



Enhancing the Industrial Base's Additive Manufacturing Capabilities

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Outline



- Advancing military supply chain development to reduce time of delivery
 - What are the needs?
- Efforts to bridge the gaps between warfighter needs & what industry can deliver
 - DoD ManTech, Joint Additive Manufacturing Community
- Leveraging public-private partnerships to develop the DoD logistics architecture
 - DoD Manufacturing Institutes and examples

Additive Manufacturing: Example Process Flow



Additive Manufacturing: Opportunities for Enhancement





Opportunities for Enhancement



A – Business practices: contracting, ordering, approval for part to be printed

B – Qualification and Certification: supported through R&D having enough data to build the library of approved parts and seek approval for not yet approved parts

C – **Access to the data:** consistent TDP in a secure digital environment accessible to the entity doing the printing

D – **Design enhancements:** support the TDP, approvals and informing the process, training for designers

E - Control of materials and processes: work orders, standards/specs and quality control

F – Certified approved personnel: to do the print, training for others in the business processes as well

G – Verification: Quality control and testing of the final product, product acceptance

H – Business feedback: changes to any of the previous steps, impact of contracts, etc.

Advantages and Limitations of AM



Advantages

- Design freedom
- Reduced waste
- Cost savings
- Agile and shorter supply chains
- Legacy Part Replacements
- Energy efficient for low volumes

Current Limitations

- Limited approved material selection
- Build speed can be slow
- Surface roughness
- Extensive testing, validation
- Build size with limited post processing



Airline seat belt buckle lightweight redesign – 3.3 MM liters fuel saved



Titanium prosthetic hand produced at ORNL

Case Study for Additive Manufacturing: Aircraft Brackets



1. Avoiding machining: Cost savings to manufacture – same bracket by Additive Manufacturing uses 95% less starting material resulting in more than 50% cost savings.* Conventional Process





Additive Process



12 g (identical)

2. Optimized design: Resulting bracket is 65% lighter, saving manufacturing materials and resulting in use phase energy savings.



* Dehoff, R , Advanced Materials & Processes, March 2013, vol. 171 No. 3, pgs. 19-22

Joint AM Objectives





Joint AM Organization





DoD Joint AM Community



	Research and Engineering	Acquisition	Maintenance and Sustainment	Logistics				
OSD	- Office of Deputy Director for Strategic Technology Protection and Exploitation	- Systems Engineering	- Office of Deputy Assistant Secretary of Defense, Materiel	- Office of Deputy Assistant Secretary of Defense for Logistics				
Joint Staff		- Joint Staff J4						
Air Force	- Assistant Secretary of the Technology a - Air Force Life Cycle N - Air Force Research Laborator	Air Force for Acquisition, nd Logistics Ianagement Center Y	- Air Force Materiel Command (AFMC/A4/10) - Air Force Logistics, A4					
Navy	- Assistant Secretary of the Navy Research, Development and Acquisition - Office of Naval Research Readiness and Logistics							
Marines	- Headquarters Marine Corps Installation and - Logistics Innovation							
Army	- Army Research Laboratory	- Deputy Assistant Secretary of the Army for Strategy and Acquisition Reform	-Army Materiel Command -Army Logistics, HQDA					
Defense Logistics Agency	- Information Operations, Chief Research and Development		-Logistics Operations, Chief Technical and Quality Assurance -Logistics Operations, Executive Director Logistics Policy and Strategic Programs					
Missile Defense Agency	- Component and Materials Engineering Division							
Defense Contract Management Agency	- Headquarters Technical Directora	te Engineering Division						

Implementation Plan Status



- Army Campaign Plan: In progress
- Navy Implementation Plan: Released
- Air Force Strategic Implementation Plan: Updated
- MDA Roadmap: In progress
- DLA Strategic Plan: Released

Navy Implementation Plan Milestones



Figure 1. Progression Milestones and Demonstrations

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http://www.dtic.mil/dtic/tr/fulltext/u2/1041527.pdf

DoD ManTech Program

MISSION:

Anticipate and close gaps in manufacturing capabilities for affordable, timely, and low-risk development, production, and sustainment of defense systems.

ManTech carries out its mission through programs in the Military Departments, participating Defense Agencies, and OSD

DoD Manufacturing USA Institutes are executed out of OSD with support from the Services.

Tenets meet key DoD ManTech requirements

DoD Manufacturing USA Institutes

America Makes: The National Additive Manufacturing Innovation Institute Est. AUG 2012 (Youngstown, OH)

Digital Manufacturing and Design Innovation Institute (DMDII) Est. FEB 2014 (Chicago, IL)

LIFT - Lightweight Innovations For Tomorrow Est. FEB 2014 (Detroit, MI)

AIM Photonics (photonic integrated circuits) Est. JUL 2015 (Albany, NY)

NextFlex (flexible hybrid electronics) Est. AUG 2015 (San Jose, CA)

Advanced Functional Fabrics of America (AFFOA) – (revolutionary fibers and textiles) Est. APR 2016 (Cambridge, MA)

Advanced Regenerative Manufacturing Institute (ARMI) (advanced tissue biofabrication) Est. DEC 2016 (Manchester, NH)

Advanced Robotics for Manufacturing (ARM)

Est. JAN 2017 (Pittsburgh, PA)

- DoD MIIs part of Manufacturing USA: whole-or government effort, in partnership with industry & academia
- Strategically aligning resources to address targeted technology spaces
- Creating 'industrial commons' for manufacturir R&D, workforce education and development
- Catalyzing defense and broader industrial 'innovation ecosystems' across the nation
- Accelerating trust in supply chain development with diversified risks

AIM Photonics Institute in Rochester, NY

Technology Project Success Stories

Replacement Parts Completed Airworthiness

World First Fully Flexible Arduino Microsystem Developing a Robust Distortion Prediction and Compensation Software Tool for Additive

First U.S. Multi-Project Wafer Capability in Integrated Photonics

Thin Wall Ductile Iron Castings

DOD Application Success Stories

Flexible Write of Array Antenna and FSS on UAV Surface

Light-Weighting to Reduce Fatal Rollovers LiFi

Printed Casting Molds Improve Aircraft Readiness

Reducing Orthotic Out-Patient Visits from 3 to 1

Education & Workforce Development Activities Flourish

- **Highly Effective Manufacturing USA Education & Workforce Development Working Group**
- 2019 American Innovation Awards
- **DoD Institute Initiatives**
 - LIFT's Operation Next & Maker Minded Programs
 - NextFlex's Flex Factor
 - America Make's ACADEMI Program
 - AIM Photonics' Future Leaders Program

AMERICAN

INNOVATION

AWARDS

ManufacturingUSA

America Makes

The National Additive Manufacturing Innovation Institute

Established: August 2012

Hub Location: Youngstown, OH

Lead: National Center for Defense Manufacturing and Machining (NCDMM)

Mission: Accelerate the adoption of Additive Manufacturing (AM) in the United States industrial base to reduce cost, reduce lead time, and increase capability of DoD warfighter products.

TECHNOLOGY DEVELOPMENT

Since launching in 2012, America Makes has executed **over 75 projects** against a consortium developed AM technology roadmap. Projects range from those addressing design tools, materials, and processes to those supporting an integrated value chain.

DoD APPLICATIONS

America Makes delivered AM repair and replacement solutions along with training for DoD sustainment organizations to improve warfighter readiness. America Makes coordinated the AM community to prioritize and accelerate formation of standards and specifications critical to industry and organic DoD adoption of AM.

WORKFORCE READINESS

Application-based training programs were developed to fill a critical training gap for design and materials engineers to improve Design for AM (DfAM) skills. America Makes is developing the next generation of workforce training program to generate industry accepted labor certifications and credentials for DoD personnel.

FACILITIES & CAPABILITIES

America Makes is an impartial **convener** of AM stakeholders, a **coordinator** of technical and workforce information, and an activation **catalyst** through the execution high-impact projects.

http://americamakes.us/

Maturation of Advanced Manufacturing for Low-Cost Sustainment (MAMLS): Problem Statement

- The AF faces significant challenges sustaining legacy aircraft operating in extended periods of service.
- Sustainment challenges include:
 - low-volume parts
 - Out-of-Production Spares (OOPS)
 - Tooling, fixtures, jigs availability
 - Lack of advanced workforce training

B52 Stratofortress: 63 years in air (Aug 2017)

- To effectively maintain and sustain aircraft, the AF must:
 - Implement additive and other advanced manufacturing technologies
 - Leverage existing expertise in advanced manufacturing technologies
 - Utilize advanced capabilities existing in the supply chain

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Program Phases

LESS CHALLENGING RESEARCH APPLICATIONS

			CY 2016	CY 2017	CY 2018	CY 2019	CY 2020
		Phase 1: "Low Hanging Fruit" - Tooling; reverse engineering; organic sustainment applications; business case development; and OEM supply chain activities. (broad-based sustainment support activities)	* 8 Feb 2016 F \$ 8.99M (hase 1 Award date FY15 CII fundin	e)		
Structural Sandwich Panel (Fairing) Family Bell Crank Family Oil Cooler Family	Structural Doublers & Brackets Family	Phase 2: "Qualification Pathfinding for Direct Part Replacement" - Direct part replacement research; tech gap ID; qualification issues; material issues; business cases; etc. (focused OEM component demos for feasibility studies)		★ 9 Мау 21 \$9	17 Phase 2 Award da 2 .056M (FY16 Ci	e I funding)	
		Phase 3: Rapid Transition & New Start Research Topics - Feature-based Qualification Using DED Understanding AM Mfg Realities Emerging Technologies for Low-criticality Part Families			★ 23 Apr	2018 Phase 3 Award d 99.0M (FY17 CII	te funding)
		TOTAL FEDERAL FUNDING (\$)					\$27M

MORE CHALLENGING RESEARCH APPLICATIONS

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MAMLS Diversity: Ecosystem

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JAMWG Directed Project

Joint Additive Manufacturing Model EXchange (JAMMEX)

Develop a system to share 3D print files in a secure environment in conjunction with DLA and the Services

JAMWG Directed Project

Advanced Tools for Rapid Qualification

- 3 Focus Areas
 - Damage surrogate models
 - Service conditions for thermoplastics
 - Corrosion
- Project call through America Makes
- JAMWG Qualification and Certification Stakeholder Council engagement

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Digital Manufacturing and Design Innovation Institute

Established: February 2014

Hub Location: Chicago, IL

Lead: UI LABS

<u>Mission</u>: Accelerate the development and transition of digital manufacturing technologies into the DoD. Provide the U.S. government and American manufacturers with the digital tools needed secure the manufacturing enterprise, reduce development & production cost, and accelerate product development.

TECHNOLOGY DEVELOPMENT

Since launching in 2014, DMDII has completed **33** projects with **30** projects ongoing. Projects seek to solve technology challenges in digital manufacturing that are too big for any one organization.

DoD APPLICATIONS

In 2018, DMDII executed a Model Based Enterprise assessment of Rock Island Arsenal that provides Army leadership with a roadmap for leveraging digital manufacturing technologies that would increase technical workforce productivity 40-45 percent and lower maintenance downtime by

30-50 percent.

WORKFORCE READINESS

2018 marks one year since DMDII's creation of **the first massive open online course on digital manufacturing and design** being available to anyone online. More than **30,000 people** have accessed the curriculum so far.

FACILITIES & CAPABILITIES

DMDII also launched the **National Center for Manufacturing Cybersecurity.** The hub will be a testbed for the creation and adoption of new cybersecurity technologies to help secure the supply chain and the warfighters who rely on these capabilities.

Distribution Statement A: Approved for public release. Distribution is unlimited. http://dmdii.uilabs.org/

Digital Engineering

- DoD is pursuing a digital engineering strategy
- DE principles and implementation possibilities provide the basis for transforming systems engineering

Digital Engineering Overview

- Combines model-based techniques, digital practices, and computing infrastructure
- Enables delivery of high payoff solutions to the warfighter at the speed of relevance
- Enhances communication across the digital enterprise by connecting people, processes, data, and capabilities
- Improves technical, contract, and business practices by ensuring an authoritative source of truth and digital artifacts

Modernizes how we design, operate, and sustain capabilities to outpace our adversaries

DMDII Project Examples

ADVANCED VARIANCE ANALYSIS & MAKE

The project uses high-performance computing to demonstrate how data coming off of a machine relates to the part made by that machine.

- It will indicate whether an anomaly in the data is, in fact, related to an anomaly in performance and/or adherence to a design specification for the part.
- The analyses will form the basis of a database of production anomalies.
- Manufacturers will use the resulting data in real time to correct an anomaly if it will affect a part's performance, or to ignore the data anomaly if there is no evidence of impact on the part's capabilities.

Team: Rolls-Royce Corporation, 3D Systems, Georgia Institute of Technology, Microsoft, National Center for Supercomputing Applications (NCSA), Penn State University Applied Research Laboratory, Southwest Research Institute (SwRI)

FROM ART TO PART

- 3D printing of alloy structures enables entirely new classes of parts. However, design-validate iterations can take at least 10 weeks for a complex part.
- DMDII is bringing 3D manufacturing left into the design phase:
 - knowledge guided pre-processing,
 - modeling distortion effects, and other factors
 - will reduce the design cycle by up to 80%.
- Team: GE Global Research, Techsolve, University of Cincinnati, University of Illinois

https://www.uilabs.org/innovation-platforms/manufacturing/projects/

JAMWG Focus Areas

≻Cybersecurity

Standard data packages

Increase collaboration on qualification

Materials database

Education and workforce development

Share best practices enabled

Impact of AM on the Supply Chain

Thank you!

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