

# 2021 Additive Manufacturing Workshop

## Backup Slides

## AM Standards

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- Bill Bihlman, Aerolytics, LLC (SAE)
- Jesse Chambers, DSPO
- Scott Crynock, America Makes
- Laura Feix, AMPP
- Elton Freeman, ERDC
- Fred Herman, SHEPRA
- Mahdi Jamshidinia, ASTM International
- Ben Kassel, LMI
- Jim McCabe, ANSI
- Adi Patel, USCG
- Matthew Spiret, Markforged
- Kate Thorn, NAVAIR
- Richard Wimberly, USMC

# AM Standards – Meeting Goals

- **Objectives**

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

- **Planned Deliverables**

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



## **AM Standards – Day 1 Agenda**

- **Opening (Introductions, Review of Goals/Agenda) (30 Mins)**
- **Briefing on AMSC Roadmap – J. McCabe (15 Mins)**
- **Briefing on Results of Survey ranking top 5-10 AMSC Gaps – J. Chambers/J. McCabe (15 Mins)**
- **Breakout Group Discussion to Agree on Top 5-10 Gaps (90 Mins)**
  1. Chambers/McCabe to each lead one of them
  2. Each group should identify a notetaker to do the report back
- **Break (30 Mins)**
- **Reports from Breakout Groups (15 Mins each)**
- **Discuss and Finalize the top 5-10 gaps (30 Mins)**

## AM Standards – Day 2 Agenda

- **Full group brainstorming: Develop potential R&D projects for the top 5-10 gaps (2.5 hours)**
- Is the gap a good candidate for an R&D project? (In your opinion, regardless of what the gap says with respect to R&D needed.)
  - If yes, why do you think so?
  - If yes, what do you recommend in terms of R&D that is needed?
  - Would the budget required be modest, moderate, or substantial?
- Break (30 Mins)
- **Summarize action items / discuss content of 6/21 outbrief to general session (1 hour)**

# America Makes & ANSI Additive Manufacturing Standardization Collaborative (AMSC)

- Launched in March 2016
-  America Makes  **ANSI**  
American National Standards Institute
- America Makes is the nation's leading public-private partnership for additive manufacturing technology and education
- ANSI is the national coordinating body for voluntary standardization in the United States, with a history of serving as a neutral facilitator to identify standards needs
- U.S. federal government agencies instrumental in formation of AMSC included: National Institute of Standards and Technology (NIST), U.S. Department of Defense (DoD), Federal Aviation Administration (FAA), along with several SDOs
- Mission: To coordinate and accelerate the development of industry-wide additive manufacturing standards and specifications, consistent with stakeholder needs, and thereby facilitate the growth of the additive manufacturing industry

## AMSC Goals

- Facilitate development of a consistent, harmonized, and non-contradictory set of AM standards and specifications
- Develop a standardization roadmap describing the current and desired future standards landscape: what's published, in development, or needed
- Drive coordinated activity among AM standards developing organizations (SDOs) and avoid duplication of effort
- Inform decision-making on resource allocation for standards participation
- Provide subject matter experts to work with SDOs
- AMSC itself is not developing standards

## AMSC Participation

- Participation is open to additive manufacturing stakeholders that have operations in the U.S.
- Membership in America Makes and ANSI is not a prerequisite
- Members include:
  - Original Equipment Manufacturers (OEMs)
  - Feedstock Material Producers
  - User Stakeholders - Industry and Government
  - R&D Community - Academia and Government
  - SDOs
- More than 300 individuals from 175 public- and private-sector organizations involved
  - Draws from aerospace, defense, medical and other sectors



# AMSC Deliverables

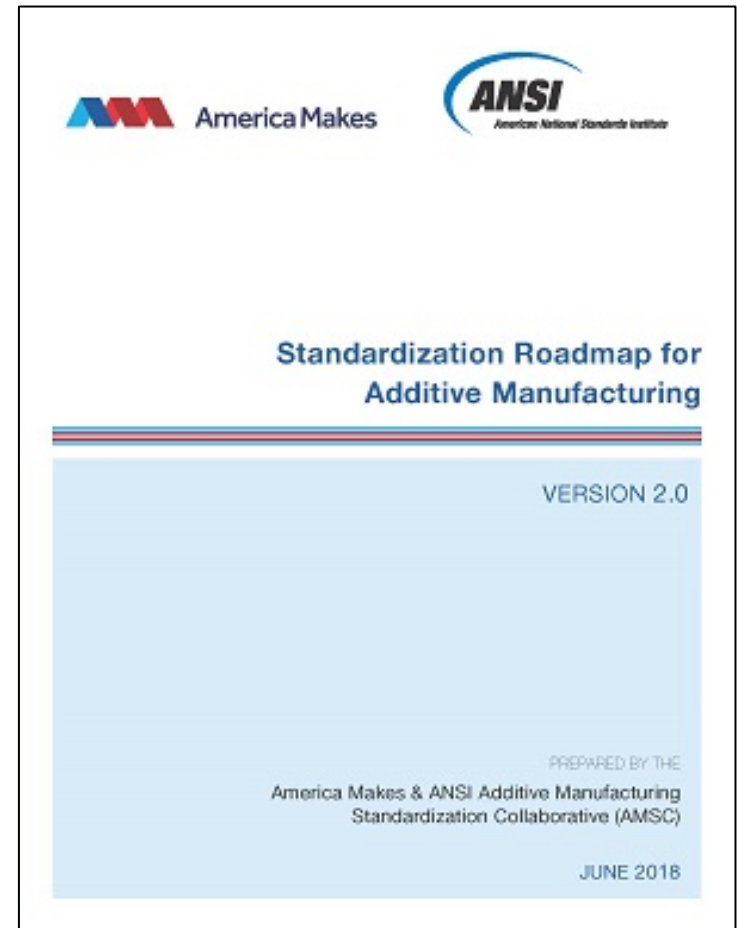
## [Standardization Roadmap for Additive Manufacturing, Version 2.0 \(June 2018\)](#)

- Identifies published and in-development standards and specifications, assesses gaps, makes recommendations for priority areas where there is a perceived need for additional standardization

## [Gaps Progress Report](#)

- Provides the latest updates by the SDOs to address the roadmap gaps

Download at [www.ansi.org/amsc](http://www.ansi.org/amsc)



# AMSC Topical Areas & Working Groups

(“life cycle assessment of an AM part”)

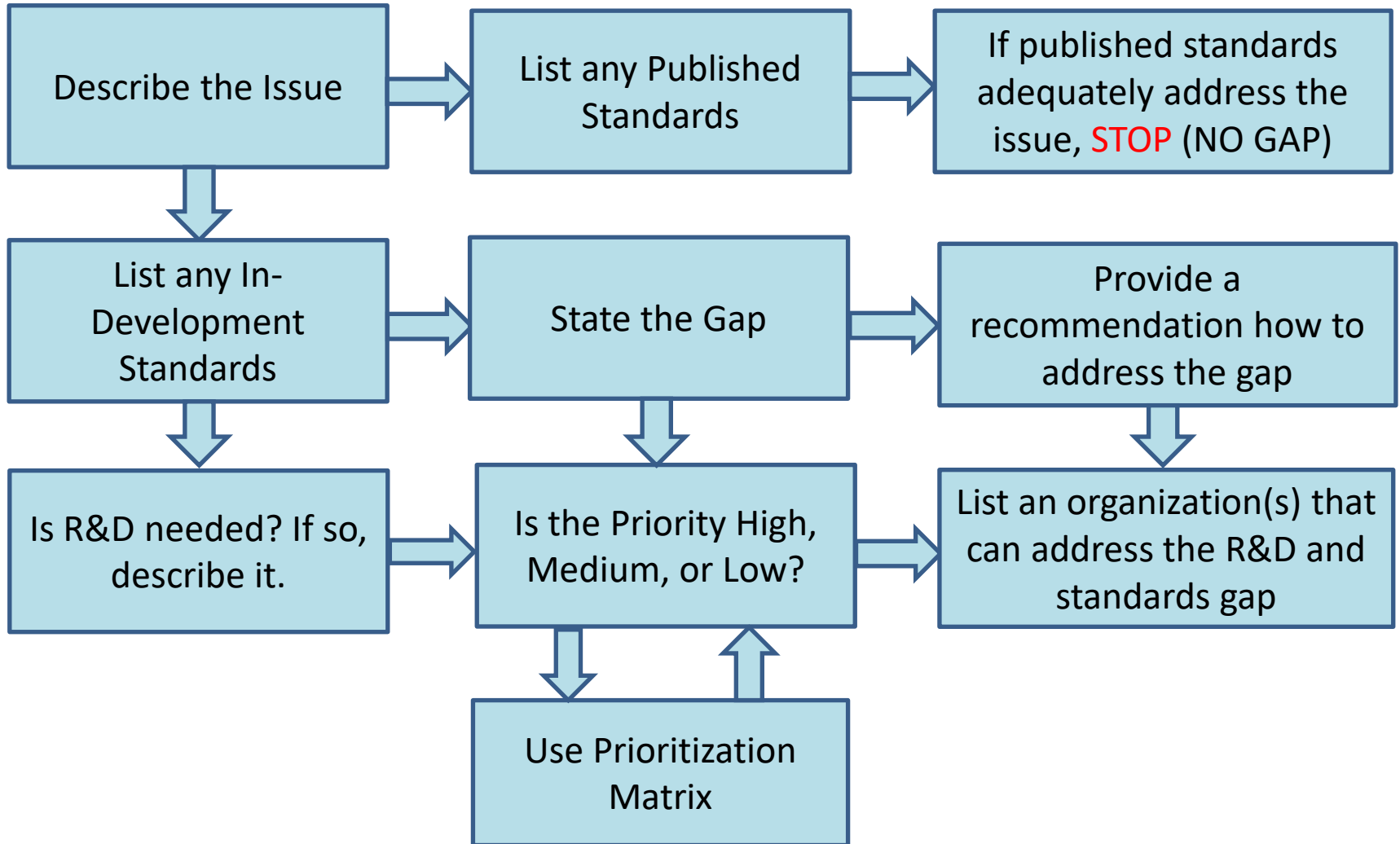
- Design
- Process and Materials
  - Precursor Materials
  - Process Control
  - Post-processing
  - Finished Material Properties
- Qualification & Certification
- Nondestructive Evaluation
- Maintenance and Repair

## Horizontal WGs

**Medical** - evaluating medical content across document

**Polymers** - evaluating polymers content across document

# Process Flow for Describing Issues and Gaps



# Sample Gap Statement

## (simple example)

- **Gap M1: AM Analyses in RCM and CBM.** Standards for AM analyses in Reliability Centered Maintenance (RCM) and Conditioned Based Maintenance (CBM+) are needed.
- **R&D Needed:** No
- **Recommendation:** Update SAE JA1012 RCM, a guide to provide analytics for AM trade-offs in RCM and CBM+.
- **Priority:** Medium
- **Status of Progress:** Not Started
- **Update:** SAE G-11M, Maintainability, Supportability and Logistics Committee, will consider inclusion of analytics for AM trade-offs in the next update of JA1012\_201108.
- **Organization:** SAE, ISO, ASTM

# Making the CASE for the Priority Level

## Criteria

- **Criticality (Safety/Quality Implications)**  
- How important is the project? How urgently is a standard or guidance needed? What would be the consequences if the project were not completed or undertaken? A high score means the project is more critical.
- **Achievability (Time to Complete)** -  
Does it make sense to do this project now, especially when considered in relation to other projects? Is the project already underway or is it a new project? A high score means there's a good probability of completing the project soon.

## Scoring Values

- 3 - critical
  - 2 - somewhat critical
  - 1 - not critical
- 
- 3 - project near completion
  - 2 - project underway
  - 1 - new project

# Prioritization Matrix (contd.)

## Criteria

- **Scope (Investment of Resources)** - Will the project require a significant investment of time/work/money? Can it be completed with the information/tools/resources currently available? Is pre-standardization research required? A high score means the project can be completed without a significant additional investment of resources.
- **Effect (Return on Investment)** - What impact will the completed project have on the industry? A high score means there are significant gains for the industry by completing the project.

## Scoring Values

- 3 - low resource requirement
- 2 - medium resource requirement
- 1 - resource intensive

- 3 - high return
- 2 - medium return
- 1 - low return

## Score rankings

- High Priority (a score of 10-12)
- Medium Priority (a score of 7-9)
- Low Priority (a score of 4-6)

# Open Gaps Breakdown - Version 2.0

Section	High (0-2 years)	Medium (2-5 years)	Low (5+ years)	Total
Design	4	15	6	25
Precursor Materials	1	4	4	10
Process Control	4	8	4	16
Post-processing	0	4	3	7
Finished Material Properties	3	1	0	4
Qualification & Certification	4	8	3	15
Nondestructive Evaluation	2	4	2	8
Maintenance & Repair	0	7	1	8
<b>Total</b>	<b>18</b>	<b>51</b>	<b>24</b>	<b>93</b>

- 65 gaps need Research & Development

AMSC “Defense Industry” Gaps Discussed in Standards SG at 2019 AMMO workshop (except those addressed by other groups as noted)	R&D Needed?
Gap D17: Contents of a Technical Data Package – in Group 1	Yes
Gap D24: An Acquisition Specification – in Group 3 (Closed)	No
Gap PC4: Machine Qualification	Yes
Gap PC6: Adverse Machine Environmental Conditions: Effect on Component Quality	Yes
Gap QC1: Harmonization of AM Q&C Terminology	No
Gap QC2: AM Part Classification System for Consistent Qualification Standards	No
Gap QC3: Harmonizing Q&C Terminology for Process Parameters (w/QC1)	No
Gap QC4: Process Approval for DoD-procured Parts	Yes
Gap QC5: Machine Operator Training and Qualification – in Group 4	No
Gap NDE7: NDE of Counterfeit AM Parts	No
Gap M7: Cybersecurity for Maintenance – in Group 1	Yes



Other “Defense Industry” Gaps Flagged as Pertinent in Standards SG at 2019 AMMO workshop but Not Discussed	R&D Needed?
Gap D28: Specification of Surface Finish	Yes
Gap NDE1: Terminology for the Identification of AM Flaws Detectable by NDE Methods	No
Gap NDE3: Standard Guide for the Application of NDE to Objects Produced by AM Processes	Yes w/details
Gap NDE6: NDE of Polymers and Other Non-Metallic Materials	Yes w/details
Gap NDE8: NDE Acceptance Criteria for Fracture Critical AM Parts	Yes w/details
Gap M9: Laser Based Additive Repair	No

<b>Other “Defense Industry” Gaps developed with substantial defense industry input</b>	<b>R&amp;D Needed?</b>
<b>Gap D18: New Dimensioning and Tolerancing Requirements</b>	<b>No</b>
<b>Gap D19: Organization Scheme Requirement and Design Control</b>	<b>No</b>
<b>Gap D21: New Terminology in Design Documentation</b>	<b>No</b>
<b>Gap D20: Neutral Build File Format</b>	<b>Yes</b>
<b>Gap PM7: AM Process-Specific Metal Powder Specifications</b>	<b>Yes w/details</b>
<b>Gap P4: Surface Finish</b>	<b>Yes w/details</b>
<b>Gap NDE4: Dimensional Metrology of Internal Features</b>	<b>Yes</b>
<b>Gap M1: AM Analyses in RCM and CBM</b>	<b>No</b>
<b>Gap M3: AM Level of Repair Analysis</b>	<b>No</b>
<b>Gap M4: Physical Inspection of Parts Repaired Using AM</b>	<b>No</b>
<b>Gap M5: Model-Based Inspection</b>	<b>No</b>
<b>Gap M6: Tracking Maintenance</b>	<b>No</b>
<b>Gap M8: Surface Preparation for Additive Repair</b>	<b>Yes</b>

## Breakout Group 1 – Top 5-10 Priorities

1. Gap QC2: AM Part Classification System for Consistent Qualification Standards
2. Gap PC4: Machine Qualification
3. Gap D17: Contents of a TDP
4. Gap QC1: Harmonization of AM Q&C Terminology
5. Gap FMP4: Design Allowables
6. Gap NDE1: Terminology for the Identification of AM Flaws Detectable by NDE Methods
7. Gap NDE3: Standard Guide for the Application of NDE to Objects Produced by AM Processes

### Maybes

8. Gap FMP1: Material Properties
9. Gap D19: Organization Scheme Requirement and Design Control
10. Gap PM7: AM Process-Specific Metal Powder Specifications
11. QC10: Verification of 3D Model

## Breakout Group 2 – Top 5-10 Priorities

- QC2
- PC4
- QC1
- FMP4
- D17
- NDE1
- NDE3
- FMP1
- PC7

### Maybes

- QC4
- PC2

# Gap NDE1: Terminology for the Identification of AM Flaws Detectable by NDE Methods

- **Good candidate for an R&D project (Y/N):** N
- **Rationale:** Addressed by ASTM E3166, Standard Guide for Nondestructive Examination of Metal Additively Manufactured Aerospace Parts After Build. Is more needed? A database? E3166 came from EO7, on NDE.
- **Recommendation (R&D needed):**
- **Investment:**

# Gap NDE3: Standard Guide for the Application of NDE to Objects Produced by AM Processes

- **Good candidate for an R&D project (Y/N):** N
- **Rationale:**
  - Some activities are underway
- **Recommendation (R&D needed):**
- **Investment (Modest or Substantial):**

## Gap QC4: Process Approval for DOD- Procured Parts

- **Good candidate for an R&D project (Y/N):** N
- **Rationale:**
  - Not clear what the issue is. It is a bit confusing. Sounds like a trade study for AM business case which is often confidential.
- **Recommendation (R&D needed):**
- **Investment (Modest or Substantial):**

## Gap D19: Organization Schema Requirement and Design Control

- **Good candidate for an R&D project (Y/N):** N
- **Rationale:**
  - Important but not necessarily a DOD funded research project
  
- **Recommendation (R&D needed):** ASME and NIST working on this. A research paper/best practices.
  
- **Investment (Modest or Substantial):**



## Gap QC10: Verification of 3D Model

- **Good candidate for an R&D project (Y/N):** N
- **Rationale:**
  - What is meant by discrepancies?
  - Engineer Research and Development Center (ERDC) verifying the model with sensory data to ensure it is doing what we think it is supposed to be doing. Looking at stress, strain, tolerance issues.
- **Recommendation (R&D needed):** Is DICOM working on it? Wish list.
- **Investment:** Substantial