National Aeronautics and Space Administration

Marshall Space Flight Center

Propulsion Systems Department

Engineering Solutions for Space Science and Exploration

Introduction

Marshall established and has maintained NASA's leadership position in space propulsion for more than five decades. These contributions enable the exploration and development of space while dramatically increasing program and mission safety and reliability and reducing overall cost.

Since the beginning of America's space program, Marshall's managers and engineers have designed, developed, integrated, and sustained propulsion systems for a range of applications.

- Apollo Program: F-1 engines from testing to flight and J-2 engines from concept development to flight
- Inertial Upper Stage (IUS): placed in orbit several science missions including Magellan, Galileo, Ulysses, and Chandra, as well as several Department of Defense (DOD) missions.
- Space Transportation Program (Shuttle): external tank, space shuttle main engine, and reusable solid rocket boosters
- Constellation Program: design, development, and testing of the Ares I-X; Orion Launch Abort System; J-2X upper stage engine; 5-segment solid rocket boosters; and upper stage main propulsion system, reaction control system, and small solids.
- Space Launch System (SLS): propulsion system design, development, and testing as well as system integration and operation.
- FATRAC Engine System: Marshall developed new propulsion technologies for the FASTRAC engine system in three years becoming the foundation for the SpaceX Merlin engine. FASTRAC technology development provided early development for the hydrogen-fueled RS-83 and the hydrocarbon-fueled RS-84 engines.
- Advanced Manufacturing (AM) Demonstrator Engine (AMDE) Project: AMDE project matured the TRL of AM liquid rocket engine components for use in upper stage engines successfully demonstrating significant reduction in cost, lead time, and complexity of hardware fabrication.
- Advanced Component Technology Development Programs: Exploring alternative AM technology approaches to address conventional AM processes to produce large scale hardware for example, alternative AM processes, alloy development, expand available material database through NASA programs, industry collaboration and academic engagement. Focusing on developing processes and suppliers for government and commercial space industry.

Capabilities Assisting Industry Through Partnerships and Space Act Agreements (SAA)

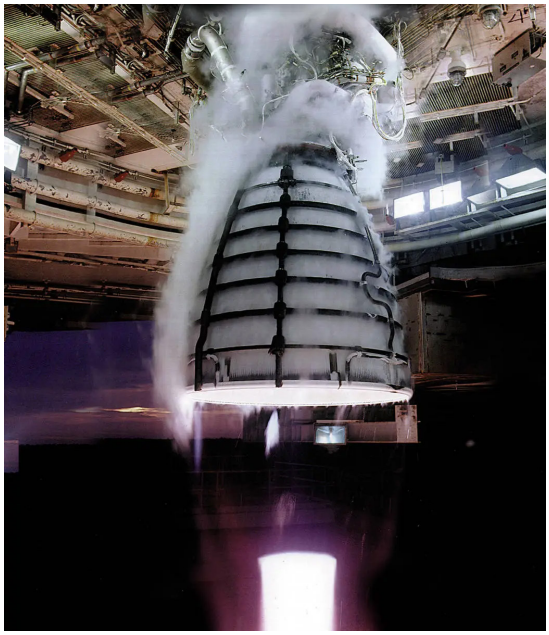
Marshall maintains a wealth of experience — from concept to operation — for propulsion systems ranging from traditional chemical boost to advanced-in-space propulsion systems including chemical, nuclear, support technologies such as alternate fuels and advanced manufacturing and materials.

For both Earth-to-orbit and in-space applications, Marshall's propulsion research, systems engineering, and testing capabilities support current and future missions unique to the nation's civil space program. The Marshall Partnerships Office connects partners with NASA capabilities and resources. Companies, academic institutions, state, and other federal agencies can use NASA resources to support their needs and initiatives that align with NASA's mission.

The Propulsion Systems Department Consists of Three Divisions:

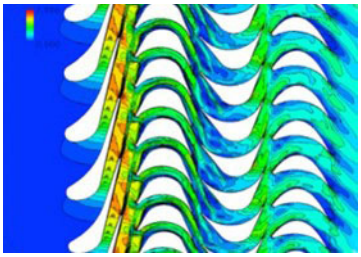
- **Liquid Systems and Integration Division**
  - Spacecraft and Integrated Vehicle Liquid Propulsion Systems Design and Technology Development for Advanced Chemical (including non-toxic) Propulsion and Long-Duration In-Space Cryogenic Propellant Storage and Transfer Systems for Chemical and Nuclear Propulsion Stages
  - Engine Systems

- Turbomachinery and Combustion Devices Design, Analysis and Advanced Development
- Valve, Actuator, and Duct Design, Analysis, & Testing



RS25 Engine Hotfire Test.

- **Propulsion Structural, Thermal, & Fluids Analysis Division**
  - Strength & Life Assessment
  - Dynamic Loads & Data Analysis
  - Flow Testing & Analysis
  - Computational Fluid Dynamics (CFD)
  - Unsteady Fluid Dynamics
  - Thermal Analysis & Design
  - Detailed Design



CFD Analysis of Two Stage Turbine.

- **Solid Systems, Thrust Vector Control, and Advanced Propulsion Division**
  - Solid Propulsion Systems Development and Integration
  - Solid Motor Design and Analysis
  - Separation & Maneuvering Solid Propulsion Systems Design & Development
  - Pyrotechnic Systems
  - Thrust Vector Control Systems, Components and Test
  - Propulsion Research & Technology including Systems Engineering/Testing for Cryogenic Fluid Management and Nuclear Thermal Propulsion as well as Development/Testing for Green Propellant and Advanced High-Power Propulsion

Five Segment Solid Motor Hot Fire Test.

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Doing Business With MSFC