2022 DoD Additive Manufacturing Workshop

Outbrief to JAMWG

20 July 2022

2022 Additive Manufacturing (AM) Workshop Information

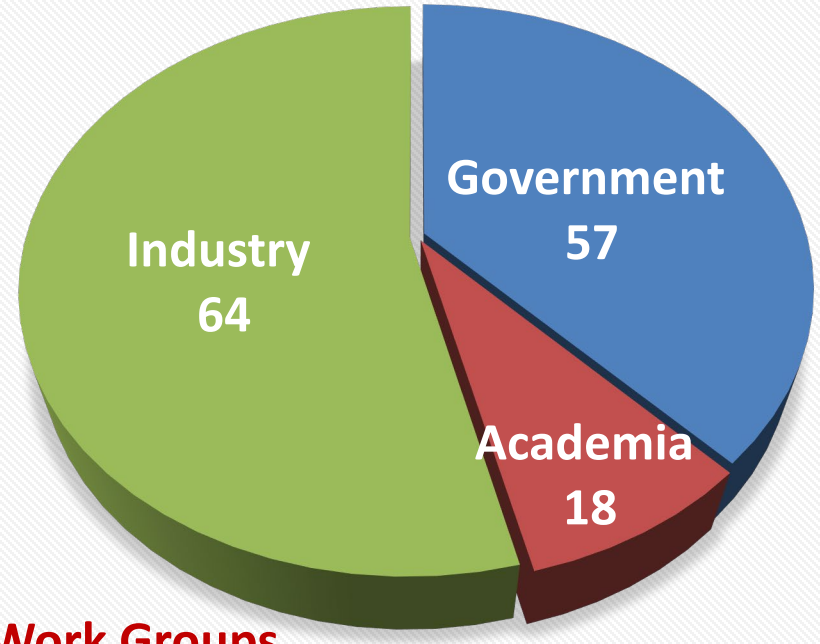
- Purpose: to address foundational aspects of additive manufacturing necessary for DOD-wide adoption of this capability
- Sponsored by DoD's Joint AM Working Group, America Makes AM for Maintenance and Sustainment Advisory Group, and the AM for Maintenance Operations (AMMO) Working Group
- 7th Year of annual AM wargame or workshop event
- Opportunity for government, industry, academia, and non-profit to actively participate in the workshop
- Over 135 people registered
- Working groups (20-35 people) consist of five key AM focus areas
- https://www.ncms.org/events/2022-additive-manufacturing-workshop/

2022 Additive Manufacturing Workshop Demographics

America Makes

139 Registrants

7 Disciplines



5 Work Groups

(20 – 35 person WGs)

Engineering 65

Cybersecurity 23

Program Mgmt 20

Logistics 17

Enterprise IT 6

Education/Tng 5

Contracts 3

2022 AM Workshop Working Group Focus Areas

Cybersecurity (wargame) Hack-a-thon and Improving AM in Small and Medium Manufacturers *Larry Lynch (USACE); Laura Elan (MxD)*

- Execute several DoD relevant hack-a-thon exercises (wargame, manufacturing operating scenarios) to identify, prioritize, and document cybersecurity vulnerabilities for AM digital workflows.
- The Cyber Marketplace, and the cybersecurity assessment process.

DOD Standardization Prioritization *Jesse Chambers (DLA)/Jesse Boyer (Pratt & Whitney)*

- Structured feedback session on standards gaps & opportunities. Identify and prioritizes gaps in methods, tools, and technologies pertinent to various standardization priorities.

Assessing Additive Manufacturing Crisis Response *Josh Heller (ASNRDA)/ John Wilcynski (America Makes)*

- Review the lessons learned from AMCPR and Covid-19 and use the information to help develop assessment formats.

2022 AM Workshop Working Group Focus Areas (Cont'd)

Additive Manufacturing Portal for Education (AMPED) *Jeremy Chang (OSD ManTech) / Courtney Puhl (America Makes)*

- Workshop 1 - Building from the last workshop the team will validate and confirm the identified and defined roles and qualify this data set.
- Workshop 2 - Explore listing and categorization of training offerings by broad classification to explore gaps, missing assets and prioritize.
- Workshop 3 – Use the AMPED portal to highlight areas of focus as well as key features that would be valuable in a full-scale launch of the tool.

Agile Inspection and Testing *Vincent Paquit (ORNL) / Derrick Lamm (Lockheed)*

- Develop a multi-year plan with phased approach to incrementally improve the ability to create the framework for agile inspection and testing of AM parts.

2022 AM Workshop

Working Group Out Briefs

2022 Additive Manufacturing Workshop

JAMWG Outbrief

Cybersecurity

Co Leads:

Laura Elan (MxD)
Larry Lynch (OSD Manufacturing Technology | OUSD Research and 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 appears to increases engagement, interest, learning, add this component to awareness for SMMs
- 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

Recommendations for Future Workshops:

1) Example opportunities for government reps to work with SMMs or other vendors to get them CMMC compliant

2) Working group for discussion of impacts of current issues being faced by industry with respect to demonstration of cyber hygiene, including feedback from government partners as to what they are hearing from companies in their supply chain

3) Provide use cases in which tools have been effective in preparing industry to meet not only compliance but also have generated positive results in business.

4) Providing access to physical equipment such as the future MxD Cyber Bunker which has a 3D printer connected in a DoD representative network as the target for a hands-on (no simulated) hackathon effort. Summarize with on the 2nd day to discuss what was learned and how to improve either the set up or procedures used to protect them.

Cybersecurity

Questions?

2022 Additive Manufacturing Workshop

JAMWG Outbrief

DoD Standardization Prioritization

Co Leads:

Jesse Chambers (jesse.chambers@dla.mil)
Jesse Boyer (jesse.boyer@prattwhitney.com)

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:

1. Reviewed responses from pre-workshop survey on the top DoD gaps from AMSC and determined if gaps need to be addressed further
2. Reduced list to the top 5 gaps to focus on for day two
3. Reviewed each of the top 5 gaps and determined the rationale behind why a needs still remains
4. 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

Assessing Additive Manufacturing Crises Response

Outbrief to JAMWG
July 20, 2022

Co Leads:
Josh Heller
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
Day 1: Accomplishments and Deliverables

1. *Created a list of **Lessons Learned** from Covid*

Engage DLA

Regulatory + Rules of Engagement (Authority,; Knowledge; Policy)

OIB Driven by "funded requirements"

Mechanisms to interact and transfer resources (OIB and Other)

Redundant & Inadequate Risk Management Framework

Interagency disconnect

Understanding demand signals and requirements

Importance of Digital Thread

Perceived barriers to IP rights

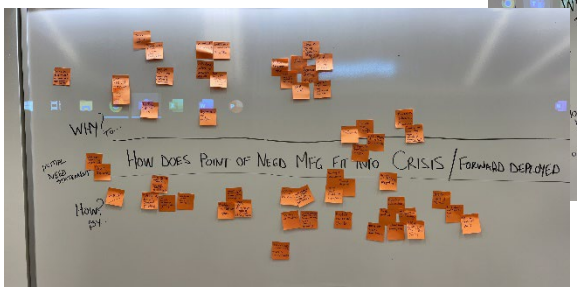
Importance and value of established partnerships

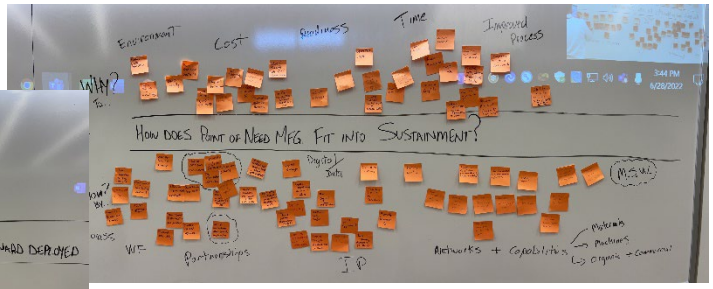
2. *Created a list of **Needs** for Crises Response*

1. Approved business model
   - Capability/capacity
   - Approval authority
   - incentives
2. Funding
3. Team to Wargame and Execute

3. *Evaluated how **Point of Need Manufacturing** fits into*

- *Crises/Forward Deployment*
- *Sustainment*





Assessing Additive Manufacturing Crises Response
Day 2: Accomplishments and Deliverables

- Reviewed Advanced Manufacturing Crisis Production Response (AMCPR) Playbook
- *Assessed crisis landscape: Regulations / Governance needs imbedded in each criteria*

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)* ○ *Process for crises response only?* ○ *Standard process and then ready to activate in normalcy or crises?*	***Ecosystem Complexity*** ✓ *Define who makes up the ecosystem, build into criteria and scenario, what organizations need involved* ✓ *Perception that suppliers would go to jail if it did not meet requirements, stakeholder indemnification*
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*	***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*

Identified 6 agnostic and tailorable example crises situations

Assessing Additive Manufacturing Crises Response Key Takeaways

- AMCPR Playbook exists, distribute / update / identify stakeholders
- On-going working group is needed
- Gather the good (worked) that was accomplished
- Develop plan for Action Officers
- Methodology vs Point Solution
- Annual wargame
- Identify and leverage existing activities
- 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

Address 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

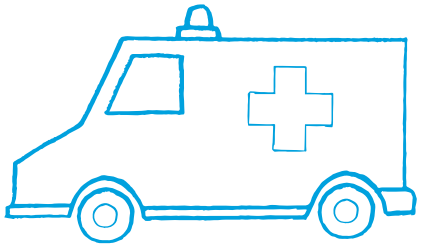
Questions?

Assessing Additive Manufacturing Crises Response

Backup Slides

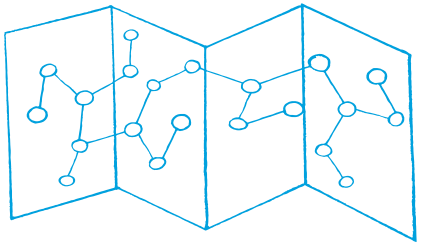
How to use this playbook

This playbook aims to support the advanced manufacturing ecosystem to collaborate and prepare for future crises by building agile manufacturing capacity and supply chain resiliency.



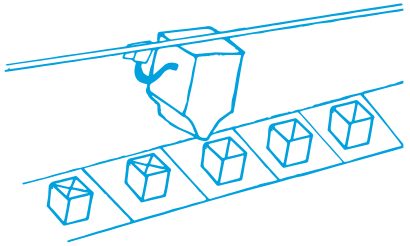
PREPARE FOR FUTURE CRISES

Use this document in anticipation of the next crisis in order to assemble and effectively target, deliver, and monitor a crisis response



FOSTER ECOSYSTEM COLLABORATION

Use this document to engage with the advanced manufacturing ecosystem and drive collaboration and high-quality, diverse solutions



BUILD CAPACITY & RESILIENCY

Use this document to identify and bridge supply capability gaps and enhance digital infrastructure in support of crisis response

Crisis Response Framework Overview

This framework was developed from insights gained during the AMCPR effort to address PPE and medical equipment shortages throughout the COVID-19 pandemic. This iterative response structure aims to accelerate the recovery and resiliency phases of an advanced manufacturing community response.

This process is cyclical for as long as necessary as crises evolve and AMCPR capabilities improve or shift over time

1. Assess Crisis Landscape

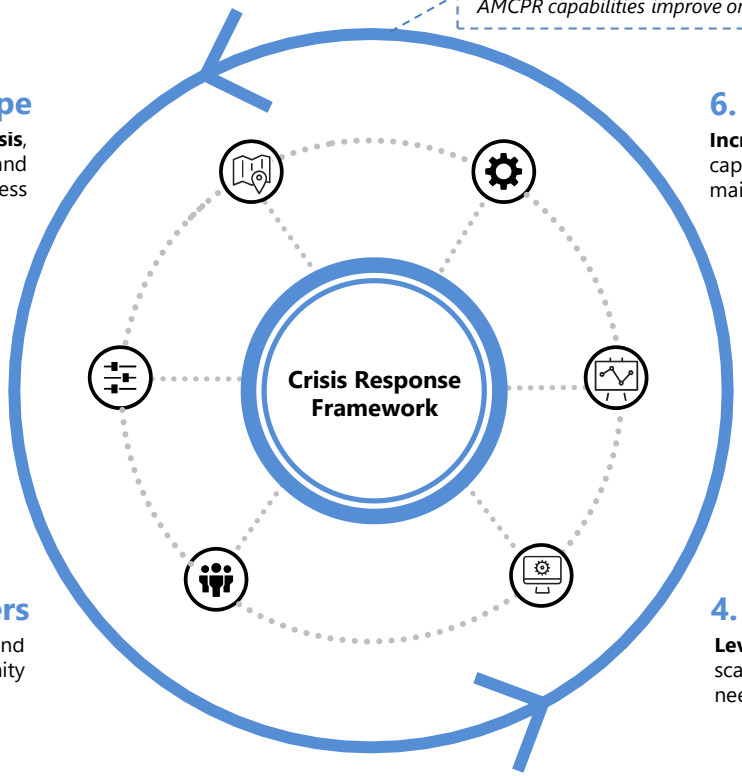
Understand key factors of the crisis, including size, geographic impact, and type response needed to address

2. Target Value Areas

Assess potential areas your organization can add value based on strengths and capabilities

3. Organize Stakeholders

Coordinate ecosystem members and broader response community



4. Activate AMCPR Exchange

Leverage existing infrastructure to scale and manufacture products for needs community

5. Monitor Crisis Response

Track performance and continuously target areas of the AMCPR can provide value

6. Enhance Capabilities

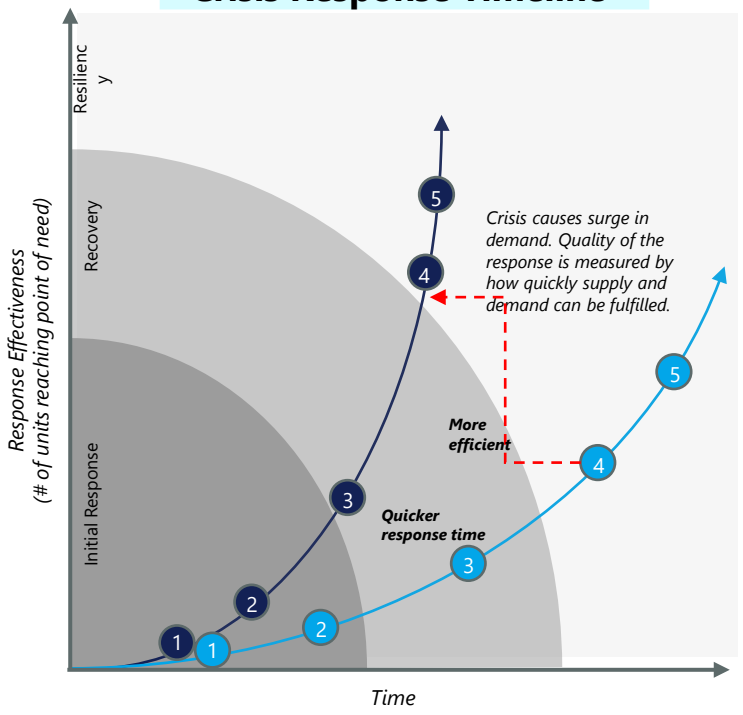
Increase preparedness through capability building and infrastructure maintenance

America Makes | Driven by NCDMM

Long-term opportunity for the AMCPR Program to accelerate the crisis response timeline

The AMCPR will **enable the mobilization of a supplier network** – targeting regions with the most acute needs - to **more quickly meet demand and deliver critically needed part**s. An established response network that is coordinated and able to mobilize regional production to meet local needs will enable the most timely and effective response to national crises, climate events, or impacted supply chains.

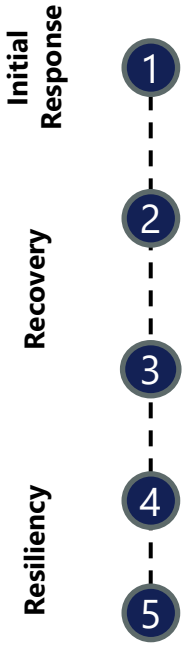
Crisis Response Timeline



: **AMCPR:** Crisis Response with Established Response Capability

: Crisis Response **without** Established Response Capability

Crisis Response Goals



1. Conduct initial crisis and response assessment
2. Identify AMCPR value areas and initiate rapid response activities
3. Return supply chain capacity to normal operations
4. Strengthen response capabilities
5. Enhance AMCPR Exchange infrastructure

Determine which crisis cycle the AMCPR is responding to

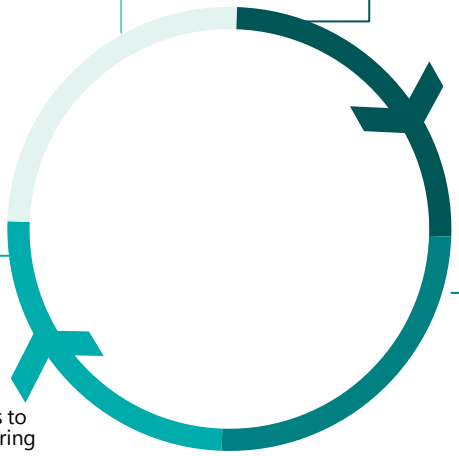
- The Federal Emergency Management Agency (FEMA) identifies four major phases of a disaster or crisis:

1. Preparedness
2. Response
3. Recovery
4. Mitigation

- The information the AMCPR needs to know when evaluating the crisis landscape changes depending on the crisis stage, in addition to the needs communities and the challenges they may face.

- These cycles can be considered when devising crisis response efforts.
- Recognition of preparation and mitigation phases will enable the AMCPR to support crises outside of immediate crisis response efforts and use its diverse ecosystem, government relationships, and COVID-19 lessons learned.

- **Consider the differences in response activities and at need communities depending on the current phase of the crisis**



Phase 1: Preparedness

This phase entails the development of emergency preparedness plans to minimize the loss of life and physical damage

Key questions:

- *What types of supply gaps are likely to appear?*
- *Which groups/businesses are less likely to prepare for disasters?*
- *Which groups/businesses will lack essential emergency response items?*

Phase 2: Response

This phase requires the necessary action to save lives and prevent further damage in a crisis.

Key questions:

- *Which groups are least likely to hear, understand, and respond to warnings?*
- *Which groups will have difficulty following emergency directives?*
- *Which groups will need emergency medical care or continuation of medical care, and which groups are least likely to have access to emergency services?*

Phase 3: Recovery

This phase focuses on the efforts after a disaster occurs to restore the community back to normal through repairing, replacing, or rebuilding property.

Key questions:

- *Which groups or industries are most likely to have experienced the greatest economic or emotional stress?*
- *What products or services are needed to revitalize groups, industries, or communities?*

Phase 4: Mitigation

This phase includes developing policies to reduce risks to people and property during a disaster.

Key considerations:

- *What digital solutions will aid in future responses?*
- *What resources are needed by at-risk groups during an emergency?*
- *What infrastructure will aid in future crisis responses?*

[1] Centers for Disease Control: Planning for an Emergency: Strategies for Identifying and Engaging At-Risk Groups

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2022 Additive Manufacturing Workshop

JAMWG Outbrief

Additive Manufacturing Portal for Education (AMPED)

Co Leads:
Courtney Puhl (courtney.puhl@ncdmm.org)
Jeremy Chang (jian-ming.chang@navy.mil)
Mateja Fiorille (mateja.fiorille@ncdmm.org)
Michael Parkyn (michael.b.parkyn.ctr@mail.mil)

Additive Manufacturing Portal for Education (AMPED)

Project Overview:

Purpose:

The purpose of this project is to build an online learning portal with training assets pathway across America Makes, the DoD enterprise, and industry at large to assist those seeking to enter the additive manufacturing industry to obtain skillsets for the desired job role

Deliverables:

- Review and Assessment of historical database - Role based assessment for training competencies for AM (interim)
- Review and Assessment of historical database - A database of existing AM training assets in the DoD and industry (interim)
- Functional requirements document for the online educational portal/website (interim)
- Sustainability plan for maintenance and hosting of technology platforms
- An online education portal for AM that links the role-based competency needs to the database of training assets that securely segregates any CUI or restricted access information to the public (final)
- Four Micro-learning modules (web based) focused on DoD/Industry Leadership

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 competancy modeling for 11 job role categories

Application	**Post Processing**	**Design**
Materials	**Management**	**Procurement**
Operations	**Safety**	**Cyber**
Quality	**Inspection**	

Additive Manufacturing Portal for Education (AMPED)

Accomplishments and Deliverables (Cont'd):

3. Defined list of 25 metadata categories suggested 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 generated a list of potential features for AMPED portal to maximize usability
    - Working group voted to prioritize most beneficial portal features

Additive Manufacturing Portal for Education (AMPED)

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

- AMPED tracking metrics can be used to identify gaps in training based on data from searches with no results
- Group members highlighted the need to share "playlist" of successful trainings
- If mapped trainings align to a certification or credential, that will be noted in the AMPED portal
  - America Makes and others do offer trainings that align to certifications/credentials however AMPED itself is not offering any certifications or credentials
- 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/Next Steps/Potential Engagement:

- Work to balance user convenience with sustainability costs
  - Some “wish list” features are beyond the scope of current project and will drive to unattainable sustainability
  - Sustainability plan will be drafted at the completion of the project (America Makes led)
- Official AMPED project kickoff 7/1/22, 18mo PoP
  - Currently completing contracting with project partners
- AMMO workshop is the first of 2 workshops
  - A second virtual AMPED workshop will be tailored to ensure representation across DoD
- America Makes/OSD are working to identify Project Steering Committee members to contribute to portal requirements, designs, and demo sessions

Additive Manufacturing Portal for Education (AMPED)

Questions?

Please contact our co-leads:

Courtney Puhl (courtney.puhl@ncdmm.org)
Jeremy Chang (jian-ming.chang@navy.mil)
Mateja Fiorille (mateja.fiorille@ncdmm.org)
Michael Parkyn (michael.b.parkyn.ctr@mail.mil)

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JAMWG Outbrief

Agile Inspection and Testing

Co Leads:

Vincent Paquit ORNL

Derrick Iamm LMCO

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), Attritable parts on Exquisite

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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.

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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.

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Roadmap: Enabling Capability (Cont'd)

Testing

Attritable 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.

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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

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Questions?

2022 Additive Manufacturing (AM) Workshop Summary

- Addressed key issues necessary for DOD-wide adoption of additive manufacturing.
- Provided a unique opportunity for government, industry, academia, and non-profit to collaborate on key issues that pertain to leveraging AM capabilities.
- Discovered and shared solutions that support the implementation of AM throughout DoD and DoD partners.
- Slides on AMMO Website https://ammo.ncms.org/
- Final Report in August 2022

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Questions?