Andreas Jaeger (TU Vienna, Fraunhofer);

Andreas Jaeger, Ing., MSc., MBA, is researcher at Fraunhofer Austria Research and the Vienna University of Technology since 2011. He is in charge of the further development and operation of the “TU Vienna Learning & Innovation Factory for Integrative Production Education” where he holds trainings and lectures for students of the university and for employees from industry.
During his study he worked as a technical project manager in Central and Eastern Europe within a global electronic enterprise for five years. At Fraunhofer he is in charge of a log-term project focusing on the diagnostic and improvement-oriented evaluation of SMEs to initiate and accompany production optimization and innovation projects. Furthermore he contributes in an applied research project related to the human’s role in smart factories.

Fabian Ranz (ESB Reutlingen)

Fabian Ranz, M.Sc., is a research associate at ESB Business School, Reutlingen University in the field of Industrial Engineering and Logistics Planning and Design. He is responsible for the set-up of the “ESB Logistics Learning-Factory”, what includes infrastructure implementation as well as didactical design. Besides, he is coordinator for the Network of Innovative Learning Factories (NIL).
Before joining ESB as a researcher, during his studies in Industrial Engineering Fabian gained experience at several multinational enterprises in engineering, logistics and strategy functions.

Fraunhofer AUSTRIA | TU WIEN Technische Universität Wien Vienna University of Technology | imw Institut für Managementwissenschaften | Hochschule Reutlingen Reutlingen University | ESB Business School

The Institute of Management Science, Department for Industrial Engineering and System Design at the Vienna University of Technology, in cooperation with the Fraunhofer Austria Research, Division Production and Logistics Management, and the ESB Reutlingen University, Division for Logistics Planning and Design are active in higher and advanced education in the field of industrial engineering. Both provide problem based, interactive hands-on training in their Learning Factories with the focus on Lean Management and the Product Creation Process.

Research of both institutes concentrates on the development and processing of scientific findings for practical application. Projects are dealing with the analysis, planning and optimization of the structure, organization and management of industrial and service enterprises and their logistics networks.

Fraunhofer Austria, TU Vienna and ESB Reutlingen collaborate in the European-wide applied research project “LOPEC” related to the systematic assessment of the personal excellence in lean logistics and the initiation of lifelong-learning on the shopfloor.

INDUSTRY 4.0 – CHALLENGES FOR THE HUMAN FACTOR IN FUTURE PRODUCTION SCENARIOS

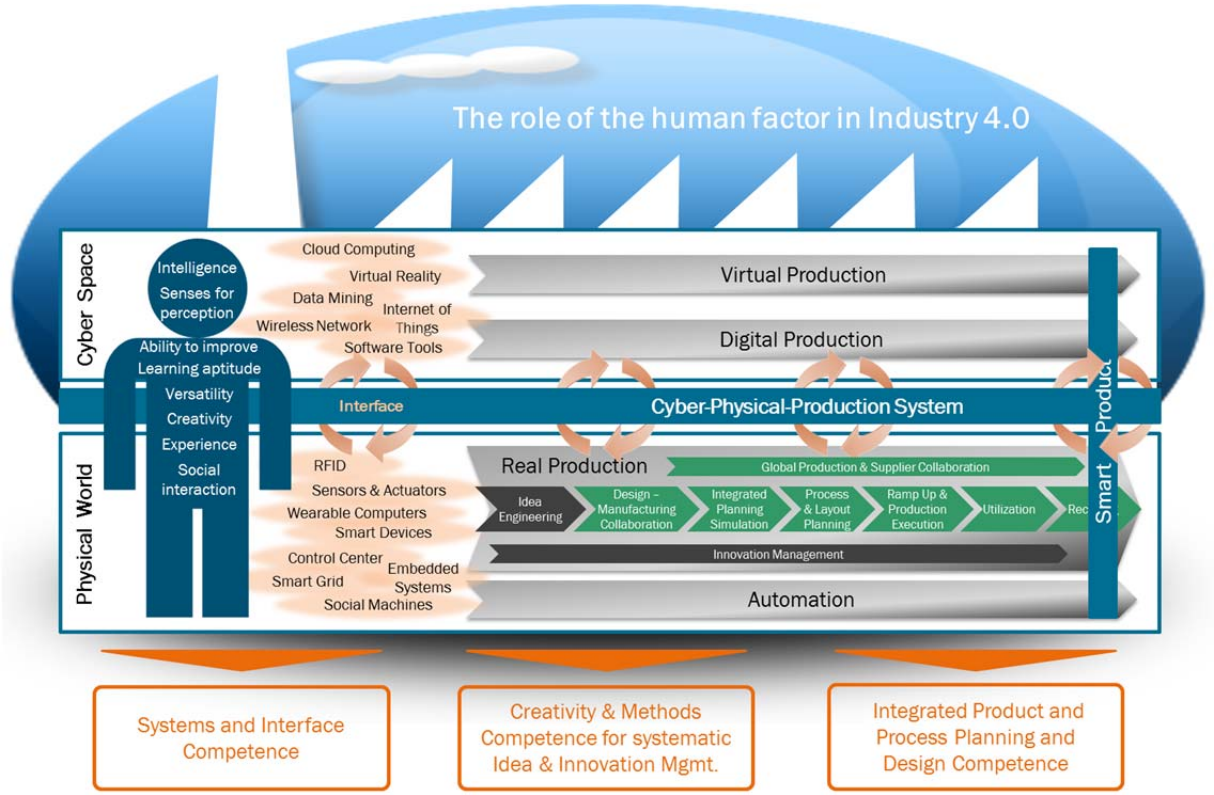
Industry 4.0 predicts that industrial processes, technological infrastructure and all corresponding business processes, with the help of information and communication technology (ICT), will advance to integrated, ad-hoc interconnected and decentralized Cyber-Physical Production Systems (CPPS) with real-time capabilities of self-optimization and adaptability.

Considering this change, the human being will remain in a dominant role, because it is not expected that the human factor with its characteristics and capabilities will be substituted entirely by autonomously acting technology in the foreseeable future. The mechanical intelligence, for instance, is limited to the selection of predefined options, while human creativity, flexibility, the ability to learn and to improve are required to design and configure systems, processes and products. Humans have the expertise and experience to analyze, assess and solve - even in exceptional situations.

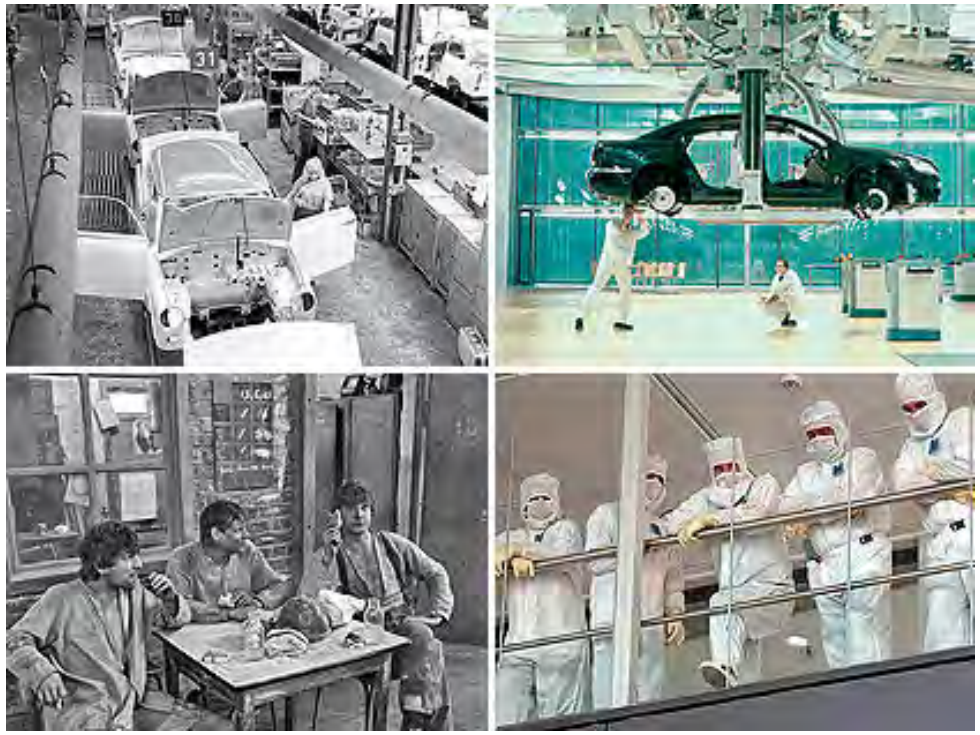
However, the amount of purely manual tasks for shop floor workers will decrease. Their role will change from a manually executing to a proactive preconceiving worker with increased responsibility. Due to the growing degree of digitalization and interconnectedness, also the tasks and responsibilities for planning and design personnel will continuously expand and become more complex. The work in versatile ad-hoc networks with advanced ICT-tools and assistance systems will lead to increased requirements regarding the knowledge, capability and capacity of the respective employees. The on-going pervasion of IT and emergence of systems with unprecedented complexity specifically require significantly improved capabilities in analysis, abstraction, problem solving and decision making from future labour.

Accordingly, the industry is asking for graduates that are educated interdisciplinary and practice-oriented. Some universities already meet these expectations, using learning factories for realistic, action-oriented classes and trainings. Lecturers are confronted with the challenge to identify future job profiles and correlated qualification requirements, especially regarding the conceptualization and implementation of CPPS, and to adapt and enhance their education concepts and methods adequately and consequently. For the new, virtual world of manufacturing a proper understanding of engineering as well as computer sciences is essential. Industry 4.0 implies this interdisciplinary split. Integrated competencies for product and process planning and design, methodological competencies for systematical idea and innovation management as well as a holistic system and interface competence will be crucial to achieve interconnection of physical and digital processes and machines.

The Vienna University of Technology and the ESB Reutlingen committed to integrate key aspects of Industry 4.0 into their respective learning factories successively. Thus, the students will act as the coordinators of the CPPS and thereby remain in the center of all learning and implementation activities.



Implications for Learning Factories from Industry 4.0
Challenges for the human factor in future production scenarios



Andreas Jäger, MSc, MBA
Prof. Dr. Wilfried Sihn

Fraunhofer Austria Research GmbH
Vienna University of Technology

Fabian Ranz, MSc
Prof. Dr. Vera Hummel

ESB Business School, Reutlingen University

Industry 4.0

The human factor in cooperation with CPPS

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Industry 4.0

The human factor in cooperation with CPPS

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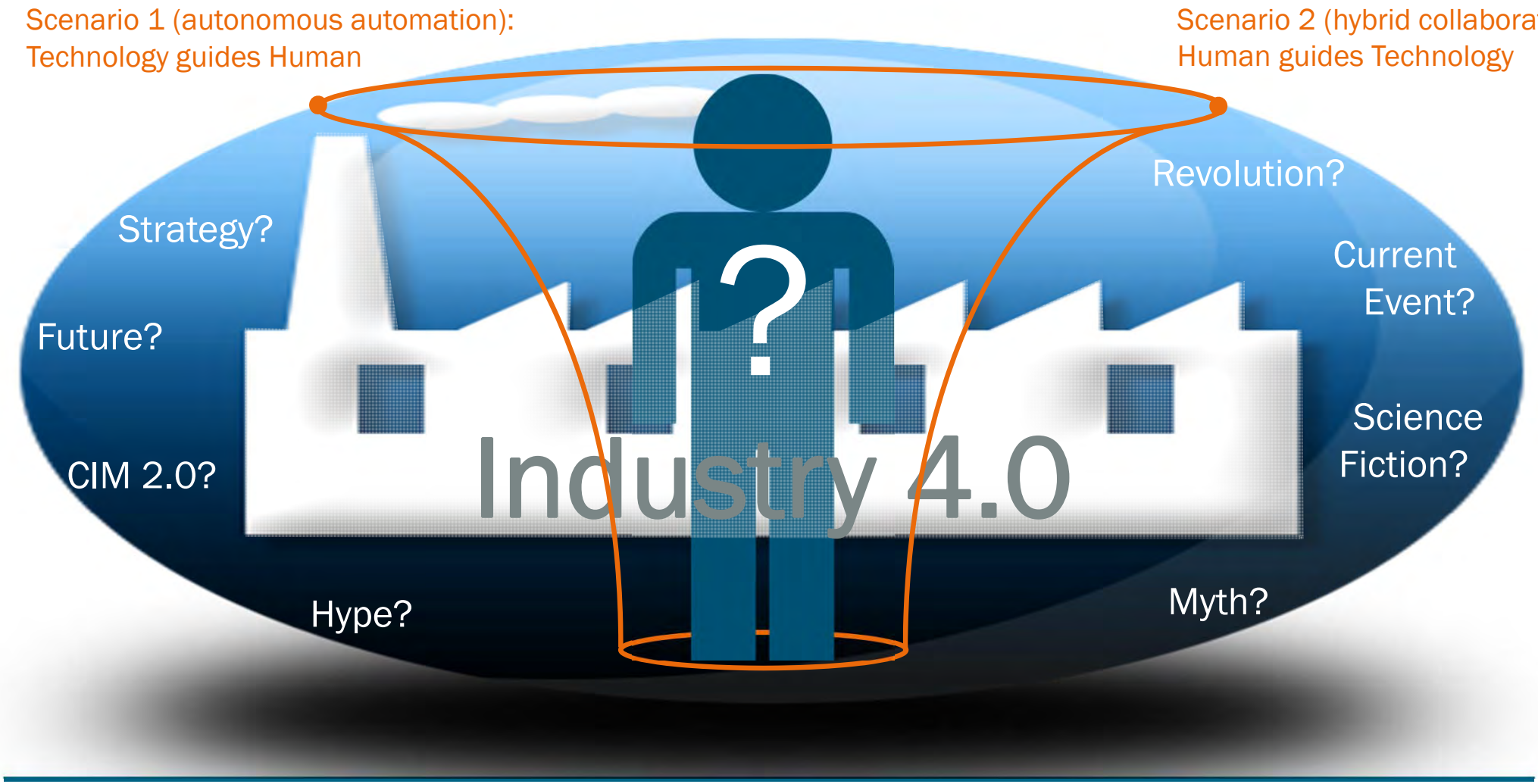
Industry 4.0

The human factor in cooperation with CPPS



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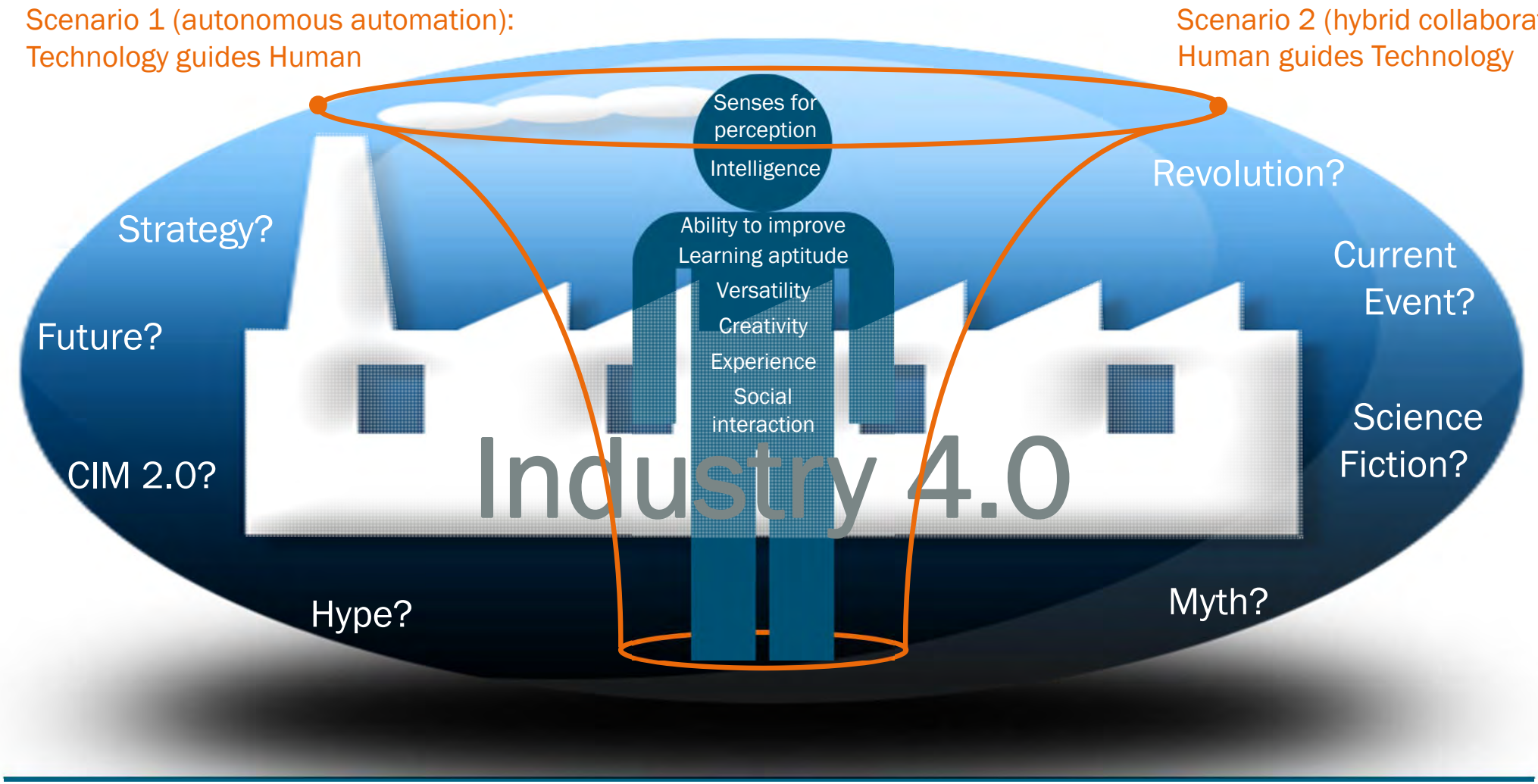
Industry 4.0

The human factor in cooperation with CPPS



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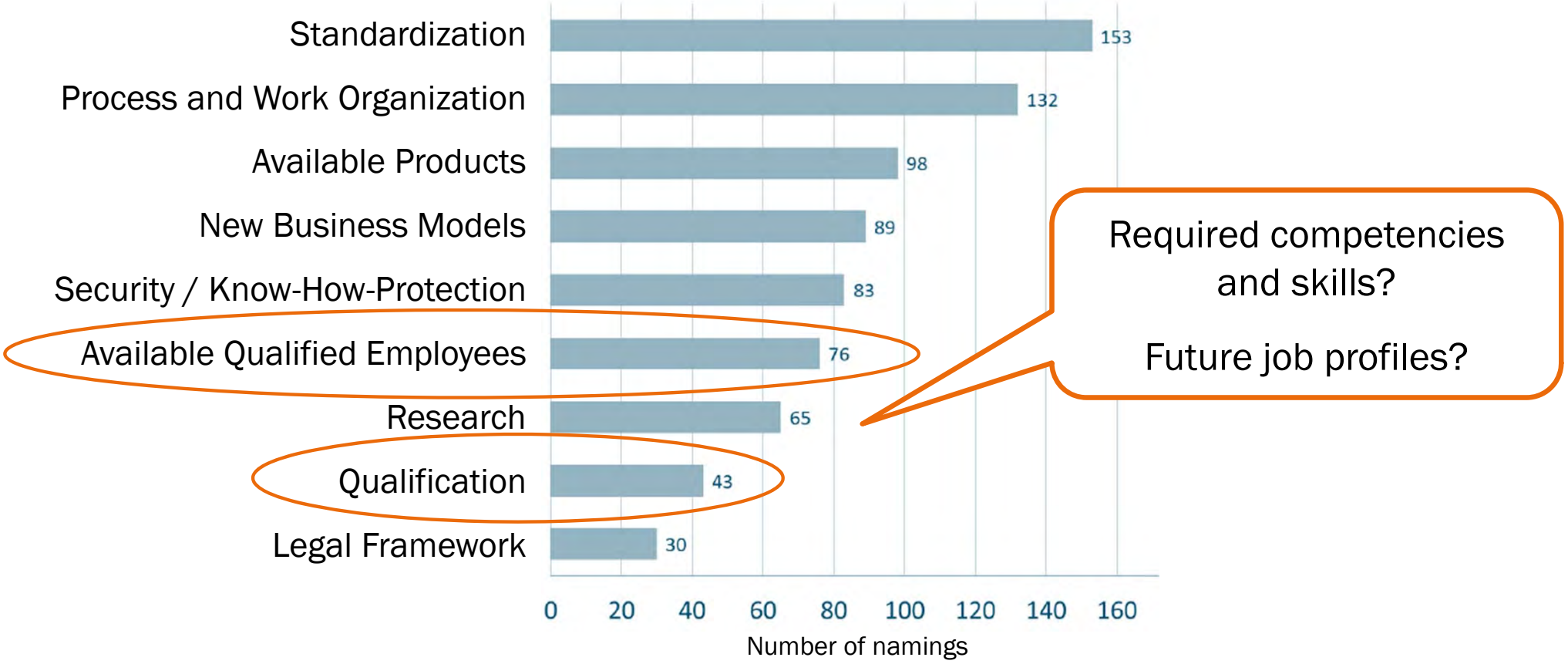
Industry 4.0

Challanges – Qualification and Education



Source: Survey by plattform-i40 (BITKOM, VDA, ZVEI) January 2013, Responses: 284 / Quote 9,2%

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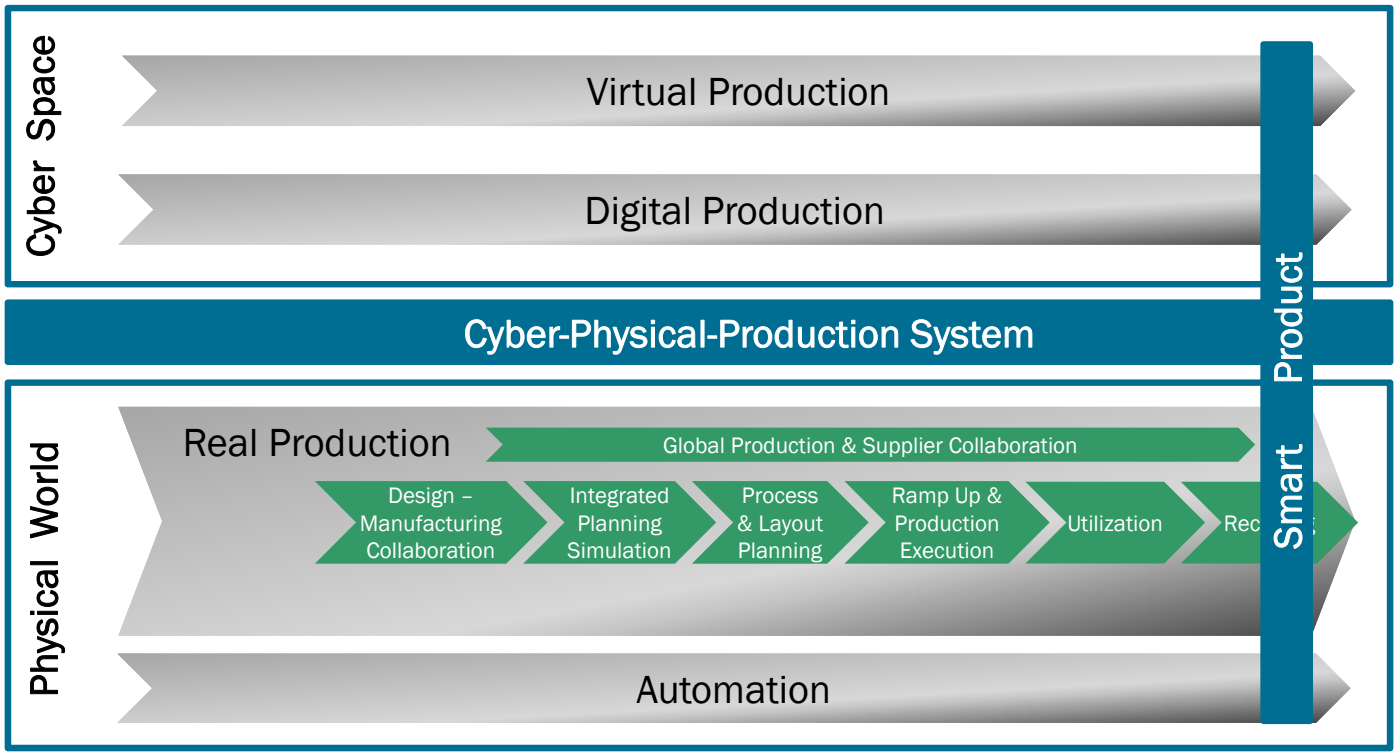
Industry 4.0

Essential competence requirements



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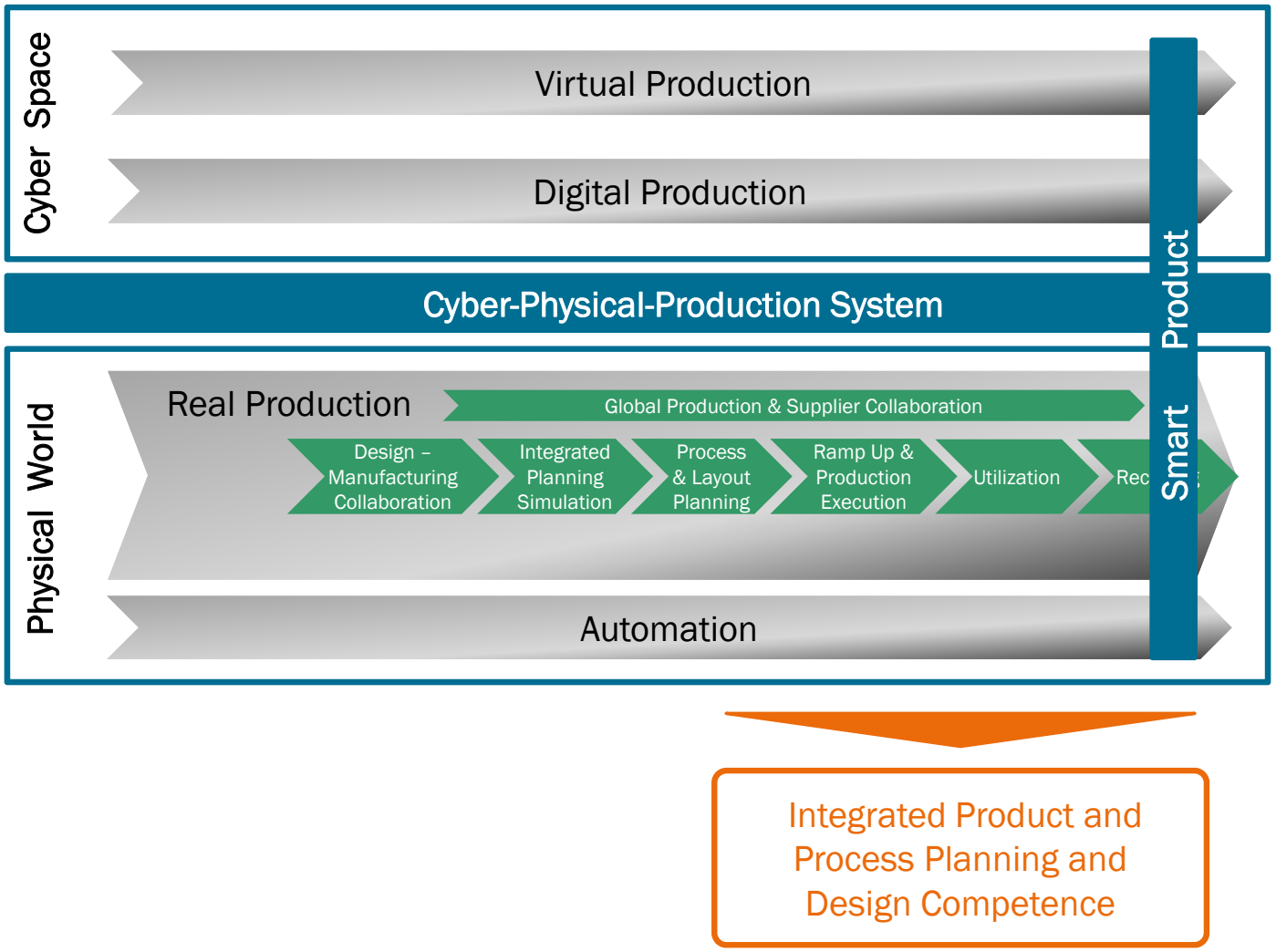
Industry 4.0

Essential competence requirements



Integrated Product and Process Planning and Design Competence

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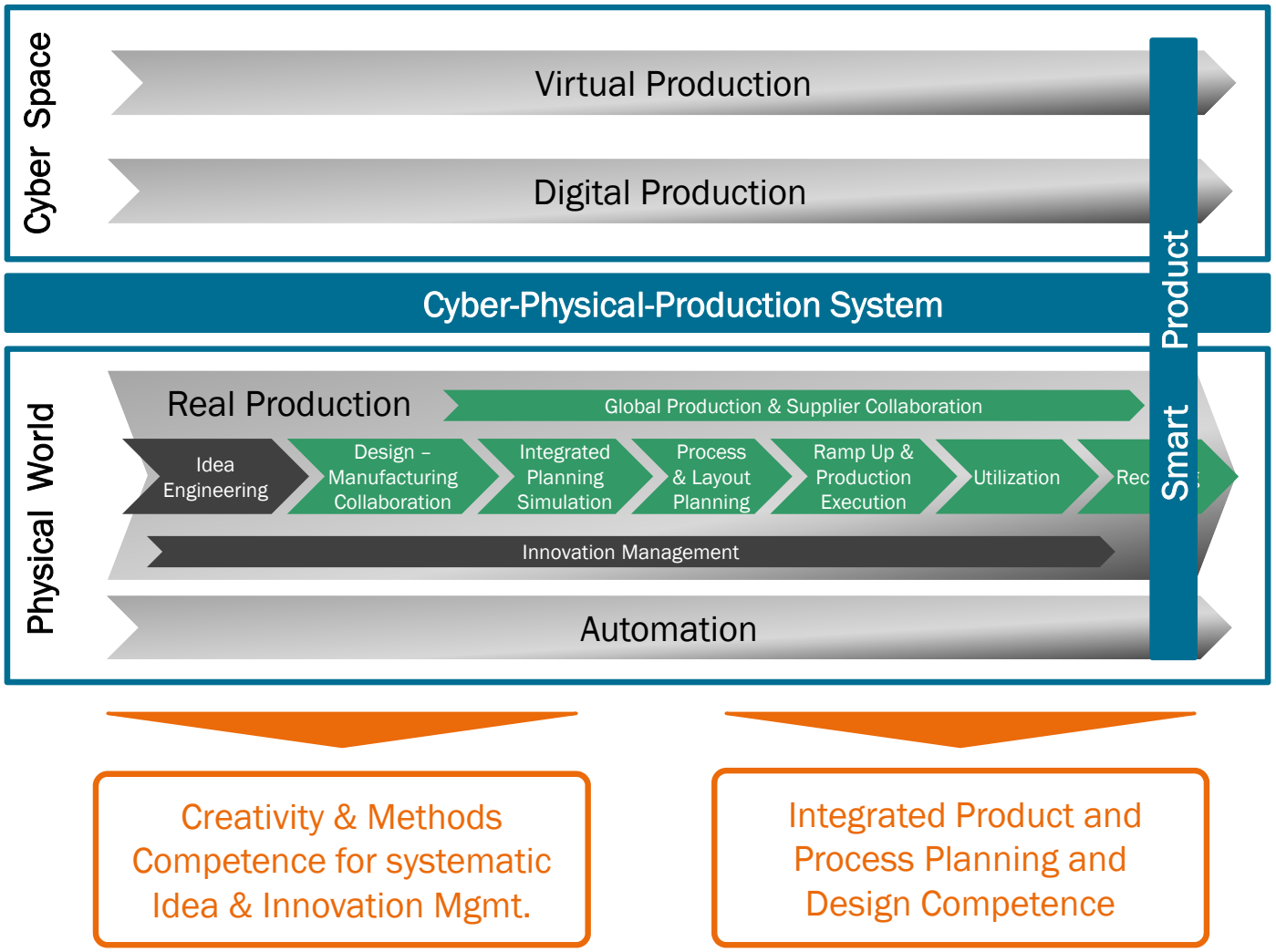
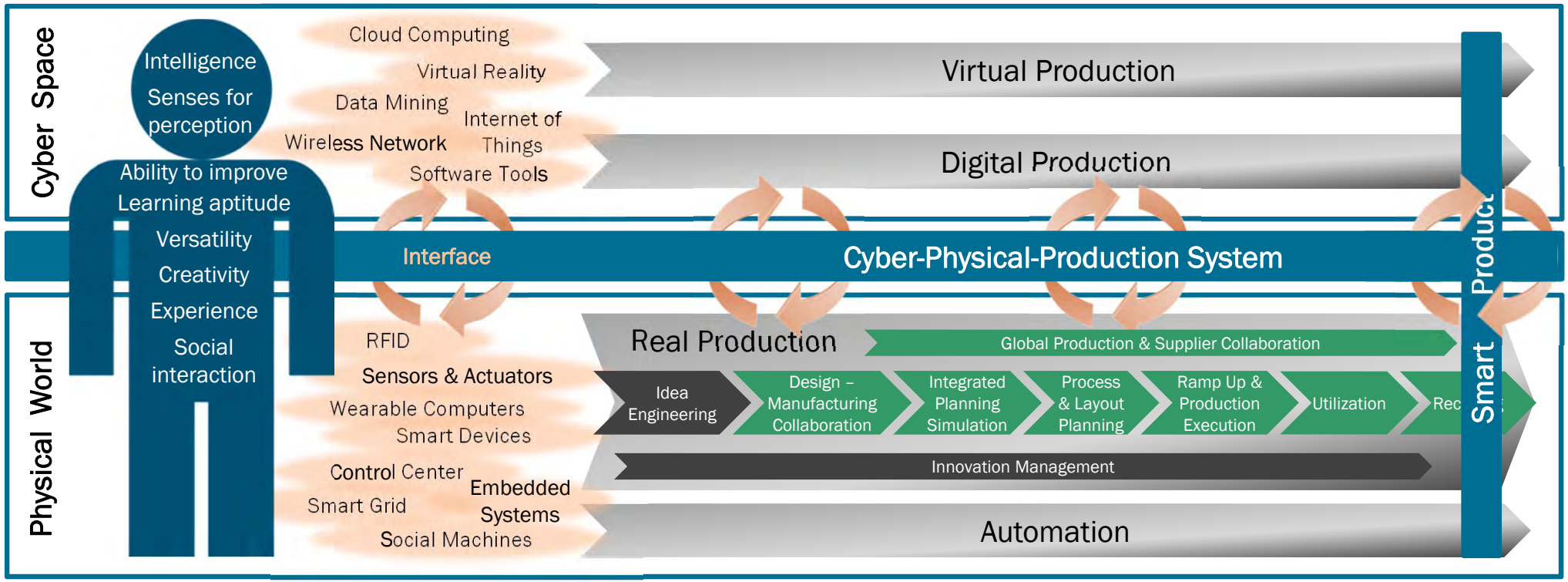
Industry 4.0

Essential competence requirements



Industry 4.0

Essential competence requirements



Systems and Interface Competence

Creativity & Methods Competence for systematic Idea & Innovation Mgmt.

Integrated Product and Process Planning and Design Competence

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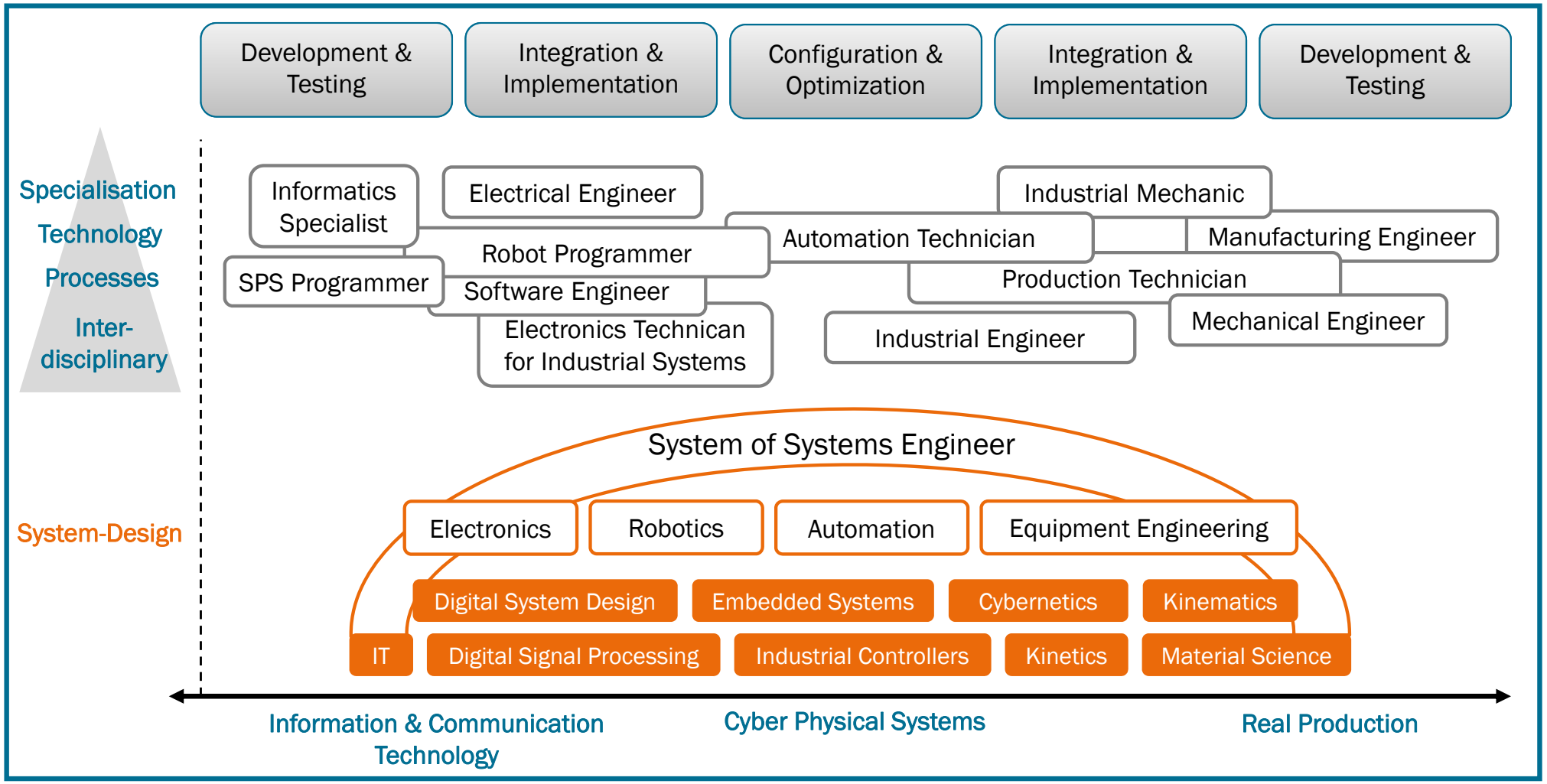
Industry 4.0

Job profiles (excerpt) for a cyber-physical working environment



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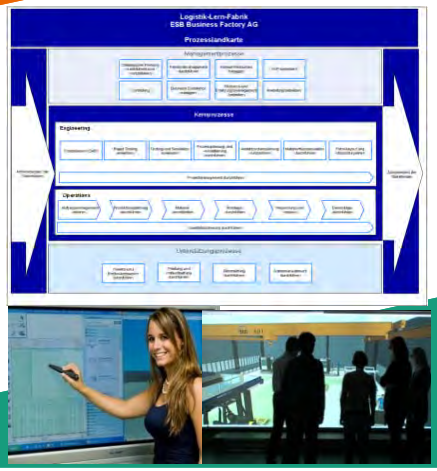
ESB Logistics-Learning-Factory

Holistic Approach from Product to Factory

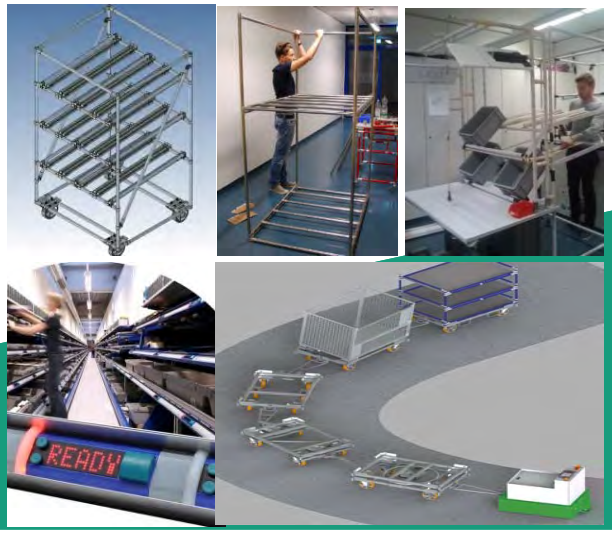
ESB LOGISTIK-LERN-FABRIK

Customization of adaptable product (high variance)

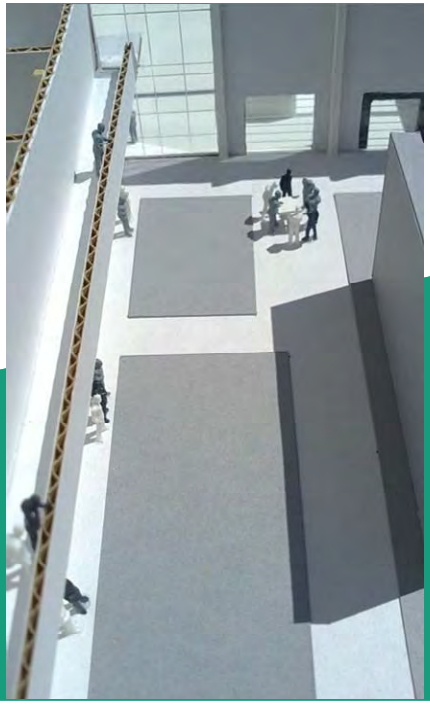
Process Design & Validation



Assembly and intralogistics systems, Jigs & Fixtures Design & Realization



System realization and ramp-up



Creativity & Methods Competence for systematic Idea & Innovation Mgmt.

Integrated Product and Process Planning and Design Competence

Systems and Interface Competence

Education | Training | Research | Industry Projects

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ESB Logistics-Learning-Factory

Integrative tie-in of virtual factory and physical system

Engineering & Operations Cockpit

Physical System Learning Factory

Customer requirements

Customer orders

CAS / CAD / PDM

Order Data

Production Program

Configuration of production system

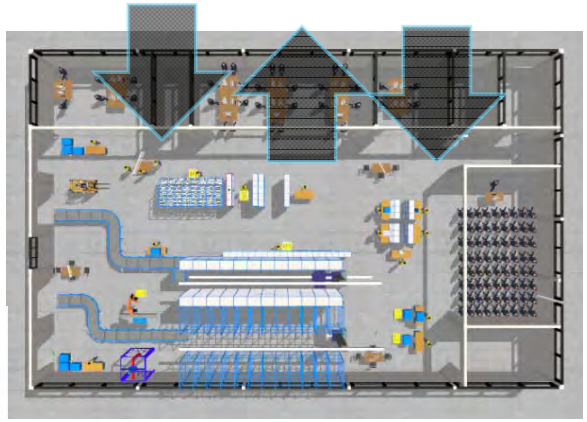
Simulation

Process- and work station design

Manufacturing Execution

Quick Adaption to Turbulences

Exemplary aspects of Industry 4.0



Transparency & Traceability

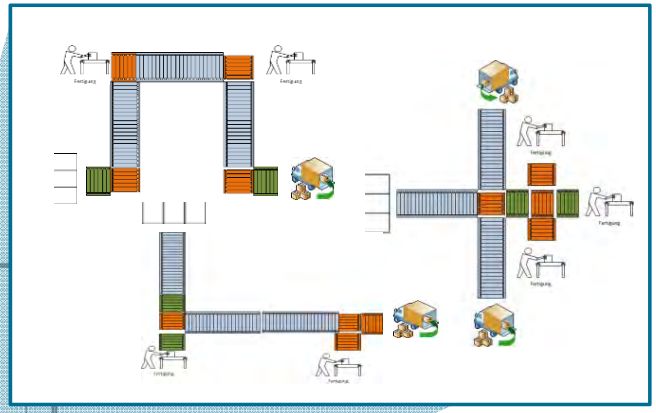
Smart, low-cost solutions for SME requirements

2013 New team & suppliers	Spring 2014 Hardware installation	Spring 2014 Software installation	July 2014 First system run	Oct 2014 First trainings with students	Nov 2014 First Industry 4.0 workshop for external	2015 New building	SS 2015 System expansion	2015 Regular operation

ESB Logistics-Learning-Factory

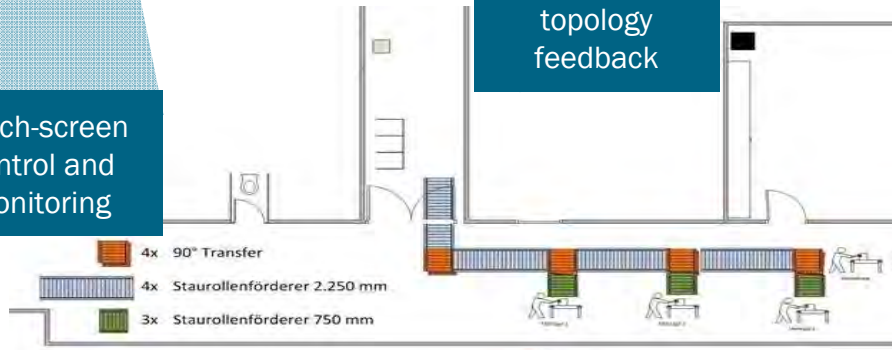
Industry 4.0– Flexible conveyor system

Forerunner-Follower-Identification

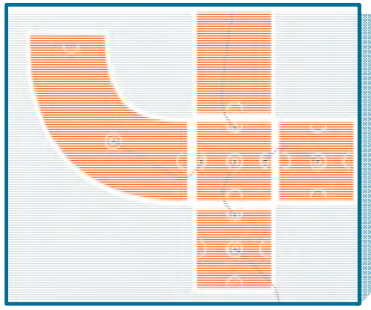


Automated topology feedback

Touch-screen control and monitoring

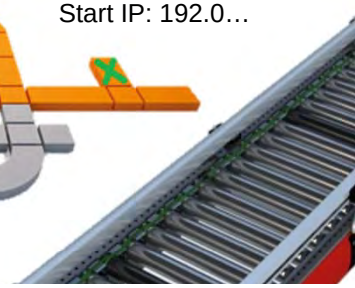


Unlimited layout opportunities with minimized changeover times



Plug-and-play for goods, power & information flow

Autonomous routing with no dead-locks



Integrated Product and Process Planning and Design Competence

Systems and Interface Competence

Pictures courtesy of:

FLEXLOG

gebhardt

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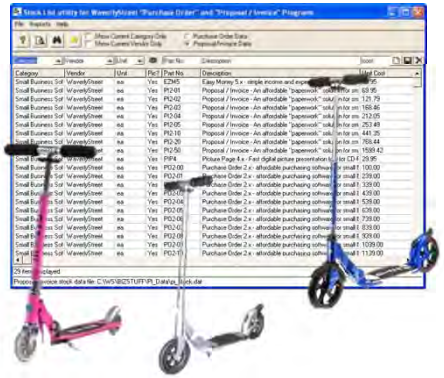
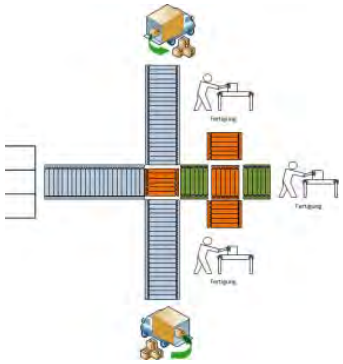
Industry 4.0– Flexible conveyor system Use Case

Flexible conveyor for changing logistical requirements

Initial order scenario (quantity, variants, dates)



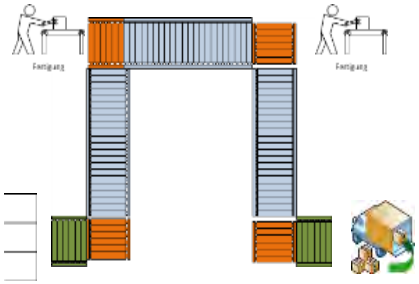
Realization of ideal plant layout



Turbulences affecting the scenario

- Demand change
- Supply outage
- Equipment defect
- Technological change
- …

Result: adapted production system



Integrated Product and Process Planning and Design Competence

Aspects for Education, Research and Industry

E Short-cyclical re-design of logistical systems, including planning as well as technical realization

R Automated planning of multimodal intralogistics systems (e.g. with unsteady conveyor)

I Development of use applications for the industry

Systems and Interface Competence

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Industry 4.0– Technical Assistance System

Technical assistance with collaborative robots

Conventional robots	Fit for the future robots	Use Case ESB Logistics Learning Factory
 © v-quadrat.	 © Kawada Industries.	Creativity & Methods Competence for systematic Idea & Innovation Mgmt.
Stationary use	Autonomous routing and navigation within the system	2D-Laser for auto-movement
Complex config	High-level programming	Intuitive teaching: Job enrichment for operators
Fenced operation	Shoulder-to-Shoulder collaboration	Tactile sensors and cognitive capabilities
Defined task	Flexible deployment	Situative integration into assembly, logistics, QC...

Open-source ROS for creative solutions & innovation sharing

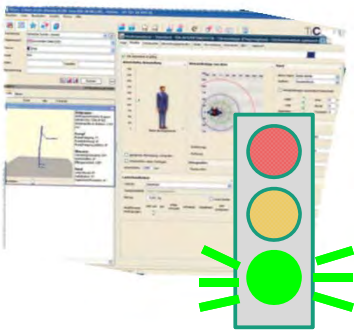
Systems and Interface Competence

ESB Logistics-Learning-Factory

Industry 4.0– Technical Assistance System Use Case

Technical assistance with collaborative robots

Work tasks (required abillity) → Design and planning of collaborative Works Systems → MTM-based ergonomic workload analysis → Task-specific teaching and deployment of the assisting system → Result



© Onexia, Inc.

- Demographic-change ready workplaces
- Technology follows the worker, not worker the technology
- Situative assistance instead of human substitution -> standardized CWSM

[VDI2860] Assembly:

- Mating (e.g.. Screwing, Plugging,, Gluing, Clipsing)
- Handling (e.g. Picking, Placing)
- Checking (e.g.. Measuring)
- Adjusting (e.g. Tuning)
- Support Ops (e.g. Cleaning)

Functions of handling:

- Store
- Adjust quantity
- Move
- Check

Aspects for Education, Research and Industry

E Integral workplace optimization and expertise enhancement in the deployment of smart local automation solutions

R Development of „ability and attribute based" standardized modules for collaborative workings systems (CWSM)

I Cost-benefit evaluation of collaborative assisting systems and best-practices of application

Systems and Interface Competence

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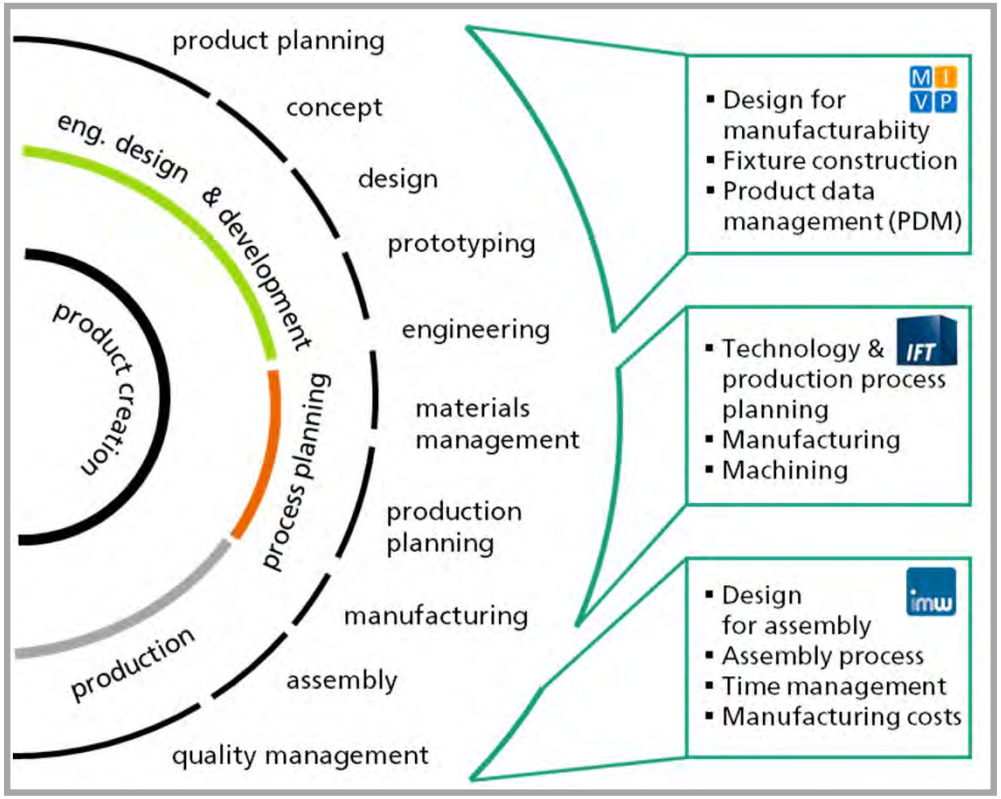
TU Vienna Learning & Innovation Factory

„i-PEP“ (integrative product emergence process)

Learning & Innovation Factory for Integrative Production Education

Process Steps



From Idea to Product

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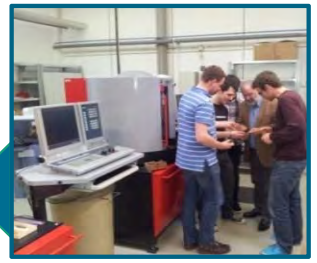
„i-PEP“ (integrative product emergence process)

Didactic Approach

Lecture for content preparation



Hands-on training

Independent learning

Presentation with feedback

Teamwork

Teambuilding

2011 Formation & initiation	2011 / 2012 Development & installation	April 2012 Pilot Run	10th May 2012 2nd Conference on LF in Vienna	2012 / 2013 Optimization of training concept	April 2013 2nd lecture	2013 / 2014 Integration of PM & creative tools	May 2014 3rd lecture	2014 - 2016 Industry 4.0 use cases

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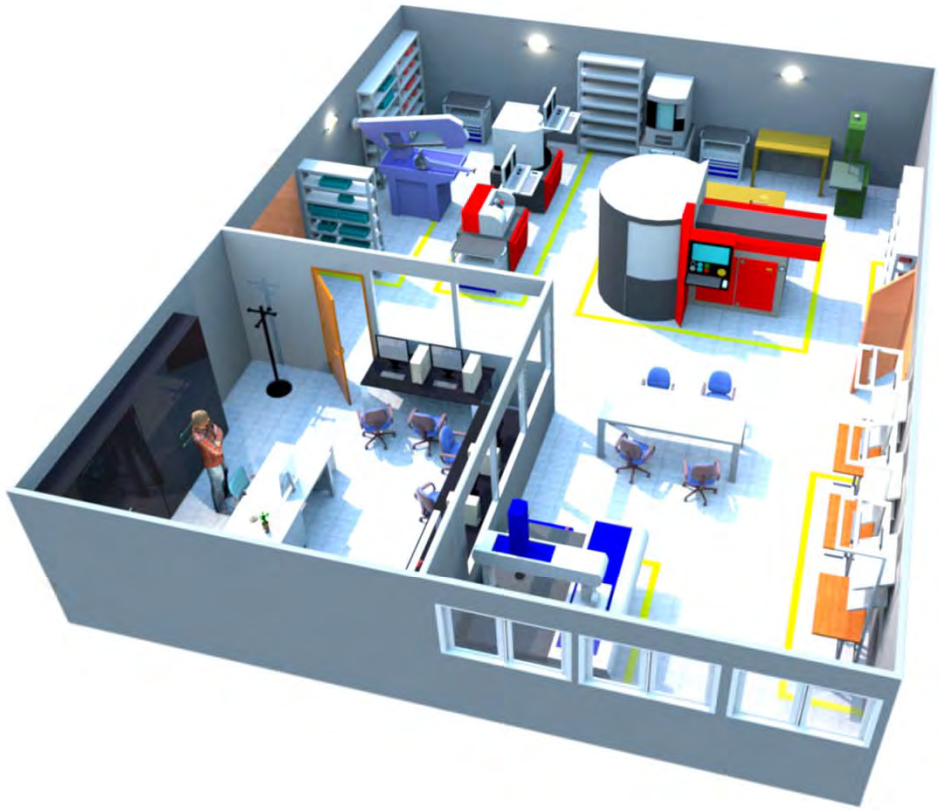
TU Wien Learning & Innovation Factory

Proceeding



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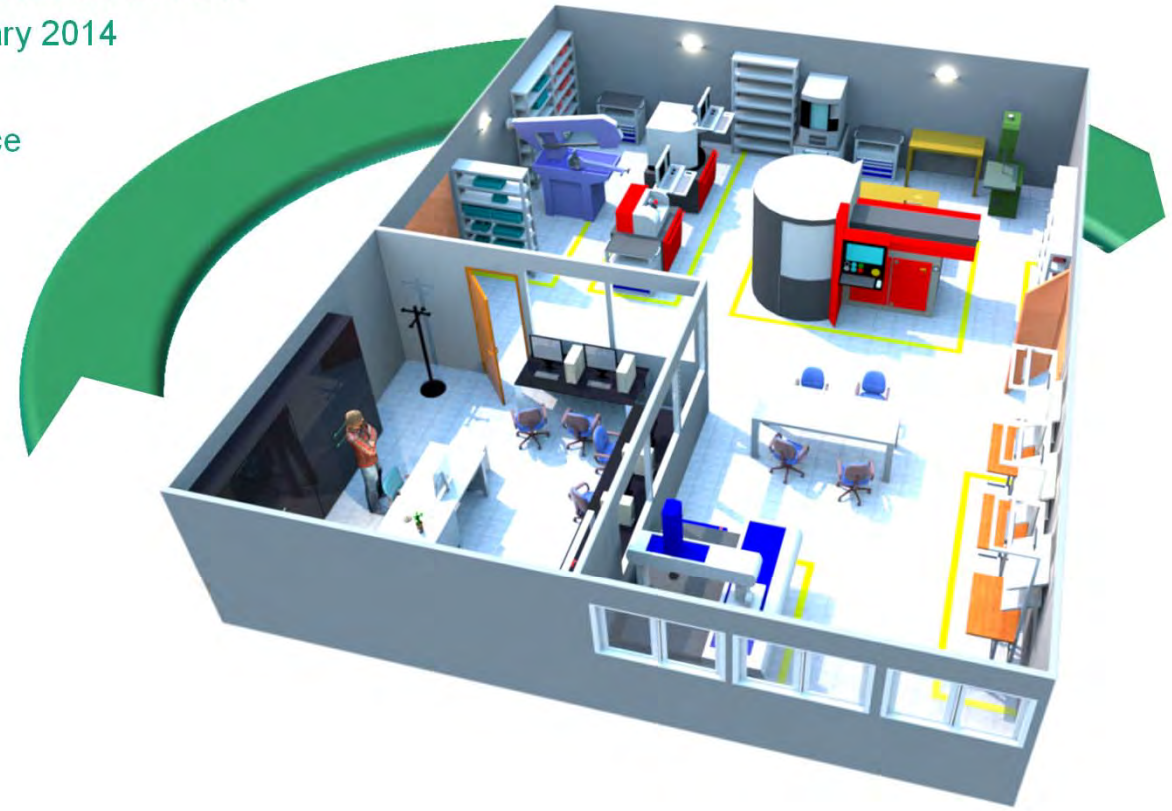
TU Wien Learning & Innovation Factory

Proceeding

Funding of physical equipment and digital infrastracture:

- Austrian Ministry for Science & Research
- 3 years, started in January 2014
- 300k€ for investments
- 170k€ inkind performance



TU Wien Learning & Innovation Factory

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PhD College:

- Ressources (Students) for CPPS research
- Transfer of use cases into the Learning Factory

TU Wien Learning & Innovation Factory

Proceeding

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PhD College:

- Ressources (Students) for CPPS research
- Transfer of use cases into the Learning Factory

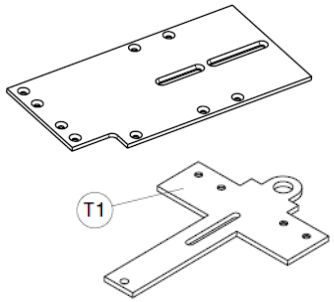
Endowed Professorship:

- Focus: Production of the Future
- Supervison of I4.0 qualification and development activities

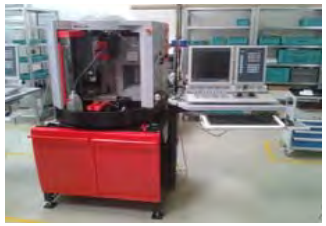
TU Vienna Learning & Innovation Factory

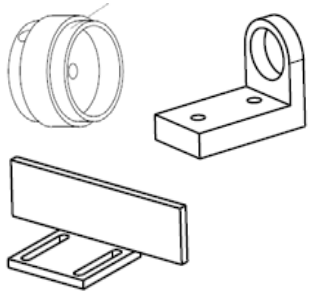
Expansion of Manufacturing Technologies

Initial situation

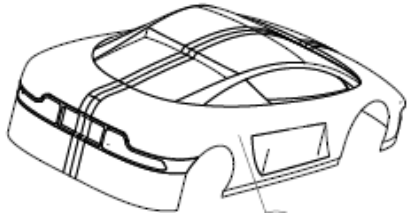


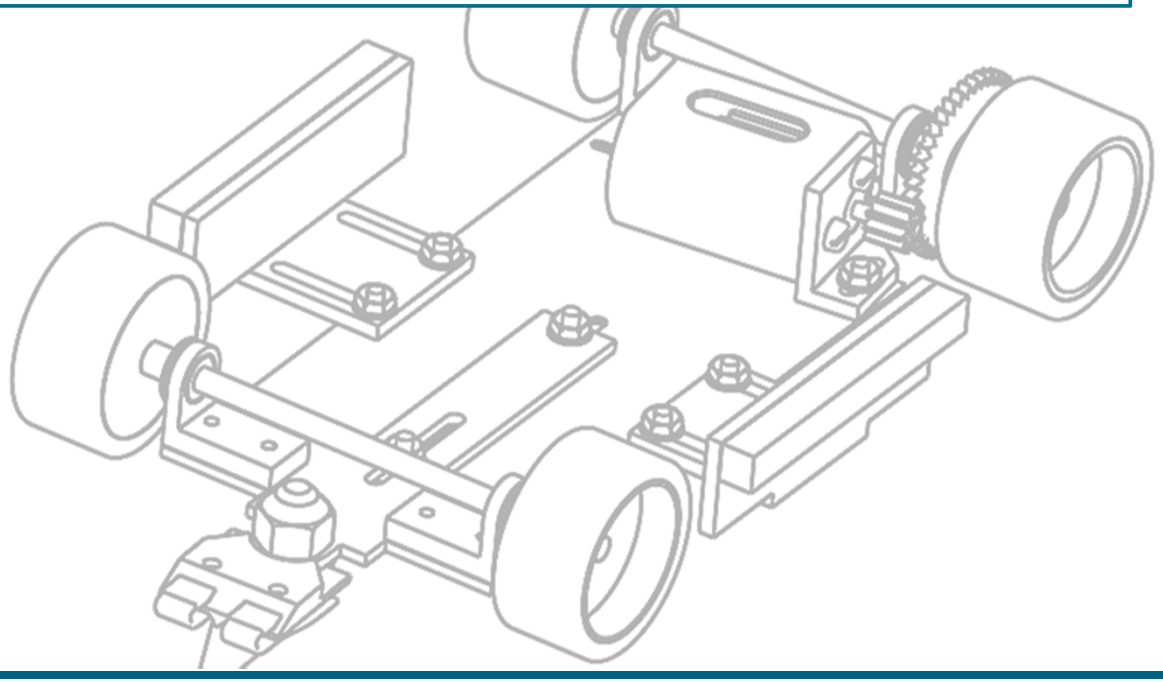
NC -turning machine & milling machine





External procurement





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Expansion of Manufacturing Technologies

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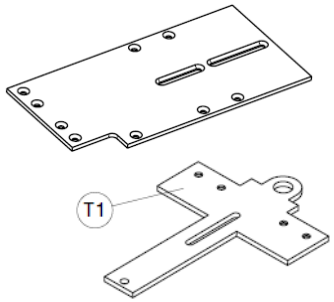

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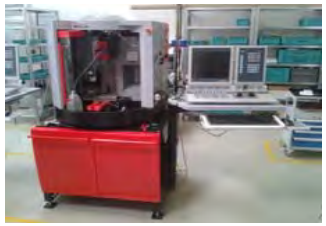
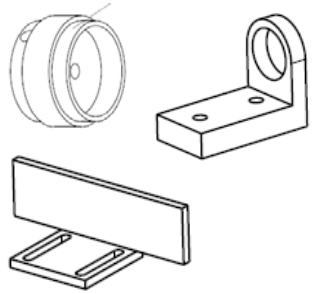
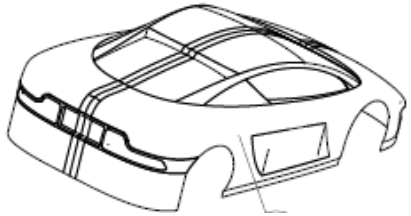




External procurement



Target situation

Laser cutting machine

Laser welding system

Bending machine

Thermoforming machine

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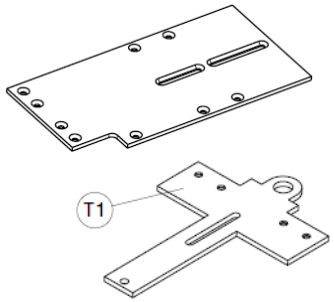
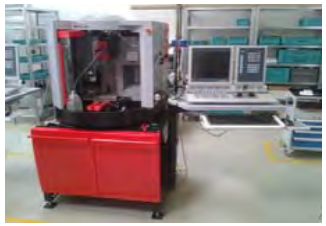
TU Vienna Learning & Innovation Factory
Expansion of Manufacturing Technologies

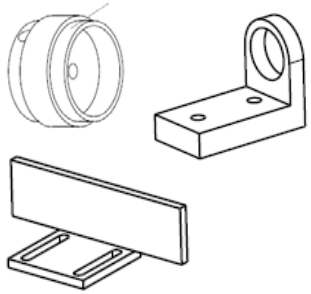
Integrated Product and Process Planning and Design Competence

Initial situation

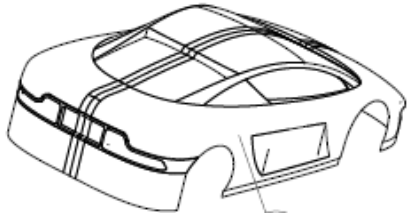


NC -turning machine & milling machine





External procurement



Preliminary, activity-based costing vs. post calculation with **real time data**

Comparision of production costs from different manufacturing methods

Make-or-buy decision

Target situation

Laser cutting machine

Laser welding system

Bending machine

Thermoforming machine

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Installation of Software – Siemens Teamcenter

Red Bull Racing Team

Integrated Idea Capture and Management

Collaborative Data Management

Project Management

Digital Product Development

Real-time Engineering Collaboration

TU Vienna Slotcar Teams

Creativity & Methods Competence for systematic Idea & Innovation Mgmt.

Integrated Product and Process Planning and Design Competence

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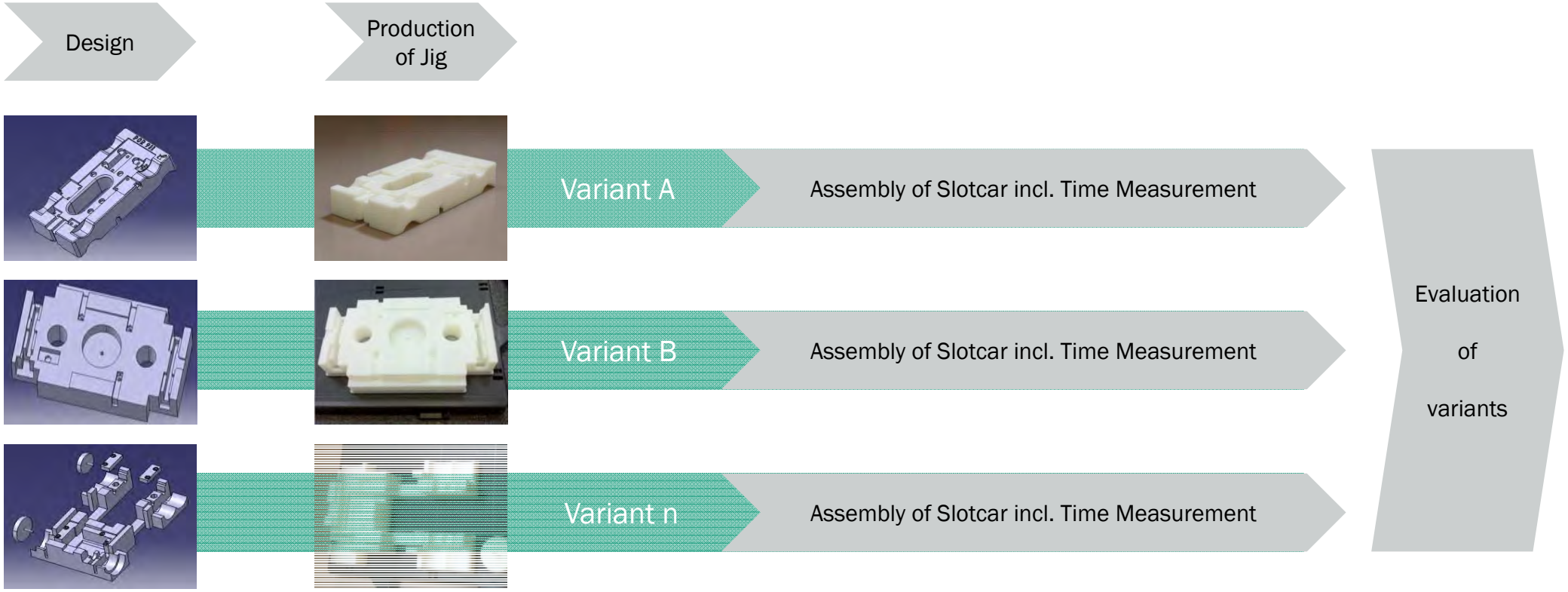
Industry 4.0 Use Case – Siemens Process Designer (Tecnomatix)



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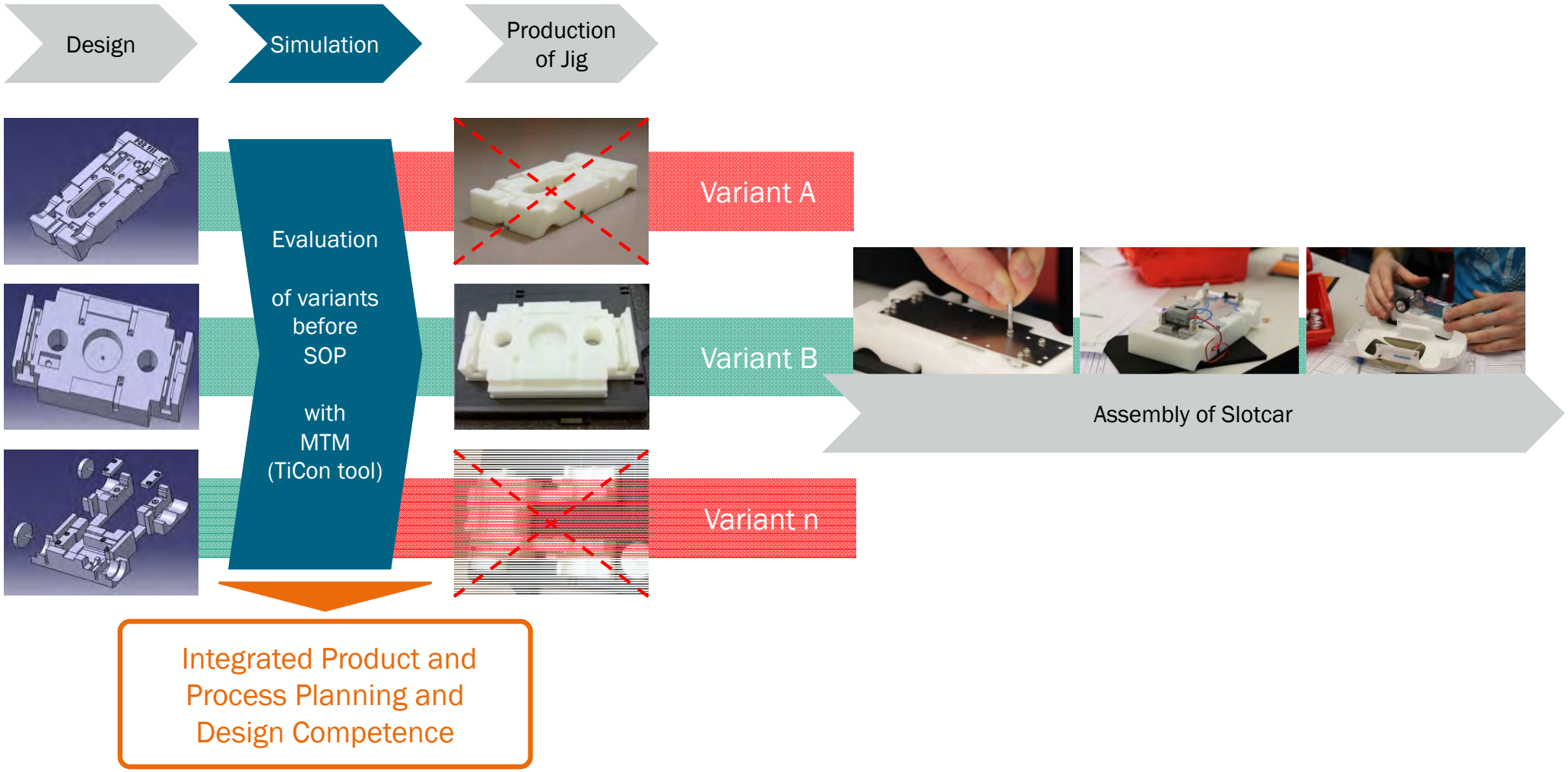
Industry 4.0 Use Case – Siemens Process Designer (Tecnomatix)



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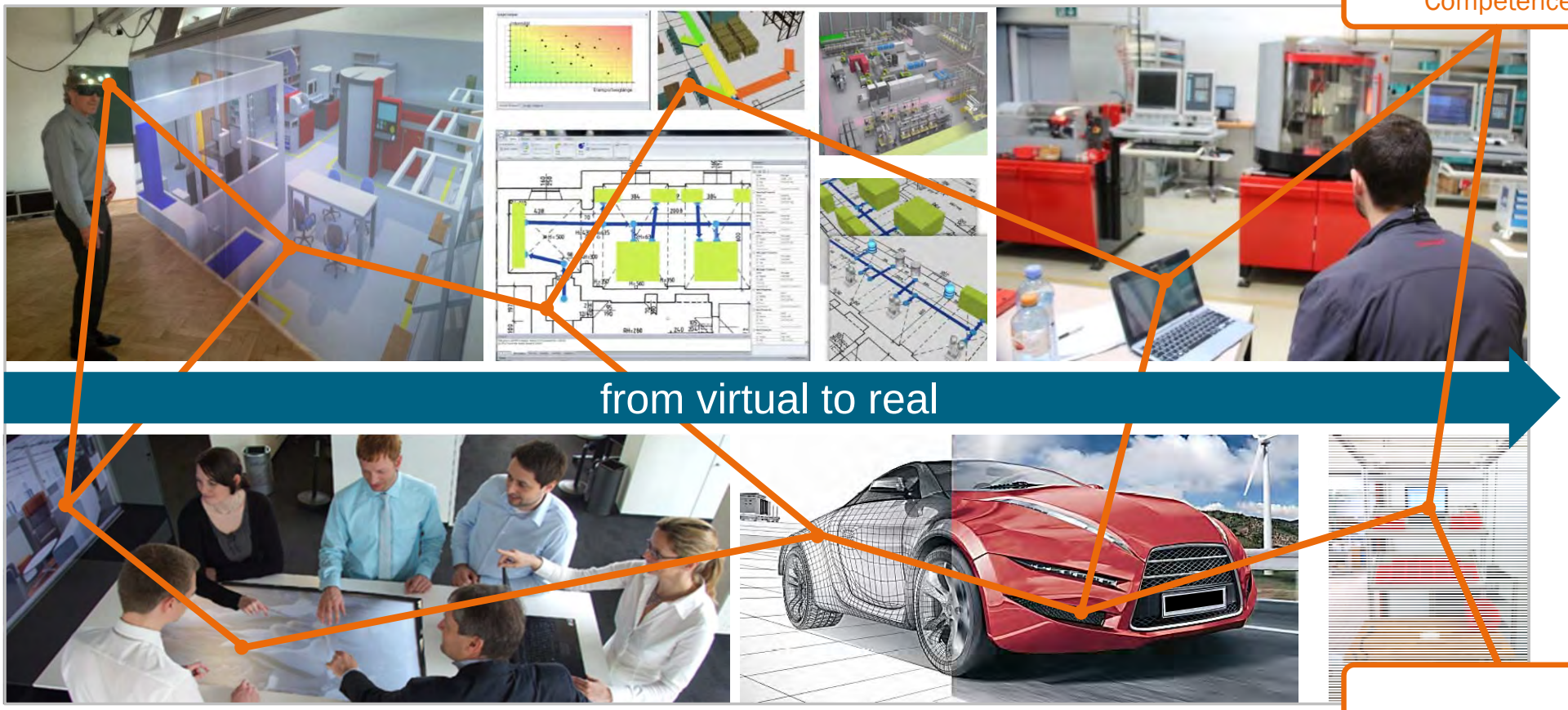
Industry 4.0 Use Case



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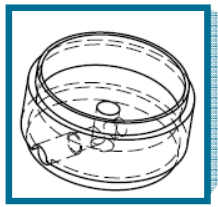
Industry 4.0 Use Case

Physical Automated and Digital / Virtual Production Cell



Slotcar Component: Wheel Rim

Articulated Robot

Driverless Transport System with integrated Roller Conveyor

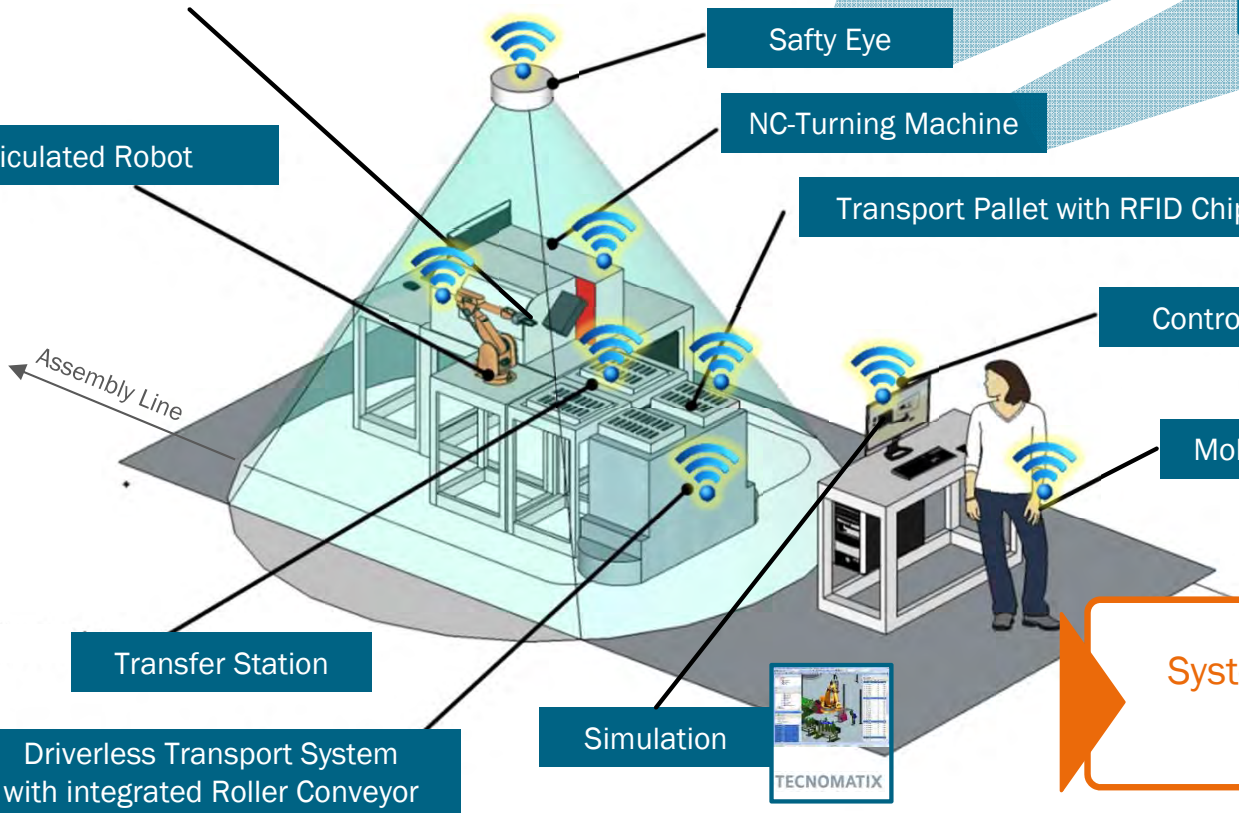
Safty Eye

NC-Turning Machine

Transport Pallet with RFID Chip

Control Center

Mobile Device with App



Transfer Station

Simulation

Systems and Interface Competence

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Thank you!

Questions

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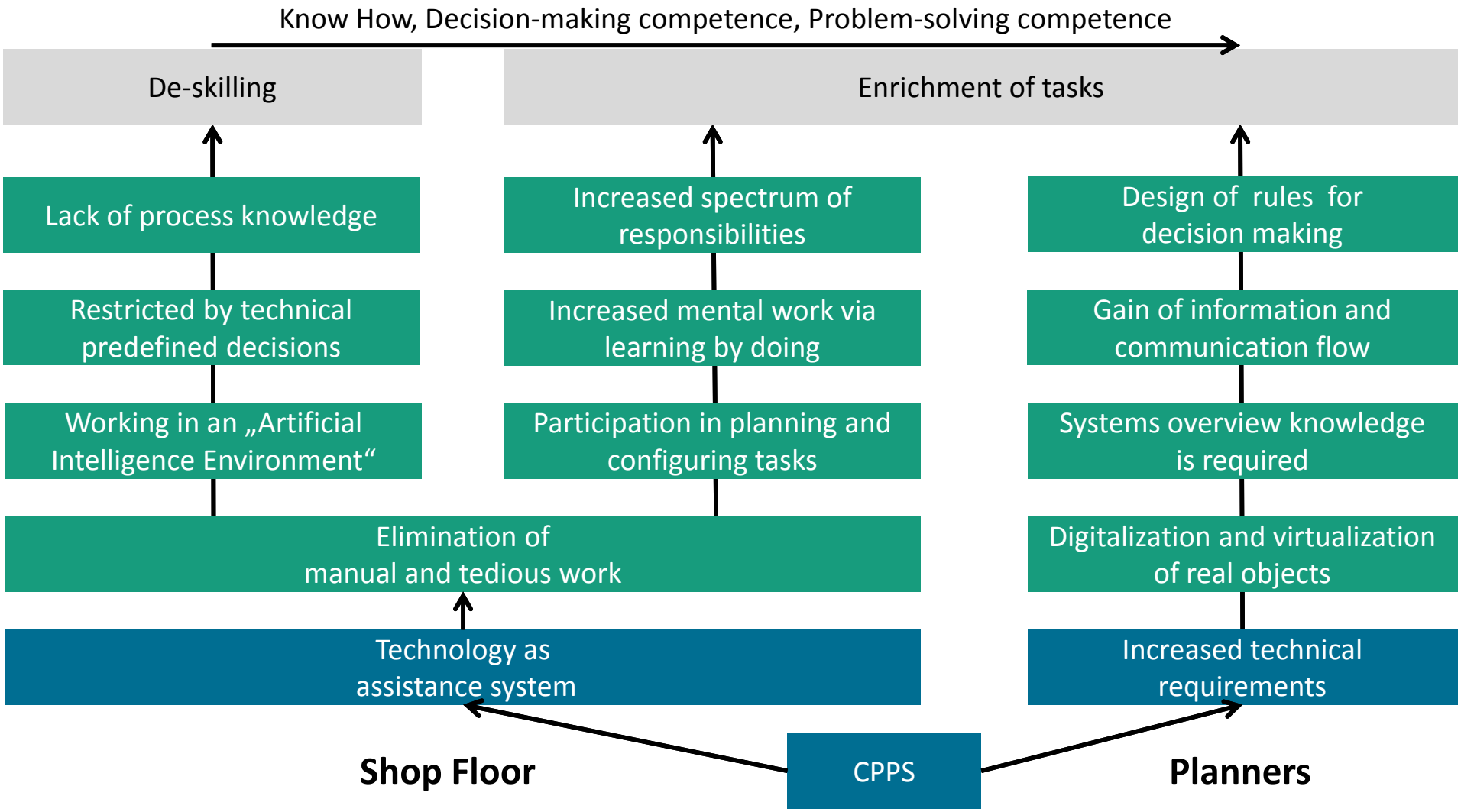
Industry 4.0

Change of qualification requirements



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Applied Research / Mobility Project

Network of Innovative Learning Factories (NIL)

- Activities related to Learning Factories:
  - Standardization of the „System Learning-Factory“, including joint development of learning modules on Industry 4.0
  - Intensification of academic exchange between the involved institutes on the level of researchers and students, including a summer school on Learning Factories (start: summer 2015)
  - Dissemination of related research results in a series of papers on Learning Factories (start: Summer 2014)

NIL
Netzwerk Innovativer Lernfabriken

Members

Sponsors

DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service
GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Applied Research Project
LOPEC

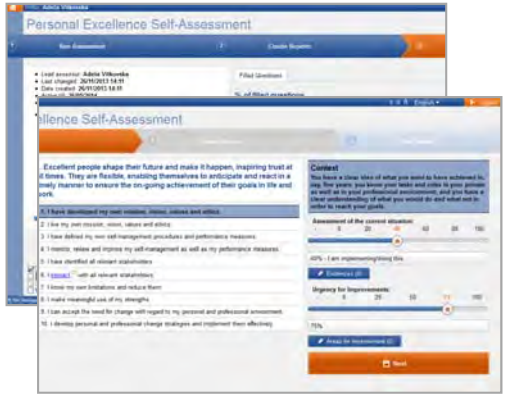
Logistics Personal Excellence by continuous Self-Assessment
LOPEC

Education and Culture DG
Lifelong Learning Programme

- Human specific addressed aspects of Industry 4.0:
  - Initiating of lifelong-learning through a blended learning approach
    -> self studying via an LMS
    -> hands-on training in the LF
  - Fostering work-life balance by self-assessment of personal, professional and business objectives
  - Sensitizing of demographic change on shop floor level with the initiation of knowledge transfer between different age groups

Learning Mgmt. System

Self-Assessment Tool



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