Prof. Dr.-Ing. Jörg Franke

Institute for Factory Automation and Production Systems

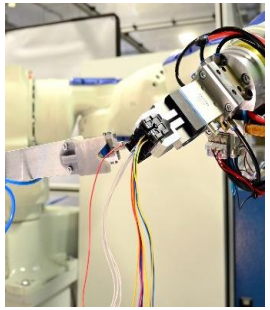
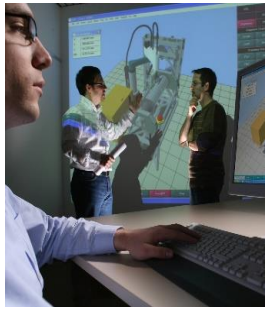
Friedrich-Alexander University Erlangen-Nuremberg

Friedrich-Alexander-Universität
Technische Fakultät

Presentation of the Institute FAPS

Research Sector Engineering Systems

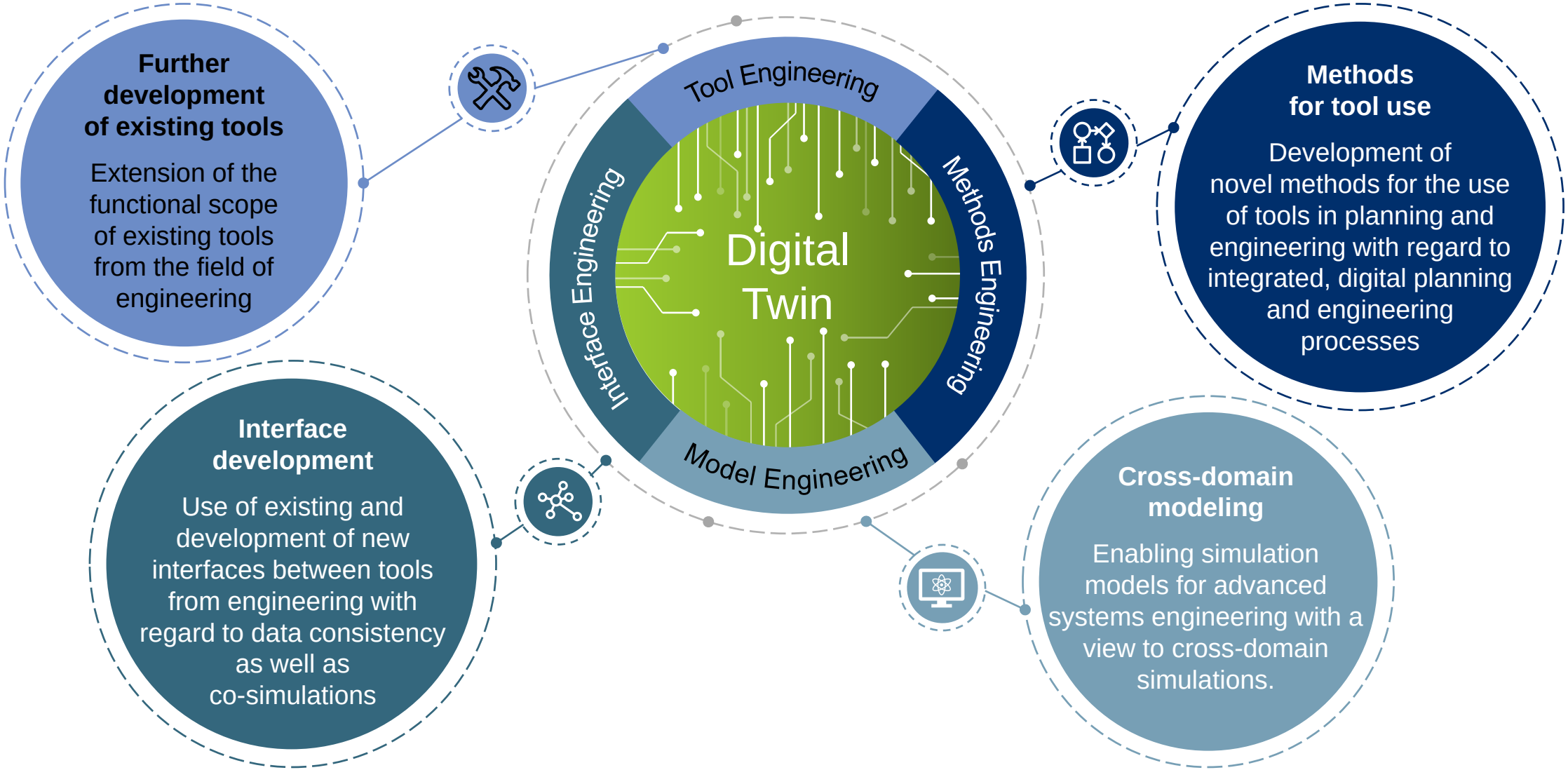
The Institute for Factory Automation and Production Systems (FAPS) is researching the production and assembly of mechatronic products.

Electronics Production	Electro-mechanical Engineering	Data and Power Networks	Home Automation	Medical Technology	Robotics	Automation Technology	Engineering Systems
							

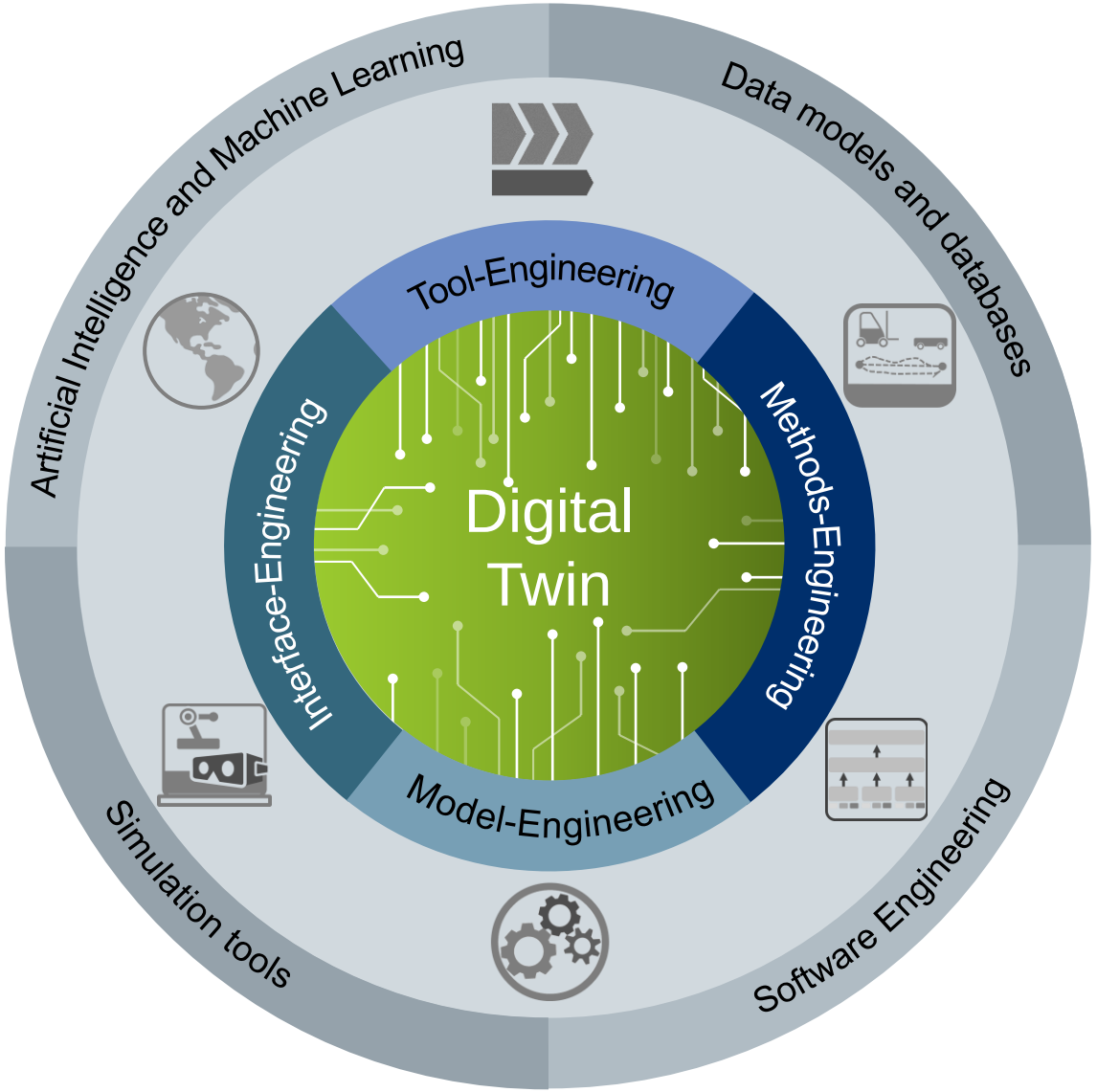
Auf AEG Nuremberg

Technical Faculty Erlangen

In order to achieve the vision of the Digital Twin in planning and engineering, it is necessary to research and develop new tools, interfaces and methods.



The research sector E|Sys pursues the vision of completely digitalizing complex mechatronic systems within the scope of efficient and integrated engineering.



Integrated engineering in the context of lifecycle management (PLM, PSLM)

Planning and virtual commissioning of production systems

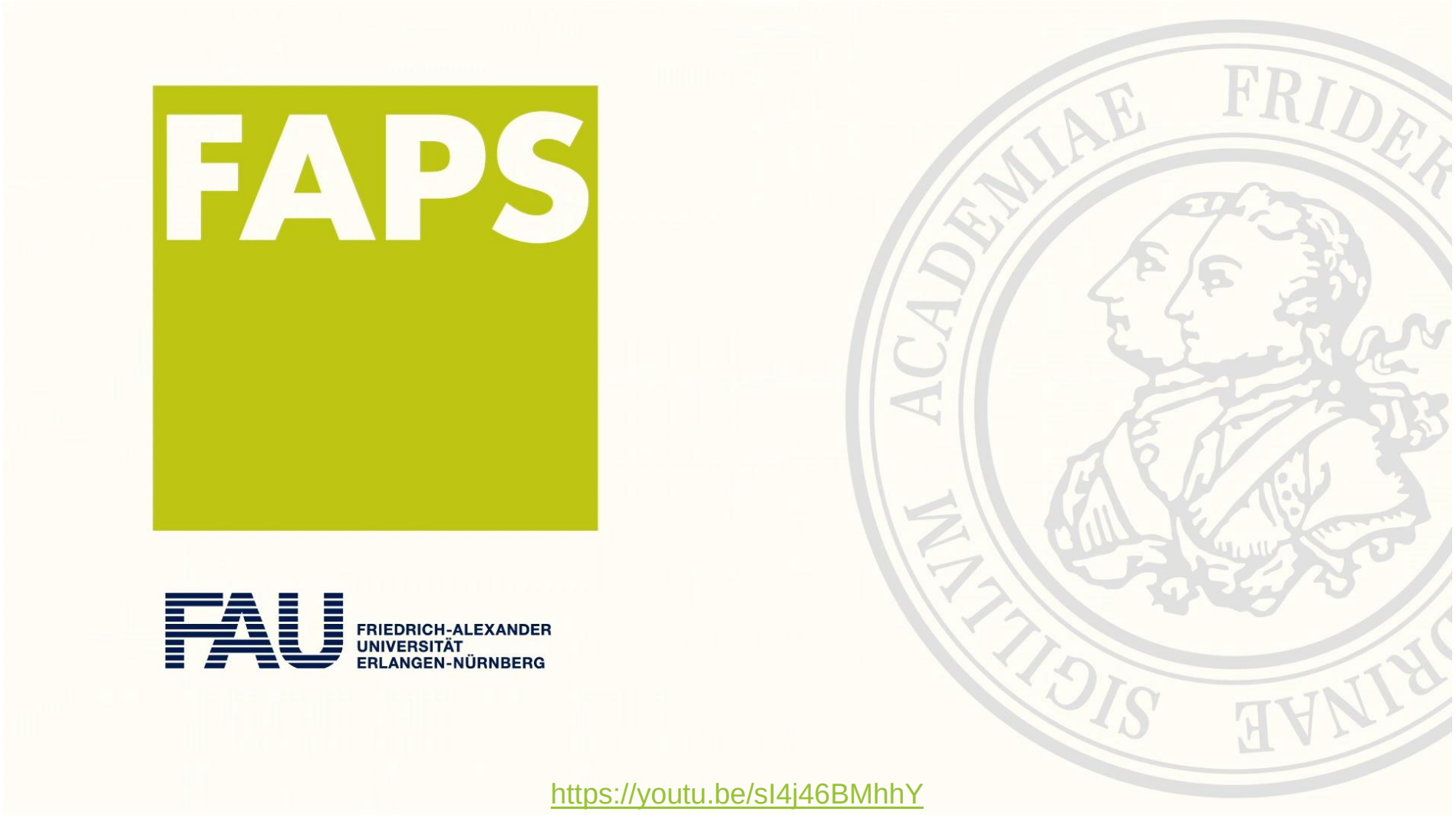
Development of digitally integrated process chains and associated data models

Process automation in interdisciplinary engineering

Engineering of resource-efficient production systems

Human-machine interaction using virtual and augmented reality (VR, AR)

The image video of the research sector illustrates the topics worked on around the digital twin.



https://youtu.be/sI4j46BMhhY

Using integrated data chains and intelligent product models, spatial opto-mechatronic assemblies are digitally modeled in the DFG research project OPTAVER.

Integrated Engineering

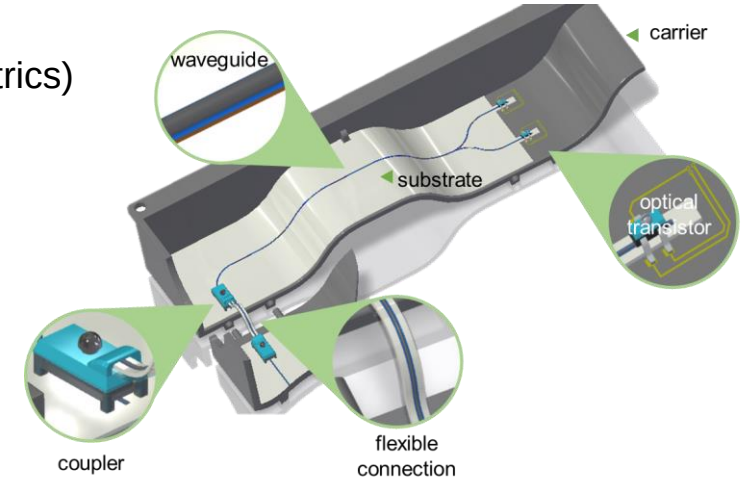
Process Automation

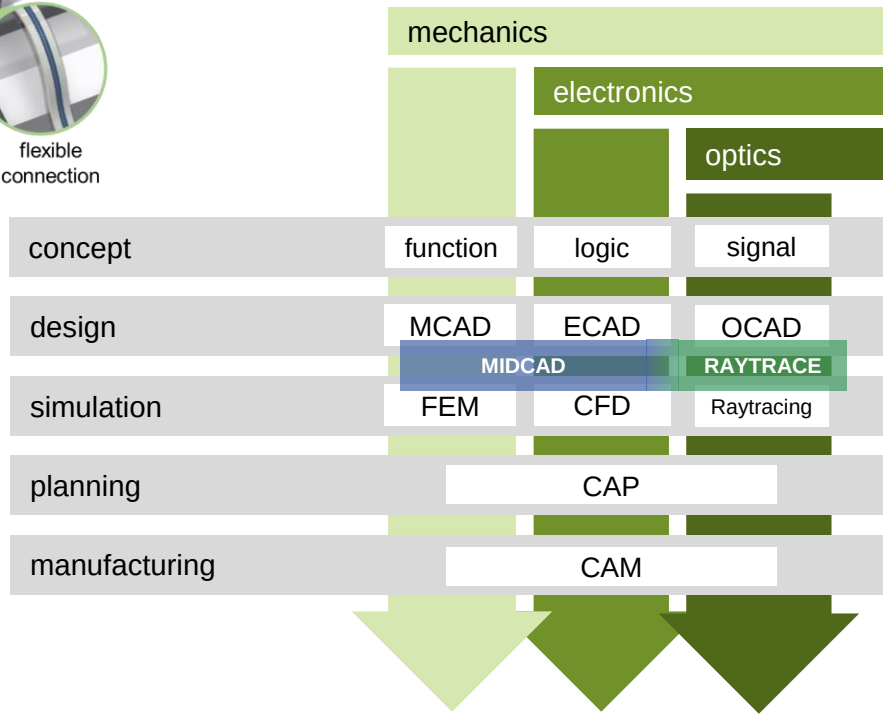
Scientific Challenges:

- Synthesis of separate domains (optics, mechanics, electrics)
- Automated path planning on 3D circuit carriers
- Consideration of optical properties through geometric properties

Goal: Merging mechatronic 3D design and optical simulation

- Creation of optical models for 3D-CAD systems with parameters like e.g. signal and coupling efficiencies as well as refractive indices
- Collection of knowledge about the correlation between design rules of 3D-Opto-MID, simulation and manufacturing processes
- Application and implementation of integrated design and layout functions for spatial opto-electronic assemblies





Research into the use of generative design in MIDs is intended to create the basis for new, nature-analogue design methods.

Integrated Engineering

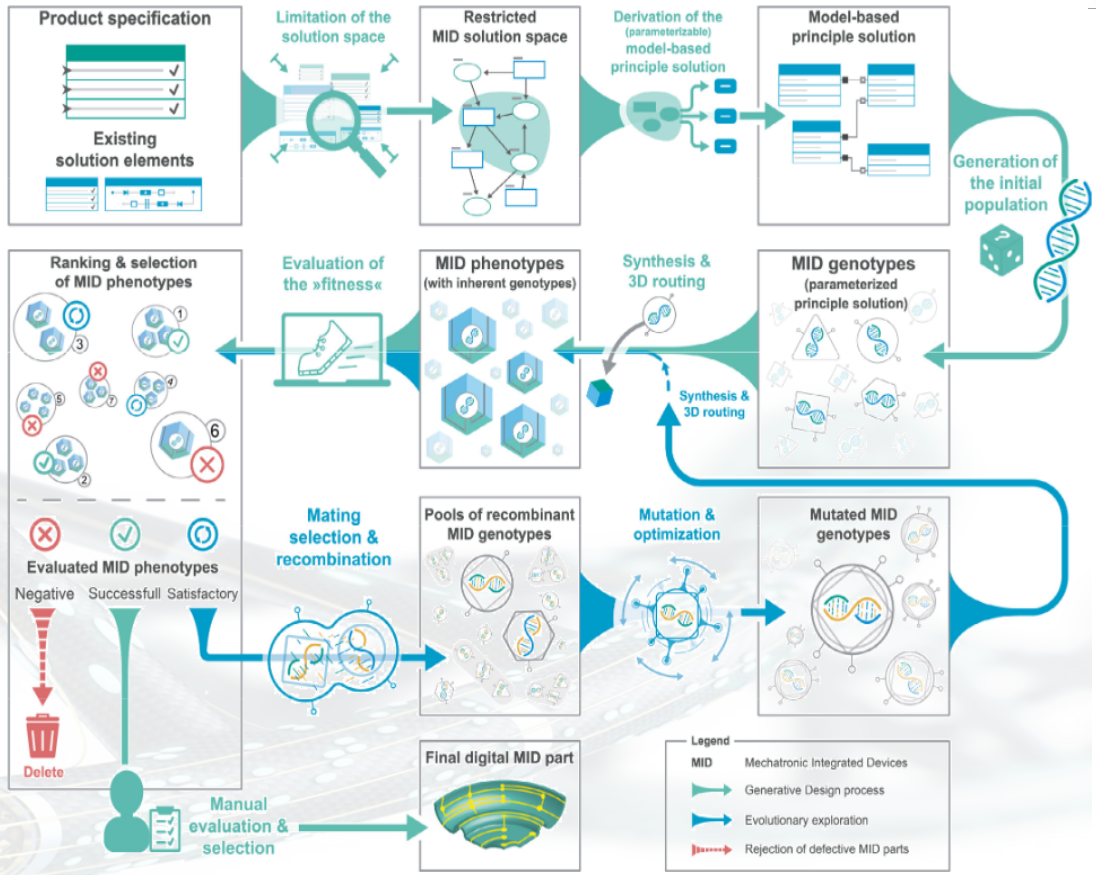
Process Automation

Scientific challenges:

- High product complexity of mechatronically integrated components (MID) leads to a challenging development process
- Product development requires manual, complex and highly iterative optimisations and adjustments
- New approaches are needed to develop valid design variants taking into account all disciplines and constraints in a resource efficient way

Goal: Exploring the potential of biologically inspired methods in the product development of spatial circuit carriers

- Multifaceted potential through natural analogue principles (in particular genetic algorithms) for the exploration of innovative design variants
- (Partially) automated evolution and synthesis of MID components based on a product specification
- Testing of established natural analogue approaches (e.g. genetic algorithms) for suitability



Fraunhofer IEM

Neotech AMT
Advanced Manufacturing Technologies for 3D Printed Electronics

JÜRGENHAKE

The PDA-RobE research project supports project management in plant engineering through process management, BPMN, XR and AI services.

Planning & Simulation

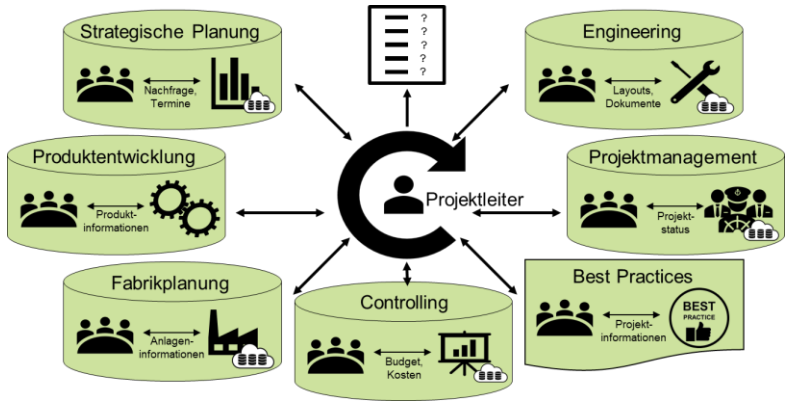
Digital Process Chains

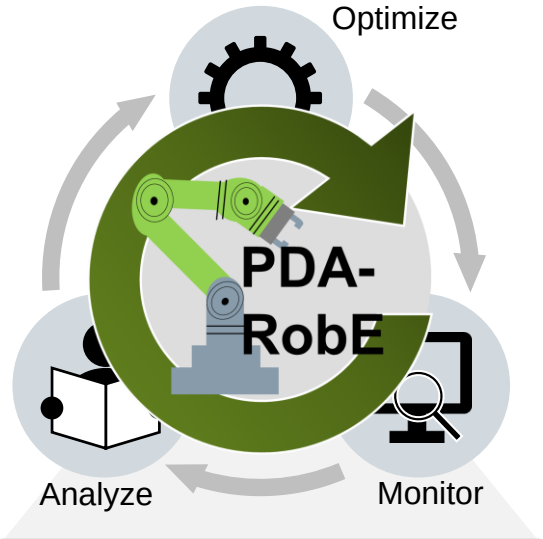
Process Automation

Human-Machine-Interaction

Situation

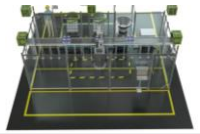
- Project planning is characterized by decentralized knowledge and media disruptions
- Manual synchronization and coordination of knowledge and processes





Project management			
Multi-user collaboration			
BPMN	PDA	XR	AI

Potentials of process management with BPMN

1	Agile process adaptation	
2	Monitoring and reporting for the continuous improvement process (CIP)	
3	Standards-based business and IT collaboration	
4	Dashboards and automatic task lists	
5	Orchestration of various technologies and services	

Problem

- (Lean-) waste in project planning
- Intransparency and real-time capability of information

Solution

- Synchronization of knowledge, tasks, processes and tools through a central, comprehensive web platform
- High user-friendliness and intuitiveness through a process and customer-oriented approach based on BPMN

Gefördert durch
Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie

InterAcDT researches the interactive-collaborative use of the Digital Twin for the simulation based planning and optimization of automated production plants.

Planning & Simulation

Process Automation

Human-Machine-Interaction

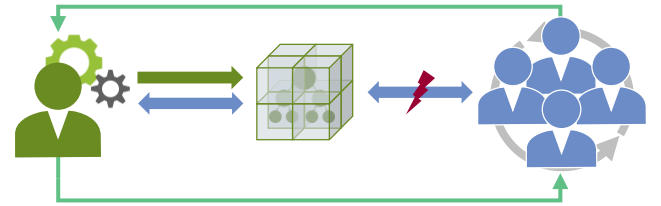
InterAcDT – Interactive-colloaborative Digital Twin for planning production systems

Initial state | Problem

- Digital Twins are becoming more detailed and complex in order to portray the reality with an increasing number of functions.
- The planning of production plants with the help of Digital Twins is limited to a small number of experts due to this complexity.
- The use of algorithms for optimization and the interaction of the users with the Digital Twin requires a large effort with regards to time and cost.

Today

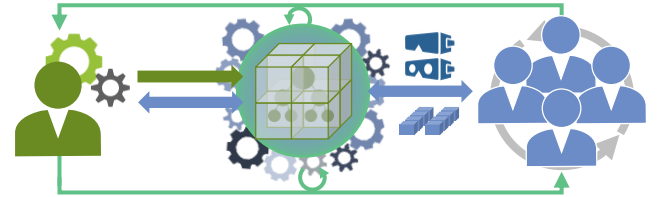
The expert is singular interface to the Digital Twin. Other stakeholders approach them with their scenarios and receive results later.



Modelling Interaction Communication

Tomorrow

Various stakeholders are able to interact with the Digital Twin with the help of experts in real time and are able to receive optimized results faster.



Target state | Solution

- **Functionalities** relevant for the future of the Digital Twin for the planning of production plants are research, implemented and methodically examined.
- An **expanded user group** is enabled to conduct a **simulation based optimization** for production plant planning in collaboration with experts.
- The **novel interaction** with the Digital Twin is illustrated with the use of **demonstrators** using VR, AR, XR-technologies designed for this purpose.

Planned demonstrators in project

Interactive material flow and layout planning

Concept visualization with multi-user VR

Concept and layout planning of plant in AR

Plant design process

Gefördert durch
Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie

FAPS researches possibilities and means for Knowledge Graph-based data integration in the context of the Additive Manufacturing process chain.

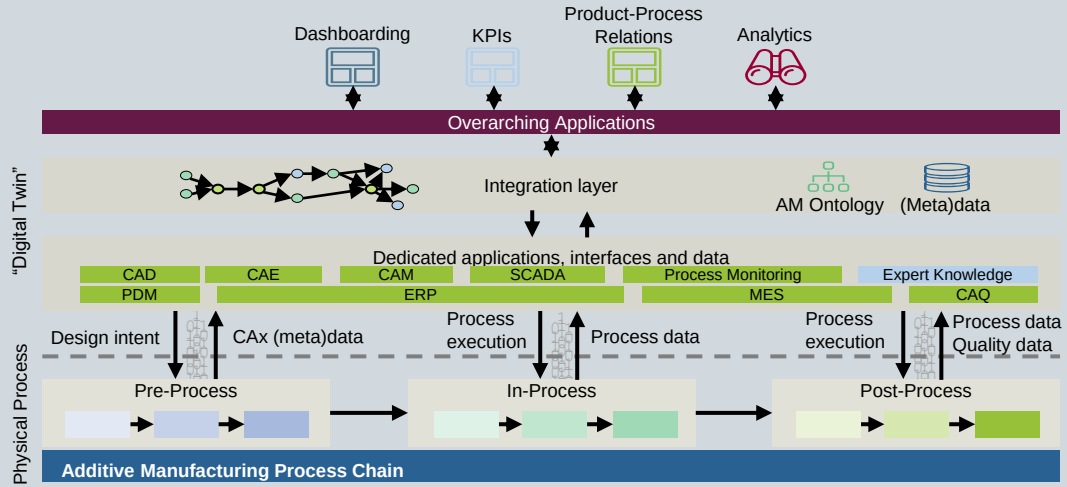
Digitale Prozessketten

Objective: Provision and usage of integrated data basis for Additive Manufacturing

- Linked Data across the process chain
- Semantic enrichment via link to ontology
- Knowledge Graph as the integration mechanism
- Web application as data sink and test bed for different visualization and analyzation scenarios

Data Integration implies access to heterogeneous and autonomous data sources

- Data sources are relational data bases, files or APIs of different applications
- Autonomous means, that the integrator has no control over the source data schemas
- Heterogeneous means that the data sources have different explicit or implicit schemas



Target architecture

- Applications are enabled to use an integrated data basis for overarching use cases
- Integration layer connects the heterogeneous and autonomous data sources via the Knowledge Graph
- Dedicated applications remain in their place at the process chain and are integrated using their specific interfaces

The autonomous control by means of artificial intelligence and intelligent sensor systems is intended to optimize production and logistics processes.

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Planning & Simulation

Process Automation

An IoT solution for production and logistics using intelligently linked multiple sensor systems (ProLog 4.0)

Goals

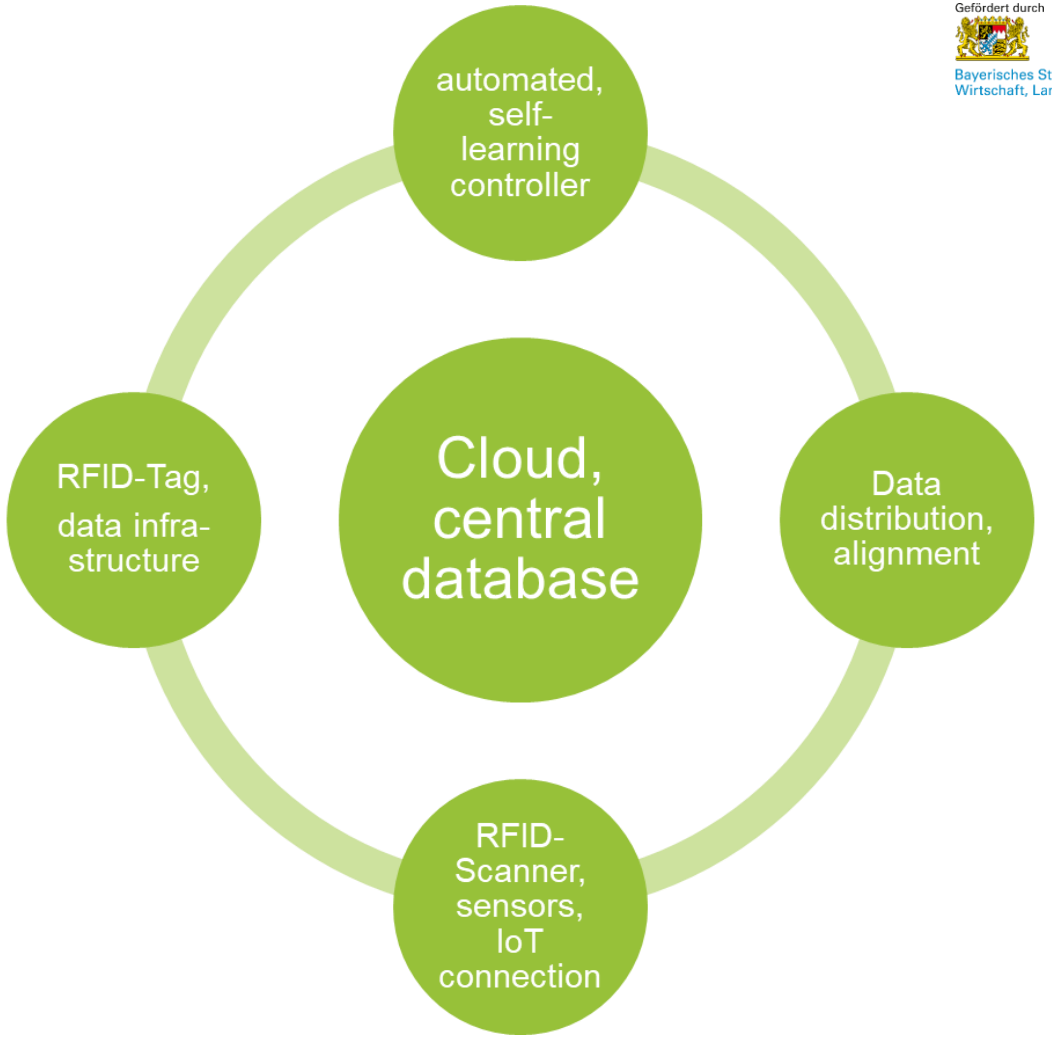
- optimization of partially or fully automated production and logistics processes through
  - enabling direct communication between production and logistics
  - based on multiple sensor data
- through continuous control of production and logistics processes
- and autarkic control of the processes by artificial intelligence.

Challenges

- complex dependence of production and logistic processes
- availability of modular and efficient sensors

Solution approach

- optimization by using artificial intelligence for the processing of raw sensor data
- expanding the use of RFID



Efficient and safe human-machine collaboration is one of the key aspects to a powerful Industry 4.0 production environment with focus on batch size 1.

Planning & Simulation

Human-Machine-Interaction

Efficient and safe human-laser collaboration (MeLasKo) –

Simple, highly efficient and safe set-up process for laser welding systems

Goals

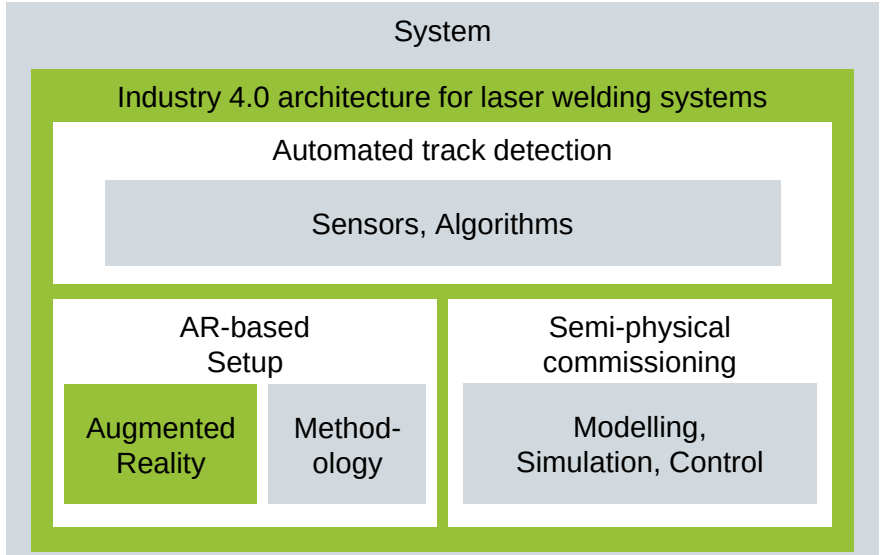
- Reduction of the burden of pure programming on operators
- Reduction of setup time to a few minutes
- Increased worker safety during setup process
- Reduction of reject parts during setup process

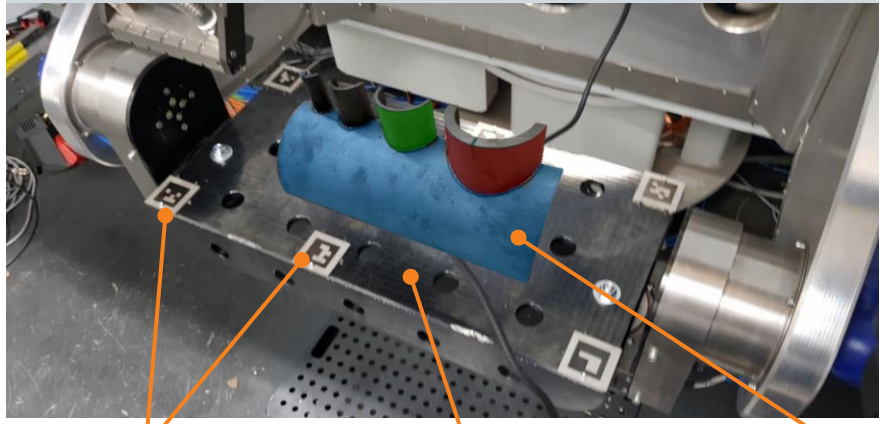
Challenges

- Complex dependency of process components and parameters
- Invisible tool

Solution

- Augmented Reality-based setup concept
  - 3D cameras generate point clouds with geometric characteristics
  - Laser beam geometries are simulated based on machine settings and matched with the detected geometries to show collisions
- Semi-physical commissioning
  - System moves through real control code, but laser beam is simulated





Marker for camera-based position detection

Worktable inside the laser welding machine

Workpiece with recognized geometric features (AR overlay)

KMU-innovativ
Vorfahrt für Spitzenforschung im Mittelstand

The DC|hyPASim project builds on the DC|VIBN project and deals with the simulation of automated production plants with regard to their energy supply.

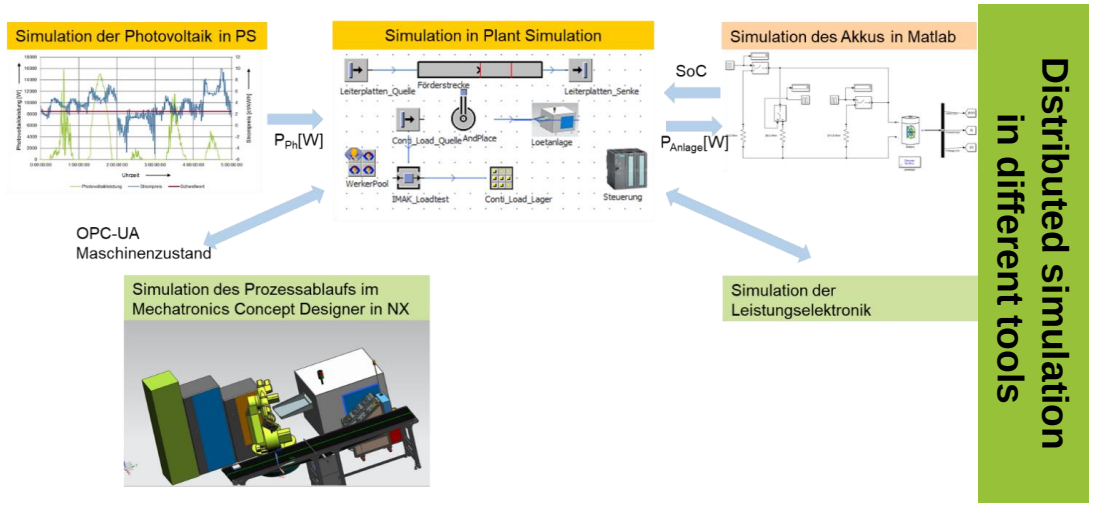
Planning & Simulation

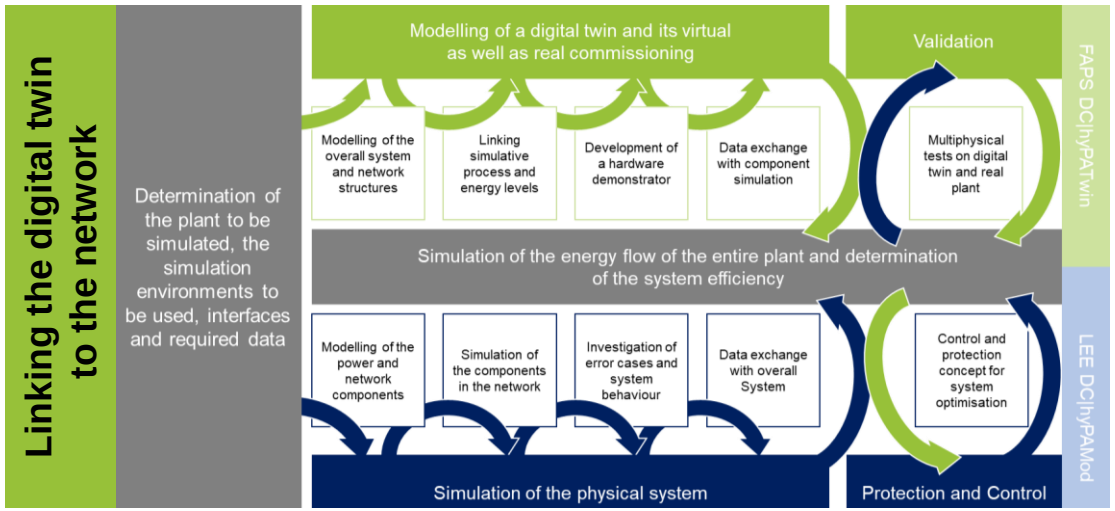
Digital Process Chains

Resource Efficiency

Aim: Use of direct current in manufacturing

- Creation of digital models for direct current grids
- Linking decentralised renewable energies and storage technologies with existing industrial grids
- Consideration of the energy exchange between DC and AC networks
- Focusing on energy storage systems
- Design of the safety technology and the control strategies.





Advantages

- Reducing the costs of the project
- Increasing quality
- Integrated Engineering
- Validation of the design of the product in relation to customer requirements
- Linking process control with control of power electronics

Through best practices and a user-centric web platform, ROBOTOP simplifies robotics engineering and enables SMEs to effectively automate their production.

ROBOTOP - Modular, open and internet-based platform for robot applications in industry and service
https://robotop-konfigurator.de/
https://www.researchgate.net/project/ROBOTOP

Planning & Simulation

Digital Process Chains

Process Automation

Human-Machine-Interaction

Goal

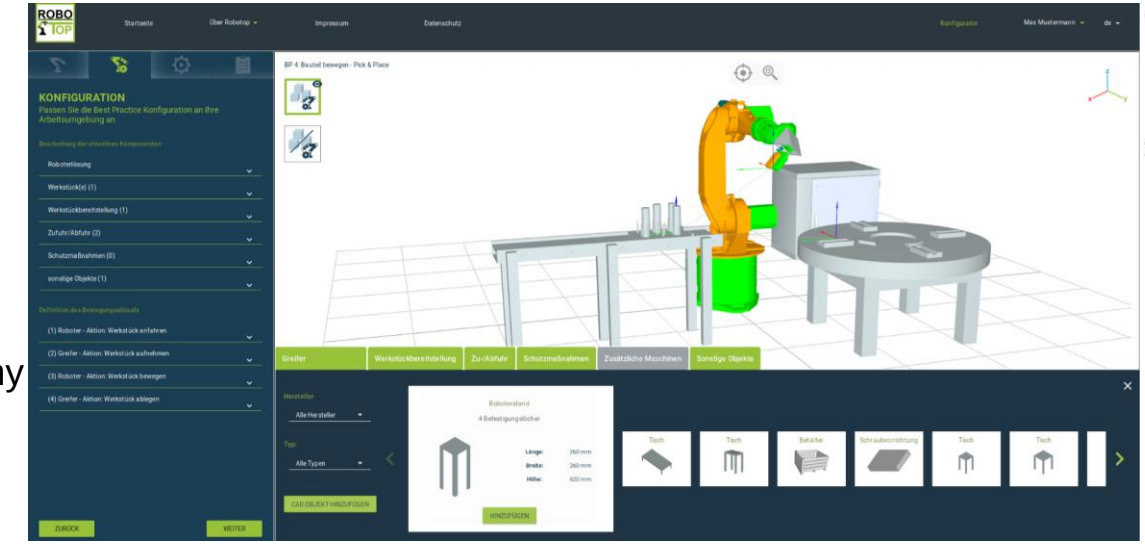
- Web configurator for robot based automation solution
- Simple, step-by-step management of a manufacturing company towards a robot-based automation solution

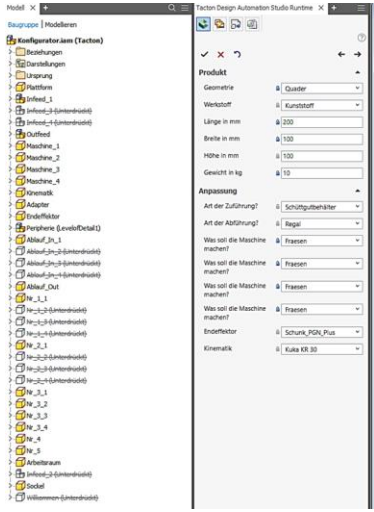
Challenge

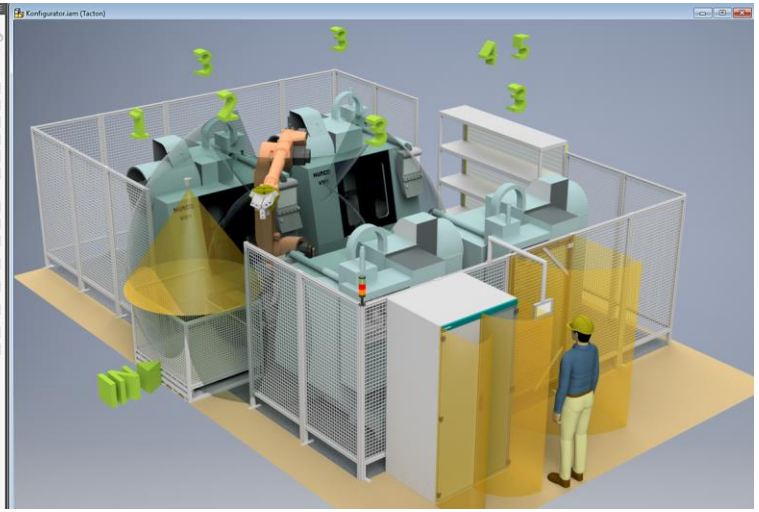
- Available digital data models and datasets
- Existing technologies and digital services
- Low willingness to provide knowledge

Solution approach

- Best practice based automation solutions
- Constraint based change configuration
- User-friendly configurator as key to success







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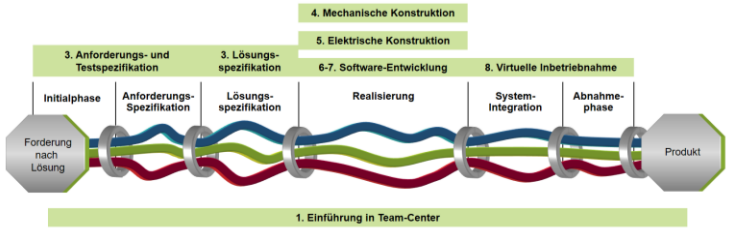
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages
PAiCE

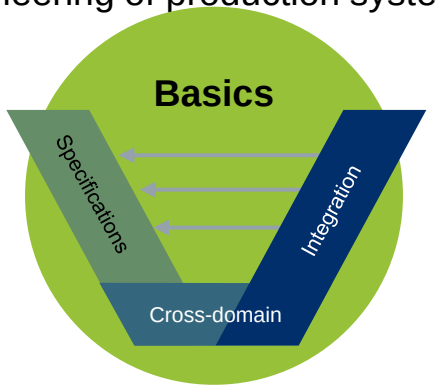
In addition to research, Engineering Systems is also involved in teaching, committee work and technology transfer.

Supervision of lectures and courses

- Practical course Integrated Engineering

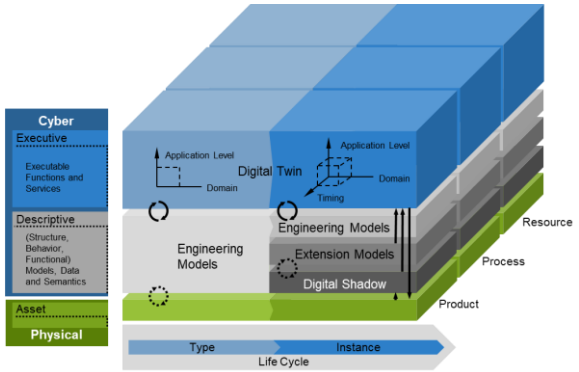


- Coordination of the lecture Production Systems
- Extension of the teaching program: Lecture Advanced Systems Engineering of production systems

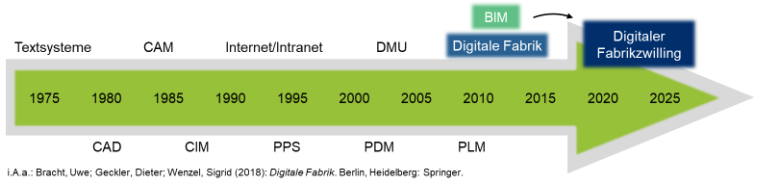


Reference models and guideline work

- Digital Twin Structure Model (DTSM)
  - Structural model for the digital twin
  - Systematization of dimensions and artifacts (twin, shadow, models)



- VDI 5000 - "Digital Factory Twin”
  - Participation in the development of a new VDI guideline
  - Drafting of points of view with other institutions and industry partners



i.A.a.: Bracht, Uwe; Geckler, Dieter; Wenzel, Sigrid (2018): *Digitale Fabrik*. Berlin, Heidelberg: Springer.

Coordination of conferences

- Intensive communication and partnership with industry
- Possibility of networking in the subject area of engineering and digitalization
- Application-oriented presentations and field reports

September 2021:
19th ASIM-Conference – digitally held

The institute FAPS offers diverse cooperation possibilities with the industry and further institutions.

	Funded research projects	Industrial collective research	Industry promotion	Direct cooperation	Student cooperation
Specific characteristics	■ Funded research activities ■ Joint application	■ Research by institute or university ■ Input through Project Monitoring Committee	■ Direct cooperation through shared staff	■ Direct knowledge and technology transfer	■ Supervision of final papers
Special benefit	■ Funding quota for industry partner normally at 40%*, for Institutes till 100%*	■ High knowledge gain by influencing industry-related research	■ Long-term research in direct cooperation	■ Service relationship with confidentiality agreement	■ Ideal Kick-off for a future research cooperation
Specialty	■ Dependency on donors ■ Small projects realizable ■ with or without focus on the region ■ Special programs for small and medium-sized companies, association members or big companies	■ Coordination and consulting by industrial research associations ■ Bottom up approach for technological needs and challenges ■ Use of research results	■ Definition for Cooperation projects, topic and focus ■ Employee of the university with a workplace inside the company and inside the institute for an ideal exchange	■ Abstract and joint academic publication of the results ■ Possibly joint patent application	■ Thesis with focus on the topic area of the institute's research sectors
Project start and duration	■ Application ca. 12 months* ■ Duration for 2-3 years*	■ Flexible application ■ Duration for 2 years	■ Start with suitable doctoral candidate ■ Promotion in 3 years*	■ Capacity-dependent start ■ Variable duration	■ Starts with suitable students (April & October) ■ Usually 6 months*
Service portfolio	■ Network development ■ Joint research and development activities ■ Capacity and machine use				

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