National Aeronautics and Space Administration

Marshall Space Flight Center

Hypersonics Research, Development, and Test

Propelling Innovation Beyond Conventional Limits

Why NASA Marshall?

NASA has been involved with hypersonic work since the 1950s. A significant understanding of hypersonic flight phenomena was obtained from highly successful programs and manned orbital flights of the Mercury, Gemini, Apollo, and space shuttle programs. Marshall has National Asset test and analysis capabilities to build on historical knowledge and support hypersonic work at other collaborative NASA Centers, industry, academia, and other government agencies (OGAs), with the ability to handle sensitive and classified material.

Test Better

Put components and systems to the test at facilities capable to push them to the environmental limits. Testing early and often reduces risk and yields more reliable solutions during operations.

Hot Gas Facility

A very flexible, combustion-driven, Mach 4 16-in × 16-in × 46-in (L) wind tunnel offers the ability to combine radiant heating and a lean combustion mix of hydrogen and missile-grade/high-purity air.

Aerodynamic Research Facility

A 14-in × 14-in tri-sonic wind tunnel uniquely provides full Mach range (Mach 0.3 – 6.0) for launch ascent in a cost- and schedule-efficient facility. Nearby additive manufacturing/rapid prototyping/structured light-scanning facilities provide opportunities to perform design parametric testing.

Hyper-thermal Test Facility/Arc Jet

A high-powered gas discharge device produces a steady, high-enthalpy flow used for thermal and ablative characterization of TPS materials. Model sizes range from 0.35-in to 4-in diameter to 1 × 3-in to 3 × 3-in plates. Test configurations include stagnation, wedge, and flat plate. Gas velocities range from subsonic to Mach 4.2.

Plasma Torch Test Facility

The Plasma Torch Test Facility enables testing of materials-argon-nitrogen (or argon-helium) plasma with or without ablative powder (typically metal oxides) as well as portable samples larger than approximately 1 in.

Impact Test Facility Hydrometer (Rain) Impact Gun

Offerings include all-weather testing with hydrometeor impact gun-velocity up to 4,000 ft/s, 2mm – 4mm projectile-water drops, and high-speed digital video.

Combined Effects Particle Impact Test Facility

A two-stage light gas gun provides sample heating up to 2000°C with a target chamber of 20-in diameter by 25-in long. Heated samples are limited to 2-in diameter. Velocity ranges from 2,000 ft/s to 10,000 ft/s (Mach 21).

Micro-Ballistic Powder Gun

A micro-ballistic powder gun offers velocity of 1,500 ft/s to 6,000 ft/s, 2-mm – 4 mm projectile spheres, and high-speed video.

Design and Build Better

Partners can work side-by-side with leading NASA materials scientists to develop, test, and employ new materials needed to succeed in extreme operating environments.

Metal Processing Laboratory

The Metal Processing Laboratory unlocks advanced high-temperature testing solutions with oxygen and inert gas exposure; precise carbon and oxygen analysis; high-temperature DTA, DSC, and TGA in oxygen environments; and reliable results to optimize materials and processes.

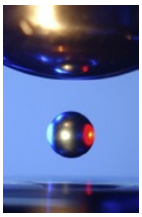
Metal Processing and Manufacturing

Government employees, contractors, and partners can discover cutting-edge manufacturing with 3D printing of refractory metals and alloys; expert welding; hot isostatic pressing; and spark plasma/direct current sintering. Maximize performance provides refractory metal feedstock powder spheroidization and graphite furnace capabilities up to 3000° C. Advanced solutions are designed to enhance precision, efficiency, and material optimization for individual applications.

High-temperature Emissivity Measurement System

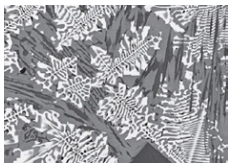
This measurement system delivers precise thermo-optical properties measurement with versatile sample sizes (9.5 mm × 9.5 mm (0.375 in × 0.375 in)) and stationary samples (1.0 mm to 3.0 mm (0.4 in to 1.2 in)) for levitated samples. The system is ideal for advanced material analysis to enhance performance and efficiency.

Electrostatic Levitation Laboratory



The Electrostatic Levitation Laboratory offers tailored solutions for superior precision and efficiency in processes with a full suite of advanced tools: pyrometer, infrared (IR) camera, ultra high-speed cameras, oxygen partial pressure control system, rapid quenching system, and precision magnetic rotation spin control (30,000+ Hz).

Metallurgy and Failure Analysis Laboratory



This laboratory enhances performance with expert sample prep, microscopy, and advanced analysis (EDS, WDS, XRD, EBSD, SIMS, ESCA, AES, AFM), offering comprehensive metallic materials analysis, engineering development, and materials processing solutions tailored to enhance research and manufacturing outcomes.

Composites

The Composites Manufacturing Facility enables the complete product development of large, and sometimes complex, composite structures. It is also well-connected to other areas that can design, test, and evaluate hardware performance.

Advanced Manufacturing Digital Solutions—Structured Light

The Structured Light Scanning Lab offers reverse-engineering, digital assemblies, match machining and manufacturing/ process development, and data capture/3D digital environment.

Damage Tolerance

Marshall provides the evaluation of a structure to perform reliably throughout its service life in the presence of a defect, crack, or other forms of damage. Offerings also include specialized fracture analysis for short-life, high-stress components commonly found in launch vehicle applications.

Non-Destructive Evaluation

Standard and special non-destructive evaluation (NDE) methods include ultrasonic, magnetic-particle, liquid penetrant, radiographic, eddy-current, thermographic, x-ray computed tomographic, shearographic, acoustic emission, microwave, and terahertz testing.

Fly Better

Users can improve the control, accuracy, and health of systems through high-fidelity simulations and analysis.

Aerodynamic Heating CFD

Aerodynamic heating CFD is used for launch vehicles during high-supersonic/lower-hypersonic regime, aero-spacecraft re-entry, stage re-entry in the high-supersonic/lower-hypersonic regime in 14 -in TWT that goes up to Mach 6.

Propulsion Fluid Dynamics Analysis

Marshall offers computational fluid dynamics, modeling, and analysis.

Propulsion Structural Analysis

Propulsion structural analysis includes structural modeling of heated composite materials (CCP, SCP, CC-SiC, etc.); design consultation (material selection, composite wrap angle designs), structural response (fracture, buckling), and failure investigations.

Propulsion Thermal Analysis

Propulsion thermal analysis includes thermal modeling of heated composite materials (CCP, SCP, CC-SiC, etc.); design consultation (material selection, composite wrap angle designs), predictive modeling (spalling, char predictions, heat-affected depths). Skills apply to internal flow for nozzle designs or external flow for thermal protection.

Propulsion Lab Work and Testing

Propulsion lab work and testing includes inert and hybrid propellant mix and cast capability, mechanical testing of propellant samples, subscale motor testing, TVC, and METCO.

Pyrotechnics and Separation Systems

These systems include explosive and pyrotechnic system design, research and development, testing, application, failure, and hazard analysis.

Systems Integration

System integration covers expertise developing strategies to integrate products and interfaces into a functional system, as well as validation and verification activities to ensure the final product meet the needs of the project:

- RF/optical sensor developments sensors
- Composite structural sensors
- Optical materials (substructure and coatings) to go along with sensor systems
- Thermal ablative materials — relation to additive manufacturing
- Interpretation of test data (comprehensive analysis based on customer requirements)

National Aeronautics and Space Administration

Marshall Space Flight Center
Huntsville, AL 35812
www.nasa.gov/center/marshall

www.nasa.gov/

Doing Business With MSFC

MSFC-02-2025-G-657270 (02)