AACHEN CENTER
FOR ADDITIVE
MANUFACTURING

Discover3DPrinting

Basic AM Seminar

Gustavo Melo; Lukas Bauch | 19. - 22. November 2024

formnext

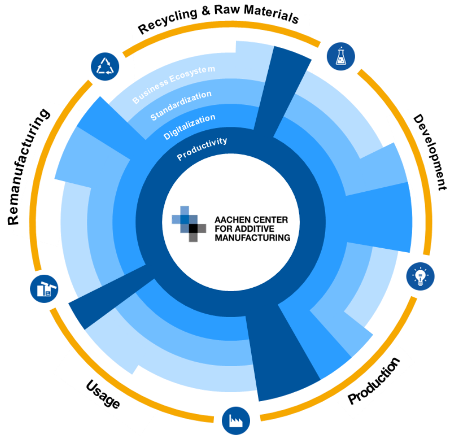
The ACAM Offers Services in the Areas of Consulting, Engineering, Research and Education with a Focus on the Additive Manufacturing Industry

Your presenter

Gustavo Melo

- Senior Consultant for ACAM Aachen Center for Additive Manufacturing GmbH
- Research Group Manager at the Digital Additive Production Chair (DAP) of RWTH Aachen University

Perspective and focus



Community

BUSINESS Member

GMH GRUPPE, GRÄNGES, MTDG, Nikon, oerlikon, TOYOTA, ZOLLERN

PROFESSIONAL Member

DENSO Crafting the Core, GKN ADDITIVE, H3D

BASIC Member

AddUp, DAIDO STEEL, Dyndrite, exafuse, GE Additive, hp, kurtz ersa, MESSER, PÖPPELMANN, PROTERIAL, PROTIQ, SCHÄFER, 上海电气, toolcraft, uptown Basel, VDM Metals

COOPERATION Member

formnext, AMGTA, Efficient Elements

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

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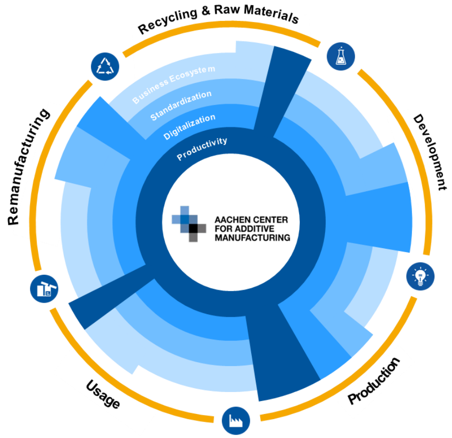

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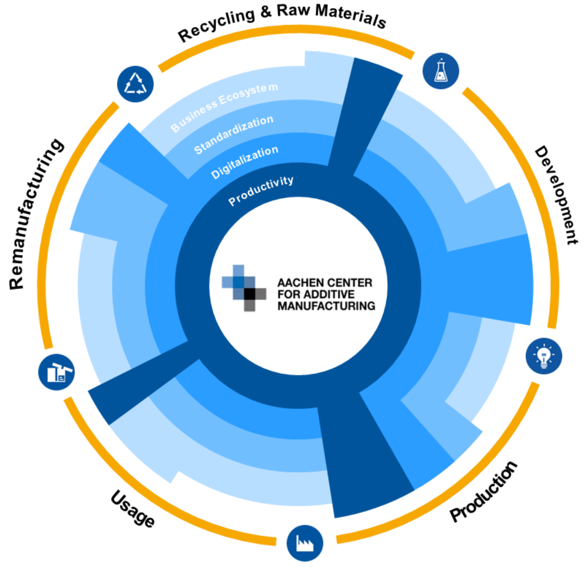
ACAM Aachen Center for Additive Manufacturing
Critical mass of people and know-how

Think Tank for the Additive Manufacturing Industry

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

Heritage
The Cradle of Metal AM

The world's most vivid and multifaceted AM ecosystem

The cradle of metal AM

1995 – **First Hybrid Machine Tool**

1997 – **Basic Patent for SLM**

2001 – **First Tool Insert**

2008 – **First Implant**

2015 – **Foundation of ACAM**

Image Source: DAP RWTH Aachen University, Fraunhofer ILT, Campus GmbH

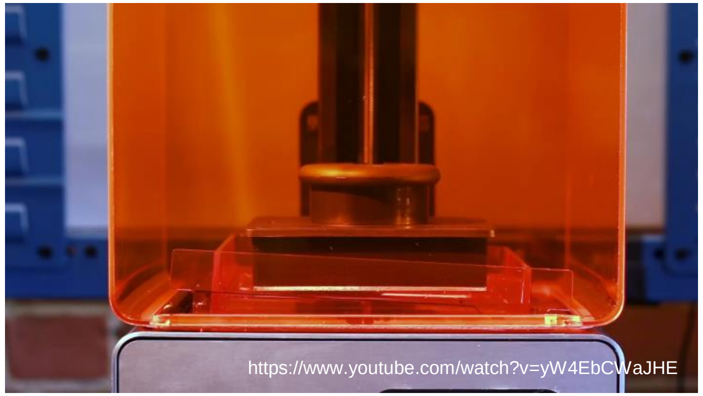
Basic AM Seminar – Content

Additive Manufacturing – Definition

Definition (ASTM 52900)

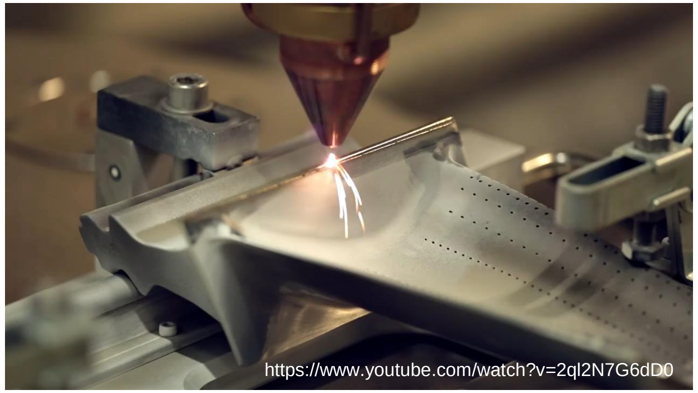
“Additive Manufacturing (AM) is defined as the process that

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



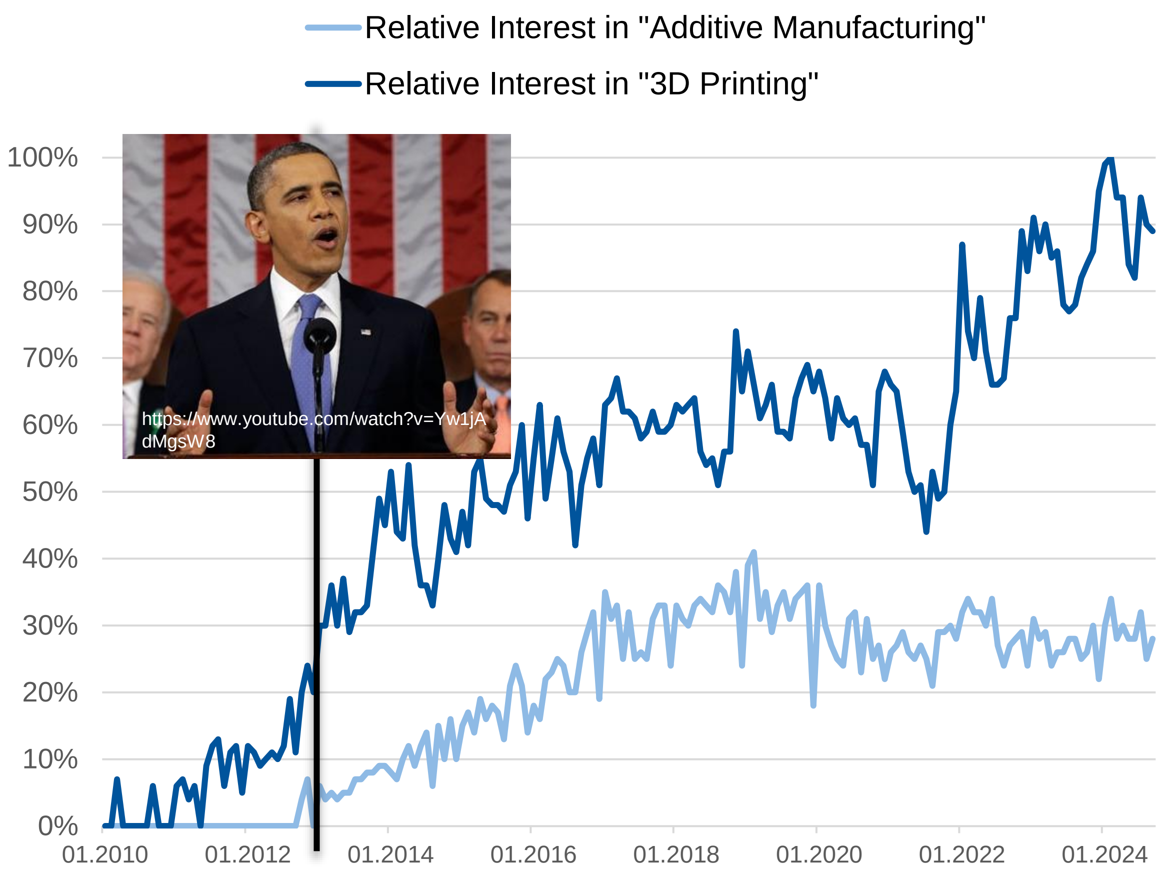
Definition (VDI 3405)

*“Manufacturing process in which the **workpiece is built up in successive layers or units**.”*



Hype or Manufacturing Revolution? - Global Interest on AM According to Google Trends

Global relative interest (Google Trends)



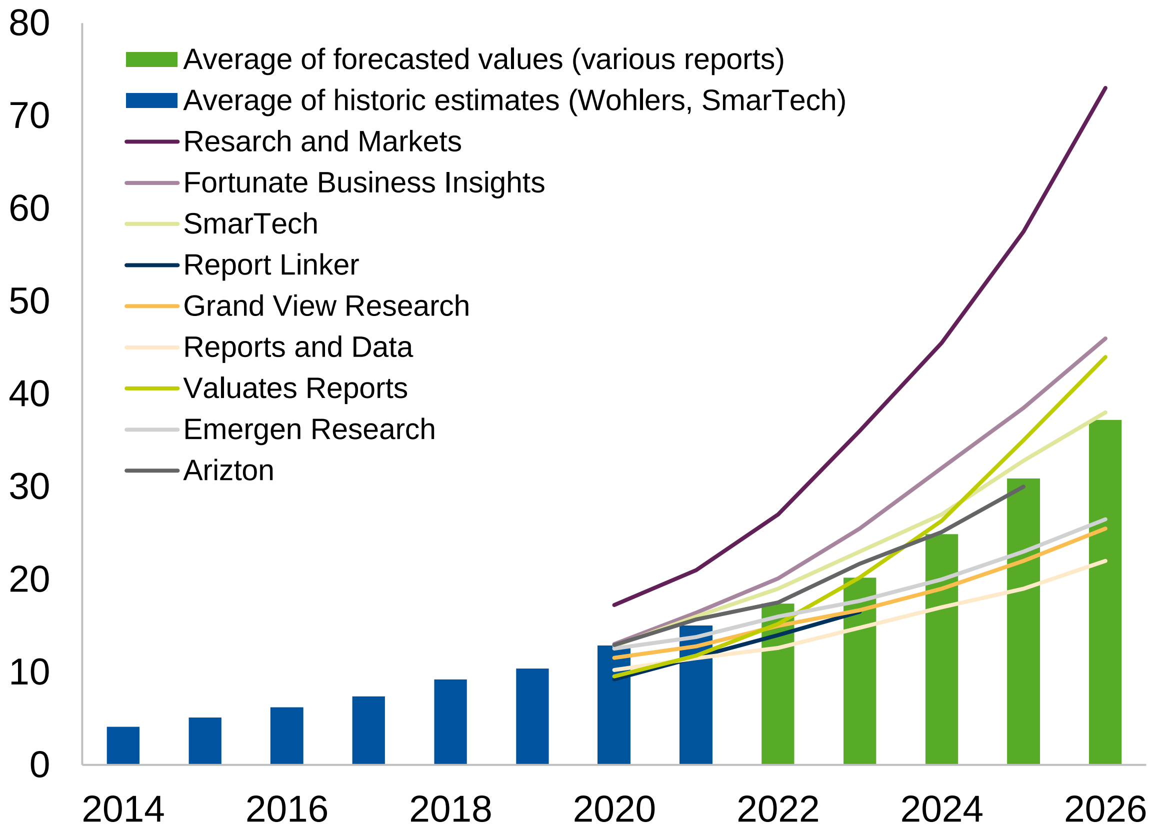
Source: Google Trends

- **Overall positive trend** of relative interest in AM and 3D printing in online search platforms
- **Lower interest in AM compared to 3D printing** because **AM** is the **more scientific term**
- **Strong increase** 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]

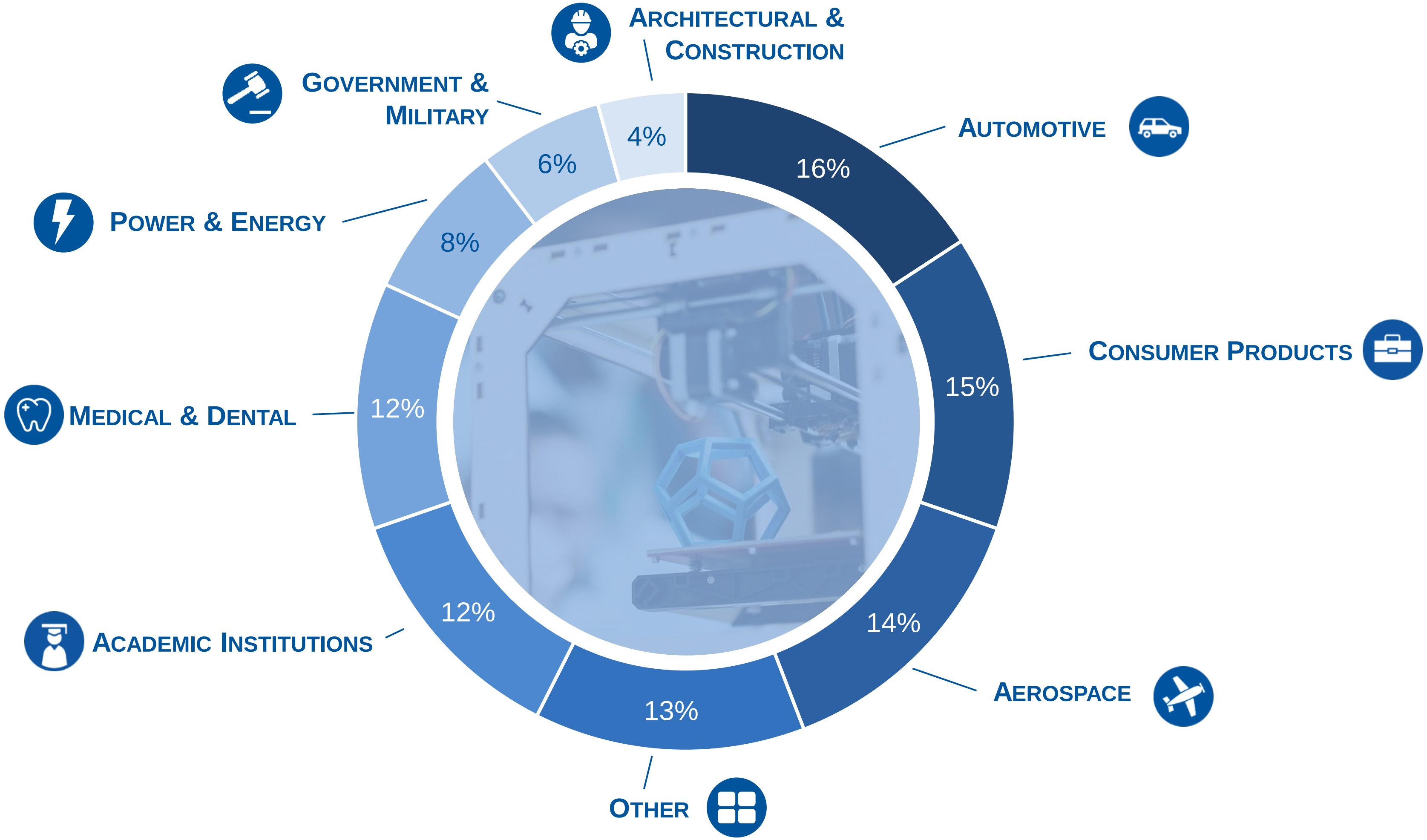


- **Overall positive** forecasted and historic growth rates in all reports
- **Diverging positive forecasts** indicate a **developing** volatile and uncertain market

- **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 2023

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 for staff in industrialized countries & 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

Source: Unsplash, Pexels

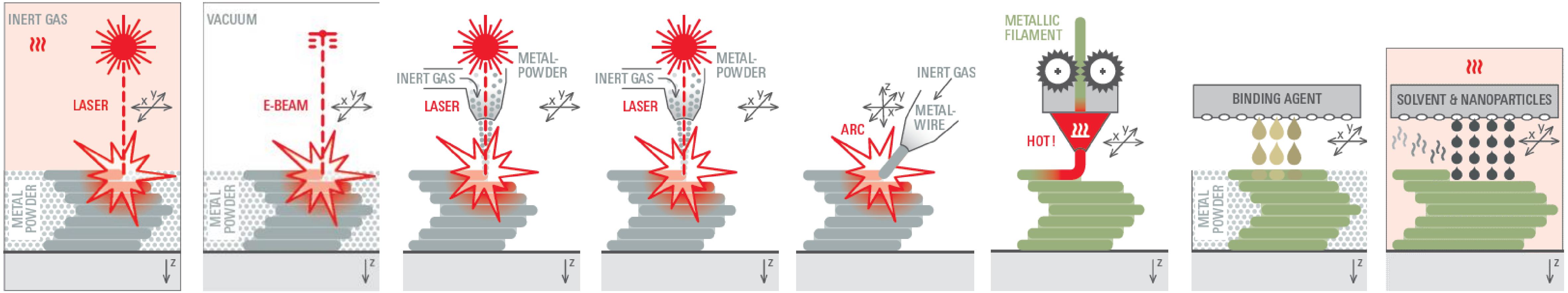
Basic AM Seminar – Content

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 Fomrnnext 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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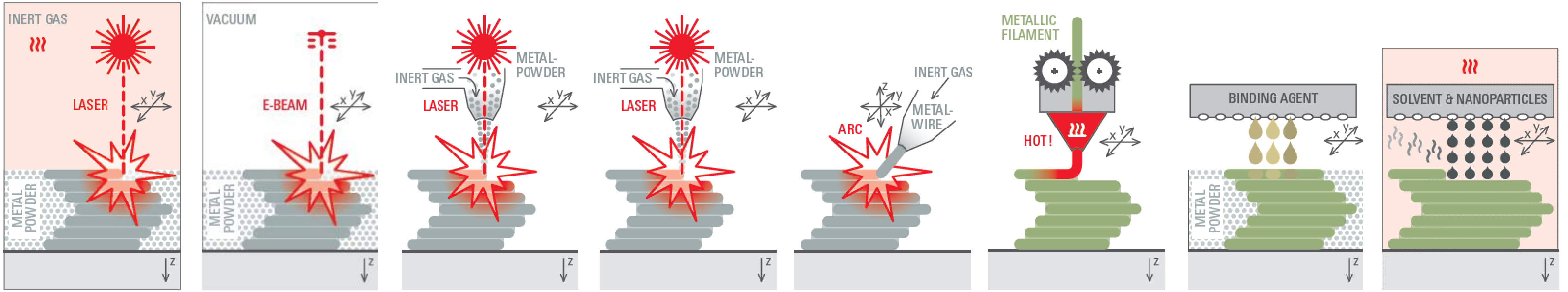
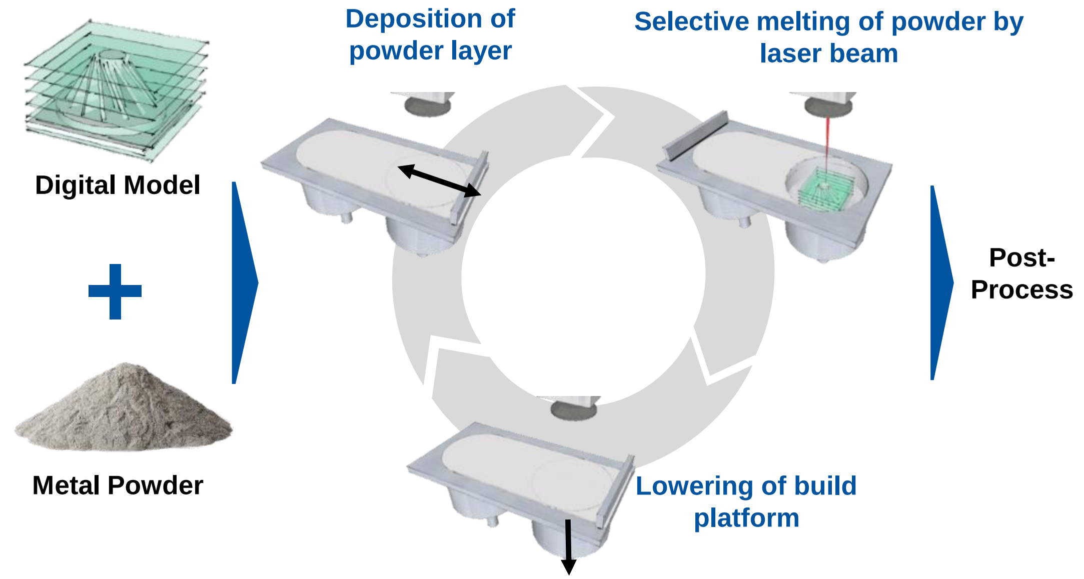


Source: Derived from Fomrnnext AM Field Guide Compact and DIN EN ISO/ASTM Terminology

AM Technologies
Laser Powder Bed Fusion of Metal (LPBF)

Process Principle

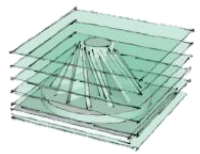


Process in Action

- 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 base alloys, CoCr, copper and alloys, Ti and alloys, Al alloys, refractory metals, Mg alloys, HEA)

AM Technologies
Laser Metal Deposition (LMD)

Process Principle



Digital Model

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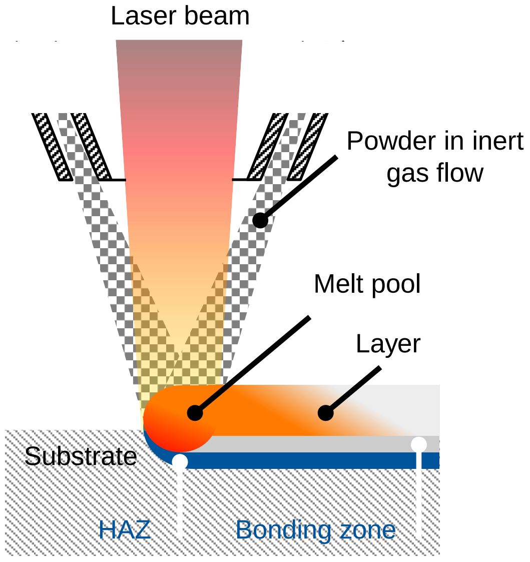
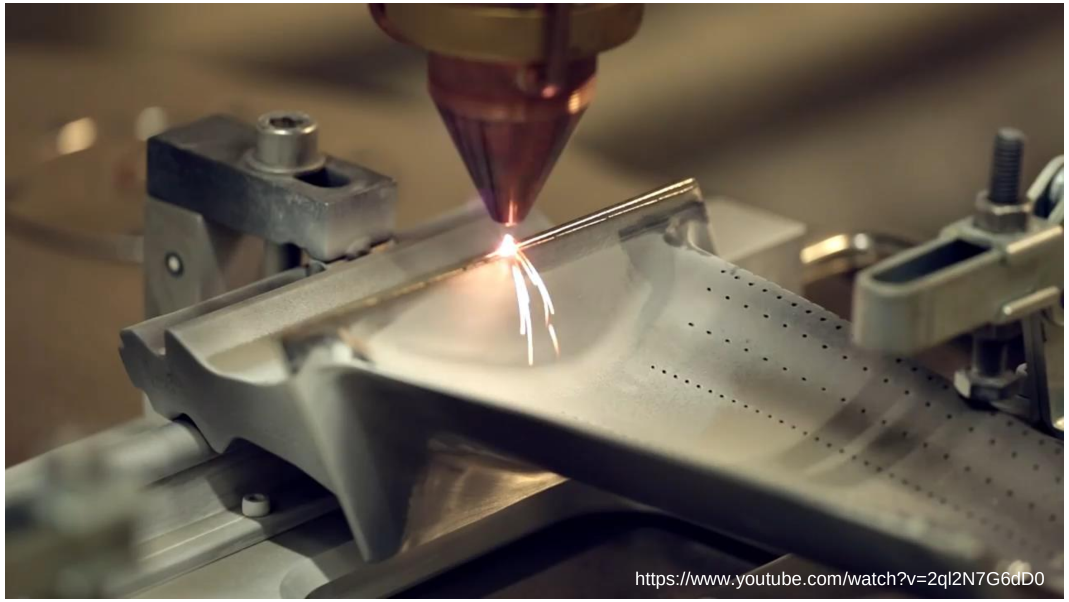
Metal Powder (also possible with wire)



Fraunhofer ILT

Post-Process

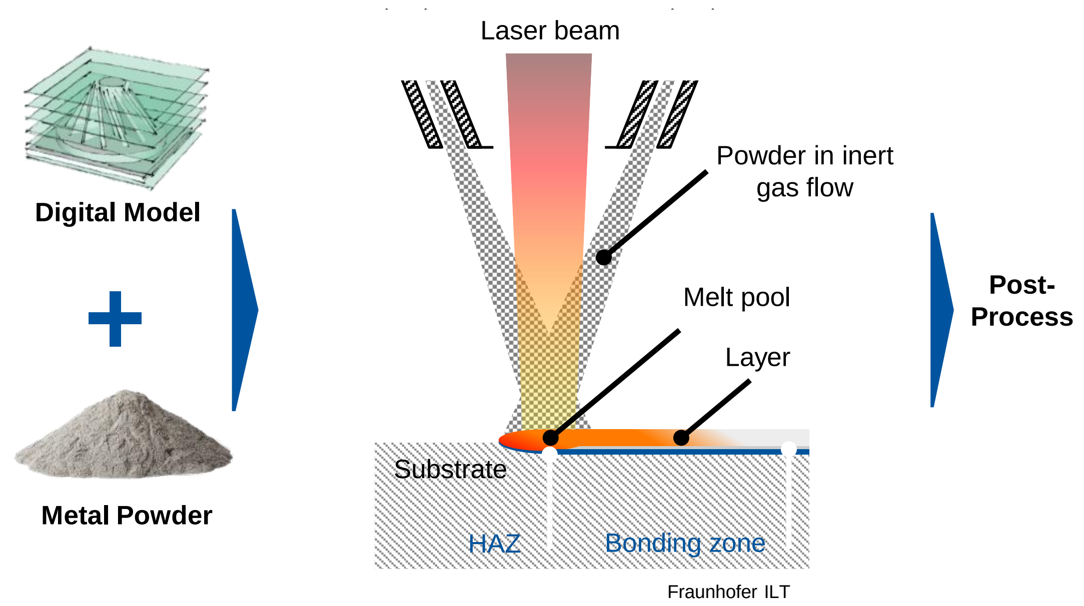
Process in Action



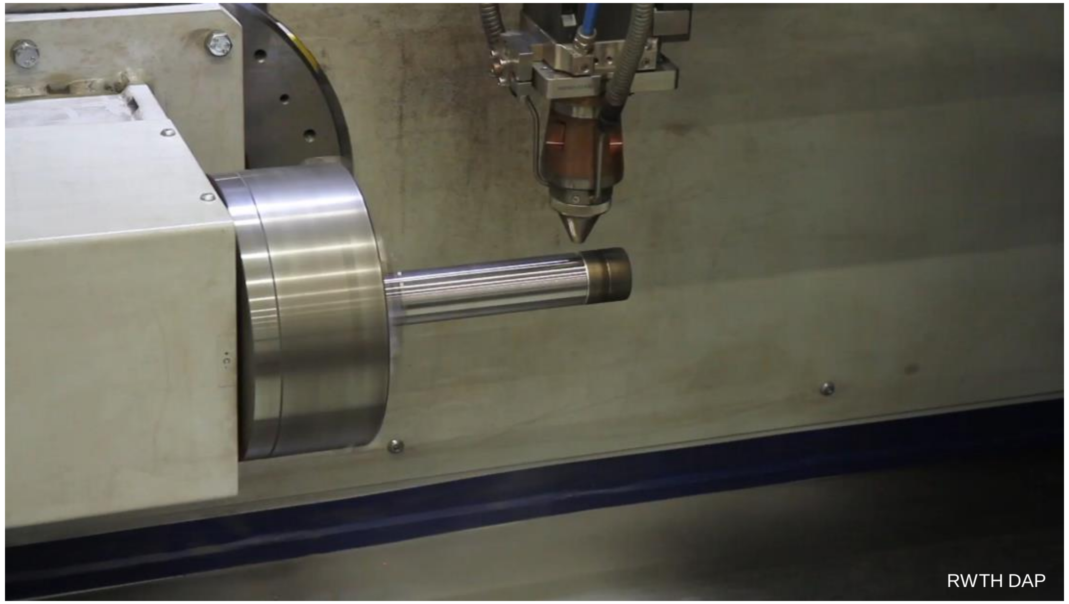
- Used for additive manufacturing, additive coating and repair (deposition on existing geometry)
- Powder is transported by an inert gas flow
- Energy for melting the metal powder is mainly deposited in the substrate, not directly in the powder
- General suitability for weldable materials, different materials qualified (e.g., steels, Ni-base alloys, Al alloys)

AM Technologies
Extreme High Speed Laser Metal Deposition (EHLA)

Process Principle



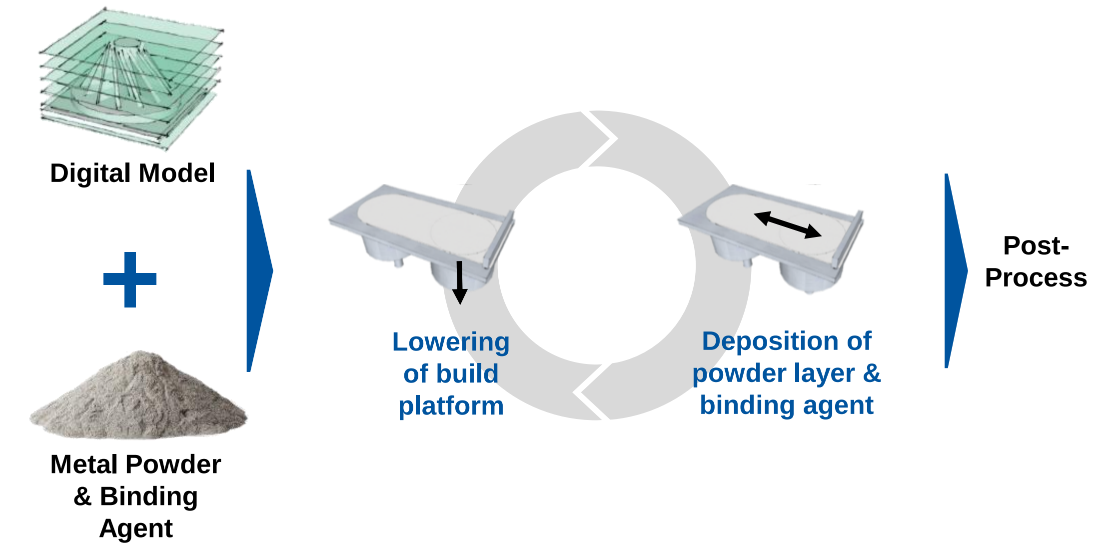
Process in Action



- Application of homogenous coatings on rotationally symmetrical parts with higher process speed than LMD
- Powder is transported by inert gas flow
- Energy is mainly deposited in the metal powder and not the substrate
- EHLA for AM of 3D parts is an emerging technology

AM Technologies
Binder Jetting (BJ)

Process Principle



Process in Action

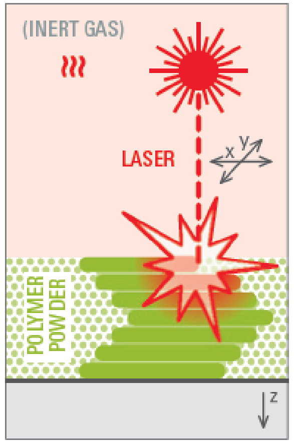
- Production of complex geometries by selective deposition of binder agent on metal powder layer by layer
- As-built part is in green state and requires further processing steps for functionality (e.g., curing, depowdering, sintering)
- Compared to LPBF lower technological maturity and less materials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

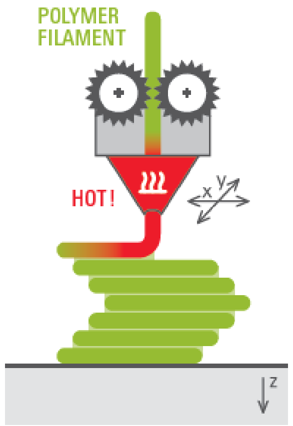
AM Technology Overview
Segmentation of Established Polymer AM Technologies

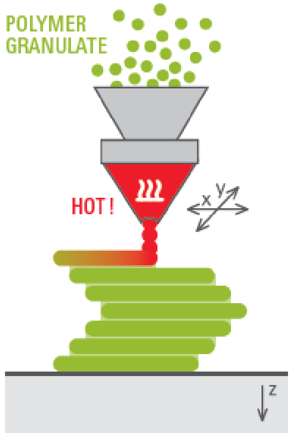
Additive Manufacturing

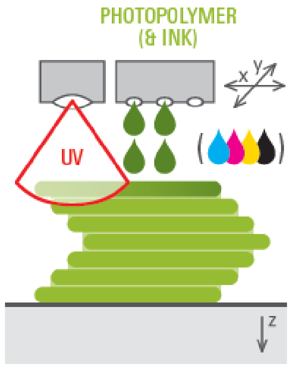
Polymer

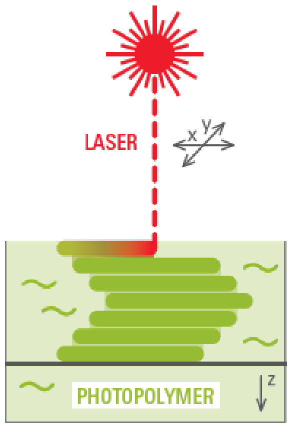
Powder Bed Fusion		*Material Extrusion*		*Material Jetting*	*Photopolymerization of Resins*	
Fused with agent + energy	Fused with laser	With filament	With granulate	Cured with UV light	Cured with laser	Cured with projector
MJF Multi Jet Fusion	**SLS** Selective Laser Sintering	**FDM** Fused Deposition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

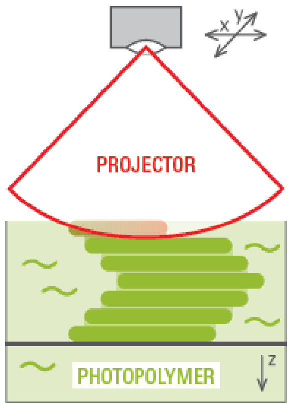












Source: Derived from Fomrnnext AM Field Guide Compact and DIN EN ISO/ASTM Terminology

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Segmentation of Established Polymer AM Technologies

Additive Manufacturing

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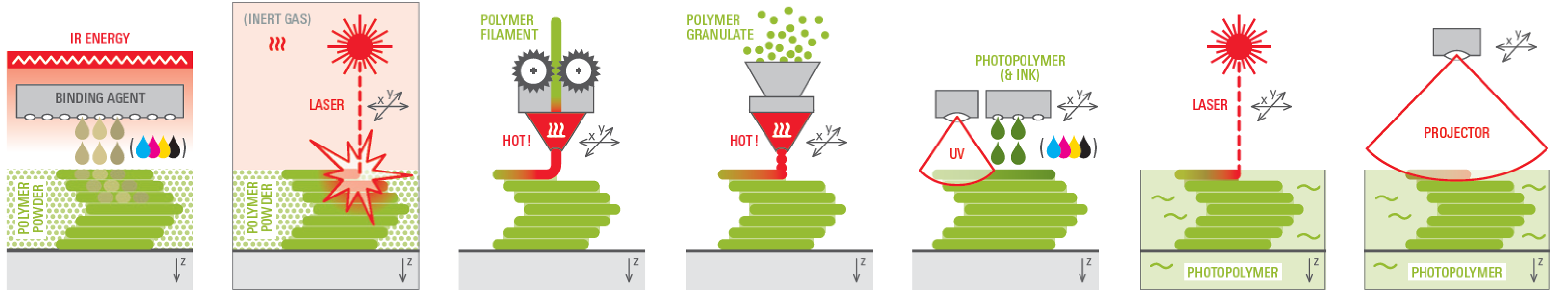
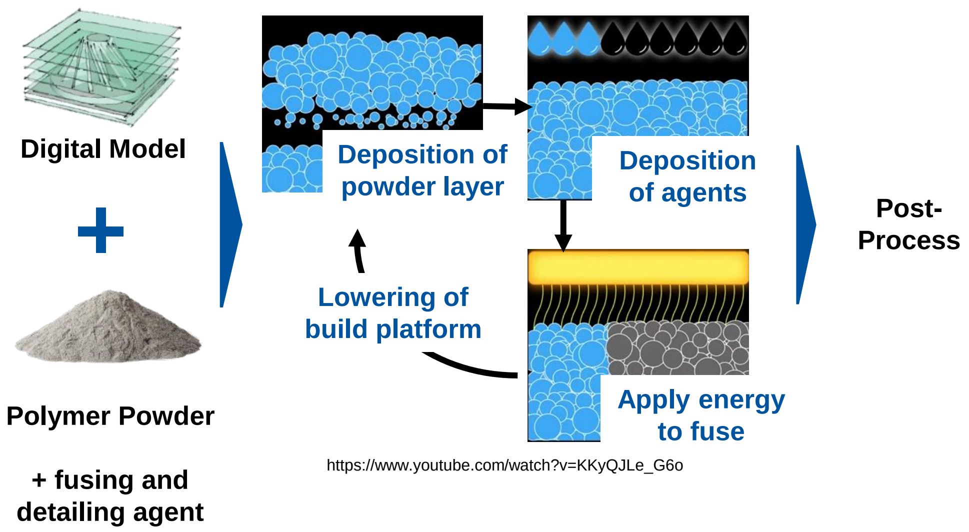


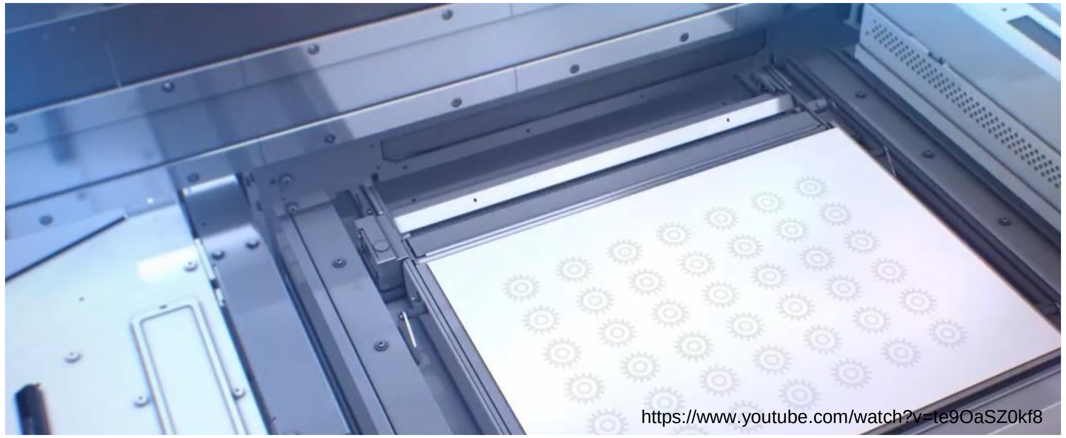
Source: Derived from Fomrnnext AM Field Guide Compact and DIN EN ISO/ASTM Terminology

AM Technologies
Multi Jet Fusion (MJF)

Process Principle



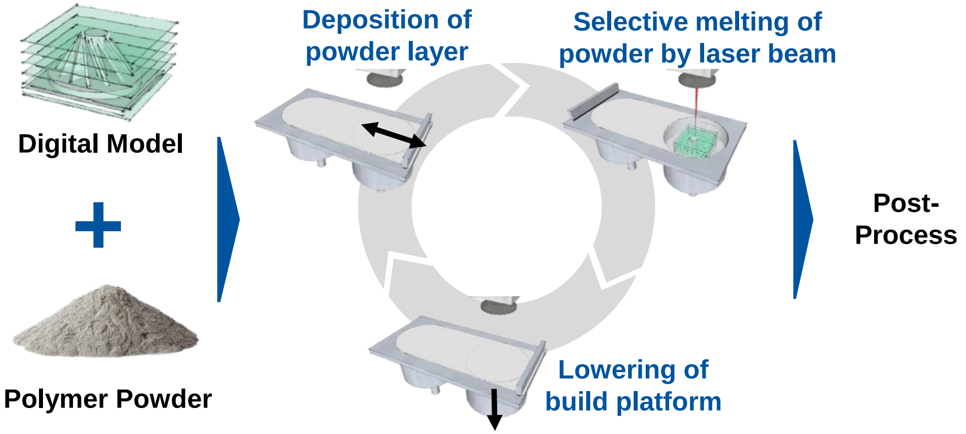
Process in Action



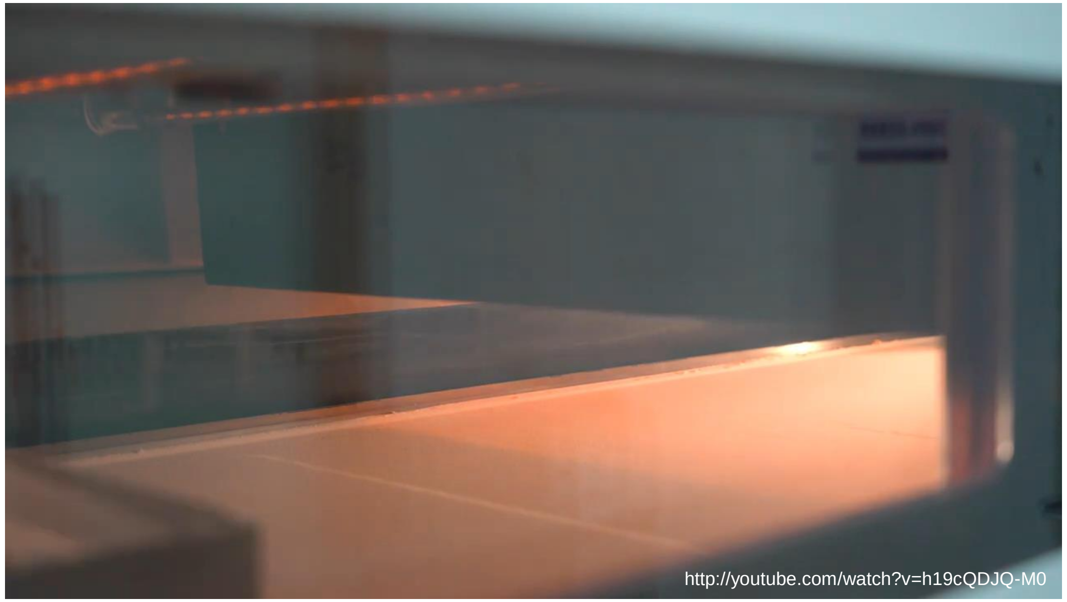
- Layer-by-layer application of material applied to powder in build chamber
- Introduction of liquid binder by inkjet print heads to bond powder particles together
- Energy input (curing) through UV lamps

AM Technologies
Selective Laser Sintering (SLS)

Process Principle



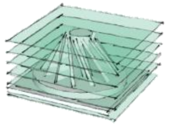
Process in Action



- 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



Digital Model

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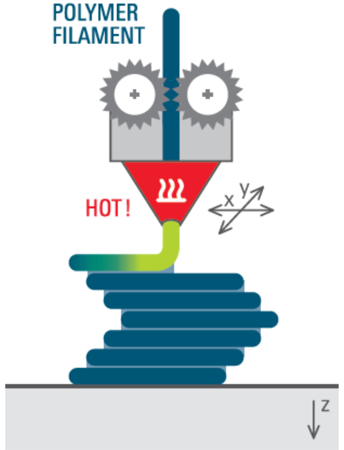
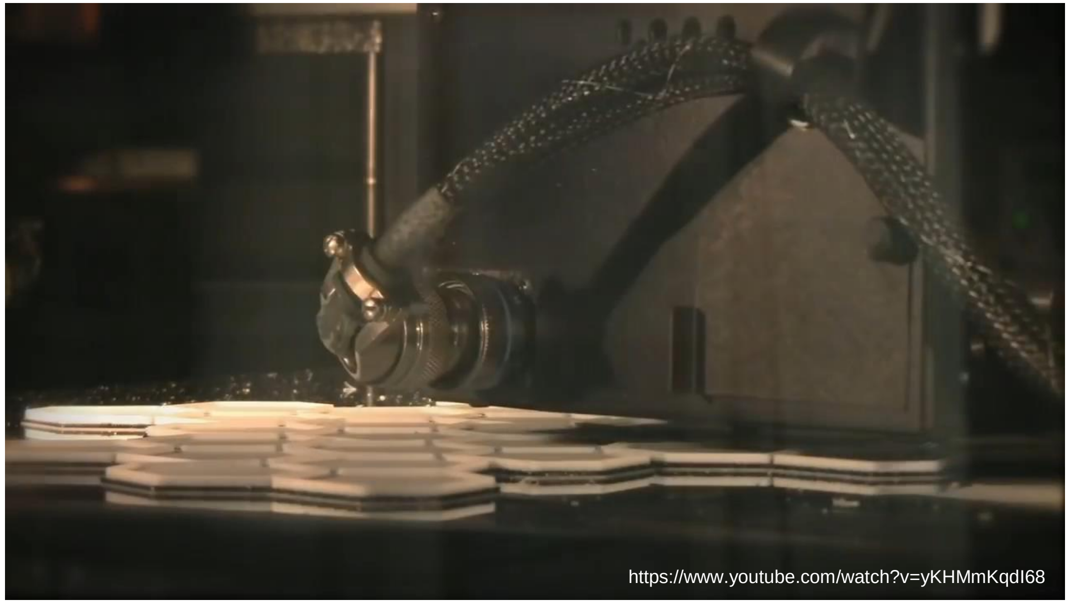
Thermoplastic feedstock (filament or pellets)



Post-Process

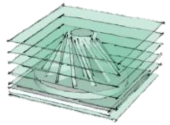
Process in Action



- Thermoplastic feedstock 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 Technologies
Stereolithography (SLA)

Process Principle



Digital Model

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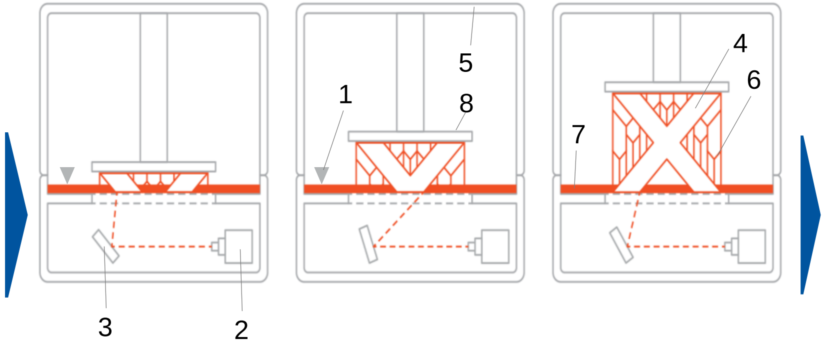
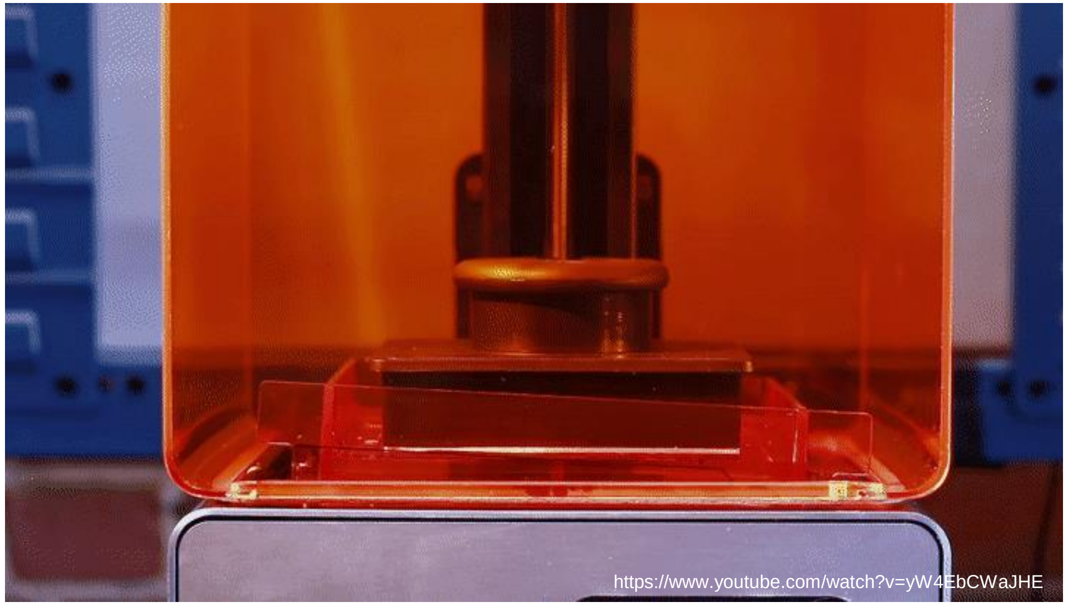
Photo-reactive resin



Post-Process

1. Surface of polymer bath
2. Laser
3. X-Y-scanner
4. Generated part
5. Housing
6. Support structure
7. Polymer batch
8. Build platform

Process in Action

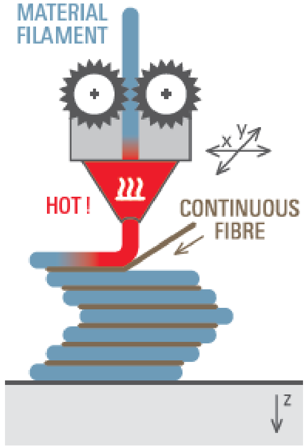


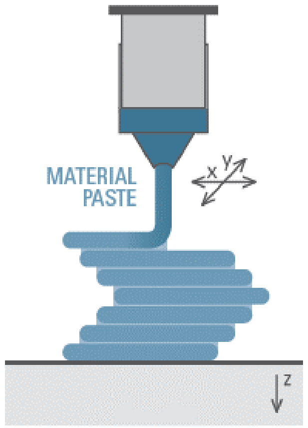
- Polymerization of photo-reactive resin by selective scanning with a UV laser beam (usually through transparent container from below)
- Requires support structures for overhangs
- Wide range of photo-reactive resins with different optical, thermal and mechanical properties

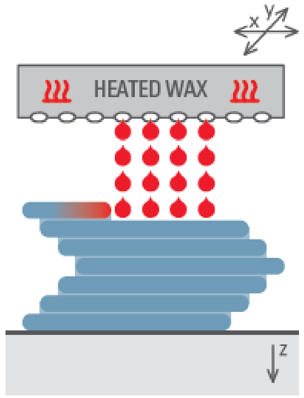
AM Technology Overview
Segmentation of Other AM Technologies

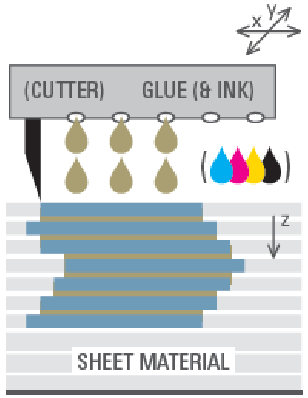
Additive Manufacturing

Reinforced polymer fibers	Any material paste	Sand or gypsum	Wax	Composite or paper
Material Extrusion		***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









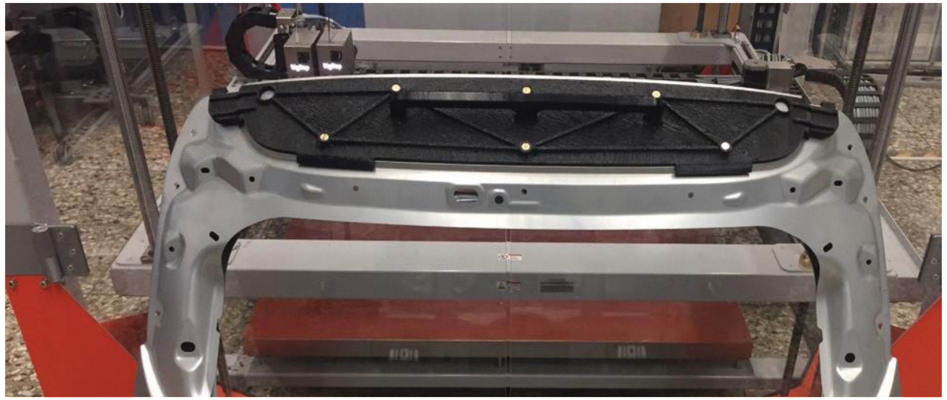
Source: Derived from Fomrnnext AM Field Guide Compact and DIN EN ISO/ASTM Terminology

Basic AM Seminar – Content

AM Application Examples
Jigs & Fixtures - Assembly and Manufacturing Aids Using FDM

Characteristics

- Frame for measuring gaps in assembly e.g. between body and the door of a vehicle
- Aids for manual positioning of badges
- Welding fixture
- AM technology: FDM (large format)



Utilized AM Benefits

- Lightweight design and materials
- Part consolidation to avoid assembly steps
- Economic small quantities
- Short time and efficiency from idea to product (e.g., 8-10 weeks to 2-3 days for seal gap frame)
- Flexible design iterations & engineering changes

Source: https://bigrep.com/ebooks/ford-upscales-their-in-house-tooling-with-bigrep-3d-printers/

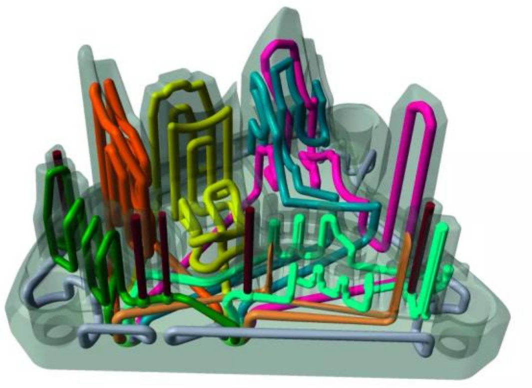
AM Application Examples
Tooling - Molding Tools and Tool-inserts Using LPBF

Characteristics

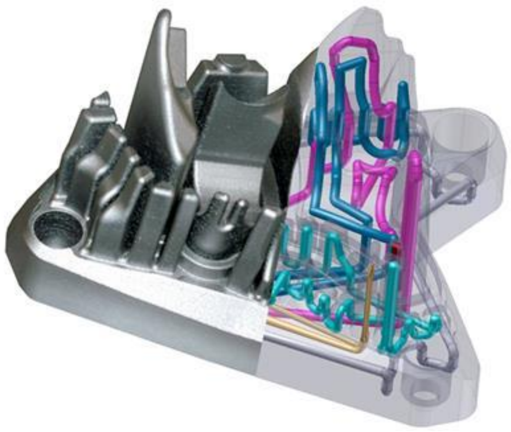
- Internal cooling channels enable faster cooling to reduce cycle times and improve quality
- Impossible to produce with conventional manufacturing
- AM technology: LPBF

Utilized AM Benefits

- Integration of functions
- Economic small quantities
- Short time and efficiency from idea to product
- Economic and ecologic sustainability though performance improvement in use



https://www.plastverarbeiter.de/werkzeuge-formen/werkzeugfertigung-2-0.html



https://www.renishaw.com/en/industrial-applications-of-renishaw-metal-additive-manufacturing-technology--15256

- Cooling phase: -11%
- Tool life: +80%

(compared to conventional)

https://www.voestalpine.com/

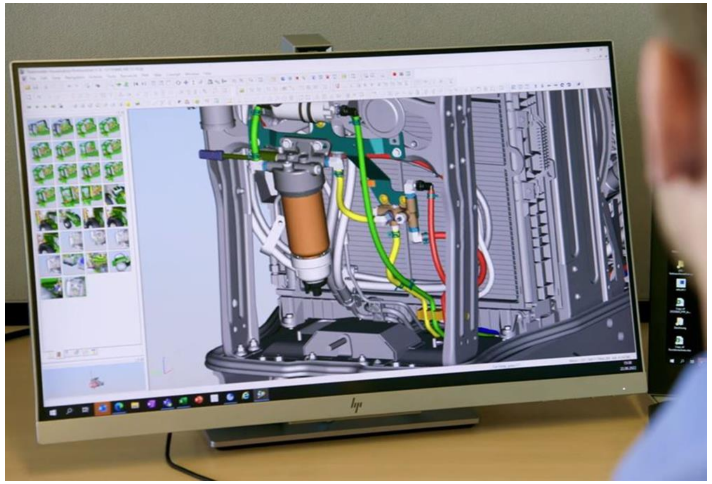
AM Application Examples
Series Part – Fuel Valves for Tractors Using Binder Jetting

Characteristics

- Series production, more than 4000 produced
- Fuel valves for tractors
- AM technology: HP Metal Binder Jetting

Utilized AM Benefits

- Design freedom for rounder and smoother internal channels
- Design freedom to reduce the component size
- 50% less expensive

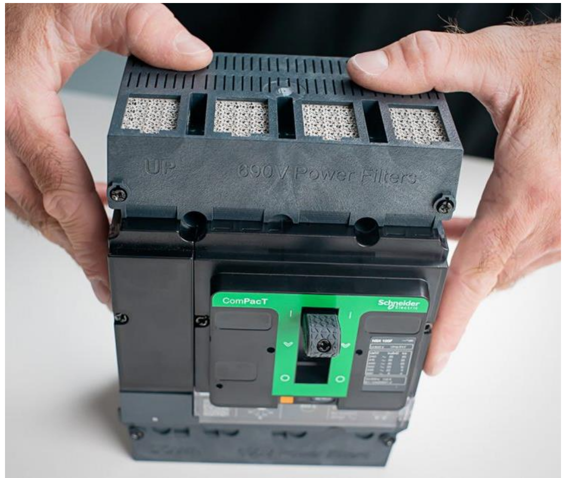



https://www.sae.org/news/2023/02/john-deere-metal-3d-printing

AM Application Examples
Series Part – Filters for Circuit Brakers Using Binder Jetting

Characteristics

- Series production with 1300 parts a month produced
- Filters for electric circuits to capture ionized particles and reduce exhaust
- AM technology: HP Metal Binder Jetting



Utilized AM Benefits

- Design freedom for features like lattice structures
- Design freedom to reduce the component size

https://www.metal-am.com/articles/metal-am-on-an-industrial-scale-gkn-additive-commercialises-binder-jetting/

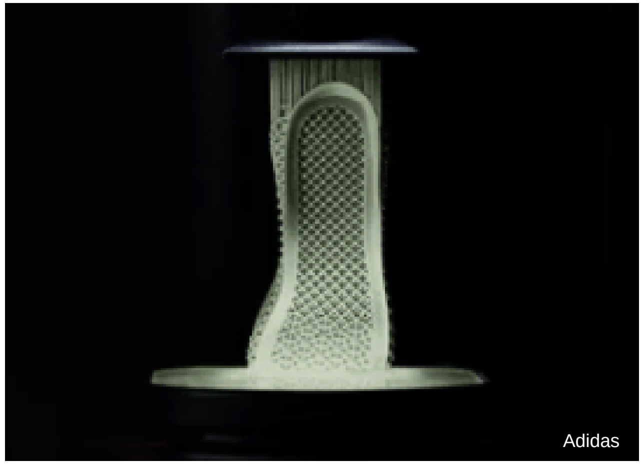
AM Application Examples
Series Part – Shoe Soles Using DLP

Characteristics

- AM lattice structure shoe sole
- Partnership of Adidas and Carbon
- AM technology: DLP / CLIP

Utilized AM Benefits

- Functional integration: Address needs of athletes for movement and cushioning
- Design freedom: Freedom to manufacture lattice structure according to digital optimization


Adidas


Adidas


Carbon


Carbon

Source: https://www.carbon3d.com/news/press-releases/adidas-unveils-industrys-first-application-of-digital-light-synthesis-with-futurecraft-4d

AM Application Examples
Series Part – Fuel Nozzle for Jet Engines Using LPBF

Characteristics

- Aerospace industry predestined for AM: Weight reduction and functional integration
- More than 100.000 fuel nozzle tips made with AM
- AM technologies: LPBF
- Application type: Series part

Utilized AM Benefits

- Monolithic design: 20 conventionally manufactured parts with need for assembly reduced to 1 AM part
- Complex lightweight design: 25% weight reduction
- Decrease of production cost and lead times


Pexels


GE Aviation


GE Aviation


GE Aviation

Source: https://blog.geaerospace.com/manufacturing/manufacturing-milestone-30000-additive-fuel-nozzles/

AM Application Examples
Series Part - Roof Mount Bracket Using LPBF

Characteristics

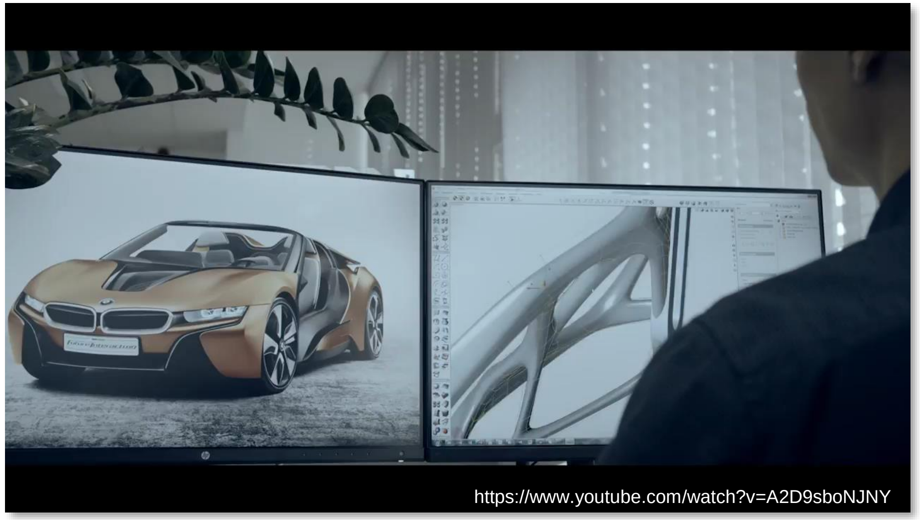
- Stiff part that holds the convertible roof of the BMW i8 roadster
- Small series end-use part
- AM Technology: Laser Powder Bed Fusion
- Material: Aluminum alloy (AlSi10Mg)

https://www.3dnatives.com/de/altair-enlighten-award-2018-220820181/#!

https://www.press.bmwgroup.com

Utilized AM Benefits

- Algorithmic design (topology optimization)
- Flexible design iterations
- Lightweight design and material (44% weight reduction)
- Economic and ecologic sustainability through material efficiency



https://www.youtube.com/watch?v=A2D9sboNJNY

https://www.youtube.com/watch?v=A2D9sboNJNY

AM Application Examples
Series Part - Coating of Brake Disks Using EHLA

Characteristics

- Additive coating of brake disks
- Up to 90 % reduction in brake disc-related particulate emissions
- Corrosion-free, also in recuperation mode
- Longer usage time with only low additional cost for coating

Utilized AM Benefits

- Economic and ecologic sustainability though performance improvement in use
- Economic and ecologic sustainability through material efficiency
- Integration of functions

www.wecodur.de/portfolio/anwendungen

https://dap-aachen.de/project/ehla

https://www.wecodur.de/portfolio/technologie/

Source: HPL Technologies, WECODUR

AM Application Examples
Repair - Turbine Blade Using LMD

Characteristics

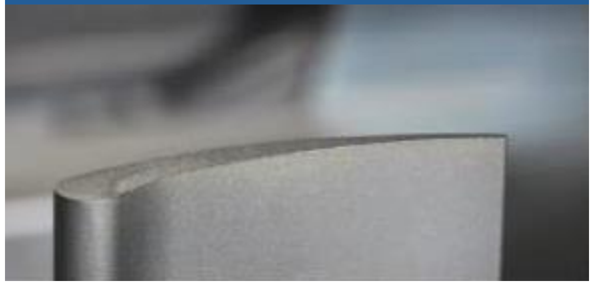
- Repair a chipped turbine blade
- Scan the damaged part and compare with undamaged CAD data
- Material: Nickel Alloy
- AM Technology: DED-LB/M

Utilized AM Benefits

- Agile repair process
- Easily adaptable to different parts
- No need to produce new part
- Time and cost effective

Turbine Blade

Before



Processing Chipped Part

After

Source: NIKON SLM - https://www.nikon.com/company/news/2024/0409_01.html

Basic AM Seminar – Content

Considerations for 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

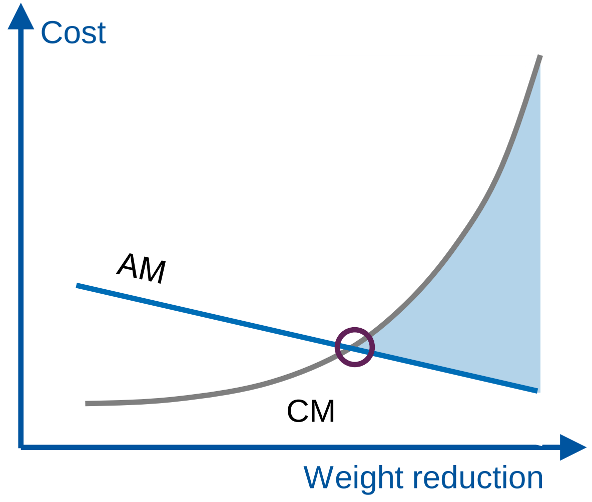
- **Different cost structure:** High upfront investment costs and high material prices, but no part specific tool cost
- **Financial return** and **technological feasibility** must be considered in **identification of parts with positive business case**
- Enables **new business models** such as mass 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

Considerations for Successful Adaption of AM

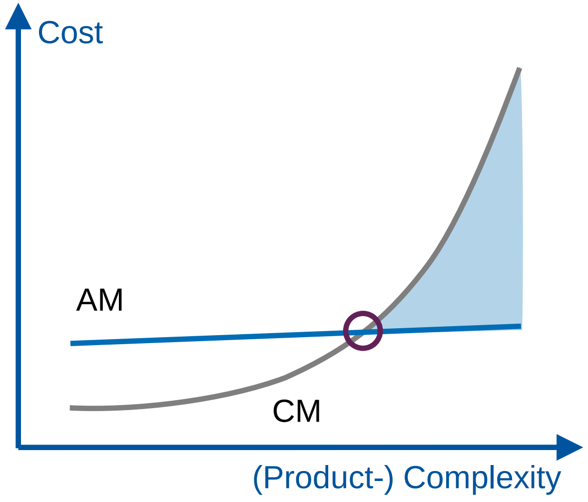
Different Cost Structure of Conventional Manufacturing (CM) and AM

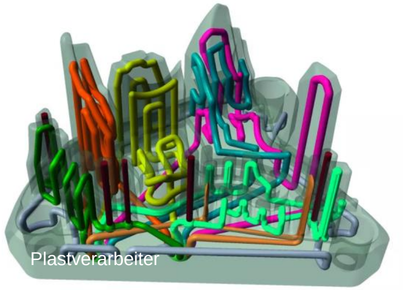
Weight reduction means cost reduction



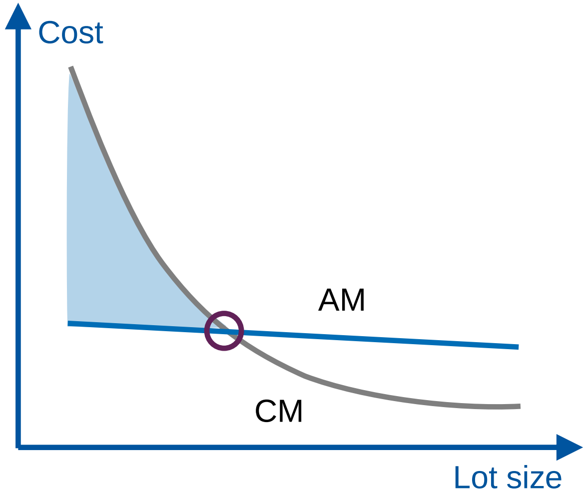

BMW Group

Complexity (almost) for free




Plastverarbeiter

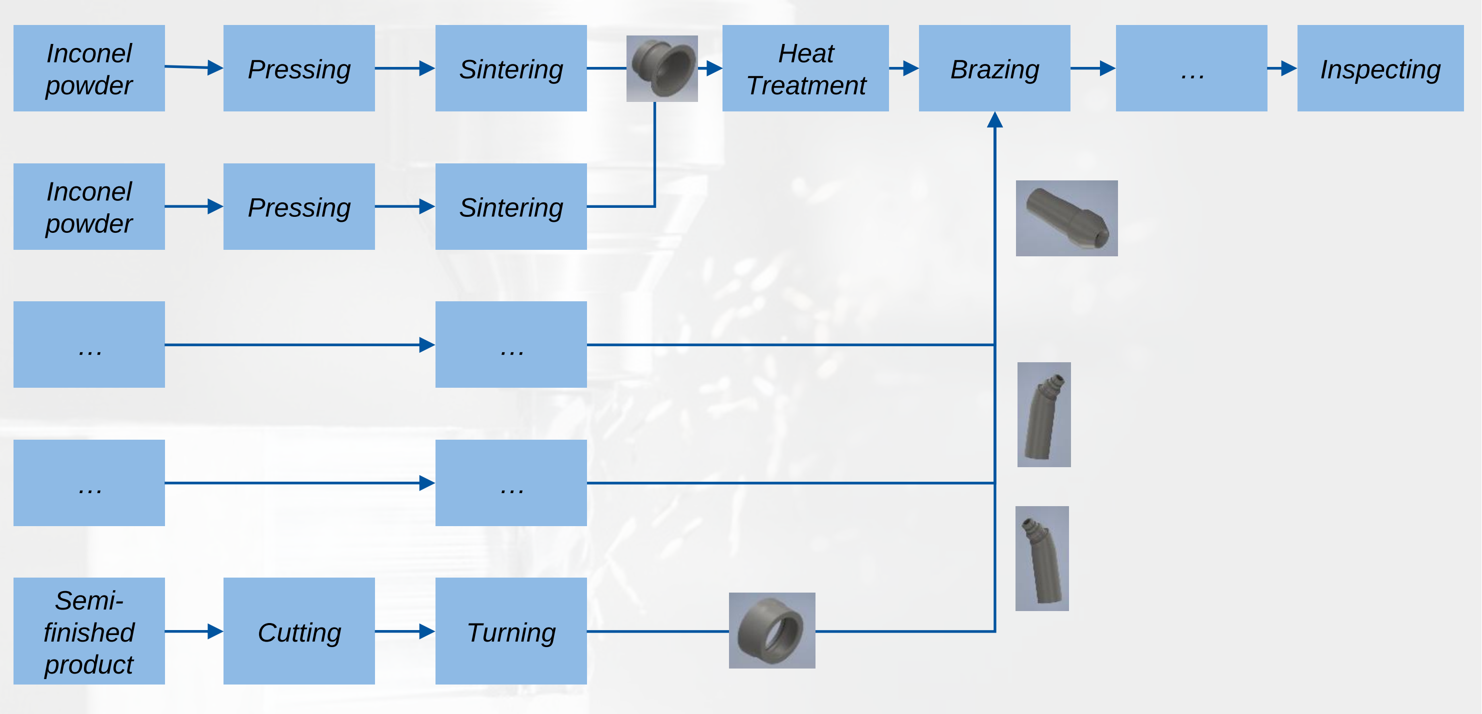
Individualization (almost) for free



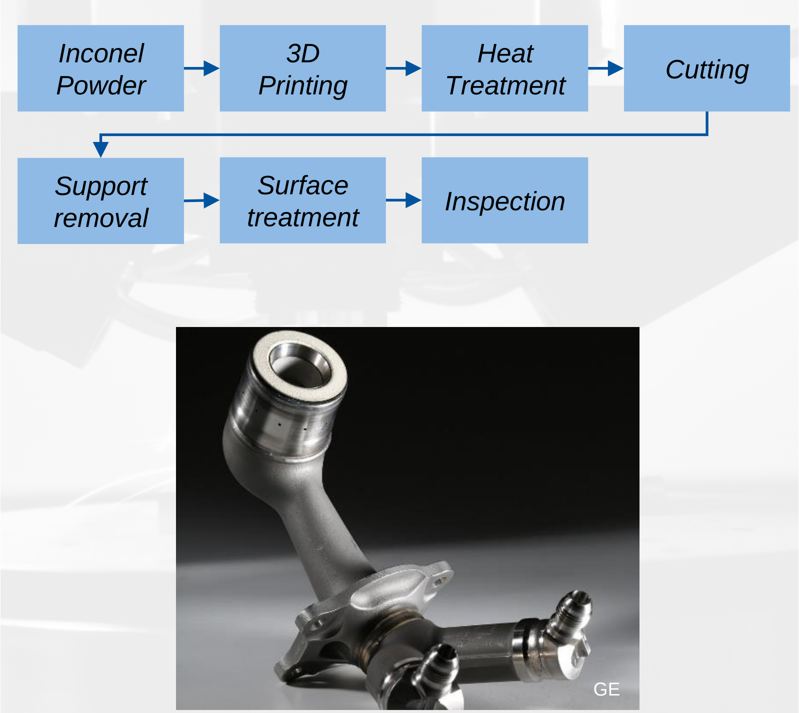

EOS

Considerations for 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)

Considerations for Successful Adaption of AM
Benefits Through an "Additive Mindset"

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Source: Effectory, TCT

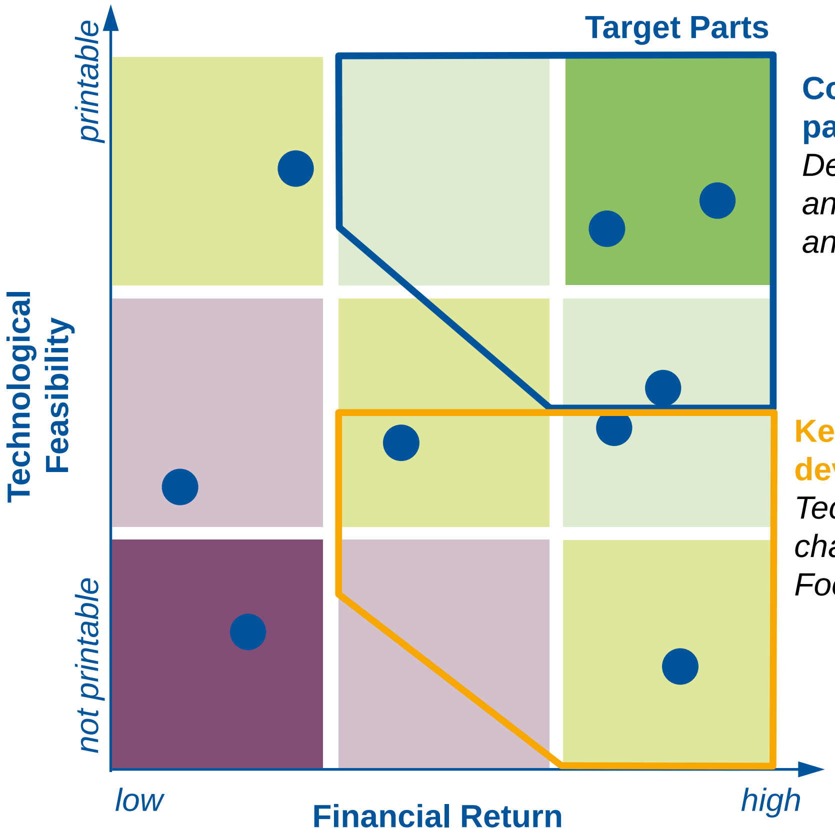
Considerations for Successful Adaption of AM
Part Identification

Part identification process

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

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

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

Considerations for Successful Adaption of AM
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Source: Effectory, TCT

Considerations for Successful Adaption of AM
Business Models Based on AM

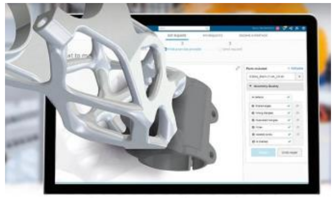
AM Benefits

- **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 for staff in industrialized countries & high degree of automation
- **Sustainability** by material reduction or efficiency in performance

Enabled business models for AM users (not a conclusive)

Digital spare part warehouse

Service provider



Online marketplace

Mass customization

Co-Production

…

Considerations for Successful Adaption of AM
Online Marketplace with Instant Quoting for On Demand Manufacturing

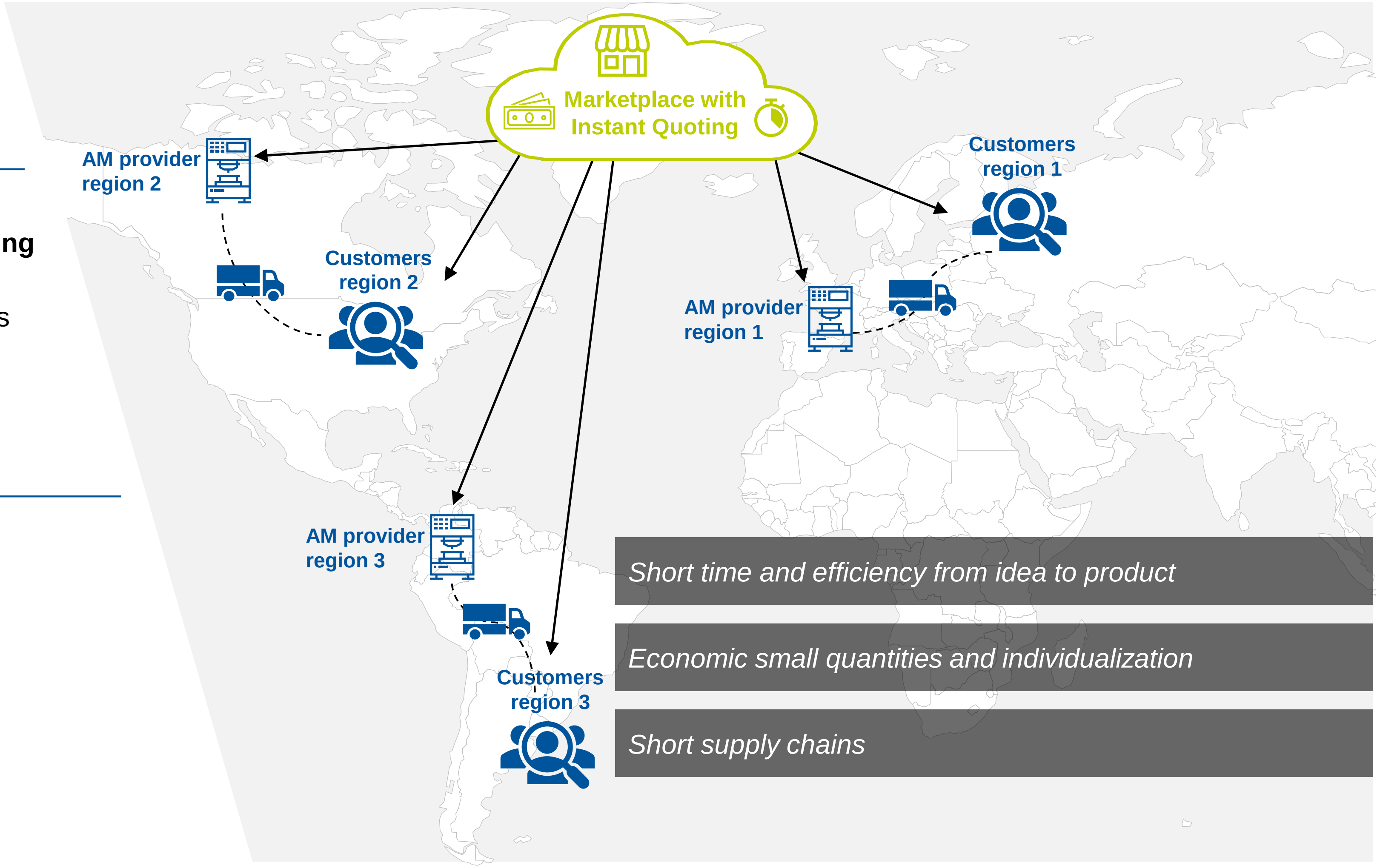
PROTIQ Xometry HUBS A PROTOLABS COMPANY

Online marketplace for AM

- Integration of manufacturing providers
- Platform for customers to **compare manufacturing services** of of different providers
- **Instant quoting tool** with cost 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
- …



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Source: Effectory, TCT

Algorithmic Design for Additive Manufacturing – Generative Design

How?

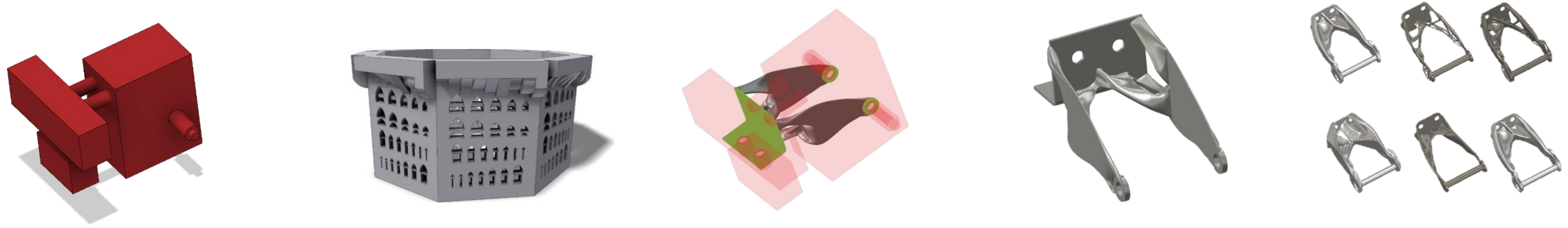
Conventional design ***Additive design***

Source: RWTH DAP, e.GO

Considerations for Successful Adaption of AM

Algorithmic Design for Additive Manufacturing – Generative Design

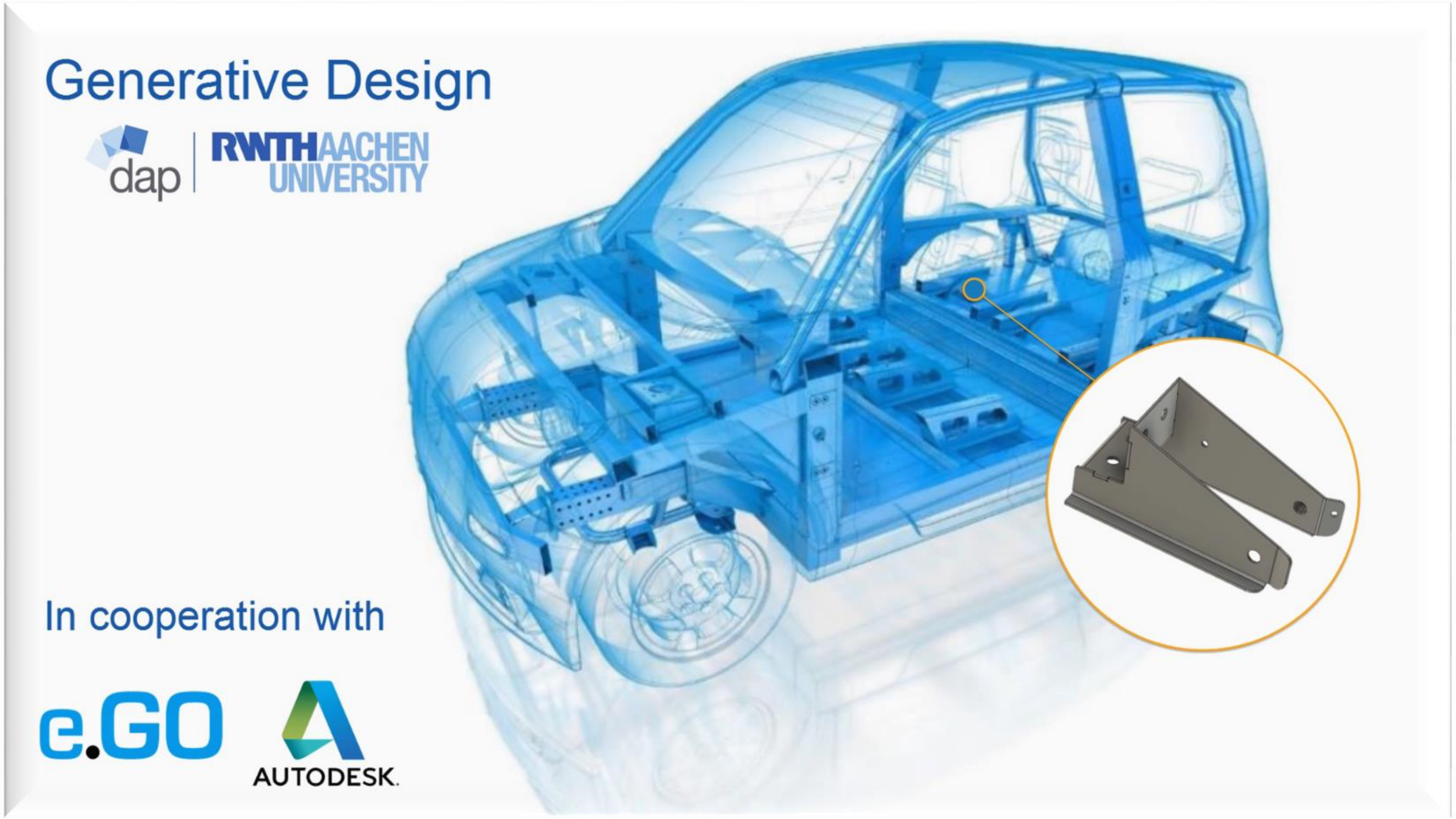
Definition of design space → *Definition of manufacturing constraints* → *Definition of loading and boundary conditions* → *Algorithmic shape optimization* → *Evaluation and adaption of generated options by engineer*



Design and process know how engineer | *Algorithmic optimization* | *Decision by engineer*

Source: RWTH DAP, e.GO

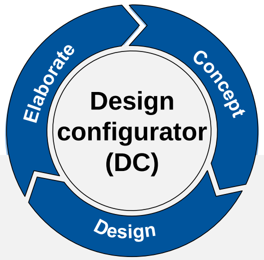
Algorithmic Design for Additive Manufacturing – Generative Design



Source: RWTH DAP, e.GO

Considerations for Successful Adaption of AM

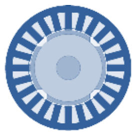
Algorithmic Design for Additive Manufacturing – Busbar Design Configurator



HaPiPro²

Boundary conditions

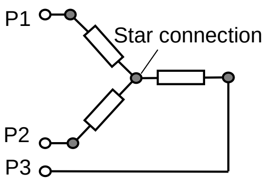
E-machine simulation



Stator & wire parameters

	A	B
1	Innendurchmesser Statornut (Anfang Hammerkopf)	274
2	Nutisolation	0,207
3	Luftspalt zw. NKN	0,05
4	Drahthöhe	2,43
5	Drahtbreite	4,45
6	Einbauspiel	0,1
7	Anzahl Lagen	12

Circuit diagram



Winding scheme

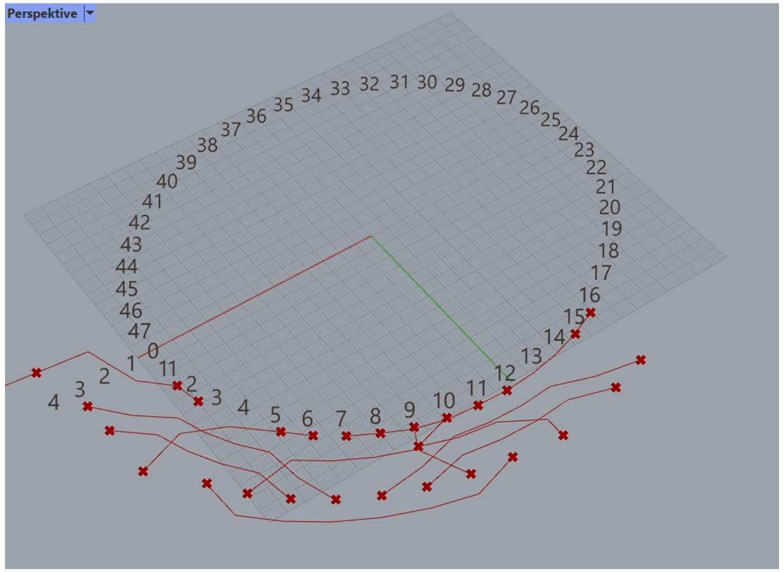
Electro magn. constr.

$R_{el}(T) = \frac{l}{A} * \rho(T_0)(1 + \alpha(T - T_0))$

AM design restr.

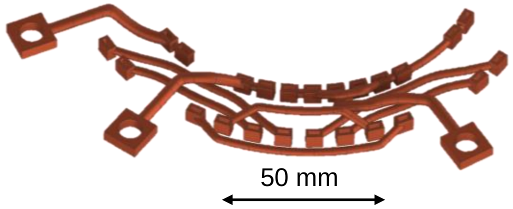
VDI 3405

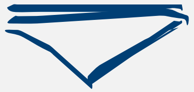
Optimization:
→ Shortest path algorithm



CAD model

Automotive Busbar





Printed pure copper busbars

Source: RWTH DAP

Considerations for 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.*

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Source: Effectory, TCT

Considerations for 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

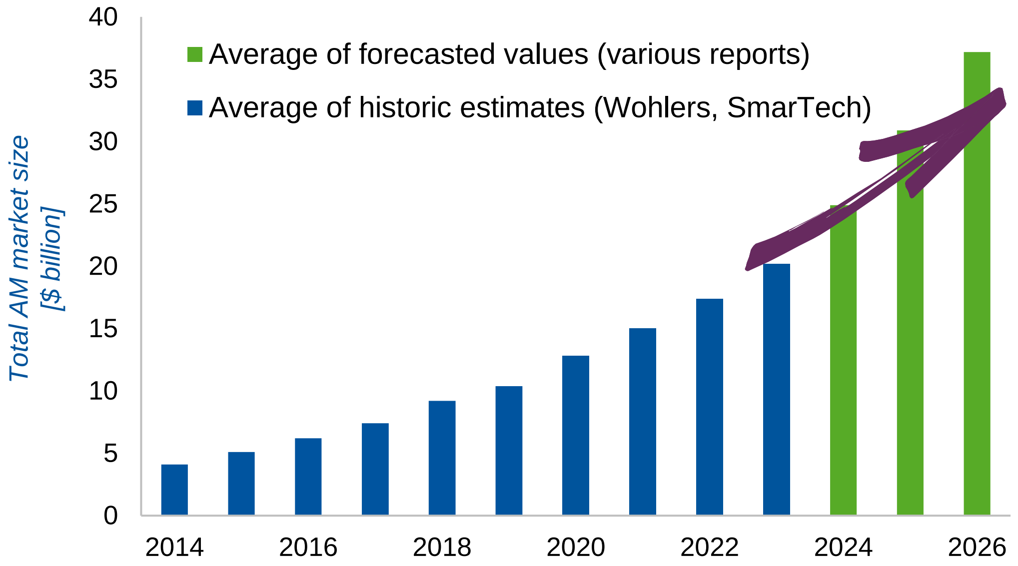
- Heat-protective gloves
- Flameproof clothing
- Full respiratory mask
- Protective shield
- ESD wristband

Prevention of health hazards requires implementation of specific safety measures

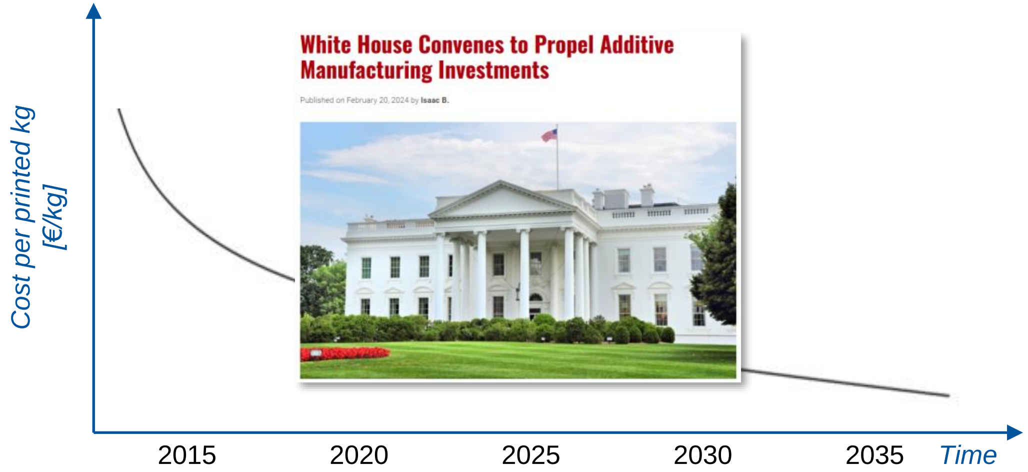
Basic AM Seminar – Content

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

Expected market development



Prognosis of cost development



- *Increase of machine productivity*
- *Decrease of material prices*
- *Higher degree of automation*
- *Increase of AM specific standards*

Continuous growth is predicted for the AM market and there is still high public funding. However, we see market consolidation and pressure on companies to become economic, which are signs of an increasing market maturity.

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

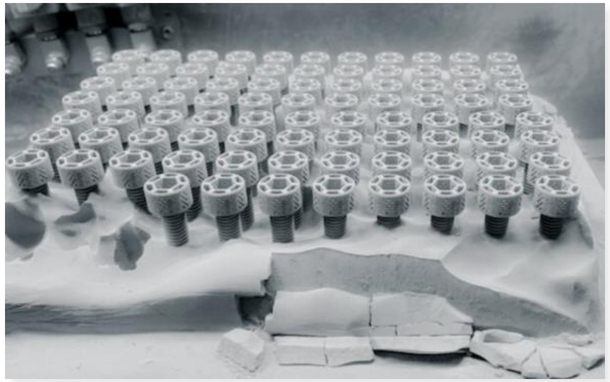
Future Perspective of AM
Emerging AM Technologies – Metal Binder Jetting for Mass Production

Expectations in productivity

- More parts per build job due to 3D nesting compared to 2D nesting with LPBF
- Higher productivity
- No support structures printing and removal required

Barriers for realization

- Additional process steps: Debinding & Sintering (sintering shrinkage compensation)
- Limited part size
- Manual effort for removal of green parts from powder cake, no automation
- Comparably low technology maturity compared to LPBF



Two Volkswagen employees check the quality of 3D printed structural parts at the Wolfsburg center (photo credit: Volkswagen)

Volkswagen and binder jetting, a winning duo?

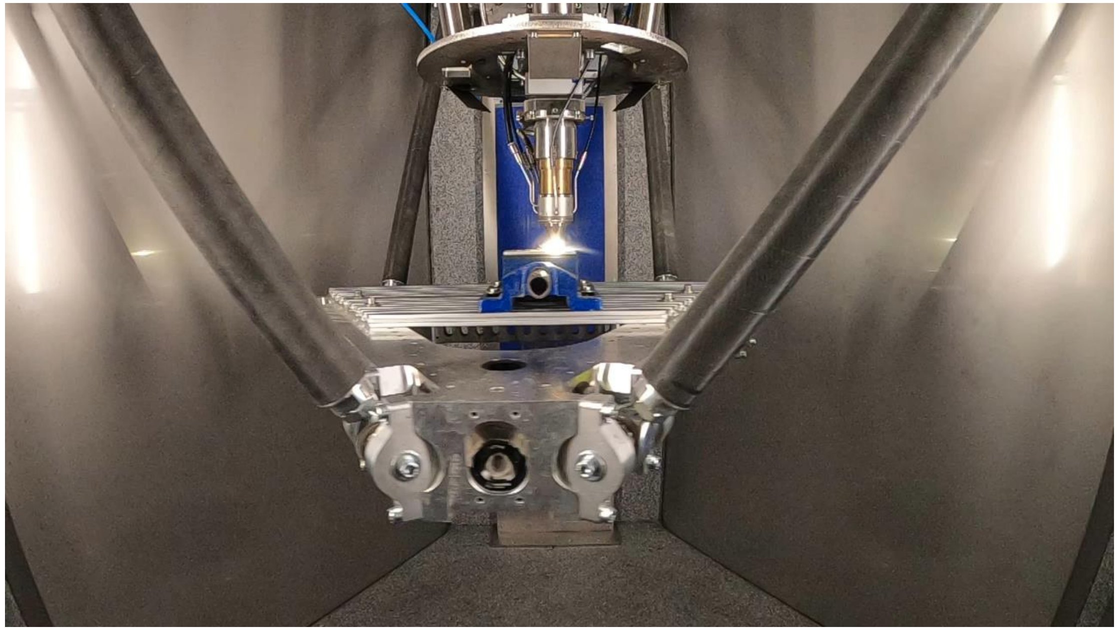
Metal AM on an industrial scale: GKN Additive draws on decades of sintering expertise to commercialise Binder Jetting

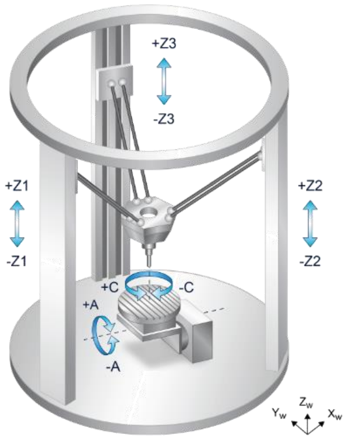
Source: 3Dnatives, AFMG, GKN, Metal AM Magazine

Emerging AM Technologies – EHLA for Non-Rotational Symmetric Parts

Characteristics of the Ponticon 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





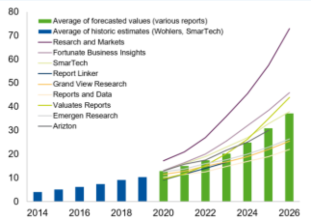
Tripod Kinematics

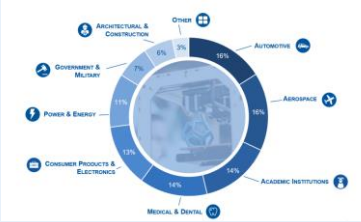
Source: Courtesy of Ponticon

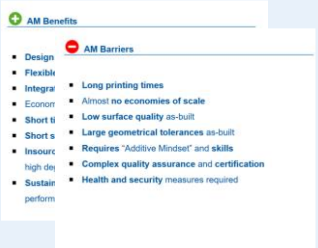
Basic AM Seminar – Content

Basic AM Seminar
Summary

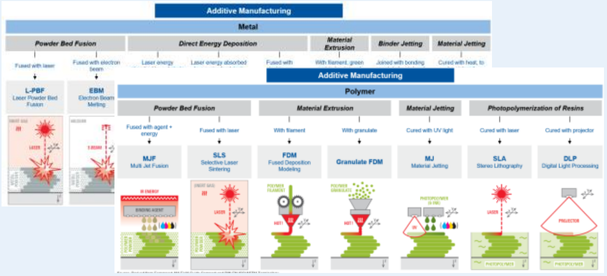
Introduction to Additive Manufacturing







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

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

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!

Gustavo Melo
Senior Consultant

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AACHEN CENTER FOR ADDITIVE MANUFACTURING

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

Get in touch!

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20.11.2024 | 09:30 – 10:30 (English)
21.11.2024 | 09:30 – 10:30 (German)
22.11.2024 | 09:30 – 10:30 (English)

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