In-Space Manufacturing at NASA Marshall Space Flight Center: Enabling Technologies for Exploration

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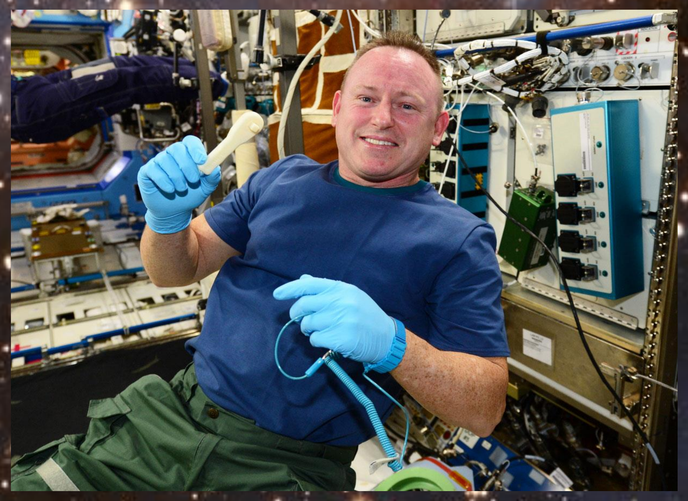
In-Space Manufacturing

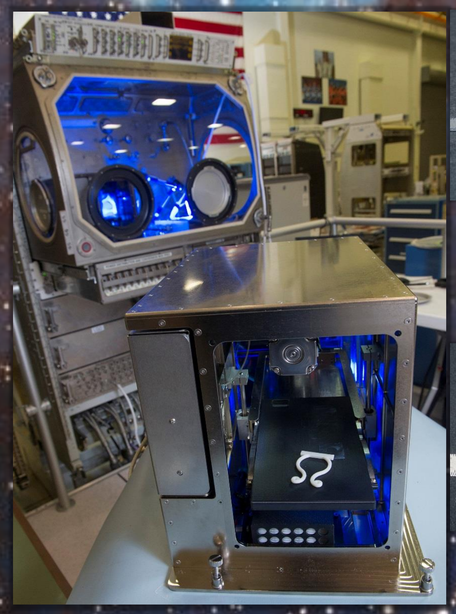
NASA Marshall Space Flight Center is currently engaged in a number of in-space manufacturing (ISM) activities that have the potential to reduce launch costs, enhance crew safety, and provide the capabilities needed to undertake long duration spaceflight safely and sustainably.

ISM uses the International Space Station (ISS) as a testbed for technology demonstrations and research activities. The recent 3D Printing in Zero G experiment conducted onboard the International Space Station demonstrated that parts of ABS (Acylonitrile Butadiene Styrene) plastic can be manufactured in microgravity using Fused Deposition Modeling (FDM). This project represents the development of a capability that is critical to future NASA missions.



3D Printing in Microgravity Technology Demonstration

The 3D print technology demonstration represents the first manufacturing capability on the International Space Station. The experimental hardware, launched in September 2014 and housed in the Microgravity Science Glovebox (MSG), printed 21 parts on orbit. These flight specimens are currently undergoing testing and evaluation in the Materials and Processes Laboratory at NASA MSFC. Comparative evaluation of the flight parts and identical ground specimens will test for any significant differences in material consolidation and/or mechanical properties that may be attributable to microgravity effects on the FDM process. The test plan for both the ground and flight parts includes visual and photographic inspection, mass and density measurement, structured light scanning, radiography, 3D computed tomography, optical microscopy, and scanning electron microscopy.



Range Coupon

Tensile specimen

"We need, I believe, to lift our eyes….[to] expand our physical boundaries….throughout the solar system, and from there to the stars. Even the beginning of realization of that vision will bring profound benefits to our planet and its life."

~Gerard K. O'Neill, *The High Frontier*

Utilization Catalog

The utilization catalog will provide astronauts with a library of part files that can be printed on-demand. The library will include crew tools as well as non-critical replacement parts. **Prior to inclusion in the catalog, parts and materials must be characterized and certified for use.**

Future ISM Activities

Future ISM activities include:

- Development of baseline material properties to facilitate design, analysis, and certification of materials manufactured using in-space techniques
- Development of a recycling capability for feedstock filament. This work is key to sustainability and improves the orbital supply chain by reducing up-mass of feedstock resupply and downmass of packaging waste.
- The Additive Manufacturing Facility (AMF), a next-generation printer developed by Made in Space. Once on-orbit, the printer will function as a user-based facility serving both NASA and external customers.
- Pursuing technology maturation and development that will enable rapid repair of external structures in space. These technologies include welding and additive manufacturing of metallics.