



ASTM INTERNATIONAL
Helping our world work better

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Recent Progress in the Additive Manufacturing Standardization

Cologne, EASA/FAA Workshop

Paul Jonas

Director of Business Development, NIAR

Mohsen Seifi, Ph.D.

Director of Global Additive Manufacturing Programs, ASTM

November, 2019

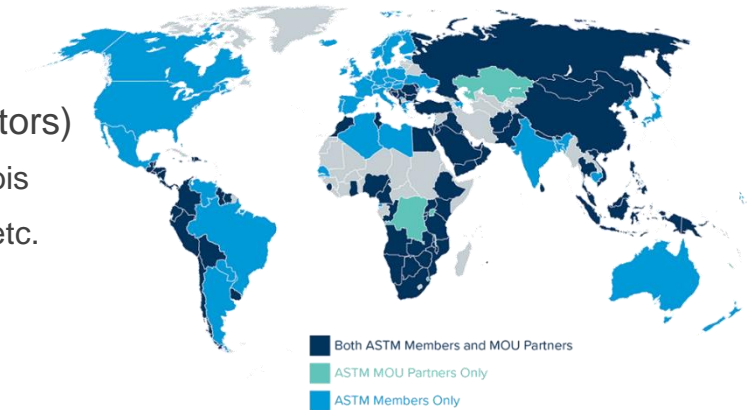
www.astm.org

About ASTM



A Proven and Practical System

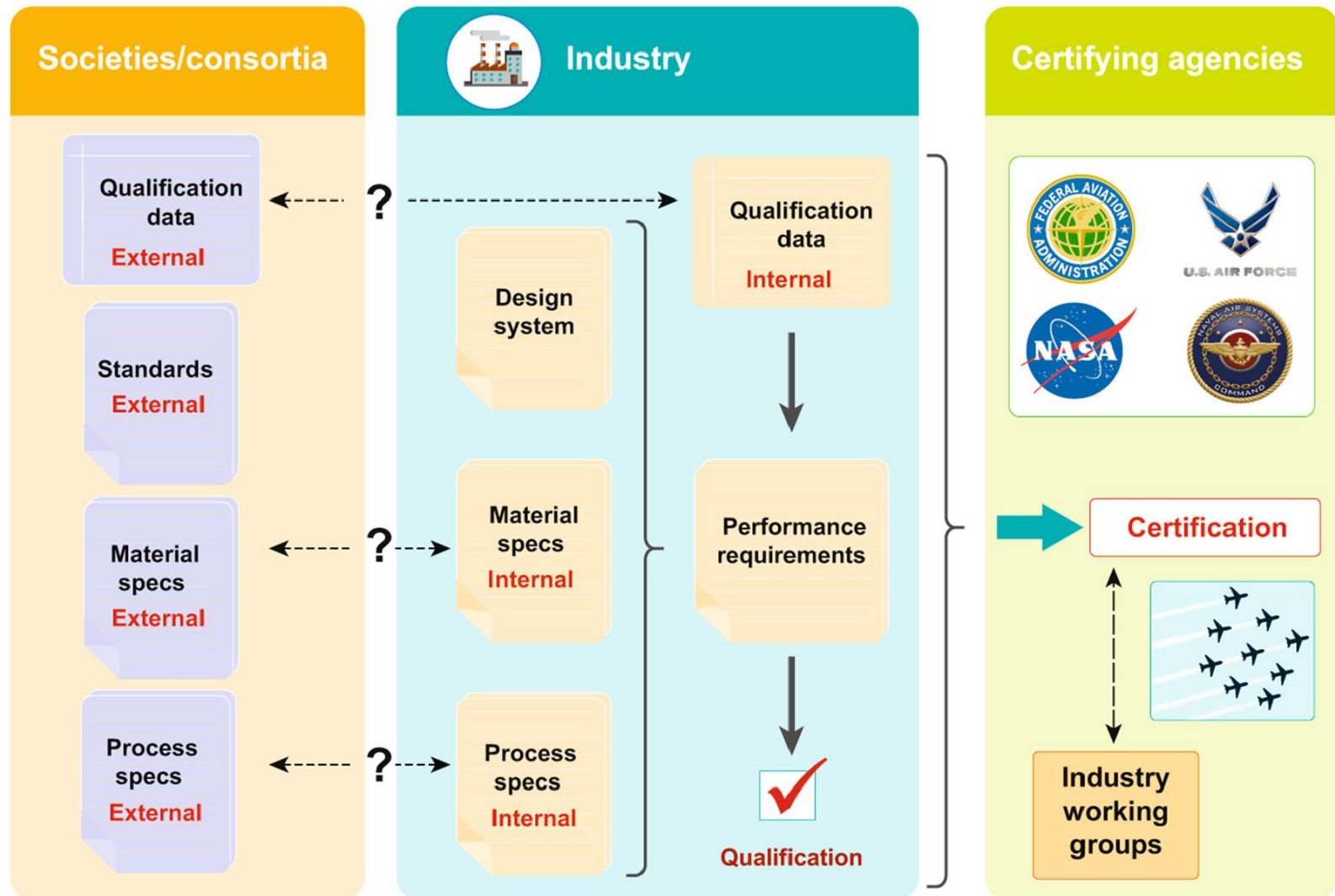
- Established in 1898 (120 years old organization)
- 150 Committees & 12,800+ Standards (Covering 90 industry sectors)
 - Recent: UAS, Commercial Space flight, Exoskeleton/Exosuits, Cannabis
 - Older: Medical devices, Pharmaceuticals, Petroleum, general aviation, etc.
- 32,000 members
 - 8,000+ International Members from 135 countries
 - 5,100 ASTM standards used in 75 countries
- Close to 300 employees, HQ in PA, Offices in DC, Europe, Middle East, China, Canada, South America, *Singapore*
- Accreditation:
 - American National Standards Institute (ANSI)
 - Standard Council of Canada (SCC)
- Process complies with WTO principles: Annex 4 of WTO/TBT Agreement
 - Development and delivery of information made uncomplicated
 - A common sense approach: **industry driven**
 - Consensus based approach
 - Market relevant globally
 - No project costs, voluntarily



150

main committees
plus 2,030+
subcommittees

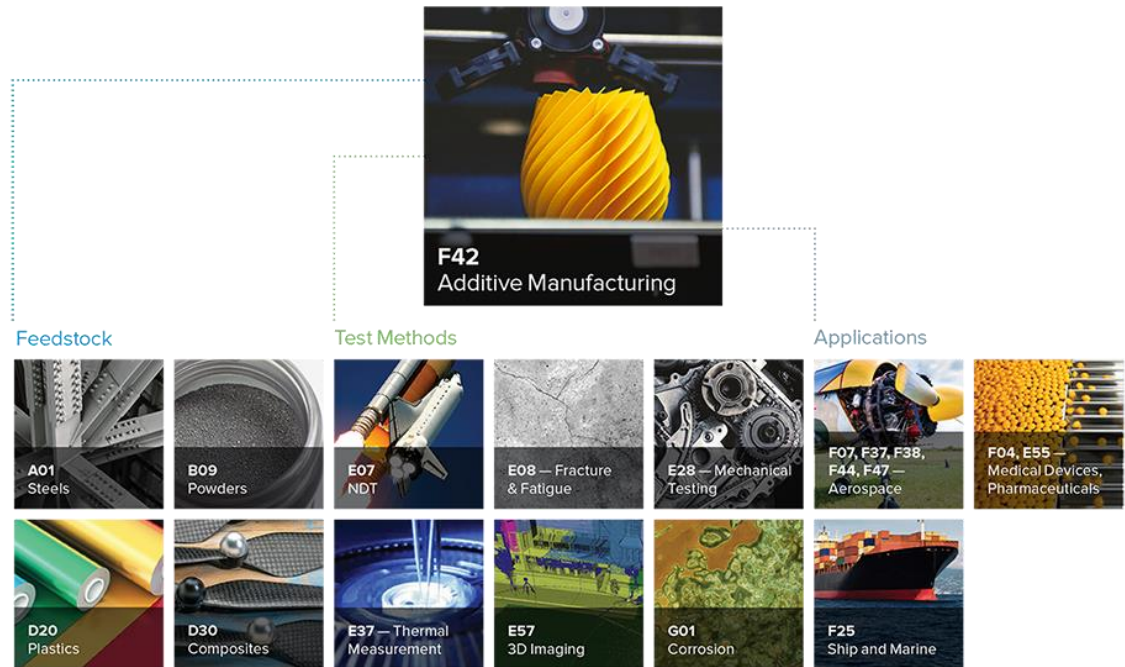
Qualification and Certification Landscape



ASTM AM Footprint



- Breadth
 - 19 Committees
 - 1000+ standards
 - 2000+ technical experts
- History (F42)
 - Oldest
 - Largest
 - Most globally relevant
- Collaboration
 - **PSDO – ISO TC261 (CEN TC438)**
 - MOU & Membership – America Makes
 - MOU – SME
 - Liaison Agreement – 3MF
 - Strategic Relationships – NASA, NIST, FAA, FDA, EASA, MMPDS, EPMA, CECIMO,



ASTM F42



Quick facts

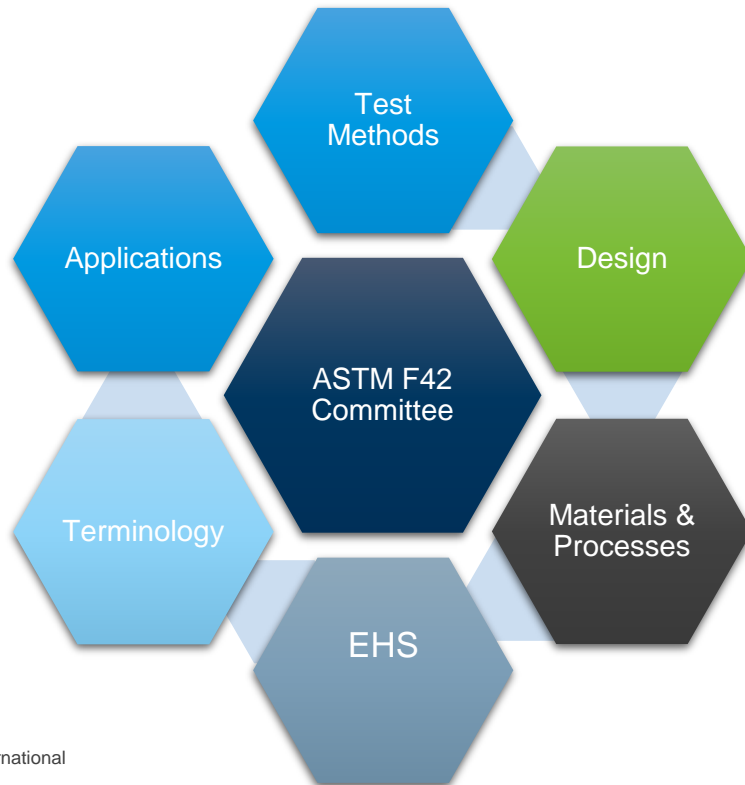
Formed: 2009

Current Membership: 800+ members (154 outside US)

Standards: 25+ published, 45+ in development in collaboration with ISO

Meet twice a year jointly with ISO, next meeting: Texas El Paso, USA, Feb. 2019

Subcommittees and Focus



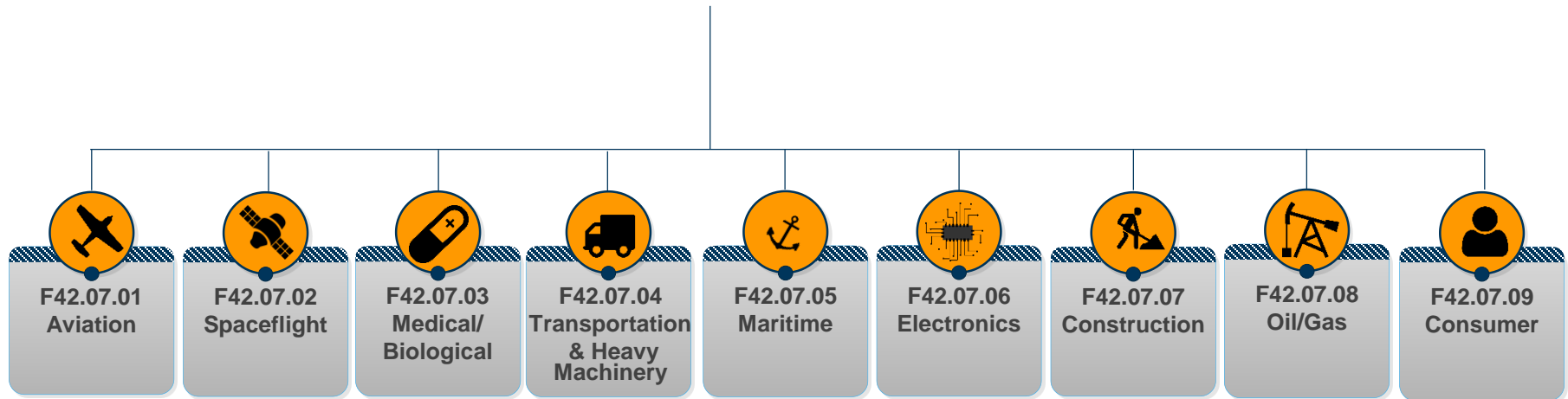
Global Representation: 30 Countries

Argentina
Australia
Austria
Belgium
Canada
China
Czech Republic
France
Germany
India
Italy
Japan
Korea
Mexico
Netherlands
Nigeria
Norway
Puerto Rico
Russian Federation
Singapore
South Africa
South Korea
Spain
Sweden
Switzerland
Taiwan
United Kingdom
United States

Sub-Committee on Applications



F42.07 Applications



Scope

- The development of **standards for additive manufacturing** in a variety of industry-specific applications, settings, & conditions.
- The work of this subcommittee will be coordinated with other F42 subcommittees, ASTM technical committees, and national/international organizations having mutual or related interests.



ASTM

AM CoE (<https://amcoe.org>)



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Research to Standards

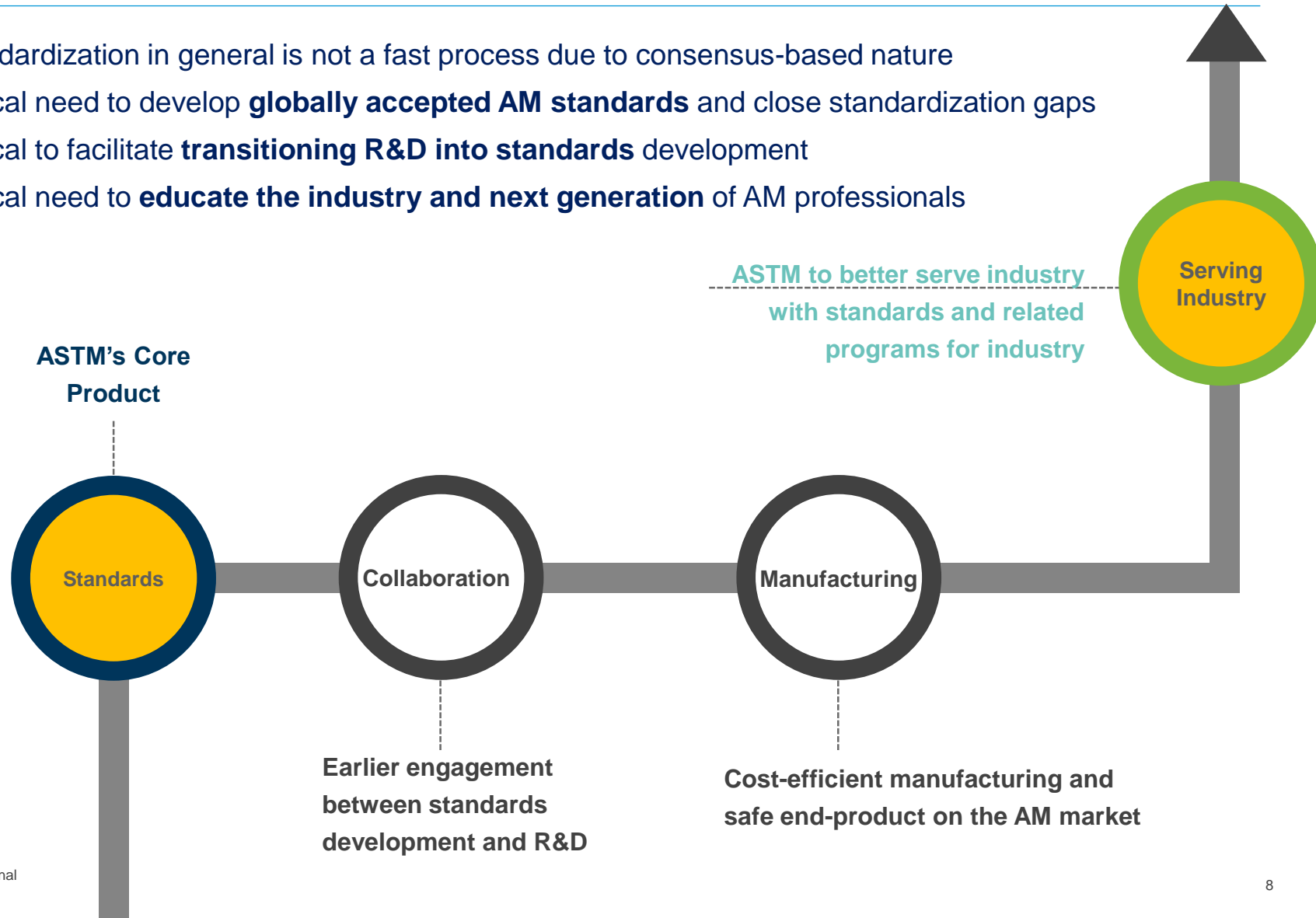
ADDITIVE MANUFACTURING

ASTM AM CoE is to coordinate, accelerate, and validate the development of international standards for the wider adoption of AM technologies.

Why ASTM Created the AM CoE?



1. Standardization in general is not a fast process due to consensus-based nature
2. Critical need to develop **globally accepted AM standards** and close standardization gaps
3. Critical to facilitate **transitioning R&D into standards** development
4. Critical need to **educate the industry and next generation** of AM professionals

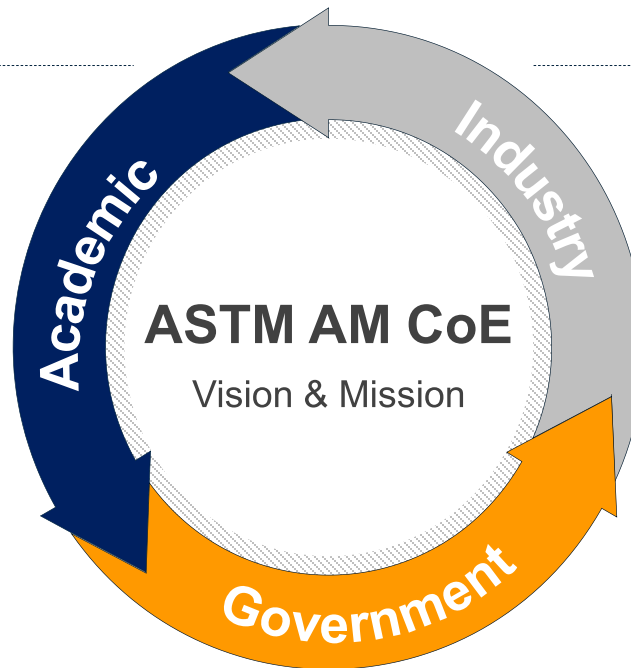


ASTM AM CoE

Clear Vision & Dedicated Mission

VISION

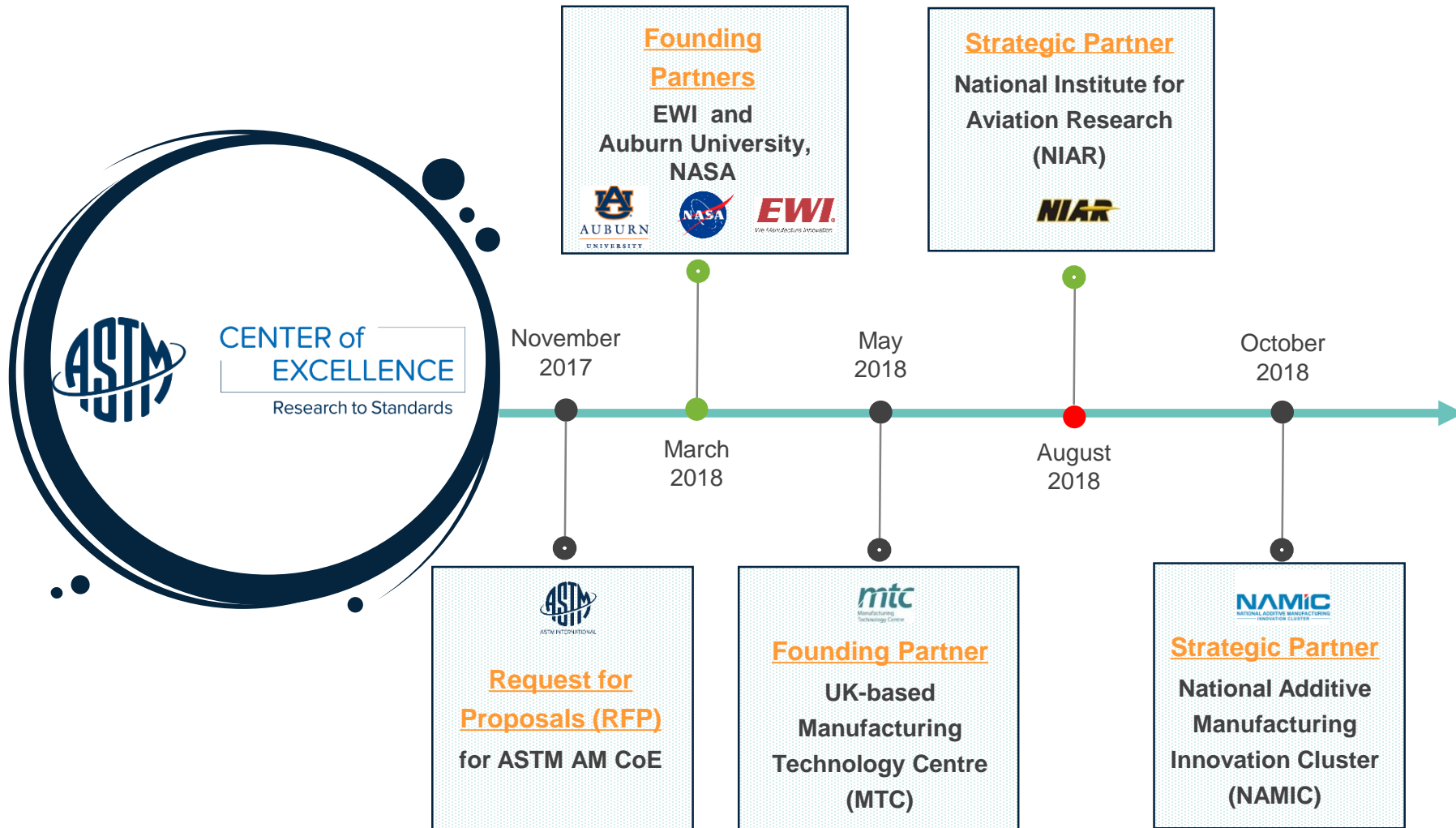
The Center facilitates collaboration and coordination between government, academia, and industry to advance AM standardization and expand ASTM and our partners' capabilities



MISSION

The Center bridges standards development with R&D to better enable efficient development of standards, education and training, certification and proficiency testing programs

ASTM AM CoE Timeline: Founding/Strategic Partners



ASTM AM CoE Locations



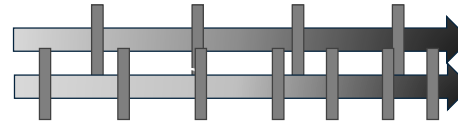


AM CoE

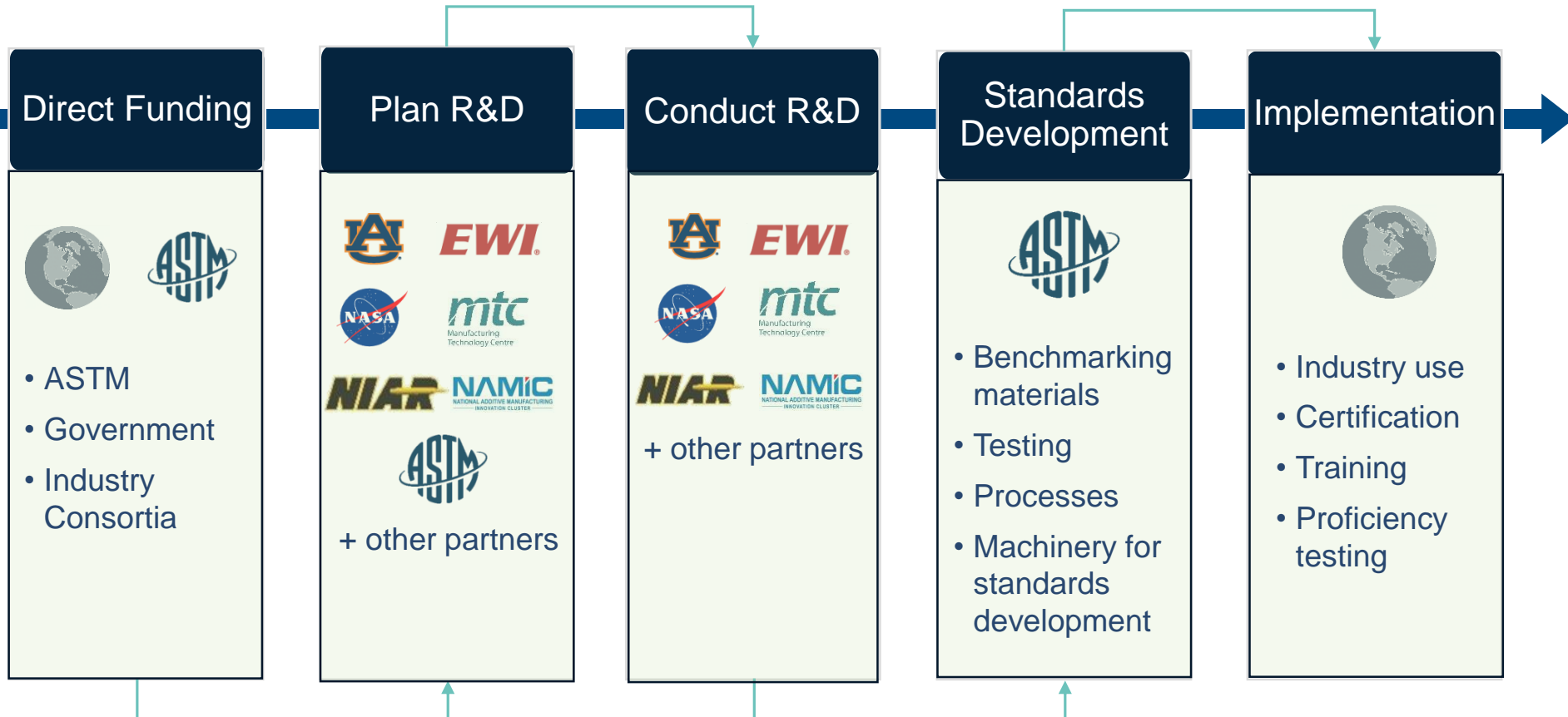
R&D Theme and Implications



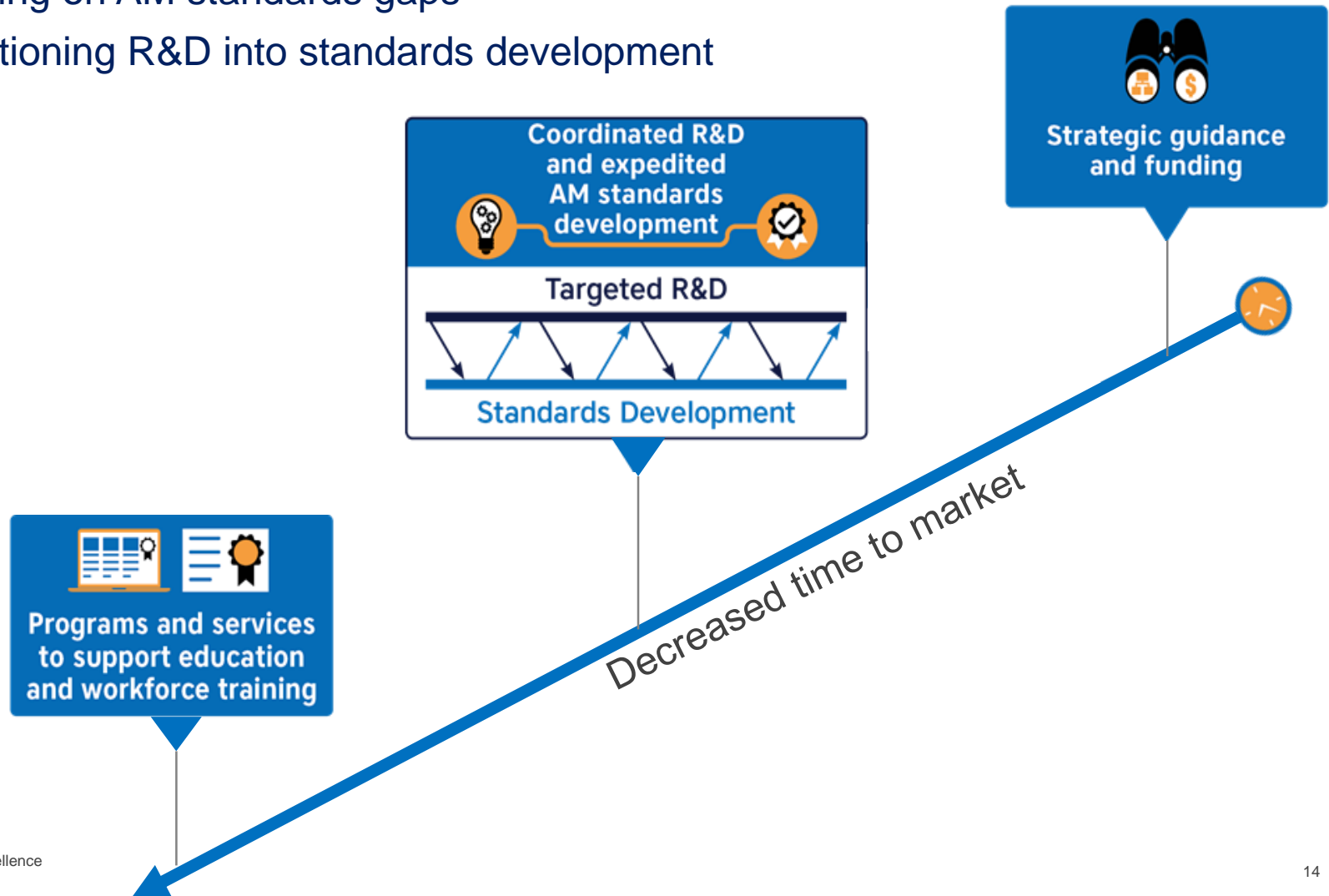
AM CoE R&D: How It Works



Tight coupling between “AM R&D” processes
and “AM standards” development processes



- Focusing on AM standards gaps
- Transitioning R&D into standards development

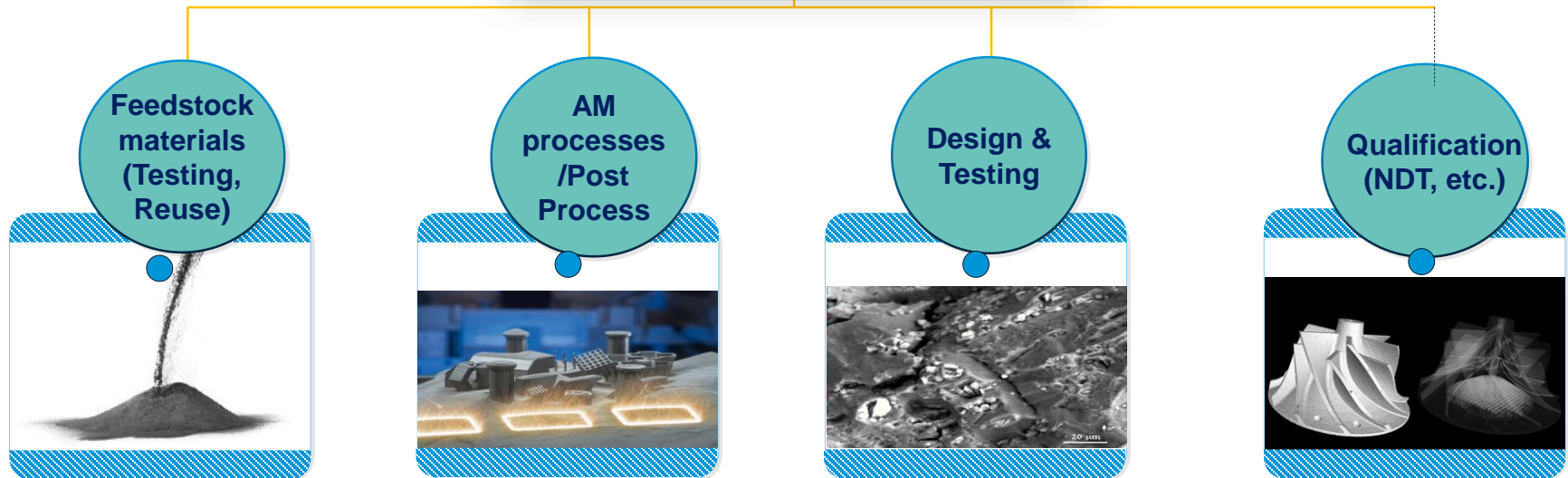


AM CoE R&D: High Priority Areas related to Structural Integrity

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



Participation: NASA, FAA, FDA, NIST, EWI, MTC, Auburn, ASTM



1st Round of R&D Projects



- All five R&D projects are progressing based on their schedule.
- AM CoE shared the latest updates in public at the 2nd AM CoE workshop on Sep. 17, 2019 in France

Project Lead	Project Idea	Est. Comp. Date
EWI	Surface Finishing and Post Processing	Nov. 2019
MTC	Feedstock (Powder quality guide)	Dec. 2019
AU	Mechanical Testing of Metal AM	Nov. 2019
NASA / AU	LB-PBF Process Qualification	Dec. 2019
NIAR	Mechanical Testing of Polymer AM	Dec. 2019



LAUNCHED

5
Research
Projects

ADDRESSING

13
Standards
Gaps

IMPACTING

16
Existing
Standards



PROJECT:
METALLIC
AM TESTING

GAPS:
3

STANDARDS:
3



PROJECT:
POST
PROCESSING

GAPS:
3

STANDARDS:
1



PROJECT:
FEEDSTOCK

GAPS:
5

STANDARDS:
3



PROJECT:
PROCESS
QUALIFICATION

GAPS:
2

STANDARDS:
4



PROJECT:
NON-METALLIC
AM TESTING

GAPS:
2

STANDARDS:
7

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AM CoE R&D: Standardization Gaps



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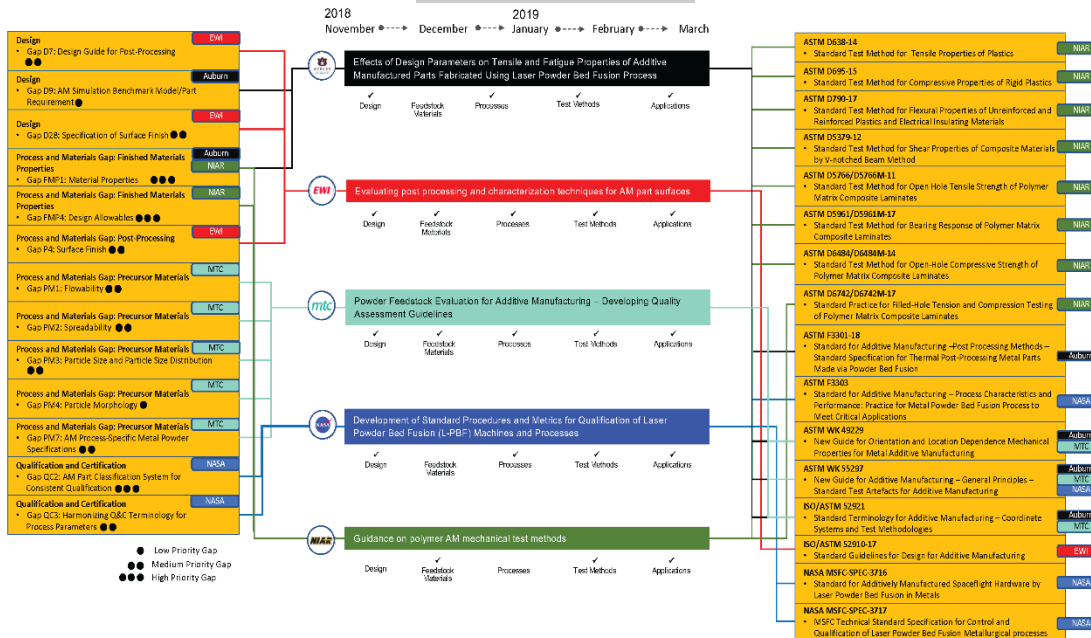
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AMSC Standards Gaps

1st Round of R&D Projects

AM Standards

13 AMSC standards gaps filled



16 existing standards impacted



LAUNCHED

5
Research
Projects

ADDRESSING

13
Standards
Gaps

IMPACTING

16
Existing
Standards

PROJECT:
METALLIC
AM TESTING

GAPS:
3

STANDARDS:
3

PROJECT:
POST
PROCESSING

GAPS:
3

STANDARDS:
1

PROJECT:
FEEDSTOCK

GAPS:
5

STANDARDS:
3

PROJECT:
PROCESS
QUALIFICATION

GAPS:
2

STANDARDS:
4

PROJECT:
NON-METALLIC
AM TESTING

GAPS:
2

STANDARDS:
7

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1st Round of R&D Projects –Work Items Update



Project Lead	Project Idea	Est. Comp. Date	Work Item Status
EWI	Surface Finishing and Post Processing	Nov. 2019	WK66682: Initial draft guide (Univ. Nottingham); EWI's data will update the draft
MTC	Feedstock (Powder quality guide)	Dec. 2019	WK66030: Initial draft from In718 and Ti64; update with Al and Fe data in Phase II
AU	Mechanical Testing of Metal AM	Nov. 2019	Support of WK49229; out for balloting in October:
NASA / AU	LB-PBF Process Qualification	Dec. 2019*	Support of ASTM WK65937; Ballot feedbacks are being used to develop the qualification procedures
NIAR	Mechanical Testing of Polymer AM	Dec. 2019	WK66029: Initial draft of testing guide; next: discussion and edits before submission

* TBC

2nd Round of R&D 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

Genikon



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

ASUM International



Nima Shamsaei
Director

Auburn University



John Vickers
Principal



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
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Mahdi Jamshidinia
AM R&D Project Manager

ASTM
International



Diversified Ideas

2nd round of AM CoE R&D Projects



News Releases: ASTM supports 9 research projects for AM standards



Project 1: LB-PBF Process Qualification



Project 5: Rapid Quality Inspection Specimen



Project 2: Design Guides for AM Processes



Project 6: Polymer AM Testing



Project 3: Design Guide for Post-Processing



Project 7: In-Process Monitoring



Project 4: Polymer AM Testing for Part Performance



Project 8: Powder Feedstock



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Research and Innovation
in Additive Manufacturing



Project 9: Data Pedigree

America Makes Projects

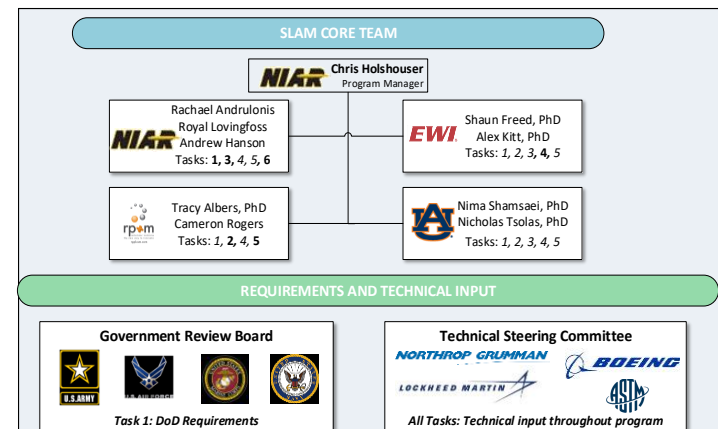
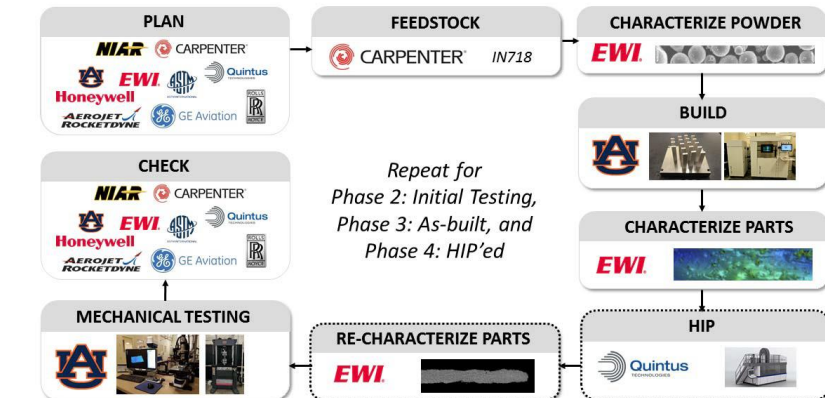


AAPT (Advancing Additive Manufacturing Post-Processing Techniques)

- **Led by:** Auburn University
- **Total Budget:** ~\$1.2M (\$800K Federal Funding)
- **Period of Performance:** 2 years
- **Problem Statement:** lack of best practices for post-processing of AM components
- **Objective:** determine and enable the use of quantitative mechanical performance debits for both as-built and HIP'ed thin walled components and components with narrow flow channels
- **WK66682:** Initial draft guide (Univ. Nottingham); EWI's data will update the draft

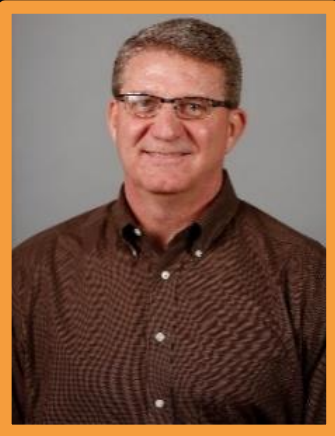
ATRQ (Advanced Tools for Rapid Qualification)

- **Led by:** NIAR
- **Total Budget:** ~\$1.5M (~\$1M Federal Funding)
- **Period of Performance:** 2 years
- **Problem Statement:** Service life predictive tools for application specific characterization do not exist for polymer AM materials exposed to harsh environmental conditions
- **Objective:** Quantify service life of AM polymer parts used in austere field environments





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Education & Workforce Dev.

Paul Jonas, NIAR; Jeff Suhling, Auburn U.

Mission Statement

- “To provide a comprehensive program that educates and trains the additive-manufacturing workforce at all levels, while continually incorporating new advances, responding to industry needs, and leveraging standardization, certification, and our partners’ expertise.”

Differentiators:

- Leveraging/utilizing standards (Potential to acquire accreditation)
- Partner diversity (Academic, Non profit, SDO, Government Agency)
- Filling the gaps
- Multi national (US, EU and potentially Asia)
- Industry driven (leveraging industry consortia network and other members)

E&WD Team

Mohsen Seifi (ASTM International); Nima Shamsaei (Auburn University); Jeff Suhling (Auburn University); Mike Ogles (Auburn University); Martin Dury (The MTC); Stuart Collett (The MTC); Paul Jonas (NIAR); Rachael Andrulonis (NIAR)



Education and Workforce Development (E&WD)



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Team Members

Auburn University

Nima Shamsaei
Mike Ogles
Jeff Suhling

EWI

Alex Kitt
Mark Barfoot

MTC

Stuart Collet
Martin Dury

ASTM

Khalid Rafi
Mohsen Seifi

Nexight Group

Jack Holmes
Changwon Suh

NIAR

Paul Jonas
Rachael Andrulonis

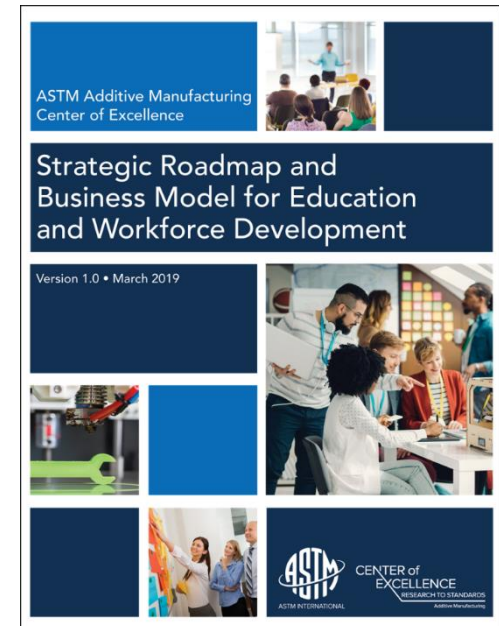
NASA

John Vickers



Recent Progress

- Developed Draft Roadmap and Business Model
 - Held biweekly team meetings to gather input on roadmap and business plan
 - Developed a document to guide program development and implementation
 - Iterating on the roadmap, which will be constantly updated as a living document
- Designed and Held First Offering of the E&WD Program
 - Created a one-day workshop offering a snapshot of the entire AM value chain
 - Used the workshop to advertise and gain feedback on the program and test the business model
 - Event was a success
 - 240 registrants from 13 countries
 - 400 slide handout book
 - >10 sponsors



Events



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Symposiums

3rd ASTM Symposium on Structural Integrity of AM Parts, November 6-8th, 2018



With Collaboration of AM CoE, F42, E08, E07



The 4th ASTM AM Symposium will be convened in Washington DC, USA Oct 8-10, 2019 (Next slide)

4th ASTM Symposium on Structural Integrity of AM Parts, October 8-10th, 2019



When: October 8 – 10, 2019

Venue: Gaylord National Resort and Convention Center, Washington DC

Sponsors

- ASTM AM CoE
- Technical Committees:
 - B09 – Metal powders and metal powder products
 - D20 – Plastics
 - D30 – Composite Materials
 - E07 – Nondestructive Testing
 - E08 – Fatigue and Fracture
 - F04 – Medical and Surgical Materials and Devices
 - F42 – AM Technologies

Supporting Organizations



Chairmen: Nima Shamsaei and Mohsen Seifi



1st ASTM AM CoE Workshop: March 25, 2019



Objective: Awareness around standardized practices, gaps and CoE R&D project to hit the gaps



2nd ASTM AM CoE Workshop: Sept. 16, 2019



When: September 16, 2019

Venue: CETIM, 60300 Senlis, France (Near Paris)

Objective: To ensure the accelerated and successful adoption of AM across a variety of industry sectors, those involved in AM technologies need a holistic understanding of the entire AM process and how they can benefit from standardized practices to ensure quality and consistency



• Workshops

• 2nd ASTM AM CoE Workshop: Sept. 16, 2019, Senlis, France



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Objectives: To ensure the accelerated and successful adoption of AM across a variety of industry sectors, those involved in AM technologies need a holistic understanding of the entire AM process and how they can benefit from standardized practices to ensure quality and consistency

13

12 interactive talks providing a comprehensive snapshot of the entire AM value chain



100

100 + participants

20

20 countries



- Each participant received a “Verification of Completion” that may be applied as credit toward earning a Training Certificate

6

6 supporting



2

2 sponsoring organizations

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innovators you can count on

RENISHAW
apply innovation™

• 4th ASTM Symposium on Structural Integrity of AM Parts: October 7-10th, 2019



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Collaboration of AM CoE, F42, E08, E07

4

4 days event, National Harbor, MD

- 1st day for student presentations competition
- 2nd day focus on "Microstructural and Mechanical Characterizations: MMC"; "Feedstock Issues"; and "Design, Modelling, and Simulation"
- 3rd day focus on "MMC"; "Processing"; "Standardizations, Qualification, and certification: SQC"; and "Post Processing"
- 4th day focus on "MMC"; "SQC"; and "In-Situ Monitoring and NDT"

300

About 300 people in attendance

30

30 nations worldwide

Australia, Belgium, Canada, Czech, China, France, Germany, Hongkong, India, Ireland, Italy, Netherlands, Singapore, South Africa, South Korea, Turkey, UK, USA, ...

110

110 talks (Industry, Government, Academia):

- 45 invited presentations
- 25 student presentation competition

3

3 panel discussions

- Challenges and Opportunities of Adopting AM in new Applications
- Current & Future States of AM in Medical Technology Industry
- Recent Progress in Qualification & Certification of AM in Aerospace & Defense

Publication: the proceedings will be published as **ASTM Technical Paper** publication out of the symposium and all the papers have gone through the review process.

6 supporting organizations



3 sponsoring



Panel Discussion at 4th ASTM AM Symposium: Recent Progress in Qualification & Certification of AM in Aerospace & Defense Industries



10/10/2019

4th ASTM Symposium on Structural Integrity of Additive Manufactured Materials & Parts

October 7-10, 2019 • Oxon Hill, Maryland (Washington, DC area)



PANEL DISCUSSION

Recent Progress in Qualification & Certification of AM in Aerospace and Defense Industry

PANELISTS:



Mark Benedict
AFRL



Marylin Gaska
Lockheed Martin



Charles Park
Boeing



Mark Shaw
GE Additive



Jennifer Wolk
Office of Naval
Research



Cindy Ashforth
FAA

MODERATOR:



Ongoing Efforts Continuing in Next Period

- Developing Next Offerings and First Certificate Pathway
 - Completed a second offering of our workshop at the F42 meeting in Paris, France
 - Planning a multi-day training course covering the stages of the AM value chain in greater detail
 - Mapping out the skills and learning outcomes for the first role-based certificate, comprised of 3-5 courses that build upon each other
- Other Planned Activities
 - Pursuing conformity with ASTM Standard for Certificate Programs
 - Seeking opportunities to engage with federal agencies and other stakeholders in the community
 - Looking for non-traditional training venues : NBAA, Oshkosh, etc...
 - September 2019: Official program evaluation meeting (one-year mark)

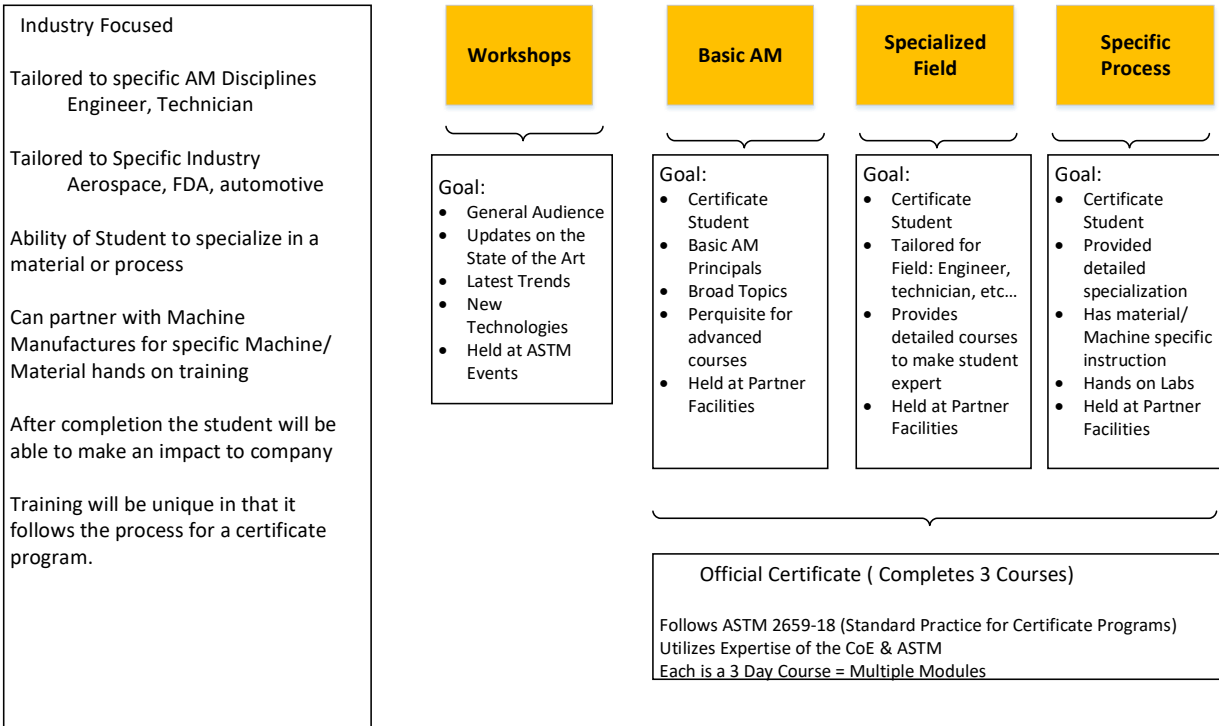
Education and Workforce Development (E&WD)



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E&WD Roadmap



Detailed Course Syllabus

- Modules for Basic AM Course Defined
- Detailed Syllabus for Each Module being Developed
 - Will require review and approval
- Courseware and instructors will be evaluated against the minimum requirements defined in the syllabus

Module	Partner
1. Terms & Definitions & Standards	Auburn
1. Feedstock	MTC
1. Design & Simulation for AM	NIAR
1. PBF Process Dev/Qual	MTC
1. DED Process Dev/Qual	MTC
1. Safety Issues	Auburn
1. NDI	MTC
1. Post Processing	Auburn
1. Mechanical Testing	NIAR
1. Qualification & Certification	NIAR

Example Syllabus - Module: Testing (B-Testing)

Overview

The ASTM AM CoE Basic AM Training Course is composed of multiple modules and taught over a 3-day period. There are ten modules that comprise the Basic AM training curriculum. Each module is presented and tested separately by various experts associated with the subject of the module. Each module has specific minimum criteria to be covered and required skills for the student. Upon successful completion of all of the modules in the Basic AM training class, the student will be awarded a certificate from the ASTM AM CoE certificate program (developed in accordance with ASTM E2659-18 standard practice for certificate programs). Additional specialized training will be available using the Basic Training Course as a prerequisite, and higher-level certificates can be awarded when those classes are completed.

Module Description: Basic AM Testing provides knowledge of the different types of testing utilized in Additive Manufacturing for development, process control, qualification and certification.

Duration: 4 hrs – Lecture – Lab tour is optional but not required.

Learning Objectives

This module outlines the different types of testing that are commonly utilized for Additive Manufacturing. The student upon completion of this module will understand the need for testing and how each type of testing is used from material and process qualification through part certification. At a minimum the student will achieve a basic understanding of the following.

- Understand the terms and definitions associated with testing
- Understand the basics of material testing
- Basic understanding of the types of test coupons and the Standards available for the coupons and testing
- Understand how tests provide material properties and how the variation in the materials and process, discovered through testing, can result in the development of design allowables.
- Understand how design allowables are derived from material properties.
- Understand how lot acceptance values are tied with the design allowables
- Basic understanding of the statistics utilized in generating design values and acceptance values.
 - A & B – Basis values
- Understand how environmental conditions may affect material properties and associated methods for determining environmental effects.
- Understand of the basics of cyclic testing – objectives and methods
- Develop feature-based design data through test
- Part and product level testing
- Lessons learned and best practices.

AM CoE Specialty Workshop Series



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America Makes

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Specialty Workshop Series

Additive Manufacturing Data Management and Schema

December 9, 2019 | Sheraton Tysons Hotel, Tysons, VA

Sponsoring organizations:



SIEMENS



Supporting organizations



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)

ASTM AM CoE is to...



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01

Close standards
gaps and meet
standards needs

02

Carry out AM R&D
to support all
industries

03

Support education,
training,
proficiency
testing, and
certification

04

Host expert-
oriented AM
events,
workshops, and
symposia