DIGITIZATION AND VIRTUALIZATION OF THE ADDITIVE PROCESS CHAIN

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Additive Conference 2020



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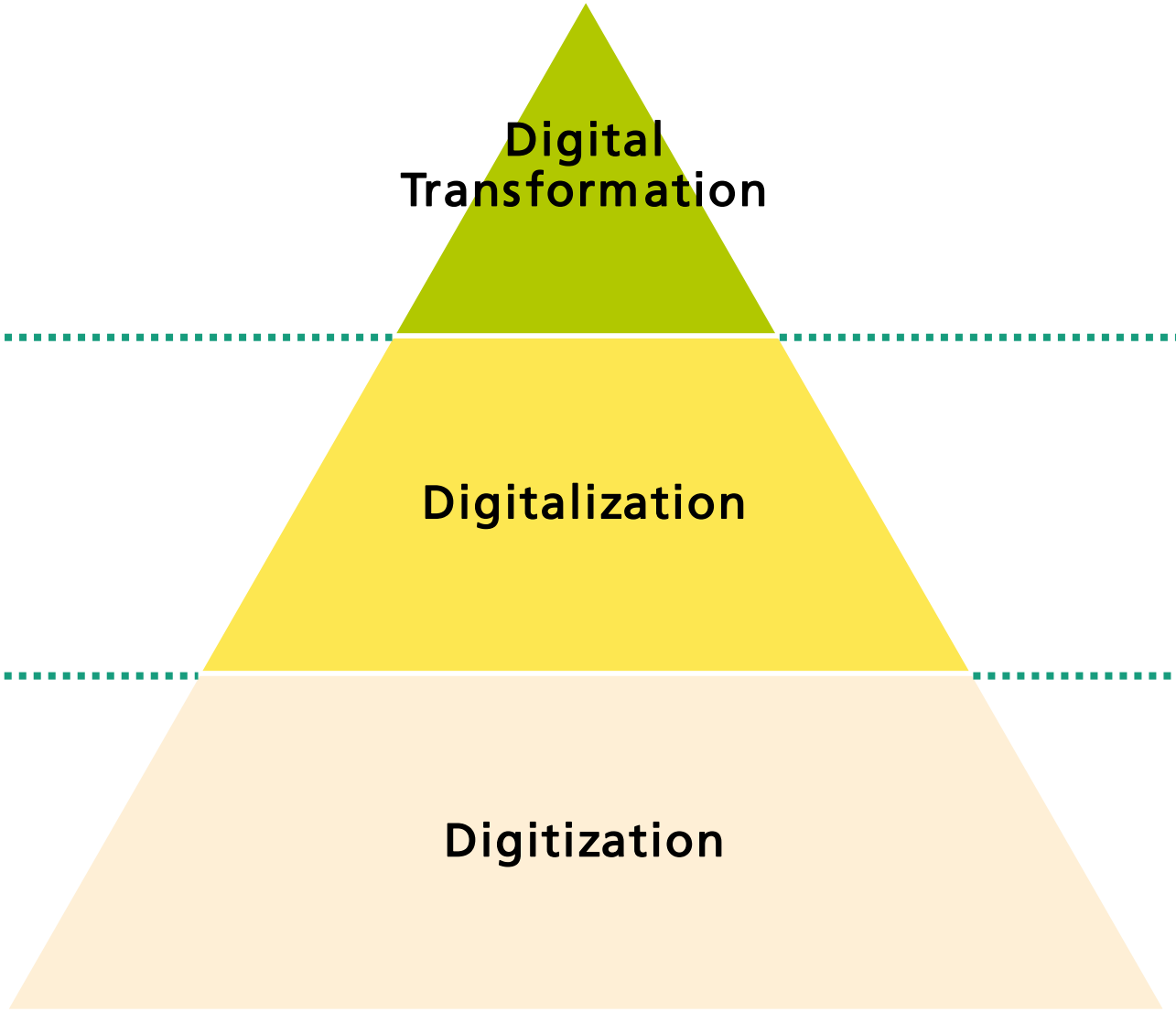
The Difference in Words

Definition

Profound transformation of business activities, competencies, and business models

Example

Building a product for costing and pricing, incl. new business model



Enabling, improving or transforming business processes with digitized data/digital technologies

Developing an application for internal use

Conversion of physical to digital object

Using an Excel spreadsheet to calculate costs and prices

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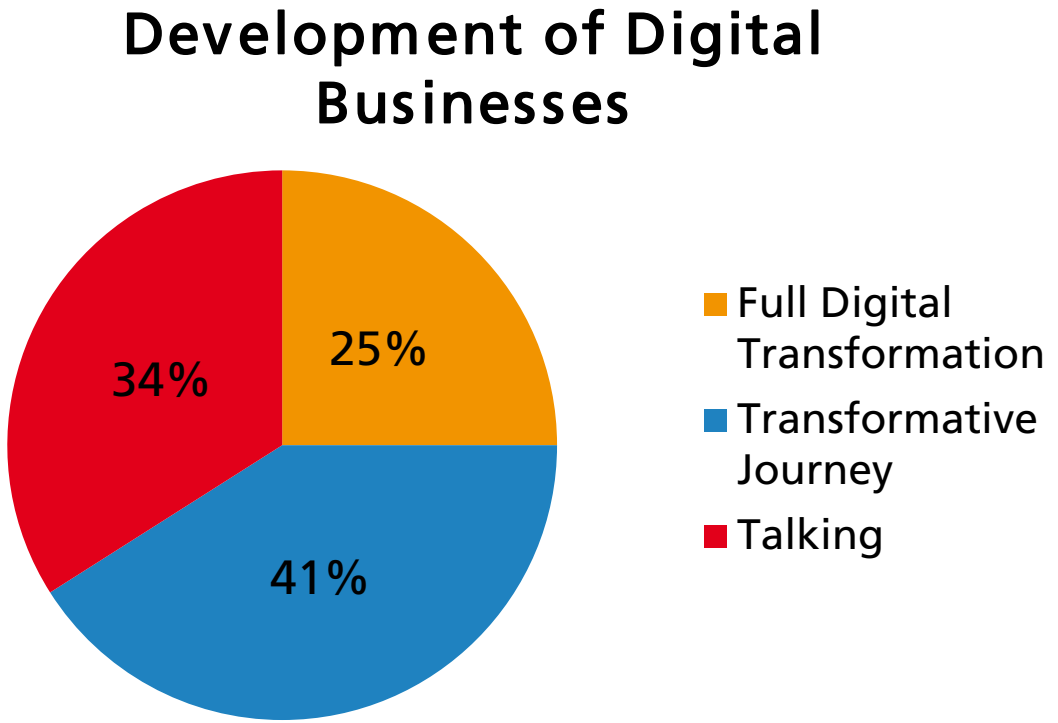
Why Differentiating Matters

84% of Executives Stated:

"Digital Maturity is Critical to Organizational Success!"

Business Leaders unsure how to harness the opportunities that digital brings to people, processes, and technology



G. C. Kane, D. Palmer, A. N. Phillips, D. Kiron, and N. Buckley,
"Achieving Digital Maturity" *MIT Sloan Management Review* and Deloitte University Press, July 2017.

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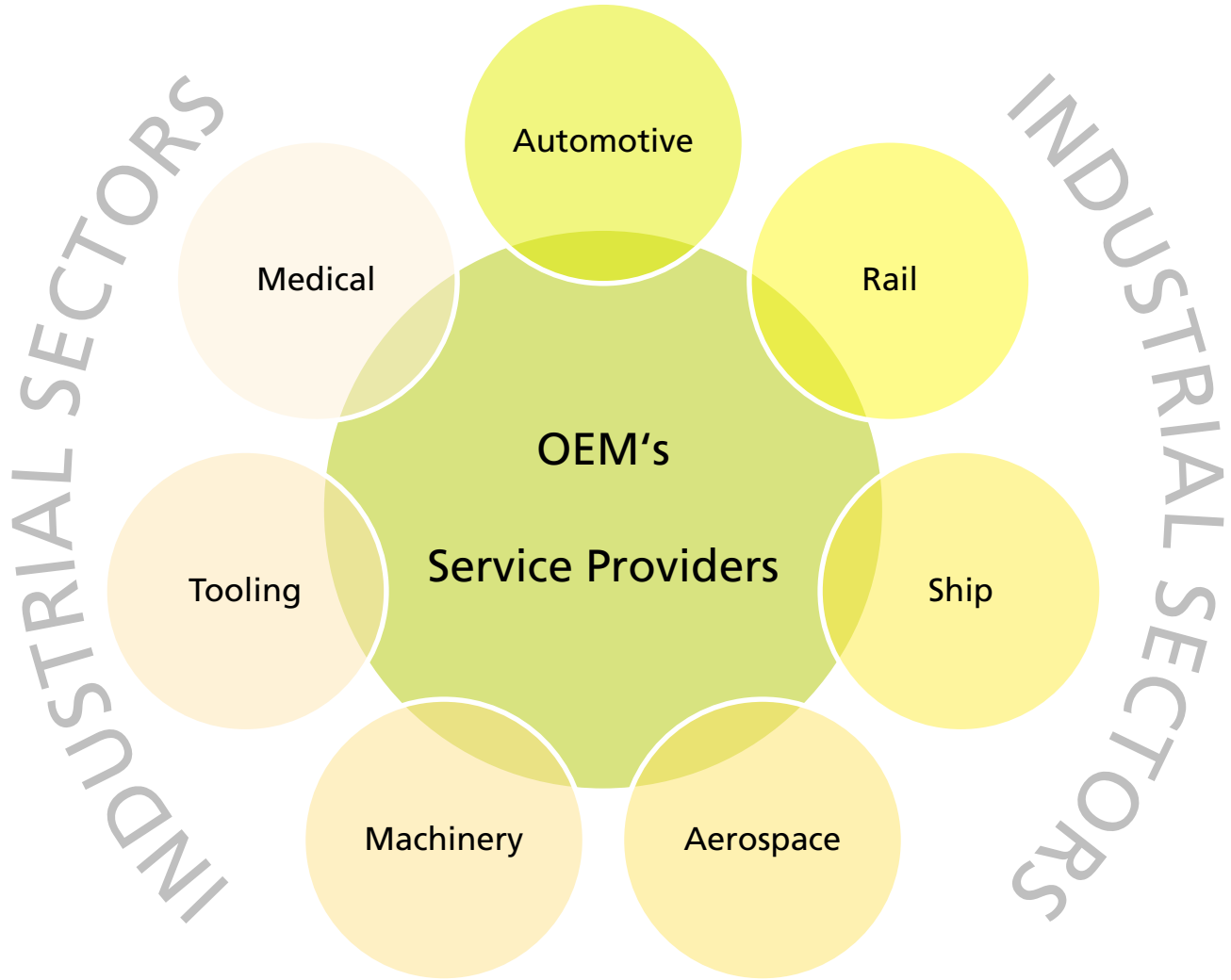
Product Requirements Management



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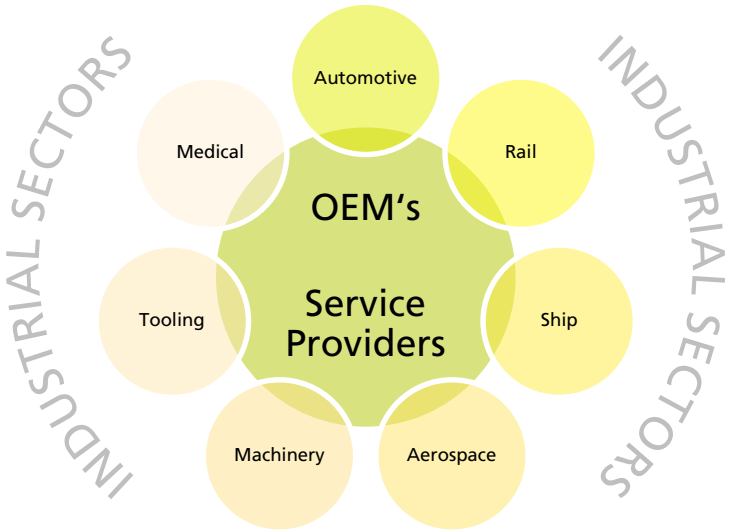
Product Requirements Management



General Industrial Requirements

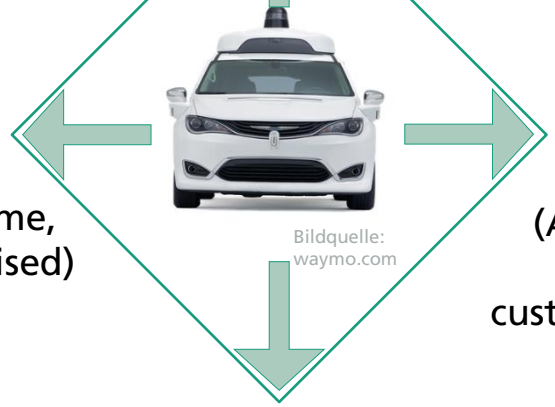
Specific Functional Requirements

Efficiency

(resource-saving & low-emission & renewable)

Time

(Just-in-time, decentralised)



Quality

(Autonomous – maximizing customer benefit)

Cost

(Profitable – pay for use)

Mechanical	Thermal
Electrical	Hydraulic
Pneumatic	…

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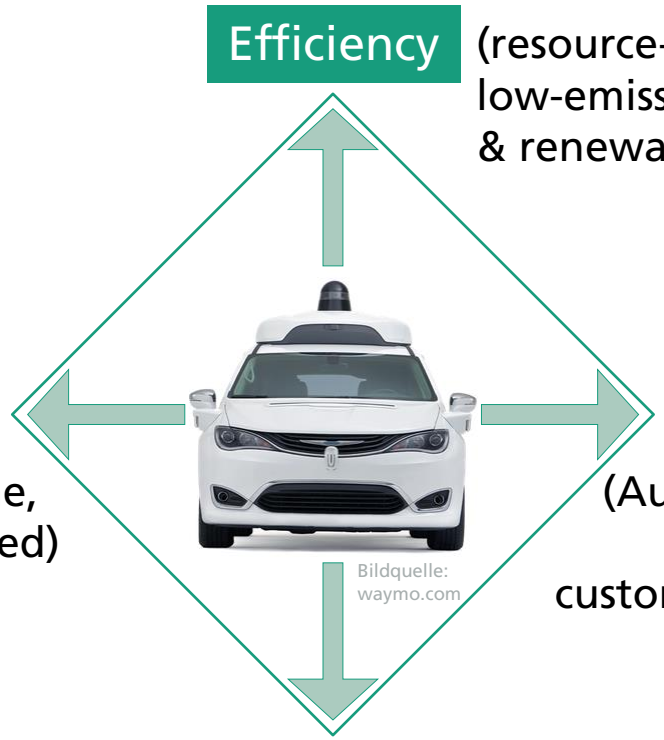
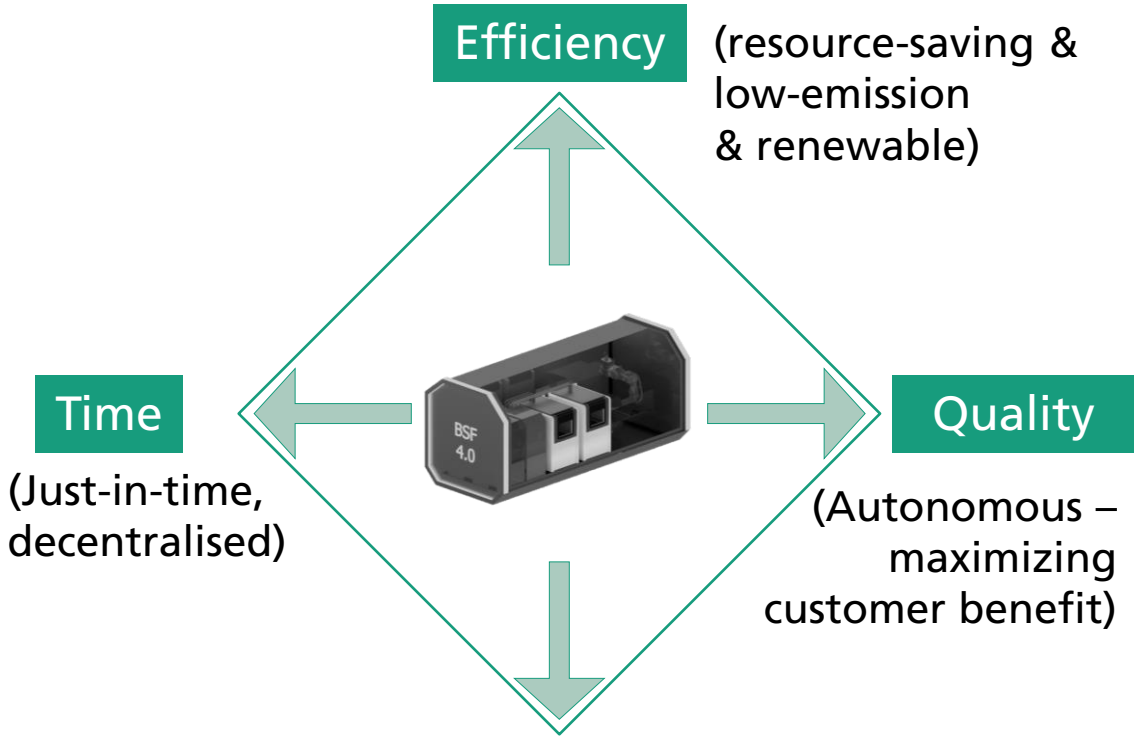
Product Requirements Fulfilment by Digital and Additive Production

Automotive industry



Additive Production



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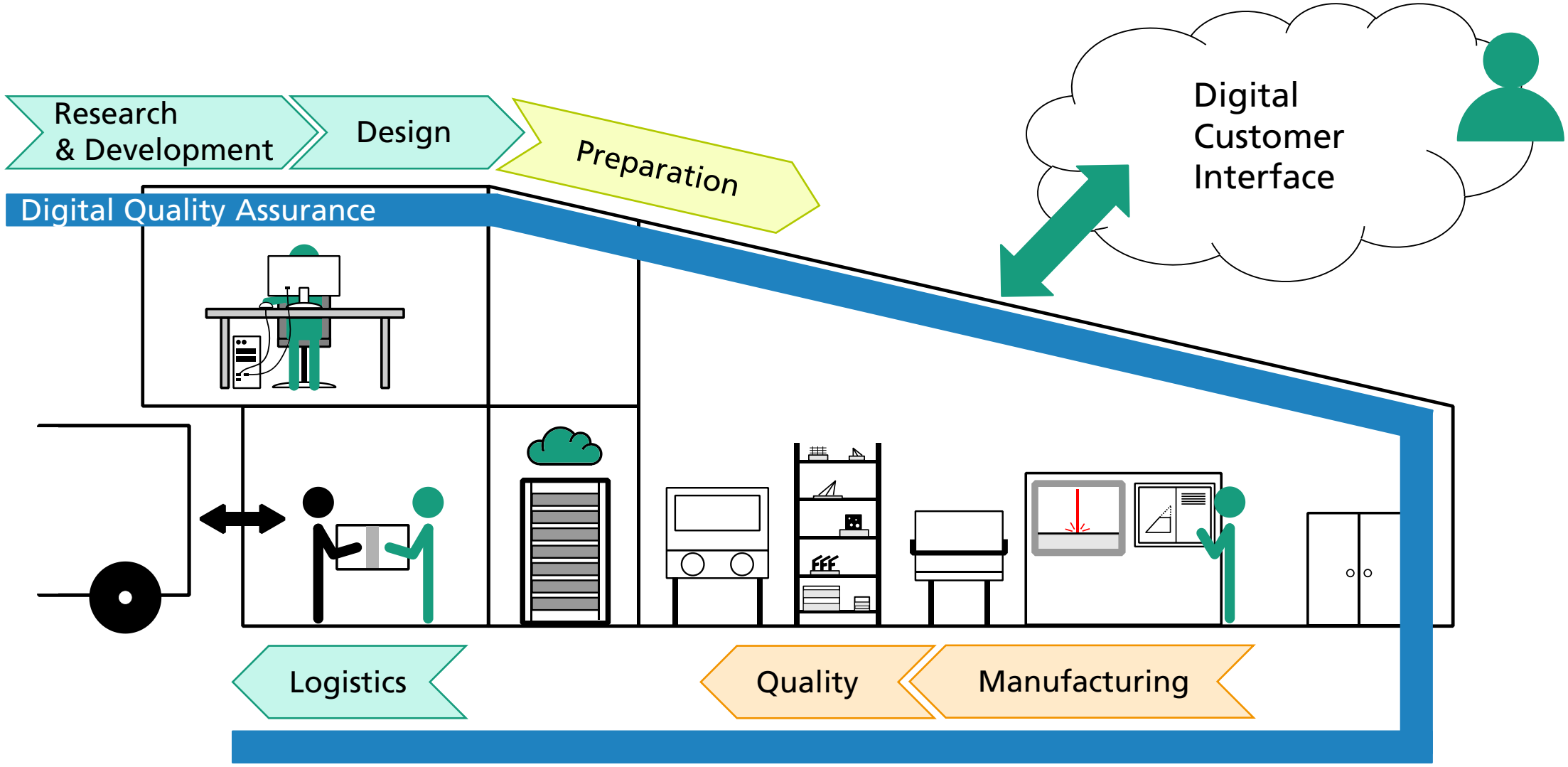
Product Requirements Fulfilment by Digital and Additive Production



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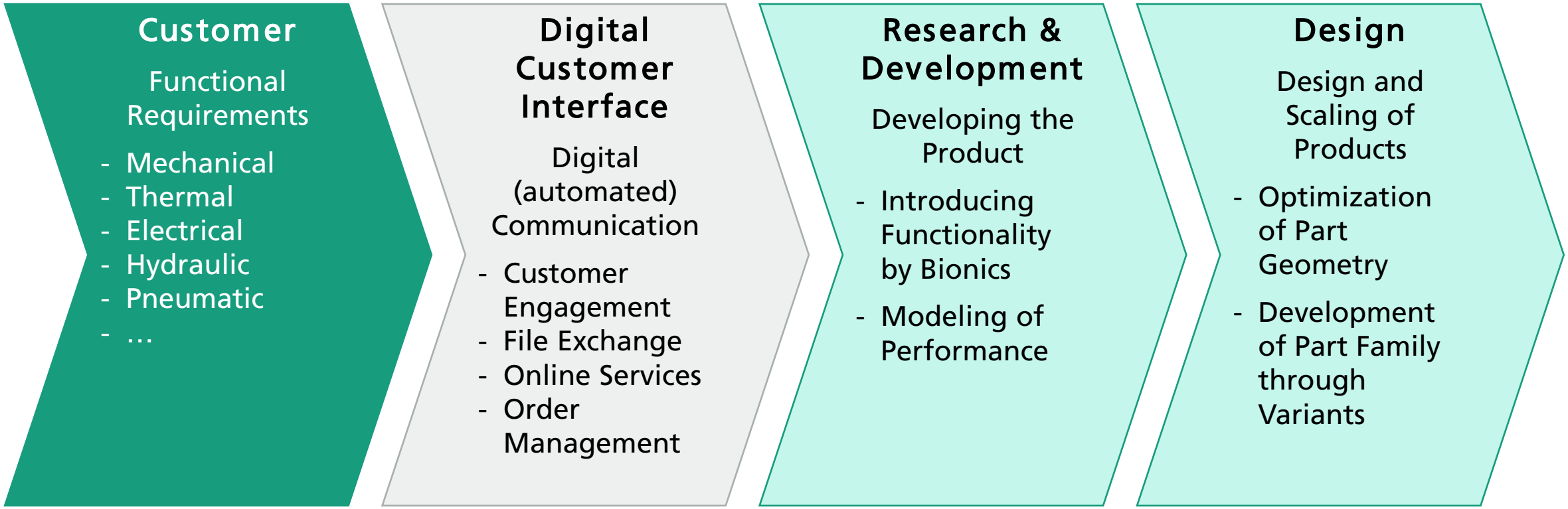
Product Requirements Fulfilment by Digital and Additive Production

Pre-Production



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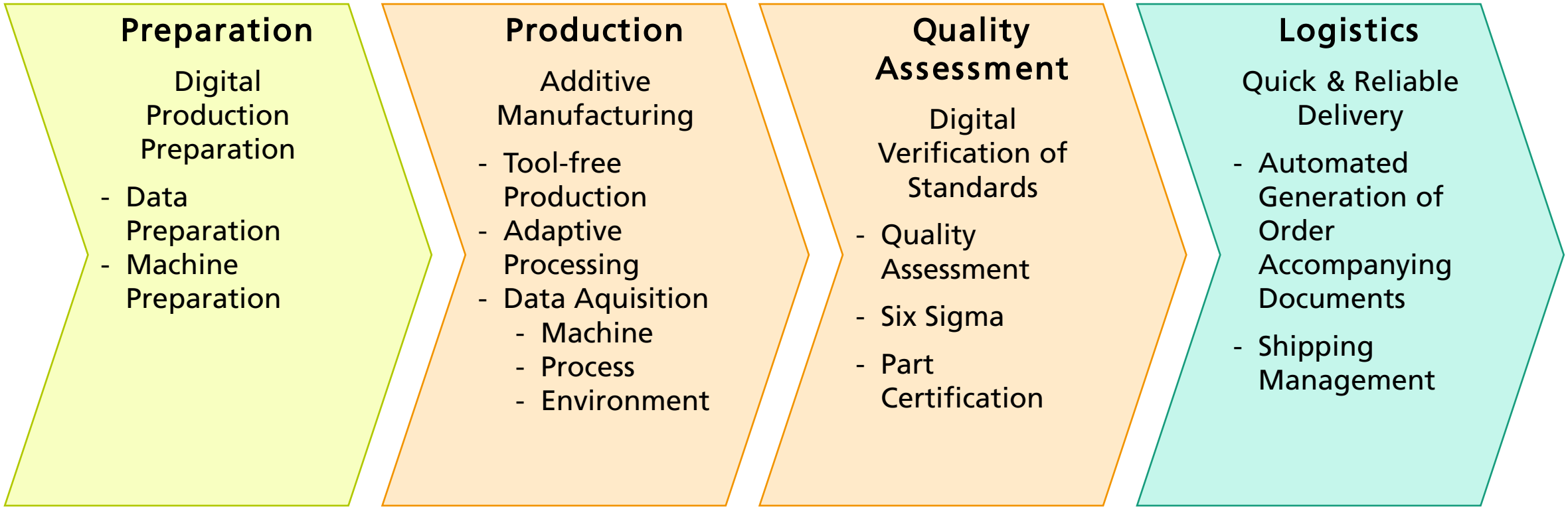
Product Requirements Fulfilment by Digital and Additive Production

In-/Post-Production



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Product Requirements Fulfilment by Digital and Additive Production

Digital Quality Assurance

Digital Part

- Design Phase Data
  - Geometry changes
  - Validation of integrated functions
- Production Phase Data
  - Prepared Build
  - Powder batch used
  - Temperature history
- Postprocessing procedure

Digital Production System

- Processing Data
  - Atmosphere
  - Power
  - Scan Speed
- Component Data
  - Performance
  - Maintenance

Digital Factory

- Production Data
  - Machine Utilization
  - Consumables
  - Environmental Data
- Layout Data
  - Production Bottle Necks
  - Production Times

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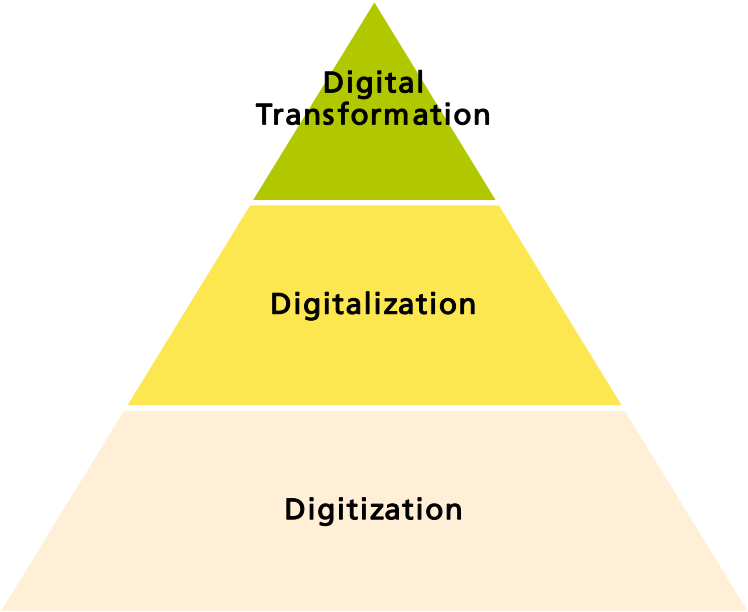
Digital Transformation of Production

Data Aquisition

Tracking of irregularities

Enabling production to adapt in real-time



Modeling the factory, production systems, manufacturing processes, and the part itself is crucial to achieve digital transformation of production!

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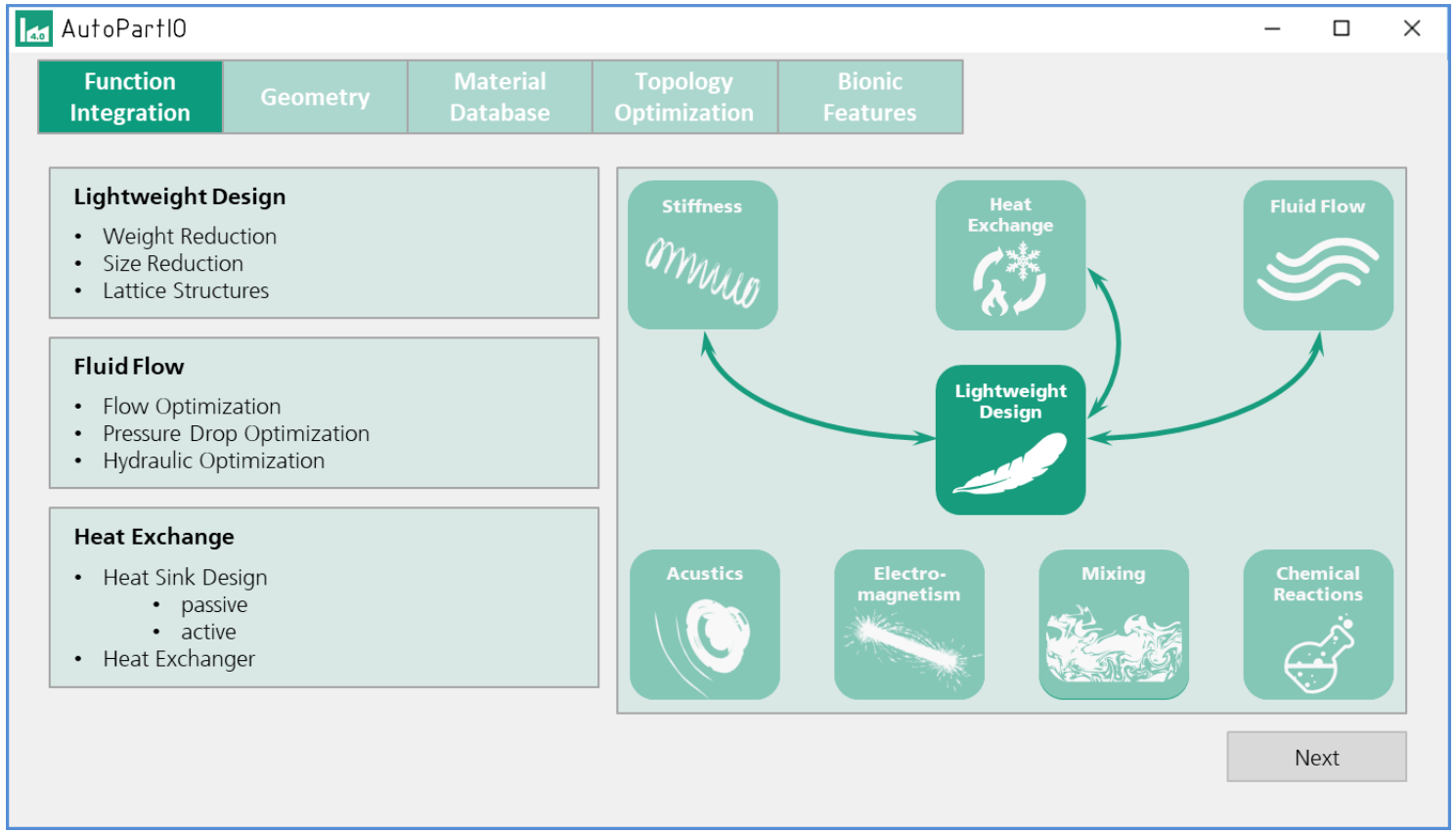
Digital Transformation by Functional Modeling



Physics of modeling

- Mechanical strength
- Fluid dynamics
- Heat transfer
- Vibration
- Electromagnetism
- Chemistry

Use to introduce specific functions to your product and predict part performance

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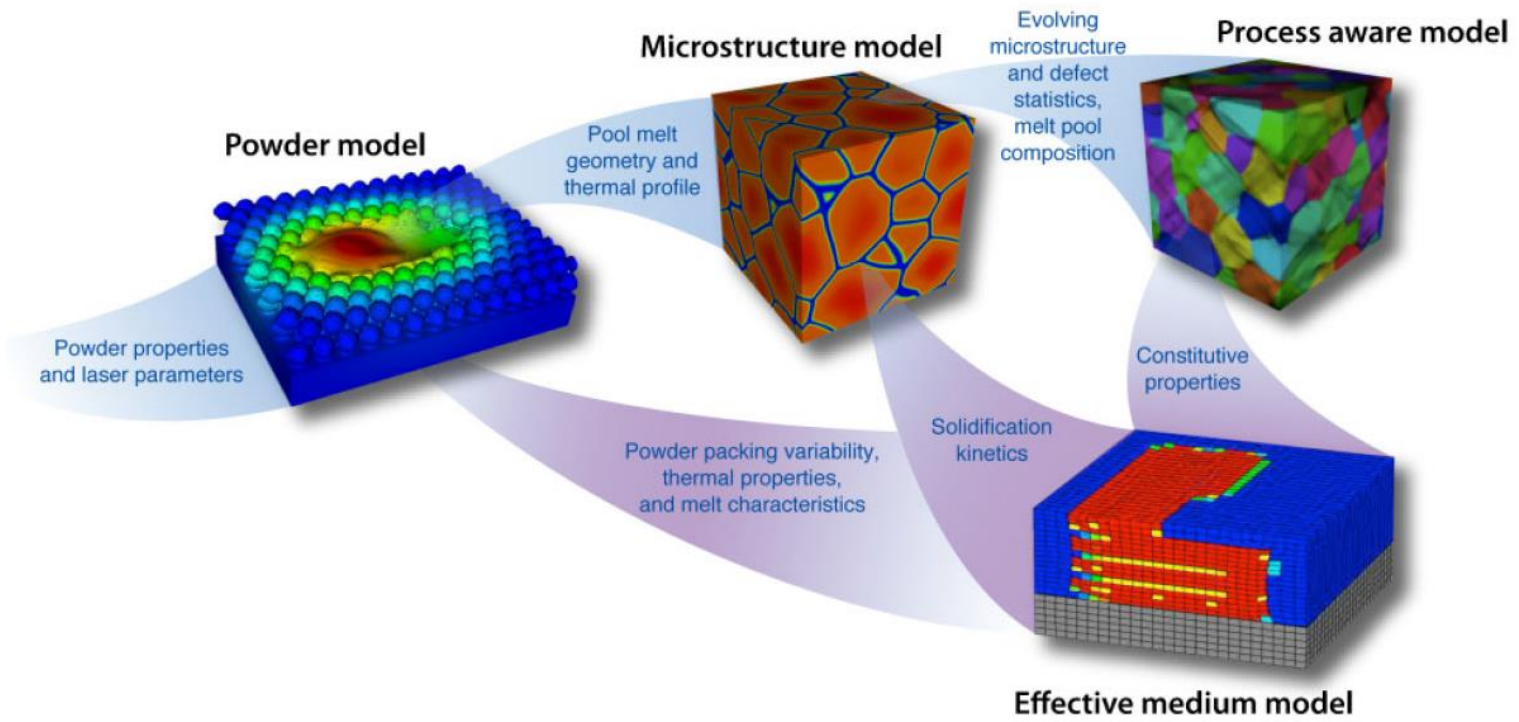
Digital Transformation by Process Modeling



Scales of modeling

- *Micro*: Microstructure of material
- *Meso*: Powder particles, melt pool dynamics
- *Macro*: Single layer
- *Part*: Complete part

Physics of modeling

- Grain growth
- Fluid dynamics
- Thermal history
- Residual stresses

Use to predict part properties, distortion, and defects
→ determine individual process parameters

W. King, A. T. Anderson, R. M. Ferencz, N. E. Hodge, C. Kamath, and S. A. Khairallah, "Overview of modelling and simulation of metal laser powder bed fusion processes at Lawrence Livermoore National Laboratory" *Materials Science and Technology 31:8, 2015, p. 957-968*.

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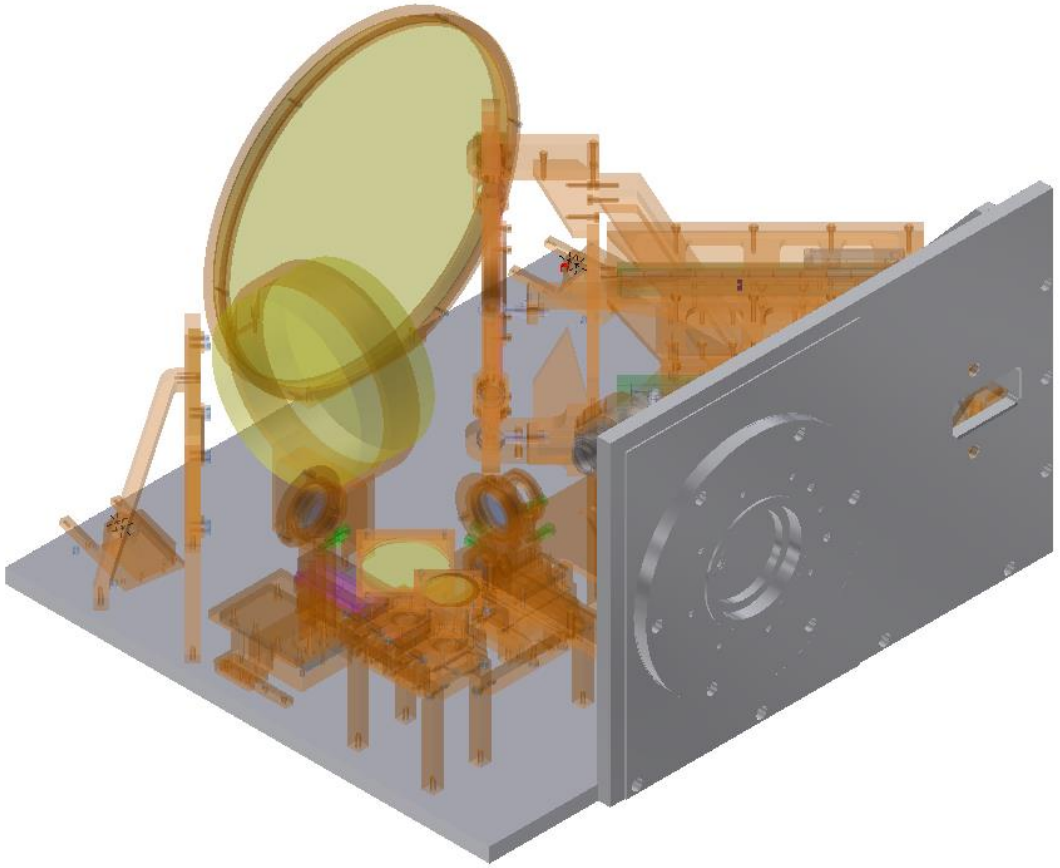
Digital Transformation by System Modeling



Scales of modeling

- *Micro*: Single Component
- *Meso*: Subassembly
- *Macro*: Full system

Physics of modeling

- Thermal history/expansion
- Mechanical loads/stresses
- Component dynamics

Use to predict the effect of environmental changes & component wear

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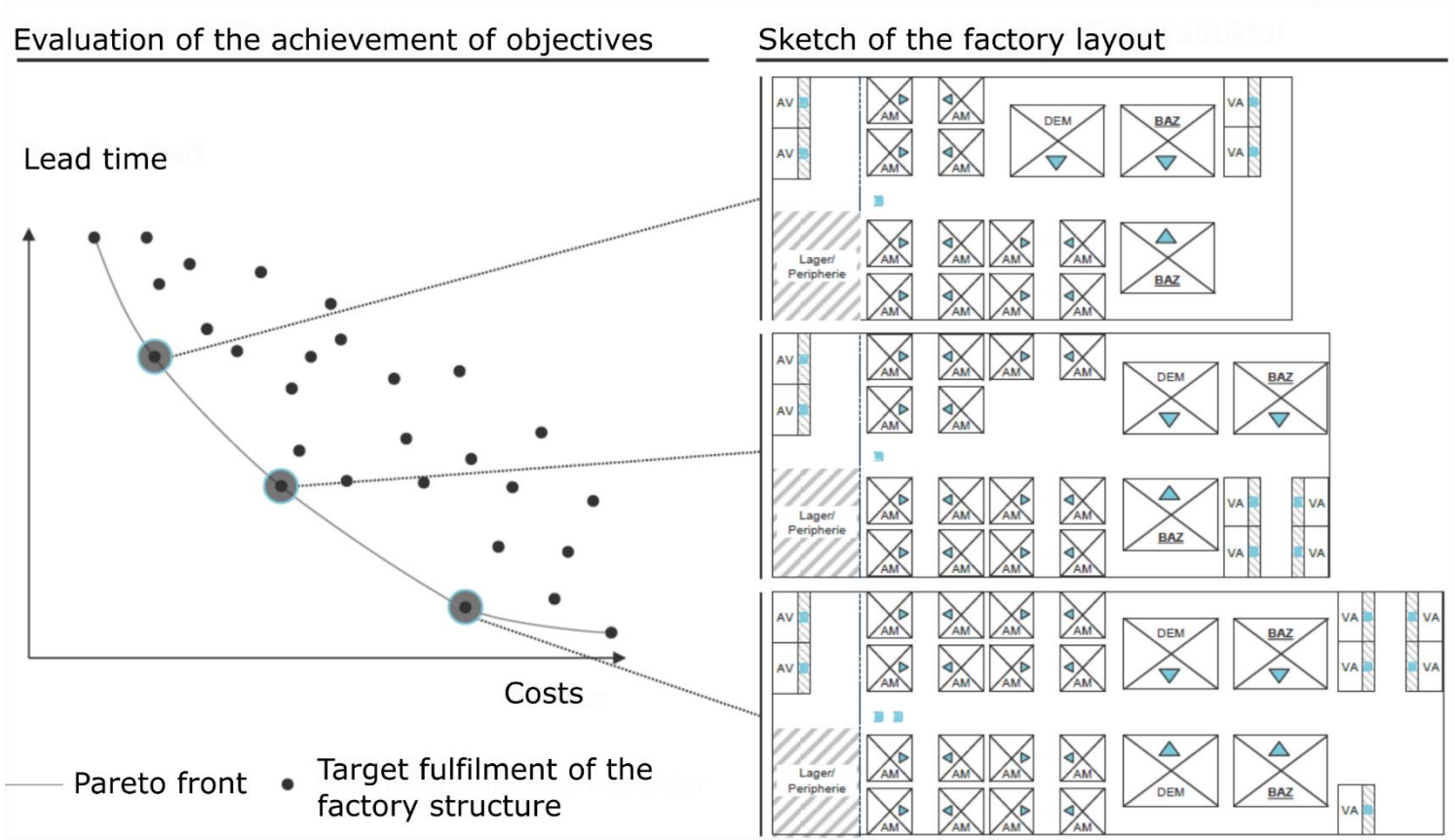
Digital Transformation by Factory Modeling



Scales of modeling

- *Micro*: Performance of single system
- *Macro*: Factory layout

Use to predict production costs, efficiency, and need of investment

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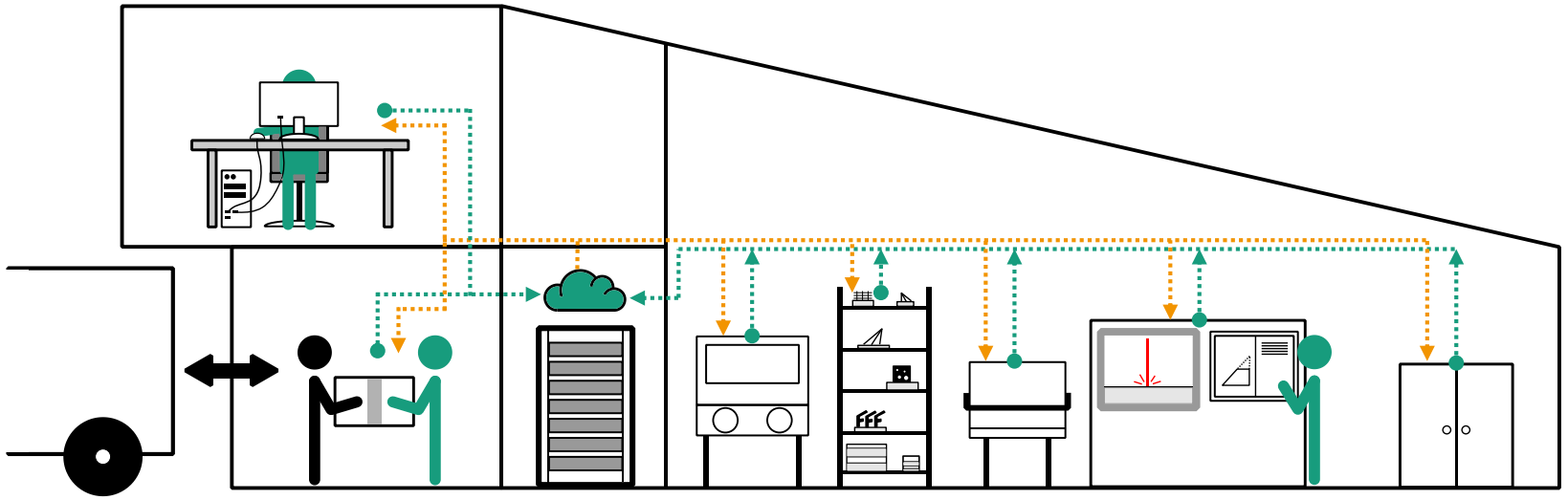
Digital Transformation by Combining Simulation and AI



Simulation

- Detailed representation of reality
- Computational effort prevents real-time application

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Artificial Intelligence

- Able to interpret data and make decisions in real-time
- Great effort for training necessary

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Digital Production

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Thank you for your attention!



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