National Aeronautics and Space Administration

Materials Technology and Development

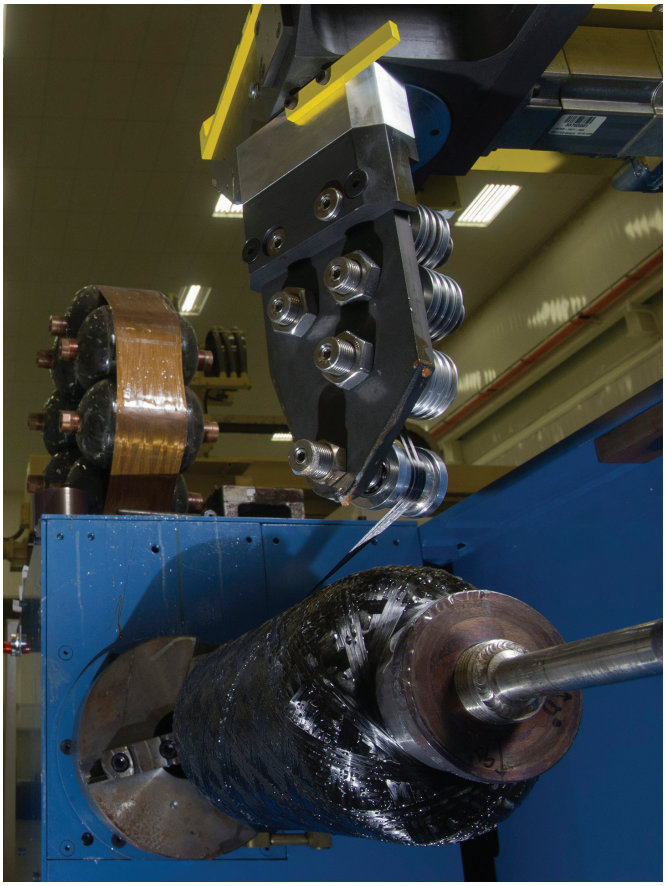
Optimizing Processes To Speed Design Solutions

In order to ensure the affordability, reliability and strength and minimize the mass of space launch and space system elements, designers must identify and qualify the optimal materials for use, as well as the processes to be applied during manufacturing. The Marshall Space Flight Center excels in identifying and selecting material and process options during design without interrupting or compromising development schedules. Because Marshall is able to develop processes in-house, its materials specialists bring to bear a depth of experience in timely materials selection that is hard to match. Marshall possesses special expertise in composite and lightweight materials, large scale structures and propulsion elements and comprehensive test and process simulation capabilities to further speed the selection process.

As a leader in process development and optimization, Marshall is home to a full-service materials research, development and manufacturing laboratory, including more than a dozen critical test facilities and a complementary suite of tools to evaluate chemical and microstructural characteristics, mechanical and fatigue properties, tribological and corrosion effects, and the influence of extreme temperature and pressure environments. The Center's materials engineers and technologists possess the hands-on experience and cutting-edge expertise to make timely, effective use of these facilities to benefit the work of NASA, its partners and the nation.

At-A-Glance

The experience and expertise of Marshall engineers and technicians enables them to select materials and optimize processes without interrupting work already underway. Any materials selection group will offer an "optimal" solution; Marshall's leaders in materials technology and development offer an optimal solution that fits best with real-world project development needs.



Marshall tests composite materials to enable lightweight design solutions.

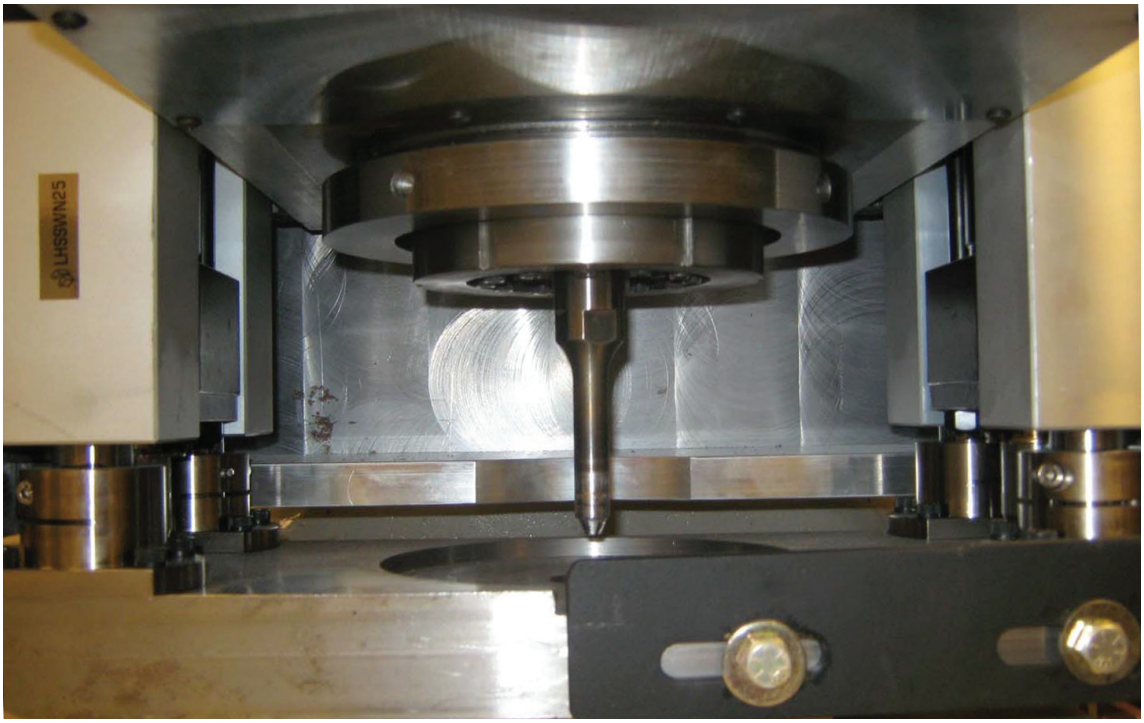
Timely Materials Selection To Enhance System Performance

New materials are constantly needed that deliver greater performance, improved cost effectiveness, superior reliability and better safety, while also minimizing environmental impact. Responsible for the selection, development and optimization of materials and advanced processes, the experts at Marshall are critical to ensuring the quality and performance of NASA's space launch and space system elements.

Marshall engineers have special expertise in composite and lightweight materials, propulsion materials and comprehensive test and process simulation capabilities to further speed the selection process. They frequently are called upon by government and industry partners to develop and optimize advanced processes for new aerospace materials. They also design and execute certification programs for the use of specialty alloys and product forms in crewed space hardware design.

Obsolescence Mitigation and the Materials Replacement Program
Obsolescence mitigation is an important aspect of Marshall's materials selection expertise. Environmental regulations, industrial process development, and materials technology advancements all drive new requirements and considerations into the selection of appropriate materials. Leveraging the Center's broad base of material properties and analysis knowledge, new materials can be found quickly to replace those that are unavailable or obsolete without impacting ongoing design cycles or production schedules.

Marshall offers a comprehensive program for replacement of thermal protection system materials that have become obsolete due to loss of suppliers, environmental regulations or changes in the manufacturing process. The program analyzes the impact of a change in materials, develops programs to demonstrate equivalence to prior materials and evaluates the capability and performance of newly developed materials.



Ultrasonic stir welding processes using portable tools will enable in-space fabrication and repairs.

Meeting Production Challenges in Real Time

Proximity to working commercial production lines — and co-location with Marshall's propulsion, structural, thermal and test facilities — enables materials engineers and technicians to work side-by-side with customers, solving real-world production challenges with minimal impact to the manufacturing flow, and delivering practical, timely solutions that meet today's needs and maintain preparedness for tomorrow. These facilities allow the Center to support any facet of materials characterization or ongoing production process analysis, while constantly advancing the state-of-the-art in materials technology and process development.

Advanced Weld Process Development Laboratory

As aerospace materials continue to evolve, sophisticated manufacturing processes must be designed for their use. Specializing in the transfer of advanced joining process from the laboratory to full-scale manufacturing of large, complex structures, this facility provides a range of advanced joining processes including friction stir welding, ultrasonic welding, variable polarity plasma arc welding, tungsten inert gas welding, electron beam welding and brazing.

Ceramic Matrix Composite Development Facility

Working to promote the use of CMC materials for propulsion, structures and thermal protection system needs, this facility has aided in CMC development for the Orion Launch Abort System; carbon-fiber-reinforced carbon for large-liquid engines and winged hypersonic vehicles; and development of advanced ceramic fuel elements for nuclear thermal propulsion.

Cryo-insulation Development Facility

Cryogenic Fluid Management (CFM) technology is an integral part of exploration systems for Earth-to-orbit transportation and crewed missions to the moon and Mars. The Cryo-insulation Development Facility provides the ability to apply primers and spray-on foam insulation (SOFI) materials to large-scale test articles, and maintains capability for cryogenic testing, chemical fingerprinting, robotic and manual foam spray operations, raw materials acceptance and personnel certification.

Subscale Solid Rocket Motor Processing Facility

This facility is used to find alternative materials for solid rocket motor applications that have suffered from material obsolescence issues. Its unique, proven plasma torch test bed (PTTB) enables engineers to evaluate a material's ability to protect against the plume environment and to validate material and process changes before implementation on full-scale motors.

Fifty Years of Cutting-Edge Solutions

Built on proven knowledge and successful delivery of flight-ready vehicles, structures, propulsion systems, and thermal protection systems, Marshall's expertise in materials technology and development constantly is honed, updated and expanded by practical, in-house research and development activities and by partnerships with commercial manufacturers, research institutions and standards organizations.

Fifty years of frontline experience in building complex systems, developing new manufacturing processes and resolving investigative actions has taught Marshall engineers how to deliver cost-effective, real-world solutions to meet the development program's needs.

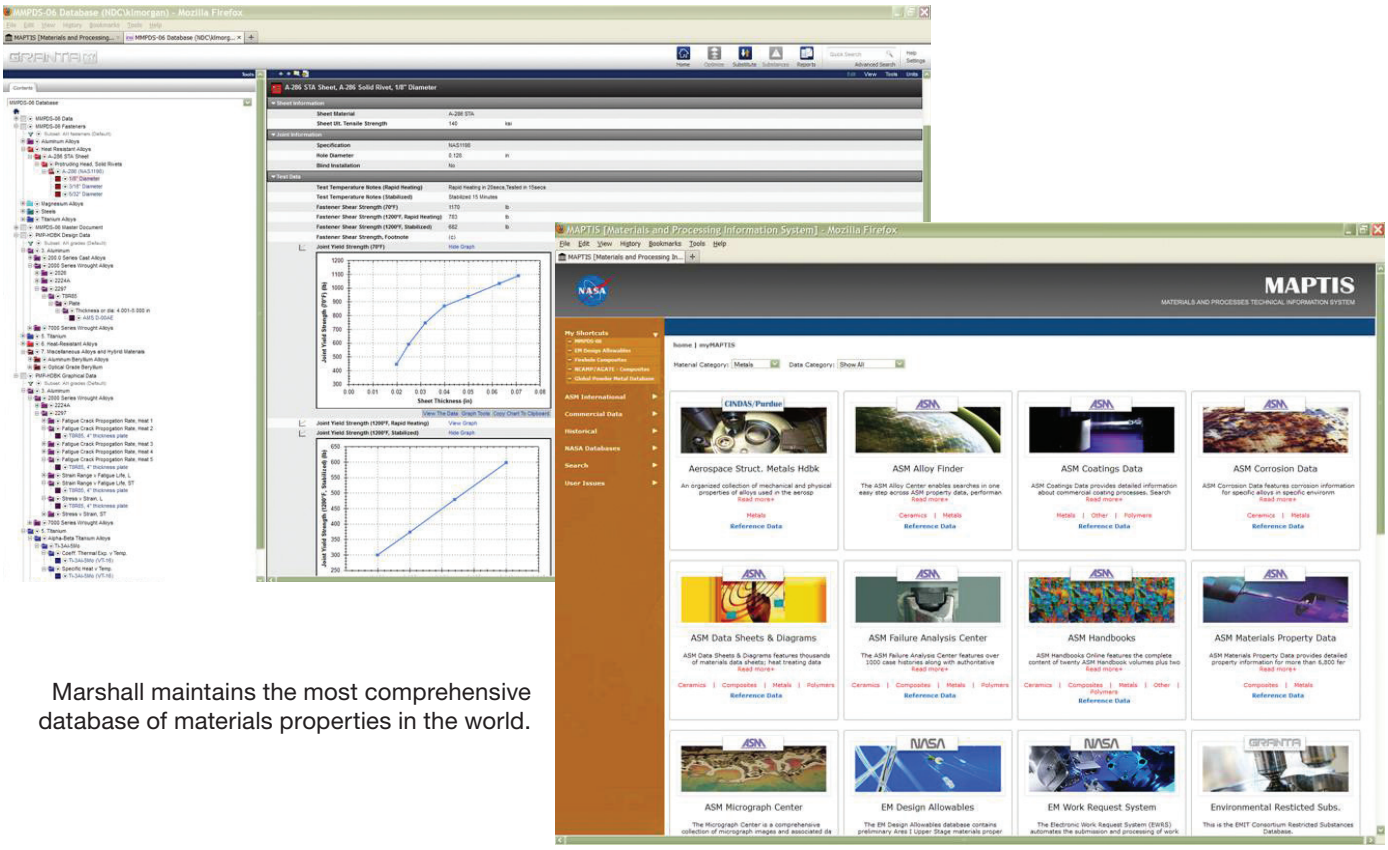
Marshall materials and technology accomplishments include:

- Development of tooling and weld schedules for the core stage of the Space Launch System
- Fabrication of a 27.5-foot-diameter shell-buckling barrel assembly to validate and update models for launch vehicle core structures
- Development of a novel approach to manufacture large-scale aluminum-lithium spin-formed domes
- Design, development and manufacturing of laser and electron-beam welding techniques to manufacture flight hardware and components of the Environmental Control and Life Support Systems aboard the ISS
- Fabrication of tungsten-based uranium dioxide CERMETs and mixed uranium carbide fuel elements for nuclear thermal propulsion
- Development of cleaners, primers, conversion coatings and anodized surfaces for the replacement of hexavalent chrome containing corrosion protection materials

Unmatched, Accessible Body of Materials Knowledge

Marshall's Materials And Processes Technical Information System (MAPTIS) provides an efficient and reliable means of supplying information needed for the selection and application of materials and processes to produce the hardware required for NASA and industry space missions. This unique resource is used throughout the aerospace community and beyond as a central clearing-house of properties data for more than 32,000 materials, drawn from more than 30+ materials property databases within NASA, DOD and other government agencies, and private industry. This extensive knowledge base furthers Marshall's ability to provide rapid materials selection expertise to Agency programs and external partners.

More than just a catalog of materials and properties, MAPTIS takes advantage of lessons learned from past failures and problems to avoid similar issues in future projects. The materials characterization data also allows projects to forego costly and redundant materials testing. New data is continually added to the system from ongoing material testing and analysis, and existing materials are updated to reflect any environmental, safety, and health classifications that might limit their use in specific applications.



Marshall maintains the most comprehensive database of materials properties in the world.

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

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