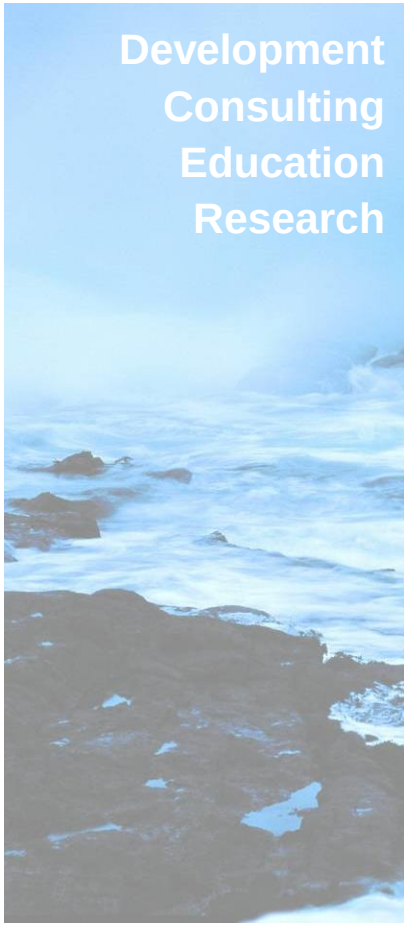
LASER ZENTRUM NORD




# Bionic Smart Factory 4.0 – Fabrikstruktur zum industriellen 3D-Druck

*Markus Möhrle*

*21. Fachtagung Rapid Prototyping*

*Hochschule Ostwestfalen-Lippe*

*4. November 2016*

TUHH Technische Universität Hamburg | iLAS

# Content

# Content

# Light Experts – Competence Center for Light Engineering

LIGHT EXPERTS

LIGHT CONSULTING

Implementation plan for …

- strategy
- product
- process


ENGINEERING IN Light PHOTONIC SOLUTIONS FOR RESOURCE EFFICIENT PRODUCTS

iLAS

BIONIC PRODUCTION

Development
Research

Production | Post-processing | Quality assurance

Design | Material | Prototyping | Quality management | Bionic Smart Factory 4.0

Competence creation and network

Light Academy

Light Alliance

# LZN and its partners were awarded for outstanding achievements

## Finalist of "Innovationspreis der deutschen Wirtschaft"


Quelle: AIRBUS


***First additive manufactured metal part for civil aircraft***

**…developed by**

- Bionic lightweight construction design in TiAl6V4
- Successfully tested
- First flight successfully completed

CONCEPTLASER hofmann innovation group AIRBUS LZN

## Deutscher Zukunftspreis 2015 – Awarded „Circle of the best"

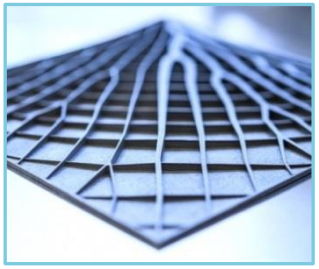
**Project Team**

CONCEPTLASER hofmann innovation group AIRBUS LZN

**Project**

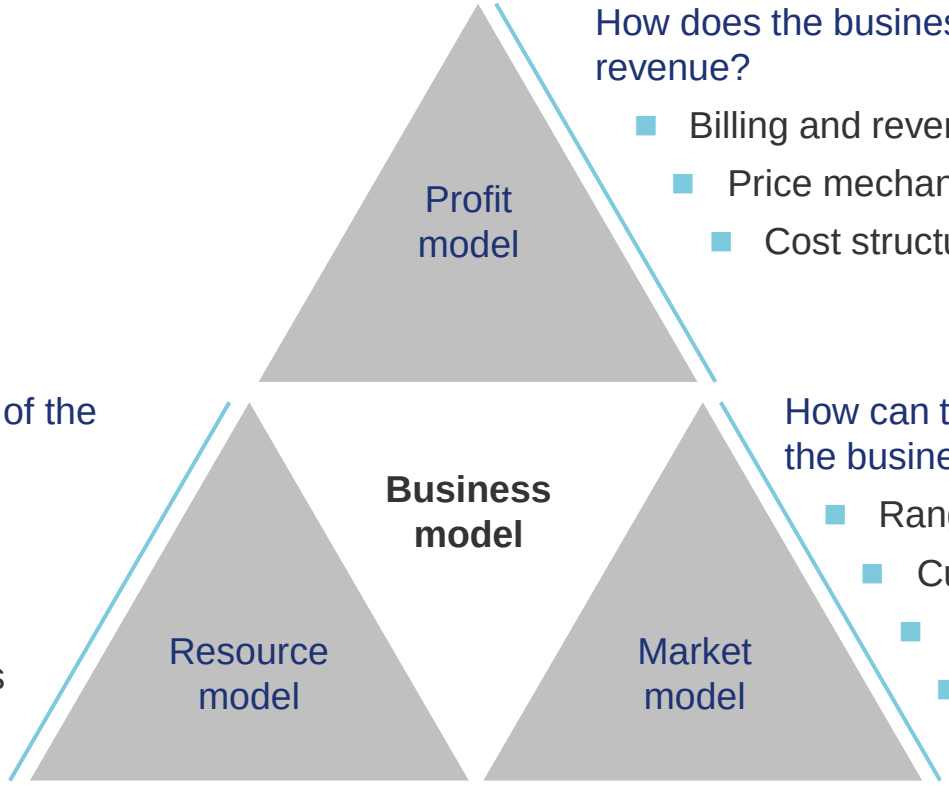
*„3-D-Printing in civil aircraft production – the next industrial revolution takes off"*

DEUTSCHER ZUKUNFTSPREIS
Preis des Bundespräsidenten für Technik und Innovation



# Content

# Business models are a combination of market, resource and profit model – Overview




How does the business model generate revenue?

- Billing and revenue method
- Price mechanisms
- Cost structure

How will the benefit of the business model be realized?

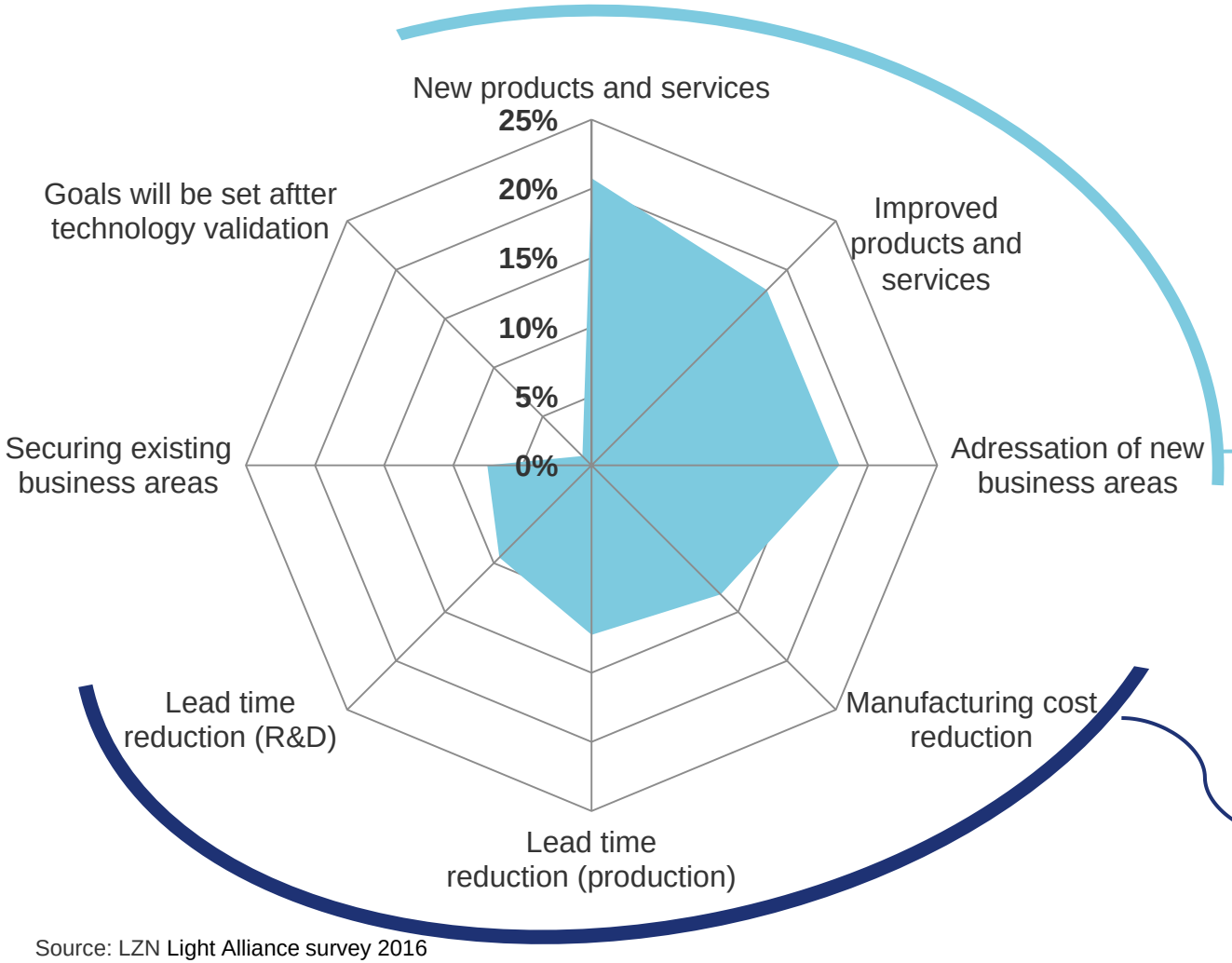
- Key resources
- Key activities
- Key partnerships

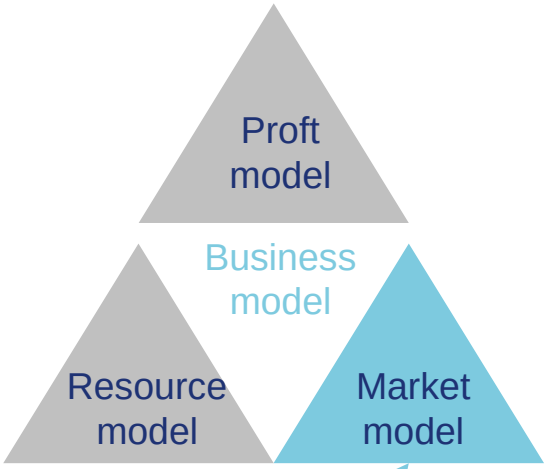
How can the products and services of the business model be marketed?

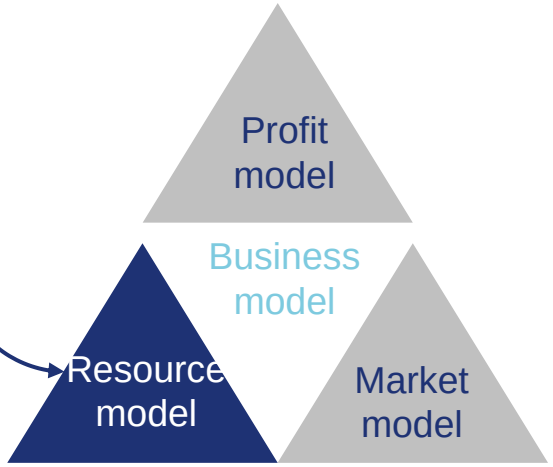
- Range of services
- Customer segments
- Customer relations
- Channels

# Primary focus on new markets and products, followed by improvement of resource model

**Share of all received answers**




Source: LZN Light Alliance survey 2016

# Additive manufacturing – The technology enables for change of old and invention of new business models

## In place… (selection)

RENISHAW apply innovation™ · EOS · additively your access to 3D printing · materialise innovators you can count on · KREATIZE · shapeways · RICOH imagine. change. · CONCEPTLASER hofmann innovation group · 3YOURMIND · Additive Industries · SLM Solutions GmbH · BIONIC PRODUCTION · stratasys

## First applications known… (selection)

AIRBUS · Jweel · LZN · …

| Machine manufacturing | Smart platform approaches | Mass customization | Bionic products – Fully integrated and resource efficient |
|---|---|---|---|

Adapted business models ⟷ New business models

| Build to print incl. prototypes | Engineering and related services | Decentralized spare parts on demand | Decentralized production (Bionic Smart Factory) |
|---|---|---|---|

toolcraft · LZN · heinkel group · DB Mobility Networks Logistics · materialise innovators you can count on · simufact Simulating Manufacturing · Altair · GMP GERMAN MACHINE PARTS

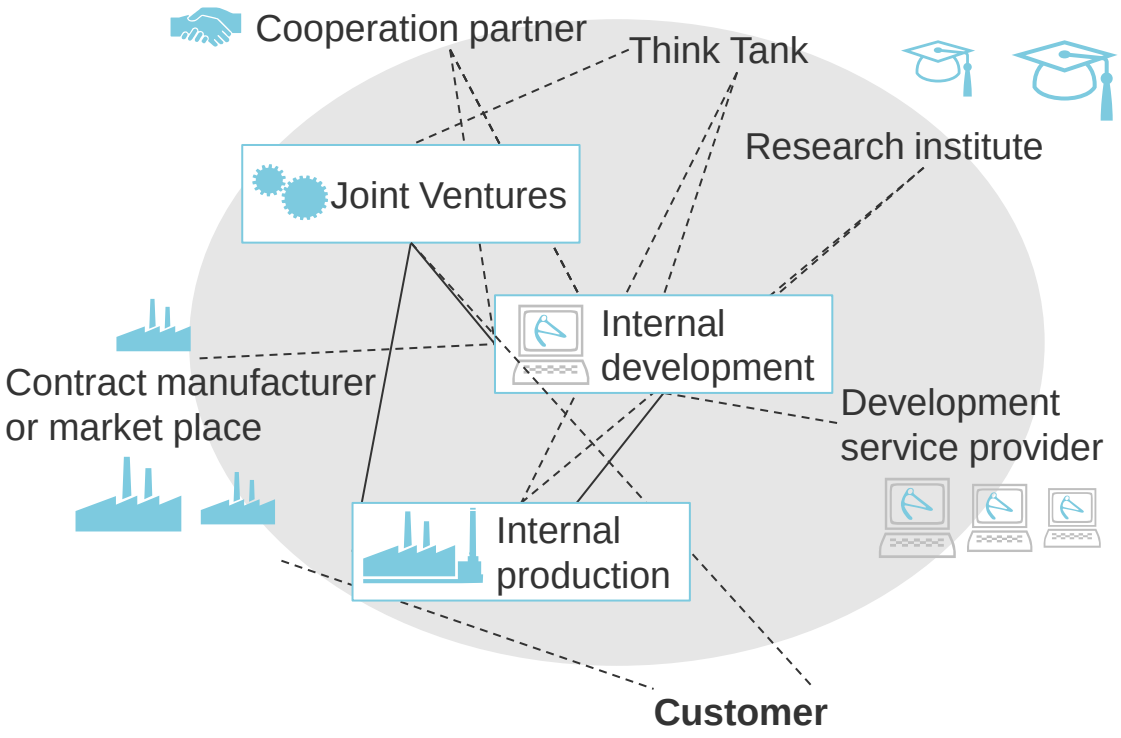
AIRBUS · LZN · … · SIEMENS · materialise innovators you can count on



Markus Möhrle: Bionic Smart Factory 4.0 – Fabrikstruktur zum industriellen 3D-Druck (2016)

# Hypothesis: Digital merger of design and process improves time, cost and quality

## Industry 4.0 – Merger of design and process




## Details

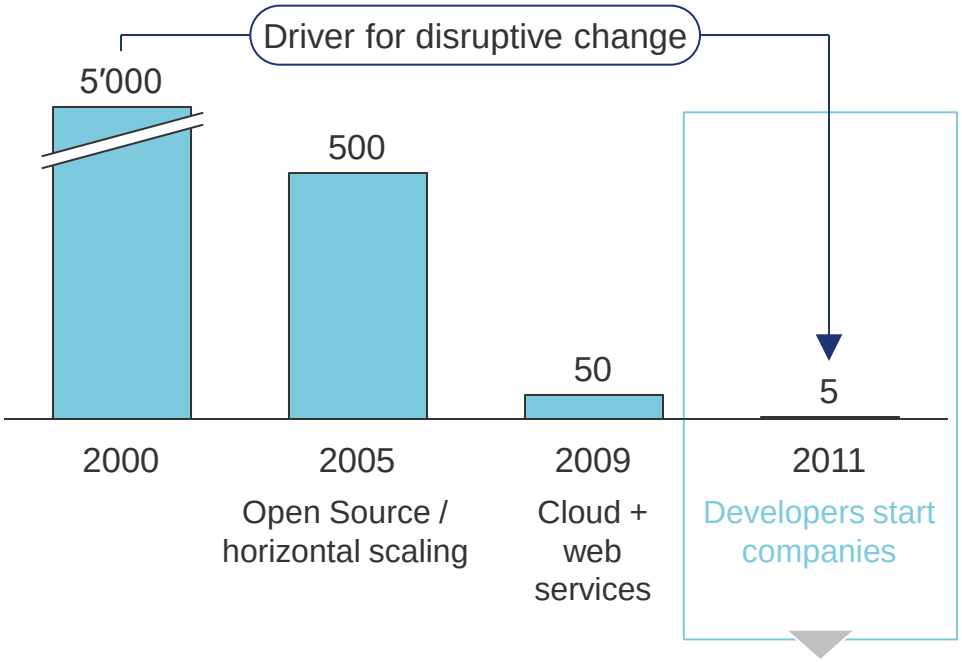
Direct production with standardized data formats enables discarding of product-specific industrialization – advantages:

- Efficient collaboration, regardless of location, internal and external with partners and service providers possible, e.g. through
  - Research institutes
  - Development service providers
- Increased merger through data exchange of:
  - Specification / development
  - Construction / design
  - Production
- Crucial: design guidelines

# Hypothesis: Design and sales of industrial goods possible through individuals in the future

## Corporate landscape industrial goods

Cost for the foundation of a internet-tech-startup ['000 USD]




Also transferable to mechanical products?

Source: Mark Suster (Upfront Ventures)

## Details

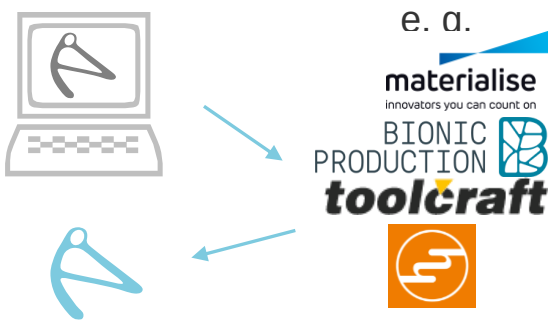
Declining capital requirements for the foundation of tech-Startups is transferred to the segment of mechanical products

- No direct access to production facilities necessary
- Investments in production facilities can be omitted

In the future, individuals are able to implement business ideas with mechanical products themselves!

# Additive manufacturing should base on a suitable cost structure

## Subcontracting




Investment: ~ 0,1 m EUR

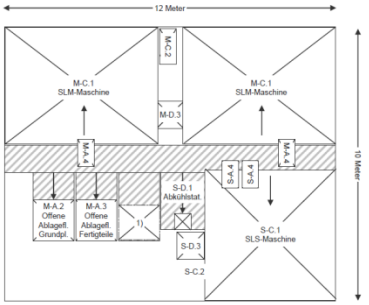
Also integrated are …

- Initiation and (basic) training of staff
- Engineering services

Subcontracted will be…

- All processing activities

## Integrated additive manufacturing




Investment: > 1,5 m EUR

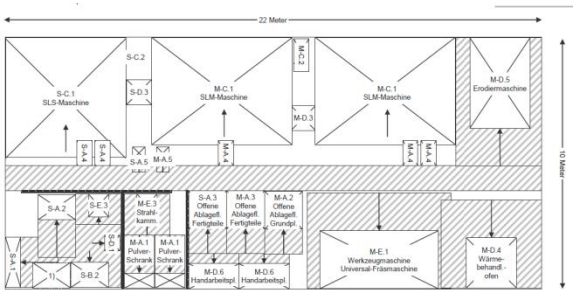
Also integrated are …

- Additive manufacturing machines for plastic und metal
- Wire eroding

Subcontracted will be…

- Post-processing steps

## Complete additive plant




Investment: > 5 m EUR

Also integrated are …

- Additional additive manufacturing machines for metal
- Heat treatment
- Cutting finish

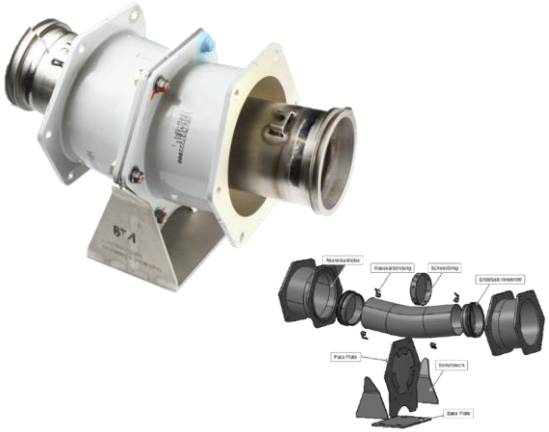
Subcontracted will be…

- Capital intense post-processing steps (e. g. HIP)

# Content

# The complexity advantage allows applications using functional integration, bionic design and lattices

## Part Integration



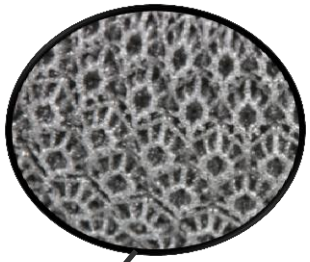
Airbus Innovation Cell & LZN

## Bionic Design

Bird bone structure

iLAS TUHH

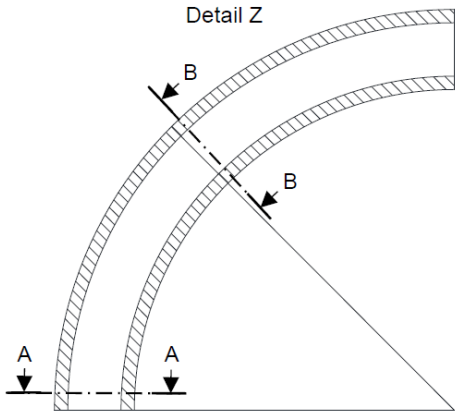
## Lattice Structures

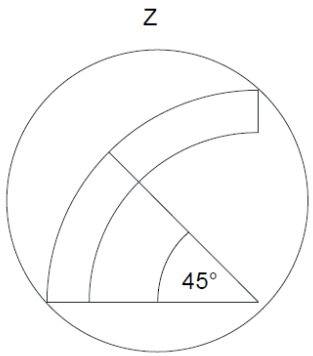


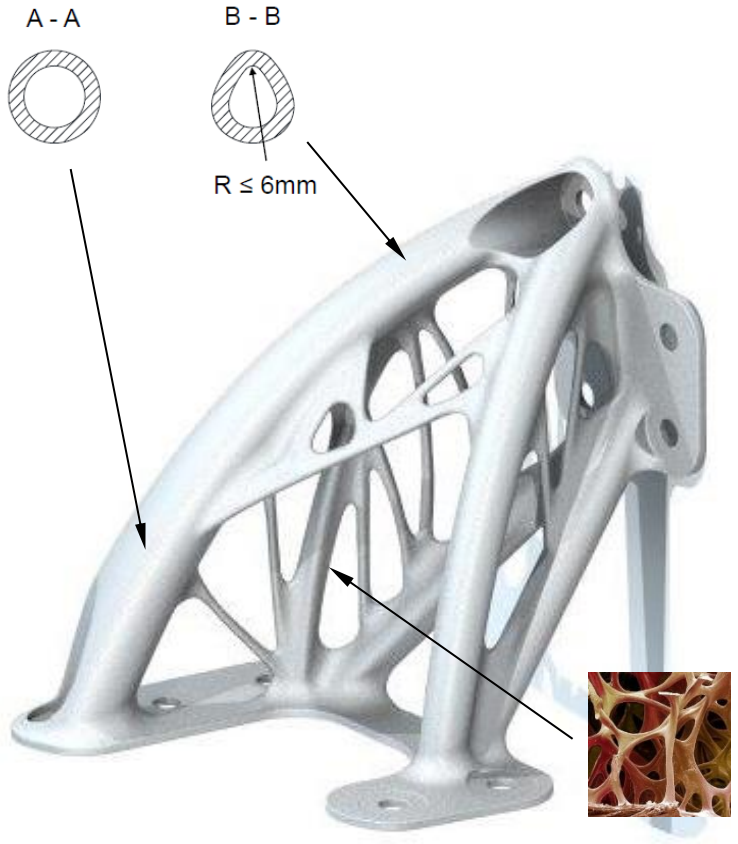
Implantcast & LZN

Airbus Innovation Cell & LZN

# Lightweight Design through topology optimization/ bionic interpretation – Example: Brackets



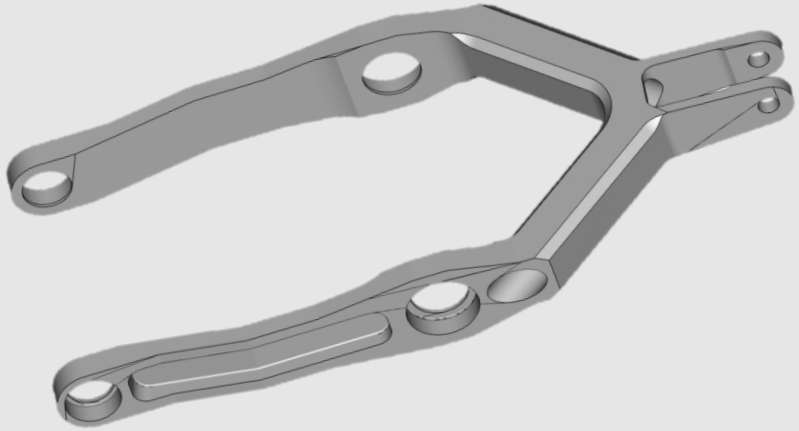




**Weight Reduction of 20 %**

# Cost reduction for series production for selected products with only low design modifications

## Conventional Design



## LAM-Design

| | |
|---|---|
| **Weight Reduction:** | **35 %** |
| **Cost Reduction:** | **20 %** |

Gefördert durch:

Bundesministerium für Wirtschaft und Technologie

aufgrund eines Beschlusses des Deutschen Bundestages

Die Untersuchungen wurden aus Haushaltsmitteln des Bundesministeriums für Wirtschaft und Technologie (BMWi), FKZ 20W1305G, gefördert.

# The best of two worlds: Hybrid space frame for new lightweight automotive concepts

- Nearly tool-free manufacturing of single components and technology demonstrators
- Virtual development of a highly functional automotive lightweight structure
- New laser-based joining concepts and manufacturing layouts

IAA
World premiere at
The **IAA 2015**

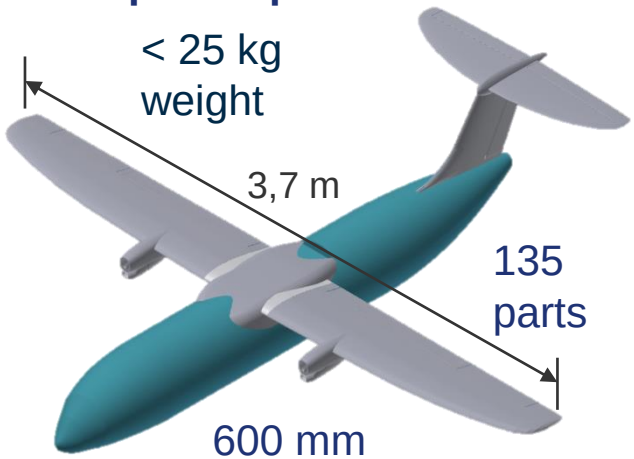
**A joint innovation project of:**

EDAG
CONCEPTLASER
BLM GROUP
LZN LASER ZENTRUM NORD

# THOR implements agile principles in advanced development – Enabled by additive manufacturing

**Additive Manufacturing**

## Development phase




< 20.000 EUR

## Testing

**Carry over of learnings**

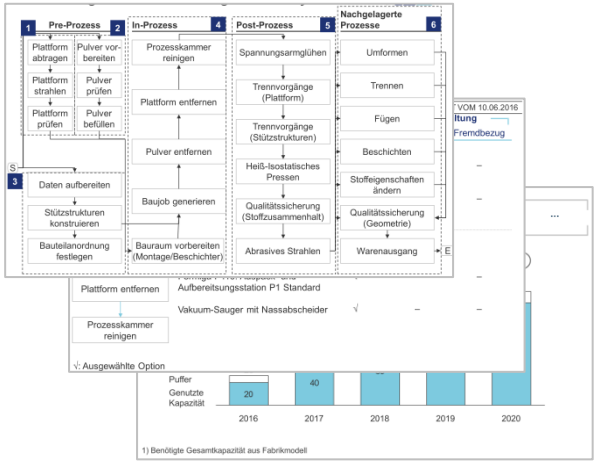
# Content

# Manufacturing plants are typically developed from target setting to final layout in three steps

## Requirements and targets

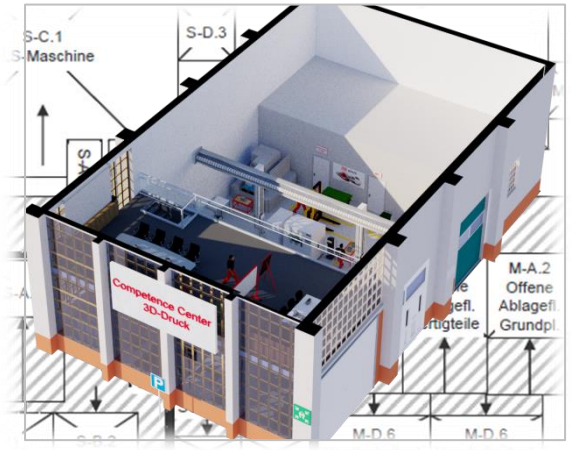

- Definition of **performance requirements** and target budgets
- Definition of **production program** (product requirements)
- Derivation of **technology sequence** from production program
- Identification of **further requirements** (e.g. existing production equipment and facility)

## Plant structure definition




- Definition of **required machinery** according to the additive **manufacturing process chain** – Based on…
  - Capacity requirements of planned products and services
  - Mode of value creation
  - Make or buy decision
- Deriving the **need for financing**
- Definition of an **organization structure**

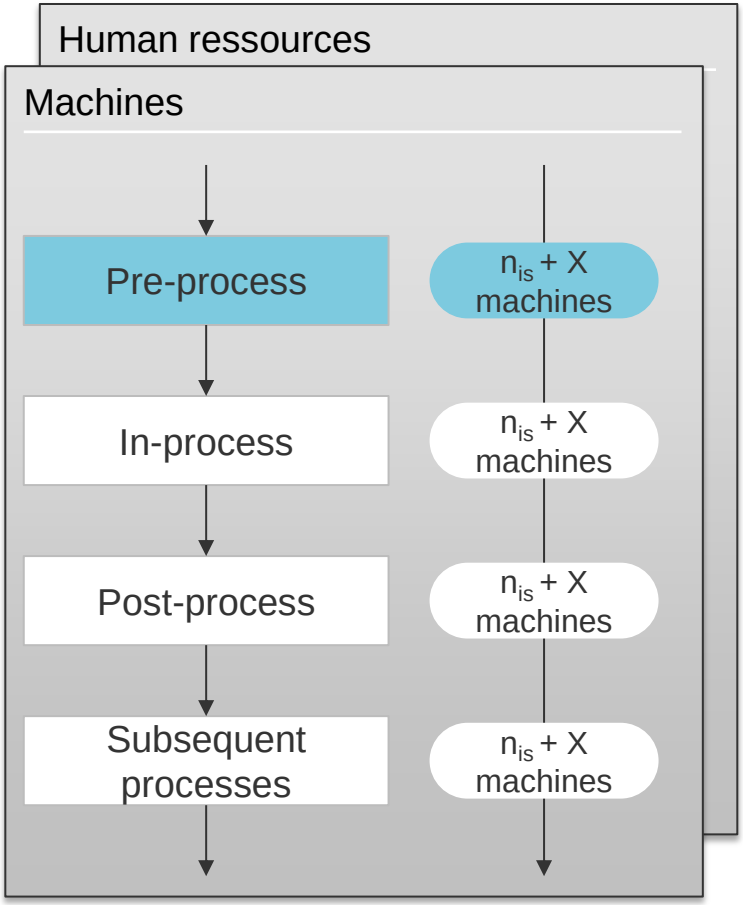
## Plant layout and visualization



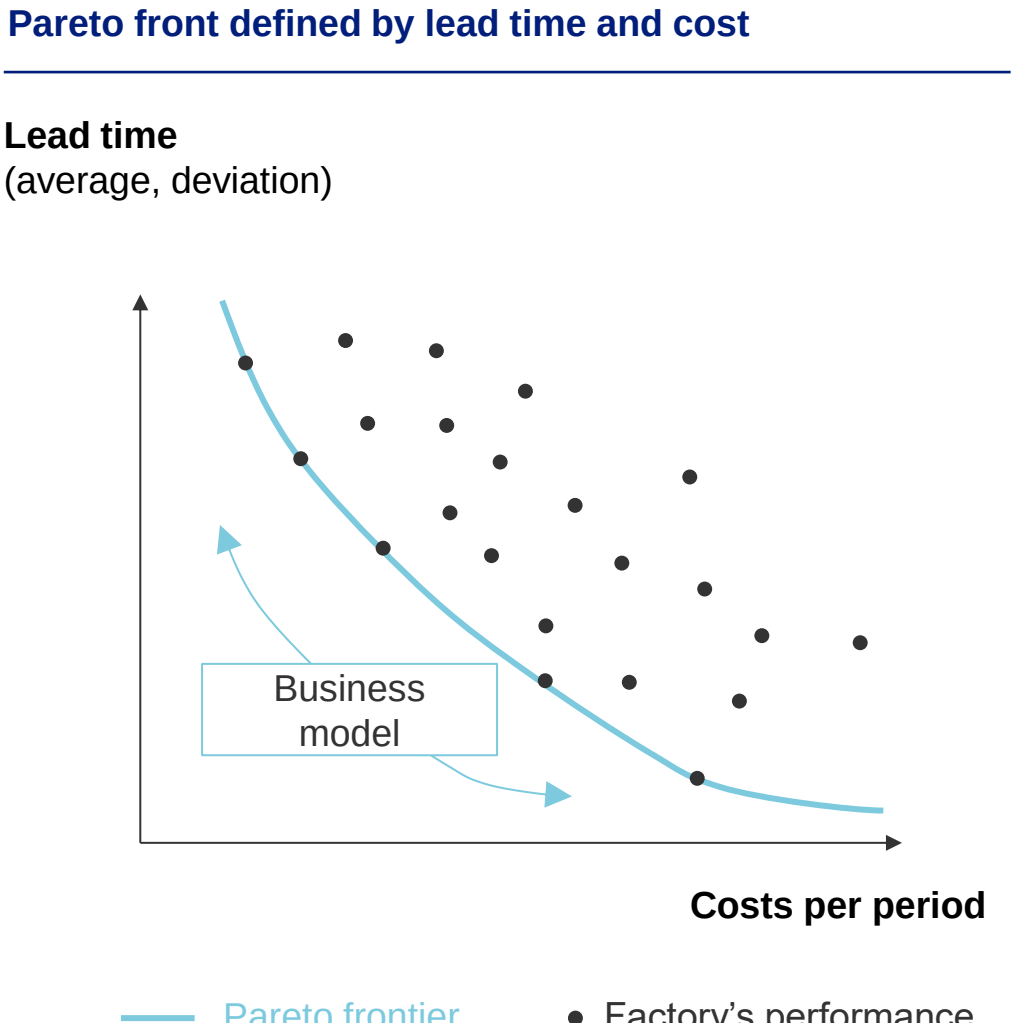

- Creation of a **layout concept to fulfill the requirements** (machines and infrastructure) under consideration of requirements and targets
- Taking into account the **available building infrastructure**
- **Visualization** (2 and 3 dimensional)

# When creating a factory structure, lead time and cost are the most important goals

## Factory structure




## Pareto front defined by lead time and cost



# By discrete event study, different factory set-ups can be easily evaluated

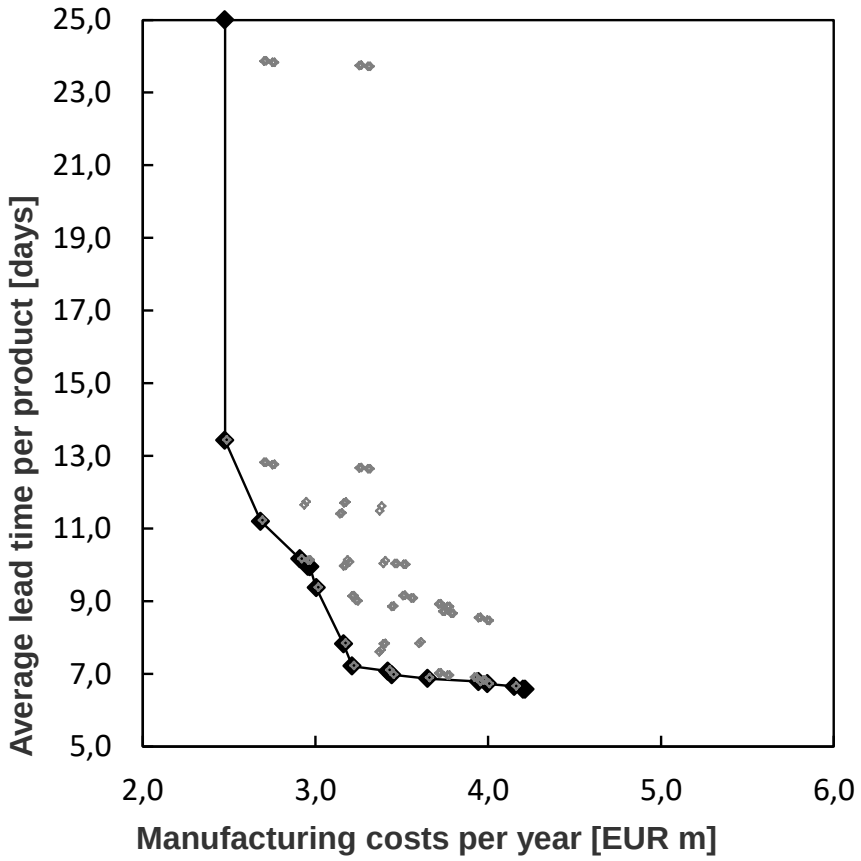

## Features

- Flexible simulation of system load and system capacities
- Comprehensive process chain in model included
- Industrial model derived from real factory observations (time management, process chain, resource requirements)

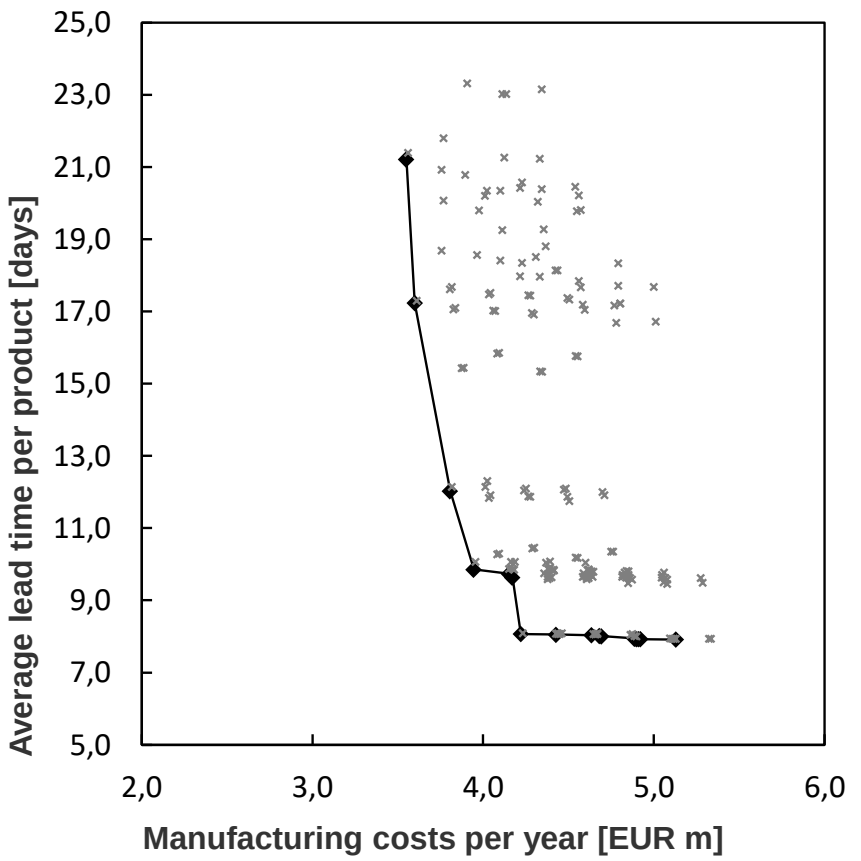
# The steep pareto front makes a business case related factory structure definition strongly necessary

Indicative

## Production program single piece and small series



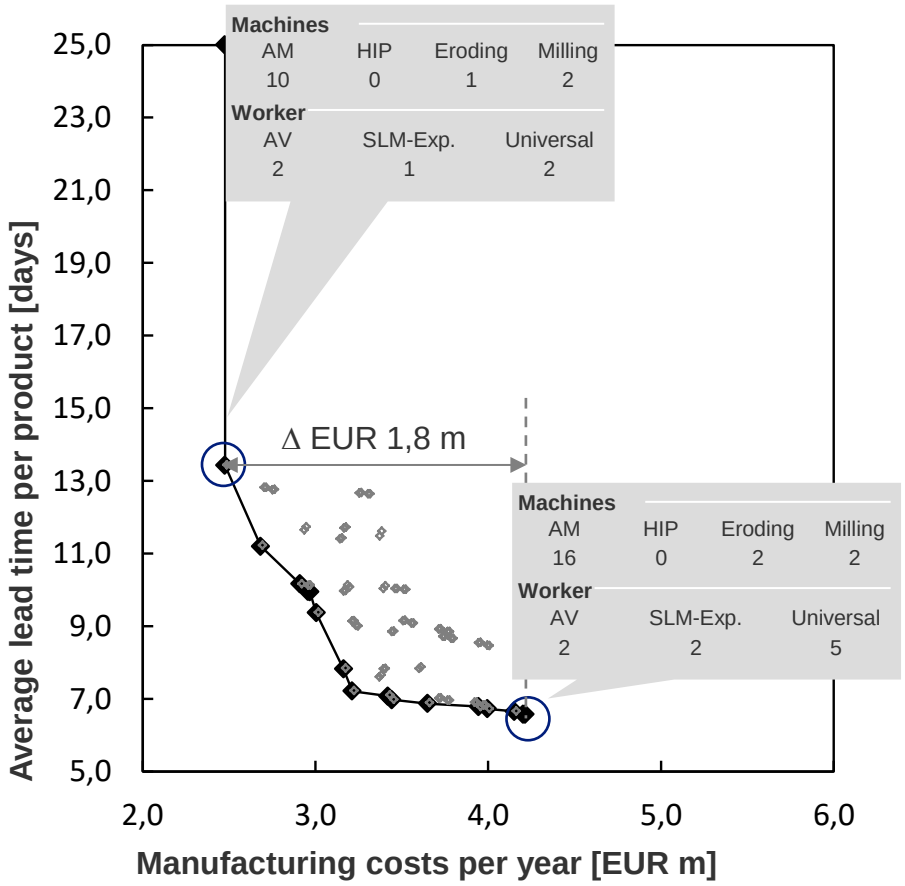

## Production program Mass production



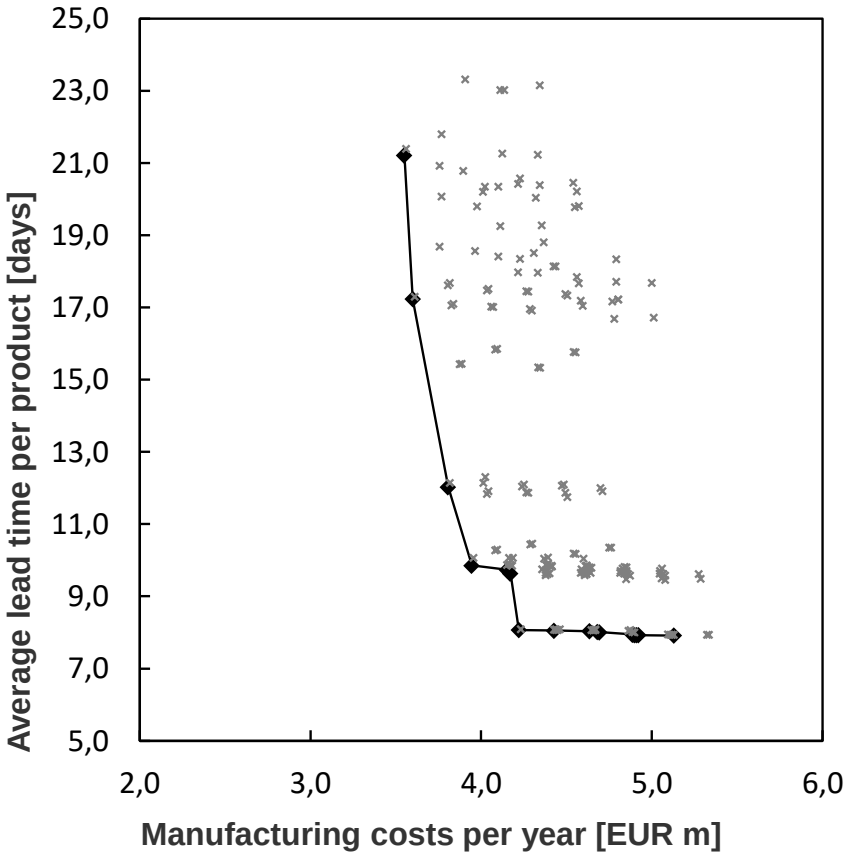
# The steep pareto front makes a business case related factory structure definition strongly necessary

Indicative

## Production program single piece and small series

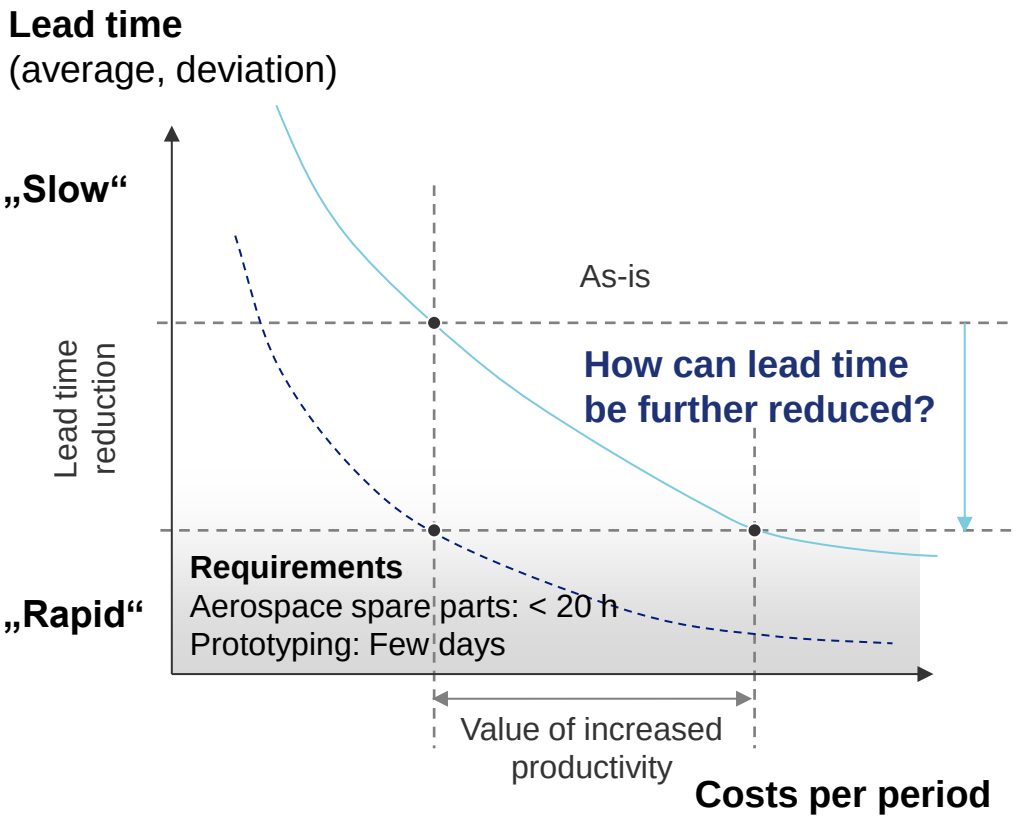



## Production program Mass production



# Full process chain lead times can be fast, but how can they become really rapid?

## Pareto front defined by lead time and cost




## 1 Process improvement


## 2 Product design

- Design for cost/bionic design
- Design for low post processing effort (HIP, machining)
- …

## 3 Dispatching mode

- Build job allocation
- Independent job-setup
- …

## 4 Supply chain improvement

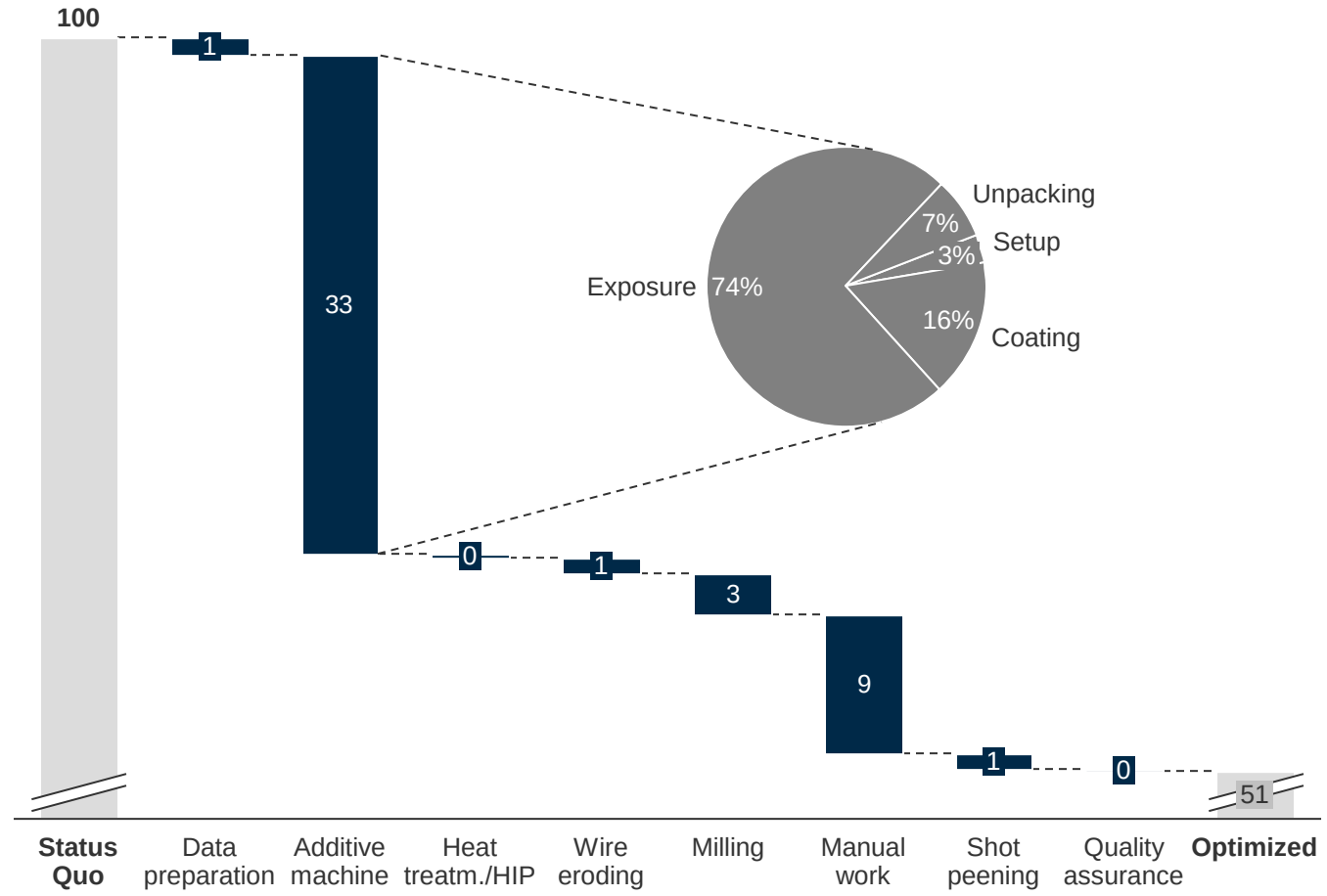
- Distributed/local manufacturing
- …

# Additive machine and manual process with the most significant cost reduction potential

Indicative

## Cost reduction potential when doubling machine speed

[% of manufacturing cost[1)]]




1) Excluding: material, area, building, overhead costs

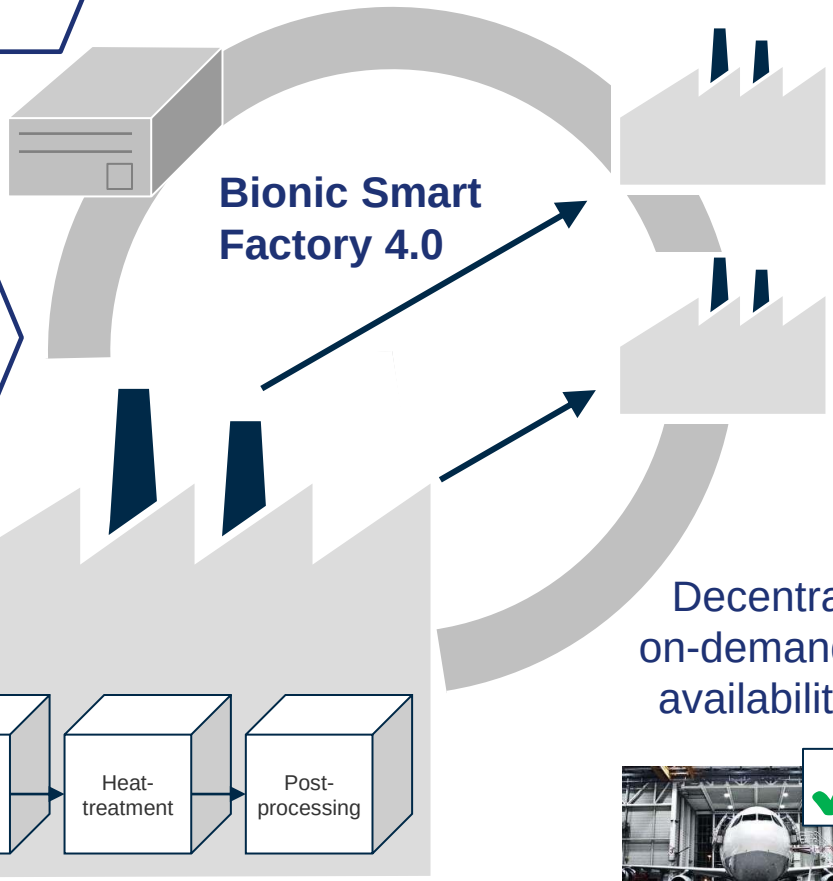
## Details

- Considered production program:
  Single piece and small series production with annual production rate of 13.000 units
- Analysis:
  Cost reduction potential with doubled machine speed
- Basis:
  Discrete event model „Werkskonzepte im Kontext additiver Fertigung“ with industrial model from LZN/iLAS

# Bionic Smart Factory: The approach for global, digital manufacturing

Digital interface for optimization…

…and job preparation




Blueprint for global expansion

Decentral on-demand availability

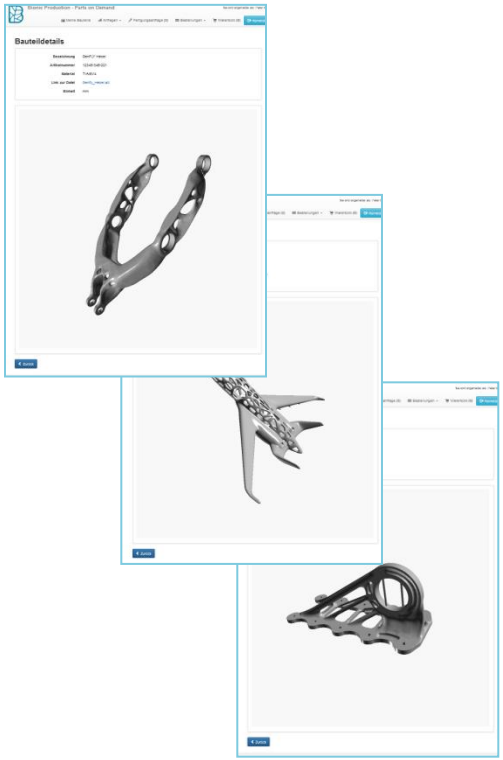
Intelligent, automatized continuously scalable plant



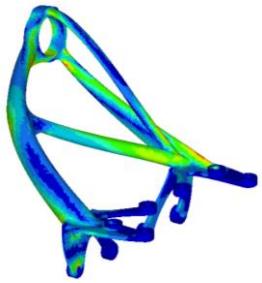
# A Smart Platform simplifies data handling and enables for automation of data processing chain

**Smart Platform:** Interface/optimization → Job preparation → Additive manufacturing → Post processing

## CAD File Upload

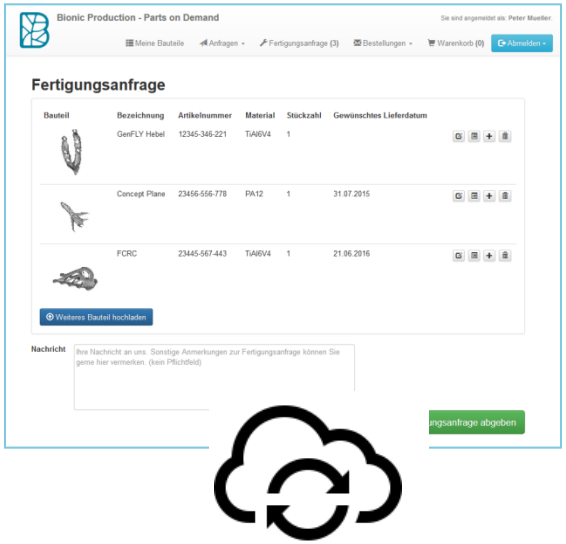



## Value Add Services

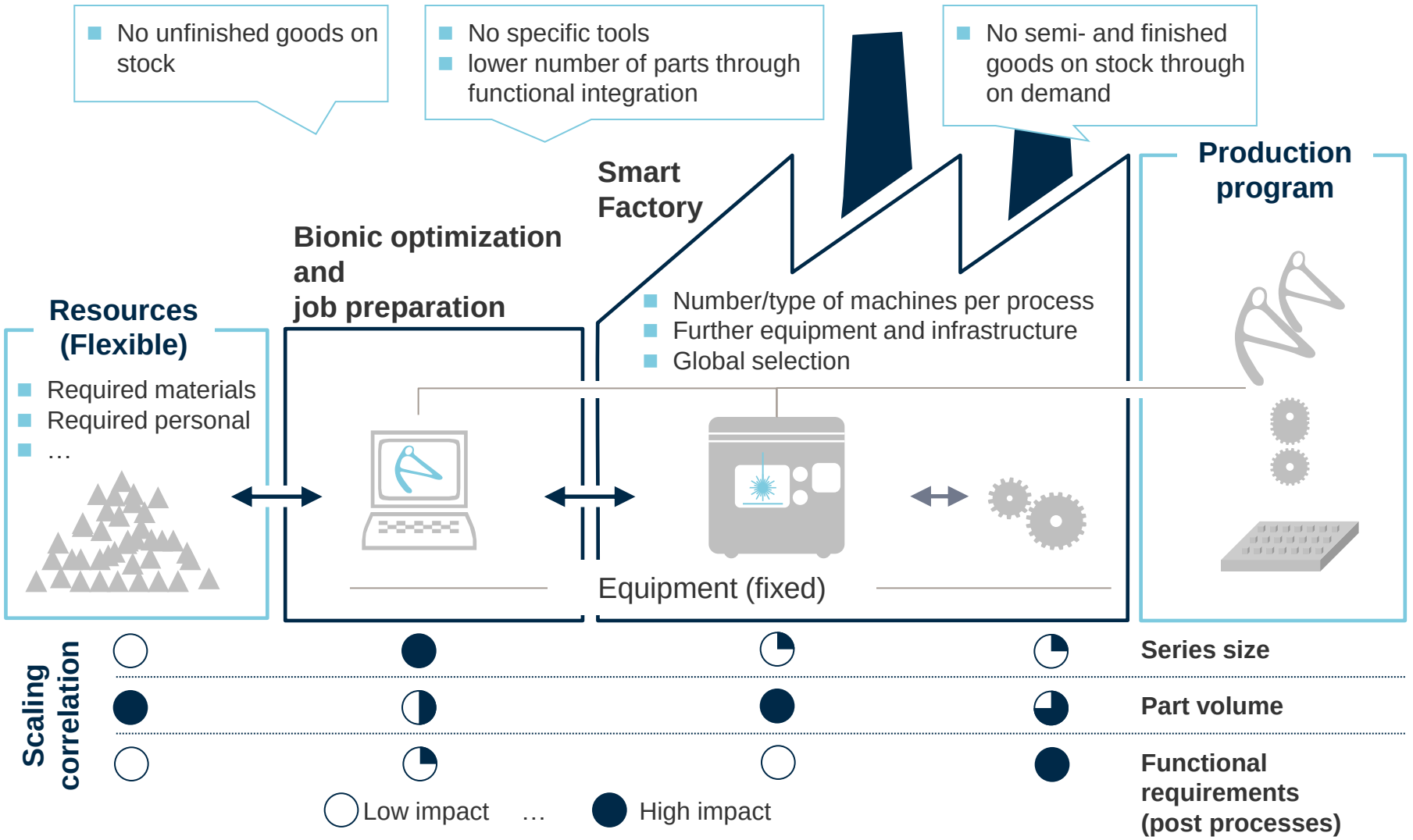


- Parts on Demand: Online (Spare) Parts Catalog
- Automated Processing of Geometry Data:
  - Offer Calculation
  - Design Checking
  - Analysis of Potentials and Part Screening

## Cloud Based Order Processing



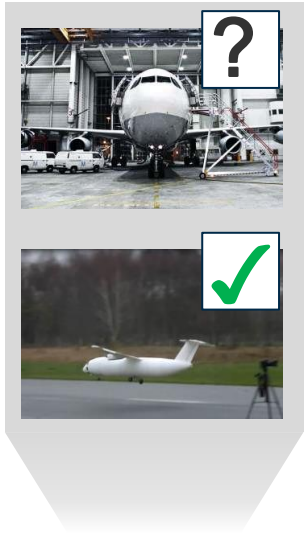
# Bionic Smart Factory is highly scalable – Quick response to a changed production program



# Bionic Smart Factory reduces lead times to near on demand – Machine productivity increase necessary

**Indicative**

**Lead time [h]**



# Thank you very much for your attention!

Markus Möhrle
markus.moehrle@lzn-hamburg.de
LZN Laser Zentrum Nord GmbH
Am Schleusengraben 14
21029 Hamburg-Bergedorf