National Aeronautics and Space Administration

Structural Testing

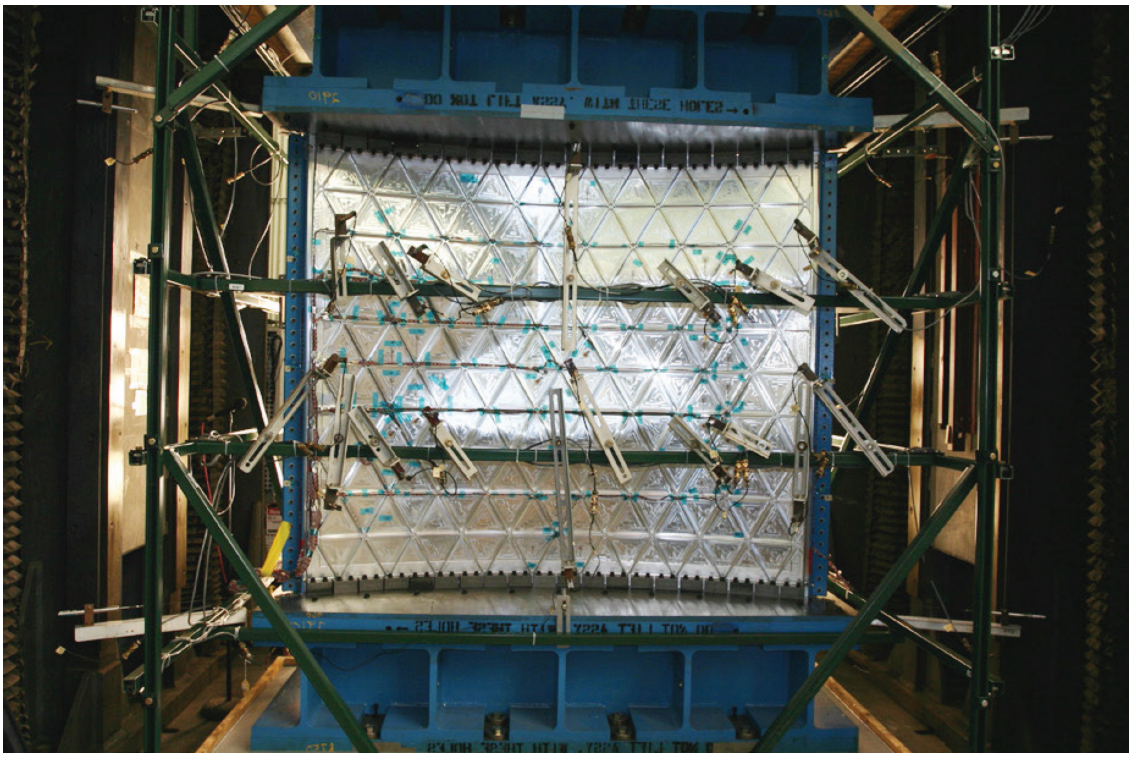
Unique Expertise in Large-Scale Structures

Safe and affordable development of new launch vehicle structures requires maximizing the return spent on ground testing. Marshall engineers have unique experience with design of tests for lift-class large structures and have deep engineering disciplinary reach-back capability to provide data acquisition, rigorous analysis, and interpretation of test results.

Marshall's structural testing capabilities have been critical to many Agency programs, including Saturn, Skylab, Space Shuttle, and the International Space Station, as well as numerous technology development projects. These capabilities include testing structures for launch vehicles and spacecraft of all sizes, in-space structures, and associated support hardware through experimental, developmental, or operational life-cycle phases. Marshall's structural testing capabilities continue to serve a vital role in support of the Space Launch System (SLS) core stage, LOX tank, LH tank, intertank, forward skirt, and engine stage, and technology developments to make future missions safer and more affordable.

At-A-Glance

Large-scale structural testing is a foundational capability for many future exploration goals. NASA's Marshall Space Flight Center provides unique test facilities and decades of experience in the testing of structural systems for launch vehicles and other space systems, including design of custom instrumentation and test programs for structural elements.



Marshall's capabilities include structural stress testing of full-scale launch vehicle hardware, as well as subscale components like this isogrid structural panel.

Comprehensive Facilities for Any Test Program

At all phases of design, development, test, and operations, projects need the ability to simulate conditions where the hardware operates. Short of actual flight, this can only be accomplished with custom-built test articles using a range of facilities that produce specific conditions. Engineers can then integrate the results of such tests into a more comprehensive understanding of what should happen, or did happen, from start to finish. Marshall has executed test programs like this for vehicles including Saturn, space shuttle, and SLS, as well as space systems including Skylab, Spacelab, and ISS.

Marshall houses a comprehensive set of structural testing facilities, as well as cross-cutting environmental testing facilities. In order to develop both test articles and custom-designed test fixtures and adapters, the Center also has a full range of engineering support capabilities, including machine shops, test support and logistics services to supply consumables and instrumentation, and test planning support for budget analysis and risk management of test programs.

Thrust structures, propellant tanks, and other components require equally demanding and precise testing, often to destruction, to ensure adequate safety margins for flight vehicles while minimizing the mass of those structures. Marshall facilities can apply millions of pounds of mechanical loads in compression, tension, and laterally, and apply environmental profiles such as heat, cold, vacuum, and humidity to test articles. Multiple facilities, high bays, and reaction floors provide proof, limit, failure, development, qualification, or flight acceptance levels and environments of testing. Notable facilities in support of structural testing include:

- The Cryostructural Test Facility, which evaluates the structural integrity of tanks and other propulsion components under compression, sheer, and tension loads
- The TS 300 Environmental Test Facility, which simulates ascent launch profiles and deep space vacuum for cryogenic fluid management
- Marshall's Large Structural Test Facilities, which can accommodate test articles up to 33 feet in diameter and apply 30 million pounds of strain vertically and 2.4 million pounds laterally, and also accommodates cryogenic temperatures, heating, and acoustics

In addition to the facilities for performing structural tests, Marshall has decades of experience with developing instrumentation for structural test articles to maximize data return. High-speed data acquisition, visible and thermal imaging at more than 18,000 frames per second, and high-definition audiovisual capture systems allow test engineers to instrument a test article in order to provide exactly the data that designers need to evaluate and characterize the systems, whether early proof-of-concept articles or flight-like structural systems.

Developing Test Programs for Structures

Marshall's test expertise extends beyond individual tests conducted on components, subsystems, propulsion systems, or structures. The Center's structural and propulsion testing team is capable of designing comprehensive test programs to take projects and programs from the early subscale component tests through full-scale testing.

Collaborating with customers to develop a test regime of appropriate complexity and rigor for each project, the Center provides a consistent and methodical approach to test programs that drives down technical risk by moving developmental hardware through a series of tests, testing individual components before integrating them into subsystems, testing those subsystems, and proceeding to final hardware configurations. Decades of experience in this kind of testing enable Marshall to execute this thorough testing rapidly, using the range of configurable facilities on site.

Shell Buckling

As part of any launch vehicle design process, structural test articles are frequently assessed to determine how to obtain the required structural strength with the lowest possible mass. The Shell Buckling Knockdown Factor test project is examining the safety margins needed in the design of future large launch vehicle structures. Research to date suggests a potential weight savings of as much as 20 percent. As this test program continues, the results will be used to develop and validate structural analysis models and generate new shell buckling knockdown factors — complex engineering design standards essential to launch vehicle design.

In order to ensure the performance of core stage and upper stage structures, the test team receives completed barrel sections, assembled on site using Marshall's large-scale manufacturing capabilities, and tests these barrel sections to failure using compression. To date, numerous subscale articles, a variety of orthogrid structural patterns, have been tested to optimize the structural design and minimize mass. In addition, full-scale "can crusher" tests have occurred to test full-scale structural barrels and verify that they can meet the extreme requirements of a launch vehicle ascent.

A shell buckling test article helps vehicle designers optimize mass and meet structural requirements.

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NP-2016-06-65-MSFC
G-156057