

# Three-Dimensional Printing In Zero Gravity

## Project Manager(s)/Lead(s)

Niki Werkheiser/ZP30  
(256) 544-8406

## Sponsoring Program(s)

Human Exploration and Operations Mission Directorate  
Advanced Exploration Systems  
Space Technology Mission Directorate  
Game Changing Development

## Project Description

The 3D printing in zero-g (3D Print) technology demonstration project is a proof-of-concept test designed to assess the properties of melt deposition modeling additive manufacturing in the microgravity environment experienced on the International Space Station (ISS). This demonstration is the first step towards realizing a ‘machine shop’ in space, a critical enabling component of any deep space mission.

The 3D Print design and flight hardware (figs. 1 and 2) are products of the commercial company Made In Space, Inc., and was acquired by NASA through a Small Business Innovative Research Phase III contract. The objective is to advance the Technology Readiness Level (TRL) to a state that will support future full-scale development for an operational flight production system using plastics on the ISS.

The objectives of this technology demonstration project are to provide: (1) A detailed understanding of the critical design and operational parameters for the additive manufacturing process as affected by the microgravity environment, (2) the first demonstration of additive manufacturing in space, (3) a detailed analysis of how acrylonitrile butadiene styrene (ABS) thermoplastic resin behaves in microgravity versus Earth’s gravity, (4) a comparison between additive manufacturing in Earth’s gravity and in a consistent, long-term exposure to microgravity, and (5) the advancement of the TRL of additive manufacturing processes to provide risk reduction and capabilities to future flight or mission development programs.



Figure 1: 3D printer unit.

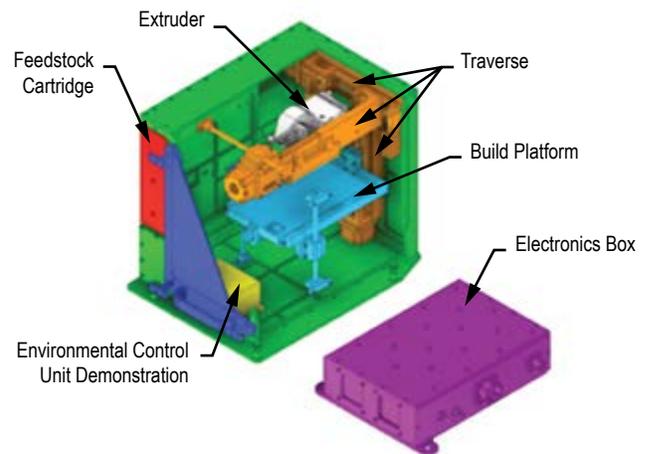


Figure 2: 3D printer components.

## Anticipated Benefits

The 3D Print will demonstrate the capability of utilizing additive manufacturing technology in space. This is the first step towards realizing an additive manufacturing, print-on-demand ‘machine shop’ for long-duration missions and sustaining human exploration of other planets, where there is extremely limited ability and availability of Earth-based logistics support.



Figure 3: 3D printer installed in the MSG on the ISS.

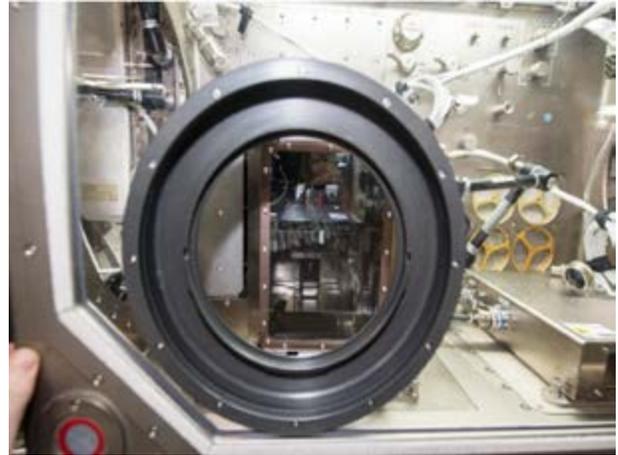


Figure 4: Closeup of 3D printer installed in the MSG.

### *Potential Applications*

The data gathered and lessons learned from this technology demonstration will be used for the next generation of melt deposition modeling in the permanent NanoRacks Additive Manufacturing Facility (AMF) as well as for any future additive manufacturing technology NASA plans to use, such as metals or electronics in-space manufacturing, on both the ISS and deep space missions. The information obtained during the 3D Print technology demonstration will be applied to the design of the next generation of additive manufacturing technology on orbit, such as the AMF and other metallic printing devices currently in development. It is expected that additive manufacturing technology will quickly become a critical part of any mission's infrastructure.

### **Notable Accomplishments**

The 3D Print launched on SpaceX-4 on September 21, 2014, at 1:52 a.m. ET and arrived at the ISS on September 23, 2014, at 6:52 a.m. ET.

The 3D printer, electronics box, and camera setup were successfully installed into the Microgravity Science Glovebox (MSG) on November 17, 2014 (figs. 3 and 4). A functional checkout was performed including extrusion of a calibration coupon. Additional calibration prints are planned.

### **References**

- 3D Print Fact Sheet, <[http://www.nasa.gov/sites/default/files/files/3D\\_Printing-v3.pdf](http://www.nasa.gov/sites/default/files/files/3D_Printing-v3.pdf)>, April 24, 2014.
- Werkheiser, N.; et al.: "3D Printing In Zero-G ISS Technology Demonstration," Abstract, ISS Research and Development Conference, NTRS 20140000628, June 26–28, 2013.
- Johnston, M.; et al.: 3D Printing In Zero-G ISS Technology Demonstration, American Institute of Aeronautics and Astronautics SPACE 2014 Conference and Exposition, doi: 10.2514/6.2014-4470, August 5–7, 2014.
- Clinton, R.: "The Road to Realizing In-Space Manufacturing," Presentation, National Research Council Committee on Space-Based Additive Manufacturing of Space Hardware Meeting, NTRS 20140008760, February 5–7, 2014.