AUTONOMOUS ADDITIVE FACTORY SYSTEMS

Dipl.-Ing. F. Beckmann



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AGENDA

1. **Motivation**
2. The right process
3. From CAD to quality assurance
4. AMF - The modular system
5. Tools for the additve factory of the future

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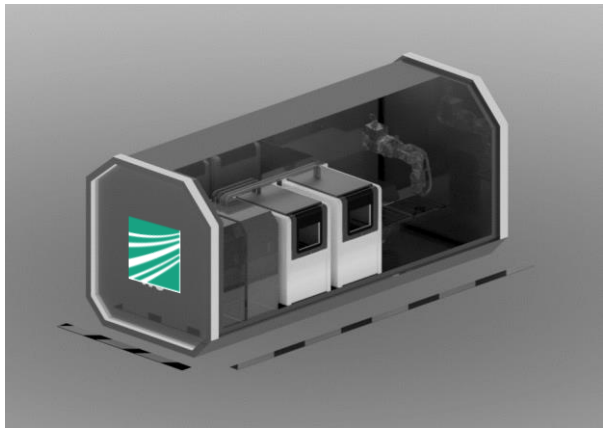
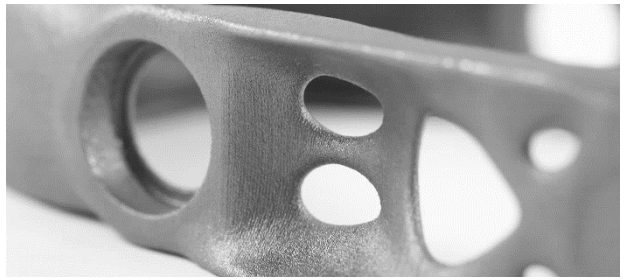
Mission Statement of Fraunhofer IAPT

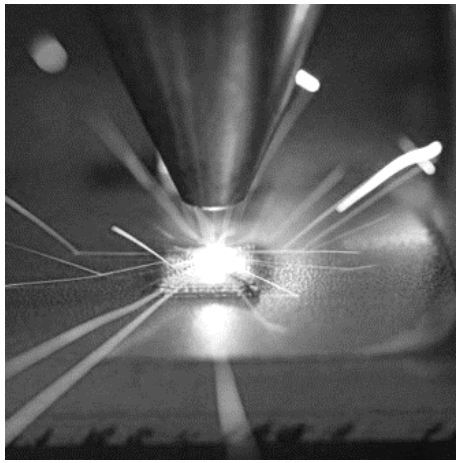
Mission

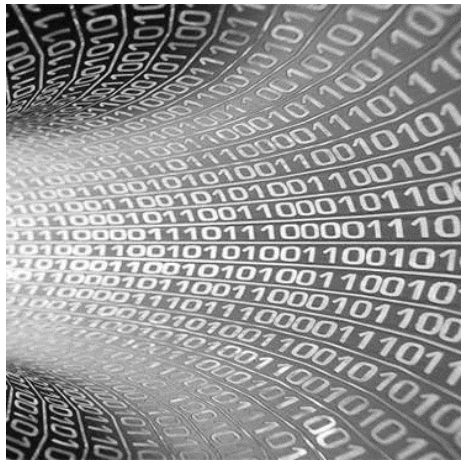
» Our mission is to industrialize additive manufacturing to create resource-efficient products for the future «











Vision

» We are the leading institute for development of industrial solutions in additive and autonomous manufacturing «

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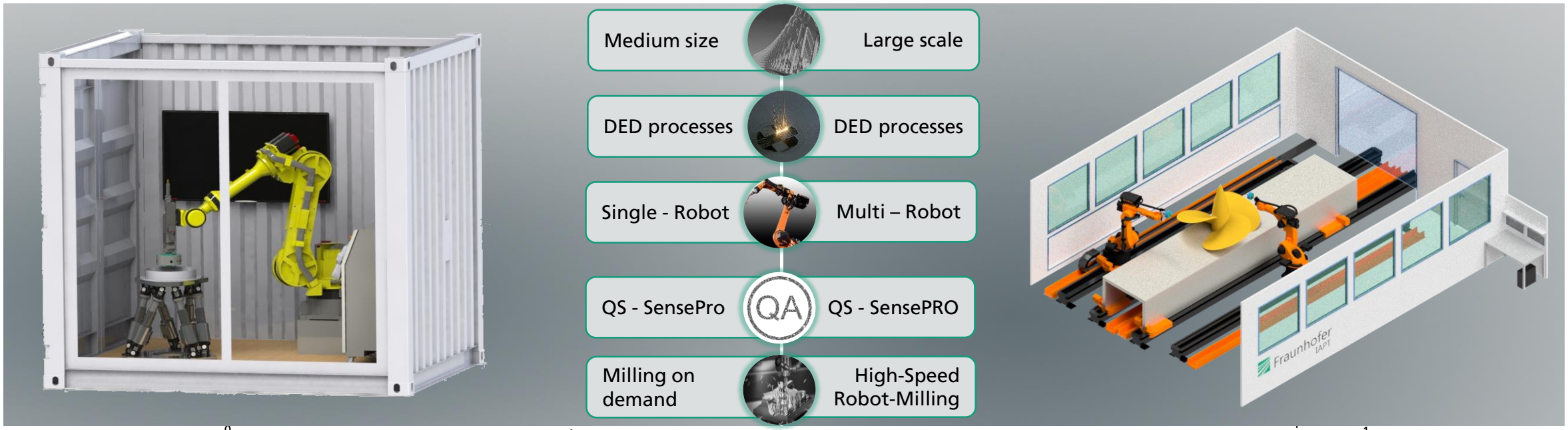
Development of mobile and stationary systems for medium to large scale structures



Digital Twin

CAD model → Data preparation → AM Process → Post Processing → Product

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Matal AM-Technologies – Powder Bed versus DED

Metal (powder bed)

SLM 500HL (SLM Solutions)



Concept M2 (Concept Laser)



EOS M290 (EOS)



TruPrint 1000 (Trumpf)



SLM 250HL (SLM Solutions)



EOS M 270 (EOS)



AconityLAB (Aconity)



Arcam A2X (Arcam)



Metal (powder/wire/nozzle)

TruLaser Robot 5020 (Trumpf)



Welding Portal (Cloos)



ORLAS Cube (OR Laser)



CMT (Fronius)



Sources: SLM Solutions, Concept Laser, EOS, Trumpf, Aconity, LZN, Arcam, Fronius

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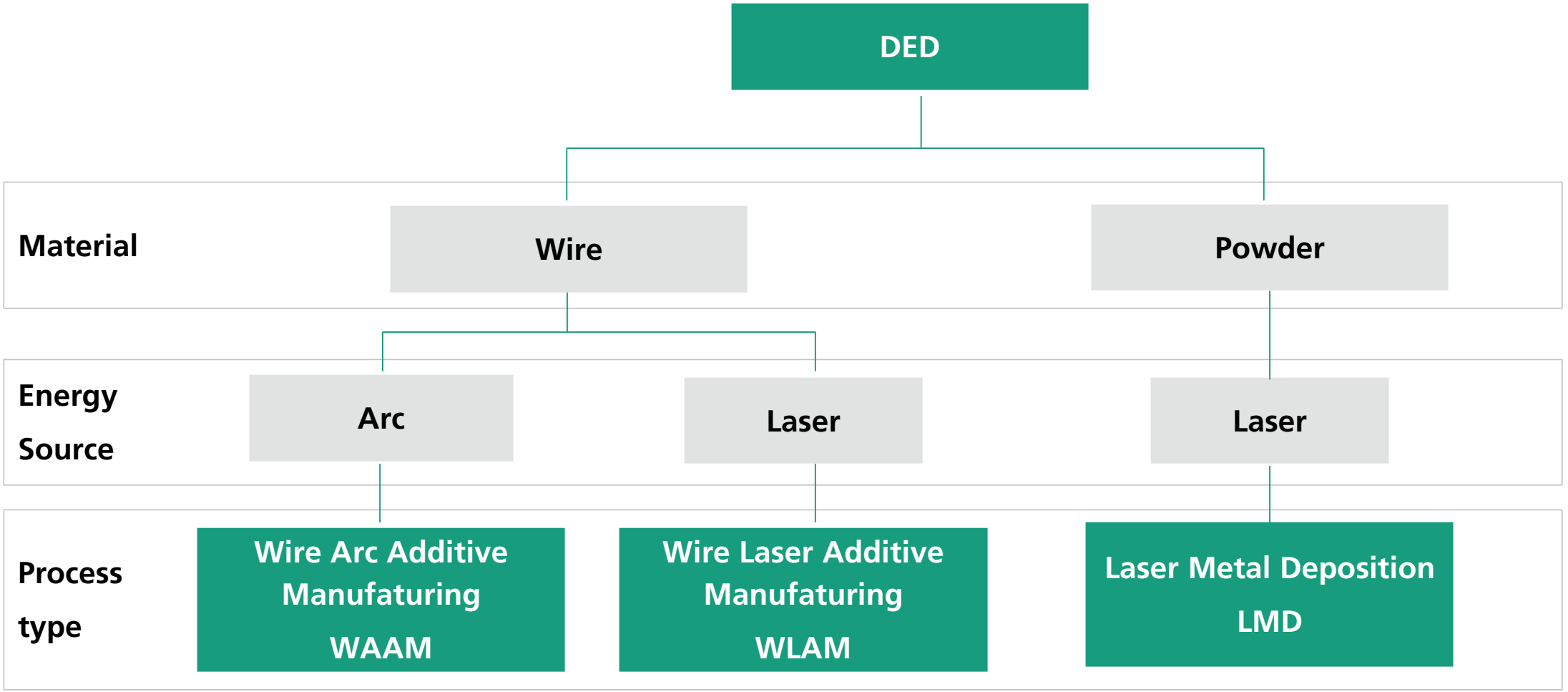
Classification of Directed Energy Deposition (DED) @Fraunhofer IAPT



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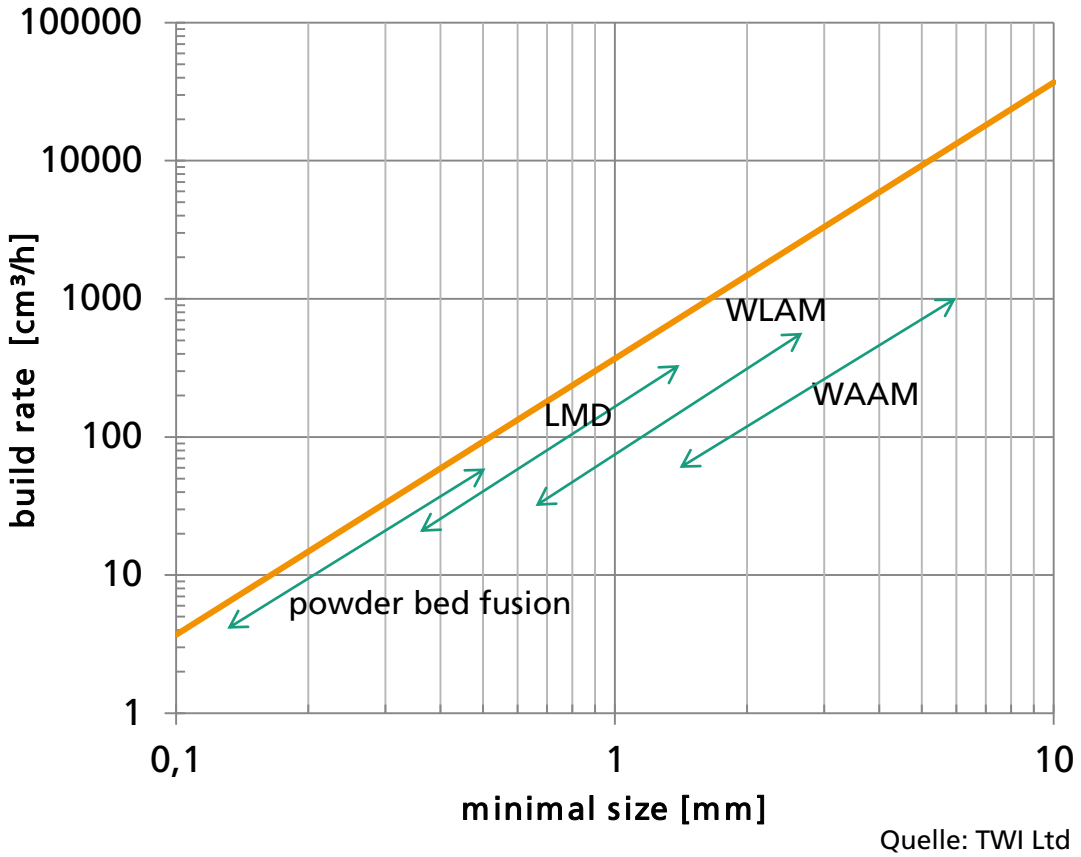
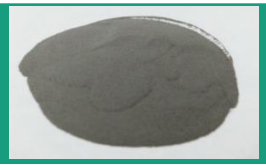
Characteristics of DED Processes



Quelle: TWI Ltd

	wire 	powder 
advantages	+ material efficiency + safety and handling + machine mounting + high range of wire materials + low price of wire materials + high build rate	+ combination of materials + special material compositions + flexibility + high coupling of energy (with laser sources) + fine structures possible + independent in build direction

Your application defines the process type
extensive knowledge in process development

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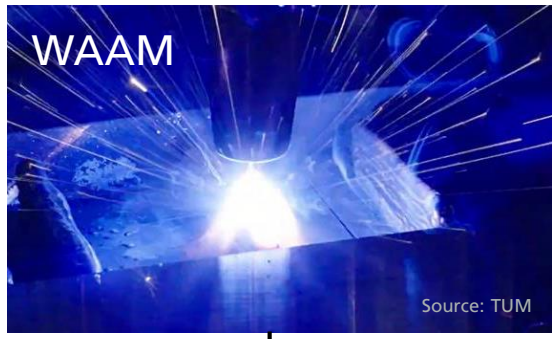
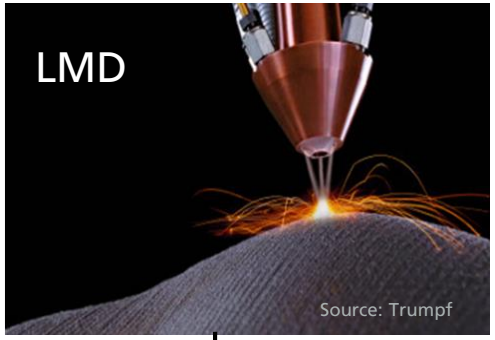
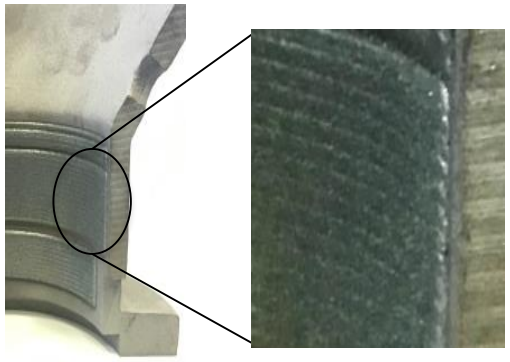
Applications of Directed Energy Deposition

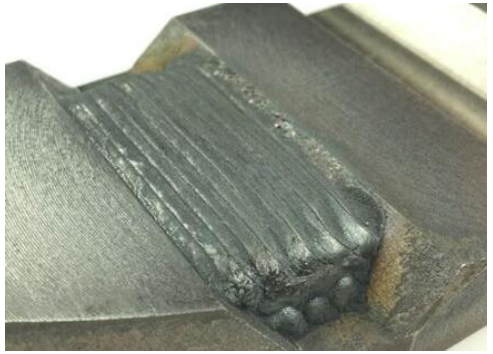




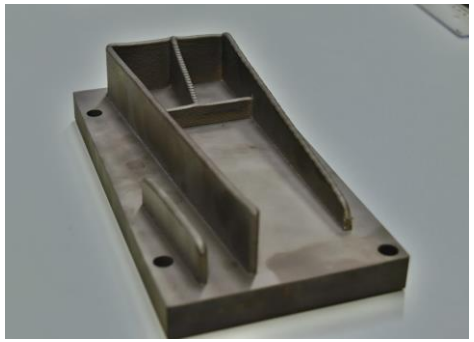
surface caldding



repair



Additive Manufacturing



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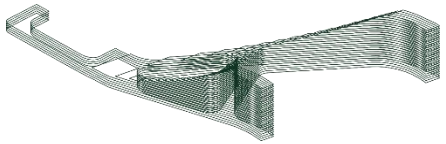
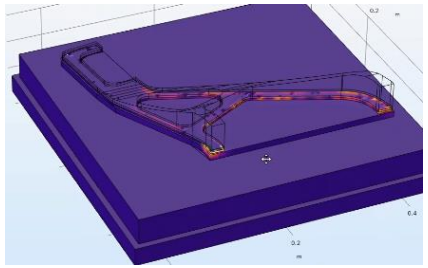
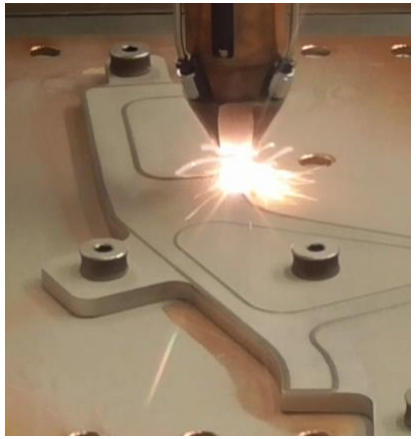
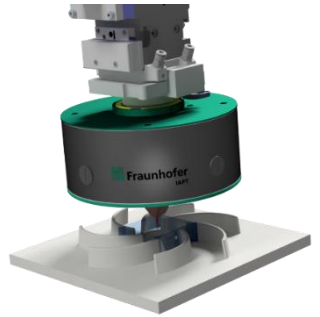
At the Fraunhofer IAPT specialists work at each step of the process to manufacture high quality parts

Geometry > Slicing > Simulation > Process > Quality Assurance

development of tailored solutions along the DED process chain

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Development of Design and Build Strategies for Optimized Geometries

welding of basic geometries with different build strategies

evaluation with automated 3D-measurement systems and metallogrphical investigation

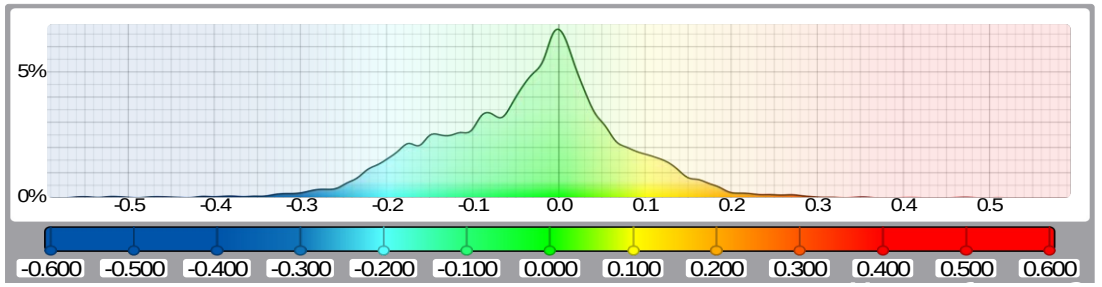
definition of structured guidelines for design and manufacturing process

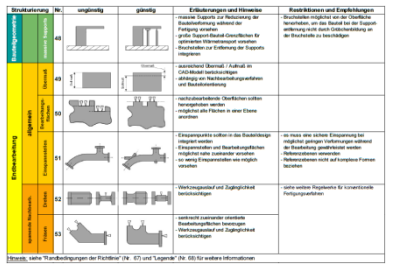


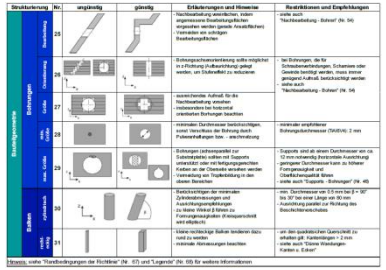


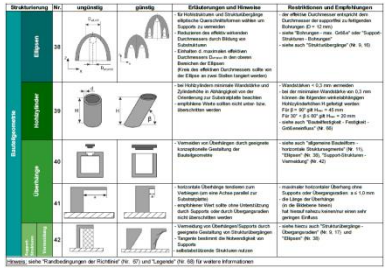












Geometry > Slicing > Simulation > Process > Quality Assurance

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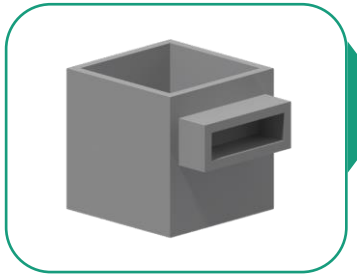
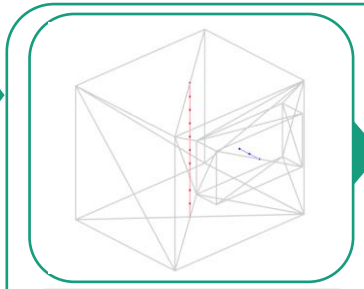
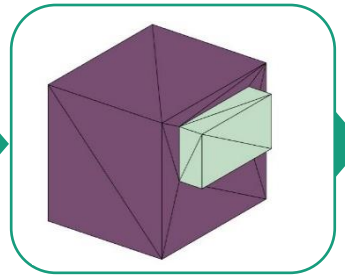
Automated Digital Process Chain for DED-Technologies



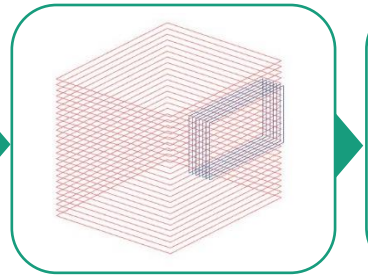
CAD



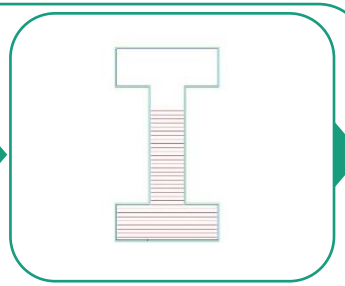
Feature Analysis



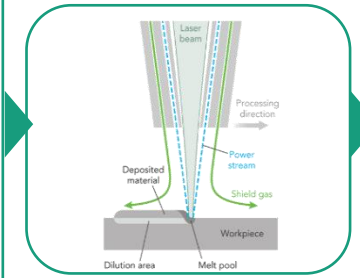
Volume Decomposition



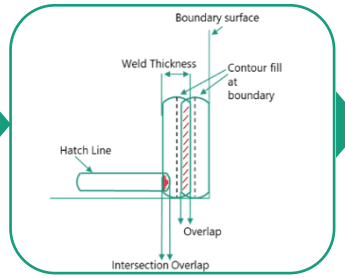
Multi-directional Slicing



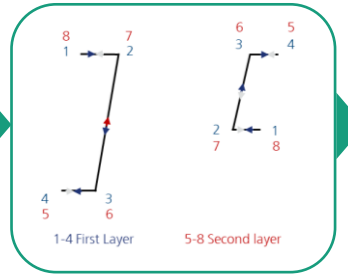
Hatching



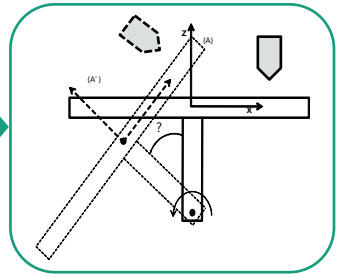
Process Parameter Set Definition



Path Planning Strategy

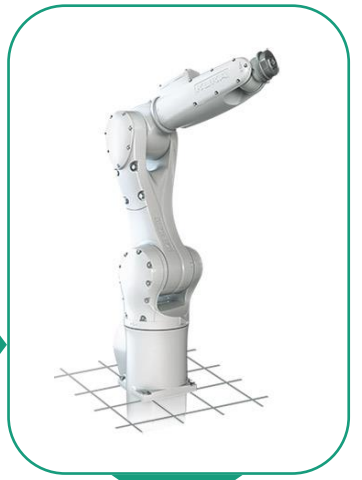


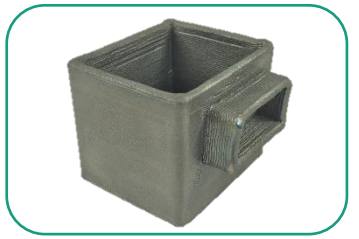
Build Strategy



External-axis and Tool Orientation

SliceME





Geometry > **Slicing** > Simulation > Process > Quality Assurance

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Optimization of DED Process Strategies

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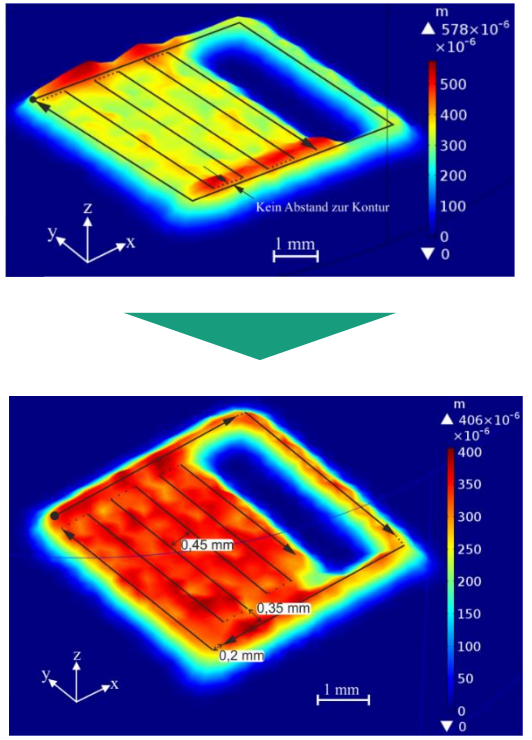
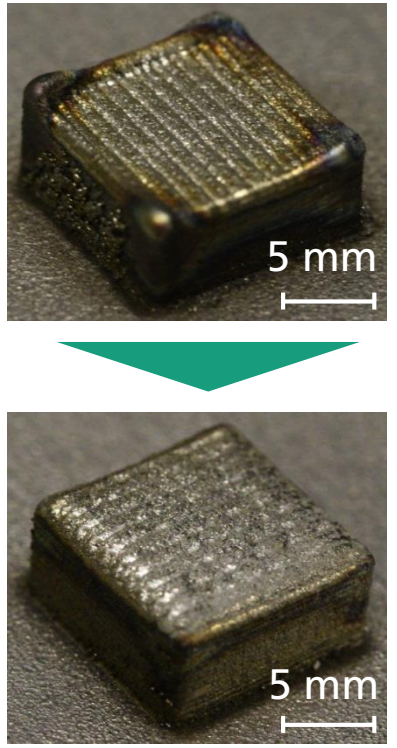
Project goal

- Inaccurate DED processes lead to challenges in process control and post processing
  - Material deposition throughout surfaces, corners, intersection etc. varies
- Approach
  - Thermal simulation of the baseplate and energy input
  - Modelling the material deposition and powder utilization
  - Prediction of the part geometry and optimization of processing strategies

Simulation



Validation



Geometry → Slicing → **Simulation** → Process → Quality Assurance

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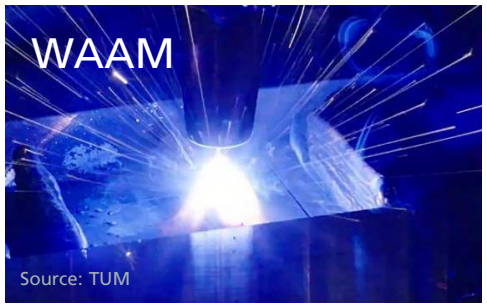
DED- and Post-Process: From Net-Shape Geometry to finished parts

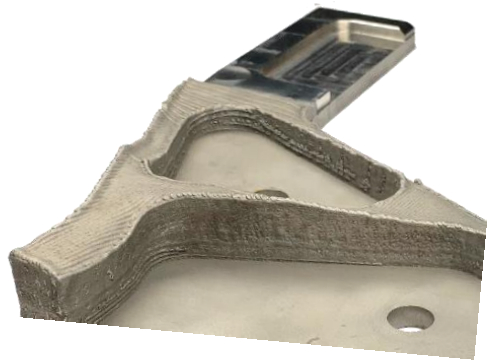














Geometry > Slicing > Simulation > **Process** > Quality Assurance

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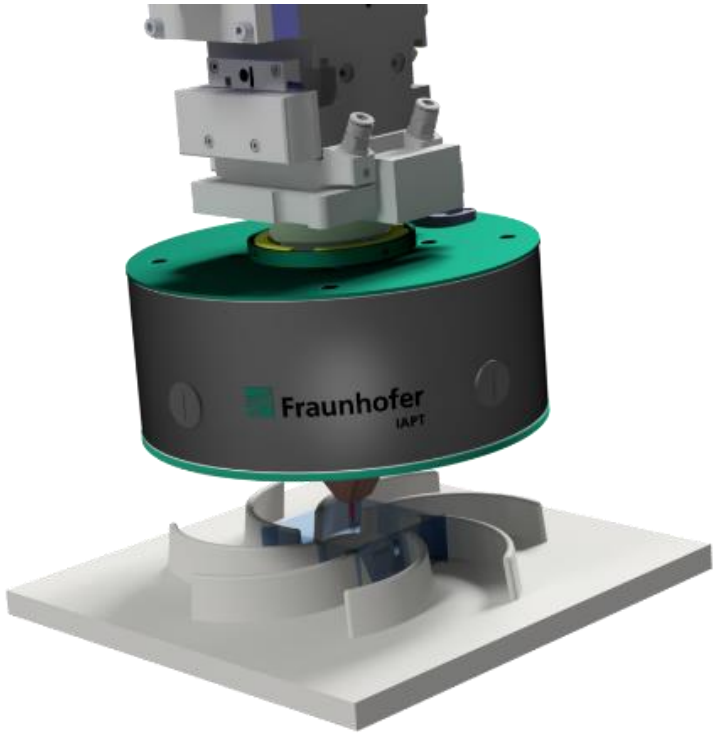
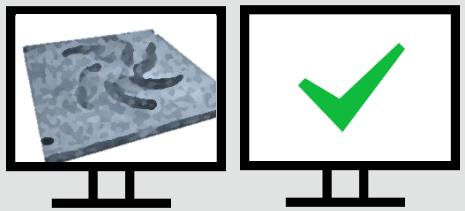
SensePRO - Innovative In-Process Quality Monitoring and Control

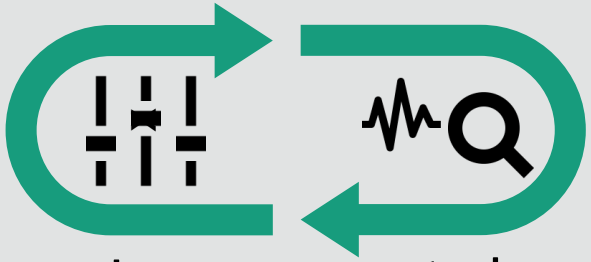
Shadowing free all-round view
through new alignment of optics



Replacement of cost-intensive CNC machines with cheap & controlled robot systems



In-process digitalization
to analyze geometrical part variances



In-process control
to stabilize the manufacturing system

Geometry > Slicing > Simulation > Process > **Quality Assurance**

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Bundesministerium für Wirtschaft und Energie
eXIST Existenzgründungen aus der Wissenschaft
Europäische Union
ESF Europäischer Sozialfonds für Deutschland
Zusammen. Zukunft. Gestalten.
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Additive Mobile Factory – AMF

One-stop solution

formnext 2019

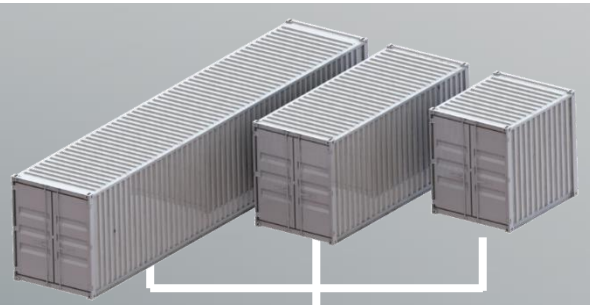
Presentation of mobile 3D printing solution and SensePRO technology



One-stop solution for decentralized spare part production



Modular Design for individual solutions



Wire-Laser-AM

Wire-Arc-AM

Powder-Laser-AM

HS Robot-Milling

CNC-Milling

Digital Twin



CAD model → Data preparation → AM Process → Post Processing → Product



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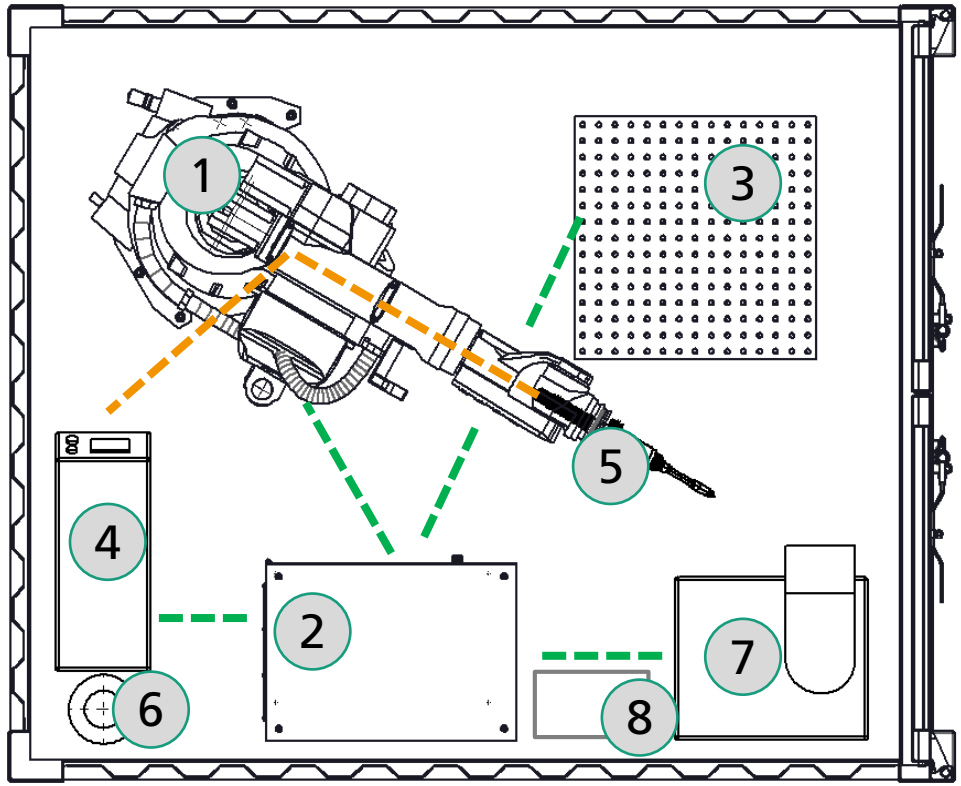
Basic AMF with WAAM Equipment

10ft Version — fast production of net-shape geometries



1. Robot (6-axis)
2. Control unit robot
3. Positioner (+2 axis)
4. Arc-source and wire feeder
5. WAAM-head
6. Gas supply
7. Extraction unit
8. Electrical support unit

Connection wire + gas

Connection data

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Additive Mobile Factory @ Formnext 2019





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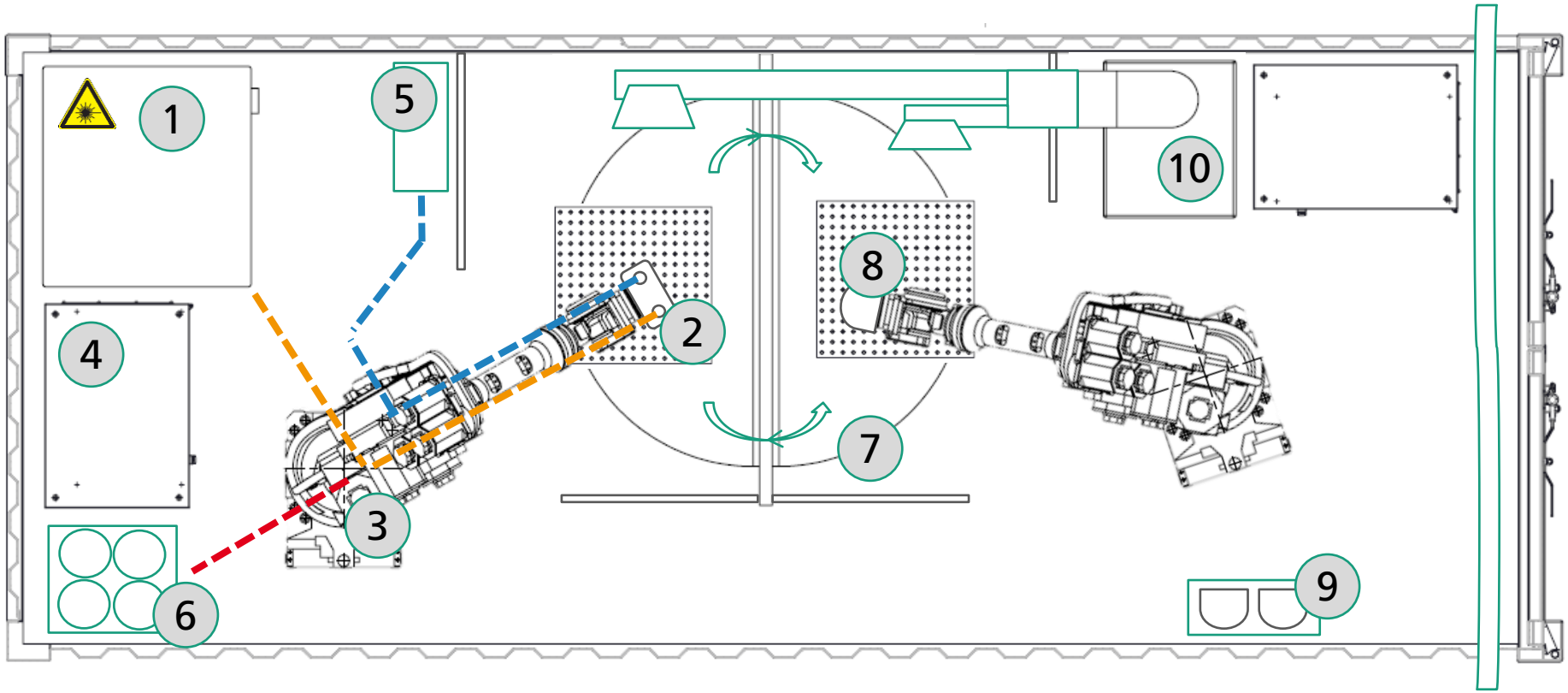
High Productitity AMF with WLAM and Robot-Machining Option

20ft Version

1. Net-shape geometry with WLAM

2. Machining via HSC Milling for final part geometry

3. enlargement to 40ft for additional post-processes



1. Laser source 5kW
2. WLAM processing head
3. Robot (6-axis)
4. Control unit robot
5. Wire feeder
6. Gas supply
7. Exchange unit
8. Machining head
9. Machining tools
10. Extraction unit

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Planning the factory of the future

Goal: Cost-effectively and efficiently production AM components with short lead times

Digital Manufacturing

- Digital Twin in Production
- Collecting and structuring data
- Development of Machine interface



Factory Management

- Management of large amounts of manufacturing data
- Management of powder stocks
- Implementation of safety standard
- Planning and tracking of material flow

Factory Simulation

- Increase in machine utilization
- Maximization of economic efficiency
- Evaluation of layout alternatives

Production Networks

- Decentralized production
- Production planning & scheduling

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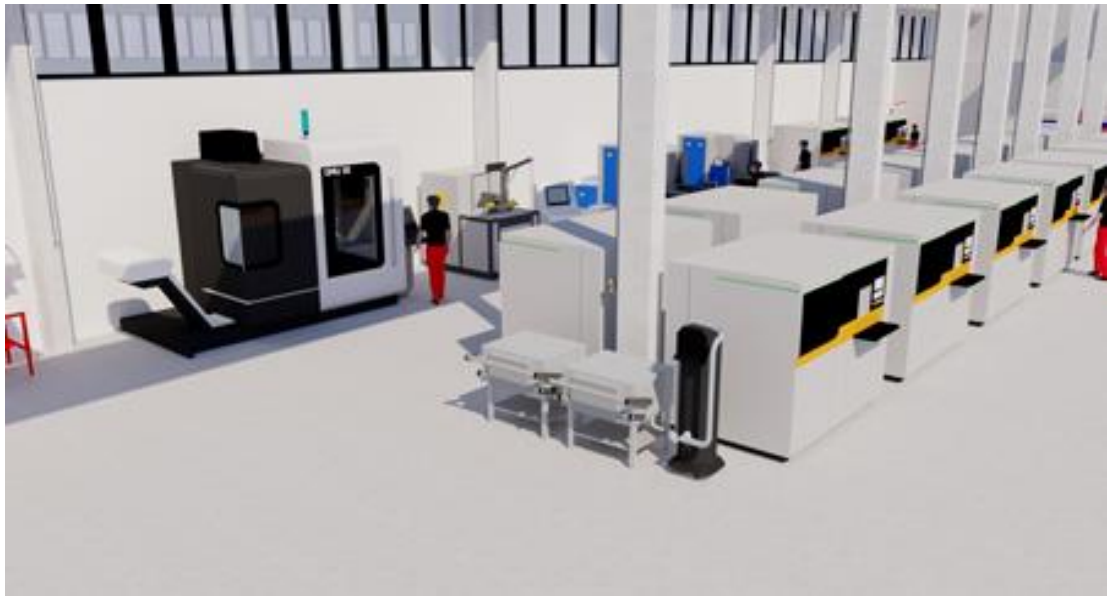
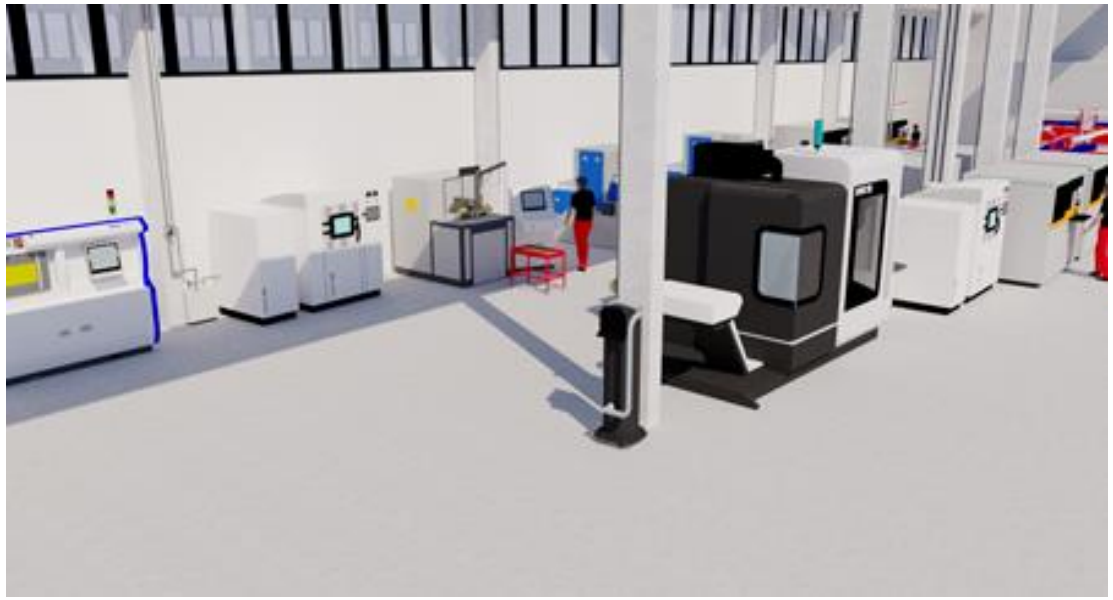
Bionic Smart Factory 4.0 – your individual factory design

Cycle time–based factory design



Cost-based factory design



Spare parts on demand

Individual parts/small series (time critical)

Rapid repair

Individual parts/small series (not time critical)

Focus: Cycle time

Focus: Costs

Digital warehouse

Complex individual parts and small series

Mass customization

Mass complexity manufacturing

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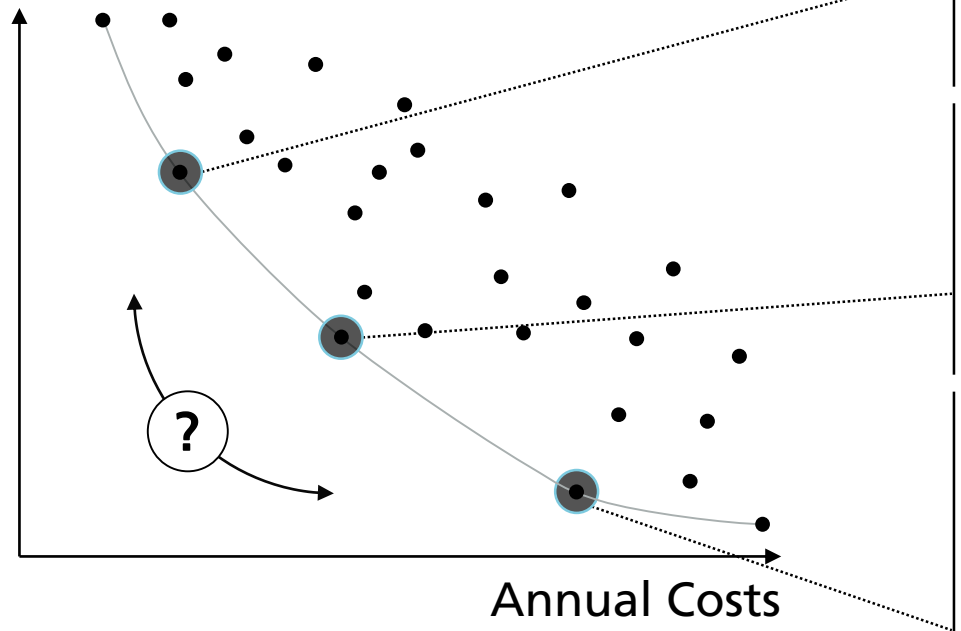
Basic principle: Pareto front by evaluation of factory design simulation

Illustration

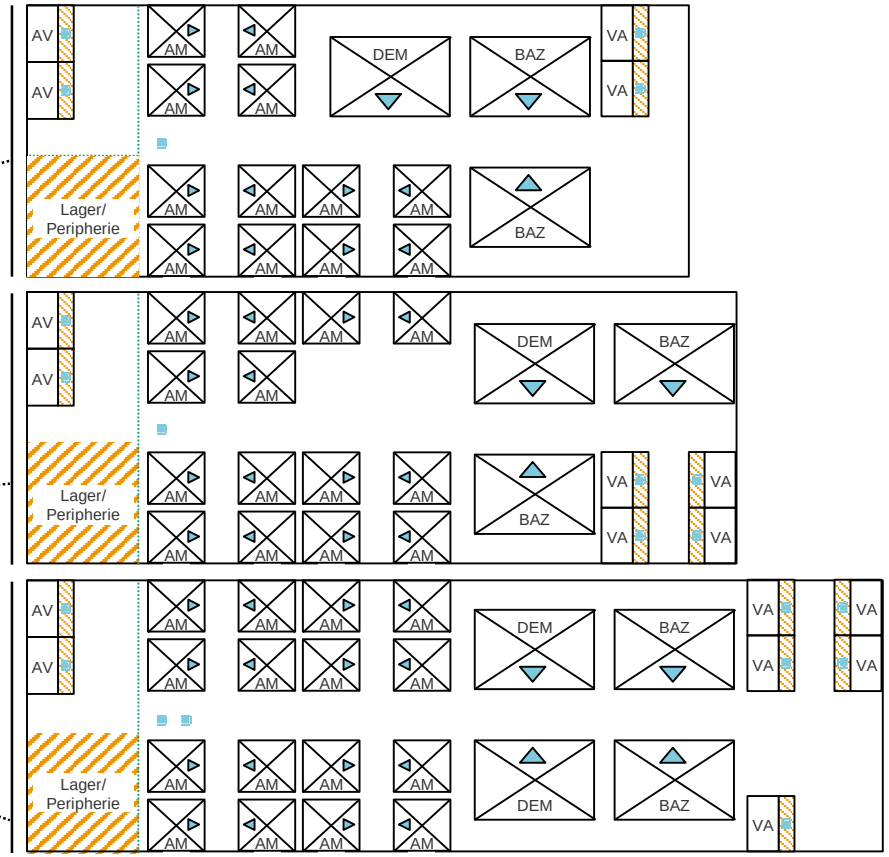
Rating target of achievement

Average cycle time



Pareto front ● Target of achievement of fabric design

Sketch of corresponding factory design



AM: Additive Maschine; Hip: Hot isostatic pressing; EDM: wire eroding machine BAZ: machining unit; AV: work preparation; VA: Foreman

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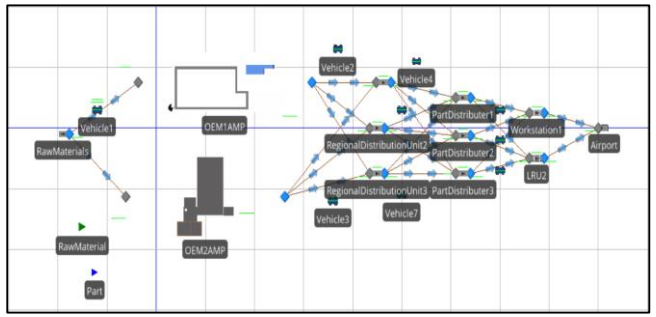
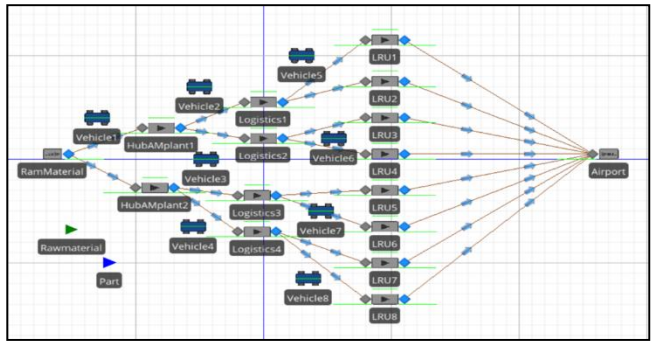
Production Networks - Which supply Chain for which Use Case?

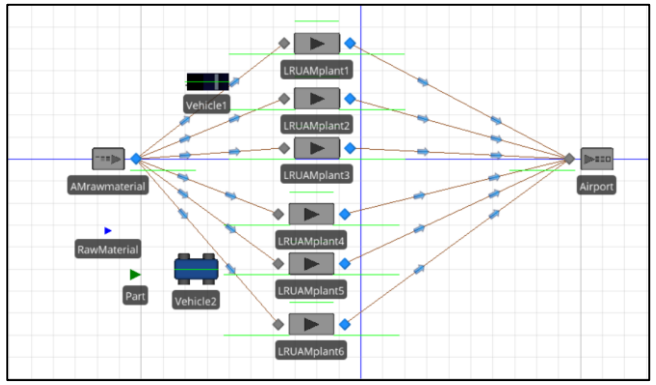
Centralized Supply Chain

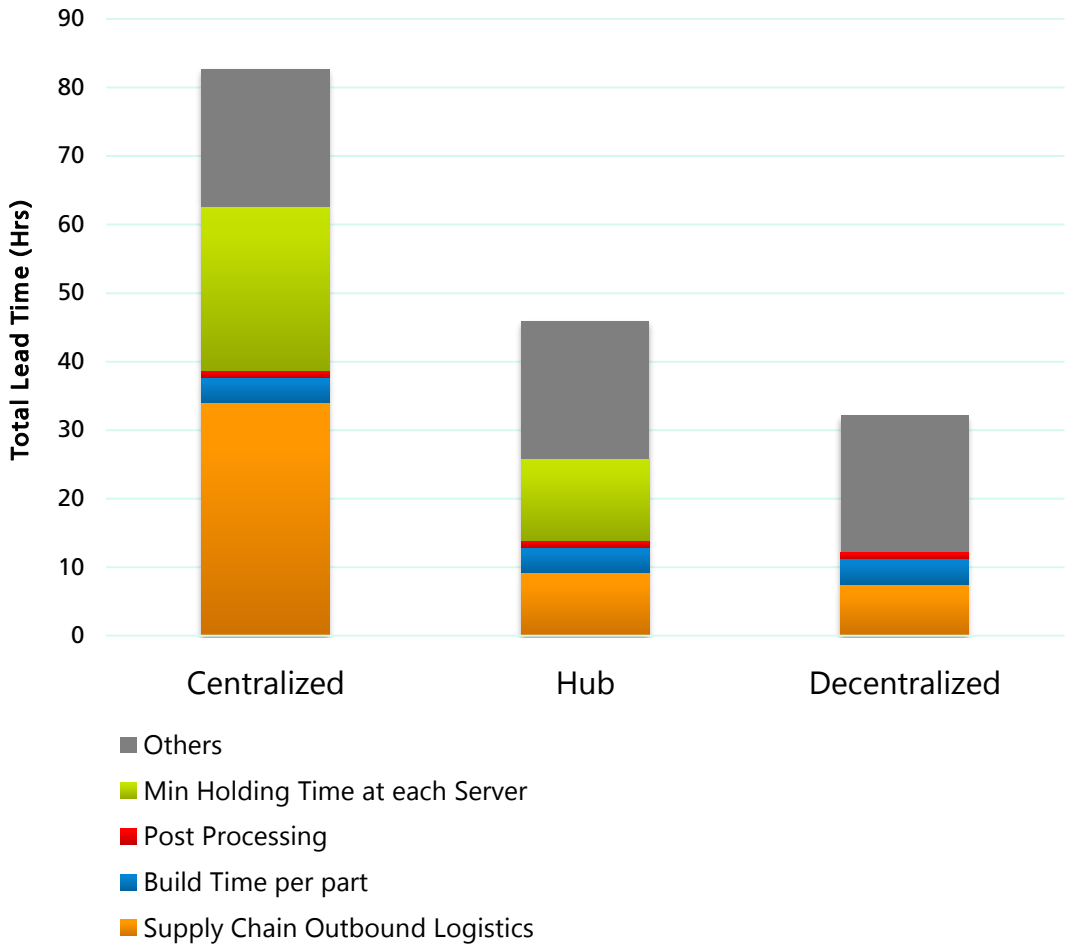


Hub Supply Chain



Decentralized Supply Chain





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Augmented Reality for AM?



Source: The Verge



Source: Bosch

The potential of AR in additive manufacturing has so far hardly been used

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AugmentedAM

Augmented Reality application to support and standardize manual setup and maintenance tasks in the LBM process chain



Benefits

- ensure worldwide reproducibility
- Improvement of work safety
- Reduction of training costs
- Less training time
- Increase in productivity



Features

- App as training and production tool for tablets and AR Smartglasses
- Support of different LBM systems
- Implementation of industrial safety guidelines

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Do you have further questions?



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