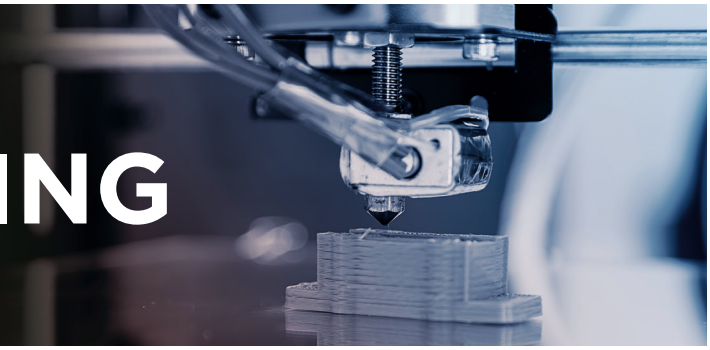
ADDITIVE MANUFACTURING

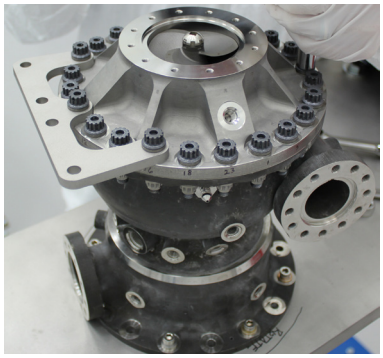
REVOLUTIONIZING WHAT WE MAKE



WHAT IS ADDITIVE MANUFACTURING?

Additive manufacturing (AM) is the class of manufacturing and production techniques characterized by the sequential addition of material over time to create a new three-dimensional object, such as a mechanical part, from a computer file. This is different from more traditional milling-based processes that subtract material from a block or molding processes where material is injected and cast into shape.

The aerospace industry already uses additive manufacturing for rapid prototyping and custom parts for which it is not economical to create new production lines. The industry is also creating highly-integrated AM parts and assemblies that dramatically reduce weight, production waste, and component counts.

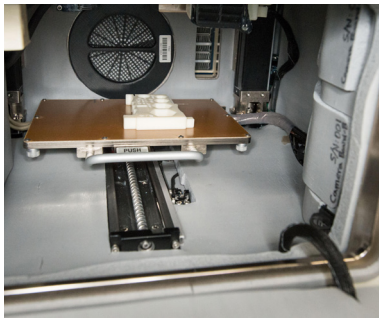


TECHNOLOGIES & APPLICATIONS

Additive manufacturing technologies include powder fusion methods that use extreme heat to form solid shapes from small granules, additive layer manufacturing methods where melted materials are added layer-by-layer, and resin-based methods where liquids are solidified using light.

The specific applications of these methods vary with the selected materials, such as metals and plastics, and the intended use. Examples include:

- GE Aviation used design for additive manufacturing to reduce the number of parts in a helicopter engine from 900 to only 16.
- Aerojet Rocketdyne printed a copper thrust chamber that reduced production time by 50 percent.
- The Additive Manufacturing Facility on the International Space Station is operated by Made In Space, Inc. as the first commercial manufacturing service in space.



POLICY ISSUES

In the aviation sector, the FAA has jurisdiction for regulating all aircraft parts. Clear guidance on how to meet existing compliance regulations is needed. Companies need a consistent rubric to ensure quality and safety standards are met without imposing new regulations that unfairly disadvantage AM parts.

In the space sector, different customers often have their own compliance requirements. While ground-based AM parts for space systems can be compared against conventional equivalents, the advent of on-orbit 3D printing indicates a future where quality must be assured for each manufactured product. The definition of those standards and compliance guidelines to meet those standards are still open questions.

WHAT'S NEXT

New technologies are increasing the speed, precision, and quality of AM methods to the point where the end products have nearly ideal physical properties and the only design limitations are the laws of physics. Previously impossible designs will emerge in aviation, propulsion, spacecraft, and on-orbit manufacturing, such as engines, rockets, and satellites entirely produced by combinations of multiple AM processes.

The combination of digital manufacturing with robotic assembly and integration portends a future where the marginal and labor costs of production become negligible. This could enable a true on-demand economy where all manufacturing and production is in response to actual demand, rather than forecast demand. Such a development would enable dramatic re-localization of manufacturing jobs and enable long-duration space exploration missions that operate with little-to-no logistical support from Earth.