America Makes

Driven by… NCDMM

America Makes – The National Additive Manufacturing Innovation Institute

The National Accelerator for Additive Manufacturing

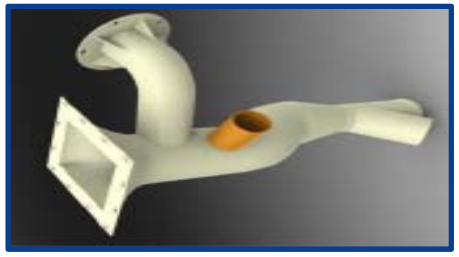
Eric MacDonald
UTEP

America Makes

Introduction to America Makes Video

https://www.youtube.com/watch?v=7qaYlJ1HOdw

Why Additive Manufacturing

Small Lot Production 	**Enables Mass Customization**   
Rapid Manufacturing	**Toolless, Extreme Cycle Time Reductions**
Lightweight Structures	**Weight removal increases mission capabilities, saves fuel costs and lessens warfighter burden**
Enables Design Complexity  Heat exchanger, courtesy of Within Technologies	**Geometric Complex, Unitized Structures**  ***Traditional Part:*** ***19 aluminum parts welded together***  ***Additive Manufacturing part:*** ***1 part*** ***30 % weight reduction*** ***Cost and lead time reductions*** **Functionally-graded materials, embedded electronics**

ASTM Definitions of Seven Main Categories of Additive Manufacturing Processes

Process Type	Method	Materials	Market
Powder Bed Fusion	Thermal energy (laser or electron beam) selectively fuses regions of a powder bed	Metals, Polymers	Manufacturing, Prototyping
Directed Energy Deposition	Focused thermal energy (laser or electron beam) is used to fuse materials as deposited	Metals	Manufacturing, Repair
Material Extrusion	Material is selectively dispensed through a nozzle and material laid down in layers	Polymers, food	Manufacturing, Prototyping
Vat Photopolymerization	Liquid photopolymer in a vat is selectively cured by light-activated polymerization	Photopolymers	Prototyping
Binder Jetting	Liquid bonding agent is selectively deposited to join powder materials	Polymers, Sand, Metals, Ceramics	Prototyping, Casting Molds, Manufacturing
Material Jetting	Droplets of build material are selectively deposited, “ink-jet printer” like	Polymers, Waxes, tissue, metals (electronics)	Prototyping, Casting Patterns
Sheet Lamination	Sheets of material are bonded to form an object	Paper, Metals	Prototyping, Manufacturing

Additive Manufacturing Challenges and Constraints to Widespread Adoption

Need/Issue	Impact If Not Addressed
Dimensional accuracy & surface finish	Additional processing cost, unusable parts
Uniform mechanical properties – different in build direction	Increased design complexity & added weight, suboptimal designs
Improved process control & repeatability	Acceptable part quality, process yield & cost
NDE methods for complex defects and part geometry-understanding of potential defects – effects of defects	Undetected defects leading to component failure
AM Standards (Materials, process, machine, quality)	Slow implementation of AM in industrial base
Qualification and Certification protocols	Slow adoption, conflicting approaches, waste in research and sustainment dollars
Design tools for AM components	Suboptimal design, increased time to market, material waste, poor performance

Why, How, What

AMERICA MAKES

WHY
The U.S. is not doing well in the Global Economy, and needs a reinvigorated Manufacturing Sector that includes a strong Defense Industrial Base.

HOW
Transform manufacturing in the U.S. through innovative, coordinated Additive Manufacturing Technology Development, Technology Transition, and Workforce & Educational Outreach.

WHAT
Accelerated adoption of additive manufacturing technologies in the U.S. manufacturing sector that yield innovative products and increased domestic manufacturing competitiveness.

Collaborate
Cooperate
Innovate

Who We Are

America Makes is a public/private partnership with substantial federal, private industry, and academic investment

The partnership is a multi-agency collaboration between industry, government and universities, led by the Defense-wide Manufacturing S&T team

We have an innovation facility in Youngstown, Ohio

We have 160 members and continue to grow

NCDMM
NATIONAL CENTER FOR DEFENSE MANUFACTURING AND MACHINING

We are operated by the National Center for Defense Manufacturing & Machining (NCDMM)

96 Industry Partners

3Diligent Corporation
3DSIM, LLC
3D Systems Corporation
3M
Advanced Methods in Innovation
Advantech US, Inc.
Alcoa
Allegheny Technologies, Incorporated
All Points Additive
AlphaSTAR Corporation
ANSYS, Inc.
Applied Optimization Inc.
Applied Systems and Technology Transfer
Arkema, Inc.
Atlantic Precision, Inc.
Autodesk, Inc.
Bastech, Inc.
The Boeing Company
Booz Allen Hamilton
Concurrent Technology Corporation
Danko Arlington
DANTE Solutions, Inc.
Deloitte Consulting, LLC
Eaton Corporation
Element Material Technology Holding USA
Element Robot, LLC
EnvisionTEC, Inc.
ESI North America, Inc.
The ExOne Company
Fabrisonic, LLC
Flight Support, Inc.
Florida Turbine Technologies, Inc.
GKN Hoeganaes Corporation
General Dynamics Global Imaging Technologies
General Electric Company
General Motors
Grid Logic Incorporated
Hapco, Inc.
HoneyPoint3D
Honeywell International Inc.
Humtown Products
Illinois Tool Works, Inc.
Inside 3D Printing
Intel Corporation
International TechneGroup Incorporated
Johnson & Johnson Global Supply Chain
Kennametal
Keystone Synergistic Enterprises, Inc.
The Lincoln Electric Company
LPW Technology, Inc.
Lockheed Martin
M-7 Technologies
MachMotion
Made In Space
Materials Science Corporation
MAYA Design Inc.
Moog, Inc.
NanoSteel Company
Northrop Grumman
OpenArc
Optomec
Oxford Performance Materials
PARC, a Xerox Company
Parker Hannifin Corporation
Patriot Solutions International, Inc.
Phoenix Analysis & Design Technologies, Inc.
PolarOnyx, Inc.
Product Development and Analysis, LLC
PTC Alliance Holdings Corp.
Raytheon
Rockwell Collins
Rolls-Royce Corporation
RP+M
SABIC Innovations Plastics Business
Sciaky, Inc.
Senvol, LLC
Sigma Labs, Inc.
Siemens Industry, Inc.
Southern Company Services, Inc.
Stony Creek Labs
Stratasys
Stratonics
Texas A&M Engineering Experiment Station
Textron, Inc.
Theken Companies, LLC
Toyota Motor Engineering & Manufacturing North America, Inc.
Triad Productions Group
Tyco Electronics Corporations
UL, LLC
United Launch Alliance, LLC
United Technologies Corporation
Wohlers Associates, Inc.
Wolf Robotics
Zimmer Biomet
Zodiac Aero Evacuation Systems

39 Academic Partners

- Arizona State University
- Binghamton University
- Carnegie Mellon University
- Case Western Reserve University
- Connecticut Center for Advanced Technology
- Georgia Institute of Technology
- Indiana University-Purdue University Indianapolis (IUPUI)
- Johns Hopkins University Applied Physics Laboratory
- Lehigh University
- Lorain County Community College
- Louisiana State University
- Michigan Technological University
- Mississippi State University
- Missouri University of Science & Technology
- North Carolina State University
- Northern Illinois Research Foundation
- Pennsylvania State University
- Robert C. Byrd Institute
- Robert Morris University
- Rochester Institute of Technology
- University of Akron
- University of Connecticut
- University of Dayton Research Institute
- University of Delaware Center for Composite Material
- University of Louisville
- University of Maryland – College Park
- University of Michigan Library
- University of Northern Iowa
- University of North Texas
- University of Notre Dame
- University of Pittsburgh
- University of Tennessee, Knoxville
- University of Texas - Austin
- University of Texas at El Paso
- Westmoreland County Community College
- Western Illinois University – Quad City Manufacturing Lab
- Wichita State University
- Wright State University
- Youngstown State University

11 Government Partners

- Air Force Sustainment Center,
- United States Air force
- Consolidated Nuclear Security, LLC; Pantex Plant /Y-12 National Security Complex
- Federal Aviation Administration
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- MIT Lincoln Laboratory
- The MITRE Corporation
- NNSA's National Security Campus
- Oak Ridge National Laboratory
- Sandia National Laboratory
- Tobyhanna Army Depot

10 Non-Profit Organizations

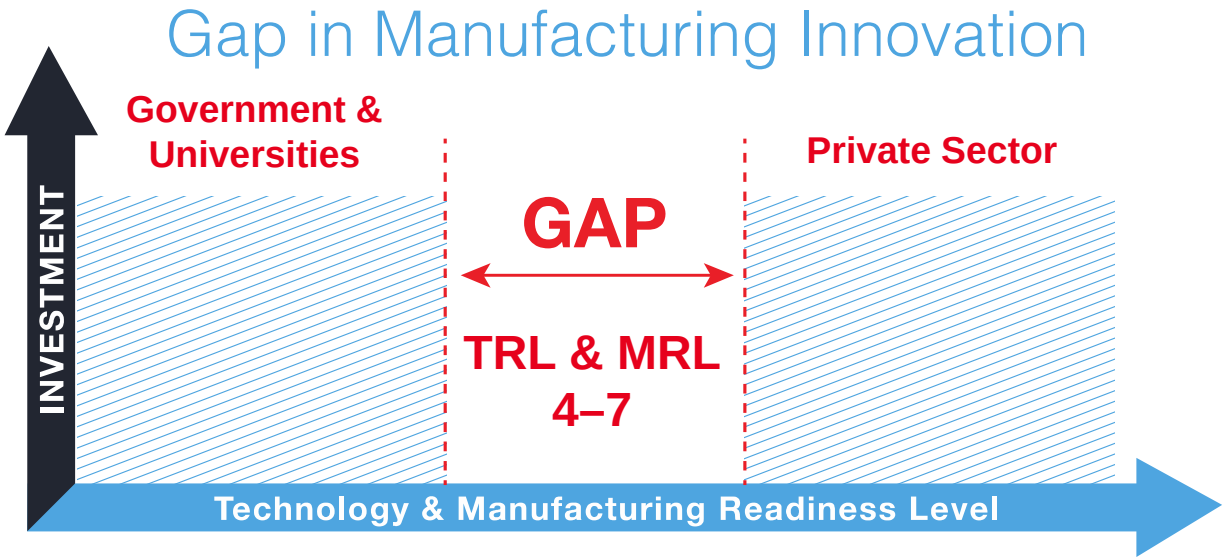
- American Foundry Society
- ASME
- ASM International
- Association for Manufacturing Technology
- EWI
- NCMS - National Center for Manufacturing Sciences
- Ohio Aerospace Institute
- SME
- Team NEO Foundation
- Youngstown Business Incubator

4 Mfg. Extension Partnerships (MEPs)

- Catalyst Connection
- Greenleaf Corporation
- MAGNET
- TechSolve

Our Purpose

Our main goal is to "Bridge the Gap"
and address Technology & Manufacturing Readiness Levels (TRL & MRL) 4-7 enabling technology transition and commercialization through funding innovation projects.



How We Approach Innovation

Project Funding – We competitively award projects to members using public and private funds, addressing prioritized topics on our member-driven technology roadmap.

Our Vast Network – We act as a connector and facilitator between all of our members. Everyone has a seat at the table to contribute and collaborate with us and one another.

Workforce Readiness – Training and educational outreach is a priority for the institute. Every Public/private funded project requires an educational outreach component.

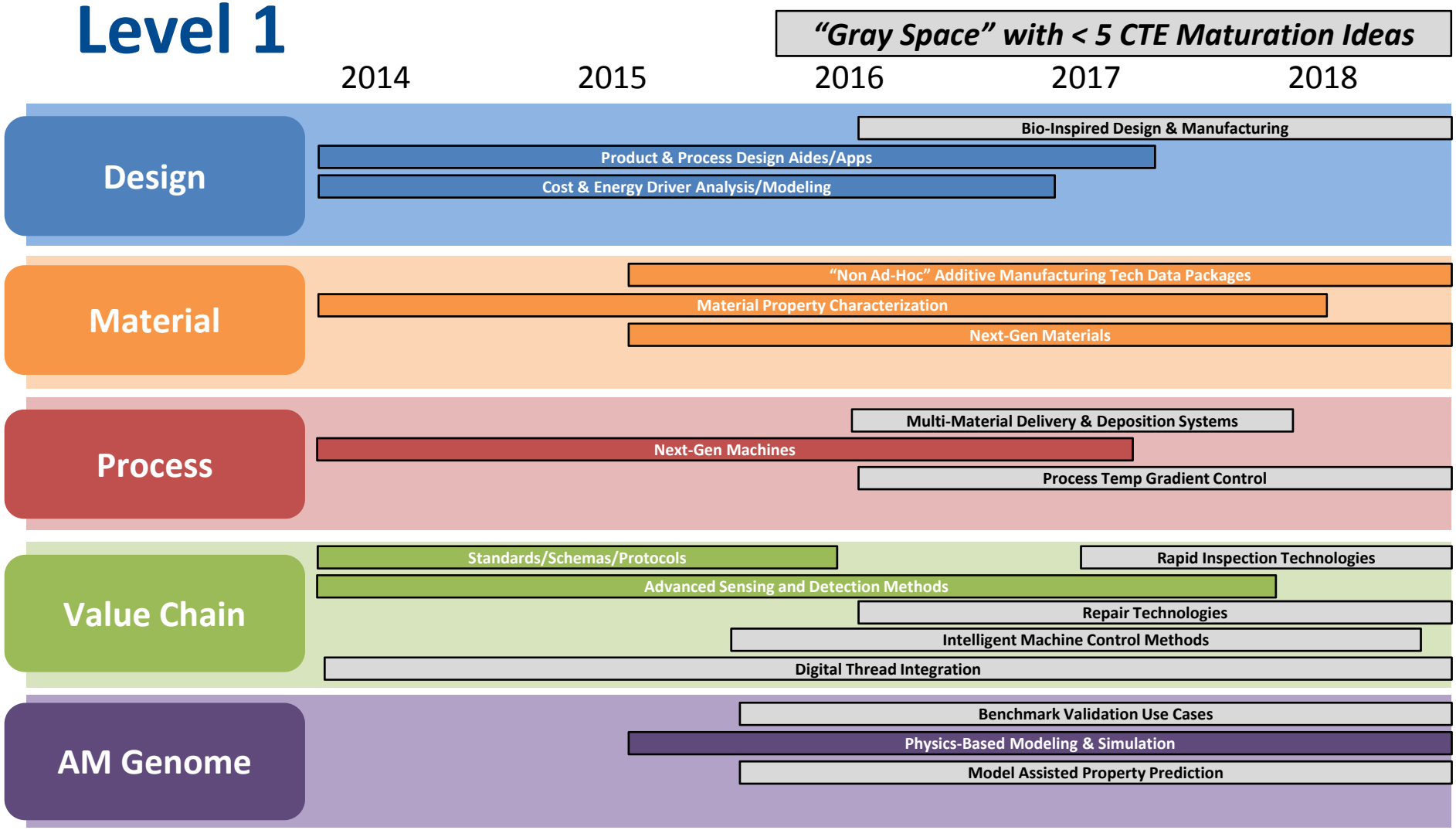
Technology Transition – We make it real. Every public/private funded project requires a pilot transition component.

Delivering Value

- Robust Additive Manufacturing Roadmapping
- Opportunity to Participate in Funded Projects
  - Consortium-driven Project Calls
  - Agency-driven Projects
  - Member-driven Projects
  - Client-driven Projects
  - Competitively-awarded Projects
  - Crowd-sourced Projects

- Access to Consortium Developed IP
  - Current Portfolio of 47 Projects valued at $59M (Includes Public Funds and Private Cost Share)
  - Current Project Calls will add $20+M → Total Portfolio in 2015 = $79M
- Use of the America Makes Innovation Factory

America Makes Technology Roadmap – Level 1



Our Approach to IP

All Consortium Developed IP is owned by the inventing organizations–
We help to conserve, integrate, and transition.

CONSERVE · INTEGRATE · TRANSITION

You Own Your IP – You will own both pre-existing IP and any you develop through consortium effort.

We Provide Protection – We have a membership agreement in place that is designed to protect your interests by ensuring that all participants play by the same set of rules.

Increase Chances of IP Adoption – We facilitate IP transition through our project-based approach and expansive network that represents multiple industries, markets, and stakeholders.

Consortium Developed IP Access Levels

Membership Level	Annual Fee – Cash and/or In-Kind Cost Share	Free Access to Consortium Developed IP for R&D	Use of Consortium Developed IP for Commercialization	Royalty-free Use of Consortium Developed IP for Commercialization
Platinum	$200,000	X		X
Gold	$50,000	X	X	
Silver	$15,000	X		

6 Project Call #1 Awards in 2013

- Projects Address Metals & Polymers
  - *Materials Characterization*
  - *Process Capability & Characterization*
  - *Quality Control*
- Each Project includes Technology Transition, Advanced Manufacturing Enterprise, and Workforce Education
- 35 Participants (8 of the 35 Are Universities)

15 Project Call #2 Awards in 2014

- *"In-Process Quality Assurance (IPQA) for Laser Powder Bed Production of Aerospace Components"* - **General Electric Aviation**
- "Developing Topology Optimization Tools that Enable Efficient Design of AM Cellular Structures" **- University of Pittsburgh**
- "AM of Biomedical Devices from Bioresorbable Metallic Alloys for Medical Applications" **- McGowan Institute for Regenerative Medicine at the University of Pittsburgh**
- "Refining Microstructure of AM Materials to Improve Non-Destructive Inspection (NDI)" **- EWI**
- "Development of Distortion Prediction and Compensation Methods for Metal Powder-Bed AM" **- GE Global Research**
- "Development of a Low-Cost 'Lens® Engine'" **- Optomec**
- "Development of Knowledgebase of Deposition Parameters for Ti-6Al-4V and IN718"**- Optomec**

15 Project Call #2 Awards (Cont'd)

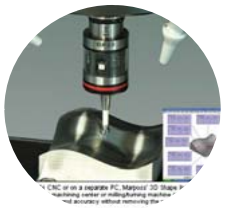
- "Automatic Finishing of Metal AM Parts to Achieve Required Tolerances & Surface Finishes" **- North Carolina State University**
- "Electron Beam Melted Ti-6Al-4V AM Demonstration and Allowables Development" **- Northrop Grumman Corporation**
- "3D Printing Multi-Functionality: AM for Aerospace Applications" **- University of Texas – El Paso**
- "Metal Alloys and Novel Ultra-Low-Cost 3D Weld Printing Platform for Rapid Prototyping and Production" **- Michigan Technological University**
- "Accelerated Adoption of AM Technology in the American Foundry Industry" **- Youngstown Business Incubator (YBI)**
- *"A Database Relating Powder Properties to Process Outcomes for Direct Metal AM"* **- Carnegie Mellon University**
- *"High-Throughput Functional Material Deposition Using a Laser Hot Wire Process"* **- Case Western Reserve University**
- *"Optimization of Parallel Consolidation Method for Industrial Additive Manufacturing"* **- Stony Creek Labs**

9 Project Call #3 Awards in 2015

- *"Parametric Design of Functional Support Structures for Metal Alloy Feedstocks"* – **University of Pittsburgh**
- *"Multidisciplinary Design Analysis for Seamless AM Design, Analysis, Build, and Redesign Workflows"* – **Raytheon**
- *"Economic Production of Next Generation Orthopedic Materials through Powder Reuse in AM"* – **University of Notre Dame**
- *"A Flexible Adaptive Open Architecture to Enable a Robust Third-Party Ecosystem for Metal Powder Bed Fusion AM Systems"* – **GE Global Research**
- *"Digital Threading of AM"* – **Boeing**
- *"A Design Guidance System for AM"* – **Georgia Institute of Technology**
- *"Cyber-Physical Design and AM of Custom Orthoses"* – **University of Michigan**
- *"A Low-cost Industrial Multi3D System for 3D Electronics Manufacturing"* – **The University of Texas at El Paso**

NIST MSAM Cooperative Agreement Program Award

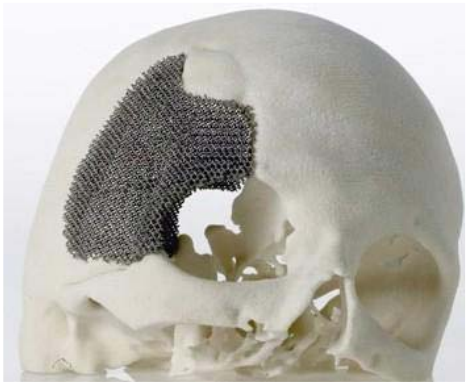
- **Won $5M, 24-Month NIST Measurement Science for Advanced Manufacturing (MSAM) Cooperative Agreement Program**: *"Holistic Approach to Solving Measurement Science Challenges in Additive Manufacturing"*
  - **Informative In-Situ Process Monitoring**
  - **Non-Destructive Evaluation**
  - **Layerwise Quality Certification for Additive Manufacturing**



- **NIST Also Awarded $2.4M Program to Northern Illinois University (an America Makes Member)** to develop tools for process control and qualifying parts made with layer-by-layer additive-manufacturing processes

Quality Parts Produced and Certified for Use in End Product(s)

Example of Funded Project



Topology Optimization

Building lightweight strength where you need it the most

Total project value: Approx. $1.0M

Project team: University of Pittsburgh

Timeline: April 2014 – August 2015

Complexity comes cheap with Additive Manufacturing.

This effort takes advantage of this unique design quality and seeks to apply geometric properties to structures to increase strength to any load-bearing components as needed.

As a result, structures are not only more resilient, but light than their traditionally designed and traditionally manufactured counterparts.

Many industries are potentially affected by this development in lightweight strength – from aerospace to automotive.

AFRL Agency-Driven America Makes Projects

AFRL Additive Manufacturing R&D Projects Competitively Awarded to America Makes Members & Managed by America Makes

- Laser Powder Feed Directed Energy Deposition Additive Manufacturing Development
- Powder Bed Fusion Of Thermoplastics Closed-loop Process Control
- Open Source Process Control For Powder Bed Additive Manufacturing Research
- Non-destructive Evaluation Of Complex Metallic Additive Manufactured Structures (Phase 1 & 2)
- Laser powder bed fusion processes for fabricating heat exchangers for propulsion applications

Special AFRL Cooperative Agreement SOW Task Executed by America Makes

- 3D Printing Skills Development for AFRL Personnel

Qualification of AM Processes and Procedures for Repurposing and Rejuvenation of Tooling

PROBLEM

New dies can cost up to $1.5M and have long lead times of 22-26 weeks. Extending life of tooling means saving a large investment of new capital and shorter lead times.

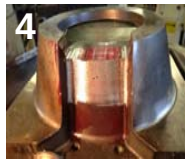
OBJECTIVE

***Develop, evaluate and qualify* novel methods of rejuvenation and repurposing of die casting tooling using additive manufacturing (AM)**

APPROACH

- Mechanical testing of coupons deposited with select AM processes and materials.
- Qualification of AM processes/suppliers and alloys that provide satisfactory properties.
- Production evaluation of tools repaired with qualified processes/alloys.
- Technology transfer and workforce education to promote the use of the AM repair methods.

- **Lead Organization**: Case Western Reserve University
- **Supporting Organization(s)**: North American Die Casting Association (NADCA), Dante Solutions, Keystone Synergistic Enterprises, Benet Laboratories, Twin City Die Casting, General Die Casters, Magma, Delaware Dynamics
- **Start Date**: 4/01/2013 **End Date**: 1/31/2015



BENEFITS

- **Extension of useful die life by at least 25%**
- **Much shorter lead times than for making new dies. Two weeks vs. 26 weeks.**
- **Significant cost savings-no more than 10% of a new die, usually less.**

IMPLEMENTATION

- **The additive tool repair methods developed in this America Makes project are being implemented across the die casting industry with NADCA assistance.**

Technology Transition

- Providing the AM / 3DP network with a conduit between large industry opportunities and Small / Medium Business innovation
  - rp+m, a founding member and small business / service provider, obtained AS9100C certification through their awarded America Makes grant enabling Aerospace OEMs Lockheed Martin, Northrop Grumman, and Boeing to source parts
  - M7 Technologies now partnering with Siemens as a metrology solutions provider

Educational Outreach

Strong emphasis on STEM for K-12

Partnering and leveraging many existing programs

- FIRST Robotics, AST2 Community Outreach Exhibit, ASM Teachers Camps, 3D Printing Summer Camps, NSF Einstein Fellows Training

3D Printers in Every School

- 100% private funding (Donor's Choose)
- 1000+ 3D printers funded
- Training, support, and materials

Workforce Training Initiatives

- AFRL, FAA, Commerce Department
- Industry members & at-large

2014 First Robotics Best Use of 3DP

3DP Hospital Repair at 2014 First Robotics Championship

MakerBot Academy

The Innovation Factory

8 WAYS MEMBERS CAN ENGAGE THE YOUNGSTOWN FACILITY

Demonstrations & one-off prototyping

Education events (camps, training)

Training on equipment & techniques

Workshop space for technical & general meetings

Showcase your projects, equipment, concepts

Fabrication and support capabilities & services

House employees at the innovation factory

Technology validation

Other Benefits of Membership

All Members:

- Access library of Additive Manufacturing resource
- Opportunities to leverage research funding and cost-sharing
- Access to comprehensive Additive knowledge-base

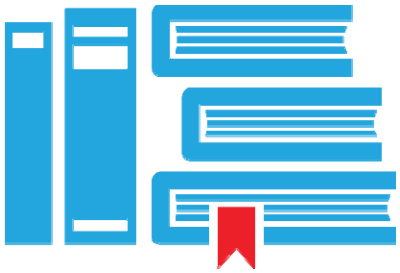
Small & Medium Enterprises:

- Network with high-level decision makers from large industry
- Help navigating complex government customer market
- IP adoption and market readiness mentoring

Large Industry:

- Insight into cutting edge of industry innovation
- Access to potential acquisitions and supply chain insight

Other Benefits of Membership



Academia:

- Leverage network for collaboration & funding opportunities
- Distribution channels for research and IP exposure

Government:

- Special project facilitation
- Infrastructure for program management and contracts

Economic Development:

- Cutting edge opportunities for your clients
- We facilitate match-making for collaboration
- Access shovel-ready economic development opportunities

America Makes Additive Manufacturing Maintenance & Sustainment Working Group

- Purpose:
  - Accelerate the productive use of additive manufacturing for commercial and government (DoD, DoE, NASA, FAA, etc.) equipment maintenance and sustainment
  - Benefits sought are increased operational availability and decreased time for maintenance, and lower recurring and non-recurring costs for equipment maintenance and sustainment
  - Focusing specifically on the use of additive manufacturing for maintenance and sustainment of commercial and defense equipment
- Collaborating closely with Greg Kilchenstein and newly formed DoD Additive Manufacturing for Maintenance Operations (AMMO) Working Group
- Monthly teleconferences to share issues and pursue solutions

The Economic Value Proposition: Leveraged Cost Sharing & ROI

- For funding sources needing work done:
  - The ability to double the work accomplished for each dollar spent
    - ❑ $1 of Investment + $1 of Cost Share = $2 of Output
    - ❑ $1M of Investment + $1M of Cost Share = $2M of Beneficial Output
  - Access to a vetted additive manufacturing supply chain network of industry & academic leaders and subject matter experts

Shared Investment

Shared Risk

Shared Reward / ROI

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Shared Investment

Shared Risk

Shared Reward / ROI

BBP 3.0 – "Increase the productivity of industry Independent Research and Development (IR&D) and Contracted Research and Development (CR&D)"

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- For funding sources needing work done:
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  - Access to a vetted additive manufacturing supply chain network of industry & academic leaders and subject matter experts
- For those doing the work and providing cost share:
  - The ability to leverage the investment by the funding source in areas of specific interest
  - The ability to spread the cost share across the performing team, further increasing the ROI
    - ❑ $1M of External Funding + $200K of Cost Share + $800K of team members cost share = $2M of Beneficial Output
- Plus proven, fair-broker Project Management at a low cost

Overview Summary

- ***We "connect the dots"***
- ***The challenge is enormous, but so is the potential payoff in the global competitive economic environment***
- ***This is a long-term play – the impact will be felt by future generations of Americans***

"Disrupt Ourselves Before Others Disrupt Us"

– The Honorable Stephen Welby, DASD Systems Engineering

When America Makes America Works

America Makes

AmericaMakes.us

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