AACHEN CENTER
FOR ADDITIVE
MANUFACTURING

Motek

Discover3DPrinting @ Motek 2023

Basic AM Seminar

Matthias Oly | October 2023

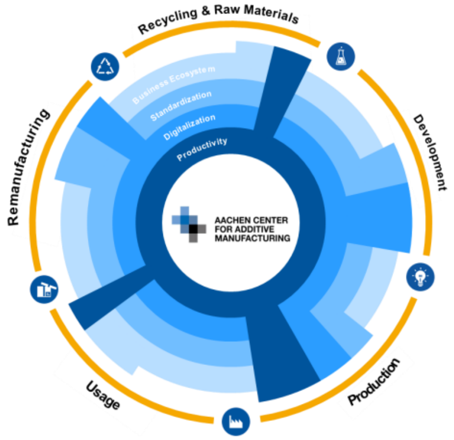
The ACAM Offers Services in the Areas of Consulting, Engineering, Research and Education with a Focus on the Additive Manufacturing Industry

Your presenter

Matthias Oly, M.Sc.

- Consultant for ACAM Aachen Center for Additive Manufacturing GmbH
- Research Associate at the Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Perspective and focus



Community

BUSINESS Members

BASIC Members

COOPERATION Members

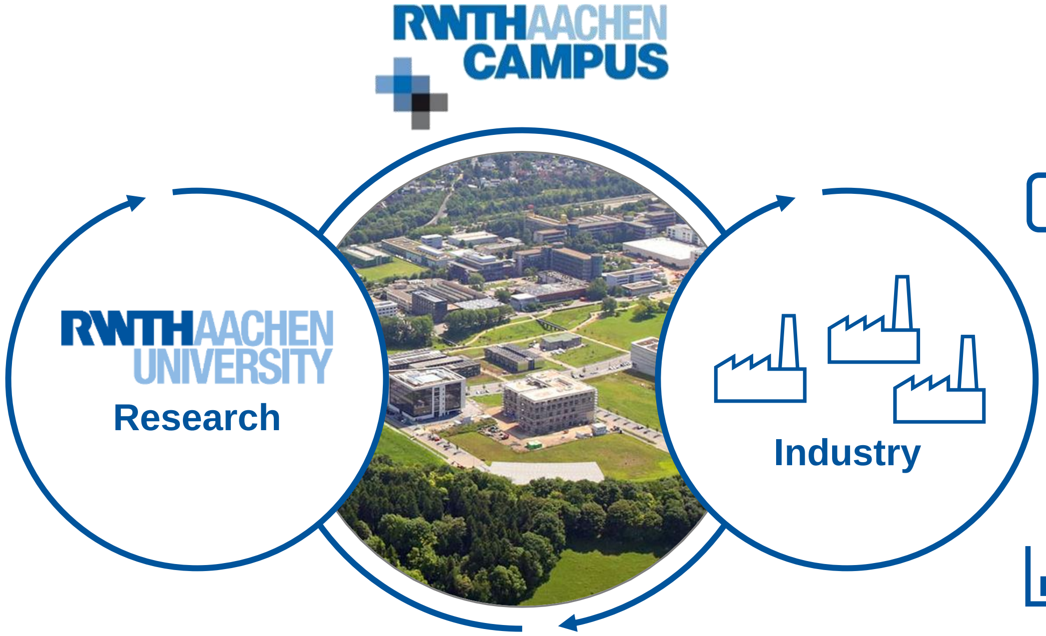
Key figures

- One-stop-shop for additive manufacturing covering the entire process chain
- Pooling of resources of RWTH Aachen Campus and facilitating industry's access to the Additive Manufacturing expertise of leading scientific and research institutions
- Over 100 researchers engaged in topics around the AM product life cycle and industry structure
- Delivery of approx. 40 industry project in consulting, engineering and research

Basic AM Seminar – Content

RWTH Aachen Campus
A Unique Research Landscape – the Engineering Valley

*„Megatrends such as digitalization, automation, mobility, climate change, globalization or demographic change are changing the world and creating major challenges for society. The combination of different scientific disciplines and companies is necessary to solve these complex relationships and issues.“**



1870 founded

260 institutes

6.000 research assistants

390 Mio. € Third party funds per year

University of Excellence since 2007

Enrollment of the companies with the objectives:

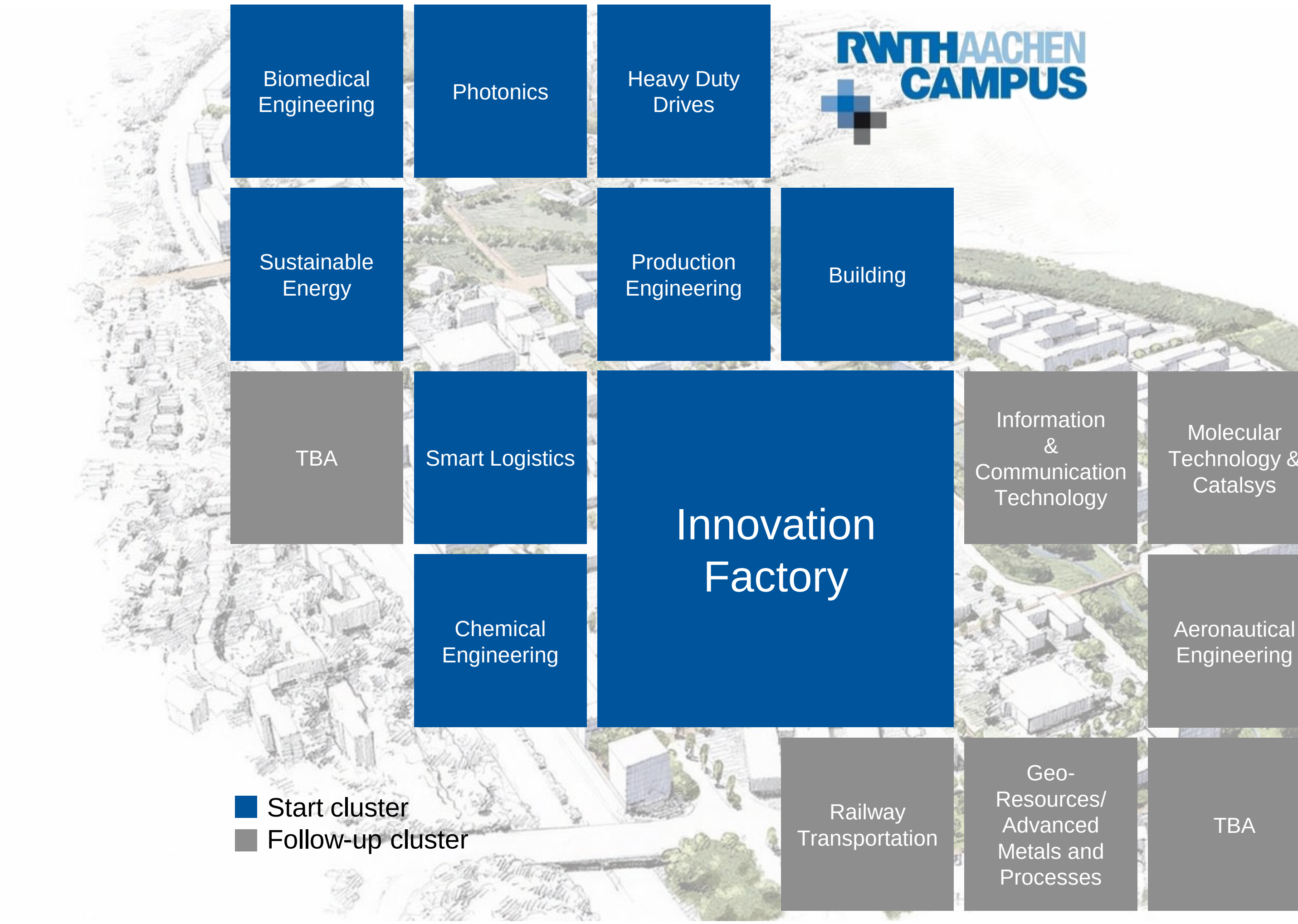
- Joint research & development
- Exchange with experts from science & business
- Use of specific further training offers
- Use of individual services

> 400 enrolled companies

Exchange and development of knowledge between research and industry –
Companies, institutes and the university share resources, utilize synergies and jointly conduct research on sustainable innovations

*Vision of the RWTH Aachen Campus

RWTH Aachen Campus:
16 Research Clusters Are Developing



Cluster Smart Logistic

Cluster Heavy Duty Drives

Cluster Photonics

Cluster Sustainable Energy

Cluster Production Engineering

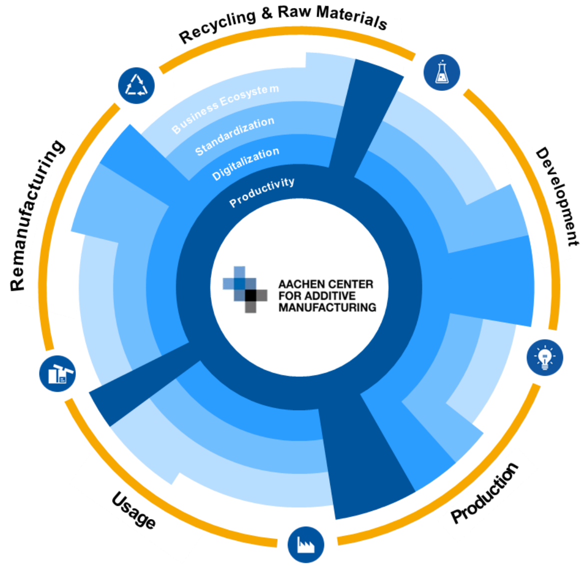
Cluster Bio-Medical Engineering

Cluster Chemical Engineering

Community
The Aachen Center for Additive Manufacturing

Navigating AM complexity

Creating opportunities by leading-edge **R&D**, professional **training and education**, and agile **engineering** and **consulting** services



- Dedicating **3,000 m²** lab space to AM research
- Connecting **100+ researchers** in the field of AM

Leading-Edge Research in Additive Manufacturing

The ACAM is your one stop shop for Additive Manufacturing research, education, engineering and consulting.

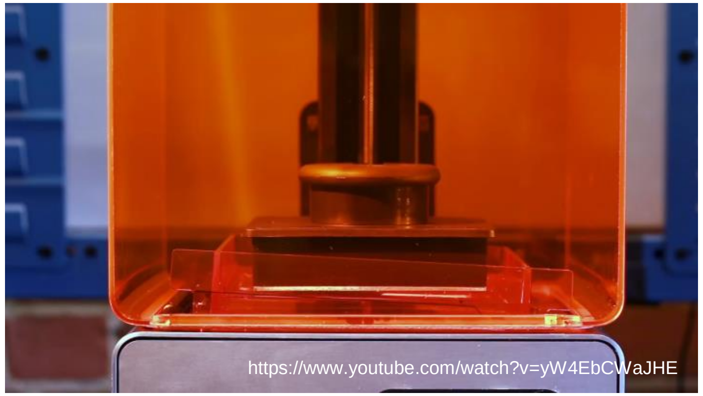
Basic AM Seminar – Content

Additive Manufacturing – Definition

Definition (ASTM 52900)

"Additive Manufacturing (AM) is defined as the process that

- ***produces components from 3D model** data*
- *by **joining material usually layer by layer**,*
- *as opposed to subtractive and formative manufacturing methods."*

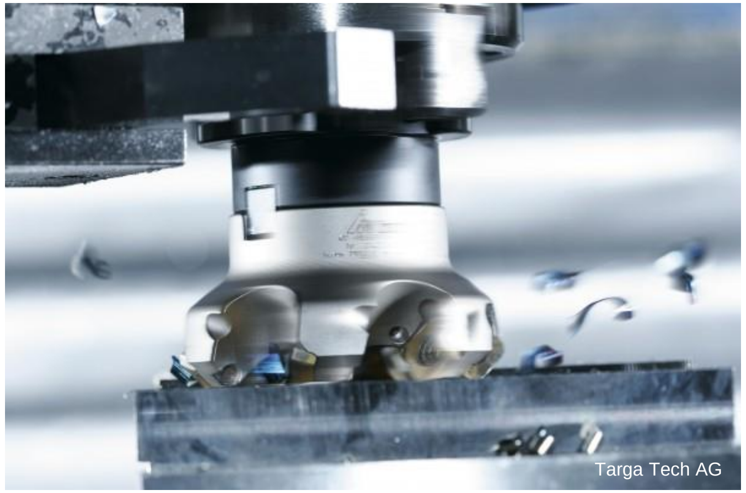


Definition (VDI 3405)

*"Manufacturing process in which the **work piece is built up in successive layers or units**."*

Introduction to AM
Subdivision of Manufacturing Technologies

Subtractive Manufacturing



Manufacturing of geometry by removing of defined areas from workpiece

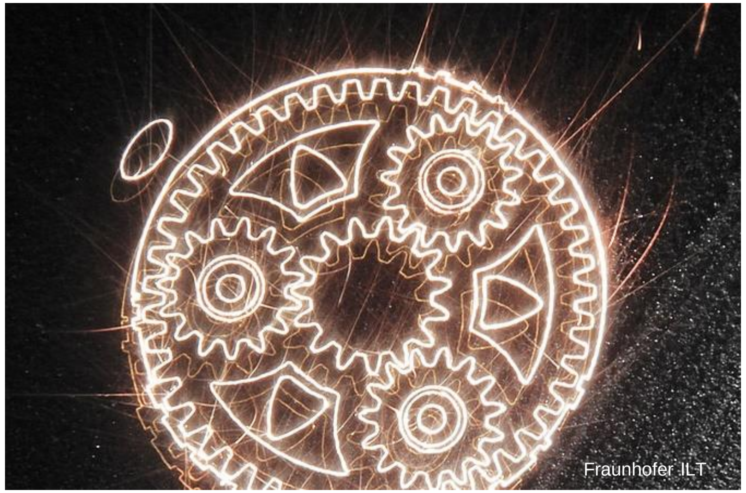
- Milling
- Turning
- …

Formative Manufacturing

Forming a given volume into geometry under the condition of constant volume

- Deep Drawing
- Molding
- …

Additive Manufacturing



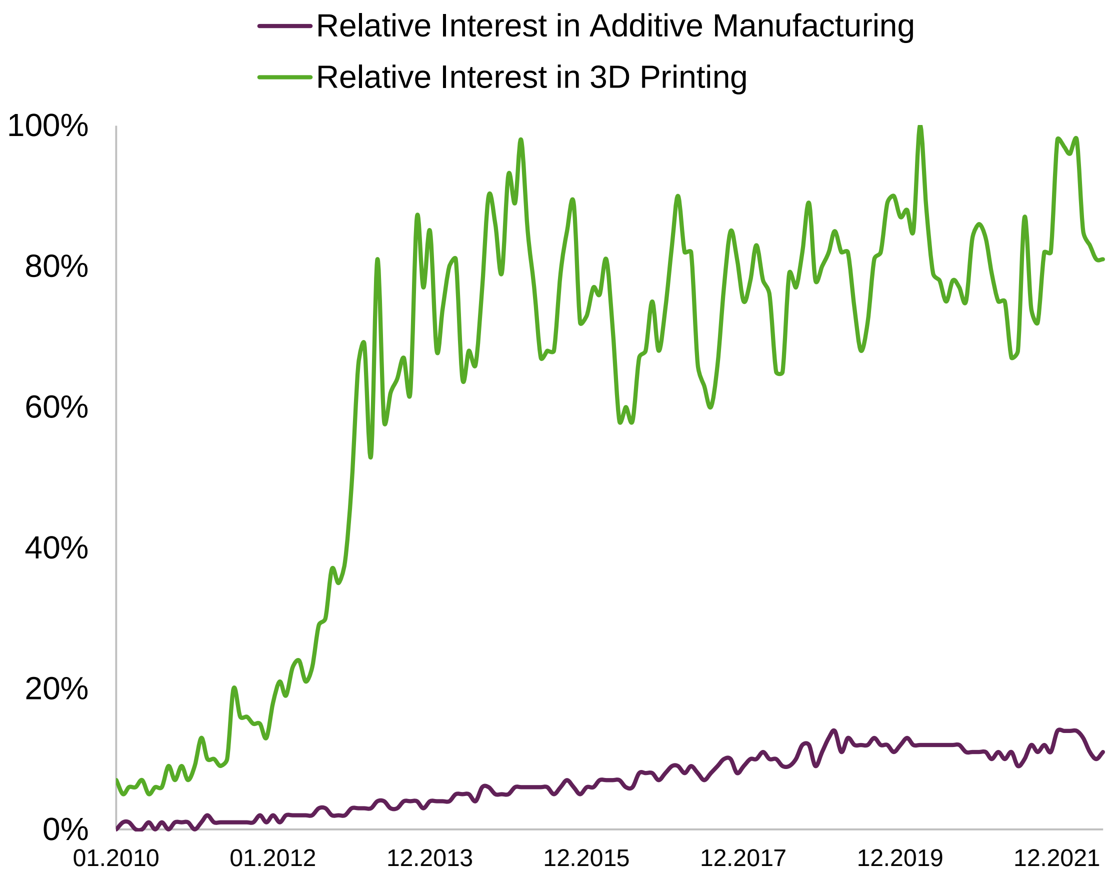
Stacking of volume elements (usually in layers)

- Laser Powder Bed Fusion
- Laser Metal Deposition
- …

Introduction to AM

Global Interest on AM According to Google Trends

Global relative interest according to Google Trends



Source: Google Trends

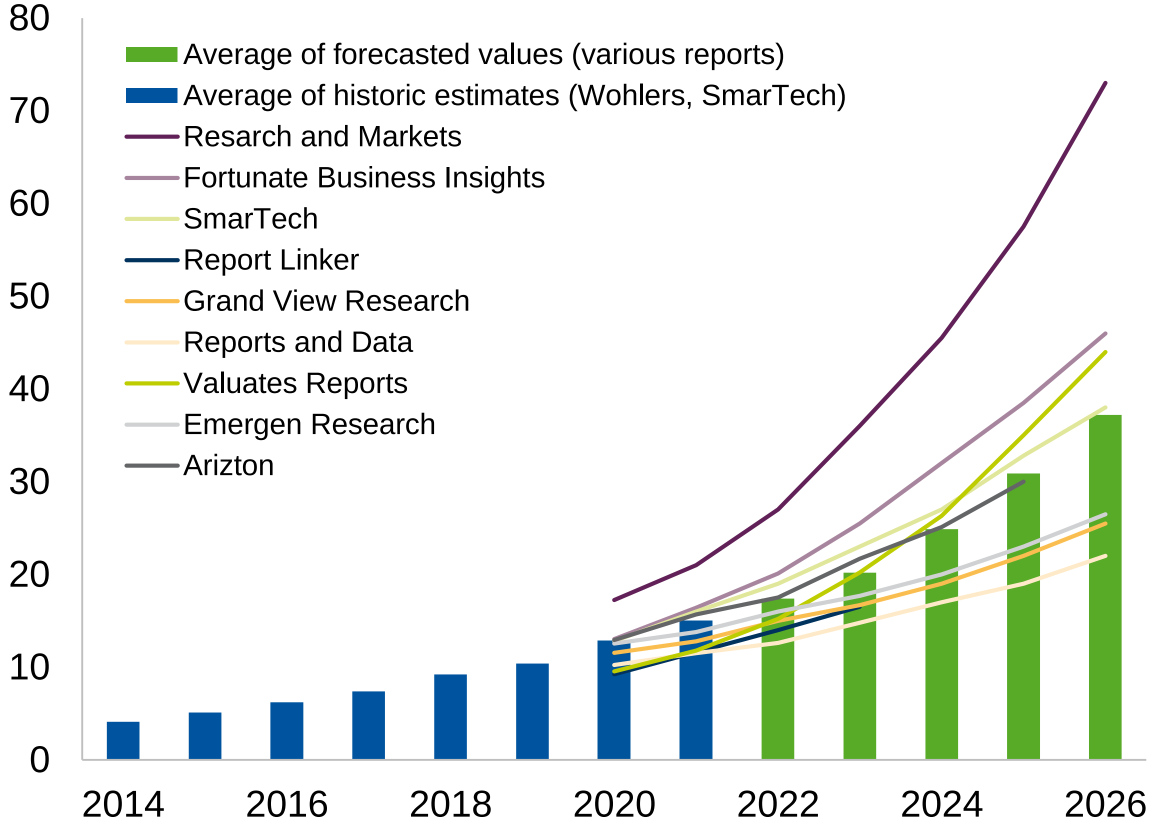
- **Overall positive trend** of relative interest in AM and 3D printing in online search engines
- **Lower interest in AM compared to 3D printing** because **AM** is the **more scientific term**
- **Strong increase (hype) until 2013/2014** of the search term **3D printing**

"3D Printing has the potential to revolutionize the way we make almost everything"

Barack Obama, State of the Union, Feb 2013

Positive Historic and Future Development of the AM Market

Total AM market size according to different market reports [$ billion]

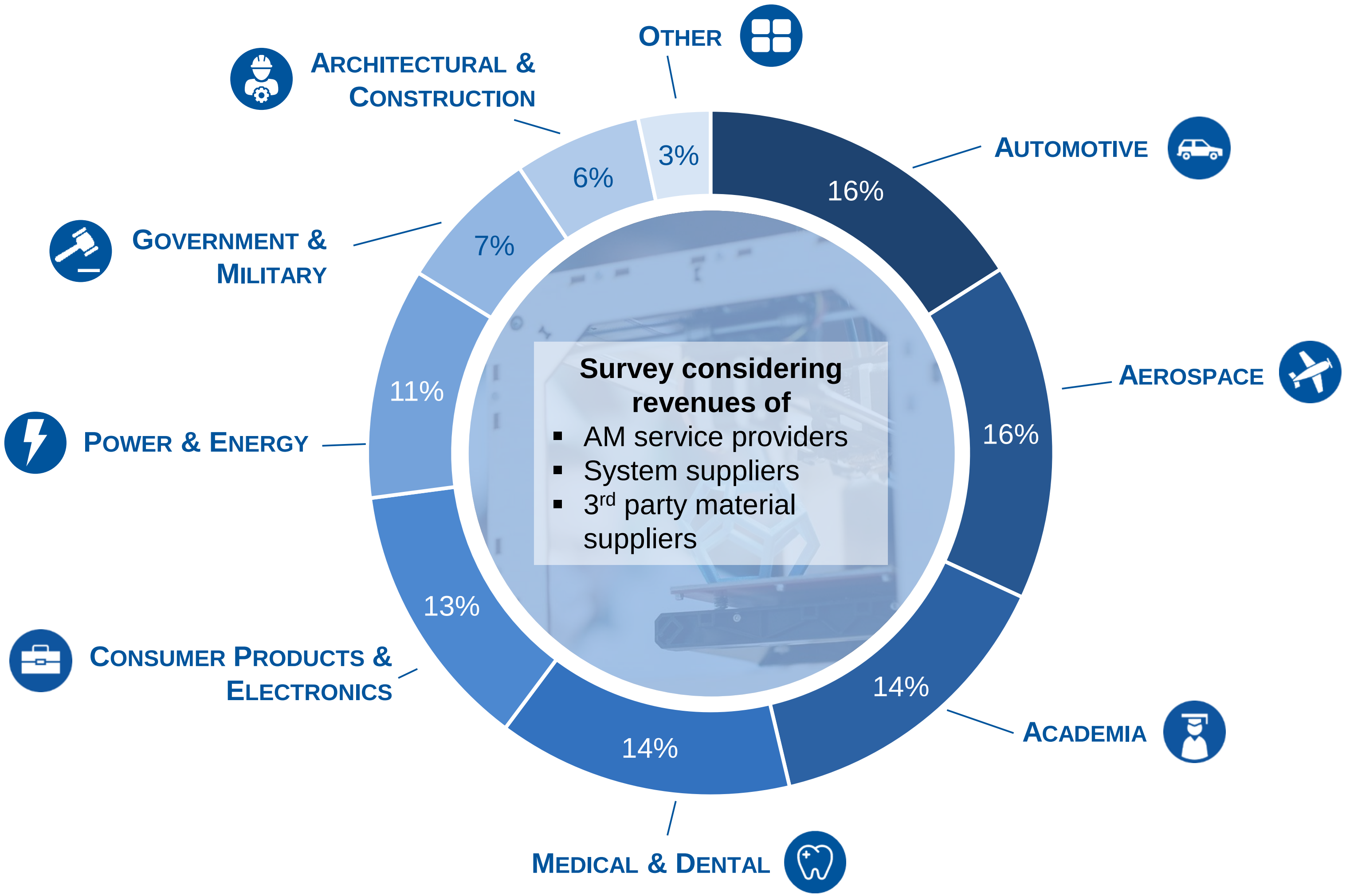


- **Overall positive** forecasted and historic growth rates in all reports
- **Diverging positive forecasts** indicate a **developing** volatile and uncertain market

- **Included revenue (primary market):**
  - AM systems
  - Software
  - Materials
  - Services

Source: Hubs Additive manufacturing trend report 2021 and cited sources

Introduction to AM
Market Overview



Source: Wohlers Report 2021

General AM Process Chain

	Pre-Processing	In-Processing	Post-Processing	Final Component
Physical Dimension	▪ Material preparation ▪ Production resource preparation ▪ Machine preparation	▪ Physical generation of geometry	▪ Build job removal and cleaning ▪ Part finishing – e.g., support removal, heat treatment, surface treatment, quality assurance	▪ Assembly ▪ Labelling, packaging, shipping
Digital Dimension	▪ Data preparation (CAD & CAM) ▪ Build job preparation ▪ Production planning	▪ Execution of machine code ▪ Printing process monitoring	▪ Acquisition and evaluation of quality assurance data	▪ Evaluation of data for long-term improvement

Introduction to AM
Key Characteristics of Additive Manufacturing

Additive

Geometry is generated by adding material instead of removing or forming

Toolless

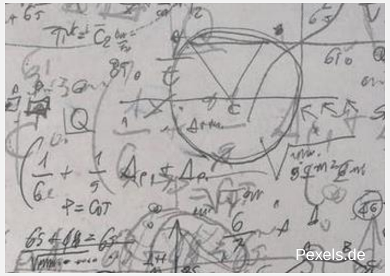
Component geometry is independent from tool

Digital

Direct manufacturing based on 3D models

Complex

Different technologies require specific expert knowledge



AM Benefits and Barriers

AM Benefits

- **Design freedom**: Complex features, lightweight, monolithic
- **Flexible design** iterations and engineering changes
- **Integration of functions**
- Economic **small quantities** and **individualization**
- **Short time** and efficiency **idea to product**
- **Short supply chain**
- **Insourcing:** Appealing due to high degree of automation
- **Sustainability** by material reduction or efficiency in performance

AM Barriers

- **Long printing times**
- Almost **no economies of scale**
- **Low surface quality** as-built
- **Large geometrical tolerances** as-built
- **Requires** “Additive Mindset” and **skills**
- **Complex quality assurance** and **certification**
- **Health and security** measures required

AM **benefits and barriers** are **not generic –** consideration of use case, AM technology and process chain mandatory

Image Sources: Unsplash, Pexels

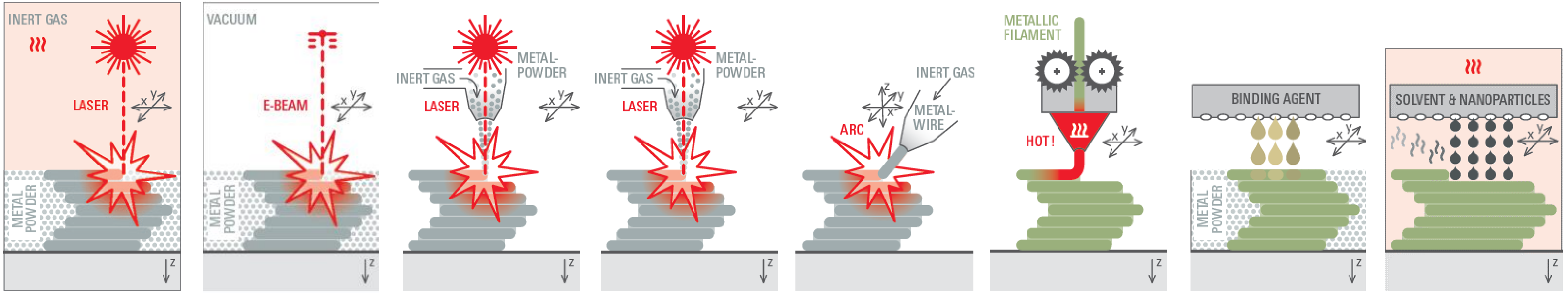
Basic AM Seminar – Content

AM Technology Overview
Segmentation of Established Metal AM Technologies

Additive Manufacturing

Metal

Powder Bed Fusion		*Direct Energy Deposition*			*Material Extrusion*	*Binder Jetting*	*Material Jetting*
Fused with laser	Fused with electron beam	Laser energy absorbed by substrate	Laser energy absorbed by powder feedstock	Fused with electric arc	With filament, green part to be sintered	Joined with bonding agent, to be sintered	Cured with heat, to be sintered
L-PBF Laser Powder Bed Fusion	**EBM** Electron Beam Melting	**LMD** Laser Metal Deposition	**EHLA** Extreme High Speed LMD	**WAAM** Wire Arc Additive Manufacturing	**Metal FDM** Metal Fused Deposition Modeling	**BJ** Binder Jetting	**NPF** Nano Particle Jetting



Source: Derived from Formnext AM Field Guide Compact and DIN EN ISO/ASTM Terminology

AM Technology Overview
Segmentation of Established Metal AM Technologies

Additive Manufacturing

Metal

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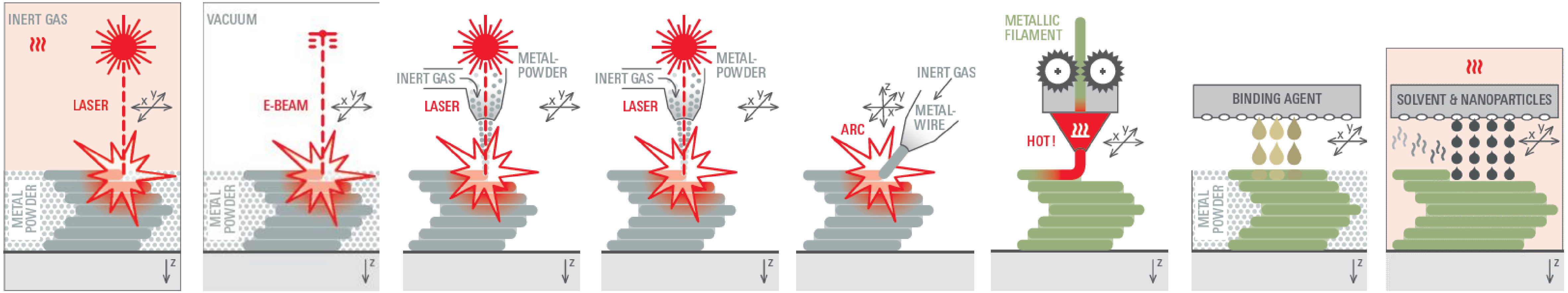
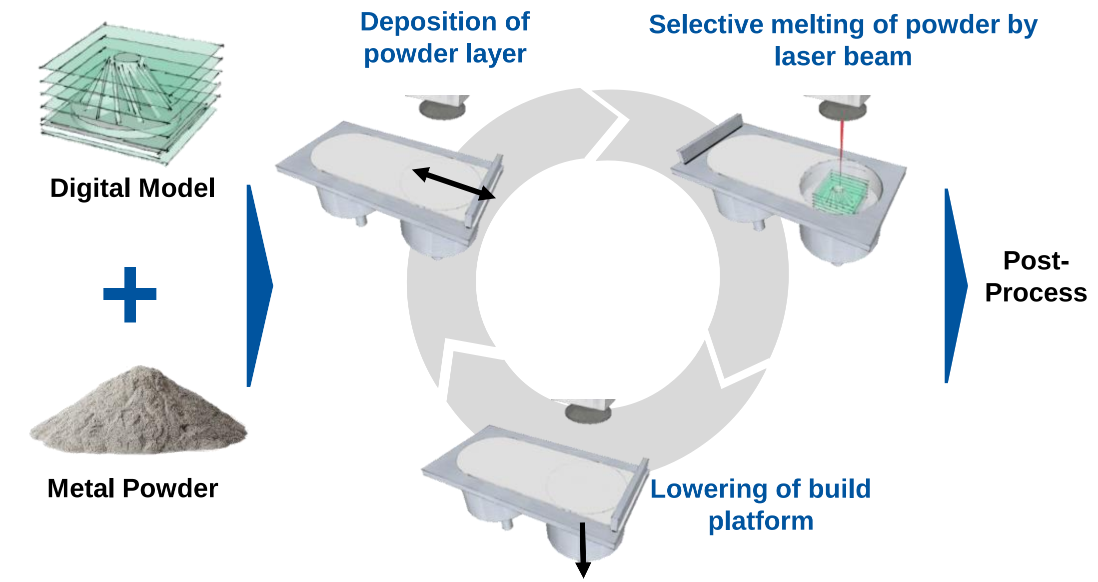


Source: Derived from Formnext AM Field Guide Compact and DIN EN ISO/ASTM Terminology

AM Technologies
Laser Powder Bed Fusion of Metal (LPBF)

Process Principle

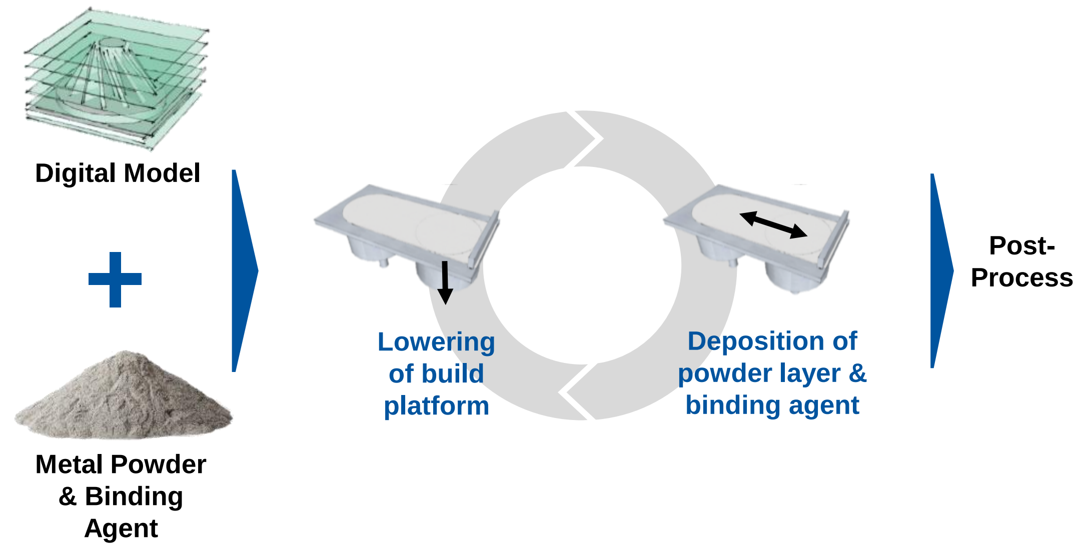


Process in Action

- Selective melting of metal powder layer-by-layer with one or more lasers
- Requires support structures for overhangs
- General suitability for weldable materials, comparably many alloys are qualified (e.g., steels, Ni based alloys, CoCr, copper and alloys, Ti and alloys, Al alloys, refractory metals, Mg alloys)

AM Technologies
Binder Jetting (BJ)

Process Principle



Process in Action

- Production of complex geometries by selective deposition of binder agent on metal powder layer by layer
- As-built part is in green state and requires further processing steps for functionality (e.g., curing, depowdering, sintering)
- Compared to LPBF lower technological maturity and less materials qualified, but potential of higher productivity

AM Technology Overview
Available Metal Materials

Precious Materials
- Mainly gold and silver material for jewelry applications

Nickel-Based
- Corrosion-resistant
- High mechanical strength
- Hardening possible

Copper Alloys
- High heat conductivity
- Low absorption of laser radiation

Cobalt-Based
- High strength & hardness
- Temperature-resistant
- Corrosion-resistant

Stainless Steel
- High ductility
- Corrosion-resistant
- Easy to post-process

Titanium Alloys
- Lightweight, high strength per density
- Corrosion-resistant

Tool Steel
- High ductility
- Corrosion-resistant
- Easy to post-process

Aluminum Alloys
- Lightweight
- Low material density
- Suitable for casting

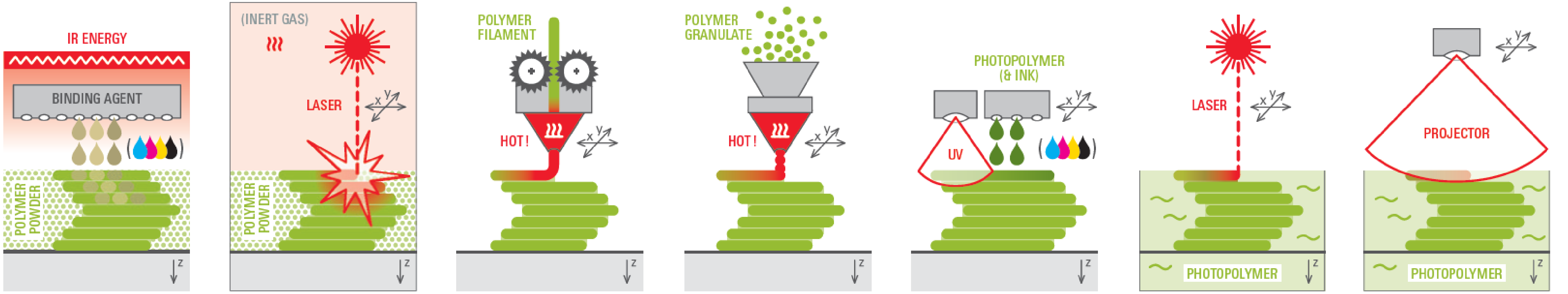
Source: BCG (2019)

AM Technology Overview
Segmentation of Established Polymer AM Technologies

Additive Manufacturing

Polymer

Powder Bed Fusion		*Material Extrusion*		*Material Jetting*	*Photopolymerization of Resins*	
Fused with agent + energy	Fused with laser	With filament	With granulate	Cured with UV light	Cured with laser	Cured with projector
MJF Multi Jet Fusion	**SLS** Selective Laser Sintering	**FDM** Fused Deposition Modeling	**Granulate FDM**	**MJ** Material Jetting	**SLA** Stereo Lithography	**DLP** Digital Light Processing



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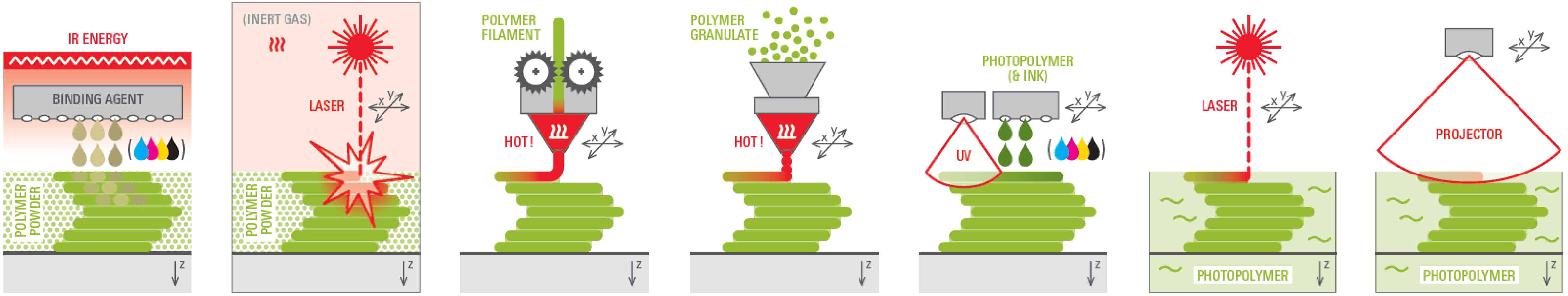
AM Technology Overview
Segmentation of Established Polymer AM Technologies

Additive Manufacturing

Polymer

Powder Bed Fusion		*Material Extrusion*		*Material Jetting*	*Photopolymerization of Resins*	
Fused with agent + energy	Fused with laser	With filament	With granulate	Cured with UV light	Cured with laser	Cured with projector
MJF Multi Jet Fusion	**SLS** Selective Laser Sintering	**FDM** Fused Deposition Modeling	**Granulate FDM**	**MJ** Material Jetting	**SLA** Stereo Lithography	**DLP** Digital Light Processing



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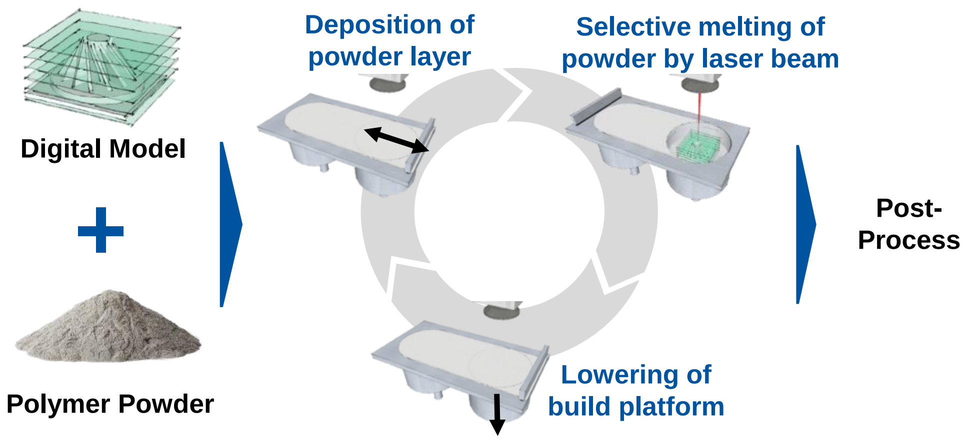
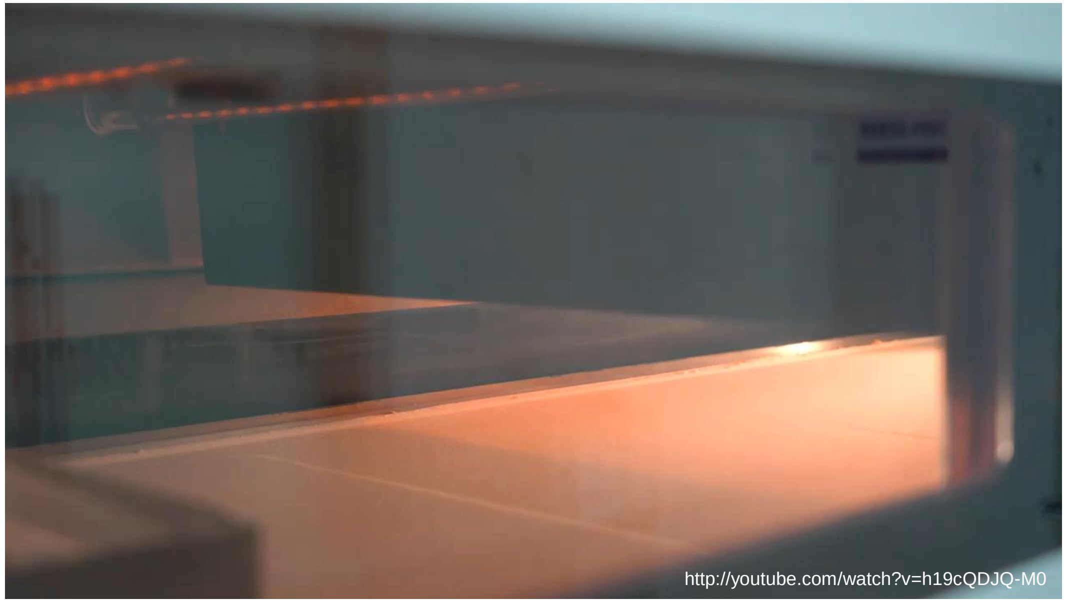
AM Technologies
Selective Laser Sintering (SLS)

Process Principle



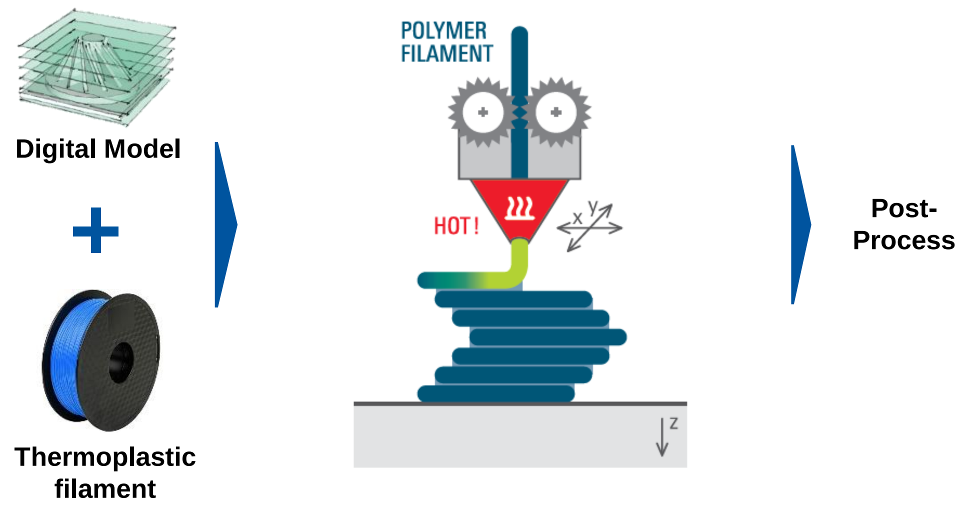
Process in Action



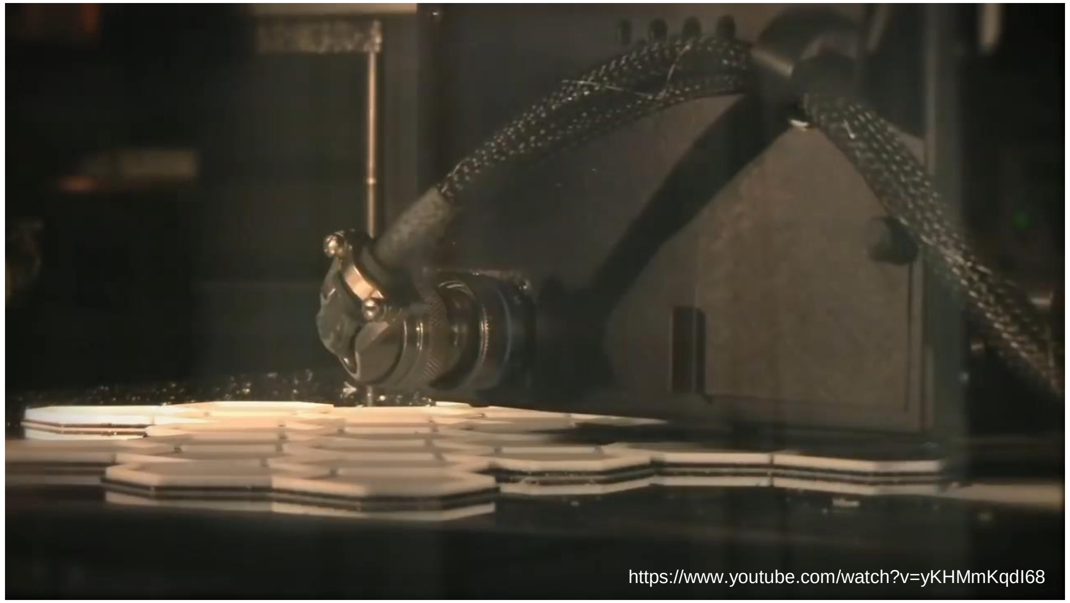
- Production of complex geometries by selective melting of polymer powder with one or more lasers
- As-built parts are usually white (polymer color)
- Many different materials available (e.g., PA11, PA12, TPU, PEEK, TPE, PP)

AM Technologies
Fused Deposition Modeling (FDM)

Process Principle

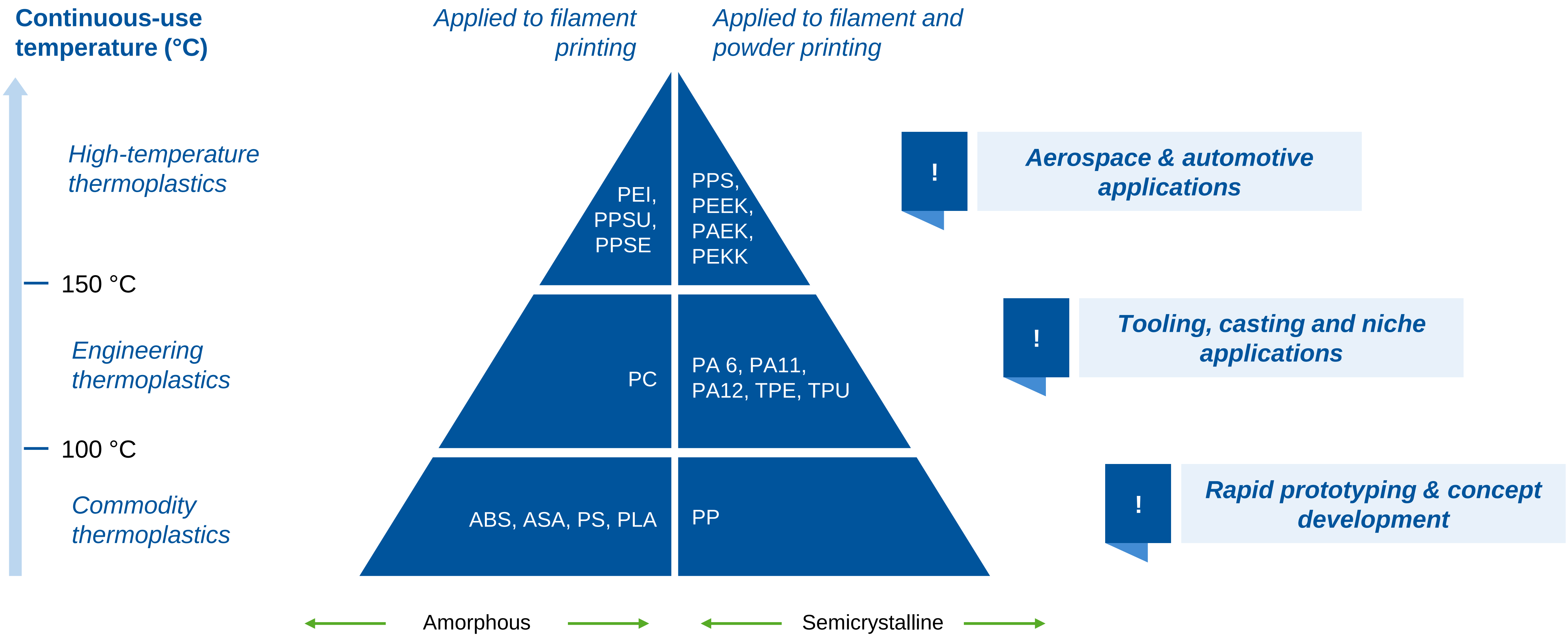


Process in Action



- Thermoplastic filament is molten and extruded through a hot nozzle
- Support structures are required for overhangs
- Use in industry, but also huge open source and DIY community
- Many materials available (e.g, PLA, ABS, PP, PA, PC, TPE, TPC, TPU, PEEK, PEKK, PPSU, PEI)

AM Technology Overview
Available Polymer Materials

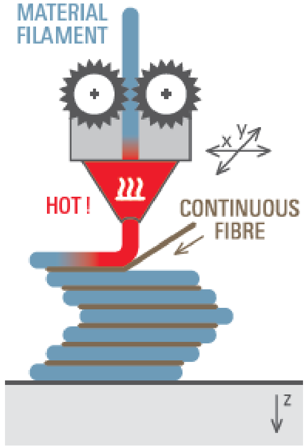


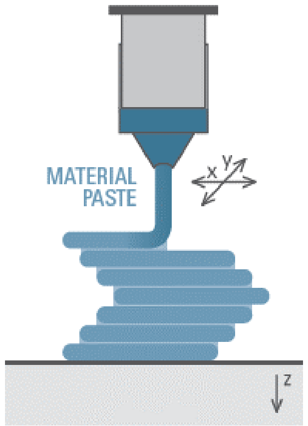
Source: 3DMaker Engineering, RapidMade, EOS, BigRep

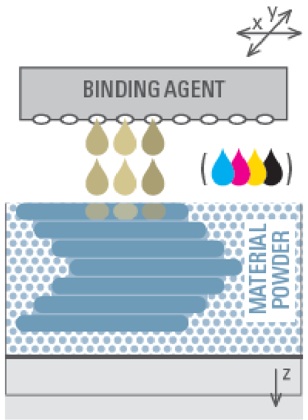
AM Technology Overview
Segmentation of Other AM Technologies

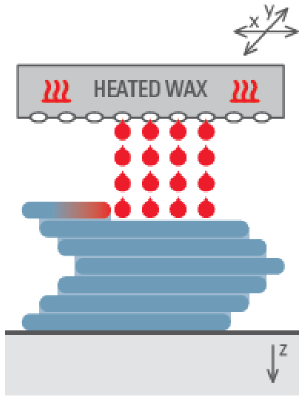
Additive Manufacturing

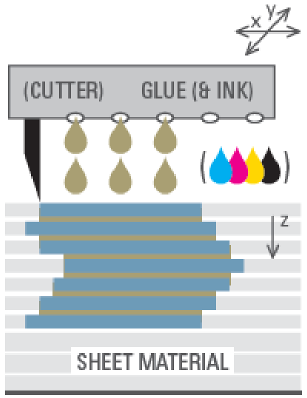
Reinforced polymer fibers	Any material paste	Sand or gypsum	Wax	Composite or paper
Material Extrusion	*Material Extrusion*	*Binder Jetting*	*Material Jetting*	*Sheet Lamination*
Material extrusion of **composite**	Paste extrusion of **any material**	Joined **sand or gypsum** with bonding agent,	Selective application of **wax** droplets	Cured with projector
CFF Continuous Filament Fabrication	**PEM** Paste Extrusion Modeling	**BJ** Binder Jetting	**DOD** Drop on Demand	**SDL / LOM** Selective Deposition Lamination / Laminated Object Manufacturing











Source: Derived from Formnext AM Field Guide Compact and DIN EN ISO/ASTM Terminology

Basic AM Seminar – Content

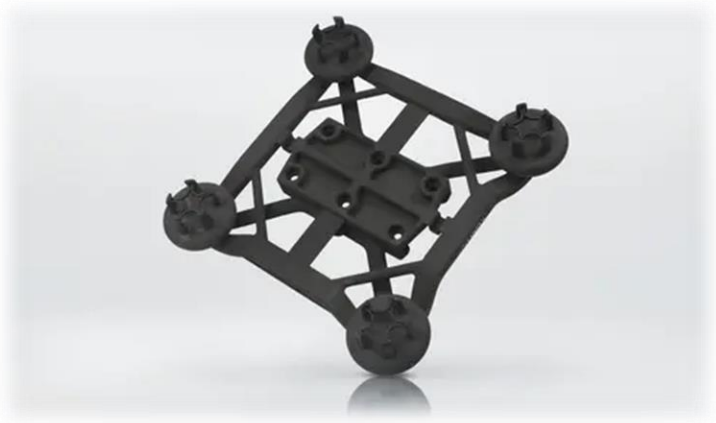
AM Application Examples
Wittmann Robot Systeme GmbH Bronchial Gripper

Characteristics

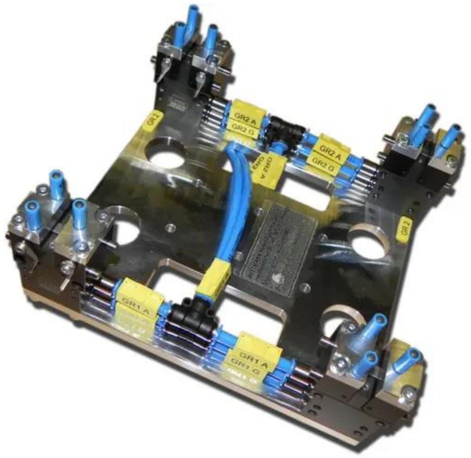
- Bronchial gripper with functional plate made of polyamide
- EOS technology in collaboration with KuhnStoff
- Over 5 million work cycles without downtime
- Direct integration of pneumatic connections and lines into the plate
- Reduction of components from 21 to only two

Utilized AM Benefits

- Weight reduction by 86% to only 220 g
- Significant cost reduction by using less material and fewer parts
- Short production time: Reduced from twelve days to just three working days



Additively manufactured
Weight: 220 g
Pieces: 2



Milled steel
Weight: 1570 g
Pieces: 21

Source: EOS, Wittmann

AM Application Examples
Schmalz GmbH Individual Vacuum Grippers

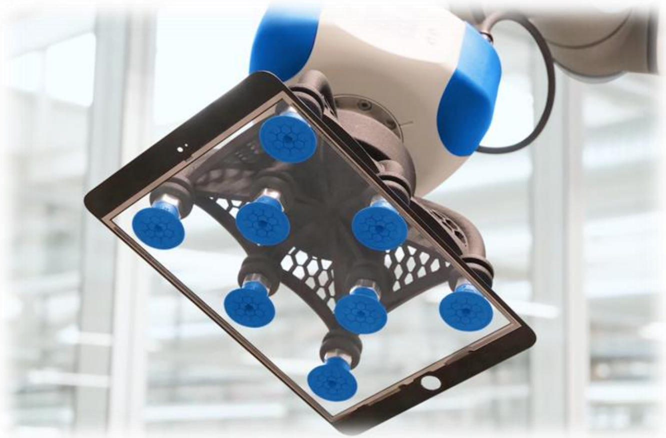
Characteristics

- In collaboration with trinckle 3D GmbH, a digital platform for the configuration of grippers was developed
- The gripper can be individually configured in six steps
- Individually designed grippers are particularly light and robust, specially designed for the respective application

Utilized AM Benefits

- Fast and flexible production of individual gripping solutions
- Reduced interference contours through integration of functions directly into the design
- Enables the combination of the gripper with different vacuum components

Additively manufactured gripper



Source: Schmalz, Trinckle

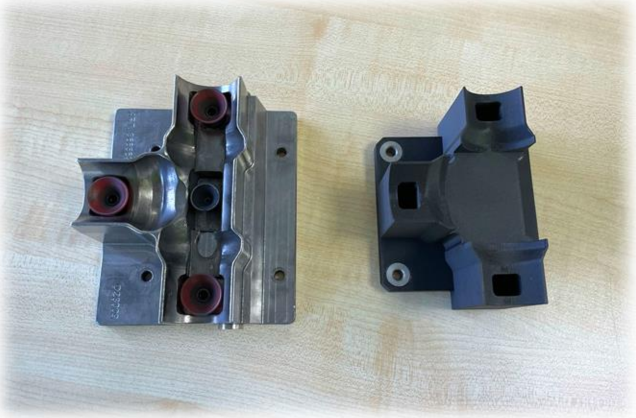
AM Application Examples
Beulco GmbH Parallel and Suction Gripper

Characteristics

- Individual workpiece contours with over 300 variants lead to high tooling costs
- Requirement for cost-efficient and adaptable gripper alternatives to conventional metal grippers
- 3D-Printed with carbon continuous fiber reinforced polymer FDM technology on Markforged 3D printers (Mark3D)

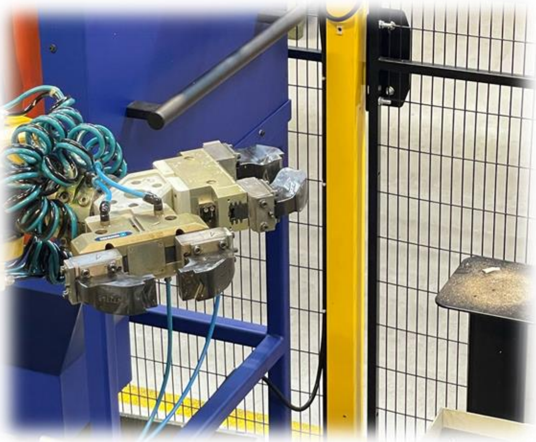
Utilized AM Benefits

- Shortening of delivery times
- Total savings of €200,000 on over 330 printed pairs of grippers and suction gripper



Milled steel
Weight: 3194 g
Costs: 1.145,00 €
Delivery Time: 4-6 weeks

Additively manufactured
Weight: 189 g
Cost: 100 €
Delivery time: 24 hours



Source: mark3D, Beulco

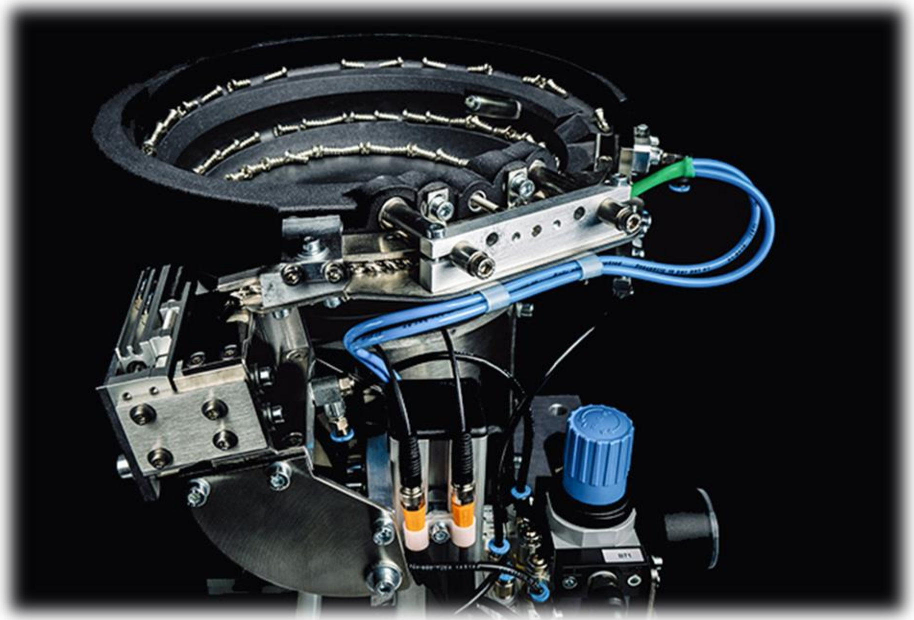
AM Application Examples
RNA GmbH Vibratory Conveyors

Characteristics

- SLS-3D printed vibratory conveyors
- The high-performance magnets used enable a high load-independent conveying capacity
- 3D deep learning AI technology helps optimization of geometry

Utilized AM Benefits

- Completely reproducible
- Flexible and can be quickly converted for other workpieces
- Different parts from the same part family can be fed



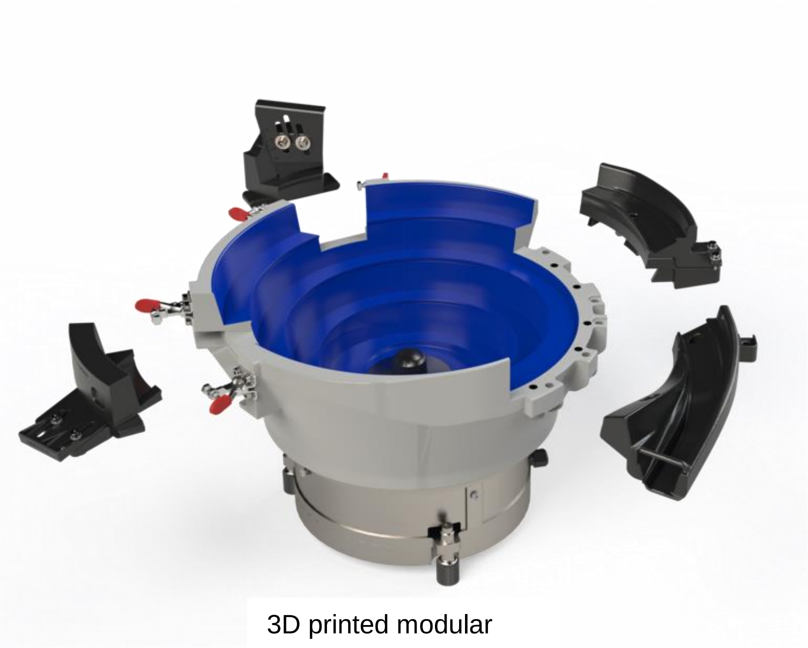
3D printed vibratory conveyor drive

Source: RNA

AM Application Examples
IFC GmbH Conveyor Pots

Characteristics

- Conveyor pot for automated feeding of bulk material
- Printed with HP Multi Jet Fusion technology
- Modular system with a "base pot" that can be flexibly adapted to different bulk materials



3D printed modular conveyor pot

Utilized AM Benefits

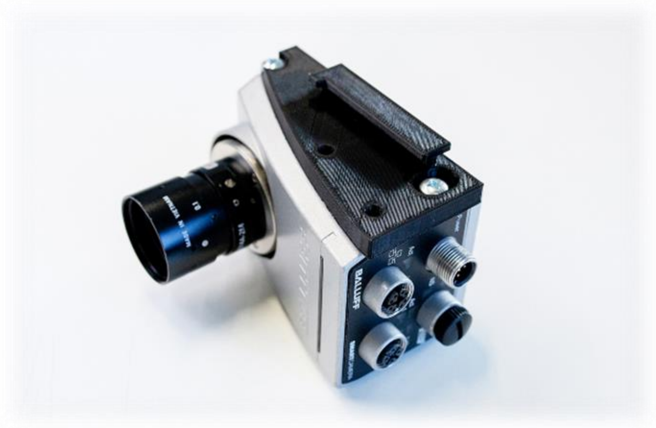
- Higher flexibility due to easier change of components for different bulk materials
- Cost efficiency due to lower manufacturing costs and avoidance of costly warehousing
- Lighter weight leads to reduced vibration and lower energy consumption and is therefor more efficient and sustainable

Source: IFC GmbH, Industrieanzeiger

AM Application Examples
3DGence Mounting Brackets for Camera Systems

Characteristics

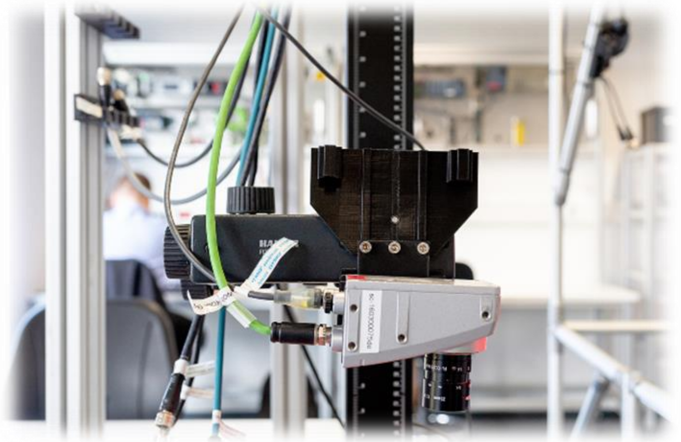
- Customization and production of customer-specific mounting brackets for industrial cameras
- FDM-printed from ABS



Additively manufactured assembly element

Utilized AM Benefits

- Fast and precise production of individual brackets
- Reduced production costs compared to traditional manufacturing methods
- Complete control over the geometry of the printed parts and reduce the need for retouches



Source: 3DGence

AM Application Examples
Research Project AddFlex of WZL of RWTH Aachen University

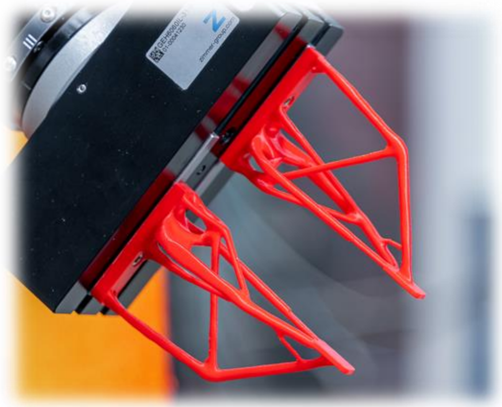
Characteristics

- Automated generative design of adaptive lightweight gripper fingers
- Simulation of the gripper supports the generation of a digital twin of the gripper in the gripping process
- FDM 3D-printed gripper fingers

Utilized AM Benefits

- After usage, grippers can be shredded and recycled material can be used to 3D-print new grippers
- Individualized gripper fingers increase flexibility and decrease cost for handling

Additively manufactured lightweight gripper fingers



Source: WZL of RWTH Aachen University

Basic AM Seminar – Content

Successful Adaption of AM
Benefits Through an "Additive Mindset"

Comparing Apples with Oranges…

***Successful AM adaption** requires **consideration of AM differences**. Without change of expectations, AM turns out as a poor substitute for established processes.*

…Additive Manufacturing is different

Different cost structure

Financial return and **technological feasibility** must be considered in **identification of parts with positive business case**

Enables **new business models** such as mass customization or digital warehousing

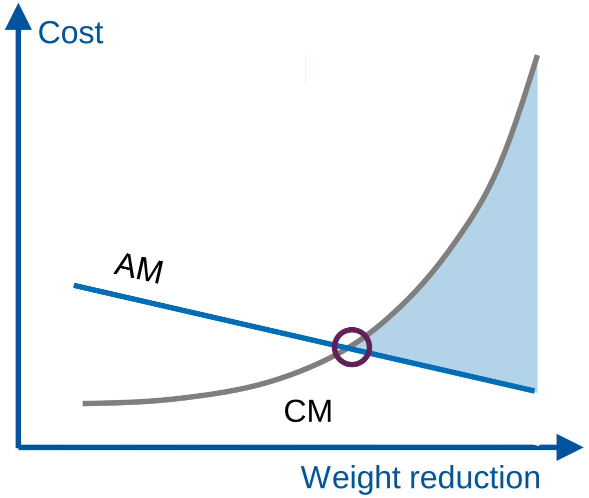
Products and required expertise along the product life cycle are different (e.g. Design for Additive Manufacturing)

Some AM technologies require complex **health & security measures**

Source: Effectory, TCT

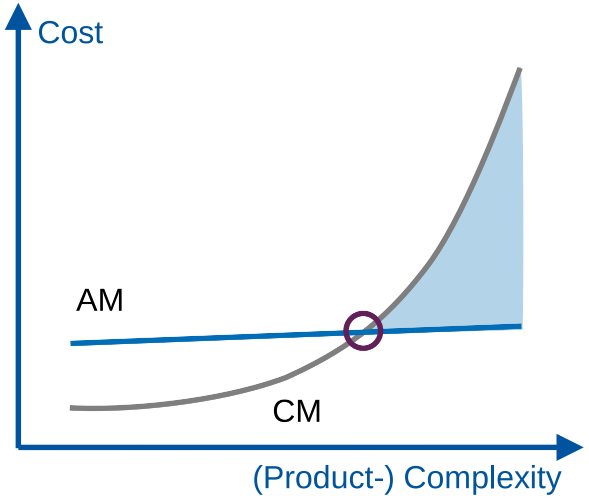
Successful Adaption of AM
Different Cost Structure of Conventional Manufacturing (CM) and AM

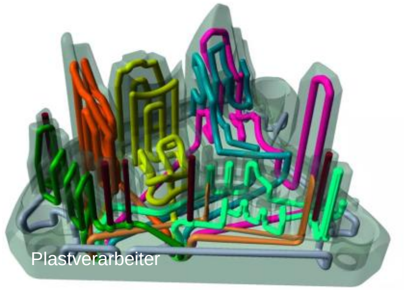
Weight reduction means cost reduction



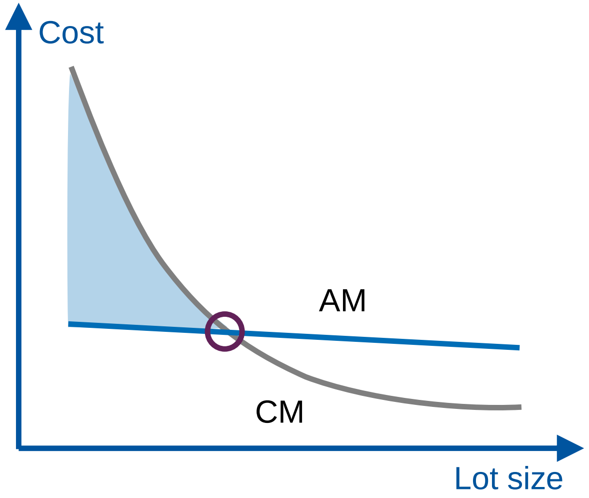

BMW Group

Complexity (almost) for free




Plastverarbeiter

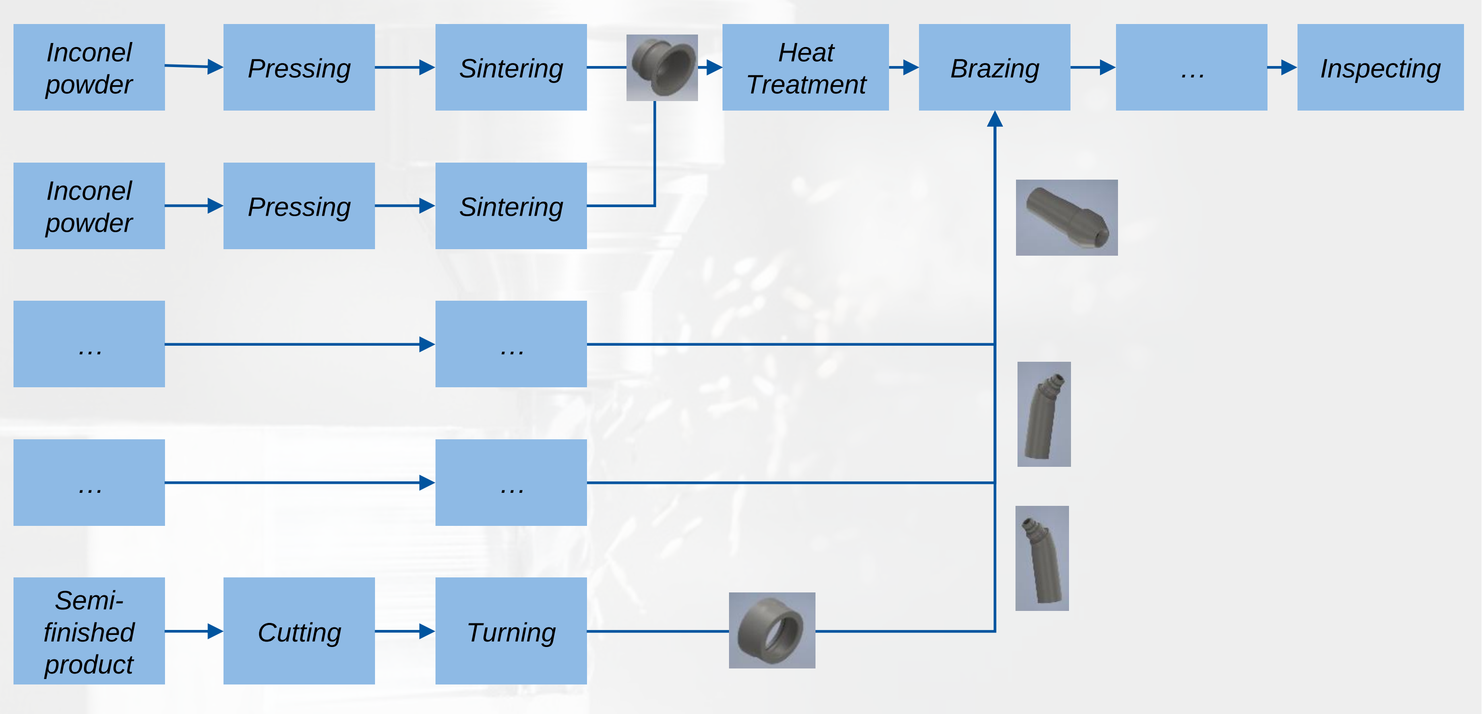
Individualization (almost) for free



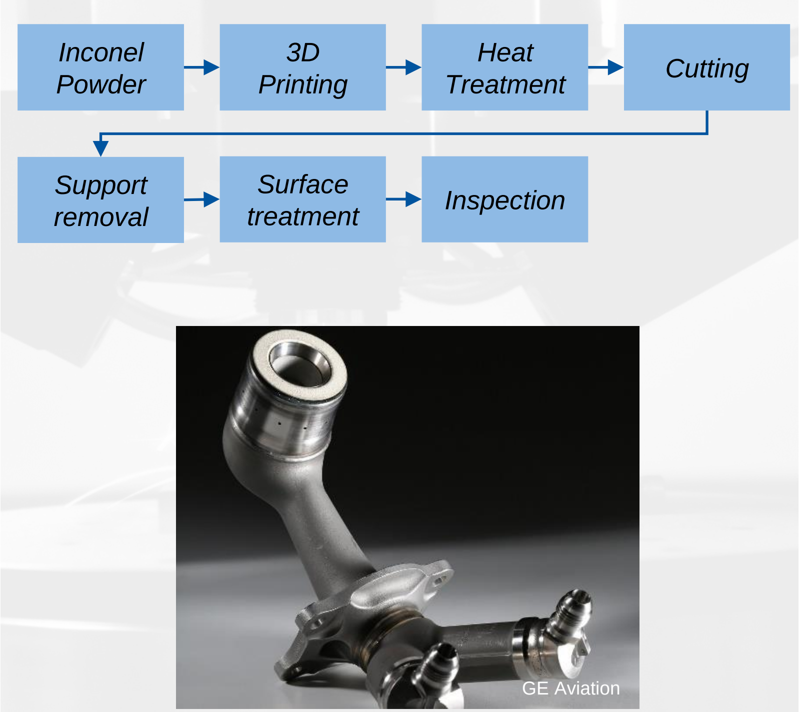

EOS

Successful Adaption of AM
Different Process Chains Result in Different Manufacturing Cost Structure

Conventional process chain



Additive process chain



Additive Manufacturing allows to transfer process chain complexity to part design (e.g. through part consolidation)

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Benefits Through an "Additive Mindset"

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…Additive Manufacturing is different

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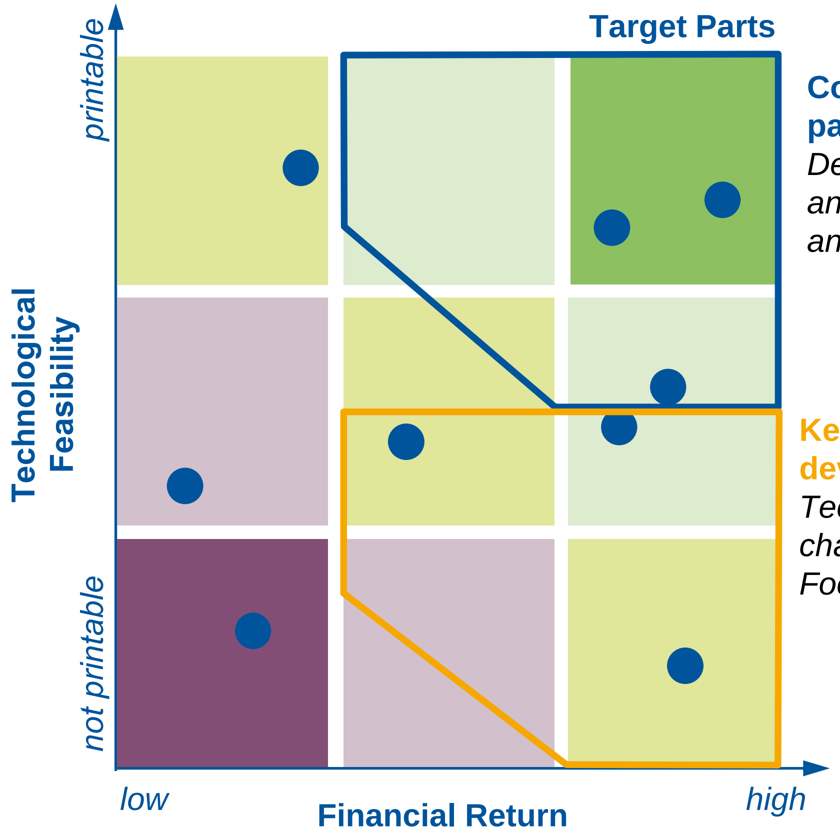
Source: Effectory, TCT

Successful Adaption of AM
Benefits Through an "Additive Mindset"

Part identification process

- *Preliminary Selection*
- *Financial Assessment*
- *Technological Assessment*
- *Implementation*

Mapping of possible candidates to find target parts for implementation



Collaboration with technology partners:
Development of prototype components and processes to validate assumptions and prove AM feasibility

Keeping in backlog for future developments:
Technology and market evolution can change the feasibility status of parts. Focus on parts with high potential ROI

Source: ACAM Webinar "Software or Expert? Part Identification for Additive" with RWTH DAP

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Source: Effectory, TCT

Successful Adaption of AM
Business Models Based on AM

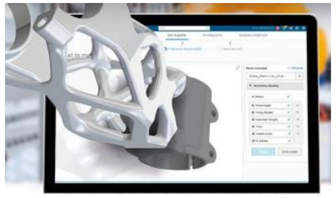
AM Benefits

- **Design freedom**: Complex features, lightweight, monolithic
- **Flexible design** iterations and engineering changes
- **Integration of functions**
- Economic **small quantities** and **individualization**
- **Short time** and efficiency **idea to product**
- **Short supply chain**
- **Insourcing:** Appealing industrialized countries & high degree of automation
- **Sustainability** by material reduction or efficiency in performance

Enabled business models for AM users (not conclusive)

Digital spare part warehouse

Service provider



Online marketplace

Mass customization

Co-Production

Others …

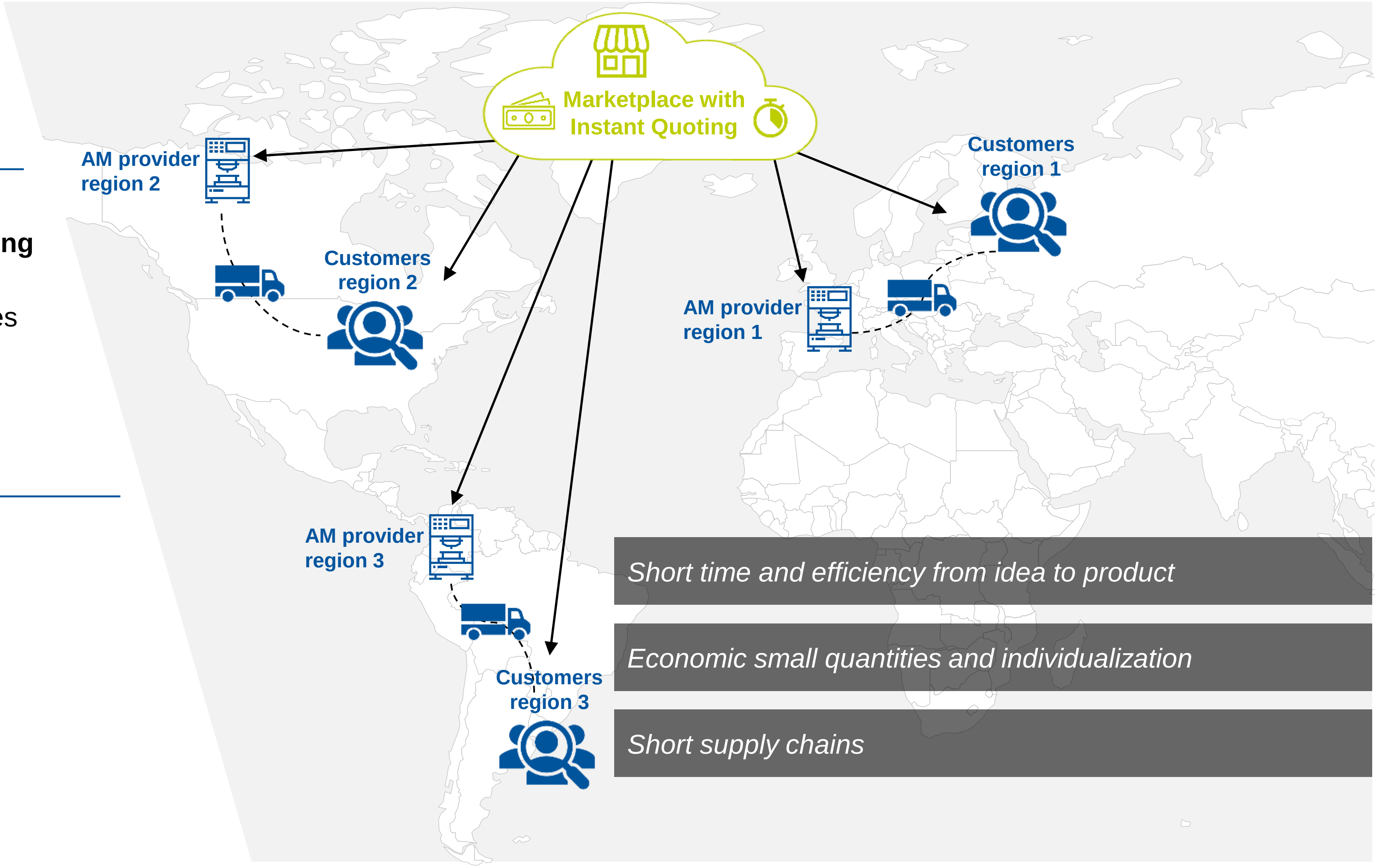
Successful Adaption of AM
Online Marketplaces with integrated AM Service Providers

Online marketplace for AM

- Integration of **AM service providers**
- Platform for customers to **compare manufacturing services** of different providers
- **Instant quoting tool** with price and delivery dates based on CAD upload by customer
- **Automated design check** of uploaded models

Exemplary AM marketplaces

- Protiq
- Xometry
- Hubs
- Jellypipe
- HP Digital Manufacturing Network
- …



Short time and efficiency from idea to product

Economic small quantities and individualization

Short supply chains

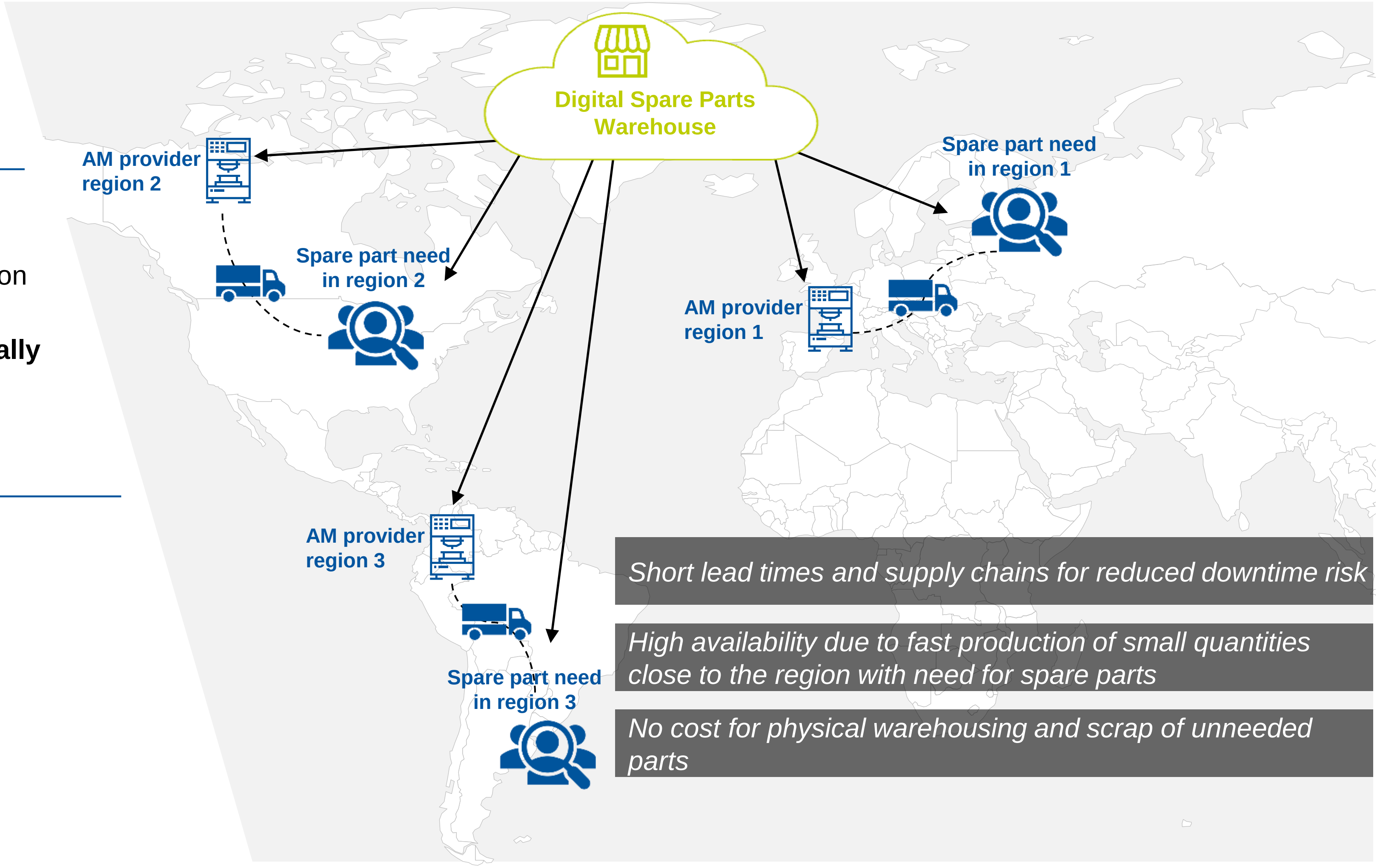
Successful Adaption of AM
Digital Spare Parts Warehouse

Digital Spare Parts Warehouse

- **No physical warehousing**
- **Digitization** of additively manufacturable spare parts & backup in virtual warehouse Production "on demand"
- Also used to **supplement obsolete conventionally manufactured parts**

Exemplary Digital Spare Parts Warehouses

- Wilhelmsen and thyssenkrupp
- FIT AG
- EvoBus GmbH, Daimler Group
- Shell
- …



Short lead times and supply chains for reduced downtime risk

High availability due to fast production of small quantities close to the region with need for spare parts

No cost for physical warehousing and scrap of unneeded parts

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Benefits Through an “Additive Mindset“

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Successful AM adaption *requires* ***consideration of AM differences****. Without change of expectations, AM turns out as a poor substitute for established processes.*

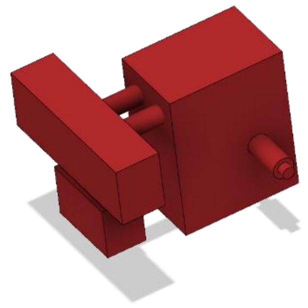
…Additive Manufacturing is different

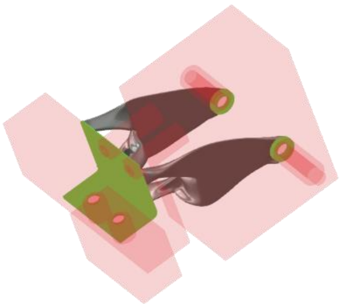
- **Different cost structure:** High upfront investment costs and high material prices, but not driven by economies of scale
- **Financial return** and **technological feasibility** must be considered in **identification of parts with positive business case**
- Enables **new business models** such as mass customization or digital warehousing
- **Products and required expertise** along the product life cycle are different (e.g. Design for Additive Manufacturing)
- Some AM technologies require complex **health & security measures**

Source: Effectory, TCT

Algorithmic Design for Additive Manufacturing – Generative Design

Definition of design space → *Definition of manufacturing constraints* → *Definition of loading and boundary conditions* → *Algorithmic shape optimization* → *Evaluation and adaption of generated options by engineer*





Design and process know how engineer

Algorithmic optimization

Decision by engineer

Source: RWTH DAP, e.GO

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Source: Effectory, TCT

Successful Adaption of AM
Health & Safety Risks and Measures for Prevention

Risks of Metal Powder

GHS05: Corrosive

GHS01: Explosive

GHS02: Flammable

GHS03: Oxidizing

GHS06: Toxic

GHS07: Harmful

GHS08: Health hazards

GHS09: Environmental hazards

Health & Safety Measures

Standard PPE

- Protective gloves
- Work protective clothing
- Respirator mask
- Tight-closing safety goggles
- Anti-static work shoes

Extended PPE

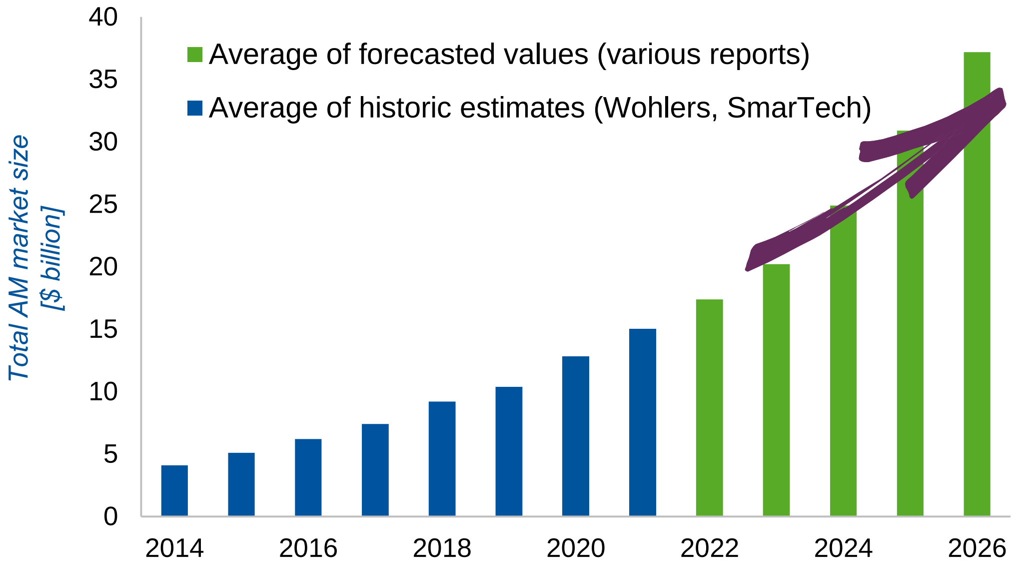
- Heat-protective gloves
- Flameproof clothing
- Full respiratory mask
- Protective shield
- ESD wristband

Prevention of health hazards requires implementation of specific safety measures

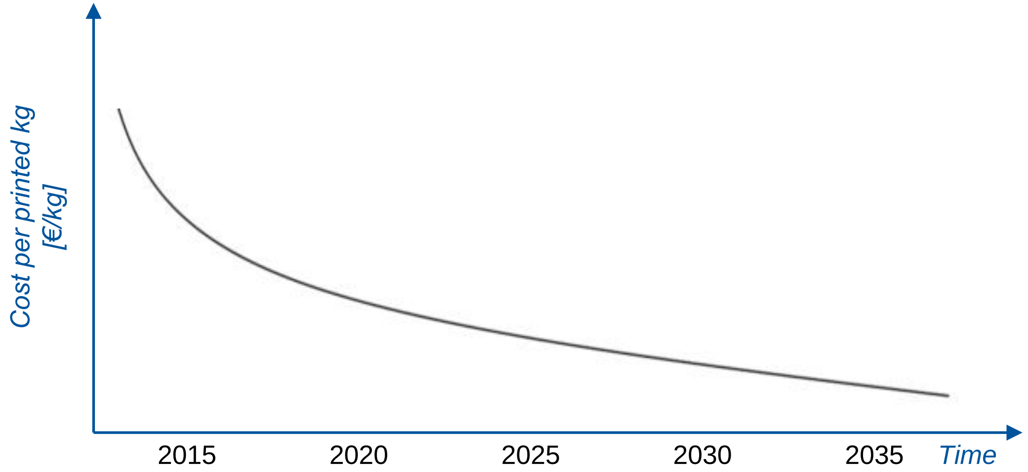
Basic AM Seminar – Content

Future Perspective of AM
What Does the Future Hold for Additive Manufacturing?

Expected market development



Expected cost development



- *Increase of machine productivity*
- *Decrease of material prices*
- *Higher technology readiness level*
- *Higher degree of automation*

**Forecasted continuous strong growth and reduced costs.
Current barriers of AM are addressed in industry and ongoing research and development.**

Source: Audi AG, Hubs, Wohlers, SmarTech, Metal-AM

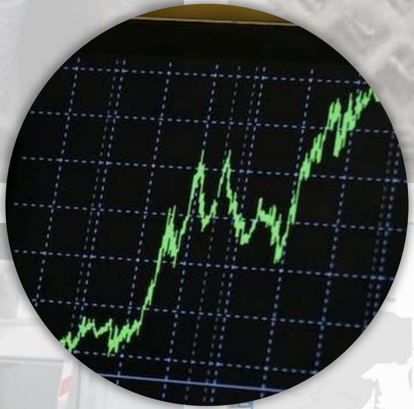
Future Perspective of AM
Key Aspects

Emerging AM Technologies

RWTH DAP

Digital Materials

Altair Enlighten



Automation & Line Integration

IDAM, BMW

Digital & Sustainable Business Models

RWTH DAP

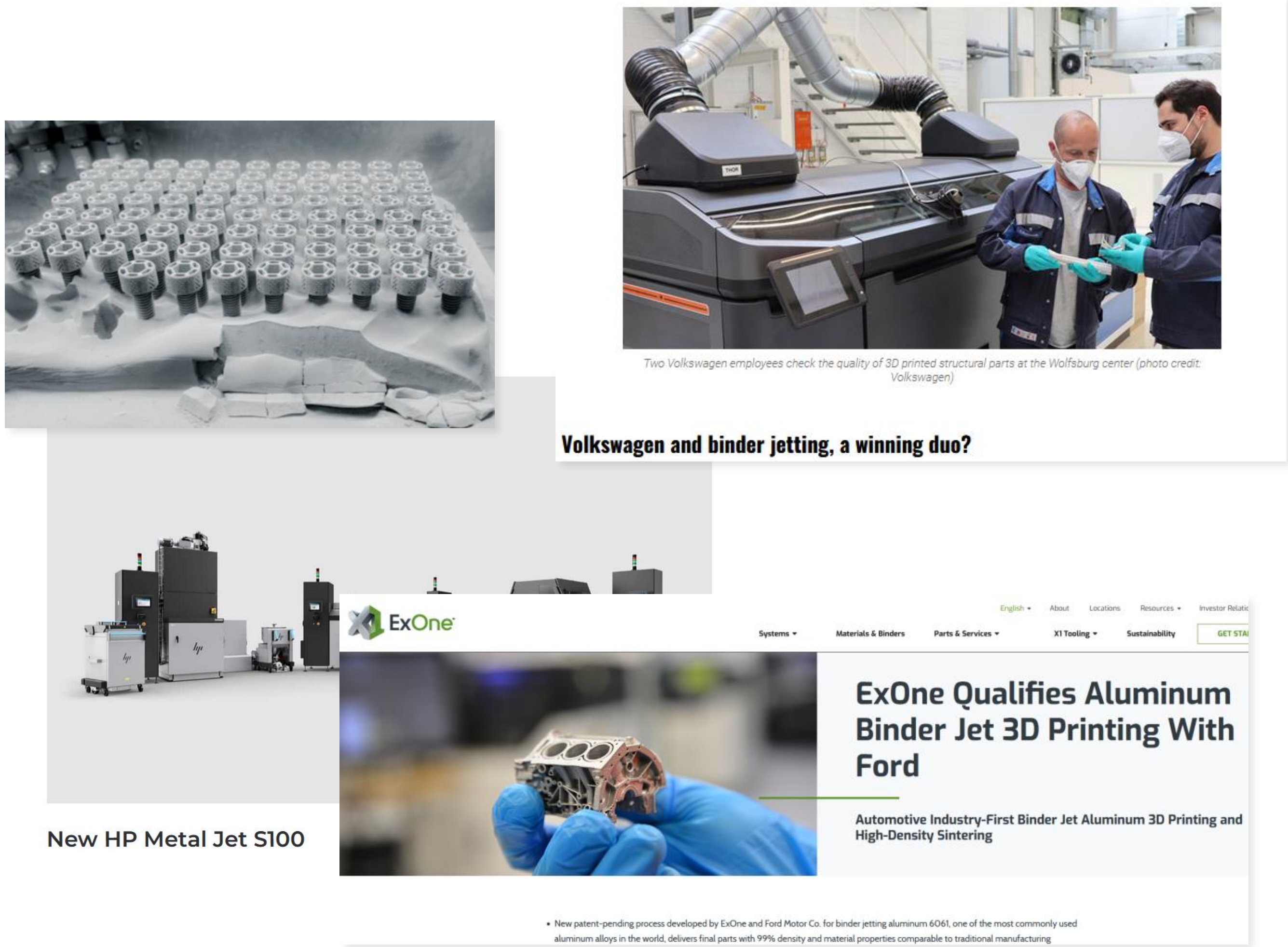
Emerging AM Technologies – Metal Binder Jetting for Mass Production

Expectations in productivity

- More parts per build job due to 3D nesting compared to 2D nesting with LPBF
- Faster printing speed especially with high filling degree

Barriers for realization

- Additional process steps: Debinding & Sintering
- Automation, e.g., removal of green parts from powder cake
- Comparably low technology maturity compared to LPBF

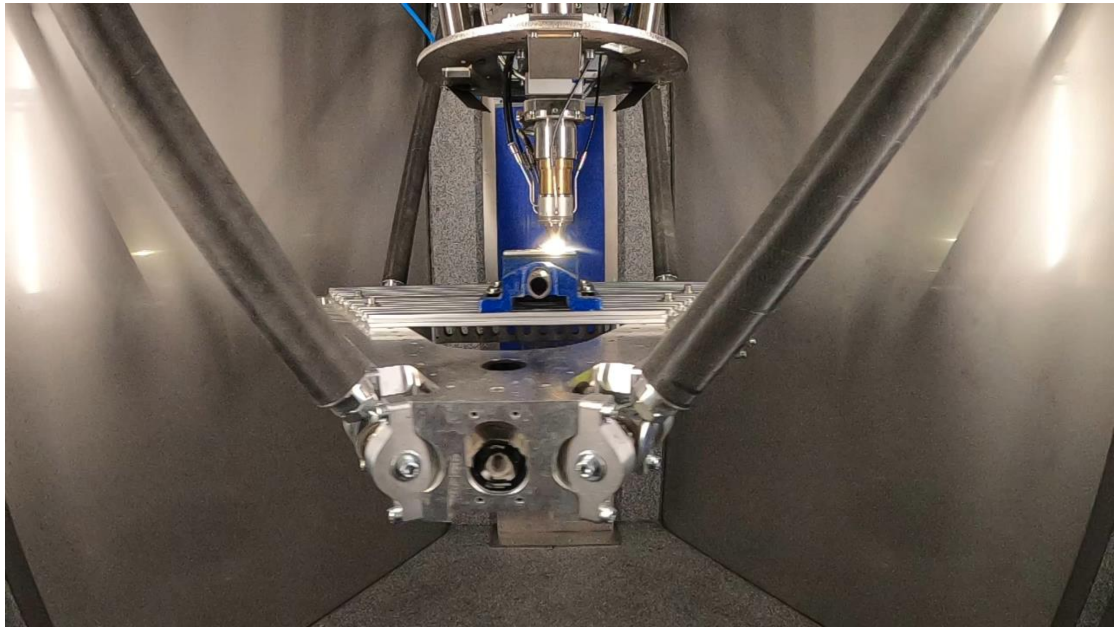


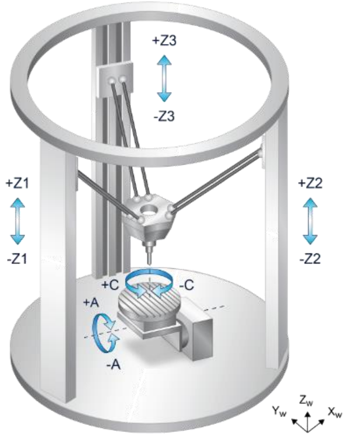
Source: ExOne, 3Dnatives, AFMG, HP

Future Perspective of AM
Emerging AM Technologies – EHLA for Non-Rotational Symmetric Parts

Characteristics of the 3D EHLA Process

- Additive coating and manufacturing of components
- Non-rotationally symmetric components possible
- Complex surfaces can be coated locally
- Wide variety of materials
- Develop and process new types of alloys



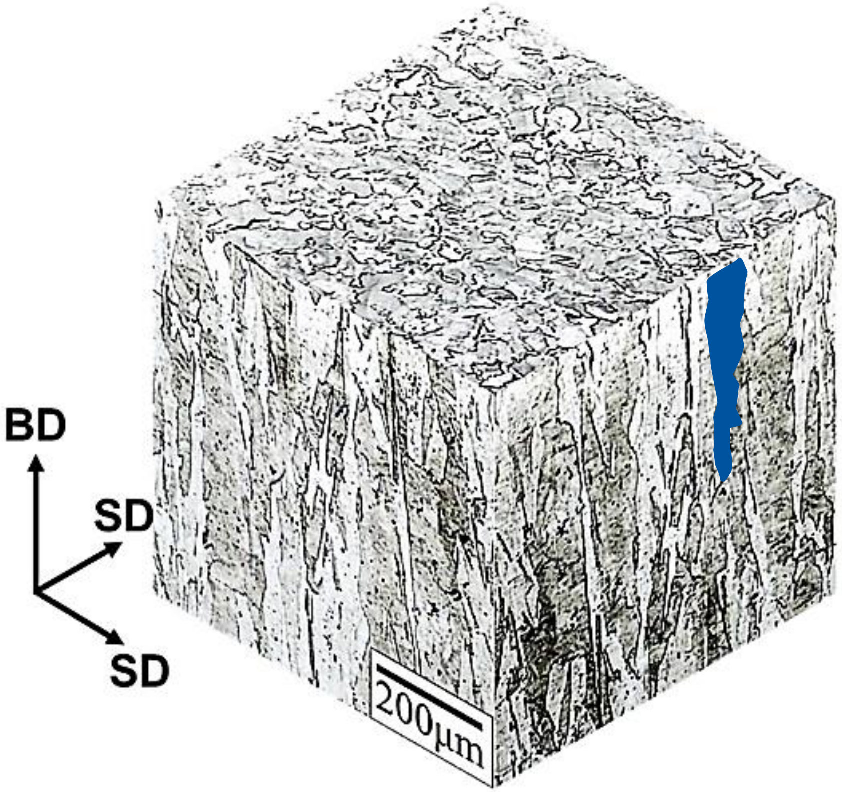


Tripod Kinematics

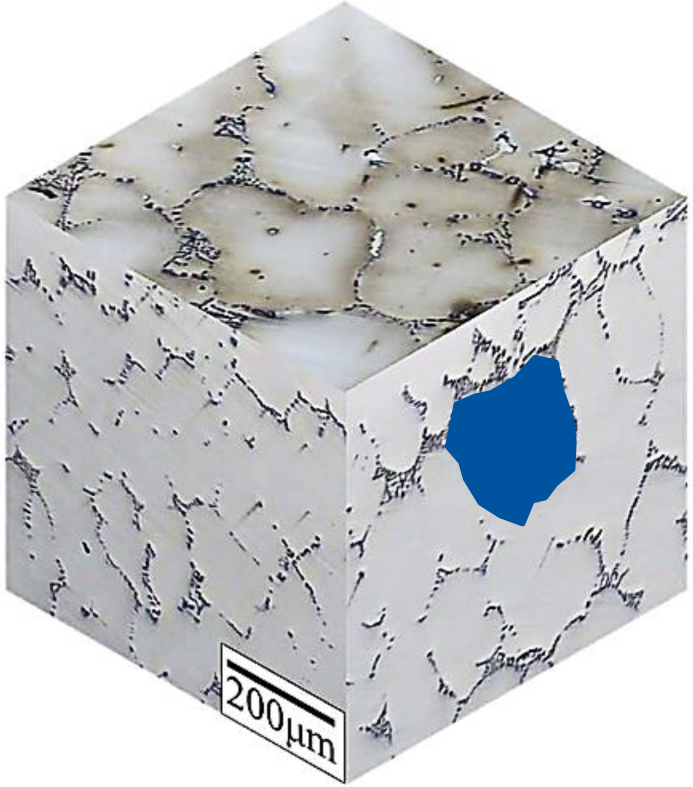
Source: Courtesy of Ponticon

Future Perspective of AM
Digital Material – Different Microstructure with Influence on Mechanical Properties

BD: build direction
SD: side direction



Microstructure after LPBF

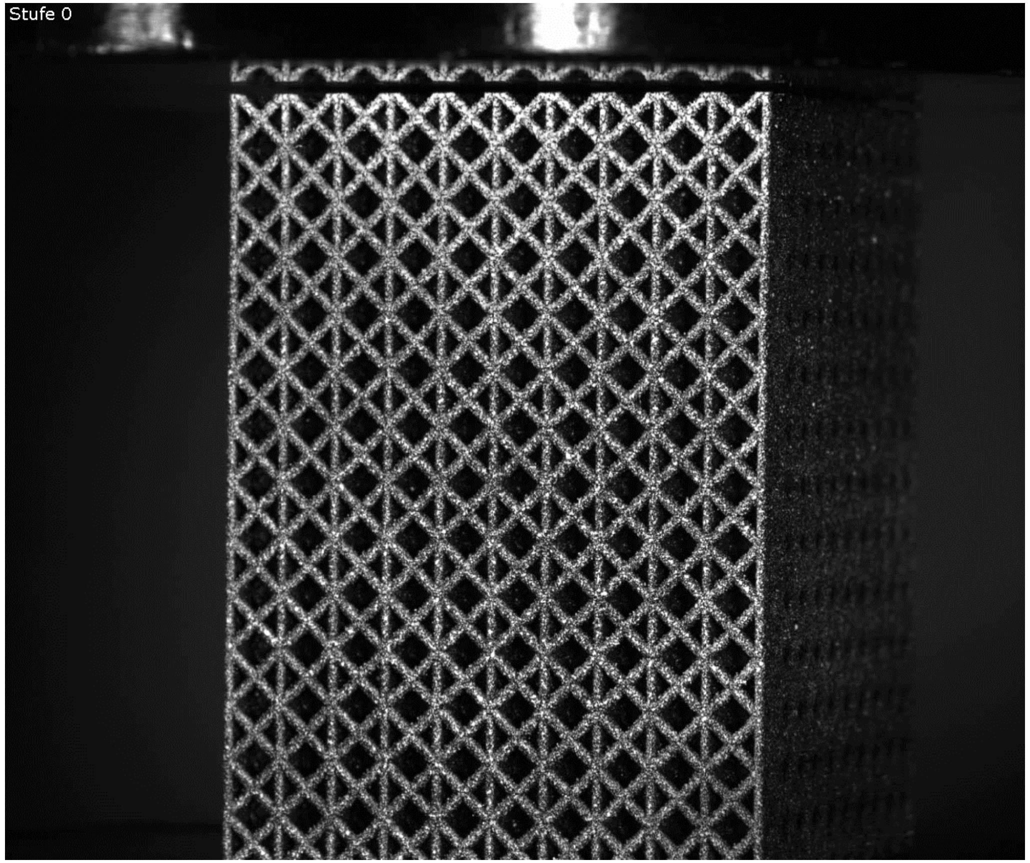


Microstructure after casting

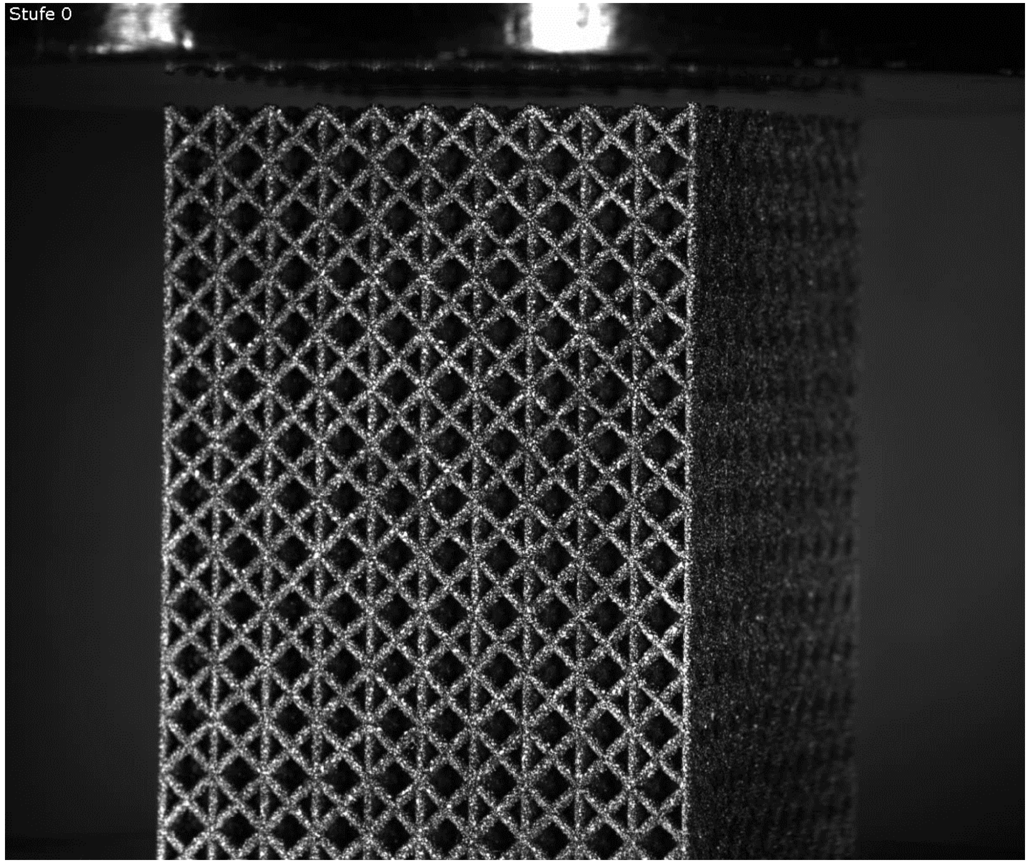
Source: Manfredi, D., & Bidulský, R. (2017). Laser powder bed fusion of aluminum alloys. *Acta Metallurgica Slovaca*, *23*(3), 276-282.

Future Perspective of AM

Digital Material – Illustration of the Effect of Locally Adapted Microstructure



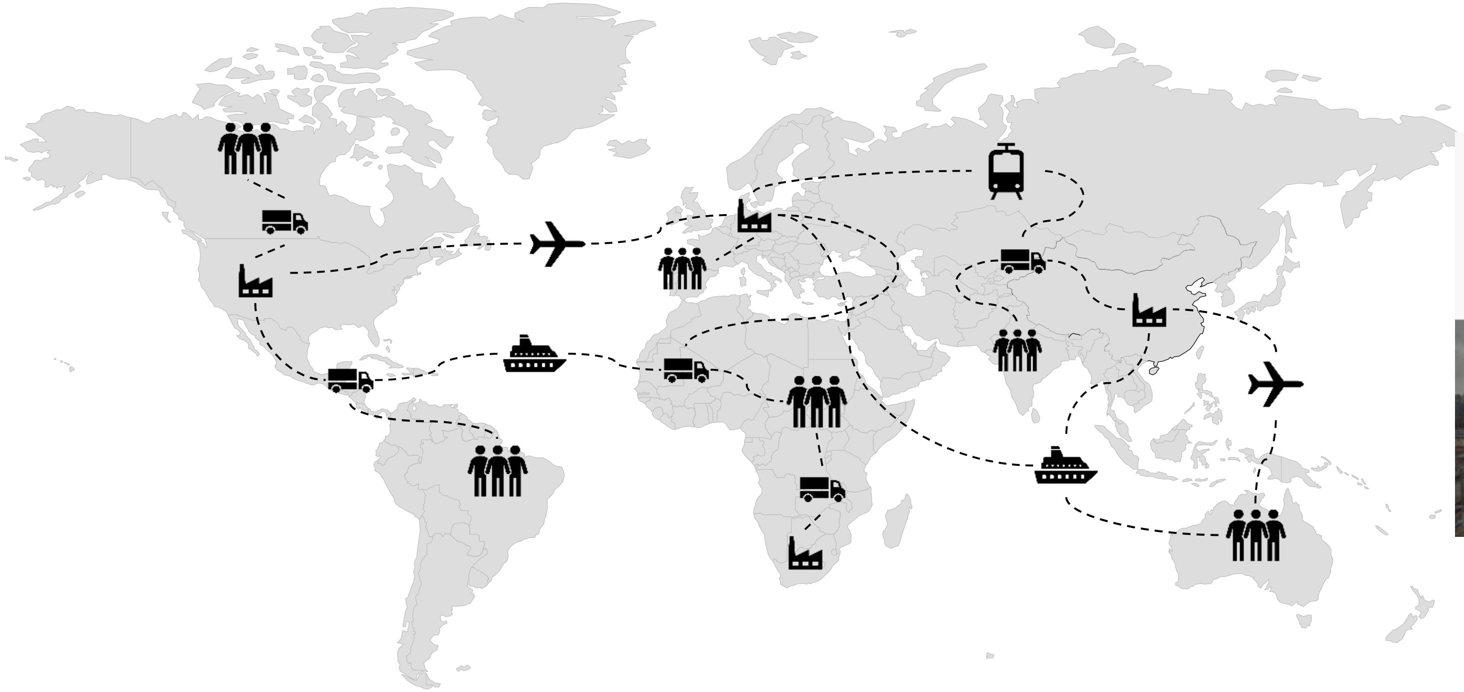
Conventional

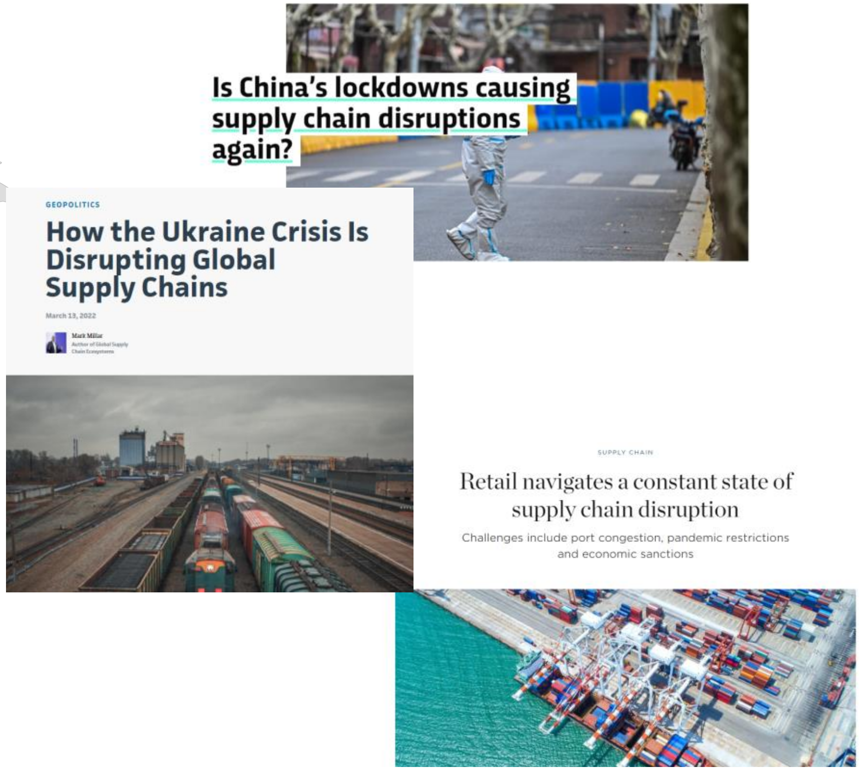


Locally adapted microstructure (digital material)

Future Perspective of AM

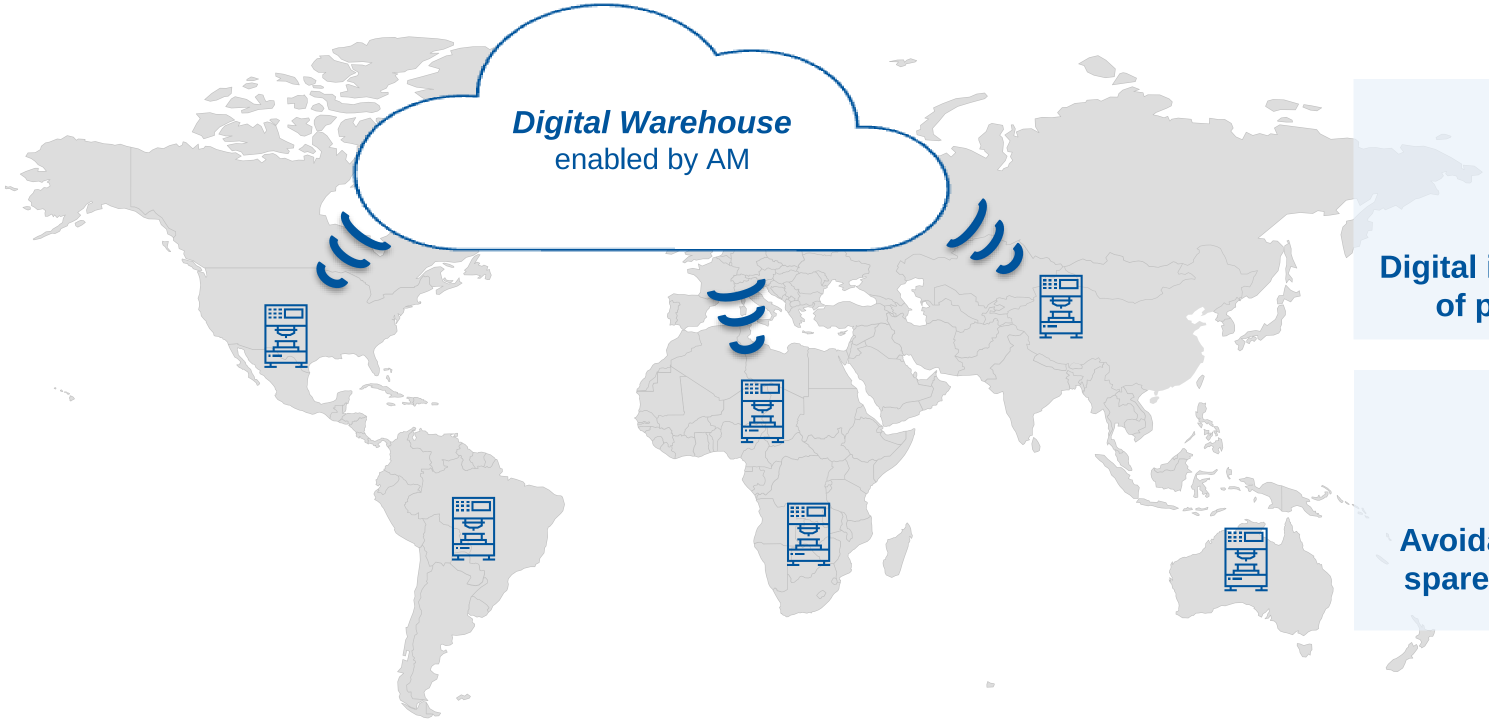
Current State: Globalized, Complex, and Vulnerable Supply Chains





Recent crises have shown the vulnerability of global supply chains. Resilience is a key element to competitiveness.

Future Perspective of AM
Digital Spare Parts Warehouses as New Business Models Enabled by AM



Digital inventory instead of physical stock

Short & fast transport routes

Avoidance of scrap if spare parts not used

Avoid obsolescence and costly idle times

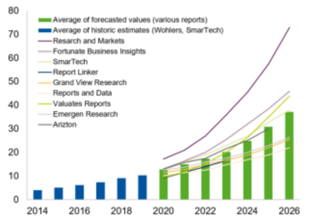
But how to ensure secure data handling and quality with different part designers and suppliers?

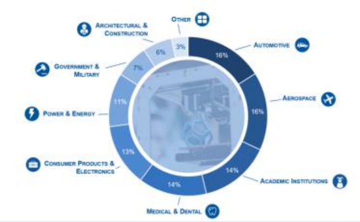
Source: RWTH DAP, WIBU, BMBF

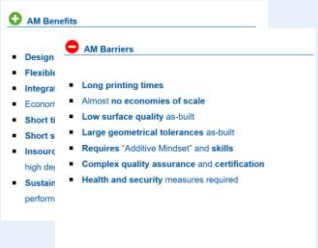
Basic AM Seminar – Content

Basic AM Seminar
Summary

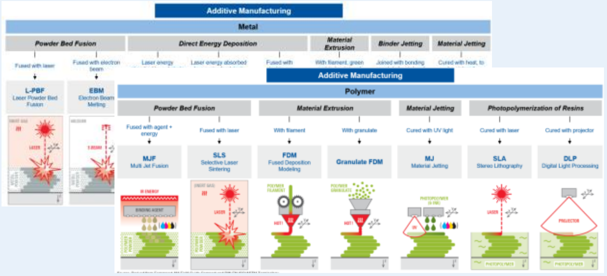
Introduction to Additive Manufacturing







Overview of AM Technologies



- High variety of established and emerging AM technologies
- Varying technology readiness
- Technology-specific characteristics, advantages and disadvantages
- Material choice according to application

Future Perspective

- Expected continuous market growth
- Cost decrease due to increased technology readiness level, productivity and industrialization
- Technological and economical challenges are addressed through industry and R&D

Successful Adaption of AM

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AM Application Examples

- Various applications along the product lifecycle
- Differentiation in rapid prototyping, rapid tooling and AM of end use parts
- Taking advantage of different AM benefits according to application

Get in touch!

Matthias Oly
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Get in touch with our experts and become a part of Europe‘s most vivid AM and engineering ecosystem!