National Aeronautics and Space Administration

Propulsion Testing

Testing Affordably and Accurately at Any Life-cycle Phase

Affordable development of new propulsion capabilities places a premium on maximizing the return spent on critical ground tests. Tests must yield high-quality results both in data and subsequent analysis, fit into aggressive development schedules, and allow developers to minimize costly test-fail-fix cycles. Marshall engineers have unique experience with rapid design of tests, work closely with customers to customize and design right-sized tests, and have deep engineering disciplinary reach-back capability to provide rigorous analysis and interpretation of test results.

Marshall's broad capabilities in propulsion testing have been critical to all of the Agency's launch vehicle programs, as well as numerous technology development projects. These capabilities include testing of liquid or solid propulsion systems and associated support hardware through experimental, developmental, or operational life-cycle phases. Marshall's propulsion testing capabilities continue to serve a vital role in support of the Space Launch System (SLS), Orion crew vehicle, NASA's commercial crew and cargo programs, and technology developments to make future missions safer and more affordable.

At-A-Glance

Launch vehicle propulsion system development, constrained by limited government budgets or cost-sensitive commercial pressures, requires the right test in the right amount of time. NASA's Marshall Space Flight Center maintains unique national test facilities and deep experience in the discipline of test engineering to support development efforts through customized test programs.

Early component testing of propulsion systems reduces technical and programmatic risk.

Liquid Propulsion Technology and Development

Marshall's test expertise extends beyond individual tests conducted on components, subsystems, or propulsion systems. The Center's 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 of flight-like hardware.

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.

Marshall has collaborated with Stennis Space Center and Aerojet Rocketdyne in developing a test program to update the RS-25 for use in the Space Launch System. Throughout 2015, a series of engine tests were conducted to collect engine performance data, including a long-duration burn at 109 percent of the engine's rated power. This will assist designers in adapting the former space shuttle engines to the new SLS mission requirements, including developing new nozzle insulation, engine controllers, and software.

Flight engine testing begins in 2016 with engine no. 2059, installed in late 2015 to the A-1 Test Stand at Stennis. The full core stage will also be tested at Stennis by installing the full flight stage on the B-2 Test Stand and firing its four RS-25 engines simultaneously, just as during an actual launch. The test program will put all the engines through the rigorous temperature and pressure conditions they will experience during an SLS mission.

The RS-25 test program is designed to provide needed data for SLS mission design in the most cost-efficient manner possible.

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 complete vehicles including Saturn and space shuttle, industry partnerships such as the RD-180, and technology development efforts such as FASTRAC.

Marshall houses a comprehensive set of testing facilities for propulsion systems. In order to develop both test articles and custom-designed test fixtures and adapters, the Center also has a full range of supporting 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.

Propulsion testing facilities at Marshall enable testing of components, subsystems, subscale motors, and full-scale engines under a variety of configurations and conditions. The test engineers in this area have supported many prior NASA programs and continue to support development of the SLS propulsion systems design. Some notable facilities in support of this testing capability include:

- Test Stands 115, 116, 500, and multiple smaller test cells, which provide the ability to test injectors, preburners, turbopumps, combustion chambers, igniters, seals, bearings, valves, engine subsystems, small solids, and vehicle acoustic modeling with minimal facility modification
- The Hydrogen Cold Flow Facility, which provides safe, inexpensive, low-pressure flow tests of hydrogen engine and subsystem components
- The Hot Gas Test Facility, which generates flow speeds up to Mach 4 and high heating rates to test materials and coatings. The Hyperthermal Test Facility can test smaller samples to much higher heating rates, including environmentally safer solid motor liner materials.
- The Solid Propulsion Test Facility, which simulates solid rocket motor combustion environments, and can test fire solids vertically or horizontally
- The Advanced Engine Test Facility, which is a two-position, tri-propellant stand capable of evaluating full-scale engine and vehicle stage systems

In addition to the extensive facilities for performing propulsion tests, Marshall has decades of experience with developing instrumentation for propulsion test articles to create maximum 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 customer's test article with all the necessary systems to provide exactly the data that the designers need to evaluate and characterize their systems, whether early proof-of-concept articles or flight-qualification of integrated systems.

Test stands such as TS500 can be quickly configured to test an array of propulsion components.

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