University of Stavanger

Jørgen Grønsund, Engineer

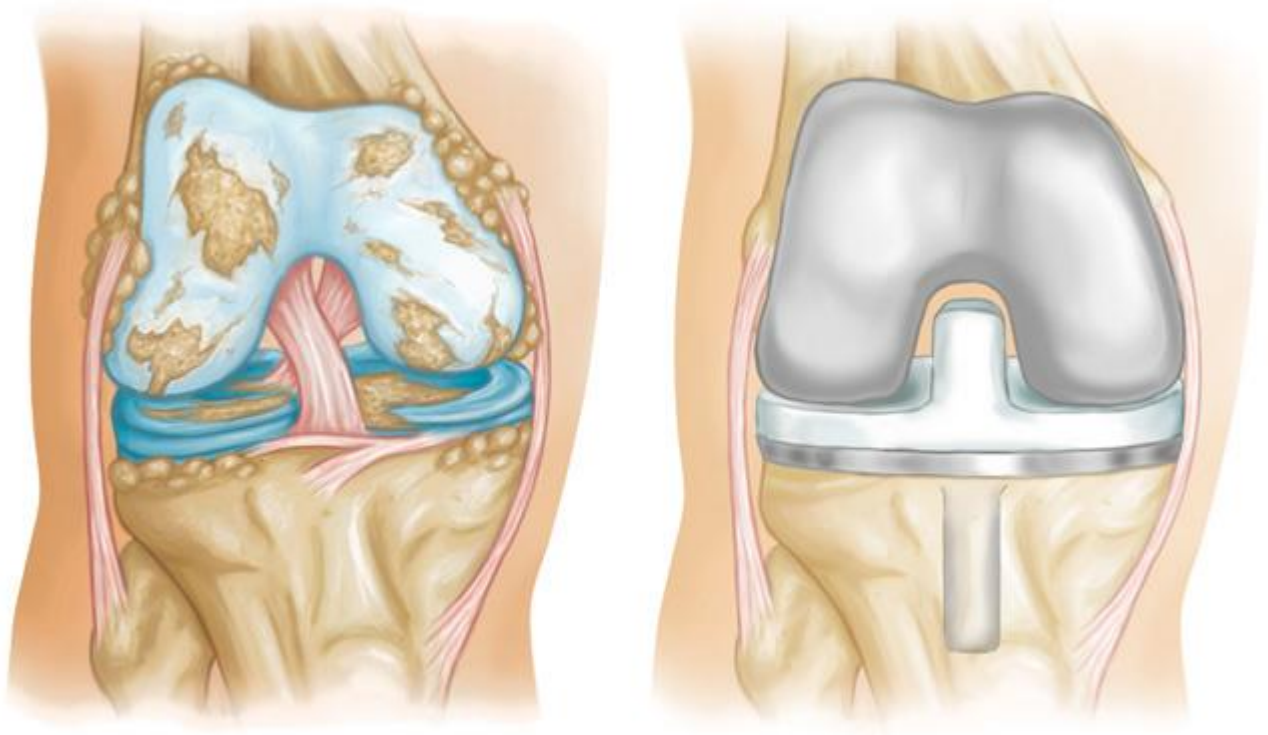
Addititive manfufacturing: Reality now!

Reality now

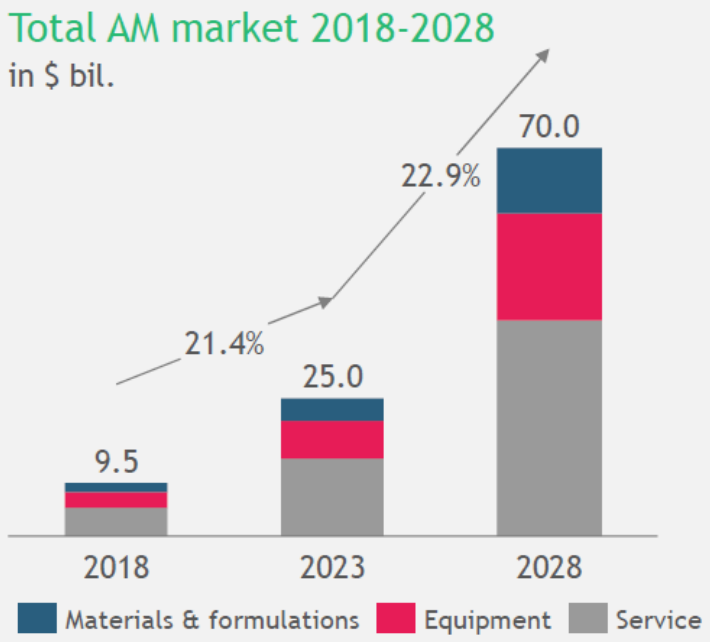
Why AM?

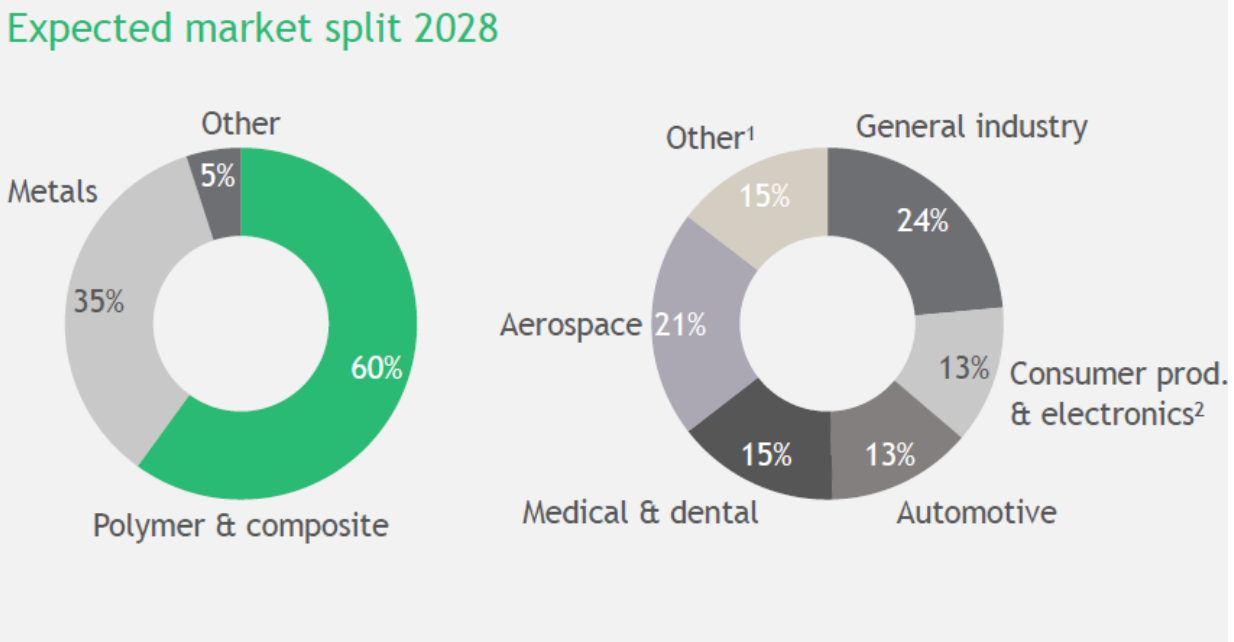
- Business benefits
  - Get products to market faster
  - Reduce manufacturing costs
  - Improve supply chain efficiency – on demand, fit for purpose
- Technical advantages
  - Complex 3D geometries
  - No tooling
  - Fast
- Environmental advantages
  - Less waste
  - Logisitical simplification

Knee replacement surgeries



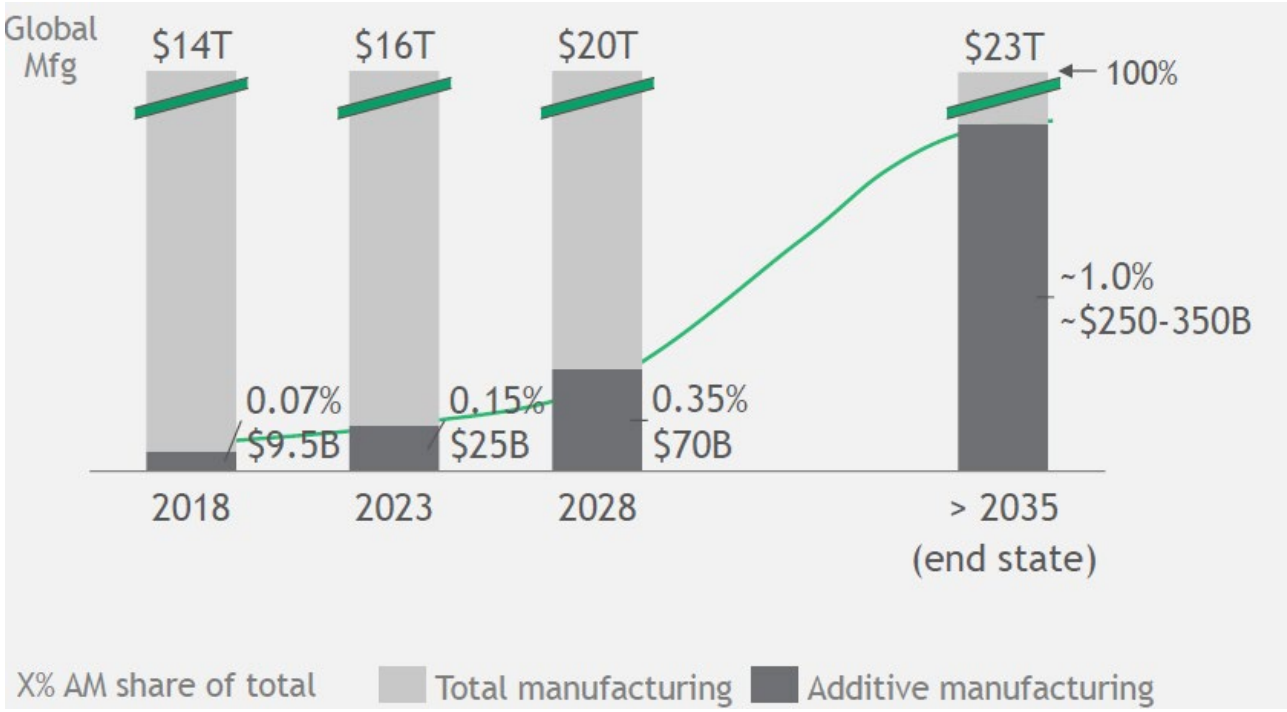
Market development





Source: BCG Additive Manufacturing Market Model

Market share

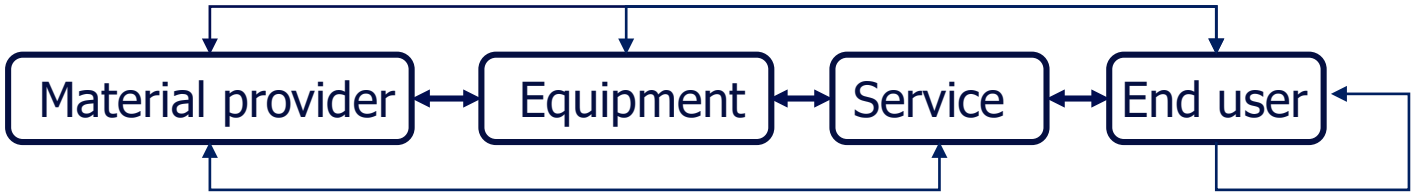


Source: BCG Additive Manufacturing Market Model

Disruption of supply chain

- Closed system – as of yesterday
  - Material provider, equipment provider, service provider and end user are separate companies and following a specific order

- Open system – disruption of the normal supply chain

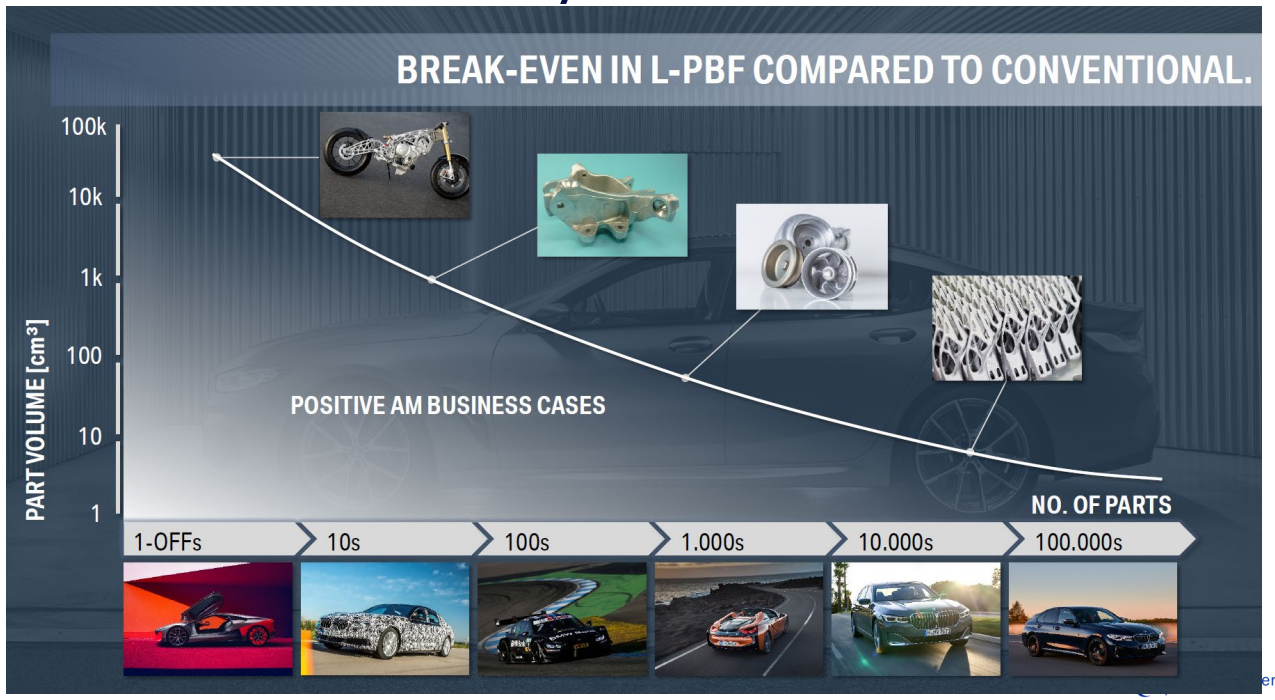


Automation

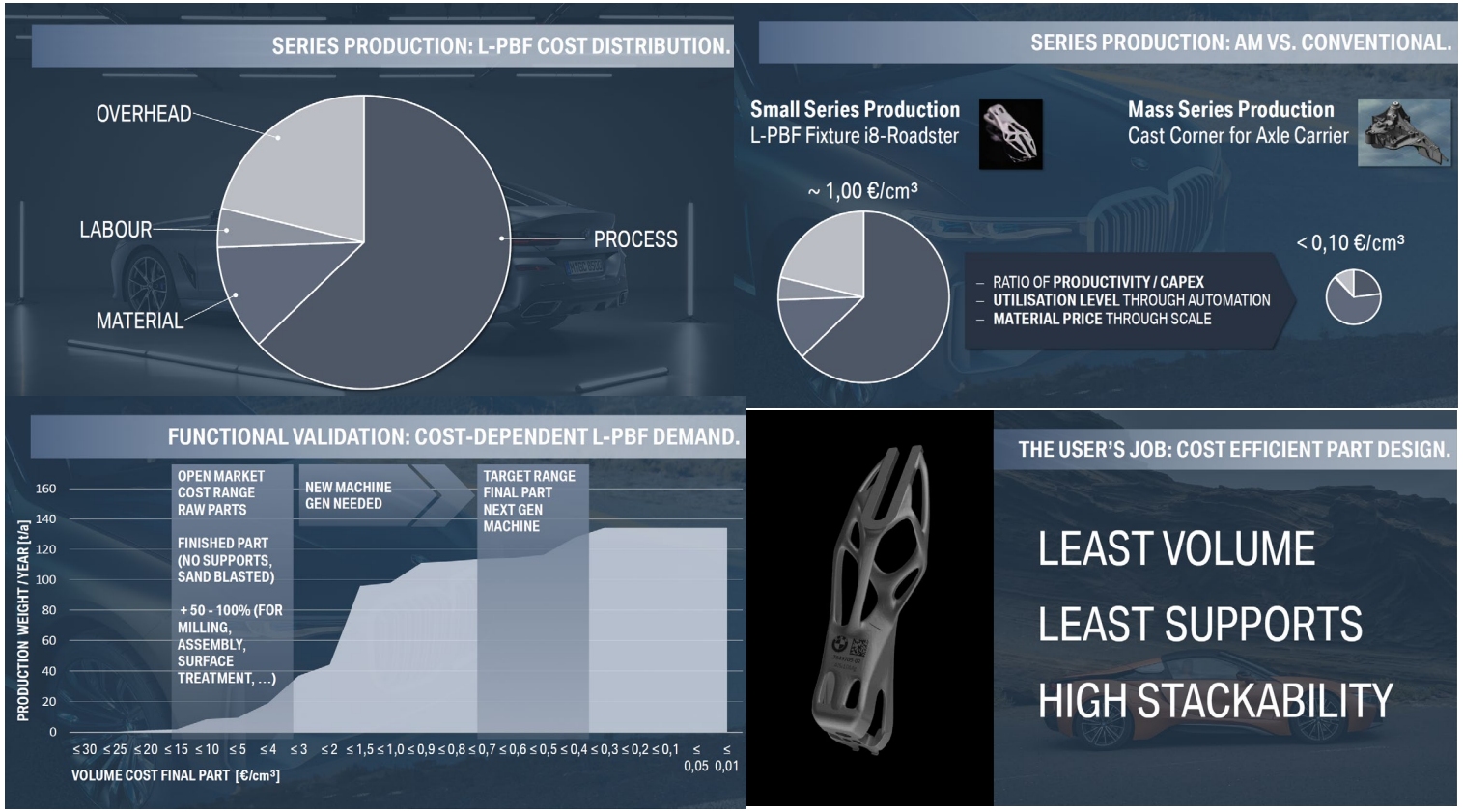

TU
INNHOLD
LEDIGE JOBBER
KONFERANSER
BLI EKSTRA-ABONNENT
SØK
LOGG INN
3D-PRINT
Skal kvitte seg med flaskehalsene i 3D-printing: Automatiserer hele prosessen
Printergiganten HP utvikler produksjonsceller som automatisk håndterer 3D-utskrevne råemner til ferdige produkter.
ADDITIVE MANUFACTURING

BMW

- «AM in industrial production is a reality not a vision»
- «Cost is limiting factor for a broad adoption in more automotive applications»
- «Standards and common interfaces are necessary to enable a broad integration»

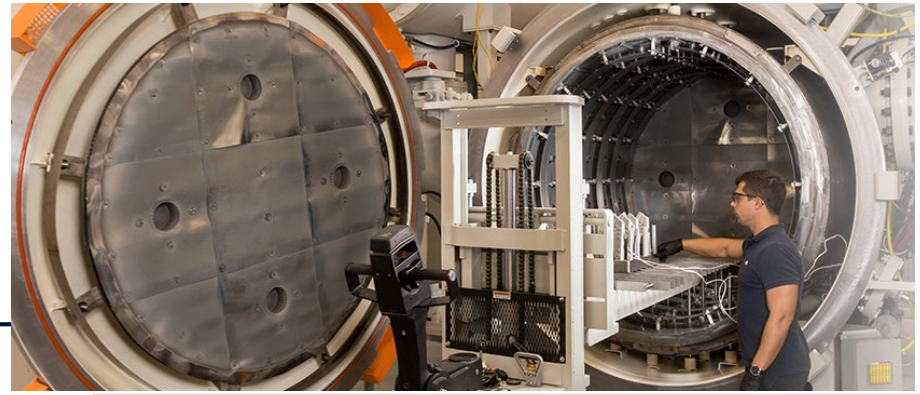


BMW


SERIES PRODUCTION: L-PBF COST DISTRIBUTION.
OVERHEAD
LABOUR
MATERIAL
PROCESS
SERIES PRODUCTION: AM VS. CONVENTIONAL.
Small Series Production
L-PBF Fixture i8-Roadster
Mass Series Production
Cast Corner for Axle Carrier
~ 1,00 €/cm³
< 0,10 €/cm³
– RATIO OF PRODUCTIVITY / CAPEX
– UTILISATION LEVEL THROUGH AUTOMATION
– MATERIAL PRICE THROUGH SCALE
FUNCTIONAL VALIDATION: COST-DEPENDENT L-PBF DEMAND.
OPEN MARKET COST RANGE RAW PARTS
FINISHED PART (NO SUPPORTS, SAND BLASTED)
+ 50 - 100% (FOR MILLING, ASSEMBLY, SURFACE TREATMENT, ...)
NEW MACHINE GEN NEEDED
TARGET RANGE FINAL PART NEXT GEN MACHINE
PRODUCTION WEIGHT / YEAR [t/a]
0
20
40
60
80
100
120
140
160
≤30 ≤25 ≤20 ≤15 ≤10 ≤5 ≤4 ≤3 ≤2 ≤1,5 ≤1,0 ≤0,9 ≤0,8 ≤0,7 ≤0,6 ≤0,5 ≤0,4 ≤0,3 ≤0,2 ≤0,1 ≤ 0,05 ≤ 0,01
VOLUME COST FINAL PART [€/cm³]
THE USER'S JOB: COST EFFICIENT PART DESIGN.
LEAST VOLUME
LEAST SUPPORTS
HIGH STACKABILITY

Diehl Aviation

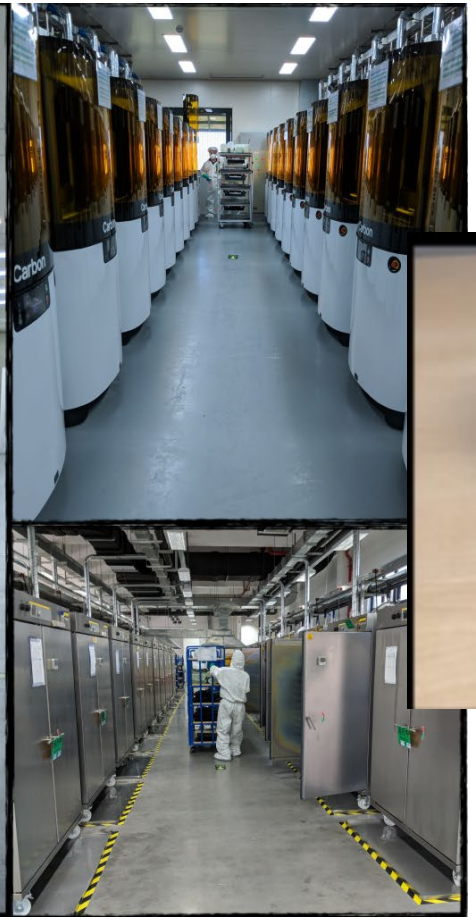
Sintavia



- **18 metal printers**
- **HIP**
- **Machining**
- **Surface finishing**
- **Design assistance**
- **In-house powder analysis**
- **Lab testing:**
  - **Hardness, SEM, mass spectrometry, mechanical testing (fatigue, tensile, crack propagation, fracture toughness, creep)**
- **Metrology**
  - **CMM, CT, 3D scanning**
- **NDT**
  - **FPI, radiography, x-ray, eddy current, ultrasonic, MPI**

Four EOS M400-4 laser machines	Three SLM Solutions 280HL twin laser machines
Two EOS M400-1 laser machines	One Concept Laser M2 Dual laser machine
Five EOS M290 laser machines	One Arcam Q20+ electron beam machine
One TRUMPF TruPrint 3000 laser machine	One Arcam A2x electron beam machine

Carbon inc – serial production



Bombardier

Parts for design validation

Design validation of *FLEXITY* tram for Gothenburg

Photo: shows area with covered lights, below them the 3D printed modified solution

Photo: 3D printed and assembled front light

- reduced lead time incl. mold costruction from **10-12** weeks to **7** days

  ➡ fast positive customer approval

- 3-4 **w**orking days between creating, printing the adapter and putting it into real test

Status:

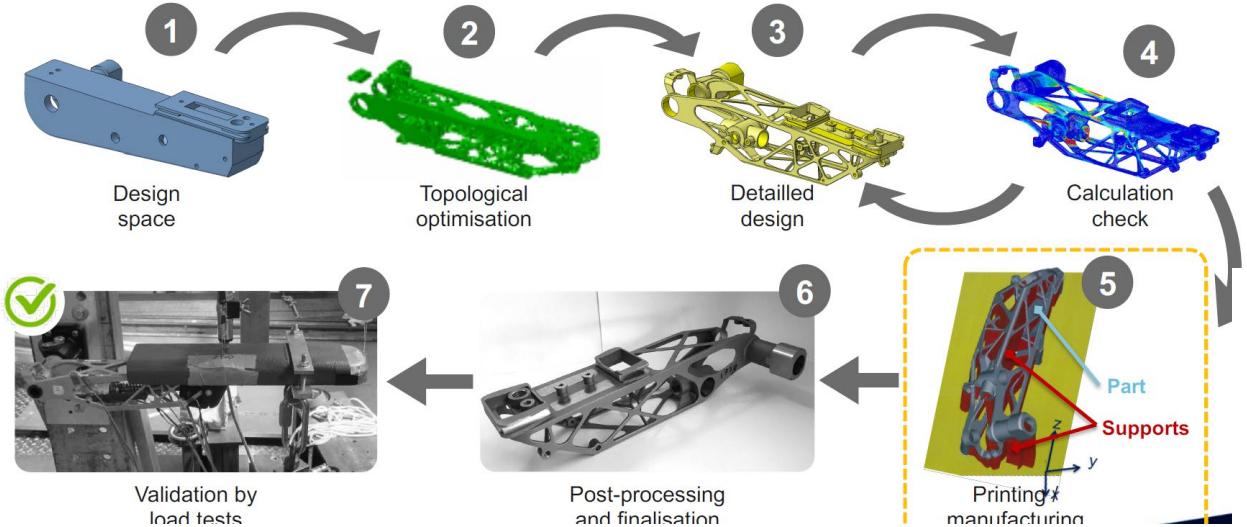
- driver's desk handle will be 3D printed part in series
- Adapter is realistic to be series part

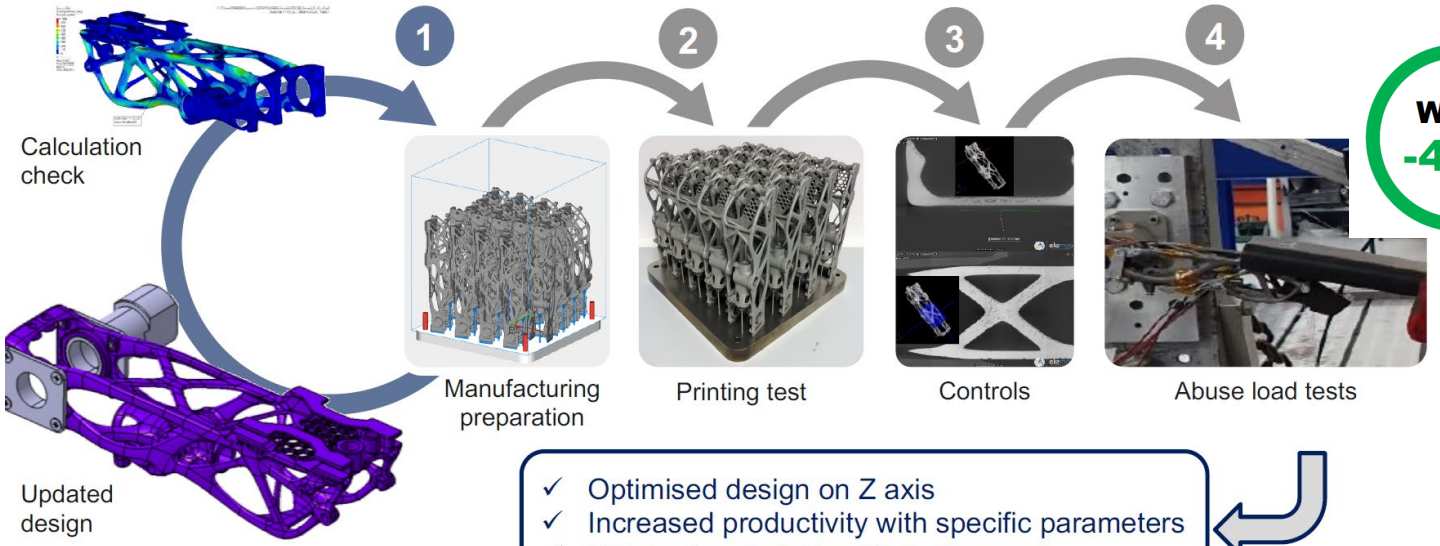
*series parts will be produced by supplier

Photo: 3D printed functional driver's desk handle for customer approval

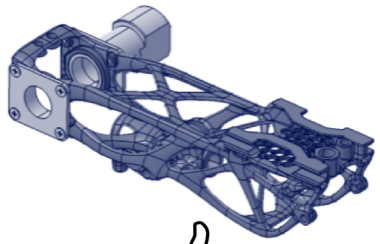
Photo: 3D printed adapter console for camera

Stelia Aerospace





- ✓ Optimised design on Z axis
- ✓ Increased productivity with specific parameters
- ✓ Matched material health to the need



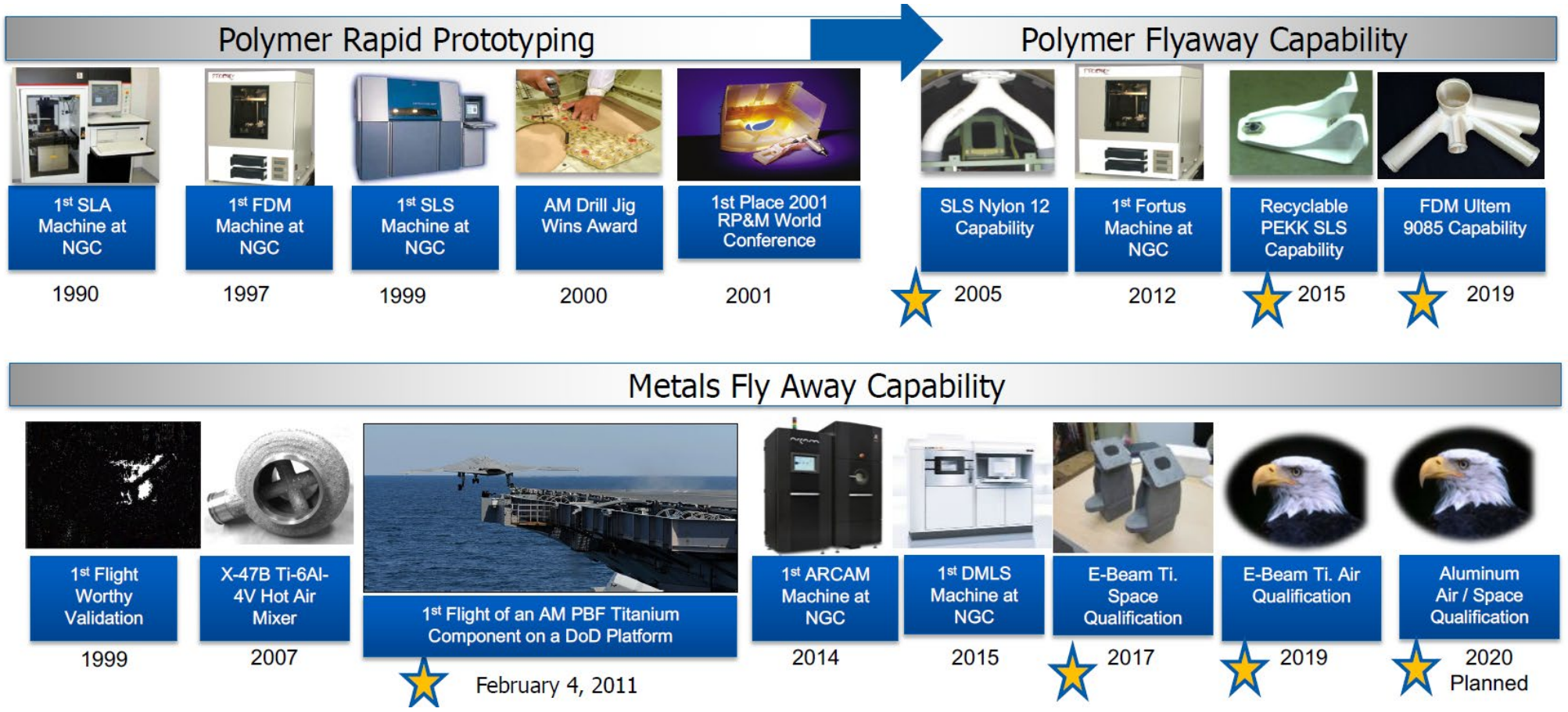
Weight -42%

Cost -12%

Our **DtP philosophy** is based on :

1. A good knowledge of part/assembly and its environment to design from a function
2. An understanding of this manufacturing process and its limits
3. An ALM design facilitating the finalisation processes (machining,drilling)
4. A rationalisation of needs in terms of controls and post-processings

Northrop Grumman



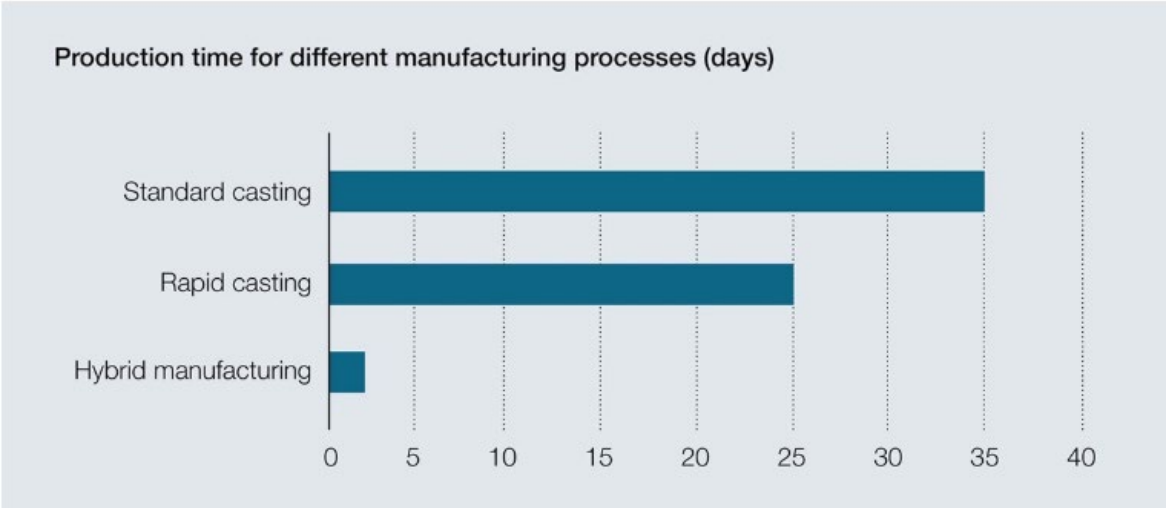
Audi Sport

AM - What do we see in production and assembly?

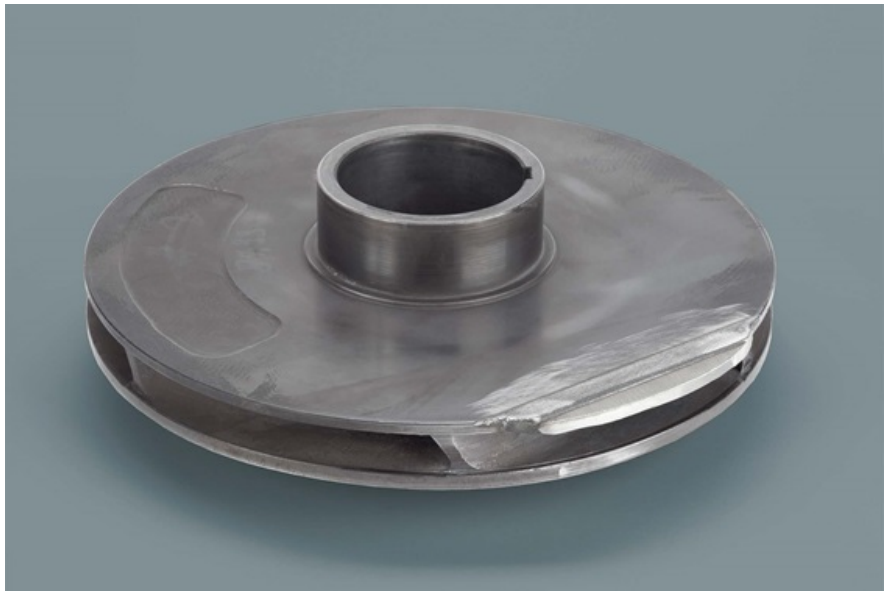
- Positioning guides
- Safety devices
- Casting molds
- Measuring Aids
- Assembly fixtures

Sulzer pumps

Production

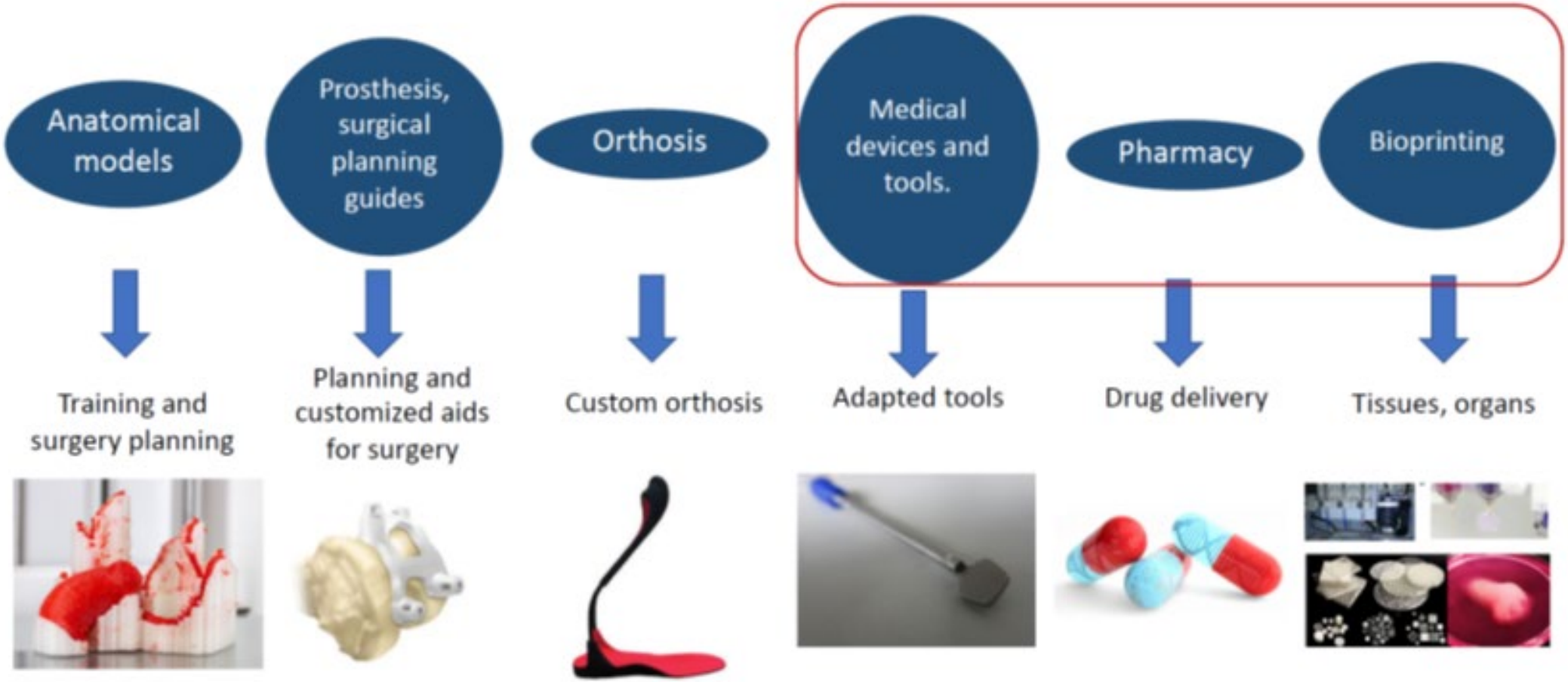


Repair



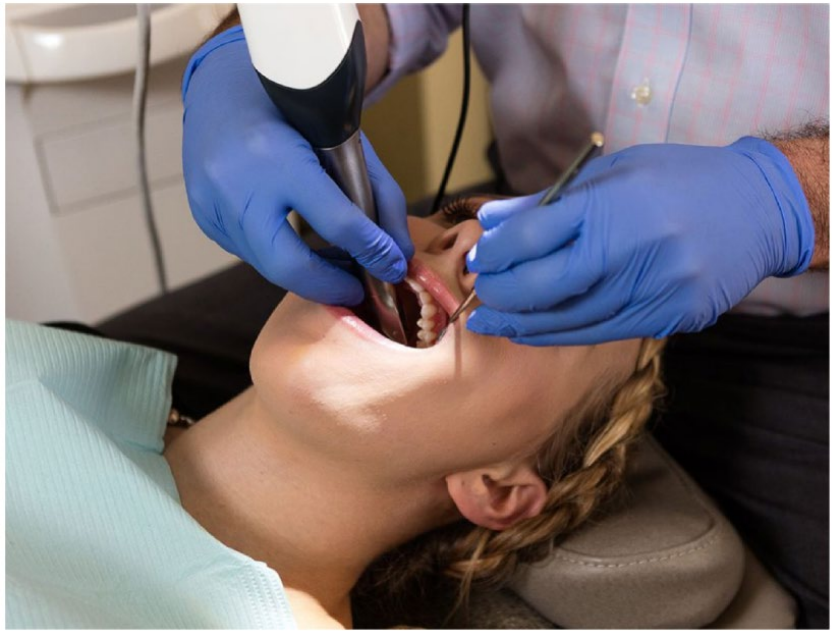
Source: Sulzer.com

Healthcare


Anatomical models
Prosthesis, surgical planning guides
Orthosis
Medical devices and tools.
Pharmacy
Bioprinting
Training and surgery planning
Planning and customized aids for surgery
Custom orthosis
Adapted tools
Drug delivery
Tissues, organs

Dental

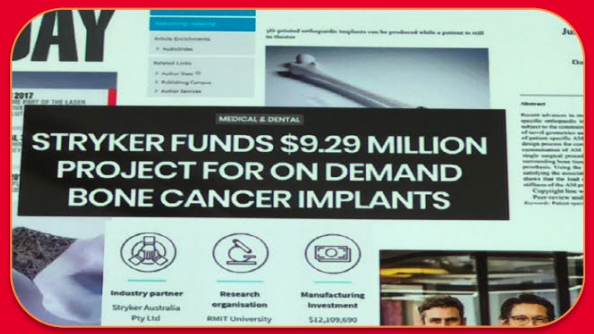
Denture Base	Denture Teeth Full-Arch
~20 ml resin	~15 ml resin
~5 €	~5 €



Just in time implants

Just-in-time Implants

AIM: To to automatically generate conformal implant structures that are biomechanically and biologically compatible with bone



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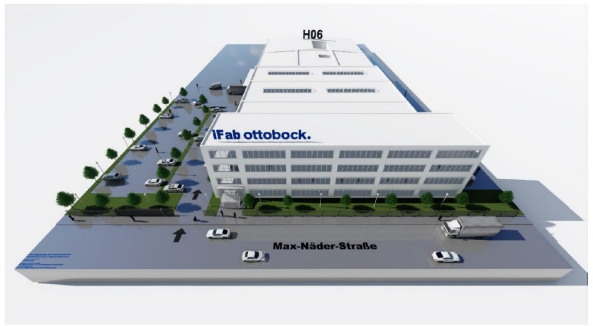
11.03.2020

Ottobock – prostethcis, orthosis, exosceletons

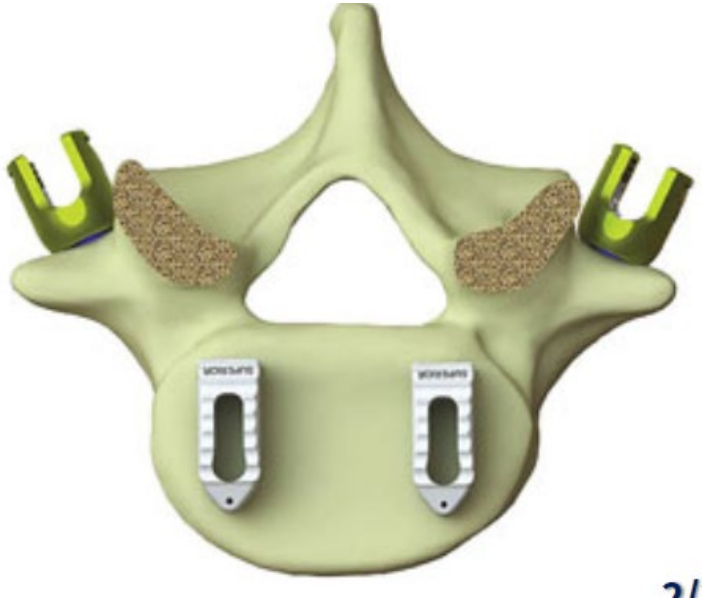
Conventional

Digital

New digital fabrication building „iFab Ottobock“

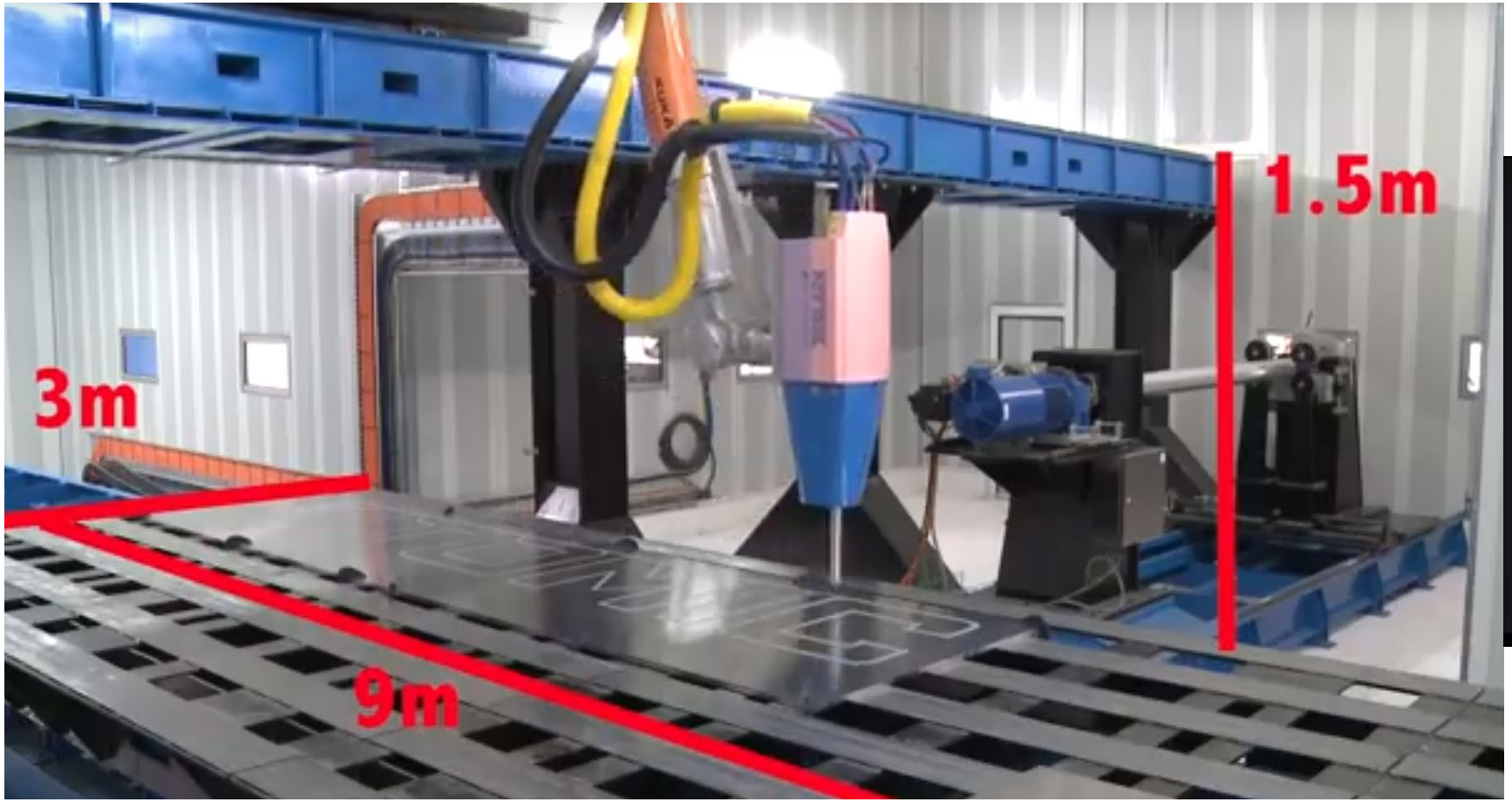


Spinal cage implants



- Bioinert
- Durable strong
- Elastic modulus comparable to bone
- Cell attracting surface

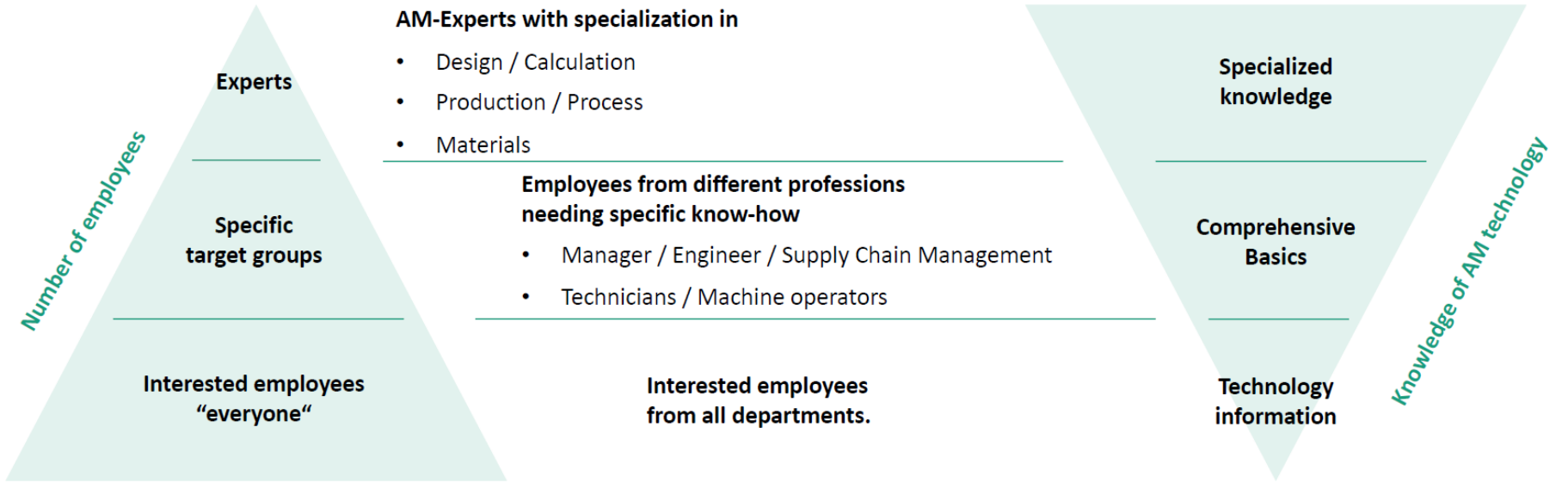
Size matters



Training needed

Implementation of Additive Manufacturing Technologies

Employees foster implementation



→ Identification of different target groups within the company

→ Differentiate building of knowhow according to target groups and strategy (Buy / Make)

Fraunhofer IGCV

Oil and gas AM factories

10 January 2020 14:50

thyssenkrupp to provide 3D printed parts to marine industry through Wilhelmsen collaboration

by Sam Davies

RSS Print

Leading maritime company **Wilhelmsen** has partnered with **thyssenkrupp** to leverage 3D printing technology for the production of vessel components.

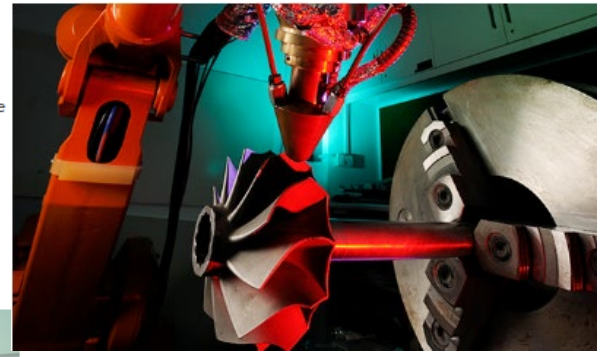
14 January 2020 16:16

Keppel Offshore & Marine receives Lloyd's Register certification to 3D print offshore grade steel parts

Keppel O&M will harness the Laser Aided Additive Manufacturing process developed by Singapore Institute of Manufacturing Technology's A*STAR department.

by Sam Davies

RSS Print



SIMTech

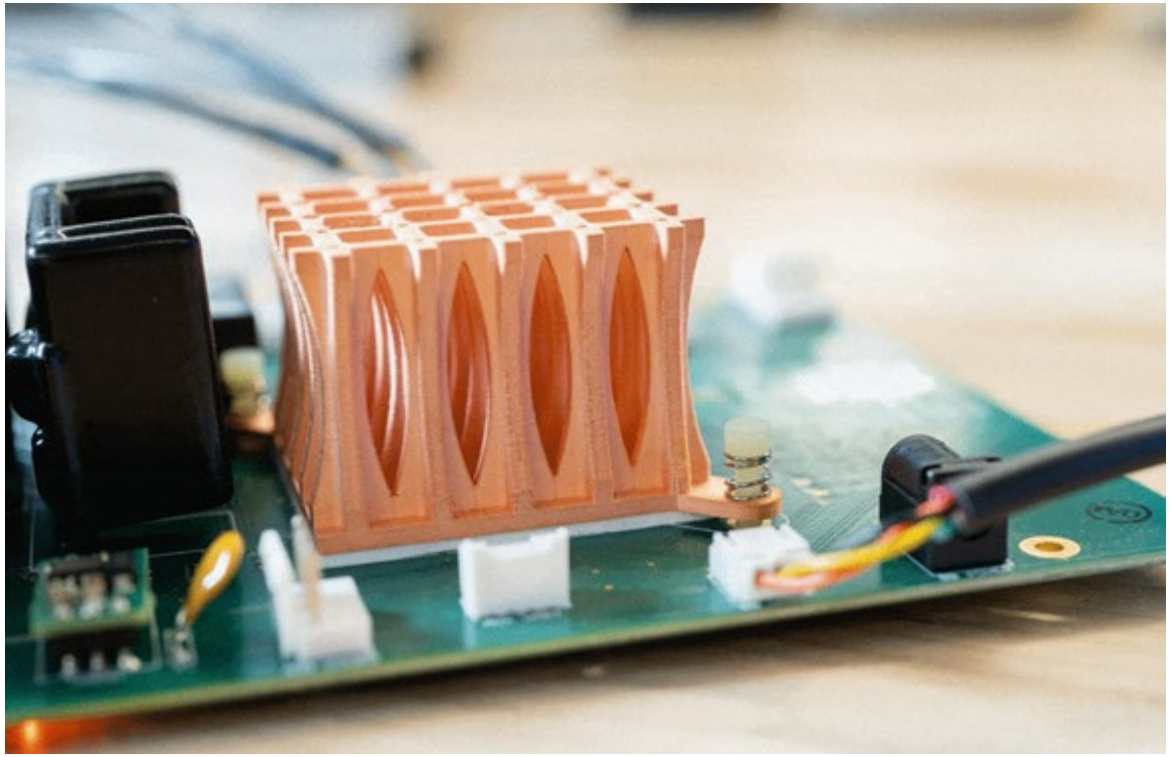
Keppel Offshore & Marine has received **Lloyd's Register (LR) Certification** to additively manufacture offshore grade steel with a 3D printing technology from **Singapore Institute of Manufacturing Technology** (SIMTech).

The certification was granted after assessing Keppel O&M's production processes, from design to post-processing and testing. Partnering with **Nanyang Technological University, Singapore** (NTU Singapore) and SIMTech's **Agency for Science, Technology and Research** (A*STAR), the company will now begin to 3D print high-value steel parts for the marine industry with the latter's **Laser Aided Additive Manufacturing** (LAAM) process.

Keppel O&M has been working with NTU Singapore and SIMTech for nearly four years to refine the additive manufacturing of steel components. NTU researchers have carried out rigorous testing on over 50 specimens of 3D printed offshore grade steel, assessing their material yield, tensile, elongation, fatigue and toughness properties against ASTM

Trio OilTec Services Castolin

Copper



Hybrid machining

- Added AM tool to CNC machines

DMG MORI

HURCO

HERMLE Machine Company

DMS DIVERSIFIED MACHINE SYSTEMS

HYBRID MANUFACTURING TECHNOLOGIES

Mazak

Matsuura

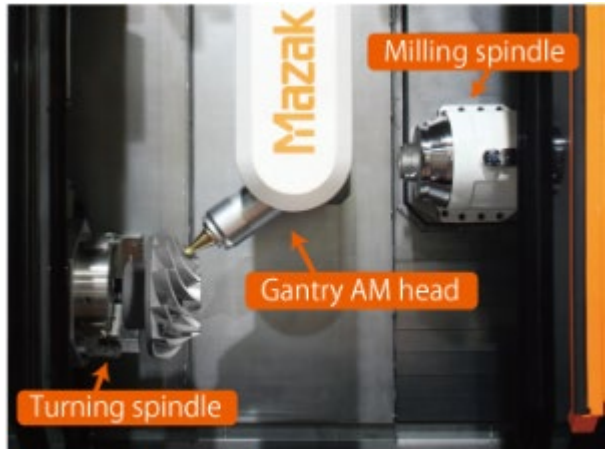
Sodick

3D HYBRID CNC METAL PRINTING TOOLS

FABRISONIC

RPM INNOVATIONS, INC.

GEFERTEC



Summary – recipe for successful AM factory

- Automated factory
- Added service – i.e finishing, milling, heat treatment
- Know your machines and materials
- It is a reality now
- Norway is missing capacity but has the knowledge

Additive manufacturing: reality now