AACHEN CENTER
FOR ADDITIVE
MANUFACTURING

Industrielle Prozessketten für die Additive Fertigung

Dr. Kristian Arntz

Fraunhofer-Institut für Produktionstechnologie IPT | ACAM Aachen Center for Additive Manufacturing | WBA Aachener Werkzeugbau Akademie

23. Fachtagung Rapid Prototyping, Lemgo, 26. Oktober 2018

RWTH Aachen University Campus

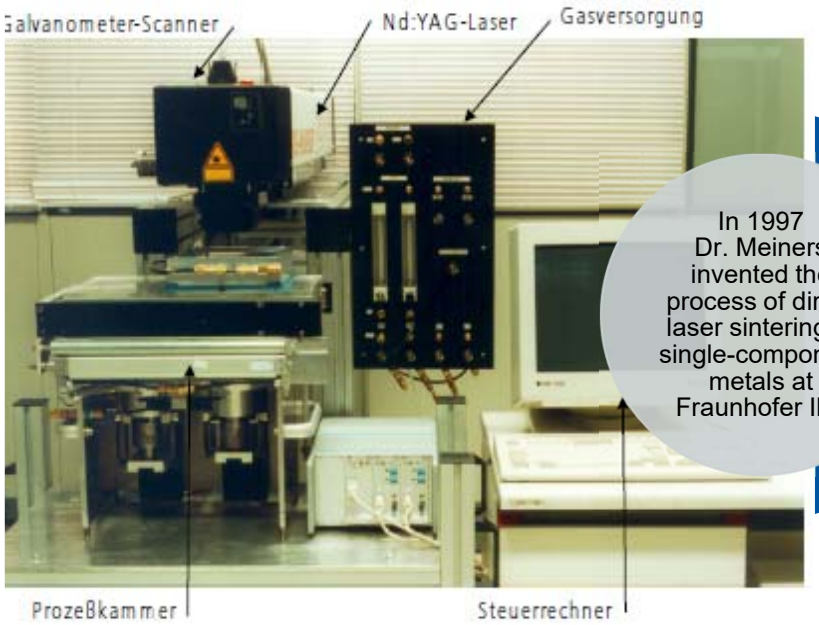
A unique research environment – and unique in its shape

Campus Melaten 2012

Campus Melaten 2016

Additive Manufacturing at the RWTH Aachen Campus

Back in the Days…



In 1997 Dr. Meiners invented the process of direct laser sintering of single-component metals at Fraunhofer ILT

„The cradle of metal AM“

1997:
Basic Patent at Fraunhofer ILT

2001:
First Tool Insert

2008:
First Implant

„The world‘s most vivid and multifaceted AM ecosystem“

Additive Manufacturing at the RWTH Aachen Campus

Nowadays – Cluster Photonics

AACHEN CENTER FOR ADDITIVE MANUFACTURING

Fraunhofer ILT

Fraunhofer IPT

dap Digital Additive Production | RWTH AACHEN UNIVERSITY

iwf An-Institut der FH Aachen

More than **100 researchers** dedicated to AM

200+ years of person years in R&D experience

3,000 m² AM lab space

Design, post-machining and testing facilities

25 systems for metal AM, 15 for polymers

L-PBF, DED, SLS, SLA, EBM, FDM

16 Mio. € yearly overall AM budget

40% industry share

Additive Manufacturing

Some highlights in research, development and cooperation

Fraunhofer ILT | Fraunhofer IPT | DAP Digital Additive Production | RWTH AACHEN UNIVERSITY | WBA WERKZEUGBAU AKADEMIE | AACHEN CENTER FOR ADDITIVE MANUFACTURING

1995: First hybrid machine tool

Development and patent of „Controlled Metal Buildup CMB“ at Fraunhofer IPT

2015: Foundation of ACAM

With 10 research partners and and a growing number (now 30) of industrial members AM is being industrialised

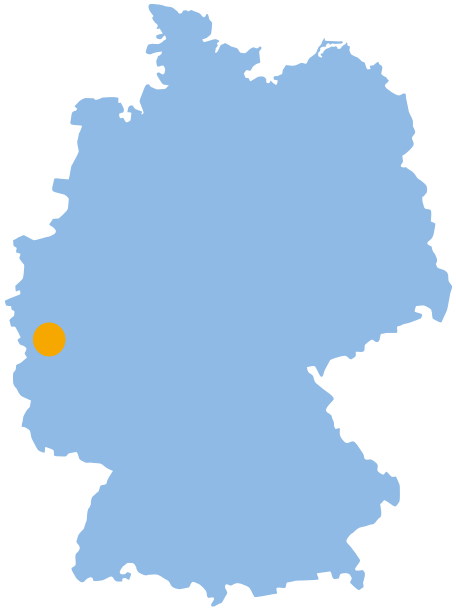
1997: Basic patent for SLM

Development and patent of laser based powder bed fusion of metals at Fraunhofer ILT

2016: LMD ten times faster

Development and patent of High Speed Laser Metal Deposition at Fraunhofer ILT

Additive Manufacturing at the RWTH Aachen Campus
R&D Stakeholders



University, research institutes and spin-off companies in Aachen

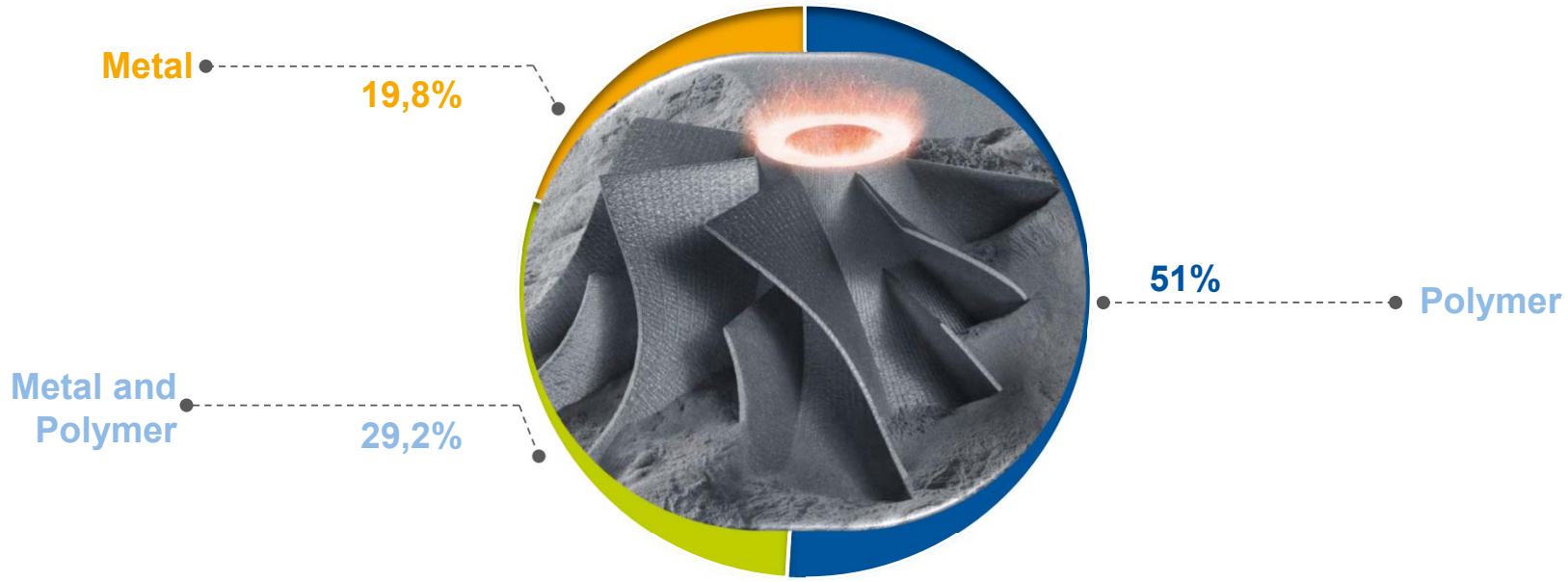
Research Partners at the

AACHEN CENTER FOR ADDITIVE MANUFACTURING

- **Primary contact partner** for Additive Manufacturing
- **We pool resources and facilitate the access to the Additive Manufacturing expertise** of the leading scientific and research institutions the RWTH Aachen Campus for the industry
- Provides opportunities for **joint R&D**, a sophisticated **training and education program**, as well as an **online platform** enabling industrial members to build business connections.

Economical perspective

The potential of Additive Manufacturing



UP

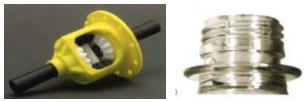
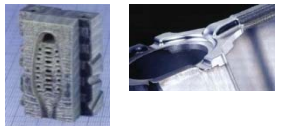
10,8 Bi. €

The global market volume of products and services in the field of Additive Manufacturing will increase to € 10.8 billion by 2020.[1]

Quelle: [1]Wohlers Report 2013; Bildquelle: trumpf.com

Technical perspective

Additive Manufacturing is a huge bundle of technologies

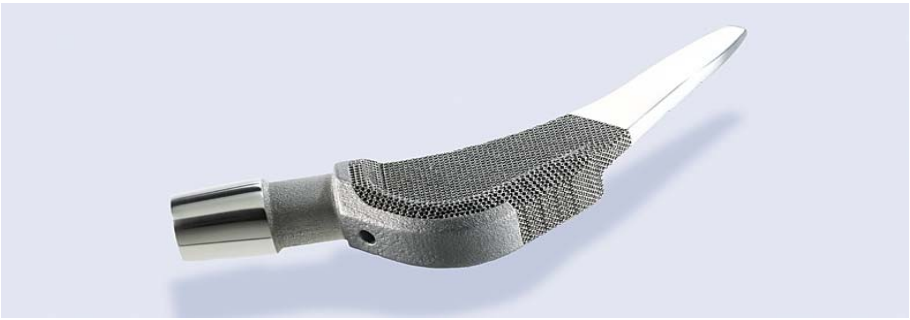
	»Prototyping«			»Manufacturing«	
Application	Concept models/ geometry models	Functional models	Prototype-tools	Direct Tooling	Direct manufacturing
Quality of component properties					
Material	Plastics	Plastics Metals	Plastics, wax Sands / ceramics	Plastics Metals	Plastics Metals Ceramics
Procedure	3DP, SL FDM Laser sintering Polymer pressure	3DP, SL FDM Laser sintering Polymer pressure	3DP, SLA FDM Laser sintering Polymer pressure Wax pressure	Laser sintering/ -melting LMD EBM	3DP, SL FDM, EBM Laser sintering/ -melting LMD
Typical application					
	Prototype mobile phone case	Prototypes drive, coke bottle	Models for founding	Tools	Tooth crown, hearing aid jacket

Source: 3DP: Binder Jetting, SL: Stereolithographie, FDM: Fused deposition modeling, LMD: Laser metal deposition, EBM: Electron beam melting

Additive manufacturing

What distinguishes this new paradigm of production?

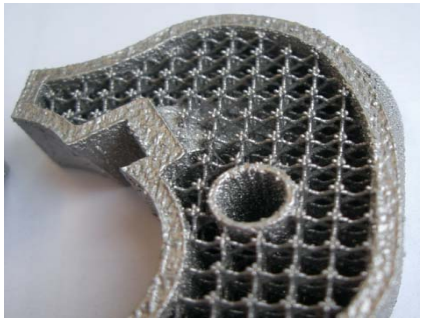
Individualization



Individual patient implants

The consumer as a designer

Complexity



Light-weight design by optimized topology

Function integration

Images: iLAS, Fraunhofer ILT, Fraunhofer IWU, Fraunhofer IFAM; Fraunhofer IPK, Concept Laser, DMRC

Additive manufacturing

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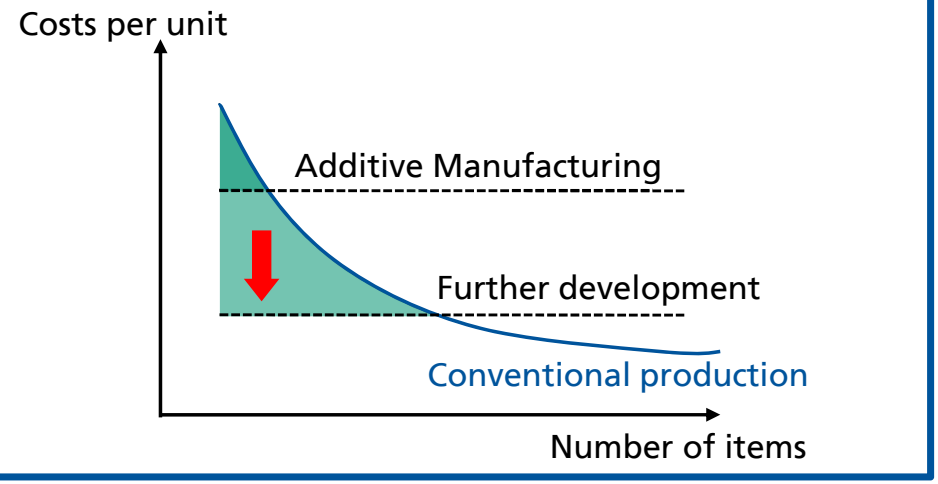
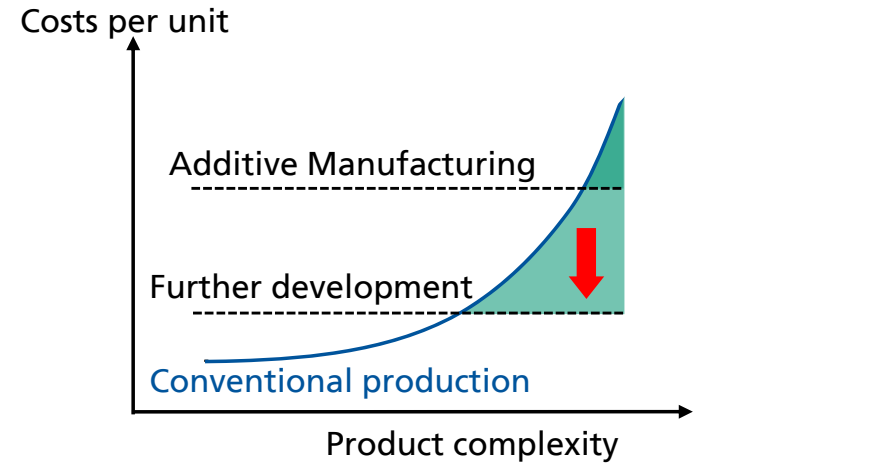
Individualization



Complexity



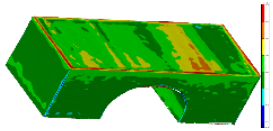
Costs for additive manufactured components are nearly independent of the number of items and the complexity!

Source: Fraunhofer ILT

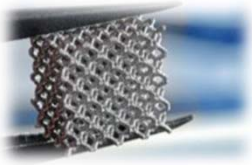
Research and Development

What we do in Additive Manufacturing

Metal AM today

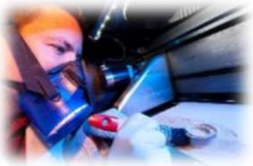


- Limited AM design knowledge & tools
- Isolated Simulation tools
- Different data formats



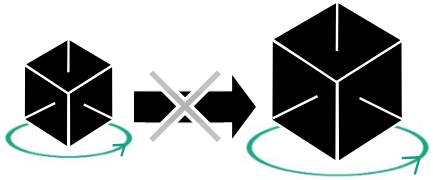
- Limited mfct. speed (1-4 Laser sources)
- Robustness
- Post process QA (CT, etc.)

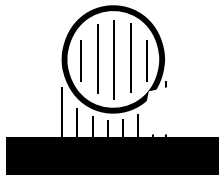
- Limited materials available
- (Almost) no AM-tailored materials



- Manual work along the process chain
- Long (& cost intensive) process chain

Deficits





Fields of action

Digital process chains & I4.0

Scalability & robustness

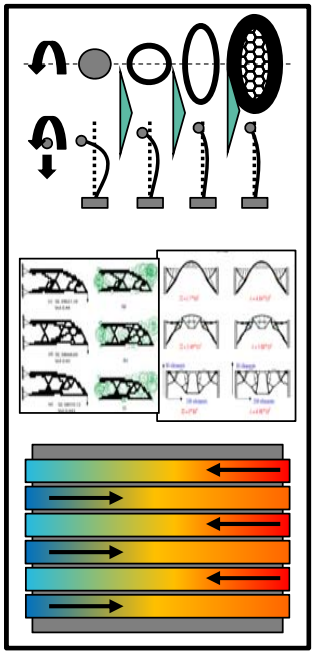
Materials

System technology & automation

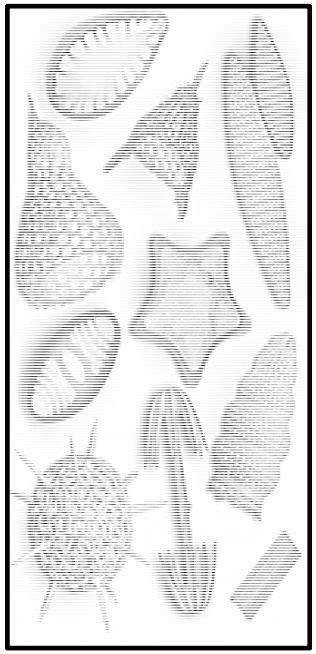
Research and Development

Algorithm-based design and AM will enable a holisitic “digital engineering”

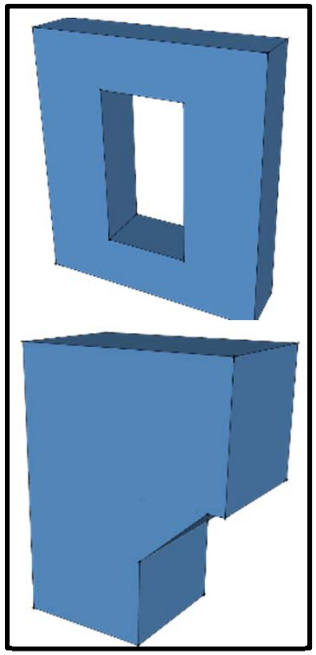
Load constraints



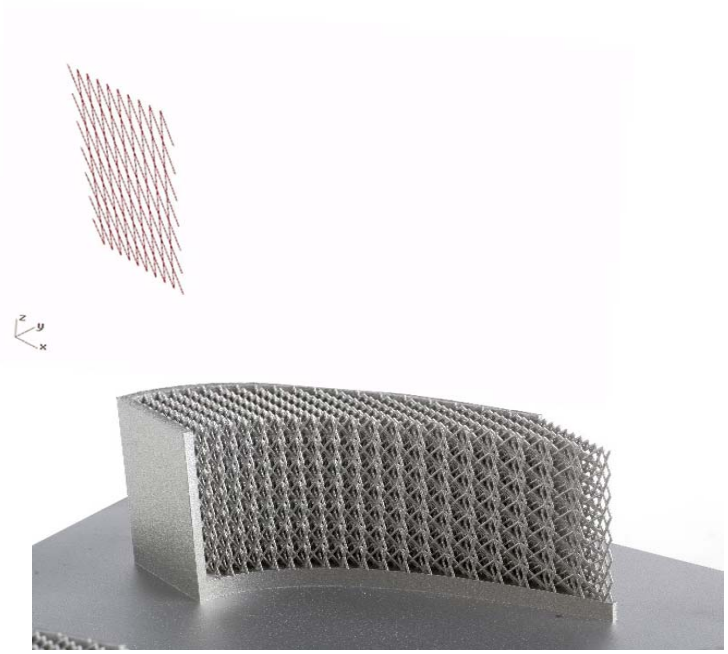
Des. restrictions



Optimization



Mfct. constraints

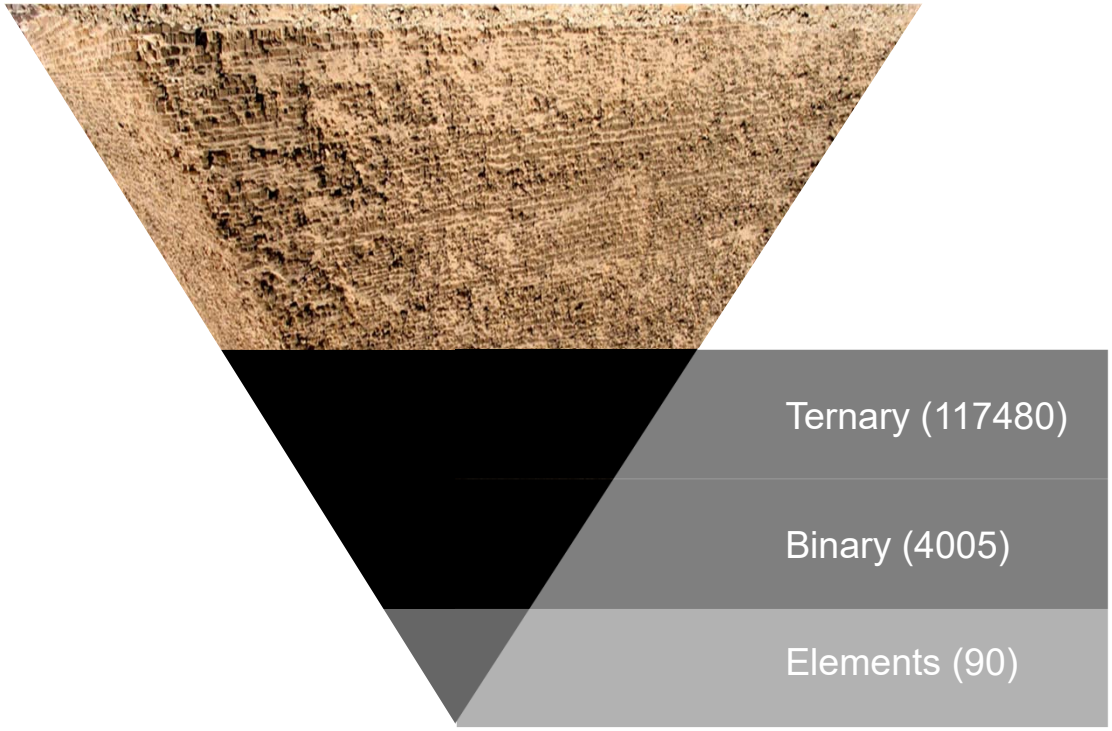


Algorithm-based lattice structures

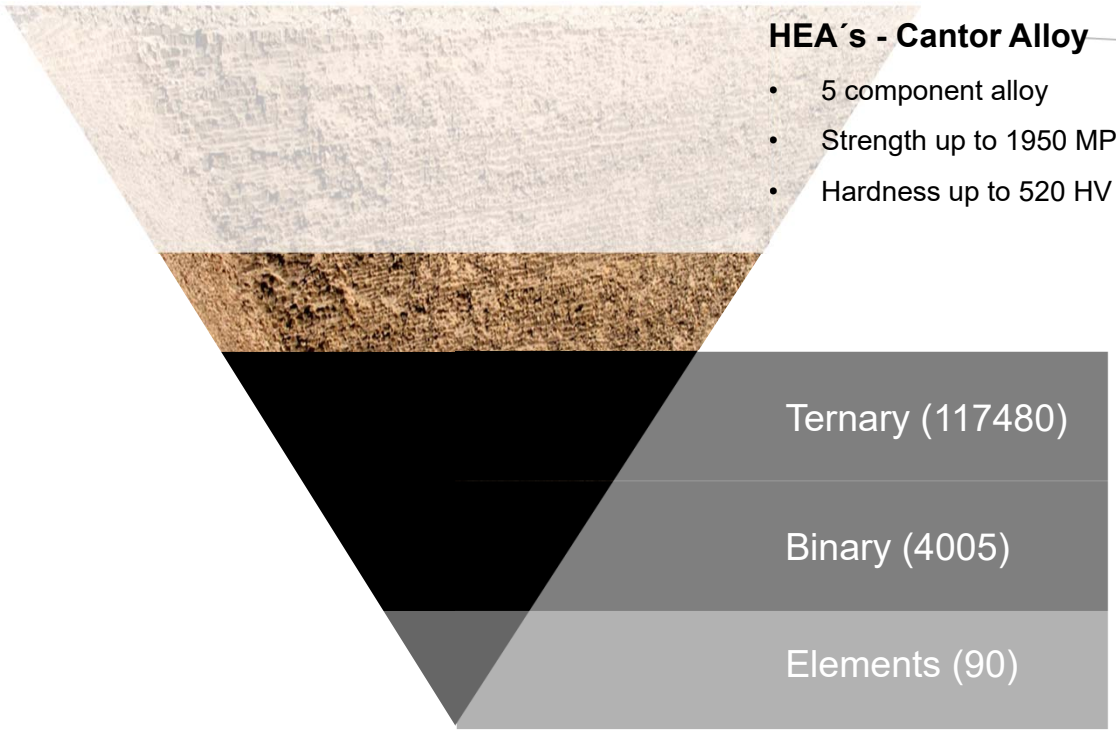
Sources: DAP/ILT

Research and Development

The inverted pyramid of materials…

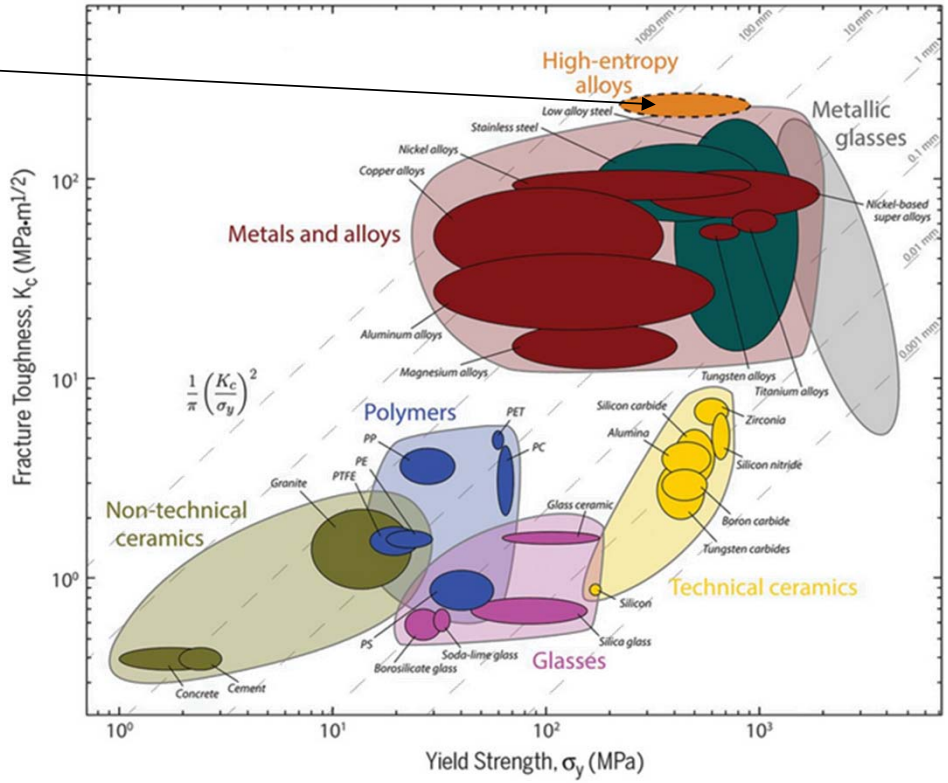


… and the fascinating example of high entropy alloys



HEA´s - Cantor Alloy

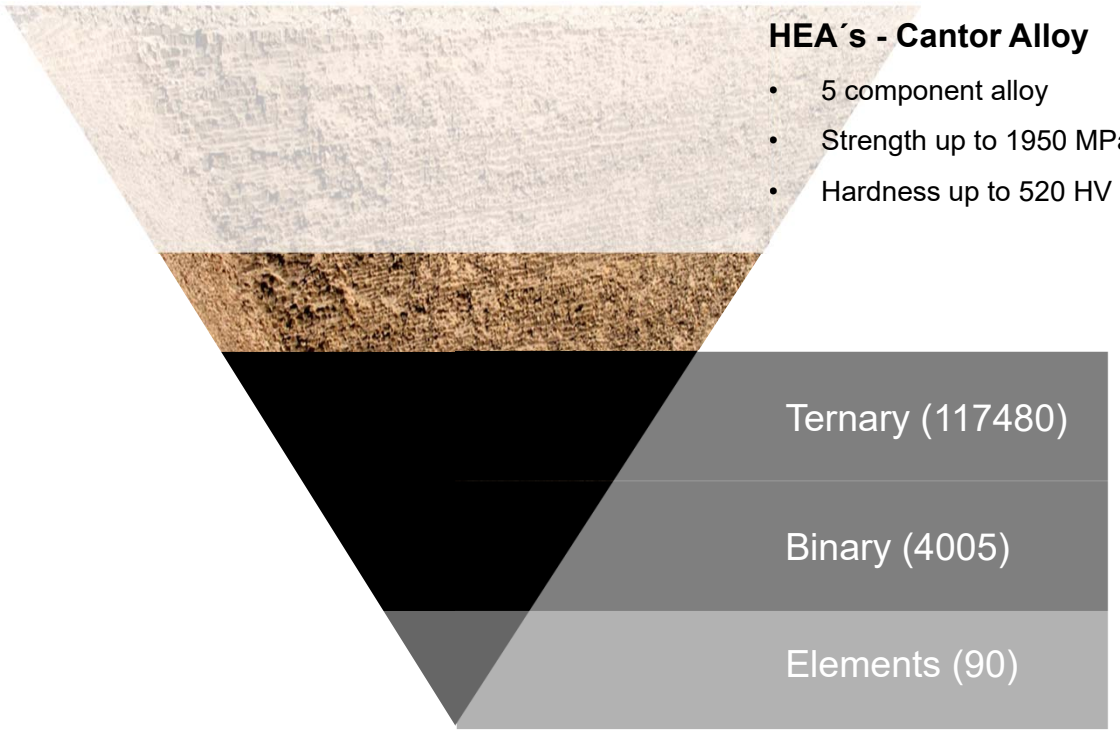
- 5 component alloy
- Strength up to 1950 MPa
- Hardness up to 520 HV



Sources: Gludovatz (2015)

Research and Development

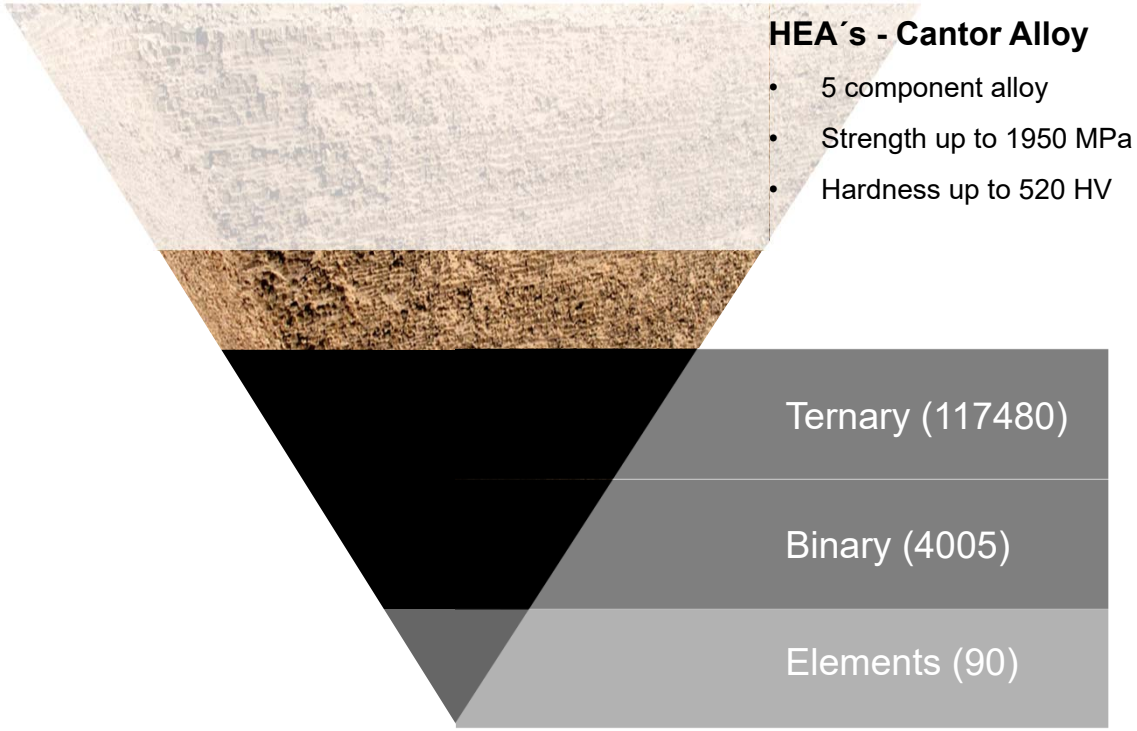
… and the fascinating example of high entropy alloys

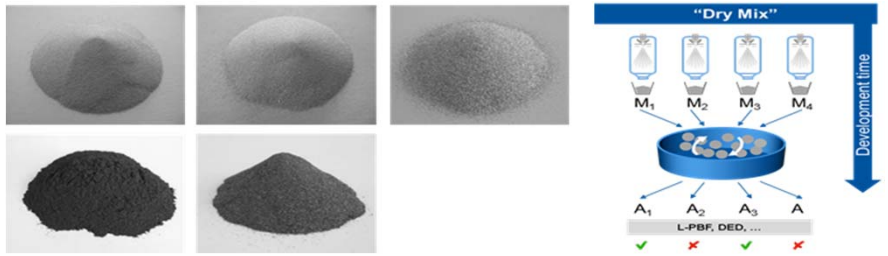


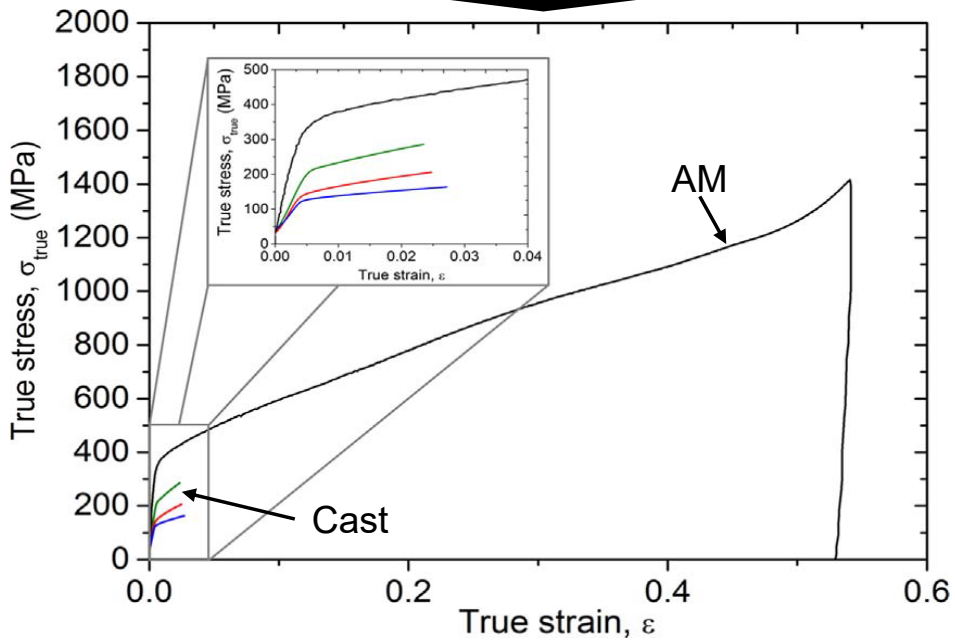
Element	Fe	Mn	Cr	Co	Ni
at.%	20	20	20	20	20
wt.%	19.92	19.58	18.55	21.02	20.93

Research and Development

… enables new materials with superior properties!



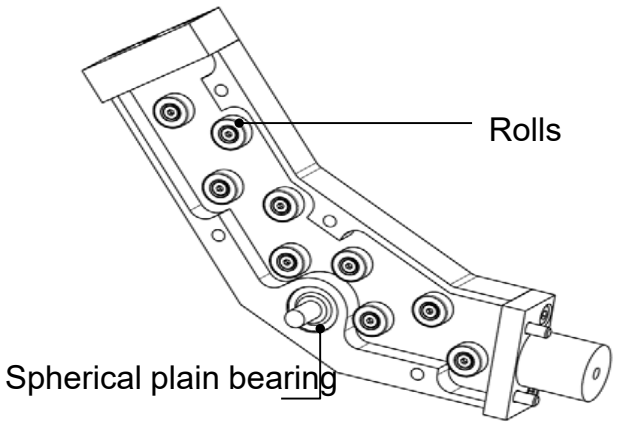




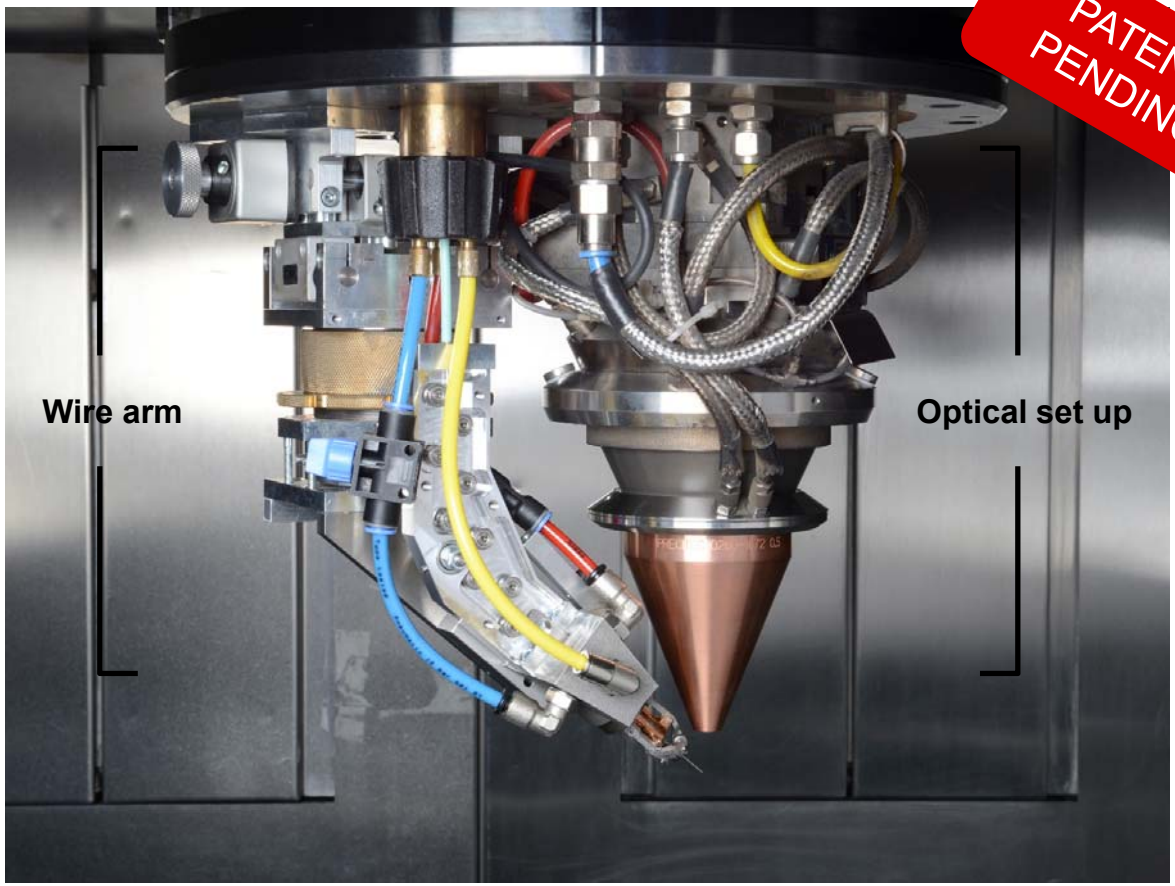
Laser Metal Deposition with Wire

Our Next Generation Wire Arm - Guidance

Wire Guidance



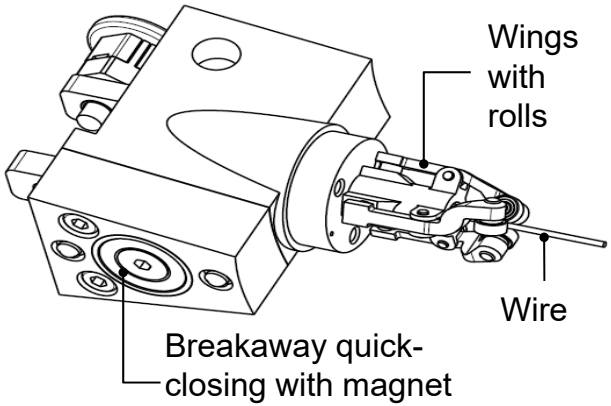
- Reduced friction
- Reduced wear
- Reduced wire bending
- Improved stiffness



Laser Metal Deposition with Wire

Our Next Generation Wire Arm - Nozzle

Wire Nozzle



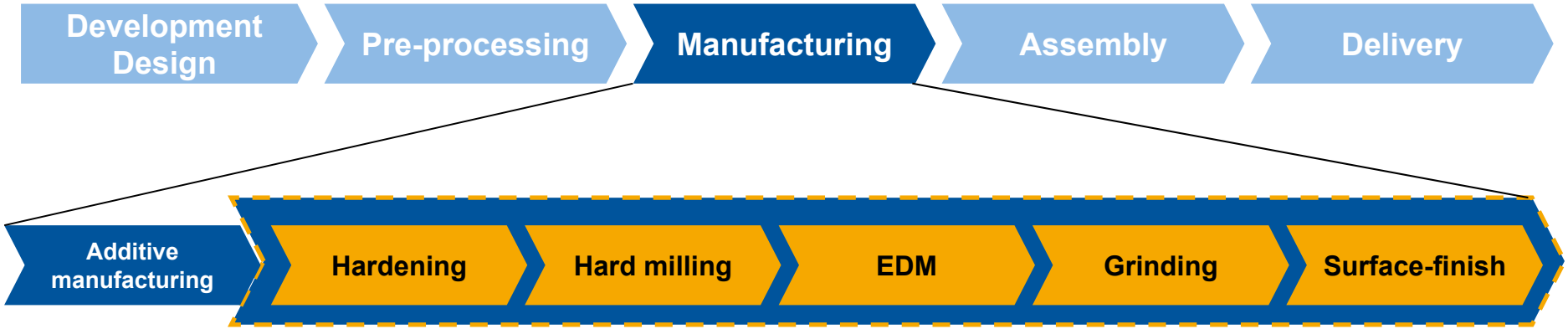
- Improved accuracy
- Reduced friction
- Reduced wear
- Protected system

PATENT PENDING

… and V3.0 to come end of 2018

Additive production: The Integration in process chains

Simplification of the manufacturing process?

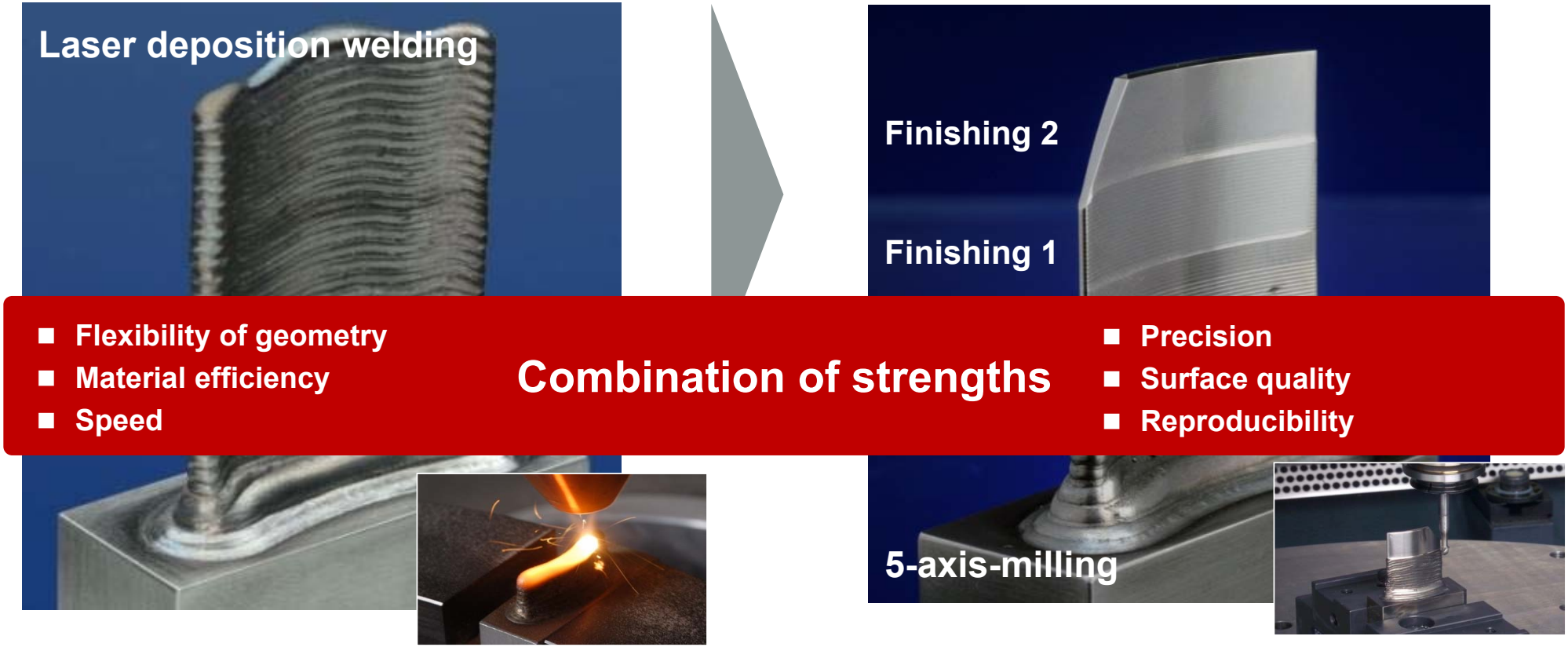


- The use of additive manufacturing process always remains a compromise between
  - Producibility of the component
  - Processing time as the sum of the sub process times
  - Lead time
- The more complex the component, the more cost-efficient gets the use of additive manufacturing process
- Methods for accurate matching between "classical" process chain and "generative" process chain are necessary

Source: Fraunhofer IPT

Process chain focus

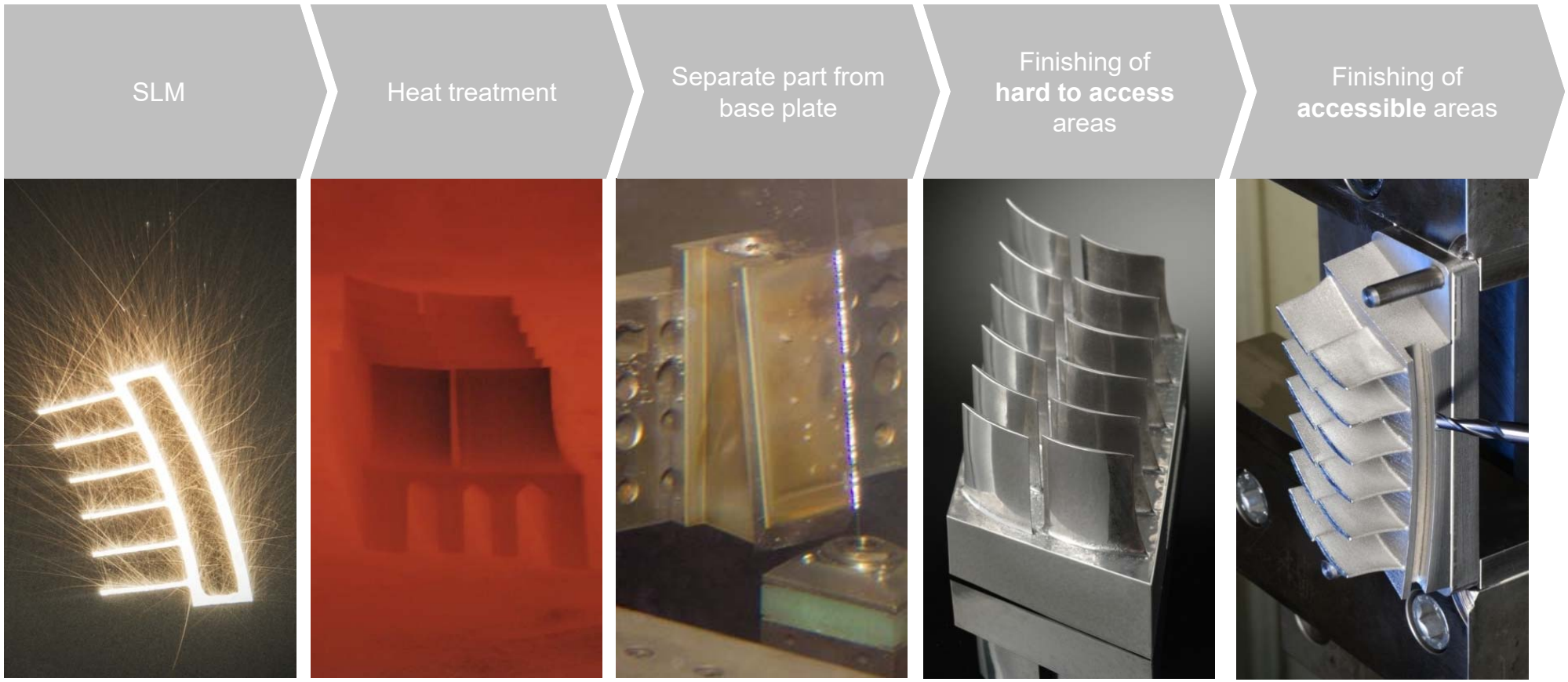
TurPro: Example of a successful operated process chain



Source: Fraunhofer IPT, Fraunhofer ILT

Process chain focus

Success story »Guide Vane Cluster«



Source: Fraunhofer IPT, Fraunhofer ILT

Hybrid part manufacturing

Realising complex milling tools at a reasonable cost

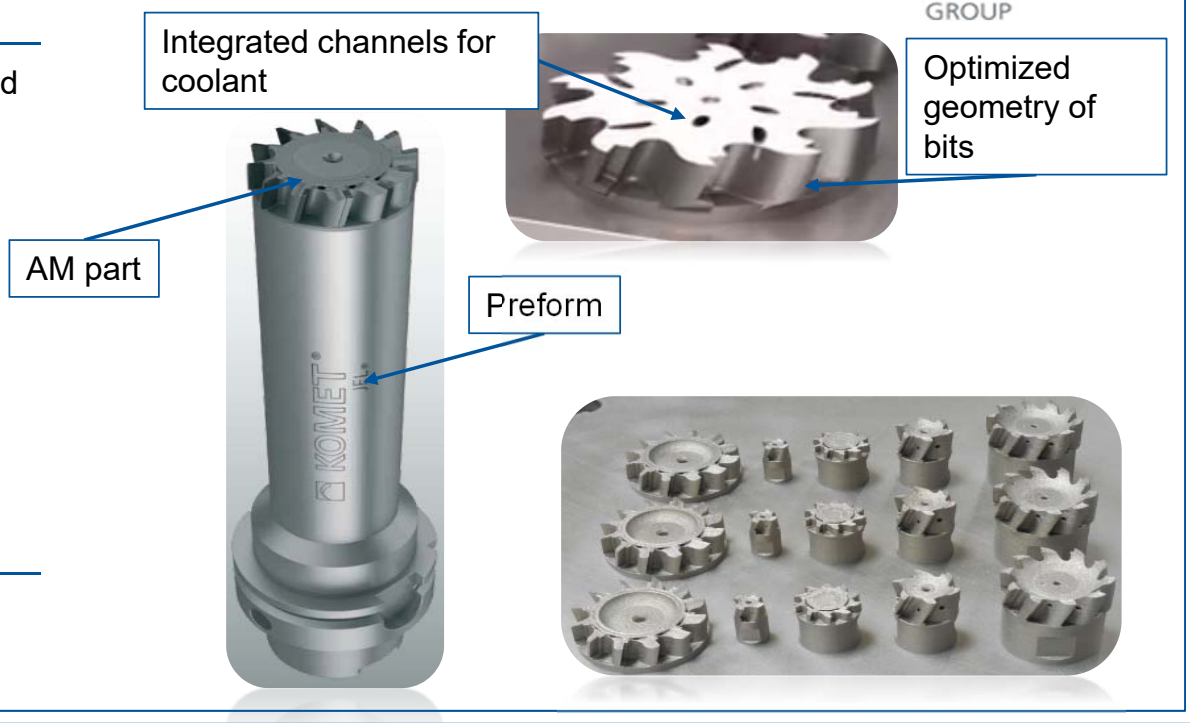
Komet Group GmbH

Advantages of AM

- Higher productivity by optimized geometry and increased number of bits.
  - Plus 50% feed rate
  - 10 instead of 6 bits (plus 67%)
- Reduced tool weight
- Integrated channels for coolant
- Shorter lead time

Production with PDF

- Hybrid manufacturing



Function improvement and reduction of lead time with AM

Source: Komet Group GmbH, Renishaw PLC, Fraunhofer ILT

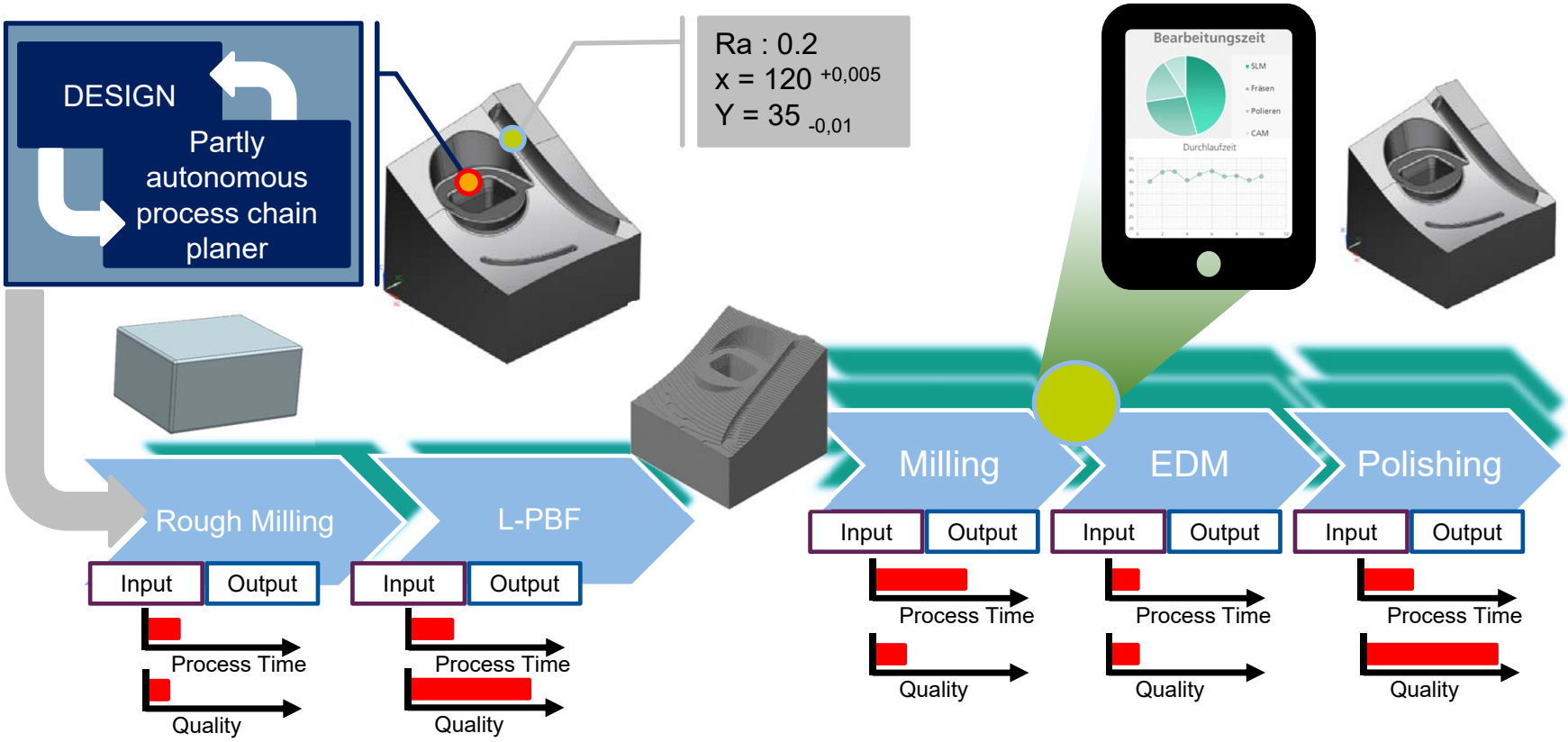
Innovative Process chain approaches

Hybrid parts – reinforcing “standard” castings

Source: Fraunhofer ILT

Evaluation of Technology alternatives

The future: Autonomous Planning of Process Chains

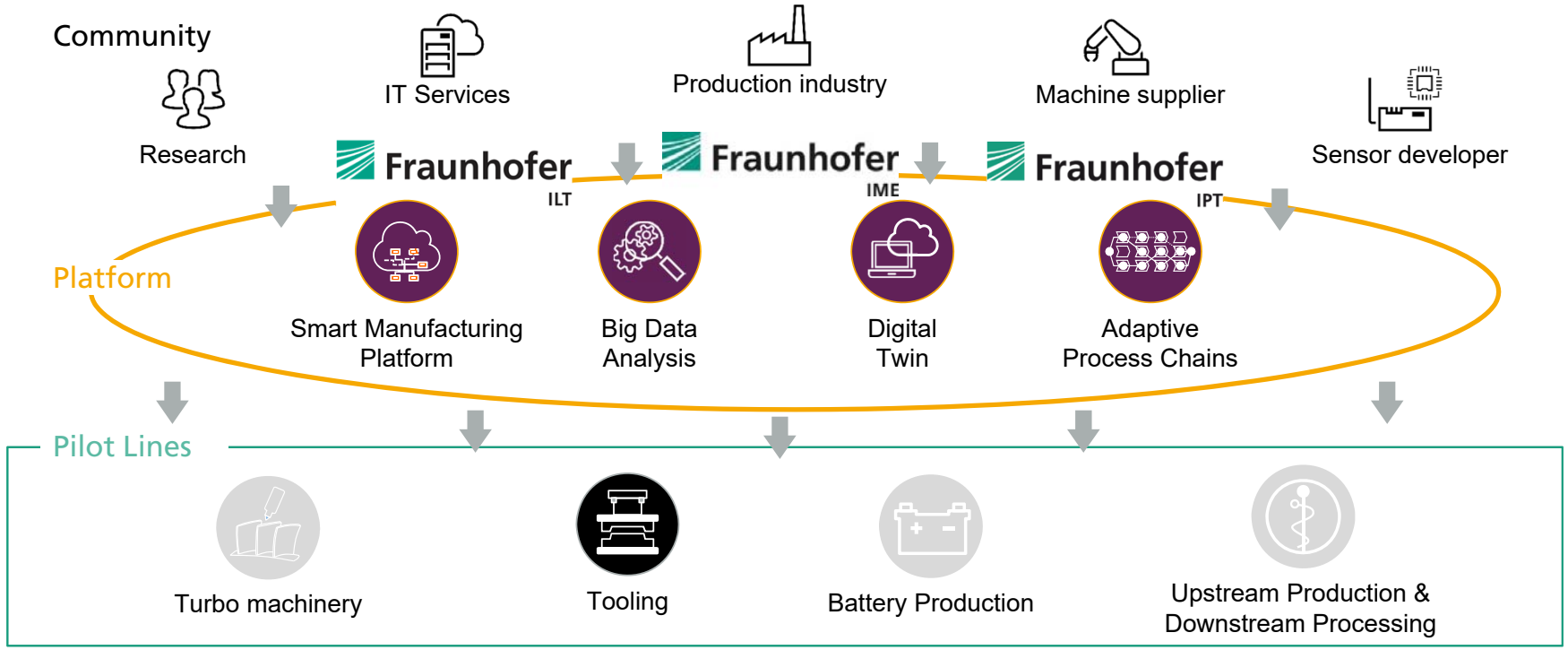


Autonomous planning of process chains will be the future
This will be based on new algorithms and a deep understanding of technologies

Join us in creating the future!

ICNAP: International Center for Networked Adaptive Production

The three Aachen-based Fraunhofer Institutes and other experts from industry and research have established the “International Center for Networked Adaptive Production” (ICNAP) to find out which new approaches in information technology can lead the way towards Industrie 4.0 and which requirements must be met..



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Herzlichen Dank für Ihre Aufmerksamkeit!

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Dr. Kristian Arntz

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