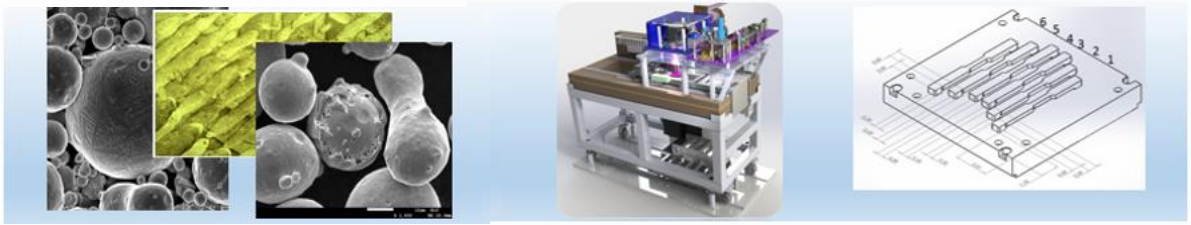
Welcome to the NIST/ASM International Virtual Additive Manufacturing Data Management Workshop

Welcome

- Accelerating Additively Manufactured Part Development and Deployment Through Fair Data

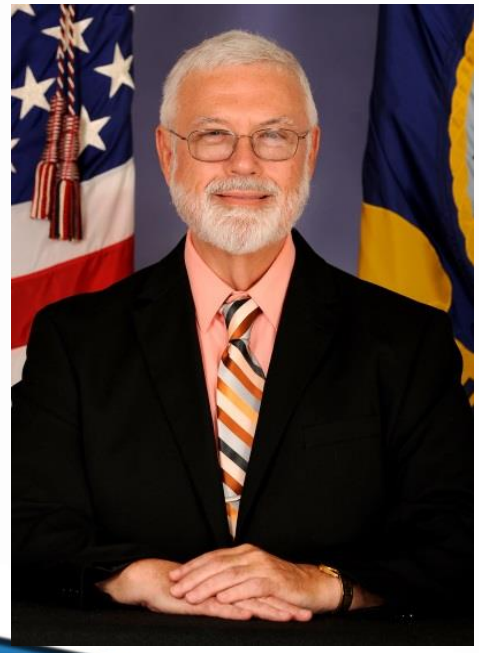


NIST Co-hosts: Yan Lu, PhD and Paul Witherell, PhD
Measurement Science for Advanced Manufacturing Program
Engineering Lab
National Institute of Standards and Technology

Oct 27-28 , 2020

Co-organizers

Dr. William E. Frazier
President
Pilgrim Consulting LLC



- A world recognized expert in materials qualification and certification, manufacturing and processing, additive manufacturing and strategic planning.
- Former Navy Senior Scientist for Materials Engineering, and Chief Scientist for the Air Vehicle Department at the Naval Air Systems Command (NAVAIR).

Dr. Raymond V. Fryan
Executive Director
ASM International

- A key member of the cross-functional CTO team, bringing his experience, leadership, and vision, to enhance and expand ASM's product offerings.
- Former Vice President of Technology and Quality at TimkenSteel Corporation, developing an ICME-capable team for innovative new products.

Special Thanks

- ASM support team: Ms. Michelle White, Ms. Carrie Hawk, Mr. Mat McNeil and Mr. James Cardwell
- Working group leads: Dr. Zachary Trautt, Mr. Peter Coutts, Mr. Thurston Sexton, Dr. Alex Kitt, Dr. Kareem Aggour and Dr. Afina Lupulescu
- NIST support team: Dr. Albert Jones, Ms. Tina Tee, Dr. Shaw Feng, Ms. Yande Ndiaye, Dr. Zhuo Yang, Dr. Hyunwoong Ko, Mr. Hyunseop Park and Dr. Tesfaye Moges.

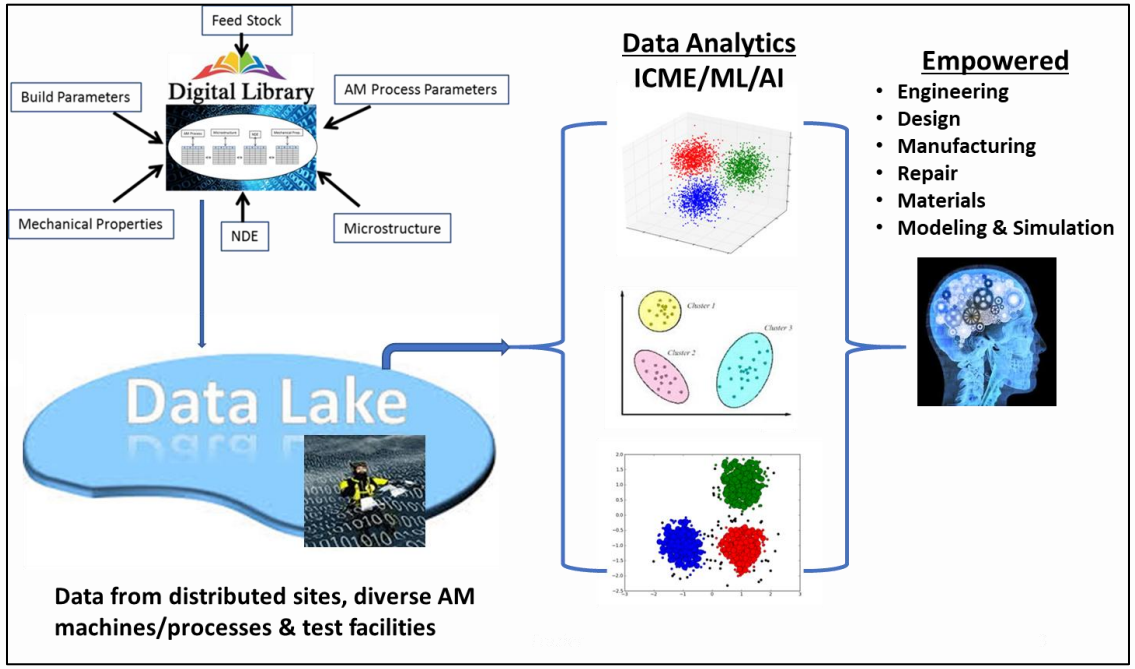
AM Key Challenges and Data

We are here to explore the use of better AM data management to address the following AM key challenges including

- **Poor product quality**
  - Un-manufacturable design
  - Wrong process parameter/scan strategy selection
  - Weak process control – low repeatability
  - Inconsistent system performance
- **Limited material choices**
- **Lengthy and costly qualification process**
  - $Millions to Qualify One Process to Make One Part
  - Years to Qualify a Process

"FAA–Air Force Workshop on Qualification/Certification of Additively Manufactured Parts", 2016

- **Data is empowering AM Material, Process and Part development and deployment**



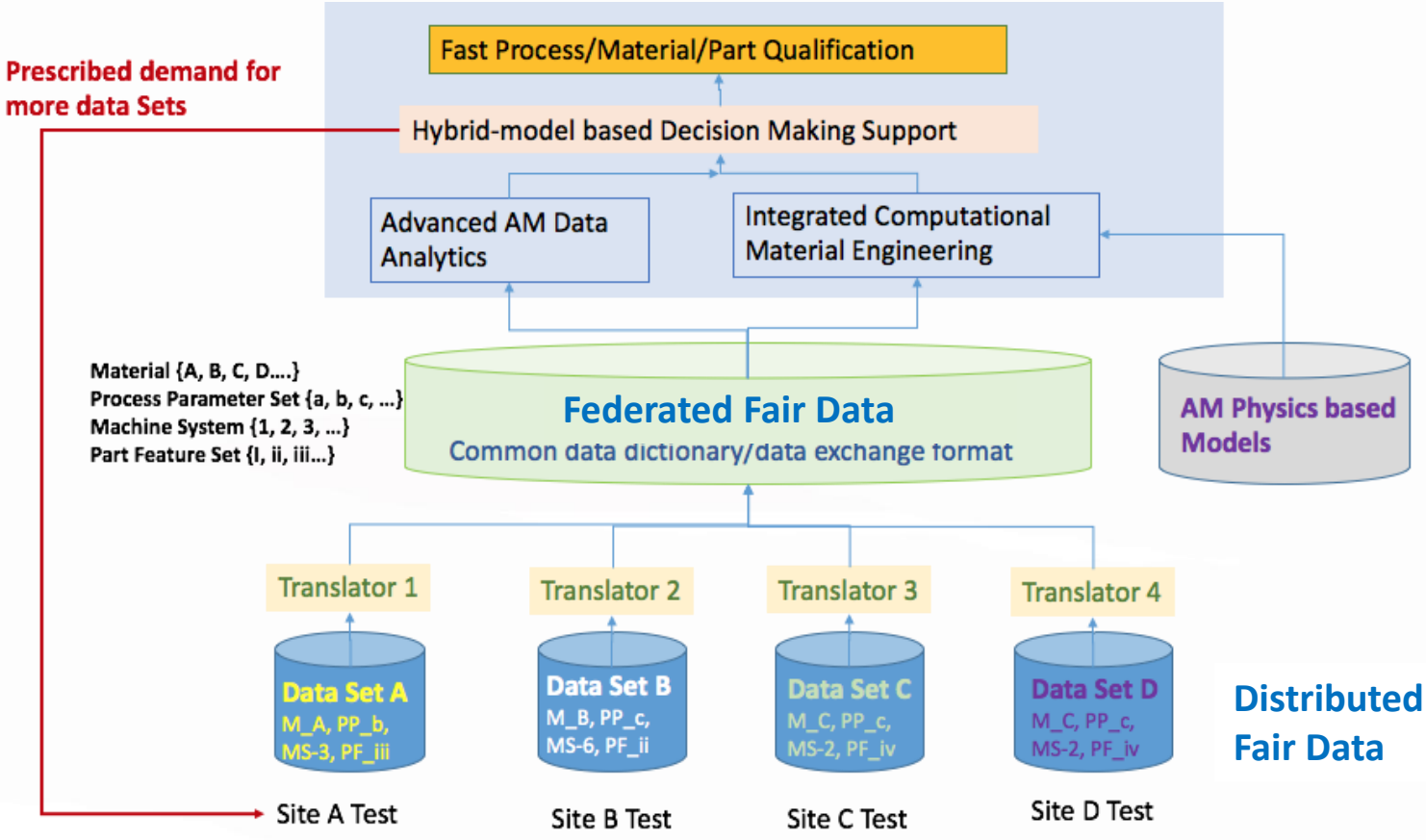
(Courtesy of Dr. Frazier)

Exploring FAIR Principles

- The power of AM data can only be fully realized if the data is findable, accessible, interoperable, and reusable (FAIR).
- Open AM data management standards are required to enable FAIR AM data attributes.

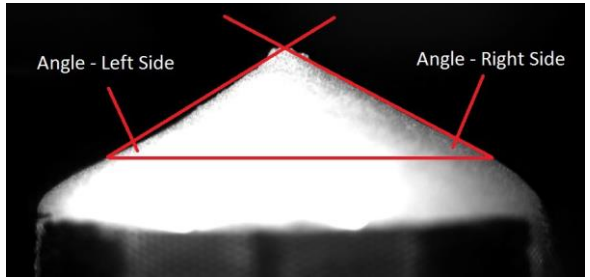
A Collaborative AM Data Ecosystem Vision

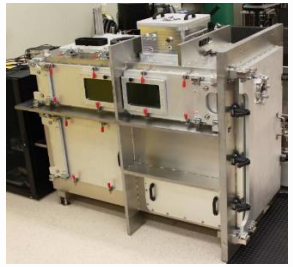
FAIR data will significantly reduce the cost and time associated with AM product deployment

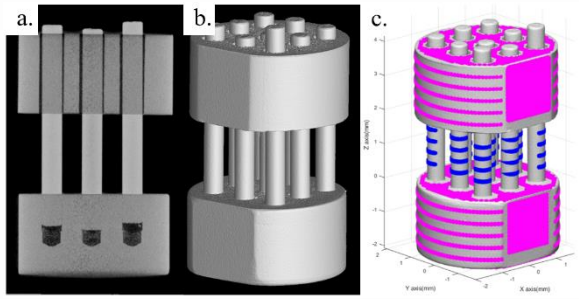


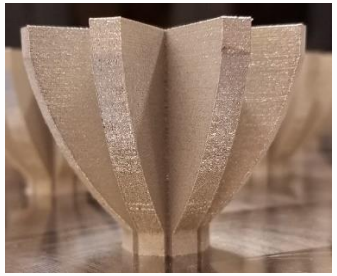
- Sharable distributed, fair data sets
- Fusion into DOE equivalent based federated fair data
- Advanced data analytics and ICME
- PSP relationship development and AM qualification.
- **Fair Data Standards for data sharing and integration**

NIST AM Data Research toward FAIR

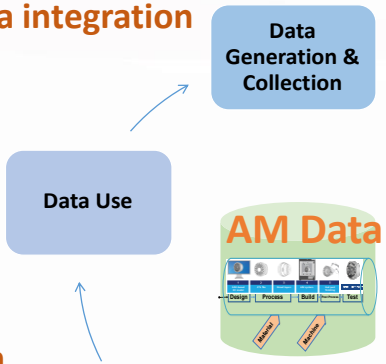






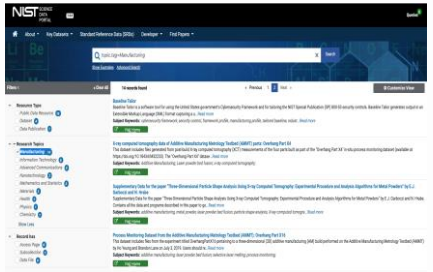


- **Continuous generation of publicly available, well-described datasets**
- **AM Data Management and Data Analytics**



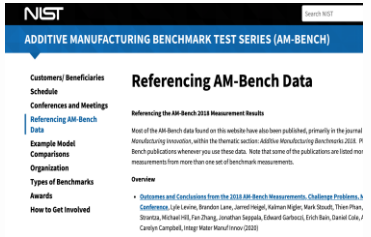
- Data integration
- Knowledge Discovery
- Data driven Decision
- Data Registration
- Data Fusion
- Data Dictionary
- Metadata
- Data Models
- Data Schema
- Database
- Data Sharing
- Open API

data.NIST.gov



- **Unstructured Data Sets**

NIST.gov/ambench



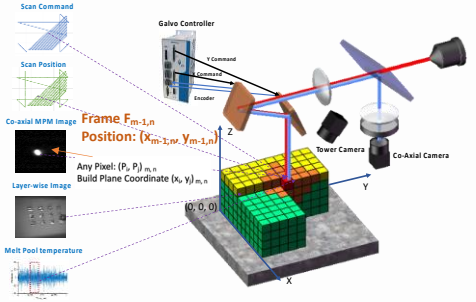
- **Individual Data Sets**

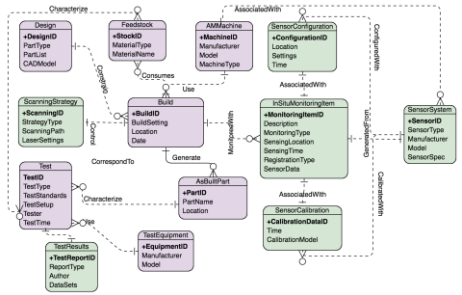
ammd.NIST.gov

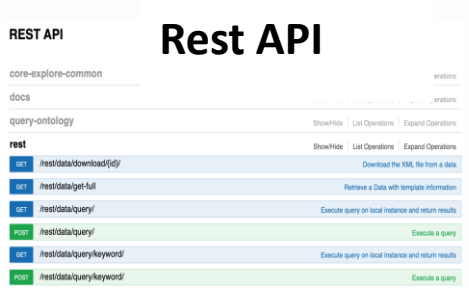
- **Structured**
- **Metadata**
- **Open API**

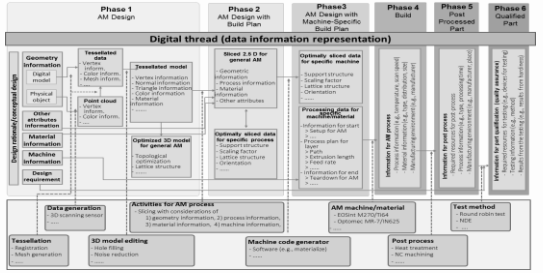
AM Data Management Accomplishment

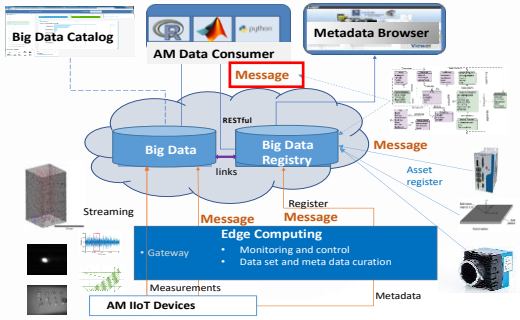
- AM Data landscape and metadata identification
- NIST Additive Manufacturing Material Database (AMMD)
- Integrated AM data model and AMMD schema
- REST API interface for data query and analytics integration
- AM Data Package
- Message-based AM Big Data Exchange
- AM Common Data Dictionary







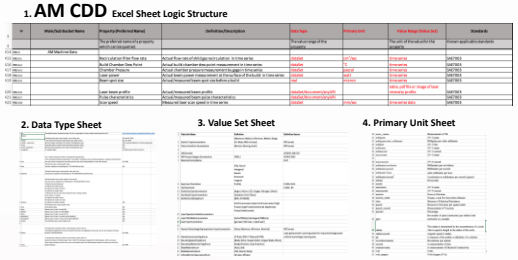




AM Data Standards Activities

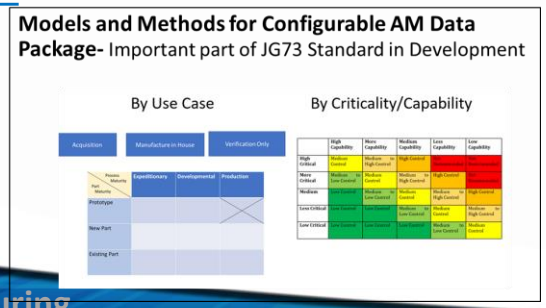
AM Common Data Dictionary

- An ad-hoc AM Data Working Group from 2018
- AM information modules
- Standard definitions of AM data elements, their data types, and allowable values
- AM common data dictionary Excel Sheet
- ASTM F42.08 WK72172
- Contact: Dr. Yan Lu, NIST



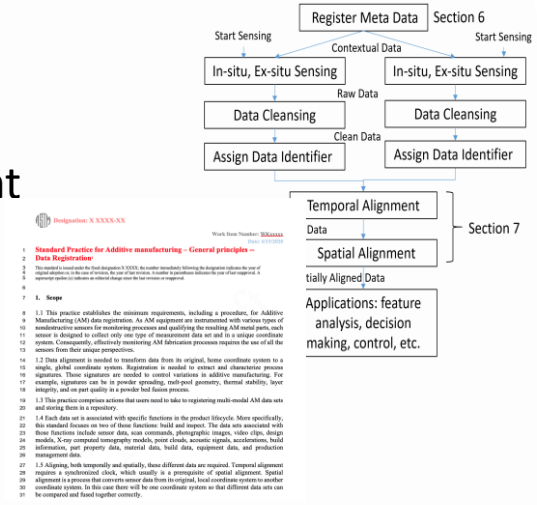
AM Data Package

- ASTM F42 ISO TC 261 JG 73
- Additive Manufacturing— Data Packages for AM Parts
- Contact: Dr. Paul Witherell, NIST



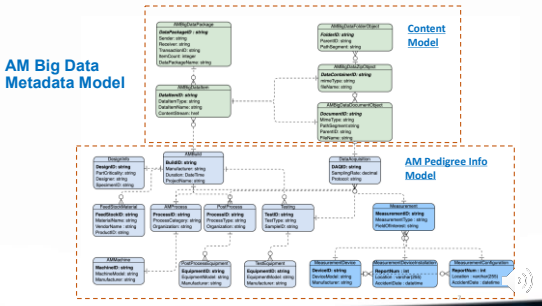
AM Data Registration

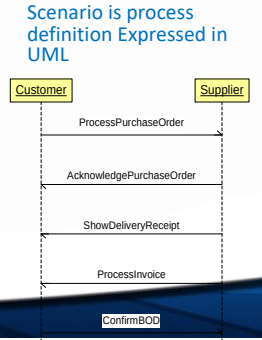
- In-situ/ex-situ data alignment
- Data set metadata
- ASTM F42.08 WK73978
- Contact: Dr. Shaw Feng, NIST



Message-based AM Big Data Exchange

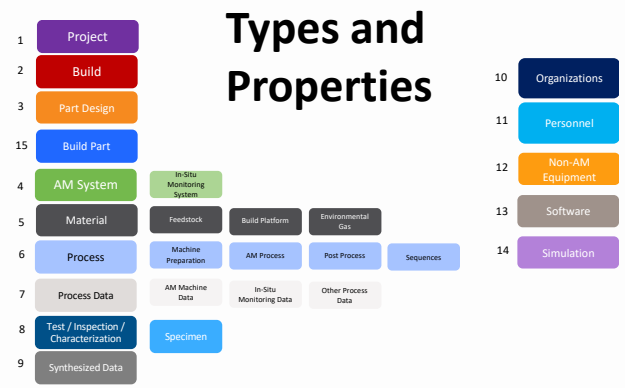
- Open Application Group Integration (OAGI) Specification message for AM Big Data Exchange Message
- Contact: Dr. Yan Lu, NIST

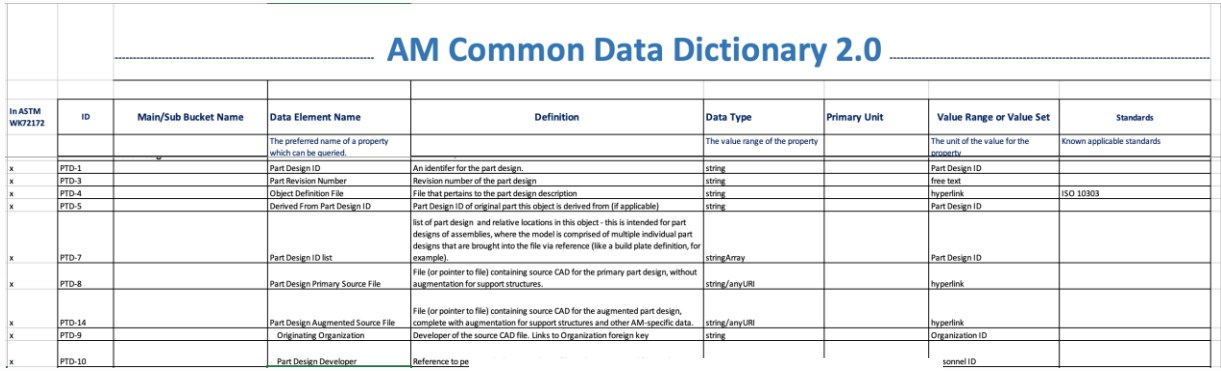


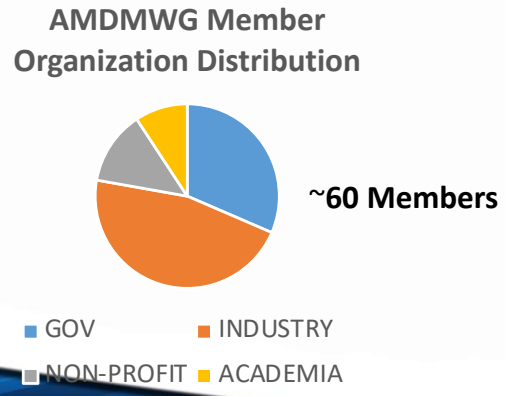


AM Data Management Working Group and CDD

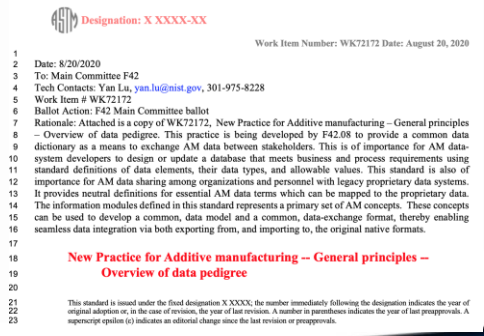
- Established during NAMTII 2018 (Thanks to Dr. Jennifer Wolk of ONR)
- Coordinated by National Institute of Standards and Technology
- Scope of the AM Data Management Working group
  - Complete AM Common Data Dictionary (CDD)
  - Develop Common Data Exchange Formats (CDEF)
  - Standard Practice for Data Curation and Integration– using CDD and CDEF
    - Exchange data between existing databases
    - Federated data into common repository through open interfaces
  - Feasibility demonstration through a qualification use case
- Bi-weekly phone calls every other Monday
- Frequent face-to-face working meetings







ASTM WK 72172 New Practice for Additive manufacturing -- General principles -- Overview of data pedigree


Designation: X XXXX-XX

Work Item Number: WK72172 Date: August 20, 2020

Date: 8/20/2020
To: Main Committee F42
Tech Contacts: Yan Lu, yan.lu@nist.gov, 301-975-8228
Work Item # WK72172
Ballot Action: F42 Main Committee ballot
Rationale: Attached is a copy of WK72172, New Practice for Additive manufacturing – General principles – Overview of data pedigree. This practice is being developed by F42.08 to provide a common data dictionary as a means to exchange AM data between stakeholders. This is of importance for AM data-system developers to design or update a database that meets business and process requirements using standard definitions of data elements, their data types, and allowable values. This standard is also of importance for AM data sharing among organizations and personnel with legacy proprietary data systems. It provides neutral definitions for essential AM data terms which can be mapped to the proprietary data. The information modules defined in this standard represents a primary set of AM concepts. These concepts can be used to develop a common, data model and a common, data-exchange format, thereby enabling seamless data integration via both exporting from, and importing to, the original native formats.

New Practice for Additive manufacturing -- General principles -- Overview of data pedigree

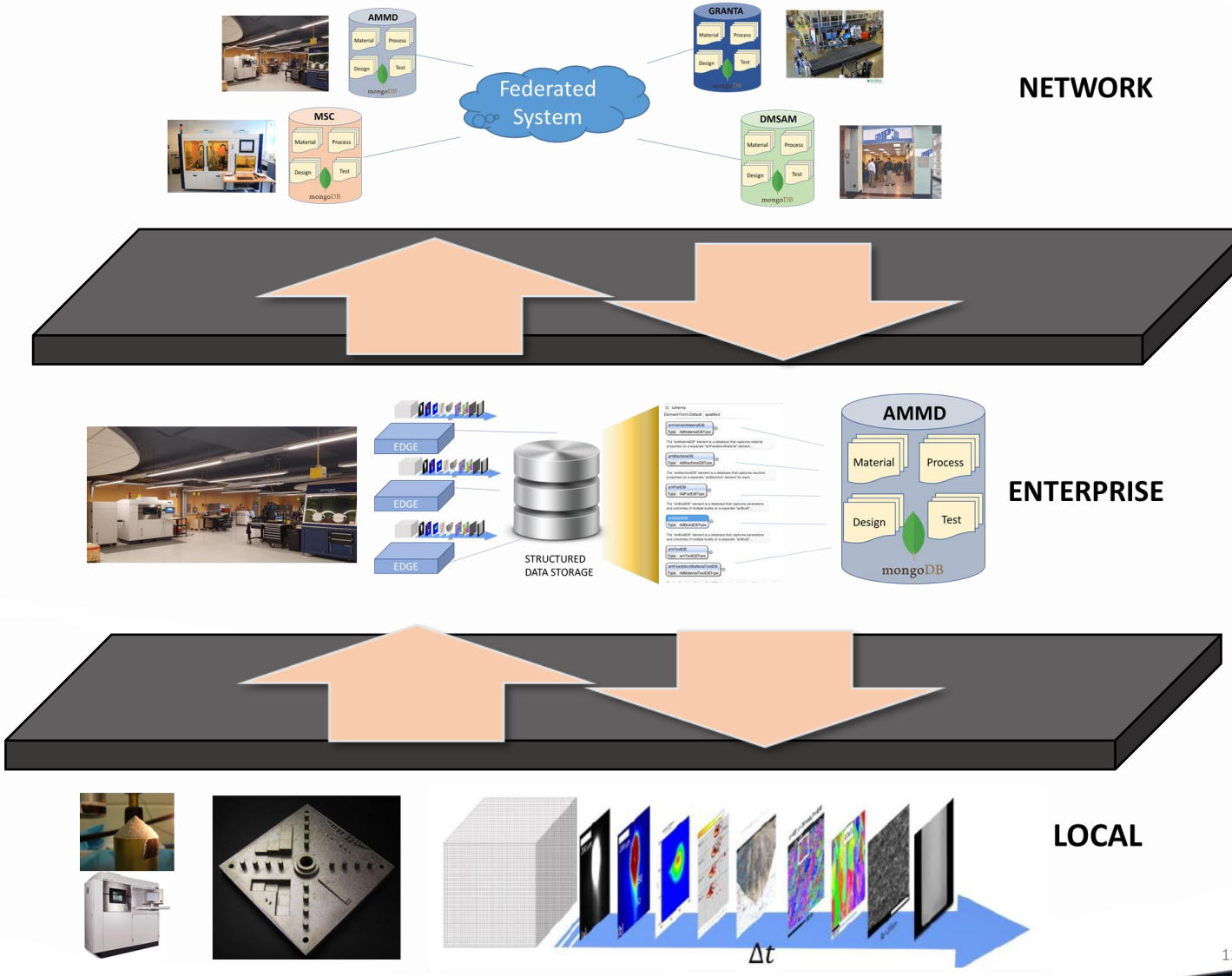
This standard is issued under the fixed designation X XXXX; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last preapprovals. A superscript epsilon (ε) indicates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

Moving Forward

- To date data efforts have been **focused**
- Much work done in **standard-based data sharing and integration**

To **break down silos** and **expose data** we need to do more

In **R&D**, in **application**, and in **standards development** activities



Towards a Sharable Data AM Ecosystem

Prototype of Implementation

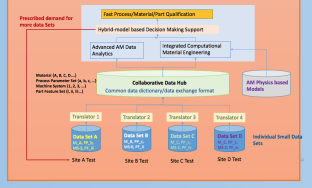
Development of Methods

AMMD

Developing Database

- Support AM Data Curation
- Derive Material-Process-Structure Relationships
- Support analysis of data

Federated Data Architecture



Linking Data

- Support Enterprise Access to Data
- Protect IP Rights of shared Data
- Support analysis of aggregated data

Proof of Concept

?

Prototype Ecosystem

- Demonstrate seamless linking of 3 data sets
- Demonstrate common query
- Demonstrate protection of data and data rights

AM Schema

Providing Structure

- Support AM Data Collection
- Derive Material-Process-Structure Relationships
- Support analysis of data

CDD

Synchronizing Data Elements

- Support common interpretation
- Support shared access of data
- Support aggregation of data

Secure De-Identification

?

Addressing IP and Cybersecurity Concerns

- Support sharing of organizational Data
- Identify Limitations of AM Data Usage
- Identify Acceptable AM Data Sharing scenarios

Challenges Ahead

Data Structure	*AM Schema*
Data Curation Tools	*AMMD/DIMSAM/GRANTA*
Common Interpretation	*CDD*
Data Access	*REST API/ Web Services*
Data Federation Tools	*Web Services?*
IP Protection	*Surrogate Models?*
Cybersecurity	*Blockchain?*
Controlled Access Rights	*Secure Login?*
Trust in Foreign Data	*Standard Specifications?*

Exploring FAIR Principles

Findable:
- F1. Data/metadata has a globally unique and persistent identifier
- F2. Data are described with rich metadata
- F3. Metadata clearly and explicitly include the identifier of the data they describe
- F4. (Meta)data are registered or indexed in a searchable resource

Accessible:
- A1. (Meta)data are retrievable by their identifier using a standardised communications protocol
  - A1.1 The protocol is open, free, and universally implementable
  - A1.2 The protocol allows for an authentication and authorisation procedure, where necessary
- A2. Metadata are accessible, even when the data are no longer available

Interoperable:
- I1. (Meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation.
- I2. (Meta)data use vocabularies that follow FAIR principles
- I3. (Meta)data include qualified references to other (meta)data

Reusable:
- R1. (Meta)data are richly described with a plurality of accurate and relevant attributes
- R1.1. (Meta)data are released with a clear and accessible data usage license
- R1.2. (Meta)data are associated with detailed provenance
- R1.3. (Meta)data meet domain-relevant community standards

go-fair.org

NIST/ASM FAIR AM Data Workshop

Assemble a group of leading practitioners, scientists, standards developers and decision makers with a vested interest in making AM Data more open to discuss a pathway forward

NIST/ASM International

Virtual Additive Manufacturing Data Management Workshop

Save the Dates: 27-28 October 2020

ASM INTERNATIONAL

Pilgrim Consulting - Pathfinding Strategies - Sage Advice -

NIST National Institute of Standards and Technology U.S. Department of Commerce

Workshop Purpose

Establish a strategic path forward regarding needed AM data management. Build consensus between industry, government, and academia as to the specific objectives, challenges, & approaches to be pursued in order to accelerate AM part deployment and reduce the time and cost associated with AM process qualification. Inform NIST programmatic strategy in AM data science. (This may include implementation strategy, building of partnerships & alliances, and management concepts.)

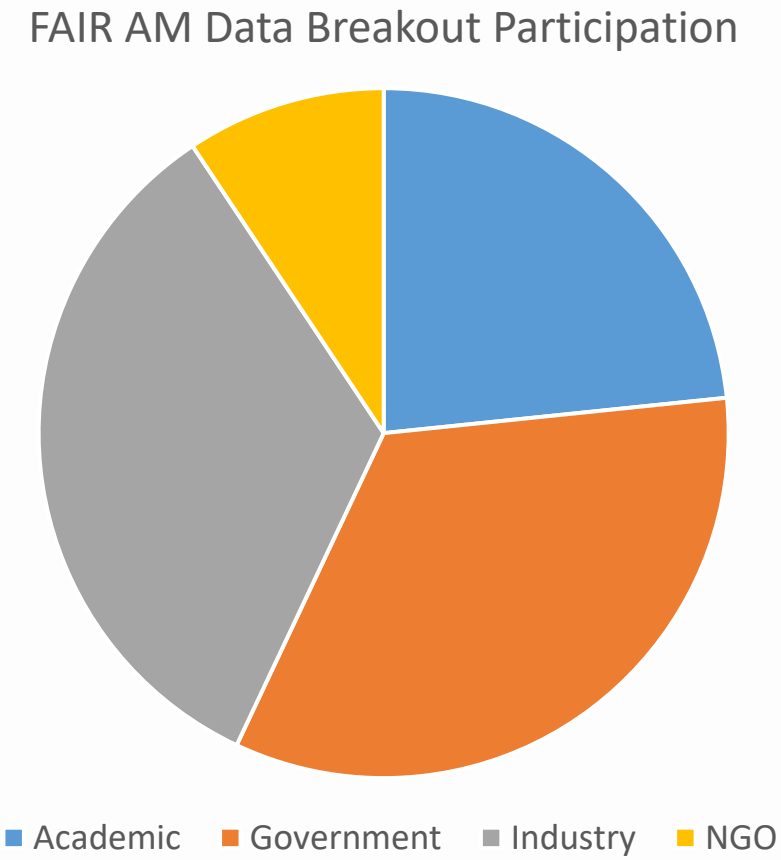
Registration is now closed. If you would still like register for this event please contact Bill Frazier at frazierwe@gmail.com

Fundamental Tenets

- The time and cost associated with AM process qualification and part certification is a major impediment to the widespread use of AM for critical metallic components.
- The identification, generation, curation, and analysis of digital AM data across the AM product lifecycle can significantly reduce the cost and time associated with AM product deployment
- The power of AM data can only be fully realized if the data is findable, accessible, interoperable, and reusable (FAIR).
- Open AM data management standards are required to enable FAIR AM data attributes.

Snapshot of Participation

- ~130 participants including organizers
  - Capped at 120
- Over 70 unique organizations represented
  - Industries represented include:
    - Aerospace, Automotive, Medical, Nuclear, Defense, Consumer Products
  - Government agencies represented include:
    - DoD, NSF, FDA, NASA, DOE, NRC
  - SDOs include:
    - ASTM, ISO, ASME, SAE as well as other NGOs



National Institute of Standards and Technology
U.S. Department of Commerce

NIST-ASM FAIR Data for AM Workshop

Welcome from the NIST Director

Walter Copan
Under Secretary of Commerce for Standards and Technology, and NIST Director

October 27, 2020