

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

Status Update for AMMO  
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# America Makes & ANSI Additive Manufacturing Standardization Collaborative (AMSC)



Nation's leading and collaborative partner in AM and 3D printing technology research, discovery, creation, and innovation

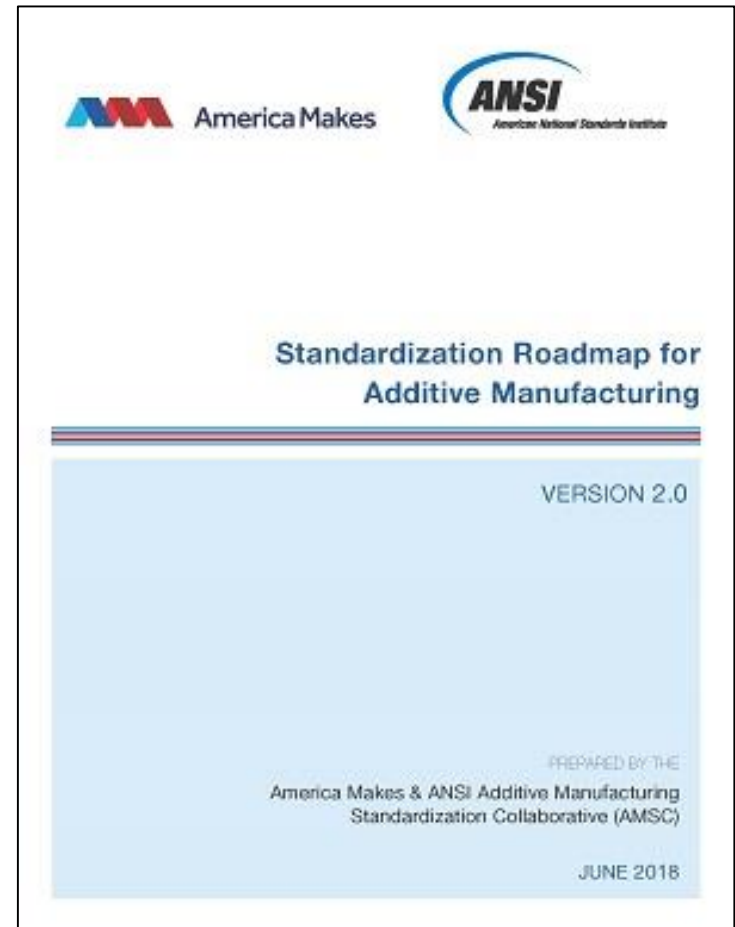


National coordinating body for voluntary standardization in the USA; serves as a neutral facilitator to identify standards needs

**AMSC 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 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
- [Standards Landscape](#)
  - A list of standards directly or peripherally related to the issues described in the roadmap
- Both available as free downloads 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 WG** - evaluating medical content across document

**Polymers WG** - evaluating polymers content across document

# New Gaps - V2.0

New Gaps	High	Med	Low
D27: Standardized Design for Additive Manufacturing (DFAM) Process Chain		1	
D28: Specification of Surface Finish		1	
PM8: Use of Recycled Polymer Precursor Materials			1
PM9: Characterization of Material Extrusion Feedstock (Filaments & Pellets)			1
PM10: Sampling of Open Liquid Feedstock System			1
P7: Heat Treatment (HT)-Polymers			1
QC16: Sterilization of Tissue Engineered Products		1	
NDE6: NDE of Polymers and Other Non-Metallic Materials			1
NDE7: NDE of Counterfeit AM Parts			1
NDE8: NDE Acceptance Criteria for Fracture Critical AM Parts		1	
<b>M9: Laser Based Additive Repair</b>			1
Totals	0	4	7

# Withdrawn/Closed Gaps - V2.0

Withdrawn Gaps	High	Med	Low
Gap D25: Configuration Control of Digital Part Design		1	
Gap PC17: Motion Control			1
Gap FMP2: Coupon Testing		1	
Gap QC11: Process Validation for Pigments and Processing Aid Materials			1
Gap M2: Using AM to Print Tools		1	
Totals	0	3	2
Closed Gaps	High	Med	Low
Gap D11: Design for 3D Printed Electronics		1	
Gap D24: An Acquisition Specification		1	
Totals	0	2	0

- 42 Gaps Substantially Revised



# Open Gaps Breakdown - Version 2.0

Priority	High		Medium		Low		Total	
Section	V1H	V2H	V1M	V2M	V1L	V2L	V1T	V2T
Design	5	4	15	15	6	6	26	25
Precursor Materials	1	1	4	4	2	4	7	10
Process Control	4	4	8	8	5	4	17	16
Post-processing	0	0	4	4	2	3	6	7
Finished Material Properties	2	3	3	1	0	0	5	4
Q&C	5	4	6	8	4	3	15	15
NDE	2	2	3	4	0	2	5	8
Maintenance & Repair	0	0	8	7	0	1	8	8
Total	19	18	51	51	19	24	89	93
<ul style="list-style-type: none"> <li>58 (v1) need R&amp;D</li> </ul>	<ul style="list-style-type: none"> <li>65 (v2) need R&amp;D</li> </ul>							

# 15 New Roadmap Sections/Subsections

- Section 1.5.10 MTConnect Institute
- Section 2.1.3 Design Tools: Standardized Design for Additive Manufacturing (AM) Process Chain
- Section 2.1.7 Design for Anti-counterfeiting
- Section 2.2.1.4 Characterization of Material Extrusion Feedstock (Filaments & Pellets)
- Section 2.2.1.5 Characterization of Liquid Feedstock
- Section 2.2.2.12 Anti-Counterfeiting
- Section 2.2.3.2 Heat Treatment: Polymers
- Section 2.3.2.3 Nadcap Program
- Section 2.3.2.9 Underwriters Laboratories
- Section 2.3.3.3 Medical Industry: Sterilization of Tissue Engineered Products
- Section 2.3.3.4 Electronic and Electrical Products Industry
- Section 2.4.6 NDE of Polymers and Other Non-Metallic Materials
- Section 2.4.7 NDE of Counterfeit AM Parts
- Section 2.4.8 NDE Acceptance Criteria for Fracture Critical AM Parts
- **Section 2.5.2 Maintenance and Sustainment of Machines**
- 36 Existing Sections/Subsections Substantially Revised; 8 Renamed/Repositioned;  
1 Withdrawn



# Phase Two Goals & Outcomes

- Update gaps already identified
  - 42 gaps substantially revised
- Expand content on polymers
  - 234 references to polymers in v2; 98 in v1
  - 18 gaps mention polymers in v2; 9 in v1
  - 5 new gaps address polymers
  - Content cuts across all working groups
- Identify potentially overlooked gaps
  - 11 new gaps added
- Engage other industries (e.g., ground vehicles/heavy equipment, energy, industrial & commercial machinery, electronics)
  - Added new Q&C section on Electronics Industry
  - List of selected new participants on next slide

# New Phase 2 Participants Included . . .

- 3 Degrees
- 3D PDF Consortium
- 3M Company
- Addaero Manufacturing
- Align Technology
- American Bureau of Shipping
- ASSE
- Ampacet
- Arkema
- Assn for Manufacturing Technology
- B11 Standards Inc.
- Caterpillar
- DNV GL
- Drip Castles
- Dupont
- Eaton Corporation
- EWI
- Ford Motor Company
- Hanover Insurance
- Honeywell
- InfraTrac
- Jet Pulverizer
- Manufacturers Standardization Society
- Nat'l Ctr. for Mfg. Sciences
- NRC
- Philips Lighting
- Quintus Technologies
- Renishaw Inc.
- Siemens Energy
- SpaceX
- TechPlas Consulting
- Thermo Fisher Scientific
- Tosoh
- TUV Rheinland of NA

# Maintenance and Repair

- Introduction (revised)
- Maintenance and Sustainment of Machines (new)
- Standard Repair Procedures (revised)
- Standard Technical Inspection Processes
- Model-Based Inspection
- Standards for Tracking Maintenance Operations
- Cybersecurity for Maintenance
- Surface Preparation for Additive Repair (renamed)

# Maintenance and Sustainment of Machines

- **Gap M1: AM Analyses in RCM and CBM.** With respect to maintenance and sustainment of AM machines, standards for AM analyses in Reliability Centered Maintenance (RCM) and Conditioned Based Maintenance (CBM+) are needed.
- **R&D Needed:** No
- **Recommendation:** Update SAE JA1012-2011, a guide to provide analytics for AM trade-offs in RCM and CBM+.
- **Priority:** Medium; **Status of Progress:** Not Started
- **Update:** SAE G-11M will consider inclusion of analytics for AM trade-offs in next update of JA1012
- **Organization:** SAE, ISO, ASTM

# Standard Repair Procedures

- **NEW Gap M9: Laser Based Additive Repair.** Current standards do not specifically address the use of laser based systems (metal powder or wire feedstock) to additively repair parts or tools.
- **R&D Needed:** No
- **Recommendation:** Ensure that laser based additive repair processes are included in AWS D20.1.
- **Priority:** Low
- **Organization:** AWS, SAE AMS-AM

# Standard Repair Procedures

- **Gap M3: AM Level of Repair Analysis.** Standards for AM LORA are needed. In performing a repair versus discard analysis, the use of AM can change the LORA decision due to shifts in factors relating to logistics delay time, spares availability, cost of spares, etc. **Trade space would address reduction of time and increase in skill set (e.g., for qualified printer operators).**
- **R&D Needed:** No
- **Recommendation:** Update SAE AS 1390:2014 **to include impact of AM on trade space of repairs.**
- **Priority:** Medium; **Status of Progress:** Green
- **Update:** SAE LCLS plans to include AM in upcoming revision of AS1390. SAE G-11M has AMSC requests on radar. AMS2680C is currently under revision
- **Organization:** SAE **LCLS**, SAE **AMS-B**, ISO, ASTM

# Standard Technical Inspection Processes

- **Gap M4: Physical Inspection of AM Parts and Tools for Defects.** A standard Inspection process for component or tooling defects is needed to consider additive manufacturing technologies as potential solutions for preventative and corrective maintenance actions.
- **R&D Needed:** No
- **Recommendation:** Update SAE JA1011/1012 to include an inspection process for additive manufacturing repairs.
- **Priority:** Medium; **Status of Progress:** Not Started
- **Update:** SAE G-11M will consider inclusion of an inspection process for AM repairs in next updates of JA1011/JA1012
- **Organization:** SAE, ISO/ASTM

# Model-Based Inspection

- **Gap M5: Model-Based Inspection.** Standard practices for model-based inspection methods using AM are needed for **repair** assessments and scheduling.
- **R&D Needed:** No
- **Recommendation:** Develop standard practices for assessing level of damage for end-use parts.
- **Priority:** Medium; **Status of Progress:** Not Started/Unknown
- **Update:** No update provided
- **Organization:** ASME, ISO/ASTM, Dimensional Metrology Standards Consortium



# Standards for Tracking Maintenance Operations

- **Gap M6: Tracking Maintenance.** A standard is needed for how preventative maintenance operations of AM machines are tracked (e.g., monitoring printer health, need for servicing, etc.).
- **R&D Needed:** No
- **Recommendation:**
- Develop a standard for tracking maintenance operations to ensure a printer is ready when needed. See also Gap PC3 on machine health monitoring.
- Develop a standard to address emergency repair/limited life parts for urgent cases in the field.
- **Priority:** Medium; **Status of Progress:** Unknown
- **Update:** None provided
- **Organization:** AWS, ASTM

# Cybersecurity for Maintenance

- **Gap M7: Cybersecurity for Maintenance.** In support of on-site repairs, guidance is needed that addresses cybersecurity considerations for maintenance and repair of parts that have 3D models ready to print. Secure storage in a database should ensure that only authorized personnel can download files and print parts.
- **R&D Needed:** Yes
- **Recommendation:** Guidance is needed to ensure the integrity and safe storage of AM files as maintenance and repair operations may take place in an uncontrolled environment. See also gap PC15 on configuration management: cybersecurity.
- **Priority:** Medium; **Status of Progress:** Not Started/Unknown
- **Update:** None provided
- **Organization:** NIST, NEMA, NDIA JWG, ASTM, **IEEE-ISTO PWG**

# Surface Preparation for Additive Repair

- **Gap M8. Surface Preparation for Additive Repair.** Standards are needed for chemical compatibility with additively manufactured materials for surface cleaning in preparation for an additive repair process. Additionally, standards are needed for removal of coatings, including paints and powder coating, and plating (chrome, zinc, etc.) for additively manufactured parts.
- **R&D Needed:** Yes
- **Recommendation:** Develop standards for approved chemical substances and mechanical processes used for the removal of coatings and plating on additively manufactured components, to include metals, polymers, ceramics, and other materials.
- **Priority:** Medium; **Status of Progress:** Not Started/Unknown
- **Update:** None provided
- **Organization:** ASTM, SAE, ISO