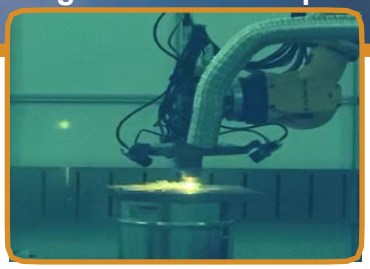
National Aeronautics and Space Administration

Marshall Space Flight Center
Additive Manufacturing

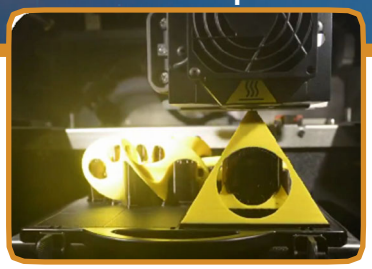
Engineering Solutions for Space Science and Exploration

Stereo Lithography

Selective Laser Melting

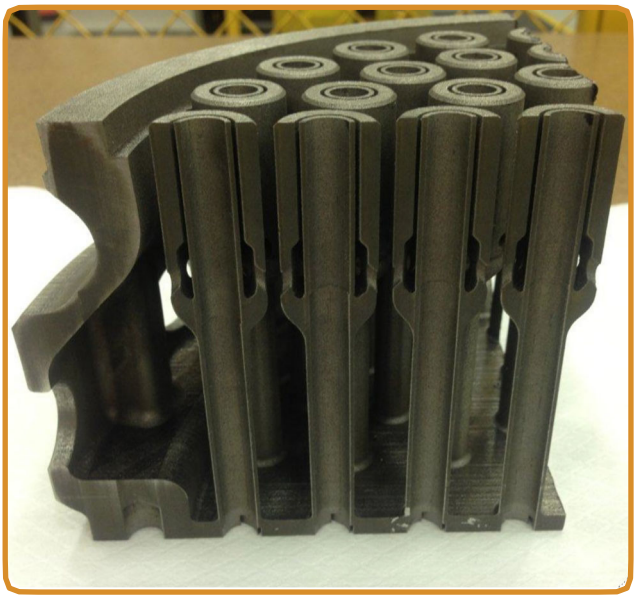


Directed Energy Deposition



Fused Deposition Modeling

Additive Manufacturing capability at Marshall Space Flight Center (MSFC) has taken on a superior ranking in terms of world class manufacturing. Complex machining can now be reduced for much of a liquid rocket engine's subassemblies and other flight hardware as selective laser melting (SLM) and Directed Energy Deposition (DED) development continues to take place. Over the last three decades this field has transformed from making inexpensive prototyping parts to developing actual flight and liquid engine components. MSFC is heavily involved in the field of AM certification, developing industry AM standards to ensure process control and continued product integrity. MSFC continues to expand collaborative partnerships across industry and academia as AM technology continues to advance at a rapid pace.

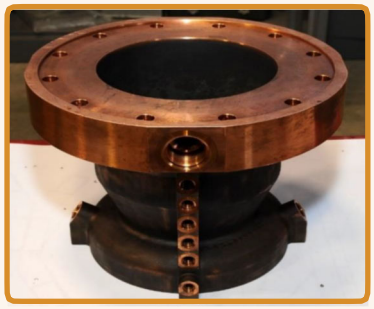


Additive manufacturing (AM), also referred to as 3D printing, is a process of making three dimensional solid objects of virtually any shape from a digital model. Parts are built up in layers from many materials such as resins and metallic powders (nickel-based alloys, titanium, aluminum, and copper to name a few). Traditional manufacturing processes often restrict engineering designs because of limitations in subtractive machining methods (reshaping standard ingots or blocks of material using mills, lathes, drills, etc.), welding and assembling. Complex shapes, which were previously impossible to produce, are now possible using AM, providing more design freedom for engineers; internal cooling passages, complex helical or vortex shapes, integrated assemblies, etc. By reducing the number of subassemblies, the number of seams and mating surfaces is reduced (minimizing the chance for leaks) and the number of machining/welding steps is reduced (titanium is very difficult to machine). AM has significantly reduced the cost and time (between 40-80% depending upon the shape of the part and material) to manufacture parts.

Capabilities

Additive Manufacturing Development

- Expertise in the design and manufacture of plastic and metallic AM components.
- Heavily focused on flight hardware development and alloy characterization for SLM and DED.
- Provide AM technical expertise and guidance through partnerships and collaborations with outside organizations.
- Heavily focused on AM certification and working with industry partnerships to enhance AM technology.

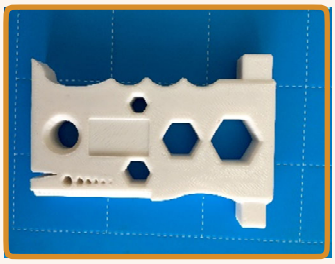


SLA

SLA is primarily used for tooling and mockups, offering high resolution with a quick turnaround time. Build volume up to 508 x 508 x 584 mm

FDM

FDM is used for flight hardware production as well as tooling and mockups, offering a variety of high strength materials. Build volume up to 914 x 609 x 914mm



SLM

SLM is primarily used for flight hardware development and alloy characterization, offering high strength and high resolution. SLM is the primary candidate AM technology for liquid rocket engine modernization and AM certification efforts. Build volume up to 400 x 800 x 500 mm

DED

DED is the latest addition to our AM equipment portfolio, enabling rapid production of large scale, near-net shape hardware. Build volume up to 12 x 8 x 10ft

Key Benefits

> Rapid, complex component manufacturing featuring a wide variety of material and equipment options

> Development of AM design and manufacturing guidelines for U.S. Industry

> Exceptional combination of experience and facilities

For more information, please visit www.nasa.gov/centers/marshall/about/business.html

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