BigDataLMD
Edge-based holistic quality platform for Laser Metal Deposition

Sebastian Hartmann
PhD Candidate – Siemens AG | TUM

SIEMENS

Agenda

1. **Siemens in the AM business**

2. **Edge-based process monitoring**

3. **BigDataLMD**
   - **3.1 General information**
     Project idea & Scope
   - **3.2 Current status**
     Hardware & Software
   - **3.3 Next steps**
     Data analytics

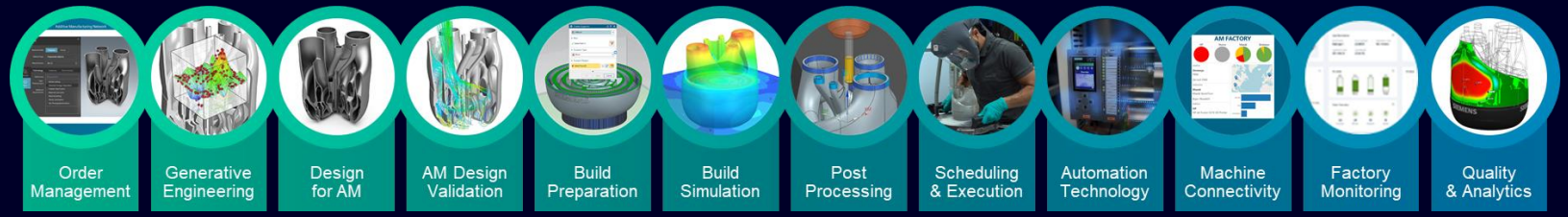
SIEMENS

Our portfolio provides an industrial AM tool chain with seamlessly integrated software and automation solutions, completed by value added services

End-to-End Software Solutions

SW solutions for end customers & machine builders

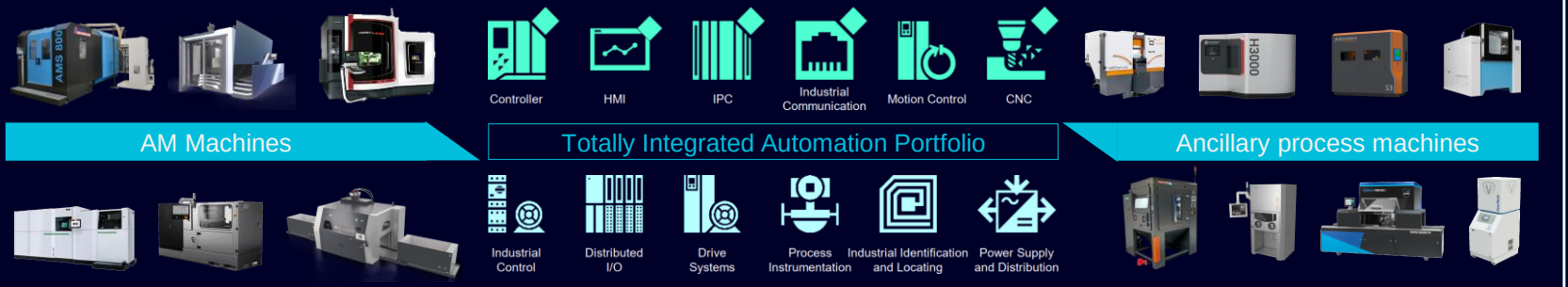
from part design, build prep and simulation up to factory IOT solutions



Automation Technology

HW and digitalization solutions

for AM machine builders and as well for pre- or postprocessing applications

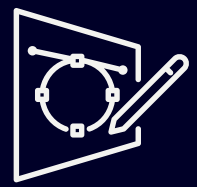


AM Value Add Services

Additional services as stand-alone business

support in answering the key questions of industrial Additive Manufacturing with expertise from design to manufacturing

Design



Define and Optimize products or design for AM

Factories

Define and Scale a state-of-the-art AM factory

Finance

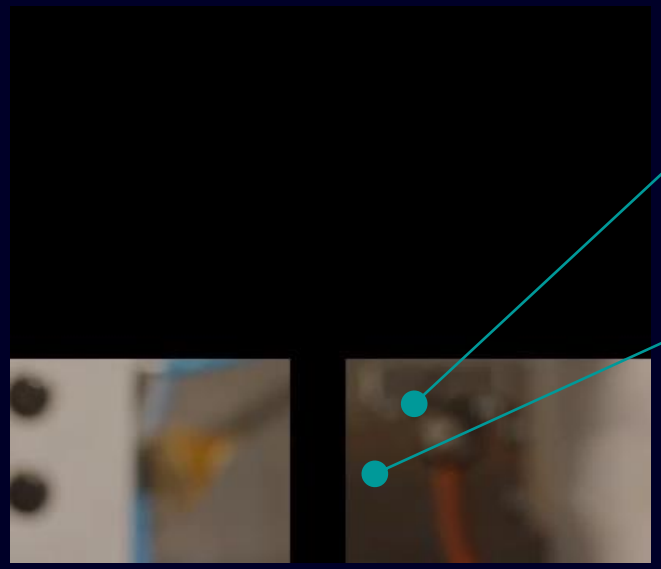
AM equipment and technology finance

to optimize your cash-flow

SIEMENS

Enabling EDGE-based process monitoring of LMD-processes
Machine level

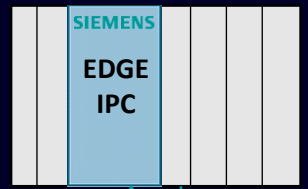
LMD process	Sensor data	Data fusion	Process control
- LMD machine equipped with sensor systems to capture specific process parameters	- Analog data from multiple sensor systems is converted and synchronized with ET200SP-I/O-module	- Fusion of sensor data with machine data (positions, velocities, laser power) - Sophisticated data analytics on EDGE IPC	- Process is controlled by adjusting laser power and/or velocity - Adjustments based on: A) Static reference value B) EDGE-data analytics



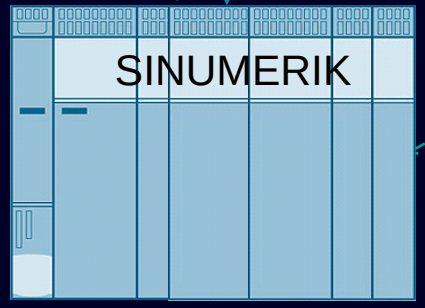
Powder:
- Feed rate

Melt pool:
- Temperature
- Dimensions
- Distance (part-nozzle)

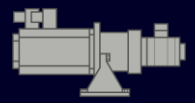
ET200SP
- I/O-Module



EDGE IPC
- Sophisticated data analytics based on real process data
- Connection to cloud applications for processdata storage



Laser power



Velocity

SIEMENS

BigDataLMD – General Information

Realize holistic quality analysis platform for LMD

SIEMENS Fraunhofer IAPT

NIT New Infrared Technologies | BeAM an AddUp company | PRECITEC

arianeGROUP | SAFRAN

MT AEROSPACE

Overview

- Project start: September 2021
- Project duration**:** two years
- Current status: Serial part production and data analysis

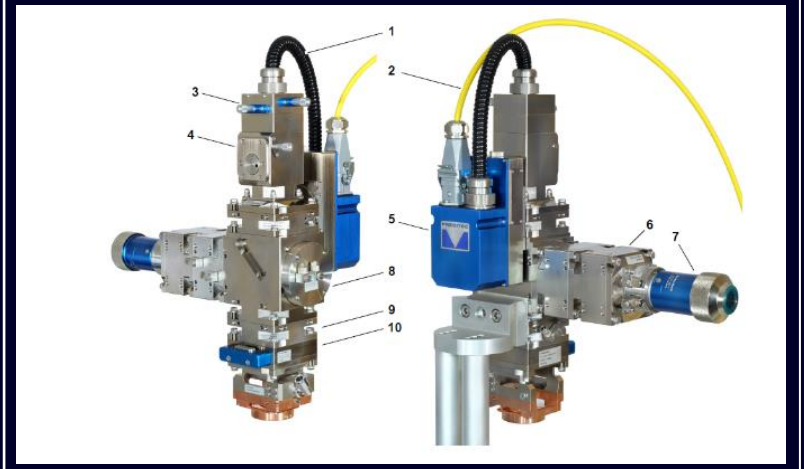
Goals

- Edge-/Web-based quality assurance tool
- Create a list of critical process influences for the LMD process

SIEMENS

BigDataLMD
Utilized sensor systems

OCT system by Precitec



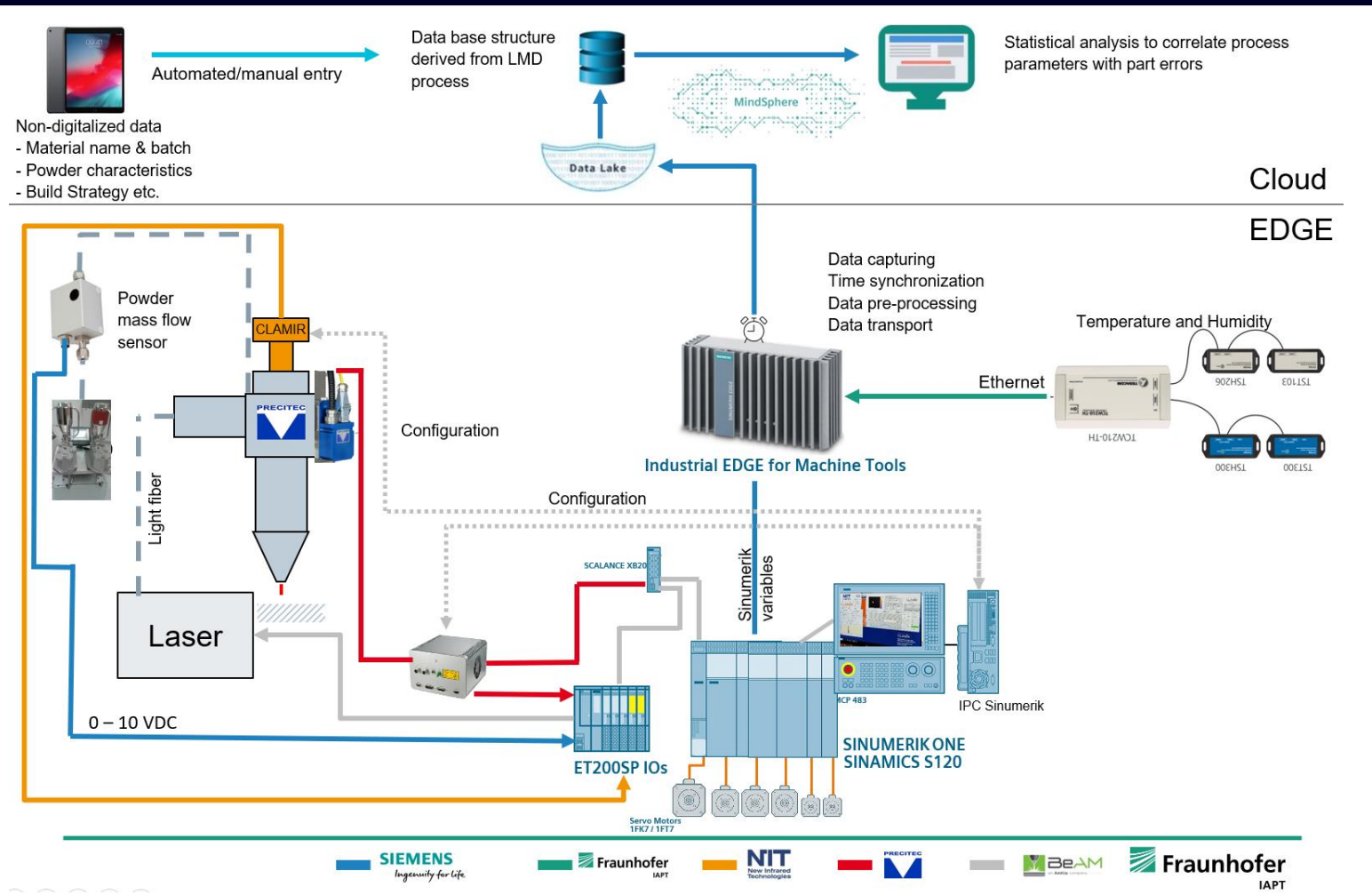
- In-situ measurement of the distance between the nozzle and the part
- Based on low-coherence interferometry

NIT system CLAMIR

- In-situ measurement of the dimensions of the melt pool
- Additional: laser power control system for LMD based on the melt pool dimensions

SIEMENS

BigDataLMD
Hardware architecture and data flow



Architecture based on

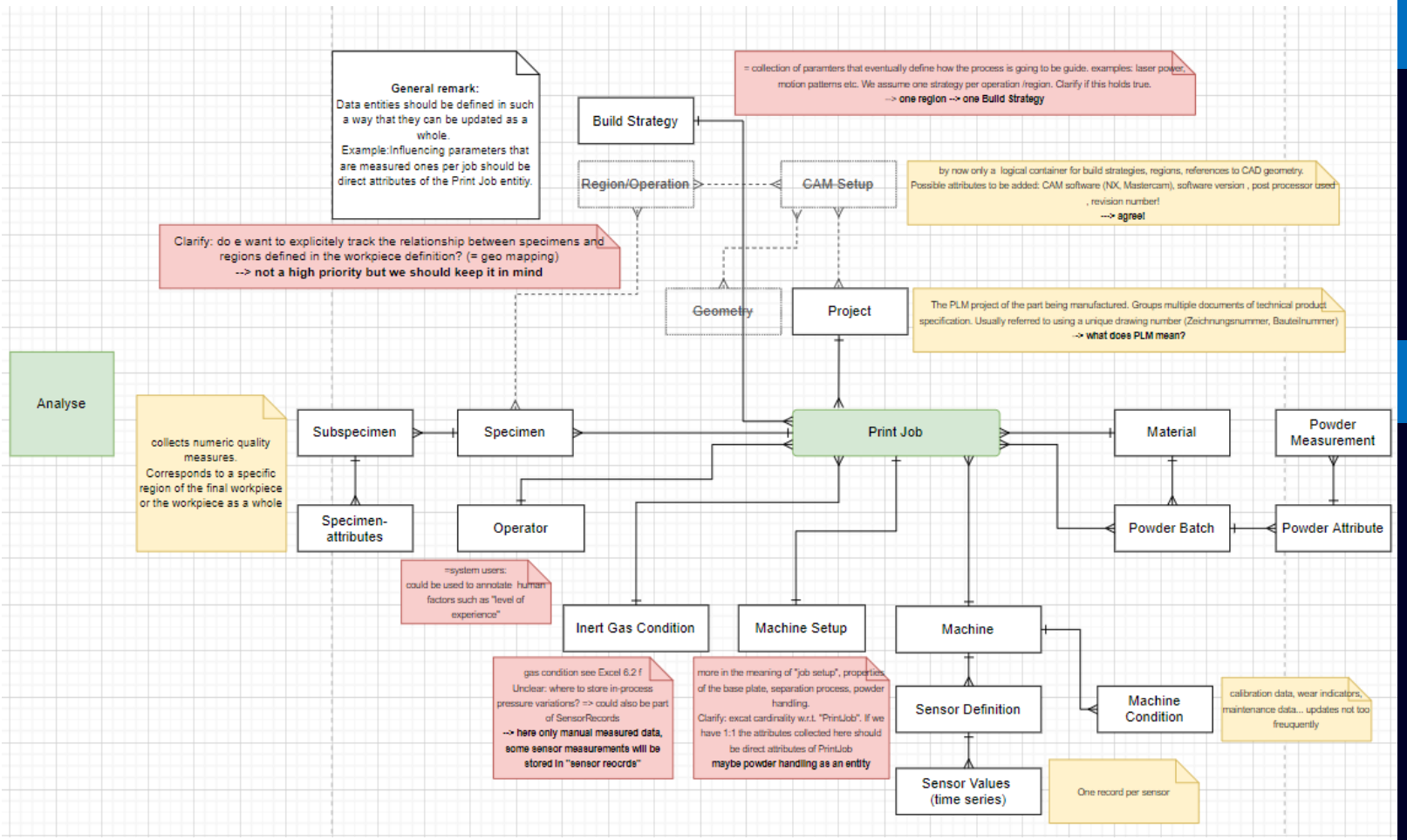
- SINUMERIK 840D sl
- Industrial EDGE IPC
- Insight Hub
- Multiple sensor systems

Utilized sensor systems

- OCT-distance measurement between nozzle and part by PRECITEC
- Melt pool monitoring by CLAMIR
- Environment sensors (temperature, humidity, oxygen ...)

SIEMENS

BigDataLMD
On-premise server utilized for data base



Database created with

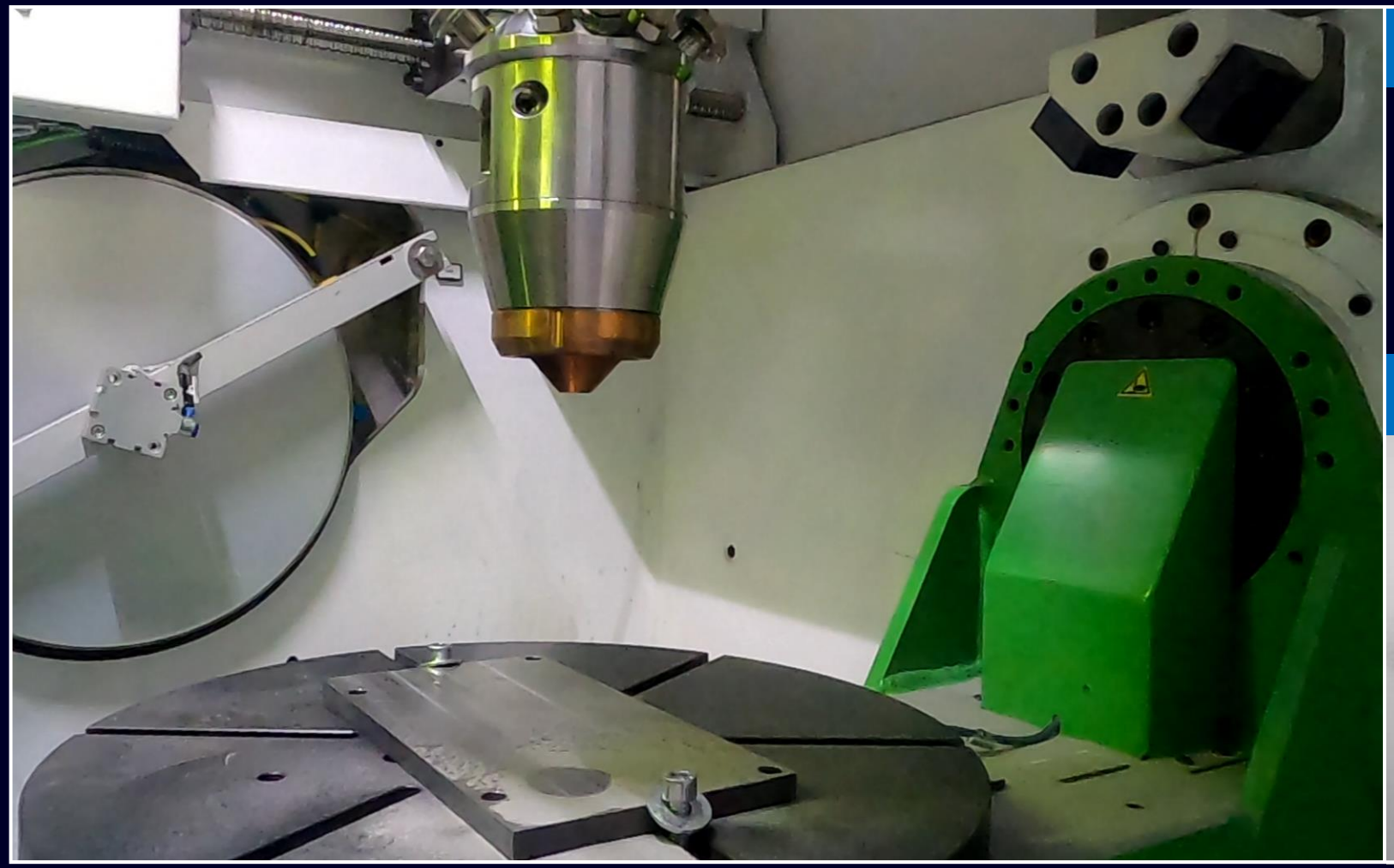
- Microsoft Entity Framework
- ASP.NET Core
- PostgreSQL + TimescaleDB

Current status

- Database tested with real production data
- More data points to be generated with future print jobs

SIEMENS

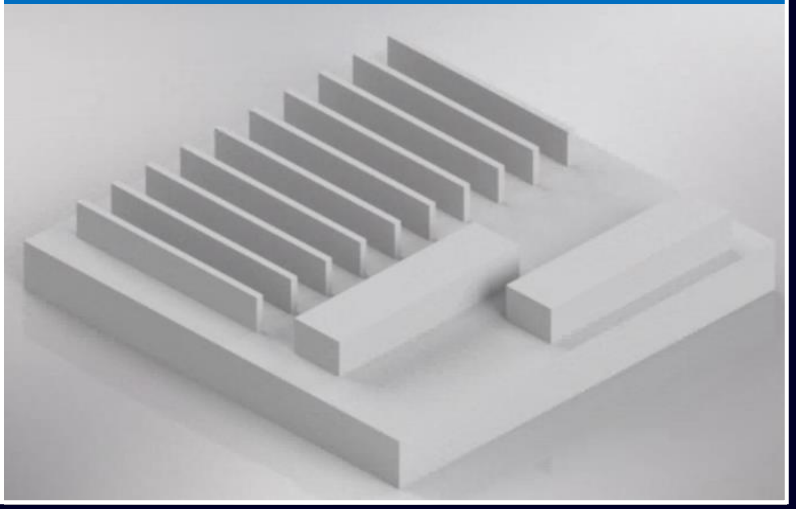
BigDataLMD
Serial production phase



Data for analysis

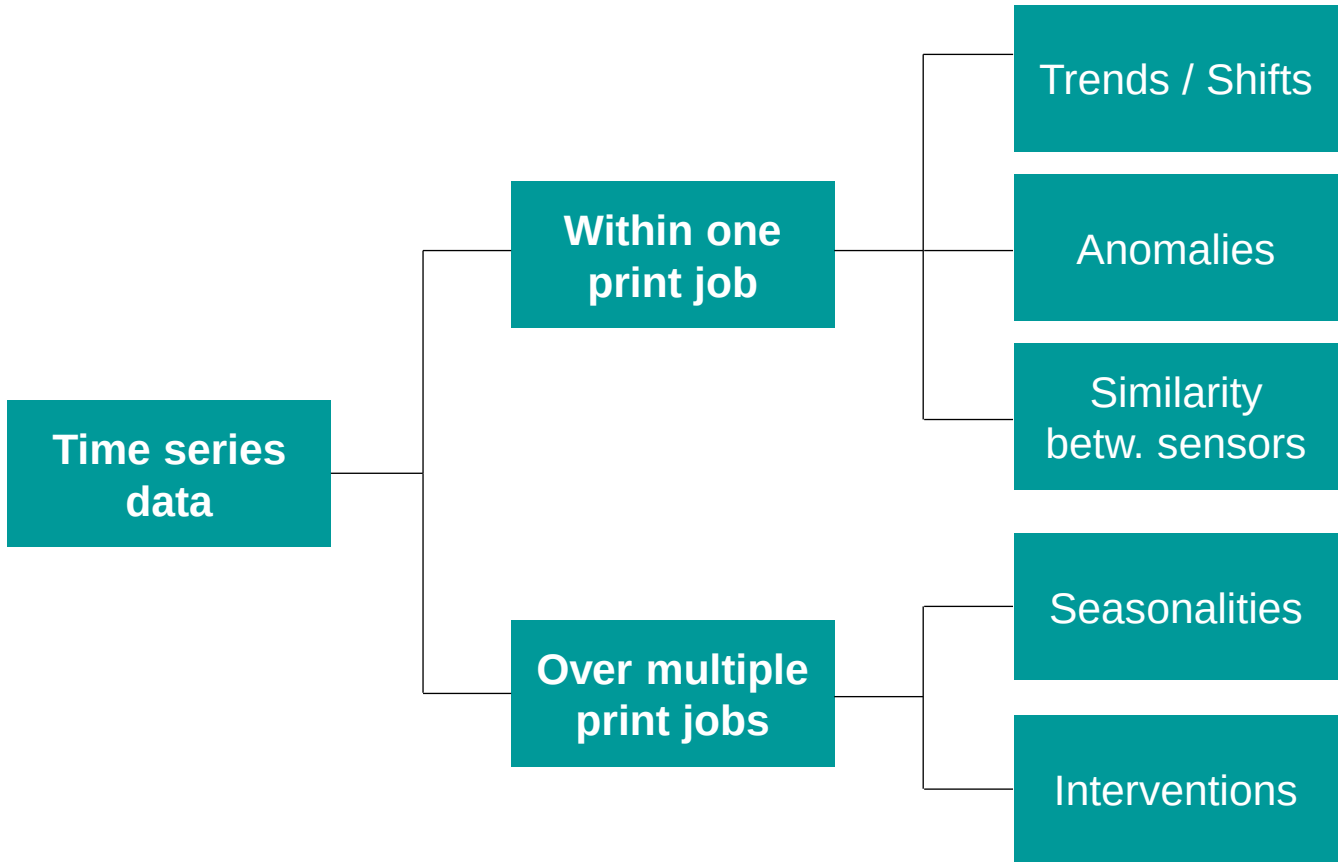
- 50+ parts are printed with constant process parameters
- Every part is measured, analyzed and destructively tested

Part geometry



SIEMENS

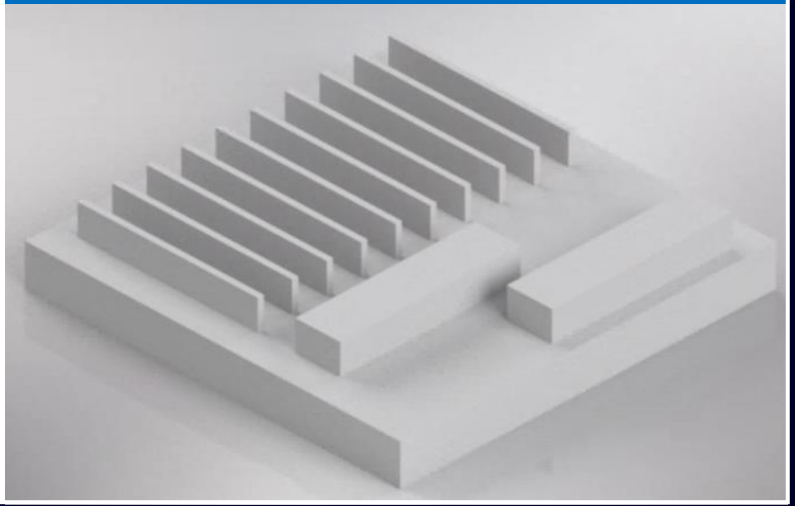
BigDataLMD
Data analytics



Data for analysis

- Statistical correlation (Six Sigma) of anomalies with the sensor data
- ML-based clustering of the data set to discover outliers and correlations to the sensor data

Part geometry



SIEMENS

Thank you for your attention!

Sebastian Hartmann
PhD Candidate in process monitoring for Additive Manufacturing

- Siemens AG | Digital Industries
  Frauenauracher Straße 80, 91056 in Erlangen, Germany
  Contact: hartmann@siemens.com

- Technical University of Munich | Chair of Materials Engineering of Additive Manufacturing
  Boltzmannstraße 15, 85748 in Munich, Germany
  Contact: sebastian.m.hartmann@tum.de

SIEMENS