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NASA ADDITIVE MANUFACTURING INITIATIVES FOR DEEP SPACE HUMAN EXPLORATION

Abstract

Additive Manufacturing (AM) is being infused into aerospace industries at an accelerated pace. Reasons for this rapid adoption include: (1) Innovation Capability e.g. design features such as topology optimization, integrated fluid passages, and mesh structures; (2) Rapid Development and Optimization - ability to quickly iterate the design, development, and test cycle; (3) Affordability – reductions in part counts, cost, and schedule. NASA's Marshall Space Flight Center (MSFC) has taken a leadership role in application of AM technologies for deep space human exploration, leading the Agency's In Space Manufacturing (ISM) initiative and the application of AM for a broad variety of space propulsion systems. MSFC has championed the development of ISM capabilities since our first reduced-gravity aircraft experiment flew in 1999. Partnering with Made In Space, MSFC placed the first 3D Printer on ISS in 2014 and the second generation printer, the Additive Manufacturing Facility, in 2016. The next ISS technology demonstration will be the Refabricator, a recycler/basic printer scheduled to launch in summer 2018. Ground-based development is progressing in common use materials, metals 3D printing, printed electronics, and the new cornerstone of ISM, the FabLab. The latest developments in each area will be described. An overview of NASA's In Space Robotic Manufacturing and Assembly ground-based risk reduction projects and the additive construction technology demonstration results from the joint NASA and U. S. Army Corps of Engineers project will also be presented. MSFC has aggressively incorporated AM capabilities for design and development of space propulsion components. The capabilities have been rapidly matured and extensively exercised to produce and hot-fire test the Additive Manufacturing Demonstrator Engine, an in-space class prototype engine. This experience base has been extended to support Aerojet Rocketdyne in the application of AM to the RS-25, the Space Launch System Core Stage engine, and to small propulsion systems and thrusters for small satellites and cubesats. The latest results from these activities will be described. In responding to a request from NASA's Commercial Crew Program for a consistent methodology for evaluation of AM processes and parts, MSFC began development of a draft standard for AM space flight hardware in late 2014. The draft was broadly disseminated for comments in mid-2015, and subsequently revised into two documents, a standard and a specification for AM space flight hardware, which were formally released by MSFC in October 2017. An overview of the key elements of these documents will be presented.