

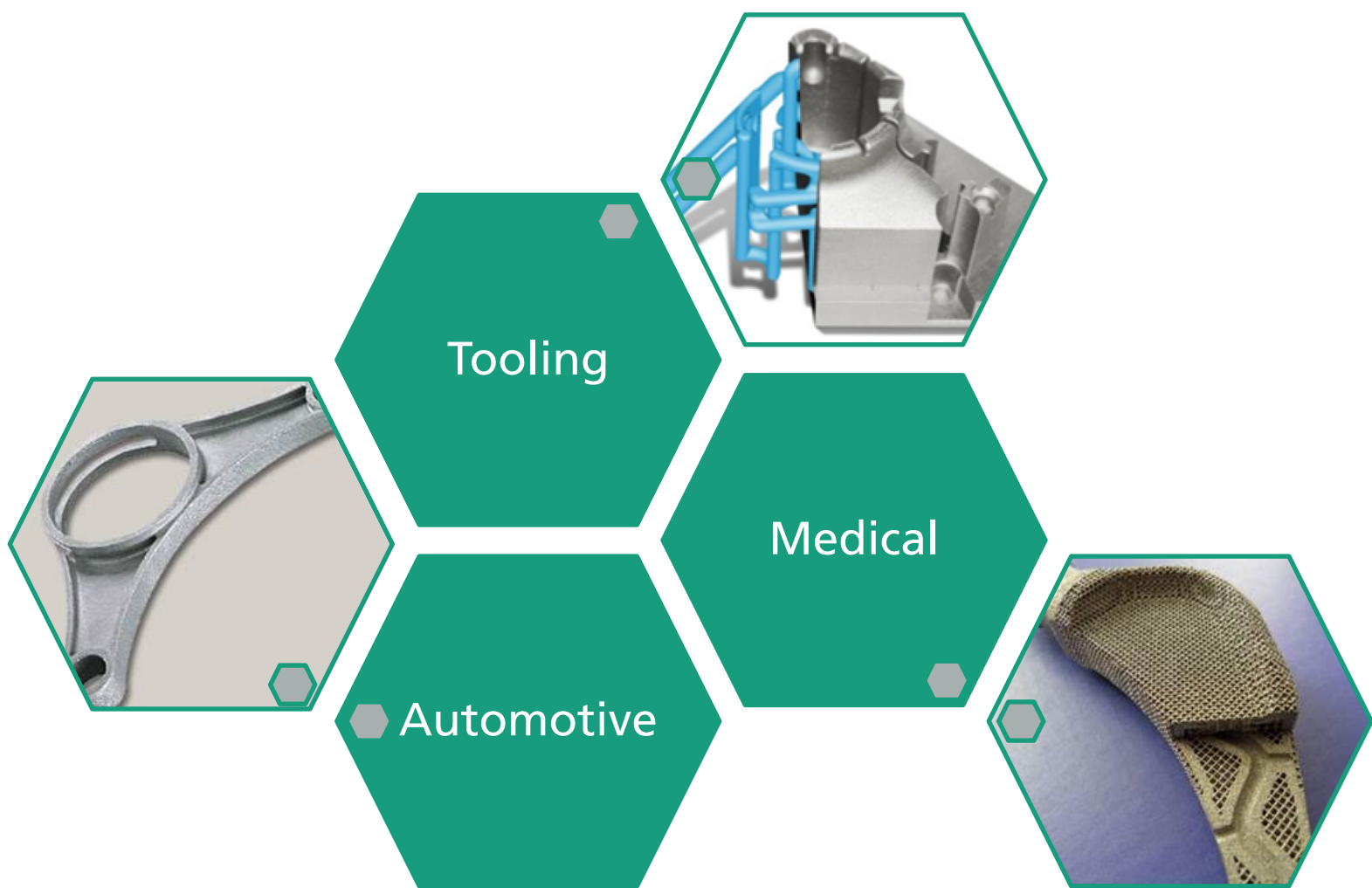
# ADDITIVE MANUFACTURING MARKETS – TOOLING, AUTOMOTIVE & MEDICAL

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2<sup>nd</sup> Munich Technology Conference on Additive Manufacturing, Munich (Germany), October 10-11, 2018



# INDUSTRIALIZATION STATUS

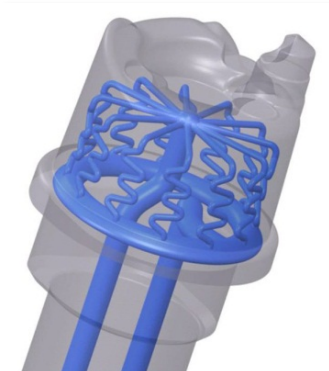
# Industrialization status

## Tooling (mold and die making)

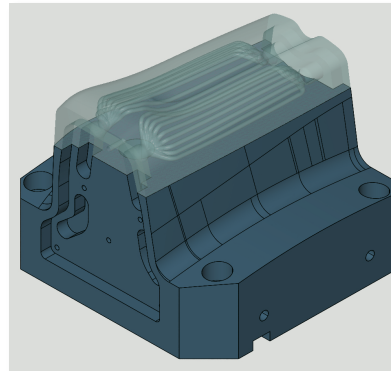
- not yet state of the art despite numerous success stories
- pioneer work to spread from injection molding to casting and forming has been done
- consider added value beyond conformal cooling, e.g. sensor integration
- design your tooling for AM → use hybrid manufacturing, lightweight your tooling!
- consider the total lifecycle cost for economic viability!
- support your tooling designers in adopting AM and take away their fear of the new design challenges (complex cooling systems, CFD analysis etc.)
- wider material choice in tool steels needed (e.g. case hardening steels)



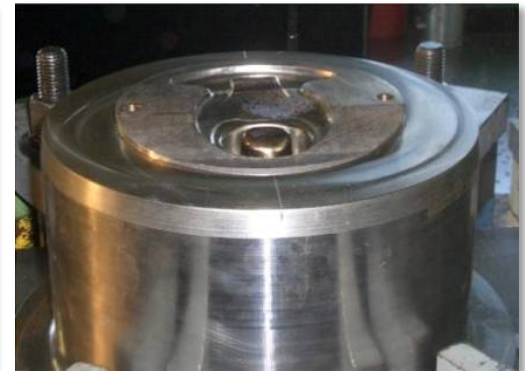
Plastic Injection Molding  
(customer: IAT Stellenbosch)



High Pressure Die Casting  
(customer: DGH Group)



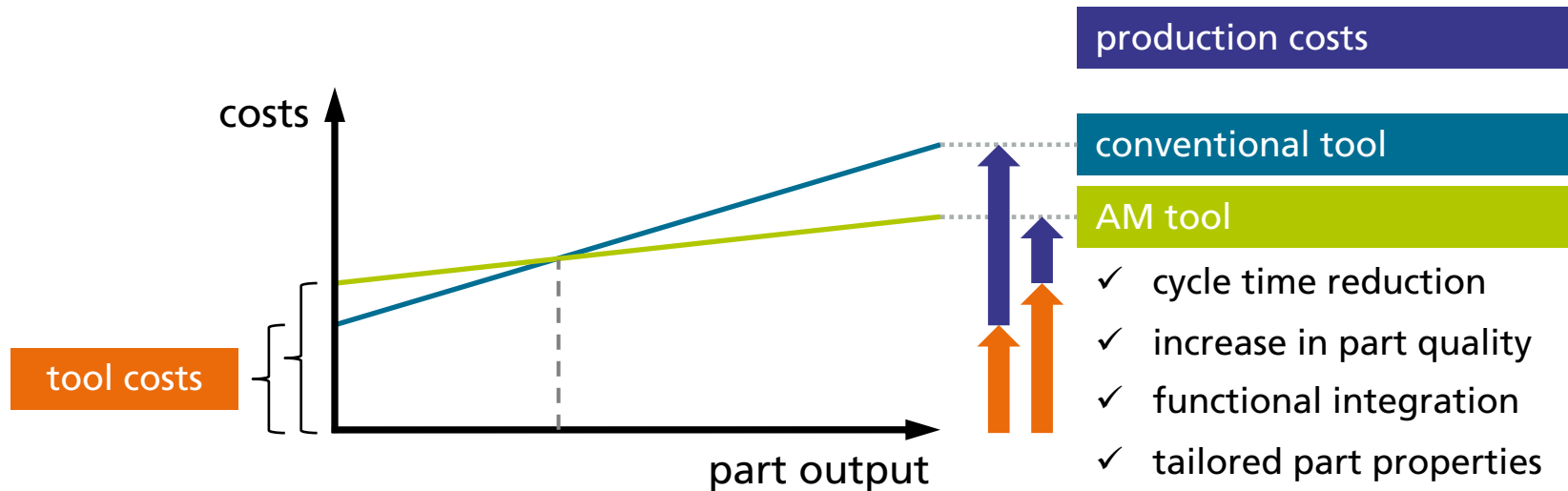
Press Hardening  
(customer: Volkswagen)



Die Forging (customer:  
Mahindra Forgings Europe)

# Industrialization status

## Tooling: Economic viability

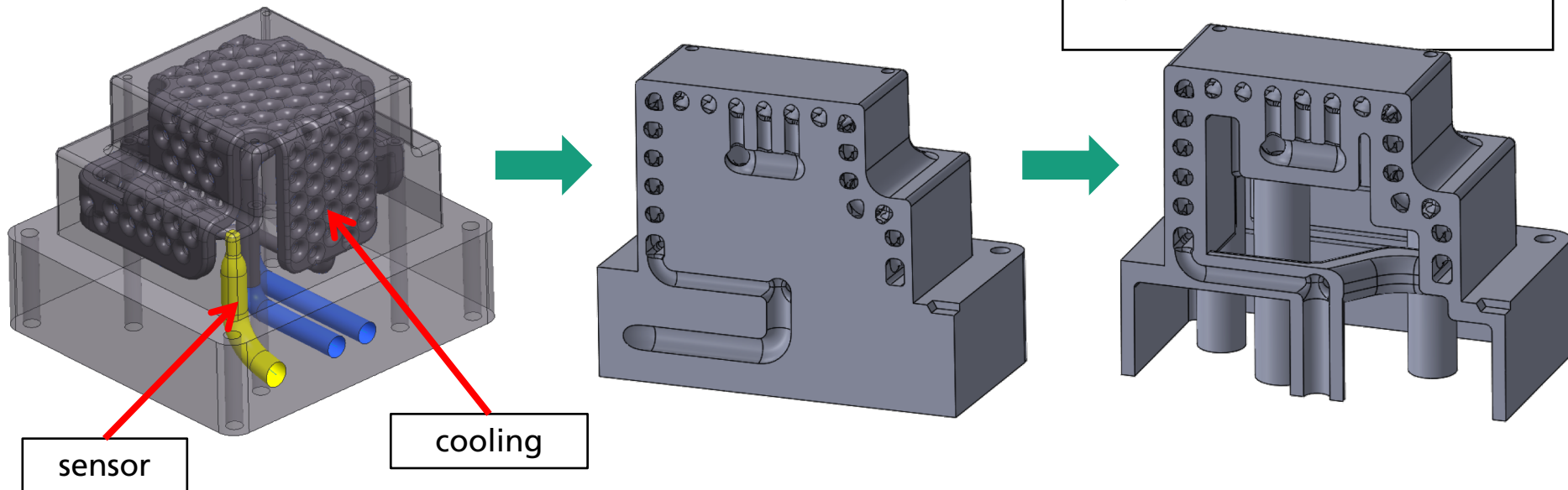
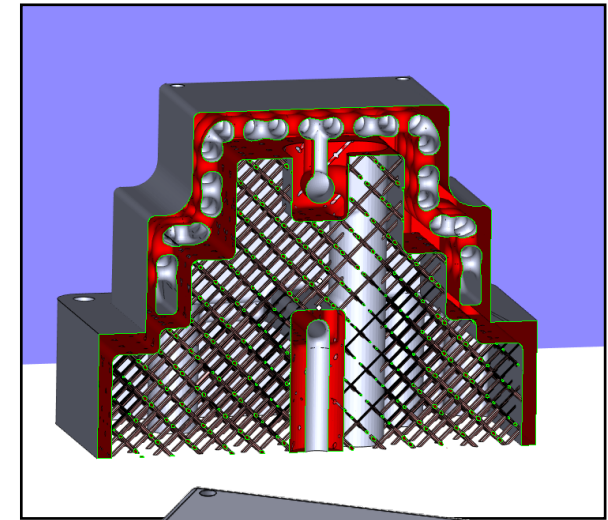




# Industrialization status

## Tooling: Topology optimization and functional integration

- design conformal cooling
- integrate sensor, venting, lubrication, ...
- create shell
- FEA- and/or topology-optimize the inner part, use lattice structures for stiffness and support

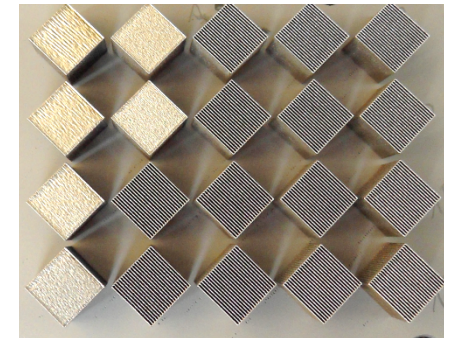
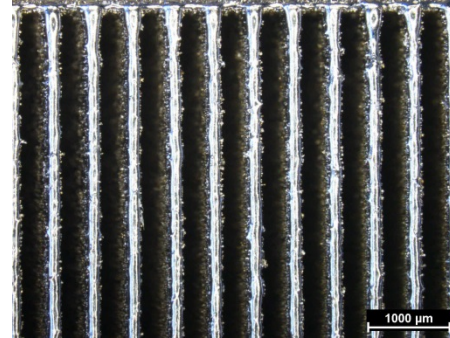
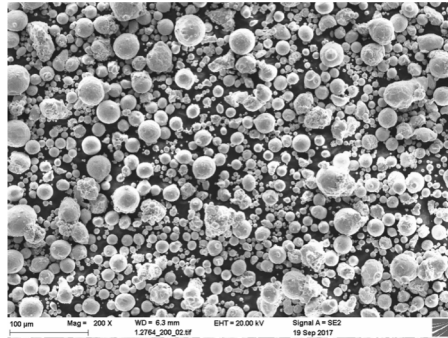


# Industrialization status

## Tooling: Material qualification for case hardening steels

1.2764

X19NiCrMo4



- application potential among others in **tooling** (mold & die making), e.g. for special injection molding applications
- dense, homogenous micro-structure (0,01% porosity)
- also suitable for **large parts**
- mechanical properties: **~40 HRC** as-built, further investigations incl. case hardening still pending

# Industrialization status

## Automotive

- prototyping and pre-series
- motorsports (e.g. Formula 1, DTM, Formula Student)
- tooling (cycle time reduction, quality improvement)
- spare parts (e.g. Daimler truck)
- individualization (e.g. Customize your Mini)
- first small series parts (e.g. Bugatti brake caliper, Audi R8 space frame node)
- first pioneer mass production parts (e.g. BMW i8 Roadster)
- hybrid processes: combine established mass production technologies with AM!

# Industrialization status

## Automotive: Substitution of conventional prototyping



**Substitution of conventional technologies for prototypes by SLM:**

- master forming
- metal forming
- joining
- cutting

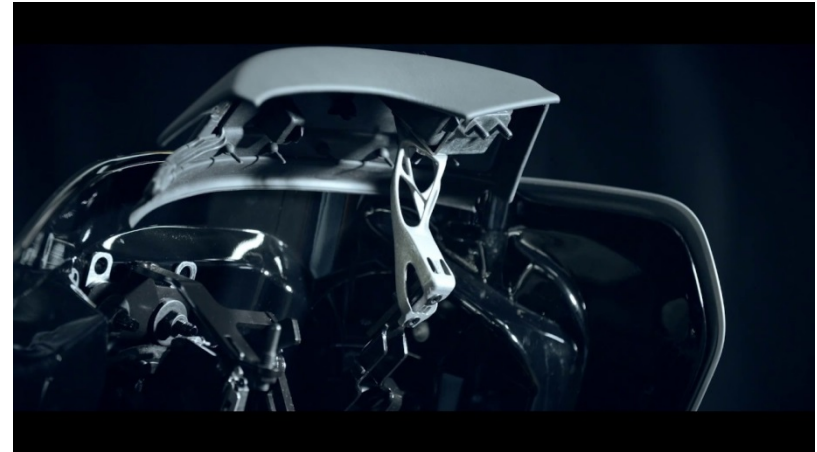
Source: BMW AG



# Industrialization status

## Automotive: Series production

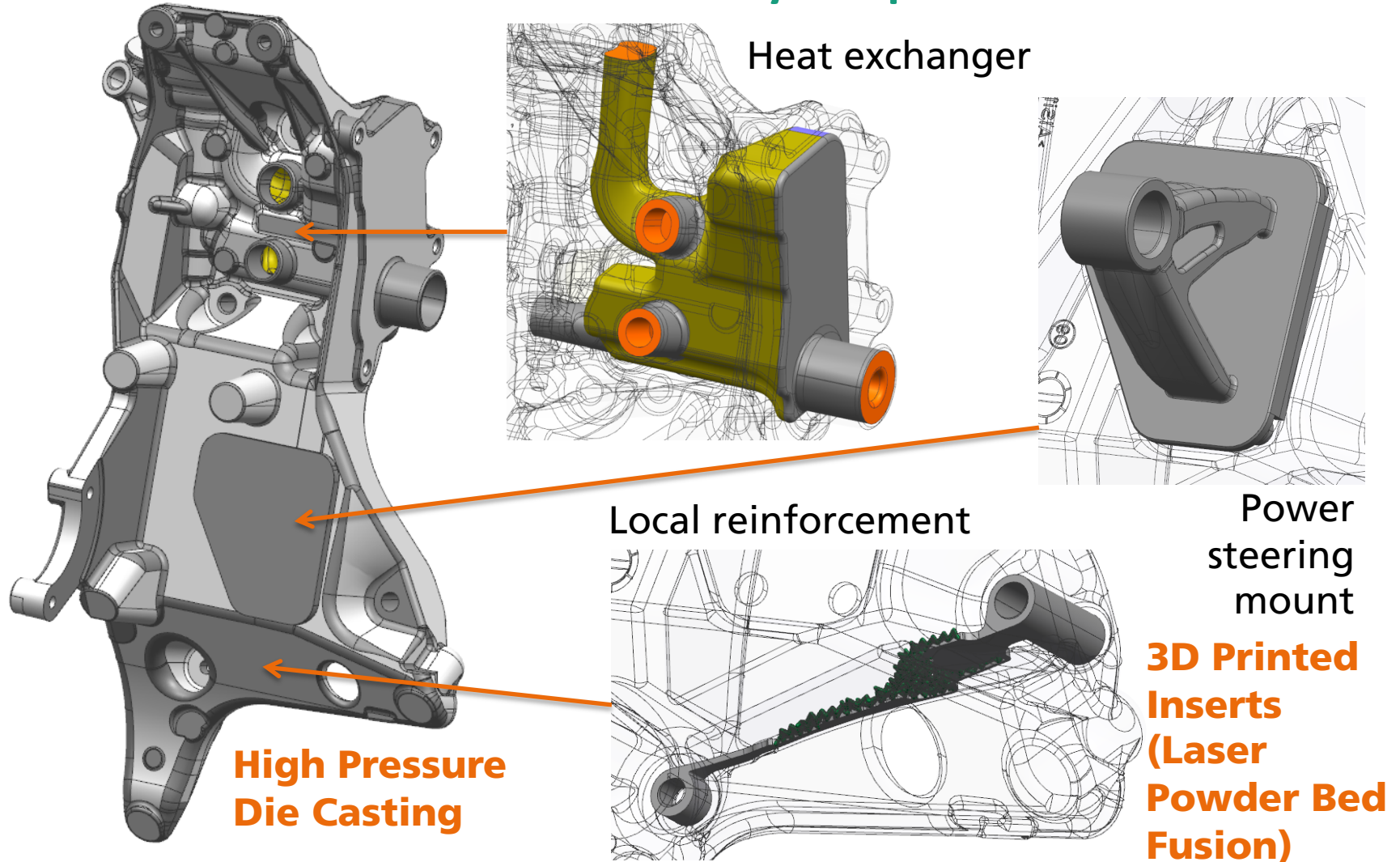
- BMW i8 Roadster: first metal printed mass production part  
<https://www.press.bmwgroup.com/global/video/detail/PF0005744/the-new-bmw-i8-roadster-with-metal-3d-printed-parts>
- Customize your Mini:  
[www.yours-customised.mini](http://www.yours-customised.mini)



Source: BMW AG

# Industrialization status: Automotive

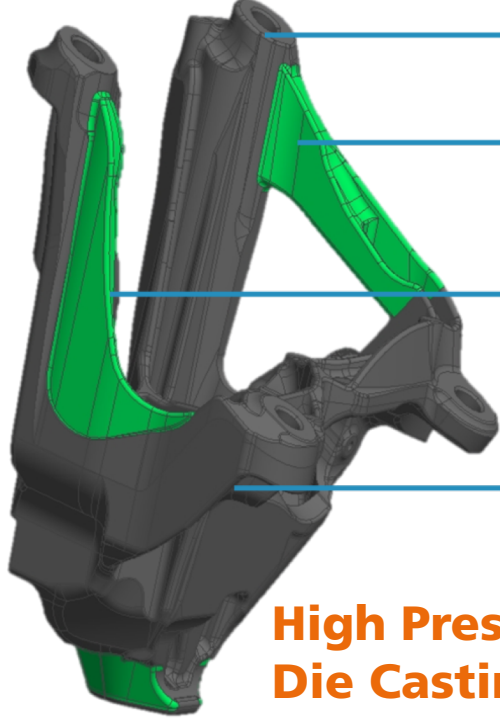
## State of research: CastAutoGen – Hybrid process chain 1





# Industrialization status: Automotive

## State of research: CastAutoGen – Hybrid process chain 2



Die cast part

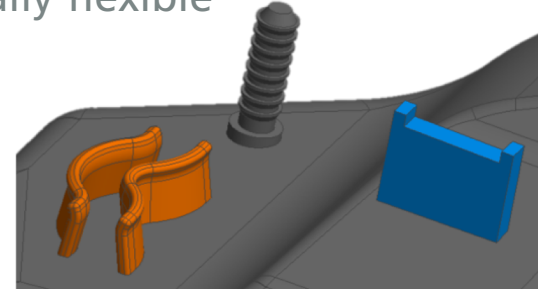
High-strength, local reinforcement from non-castable material

Individual geometry features on die cast part with standard geometry

Individual, geometrically flexible joining elements

- Threaded pin
- Clip mount
- hose fixation

**High Pressure Die Casting**



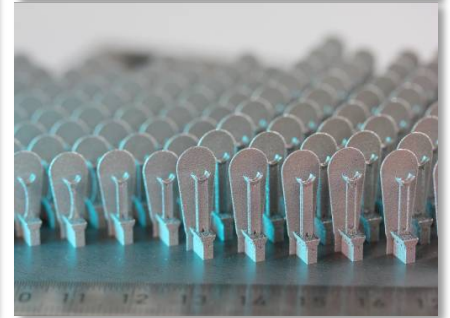
### 3D Printed Features (Laser Metal Deposition)



# Industrialization status

## Medical & Dental Technology

- Functional integration (surface / volume structures, smart materials, channels and cavities)
- Design 4 AM: downsizing, patient-specific and CT data based design
- Theranostic implants: self-detect and cure unwanted loosening
- mass production has already started (Stryker AM factory, FDA approval, standards)



# Industrialization status

## Medical: State of the art

### Pioneer applications for series production



- Manufactured by Electron Beam Melting in titanium
- Trabecular surface structures
- Numbers (as of 2011 already!)
  - > 30,000 manufactured
  - > 10,000 implanted
- Cost benefits!
  - 16 cups (size 48) in 12 h  
→ < 50 €/cup  
→ conventional tantalum coating already 30 - 60 €/cup

### Acetabular cups

Source: Arcam AB

# Industrialization status

## Dental: State of the art

### Pioneer applications for series production



### Dental crowns and bridges

- Manufactured by Laser Beam Melting in CoCr
- Numbers (as of 2012 already):
  - 40 metal AM machines from EOS only (plus more from all other machine manufacturers!) for dental production worldwide
- Cost benefits:
  - Up to 450 crowns and bridges in 24 h



# Industrialization status **Medical: State of research**

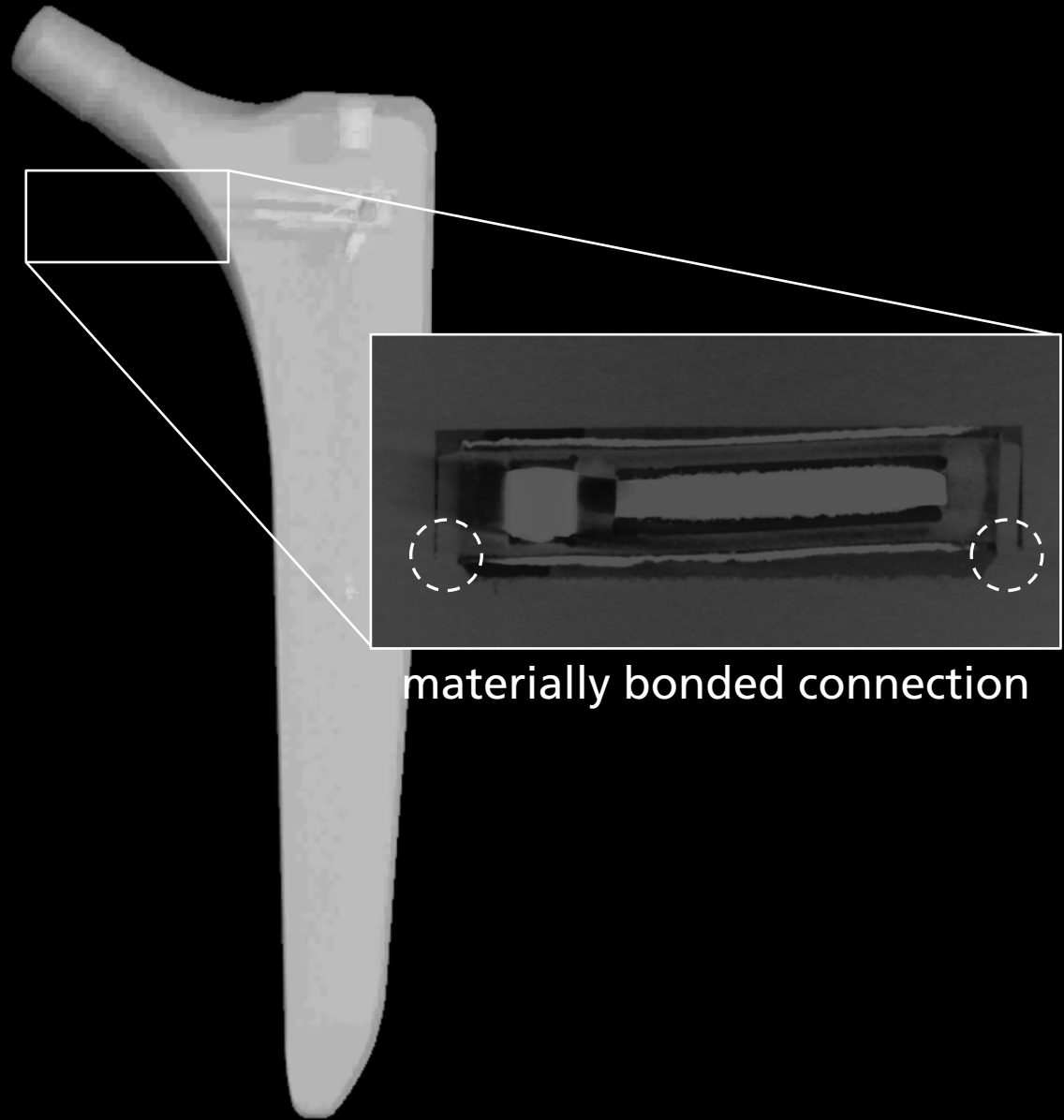
fully hermetical encapsulation and  
materially bonded integration  
of sensor/actuator system  
inside hip stem

additively manufactured hip stem in titanium

+ wireless data and energy transmission



# CT Image

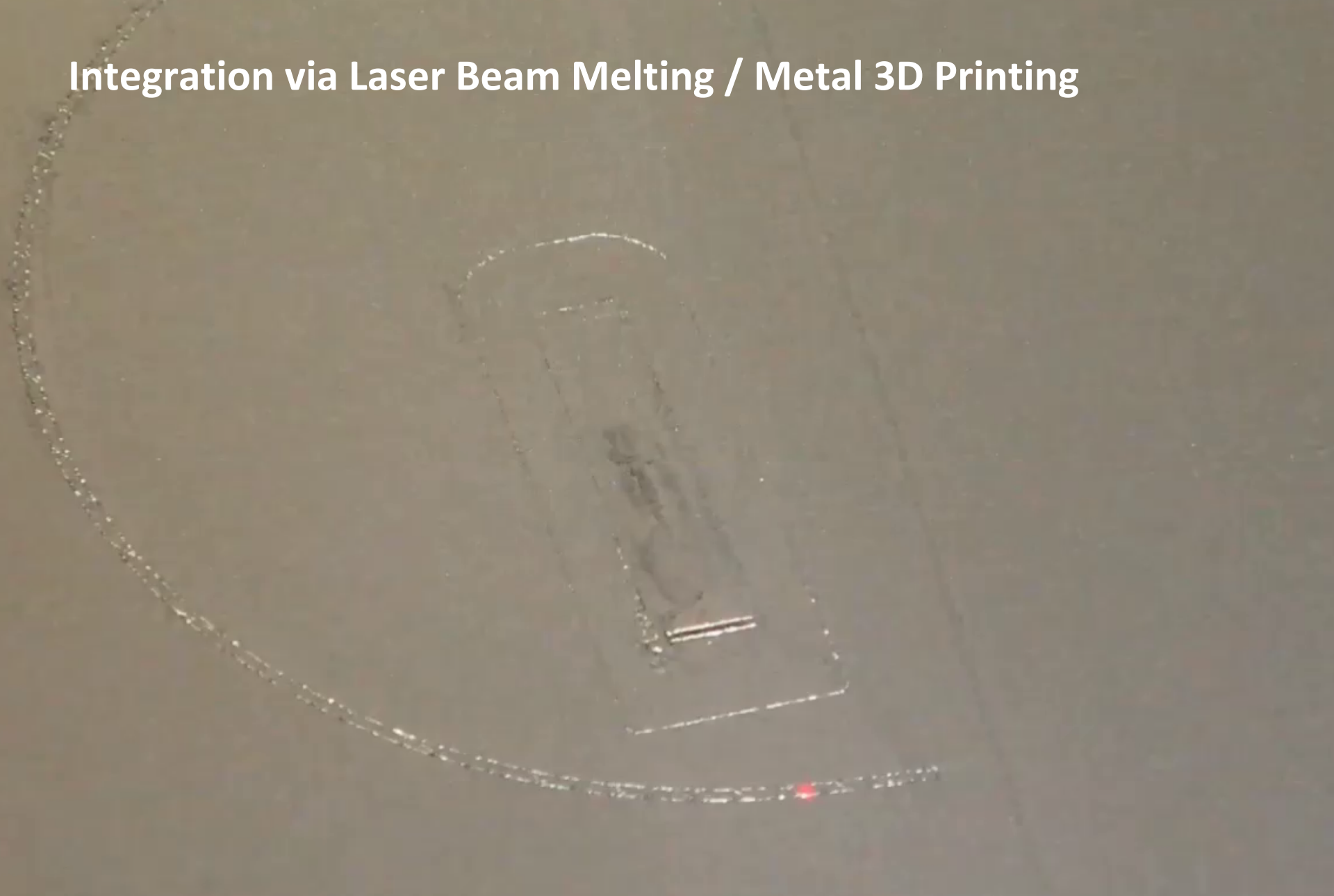


materially bonded connection



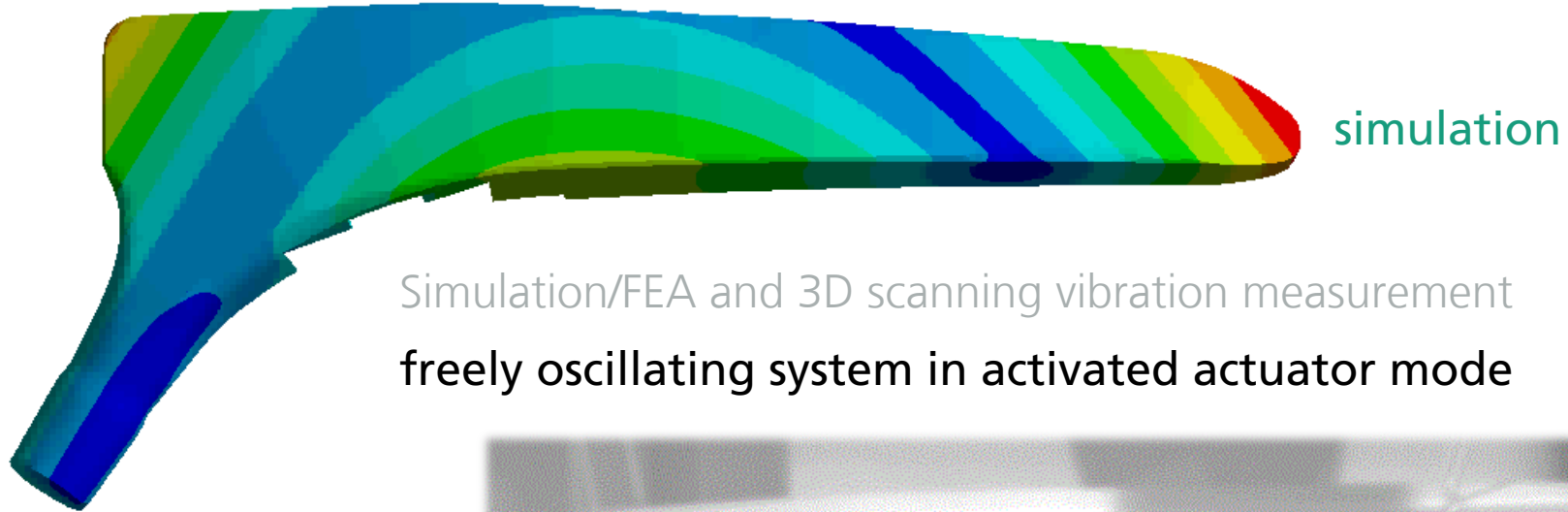


# Integration via Laser Beam Melting / Metal 3D Printing

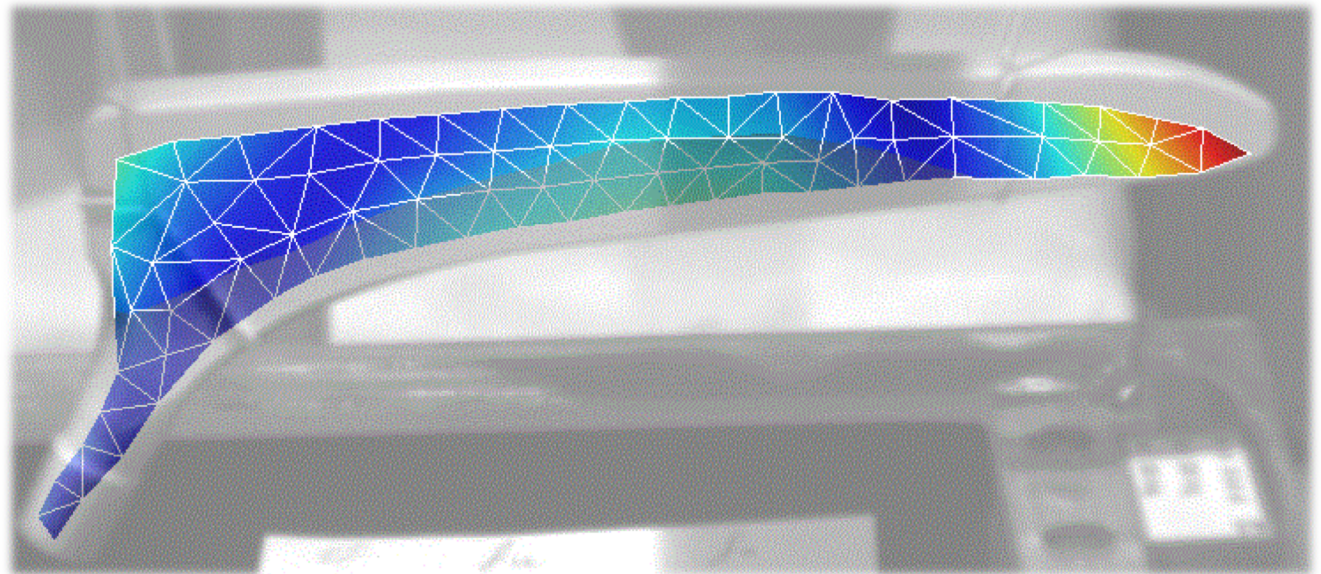


# Industrialization status

## Medical: State of research



experiment



# Thank you for your attention!



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