AM Data Modeling Efforts

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Key Data Modeler Contributors

- Kareem Aggour: GE Aviation Research
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- Yan Lu: NIST
- Afina Lupulescu: ASM
- Luke Mohr: EWI
- Hunter MacDonald: Hexagon
- Mike McNair: SAE
- Shengyen Li: NIST
- Mike Vasquez: 3 Degrees
- …

Agenda

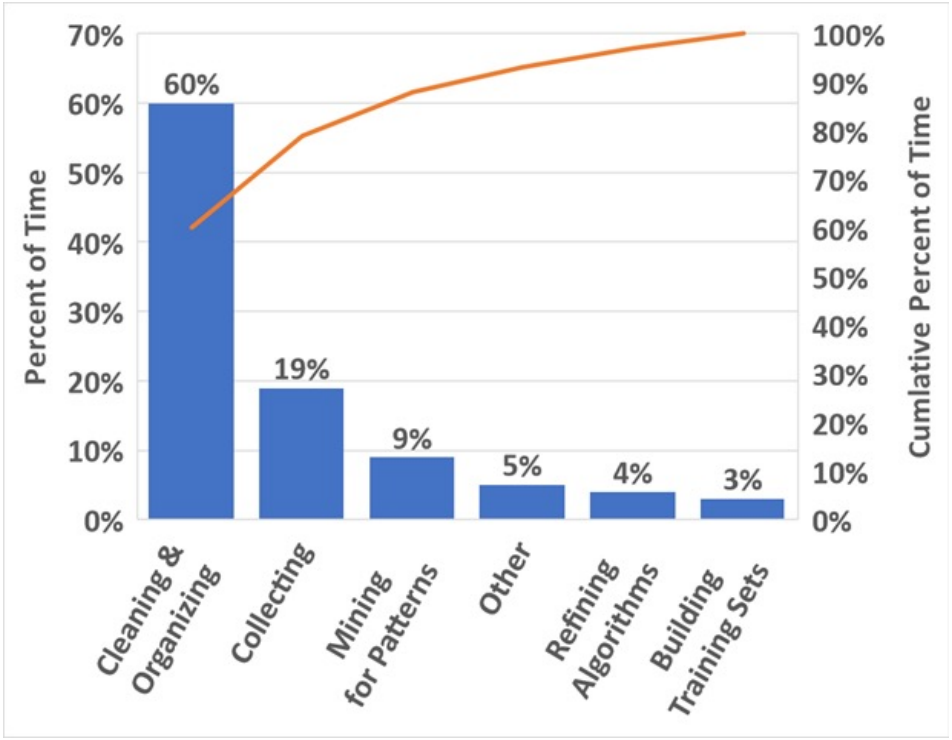
- Problem Statement
- Effort to Date
- Help Needed

Problem Statement

General Problem Statement: Value of FAIR Data

EU study on general research community cost of not following FAIR practices:

- **≥ €10.2 B/yr.** Cost of not having FAIR data
- **≥ €16.9 B/yr.** Cost to innovation
- **80%** of the duplicative funded work could be eliminated.
- **72%** of the research data generated could be made open.
- **28%** must remain closed due to security and privacy reasons.



People who work primarily with data

80% of their time

Finding, filtering, reformatting, and integrating data

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PwC EU Services, "Cost of not having FAIR research dat," (European Commission, PwC EU Services, Brussels, ISBN978-92-79-98886-B, DOI: 10.2777/02999, March 2018)

AM Specific Problems: Value of FAIR Data

Redundancy: Design allowable data sets

- Cost $3-5M to generate per process specification (specific to material, AM process type, AM equipment type, heat treat, etc.)
- An aerospace company recently estimated that the community had spent >$250M generating redundant design allowable datasets for the same material
- The material referenced is an industry standard material not associated with having a competitive advantage

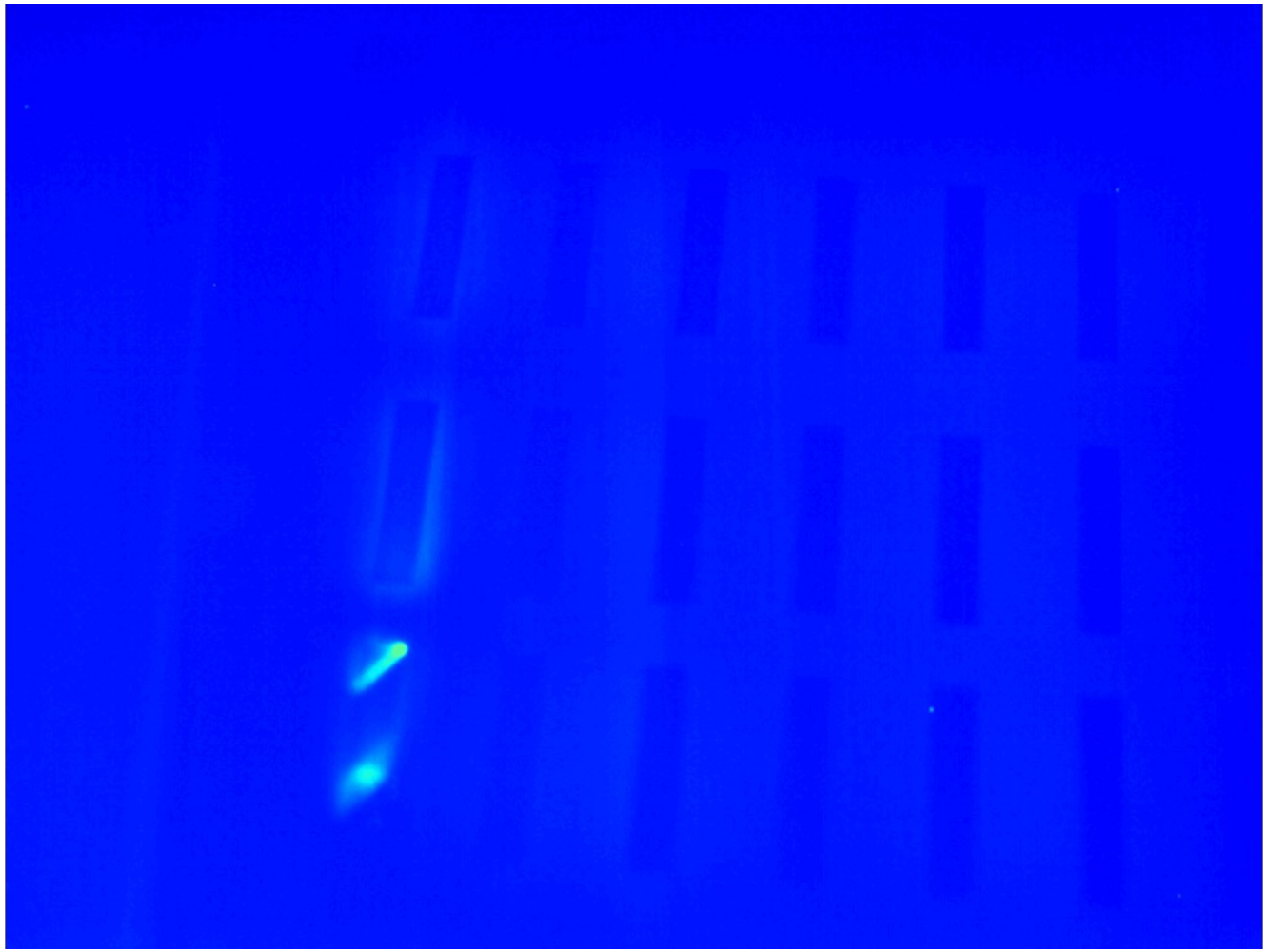
Process Understanding: Process qualification

- Scaling an AM process to a second, identically configured system costs >6 months, >$1.5M

AM Challenges

- Many islands of unstructured & uncoordinated work
- No established means to convergence on a consensus solution
- AM equipment are often “black boxes” which limit data accessibility
- Data viewed as IP. Data models viewed as IP by extension
- Data generators are not the ones who benefit from data

AM Datasets can be HUGE



Effort to Date

Workshops

- Empowering Small and Medium Size Enterprises Through Effective Additive Manufacturing Data Management [2023]
- Data Enabled Accelerated AM Process Qualification [2022]
- Additive Manufacturing Data Management and Schema Workshop [2020]
- Additive Manufacturing for Maintenance and Overhaul [2020]
- Additive Manufacturing for Maintenance and Overhaul [2019]
- …

ASTM F42.08 – AM Data

Scope: The development of AM standards that relate to AM data interoperability, AM data analytics, and AM data management (including but not limited to data security) (not including design data).

ASTM F42.08 – AM Data

Approved:

- **ASTM F3490-2021 (Data Pedigree):** Approved, ad-hoc group developing AM common data model which may be included in first revision of F3490
- **ASTM F3560-22 (CDEF for PSD):** Approved(Based on ASTM CoE R&D)
- **ASTM F3605-23 (File Structure for In-Process Monitoring):** Approved(Based on ASTM CoE R&D)

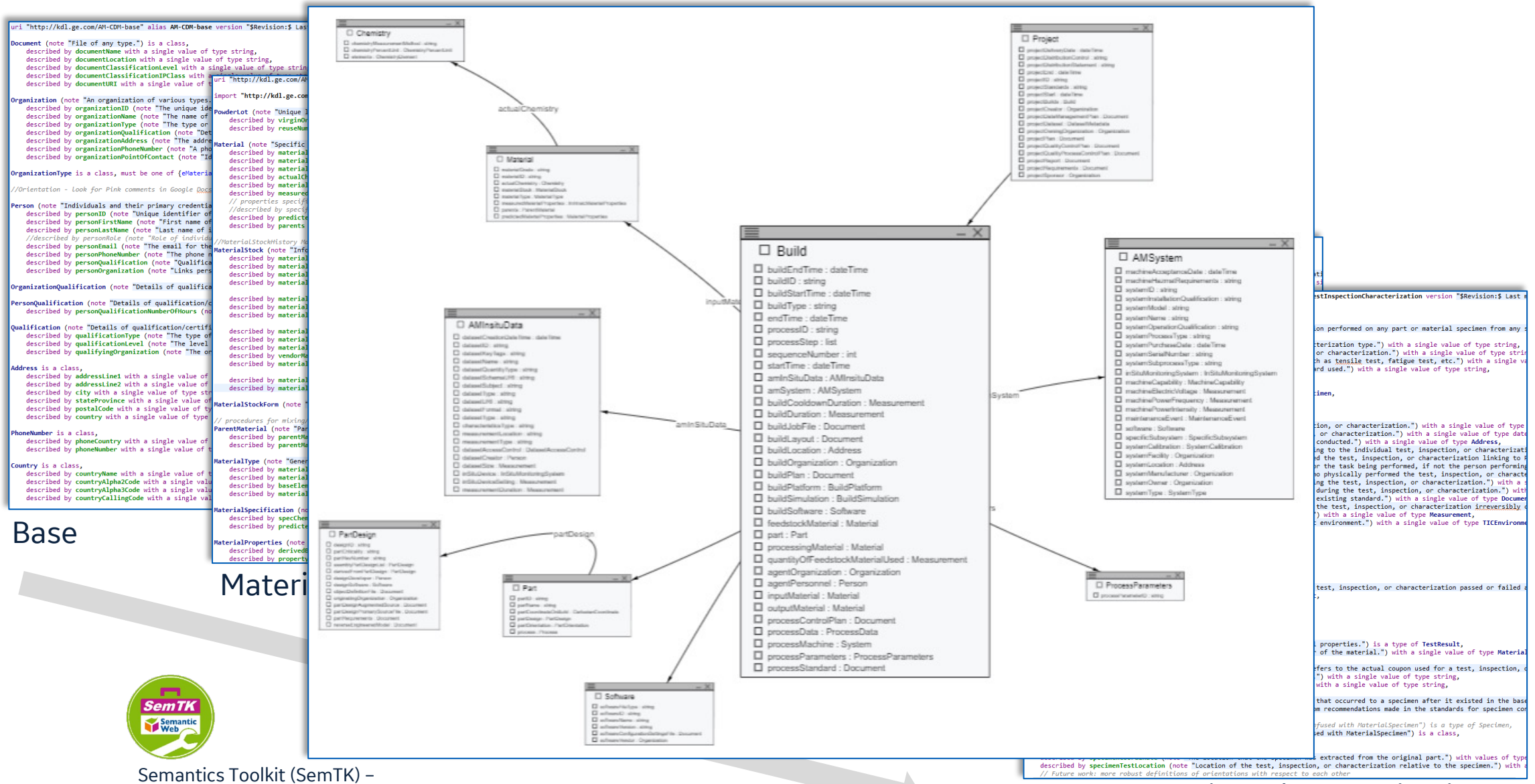
Joint Standards in Development:

- **ISO/ASTM PWI 52953 (Data Registration):** Addressing one negative from F42 committee ballot

Early Stage:

- **WK76970* (Guidelines for Technical and Intellectual Property Authentication and Protection)**
- **WK78322* (Guidelines for AM Security)**

Build-centric view (visualized in SemTK)



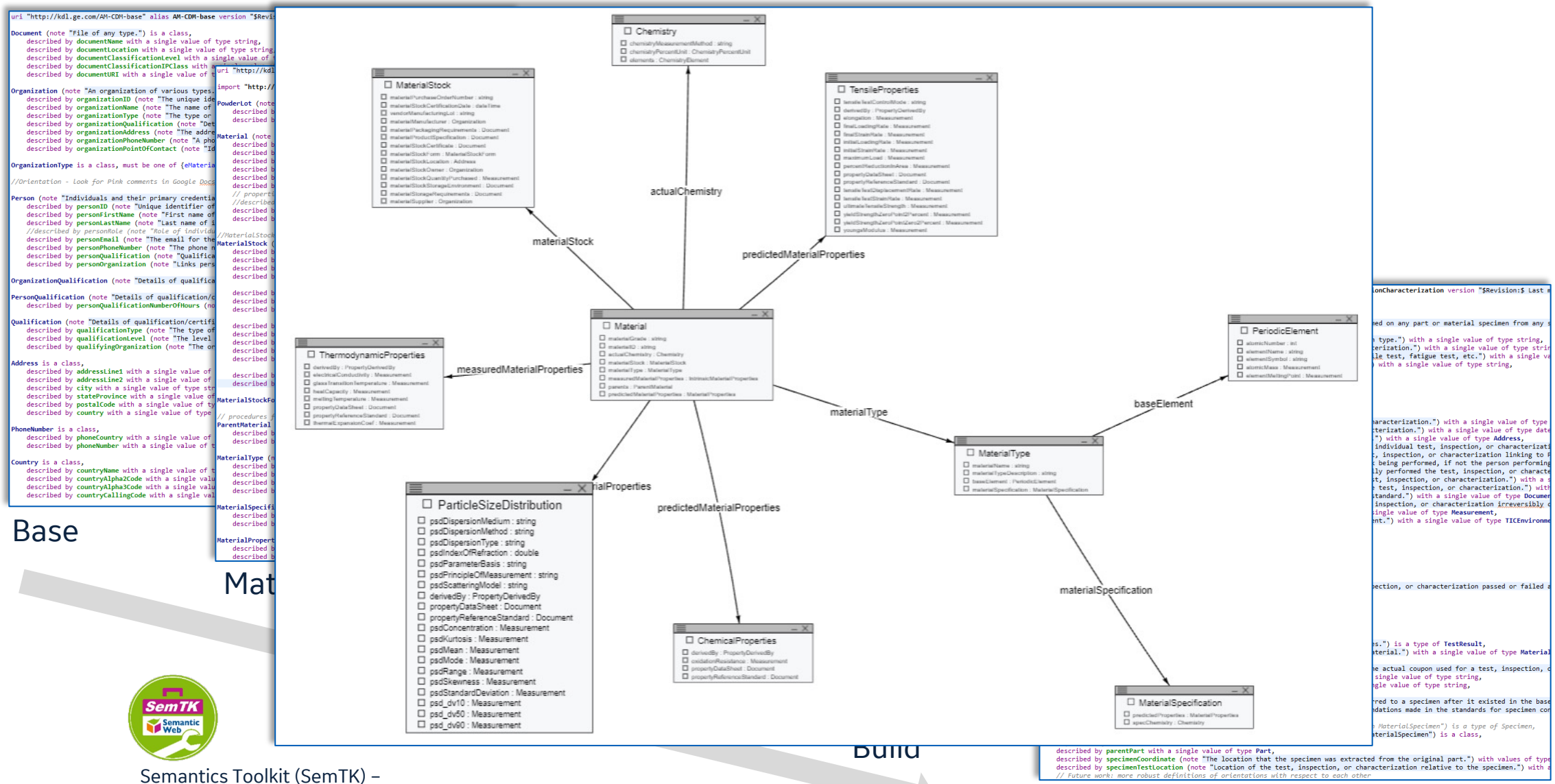
Base

Materi

Test-Inspection-Characterization

Semantics Toolkit (SemTK) – https://github.com/ge-semtk/semtk

Material-centric view (visualized in SemTK)



Base

Mat

Build

Test-Inspection-Characterization

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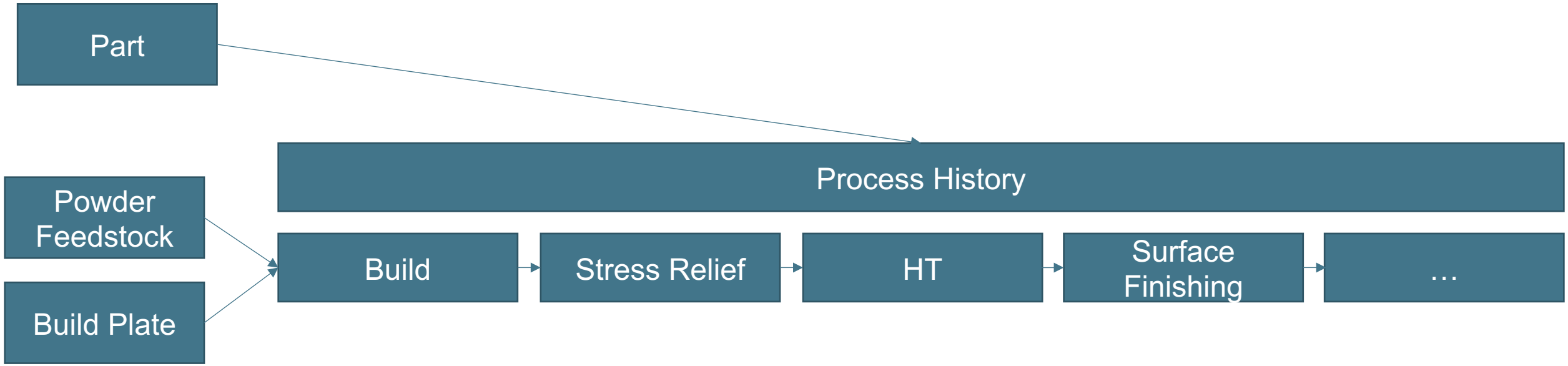
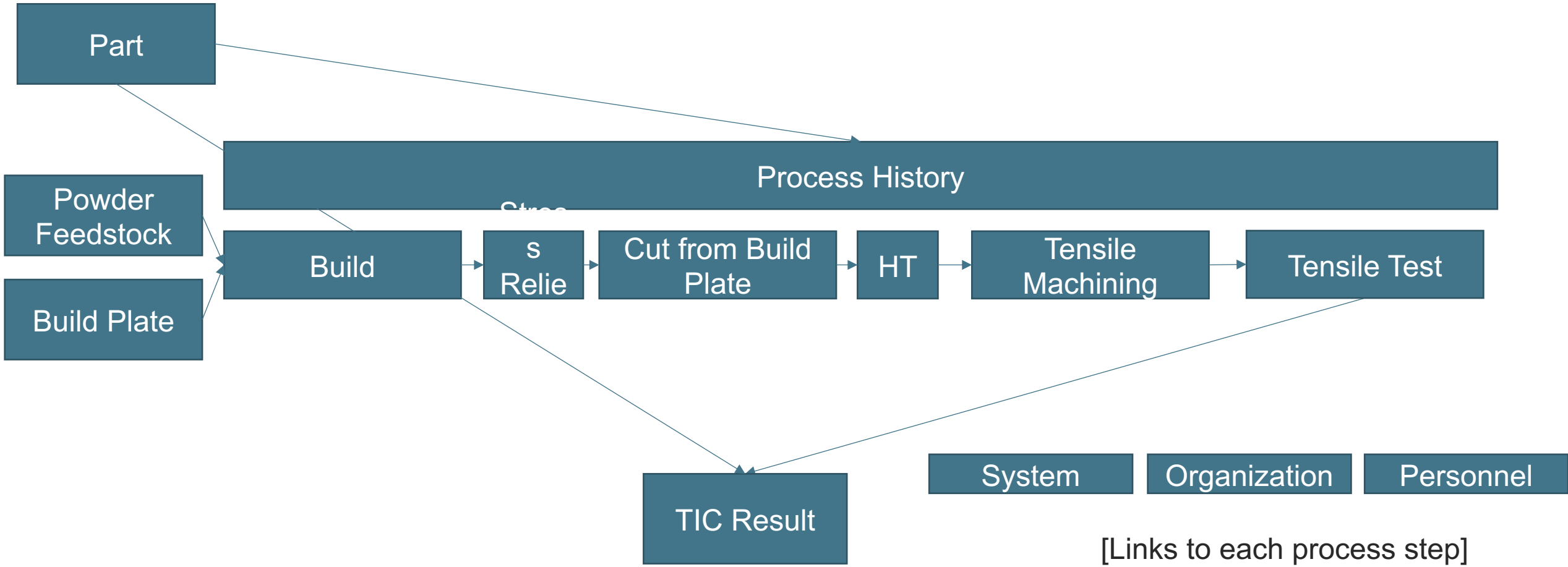
AM Common Data Model: Example View



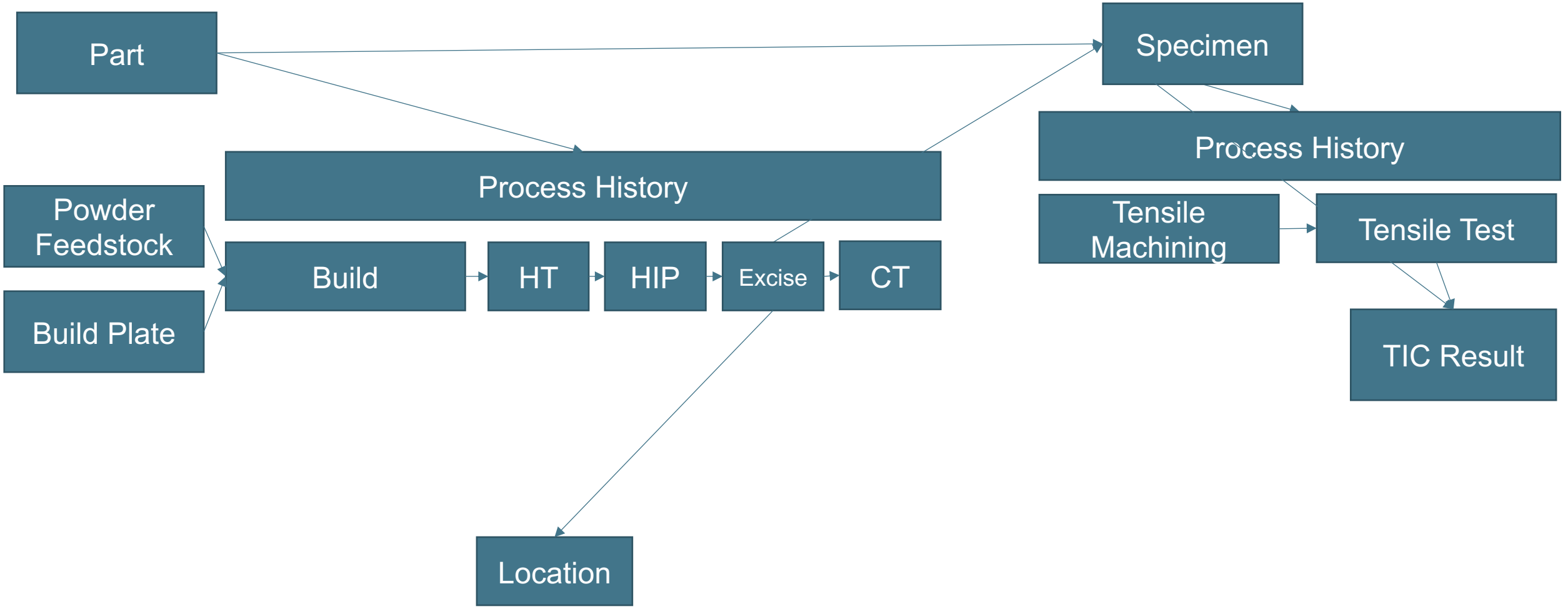
System | Organization | Personnel

[Links to each process step and TIC]

AM Common Data Model: Example View



AM Common Data Model: Example View



Help Needed

AM is not all New

(Usual) AM Process Steps:

- Powder Manufacturing
- Powder Characterization
- AM Build
- Thermal Post Processing
- Machining
- Nondestructive Testing
- Destructive Testing

Legend:

- Legacy Process with Data Standardization
- Legacy Process with Standard Test Methods
- Other Legacy Process

Questions

- Will Adopting IOF Accelerate our Efforts?
- How Does IOF Help Define:
  - Data Structures/Schemas/Models?
  - Common Data Exchange Formats?
  - IIoT Communications
- Will Adopting IOF Help with PEST Challenge?

Thank you for your time.

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