America Makes
Request for Information

Methods and Approaches for Sustainable AM Operations

Prepared by

The National Center for Defense Manufacturing and Machining (NCDMM)

Jason Thomas, Portfolio Manager

236 W. Boardman Street

Youngstown, OH 44503

Phone: 330-610-0415

projectcall@americamakes.us

12 April 2023

Disclaimer: This RFI **DOES NOT** constitute a Request for Proposal and is not to be construed as a commitment, implied or otherwise, by NCDMM that any award or contracting action will be issued. Response to this notice is not a request to be added to a bidders list or to receive a copy of a solicitation. No entitlement to payment of direct or indirect costs or charges by NCDMM will arise as a result of the submission of the requested information. No reimbursement will be made for any costs associated with providing information in response to this announcement and any follow-up information requests. Responses to this RFI may be considered in the future determination of an appropriate strategy for America Makes. NCDMM may not respond to any specific questions or comments submitted in response to this RFI or information provided as a result of this request. Any information submitted by respondents as a result of this notice is strictly voluntary.

Introduction: Driven by the National Center for Defense Manufacturing and Machining (NCDMM), America Makes is a Department of Defense Manufacturing Innovation Institute focused on additive manufacturing (AM) technologies. Since its inception, America Makes has leveraged a national collaborative ecosystem to advance the readiness level of AM technologies and invigorate the knowledge base, skills, and training available for the domestic AM supply chain. Our strategy is the product of collaboration with our membership, which is comprised of representation from all tiers of the domestic AM supply chain.

AM technologies offer a range of benefits including unique product geometries, relatively fewer tooling requirements, and relatively shorter lead times in comparison to other manufacturing methods. The industrialization of AM represents an opportunity to convert demonstrated manufacturing capability to capable manufacturing capacity. Industrialization requires cost-effective operating models and practices. These emerging realities require widespread understanding within the domestic supply chain including manufacturing operational practices that address sustainability and robust quality control.

AM Sustainability

There are opportunities within an AM product life cycle to promote sustainable practices through design, material selection and development, material handling, and recycling. AM-enabled lightweight design and consolidation of parts offer potential to reduce energy consumption and emissions relative to other manufacturing methods. AM design approaches can promote system-level fuel efficiency improvements which may consequentially reduce total service life emissions and operating costs (fuel consumption).

Reuse and recycling of AM materials may lead to more cost-effective and sustainable AM workflows (product life cycles). Material development and material selection can influence how readily AM materials may be reused and/or recycled. There is also a need for evidence that demonstrates reused and recycled materials can yield repeatable and acceptable performance.

AM Operational Qualification

Repeatable and reproducible AM operations are centered on three forms of qualification. These are commonly referred to as installation qualification, operational qualification, and product qualification. Respondents to this RFI are encouraged to consider the February

2020 AIA additive manufacturing working group publication titled, “Recommended Guidance for Certification of AM Component” as reference. (https://www.aia-aerospace.org/wp-content/uploads/AIA-Additive-Manufacturing-Best-Practices-Report-Final-Feb2020.pdf)

Installation qualification (IQ) commonly includes an evaluation of AM equipment (including ancillary equipment) which successfully demonstrates factory acceptance testing and on-site (within the manufacturing facility) setup, calibration, and site acceptance testing. Product or process performance qualification (PQ) is defined as a successful demonstration that the AM process (workflow) meets all product-specific requirements while following a series of process controls. The evidence to successfully demonstrate this may be obtained from components and material produced from several builds and rely upon statistical analysis.

Operational qualification (OQ) is a myriad of tasks that leads to process control documentation substantiated through characterization, analysis, and testing to confirm the process can deliver material specification requirements. OQ commonly occurs between the time the machine is deemed passing site acceptance testing and when product qualification starts. The level of effort and understanding needed to achieve operational qualification is vast. OQ is when quantitatively analyzing AM processes through serial production and over time becomes more substantial. Examples of factors that can be a part of OQ may include:

- Facility controls
- Operator training and qualification
- Work instructions
- Software configuration controls
- KPV controls and documentation
- Machine configuration controls
- Preventative maintenance
- Machine calibration
- Machine requalification
- Feedstock control, management, handling, and reuse
- Build interruptions
- Monitoring
- Documentation and records keeping
- Powder removal
- Thermal processing - stress relief, HIP, and heat treatment
- Machining including build plate and support removal
- Surface finishing/conditioning

Each of these factors require some form of verification and validation. However, the amount, type, and means of sampling, documentation, testing, analysis, etc. can vary depending on the operator, AM process, material, application, and customer. Given the wide range of factors encompassed with OQ, it is no surprise that process and material qualification can be costly and time-consuming.

There is a need for establishing consensus balanced with practicality and rigor when it comes to the number, practices, types, and methods of testing to foster operational qualification (establishing the amount of objective evidence necessary to show an AM process is yielding stable material performance). It is worth noting that executing OQ also assumes one has a sufficient understanding of the processes, microstructures, and properties which constitute AM material performance. There is a desire to understand how the supply chain can execute OQ more effectively, not to be confused with product acceptance or PQ. It is believed that with more suppliers understanding the details of effective AM OQ, the time to achieve PQ will shorten and we will be able to convert more AM capability to capable AM manufacturing capacity.

Specific Information of Interest: NCDMM is soliciting information supporting the America Makes mission of promoting and accelerating the development and deployment of innovative, cost-effective, energy-efficient additive manufacturing (AM) technologies to meet defense and/or commercial needs. The goal of this RFI is to better understand the current state of the AM supply chain and the opportunities, needs, and priorities which will substantiate AM sustainability and robust AM controls and operational qualification in line with the interests of the domestic AM supply chain. These inputs may be used as a source of information for developing technical scoping requirements for future project calls, workshops, event themes, etc.

America Makes is looking for inputs from the domestic AM supply chain and the membership to offer perspective on needs that address two topic domains:

1. Needs and priorities for the development and demonstration of sustainable AM practices and products
2. Needs and priorities for the development and demonstration methods and approaches which deliver validated objective evidence to substantiate robust AM manufacturing operations (operational qualification)

Responses to this RFI are not limited to certain AM technologies, processes or materials.

Examples of the types of information respondents may choose to provide include, but are not limited to:

- Cost-benefit analysis for sustainable AM design
- Metrics development for sustainable AM
- Cost modeling for AM sustainability applications
- Areas of future investigation and R&D not outlined in the introduction section which deserves further consideration for topic 1 or 2
- Material reuse and recycling studies which evaluate cost, energy consumption, and material performance

- Material trade-off studies for design, lightweight, and life cycle cost/emissions analysis
- Specific AM processes, technologies, or materials where further focus and development are needed
- Feedstock effects on AM material quality
- Demonstrations of AM process KPV's – windows of consistent and robust material behavior
- AM material characterization and testing
- Demonstrations of post-processing KPV's – heat treatment, machining, finishing, order of operations to validate robust behaviors
- Demonstrations of inspection technologies to validate robust process and material quality
- Pre-requisite requirements such as conditions that must exist prior to executing an AM operational qualification study including calibrations, maintenance data, installation qualification information/conditions as well as necessary considerations, documentation, etc. which would add confidence and value to subsequent efforts assuming these initial conditions exist
- How data sharing or data sharing collaborations may play a role in these types of efforts
- Statistical process control studies and how quality controls may be developed, demonstrated, and validated
- Validation of measurement practices for demonstrating robust material performance

Submission Details and Formatting: All responses shall be submitted electronically to the technical contact at rfi@americamakes.us and marked with "America Makes RFI – Sustainable AM Operations". All responses must be received by 5 pm Eastern on Friday, May 12, 2023. Paper and fax submissions will not be accepted. Responses will be acknowledged with an email confirmation from NCDMM on the next business day. If a confirmation email is not received within two business days, please follow up to ensure delivery. NCDMM is not responsible for email system malfunctions or undeliverable emails.

Respondents are asked to limit responses to one topic. Respondents may submit more than one response to this RFI. Responses to this RFI are encouraged, but are not limited, to address the following:

- Organization background and efforts in AM technology research and development along with associated products and applications related to topics 1 or 2
- Organization priorities that align with topic 1 or 2 and how your organization could benefit from further R&D investment

- Future R&D (approach, milestones, deliverables, timelines) needed to address topics 1 or 2.
- Specific desired outcomes, deliverables, or factors that would constitute a success coming from future R&D
- Opportunities where R&D investments may benefit development and validation of standardized approaches/methods
- Perspectives on how these investments can best foster reuse across the AM supply chain in terms of focus, approach, data types, data curation, and management
- Any other relevant factors which respondents deem meaningful, relevant, or useful to better detail the current state of the AM supply chain or future needs and priorities to benefit advancement of topics 1 or 2

No phone calls will be accepted. Any comments, concerns, or questions regarding this RFI must be emailed to rfi@americamakes.us prior to May 4, 2023. No comments, concerns, or questions received after this date will be reviewed or receive a response. Answers to all questions will be posted to americamakes.us by May 8, 2023.

Please limit each response to a single topic. All responses are encouraged to use the following formatting:

1. **Cover page:** Include corporate cage code and duns number on the cover page.
2. **Email:** Submit only one (1) electronic copy in response to this request for information
3. **Figures, graphs, images, and pictures:** Figures and tables must be numbered and referenced in the text by that number. They should be of a size that is easily readable and may be in landscape orientation. They must be formatted to print on an 8.5 x 11-inch paper size.
4. **Font:** Responses should be prepared with easy-to-read font such as Times New Roman or Arial (11 point minimum), single-spaced. Smaller font may be used in figures and tables but must be legible.
5. **Page layout:** The Technical Volume must be in portrait orientation except for figures, graphs, images, and pictures. Pages shall be single-spaced, 8.5 by 11 inches, with at least one-inch margins on both sides, top, and bottom.
6. **Page limit:** 10 pages
7. **Information controls:** The information submitted shall be UNCLASSIFIED