

2022 DoD Additive Manufacturing Workshop

Final Outbrief

29 June 2022

MXD Facility in Chicago

2022 Additive Manufacturing (AM) Workshop Objectives

- Address key issues necessary for DOD-wide adoption of additive manufacturing.
- Provide a unique opportunity for government, industry, academia, and non-profit to collaborate on key issues that pertain to leveraging AM capabilities.
- Discover and share solutions that support the implementation of AM throughout DoD and DoD partners.

2022 AM Workshop Working Groups

- **DOD Standardization Prioritization**
- **Cybersecurity (wargame) Hack-a-thon & Improving AM in Small and Medium Manufacturers**
- **Manufacturing Crisis Response**
- **Additive Manufacturing Portal for Education (AMPED)**
- **Agile Inspection and Testing**

2022 AM Workshop

Working Group Out Briefs

2022 Additive Manufacturing Workshop

Final Outbrief

DoD Standardization Prioritization

Co Leads:

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DoD Standardization Prioritization

Objectives

1. (Day 1) Determine defense industry AM standardization priorities
2. (Day 2) Make recommendations for addressing the Research and Development gaps

Planned Deliverables

1. Identify the top 5-10 defense industry standards gaps in the ANSI and America Makes AMSC Standardization Roadmap for Additive Manufacturing
2. (Day 2) Develop a Statement of Objective (SOO) for the top gaps and how they can best be addressed through R&D projects

DoD Standardization Prioritization

Accomplishments and Deliverables:

Reviewed responses from pre-workshop survey on the top DoD gaps from AMSC and determined if gaps need to be addressed further

1. Reduced list to the top 5 gaps to focus on for day two
2. Reviewed each of the top 5 gaps and determined the rationale behind why a needs still remains
3. Identified recommendations on how needs could possibly be filled in the future.

DOD Prioritized AM Standards Gaps

1. Gap PC4: Machine Qualification
2. Gap QC2: AM Part Classification System for Consistent Qualification Standards
3. Gap D17: Contents of an AM TDP
4. Gap PC7: Recycle & Re-use of Materials
5. Gap FMP1: Material Properties/Gap FMP4: Design Allowables

Priority 1-PC4: Machine Qualification

Rationale: Lack of understanding of existing standards available. Lack of alignment and challenge with AM between Machine Installation vs Material Properties/Design Allowables vs Qualification (Process/Machine).

- Available Stds (Powder Bed Fusion): ISO/ASTM 52904, 52941, 52930, AMS 7032, NAVAIR Design Data Report
- **Ideal Process if “easy”:**
 - Machine “Calibration/Certification” Standard (key items defined; laser power, spot size, gas flow, etc.)
 - Material Properties/Design allowable (i.e. MMPDS) method defined,
 - Material Properties/Design Allowables created,
 - Standards/Artifacts(Test Coupon)/Proof Material defined,
 - Machine/Process/Material specification meets line 3 (i.e. “Mat1”), and product intent (length of build, layer thicknesses, materials, vaporization, sequence/path planning, part classification). Would include Requalification/Equivalence

Recommendation:

- Research (Y/N) Y: Desired to have publicly available data on expected variation between machines and long run builds (i.e. over 15 days)
- Possibly use a reference material and better define standards/artifacts for process/material qualification
- Survey existing standards (currently focused on PBF) and create standards for DED, MEX, BJT, etc.
- With a proof material, and standards will enable better sharing of data and pedigree.

Investment/Opportunities: Medium to High

- Continue to work with JAMA, SDOs, JAMWG, NIST

Priority 2-QC2: AM Part Classification System for Consistent Qualification Standards

Rationale: Very few standards have been published in this area that cover DoD interest.

- *API STD 205, Additively Manufactured Metallic Components for Use in the Petroleum and Natural Gas Industries*
- *NASA-STD-6030 Additive Manufacturing Requirements for Space Flight*
- *AWS, D20.1/D20.1M-2019, Specification for Fabrication of Metal Components using Additive Manufacturing*
- ASTM WK70164 is currently in work but not currently released.
- ASTM standard only covers Aviation and does not include other subject areas.

Recommendation:

- 1) Once ASTM WK70164 is officially published, standard should be considered for DoD adoption.
- 2) ASTM WK70164 should be used as a baseline to create additional standards in other areas (subs, nuclear, etc.)

Investment:

Priority 3-D17: Contents of a TDP

Rationale:

- Not just the contents of a TDP (**authoritative definition of an item**) but all the supporting documentation and effort. Very integrated with previous two gaps. Currently includes the material/machine qualification (costly and long lead time). Critical Safety parts typically send “build” file. Seems to be a short term fix to address lack of material properties/machine qualification standards. Very restrictive with current requirements.
 - MIL-STD-31000B Published

Recommendation:

- Separate Material properties in other specifications and include witness coupons for verification (material specific and part classification) and show process is in control.
- Benchmark AM TDP vs Casting TDP, etc.
- Review where certain requirements can be transitioned to a standard.
- Airworthiness awareness/acceptance of existing AM standards, industry best practices, and processes

Investment:

- Data to support equivalency of similar equipment types: Model to Model and OEM to OEM

Priority 4-PC7: Recycle & Re-use of Materials

Rationale:

- Definition of reuse methods;
- Lack metrics to define reuse: Inputs (Build geometry, etc.), outputs (chemistry, consolidated materials).
- How is it defined/included in Material Properties/Design Allowables?
- Current DOD experience is with non-continuous sieving methods.
- Does this include cleaning, storage, Recert vs. re-use?
- Also covered in TDP information.

Recommendation:

- Review of current standards: AMS 7031, ASTM COE projects, ASTM F42.01 items
- Possible suggestion is the process to be proved by the supplier for the application and cost structure (Process control to meet properties/allowables)
- Minimum reuse amount to be included in the material property/design allowable data

Investment:

- Research: Y Evaluation methods (powder condition), Sensitivity, Machine Cleanliness evaluation

Priority 5-FMP1: Materials Properties, FMP4: Design Allowables

Rationale:

- Common methodology to collect, communicate, and compare data. Need to have consensus on acceptable data. Ultimately would have publicly available design allowables and baseline material properties “MatOne”
- Lack of awareness\dissemination\rapid updates of MMPDS, CMH-17 progress
- Need to move from point solutions, to part family (“grades”), to overall AM process qualification

Recommendation:

- Leverage work with NIAR/JMAD
- Adoption/review of ASTM projects related to miniature Tensile specimens, rapid qualification, etc.
- Follow-up on potential C&D publication of MMPDS.

Investment:

- Potential future JMAD projects

DOD Standardization Prioritization

Key Takeaways:

- Although AMSC is a useful tool for gaps, there is still a need for a good reference (centralized search) for all Additive Manufacturing Standards.
- For some instances, there needs to be clarification of the intended meaning for particular AMSC listed gaps such Machine Qualification, Material Properties, Design Allowables, etc.
- Powder Bed Fusion tends to dominate the conversation, but other methods still need to be considered.
- Significant discussion regarding Design Allowables and the financial impact related follow-on applications
- *Further opportunity to support future material/process qualifications to be prioritized by DOD. Currently working PBF-LB/Ti, what is next and should be working soon.*

DOD Standardization Prioritization

Questions?

2022 Additive Manufacturing Workshop

Final Outbrief

Cybersecurity

Co Leads:

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Engineering)

Cybersecurity

Objectives:

1. Day 1: Learn about manufacturing cyber vulnerabilities and defense tactics in a red team / blue team cyber game environment. Identify future R&D investment, product development, and education and workforce development efforts for the AM supply chain
2. Day 2: Demonstrate the tools available from the Cyber Marketplace to gain prioritized tools, services, and policies that should be implemented to close security gaps identified in Day 1

Planned Deliverables:

1. List of cybersecurity threats with highest risk to AM and manufacturing environments as determined by the output of the Red Team / Blue Team Hackathon
2. Cyber assessment and Plan of Action that identifies potential gaps in AM and manufacturing cybersecurity that may expose environments to potential cyber threats

Cybersecurity

Accomplishments and Deliverables:

1. Played a Cyber Hackathon Game and identified and reinforced key security threats and our cyber controls for manufacturing environments
2. Created cyber awareness and identified key activities to improve cybersecurity posture for manufacturing environments
3. Reviewed cybersecurity frameworks and guidance, focusing on **CMMC 2.0**
4. Began (and completed) (2) CMMC 2.0 Level 1 assessment the MxD Cyber Marketplace

Cybersecurity

Key Takeaways:

1. People are (still) the weakness link in cybersecurity → **do not forget to include security training and awareness as part of your security controls**
2. You can't do everything at once → **Identify your needs and start now**
3. Leadership awareness is imperative for a successful cyber program → **include all levels of the organization in cybersecurity**

Cybersecurity

Recommendations and Next Steps:

- Cyber awareness with gamification element increases engagement, interest, learning, add this component to awareness
- Need to expand the awareness campaign to assure there is a multi-prong approach, include all the elements/tools, scaling considerations, and messaging
- Expand visibility through additional partnerships, use current institutional partnerships for teaming with lateral partners
 - Collaborate with existing Institute partners, e.g. America Makes
 - Possibility to piggyback engineering and innovation with CMMC and to offer solutions

Cybersecurity

Questions?

2022 Additive Manufacturing Workshop

Final Outbrief

Assessing Additive Manufacturing Crises Response

Co Leads:
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John Wilczynski

Assessing Additive Manufacturing Crises Response

Objectives & Planned Deliverables:

1. Scenarios and Use Cases
2. Questions that would be answered by an assessment
3. A proposal for
 - a. Type of assessment (e.g., wargame, table-top exercise, chalk talk, demonstration, exercise, or other)
 - b. Realistic timeframe for when an assessment could be conducted (e.g. could an exercise be held in FY23?)

Assessing Additive Manufacturing Crises Response

Accomplishments

1. Assessed the crisis landscape

Regulations / Governance needs imbedded in each criteria

a. Process Complexity

- ✓ *Anticipate what those needs are, and prepare for it*
- ✓ *Not clear on who's in charge (state vs federal)*
- ✓ *Response speed*
- ✓ *No overarching process (may not be singular process pending types of scenario)*
- ✓ *Should it be process for crises response only? Vs standard process and then ready to activate in normalcy or crises*

b. Product Complexity

- ✓ *verified equipment technology and support exists during Covid, better understanding of materials is needed*
- ✓ *Better automated software system that documents the requirements and solution*

c. Ecosystem Complexity

- ✓ *define who makes up the ecosystem, build into criteria and scenario, what organizations need involved*
- ✓ *people thoughts they were going to jail if it did not meet requirements. Stakeholder indemnification*

d. New Dimension ~ Viability of alternative

- ✓ *Go/No Go Decision (does AM make sense)*
- ✓ *Resources; How many do you need; Interim vs Bridge vs Permanent solution*

Assessing Additive Manufacturing Crises Response

Accomplishments (cont)

2. Crisis Scenarios:

Identified 6 example crises situations (National Disaster, National Security, Pandemic, Embargo, Cyber Attack, Regional Natural Disaster) and down selected to the following.

1. National Security
2. National Disaster

Solutions need to be agnostic and tailorable to Scenarios

Assessing Additive Manufacturing Crises Response

Key Takeaways:

- Develop plan for Action Officers
- Consider annual wargame ~ Consider existing activities
- Methodology vs Point Solution
- Gather the good (worked) that was accomplished
- On-going working group is needed
- Playbook, Distribution/Scope/Stakeholders
- Critical to understand “who is in charge”
- Need: **Authority/Knowledge Base /Policy**
- Work with OSD to determine applicability to “All Partners Access Network (APAN)”

Assessing Additive Manufacturing Crises Response

Recommendations and Next Steps:

Addressing the following from DoD Additive Manufacturing Strategy

Goals

- Expand proficiency in AM: **learn, practice and share** knowledge
- Align AM activities across DoD and with external partners

Primary Need Addressed

- New business models for contracting and acquisition of AM digital technical data
- Logistics model for production of AM parts at forward operating locations

Assessing Additive Manufacturing Crises Response

Recommendations and Next Steps:

1. On-Going Working Group
2. DoD Capability Fold into Prototype
 - Round out existing AMCPR Playbook
 - OIB Benefit
 - IB Benefit
 - Capture/Establish “National AM Knowledge”
 - ✓ “Clearinghouse for Information”
 - Wargame ~ Identify and Test Concepts
 - Normalcy
 - Crisis
 - Connect Digital Thread ~ Leverage existing platform (JAMMEX; 3YourMind) ~ Become google maps of AM Digital Advanced Additive Manufacturing (DAAM) System
 - Inform/Drive Policy and Law

Assessing Additive Manufacturing Crises Response

Questions?

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Additive Manufacturing Portal for Education (AMPED)

Co Leads:

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Additive Manufacturing Portal for Education (AMPED)

Objectives:

1. Identify and define critical job roles (listing of additive manufacturing roles validated 2020 AMMO) to support the advancement of additive manufacturing (AM) across the DoD enterprise and industrial defense base
2. Analyze DoD training offerings to identify required metadata categories to be used in AMPED portal
3. Explore key features, functions, usability of the AMPED portal that would be valuable in a sustainable full-scale launch

Planned Deliverables:

1. Focused list of critical job roles/competancies within DoD/industry required to advance adoption of AM
2. List of most valuable metadata categories to best describe available trainings mapped to required job roles/competancies. Identify existing training assets for focused list of critical job roles. Contrast requirements of different branches of service.
3. Highlight key features and overall functionality of AMPED portal based on working group consensus, while maximizing sustainability of the platform

Additive Manufacturing Portal for Education (AMPED)

Accomplishments and Deliverables:

1. Ranked job roles from 2020 AMMO workshop to AM criticality
2. Documented 11 job role categories required to advance adoption of AM
 - Completed competency modeling for 11 job role categories

**Application
Materials
Operations
Quality**

**Post Processing
Management
Safety
Inspection**

**Design
Procurement
Cyber**

Additive Manufacturing Portal for Education (AMPED)

Accomplishments and Deliverables (Cont'd):

3. Defined list of 25 metadata categories to be required to adequately describe trainings mapped on AMPED
4. Brainstormed key features and overall functionality of AMPED portal while maximizing sustainability of the platform
 - Working group voted to prioritize top portal features

Additive Manufacturing Portal for Education (AMPED)

Key Takeaways (what did you learn that doesn't fit into any other box):

- AMPED can be used to identify gaps in training based on data from searches for with no results
- Group members highlighted the need to share “playlist” of successful trainings
- DoD has a sustained need for AM training, amplifying the need for AMPED long term
- Better is the enemy of good enough

Additive Manufacturing Portal for Education (AMPED)

Recommendations and Next Steps:

- Some wish list features are beyond the scope of current project and will drive to unattainable sustainability
- Work to balance user convenience with sustainability costs
- Official project kickoff 7/1/22, 18mo PoP
- America Makes will work to amplify AMPED to further adoption/use

Additive Manufacturing Portal for Education (AMPED)

Questions?

2022 Additive Manufacturing Workshop

Final Outbrief

Agile Inspection and Testing

Co Leads:

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Agile Inspection and Testing Working Group



Agile Inspection and Testing

Objectives & Planned Deliverables:

1. Define Agile Inspection and Testing
2. Short Term and Long Term Benefits of Implementation
3. Roadblocks and Challenges with AM part inspection and Testing
4. Roadmap

Agile Inspection and Testing

Accomplishments and Deliverables:

- **Definition:** Versatile and adaptable solutions that leverage technology to accelerate observed understanding and decision making to enhance warfighter readiness.
- **Short Term 1-3yrs:** Supply Chain Resilience Shorter Schedules, Cost Saving (Lead Time Reduction, Reduce expediting cost, Over Head Cost/Non-Recurring/Capitol), (NTIB) National Technology Industrial Base, adoption of agnostic testing
- **Long Term 3-5yrs:** Accelerate the Adoption of AM Cost Savings, Shorter Schedules (Lead Times, Readiness, Testing), Attributable parts on Exquisite

Agile Inspection and Testing

Accomplishments and Deliverables (Cont'd):

- **Roadblocks:** Damage & Durability Tolerance/Effects of Defects, known variability of AM process (material state/performance), Material Design Bias, Risk based Design, Lack of Standards and Specification, Documented Certification: Equipment, Parts, People, Process. PoD/QA plan, Current NDI/NDT/NDE Technology, Manpower/Labor to perform testing, Manufacturing Limitations, Processing Sensitives, Lack of Technical Data, Big Data Utility/Management, Fabrication Size constraints, In-situ processing monitoring trust, Data completeness/pedigree for qualified AM parts, inherent uniqueness of AM parts, workforce competency, vetted multi-scale testing methods, relevant standard test methods, adoption of new test methods.



Agile Inspection and Testing

Roadmap: Enabling Capability

Metal AM NDE/NDI/NDT Toolbox

go/no go criteria for inspection (Material State).

Rapid Inspection methods (PCRT) TRL4/MRL8

Probability of Detection to enable in-situ process monitoring TRL4/MRL8 and conventional NDI methods TRL8/MRL8

Effects of Defects Study TRL4

Surface roughness acceptance thresholds, Porosity & Density acceptance thresholds, non-conformance definition go/no go criteria for inspection (Dimensional).

Leverage Quality Information Framework (ANSI Standard)

Data Solutions

Data Sharing Model (addresses IP concerns for industry/government/Controlled/Classified Information CUI) TRL3

Enterprise Hardware Services/Solutions: Cloud vs on-prem vs air gapped

Enterprise Data Management with Common M&P Database: Findable, Accessible, Interoperable, Reusable (FAIR) TRL5

Common Enterprise Secure data exchange/protocols TRL4

Big Data Solutions and Analytics

Technical Data Package for Certificate of Conformance: JAMMA TRL7

Governance

DLA 2.0: DLA 1.0 SD-6 evolution to support DoD Agile Operation

Flexible Distributed Manufacturing and Operation Framework.

Address Equivalency, Address Material & Process Standards, Outline Testing Methods, Signature/Acceptance

Authority, accreditation program (existing or new), Workforce Training, Workforce Digital Transformance

ex: Certification for NDI: Cat1, Cat2, Cat3, Legacy Drawing to Modern Drawing Formats

Use Case: Small Business, qualified metal AM, EOSm290/SLM280, 1:1 replacement, low criticality.

Agile Inspection and Testing

Roadmap: Enabling Capability (Cont'd)

Testing

Attributable Parts on Exquisite Vehicle Guidance Document

Less than full life

Business Case

testing: S/N curves, Inspection Schedule intervals

Environmental Performance Sensitivity Testing and Simulation

Environmental Corrosion, Material Compatibility

Long Term: AI/ML to reduce DOE

Accelerate fatigue / testing campaigns methods/methodologies/workflow

Evolved Conformance testing to support Digital CofCs.

Reduced Building Block Approaches for Unitization not needed for 1:1

Sampling Approaches for reduced testing maintaining operational repeatability

Single Point Statistics

Use Case: Small Business, qualified metal AM, EOSm290/SLM280, 1:1 replacement, low criticality.

Agile Inspection and Testing

Recommendations and Next Steps:

- *Draft* : Attritable Parts on Exquisite Vehicle Guidance Document
- *Draft* : Flexible Distributed Manufacturing and Operation Framework.
- *Draft* : Technical Data Package for Certificate of Conformance

Agile Inspection and Testing

Questions?

2022 AM Workshop

Final Report

- Send “Finished” Outbriefs
- Send all WG Briefs & Digital Notes
- NLT 8 July to Ray Langlais (rlanglais@lmi.org) & Candice Belaire (Candice.Belaire@ncms.org)

2022 AM Workshop

Survey Link

<https://www.surveymonkey.com/r/22AMWorkshop>