,149 lb.)	16,300 kg (35,935 lb.)
Payload Fairing Outer Diameter	3.9 m (154 in.)	3.9 m (154 in.)	5.4 m (213 in.) NSSL Cat B Payload Envelope
Stage 1	2x RD-181	7x Miranda	7x Miranda
Stage 2	CASTOR 30XL	CASTOR 30XL	1x Vacuum-optimized Miranda
Stage 3 (Optional)	--	--	1x Liquid Stage
Propellant	LOx/RP-1, Solid	LOx/RP-1, Solid	LOx/RP-1
Booster Diameter	3.9 m (154 in.)	4.3 m (172 in.) 3.9 m (154 in.)	4.3 m (172 in.)

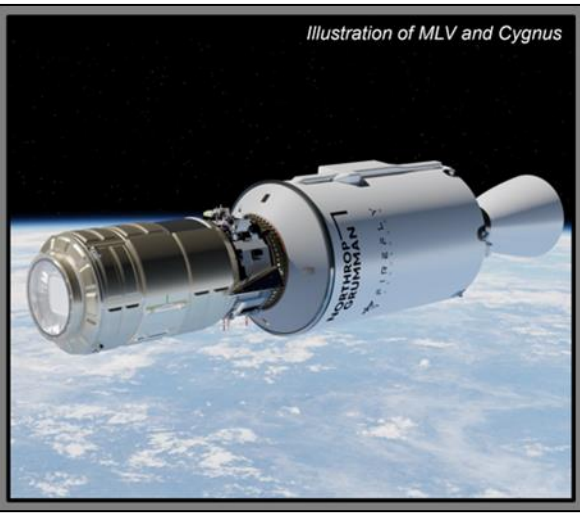

Figure 2-2. Vehicle Configuration and Performance Changes from Antares 230+ to MLV

3. LAUNCH LOCATION

MLV will initially launch from the Mid-Atlantic Regional Spaceport (MARS) Pad 0A at the NASA Wallops Flight Facility (WFF), VA, and there are plans to add a West Coast launch site for high inclination trajectories in the future. WFF is well suited for a broad range of trajectories for Earth orbit and interplanetary missions. LEO trajectories with inclinations ranging from 38-60 deg. are available from WFF, as well as GTO, TLI and other trajectories. Inclinations from 50-60 deg. may require maneuvers to avoid overflight of parts of South America and are assessed case by case.

In addition to the MARS pads, the Virginia Spaceport Authority operates the Payload Processing Facility (PPF) at WFF, providing spacecraft processing and propellant loading for both unclassified civil/commercial and classified national security payloads. The facility is conveniently located on Wallops Island, a short distance from the launch vehicle Horizontal Integration Facility (HIF) and Pad 0A. NG has an established presence and decades of experience launching from WFF. The range has supported 18 Antares missions from Pad 0A since 2013. Pad 0A is specifically designed to accommodate medium-class liquid rockets such as the Antares and will undergo further enhancements for the larger and more powerful Antares 330 and MLV launch vehicles.

Figure 3-1. MLV Will Operation from Established Facilities on Wallops Island, VA

4. PERFORMANCE

Performance information for a baseline expendable two-stage MLV from the WFF is provided below. Customer-specific performance analysis would be done on a case-by-case basis. MLV's future roadmap includes first stage reusability to provide economies of scale and an optional liquid third stage to reach higher energy destinations.

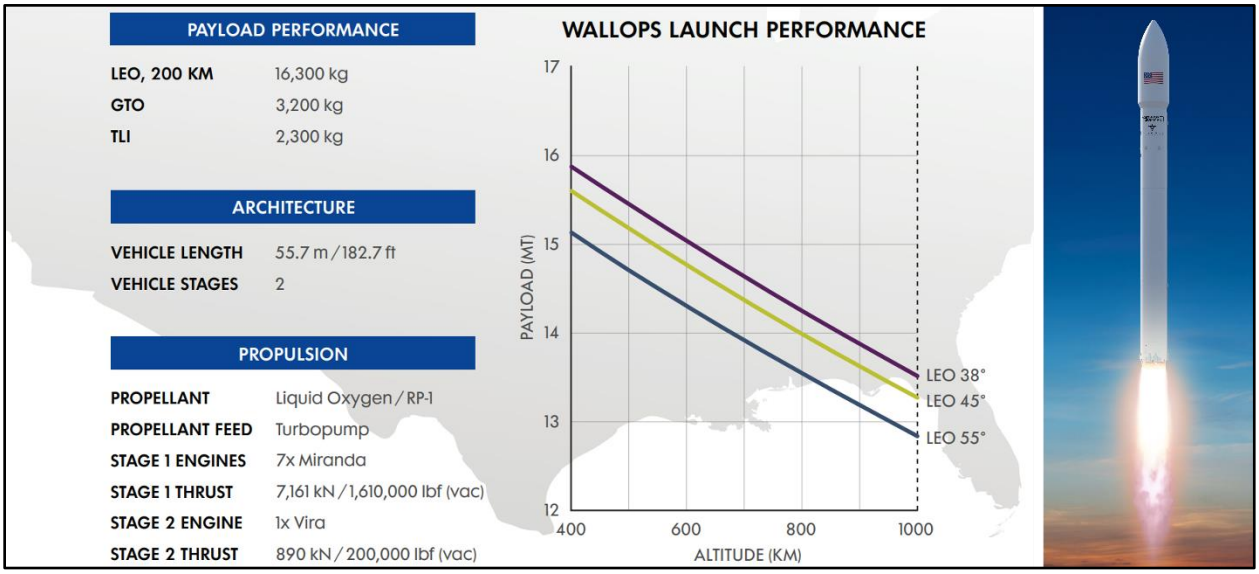

Figure 4-1. MLV Performance – One and Two Burns to LEO from WFF

5. PAYLOAD INTERFACES

MLV supports multiple Payload Attach Fitting configurations from the standard 1,575 mm and 2,624 mm bolted interfaces up 4,000 mm. MLV supports the deployment of multiple payloads per mission. The restart capability on the MLV liquid propellant second stage provides the ability to deploy payloads into multiple orbits within performance limitations. MLV can support a wide range of dispenser and separation system options, and our modular avionics architecture can scale to provide varying electrical interfaces.

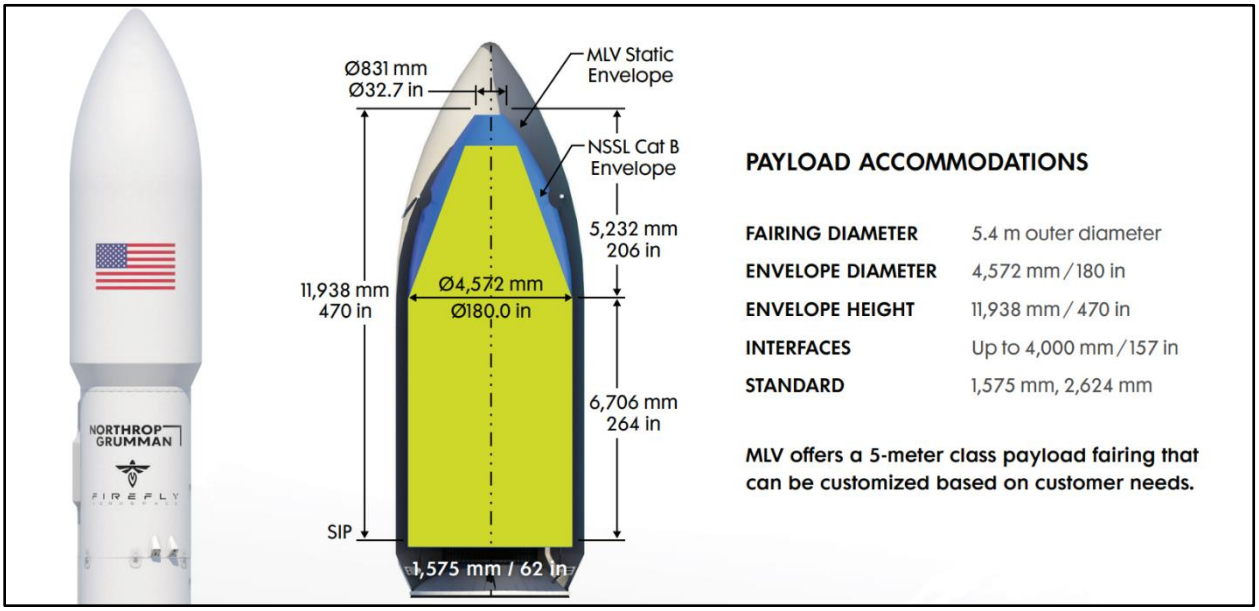

Figure 5-1 MLV Provides a Standard U.S. Category B Payload Envelope

6. LEO SPACE STATION LOGISTICS

As shown in the performance charts, MLV provides significant performance to LEO for single and multiple payload customers on an economical medium-class vehicle. MLV also provides both the International Space Station community and the future commercial space station providers with a significant increase in both performance and payload envelope compared to the legacy Antares that Cygnus and other cargo resupply transports can take advantage of. For instance, the Pressurized Cargo Module on the Cygnus can be expanded both in length, as is planned for future NASA missions, and in diameter up to the 180 in. static envelope. MLV's performance to a typical ISS transfer orbit is provided in the table below.

The figure below shows a reference mission profile to a transfer orbit in LEO typical of a Commercial Resupply Services (CRS) mission to the ISS from WFF. It is performed with a single burn of the MLV Stage 2 to LEO, followed by the cargo spacecraft separation. The launch vehicle mission concludes with a C/CAM and separation coast, followed by a reorientation and disposal burn at a predetermined time to ensure safe atmospheric reentry. The mass-to-orbit capability for this mission is approximately 16,000 kg.

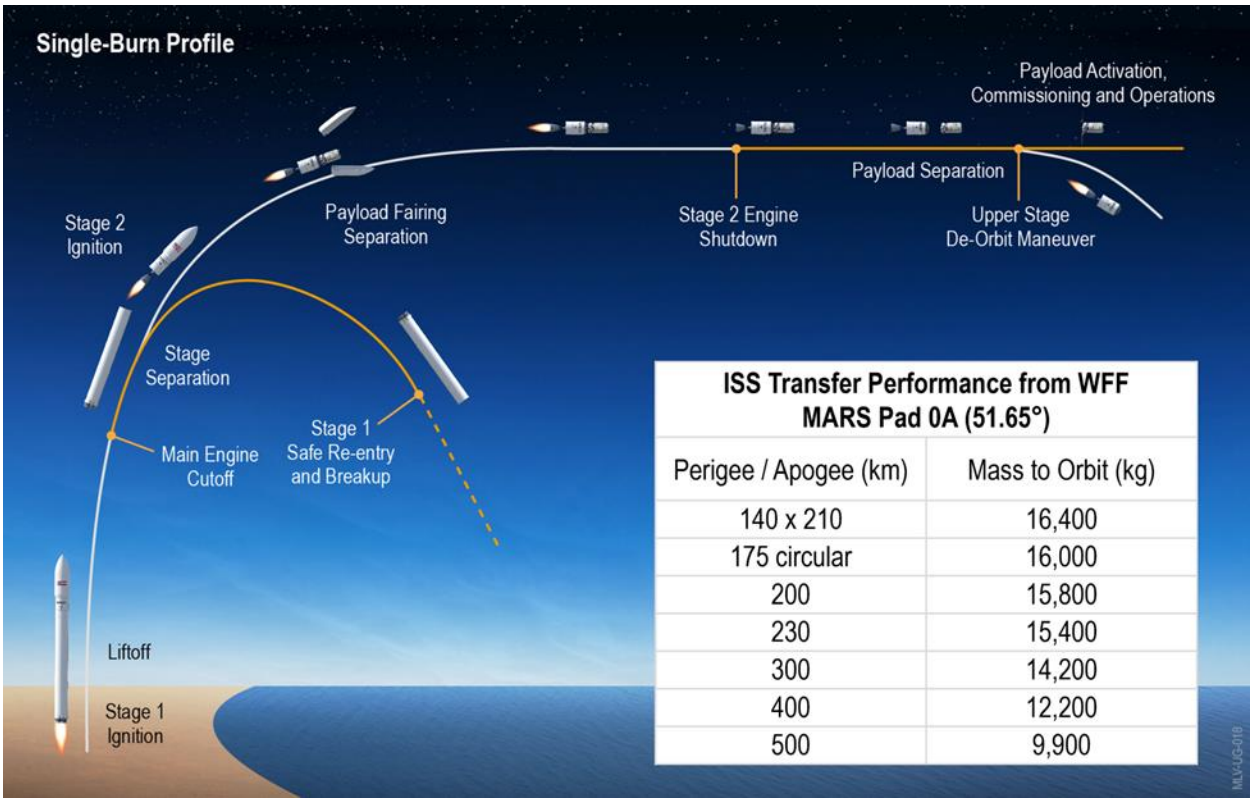

Figure 4-1. MLV Performance to ISS Transfer Orbits

7. CONCLUSION

The companies are leveraging their experiences from the Firefly Alpha and NG Antares, Minotaur and Pegasus programs to take MLV to the next level. The outcome will be a powerful, dependable, and affordable launch vehicle to provide greater access to space.

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