In-Space Manufacturing Project at NASA Marshall Space Flight Center

National Aeronautics and Space Administration

In-Space Manufacturing (ISM) Overview

- Responsible for developing advanced manufacturing capabilities to reduce Earth dependence and enable sustainable manufacturing for long duration exploration missions
  - Test & advance desired technologies
  - Establish skills & processes (design, characterization, certification) to enable new capabilities to become institutionalized
- Leverage industry, academia, & other government agencies to meet these objectives
- Utilize ground-based and space-based demonstrations
  - International Space Station (ISS) proving ground for evolution of new technologies

TECHNOLOGIES

SKILLS & PROCESSES

Design + Optimize

Characterize

Certify

On-demand Manufacturing Capability for Exploration Missions

ISS: The Proving Ground for Space-Based Manufacturing Technologies

3D PRINTING IN ZERO G TECHNOLOGY DEMONSTRATION MISSION

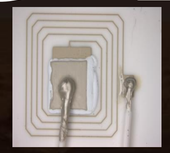
- Payload developed through a phase III Small Business Innovative Research (SBIR) contract with Made In Space
- First demonstration of 3D printing on-orbit
- Manufactured 42 ground control and flight specimens as part of phase I (Nov.-Dec. 2014) and 34 additional flight specimens as part of phase II (June-July 2016)
- Specimens evaluated for density, dimensional variation, internal structure, mechanical properties, and chemical composition
- No engineering significant effects on the Fused Deposition Modeling (FDM) process noted to date

REFABRICATOR: RECYCLING ON-ORBIT AND CLOSING THE MANUFACTURING LOOP

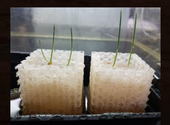
- In-space recycler technology demonstration for the International Space Station (ISS)
- Unit is an integrated printer and recycler to demonstrate the feasibility of plastic recycling in a zero gravity environment
- Payload Developed by Tethers Unlimited Inc. (TUI) under a Small Business Innovative Research (SBIR) contract
- ReFabricator implements a technique caused Positrusion (developed by TUI) for producing high quality feedstock from input plastic material
- Ability to process onboard waste plastic materials into useful feedstock for further use could translate into launch mass savings for future crewed missions
- Technology also has broader significant to reprocessing of plastic materials on earth
- Payload will be operational on ISS in 2018

Ground Based Research and Development Activities

- Development of printed, infusible technologies for sensing, energy harvesting, and energy storage using the nScrypt capability for printable electronics
- Ground-based studies on manufacturing process optimization for fused deposition modeling
- Microstructural material modeling of fused deposition modeling with group at Ames Research Center (ARC)
- Project on making filament and 3D printing with biologically derived materials (collaboration between Kennedy Space Center VEGGIE experiment, Ames Research Center Synthetic Biology Group , and ISM project at MSFC)



Printed wireless humidity sensor



Plant growth in 3D printed blocks of biologically derived filament

Toward a Multimaterial Fabrication Facility for ISS ("FabLab")

- **Utilization of Made in Space's Additive Manufacturing Facility (AMF) for materials characterization studies and production of functional parts for ISS use**
- **Development of constituent FabLab technologies through SBIR opportunities:**
  - **3D printing of metals (Techshot)**
  - **sterilization of 3D printed parts for biomedical applications (Tethers Unlimited)**
  - **Development of higher strength, thermally reversible thermoset materials for 3D printing (Cornerstone Research Group)**
  - **development of additive electronics capabilities**
  - **Hybrid manufacturing capability for precision parts**
- **Broad agency announcement for MultiMaterial Fabrication Laboratory for ISS in April 2017**