Engineering America's Current and Future Space Transportation Systems: 50 Years of Systems Engineering Innovation for Sustainable Exploration

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Abstract

Over the past 50 years, the National Aeronautics and Space Administration (NASA) has delivered space transportation solutions for America's complex missions, ranging from scientific payloads that expand knowledge, such as the Hubble Space Telescope, to astronauts and lunar rovers destined for voyages to the Moon. Currently, the venerable Space Shuttle, which has been in service since 1981, provides the United States' (U.S.) capability for both crew and heavy cargo to low-Earth orbit to construct the International Space Station, before the Shuttle is retired in 2010. In the next decade, NASA will replace this system with a duo of launch vehicles: the Ares I Crew Launch Vehicle and the Ares V Cargo Launch Vehicle (Figure 1). The goals for this new system include increased safety and reliability coupled with lower operations costs that promote sustainable space exploration for decades to come. The Ares I will loft the Orion Crew Exploration Vehicle, while the heavy-lift Ares V will carry the Altair Lunar Lander and the equipment and supplies needed to construct a lunar outpost for a new generation of human and robotic space pioneers.

Figure 1. Concept of the Ares I (right) and Ares V launch vehicles.

NASA's Marshall Space Flight Center manages the Shuttle's propulsion elements and is managing the design and development of the Ares rockets, along with a host of other engineering assignments in the fields of science and exploration. Specifically, the Marshall Center's Engineering Directorate houses the skilled workforce and unique facilities needed to build capable systems upon the foundation laid by the Mercury, Gemini, Apollo, and Shuttle programs. The current approach is similar to the Apollo Saturn V launch vehicle model, with some design work and structural testing being performed in house, while industry partners build and operate the transportation systems.

This paper will provide details of the in-house systems engineering and vehicle integration work now being performed for the Ares I and planned for the Ares V. It will give an overview of the Ares I system-level test activities, such as the ground vibration testing that will be conducted in the Marshall Center's Dynamic Test Stand to verify the integrated vehicle stack's structural integrity and to validate computer modeling and simulation (Figure 2), as well as the main propulsion test article analysis to be conducted in the Static Test Stand. These activities also will help prove and refine mission concepts of operation, while supporting the spectrum of design and development work being performed by Marshall's Engineering Directorate, ranging from launch vehicles and lunar rovers to scientific spacecraft and associated experiments. Ultimately, fielding a robust space transportation solution that will carry international explorers and essential payloads will pave the way for a new century of scientific discovery beyond planet Earth.

Figure 2. The Space Shuttle was structurally tested in the Marshall Center's Dynamic Test Stand, which will be used for the Ares I integrated stack testing.