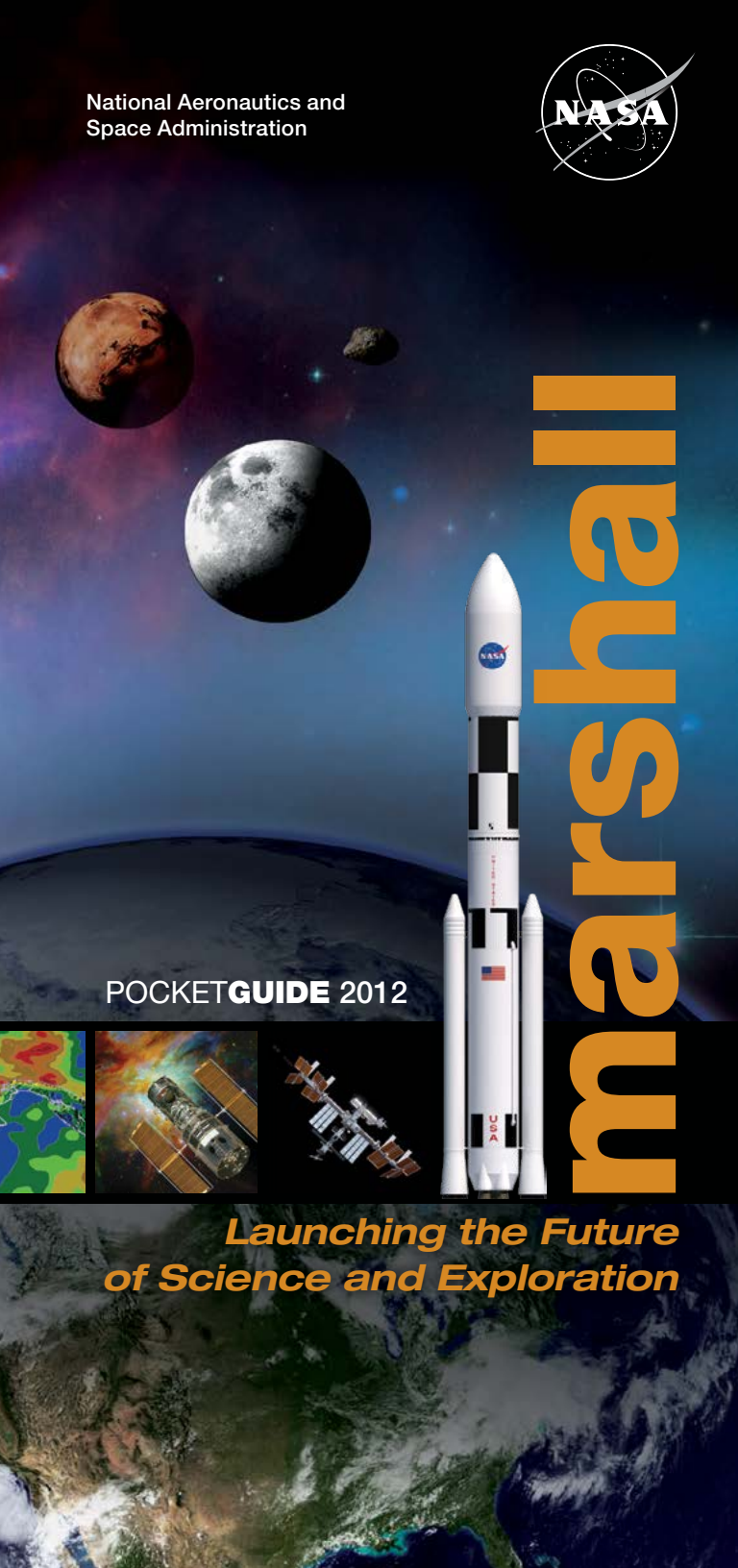
National Aeronautics and
Space Administration



marshall

POCKET**GUIDE** 2012

Launching the Future of Science and Exploration

Launching the Future of Science and Exploration

Fiery rockets bound for the unknown — men and women doing research every day aboard a giant orbiting laboratory — telescopes and probes staring into the distant depths of the universe and the wonders of our own changing planet — behind all these incredible accomplishments you will find the vision and expertise of the teams at NASA's Marshall Space Flight Center.

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NASA's Strategic Direction

NASA Mission

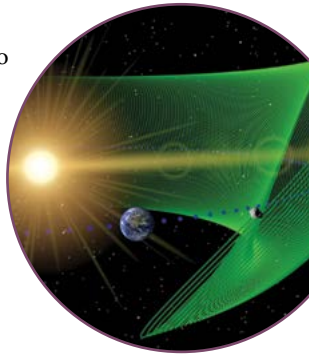
Drive advances in science, technology and exploration to enhance knowledge, education, innovation, economic vitality and stewardship of the Earth.

Exploration Plans

We are at the threshold of an unprecedented era in space exploration. NASA's bold vision for the future is to expand human presence throughout the solar system. The ultimate aim: men and women walking on the red sands of Mars.

With the International Space Station (ISS) as a test bed and the collective efforts of many nations, NASA envisions the following accomplishments are possible over the next 25 years:

- A deep space habitat is deployed to an Earth-moon Lagrange point.
- Robotic missions provide greater knowledge of the worlds we plan to visit.
- Humans visit a near-Earth asteroid.
- Humans return to the moon for longer stays and possible habitat development.



Each step is a remarkable achievement in its own right. And each step fosters development of new capabilities, technologies and systems to place humans on Mars. Marshall's diverse and talented team, with proven technical and scientific know-how and state-of-the-art facilities, plays key roles at every step.

Why Explore

Early in our lives an innate thirst for knowledge sets us stargazing in delicious anticipation of what we might see. Space exploration both quenches and perpetuates that thirst through a never-ending wave of discovery, creating a better future for humankind by

- Expanding the frontiers of scientific research.
- Enhancing our knowledge of planet Earth and the measures needed to protect it.
- Driving innovations and advancements that improve and even save human lives.
- Invigorating the country's economy by sparking technology advancements and creating new industries.
- Encouraging international cooperation.
- Inspiring new generations of engineers, scientists and technologists.

Join us as we unlock the mysteries of space and harvest its limitless benefits for humankind.

We've really only just begun. Look up. That's where we're going!

About Marshall

Adaptable, affordable, inspiring

From the development of mighty rocket engines to extraordinary scientific discoveries about our universe, Marshall Space Flight Center is 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 as we:

- Develop and test tomorrow's flagship space vehicles and rocket engines.
- Create new ways to support living and working in space.
- Observe Earth to better care for it and ourselves, and explore the solar system and beyond to increase our understanding of the cosmos and our place in it.

Marshall Goals

- Develop and operate integrated vehicles and systems to enable human space activities.
- Develop, integrate and operate instruments and conduct research to expand knowledge of the universe.
- Develop, test and mature new space technologies to enable NASA missions and benefit the nation.
- Provide and manage program, project and institutional capabilities to conduct NASA's and Marshall's space activities.
- Share NASA and Marshall with the public, educators and students to foster communication, participation and innovation to benefit the interests of the nation.

Marshall Profile

- **Nearly 6,000** employees (civil service and contract, including Michoud Assembly Facility in New Orleans)
- **3rd largest employer** in the Huntsville area
- **More than 125** unique and specialized facilities and labs
- **26 core capabilities** including key facilities and expertise
- **$2.5 billion** FY 2011 budget

Sustainability

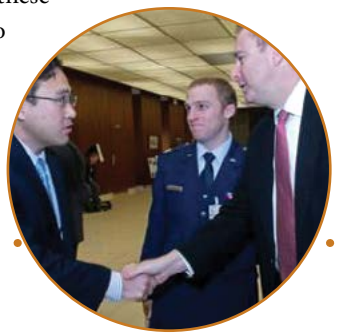
Marshall is decreasing utility, operations and maintenance costs to create a leaner, greener campus by replacing inefficient buildings with LEED-certified (Leadership in Energy and Environmental Design) buildings. Marshall now has three such buildings with a fourth under construction.

Marshall in the Community

Marshall is located in Huntsville, Alabama, on the U.S. Army's Redstone Arsenal. The Arsenal is a major federal research, development, test and engineering center for the nation's missile defense and aviation programs.

The adjacent Cummings Research Park is home to 300 defense, aerospace and technology corporations and The University of Alabama in Huntsville, with one of the highest-rated engineering management programs in the nation.

Huntsville's unique synergy of government, business and university research creates a fertile environment for collaborating with other agencies, commercial companies and academia. We are engaged in more than 200 partnerships, fostering co-development of technologies or providing NASA capabilities to the private sector and academia. Such teamwork is essential to developing innovative technologies for future space missions. These partnerships not only make space flight more affordable, they also contribute to our nation's economic strength as these innovations transfer to commercial use.



Inspire, engage, educate

NASA has a long-standing tradition of investing in the nation's education programs. Education plays a central role in preparing, inspiring, exciting, encouraging and nurturing today's young minds—the workforce of tomorrow.

Marshall hosts several efforts to foster education in Science, Technology, Engineering, and Mathematics (STEM):

- The annual **NASA Great Moonbuggy Race** engages national and international high school and college students in an engineering competition. Students design, build and race a human-powered vehicle on a simulated lunar surface.
- **NASA Student Launch Projects** involve middle school, high school and university teams in eight-month systems engineering projects. Each team designs, builds and launches a reusable rocket with a scientific or engineering payload onboard to one mile above ground.
- **The Student Online Application for Recruiting Interns, Fellows, and Scholars (SOLAR)** allows students to search and apply for all types of higher-education internship, fellowship and scholarship opportunities. A single application places the student in the pool for consideration by all NASA mentors.
- The Marshall **Educator Resource Center** (ERC), located at the U.S. Space & Rocket Center, provides resources, expertise and facilities for formal and informal educators. NASA's unique mission provides rich content for educational products aligned with national STEM standards.

Learn more

About Marshall
www.nasa.gov/centers/marshall/about

Marshall's Work in Support of NASA's Mission

Ready for the challenges of the future

Marshall supports the Agency's efforts in

- Lifting From Earth
- Living and Working in Space
- Understanding Our World and Beyond

The Marshall team is leading development of NASA's Space Launch System, or SLS. The new heavy-lift launch vehicle will send human explorers, their equipment, cargo and science payloads on new missions of discovery beyond low-Earth orbit and provide backup transportation to the International Space Station.

The Center is also developing advanced, affordable space systems and technologies that enable astronauts to live and work safely in the harsh space environment—whether in the space station's active research facilities or during long-term, deep-space expeditions yet to come.

And we are developing robust science missions to expand understanding of our planet, the solar system and the universe.

All of these activities support high-value research and discovery missions in deep space, strengthening our nation's technology base and economy and inspiring the world.

Lifting From Earth

America's space program is an enduring gift to future generations, enriching and sustaining the nation's legacy of exploration, discovery and progress. Marshall is a leader in meeting our country's space transportation challenges.

The nation's journey to space began here more than a half-century ago. And now our dedicated team is guiding the development and testing of tomorrow's flagship rocket, systems and engines. We are delivering the means to lift a new generation of explorers and their inventions into space—boosting their imaginations, pride and career aspirations.

From Mercury to Gemini, and from Apollo to the space shuttle, Marshall has been at the forefront of the country's space propulsion and transportation achievements. We are merging the best lessons from those programs with the best practices of today's industries to provide affordable solutions for the new challenges of the 21st century and beyond.

The Space Launch System

Marshall is managing development of NASA's SLS launch vehicle, which will be the most powerful rocket ever built. The SLS is essential to fulfilling NASA's exploration vision. This heavy lifter will take astronauts deeper into space than ever before: beyond the moon, to asteroids and on to Mars.

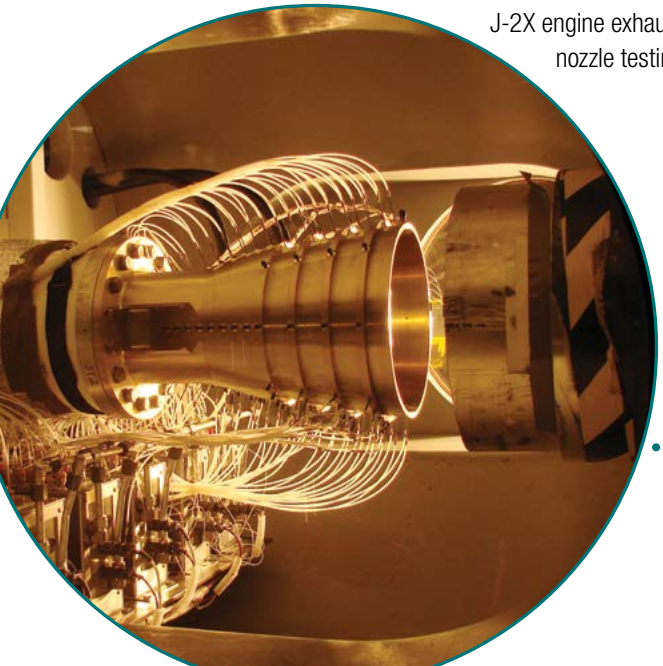
The SLS will transport humans—aboard the Orion Multi-Purpose Crew Vehicle (MPCV)—and high-priority science payloads to entirely new destinations in deep space, opening incredible frontiers for discovery.

Benefiting from Marshall's long history, experience and insight into vehicle development, the SLS will form the foundation for safe and sustainable human exploration, expanding America's presence in space and contributing to economic growth. It will also promote international cooperation, as well as create opportunities to enrich the future for people around the world. And finally, SLS will help ensure the nation's access to the International Space Station by serving as a back-up should other launch vehicles be unavailable or unable to supply and support ISS cargo and crew requirements.

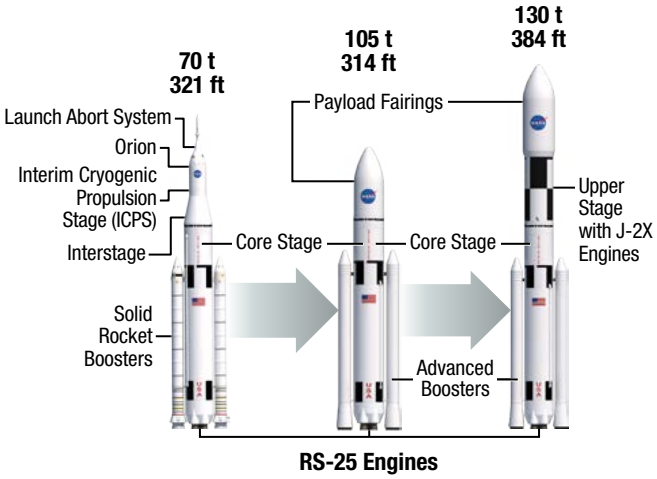
Marshall performs SLS systems engineering and integration, bringing together the exacting work of American companies across the nation. Work is already underway. The SLS architecture was selected after NASA analyzed literally thousands of concepts, including studies presented by government and industry experts from large and small businesses. These concepts were measured against NASA's requirements to take astronauts beyond Earth orbit. The Agency then selected the best option combining safety, affordability and sustainability. It uses a mix of available engines, assets and hardware already in development to meet a first flight date of 2017 and an evolved capability after 2021.

This approach maximizes return on investment from earlier space flight systems and minimizes start-up costs.

It also engages the U.S. workforce and builds on its space flight foundation. This strategy includes manufacturing large structures at the Michoud Assembly Facility in Louisiana, testing engines at the Stennis Space Center in Mississippi and then launching the SLS rocket from the Kennedy Space Center in Florida.



J-2X engine exhaust nozzle testing



The first SLS vehicle will carry up to 70 metric tons (t) into space. It includes a core stage powered both by the venerable liquid hydrogen and liquid oxygen fueled RS-25 engines, which served the space shuttle program with 100 percent mission success, and by five-segment solid rocket boosters based on the space shuttle boosters and upgraded for the Ares launch vehicles.

Marshall will use development phases called "block upgrades" to meet schedule requirements while evolving the SLS rocket in affordable and sustainable ways. Powerful advanced boosters, which may be liquid or solid, will be developed to increase its lift capacity to 105 t, allowing for larger payloads. Later, an upper stage powered by J-2X engines—which are now in testing to prove the new design's performance and reliability—will be added to increase lift capacity to 130 t, about 10 percent more than the Saturn V moon rocket. This evolved SLS rocket will then have the robust, mature capabilities required to take crews, equipment and mission payloads into deep space.

Learn more

www.nasa.gov/sls

Supporting Commercial Spaceflight

Marshall plays a vital role in enabling and enriching the commercial use and exploration of space. Together, Marshall and industry are helping to prepare the nation for the challenges of a future unfolding far beyond the boundaries of our home world.

Photo credit: United Launch Alliance

At Marshall, we offer our laboratories, test sites and other cutting-edge facilities—plus the expertise of our scientists, engineers and propulsion experts—to leading aerospace companies and small businesses. The center maintains more than 200 active Space Act Agreements and other partnerships with leaders in industry and government. Our goal is to foster development of innovative commercial resources, capabilities and spinoff technologies that benefit everyone.

These partnerships often help improve our own processes and products as we learn of commercial companies' innovative management practices and cost-effective solutions.

Propulsion Systems Research

At Marshall, we are developing safe, affordable, cutting-edge propulsion systems and technologies to enable human and robotic excursions to points all across the solar system.

The center is NASA's primary resource for design and development of space propulsion systems. We build on the engineering expertise that launched a half-century's worth of famous space transportation and propulsion systems—from the Apollo-era Saturn moon rockets, to more than 130 space shuttle flights and a host of robotic science missions.

The temperatures, pressures and other extreme environments associated with liquid and solid rocket propulsion push the limits of engineering. Marshall has decades of experience in design, analysis and testing of everything from coatings and other materials to rocket nozzles and other structures and complete systems such as turbopumps. We also investigate bold new alternative propulsion systems. These include a range of innovations, from solar sails to nuclear-based technologies that could revolutionize future robotic and human exploration across the solar system.

National Institute for Rocket Propulsion Systems

Marshall has brought together stakeholders in government, industry and academia to formulate the National Institute for Rocket Propulsion Systems (NIRPS). The Institute's mission is to foster a vibrant rocket propulsion community that provides reliable and affordable propulsion systems for the nation's defense, civil and commercial needs.

Rocket and missile propulsion systems play a critical role in national security, space exploration, economic growth and education. Recent studies have warned that the supporting propulsion industrial base is eroding due to long-term industry downsizing, a shortage of new programs, limited career opportunities and rising pressure on discretionary federal budgets.

It is envisioned that NIRPS will be a multi-agency organization that policymakers can look to for comprehensive information about the state of technology, infrastructure and other issues affecting the propulsion industry.

The Institute will serve as a resource for collaboration among all sectors of the U.S. propulsion base to develop policy options, identify technology needs and required guidance and offer solutions that make best use of available national resources to meet future demand.

With a small staff based at Marshall, the Institute will operate mainly as a "virtual" organization, leveraging existing resources across the nation's propulsion base.

Learn more

http://nirps.msfc.nasa.gov

Living and Working in Space

Marshall creates the systems humans need to thrive in space and supports operations for scientific research in that challenging environment.

As NASA prepares for human exploration of the solar system, Center teams are researching and developing methods to protect humans and equipment from space weather and radiation. Building on expertise gained in developing the life support systems for the International Space Station (ISS), we are also working on systems to sustain crews during the long-duration missions to come.

In addition, Marshall scientists, engineers and technologists develop systems that support science operations and investigations on the ISS. The station remains an important vantage point for studying Earth and space and unites many nations through science and exploration. Our Payload Operations Center (POC) coordinates science operations on the station. This responsibility is pivotal to America's leadership role in the station's global partnership and builds collaboration that will be fundamental to future space ventures.

International Space Station

Marshall led the design, development and testing of the space station's **Regenerative Environmental Control and Life Support System (ECLSS)**. ECLSS "breathes life" into the station, providing water and oxygen for crew members and recycling waste water into usable water.

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

- Six **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.

ISERV, the ISS-SERVIR Environmental Research and Visualization System, will look through the WORF and can be tasked to acquire near-real-time data about environmental disasters occurring on Earth, transmitting the data within hours of the event.

Payload Operations Center (POC)

The POC at Marshall is the 24/7 command post for research and technology activities aboard the space station. The POC manages all U.S. science experiments, coordinates with the international partners and trains astronauts and ground team flight controllers.

The POC controls science operations remotely, receives vital information from the station through telemetry signals and monitors research operations using downlinked video. This facility is also a certified backup control center for the station and can support space station command and control if Johnson Space Center flight controllers must relocate here due to a hurricane or other emergency.

As the heart of space station science operations, the POC is fundamental to pushing the boundaries of our country's scientific frontiers.

Learn more

International Space Station Research & Technology
www.nasa.gov/mission_pages/station/research/index.html

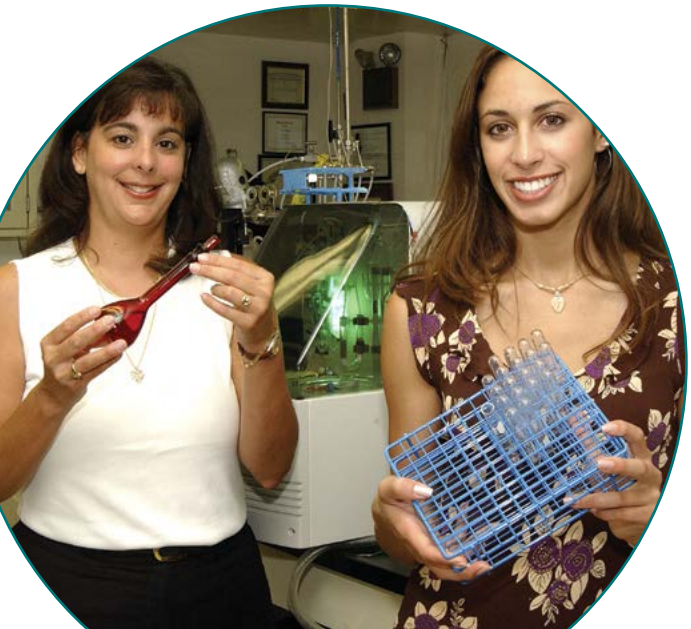
Payload Operations Center
www.nasa.gov/centers/marshall/shuttle_station/ops.html

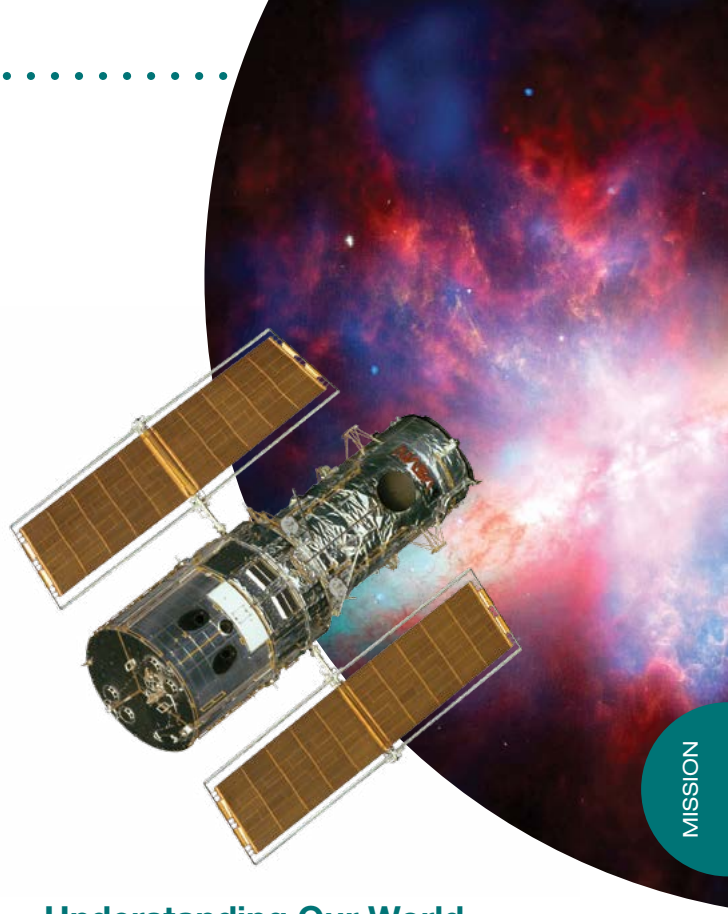
Future Systems

Whether working in the space station, traveling across the solar system or exploring the surface of a new world, humans will require innovations in systems and technologies.

Advancements in hardware and systems for generating and recycling life-sustaining resources will become increasingly important. Multiple "Atmosphere Revitalization System" projects, including the Atmosphere Resource Recovery and Environmental Monitoring (ARREM) system, are under way at Marshall. Our researchers are developing new and better ways to recycle air and maintain clean, healthy living spaces in the space station and in vehicles headed for deep space.

Marshall teams also develop materials, products, tools and technologies to mitigate the harmful effects of space weather and radiation on human and robotic explorers and their vehicles, science payloads and supplies. Our research and development efforts include planetary habitats and structures, dust management methods and debris shielding.





Understanding Our World and Beyond

Whether studying what's happening on Earth today or investigating phenomena at the edge of time itself, Marshall thrives on a strong synergy between science and exploration. Center teams use specialized scientific spacecraft and instruments and innovative research and monitoring techniques to explore our own planet and the worlds within and outside our solar system.

Marshall was instrumental in managing the design, development and construction of the **Hubble Space Telescope**. Hubble has helped us to see light-years away and to better understand the universe. We continue our legacy of advanced space research with the Chandra X-ray Observatory, the Fermi Gamma-ray Space Telescope and the James Webb Space Telescope.

Earth Science

Earth scientists at Marshall use satellites and other advanced technologies to collect data and conduct research on our global climate system. The information gathered is used for improving weather predictions, urban planning and natural resource and environmental management.

Weather Research and Prediction

- Marshall's atmospheric scientists are developing sophisticated instruments and technologies to examine the Earth's most intense storms. For example, the **Hurricane Imaging RADiometer (HIRAD)** maps wind and rainfall to determine the strength and structure of hurricanes. This information improves forecasts and helps minimize property damage and loss of life.
- Marshall pioneers improvements in weather prediction. Our **Short-term Prediction Research and Transition (SPoRT) Center** team "translates" high-resolution NASA scientific data for use by National Weather Service regional forecasters and models. These tools improve the accuracy of severe weather forecasts.

Environmental Monitoring

- The **SERVIR** program provides satellite-based Earth observation data and science applications to help developing nations in Central America, East Africa and the Himalayas improve their environmental decision making. The SERVIR system provides this critical information to help countries assess damage, respond to disasters and environmental threats and manage natural resources.
- Marshall also partners with public and private organizations to provide a system called Partnering Earth Observations for People Living Environmentally-Arctic Collaborative Environment, or **PEOPLE-ACE**. This system provides environmental information about the changing Arctic climate and environment to enable local, regional and international responses.
- In addition, Marshall's applied scientists provide satellite data and sophisticated modeling to the Center for Disease Control and Prevention (CDC) and public health officials. This information helps officials make informed decisions regarding public health concerns such as the impacts of infectious diseases and the effects of urban growth on climate and air quality. Our research is also applied to meet societal needs in such areas as agriculture and coastal environments.

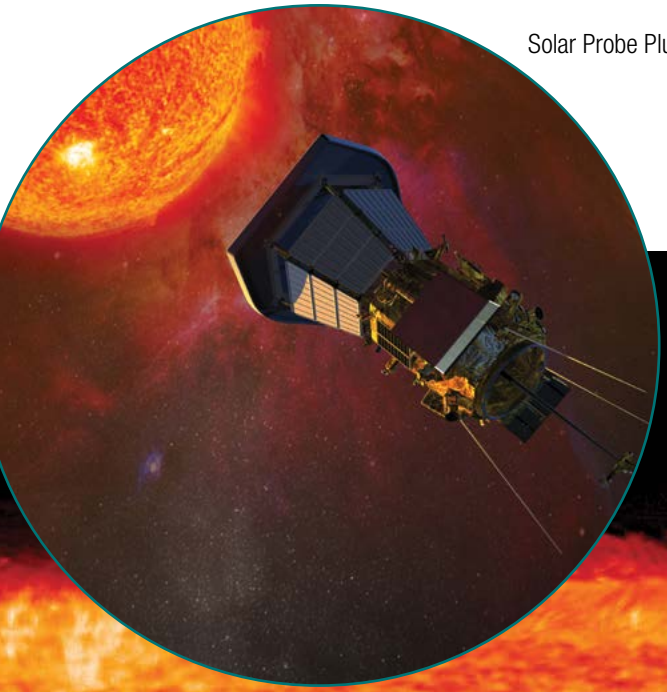
Learn more

www.nasa.gov/servir

Solar Science

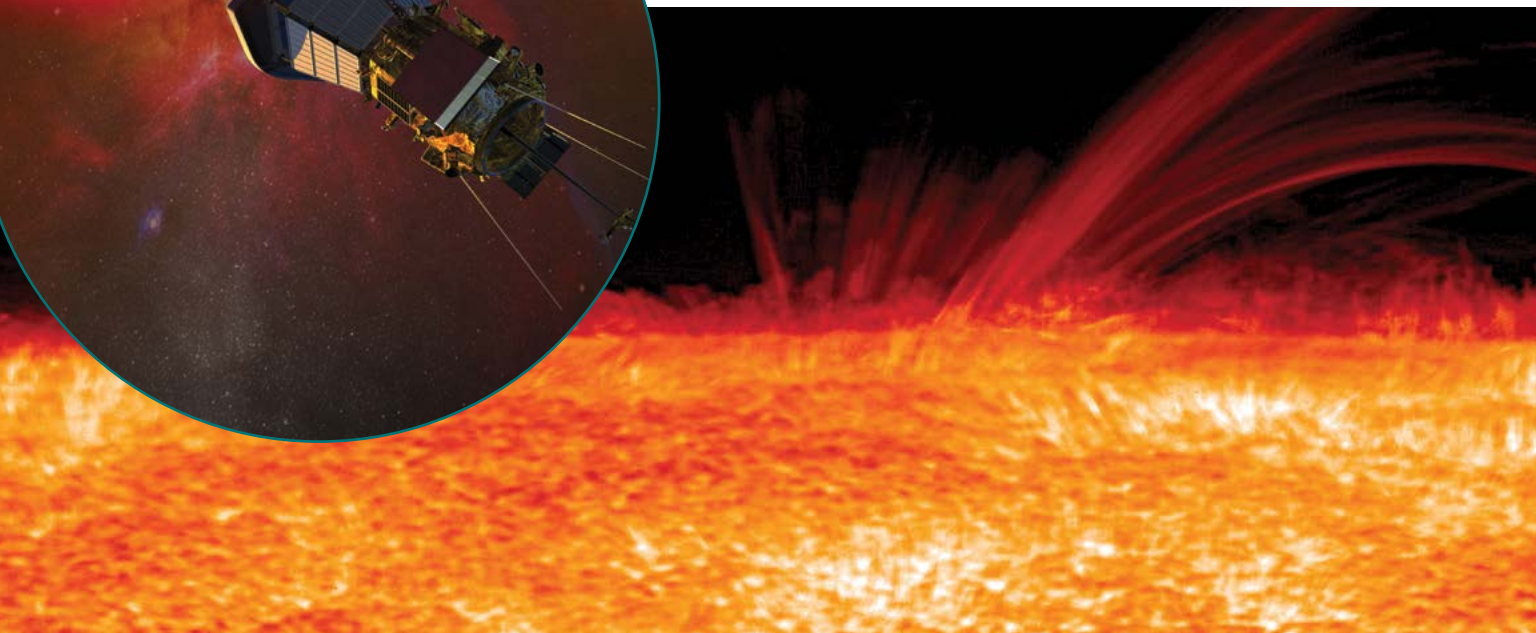
Marshall's solar physics team investigates how the sun works, why it changes and how these changes impact Earth and the space environment. Using everything from orbiting platforms to probes that plummet into the sun's corona, we provide unprecedented high-resolution images, map the sun's complex magnetic fields, measure solar radiation and characterize the solar wind.

- Marshall manages the U.S. portion of science operations for the **Hinode** mission, a collaborative endeavor of NASA; Japan's National Astronomical Observatory; and the space agencies of Japan, the United Kingdom, Norway and Europe. Hinode's measurements of the sun's magnetic field and ultraviolet/x-ray radiation will help NASA predict solar events that affect communication systems on Earth. Mission data will also help NASA develop ways to protect crews and electronic systems in space from harmful solar radiation.



Solar Probe Plus

- Marshall's Heliophysics team has partnered with Goddard Space Flight Center and the Smithsonian Astrophysics Observatory (SAO) to develop an instrument called **SWEAP**, or Solar Wind Electrons, Alphas and Protons. This instrument will ride aboard the Solar Probe Plus, the first mission to plunge into the sun's corona, where temperatures approach 2,600 degrees Fahrenheit. SWEAP will determine the structure and dynamics of the sun's magnetic field and its solar wind properties.
- The **Solar Ultraviolet Magnetograph Investigation (SUMI)** telescope is an advanced instrument built by a Marshall team to measure the strength and direction of the magnetic field in the sun's transition region. SUMI is helping to explain the genesis of explosive solar flares, raging sun storms and other perilous space weather.
- Solar physicists at Marshall are also working on the **High Resolution Coronal Imager (Hi-C) telescope**. Hi-C will image the sun at a higher resolution than ever previously achieved. One major scientific impact of its findings will settle a long-standing debate regarding the relationship of the sun's core temperature to its level of structure.



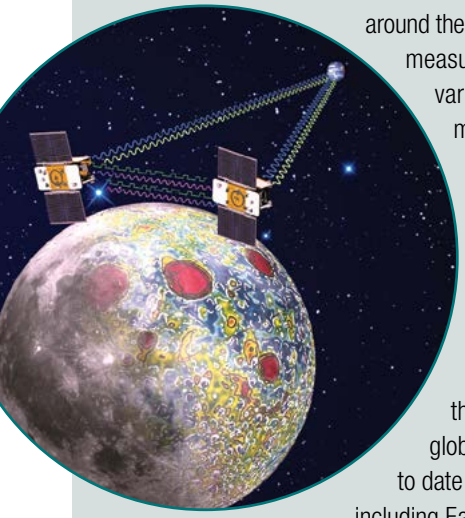
Lunar Science

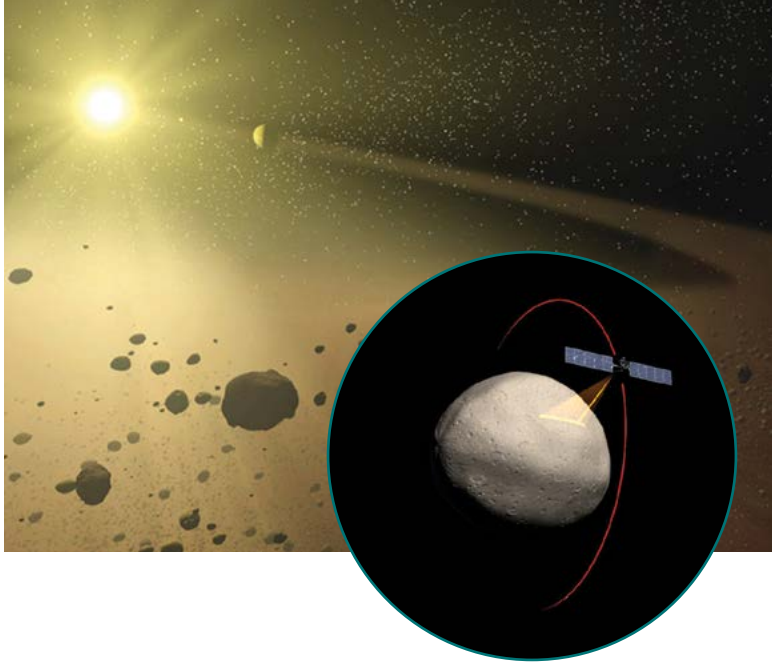
Marshall is preparing for robotic missions that will help engineers and scientists better understand the moon's environmental conditions and available resources.

NASA's Lunar Quest Program at Marshall manages these lunar missions:

- **Lunar Atmosphere and Dust Environment Explorer (LADEE)** will gather detailed information about conditions near the moon's surface and about the environmental influences on lunar dust.
- **Lunar Reconnaissance Orbiter (LRO)** is providing a comprehensive atlas of the moon to help scientists and engineers find safe landing sites, locate potential resources, understand the environment and demonstrate new technologies.
- **Lunar Mapping and Modeling Project (LMMP)** integrates data from these robotic missions with existing information to develop maps and models that enable the design of a lunar outpost.

NASA's Discovery Program at Marshall manages the **Gravity Recovery and Interior Laboratory (GRAIL)**. Launched in 2011, it involves twin spacecraft called "Ebb" and "Flow" flying in tandem around the moon to precisely measure and map variations in the moon's gravitational field. Scientists will use this information to determine the structure of the lunar interior from crust to core, resulting in the most accurate global gravity field to date for any planet, including Earth.





Discovery and New Frontiers

Marshall manages the Discovery and New Frontiers programs. These highly successful planetary science programs provide mission opportunities that complement the Agency's larger planetary exploration goals. Missions include flybys, orbiters, landers and sample returns. They probe the nooks and crannies of our solar system, unveiling never before seen worlds and enthralling us with unprecedented close-up views of those we have seen only at a distance.

Learn more

Lunar Quest Program
www.nasa.gov/lunarquest

Discovery Program
http://discovery.nasa.gov

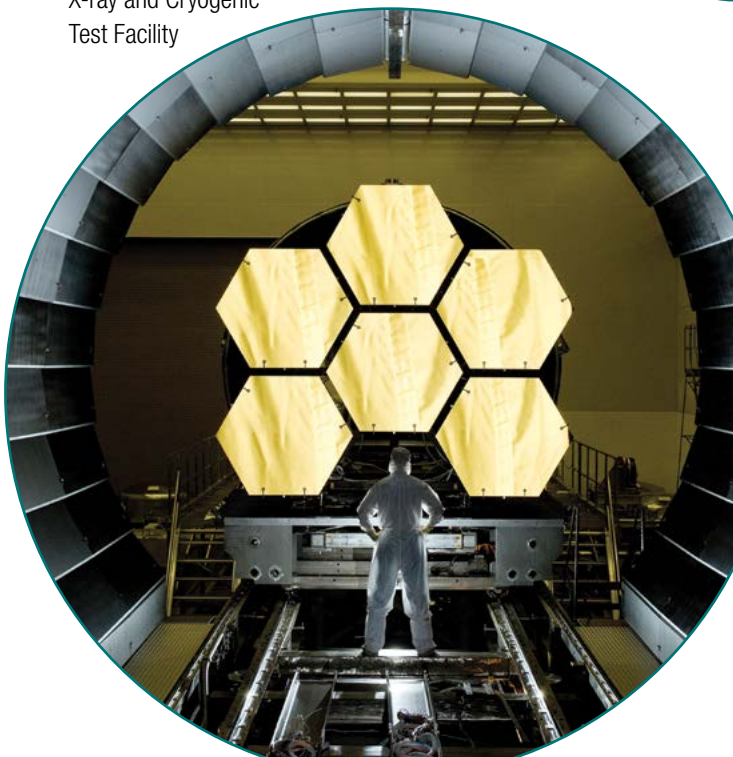
New Frontiers Program
http://newfrontiers.nasa.gov/

Exploring Our Universe

To explore the universe and its infinite wonders, NASA-created space-borne technologies and instruments "see" in different electromagnetic wavelengths such as visible light, gamma rays, X-rays and infrared. Marshall scientists design, develop and test these sophisticated techniques and instruments in the Center's specialized facilities.

- Marshall provides scientific expertise and management for the **Chandra X-ray Observatory**, including development, construction and current operation. The universe is a place of sudden and chaotic violence, teeming with supernova explosions, million-degree clouds of intergalactic gas and seething disks of torn-up matter swirling around black holes. Chandra, with its unique ability to see this crucial hot world that holds the key to many scientific mysteries, is helping scientists understand the evolution and structure of the universe.
- The **Fermi Gamma-ray Space Telescope** is making pioneering observations of gamma-ray bursts (GRBs), the highest detectable form of electromagnetic radiation, at higher energies than ever before observed from space. In GRBs, we may be seeing the first generation of stars, from the earliest galaxies created after the Big Bang. Not only do GRBs help scientists learn about our universe's history; they also help explain its physics. Marshall developed the Gamma-ray Burst Monitor (GBM), an instrument on board Fermi. Together, the Fermi Large Area Telescope and GBM detect and analyze gamma ray bursts with unprecedented precision and coverage.
- The **James Webb Space Telescope (JWST)** is an infrared observatory that can look back in time to find the first stars and galaxies that formed in the universe. Marshall teams used our world-class X-ray and Cryogenic Facility to conduct cryogenic optical testing of the telescope's primary mirror segments. Marshall will also test other JWST flight and ground hardware elements. The telescope is targeted to launch in 2018.

X-ray and Cryogenic Test Facility



Keys to the Future

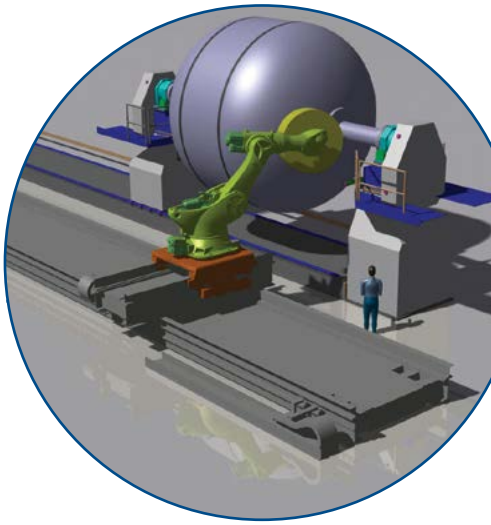
Solving the unique challenges of space exploration

Marshall is building partnerships and developing revolutionary technologies to solve the unique challenges of space exploration.

Our innovative engineers, technologists and scientists leverage proven capabilities in propulsion, space transportation, space systems and scientific research to partner with industry, academia and other government agencies. These partnerships generate solutions for future space adventures—solutions that, in turn, benefit us here on Earth.

Healing Technology for Cancer Patients

NASA light technology for plant growth experiments in space eases the painful side effects of cancer treatment and aids the healing of wounds, burns and diabetic skin ulcers. The High Emissivity Aluminiferous Luminescent Substrate, or HEALS, provides the equivalent light energy of 12 suns from each of 288 LED chips—each the size of a grain of salt.



Technology Development

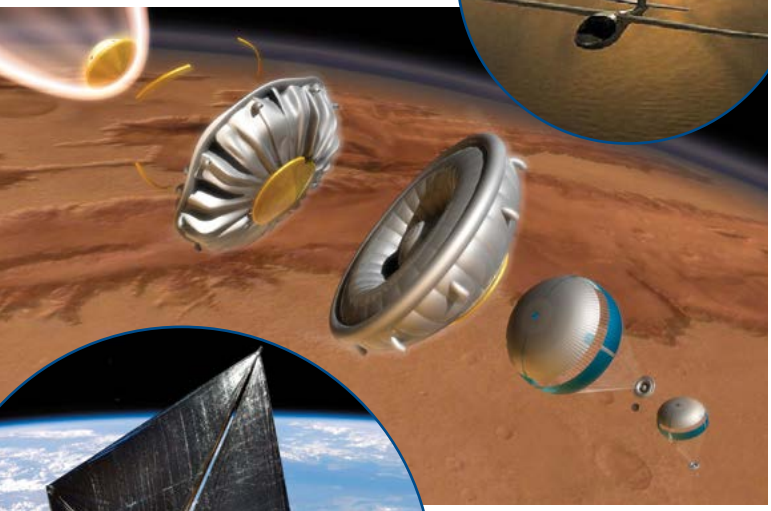
Marshall technology breakthroughs range from new developments in space transportation and propulsion to key advancements in space systems and science research.

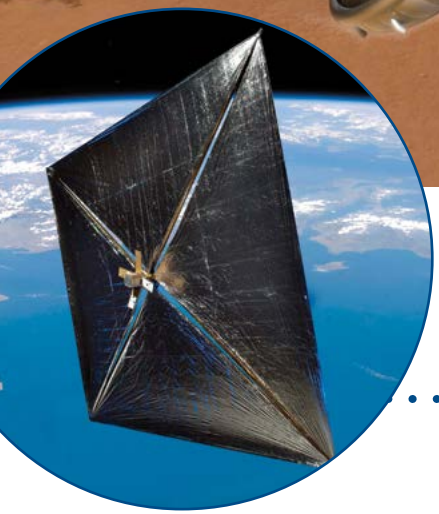
We're learning to build vehicles and systems that can self-diagnose and solve issues in flight. We're developing ways to harvest critical materials on other solar system bodies for fuel or life support. We're investigating new composites to build lighter, safer rocket propellant tanks and other flight hardware. And we're using state-of-the-art facilities to analyze space weather; build sophisticated new sensors and measurement systems; and conduct testing for high-profile NASA missions.

On behalf of NASA's Space Technology Program, Marshall hosts two technology program offices: NASA's Centennial Challenges and the Technology Demonstration Missions program.

NASA's Centennial Challenges

Centennial Challenges are technology prize competitions created in 2005 to inspire innovation and encourage the entrepreneurial spirit. The program challenges enterprising individuals, small businesses and student groups to come up with innovative solutions for technical problems of interest to NASA and the nation. Projects range from inexpensive transportation power systems to low-cost ways of returning samples from planets, moons and other destinations across the solar system. These solutions can have a significant impact on the evolution of existing technologies such as the formation of a new, ground-breaking concept design, product, or business venture.





Technology Demonstrations

The Technology Demonstration Missions program, managed for NASA by Marshall, helps revolutionary, system-level technologies "bridge the gap" between laboratory development and demonstration in space.

The program office at Marshall oversees nine projects, each carefully matured to flight-readiness status through intensive laboratory and field testing, each with the potential to transform the way we live and work in space, each upholding NASA's long and successful history as a technology innovator for the nation.

Projects now under way include:

- An autonomous landing hazard avoidance technology permitting planetary landers to recognize a targeted landing site, assess potential hazards and course-correct in real time during descent.
- New advances in cryogenic propellant storage and transfer to prevent fuel loss and enable new missions beyond low-Earth orbit.
- Testing to demonstrate how telerobotics — the remote control of robotic arms, rovers and other devices — can protect astronauts and enhance productivity in space.
- Breakthrough flight technology demonstrating the use of inflatable structures to slow spacecraft descending through planetary atmospheres.
- Heat shield instrumentation (part of NASA's Mars Science Laboratory mission) designed to rewrite thermal protection hardware design for future planetary landers.
- A small-satellite project to deploy and operate a nearly 13,000-square-foot sunlight propelled sail — an inventive alternative to conventional propellant-based spaceflight.

Collaborative Partnerships

Marshall shares its facilities and expertise through partnerships with industry, academia and other government agencies, to the mutual benefit of all.

Marshall's Partnerships Office is the vehicle for this collaboration. The Office pursues new and innovative approaches to pair the Center's capabilities with external customer needs and to pair external partner expertise with Center needs. By emphasizing long-term relationships and understanding commercial business requirements, Marshall is transforming conventional government approaches to doing business.

NASA's **Innovative Partnerships Program**, managed at Marshall, works with industry partners to spin off space technology and adapt it for cutting-edge applications across the medical, communications, safety and transportation industries and more.

Our **Small Business Innovation Research Program** and **Small Business Technology Transfer Program** have contributed to technologies that make clean drinking water available throughout the world, alleviate chronic pain for soldiers and civilians and deliver artificial intelligence based technology to improve tutoring programs.

Technology transfer promotes commercial activity, encourages economic growth and stimulates innovation in business and commerce.

Photo credit: Water Security Corporation

NASA Spinoff Technologies

Reflecting on Space Benefits—A Shining Example

Reflective insulation technology developed to keep spacecraft and astronauts safe and functional in the extreme environment of space is now used to make insulating blankets that comfort and warm victims of natural disasters.

The blankets also protect marathoners from hypothermia after their grueling races, keep football fans warm in outdoor stadiums and have even kept manatees warm in a tag and release research program.

Cleaning Oil Spills from Land

Phototrophic cells developed for water purification in space are now cleaning up environmentally damaging oil spills such as that from the catastrophic 2010 oil rig explosion in the Gulf of Mexico. This technology, which packs millions of photosynthetic bacteria into a single cell, also remediates wastewater systems and waste from livestock farms and food manufacturers.

Success through Partnerships

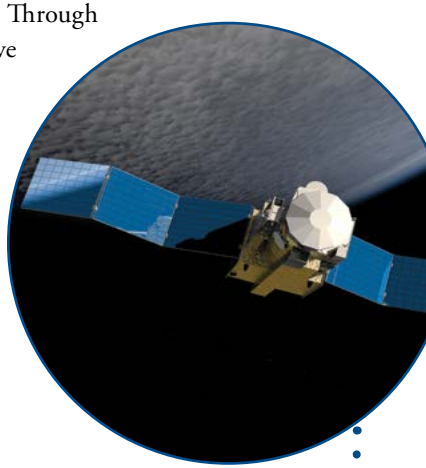
Sierra Nevada Corporation needed facilities and expertise to test a new spacecraft design for transporting crew and cargo to and from the International Space Station. Marshall's experience and unique tri-sonic wind tunnel offered a proven way to test the company's Dream Chaser vehicle. The result was a time and cost savings for Sierra Nevada and potential future work for joint development, testing and operations of advanced space systems.

Artist rendering of Sierra Nevada Corporation's Dream Chaser space plane. SNC is building this space shuttle-like human spacecraft for NASA to provide astronaut transport to the space station.

Robert Lightfoot, left, Marshall Center Director, and Mark Sirangelo, head of Sierra Nevada Space Systems, sign a Space Act Agreement to allow the company to conduct wind tunnel testing on a new spacecraft design. (Sierra Nevada/Steve Crecelius)

Capabilities

Marshall's highly experienced employees, equipped with unique facilities, have led some of America's most exciting space endeavors. Through this strong legacy, we have developed a portfolio of capabilities focused to align with the nation's and the Agency's needs. Our industry partners often seek access to this distinctive expertise through agile tools such as the Agency's Space Act Authority.



We do the hard stuff, start to finish.

- Research, develop and test new propulsion technologies.
- Create and test advanced materials, processes and designs for rockets, spacecraft systems and science instruments to withstand the rigors of space.
- Research, develop, build, integrate and test new space systems.
- Define, develop and operate exploration missions and the scientific experiments on board.

As NASA works with American companies to open a new era of access to space, Marshall seeks innovative and transformative fuels that are less harmful to our environment.

Artist's image of a satellite in orbit. Satellites run off a highly toxic fuel called hydrazine. Marshall is seeking green propellant alternatives to the highly toxic fuel. (NASA)

Key Marshall Propulsion Capabilities

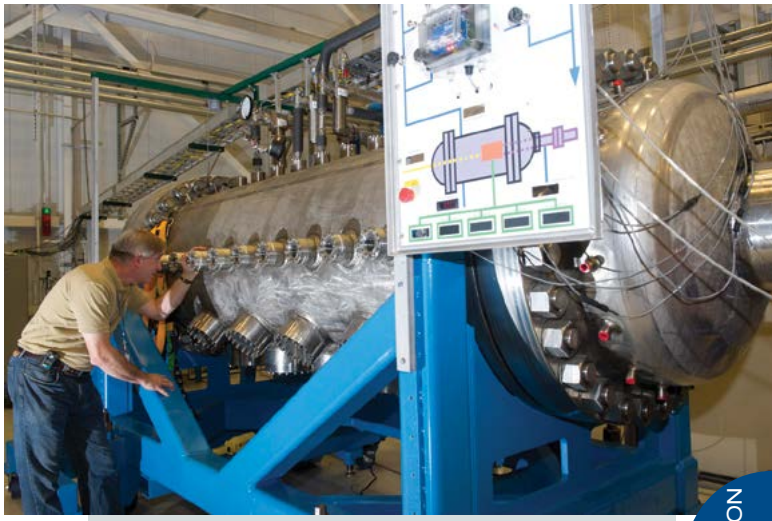
- Computational fluid dynamics
- Materials diagnostics, nondestructive evaluation and failure analysis
- Material technology and development
- Mechanical propellants, pressurants and calibration
- Propulsion systems research and technology
- Propulsion testing
- Thermal systems design

Propulsion

Marshall researches, develops and matures propulsion technologies for space transportation and science missions. We contribute engineering expertise for all transportation phases, including boost, upper stage and in-space applications.

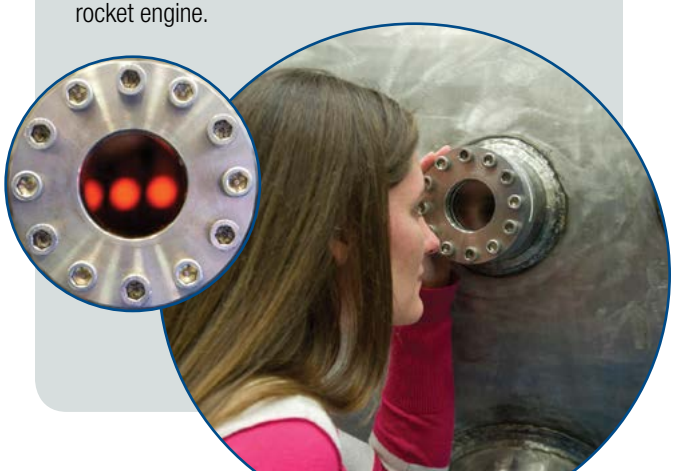
With these capabilities we develop and test

- Propulsion systems such as chemical, electric, nuclear and propellant-free systems such as solar sails.
- Engines and solid rocket motors, from micro-thrusters to systems producing millions of pounds of force.
- High-speed turbines, such as the J-2X turbopump, for rocket propulsion.
- Propulsion components in extreme temperatures and flow conditions.



INNOVATION

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.



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

Space Transportation/Launch Vehicles

Marshall know-how is manifest in every stage of spacecraft and launch vehicle development. Expert teams at Marshall develop, test and evaluate materials, processes, designs and systems as well as full-up vehicles like the nation's new Space Launch System. Our comprehensive approach ensures safety, quality and cost-effectiveness.

With our space transportation capabilities we perform

- System design and analysis 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.

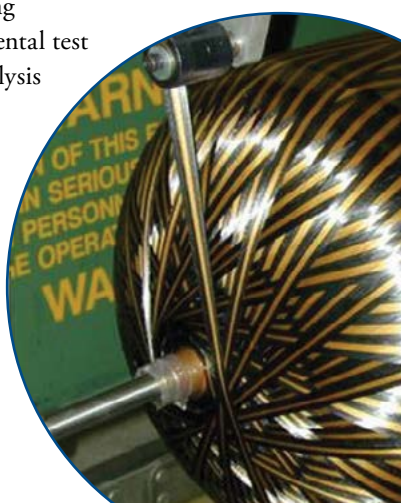
Marshall engineers use the Collaborative Engineering Design and Analysis Room (CEDAR) to study design and simulations of exploration projects.

Advanced Weld Process Development Laboratory

Welding and manufacturing teams at Marshall manage metal joining and manufacturing processes for a wide variety of applications including large propellant tanks and primary vehicle structures. The Advanced Weld Process Development Laboratory is part of the National Center for Advanced Manufacturing (NCAM) at Marshall.

Key Marshall Expertise

- Advanced concepts and architectures
- Advanced manufacturing
- Avionics and electrical systems
- Control systems design, development and analysis
- Damage tolerance and fracture mechanics
- Large-scale manufacturing
- Structural and environmental test
- Systems engineering, analysis and integration
- Vehicle development and integration



Composites Manufacturing

Space Systems

Marshall has long been a leader in developing large space structures and the space systems that support them. Our contributions have included the Lunar Roving Vehicle, Skylab, Spacelab, and International Space Station modules. Many of Marshall's space systems are showcased in the ISS:

- Logistics modules and connecting "nodes"
- Materials Science Research Rack (MSRR) experiment integration
- Environmental Control and Life Support System (ECLSS)
- Our Payload Operations Center, the space station's primary science command post
- Microgravity Science Glovebox

With a range of space systems capabilities, Marshall is laying the foundation for a new era of space exploration.

Key Marshall Expertise

- Advanced concepts and architectures
- Avionics and electrical systems
- Control systems design, development and analysis
- ECLSS design and development
- Material technology and development
- Mission operations
- Optical systems technology, development and integration
- Payload systems technology, development and integration
- Space environments and effects

The Fast, Affordable, Science and Technology SATellite (FASTSAT) Microsatellite was designed, built and tested at Marshall. FASTSAT is NASA's first microsatellite designed to enable scientific and technology payloads, or rideshares, to be flown at lower cost than previously possible. Marshall also manages mission operations for FASTSAT.

Marshall solar physicists and engineers designed and built the Solar Ultraviolet Magnetograph Investigation, or SUMI, to determine the strength and direction of magnetic fields in a region of the sun where the magnetic field has never been measured.

Science

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

Our scientists

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

Key Marshall Scientific Expertise

- Advanced concepts
- Control systems design, development and analysis
- Earth science research and applications, heliophysics, high-energy astrophysics and planetary science research
- Mission operations
- Optical systems technology, development and integration
- Payload systems technology, development and integration
- Space environments and effects
- Structural and environmental test
- Thermal systems design

Visiting Marshall

Because access to Redstone Arsenal is restricted, visitors to Marshall must have prior approval to visit and must obtain a badge at the Redstone Arsenal Visitor's Center at Gate 9 on Research Park Boulevard/Rideout Road South or at Gate 10 on Martin Road.

The Official Visitor Information Center for Marshall is located at the U.S. Space & Rocket Center. Interactive exhibits and unique historic artifacts demonstrate Marshall's critical role in supporting NASA's missions.

www.ussrc.com
256–837–3400
1–800–63SPACE

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256–544–0034

History Office
256–544–6840

Legislative Affairs
256–544–2030

Community and Industry Relations
256–544–4052

NASA Educator Resource Center
256–544–5812

Freedom of Information Act (FOIA) Requests
256–544–1837

Marshall Partnerships Office
msfc-saa-@mail.nasa.gov

NASA's exhibits program presents informative displays, models, artwork and technology demonstrations to museums, conferences, schools and other sites around the country.

The Speakers Bureau connects Marshall volunteers to schools, community groups, museums and other venues throughout a six-state region including Alabama, Tennessee, Arkansas, Missouri, Iowa and Louisiana. These volunteers reach out to an estimated 12,000 people each year.

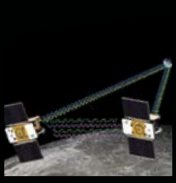
Request a Speaker or Exhibit
www.nasa.gov/centers/marshall/about/request.html

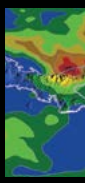
Speaker Requests
256–544–1715

Exhibit Requests
256–544–6541

Somewhere, something incredible is waiting to be known.

– Carl Sagan





National Aeronautics and Space Administration

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