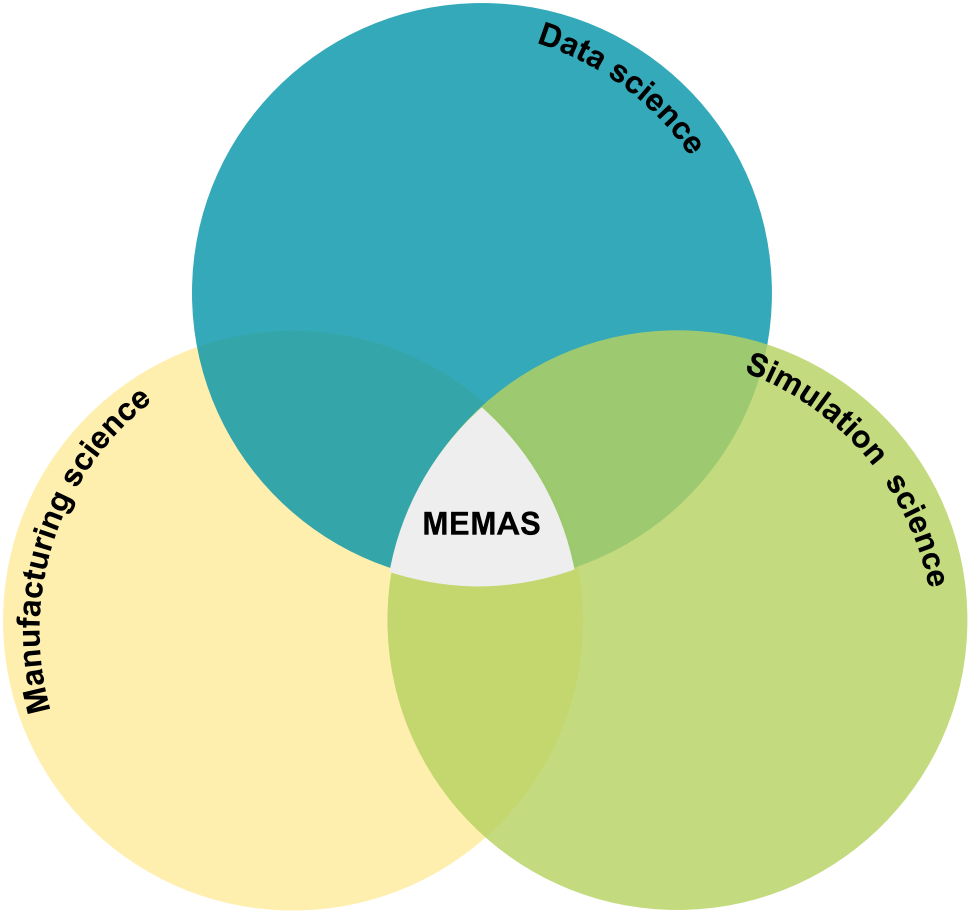
INTEGRATED DATA MANAGEMENT FOR ADDITIVE MANUFACTURING ENABLING HIGH-FIDELITY MODELING

Project MEMAS - Metadata Enriched Manufacturing data for Automated Simulation

Nicolas Unger, Institute of Vehicle Concepts, 04.-06. November 2024

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

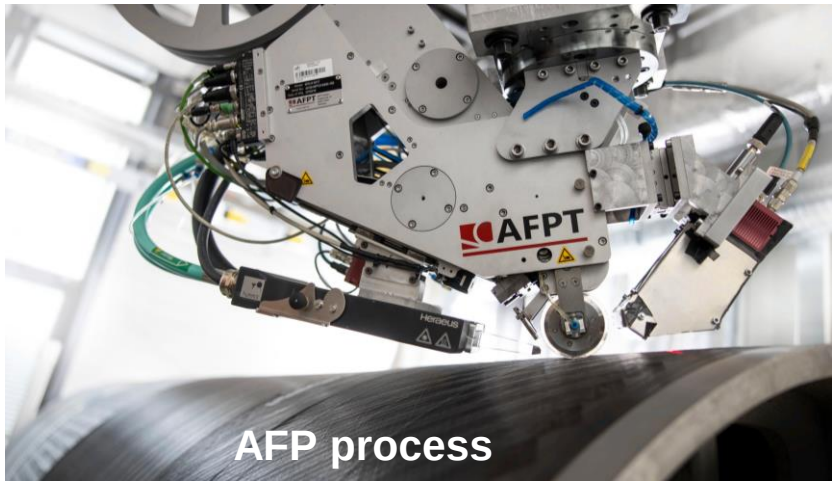


Project MEMAS – Goals

- 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)
2. Robotic Screw Extrusion Additive Manufacturing (SEAM)



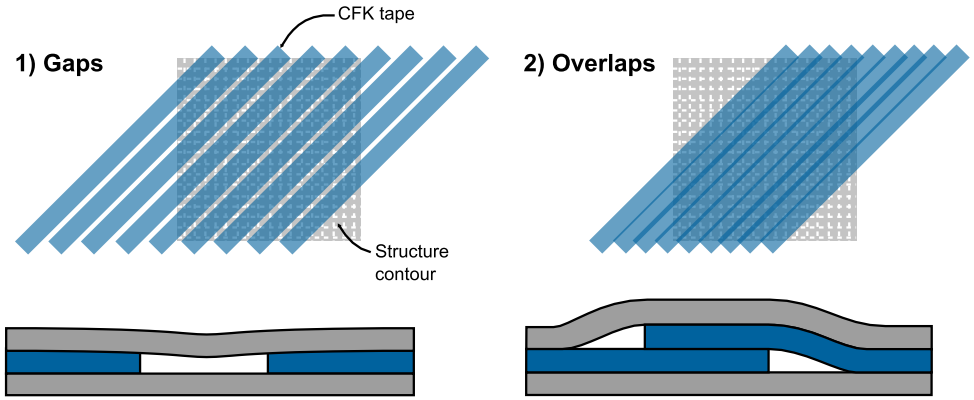
AFP process


Robotic SEAM

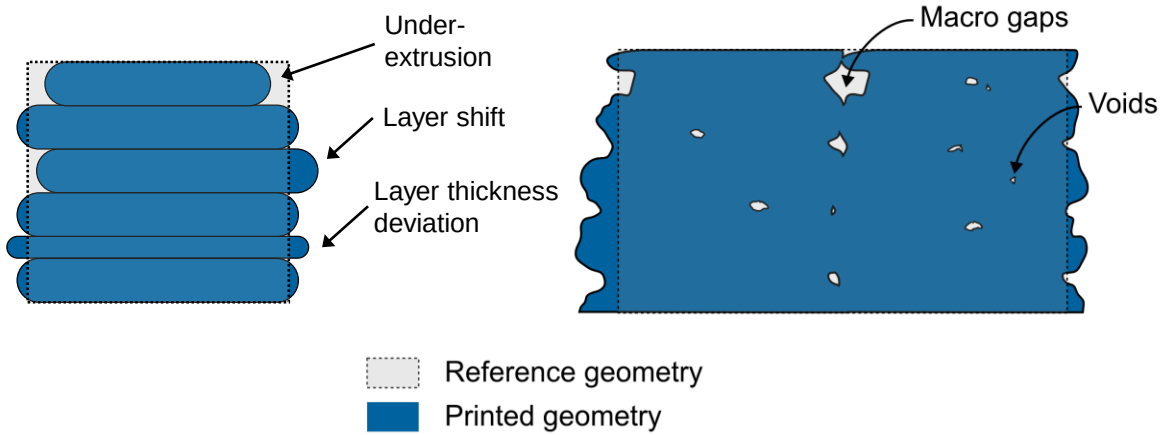
Why individual models?

- Large influence of manufacturing parameters on the quality of the end product
- Local defects have global effects on part performance

AFP



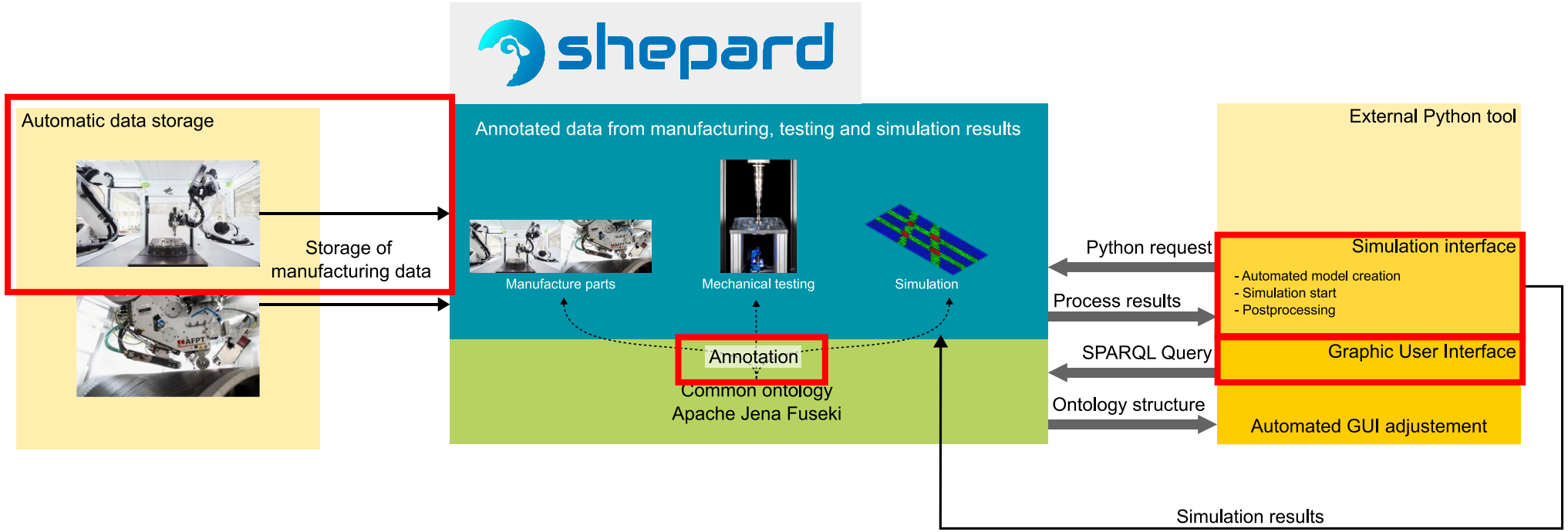
Robotic SEAM



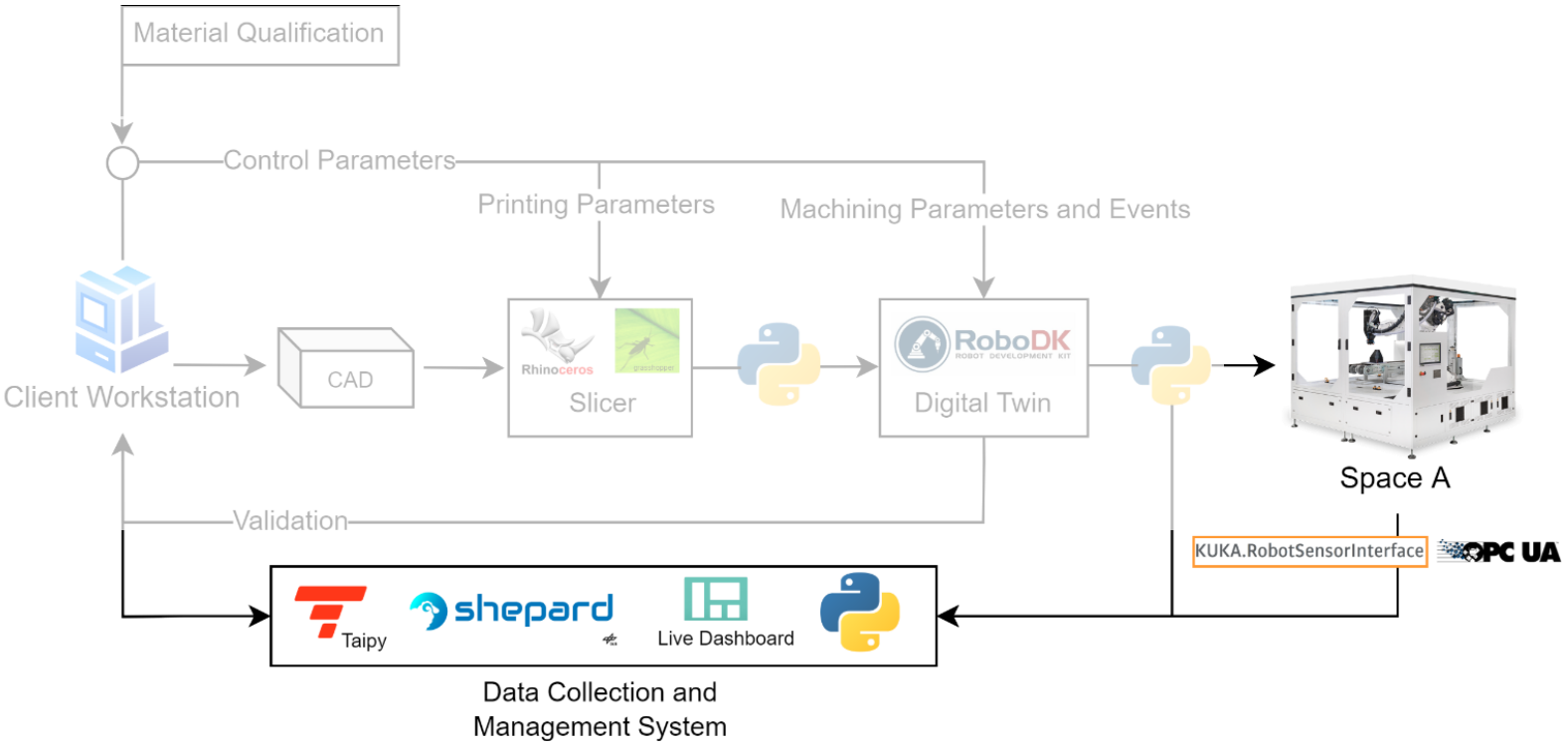
- Estimation of defects from data:
  - direct measurement (e.g. robot data)
  - derivation through analytics and process models (e.g. extrusion data)

The MEMAS approach

- Develop a common platform for manufacturing, test and simulation data
- Use of metadata and a common ontology to bridge the different fields
- Automated acquisition and annotation of heterogeneous data
- FAIR data storage and individual tools & interfaces



Data Acquisition – Technical Details



KUKA.RobotSensorInterface

- Real-time monitoring and control
- High temporal data resolution
- Absolute velocities and accelerations
- Actuator and motor currents reflecting the operational status

OPC UA

- Open, cross-platform standard
- Secure and reliable data exchange
- Actual and target temperatures across different zones
- Motor RPMs and operational statuses
- Cooling degrees and sensor outputs

Taipy

- Python open-source library designed for easy development of data-driven web applications
- Covers both front-end and back-end
- Can handle for large data-sets

shepard

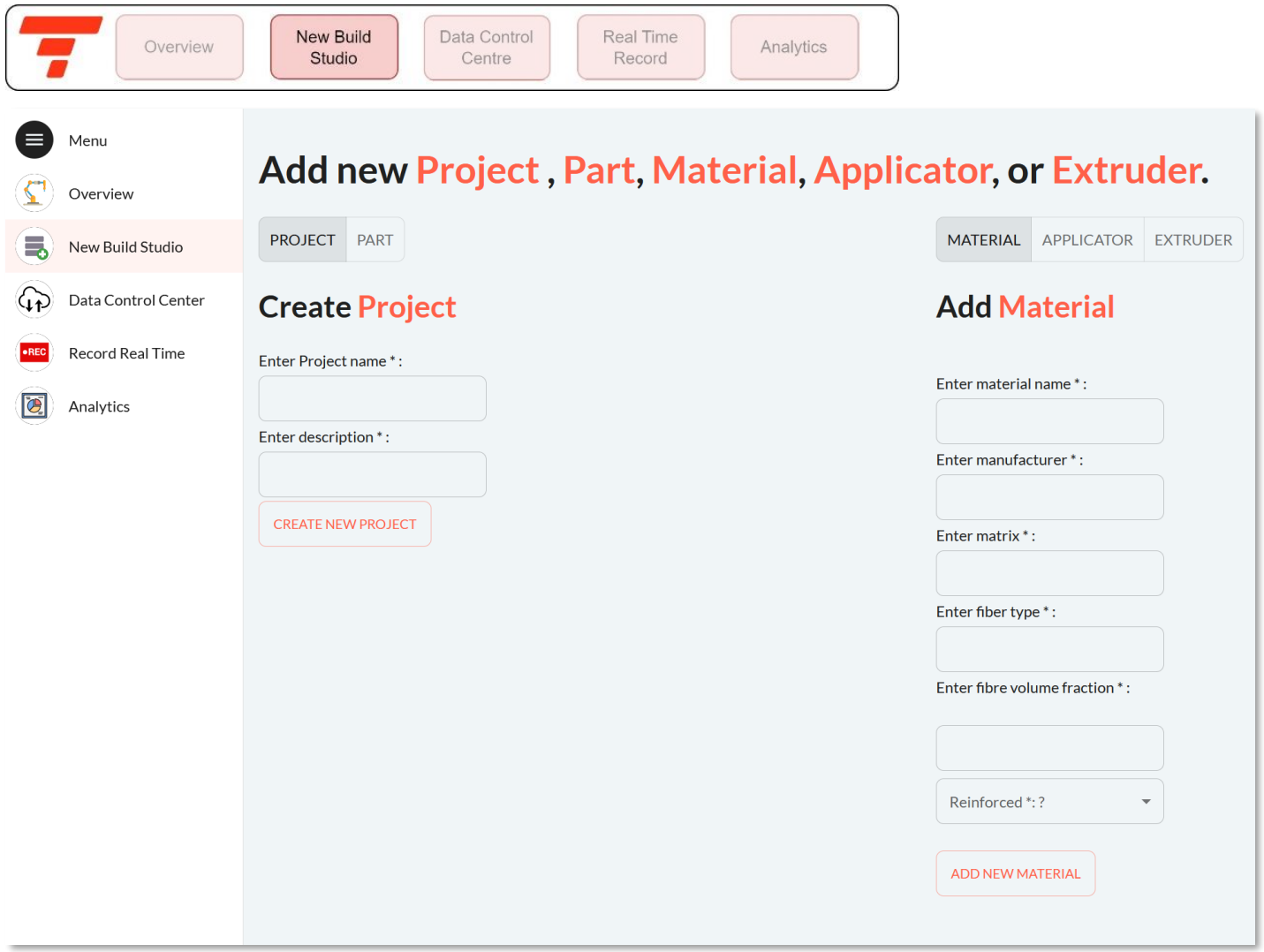
- multi-database storage system for highly heterogenous research data and related metadata
- Developed at DLR BT
- Open-source

Data Acquisition GUI

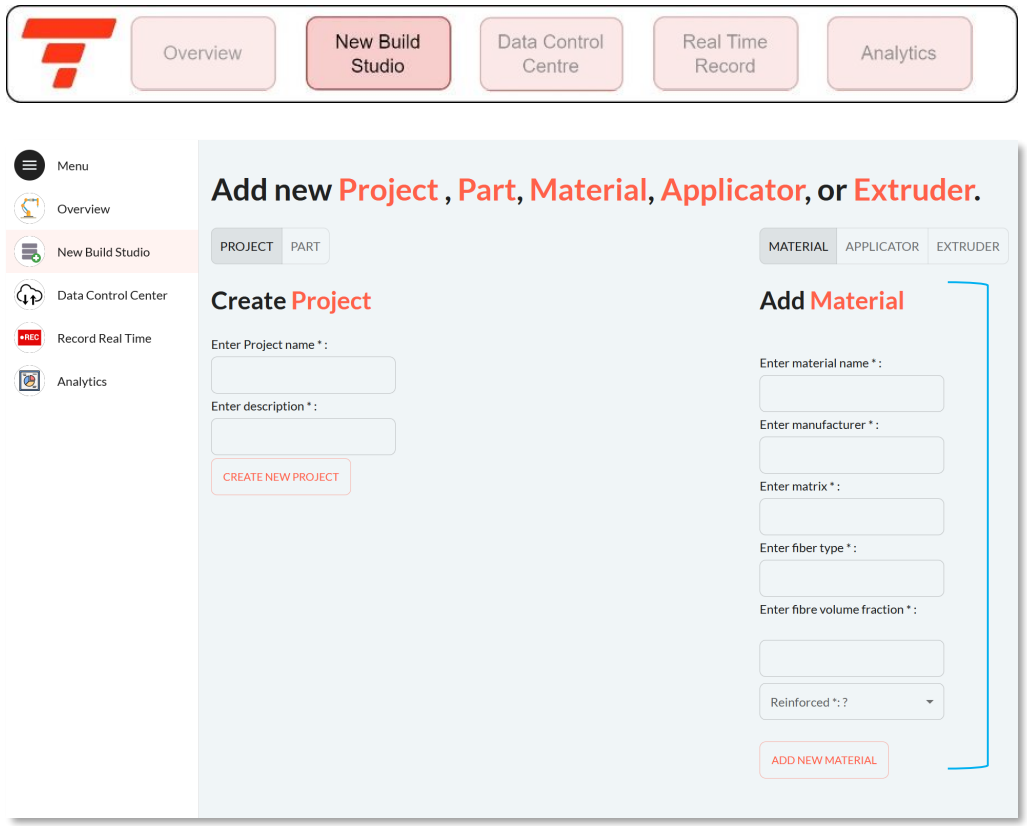
Control data acquisition and systematically store data to database adhering to FAIR principles

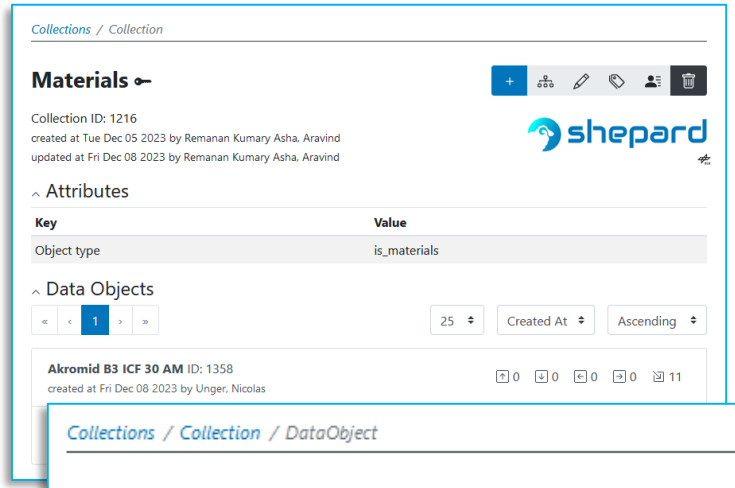
- Create projects, parts, materials etc.
- Add metadata & additional heterogeneous data (e.g. CAD)
- Configure manufacturing data collection
- Toggle data recording
- Perform analytics

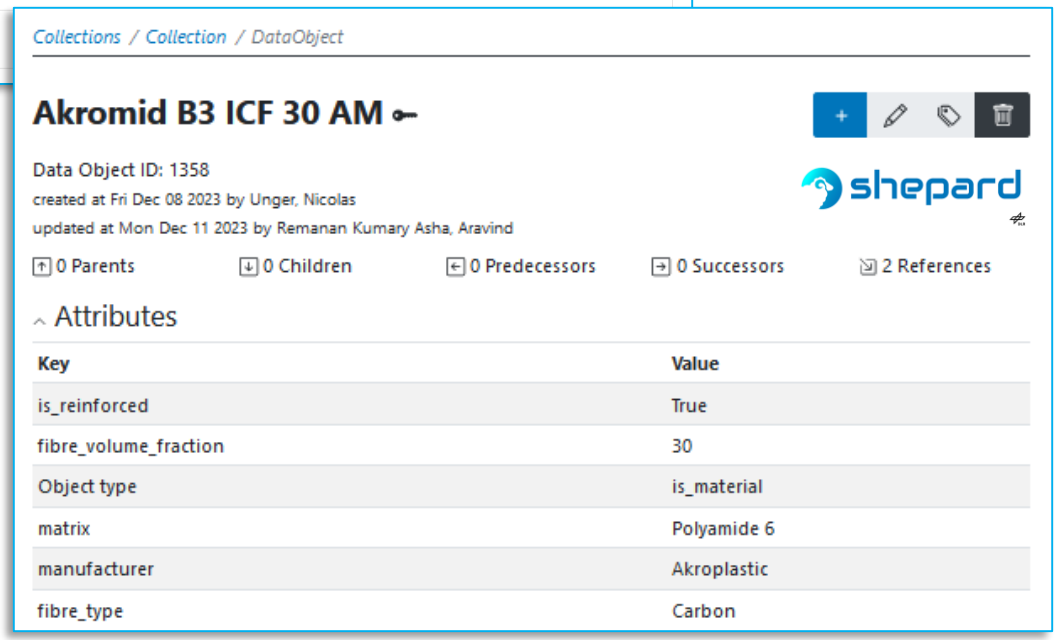
Data Acquisition GUI – New Build Studio



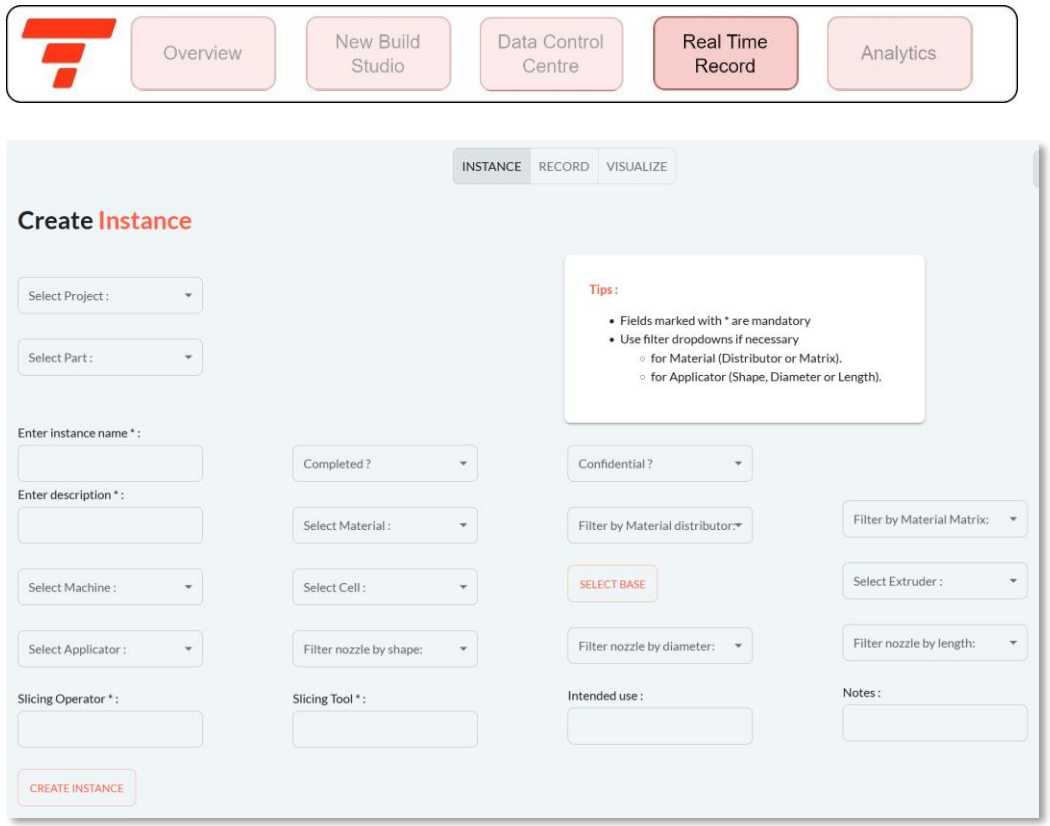
Data Acquisition GUI – New Build Studio

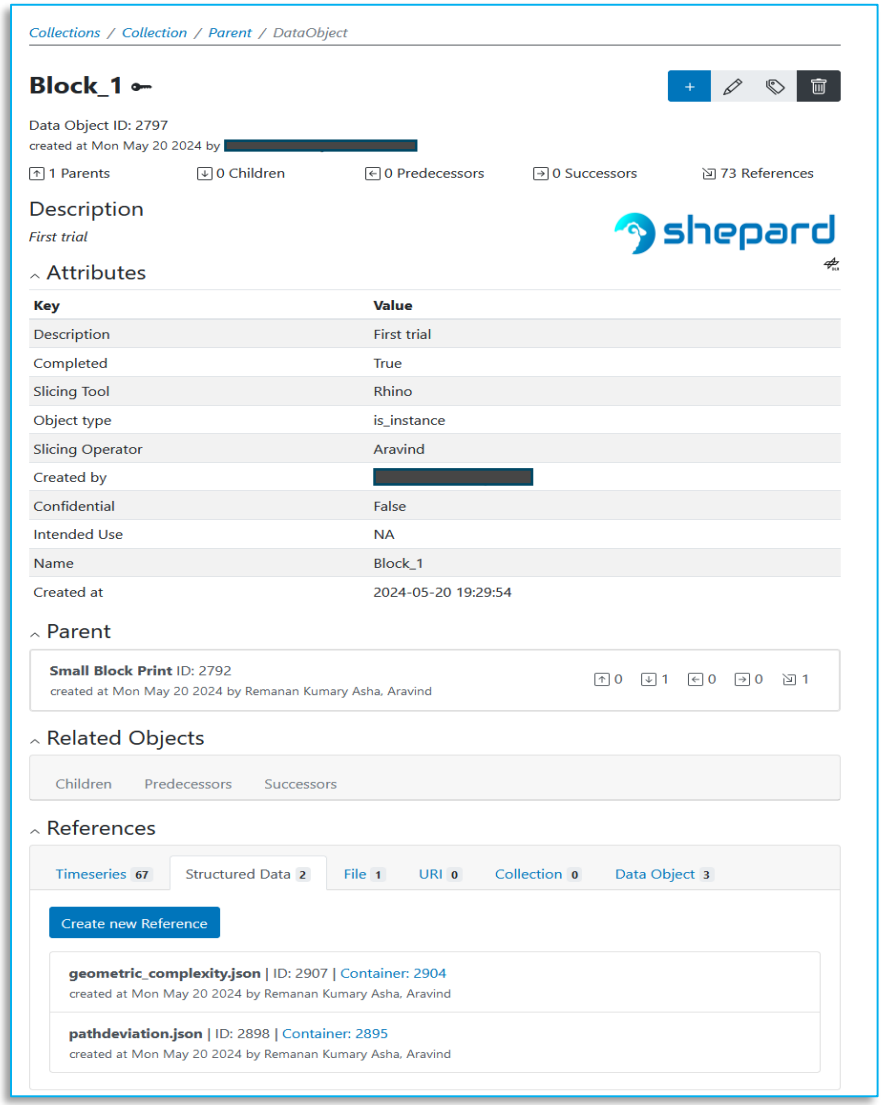






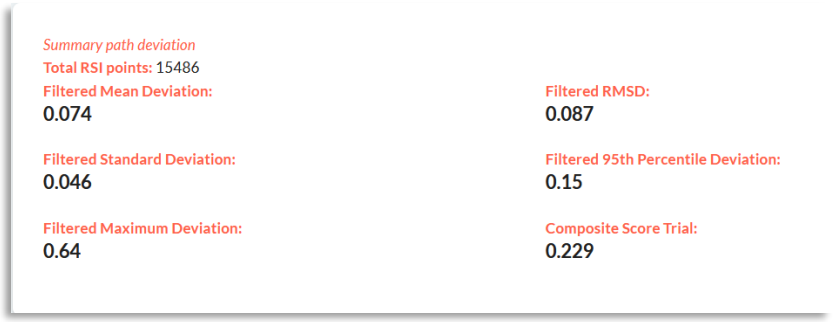
Data Acquisition GUI – Real Time Record



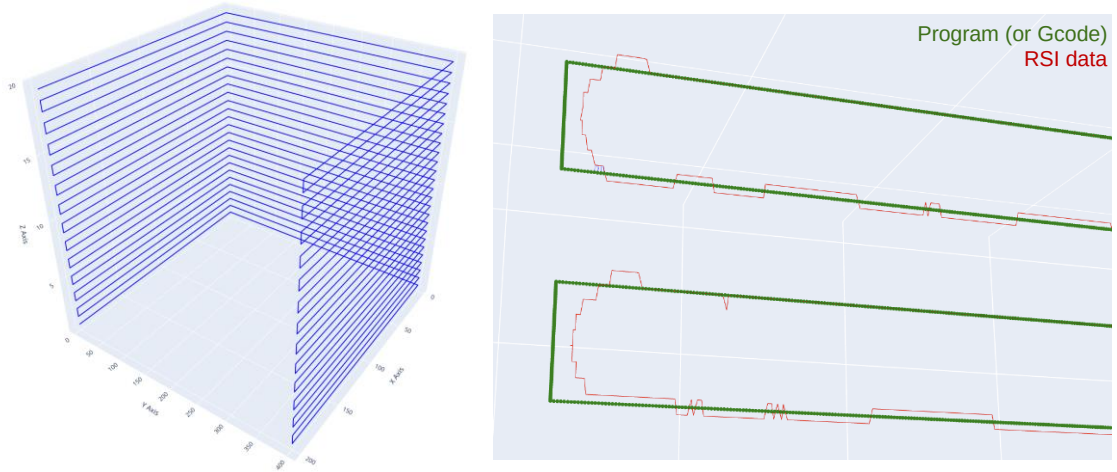


- Create instance of a part
- Add relevant metadata, such as Material, Nozzle, Robot Base
- Configure and start data acquisition

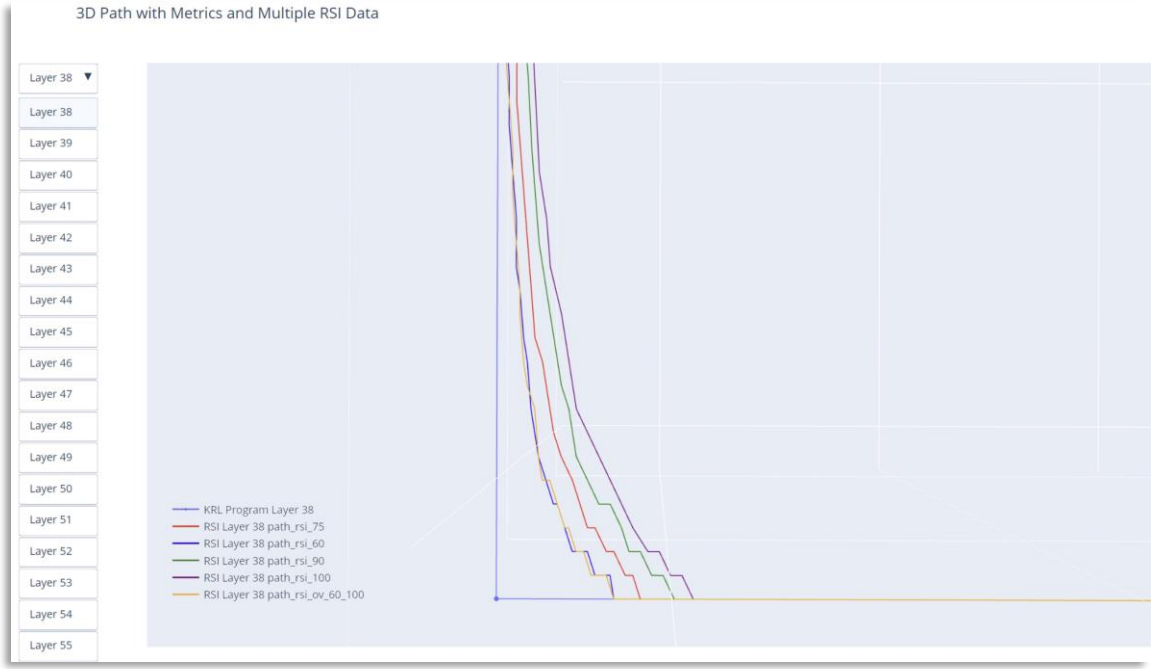
Data Acquisition GUI – Analytics



Path deviation summary as per customized metrics



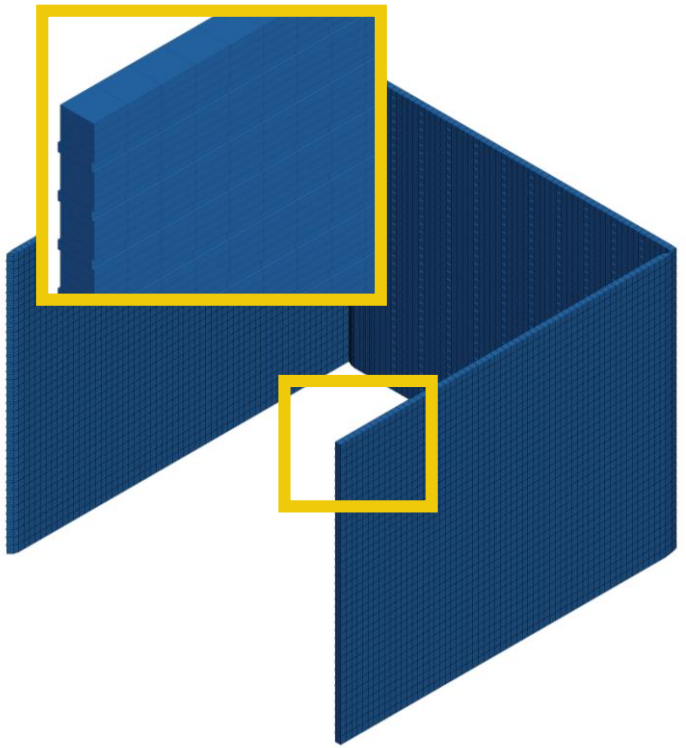
Path deviation comparison of nominal paths that is the SRC code to actual positioning captured within RSI data



Layer by layer comparison of multiple instances (with varying velocity) for path deviation to nominal – visualization of velocity effect over path deviation at higher reorientation

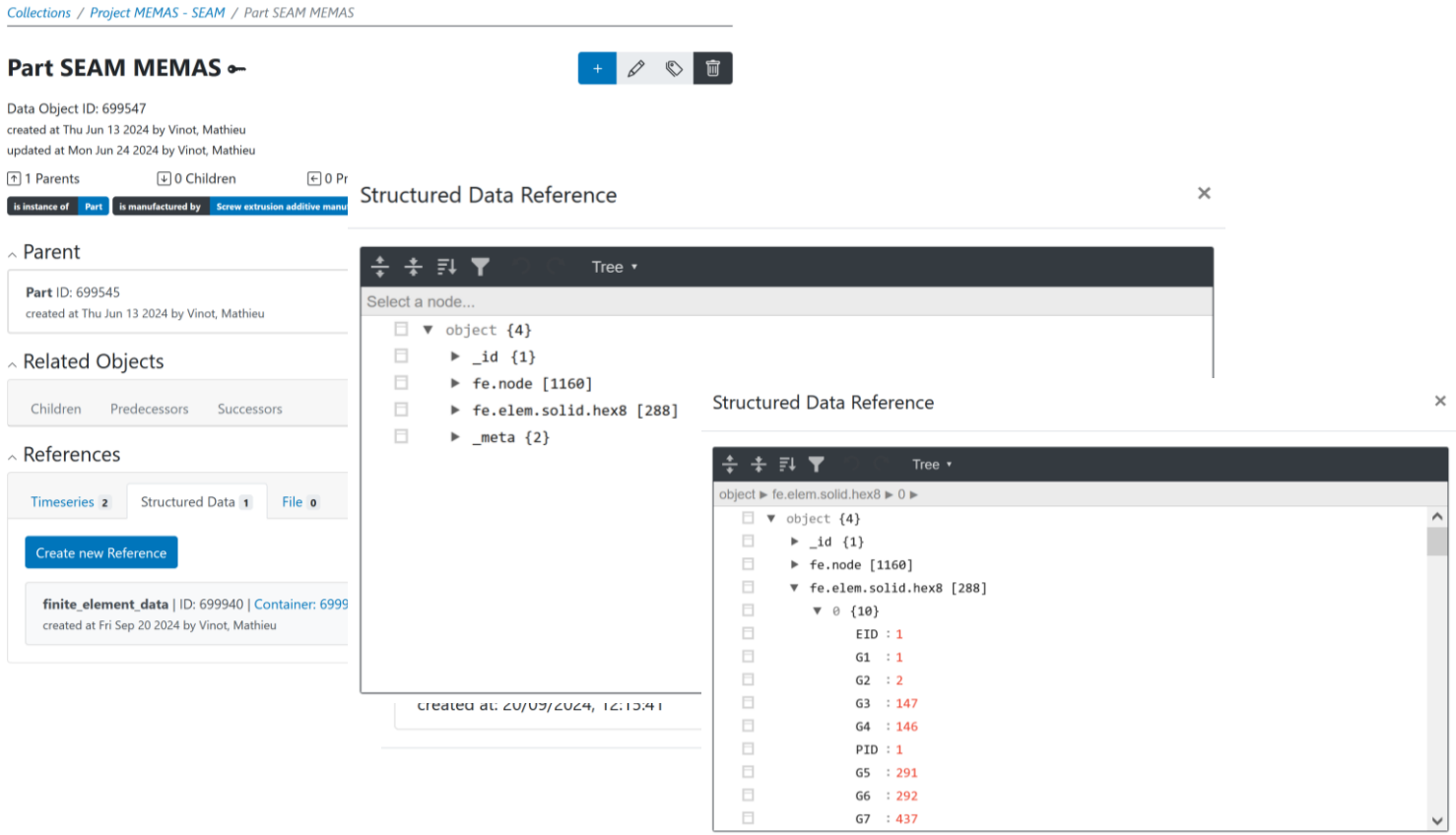
Simulation Creation GUI

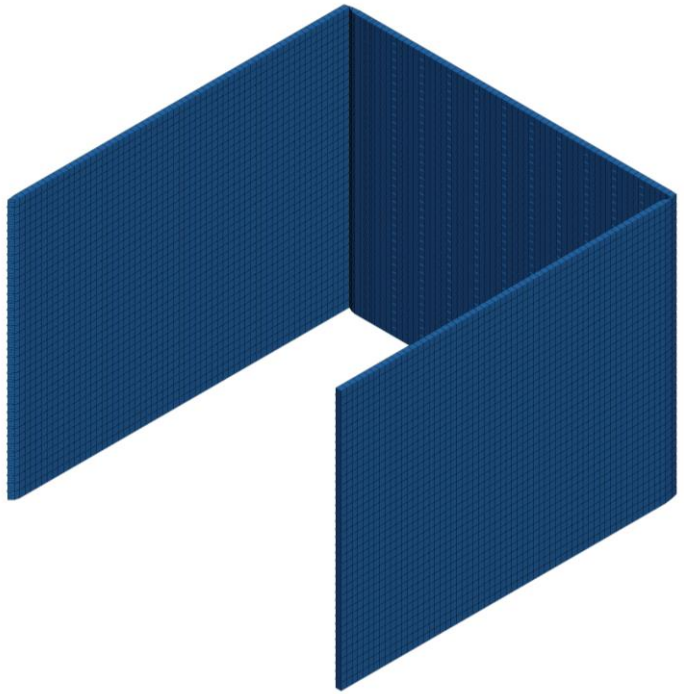
- Selection of part to be simulated and automatic recognition of process type based on semantic used
- User input about degree of detail in simulation model and actual/ideal geometry



Simulation Creation GUI

- Storage of simulation model back into shepard with semantic annotations
- Use of software neutral data formats for finite-element mesh data





Conclusion and Outlook

- Implemented a FAIR data storage for heterogenious data in shepard IDMS
- Created an application-oriented ontology for the manufacturing, testing and simulation of composite structures
- Developed a data acquisition & metadata annotation pipeline for Robotic SEAM
- Developed GUIs for pipeline configuration, data analytics and simulation model creation

- Manufacturing of a hybrid structure with AFP and Robotic SEAM for concept validation
- Expansion of the framework, analytics & simulation tools