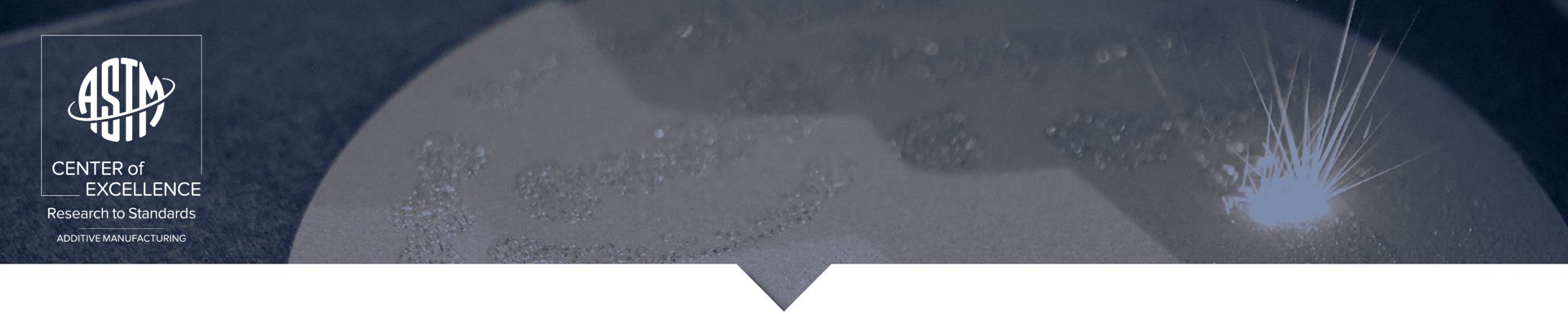


ASTM INTERNATIONAL
Additive Manufacturing Center of Excellence

Additive Manufacturing Industrialization Through Collaborative Research & Standardization

Mahdi Jamshid, PhD
ASTM International

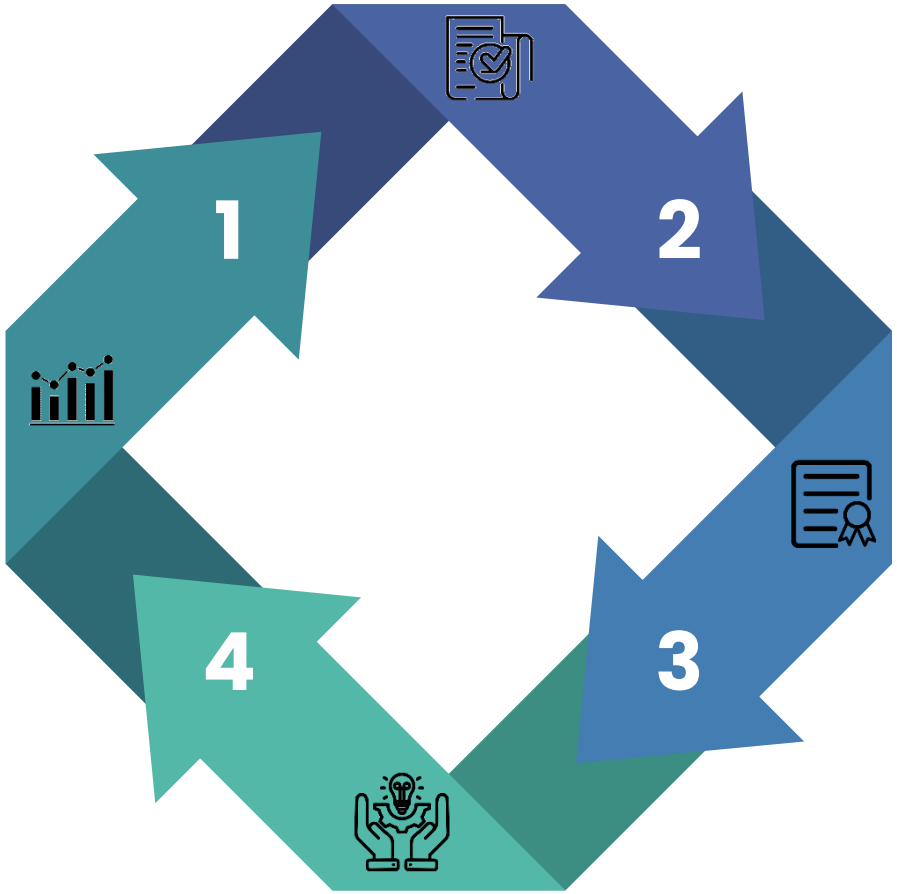
www.amcoe.org

Problem Statement

(Limited Access to)

High Quality/Pedigree Data ☆

Even more challenging for SMEs



(Insufficient)

Consensus-based Standards ☆

(Slow)

Adoption of (AM) Technology

(Expensive)

Qualification & Certification

☆ will be briefly covered in this talk

ASTM AM CoE

- **ASTM formed Additive Manufacturing Center of Excellence (AM CoE) in 2018**

Mission

The Center bridges standards development with R&D to better enable efficient development of:

- Standards
- Education and training
- Certification and proficiency testing programs

Vision

The Center facilitates collaboration and coordination among government, academia, and industry to:

- Advance AM standardization
- Expand ASTM International's and our partners' capabilities.

ASTM Committee F42 is dedicated to AM and has technical subcommittees focused on the development of consensus-based standards. This is happening in partnership with ISO TC261.

ASTM AM CoE is a collaborative partnership among ASTM and organization representing government, industry, and academia that conducts strategic R&D to advance standards across all aspects of AM in addition to create E&WD and Certification Programs.

Research To Standards (R2S) Initiative

CENTER of EXCELLENCE Research to Standards
ADDITIVE MANUFACTURING

- **7** Rounds of Project Call
- **36** R&D Projects
- **32** Technical Experts
- **27** Organizations

Please feel free to contact AM CoE, if you're interested in any of the active projects.

Example Published Standards

CENTER of EXCELLENCE Research to Standards
ADDITIVE MANUFACTURING

Designation: F3490 – 21

Standard Practice for Additive Manufacturing — General Principles — Overview of Data Pedigree[1]

This standard is issued under the fixed designation F3490; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The scope of this document outlines the interpretation of additive manufacturing (AM) data. Currently, legacy AM data is stored in different databases or data management systems, each of which uses its own data dictionary. A common data dictionary allows AM data pedigree to be discovered, mapped, federated, and analyzed to improve both the understanding and qualification of AM processes and parts.

1.2 A common data dictionary facilitates the interoperability, searchability, and reusability of AM data by *(1)* identifying the general AM data pedigree elements already defined in a standardized terminology and *(2)* defining those salient terms with indisputable semantics (meanings). The goal of this document is to provide a first subset of the common data dictionary by which AM data may be collected, curated, and shared, regardless of which technology platform and software are used for data storage and exchange.

1.3 The common data dictionary also specifies a way to group AM data pedigree into fifteen information modules pertaining to different aspects of the entire additive manufacturing process.

1.4 The common data dictionary approach specifies data element names that serve to uniquely identify the AM data elements. The data type, value domain, and term definition for each data element are also specified in this practice. References are provided for those data elements with established definitions in existing standards.

1.5 The data elements identified in this common data dictionary are considered essential, because they are most frequently encountered in AM, process agnostic and technology independent. They are broadly applicable to all the process categories defined in ISO/ASTM 52900. It is intended to be a starting point, not all-encompassing.

1.6 The common data dictionary does not specify:

1.6.1 A complete set of data items to be exchanged through AM development lifecycle and value chains.

1.6.2 A minimum set of data items to be exchanged for AM lifecycle and value chain activities.

1.6.3 A common AM data exchange format.

1.6.4 The details associated with how the common descriptions of data items should be implemented for the development of new data systems or data federations among heterogeneous data systems.

1.7 Additional data elements beyond those defined in existing ASTM, ISO, AWS, NASA and SAE standards have been introduced to provide increased utility for AM. These new data items are generally common-sense and frequently used in the AM industry.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A1080 Practice for Hot Isostatic Pressing of Steel, Stainless Steel, and Related Alloy Castings
E1338 Guide for Identification of Metals and Alloys in Computerized Material Property Databases
E2077 Specification for Analytical Data Interchange Protocol for Mass Spectrometric Data
E2339 Practice for Digital Imaging and Communication in Nondestructive Evaluation (DICONDE)

[1] This practice is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.08 on Data.
Current edition approved Dec. 15, 2021. Published March 2022. DOI: 10.1520/F3490-21.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Designation: F3560 – 22

Standard Specification for Additive Manufacturing – Data – Common Exchange Format for Particle Size Analysis by Light Scattering[1]

This standard is issued under the fixed designation F3560; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification has been developed to facilitate exchanging and analyzing particle size distribution (PSD) by light scattering data from databases, data management systems, point of origin, or other data sources that may use different data dictionaries, schemas, or formats.

1.2 This specification prescribes the use of a common exchange format in such a way that PSD data defined through proprietary means can be easily exchanged for process understanding and qualification.

1.3 This specification facilitates the interoperability of PSD data by identifying the data elements defined in standardized terminology, as well as defining those salient terms with indisputable meanings. In doing so, this specification extends the common AM data dictionary defined in Practice F3490 to encapsulate PSD process-specific data elements. Generic data elements and relationships present in that standard are inherited and applied in this practice where relevant.

1.4 This specification specifies names that serve to uniquely identify the PSD data elements. The data type, value domain, and term definition for each data element are also specified in this practice. References are provided for those data elements with established definitions or reporting guidelines in existing standards.

1.5 This specification prescribes a file format and structure for the exchange of PSD data. This format defines a method for sharing data via the defined PSD data elements herein and provides a basis for validation of data exchanged using this format.

1.6 This specification recommends levels of data sharing that vary from minimal to robust. It prescribes best practices for checking conformance based on the common data exchange format.

1.7 This specification does not specify:

1.7.1 An exhaustive set of data items that could be exchanged related to PSD by light scattering.

1.7.2 A definition of a minimum viable data set for PSD by light scattering.

1.7.3 Data items or an exchange format for PSD methods other than light scattering, for example, imaging or sieving.

1.7.4 Data elements for data modules related to PSD (for example, for personnel, material, or equipment).

1.7.5 The implementation details of how data should be imported to proprietary data management systems from the common data exchange format.

1.7.6 The implementation details of how data should be exported from proprietary data management systems to the common data exchange format.

1.7.7 Guidelines for creating unique identifiers for data module records

1.8 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B821 Guide for Liquid Dispersion of Metal Powders and Related Compounds for Particle Size Analysis
B822 Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering
E1617 Practice for Reporting Particle Size Characterization Data
E3340 Guide for Development of Laser Diffraction Particle Size Analysis Methods for Powder Materials

[1] This specification is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.08 on Data.
Current edition approved Aug. 1, 2022. Published October 2022. DOI: 10.1520/F3560-22.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Designation: F3605 – 23

Standard Guide for Additive Manufacturing of Metals — Data — File Structure for In-Process Monitoring of Powder Bed Fusion (PBF)[1]

This standard is issued under the fixed designation F3605; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide provides standardized procedures and requirements for converting acquired in-process monitoring data into one file representing the printing process of powder bed fusion (PBF) for quality evaluation.

1.2 Many of the operational descriptions included in this guide are intended as general overviews. They may not present the detailed information required.

1.3 This guide covers:

1.3.1 Data registration,

1.3.2 Extraction of in-process data, and

1.3.3 File conversion and visualization.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ISO/ASTM Standards:*[2]

ISO/ASTM 52900:2015 Standard Terminology for Additive Manufacturing — General Principles — Terminology
ISO/ASTM 52915:2020 Specification for Additive Manufacturing File Format (AMF) Version 1.2
ISO/ASTM 52921:2013 Standard Terminology for Additive Manufacturing — Coordinate Systems and Test Methodologies

3. Terminology

3.1 *Definitions*—For the purpose of this guide, refer to the terms and definitions in ISO/ASTM 52900:2015 and ISO/ASTM 52915:2020.

4. Summary of Guide

4.1 The raw data could be obtained from various in-process monitoring systems. This guide does not involve specific details of these systems, such as sensors and controllers. It is assumed that the user has completed the system setup and calibration and can successfully collect the in process monitoring data.

4.2 The user shall provide the details of the data-processing method and choose the information embedded into the final converted file to satisfy their special requirements. They shall be fully aware of the effect of data processing to avoid extracting misleading information and erroneous interpretation.

NOTE 1—Any data processing is recommended to be applied only to a working copy of the data with the raw data preserved.

4.3 The focus of this guide is on extracting and demonstrating the information from the printing process and leaves the part quality to the user to draw their own conclusion.

5. Significance and Use

5.1 The converted file will be organized in a specific structure to reflect the relationship between the in-process monitoring data with the quality of the printing process.

5.2 This standard file structure will help ensure the data compatibility across various printing systems, analyses, and illustration software. It aims to be self-explaining and easy to use to accommodate data sharing in a large base of users.

5.3 The converted file can be used for the evaluation of printing quality and the detections of defects and anomalies.

6. Data Registration

6.1 This necessary procedure aims to transform different sets of geometrically or temporally related in-process data into a single and global coordinate system before converting them into one file.

[1] This guide is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.08 on Data.
Current edition approved Feb. 1, 2023. Published March 2023. DOI: 10.1520/F3605-23.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

What to Focus on?

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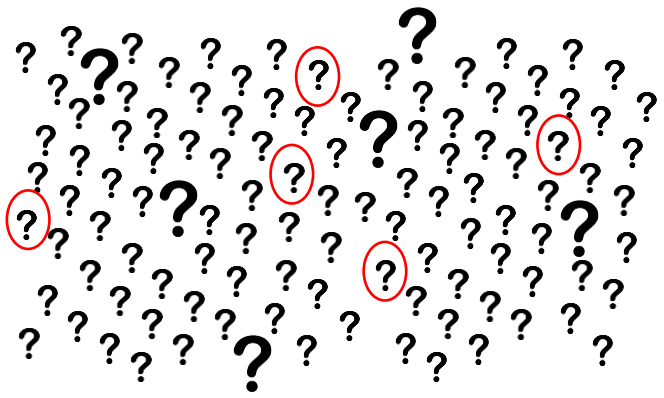
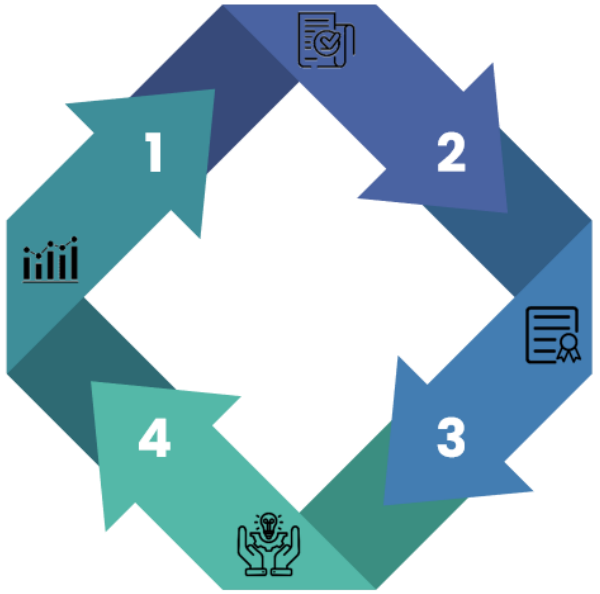
What are the gaps and needs, with the highest impact and return on investment



Gaps

High Quality/Pedigree Data



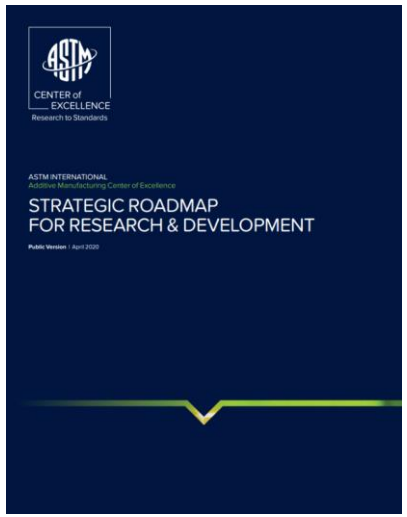
Consensus-based Standards

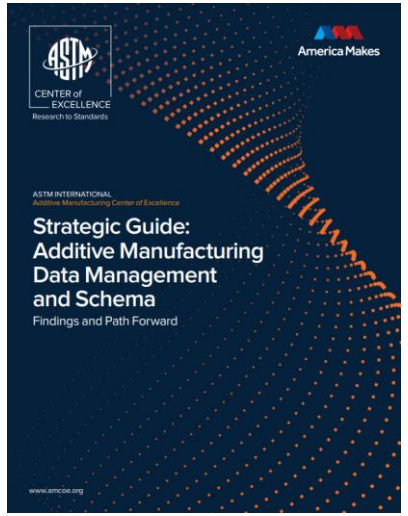
Adoption of (AM) Technology

Qualification & Certification

Guidance on Priorities and Requirements

- Various tools and approaches have been developed to gain insights on Research and standardization needs.
- Findings have been publicly disseminated through the development of strategic guides and roadmaps.





Literature Review | Targeted Surveys | Expert Interview | Technical Workshop | Brainstorming Sessions

Strategic Guides & Roadmaps

Inform R&D and Standardization

Led to the formation of Subcommittee F42.08

How About Larger Gaps?

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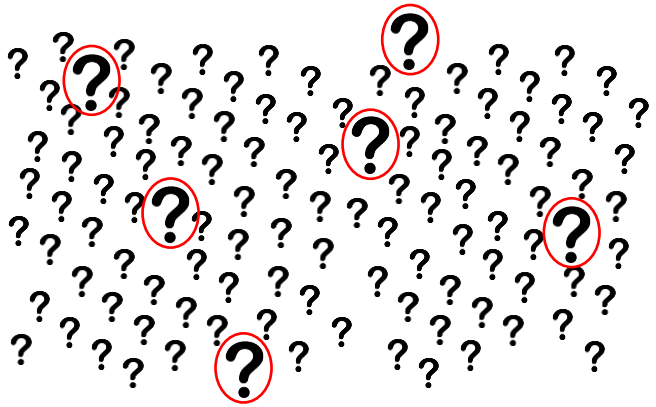
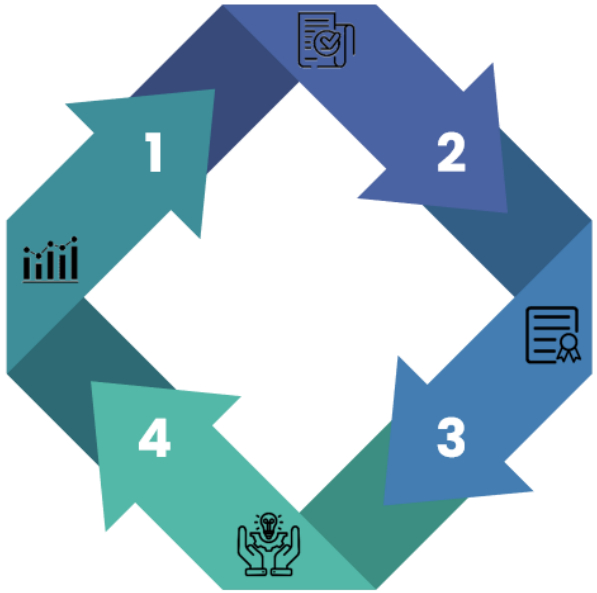
Research to Standards
ADDITIVE MANUFACTURING

Some gaps and needs may require a much larger funding and multi-organizational collaboration to be addressed.



Gaps



High Quality/Pedigree Data

Consensus-based Standards

Adoption of (AM) Technology

Qualification & Certification

AM CoE CMDS - Mission Statement

CENTER of EXCELLENCE Research to Standards
ADDITIVE MANUFACTURING

- The AM CoE Industry Consortia, in coordination with members and with input from regulatory agencies, will accelerate adoption of AM technologies through standardization by:

BEST PRACTICES & REQUIREMENTS

Data Terminology, Pedigree, Specimen Geometry, Manuf. & Test Plan, Pedigree & Combinability Evaluation

GENERATE HIGH-PEDIGREE DATA

Through consortia-funded R&D projects, to drive process-based material specification and material allowable

DATA MANAGEMENT STRATEGY

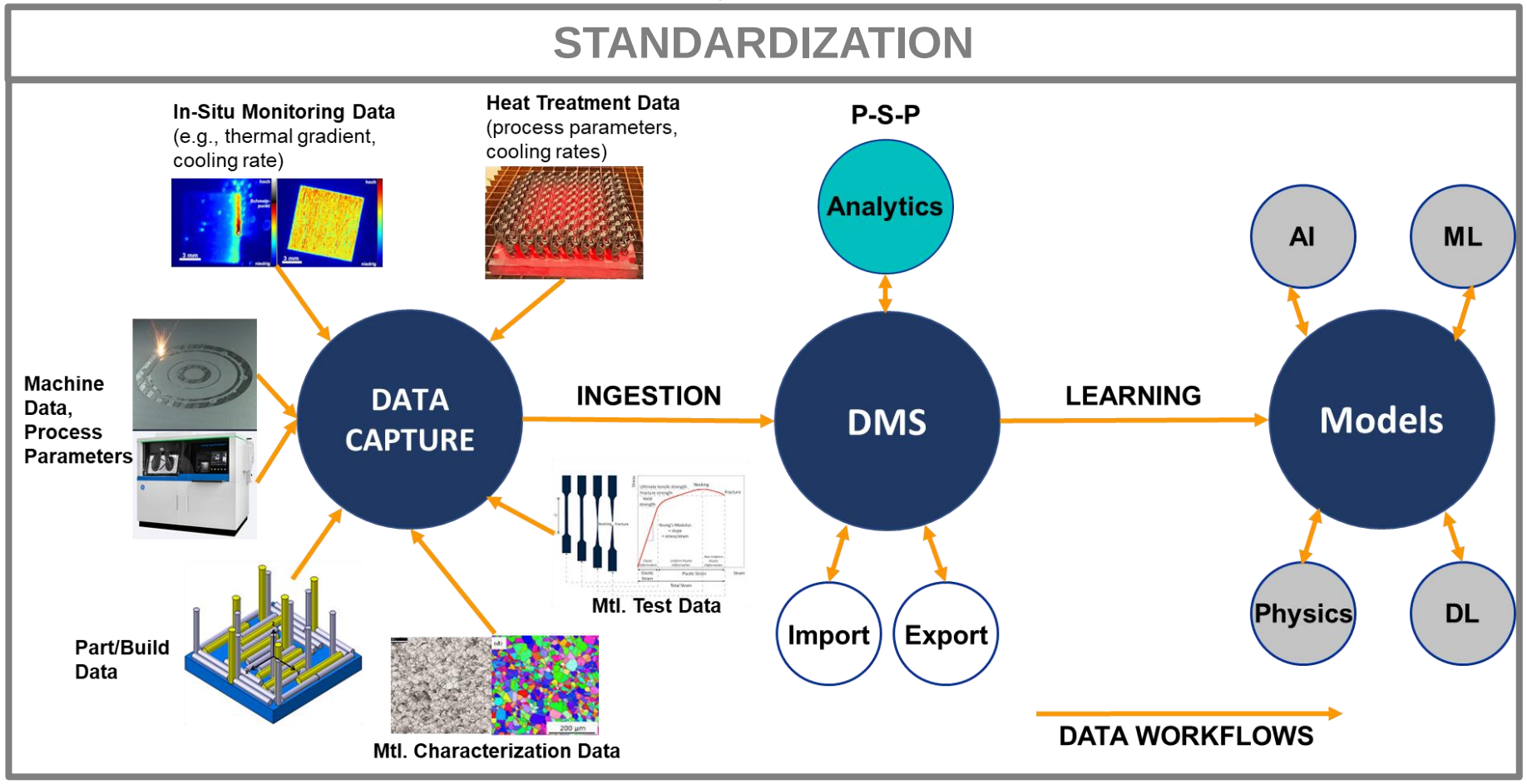
Secure, Member-only Access, Following standard principles (e.g., CDD, CDEF, FAIR*) for data management

STANDARD DEVELOPMENT

Transferring lessons learned and consortium approved materials data to standardization committees

Represented by various stakeholders including SMEs

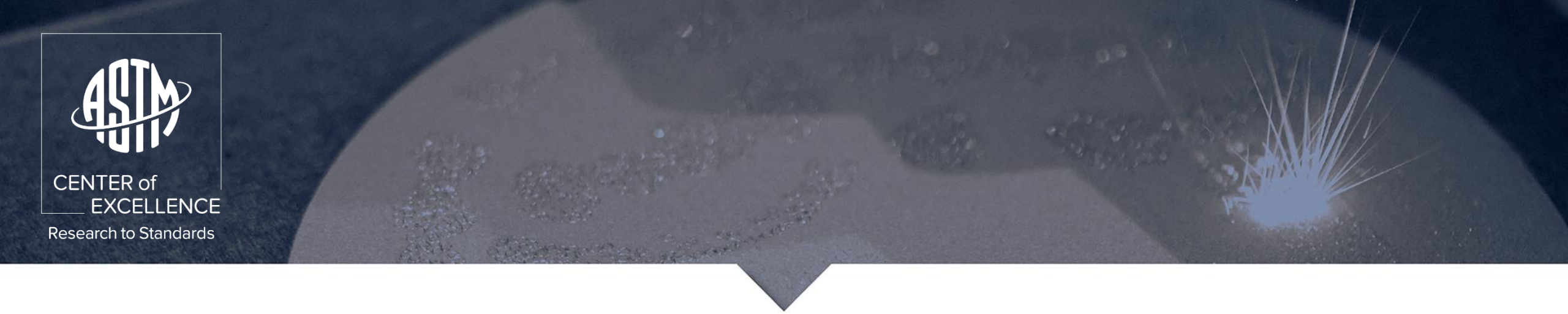
AM CoE CMDS – Data Workstream



- **Standardize, Optimize and Automate Data Workflows**
- **Data Management, Security, Sharing**
- **Model Development, Learning**

Other Programs (relevant to SMEs)

- E&WD
- AMQ
- Advisory Services



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Thank you.

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