National Aeronautics and Space Administration

Marshall Space Flight Center

Core Capabilities and Services

Propulsion Systems

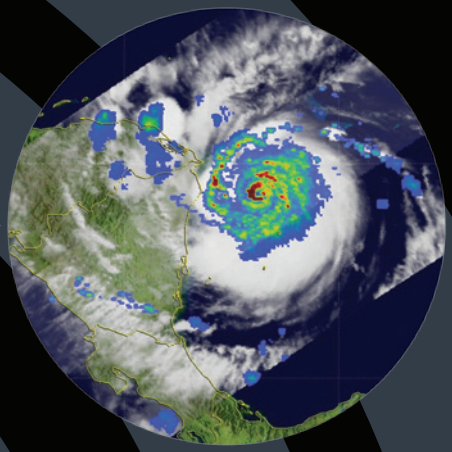
Space Transportation/
Launch Vehicles

Space Systems

Scientific Research

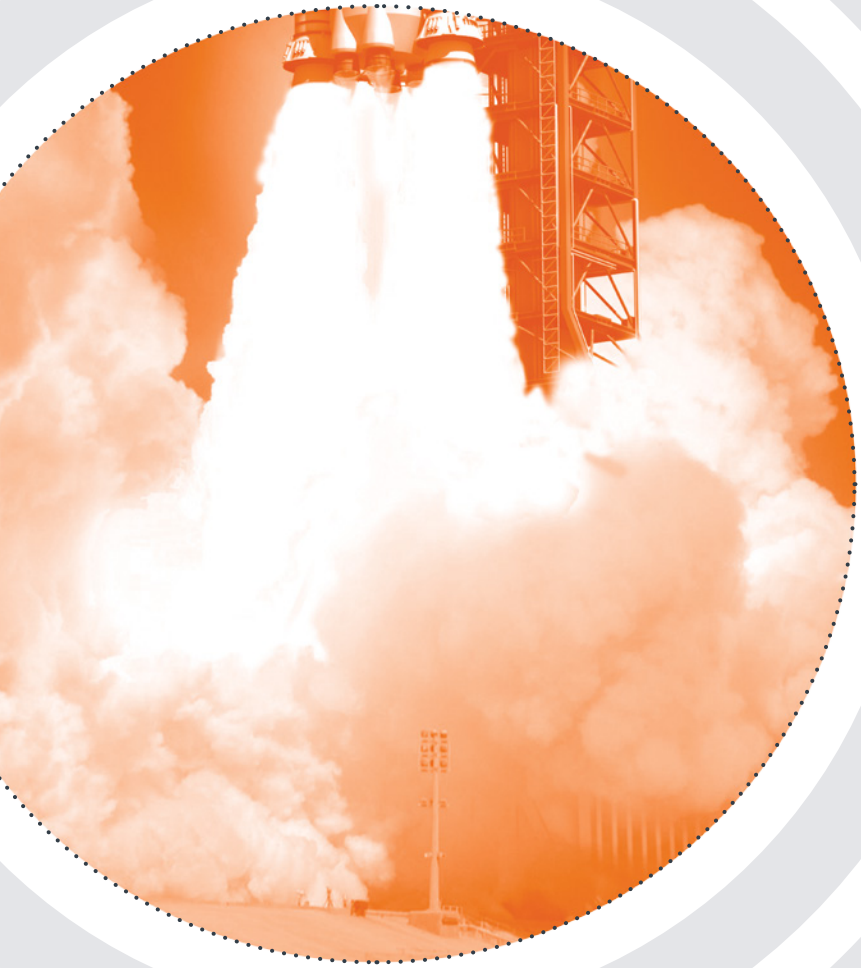
marshall

Launching the Future of Science and Exploration



Marshall Space Flight Center

Equipped with superior experience, critical skills, and unique facilities, teams at Marshall Space Flight Center continue to lead some of America's most exciting space endeavors. Through 50 years of scientific and technological excellence, we have developed a broad portfolio of capabilities.



Marshall Space Flight Center

Propulsion Systems

Marshall performs research, matures technologies, and develops, tests, and sustains propulsion systems for both Earth-to-orbit launch and in-space missions. We contribute engineering expertise for all phases of space transportation, including boost, upper stage, and in-space applications. With our suite of propulsion systems capabilities, we are able to address the design, development and integration of propulsion systems and components ranging from micro-thrusters to systems producing millions of pounds of force.

- Liquid propulsion systems including integrated booster and upper-stage systems, spacecraft propulsion, propulsion system health management, RCS/ACS, and cryofluid management for long-term propellant storage.
- Advanced propulsion and power research and development including high-power electric propulsion, nuclear thermal propulsion, space nuclear power systems, nuclear surface power systems, and propellant-free systems such as solar sails and electrodynamic tethers.
- Solid propulsion systems including solid boost propulsion, upper and in-space propulsion, separation and maneuvering systems, and launch abort motors.
- Propulsion component design and development including advanced rotating machinery, injectors, nozzles, preburners and ignition systems, valves, actuators, and thrust vector control systems.

Integrated end-to-end capability to develop safe, affordable, reliable, and robust propulsion systems

Propulsion Systems

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.

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

- **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 a number of 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**: propulsion system design, development, and testing as well as system integration and operation

In addition to developing the propulsion systems, Marshall maintains a robust propulsion technology maturation effort. The Earth-to-Orbit Propulsion, Advanced Space Transportation, Next-Generation Launch Technology, and Space Launch Initiative programs provided significant technological advances that increased performance, safety, and reliability while decreasing propulsion systems life-cycle costs. These technology programs enabled integrated technology demonstrations such as the Fastrac engine system, developed in only three years, and provided early development for the hydrogen-fueled RS-83 and the hydrocarbon-fueled RS-84 engines. This Fastrac engine was foundational for the Space Exploration Technologies (SpaceX) Merlin engine.

NASA Mission Benefit

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

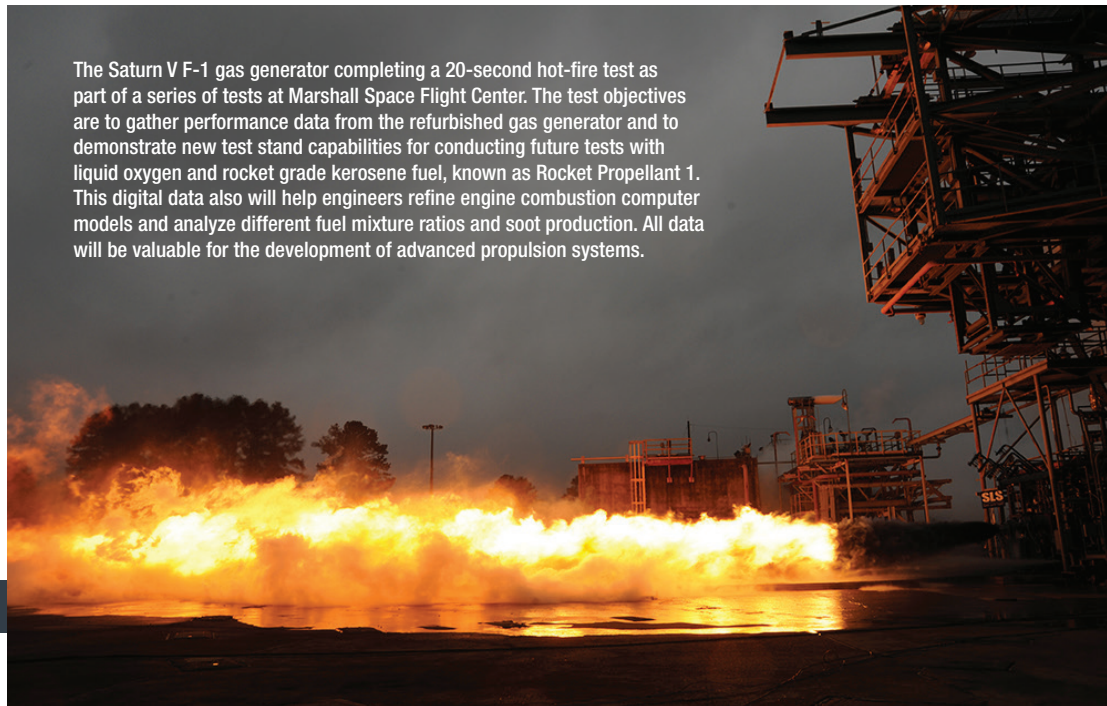
For both Earth-to-orbit and in-space applications, Marshall's propulsion research, systems engineering, and testing capabilities support current and future missions unique to the nation's civil space program. Marshall's propulsion systems development and test capabilities ensure responsible government oversight and insight into technology and life-cycle challenges related to NASA's cutting-edge missions.

National Benefit

Marshall's participation in development efforts such as Shuttle and IUS has provided space access capabilities to DOD as well as the civil space sector. Marshall's propulsion research and development also supports the U.S. commercial sector. Our engineers and facilities have supported NASA's Commercial Crew and Commercial Cargo programs in engineering phases from concept development to test.

In a budget-constrained environment, the nation needs integrated stewardship of propulsion capabilities to remain a world leader in aerospace.

To support this stewardship, the center is working with DOD, industry, and academic partners to stand up a new national organization. The National Institute for Rocket Propulsion Systems is maintaining and advancing U.S. leadership in all aspects of rocket propulsion. The Institute's mission is to foster a vibrant rocket propulsion community that provides reliable and affordable propulsion systems in support of the nation's defense, civil, and commercial needs.



The Saturn V F-1 gas generator completing a 20-second hot-fire test as part of a series of tests at Marshall Space Flight Center. The test objectives are to gather performance data from the refurbished gas generator and to demonstrate new test stand capabilities for conducting future tests with liquid oxygen and rocket grade kerosene fuel, known as Rocket Propellant 1. This digital data also will help engineers refine engine combustion computer models and analyze different fuel mixture ratios and soot production. All data will be valuable for the development of advanced propulsion systems.

Technical Capabilities

- Propulsion System Design, Analysis, Development, Integration and Health Management
- Propulsion Research and Technology
- Propulsion Valves, Actuators, and Ducts Design, Analysis, Test, and Advanced Development
- Propulsion Thrust Vector Control (TVC)
- Systems Design, Development and Integration
- Propulsion Turbomachinery and Combustion Devices Design, Analysis and Advanced Development
- Propulsion Fluid Dynamics Modeling and Testing
- Propulsion Testing
- Advanced Manufacturing
- Damage Tolerance and Fracture Mechanics
- Materials Diagnostics, Nondestructive Evaluation, and Failure Analysis
- Materials Technology and Development
- Thermal Systems Analysis and Design
- Structural, Loads, and Rotordynamics
- Structural and Environmental Testing
- Safety and Mission Assurance
- Systems Engineering, Analysis, and Integration
- Vehicle Development and Integration
- Space Environments and Effects
- Advanced Concepts and Architectures
- Program/Project Management

Partner Collaboration and Services

Marshall collaborates with and provides unique technical services to a variety of partners:

- Aerojet
- Alliant Techsystems Inc. (ATK)
- Blue Origin
- Dynetics
- Northrop Grumman
- Orbital Sciences Corporation
- Pratt & Whitney Rocketdyne
- Sierra Nevada Corporation
- Space and Missile Defense Command (SMDC)
- Space Exploration Technologies (SpaceX)
- Southwest Research Institute
- The Boeing Company
- U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC)
- U.S. Air Force
- U.S. Army Redstone Technical Test Center (RTTC)
- Virgin Galactic

J-2X Rocket Engine

- Advanced engine design, modeling, and analysis
- Materials development
- Component testing

Take a 40-year-old rocket engine design, enlarge it, update it with contemporary technologies and materials, and rigorously test subcomponents and components before taking it through a full-power hot-fire testing of its powerpack and full-scale development engines in record time. Working closely with industry, Marshall propulsion engineers called on their expertise in design, modeling, analysis, manufacturing, materials, component testing, and control systems to develop the Space Launch System's J-2X, an affordable, restartable liquid-oxygen/liquid-hydrogen fueled engine. This engine delivers up to 294,000 pounds of thrust for future missions such as propelling the first astronauts to asteroids and Mars. The most efficient engine of its type, the J-2X represents the capability to put large payloads into orbit or send payloads and crews on ambitious deep space missions. Advanced manufacturing work is making the J-2X safe and affordable.

Infrastructure and Facilities

During Marshall's 50-plus years, the center has built numerous specialized facilities necessary for propulsion development. These include:

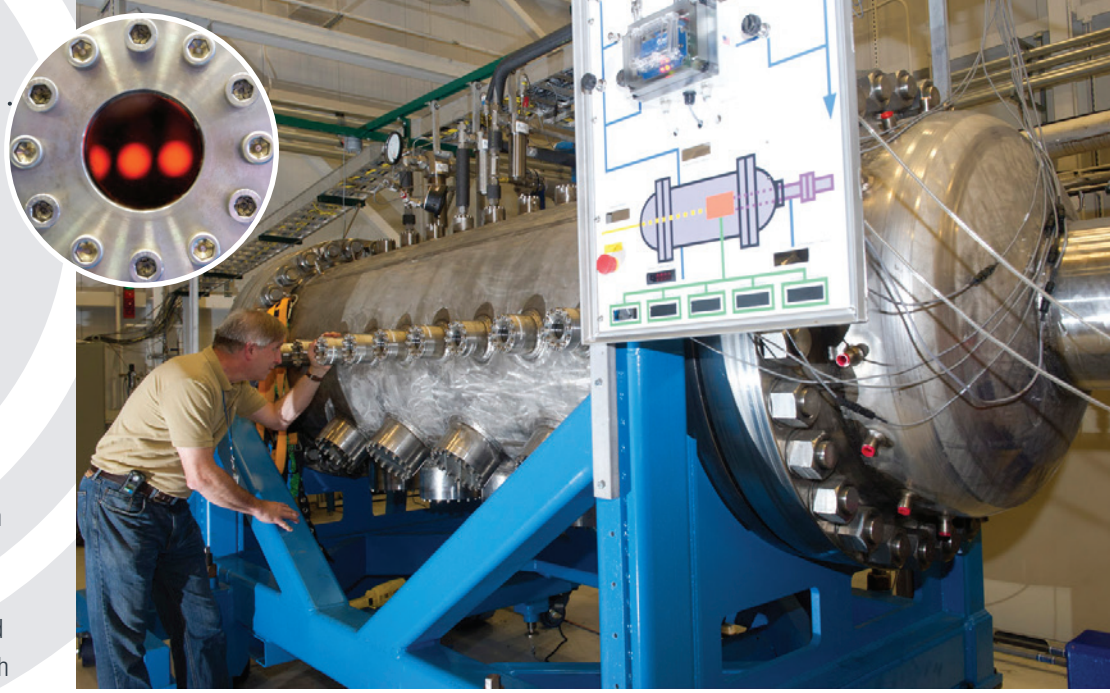
Control Mechanisms Development Laboratory
The Control Mechanisms Development Laboratory provided for anomaly investigation for Space Shuttle Main Engine and Solid Rocket Booster Thrust Vector Control (TVC) actuation issues and for the development and test of TVC and/or aerosurface actuators (both hydraulic and electromechanical). Marshall is the only NASA facility capable of testing under load the large actuators needed to fly launch vehicles, and is currently supporting the Space Launch System's design and development.

Friction Stir Welding (FSW)
Marshall is home to a world-class FSW facility capable of joining barrel or dome segments up to 33 feet (10 meters) in diameter. FSW provides seamless, stronger joints between tank and structural segments with fewer defects than possible using conventional arc welding. This technology will be used to develop the Space Launch System's core stage, which will be powered by RS-25 engines (space shuttle main engines), which were developed at Marshall.

Hydrogen Test Facility (HTF)
The HTF provides materials and mechanical testing services in a liquid or gaseous hydrogen environment to customers, payloads, and projects.

Medium Pressure Small Flow-rate Component Test Stand (TS115)
TS115 is ideal for evaluating medium-pressure, small-flow-rate propulsion system components and combustion devices.

Nozzle Test Facility (NTF)
The NTF provides a low-cost, quick-turnaround air flow facility for conducting performance parametric studies such as simulations of a variety of nozzle geometries and plume configurations, investigating nozzle thrust performance over a wide range of altitude conditions, and studying nozzle geometry efficiency and plume characteristics over simulated operating ranges.



The Nuclear Thermal Rocket Element Environmental Simulator (NTREES) is a non-nuclear facility for affordable testing of prototypical nuclear rocket fuel under conditions that simulate an operating nuclear rocket engine.

Propulsion Research & Development Laboratory (PRDL)
The PRDL is designed for a broad range of propulsion concepts including low Technology Readiness Level (TRL) research (TRL<6), and encourages interdisciplinary research. It features 66,000 square feet of usable lab space.

Test Stand 116 High Pressure Medium Flow-rate Component Test Stand (TS116)
TS116 is ideal for testing high-pressure, medium flow-rate engine subsystem components and combustion devices. This multiposition facility is configured to allow buildup and/or operation of multiple positions with minimal impact to the other positions, saving time and operation costs. A variety of engine components have been tested in this facility, including those from MC-1, RS-68, X-33, J-2, the Orbital Space Plane (OSP) Pad Abort thrusters, and the J-2X engine.

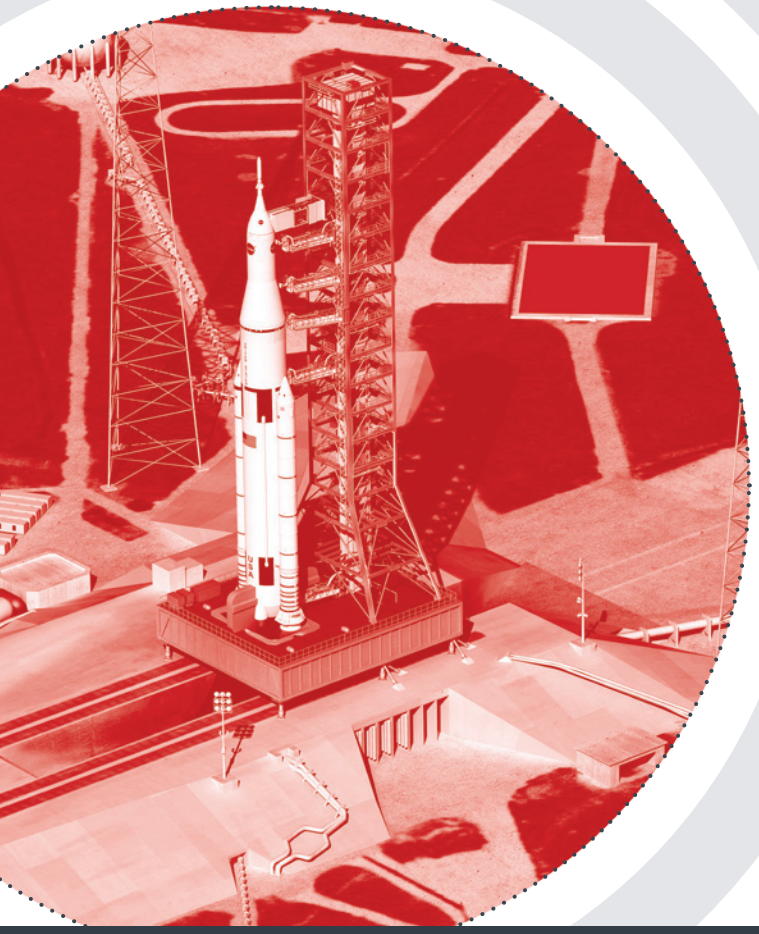
Tribology Test Facility
The Tribology Test Facility provides for the testing of bearings and lubricants under conditions approximating the in-use environment.

Turbine Test Facility
The Turbine Test Facility provides a low-cost quick-turnaround air flow facility for conducting performance parametric studies of a wide variety of turbine hardware such as liquid oxygen/fuel turbopump turbine blade geometries; investigating inlet feed lines, turning vane geometries and their effects on turbine performances; and studying performance and blade geometry efficiency over simulated operating range.

Pump Waterflow Test Facility
The Pump Waterflow Test Facility provides a low-cost quick-turnaround waterflow facility designed for testing impellers or inducer/impeller combinations. This facility verifies design and design methodology, validates meanline and computational fluid dynamics (CFD) predictions, identifies deficiencies in a proposed design, and reduces system risk. Products include head rise, efficiency, integrated shaft loads, suction capability, inlet and exit swirl, and identification and tracking of cavitation phenomena.

Space Transportation and Launch Vehicles

Integrated end-to-end capability to develop and sustain transportation systems



Marshall capabilities and expertise support every stage of spacecraft and launch vehicle development and operations. Expert teams at Marshall develop, test, and evaluate materials, processes, designs, and systems as well as full-up vehicles, such as the nation's new heavy-lift, human-rated Space Launch System (SLS) for exploration beyond Earth's orbit. Our comprehensive approach ensures safety, quality, and cost-effectiveness.

Our space transportation capabilities allow us to expertly perform:

- System design, analysis, integration, and testing of structural, avionics, and flight mechanics systems
- End-to-end systems engineering to integrate spacecraft and vehicles with ground processing and launching facilities
- Vehicle technical design and verification, from concept through post-flight assessments
- Sustaining engineering support to space transportation systems through the decades that their operational life cycle may encompass

Space Transportation and Launch Vehicles

For more than 50 years, Marshall has contributed expertise and extensive infrastructure in end-to-end development of space transportation systems and technologies. This expertise has been instrumental to the success of the International Space Station's habitation and laboratory modules, to putting NASA's Great Observatories such as Hubble and Chandra at their proper orbits, and sending spacecraft to the farthest reaches of the solar system. Our continuing success is grounded in our excellence in complete systems engineering, design, development, test, and sustaining engineering.

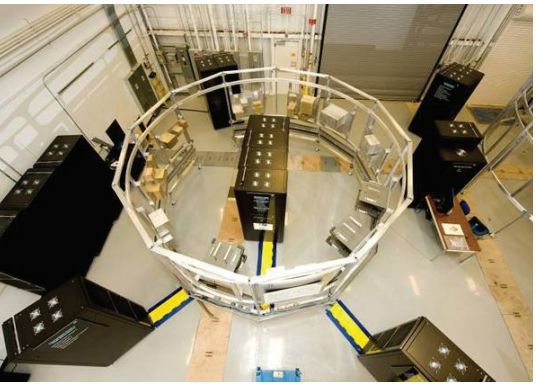
- Concept definition for all of NASA's space transportation systems began at Marshall—from the Saturn rockets, the space shuttle, and Ares rockets to the current Space Launch System (SLS) and flight demonstration programs such as the X-37, an innovative space system that the U.S. Air Force now operates.
- The Collaborative Engineering and Design Analysis Room (CEDAR) allows engineers to input, integrate, and evaluate computer-aided hardware designs in real time, performing rapid preliminary design and mission concept definition studies for potential future NASA missions.
- In the development of launch vehicles, from the Saturn V family of rockets to the SLS, Marshall developed advanced manufacturing processes and built world-class tools and machinery for building full-scale rocket stages. Manufacturing processes are tested at Marshall before being implemented at the contractor production facility at the Michoud Assembly Facility (MAF) in New Orleans. This process provides NASA with critical knowledge and insight into the manufacturing processes, reducing cost and increasing manufacturing efficiencies.
- Beginning in the 1960s with the all-up testing of the Saturn V, Marshall has been a leader in integrated systems testing for space transportation systems. The Saturn V and space shuttle were first stacked at Marshall's historic dynamic test stand for ground vibration testing. Lessons learned in these tests greatly mitigated launch risks.

NASA Mission Benefit

Marshall provides NASA with a wealth of experience, from conceptualization of space transportation systems to their operation. The center's broad and unique combination of skills and facilities encompassing launch vehicle structural designs, flight mechanics, and system engineering ensures responsible government oversight and insight into technology and life-cycle issues related to NASA missions.

National Benefit

The development of complex space transportation systems, including a national heavy-lift capability, is critically important to enhancing U.S. aerospace competitiveness. Innovative manufacturing developments, such as friction stir welding, contribute to the viability of a domestic aerospace structures manufacturing industrial base. Marshall's capabilities in space transportation often find related and even novel uses in other sectors such as defense, science, homeland security, energy, emergency services, medicine, and more.



Systems Integration Laboratory, where software and hardware come together for the avionics system.

Technical Capabilities

- Vehicle Development and Integration
- Program/Project Management
- Systems Engineering, Analysis, and Integration
- Advanced Concepts and Architectures
- Natural Environments
- Space Environments and Effects
- Guidance, Navigation, and Control
- Avionics and Electrical Systems
- Structural and Environmental Testing
- Thermal Systems Design
- Safety and Mission Assurance
- Large-scale Manufacturing
- Advanced Manufacturing
- Materials Data Management
- Materials Diagnostics, Nondestructive Evaluation, and Failure Analysis
- Materials Technology and Development
- Damage Tolerance and Fracture Mechanics
- Aerodynamics Research
- Propulsion Systems Research, Technology, and Development
- Propulsion Testing
- Propulsion Fluid Dynamics
- Human Factors Engineering
- Aerosciences/Aerothermodynamics
- Vehicle Health Management
- Structural Dynamics and Fracture Mechanics

Partner Collaboration and Services

Marshall collaborates with and provides unique technical services to a variety of partners:

- Alliant Techsystems Inc. (ATK)
- Dynetics
- Lockheed Martin (Michoud)
- Lockheed Martin Space Systems
- Orbital Sciences Corporation
- Sierra Nevada Corporation
- Space and Missile Defense Command (SMDC)
- Space Exploration Technologies (SpaceX)
- The Boeing Company
- U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC)
- U.S. Army Redstone Technical Test Center (RTTC)
- Pratt & Whitney Rocketdyne
- Northrup Grumman
- Virgin Galactic
- Georgia Institute of Technology (GA Tech)
- Oakland University

Mighty Eagle Autonomous Robotic Lander

- Autonomous navigation and guidance control
- Propellant management
- Propulsion systems

Developing a machine that can navigate a hostile, airless world is one of the hardest challenges in space exploration. Using its capabilities in guidance, autonomous navigation and control, propulsion systems, testing, and integrating a team, Marshall built and tested a free-flying robotic prototype lander. Fueled by 90 percent pure hydrogen peroxide and commanded by an onboard computer, the Mighty Eagle demonstrated the ability to ascend hundreds of feet, translate, and land on a pre-designated target. It successfully matured technologies and knowledge needed for a new generation of small, smart, versatile robotic landers capable of achieving scientific and exploration goals on the surface of the moon, asteroids, or other bodies. It also continues to serve as a technology testbed and training tool for engineers.

Infrastructure and Facilities

Marshall has built several world-class or one-of-a-kind facilities necessary for developing space transportation systems. These include:

Aerodynamics Research Facility (ARF)
The ARF provides a low-cost test alternative to much larger test facilities for early database development of aerospace systems. The ARF is a trisonic facility (subsonic/transonic/supersonic are attainable and a broad range of Mach numbers from .25 to 5 are available).

Collaborative Engineering and Design Analysis Room (CEDAR)
The CEDAR allows engineers to input, integrate, and evaluate hardware designs on site or remotely.

Cryostructural Test Facility (CTF)
The CTF is used to evaluate the structural integrity of cryogenic tanks and other space transportation components at ambient and cryogenic temperatures under compression and sheer loads. The facility provides for cryogenic testing using liquid hydrogen and nitrogen as well as various gases, including hydrogen, nitrogen, helium, and missile-grade air at 150 psig.

Control Mechanisms Development Laboratory
The Control Mechanisms Laboratory provides for anomaly investigation for Solid Rocket Booster Thrust Vector Control (TVC) actuation issues and for the development and test of TVC and/or aerosurface actuators (both hydraulic and electromechanical). Using sophisticated modeling and simulation capabilities, this is the only NASA facility capable of testing under load the large actuators needed to fly launch vehicles.

Environmental Test Facility (ETF)
The ETF is used to simulate the extreme environments that space hardware is expected to withstand during operations. The ETF provides these environments using 27 chambers capable of high vacuums, extreme temperatures and humidity, and high altitude conditions. Additionally, the ETF can perform vacuum bakeout and launch and re-entry testing.

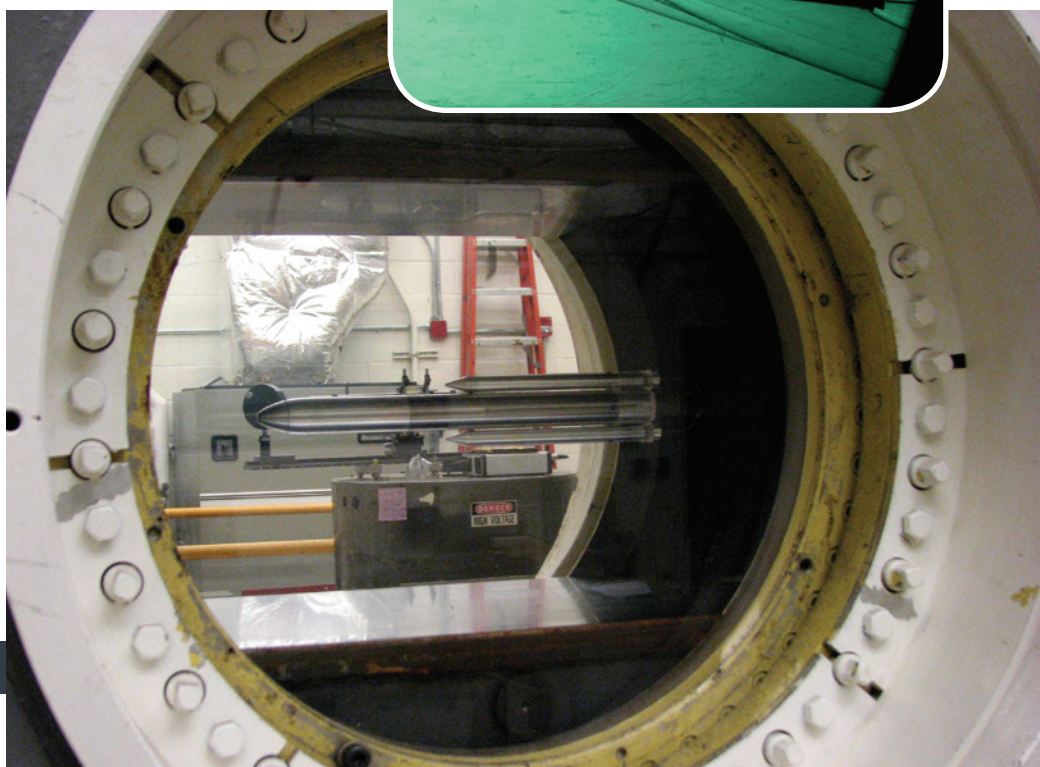
Friction Stir Welding (FSW)
Building 4755 houses a world-class FSW facility capable of joining barrel or dome segments up to 33 feet (10 meters) in diameter. FSW provides seamless, stronger joints between tank and structural segments with fewer defects than with conventional arc welding.

Hydrogen Test Facility (HTF)
The HTF provides mechanical property data and mechanical testing services to customers, payloads, and projects to support hardware development.

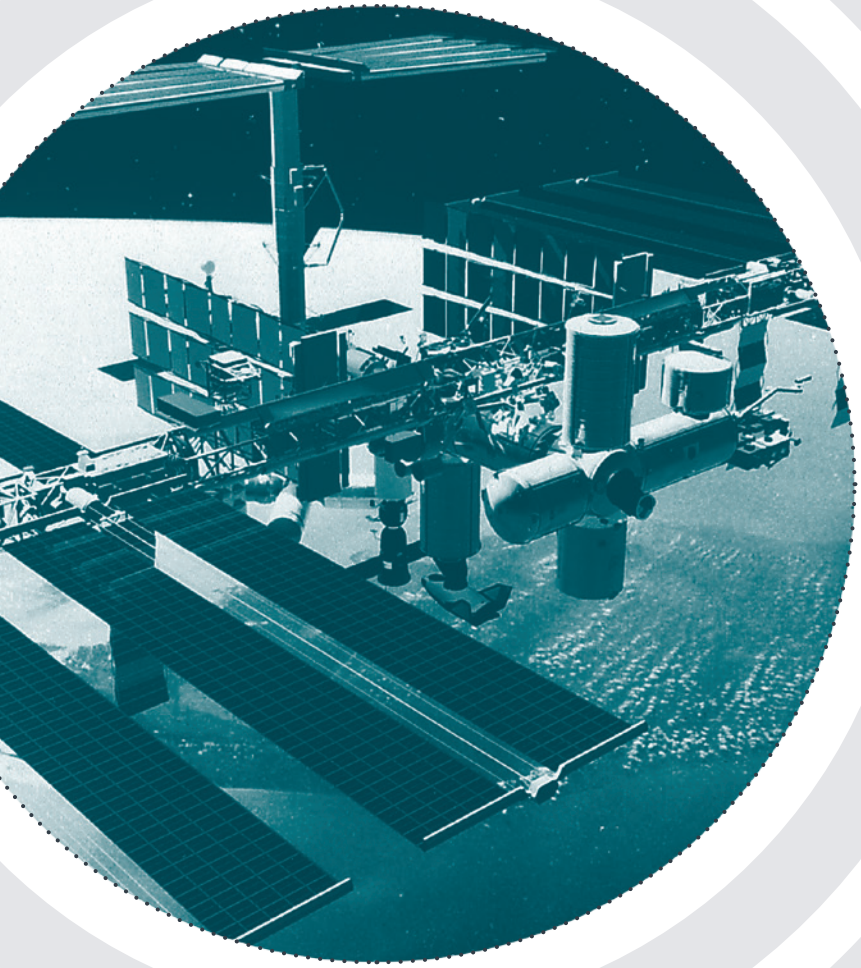
Michoud Assembly Facility (MAF)
Managed by Marshall and located in New Orleans, Louisiana, MAF is a major space vehicle manufacturing and assembly facility that ranks among the world's largest manufacturing sites.

Multi-axis Milling Machine
This horizontal, robotic milling tool — the largest of its kind in the world — gives NASA the ability to cut unique shapes out of metal.

Test Stand 300 Multi-hazardous Thermal Vacuum Chamber Facility
Test Stand 300 test facility has multiple vacuum chambers for conducting hazardous tests using cryogens and/or heat loads to simulate liftoff, vehicle ascent, and deep-space profiles. The 20-foot Vacuum Chamber, with its liquid nitrogen cold walls, enables the customer to test various cryogenic fluid management technologies for in-space storage of cryogenic propellants such as thermodynamic venting and cryo-cooling to prevent boil-off for long-term in-space storage.



Engineers at Marshall test the 130-metric-ton heavy-lift configuration of the Space Launch System rocket in the Trisonic Wind Tunnel.



Marshall Space Flight Center

Space Systems

Marshall supports NASA in developing large space structures and their supporting space systems, including the Lunar Roving Vehicle, Skylab, Spacelab, and space station modules. Marshall also develops and manages small satellite projects and scientific payloads on a variety of spacecraft.

With our suite of space systems capabilities, we develop, test, and manage:

- Fast, Affordable, Science and Technology Satellite (FASTSAT)
- Logistics modules and connecting nodes
- Environmental Control and Life Support System
- Payload Operations Center, the space station's primary science command post
- Materials Science Research Rack experiment integration
- Microgravity Science Glovebox

With a range of space systems capabilities, Marshall is laying the foundation for a new era of space exploration. This includes space systems technology demonstrations, scientific spacecraft, and advanced concepts for future habitats.

Designing, developing, analyzing, and testing the structures, mechanisms, and thermal, environmental, avionics, robotics, power, software, and life support systems needed for space activities

Space Systems

Marshall's role in developing systems for humans to live and work in space extends from our current work with the space station to our beginnings in the Apollo Program.

- The center has made significant contributions to the International Space Station (ISS), including the integration of several node elements that expanded its capacity for scientific and exploration research.
- Marshall led the design, development, and testing of the Environmental Control and Life Support System (ECLSS), which provides oxygen and clean drinking water for the crew aboard the ISS.
- Marshall led the design, development, and testing of a small satellite (FASTSAT), demonstrating a sustainable capability to build, deploy, and operate a science technology flight mission at lower costs.
- For the successful Ares I-X development flight test, Marshall-led teams used new and existing systems to develop and integrate avionics as well as the propulsion elements for the first stage and roll control propulsion.
- Marshall worked with the European Space Agency to design and develop Spacelab, a system of pressurized modules, pallets and other hardware that allowed scientists to perform a host of experiments in a near-weightless microgravity environment aboard the space shuttle.
- Marshall was instrumental in transforming the Saturn V third stage into Skylab—the first U.S. space station in which humans lived and worked in space for an extended period.
- From the Apollo era to the ISS, Marshall has developed and integrated scientific payloads for research on numerous materials in microgravity environments.

Marshall is performing studies, analysis, and prototype research and development for systems to support a new era of space exploration. These include in-situ research utilization; radiation measurement, monitoring, and mitigation; spacecraft development, integration, testing, and operation; instrument and experiment development, testing, and operation; and large optics research, development, and testing.

NASA Mission Benefit

With the Space Launch System providing an affordable solution for sustainable human space exploration, Marshall continues to provide the space systems needed to expand America's presence in space. With its experienced workforce and specialized laboratory and test facilities, the center provides crucial insight for evaluating future space hardware, from new materials and subsystems to the integration of systems-of-systems.

In addition to developing new ways to recycle air and water for vehicles headed for deep space, Marshall teams also develop materials, products, tools, and technologies to mitigate the harmful effects of space weather and radiation for future human and robotic exploration missions.

National Benefit

Space systems development at Marshall provides a unique asset for the nation in the management and integration of large, complex space systems. This capability will be required for future habitats, vehicles, and other space structures used in human exploration of space. Marshall also applies its expertise in space environments to help assess the potential impacts of severe space weather events on the national power grid.

Marshall plays an important role in transferring NASA technology. For example, a water purification system based on ECLSS technology is being used to improve the quality of life in developing countries and remote locations in support of U.S. soldiers.

In the grasp of the International Space Station's Canadarm2, the Marshall-managed Multipurpose Logistics Module (MPLM) is transferred from space shuttle Discovery's payload bay to be permanently attached to the Earth-facing port of the station's Unity node. Earth's horizon and the blackness of space provide the backdrop for the scene.

Technical Capabilities

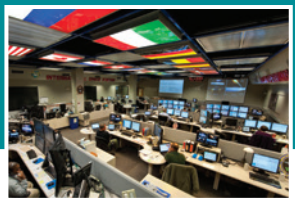
- Program/Project Management
- Systems Engineering, Analysis, and Integration
- Payload Systems Technology, Development, and Integration
- Mission Operations
- Safety and Mission Assurance
- ECLSS Design and Development
- Space Environments and Effects
- Guidance, Navigation, and Control
- Optical Systems Design, Development, Fabrication and Test
- Thermal Systems Design
- Structural and Environmental Testing
- Avionics and Electrical Systems
- Vehicle Development and Integration
- Materials Data Management
- Materials Diagnostics, Nondestructive Evaluation, and Failure Analysis
- Materials Technology and Development

Partner Collaboration and Services

Marshall collaborates with and provides unique technical services to a variety of partners:

- Alliant Techsystems Inc. (ATK)
- Ball Aerospace & Technologies Corp.
- Defense Advanced Research Projects Agency (DARPA)
- Emcore
- Loral Space & Communications
- Northrop Grumman Corporation
- U.S. Army Redstone Technical Test Center (RTTC)
- U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC)

International Space Station (ISS) Design, Manufacturing, and Operations



- Vehicle development and integration
- Structural and environmental test
- ECLSS design and development
- Space environments and effects
- Payload integration and operations
- Safety and mission assurance

To explore space, humans and their equipment are pitted against the harshest of environments. Crews of up to six have been living and working continuously on the ISS for more than a decade thanks to Marshall's broad capabilities in space systems. Marshall managed the design, manufacture and test of the station's Environmental Control and Life Support Systems. The center also managed the development of the station payload racks and other hardware and continues to manage payload integration and sustaining engineering. Marshall also provides round-the-clock payload operations management on the station and continues to develop life-support technologies to further reduce the cost of resupplying the ISS and make long-duration human missions more feasible and affordable.

Infrastructure and Facilities

Marshall's expertise crosses the spectrum of in-space systems engineering and science. The center's labs prepare experiments for space, test systems that support life, and integrate and test multiple types of space systems.

Space Environmental Effects (SEE) **Lab**
Marshall's SEE test facilities include multiple unique test systems comprising the most complete SEE testing capability available, all in one location. These test capabilities include charged particle radiation (electrons, protons, ions), ultraviolet radiation, vacuum ultraviolet radiation, atomic oxygen, plasma effects, spacecraft charging, lunar surface and planetary effects, vacuum effects, and hypervelocity impacts.

Small Projects Rapid Integration and Test Environment (SPRITE)
The SPRITE facility is a modular hardware-in-the-loop avionics development and test facility. It provides design support, testing, evaluation, and verification of flight software and avionics components for small spacecraft and payloads. The layered modular design of the facility allows it to leverage a library of plant models, including space environments; standard serial, analog, and digital interfaces; and advanced visualization capabilities.

Flight Robotics Laboratory
Also known as the "Flat Floor Facility," this lab enables objects to float on a thin layer of air atop the world's flattest floor. This facility allows controllers to test techniques for spacecraft docking or remote-controlled robotics.

ECLSS Test Bed
Marshall's ECLSS test bed allows engineers to test and develop systems for delivering clean air, a comfortable living environment, and potable water on the International Space Station. Test modules simulate the space station environment, with treadmills, urine and perspiration sample collection tools, and a laboratory for processing.

Huntsville Operations Support Center (HOSC)
The HOSC provides multiple program facilities, systems, and services, which support various mission phases of spacecraft and payloads. Though the HOSC may be best known for supporting the space shuttle propulsion systems operations, it also manages satellites and other scientific payloads. The HOSC supports ground system services, including telemetry, voice, video, information management, data reduction, and payload planning.

Marshall also led development of four key systems supporting science operations and investigations aboard the station:

- **EXPRESS Racks** house a variety of science experiments, supplying them with power, data and video distribution, and thermal control interfaces.
- The **Materials Science Research Rack** allows crew members to perform materials research in microgravity, leading to the discovery of new or improved materials.
- The **Microgravity Science Glovebox** provides a sealed environment for astronauts to conduct experiments containing potentially hazardous fluids, flames, or fumes.
- The **Window Observational Research Facility**, or WORF, is the station's "window on the world," enabling Earth imaging via cameras, multispectral scanners, and other specialized equipment.

Sunspot Thermal Vacuum Chamber (Class 8 Clean Room Attached, Temperature Range of –170 to 200 °C, Vacuum Pressure of 10^–7 Torr)

Marshall Space Flight Center

Scientific Research

Marshall develops, tests, and manages scientific instruments, experiments, and spacecraft that gather vital information about Earth and space.

Our scientists:

- Seek to understand dark matter and dark energy through X-ray astronomy investigations and studies of gamma-ray bursts and cosmic rays
- Study and predict the sun's dynamics to improve forecasts of the solar eruptions and space weather that can affect humans
- Develop tools to provide better monitoring and prediction of Earth's weather, climate and other environmental impacts
- Study planetary atmospheres, interiors, and histories

Fundamental research, data analysis and modeling, science instrument and payload development, and flight missions supporting NASA Earth and space science missions

Scientific Research

Since the early days of the space program, Marshall has increased human understanding of the universe through its contributions to heliophysics, astrophysics, and planetary and Earth sciences. The center has a rich heritage in managing and developing instruments and spacecraft that deliver cutting-edge scientific discoveries. Marshall has played a key role in each of NASA's flagship observatories, including HEAO, Hubble, Compton, Chandra, and the James Webb Space Telescope.

Astrophysical Science—Marshall designed and built the Hubble Space Telescope. Along with Hubble, the Marshall-managed Chandra X-ray Observatory and the Marshall-built Gamma-ray Burst Monitor aboard the Fermi Gamma-ray Space Telescope continue to deliver unprecedented scientific images and information to help us decipher the origin, structure, and evolution of the universe. The center also provides expertise in highly sophisticated X-ray optics in the areas of design, development, and testing, having performed cryogenic testing of NASA's James Webb Space Telescope's 18 mirrors.

Heliophysics and Planetary Science—Marshall scientists are studying the structure and dynamics of the sun and developing predictive models to forecast solar eruptions and space weather.

- The Solar Wind Electrons Alphas and Protons (SWEAP) investigation is part of the Solar Probe Plus mission. SWEAP will sweep up a sample of the sun's atmosphere, enabling a dramatic shift in our ability to characterize and forecast the star's radiation environment.
- The Solar Ultraviolet Magnetograph Investigation (SUMI) and High Resolution Coronal Imager (Hi-C) telescope are taking advantage of low-cost access to space and yielding outstanding results. Hi-C has provided images of the sun at a higher resolution than has ever been achieved.
- The center's scientists also chair Mars Exploration Rover working groups, participate in analog field campaigns, and operate a state-of-the-art lunar and planetary sample analysis laboratory.

Earth Science—Marshall's scientists observe and analyze data on our global climate system, providing information to help decision makers.

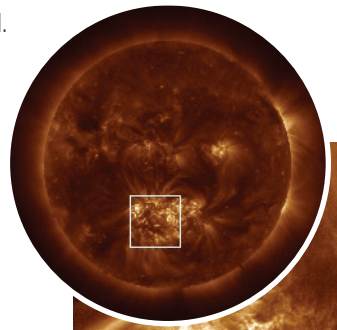
- Hurricane Imaging Radiometer (HIRAD) maps wind and rainfall.
- Short-term Prediction Research and Transition (SPoRT) Center translates high-resolution scientific data for use by the National Weather Service.
- The SERVIR project integrates satellite information about natural or man-made disasters to provide real-time information to public health agencies and relief workers.

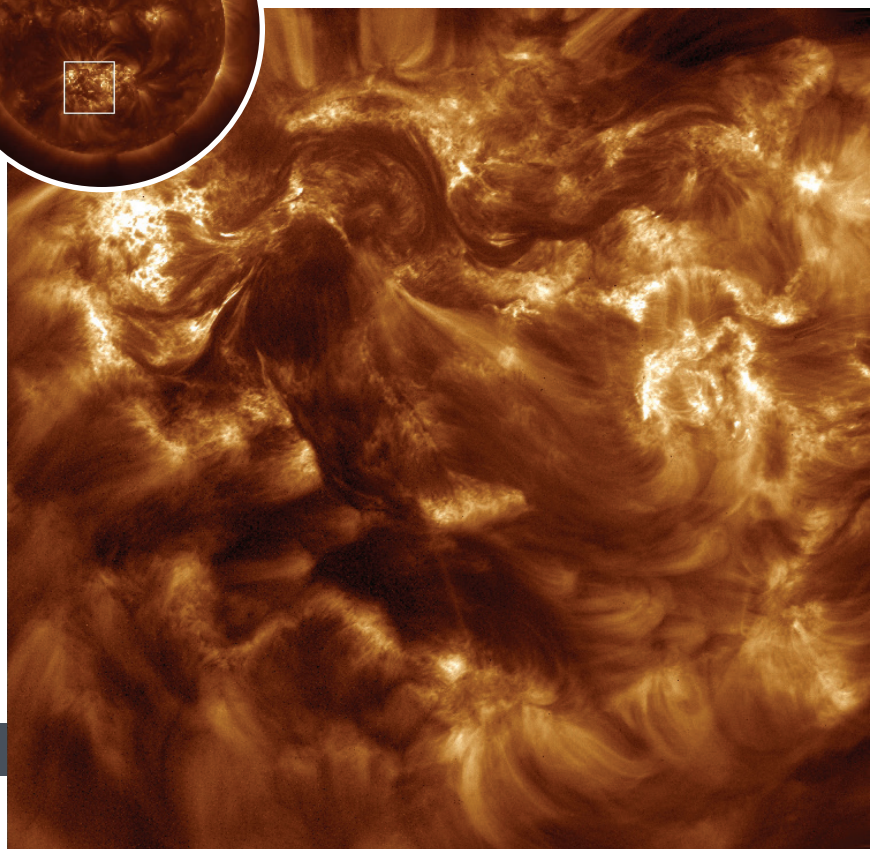
NASA Mission Benefit

Based on the 2010 National Space Policy goals, Marshall science remains a critical asset for advancing NASA's Earth and space observation capabilities to monitor climate and global change, to forecast terrestrial and space weather, to manage natural resources and support disaster response and recovery efforts, and to better understand the universe and our place within it.

National Benefit

Marshall's science programs provide vital data and technology to the National Weather Service, National Oceanographic and Atmospheric Administration, U.S. Agency for International Development, and the Centers for Disease Control and Prevention. The analysis and modeling of the sun and space by our heliophysics team helps to protect the nation's satellite assets and ground-based power grids. Our high-energy astrophysics research has helped to uncover previously unknown gamma-ray events produced by lightning flashes on the Earth, aiding in our understanding of terrestrial weather phenomena. Marshall's astrophysicists are also revolutionizing the capabilities of high-energy X-ray optics and expanding the capabilities of neutron optics for the Department of Energy and medical optics for the National Institutes of Health. Advances in Earth science are helping to provide more accurate worldwide weather forecasting and tracking of climate change.





The Hi-C is an excellent example of Marshall's expertise in optics. The image shown here is from the solar active region highlighted in the upper left image. These Hi-C images are at a resolution of 0.2" or 90 miles. This resolution is the equivalent of resolving a dime from 10 miles away.

Technical Capabilities

- High-energy Astrophysics
- Heliophysics Advanced Concepts and Architectures
- Space Environments and Effects
- Planetary Science
- Earth Science
- Applied Earth Science
- Optical Systems Design, Development, Fabrication, and Test
- Advanced Concepts
- Payload Systems Technology, Development, and Integration
- Mission Operations
- Program/Project Management
- Safety and Mission Assurance
- Thermal Systems Design
- Structural and Environmental Test
- Guidance, Navigation, and Control
- Systems Engineering, Analysis, and Integration

Partner Collaboration and Services

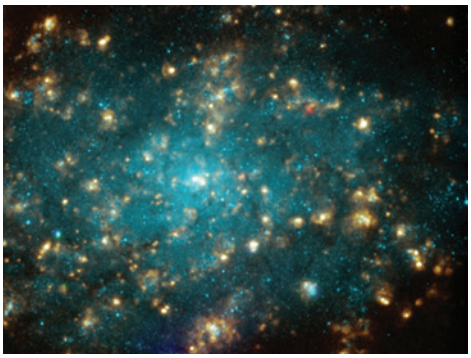
Marshall collaborates with and provides unique technical services to a variety of partners:

- U.S. Agency for International Development
- Harvard Smithsonian Astrophysical Observatory
- Johns Hopkins University Applied Physics Laboratory
- National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS)
- Orbital Sciences Corporation
- Southwest Research Institute
- The University of Alabama in Huntsville
- U.S. Army Aviation and Missile Research Development and Engineering Center (AMRDEC)
- Von Braun Center for Science and Innovation

Chandra X-ray Observatory

- Optical systems design, development, fabrication, and test
- Systems engineering, analysis, and integration
- Space environments and effects
- Heliophysics, astrophysics, Earth science, planetary science

The most powerful and mysterious objects and events in the universe—such as black holes and quasars—emit most of their energy in the invisible, high-energy X-ray region. Marshall combined its expertise and capabilities in science and engineering to develop the Chandra X-ray Observatory to collect images and spectra to better understand the structure and evolution of the universe. Launched in 1999, Chandra can see objects 20 times fainter with eight times greater resolution than any previous telescope. Creating that capability required integrating world-class design, manufacturing, and testing, as well as the durability to survive the space environment beyond the reach of a repair mission. Marshall also worked to modify the two-stage Inertial Upper Stage for the Chandra mission. At 13 years and counting, Chandra is still making discoveries.



Infrastructure and Facilities

Much of Marshall's science work is performed at the National Space Science and Technology Center (NSSTC), which encompasses more than 55,000 square feet of laboratory space. Its facilities include laboratories and work spaces for many of Marshall's science programs, including the Chandra X-ray Observatory, Hi-C, Hinode, HIRAD, SERVIR, SPoRT, SUMI, SWEAP, and others. Marshall's X-ray and Cryogenic Facility (XRCF) is a unique, world-class optical, cryogenic and X-ray test facility—in fact, the world's largest X-ray telescope test facility. Capable of operating in the extreme temperatures in space, the facility consists of a 1,700-foot-long X-ray guide tube, a horizontal cylindrical vacuum chamber called the Instrument Chamber, and two clean rooms rated up to Class 1,000 (classifying the room's contamination level at less than 1,000 particles ½ micron and larger in diameter per cubic foot).

Earth Science

- Climate Laboratory
- Earth Science Computer Laboratory
- Electronics Sensor Laboratory
- Lightning Optics Laboratory
- Microwave Instrumentation Laboratory
- SERVIR Laboratory (remote sensing visualization)
- SPoRT Laboratory

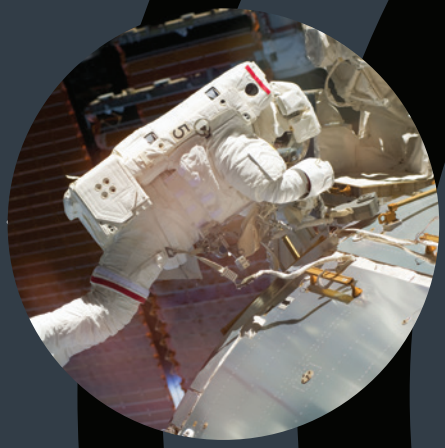
Space Science

- Beowulf Computer Cluster Laboratory
- Cosmic-ray Detector Development Laboratory
- Cosmic-ray Tracking/Analysis Laboratory
- Dusty Plasma Laboratory
- Extremophile Microbiology Laboratory
- Fermi Burst Monitor Instrument Operations Center
- Gamma-ray Laboratory
- Instrument Development Laboratory
- Low-Energy Electron and Ion Facility
- Solar Optical Laboratory
- Solar Physics Sounding Rocket Payload Laboratory
- Ultraviolet Instrument Calibration Laboratory
- X-ray Detector Development Laboratory
- High-intensity Solar Environment Test (HISET) Laboratory

Advanced Optics

- Integrated Optics Laboratory
- Optics Laboratory (thin disk and dye laser)
- X-ray and Cryogenic Facility

NASA scientists work on the Fast, Affordable, Science and Technology Satellite, or FASTSAT, after successfully completing a comprehensive pre-shipment review.



Marshall Space Flight Center…

Launching the Future of Science and Exploration

- Marshall brings vital resources to NASA and the nation for solving the unique challenges of space exploration. Our capabilities and experience are essential to nearly every facet of NASA's mission of exploration and discovery:

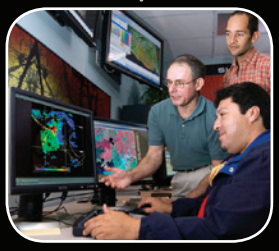
  – Traveling To and Through Space

  – Living and working in space

  – Understanding our world and beyond

Marshall Space Flight Center's

technical capabilities and engineering expertise are essential to the nation's space exploration goal to send humans beyond Earth and into deep space. Our unique expertise is in large-scale, complex space systems development with a core capability in propulsion. We advance space technologies, spark economic development, and inspire a new generation of explorers.



National Aeronautics and Space Administration

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