National Aeronautics and
Space Administration

Advanced Manufacturing Technology (AMT) Overview Quad Charts (FY2016)

Part of the package presented in the

Advanced Manufacturing Technology (AMT) Charts presented at STMD Game Changing Development Program FY2016 Mid Year Review

AMT Project Manager:
John Fikes

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AMT
Advanced Manufacturing Technology Project Overview

Advanced manufacturing is critical to all NASA mission areas. The AMT project elements and tasks develop and mature innovative, advanced manufacturing technologies that will enable more capable and lower-cost spacecraft and launch vehicles. The AMT Project is making use of cutting edge materials and emerging capabilities including: metallic processes, additive manufacturing, composites, and digital manufacturing. The AMT project supports the National Manufacturing Initiative involving collaboration with other government agencies.

Integration with other projects/programs and partnerships

- CIF, SBIR/STTR, STRG, TDM, Centennial Challenges
- HEOMD, ARMD
- Industry, OGA, Academia

Technology Infusion Plan:

- Potential customer infusion (TDM, HEOMD, SMD, OGA, Industry)
- Produce game changing and next generation manufacturing technology and work with various NASA mission directorates and programs(e.g. SLS) to infuse the technology to dramatically improve affordability and capability.
- Collaborate with other Agencies, Industry and Academia.
- Industry Days, NASA roadmap

Key Personnel:

Program Manager: Steve Gaddis

Project Manager: John Fikes

Lead Center: MSFC

Supporting Centers: ARC, GSFC, GRC, KSC, LaRC

NASA NPR: 7120.8

Guided or Competed: Guided

Type of Technology: Push and Pull

Key Facts:

GCD Theme: Lightweight Materials and Advanced Manufacturing

Execution Status: Thematic Plan

Technology Start Date: N/A

Technology End Date: N/A

Technology TRL Start: 3

Technology TRL End: 6

Technology Current TRL: N/A

- **Technology Lifecycle Phase:** AMT/Project level does not have lifecycle phase, but each technology element does.

AMT
Manufacturing Initiative Overview

The AMT Project supports multiple activities within the Administration's National Manufacturing Initiative. A key component of the Initiative is the Advanced Manufacturing National Program Office (AMNPO), which includes participation from all federal agencies involved in U.S. manufacturing. In support of the AMNPO the AMT Project supports building and Growing the National Network for Manufacturing Innovation (NNMI) through a public-private partnership designed to help the industrial community accelerate manufacturing innovation.

Integration with other projects/programs and partnerships

- Worked with the AMNPO to prepare the NNMI 2016 Annual Report and 2016 Strategic Plan, both of which were issued by the White House
- Worked with the National Science and Technology Council (NSTC) Subcommittee on Advanced Manufacturing (SAM) to contribute to the NSTC 2016 advanced manufacturing national priorities paper, also issued by the White House

Technology Infusion Plan:

- PC
- Potential customer infusion (TDM, HEOMD, SMD, OGA, Industry)
- Leverage
- Collaborate with other Agencies, Industry and Academia.
- NASA roadmap

Key Personnel:

Project Manager: John Fikes

Project Element Manager: Jeramie Broadway

Lead Center: MSFC

Supporting Centers: ARC, GSFC, GRC, KSC, JPL, LaRC

NASA NPR: 7120.8

Guided or Competed: Guided

Type of Technology: Push and Pull

Key Facts:

GCD Theme: Lightweight Materials and Advanced Manufacturing

Execution Status: Thematic Plan

Technology State Date: N/A

Technology End Date: N/A

Technology TRL Start: 3

Technology TRL End: 6

Technology Current TRL: N/A

- **Technology Lifecycle Phase:** N/A

AMT
Materials Genome Initiative Overview

Overall objective: Develop computational tools to assist in the manufacture, design and certification of new materials and processes. These tools will reduce the time and costs to infuse new materials while also improving reliability. This program is currently focusing on additive manufacturing as this technology has high payoff for NASA and requires computational design tools.

Integration with other projects/programs and partnerships

- NASA Launch vehicle programs (SLS).
- Commercial launch providers.
- DoD launch vehicles.
- ARMD advanced manufacturing efforts.
- Commercial airframe manufacturers.

Technology Infusion Plan:

- PC – SLS.
- PC - DoD, Establishing collaborations with DoD via the National MGI effort. Work in NASA MGI element is complimentary with efforts in DoD
- PC – Alcoa, Establishing a SAA to evaluate design tools for use in manufacture of light alloy components.
- Comments/Anticipated use - Process and materials design tools will be developed and supplied to the SLS program to assist in the manufacture and qualification of components via additive manufacturing.

Key Personnel:

Project Manager: John Fikes

Project Element Manager: Terryl Wallace

Lead Center: LaRC

Supporting Centers: ARC, MSFC

NASA NPR: 7120.8

Guided or Competed: Guided

Type of Technology: **Push**

Key Facts:

GCD Theme: Lightweight Materials and Advanced Manufacturing

Execution Status: Year 3 of 3

Technology Start Date: Oct. 2013

Technology End Date: Sept. 2016

Technology TRL Start: 3

Technology TRL End: 6

Technology Current TRL: 3

Technology Lifecycle Phase: Implementation

AMT
Low Cost Upper Stage-Class Propulsion Overview

The LCUSP will demonstrate the ability to produce a low cost upper stage-class propulsion system using additive manufacturing technologies. LCUSP will do this by (1) developing a copper alloy additive manufacturing design process, (2) developing a new Nickel Jacket additive manufacture/application process (3) additive manufacture a 25K-class regenerative chamber/nozzle, (4) testing chamber and then chamber/nozzle system in a hot fire resistance test.

Integration with other projects/programs and partnerships

Liquid Propulsion System (LPS) Test Bed (being developed at MSFC with additive manufactured components such as injectors, LOx and H2 Turbopumps) plans to utilize the LCUSP Combustion Chamber or utilize the capability established under this project to fabricate a chamber. Industry partners are investigating possible partnerships with LCUSP for possible opportunities for fabrication of SLM combustion chambers to reduce cost of engine development.

Technology Infusion Plan:

PC, Propulsion, HEOMD, Potential use in manufacturing process of flight engines 2017. Military & Industry (SpaceX, Aerojet-Rocketdyne, Orbital-ATK, ULA, Blue Origin, ASRC Federal, numerous copper machine shops, suppliers, and electronics manufactories.

Infusion Status as of April 2016: Fabricated GRCop-84 Combustion Chamber Liners & applied Inconel625 on SLM GRCop-84 samples. Full application of Inconel 625 Nickel Jacket complete on UNIT 1 & 2. Testing and Inspections are on-going with good results thus far.

Key Personnel:

Project Manager: John Fikes

Project Element Manager: Tony Kim

Lead Center: MSFC

Supporting Centers: LaRC & GRC

NASA NPR: 7120.8

Guided or Competed: Guided

Type of Technology: Push

Key Facts:

GCD Theme: LMAM, Lightweight Materials and Advanced Manufacturing

Execution Status: Year 2 of 3

Technology State Date: April 2014

Technology End Date: June 2017

Technology TRL Start: 3

Technology TRL End: 6

Technology Current TRL: 4/5

Technology Lifecycle Phase: Implementation (Phase C/D)

AMT
ACME Overview

- Additive Construction with Mobile Emplacement (ACME) is 2D and 3D printing on a large (structure) scale using in-situ resources as construction materials to help enable on-location surface exploration.
- ACME is a joint effort between NASA/GCD and the U.S. Army Corps of Engineers (USACE).
- Applications are in the construction of infrastructure on terrestrial and planetary surfaces.

Integration with other projects/programs and partnerships

- Current partnership between MSFC, KSC, the USACE, Contour Crafting Corporation (CCC), and the Pacific International Space Center for Exploration Systems (PISCES).
- Collaboration with the JSC Hypervelocity Impact group.
- ACME personnel involved in the 3D Printed Habitat Centennial Challenge rules committee and serving as judges and subject matter experts (SME) for the various activities.
- 3D printing materials research involves members of industry (BASF, Premier Magnesia) and academia (Auburn University, Mississippi State).
- In-Situ Resource Utilization (ISRU) project integration & uses.

Technology Infusion Plan:

- Potential Customer: HEOMD, USACE and Industry (Caterpillar Inc.).
- Phased approach for maturation of hardware: ACME units intended to serve as prototypes for the USACE devices which will be used in domestic and international venues.
- ACME project advances in-situ resource utilization (ISRU), contour crafting, and zero launch mass construction materials development.
- Designed for use on planetary surfaces, can be deployed prior to human landing. Technology developed has terrestrial applications, and has large implications for the art of the possible in construction

Key Personnel:

Project Manager: John Fikes

Project Element Managers: John Fikes and Rob Mueller

Lead Center: Co-led by MSFC and KSC

Supporting Centers: None

NASA NPR: 7120.8

Guided or Competed: Guided

Type of Technology: Push for planetary ISRU, pull for terrestrial applications

Key Facts:

GCD Theme: LMAM

Execution Status: Year 2 of 3

Technology Start Date: 1/31/15

Technology End Date: 9/30/17

Technology TRL Start: 3

Technology TRL End: 5

Technology Current TRL: 4

Technology Lifecycle Phase: Formulation (Phase A)