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Research to Standards
ADDITIVE MANUFACTURING

SME Strategy Day- AM Ecosystem Stakeholder

Recent Progress in AM Standard Development at ASTM AM CoE

Mahdi Jamshidinia, Ph.D.
Additive Manufacturing R&D Project Manager

Wednesday, November 6, 2019;
Chicago, IL

ASTM INTERNATIONAL
AUBURN UNIVERSITY
EWI We Manufacture Innovation
mtc Manufacturing Technology Centre
NAMIC NATIONAL ADDITIVE MANUFACTURING INNOVATION CLUSTER
NASA
NIAR

Outline

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01 Problem Statement and Motivation

02 ASTM AM CoE

- How it works
- R&D Projects- Round 1
- R&D Projects- Round 2

03 ASTM Upcoming Events

04 Q&A

Problem Statement & Motivation

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- **AM standards development is a lengthy process**
- **Innovative solutions are required** to keep up with rapid pace of AM technology development
- **Current approach** could result in:

Standards gaps and duplications of efforts

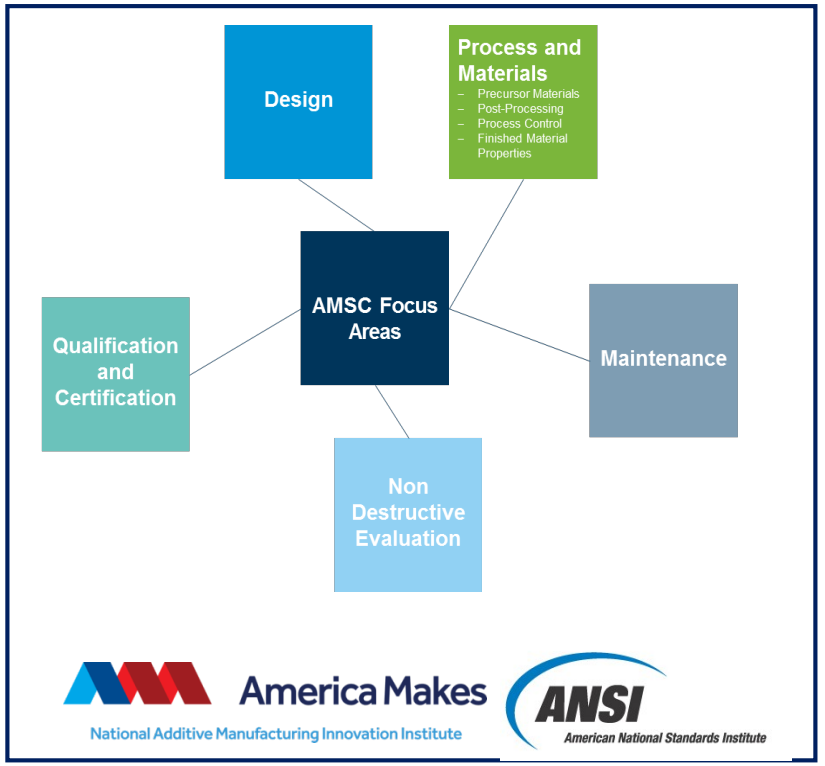
Inconsistent standards R&D across industries globally

No dedicated workforce to drive R&D for standards development

Lack of global acceptance of standards

ASMC Roadmap: Recap

- 18 gaps as **high priority**,
- 51 as **medium priority**,
- 24 as **low priority**.
- **65 gaps require R&D!**



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ASTM AM CoE

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- How it works
- R&D Projects- Round 1
- R&D Projects- Round 2

ASTM AM CoE:
Founding and Strategic Partners

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November 2017
Request for Proposals (RFP) for ASTM AM CoE

March 2018
Founding Partners
EWI and Auburn University/NASA

May 2018
Founding Partner
UK-based Manufacturing Technology Centre (MTC)

August 2018
Strategic Partner
National Institute for Aviation Research (NIAR)

October 2018
Strategic Partner
National Additive Manufacturing Innovation Cluster (NAMIC)

ASTM AM CoE: How it works

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- ASTM
- Government
- Industry Consortia

Direct Funding

Plan R&D

+ other partners

CoE

+ other partners

Conduct R&D

Standards Development

- Industry use
- Certification
- Training
- Proficiency testing

Implementation

AM CoE R&D: High Priority Areas

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R&D Themes: Defined based on the input of the CoE R&D team

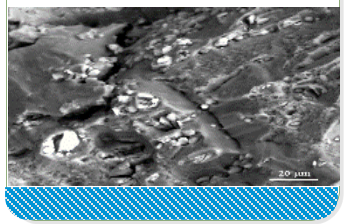
Participation:

- NASA, FAA, FDA, NIST and AM CoE partners

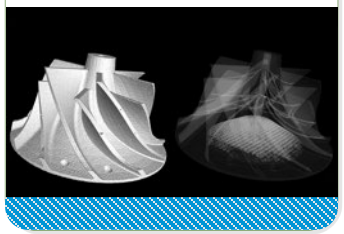
Feedstock materials (Testing, Reuse)

AM processes /Post Process

Design & Testing



Qualification (NDT, etc.)



AM CoE R&D: 1st Round of R&D Projects

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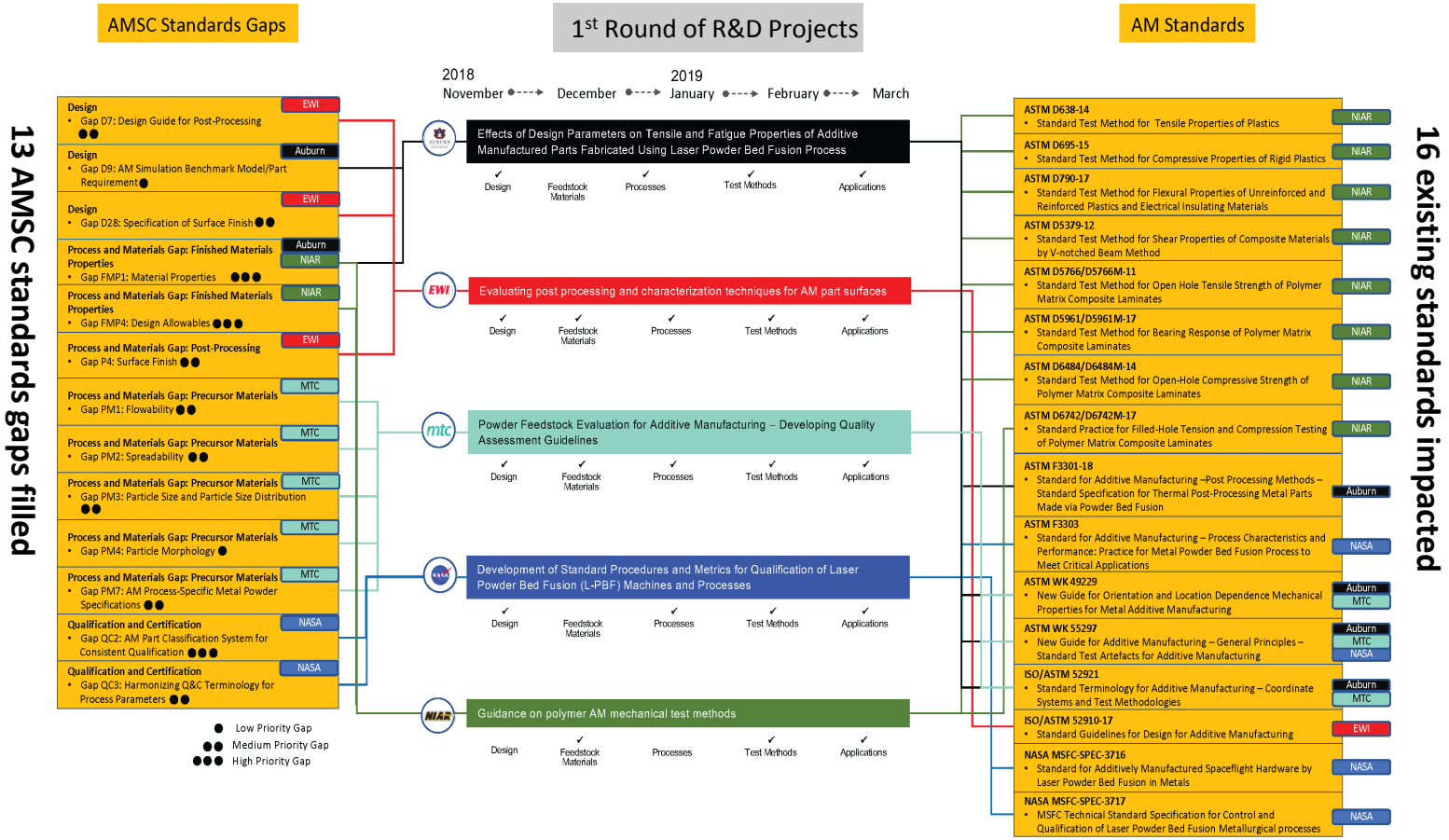
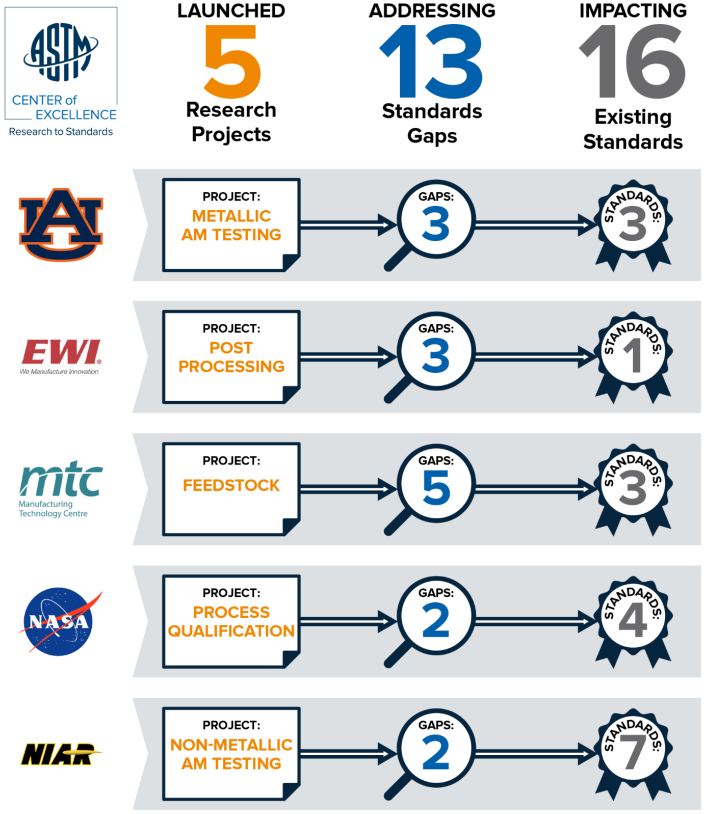
Project Lead	Project Idea
EWI	Post Processing (Surface finishing and Characterization)
MTC	Feedstock (Powder quality guide)
AU	Mechanical Testing of Metal AM
NASA / AU	LB-PBF Process Qualification
NIAR	Mechanical Testing of Polymer AM

- **All five R&D projects are progressing** based on their schedule and near the final stage.
- **AM CoE shared the latest updates in public** at the 2nd AM CoE workshop on Sep. 17, 2019
- **Total of five work items has been registered** for these projects in order to transition the R&D results to consensus-based standards.

AM CoE R&D: Standardization Gaps





1. MTC: Powder Feedstock Characterization

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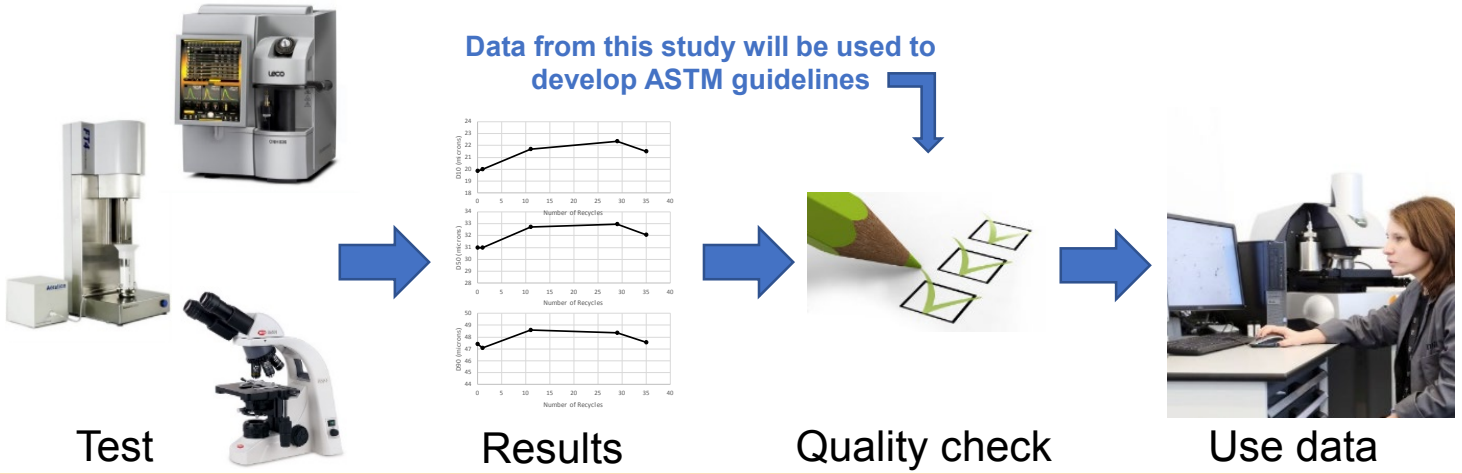
Title	Powder feedstock evaluation for additive manufacturing (AM) – developing quality assessment guidelines
Summary	• MTC will conduct research aimed at developing quality assessment standards for metal powders used in additive manufacturing machines. • This feedstock characterization research will contribute to a standard guide that helps people who need to evaluate powder quality and recyclability.
Objective	• Identify the key powder properties that control powder-bed AM processes, to include at least one Electron Beam Melting (EBM) machine and three Laser-Powder Bed Fusion (L-PBF) machines. • Conduct an operator proficiency study at MTC with 3 operators and 2 virgin Ti64 powders (EBM and L-PBF grades) following the identified ASTM test standards as described in Table 1. Each operator will perform each test 10 times to give an indication of the 'true' value of the measurement. • Provide recommendations on updating of existing ASTM standards where possible, and draft a new working item providing guidelines on when to accept test data for reporting.



2. NASA/AU: Process Qualification

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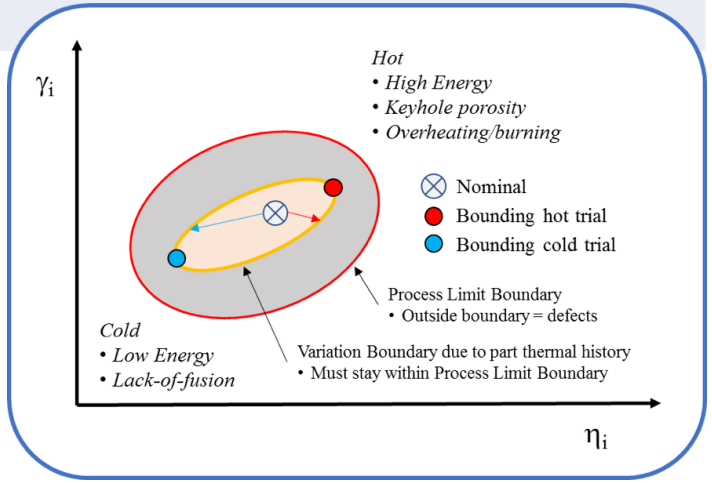
Title	Development of Standard Procedures and Metrics for Qualification of Laser Powder Bed Fusion (LB-PBF) Machines and Processes
Summary	• NASA will work to develop standard procedures, metrics, and comprehensive requirements to help qualify machines and processes in laser powder bed fusion. • This process qualification and assessment research aims to establish much-needed consensus in this area across the additive manufacturing community.
Objective	• Develop consensus within the ASTM CoE community regarding minimum requirements for the qualification of L-PBF machines and processes. • Establish a **standard set of procedures, test methods, and evaluations** used to establish L-PBF qualification based on fundamental objectives. • Establish **quantitative and/or qualitative metrics** applicable to each evaluation to **define successful machine and process qualification**. • Conduct **development and round-robin-style trials** of the qualification evaluations and associated metrics. • Establish **a set of recommendations to appropriate** F42 sub-committees for standards implementation.

Process Limit Boundary



3. EWI: Post-Processing

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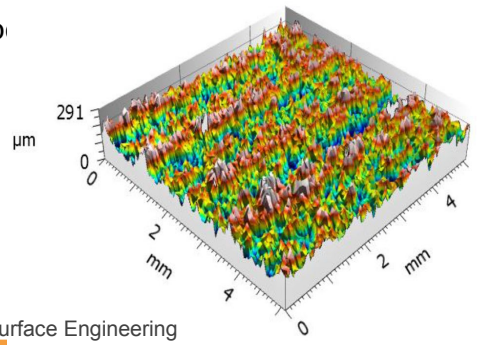
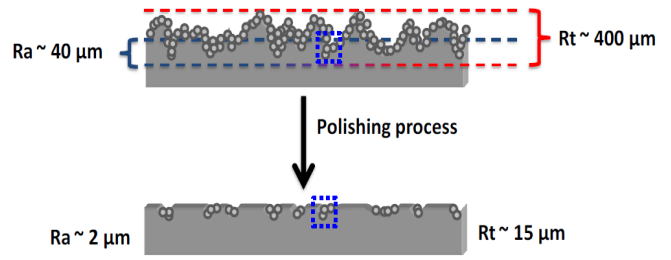
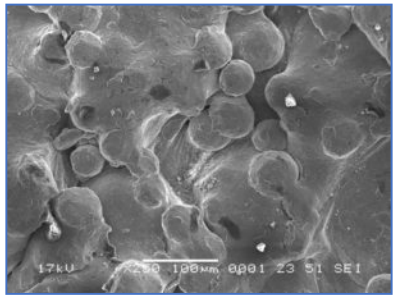
Title	Evaluating post-processing and characterization techniques for AM part surfaces
Summary	• EWI will research how various surface finishing techniques for additively manufactured products impact performance and structural integrity. • This post-processing research will help standardize surface quality and measurement metrics.
Challenge	• **Finishing and characterizing the surface quality of these complex geometries** is still a challenge. ○ AM surfaces are challenging to measure as they exhibit **new surface topographies** that have not been dealt with historically. ○ Each of the surface finishing processes also result in **varying surface topographies** even though the surface quality metric may be similar.
Objective	• EWI will identify common post-processing techniques applicable to AM, along with key surface measurement techniques, and **identify surface measurement metrics** that provide coherent information for AM components. • This work aims at **understanding AM surfaces before and after finishing** using various surface characterization techniques: ○ Tactile ○ Focus variation ○ White light interferometry ○ Laser confo microscopy



Images: REM Surface Engineering



Representation of the surface obtained by the metal powder melted/sintered method and the subsequent metal removal, necessary to produce a smooth surface. Highlighted by the dotted blue square is a valley full of partially melted/sintered powder covered by a peak on the top.



As built AM Surface*

4. Auburn: Metallic AM Testing

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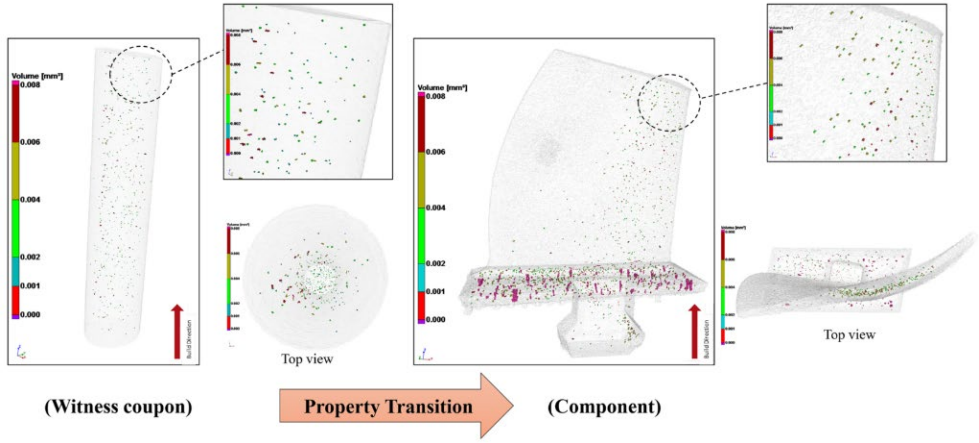
Title	Effects of Design Parameters on Tensile and Fatigue Properties of Additive Manufactured Parts Fabricated Using Laser Powder Bed Fusion Process
Summary	• Auburn University will investigate some of the mechanical testing issues with metal additive manufacturing to better understand the **relationships between the properties of test specimens and the performance of parts**. • This study will contribute to a standard that guides how to design specimens (i.e., test coupons) that are most representative of additively manufactured components.
Objective	• The objective of the proposed research is to better understand the relationships between test coupon and part performance by conducting systematic experimental procedures and simulations focused on the effects of part size, geometry, and time interval.



Need for establishing specimen property-part performance relationships (need for developing appropriate standards for AM) to address:

- Geometry/size
- Time intervals
- Build orientation

M Seifi, M Gorelik, J Waller, N Hrabe, N Shamsaei, S Daniewicz, JJ Lewandowski, "**Progress Towards Metal Additive Manufacturing Standardization to Support Qualification and Certification**," *JOM,* **Vol.** 69, pp. 439–455, 2017

5. NIAR: Non-Metallic AM Testing

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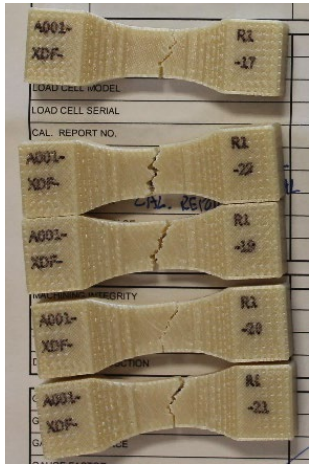
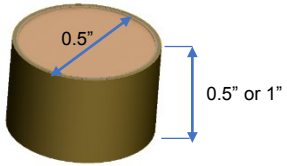
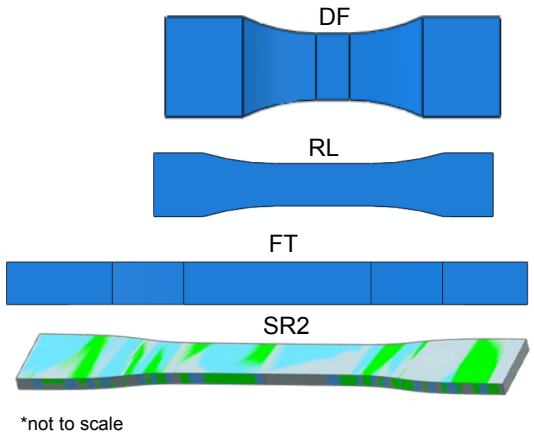
Title	Guidance on Polymer AM Mechanical Test Methods
Summary	• NIAR will focus on mechanical testing issues surrounding polymers used in additive manufacturing. • They will look to create guidelines and best practices aimed at applying existing mechanical testing methods in this fast-growing area.
Approach/Implementation	• Initial Coordination with D20, D30, F42, and NIST • Development of guide(s) including targeted mechanical tests/round robin studies in collaboration with other organizations • Guide(s) submitted to ASTM Committees







*not to scale

AM CoE R&D: R&D to Standard

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Post Processing;

WK66682: guide for surface texture measurement of additively manufactured parts

Mechanical Testing of Polymer AM

WK66029; A rough draft of the testing guidance (two materials (ULTEM 9085 and PC), two properties (D638 and D695), alternative geometries)

Mechanical Testing of Metal AM

Support of ASTM WK49229; out for balloting in October

L-PBF Process Qualification; NASA

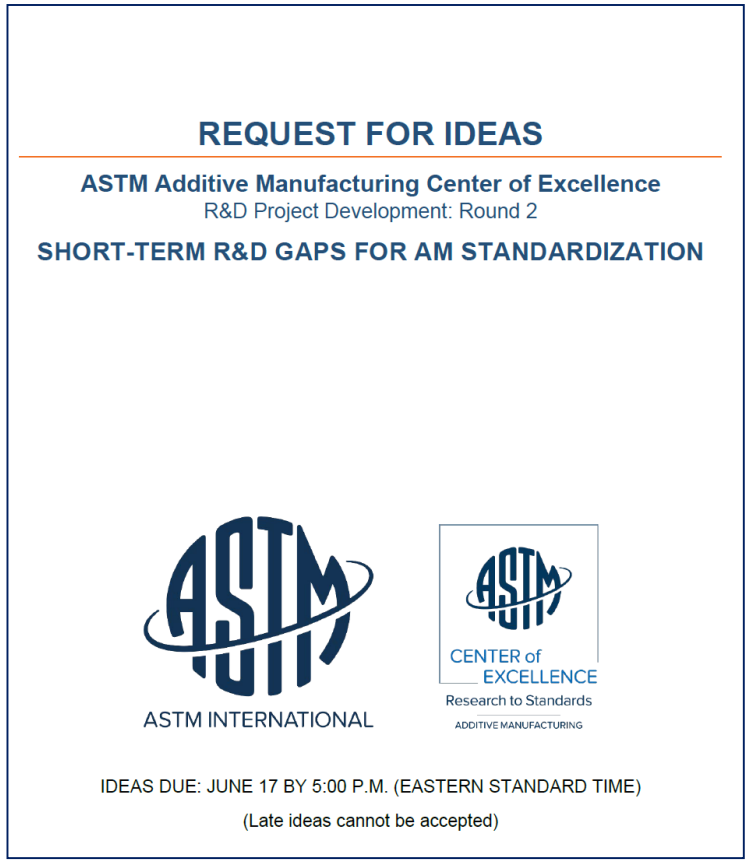
Support of ASTM WK65937; lightly edited version of MSFC-SPEC-3717, balloted under F42.05(19-01) this spring

Feedstock

WK66030 is currently being drafted and populated with the data collected so far on Ti64 and IN718

AM CoE R&D: 2nd Round of Projects

Implemented more systematic approaches for the 2nd round of R&D projects


REQUEST FOR IDEAS

ASTM Additive Manufacturing Center of Excellence

R&D Project Development: Round 2

SHORT-TERM R&D GAPS FOR AM STANDARDIZATION

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IDEAS DUE: JUNE 17 BY 5:00 P.M. (EASTERN STANDARD TIME)

(Late ideas cannot be accepted)

- AM CoE received **ideas** from ASTM F42 members to define **short-term R&D needs critical to advancing AM standards development**.
- This Request for Ideas (RFI) presents an **opportunity for ASTM F42 members** to propose a need/funding idea **to accelerate their standards development work**.

ASTM AM CoE: R&D Team

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John Bakuckas
Structural Integrity Manager
FAA

Matthew DiPrima
Research Scientist
FDA

Matthew Donovan
ASTM F42 Vice Chair
Oerlikon

Ben Dutton
Technical Specialist
The MTC

Michael Gorelik
Chief Scientist
FAA

Christopher Holshouser
Technical Director
NIAR

Kevin Jurrens
Deputy Chief
NIST

Richard Russell
Technical Fellow
NASA

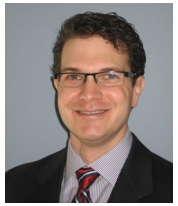
Adam Brooks
Research Fellow
EWI

Mohsen Seifi
Director
ASTM International

Nima Shamsaei
Director
Auburn University

John Vickers
Principal
NASA

Doug Wells
Research Engineer
NASA



Shawn Moylan
Mechanical Engineer
NIST

Gary Ng
Research Engineer
NAMIC/ARTC

Alex Liu
Head, Additive Manufacturing Programs – APAC Region
ASTM International

Mahdi Jamshidinia
AM R&D Project Manager
ASTM International

AM CoE R&D: 2nd Round of Projects

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News Releases: ASTM supports 9 research projects for AM standards

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- **Project 1:** LB-PBF Process Qualification
- **Project 2:** Design Guides for AM Processes
- **Project 3:** Design Guide for Post-Processing
- **Project 4:** Polymer AM Testing for Part Performance
- **Project 5:** Rapid Quality Inspection Specimen
- **Project 6:** Polymer AM Testing
- **Project 7:** In-Process Monitoring
- **Project 8:** Powder Feedstock
- **Project 9:** Data Pedigree

AM CoE R&D – New Funding Mechanisms

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REQUEST FOR IDEAS

ASTM Additive Manufacturing Center of Excellence
R&D Project Development: Round 2

SHORT-TERM R&D GAPS FOR AM STANDARDIZATION

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IDEAS DUE: JUNE 17 BY 5:00 P.M. (EASTERN STANDARD TIME)
(Late ideas cannot be accepted)

- RFI-Rev. 2
  - All ASTM Committees can submit their R&D ideas
  - Projects will be conducted by AM CoE members
- Call for Projects (CFP)
  - Late Nov. – Early Dec. 2019
  - Projects will be conducted by non-CoE members

CALL FOR R&D PROJECTS

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KEY DATES	
INQUIRIES AND QUESTIONS DUE	DECEMBER 2, 2019, BY 5:00 P.M. EASTERN STANDARD TIME (EST)
LETTERS OF INTENT DUE	DECEMBER 2, 2019 BY 5:00 P.M. (EST)
INFORMATIONAL WEBINAR	DECEMBER 5, 2019, AT 10 A.M. (EST)
PROPOSAL DUE*	DECEMBER 20, 2019 BY 5:00 P.M. (EST)
SELECTION ANNOUNCEMENT	FEBRUARY 10, 2020, AT THE ASTM F42 MEETING

*Late proposals cannot be accepted

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ASTM Upcoming Events

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AM CoE Specialty Workshop Series

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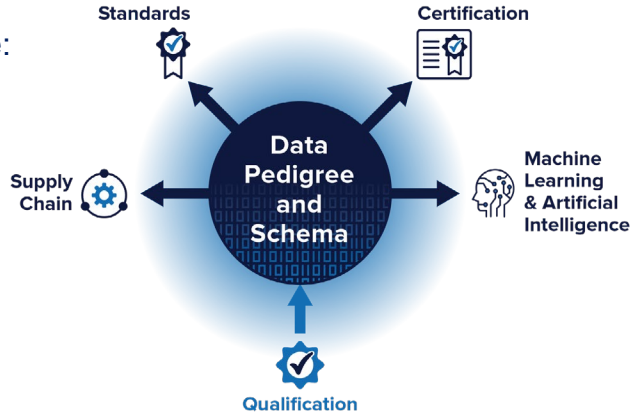
01 Jointly developed workshop by **ASTM** and **America Makes**

02 **Topics** addressed in this workshop will include:

- AM data generation and pedigree
- Advanced data-driven approaches in AM
- AM database and data management system (access, standardization, maintenance, security, and dissemination)



03 ASTM is developing a **Roadmap** to support improved data sharing and use and ensure the timely development of related standards.

04 **Workshop Chairs:**

- Mahdi Jamshidinia (AM R&D Project Manager at ASTM)
- Alex Kitt (Product Manager at EWI)
- Brandon Ribic (Technology Director at America Makes)

Take Away

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0 ASTM AM CoE is filling the gap in AM Standardization (funding R&D, generating data, coordination of stakeholders)

1 RFI is an opportunity for ASTM F42 members to propose their ideas to accelerate their standards development work

0 - Next: all ASTM committees will be able to participate in RFI

2 CFP; a new funding mechanism to engage non-CoE members in R&D for AM standardization

0 ASTM AM CoE Specialty Workshop: AM Data Management and Schema, December 9, 2019

3

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4

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Q&A

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Helping our world work better

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