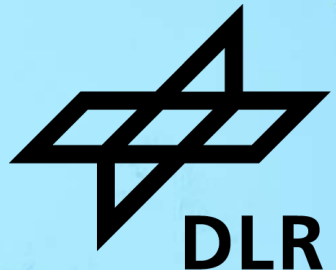


PROJECT MEMAS: A FRAMEWORK FOR FAIR DATA STORAGE IN COMPOSITE ENGINEERING

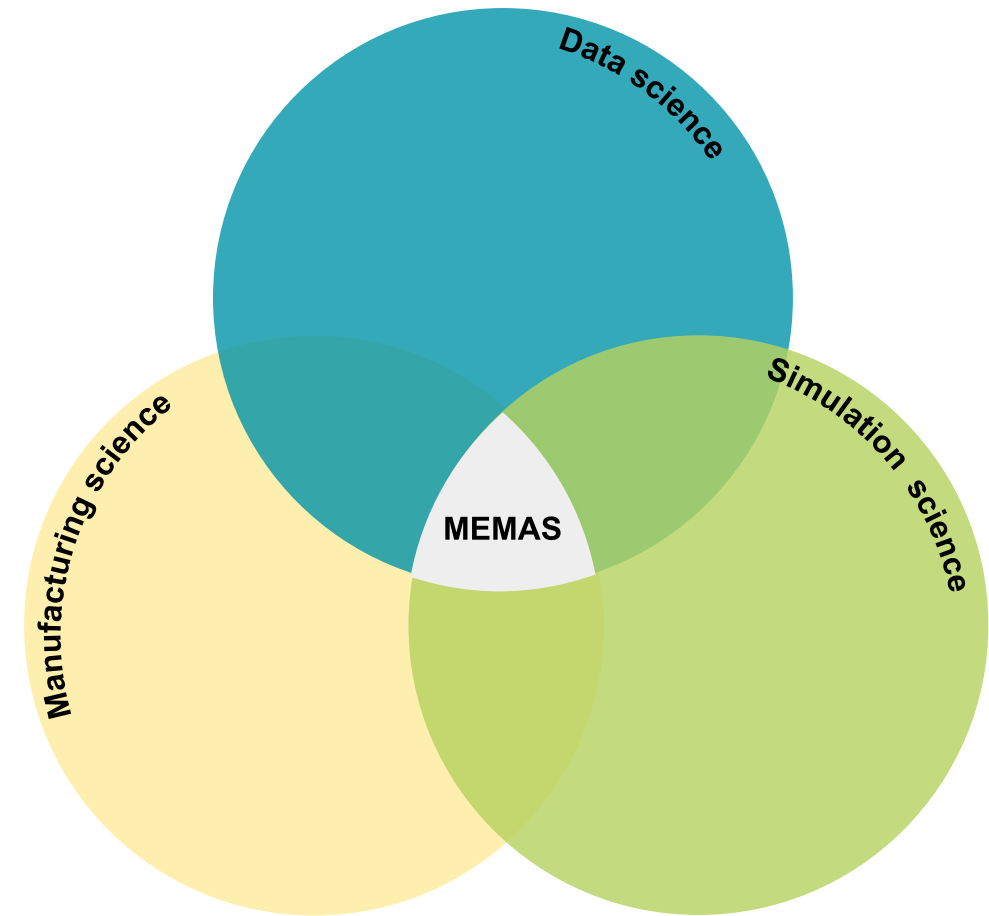
Project MEMAS - Metadata Enriched Manufacturing data for Automated Simulation



Presentation of project partners



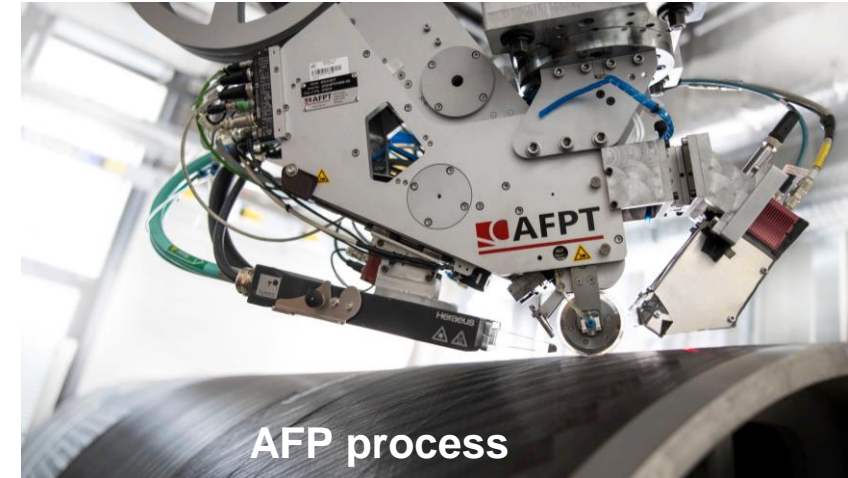
- **DLR BT-SIN (aeronautic):**
Mathieu Vinot – Project Lead
- **DLR BT-AQP (aeronautic):**
Roland Glück
- **DLR FK-FLK (transport):**
Nicolas Unger, Pradnil Kamble



Project MEMAS – Goals



- Create digital models of each individual manufactured part to increase confidence in simulation and improve manufacturing quality
- Develop a metadata-based simulation framework

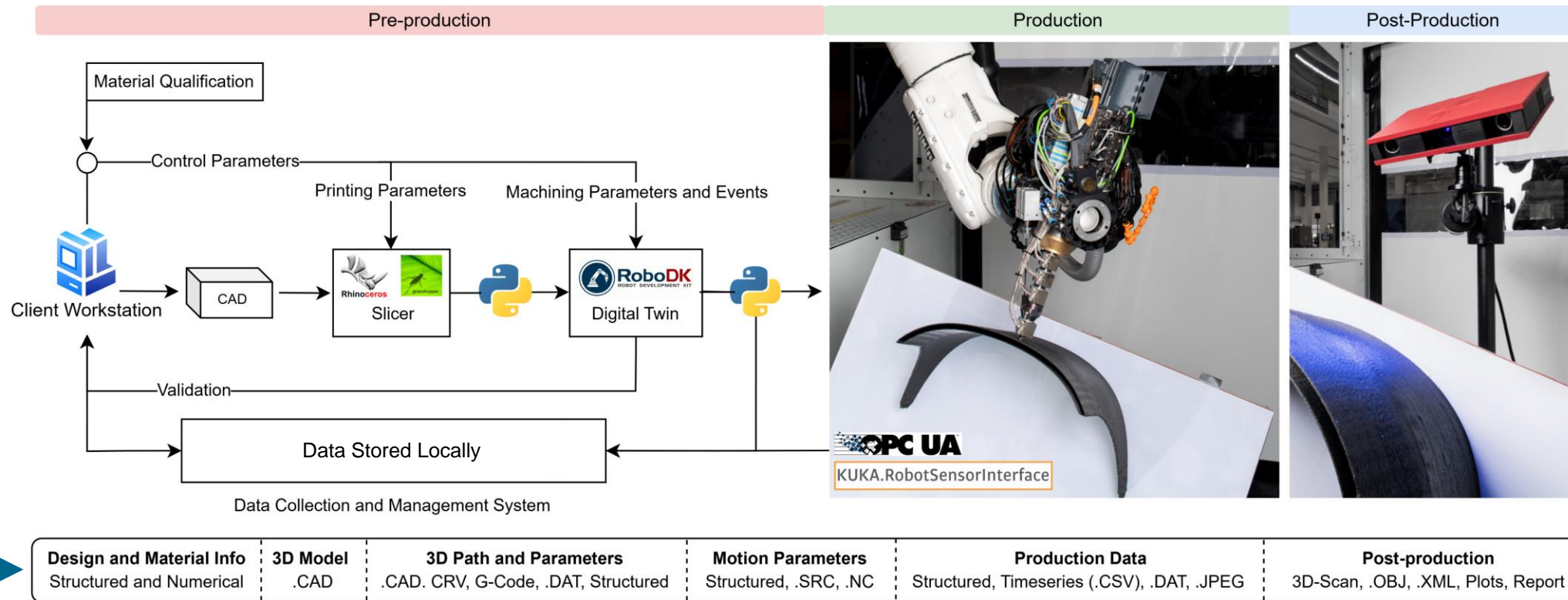


Complex manufacturing processes

1. Automated Fiber Placement (AFP@DLR BT-AQP)
2. Robotic Screw Extrusion Additive Manufacturing (SEAM@DLR FK-FLK)



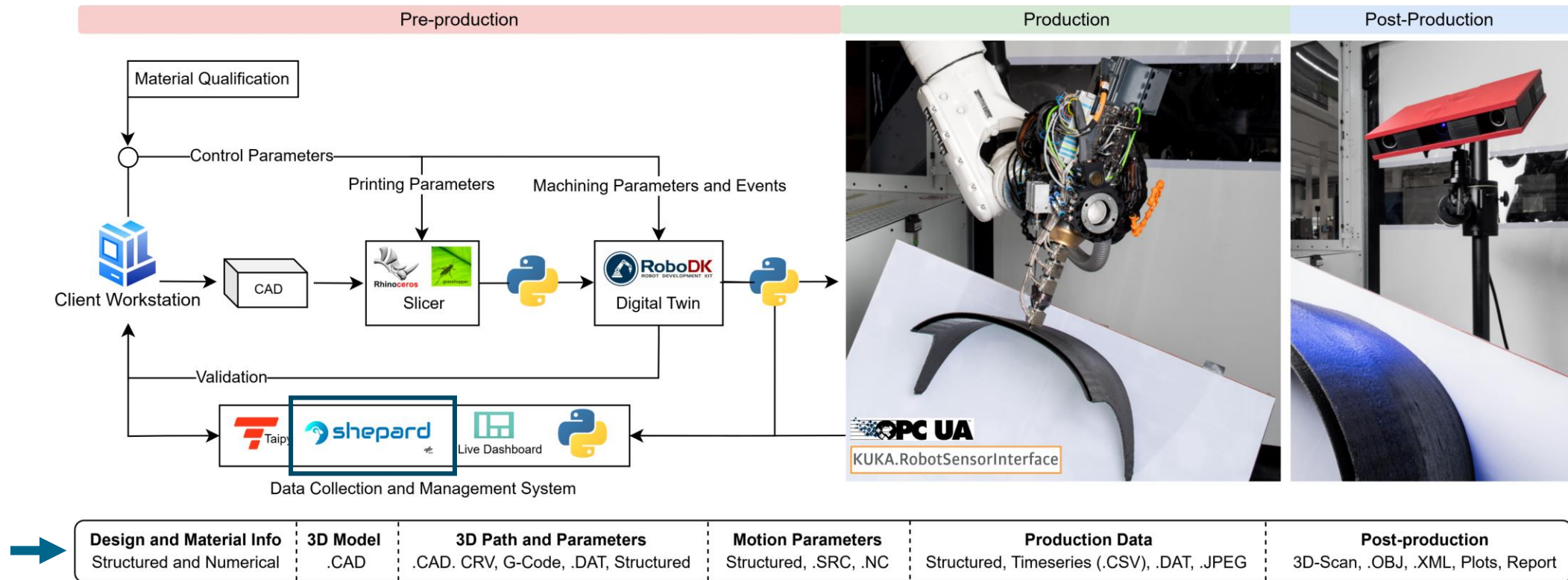
Heterogenous Data in Robotic SEAM



unFAIR

- Data stored locally across directories, poor indexing and searchable metadata
- Python scripts to access data and retrieve for analysis – limited
- No consistent schema – hard to merge and reuse heterogenous data
- No Metadata enrichment and versioning – poor traceability

Heterogenous Data in Robotic SEAM



Towards FAIR

- GUI for metadata enrichment
- API for flexible access with Python script (Object ID as persistent identifier)
- multi-database storage system for highly heterogenous research data, semantics and metadata
- Unified schema and semantic mapping for instance level retrieval

Multi-domain Ontology

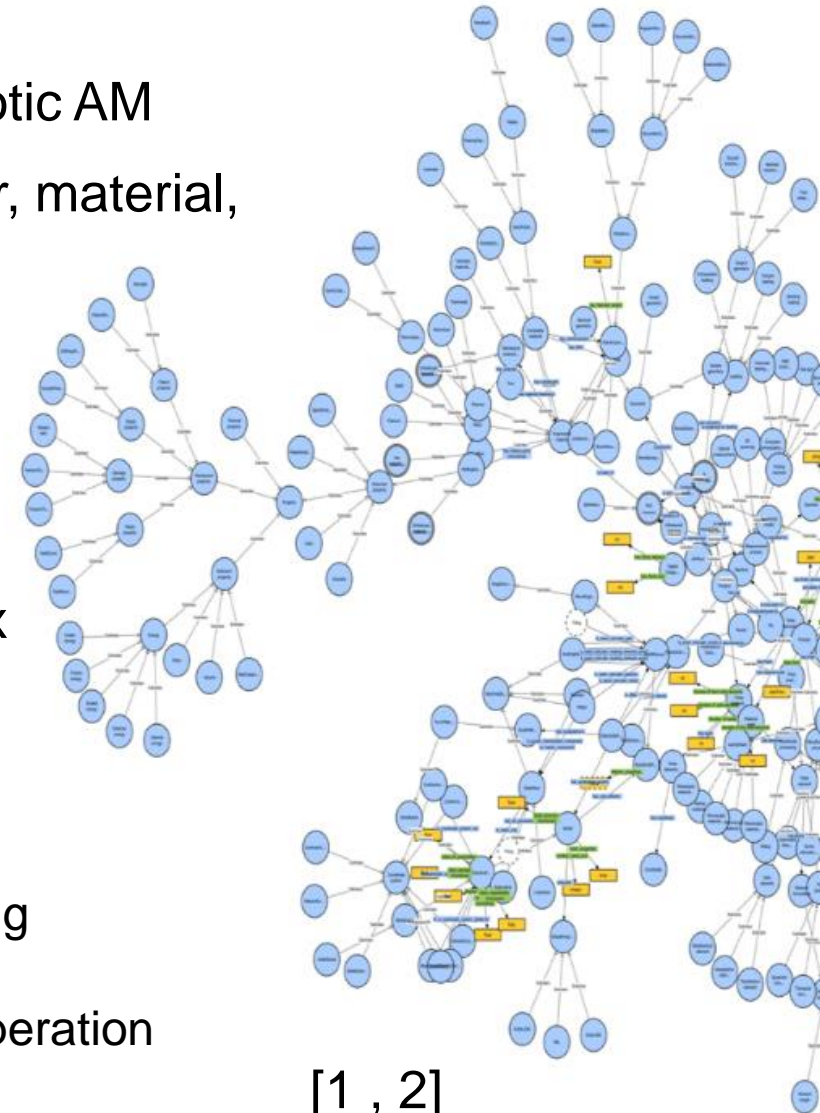


Started with

- New conceptual approaches in common ontology design for robotic AM
- Identifying common concepts and testing (end effector, applicator, material, FEM analysis, mechanical testing ...)

Challenges when we begin

- Searching for suitable ontologies (cross-domain)
 - Available ontologies were comprehensive, too large and complex
 - Lack of modularity
-
- HMC events led to discovering ontologies
 - Integration of *Prov-O* ontology and *Ontology of units of Measure* ongoing
 - Discussion ongoing with the *PolyMat* ontology developers <https://dlr-dw.gitlab.io/poly-ontologies/polymat-ontology/index.html> for further cooperation



[1 , 2]

Data standardization through json schema



Challenge: harmonization of data formating for RDMS

- Management and storage of data about fixtures, test standards, test instruments, materials
- Adapted from the framework of <https://inst.intra.dlr.de/>

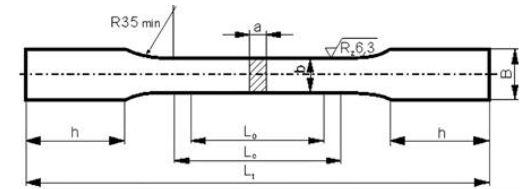
Definition of json schemas



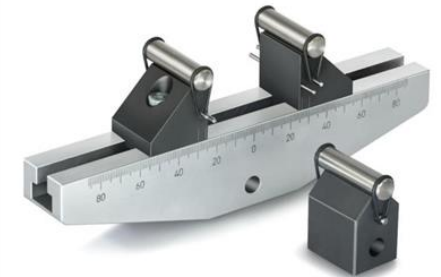
Automatic generation of web interface



Data storage on shepard



<https://gwp.eu/leistung/rundzugprobenfertigung-nach-din-50125/>



<https://www.pruefmittel24.com/artikel/nummer/75030300>



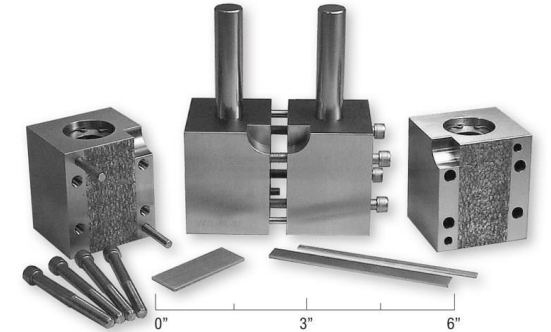
<https://www.kistler.com/DE/de/c/produkte-fuer-die-fahrzeugentwicklung-und-pruefung/AC01-products-for-the-automotive-development-and-testing-sector>

Data standardization through json schema



```
"$schema": "https://json-schema.org/draft/2020-12/schema",
"$id": "xxx",
"title": "Fixture information",
"description": "json schema for fixture information",
"type": "object",
"properties": {
  "FixtureName": {
    "title": "Name of the fixture",
    "description": "A common or technical name used for the fixture",
    "type": "string"
  },
  "LoadingType": {
    "title": "Type of loading",
    "description": "A classification of the type of loading applied through the fixture",
    "type": "string",
    "enum": ["Tension", "Compression", "Shear", "Bending", "Impact"],
    "$ref": "https://inst.intra.dlr.de/schemas/RegexPatterns.json#/properties/allowed_symbols"
  },
  "LoadingSpeedType": {
    "title": "Type of loading speed",
    "description": "A classification of the type of loading speed achievable with the fixture",
    "type": "string",
    "enum": ["Quasi-static", "Dynamic", "Fatigue"],
    "$ref": "https://inst.intra.dlr.de/schemas/RegexPatterns.json#/properties/allowed_symbols"
  }
},
```

Automatic field recognition
incl. data types and generation
of user input fields



<https://www.compositesworld.com/articles/the-combined-loading-compression-clc-test-method>

Template for data upload

This field helps you to select a template for the automatic upload of new data

Which template do you want to use?

Fixture information

Upload json file manually

Drag and drop file here
Limit 200MB per file

Browse files

Schema details

FixtureName

A common or technical name used for the fixture

Compression fixture

LoadingType*

A classification of the type of loading applied through the fixture

Compression x

LoadingSpeedType*

A classification of the type of loading speed achievable with the fixture

Quasi-static x

FixtureIdentifier*

A common identifier of the fixture

Data standardization through json schema



Template for data upload

This field helps you to select a template for the automatic upload of new data

Which template do you want to use?

Fixture information

Upload json file manually

Drag and drop file here
Limit 200MB per file

Browse files

Schema details

FixtureName

A common or technical name used for the fixture

Compression fixture

LoadingType*

A classification of the type of loading applied through the fixture

Compression

LoadingSpeedType*

A classification of the type of loading speed achievable with the fixture

Quasi-static

FixtureIdentifier*

A common identifier of the fixture

Collections / BT-SIN fixtures

BT-SIN fixtures

Collection ID: 5144
created at Mon Jan 24 2022 by Yoo, Sanghyun
updated at Thu Feb 08 2024 by Vinot, Mathieu

Description

Database of test fixtures used at the department BT-SIN

Data Objects

«	<	1	>	»	25	Created At	Ascending		
Tension_10kN_grip ID: 5146					↑ 0	↓ 2	← 0	→ 0	↻ 1
created at Mon Jan 24 2022 by Yoo, Sanghyun									
Tension_20kN_grip ID: 5147					↑ 0	↓ 0	← 0	→ 0	↻ 1
created at Mon Jan 24 2022 by Yoo, Sanghyun									
Shear_V-notched_rail ID: 5148					↑ 0	↓ 0	← 0	→ 0	↻ 2
created at Mon Jan 24 2022 by Yoo, Sanghyun									
DLR compression ID: 5151					↑ 0	↓ 0	← 0	→ 0	↻ 4
created at Mon Jan 24 2022 by Yoo, Sanghyun									
Slack adapter_ICONIC ID: 5216					↑ 0	↓ 0	← 0	→ 0	↻ 4
created at Wed Jan 26 2022 by Yoo, Sanghyun									

9

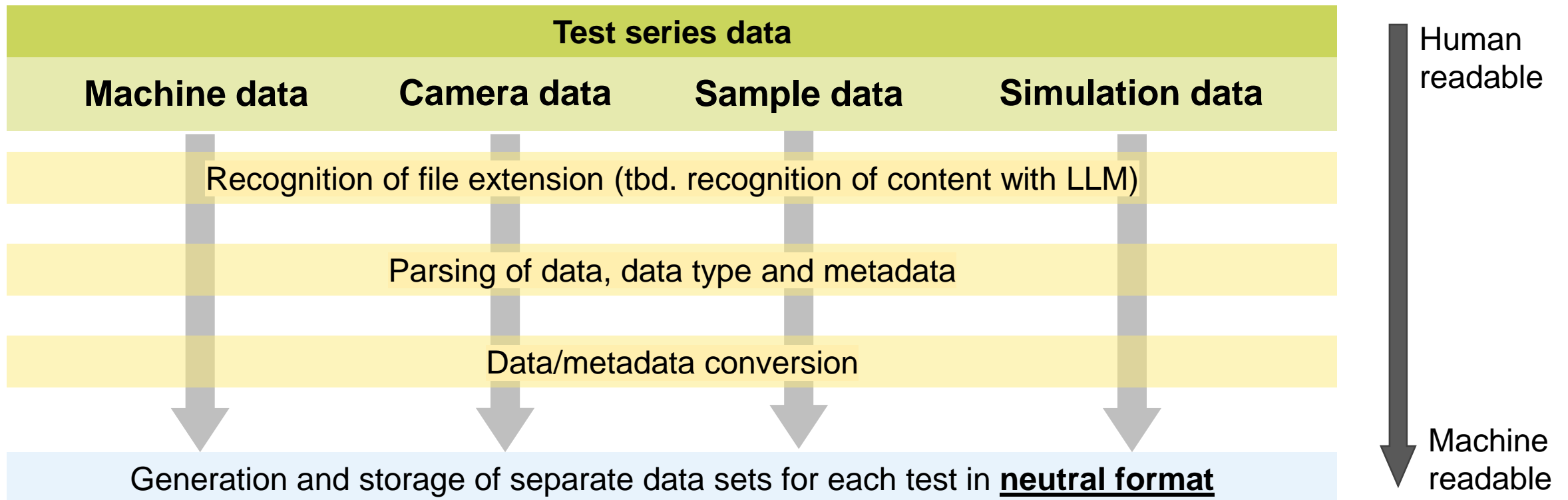
Pradnil Kamble, Institute of Vehicle Concepts, 12.-14. May 2025

Automatic parsing of research datasets



Challenge: accessibility to non-experts

- Automatic parsing of heterogeneous and multi-source research files
- Minimization of human errors



Automatic metadata extraction from research datasets



Challenge: accessibility to non-experts

- Automatic parsing of heterogeneous and multi-source research files
- Minimization of human errors

```
#PHOTRON WAVE DATA
#SheetType,,A
#Date,,2024/5/6
#Time,,20:39:0
#CameraType,,FASTCAM SA-Z type 2100K-M-16GB
#CameraID,,24
#AnalogBoardType,,NIDAQ USB-6363 (BNC),
#FrameRate(fps),,15000
#SaveStep,,1
#ShutterSpeed(sec),,1/15371
#ImageWidth,,200
#ImageHeight,,1024
#TriggerMode,,Manual 50302
#NumberOfFrames,,651
#FrameRange,,17700 to 18350
#UseZeroFrame,,1
#SamplingRate [sps],,15000.000000
#Sampling/Frame,,1
#NumberOfDatas,,651
#Sloap,,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000
#Intercept,,0.000000,0.000000,0.000000,0.000000,0.000000,0.000000

DataNo,FrameNo,SampleNo,Weg,HBM,Kistler_9371B,DMS_long_white,DMS_cross_red,DMS_long_g
0,17700,0,-7.170907,0.000011,-0.003045,0.011380,0.003911,-0.010322
1,17701,0,-7.297865,0.009455,-0.001178,0.014610,0.005266,-0.011167
2,17702,0,-7.183152,0.007844,-0.004400,0.012033,0.003655,-0.006656
3,17703,0,-7.156729,0.009777,-0.006011,0.014288,0.004300,-0.005367
4,17704,0,-7.144163,0.010099,-0.003111,0.013966,-0.002789,0.003333
5,17705,0,-7.157696,0.010099,-0.003756,0.009133,0.002688,0.000433
6,17706,0,-7.305276,0.009455,-0.010845,0.011066,0.004944,-0.005045
7,17707,0,-7.195075,0.006233,-0.004078,0.015577,-0.000534,-0.022445
8,17708,0,-7.186052,0.009455,-0.006334,0.015899,0.001400,0.002688
9,17709,0,-7.197330,0.010744,-0.007945,0.013966,0.005588,-0.004400
```



Metadata (json, StructuredData)



Units

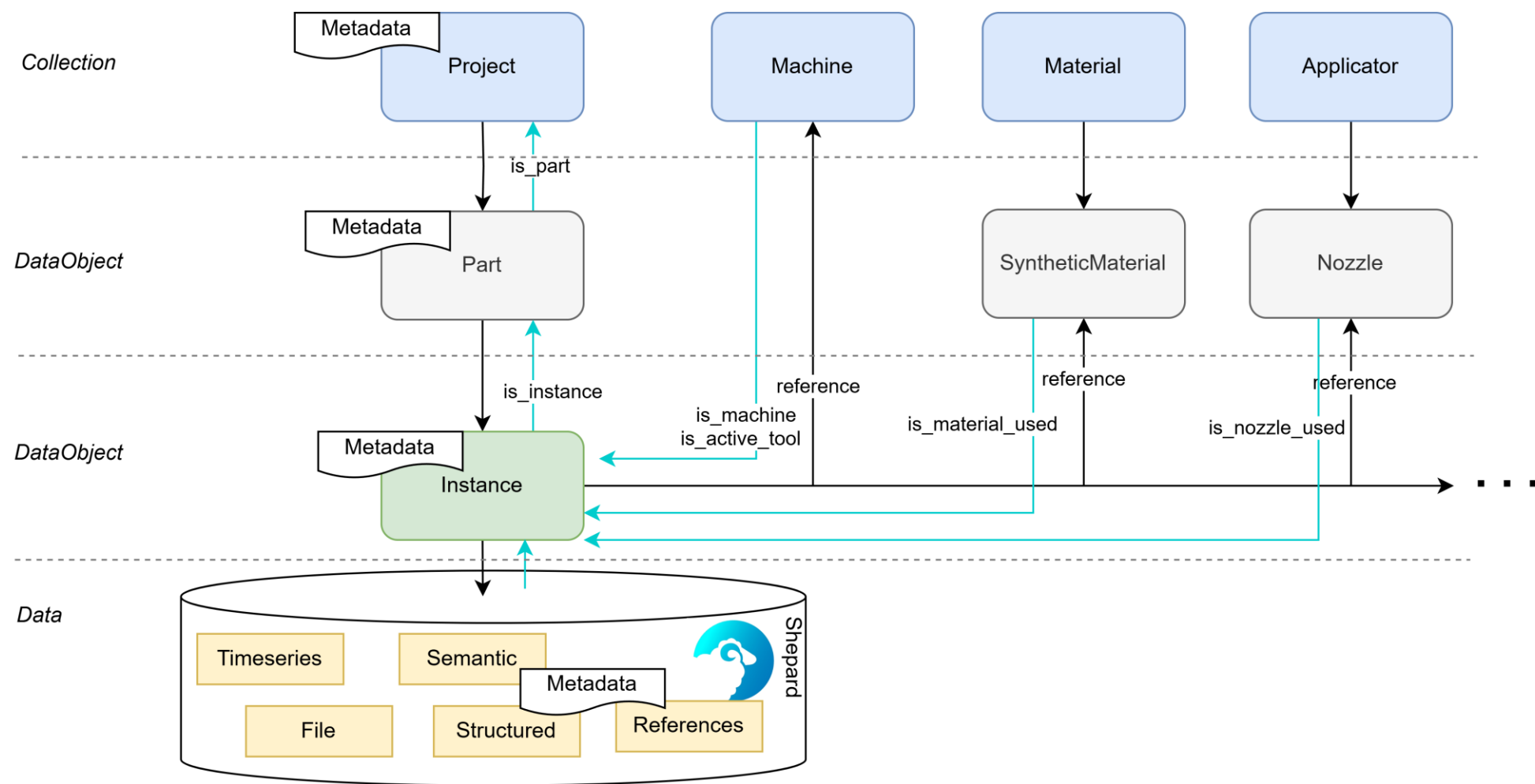


Data labels



Time series (TimeSeries)

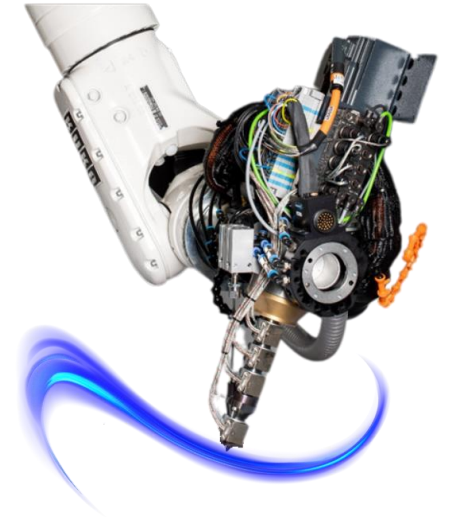
Systematic Data Structure



Conclusion



- FAIR data storage for heterogenous data in Robotic AM
 - **Findable:** Object ID, metadata, structure and semantic annotation
 - **Acessible:** Central database. data accessible via their ID and limited with permissions (individuals or groups)
 - **Interoperable:** Ontology-based annotation enables application to other ontologies via equivalencies
 - **Reusability:** Structured workflow, ontology and metadata richly describe data + parsing tools make it machine-actionable
- Foundation to enable scalable querying, integration, and machine-actionable reuse
- Going forward, all data will be structured, documented, and published online.
- Project results in detail will be presented at the Fair Friday long talk on 6th June.
- The topic remains under active consideration at our institute for future research.



- [1] M. Vinot, N. Unger, P. Kamble, R. Glück, and N. Toso, "Project MEMAS: ontology-based storage system for manufacturing and simulation data in the field of composite materials," 2023. DOI: 10.5281/zenodo.10074677
- [2] N. Unger, P. Kamble, M. Vinot, and R. Glück, "Project MEMAS: Integrated Data Management for Additive Manufacturing enabling High-Fidelity Modeling," 2024. DOI: 10.5281/zenodo.14067020
- [3] R. K. A. Aravind and P. Kamble, Optimizing Heterogenous Data Management for Robotic Screw Extrusion Additive Manufacturing, Ph.D. dissertation, Universität Koblenz, 2024.

Project Team



Mathieu Vinot



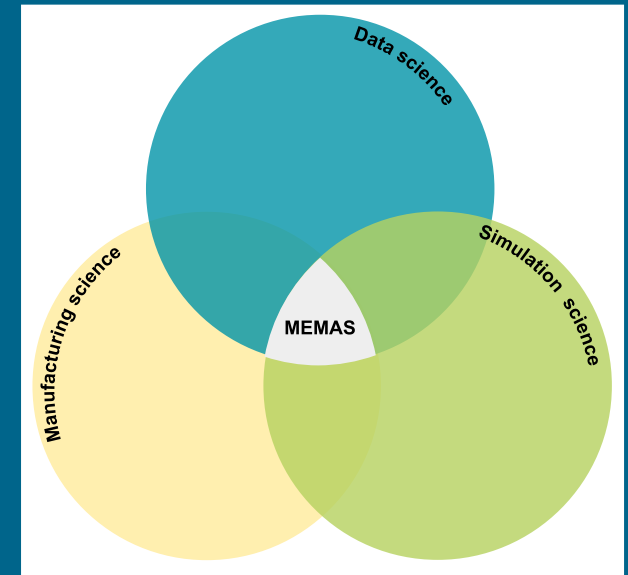
Roland Glück



Nicolas Unger



Pradnil Kamble



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