FAIR - Additive Mfg. Data - Interoperability

ASM International Data Ecosystem Initiative

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Outline

• Interoperability Intro & Context
• ASM Data Ecosystem intro
• ASM Interoperability Engagement
  • Example Use Case Projects
• Interoperability – Fair Principles
The World is Changing!

1st
Mechanization, water power, steam power

2nd
Mass production, assembly line, electricity
Materials 2.0 ALL Empirical

3rd
Computer and automation
Materials 3.0 Thermo. Design Partially Empirical

4th
Cyber Physical Systems
Materials 4.0 Multi-scale Modeling, ML, Minimally Empirical

5th
Mass customization & cyber physical cognitive systems
Materials 5.0 (?) Truly Rapid Insertion of New Materials? AM goes Mainstream?

ASM Burning Platform ➔ Enable Materials 4.0
ASM’s Place – Enabling Discovery to Become Application

Science Discovery Inductive Reasoning
Invention Innovation Improvement
Engineering Application Deductive Reasoning

ASM - Enabling Materials 4.0 Competency in Industry
Thoughts on Progress – a Simple Model

Scalability requires standardization, collaboration, best practices, and engineering optimization.
ASM – Leading COP on Materials Data to Enable Materials 4.0
Additive Manufacturing Interoperability Connection

CDD IS For AM Community! – Less Machine, Process or Company Specific
ASM International – Interoperability History

➢ Materials Properties Database Committee (MPDC) work on data sharing formats:
  ➢ .xml, Matml, .xsd, RDF/OWL

➢ International Projects – Data Sharing Formats:
  ➢ FATEDA (Fatigue Testing Data)/ .xml
  ➢ METEDA (Mechanical Testing Data – Tensile, Creep-Fatigue)/ .xml; RDF/OWL
  ➢ NATEDA (Nano Testing Data)/.xml, Express

Many Viewpoints and Perspectives! (emerging consensus)

More Viewpoints and Perspectives – Test Specific!

Data Interoperability “Best Practices” Are Emerging...Consensus Achieved Slowly!
ASM Engagement - Smart Manufacturing - Digital Twin/ISO Project

- **Robot scheduling** - David Odendahl, Boeing
  - Flexible Schedule for robot fill and drill
    - ASM Int./AFRL Interoperability Project
      - Alignment with ISO 10303 & ISO 23247
      - Interoperability Files
        - Express/STEP to RDF/OWL translation
        - Including Hardness/ML Evaluation

- **Tool life optimization** (Tool life increase of 15%)
  - Bengt Olsson, Sandvik
    - ASM Int. – Materials Properties Implementation
      - Alignment with ISO 10303 & ISO 23247
      - Spikey Project for Microstructural Evaluation

- **Advanced metrology** (Reduce weight by 500lb)
  - Jan De Nijs, Lockheed
    - Exact Match of Fastener to Hole

Engagement in Digital Twin ISO Activities!
Use Case 1/Boeing – Flexible Schedule for Robot Drill & Fill

On-shoring can increase by 50%

Industry 4.0 ➔ Industry 5.0! – In all Cases, you need Materials
Digital Twin – BOEING/Robot Scheduling

User entity
- Supervisory Control
- Coordinator
- State Machine (supervisory)
- Combiner

Core entity
- Process Digital Twin
- Wing Digital Twin
- Equipment (Cell) Digital Twin
- MTConnect

Data Collection sub-entity
- MTConnect Agent
- Data Cache (cell)
- State Machine (cell)

Device Control sub-entity
- Device Control
- State Machine (process)
- Data Cache (process)

Models
- Product/Process

Commands
- Stop/Go, etc.

State Stream
- Rapid (AP238 execution state)
- Plunge complete, etc.

Instructions
- Gcodes, etc.

ISO 23247-4

Industry 4.0 - Progress toward Industry 5.0!
Use Case 2/Sandvik – Tool Life Optimization

Machine parts
Monitor tool diameter
Compute tool engagement
Store linked data

OMAC
Machining Context Macros
Gcode ops

ANSI
MTConnect
Stream results

STEP Tools
STEP Agent
Apply Results

ISO
STEP-NC
Twin model

Digital Twin - Connecting Modeling and Materials Communities Using a Common Language
Digital Twin – SANDVIK/ Tool Life Optimization

ISO 23247-4

...Requires Knowledge of Materials and Consumable Tooling
Interoperable
The data usually need to be integrated with other data. In addition, the data need to interoperate with applications or workflows for analysis, storage, and processing.

- **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

Interoperability – We CAN do this, but we need a PLAN!
Interoperability – The Plan!

• **formal** *broadly applicable language*
  • ...be able to exchange and interpret each other’s data.
  • ...be readable for machines without ...specialised or ad hoc algorithms, translators, or mappings.
  • ...each computer system at least has knowledge of the other system’s data exchange formats
  • ...controlled vocabularies, ontologies, thesauri, a good data model.

Can’t we all just get along?
Interoperability – The Plan!

• I1...formal... *broadly applicable language*

• I2...vocabularies that follow Fair Principles
  • needs to be documented and resolvable using globally unique and persistent identifiers.
  • ...needs to be *easily findable and accessible by anyone who uses the dataset.*

Can’t we all just get along?

Ease of Communication ➔ Daunting
Foundation of Common Language!
Interoperability – The Plan!

• **I1**...formal... *broadly applicable language*

• **I2**...vocabularies that follow Fair Principles

• **I3**...data/metadata include quality references to other data
  • ...create as many meaningful links as possible between (meta)data resources to enrich the contextual knowledge
  • ...the scientific links ... need to be described.
  • ...all datasets need to be properly cited.

Can’t we all just get along?

Ease of Communication ➔ Daunting
Foundation of Common Language!

After Foundation, Linkage is KEY
Interoperability – The Plan!

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Interoperability – Not EASY!
Summary – ASM Position on Interoperability

• Data Ecosystem – Counting on it!

• Communities of Practice – Encouraging it!
  • Other Societies, Gov’t, Industry, Academia
  • Committees, Task Forces, Ad Hoc COP’s

• Project, consortium, SDO actions – Building it!

• Data Sharing Formats Challenges – Tackling it!

• Collaboration – Embracing it!
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Interoperability – Challenging, but **NOT Impossible!**
THANK YOU!