Fraunhofer
IWU

Projektgruppe
Ressourceneffiziente mechatronische
Verarbeitungsmaschinen

iwb

TUM

May 7th, 2013 | MUNICH

# 3RD CONFERENCE ON LEARNING FACTORIES

# 3rd CONFERENCE ON LEARNING FACTORIES

## Increasing resource efficiency through education and training

## May 7th, 2013

# Content

**» What I hear, I forget.**
**What I say, I remember.**
**What I do, I understand. «**

(Laozi, Chinese philosopher, 6th century BC)

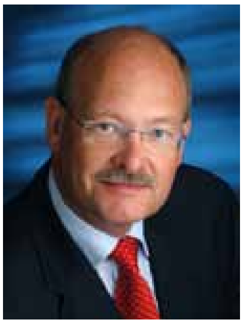
# PREFACE

## Increasing resource efficiency through education and training

Resource efficiency in production becomes increasingly important. But sustainably it can only be improved, while employees of all hierarchies are sensitized to that topic. In our opinion, learning factories can play an essential part to achieve this goal by teaching methods practically and in a realistic environment. The topic invites us to discuss the further development of learning factories into advanced training centers not only considering economic factors but also expanding the focus on different aspects of resource efficiency. Therefore, we offer the following three sessions:

- Learning factories for optimization of energy efficiency
- Sustainable efficiency in production and logistics through lean learning factories
- Creating the future with digital learning factories

The objective is to learn more about learning factories and to discuss didactical approaches. Therefore, we look forward to welcoming you to the third conference on learning factories in Munich.



Prof. Dr.-Ing. Gunther Reinhart
Conference Chairman

Director of the *iwb*
Head of project group RMV
of Fraunhofer IWU

www.iwu.fraunhofer.de/learningconference
www.energielernfabrik.de

## Conference Agenda:

| | |
|---|---|
| 09:00 | **Opening of the conference**<br>***Prof. Gunther Reinhart \| Conference Chairman***<br>***Prof. Klaus Bengler \| Dean of the Faculty of Mechanical Engineering of TU München*** |
| 09:10 | Welcoming speech and presentation of the Initiative on Learning Factories<br>***Prof. Eberhard Abele \| PTW \| TU Darmstadt*** |
| | **Session 1: Learning factories for optimization of energy efficiency**<br>***moderation: Prof. Eberhard Abele \| PTW \| TU Darmstadt*** |
| 09:15 | Green Factory Bavaria - Knowledge transfer to increase energy efficiency in manufacturing<br>***Prof. Rolf Steinhilper \| LUP \| University of Bayreuth*** |
| 09:45 | Integration of process simulations into the CIP of energy efficiency at Daimler Trucks<br>***Christian Oberthür \| Daimler AG*** |
| 10:15 | Coffee Break |
| 10:45 | Die Lernfabrik - Research and education for sustainability in manufacturing<br>***Prof. Christoph Herrmann \| IWF \| TU Braunschweig*** |
| 11:15 | The concept of the new Research Factory at Fraunhofer IWU - to objectify energy and resource efficiency R&D in the E3-Factory<br>***Prof. Matthias Putz \| Fraunhofer IWU*** |
| | **Session 2: Sustainable efficiency in production and logistics through lean learning factories**<br>***moderation: Prof. Wilfried Sihn \| Vienna University of Technology*** |
| 11:45 | Lean Basic Training at ZF Lenksysteme<br>***Dr. Sebastian Böttcher and Marcus Schramm \| ZF Lenksysteme GmbH*** |
| 12:15 | Lunch |

| | |
|---|---|
| 13:15 | Current activities and future challenges of the Process Learning Factory CiP<br>***Prof. Joachim Metternich \| PTW \| TU Darmstadt*** |
| 13:45 | Qualification as an effective tool to support the implementation of lean<br>***Werner Beauvais \| Schaeffler AG*** |
| 14:15 | Beyond lean learning factories - The model plant Ueberlingen as nucleus for the learning organization<br>***Marc Goldschmidt \| MTU Friedrichshafen GmbH*** |
| 14:45 | Coffee Break |
| | **Session 3: Creating the future with digital learning factories**<br>***moderation: Prof. Gunther Reinhart \| iwb \| TUM*** |
| 15:15 | XPRES - a digital learning factory for adaptive and sustainable manufacturing of future products<br>***Dr. Gunilla Sivard and Dr. Thomas Lundholm \| IIP \| KTH Stockholm*** |
| 15:45 | Innovation of virtual commissioning solutions with the help of our Smart Automation research plant<br>***David Koch \| Siemens AG, Industry Automation*** |
| 16:15 | Digital - Real Learning Factory for manufacturing engineering<br>***Prof. Engelbert Westkämper \| IFF \| University of Stuttgart*** |
| 16:45 | Transfer to iwb factory hall (Garching) |
| | **Evening event:**<br>**Visit to the shop floor of *iwb* learning factories** |
| 17:45 | Introduction of the Model Factory for Energy Productivity (LEP) and the Learning Factory for Lean Production (LSP)<br>Get together with a stand-up reception |
| | Transfer back to hotel with stopover at Munich main station |

# Opening of the Conference

## Prof. Dr. Klaus Bengler - Dean of the Faculty of Mechanical Engineering of Technische Universität München

Klaus Bengler graduated in psychology at the University of Regensburg in 1991 and received his PhD in 1994 in cooperation with BMW at the Institute of Psychology (Prof. Dr. Zimmer). After his Ph.D. he was active on topics of software ergonomics and evaluation of human-machine interfaces. He investigated the influence of additional tasks on driving performance in several studies within EMMIS EU project and in contract with BMW. In 1997 he joined BMW. From several projects he is experienced with experimental knowledge with different kind of driving simulators and field trials. At BMW he was responsible for the HMI project of the MOTIV program, a national follow on the program of PROMETHEUS. Within BMW Research and Technology he was responsible for projects on HMI research and leader of the usability lab.
Since May 2009 he is leader of the Institute of Ergonomics at Technische Universität München which is active in research areas like digital human modeling, human robot cooperation, driver assistance HMI and human reliability. He is leading the German Standardization Group (FAKRA) AK-10 "Mensch als Fahrzeugführer" and is active member of ISO TC22 SC13 WG8 "Road vehicles - Ergonomic aspects of transport information and control systems" as well as member of VDI working group "Menschliche Zuverlässigkeit".

"Talents are our assets, reputation is our return." A mission statement fitting of an entrepreneurial university.
Technische Universität München (TUM) is one of Europe's top universities. It is committed to excellence in research and teaching, interdisciplinary education and the active promotion of promising young scientists. The university also forges strong links with companies and scientific institutions across the world. TUM was one of the first universities in Germany to be named a University of Excellence. In the international Shanghai Ranking (ARWU), TUM was rated the number one German university both in 2011 and 2012.

# Introduction of the Initiative on Learning Factories

Prof. Dr. Eberhard Abele - Head of the Initiative on Learning Factories

The production of the future is determined by shorter product life cycles and at the same time by increasing varieties in technologies, standards and methods. The challenge for industrial companies as well as for universities is therefore to establish more effective and sustainable methods for knowledge enhancement and knowledge transfer. Lifelong learning will become a crucial aspect for production engineers.
To cope with this challenge more and more companies and universities build up learning factories. Trainings in such a facility are more effective and efficient than any other didactical approach known by now. To learn more about these factories and to discuss didactical approaches we founded the Initiative on Learning Factories.

Munich | 07.05.2013

TECHNISCHE UNIVERSITÄT DARMSTADT

PROZESSLERNFABRIK

## Welcoming speech and presentation of the Initiative on European Learning Factories

Prof. Dr.-Ing. E. Abele
Prof. Dr.-Ing. J. Metternich
Dipl.-Wirtsch.-Ing. M. Tisch
Dipl.-Wirtsch.-Ing. J. Cachay

Institut für Produktionsmanagement, Technologie und Werkzeugmaschinen

Center für industrielle Produktivität

*www.prozesslernfabrik.de*

## The future working environment of our graduates often is production-related

TU DARMSTADT

**70% of the students are going to work within the departments of production, development or quality assurance**

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## Initial situation for students in Production Management

PTW TU DARMSTADT CiP

Survey among 50 staff managers and directors:

- What are alumni of Technische Universität Darmstadt good at?
- Where is a need for improvements?

**Results**

- As future employees in production, the alumni lack of:
  - Knowledge about processes and Lean methods
  - Skills in the establishment and adaption of production systems
  - Perception of ideal workflows in manufacturing and enthusiasm for continuous improvement

Source: PTW (2005), picture: methode .de

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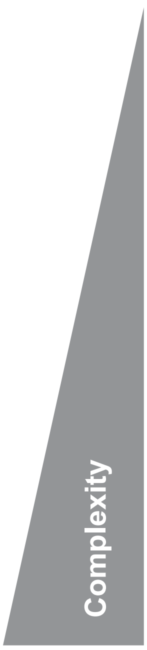
## Deficits of graduates and young professionals in production-related corporate divisions (example)

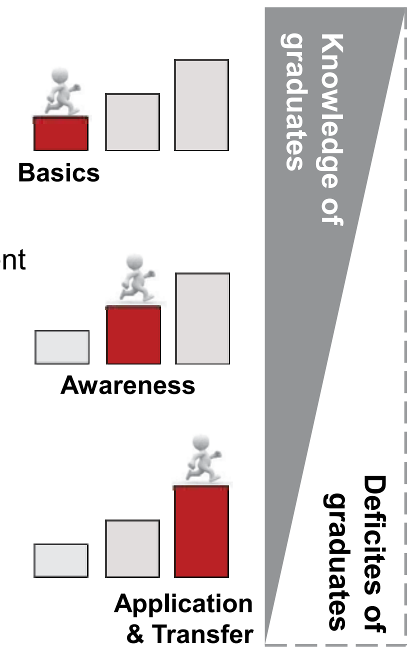
PTW TU DARMSTADT CiP




- Basics of manufacturing processes
- Basics machine tools
- Basics automation
- Basics Lean methods and principles

- Enthusiasm for continuous improvement
- Ideal processes in production
- Quality awareness
- Knowledge about production systems (construction and function)

- Application of lean methods
- Quality management systems
- Systematic problem solving and production process improvement

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## Learning by experience on the shopfloor gains lasting knowledge and skills

**What I hear, I forget.**

**What I say, I remember.**

**What I do, I understand.**

**Laozi, Chinese philosopher**

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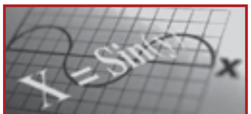
## Properties and probable application ranges of learning factories

Probable application ranges

**Education**
- Universities
- Vocational schools
- Enterprises

**Advanced Training**
- Groups
- Small and medium sized enterprises
- Job-seekers



**Knowledge & innovation platform**
- Innovations
- Testing environment
- Applied research

**Network**
- Learning factories
- Industry
- High schools

**Learning**

**factory**

Properties

- Methodology
- Technics
- Organisation

**Didactics**

- Real products
- Machines
- Assembly

**Experimental Area**

- Slides
- Didactic cells
- Demonstrations

**Visualization**

- Researcher
- Trainer
- Factory staff

**Workforce**

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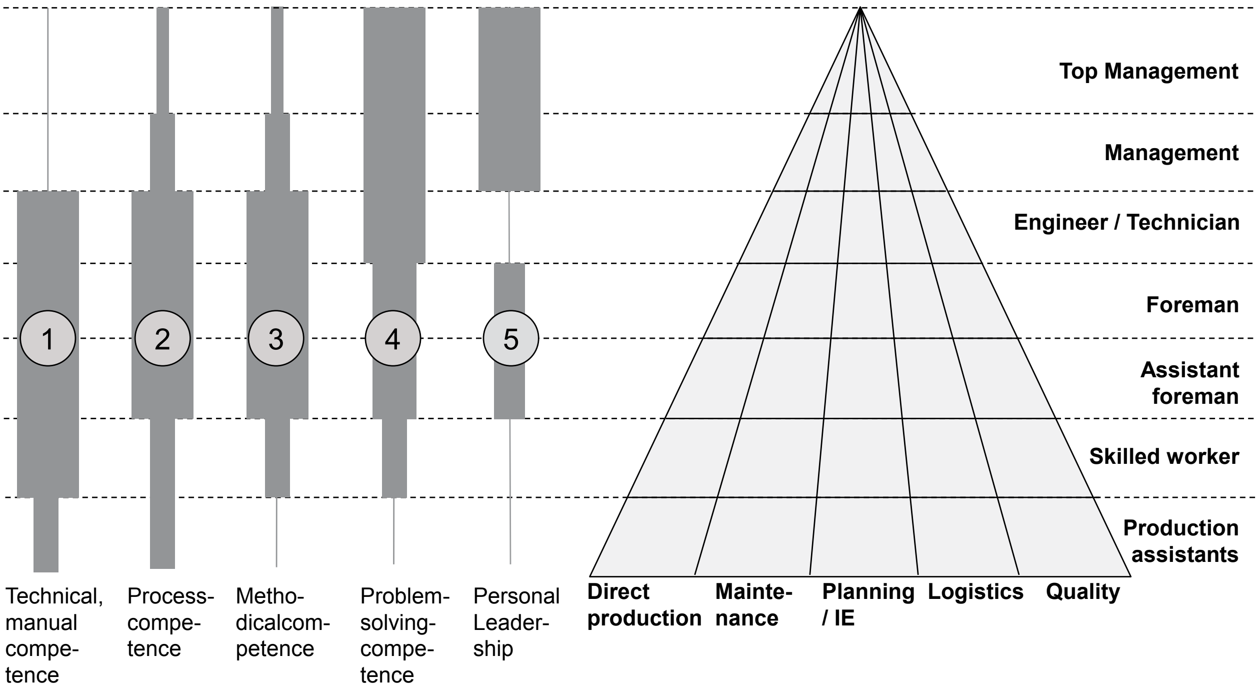
## Competence requirements at different organizational levels






## Specific competence requirements of a foreman assistant in the direct production, example machining

| Competence classification | | description | example |
|---|---|---|---|
|  | **Technical, manual competence** (1) | Ability to handle all manual tasks in the own sphere of action | Tool setting and setting of the milling machine |
|  | **Process-competence** (2) | Ability to capture the cause-effect relationships of production processes in the own sphere of action | Overviewing the specific interaction of parts feeding, processing and removal |
|  | **Methodological-competence** (3) | Ability to apply methods to improve production in the own sphere of action | Application of the method SMED (quick changeover) in a concatenated system |
|  | **Problem-solving-competence** (4) | Little ability to solve complex problems in the own sphere of action | Error search and root cause analysis on reject parts |
|  | **Personal Leadership** (5) | Ability to lead the staff regarding technical matters | Effective moderation of daily shift meeting and work allocation |

## Founders of the Initiative on European Learning Factories in 2011

RTL: Professor Laszlo Monostori, Professor Wilfried Sihn, Professor Friedrich Bleicher, Professorin Vera Hummel, Professor Kurt Matyas, Professor Eberhard Abele, Dr. Thomas Lundholm, Dr. Dimitris Mavrikios, Christian Morawetz, Professor Ivica Veza, Professor Toma Udiljak, Jan Cachay, Professor Bengt Lindberg. Not on the picture: Professor Gunther Reinhart, Professor Pedro Cunha

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## Founders of the Initiative on European Learning Factories in 2011

| | |
|---|---|
| Institute of Production Management, Technology and Machine Tools (PTW), TU Darmstadt | Prof. Eberhard Abele (president since 2011) |
| ESB Business School, Reutlingen University | Prof. Vera Hummel |
| Royal Institute of Technology | Prof. Bengt Lindberg |
| Laboratory for Manufacturing Systems & Automation Department of Mechanical Engineering and Aeronautics | Prof. George Chryssolouris |
| Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture | Prof. Ivica Veza |
| Institute of Management Science Vienna University of Technology | Prof. Wilfried Sihn (vice president) |
| Institute of Production Engineering and Laser Technology Vienna University of Technology | Prof. Friedrich Bleicher |
| Institute for Machine Tools and Industrial Management Technische Universität München | Prof. Gunther Reinhart |
| Center for Integration and process Innovation | Prof. Pedro Cunha |
| The Computer and Automation Research Institute, Hungarian Academy of Sciences, cooperation with Budapest University of Technology & Economics | Prof. Laszlo Monostori |

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## Status Initiative on European Learning Factories

PTW TU DARMSTADT CiP

**What happend so far**

- Meeting at CIRP in Pisa, August, 26th 2010
- Commitment to pursue with an initiative
- Meeting at CIRP in Paris, January, 27th 2011
- Commitment on founding the initiative on May, 20th 2011 in Darmstadt
- 1st conference on learning factories, May 19th 2011 in Darmstadt
- Founding meeting, May 20th 2011 in Darmstadt
- Meeting at CIRP in Paris, January, 26th 2012
- General assembly Vienna, May, 9th 2012
- Meeting at CIRP in Hongkong, August, 21th 2012
- Proposal CIRP CWG at CIRP in Paris, January, 24th 2013

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## Cooperation possibilities for academic Learning Factories

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| | I Exchange of Learning Factory experiences | II Further enlargement of Learning Factory possibilities |
|---|---|---|
| (Further) education  | ▪ Exchange of teaching modules for Production Eng. (Slides, Learning cells)<br>▪ Lessons learned<br>▪ Exchange existing business models, marketing strategies, flyers | ▪ Develop competency-oriented learning systems and teaching modules for the factory of the future together |
| Research  | ▪ Possible application areas and their specific requirements<br>▪ Possible cooperation regarding existing research activities<br>▪ Didactical concepts | ▪ Acquisition of collaborative research projects<br>▪ Explore industry-relevant topics (Fast production ramp-ups, Cellular manufacturing, Lean for Intralogistics, Lean-IT, etc.) |

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## There are several learning factories in industry and universties, which face the challenge of continuous learning






| | Learning Factory for Lean Production (LSP), iwb, TU Munich | Process learning factory CiP, TU-Darmstadt | Learning Factory for energy productivity (LEP), iwb, TU Munich | Lean Centre, Volkswagen, Wolfsburg | Process simulation facility, Daimler, Mannheim |
|---|---|---|---|---|---|
| **Objective** | • To enable capacities for process optimization | • To enable capacities for process optimization | • To enable capacities for optimization regarding energy productivity | • To increase productivity<br>• Enhancement of production system | • To train managers in methods of lean manufacturing and lean administration |
| **Target group** | • Students<br>• Industry projects | • Students<br>• Industry: From level of operation to management | • Students<br>• Industry (all hierarchy levels) | • Executives, team leaders and technicians who act as multiplicator in the company | • From level of promotion candidates to vice president |
| **Content of teaching** | • Principles, Methods and Tools of Lean Manufacturing | • Methods and Tools of Lean Manufacturing and Lean Office | • Analysis, evaluation and optimization regarding energy productivity | • Methods and Tools of Lean Manufacturing | • Leadership in a lean environment shop floor management problem solving methods |
| **Products** | • Planetary gear<br>• Spur gear | • Pneumatic cylinder (Bosch Rexroth)<br>• Gear Motor (SEW) | • Planetary gear | • Auto parts<br>• Adhesive tape roller | • Turbo charger<br>• Order Process |
| **Processes and equipment** | • Assembly<br>• Machining<br>• Quality control | • Whole value stream (Machining, Assembly QM, Logistics)<br>• Shop floor supporting functions (Processing of orders) | • Machining<br>• Hardening<br>• Assembly<br>• Handling | • Exemplar work cycles to demonstrate best practices<br>• 22 stations with praxis modules | • Assembly of the turbo charger including shop floor supporting processes<br>• Transformable Assembly equipment |

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## Topic overview of Learning factories used by McKinsey

**Overview of the different functional dimensions**

| | | CiP | | | LEP | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lean manufacturing** | Lean principles in aspects of technical system, management and mindset and behavior | ✓ | ✓ | ✓ | | ✓ | ✓ | | | ✓ |
| **Energy efficiency** | Energy productivity thinking from diagnosis to implementation methods | | | | ✓ | | | | ✓ | ✓ |
| **Quality** | Quality modules concerning effectivity and efficiency of a quality organization | | | ✓ | | | | | | |
| **Pharma** | Pharma specific topics with focus on pharma quality value stream | | | ✓ | | | | | | |
| **Service/office** | Back office processes in banking, insurance and branch sales | | ✓ | ✓ | | | ✓ | ✓ | | |
| **Service/call center** | Optimization of real call center operation | | | ✓ | | ✓ | | ✓ | | |
| **R&D** | Tear down and development process | | ✓ | ✓ | | ✓ | | ✓ | | |
| **Lean IT** | Optimization of IT development process | | ✓ | | | | | ✓ | | |
| **Continuous process** | Continuous process training module ideal for Food, Chemical & Pharma industries | | ✓ | | | | | | | |
| **Purchasing & supply management** | Combines elements of strategic sourcing and lean principles | | | | | ✓ | | ✓ | | |
| **Digital marketing** | Set up a digital communication strategy | | | | | | | ✓ | | |
| **And also** | Supply chain, B2B pricing, sourcing, performance leadership, hospital | | | | | | | ✓ | | |

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## Growing McKinsey model factory network

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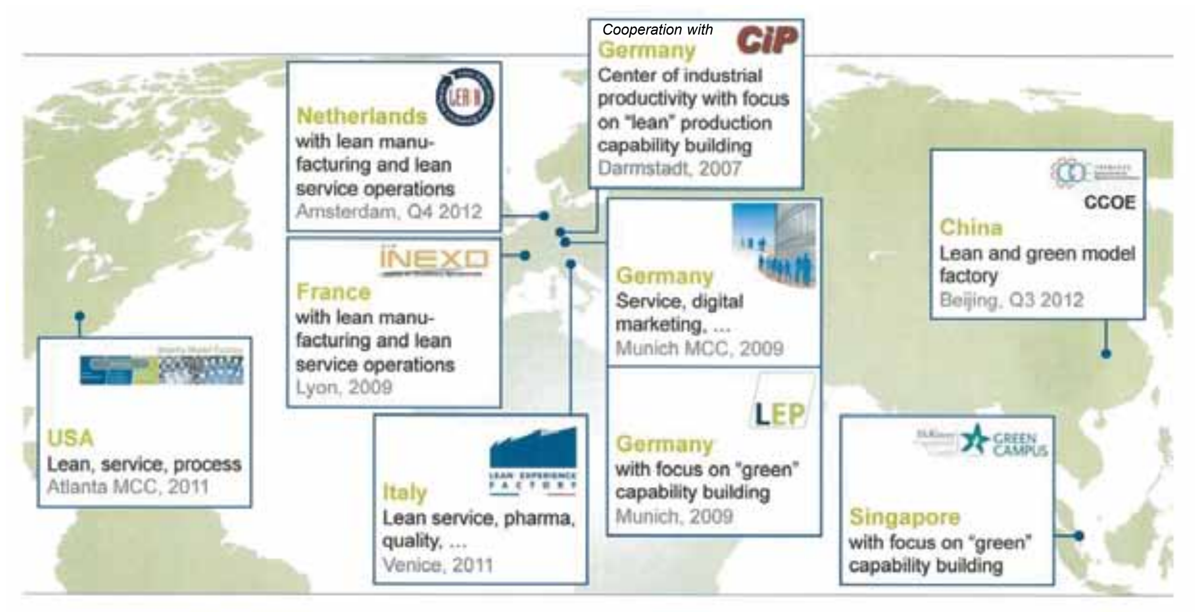


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## Our vision for the year 2020: A model company at the campus

TU DARMSTADT

„Model Company"
Technische Universität Darmstadt

**Process Learning Factory „CiP"**

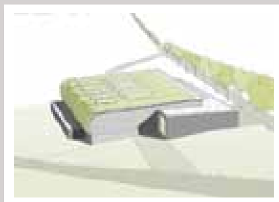
established in 2007

**Energy Efficiency Factory „Eta"**

planned and requested

**Logistics Learning Factory**

planned and requested



**Center of product development**

In discussion

Ongoing expansion by network activities and collaborative research

Targets:
- Enlargement of current education offer for students and industry employees
- Research in comprehensive processes
- Integration and cooperation of several departments in a common object
- Motivation for multidisciplinary research activities

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# SESSION 1:

## Learning factories for optimization of energy efficiency

# Session 1:
## Learning factories for optimization of energy efficiency

Moderation: Prof. Dr. Eberhard Abele

The Institute Director **Professor Dr.-Ing. Eberhard Abele** studied mechanical engineering at the Stuttgart University of Technology. He was a researcher and department leader at the Fraunhofer Institute for manufacturing engineering and automation (IPA) in Stuttgart, Germany. In the past he was holding several management functions in a German automotive supply company as head of production planning and head of special purpose machine tool. In the same company he was head of production technology and technical director. Since 2000 he is director of the Institute for Production Management, Technology and Machine Tools (PTW) at the Technische Universität Darmstadt. Professor Abele is chairman of the team "production research 2020" (Produktionsforschung 2020) of the German Ministry of Education and Research, fellow of the International Academy for Production Engineering (CIRP) and a member of the German Academy of Science and Engineering (acatech). He published about 200 international research publications in the fields of cutting, automation, robotics, machine tools, and production management.

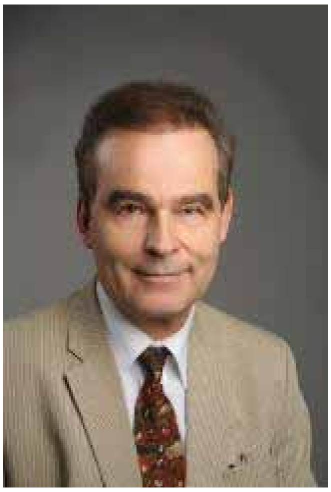
PTW
TU DARMSTADT

The Institute of Production Management, Technology and Machine Tools (PTW) is one of the leading German research institutes for production technology. Currently about 40 associate researchers focus their work on innovation along the manufacturing value chain. This includes the development of machine components and cutting tools, technologies for high speed machining, energy efficient machine tools and manufacturing processes and production management.
As a pioneer the PTW opened in 2007 its own learning factory CiP on the campus of the Technische Universität Darmstadt. Producing real products the CiP represents a complete industrial production facility including machining and indirect processes. Since 2007 by far more than 1.000 professionals have been receiving training in the CiP. Meanwhile its curriculum of lean production methods has been continuously developed.

In the year 2013 the PTW celebrates its 120st anniversary.

# Session 1:

## Green Factory Bavaria - Knowledge transfer to increase energy efficiency in manufacturing



**Prof. Dr.-Ing. Rolf Steinhilper** studied Factory Management and Automotive Technology at the University of Stuttgart, Germany from 1971 – 1978. He worked within the Fraunhofer Research Association on projects from Manufacturing, Remanufacturing, Recycling and EcoDesign for major industrial clients in Europe, USA and Canada, Japan, China and Taiwan from 1978-2000. Since 2001 he is full professor for Manufacturing and Remanufacturing Technology at the University of Bayreuth, Germany; since 2006 he is also responsible for the Fraunhofer Project Group "Process innovation" there.

His team consists of more than 30 specialized scientists and engineers. They work on industry projects in the field of lean production and manufacturing technology. Since energy efficiency is one of the future challenges for manufacturing companies increasing energy efficiency is one of their major tasks.

Rolf Steinhilper has published 15 books and more than 250 scientific articles. In 1993 Rolf Steinhilper has been awarded with the European Environmental Prize.

Bayreuth's Fraunhofer-Project Group Process Innovation, directed by Professor Dr.-Ing. Rolf Steinhilper, has been an experienced R&D partner in production technology and innovation management for years. The research focus is on advancing lean production methodologies and technology development for product remanufacturing. On top of that selectively implementing efficient lean methods and production systems, several new methods and technologies for energy efficient manufacturing have been developed and introduced over the past years.

In manufacturing related research, the institute holds manifold facilities: Assembly and disassembly laboratory, cleaning laboratory, CNC turning and milling machines, quality assurance laboratory, model factory for developing innovative workstation designs and production workflows, material flow simulation and factory planning laboratory.

# GREEN FACTORY BAVARIA

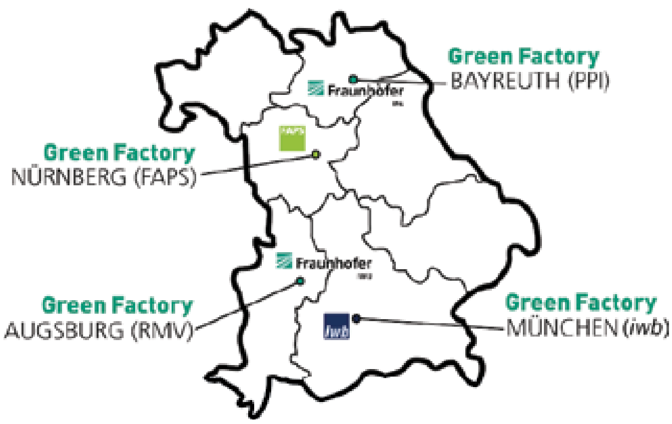
KNOWLEDGE TRANSFER TO INCREASE ENERGY EFFICIENCY IN MANUFACTURING

PROF. DR.-ING. ROLF STEINHILPER

MUNICH, MAY 7TH, 2013

3RD CONFERENCE ON LEARNING FACTORIES

Green Factory BAVARIA




## AGENDA

- **Introduction to Fraunhofer Bayreuth and Initial Situation**
- Green Factory Bavaria: Overview
- Green Factory Bavaria Bayreuth: Process Elements and Learning Concepts
- Summary



2

## Fraunhofer Project Group Process-Innovation Located at Bayreuth University since 2006

### Bayreuth University: Facts & Figures

- Established in 1975
- About 10,000 students
- 6 faculties
  - Mathematics, physics and informatics
  - Biology, chemistry and geo sciences
  - Law and economics
  - Linguistics and literature
  - Cultural sciences
  - Engineering and applied sciences



3

Green Factory BAVARIA

## Our Team

➡ Shaping the green *future in manufacturing* companies together with you!



4

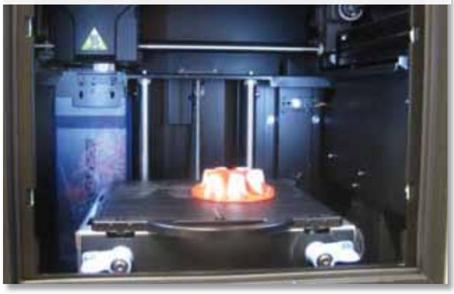
Green Factory BAVARIA

## Our Competences

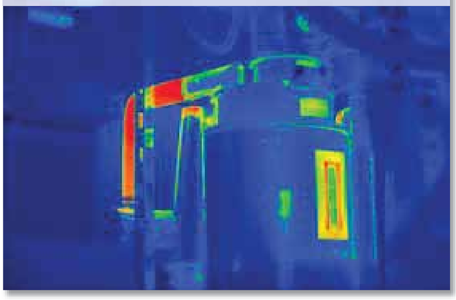
Remanufacturing

Production management

Technology management



**Ressource efficiency**





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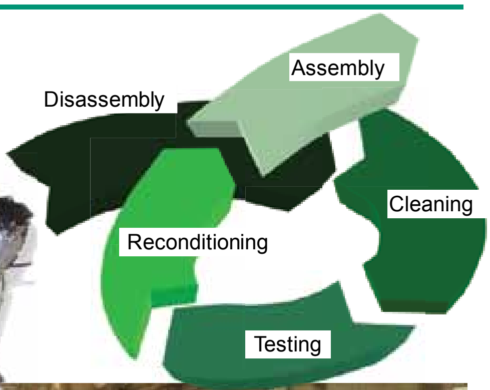
## Our remanufacturing competence: „Good as new“ in five steps

### Product and Process Knowhow



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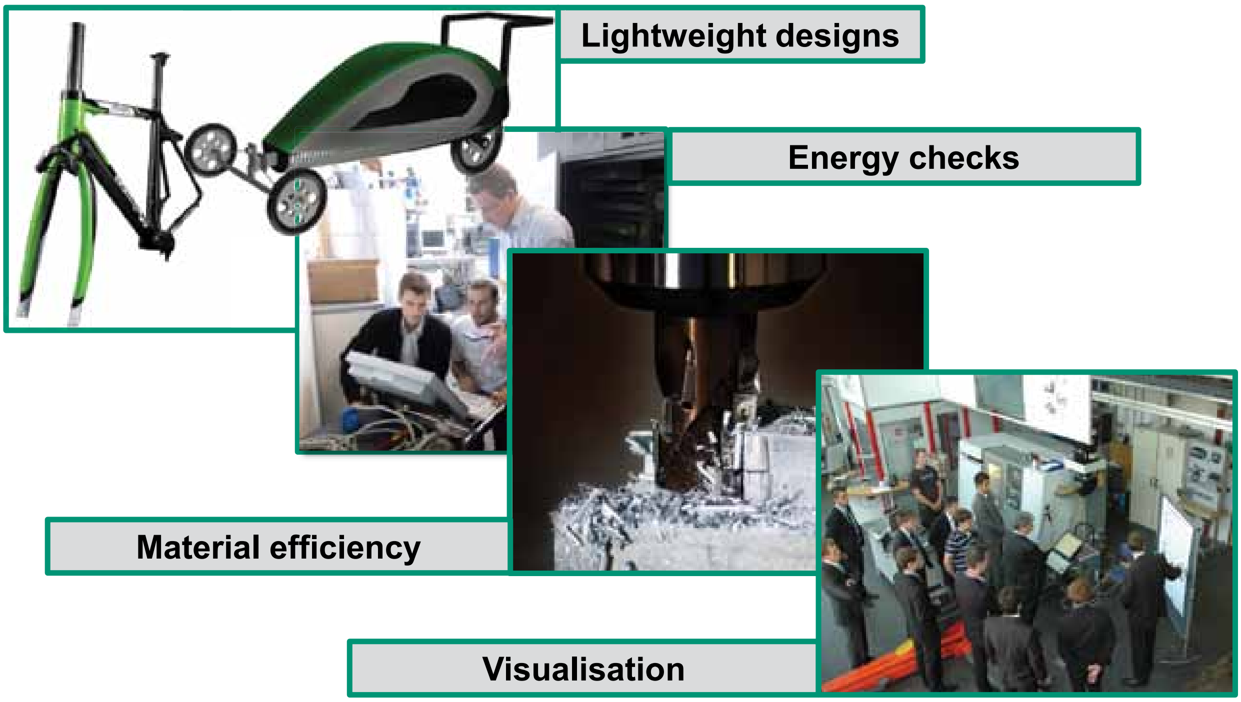
## OUR RESSOURCE EFFICIENCY COMPETENCES



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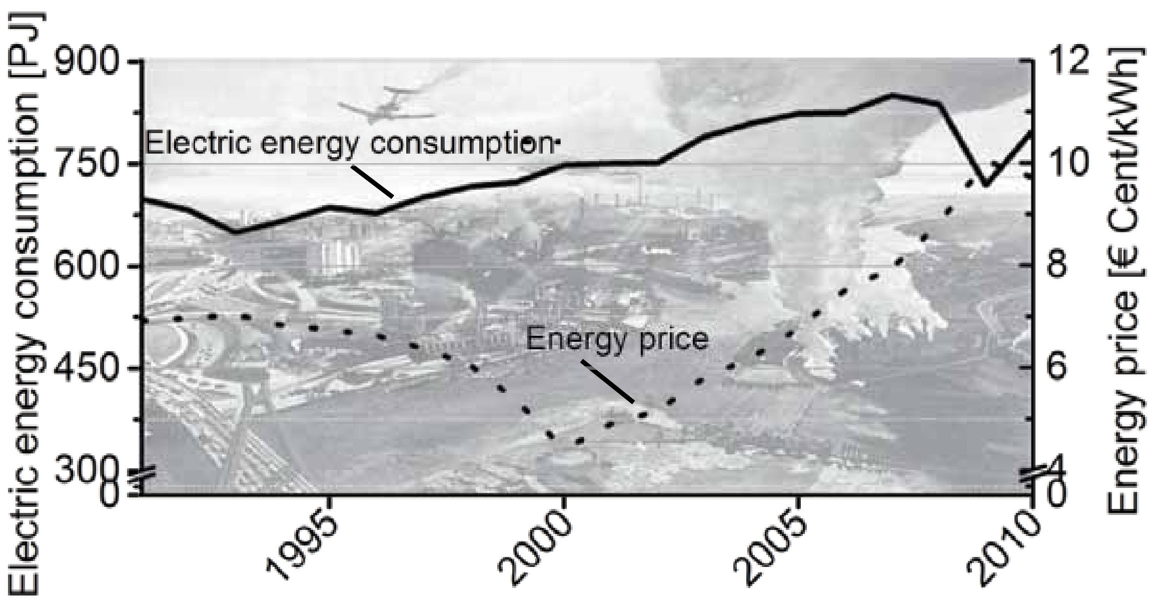
## ELECTRIC ENERGY CONSUMPTION AND PRICES VALID FOR GERMAN INDUSTRY




➡ Doubling of electric energy prices during the last decade

- Source: www.bmwi.de/BMWi/ Navigation/Energie/Statistik-und-Prognosen/ energiedaten.html, visited 07.06.2012



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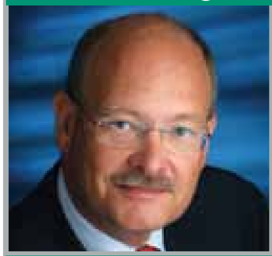
## Four key promoters

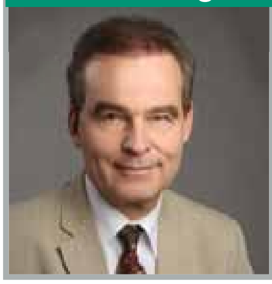
Prof. Dr.-Ing. Michael Zäh

Prof. Dr.-Ing. Gunther Reinhart



Prof. Dr.-Ing. Jörg Franke

Prof. Dr.-Ing. Rolf Steinhilper







## Agenda

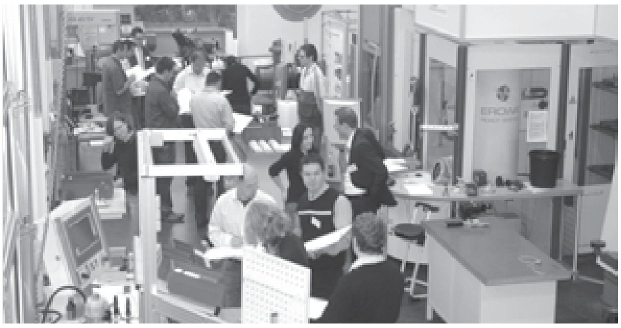
- Introduction to Fraunhofer Bayreuth and Initial Situation
- **Green Factory Bavaria: Overview**
- Green Factory Bavaria Bayreuth: Process Elements and Learning Concepts
- Summary

# PROJECT GOAL OF GREEN FACTORIES BAVARIA

in Augsburg, Bayreuth,
Munich and Nuremberg

- Know-how transfer into companies
- Upgrading of exisiting learning factories at Bayreuth and Munich
- Enabling companies towards an efficient energy use
- Didactic, demonstrative and explorative platforms

Learning Factory at Fraunhofer Bayreuth



Learning Factory at Munich University of Technology (iwb)



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Green Factory BAVARIA

# ALLOCATION OF RESEARCH TOPICS

**RMV Augsburg**
- Factory building and equipment
- Company organization and order processing
- Joining and handling processes

**PPI Bayreuth**
- Production logistics and service engineering
- Primary shaping
- Disassembling and cleaning

**FAPS Erlangen**
- Technical planning and control of production systems
- Electrical Engineering
- Electronic and mechatronic production

***iwb* München**
- Additive manufacturing processes
- Machining processes (e.g. machine tools)
- Laser cutting and welding

**Interdisciplinary Topics**
- Measuring tech.
- Energy-KPI's
- Simulation
- Certification
- Standardisation
- Technology transfer
- Energy monitoring
- …



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Green Factory BAVARIA

## AGENDA

- Introduction to Fraunhofer Bayreuth and Initial Situation
- Green Factory Bavaria: Overview
- **Green Factory Bavaria Bayreuth: Process Elements and Learning Concepts**
- Summary



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Green Factory BAVARIA

## GREEN FACTORY BAYREUTH: SCOPE

### Green Processes

- Manufacturing logistics
- Primary shaping, Disassembly
- Cleaning technology

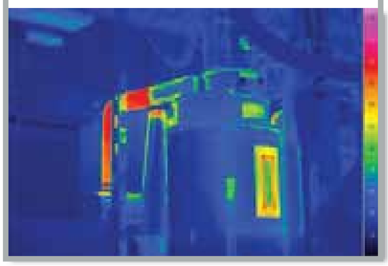
→ Demonstration of a manufacturing process for carbon fibre reinforced plastics

### Green Services

- Identification of energy saving potential in manufacturing
- Energy efficiency upgrading of plant and machinery
- Know how transfer via practical seminars

### Green Technologies

- Energy efficiency measurement
- Decentralized energy supply
- Energy recovery
- Energy storage
- Remanufacturing





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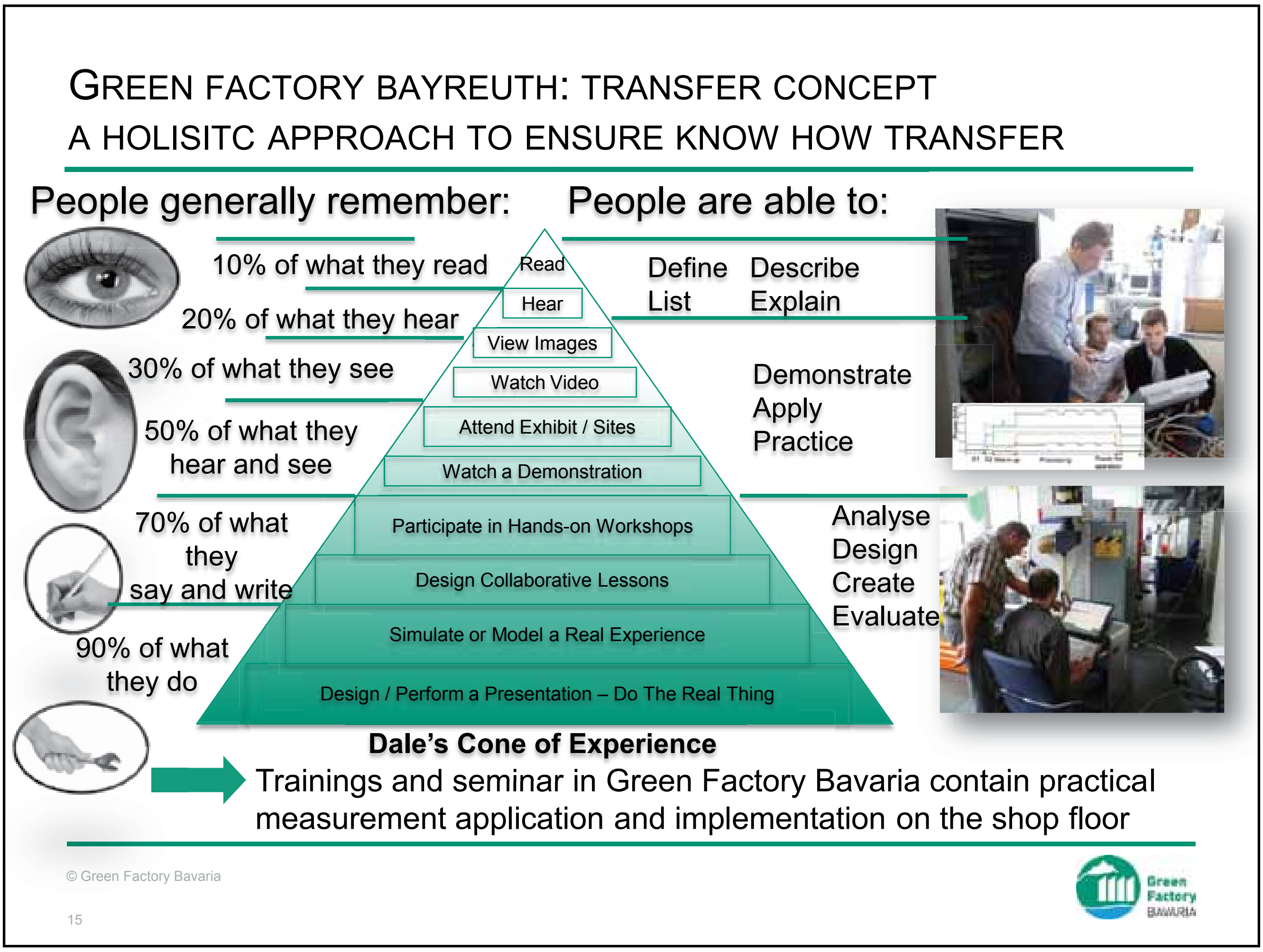
GREEN FACTORY BAYREUTH: TRANSFER CONCEPT
A HOLISITC APPROACH TO ENSURE KNOW HOW TRANSFER
People generally remember:
People are able to:
10% of what they read
20% of what they hear
30% of what they see
50% of what they hear and see
70% of what they say and write
90% of what they do
Read
Hear
View Images
Watch Video
Attend Exhibit / Sites
Watch a Demonstration
Participate in Hands-on Workshops
Design Collaborative Lessons
Simulate or Model a Real Experience
Design / Perform a Presentation – Do The Real Thing
Define List
Describe Explain
Demonstrate Apply Practice
Analyse Design Create Evaluate
Dale's Cone of Experience
Trainings and seminar in Green Factory Bavaria contain practical measurement application and implementation on the shop floor
© Green Factory Bavaria
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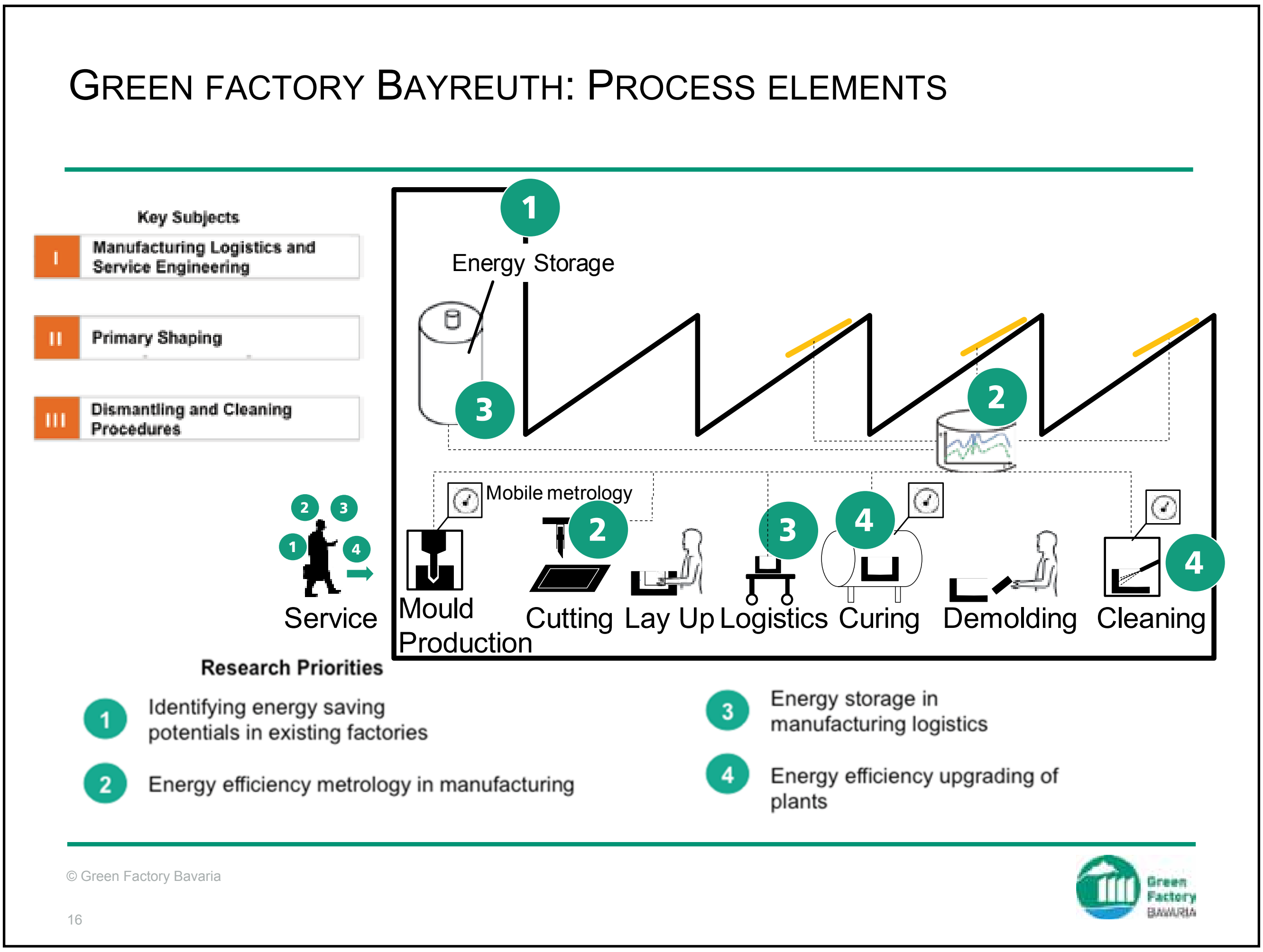
Green Factory BAVARIA


GREEN FACTORY BAYREUTH: PROCESS ELEMENTS
Key Subjects
I Manufacturing Logistics and Service Engineering
II Primary Shaping
III Dismantling and Cleaning Procedures
Energy Storage
Mobile metrology
Service
Mould Production
Cutting
Lay Up
Logistics
Curing
Demolding
Cleaning
Research Priorities
1 Identifying energy saving potentials in existing factories
2 Energy efficiency metrology in manufacturing
3 Energy storage in manufacturing logistics
4 Energy efficiency upgrading of plants
© Green Factory Bavaria
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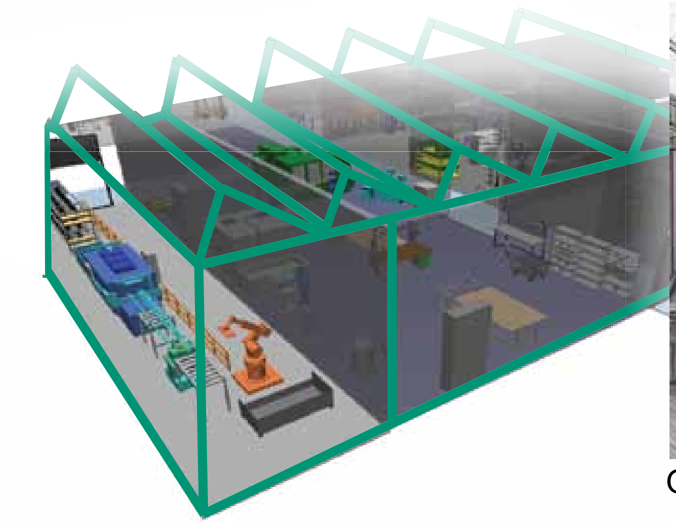
## GREEN FACTORY BAYREUTH: OVERVIEW VISUALISATION OF AN ENERGY EFFICIENT FACTORY



Quality management of a carbon fibre reinforced plastics - bicycle frame

➡ The manufacturing of a selected bicycle frame offers a wide transferability to other branches (e.g. automotive, aerospace, sports and medical industry)



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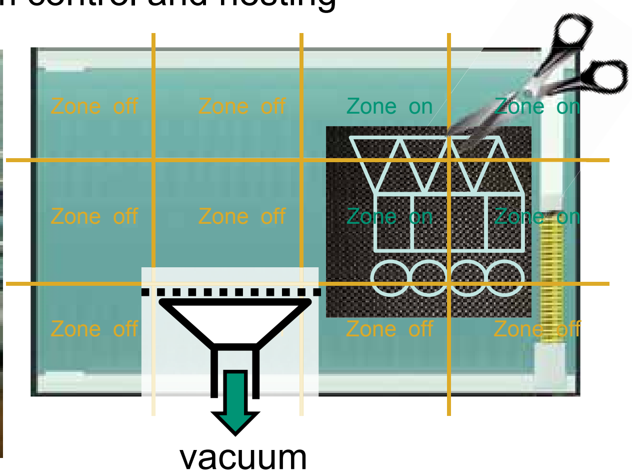
## IDENTIFICATION OF SAVING POTENTIALS OF ACCELERATED MASSES AND CLAMPING – CUTTER IN CFRP-MANUFACTURING

Electric power measurement, vacuum control and nesting




➡ Know how transfer to enable industry partners to identify energy losses and suitable optimisation measures: e. g. reduction of accelerated masses and optimisation of machine control



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## IDENTIFICATION OF SAVING POTENTIALS IN THERMAL PROCESSES: AUTOCLAV IN CFRP-MANUFACTURING

Electric power measurement and thermal imaging


Know how transfer to enable industry partners to identify energy losses and suitable optimisation measures: e. g. insulation, energy recovery and storage



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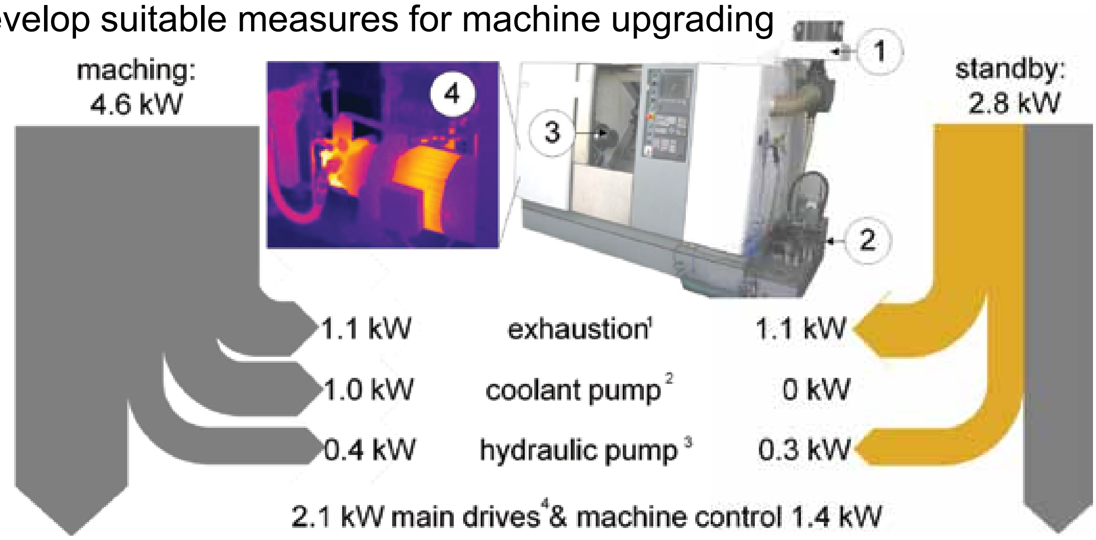
Green Factory BAVARIA

## MOBILE ENERGY MEASUREMENT CONCEPTS: EXAMPLE MACHINING OF CFRP-MOLDS

Gathering of measurement data to allocate saving potentials and to develop suitable measures for machine upgrading




Existing machines offer energy saving potential via machine upgrading
In this example 50% saving potential during standby mode



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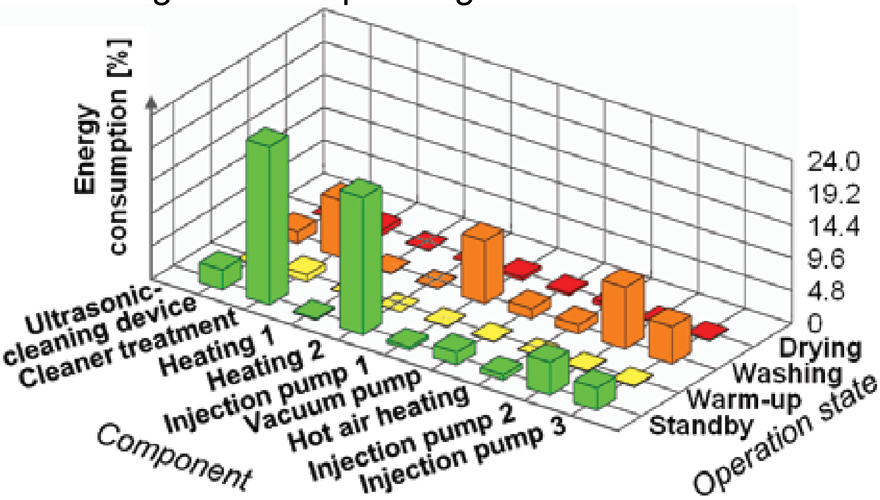
Green Factory BAVARIA

# INDUSTRIAL CLEANING TECHNOLOGIES: ENERGY CONSUMPTION ANALYSIS ACCORDING ISO\ DIS 14955

Electric power demand per component during variable operating-states




➡ Upgrading as a green service for machine manufacturer:
Know how transfer in compliance to the latest ISO-standards





# AGENDA

- Introduction to Fraunhofer Bayreuth and Initial Situation
- Green Factory Bavaria: Overview
- Green Factory Bavaria Bayreuth: Process Elements and Learning Concepts
- **Summary**

## Summary– Chances For Industry

### Your Benefits

→ Development of energy-saving potential by means of

innovative processes | intelligent utilization | efficient control engineering | optimized power electronics | new materials

→ Establishment of a Bavarian network "Energy Efficient Production"

→ Individual research, development and consulting projects

→ Development checklists, methods, learning materials

→ Energy efficiency potential quick check

→ Training of professionals

→ Publication of technical publications and books

→ Joint participation in conferences trade fairs in-country and abroad



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## Become a partner and sponsor of Green Factory Bavaria

| Gold | Silver | Bronze |
| --- | --- | --- |
| ▪ Work on joint research topics | | |
| Capacity per 12 man-months | Capacity per 6 man-months | Capacity per 2 man-month |
| ▪ Common applications for publicly funded research projects<br>▪ Assignment of a dedicated laboratory space in a Green Factory | | |
| Space: 60 sq.m. | Space: 30 sq.m. | Space: 10 sq.m. |
| ▪ Use of the infrastructure of the Green Factory and the concerned university<br>▪ Use and further development of the machines, plants, methods or software tools, placed at the disposal by the sponsors | | |
| ▪ Designation of a selected academic staff as “Sponsor Dedicated Ambassador (SDA)“<br>▪ Assignment of a seat in the industrial advisory board that consults the long-term content and organizational alignment of Green Factories | | |



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## The future home of Green Factory Bayreuth - 2014


New building includes 800 m² space for learning factory

Bayerisches Staatsministerium für Wirtschaft, Infrastruktur, Verkehr und Technologie

AufbruchBayern



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## Contact

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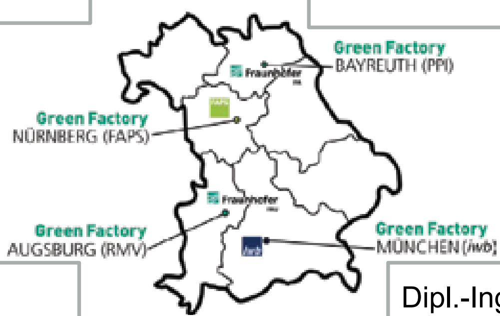


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# THANK YOU FOR YOUR ATTENTION

See you in Bayreuth!



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Green Factory BAVARIA

# **Session 1:** Integration of process simulations into the CIP of energy efficiency at Daimler Trucks

**Christian Oberthür** is TOS (Truck Operating System) trainer at the OMCD (Operational Management Counsel Department) TrainingCenter at Daimler's Mannheim based plant. After his apprenticeship as a tool mechanician at MEGA PLAST GmbH (2002-2006) he studied mechanical engineering (2007-2011) at Hochschule Furtwangen University (HFU) and University of New Brunswick (UNB, Canada).
He started his career at Daimler in 2010 during an internship and later wrote his bachelor thesis. His job was to design a process simulation facility for energy efficiency that fits into the portfolio of the TrainingCenter in Mannheim.
In 2011 he became trainer for the operating sytem of Daimler Trucks (TOS). He is performing management trainings as well as improvement projects. Since 2012 the Hochschule Furtwangen University (HFU) engages him as assistant professor to lecture about lean management.

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Daimler AG is one of the world's most successful automotive companies. With its divisions Mercedes-Benz Cars, Daimler Trucks, Mercedes-Benz Vans, Daimler Buses and Daimler Financial Services, the Daimler Group is one of the biggest producers of premium cars and the world's biggest manufacturer of commercial vehicles with a global reach. Daimler Financial Services provides financing, leasing, fleet management, insurance and innovative mobility services.
The company's founders, Gottlieb Daimler and Carl Benz, made history with the invention of the automobile in the year 1886. As a pioneer of automotive engineering, Daimler continues to shape the future of mobility today: The Group's focus is on innovative and green technologies as well as on safe and superior automobiles that appeal to and fascinate its customers. For many years now, Daimler has been investing continually in the development of alternative drive systems with the goal of making emission-free driving possible in the long term. So in addition to vehicles with hybrid drive, Daimler now has the broadest range of locally emission-free electric vehicles powered by batteries and fuel cells. This is just one example of how Daimler willingly accepts the challenge of meeting its responsibility towards society and the environment.
Daimler sells its vehicles and services in nearly all the countries of the world and has production facilities on five continents. Its current brand portfolio includes, in addition to the world's most valuable premium automotive brand, Mercedes-Benz, the brands smart, Maybach, Freightliner, Western Star, BharatBenz, Fuso, Setra and Thomas Built Buses. The company is listed on the stock exchanges of Frankfurt and Stuttgart (stock exchange symbol DAI). In 2011, the Group sold 2.1 million vehicles and employed a workforce of more than 271,000 people; revenue totaled €106.5 billion and EBIT amounted to €8.8 billion.

DAIMLER

# Integration of Process Simulations into the CIP of Energy Efficiency at Daimler Trucks

Mercedes-Benz FREIGHTLINER FUSO WESTERN STAR THOMAS BUILT BUSES BHARATBENZ

Munich, May 7th, 2013
Christian Oberthuer

T/OGC - OMCD TrainingCenter Mannheim

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# Integration of process simulations into the CIP of Energy Efficiency at Daimler Trucks

1 Why and how do we qualify people ?

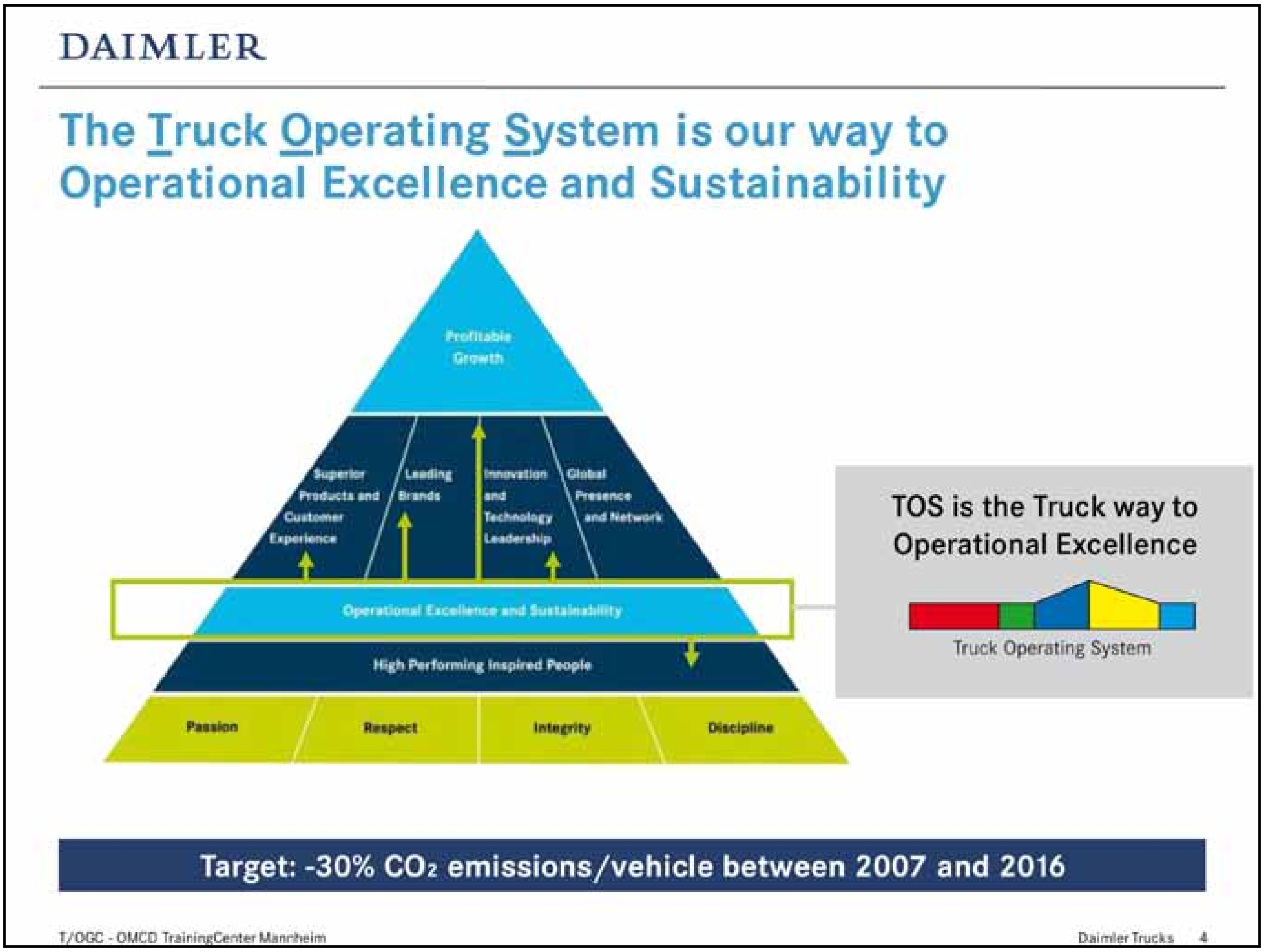
2 How can we integrate the process simulations into continuous improvement ?

3 What further effects can we reach with process simulation ?

4 Summary and Q&A

T/OGC - OMCD TrainingCenter Mannheim Daimler Trucks 2


DAIMLER
For our future...
...nothing is more important than fascinating and ecological products together with highly pleased customers
Ø 1104 kg $CO_2$/unit
Ø 2829 kg $CO_2$/unit
S MB 1664
S MB 9300
In total Daimler consumed 10.599 GWh energy in 2011
Daimler Trucks 3


DAIMLER
The Truck Operating System is our way to Operational Excellence and Sustainability
Profitable Growth
Superior Products and Customer Experience
Leading Brands
Innovation and Technology Leadership
Global Presence and Network
Operational Excellence and Sustainability
High Performing Inspired People
Passion
Respect
Integrity
Discipline
TOS is the Truck way to Operational Excellence
Truck Operating System
Target: -30% $CO_2$ emissions/vehicle between 2007 and 2016
T/OGC - OMCD TrainingCenter Mannheim
Daimler Trucks 4

DAIMLER

## The Operational Management Counsel Department supports the TOS implementation

**OMCD**

**Kevin Bangston**
Director

| Lean Management TG & Asia | Lean Management TE & NAFTA | Global Training & Change Processes | Global Project Mgmt. & Process Office | Strategic Projects |
|---|---|---|---|---|
| **Thomas Jung** Senior Manager  | **Frank Marschner** Senior Manager  | **N.N.** Senior Manager | **Dr. Silke Schulz** Senior Manager  | **Jutta Lischke** Senior Manager  |
| *‚TOS/Lean Management for Powertrain worldwide and Trucks Asia'* | *‚TOS/Lean Management for Trucks Europe & Latin America and Trucks Nafta'* | *‚Training & Change Management Worldwide'* | *‚Project Mgmt. Support & Methods worldwide, Commercial Vehicle Development System and Global Process Office Trucks'* | *‚Strategic Projects (IIP) & Indirect TOS/Lean Management Worldwide'* |

**Five specialized departments within one unit ensure customized consulting, education and project support**

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## The Process Simulation Facilities @ TC Mannheim

Manufacturing: TPM/Fast Changeover; PSF-Energy Efficiency → Assembly & Logistics: PLF-Direct → Order Management: PLF-Indirect

**Manufacturing**

**1 cross-functional value stream**

- One product from machining to sales

+

**Assembly & Logistics**

**Almost similar methods**

- CIP approach
- Stabilize, Flow, Tact, Pull

=

**Order Management**

**One common understanding**

- Easy knowledge transfer
- Train the CIP behavior

- **Additional modules according Lean philosophy e.g. Shop Floor Management and KPI* derivation**

* KPI = Key Performance Indicators

Daimler Trucks

DAIMLER

## Integration of process simulations into the CIP of Energy Efficiency at Daimler Trucks

1. Why and how do we qualify people ?
2. How can we integrate the process simulations into continuous improvement ?
3. What further effects can we reach with process simulation ?
4. Summary and Q&A

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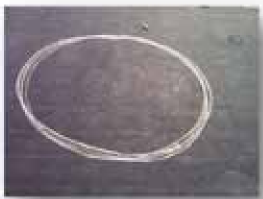
## Lean Trainings directly support the CIP process in three major fields of action

**Process Support**
- Chalk Circle
- Standardized waste walks



**ee Project Preparation**
- Dedicated training for project groups

**ee Employee Level Trainings**
- Adopted didactic concept and organizational frame work
- Local execution of trainings

T/OGC - OMCD TrainingCenter Mannheim — Daimler Trucks 8

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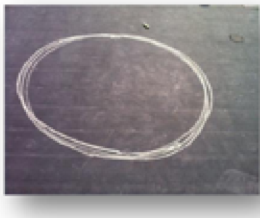
## The Chalk Circle uses knowledge of the trainees and their third party perspective to find wastes



- Process Simulation Facility guarantees didactic success
  - **Controllable** starting situation
  - **Quick** implementation of change
  - **Immediate** success
- Chalk Circle or Waste Walks are used in various Lean trainings at Daimler Trucks
  - Randomly choose a **repetitive process**
  - **Monitor process** for 20-40 min at 3 to 5 spots
  - Evaluate waste **and** best practice
  - Suggest improvements **to process owners**
- Real process environment helps to transfer knowledge
  - **Realistic** dimensions and ramifications
  - **Successful** diagnosis
  - **Handover** of improvements to functional areas

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## Project groups are supported before the project starts and at critical points

Organization of TOS Expert Projects
- Lean experts, trainees and functional area representatives
- 3 months separated in **3 phases**
- Energy Efficiency as **main or subordinate target**

| Analyze | Implement | Stabilize |
|---|---|---|
| • Prepare project group with basic qualification<br>• Focus specific project topic in training | • Support in the application of specific methods<br>• Support in measurements with hardware and know how | • Revisit areas with chalk circle or waste walk to ensure sustainability<br>• Use project success as best practice |

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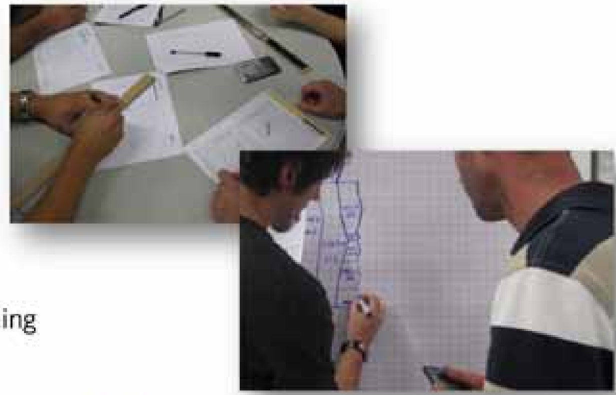
## Reaching a broad range of workers by using a mobile education module following the PSF concept

**Why** do trainings beyond the PSF?

- Increase of training capacity to quickly spread knowledge
- Reduce travel efforts for blue color staff across Germany
- Empower local Lean representatives:
  - "Train the Trainer" processes
  - Handover processes for two plants
  - Make use of own production sites within training



ee is more than a management decision…

ee is an integral target which needs:

- a common understanding of its importance
- CIP ideas from people on site
- convinced people who believe in the fact that methods work in every industrial environment
- target group specific learning contents

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## Integration of process simulations into the CIP of Energy Efficiency at Daimler Trucks

1 Why and how do we qualify people ?

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4 Summary and Q&A

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# Qualification has become an integral part of Management Trainings

Roll-out as part of management qualification started

- **More than 300** managers and experts trained so far
- Focus on **Truck Powertrain** components and corporate functions
- Focus on **1 day** trainings

Roadmap shows upcoming challenges for qualification

- **Clear target** for qualification rate
- Focus on **manufacturing engineering** addressed with 2 and 3 day trainings


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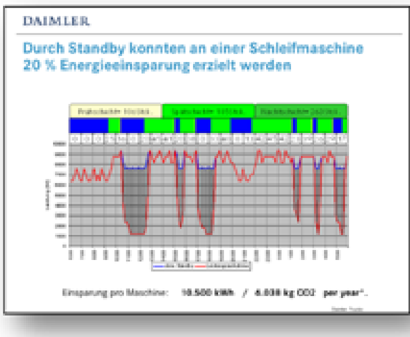
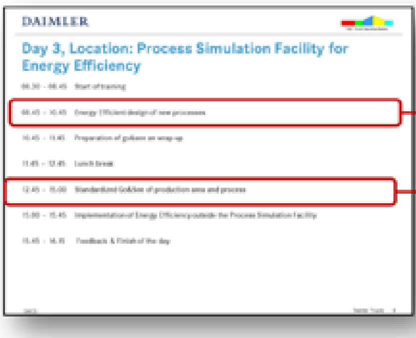
# Next generation equipment and building technology builds foundation for long term success

Energy Efficiency know how is integrated in equipment procurement process

- Checks and measurements at **various points** in procurement process
- Lifecycle energy costs are **part of TCO***




Training covers energy efficiency in process design

- **Practical application** of checks in equipment procurement process
- Waste walk with best practice of new equipment

T/OGC - OMCD TrainingCenter Mannheim *Total Cost of Ownership Daimler Trucks 14

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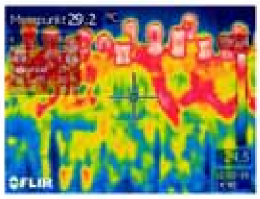
## „Spreading the virus“ across and beyond Daimler supports our way to a green automotive production

- Process Simulation Facility operated by apprentices
- Apprentices **train their colleagues**



- Lean Training is part of Daimler's talent program
- **PSFee included** since 2012

- Kaizen champions contribute to the CIP with hundreds of suggestions
- ee-Training is a **reward** for past successes and an **investment** in future suggestions

- The **Jugendakademie** is part of Daimler's education marketing
- **Kick-Off** event at PSF-ee
- Since 2013 ee trainings can be booked by **universities** and associated companies

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PSF-ee = Process Simulation Facility for Energy Efficiency

Daimler Trucks 15

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## Integration of process simulations into the CIP of Energy Efficiency at Daimler Trucks

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Thank you!
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Daimler Trucks 17

# Session 1: Die Lernfabrik - Research and education for sustainability in manufacturing

**Prof. Dr.-Ing. Christoph Herrmann** is university professor for Sustainable Manufacturing & Life Cycle Engineering and co-director of IWF, Institute of Machine Tools and Production Technology, Technische Universität Braunschweig. Since 2009 he leads the Joint German-Australian Research Group on "Sustainable Manufacturing and Life Cycle Management" together with Prof. Sami Kara from the University of New South Wales (UNSW), Sydney. Prof. Herrmann has studied mechanical engineering / production engineering. He was research assistant at IFH (Institute of Production Automation and Handling Technology) and IWF. After his doctor degree (Dr.-Ing.) in 2003 he habilitated in production engineering in 2008 and was appointed associate professor (apl. Prof.) in 2011. As a company's founder (2002-2007) he has transferred tools and services to support design for environment into the electric/electronic and automotive industry.
From 2005 to 2008 he was also scientific director of KERP Center of Excellence Environment & Electronics, Vienna. From 2009 to 2013 he was scientific director and member of the NFF (Niedersächsisches Forschungszentrum Fahrzeugtechnik), Germany. In 2011 Prof. Herrmann's team together with colleagues from Fraunhofer and industry partners has won the German Resource Efficiency Award from the Federal Ministry of Economics and Technology, Germany. Professor Herrmann has conducted various industry and research projects in the context of life cycle engineering and sustainable manufacturing on national and international level. He was chairman of the international conference series Eco-X in 2005 and 2007 in Vienna and chairman of the 18th CIRP Conference on Life Cycle Engineering held in Braunschweig in 2011. He has published more than 200 papers, book publications as author, co-other and editor.

The Institute of Machine Tools and Production Technology (IWF) of the Technische Universität Braunschweig is part of the Faculty of Mechanical Engineering and has a long tradition and history.
Today the institute has two directors: Prof. Dr.-Ing. Klaus Dröder (Production Technology & Process Automation) and Prof. Dr.-Ing. Christoph Herrmann (Sustainable Manufacturing & Life Cycle Engineering). Main research areas are manufacturing processes, manufacturing technologies for lightweight and functional structures, process simulation, mechanisms and robotics, mechatronics/adaptronics and smart materials, handling/assembly automation, e-mobility, battery production, energy and resource efficiency, life cycle planning, life cycle assessment/costing.

Technische Universität Braunschweig

Die Lernfabrik
Research · Education · Application

## Die Lernfabrik – Research and Education for Sustainability in Manufacturing

Prof. Dr.-Ing. Christoph Herrmann
Institute of Machine Tools and Production Technology (IWF)
Sustainable Manufacturing & Life Cycle Engineering Research Group

## Agenda

- Short Introduction to IWF
- Sustainability and Industry
- Holistic Perspective on Factories
- Die (grüne) Lernfabrik * – Concept and Implementation
  * The (Green) Learning Factory
- Summary and Outlook

Technische Universität Braunschweig

Prof. Christoph Herrmann | IWF | TU Braunschweig | 3rd CONFERENCE ON LEARNING FACTORIES
7th May, 2013 | Slide 2

Die Lernfabrik
Research · Education · Application

## Agenda

**Short Introduction to IWF**

Sustainability and Industry

Holistic Perspective on Factories

Die (grüne) Lernfabrik * – Concept and Implementation

* The (Green) Learning Factory

Summary and Outlook

Technische Universität Braunschweig

Prof. Christoph Herrmann | IWF | TU Braunschweig | 3rd CONFERENCE ON LEARNING FACTORIES

7th May, 2013 | Slide 3

Die Lernfabrik – Research · Education · Application

## Institute of Machine Tools and Production Technology

Institut für Werkzeugmaschinen und Fertigungstechnik IWF

**Prof. Dröder**
**> Production Technology & Production Automation <**

**Production Technology – Dr. Hoffmeister –**

- cutting processes
- precision machining
- machining and processing of derived timber- and synthetic materials
- machine tool development
- modeling & simulation

**Assembly and Production Automation – Dr. Raatz –**

- development of automated handling- and assembly processes
- robot technology and assembly cells
- machine concepts for handling, assembly, automation

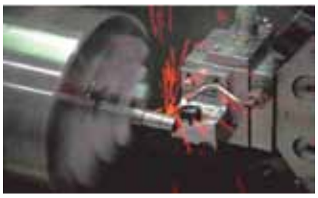
**Prof. Herrmann**
**> Sustainable Manufacturing & Life Cycle Engineering <**

**Sustainable Manufacturing – Dr. Thiede –**

- energy- and resource efficiency in manufacturing (metering, modeling & simulation, visualization, ERP-integration)
- vision "Mineral Oil free Production" – alternative cooling lubricants

**Life Cycle Engineering – Dr. Dettmer –**

- life cycle evaluation (life cycle assessment, life cycle costing)
- technology management
- circulation factories (disassembly , recycling, reuse, remanufacturing)
- methods and tools supporting EMFA and DfE



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7th May, 2013 | Slide 4

Die Lernfabrik – Research · Education · Application

Fraunhofer IWU iwb

## Agenda

Short Introduction to IWF

**Sustainability and Industry**

Holistic Perspective on Factories

Die (grüne) Lernfabrik * – Concept and Implementation

* The (Green) Learning Factory

Summary and Outlook

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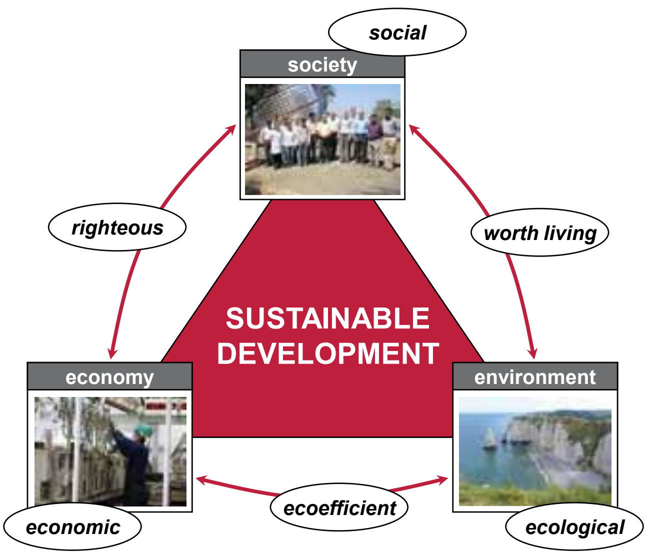
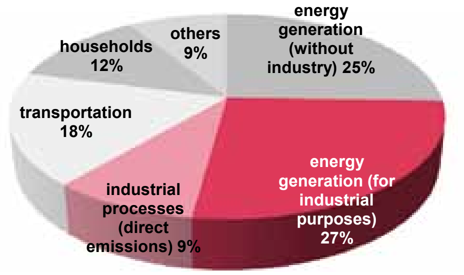
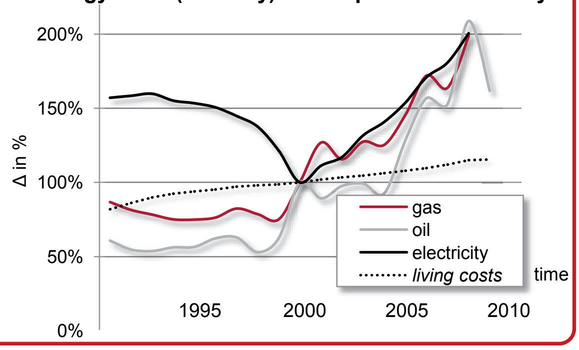
## Sustainability and Industry




**Composition of $CO_2$ Emissions in Germany**




**Energy Price (Industry) Development in Germany**

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Die Lernfabrik Research · Education · Application

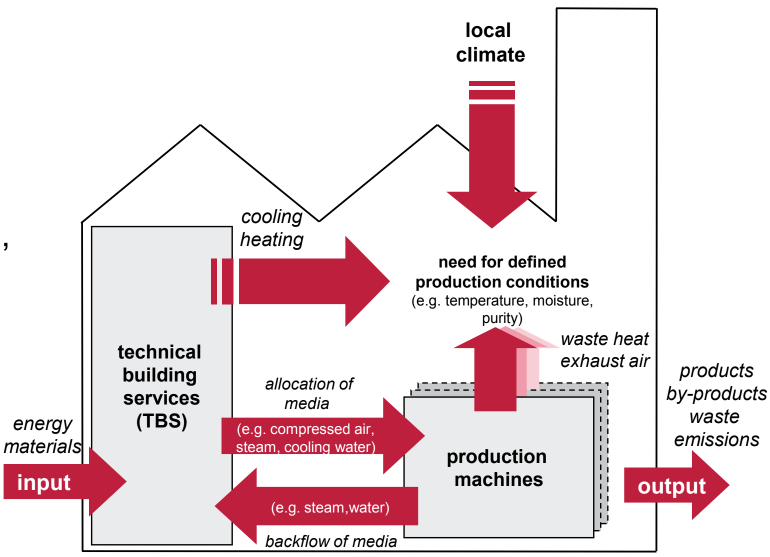
## Agenda

- Short Introduction to IWF
- Sustainability and Industry
- **Holistic Perspective on Factories**
- Die (grüne) Lernfabrik * – Concept and Implementation
  * The (Green) Learning Factory
- Summary and Outlook



## Holistic Perspective on Factories

- energy and resource consumption in factories determined by manifold single consumers
- holistic perspective necessary
  - production – single processes, machines, process chains
  - technical building services (TBS), e.g. compressed air, renewable energies
  - building shell
- consideration of all relevant energy and material flows



## Agenda

Short Introduction to IWF

Sustainability and Industry

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Summary and Outlook

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## Concept – Motivation and Objectives

**Motivation**

- increasing relevance of  the topic “Sustainability in Manufacturing“
- important background knowledge is often missing
- difficult communication due to e.g. “non-visible influences” (e.g. electricity) or indirect impact (e.g. contribution of energy consumption to climate change)
- dynamic interaction of single consumers
- “the one” efficiency-measure does not exist

**Objectives**

- creating a test bed as a platform for experimentation
- enabling practical experience and further development of the topic and specific fields of action

Reference: Volkswagen AG

Reference: Messer Industriegase GmbH

Reference: Handelskammer zu Leipzig

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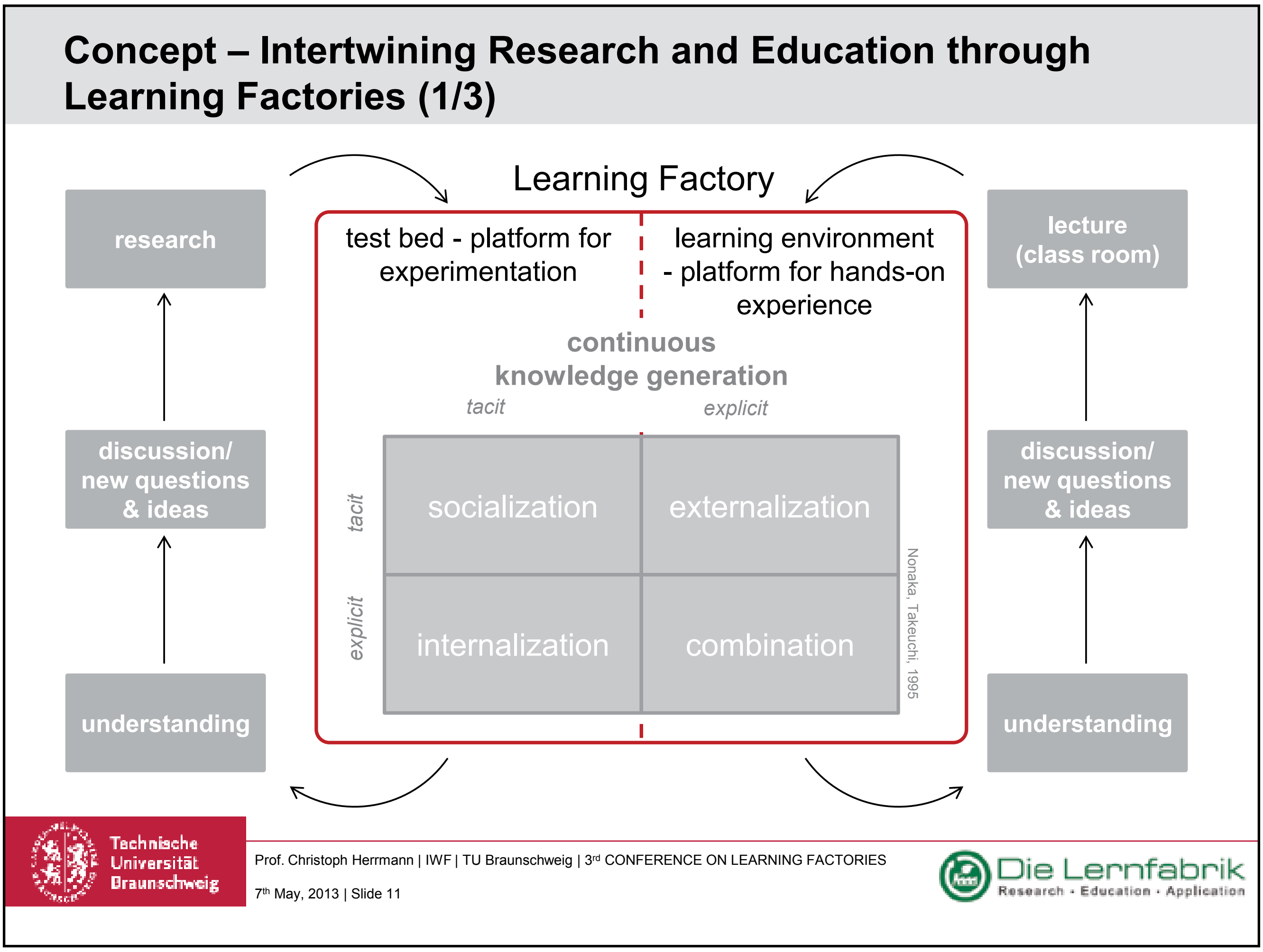
Concept – Intertwining Research and Education through Learning Factories (1/3)
Learning Factory
research
discussion/ new questions & ideas
understanding
lecture (class room)
discussion/ new questions & ideas
understanding
test bed - platform for experimentation
learning environment - platform for hands-on experience
continuous knowledge generation
tacit
explicit
tacit
explicit
socialization
externalization
internalization
combination
Nonaka, Takeuchi, 1995
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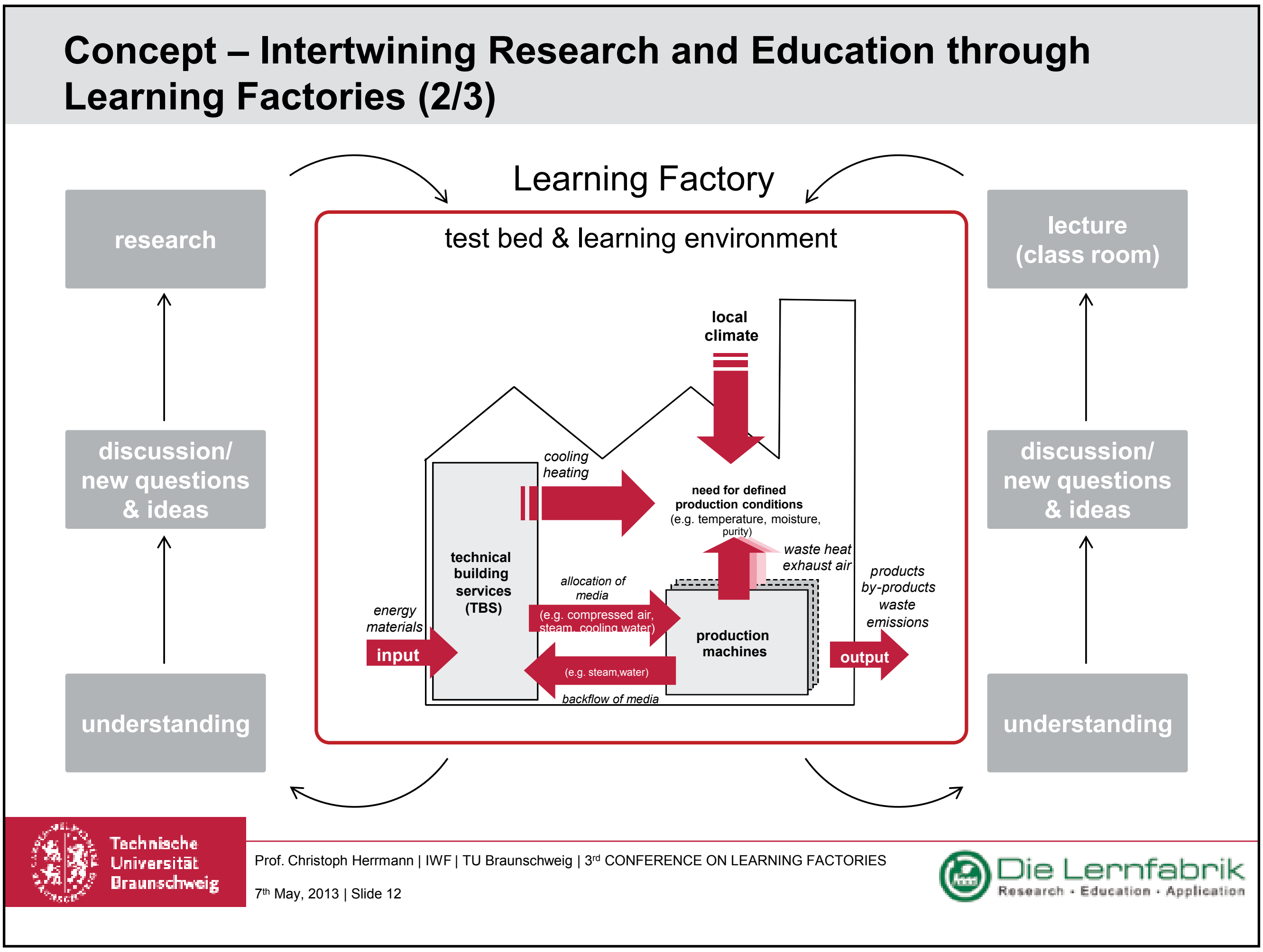
Concept – Intertwining Research and Education through Learning Factories (2/3)
Learning Factory
research
discussion/ new questions & ideas
understanding
lecture (class room)
discussion/ new questions & ideas
understanding
test bed & learning environment
local climate
cooling heating
need for defined production conditions (e.g. temperature, moisture, purity)
technical building services (TBS)
waste heat exhaust air
products by-products waste emissions
allocation of media
(e.g. compressed air, steam, cooling water)
energy materials
input
production machines
output
(e.g. steam,water)
backflow of media
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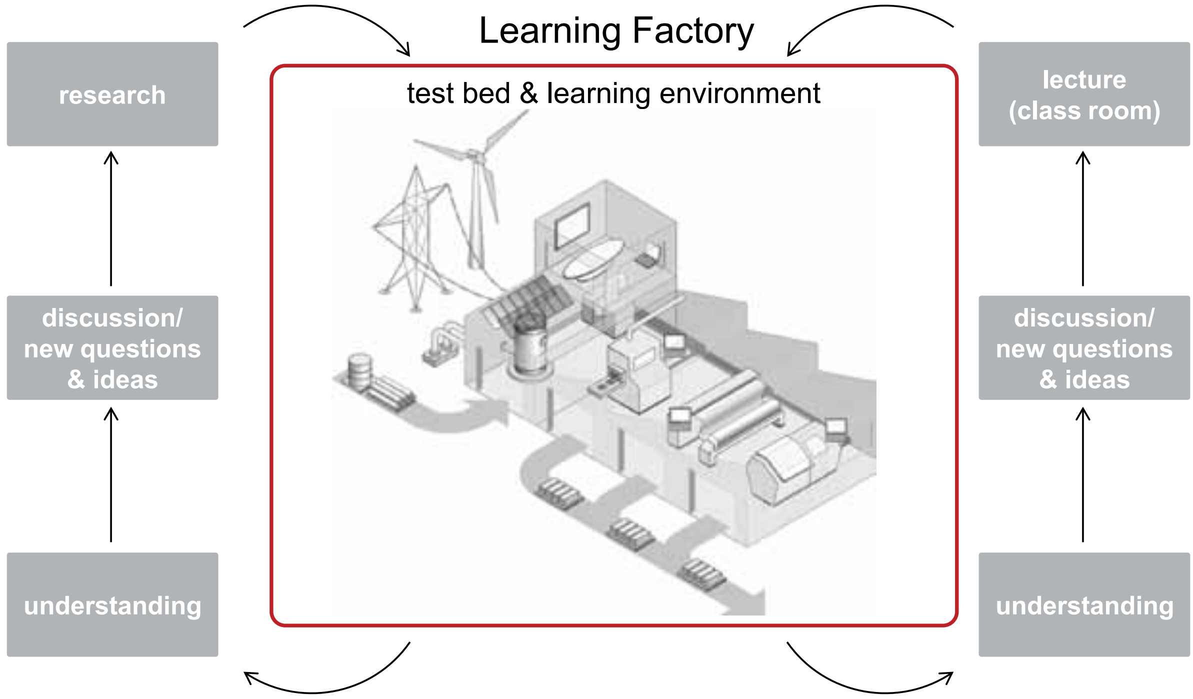
## Concept – Intertwining Research and Education through Learning Factories (3/3)

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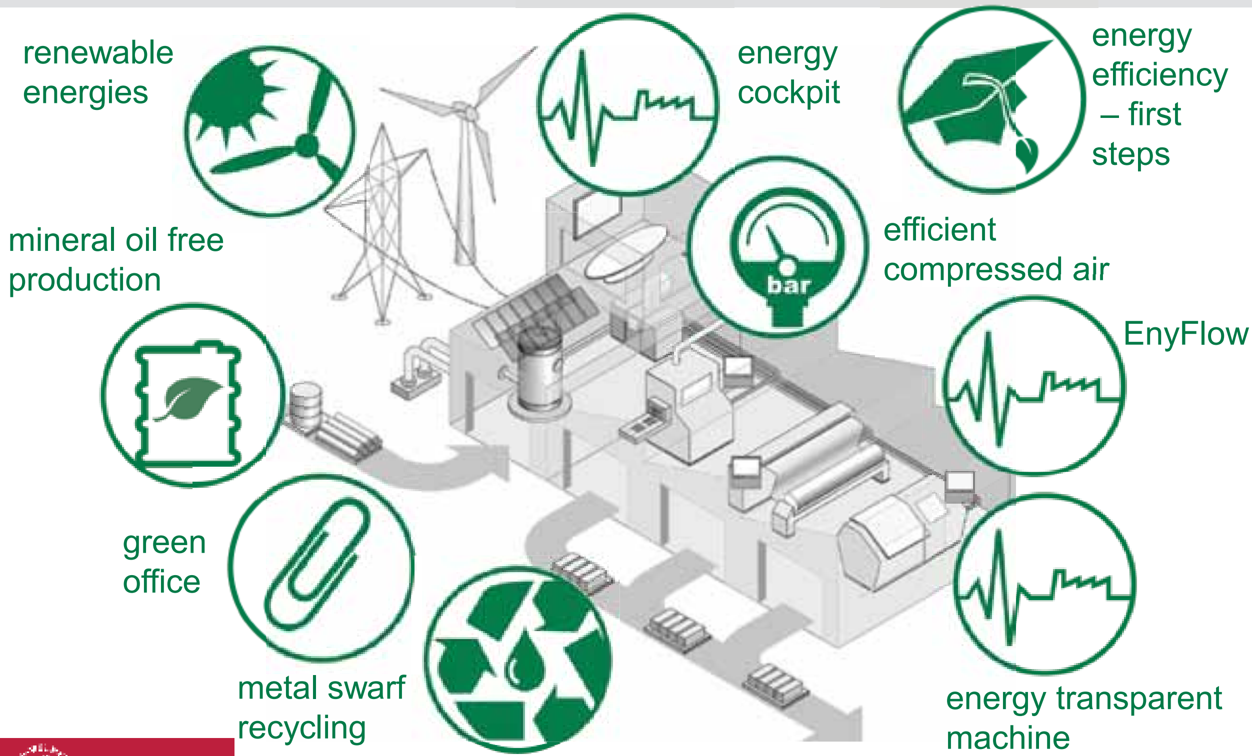
## Implementation – Elements of the Test Bed and Learning Environment

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## Implementation – Efficient Compressed Air


### Compressed Air – How to Use

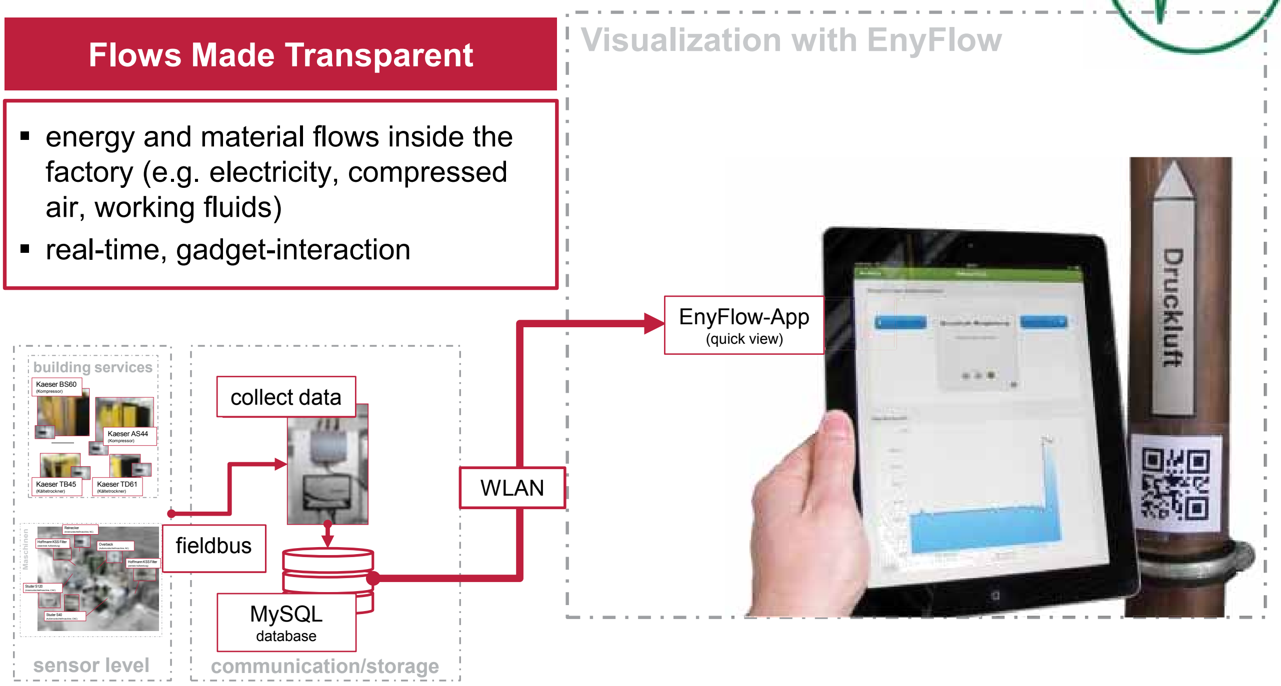
- analysis of the whole energy conversion process (calculate cost and related environmental impact)
- design of supply lines (dimensioning, use of different tools)
- find and eliminate leaks




## Implementation – EnyFlow (1/2)

### Flows Made Transparent

- energy and material flows inside the factory (e.g. electricity, compressed air, working fluids)
- real-time, gadget-interaction



## Implementation – EnyFlow (2/2)

**Flows Made Transparent**

- energy and material flows inside the factory (e.g. electricity, compressed air, working fluids)
- real-time, gadget-interaction

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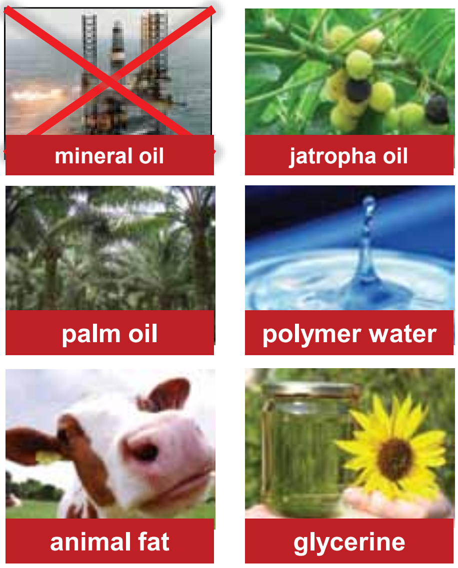
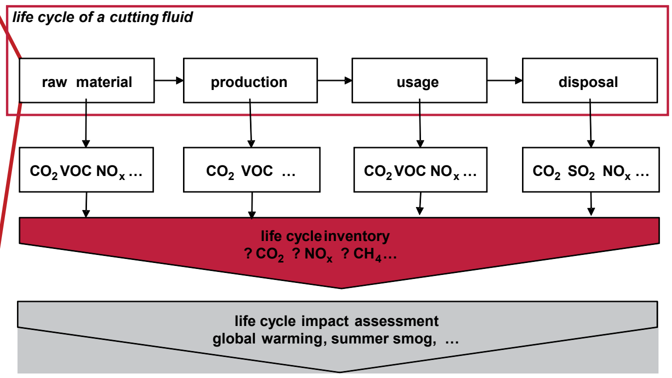
## Implementation – Mineral Oil Free Production (1/2)




Life Cycle Assessment

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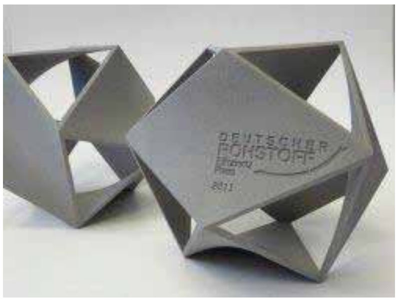
## Implementation – Mineral Oil Free Production (2/2)



DEUTSCHER ROHSTOFF Effizienz Preis

Bundesministerium für Wirtschaft und Technologie

**Substitution of Mineral Oil Based Fluids**

- mineral oil-free working fluids and hydraulic fluids
- how to use life cycle assessment and life cycle costing for decision making

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## Implementation – Renewable Energies


**Energy Management**

- management of supply with different energy carriers, e.g. peak balancing
- towards zero emission and self-sustaining factories

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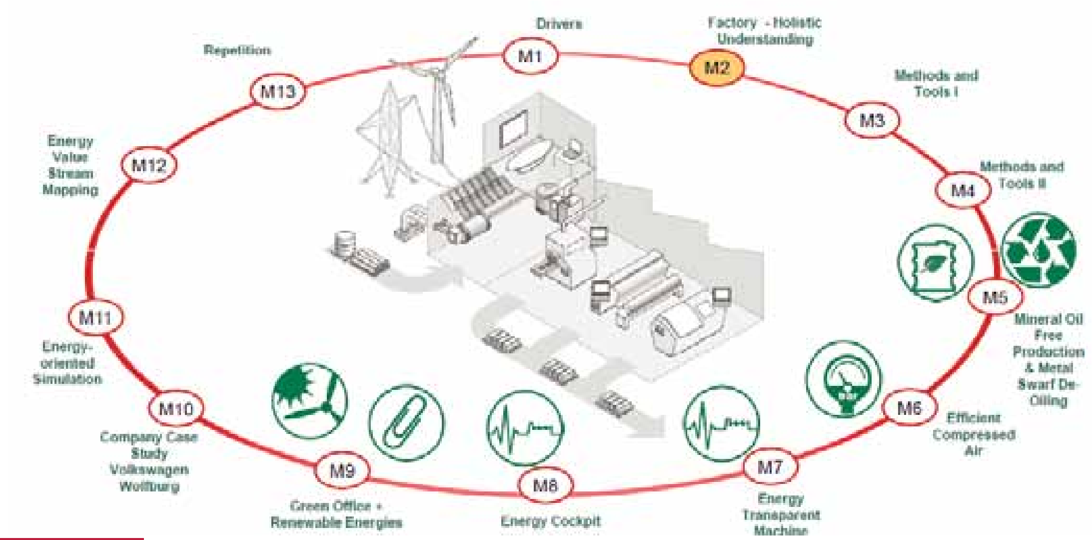
## Implementation – Master Course "Sustainability in Production Engineering"

practical exercises in "Die Lernfabrik"

lecture (class room)

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**Summary and Outlook**

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## Summary and Outlook

- research

  *derivation, prototypical installation/implementation and testing of innovative approaches (methods, tools, technologies) for improving energy and resource efficiency and effectiveness*

- education

  *platform for practical exercises as part of bachelor and master courses as well as for workshops with students and industry*

- application

  *"live experience" of developed approaches for improving energy and resource efficiency and effectiveness in industry-near demonstrators, e.g. battery production*

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Die Lernfabrik Research · Education · Application

## Die Lernfabrik – Research and Education for Sustainability in Manufacturing

Prof. Dr.-Ing. Christoph Herrmann
Institute of Machine Tools and Production Technology (IWF)
Sustainable Manufacturing & Life Cycle Engineering Research Group

# **Session 1:** The concept of the new Research Factory at Fraunhofer IWU – to objectify energy and resource efficiency R&D in the E3-Factory

**Prof. Dr.-Ing. Matthias Putz** received his PhD in Mechanical Engineering in 1986. After that, he started his scientific career as Senior Research Assistant at Department of Machine Tools (forming machines and presses) at Chemnitz University of Technology. During that time he had the chance to work as visiting lecturer at the Department of Mechanical Engineering at University of Aleppo in Syria (1988 until 1990). From 1993 until 1994, Professor Putz worked in the German metal working industry, where he collected considerable experience in managing large projects as Project Engineer and Manager. In 1994, he started his career at Fraunhofer IWU in Chemnitz. From 1999 to 2000, he coordinated the Fraunhofer IWU research branch office activities in Ann Arbor, Michigan, USA. Afterwards, he worked as Division Director of Forming Technology at Fraunhofer IWU until 2005. In 2006 and 2007, he was responsible as Chief of Engineer Research and Development and as Deputy Director at Fraunhofer IWU Chemnitz. Since 2008, Professor Putz has been the Coordinator of the BMBF-funded R&D Innovation Alliance "Green Carbody Technologies" InnoCat. From 2008 to 2011, he worked as Division Director System Technology followed by the position as Division Director Production Management at Fraunhofer IWU in 2012.

„Research for the Future" is the motto of the Fraunhofer Institute for Machine Tools and Forming Technology IWU. This is exemplified by the Institute's strong emphasis on application-oriented research and development in the field of production technology for the automotive and mechanical engineering sectors.
With an annual budget of about 34 million euros and over 520 highly qualified engineers and scientists, combined with laboratories for machine tools, forming and joining technology, mechatronics, precision technology and Virtual Reality in Chemnitz, Dresden, Augsburg and Zittau, Fraunhofer IWU is recognized as one of the leading contractual research and development institutions across Germany in our specialized fields of work.

# 3rd Conference on Learning factories

**"Increasing resource efficiency through education and training"**

## The concept of the new Research Factory at Fraunhofer IWU – to objectify energy and resource efficiency R&D in the $E^3$-Factory

Prof. Matthias Putz
Fraunhofer IWU Chemnitz

Munich, May 7th 2013

München, 7.5.2013 - Pz



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## The FRAUNHOFER IWU

An Institute of the Fraunhofer-Gesellschaft

FRAUNHOFER IWU 20 Jahre IDEENFABRIK

- **Short Profile**

- ~ 510 employees
- 29 M € volume in project research (2012), ~50% industry
- 4 000 m² testing field
- Institute branches in **Chemnitz,** Dresden, Augsburg, Zittau

IWU testing fields

R&D competency **"Resource-Efficient Production"**

**Fields of Research**

- Machine tools
- Mechatronics
- Lightweight structures
- Cutting technologies
- Forming technologies
- Joining and assembly technologies
- **Production management**

IWU Campus Chemnitz

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## AGENDA

1. Energy and resource efficiency – drivers and challenges

2. Research focus energy and resource efficient factory
   - The E³-factory – the IWU approach

3. BMBF Innovation Alliance "Green Carbody Technologies" - *InnoCaT*
   - The *InnoCaT* Reference Factory

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## Energy and Resource Efficiency – Drivers and Challenges

### Competiveness Factors for the Factories of the Future

- **AVAILABILITY and PRICE of the required resources are prerequisites for success in the economic competition**
- **Energy- and resource-efficient technology OPTIONS lead to sustainable competitive advantages**
- **Energy MANGEMENT on a high level will be decisive for mastering the turnaround in energy policy**

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## Energy Efficiency 2.0

Ensuring prosperity in a more complex “energy environment” for industry

Energy Efficiency 1.0

- **Savings**
  energy becomes scarce and expensive

2012 et seq.

**Energy Efficiency 2.0**

- **Volatility**
  energy shortage and surplus alternate, storage requirements
- **Regionality**
  energy cannot be transported arbitrarily
- **Conjunction of rolls**
  rols of consumers and producers mix
- **Transparency**
  broad opinion making process without ideologies in the population

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## Boundary Conditions in Energy Production (Germany)

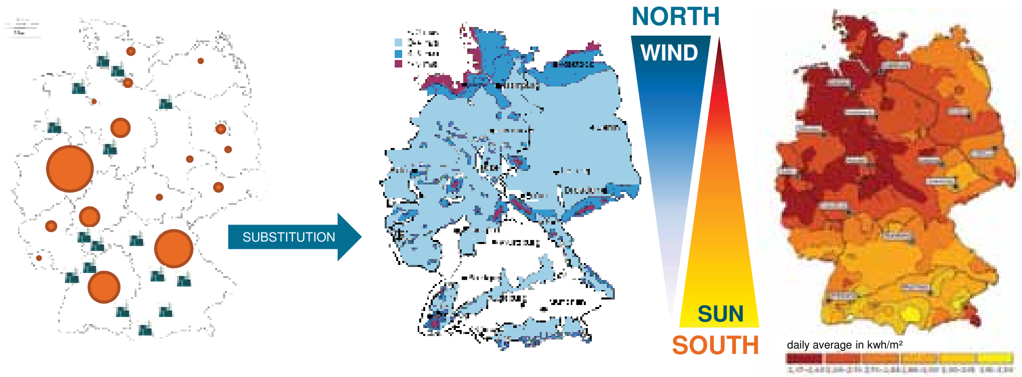
**Industry influences amount of energy demand**

GDP Portions and Nuclear Power Plants in Germany

**Energy yield in renewable energies**

Wind Energy

Solar Energy




**Future Challenges / Problems**

- Inflexible ad hoc production and supply of energy
- High expenditure for the transport of energy between north and south
- Missing storage capacity / high losses of transformation

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## Using a mobility approach … ?

**USA**

Houses follow jobs …

**Germany**

Factories follow energy allocation ?



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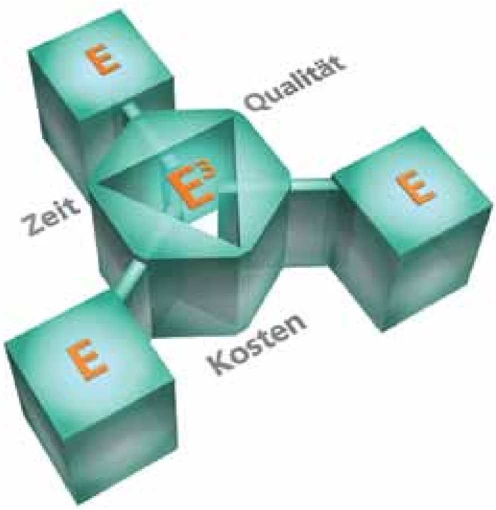
## E³-Factory of the Future – towards E³-Production

E³-Factory – value creating and competitive




Efficient

Emission neutral

Embedding human needs



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## Research Focus "energy efficient factory" ?

- Increase in cost for electricity 2000-2011: approx. 100 % (automotive industry)
- Business success = **f** (quality, productivity, flexibility, **energy cost**)

→ **E³- factory:** energy self-sufficient, emission neutral, ergonomic **factory**

3-Step-Method in Production Technology to Reduce the Energy Cost / "Needs"

- Production optimized in efficiency
  - Efficiency technologies, process reliability
  - Low-energy production plants
  - → **Efficiency**
- Total energy management
  - Energy chains, "closed" energy cycles
  - → **Sustainability**
- Use of independent energy sources
  - → **Substitution**

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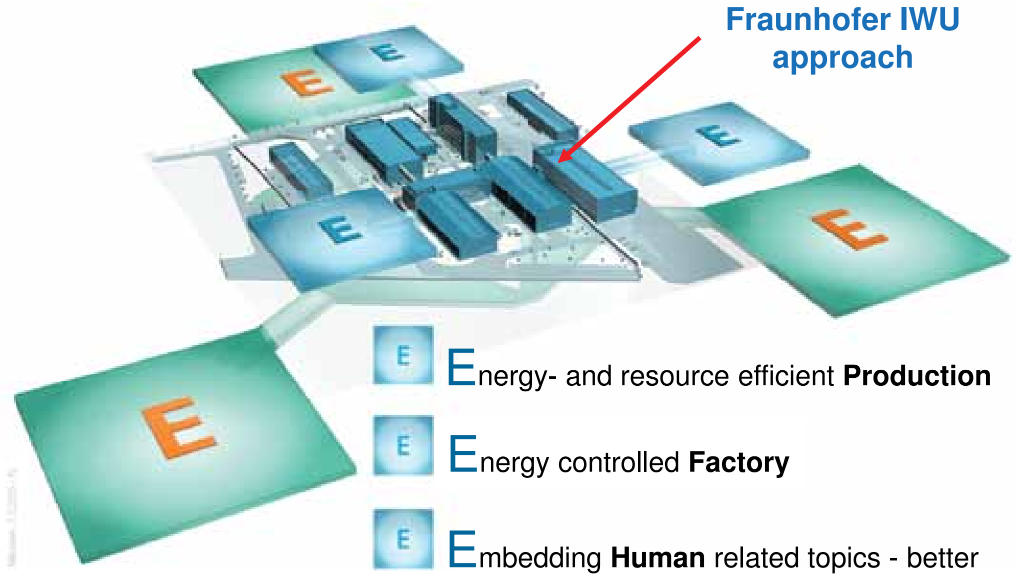
## E³ - Factory of the Future – E³-Production …

E³ - Factory – the value creating, competitive factory




Energy- and resource efficient **Production**

Energy controlled **Factory**

Embedding **Human** related topics - better



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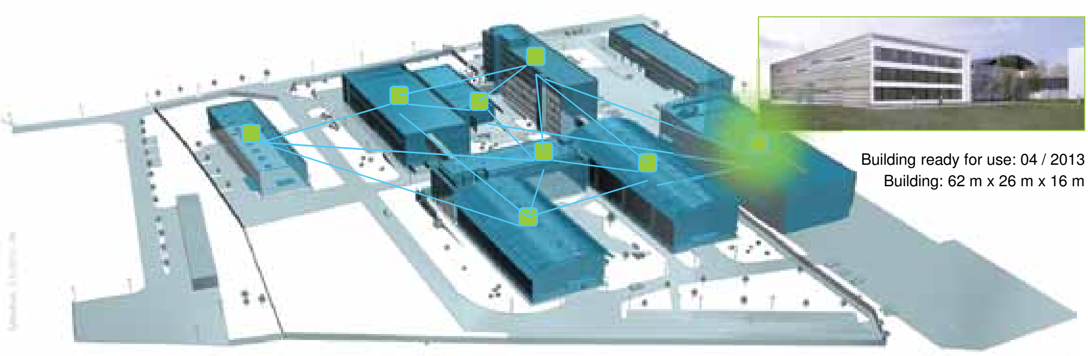
## E³ - Factory of the Future – E³-Production …

New E³-Factory – testing field at Fraunhofer IWU Chemnitz

IWU approach: **R&D-factory "Resource efficient Production"**

- Advanced Technology focus: a) Body-in-white; b) Powertrain components
- New Control and Management focus: Use of alternative energy sources in production and new level of energy management
- Interaction of Production techniques and facility/building utility management



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# Total Energy Management

## Recording and Balancing of the Resource and Energy Consumption on Technology level

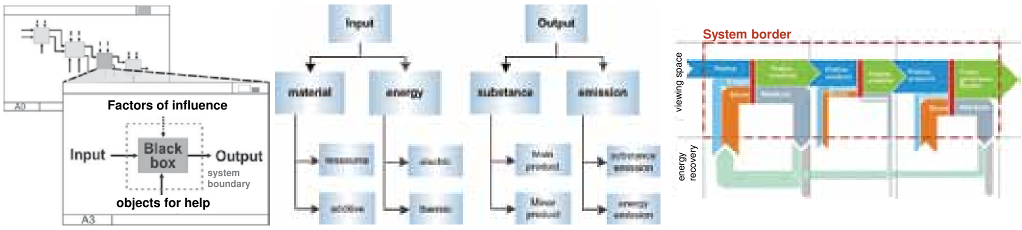
**balancing of the individual processes** → **process chain balance (= total balance)** → **Technology options and measures to increase efficiency**

- Approach of systems theory
- Energy-oriented analysis of the process parameters

- Representation of the processes as modules

→ Flexibility as regards link to the process chains

- Reference values for evaluation
- Detection of energy- and resource-sensitive control variables



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# Total Energy Management

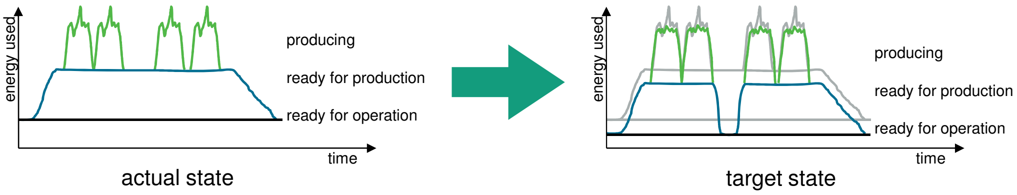
## Energy-Sensitive Control in carbody production

→ Model of dependencies between the components of the plant / infrastructure / building control system (dependency graph)

- Determination of **resource relationships** between components
- Recognition of logically directly adjacent components

- Procedure during operating production
  - **Reacting** to consumption changes of components
  - **Suggestions** for optimized operating states of dependent components

→ **Specific use of potential savings**



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# E³ - Factory of the Future (Fraunhofer IWU)

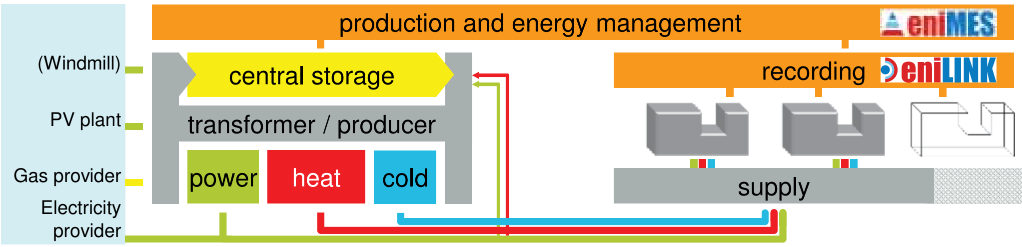
## General Energy Concept

IWU research factory »Resource Efficient Production«

Decentralized production of energy & media by using renewable energy.

Energy storage (short-term, medium-term, long-term) to smooth out peaks, to refeed energy loss and for independent operation.

Energy-sensitive management to completely record and synchronize all flows of order, material and energy.



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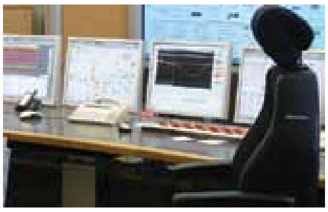
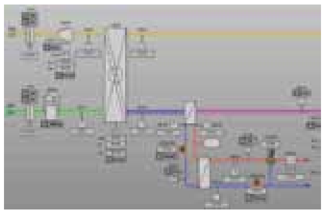
## Need for action

Production (MES)



Energy (EMS)



IS, Building (BMS)

**Coordinated control** of all components of production & infrastructure (production, building)

**Optimization of resource utilization** during factory operation, taking all production targets into account

**Basis: Transparency** concerning resource utilization and resource flows by means of monitoring

eniMES

function blocks | standardized interfaces | modular services



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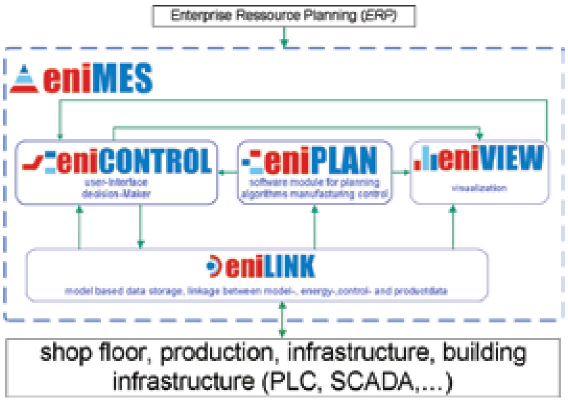
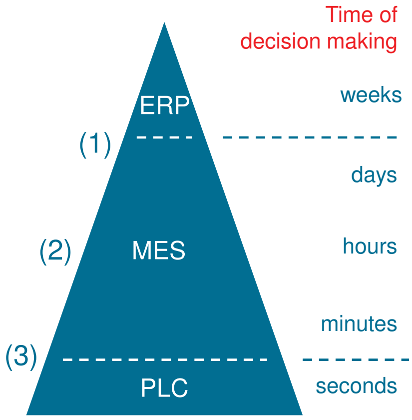
## Software framework eniMES

(1) Energy-sensitive order scheduling (part of eniPLAN)

(2) Energy-sensitive control of material flow (part of eniPLAN)

(3) Energy-sensitive control of operating states (eniCONTROL)



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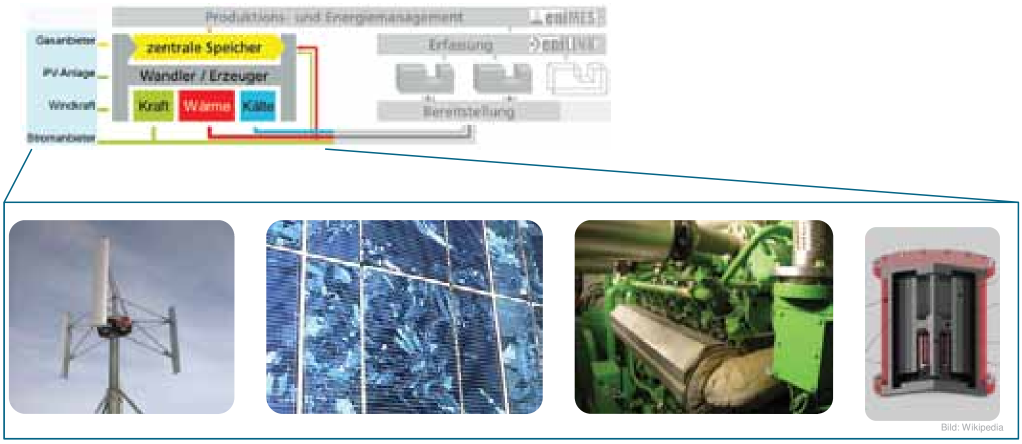
## Energy supply concept

eniFAB




Wind turbine (future Demonstrator) IWU production technology competence (hydroforming of metal rotor blades).

System demonstrator Photovoltaic (58,5 $kW_{peak}$) (included in facility)

El. power, heat and cold provided by a BHKW (238 $kW_{el}$/363 $kW_{th}$) coupled with an absorption-machine (210 $kW_{th}$).

Flywheel (500 kW·14s) collects excessive el. energy and delivers it to smoothening load pikes



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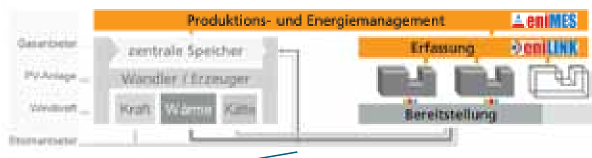
## Energy management concept

eniMES




**Semantic-Web-based information system**

To automat. link measured energy data with planning and operational data of the equipment (structure, behavior, condition) and by this generating new knowledge.

**Energy sensitive Control system**

Optimize all resource needs, recognizing completely the production targets, by a coordinated control of production, Infra structure, facility automation.

**Interaction and Visualization**

Web based services for an interactive visualization of simulated and real Energy data (usable on any standard conform web browser) as basis for mobile-IT assistant systems.

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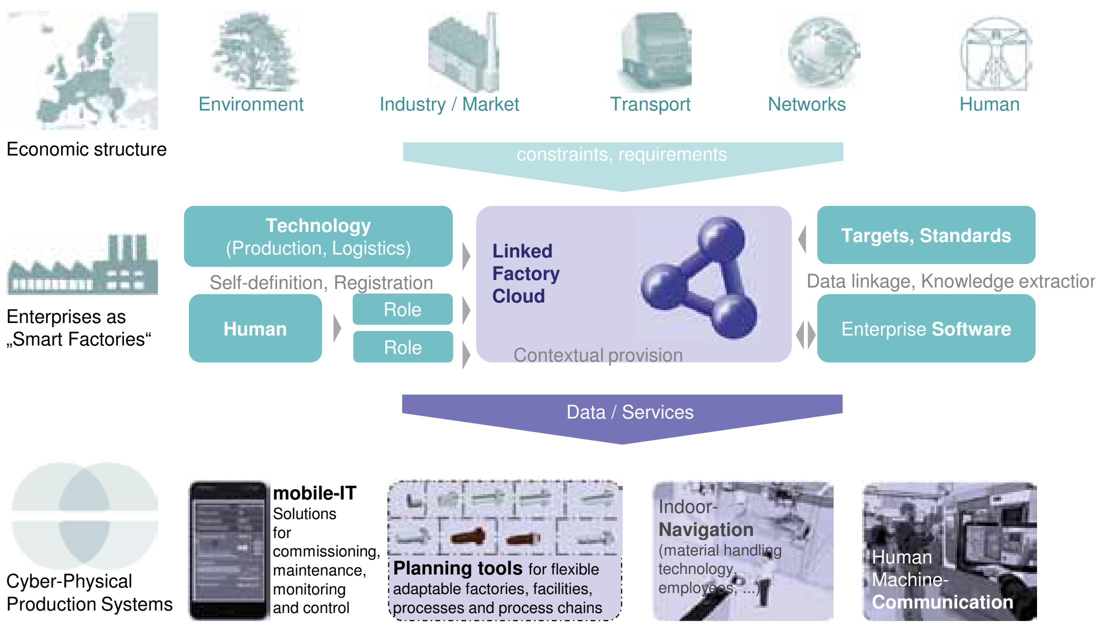
## IWU approach towards Industry 4.0

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# AGENDA

1. Energy and resource efficiency – drivers and challenges
2. Research focus energy and resource efficient factory
   - The E³-factory – the IWU approach
3. BMBF Innovation Alliance "Green Carbody Technologies" - *InnoCaT*
   - The *InnoCaT* Reference Factory

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## INNOVATION ALLIANCE "GREEN CARBODY TECHNOLOGIES"
## *InnoCaT*

### Partners


### Joint Projects

| | |
|---|---|
| **Project duration:** | **3 years** (2010-2012) |
| **Total number of partners:** | **60** |
| **Total number of subprojects:** | **30 (selected)** |
| **Total project volume:** | **approx. 30 Mio Euro** |

Innovations-Allianz
Green Carbody Technologies

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## Innovation Alliance “Green Carbody Technologies“

**Research Approach**

- Research for **car body production,** oriented towards technology and plants
- Integrated approach for early **planning** and permanent **control**

semi-finished product sheet metal | tool making | press plant | car body | painting

**Planning** →

| Energy expenditure for **resources** | Energy requirements of **technologies** | Energy consumption of **production equipment** | Energy requirements for **infrastructure** |
|---|---|---|---|

**Research Focus**



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## »Planning of Low-Energy Production«

## frame-project *InnoCaT 1*

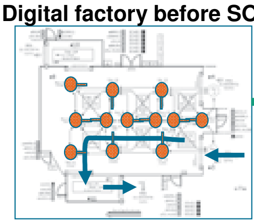
Innovations-Allianz Green Carbody Technologies

Today:
- “Energy“ underrepresented as criterion of planning and control
- Evaluation of energy efficiency is subjective and inhomogeneous

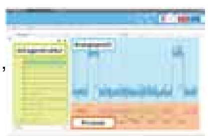
Research focus: **“energy data sensitivity“**

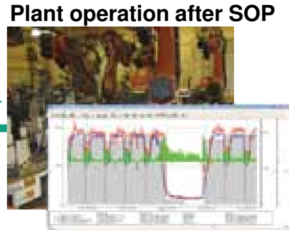
1. **Production information systems** → **Energy-related efficiency indicators**
2. **Planning before SOP** (“digital factory“) → **Energy parameters comprehensive of several units**
3. **Production control** (after SOP) → **Comprehensive resource control**

**Digital factory before SOP** | **Making energy measurable and assessable** | **Plant operation after SOP**



Recording and management of the models (PPR), energy data and measured values





Planning tools with a function of energy prognosis

Reference numbers and IT basis components (data-/models, interfaces, service)

Data integration DiFa - MES for energy-sensitive control



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## Innovation Alliance "Green Carbody Technologies"
## Fields of Research 2010 - 2012

| | |
|---|---|
| **InnoCaT 1 Planning** | Systems of **energy information** and **data** management |
| | Planning **methods** and planning **tools** |
| | **Operative** resource management |
| **InnoCaT 2 Press Plant** | Resource-efficient **forming processes** |
| | Energy-efficient **systems engineering** |
| **InnoCaT 3 Tool Making** | Energy balance in the **tool life cycle** |
| | Tool concept for **optimized use of resources** |
| | Energy-efficient **production** and **repair** in tool making |
| **InnoCaT 4 Car Body Engineering** | Evaluation and design of **processes for car body construction** |
| | Innovative **electrical components** and control technology |
| | Strategies for **lightweight construction** |
| **InnoCaT 5 Painting** | Optimization of the process steps of **spray painting** and **drying** |
| | **Modularization** of car body construction |





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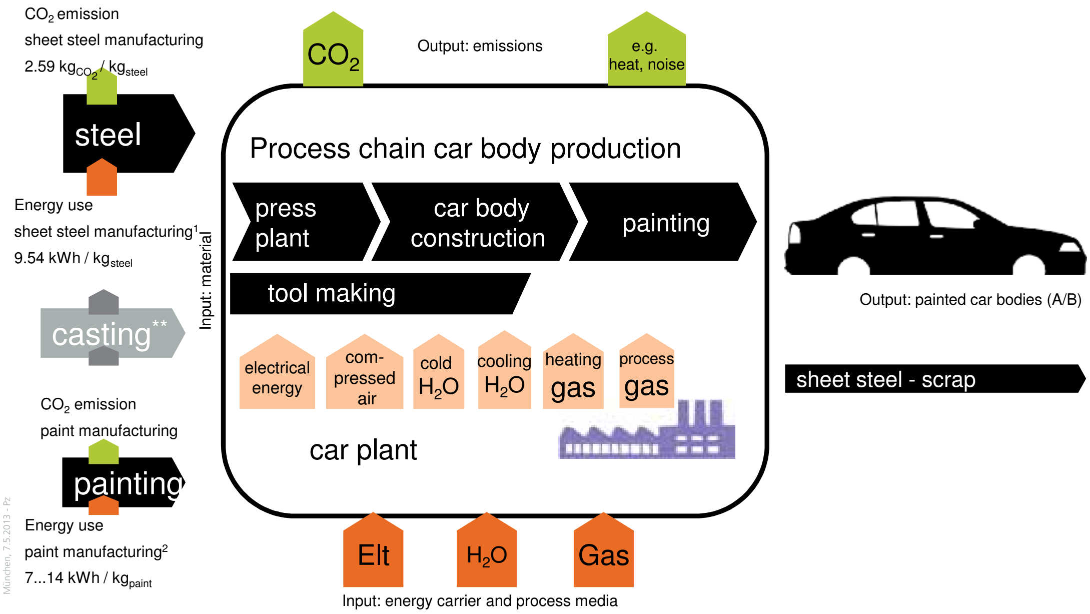
## The InnoCaT Reference Factory - *Concept and Effect*
### Energy and material flow in the processes of car body production






[1] *Source: Federal Environmental Agency, data base PROBAS, 2012*
[2] *Source: InnoCaT5, 2012*



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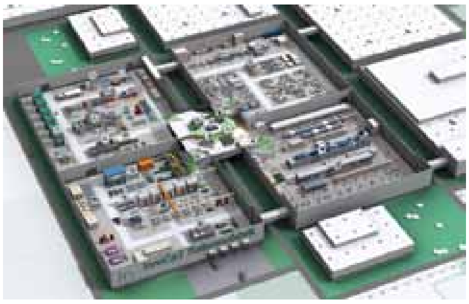
## INNOVATION ALLIANCE “GREEN CARBODY TECHNOLOGIES“

# The InnoCaT Reference Factory

*Concept and Effect*



Data and parameters (a selection)

| Denomination | Amount | Remark or unit |
|---|---|---|
| output | 250,000 | cars per year |
| shifts | 690 | shifts per year |
| weight of car body, including add-on parts | 344 | kg |
| number of sheet parts (outer shell per model) | 12 | manufactured at OEM |
| length of the laser-welded seams | 21 | m |
| surface of the car body (cataphoretic painting) | 90 | $m^2$ |
| surface of the car body (top coat) | 24 | $m^2$ |
| energy use – manufacturing of sheet steel (zinc-coated) | 9.54 | MWh per ton |

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## The InnoCaT Reference Factory - *Concept and Effect*

### Evaluation of the InnoCaT effects by using two calculation approaches

”factory“ level

total energy expenditure

Real energy consumption (electrical, gas, compressed air) of the assembly sections press plant, tool making, car body construction and painting

+ proportionate demand of central infrastructures

+ cumulated energy expenditure for material (steel, paint)

→ scaled to reference factory (production volume)

→ divided to assembly sections and individual stations

**Potential in the subproject evaluation → *InnoCaT*-effect for the total reference factory**

direct energy requirements

”product“ car body

Specific energy requirements (electrical energy, gas, compressed air) for typical product-oriented operations in above-mentioned assembly sections
+ cumulated energy expenditure for material (steel, paint)

→ projected to size per car body Klasse A / B

→ projected to reference factory (production volume)

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Thank you for your attention!
matthias.putz@iwu.fraunhofer.de
E³-Factory
E
E
E
Fraunhofer
IWU
InnoCaT Referenzfabrik
INNOVATION ALLIANCE "GREEN CARBODY TECHNOLOGIES"
www.greencarbody.de
Fraunhofer
IWU

# SESSION 2:

## Sustainable efficiency in production and logistics through lean learning factories

# Session 2:
## Sustainable efficiency in production and logistics through lean learning factories

Moderation: Prof. Dr. Wilfried Sihn

Wilfried Sihn, Univ.-Prof. Prof. eh. Dr.-Ing. Dr. h.c. Dipl.-Wirtsch.-Ing., is Professor and Head of the Division Industrial Engineering and System Design at the IMW since 2004. Before, he was Deputy Director of the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA) in Stuttgart, and is Director of Fraunhofer Austria since December 2008. He has been active in the field of applied research and consulting services for more than 25 years now. His areas of expertise include production management, corporate organization, enterprise logistics, factory planning, order management, and business process reengineering.
Prof. Sihn was instrumental in developing concepts as the Fractal Company. As well, he is Vice-President of the "International Society of Agile Manufacturing" and International Editor of the journal „Agility and Global Competition", as well as Guest Editor of the „International Journal of Technology Management (IJTM)".He holds lectures on the above-mentioned topics at national and international conferences. His more than 200 publications also include several books, making him an active player in scientific and practice-related discussions.

Fraunhofer AUSTRIA

imw INSTITUT FÜR MANAGEMENTWISSENSCHAFTEN

The Institute of Management Science / Department for Industrial Engineering and System Design (IMW) at the Vienna University of Technology can offer expertise in the main areas such as Production Management & Logistics Management as well as Quality-, Process- and Product Management. Research concentrates on the processing of scientific findings for practical applications. Numerous positive project results proof the reliable methodological background of the department. IMW is co-operating with the Fraunhofer Austria Research GmbH that is performing applied and industry oriented research. Projects are dealing with the planning and optimization of the structure, organization and management of industrial and service enterprises or their logistics networks and is specialised in structuring and optimisation of production and logistics processes in a high-tech and highly automated environment. Special emphasis is given to the matching of IT systems with the requirements of operational domains in particular with respect to the organisation of socio-technological systems.

# **Session 2:** Lean Basic Training at ZF Lenksysteme

**Dr. Sebastian Boettcher** is working at ZF Lenksysteme GmbH since April 2012. He is responsible for the coordination of the ZF Lenksysteme production systems in plant Bietigheim with approximately 600 employees.
He studied systems engineering at Chemnitz University of technology till 2004. From 2005 to 2008 he was industrial Ph.D-student and internal lean consultant for the Bosch Production System at Robert Bosch GmbH.
After receiving the Ph.D. he went to MBtech Consulting GmbH (formerly a 100% subsidiary of Daimler AG) in Sindelfingen. He started as consultant for lean and optimization projects. At the end he was a senior consultant and supported clients in lean transformation in production as well as in administration.

**Marcus Schramm** studied mechanical engineering at Fachhochschule in Esslingen a.N. and graduated in 1999.
He has worked at ZF Lenksysteme GmbH since November 1999. He is responsible for the coordination of the ZF Lenksysteme production systems in the central office in Schwaebisch Gmuend.
Between 1999 and 2007 he was working as a planer and was a group leader for assembly line planning at ZF Lenksysteme GmbH.
Since 2007 he has responsibility for implementing the ZF Lenksysteme production system in the ZF Lenksysteme GmbH worldwide.

ZF Lenksysteme

As a joint venture between Robert Bosch GmbH and ZF Friedrichshafen AG, we are a pacesetter and trendsetter in the field of steering systems for passenger cars and commercial vehicles.
Bends, switchbacks, parking spaces, rough roads, slippery road surfaces and sudden lane-change manoeuvres – this is our world. We call it the fascination of steering.
Whether ZF-Servotronic speed-dependent rack-and-pinion power steering, energy-saving ZF-Servolectric electric power steering,
active steering, steering columns with memory or low-consumption steering pumps – we set the course for technological change and are a highly capable, experienced partner for the automotive industry.
ZF Lenksysteme GmbH has had its headquarters in Schwaebisch Gmuend, approximately 50 km to the east of Stuttgart, since 1999. Around 5,000 employees work here in three factories. We maintain 17 locations worldwide in eight countries with more than 13,000 employees. In 2011, the company achieved a turnover of more than 3.6 billion euros.

ZF Lenksysteme

# Lean Basic Training at ZF Lenksysteme

## 3rd Conference on Learning Factories

Dr. Sebastian Boettcher, Marcus Schramm

May 7th, 2013



ZF Lenksysteme

## Agenda

1 ZF Lenksysteme GmbH

2 ZPS – ZFLS Production System

3 ZPS Training

## Owner Structure

ZF Lenksysteme

Driveline and Chassis Technology

**ZF Friedrichshafen AG**
Subscribed capital: 300 € m

50%

BOSCH
Invented for life

**Robert Bosch GmbH**
Subscribed capital: 1,200 € m

50%

**ZF Lenksysteme GmbH**
Subscribed capital: 127,8 € m

ZF Lenksysteme

 ZFLS public 3

## Facts and Figures

ZF Lenksysteme

### 2011 at a glance

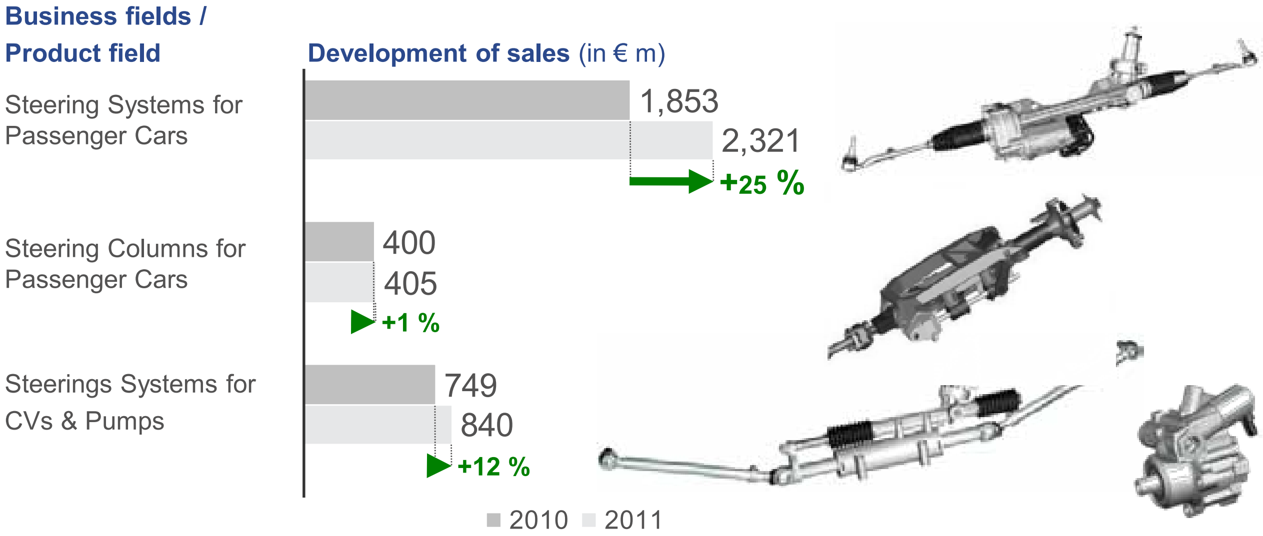
| | 2011 | 2011/2010 |
|---|---|---|
| Turnover | 3,566 € m | +19 % |
| Employees | 11,725 | +12 % |
| Investment | 287 € m | +71 % |
| R&D costs | 171 € m | +22 % |
| Operating Profit | 177 € m | +21 % |
| Equity capital ratio | 33 % | -3 % |
| Yield in sales | 5,0 % | +2 % |

 ZFLS public 4

# Key Data Turnover

ZF Lenksysteme

## Development and share of turnover by Business fields/Product field 2011




**Turnover Group:**
**+19 % to 3,566 € m**

 ZFLS public 5

# Manufacturing Locations

ZF Lenksysteme

**17 Locations**
**8 Countries**
**4 Regions**

 ZFLS public 6

## Agenda

ZF Lenksysteme

| | |
|---|---|
| 1 | ZF Lenksysteme GmbH |
| **2** | **ZPS – ZFLS Production System** |
| 3 | ZPS Training |

 ZFLS public 7

## History of ZPS

ZF Lenksysteme

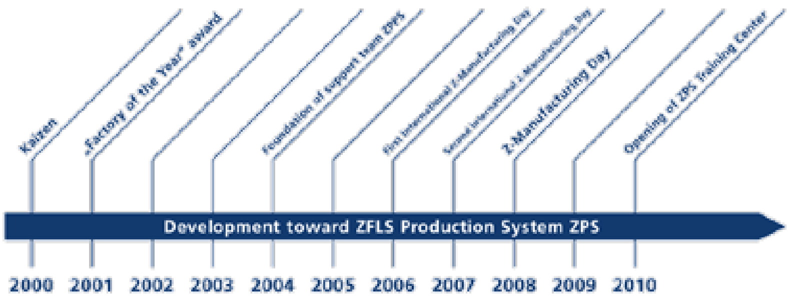
### What ist ZPS?

The “Fully Integrated Production System“ of ZF Lenksysteme

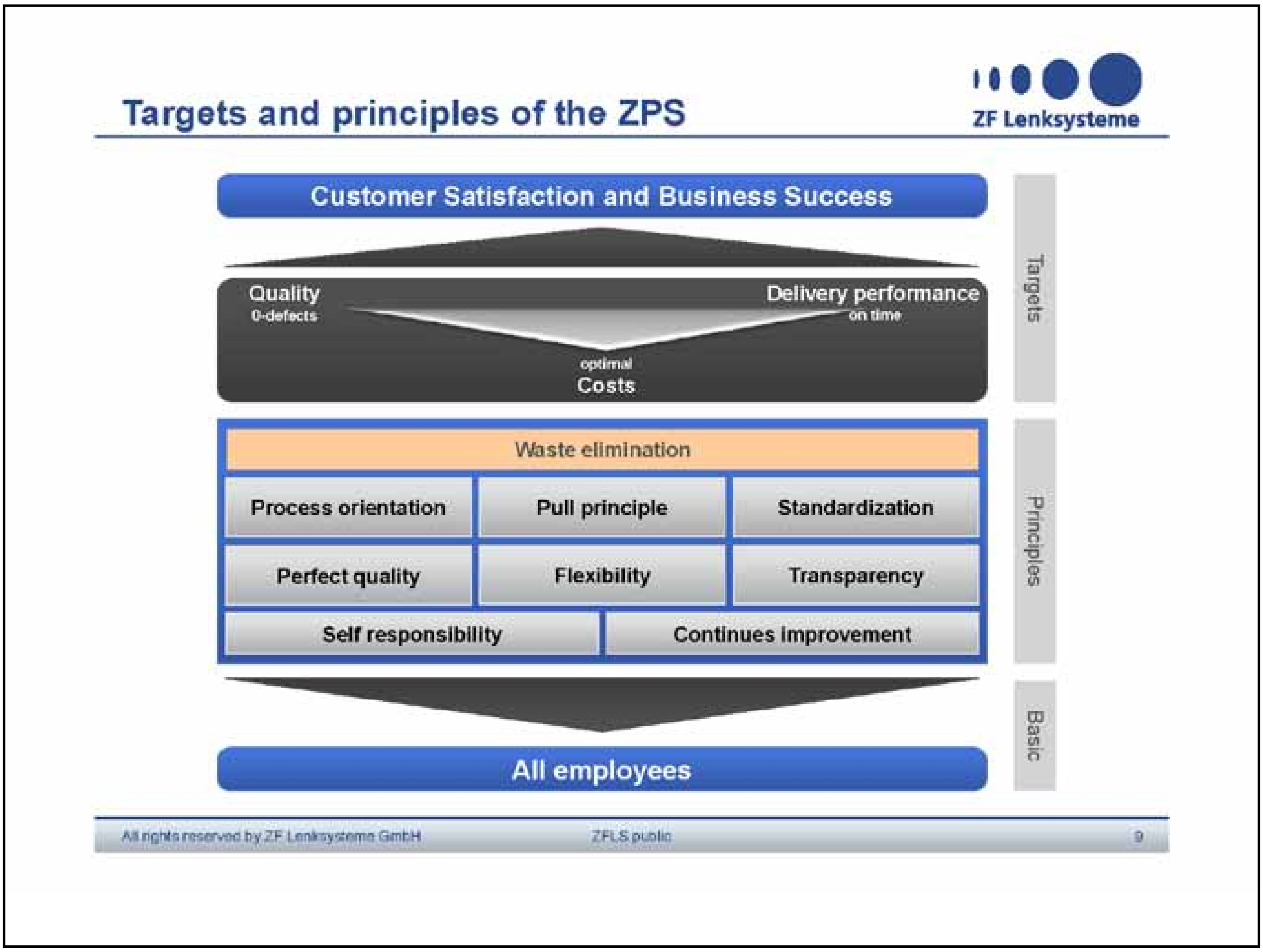
### What are the origins of ZPS?

ZPS is based on the Toyota Production System and applies several years of experience in implementing the Kaizen principles.

Basic elements from BPS (Bosch Production system) & Formel ZF supported our development process “Fully integrated Production System ZPS“




 ZFLS public 8


Targets and principles of the ZPS
ZF Lenksysteme
Customer Satisfaction and Business Success
Quality
0-defects
Delivery performance
on time
optimal
Costs
Targets
Waste elimination
Process orientation
Pull principle
Standardization
Perfect quality
Flexibility
Transparency
Self responsibility
Continues improvement
Principles
All employees
Basic
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ZFLS public
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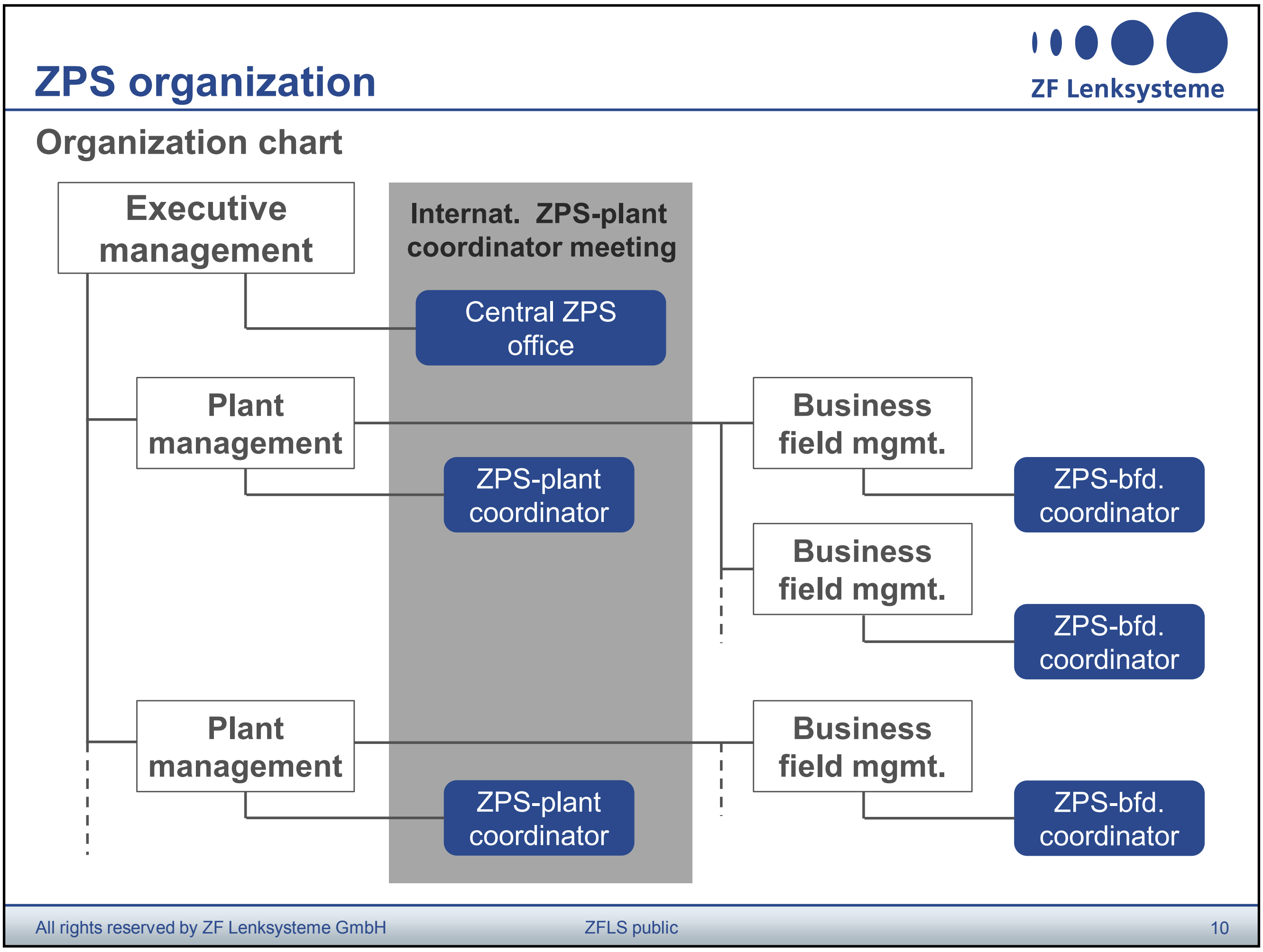
ZPS organization
ZF Lenksysteme
Organization chart
Executive management
Internat. ZPS-plant coordinator meeting
Central ZPS office
Plant management
ZPS-plant coordinator
Business field mgmt.
ZPS-bfd. coordinator
Business field mgmt.
ZPS-bfd. coordinator
Plant management
ZPS-plant coordinator
Business field mgmt.
ZPS-bfd. coordinator
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## Agenda

ZF Lenksysteme

1 ZF Lenksysteme GmbH

2 ZPS – ZFLS Production System

3 ZPS Training

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## ZPS Training concept

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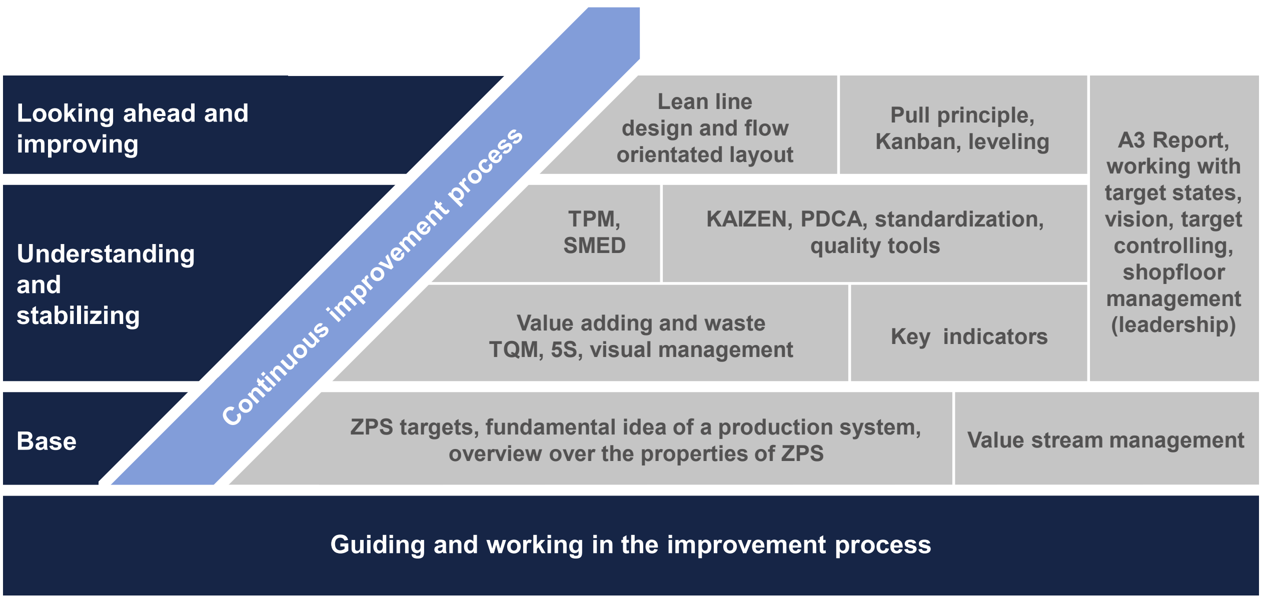



 ZFLS public 12

ZF Lenksysteme

## Redesign ZPS Training

### Premises

**Learning ZPS in the past**

- theoretical training with many power-point slides at the front
- main focus on teaching ZPS-tools (5S, TPM, milk run, quick change over, etc.)
- much theory, less practical training
- less involvement of participants
- no review of the teaching contents
- no link to practical exercise and daily business

**Redesign ZPS basic training**

Production System

**New ZPS Training**

- short introduction into theory
- understanding holistic approach of ZPS and value stream thinking
- strengthen awareness to identify waste
- practical simulation and individual group work
- intensive involvement of participants
- reference to practical experience
- transfer training to daily business

 ZFLS public 13

ZF Lenksysteme

## Approach ZPS Training

### Overview of ZFLS Production System

- **Background:** Why are improvements necessary?
- **Proceeding:** Improvement work with the ZPS systematic
- **Analysis:** How can we recognize the real problems and identify the waste?
- **Implementation:** Systematic development and implementation of improvements
- **Performance measurement:** How can we evaluate the changes?
- **Daily Business:** Which improvement at the own workplace can be done by the operators?

**Learning by doing:**
Application of ZPS will be explained with a practical simulation

**Target group:**
Employees of production and the directly supporting departments (logistics, maintenance, quality, supervisors) and all in ZPS interested people

 ZFLS public 14

# Storyboard of ZPS Training

ZF Lenksysteme

## Main phases of each training

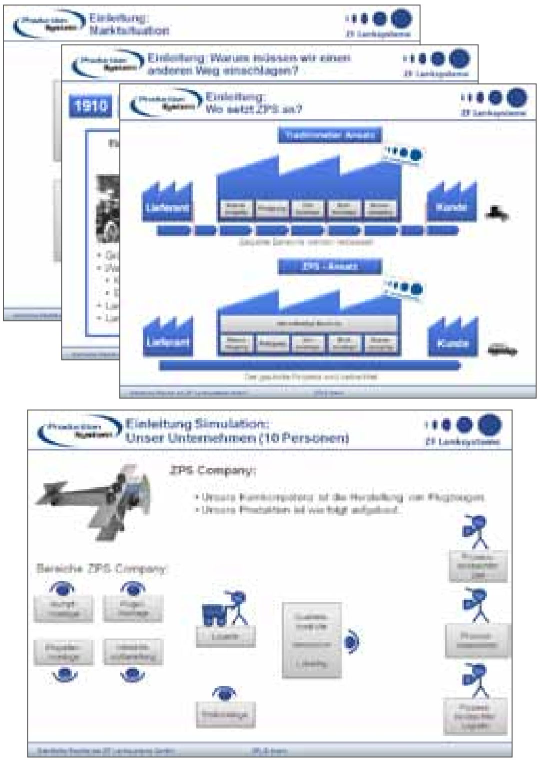
| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| phase | welcome and get in contact | transpa-rency, intro-duction | practical training loops: learning by doing — 3.1 simulation, 3.2 feedback, key indicators, 3.3 analyze, 3.4 improve | reflection and transfer | feedback and goodbye |
| content | ▪ self introduction and own experiences<br>▪ agenda<br>▪ targets | ▪ short introduction with backround information about produc-tion systems | | ▪ debriefing<br>▪ transfer learned skills to daily business | ▪ lessons learned for trainers |
| role of trainees | more active | passive | ▪ very active in simulation and feedback<br>▪ group work in analysis and improvement phases | more active | more active |
| time | 30 minutes | 30 minutes | 1.5 day | 60 minutes | 30 minutes |

 ZFLS public 15

# Welcome and introduction phase

ZF Lenksysteme

## Phases 1 and 2




- introduction to training
- understanding the pre-experience of the trainees
- short overview about the history, development and background of production system with only 5 power-point slides

- introduction to the simulation “ZPS Company”
- explain the roles and workplaces as well as work content

 ZFLS public 16

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## Practical training loops

ZF Lenksysteme

### Phase 3.1

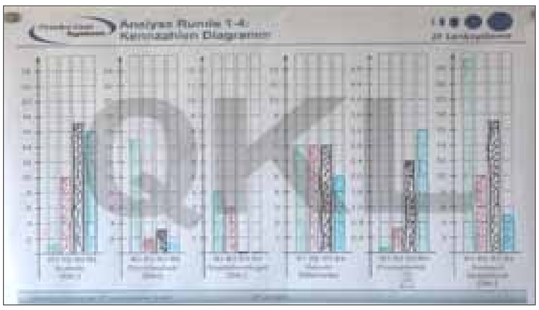

- participants have to produce ZPS-airplanes
- 7 workplaces and 1 person for logistics
  - pre-assembly motor, pre-assembly tail, pre-assembly wings, final assembly, preparation packaging, quality check, packing and labeling
  - logistic for delivery
- process observer (min. 1 person)
- premises
  - 15 planes in 15 minutes
  - lot size: 4
  - screwdrivers and wrenches have to be used

 ZFLS public 17

## Practical training loops

ZF Lenksysteme

### Phase 3.2


response of the participants after the first simulation:

- Very busy and stressful
- It is the same as it is in the plant, every time the logistic
- The only problem is logistic
- I´ve got a good work place
- Nothing to do
- I wouldn´t do that for eight hours

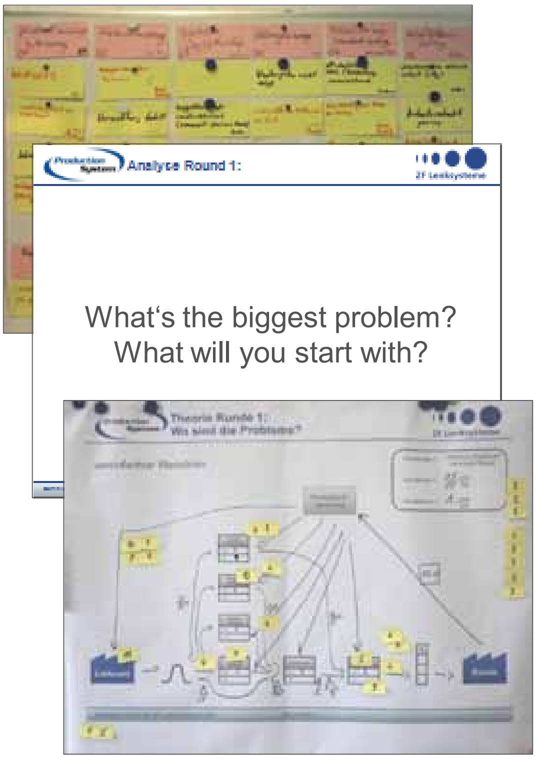
key indicators for quality, costs and delivery show the performance and the improvement during the training loops

 ZFLS public 18

## Practical training loops

ZF Lenksysteme

### Phase 3.3




- collecting of every ones problems
- clustering the problems
- discussion about the biggest problem
- explaining the value stream as a analyzing method
- participants create a rough value stream (base is given)
- sort the problems to the workplaces
- explaining that stock means there is a problem

 ZFLS public 19

## Practical training loops

ZF Lenksysteme

### Learning content per simulation and optimization turn

1 analysis + improvement 2 analysis + improvement 3 analysis + improvement 4

SIMULATION

- what's the biggest problem
- value stream mapping and design
- one piece flow
- 7 kinds of waste
- visual management and 5S

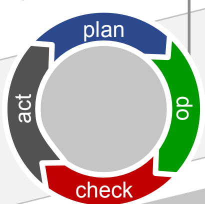
SIMULATION

- poka yoke and fixtures
- visualization and standardization
- flow oriented layout
- lean line design
- operator balance chart

SIMULATION

- Kanban / 2-bin-system
- standard number of parts
- cyclic material supply

SIMULATION




reflecting individual feeling and key performance indicators

 ZFLS public 20

# Practical training loops

ZF Lenksysteme

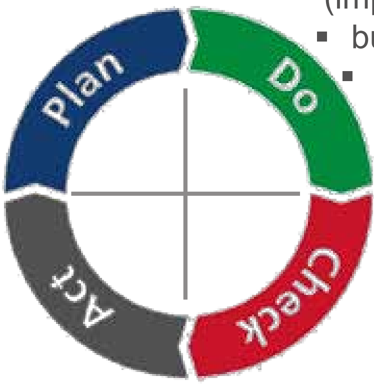
## Procedure of the PDCA systematic

### Understanding the situation

- value stream analysis and design
- where do we have the biggest problem?

### Implementing of measures

- focus on max. 3 projects (improvements)
- bundling of capacity
- reasonable use of resources




### Review target definition

- problem solved ?
- sustainable?
- roll out in other areas
- definition of new targets

### Checking of effectivity

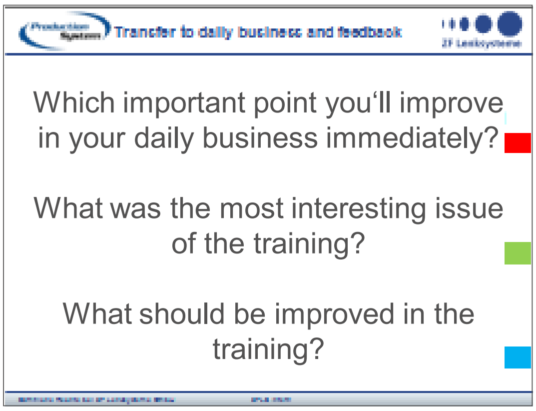
- simulation
- subjective impression
- checking with key figures

 ZFLS public 21

# Reflection and feedback phase

ZF Lenksysteme

## Phases 4 and 5




- I will clean my work place
- Optimizing the content of the bins
- I will bring more transparency to my work place

- the simulation
- the check with the key figures
- working with the value stream

- additional variant of the plane
- use of a magnetic board for the value stream
- mapping a value stream in the plant

 ZFLS public 22

# Lessons learned

ZF Lenksysteme

## 7 key findings of success

1. creating an opened minded situation by considering and reflecting own personal experience
2. practical training first – less power point slides
3. group working on own ideas to find feasible solutions creates high self-motivation of trainees
4. approach of value stream mapping and socratic questions support the way of lean thinking
5. detailed discussion of lessons learned and transfer to daily business is important for sustainability of training content
6. standardized moderator guide assures consistent training results
7. train the trainer approach for worldwide rollout

Production System

 ZFLS public 23

# **Session 2:** Current activities and future challenges of the Process Learning Factory CiP

**Professor Dr. Joachim Metternich** holds the chair of Intralogistics and Production Management at the Technische Universität Darmstadt (TUD). After studying industrial engineering he worked as research associate at the Institute of Production Management, Technology and Machine Tools (PTW) of the TUD where he graduated as Dr.-Ing. in the year 2001.
Until 2004 he was the assistant to the Chief Operating Officer of the leading German Machine Tool Manufacturer TRUMPF Werkzeugmaschinen GmbH. After holding a position as a production manager for BOSCH Diesel s.r.o. in the Czech Republik he became in 2008 head of the production system of the Knorr-Bremse AG, a German manufacturer of braking systems for rail vehicles.
Since 2012 he is deputy director of the PTW together with Professor Abele.

PTW TU DARMSTADT

The Institute of Production Management, Technology and Machine Tools (PTW) is one of the leading German research institutes for production technology. Currently about 40 associate researchers focus their work on innovation along the manufacturing value chain. This includes the development of machine components and cutting tools, technologies for high speed machining, energy efficient machine tools and manufacturing processes and production management.
As a pioneer the PTW opened in 2007 its own learning factory CiP on the campus of the Technische Universität Darmstadt. Producing real products the CiP represents a complete industrial production facility including machining and indirect processes. Since 2007 by far more than 1.000 professionals have been receiving training in the CiP. Meanwhile its curriculum of lean production methods has been continuously developed.

In the year 2013 the PTW celebrates its 120st anniversary.

**Munich | 07.05.2013**

# Current activities and future challenges of the Process Learning Factory CiP

Prof. Dr.-Ing. J. Metternich
Prof. Dr.-Ing. E. Abele
Dipl.-Wirtsch.-Ing. M. Tisch

Institut für Produktionsmanagement, Technologie und Werkzeugmaschinen

Center für industrielle Produktivität

*www.prozesslernfabrik.de*

## Agenda

TU DARMSTADT

**Topics**

- What is a Learning Factory?
- Learning Factory Design
- The Learning Factory „CiP" today – what is going on?
- Future Questions …

Institute of Production Management, Technology and Machine Tools | Prof. Dr.-Ing. E. Abele / Prof. Dr.-Ing. J. Metternich | 230404JM1 | 1

## Today the need for better qualification and research possibilities on excellence in production systems is widely accepted…

PTW TU DARMSTADT CiP

**education**

**Engineering Graduates need …**

- knowledge about production processes and lean methods
- perception of workflows and enthusiasm for CI

**industry**

**Companies need to …**

- train associates on lean methods
- improve their problem solving skills
- benefit from latest research results

**research**

**Research assistants need the opportunity to …**

- experience real manufacturing processes
- experiment on real industrial machines and process flows

Institute of Production Management, Technology and Machine Tools | Prof. Dr.-Ing. E. Abele / Prof. Dr.-Ing. J. Metternich | 230404JM1 | 2

## Which setting of teaching methods will effect greatest benefit?

PTW TU DARMSTADT CiP

Which teaching methods requires the factory of the future?

Which methods are suitable for which content?

Which combinations make sense?

**Lecture**

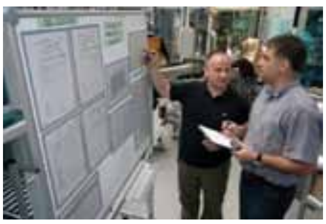
**Business Game**

**Simulation**

**E-Learning**

**Demonstration**

**Roleplay**



**Seminar**

**Action-oriented learning in Learning factories**

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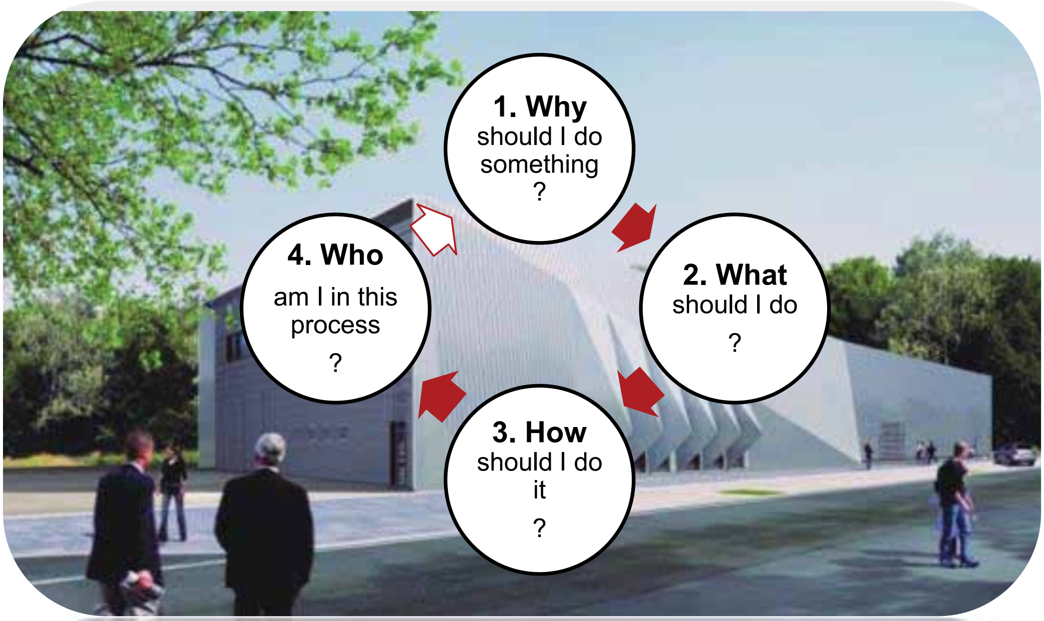
## Questions from a trainee's perspective – we need to address each of them adequately




Statement: For production related individuals and topics the best place to answer these questions consistently is a Factory.

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## Our definition of the term "Learning Factory"

The **goal of a learning factory** is to systematically improve a trainee's competency to optimize (production) processes.

**Competency** in this context means the ability to transfer the learnt to another environment and implement it there successfully.

To achieve this learning factories foster an **action-oriented approach** with participants acquiring competencies in a structured self-learning processes

- through dealing with realistic problems,
- in a close to reality environment,
- by the systematical integration of appropriate methods.


Source: Tisch et al. (2013) - A systematic approach on developing action-oriented, competency-based Learning Factories

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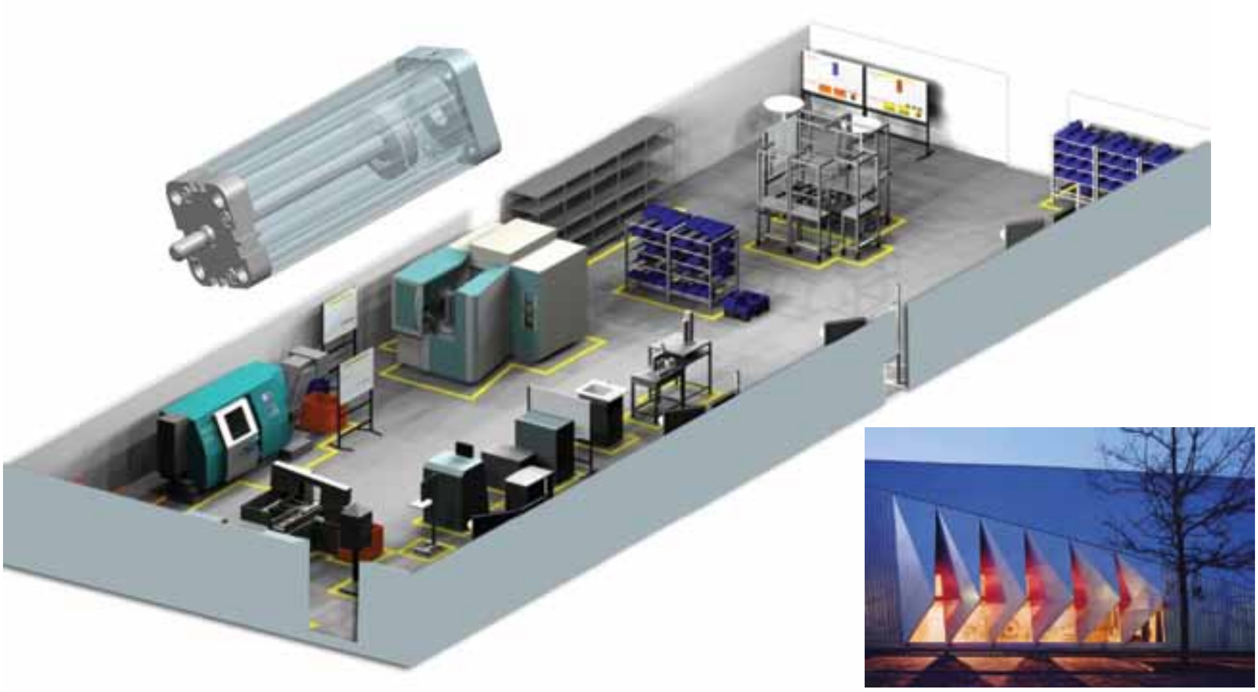
## How to build a Learning Factory from scratch?



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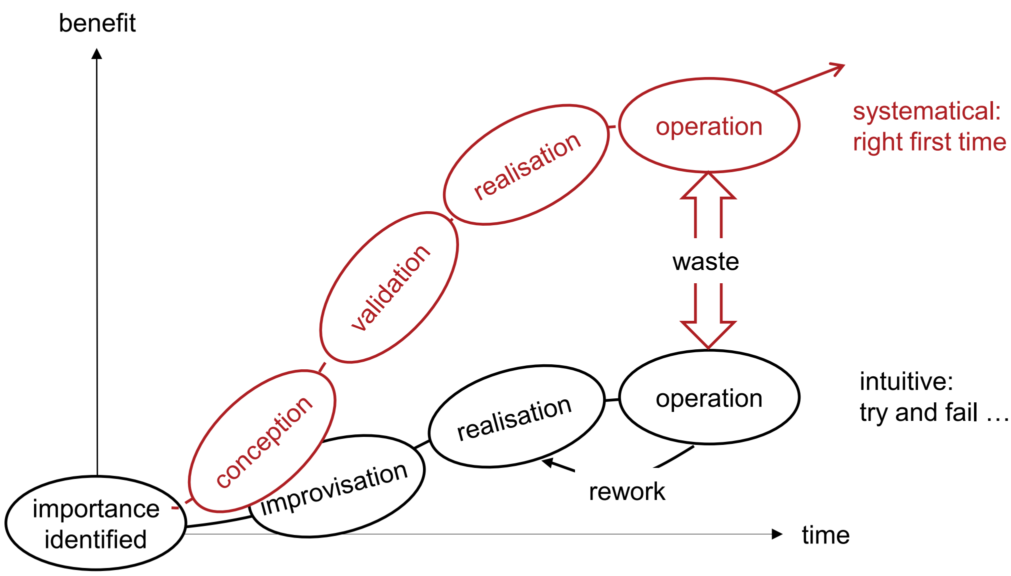
## Two different ways to shape a learning factory




Source: Abele et al. (2012) – Lernfabriken einer neuen Generation

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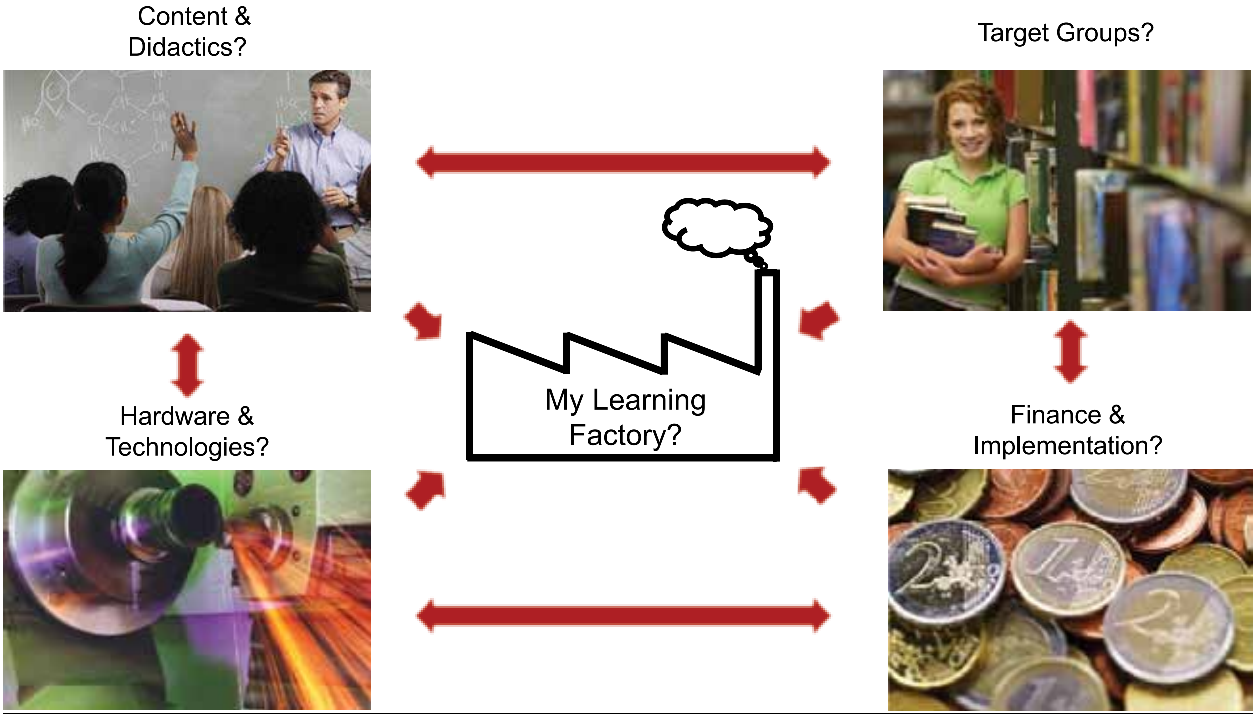
## A range of questions needs to be considered from idea to realisation

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## Definition of a Learning Factory Profile from a Typology

| characteristic | features | | | | | |
|---|---|---|---|---|---|---|
| **operating organization** | industry | consulting | university | technical college | professional school | |
| **type of use** | education / training | research | further industrial use | | | |
| **industrial target groups** | operational staff | engineer | manager | | | |
| **academic target groups** | students | research staff / post graduated | | | | |
| **other target groups** | lean experts / lean specialist | other consultants | | | | |
| **selected industries** | machine building | automotive industry | chemical industry | electrical industry | insurance, banks, etc. | |
| **product** | real product | imaginary (didactic) product | | | | |
| **production process** | machining | assembly | logistics | IT | indirect | production |
| **module content** | process impr. | diagnosis | system design | quality control | | |
| | quality | material flow | techn. opt. | lean transfer | | |
| **integrated departments** | production | distribution | purchasing | ideas mgmt. | design / development | prod. planning / control |
| **integrated teaching methods** | presentation | demonstration | tutorial | web-based training | simulation game | |
| | discussion | case study | role play | experimental game | … | |

Source: Tisch et al. (2013) - A systematic approach on developing action-oriented, competency-based Learning Factories

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## Definition of a Learning Factory Profile from a Typology

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| other target groups | lean experts / lean specialist | other consultants | | | | |
| selected industries | machine building | automotive industry | chemical industry | electrical industry | insurance, banks, etc. | |
| product | real product | imaginary (didactic) product | | | | |
| production process | machining | assembly | logistics | IT | indirect | production |
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Source: Tisch et al. (2013) - A systematic approach on developing action-oriented, competency-based Learning Factories

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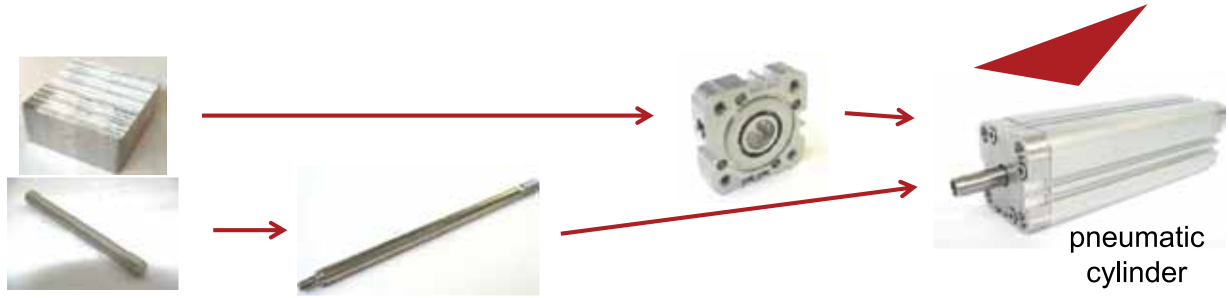
## Configuration: A product must be chosen whose production technologies fit the requirements of the profile

| | | |
|---|---|---|
| type of use | education / training | |
| selected industries | machine building | automotive industry |

- Machining and Assembly
- Volume Product
- Medium Variety
- …




**Band saw Kasto Sba A2**

**Turning machine Index C65**

**Milling machine Deckel Maho DMC 50H**

**Assembly line pneumatic cylinder**

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## Definition of a Learning Factory Profile from a Typology

PTW TU DARMSTADT CiP

| characteristic | features | | | | | |
|---|---|---|---|---|---|---|
| operating organization | industry | consulting | university | technical college | professional school | |
| type of use | education / training | research | further industrial use | | | |
| industrial target groups | operational staff | engineer | manager | | | |
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| other target groups | lean experts / lean specialist | other consultants | | | | |
| selected industries | machine building | automotive industry | chemical industry | electrical industry | insurance, banks, etc. | |
| product | real product | imaginary (didactic) product | | | | |
| production process | machining | assembly | logistics | IT | indirect | production |
| module content | process impr. | diagnosis | system design | quality control | | |
| | quality | material flow | techn. opt. | lean transfer | | |
| integrated departments ? | production | distribution | purchasing | ideas mgmt. | design / development | prod. planning / control |
| integrated teaching methods | presentation | demonstration | tutorial | web-based training | simulation game | |
| | discussion | case study | role play | experimental game | … | |

Source: Tisch et al. (2013) - A systematic approach on developing action-oriented, competency-based Learning Factories

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## Configuration: Other features and equipment also come from the profile's requirements

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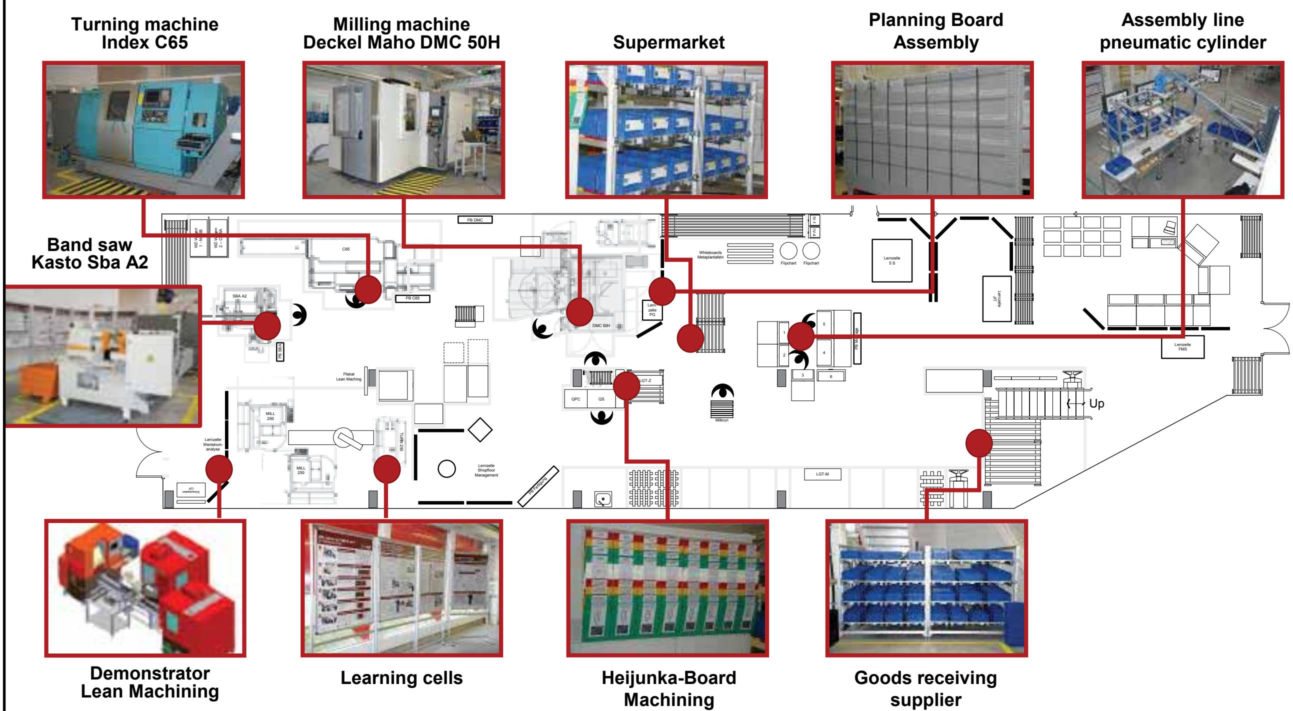


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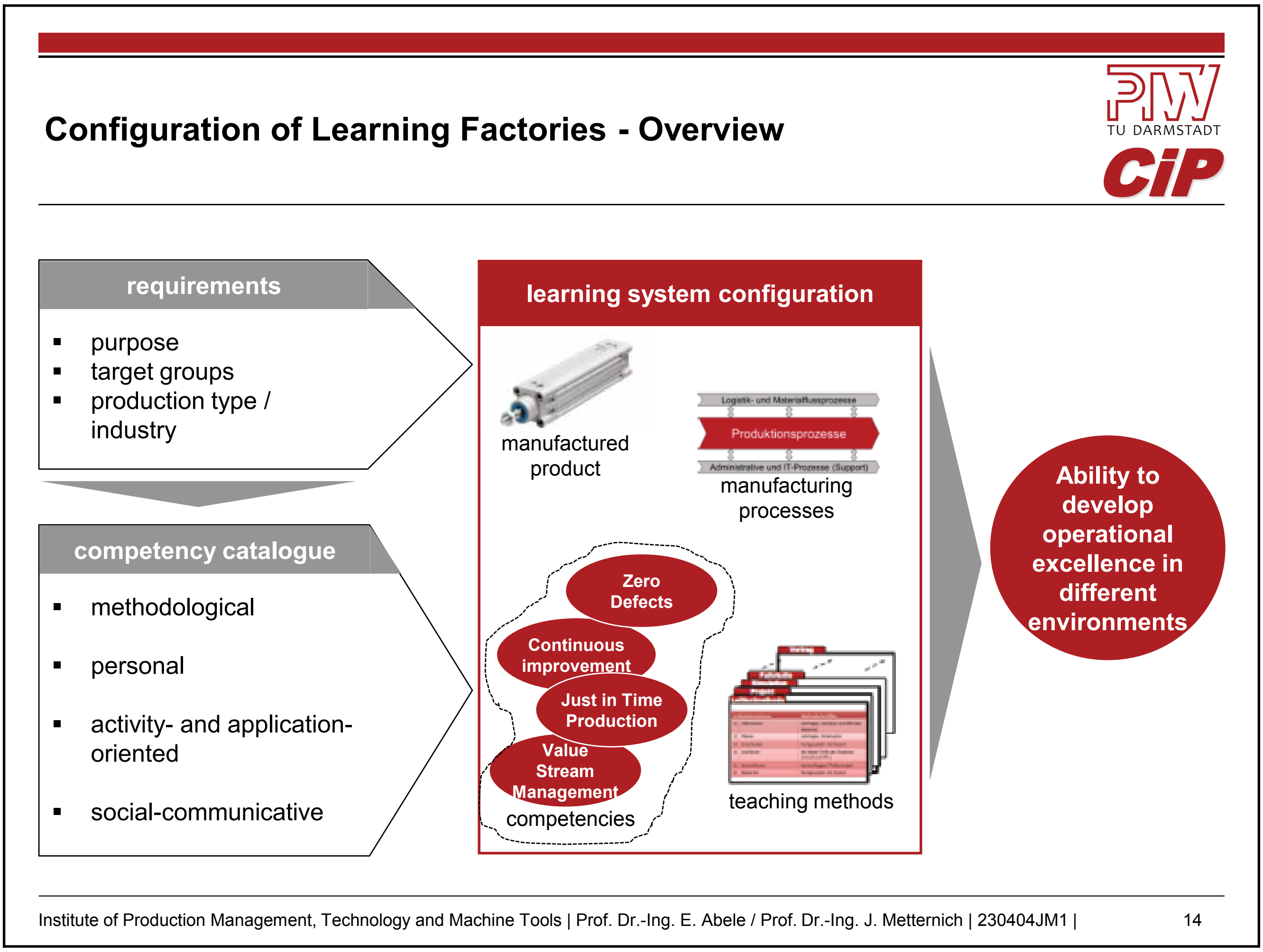
Configuration of Learning Factories - Overview
TU DARMSTADT
CiP
requirements
purpose
target groups
production type / industry
competency catalogue
methodological
personal
activity- and application-oriented
social-communicative
learning system configuration
manufactured product
Produktionsprozesse
manufacturing processes
Zero Defects
Continuous improvement
Just in Time Production
Value Stream Management
competencies
teaching methods
Ability to develop operational excellence in different environments
Institute of Production Management, Technology and Machine Tools | Prof. Dr.-Ing. E. Abele / Prof. Dr.-Ing. J. Metternich | 230404JM1 |
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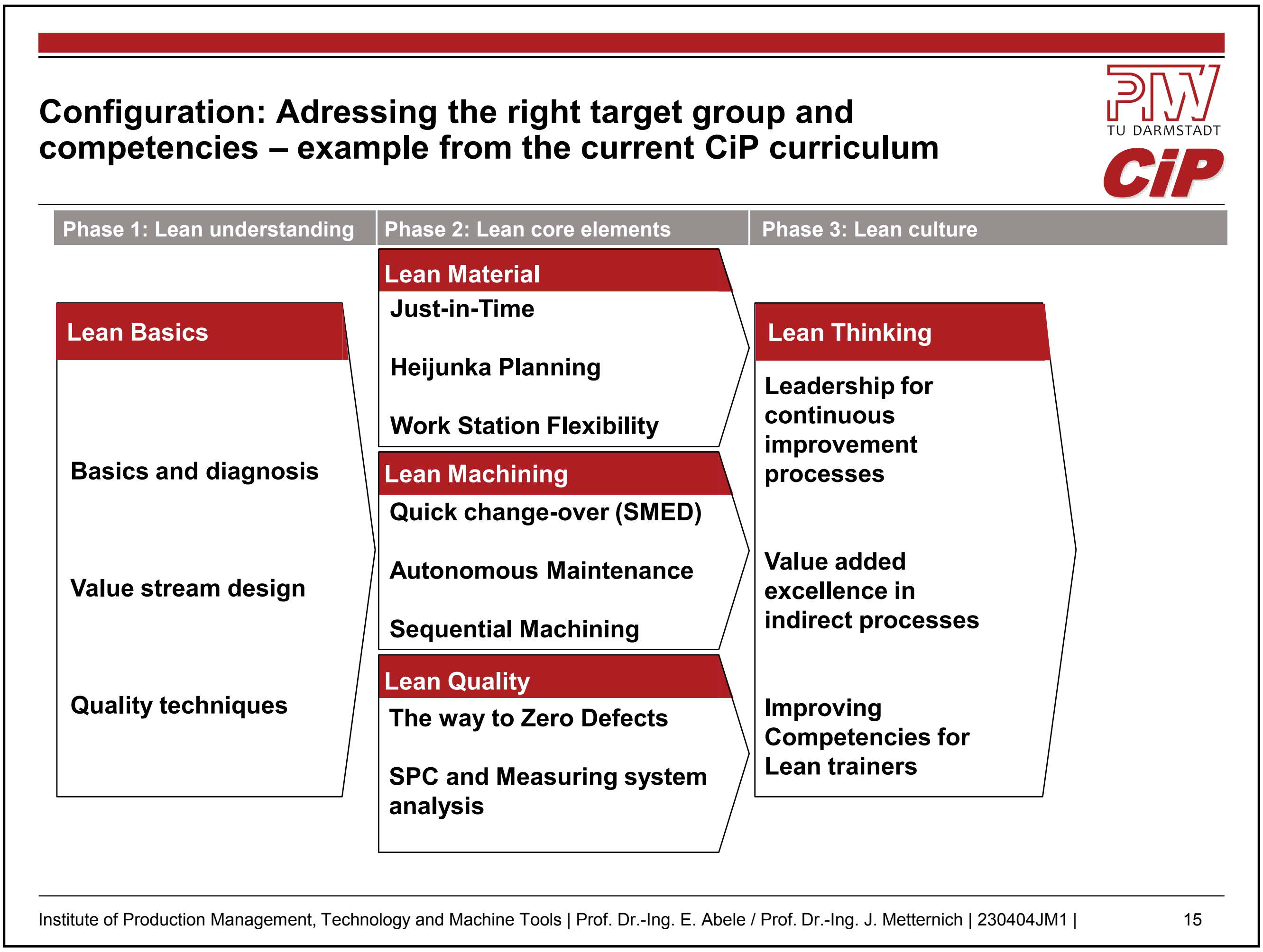
Configuration: Adressing the right target group and competencies – example from the current CiP curriculum
TU DARMSTADT
CiP
Phase 1: Lean understanding
Phase 2: Lean core elements
Phase 3: Lean culture
Lean Basics
Basics and diagnosis
Value stream design
Quality techniques
Lean Material
Just-in-Time
Heijunka Planning
Work Station Flexibility
Lean Machining
Quick change-over (SMED)
Autonomous Maintenance
Sequential Machining
Lean Quality
The way to Zero Defects
SPC and Measuring system analysis
Lean Thinking
Leadership for continuous improvement processes
Value added excellence in indirect processes
Improving Competencies for Lean trainers
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15

## Configuration: Training logic within CiP

- Which waste do we deal with?
- Why is this waste painful at all?

need to act

**1. Why**
problem under-standing

**2. What**
method under-standing

- Which method is appropriate?
- How does it work?

desire to act

**3. How**
experience

- Method application
- before – action – after -> less waste

basic understanding

**4. Who**
self reflection

- Why did we achieve what we achieved?
- What was my role?

ready to go

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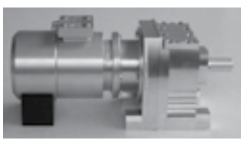
## The CiP learning factory today – the product range is chosen to cover different production characteristics

### Low Variety Production: Pneumatic Cylinder

- Realization of a complete value stream including machining, assembly and indirect processes

### Low Volume, high variety: Gearbox Motor

- About 4.000 different variants



### Chaku Chaku Machining: Key Fob (as give away)

- Flexible Adaption of Machining Centers to Volume and Product

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## The CiP is the place to integrate three major approaches …

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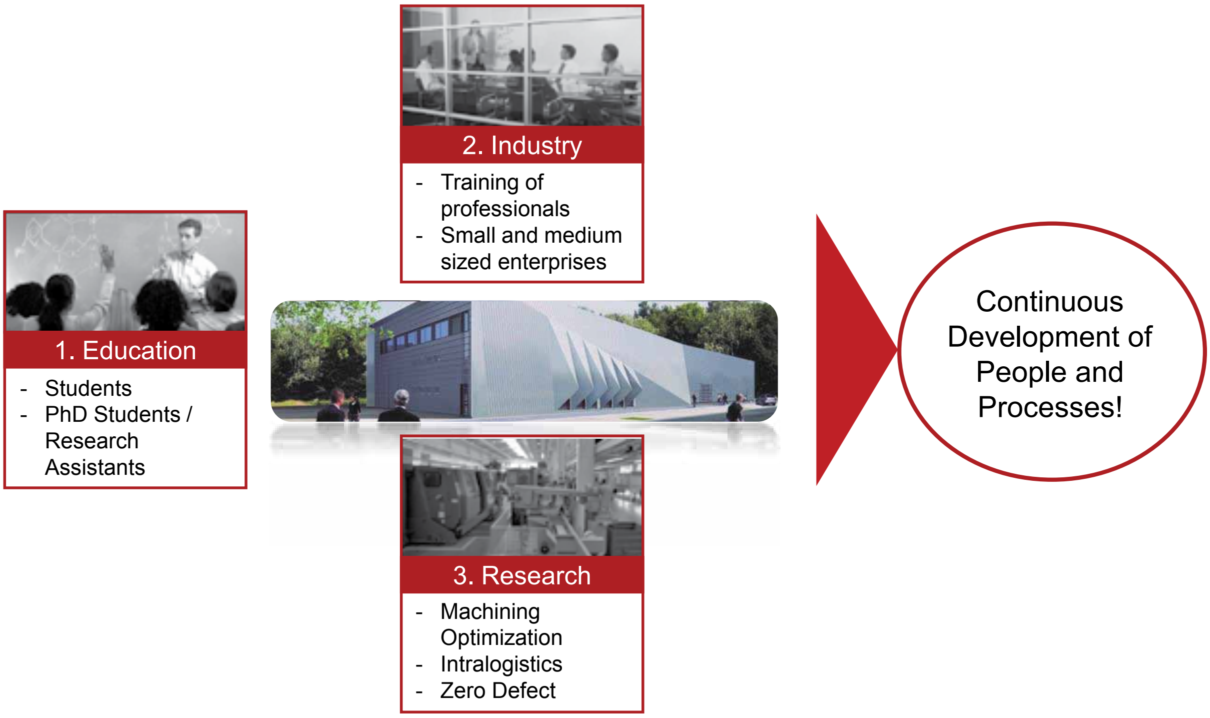


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## 1. Education: Integration of the process learning factory in the education of mechanical engineering students

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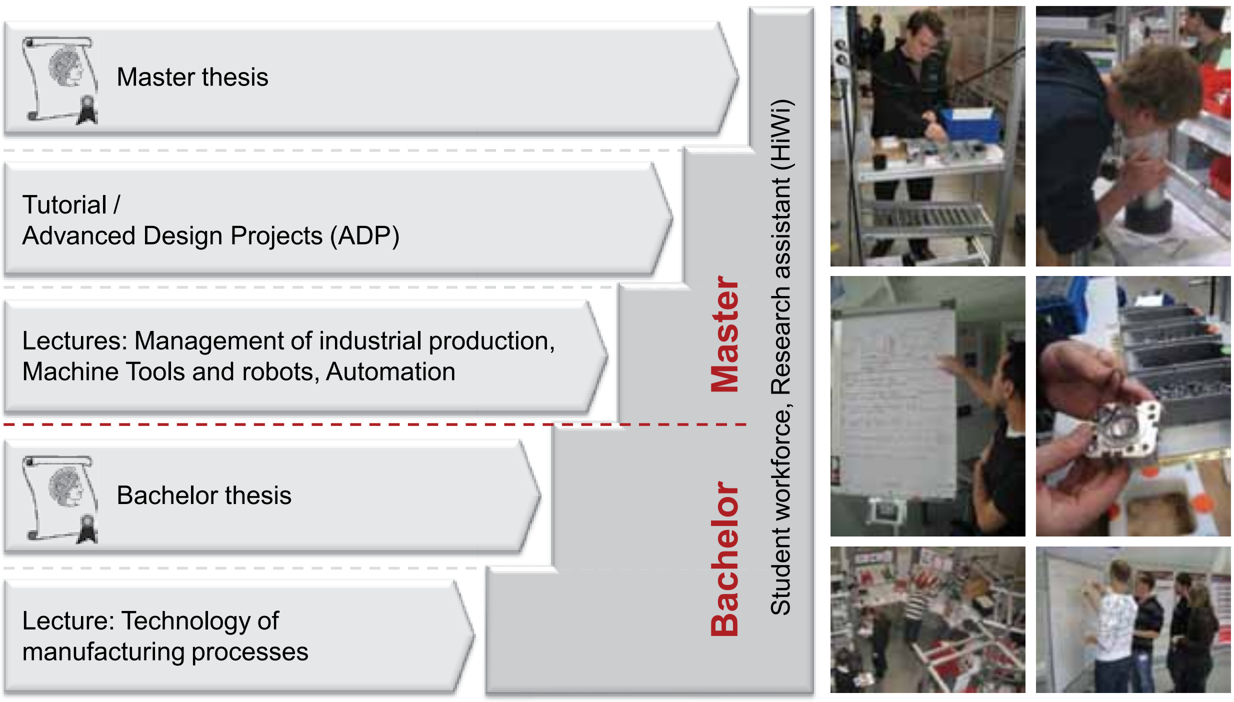


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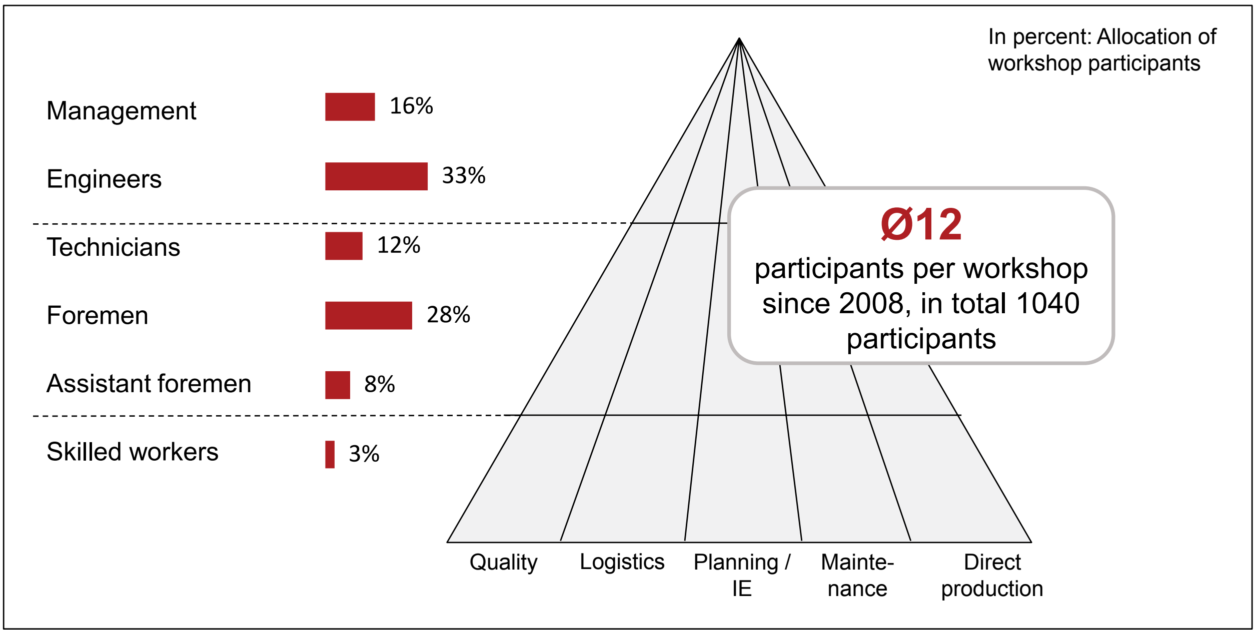
## 2. Industry: A wide range of managers and professionals have been trained at the process learning factory CiP




Source: Abele et al. (2013) - Learning factories for future oriented research and education

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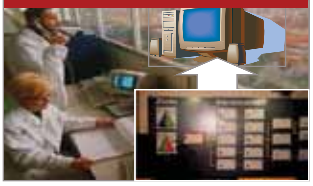
## 3. Research: Current Topics of the CiP-Team (Examples)

**Lean Production and IT**



- PPS and lean production control (Heijunka and Pull)
- IT and CI-processes

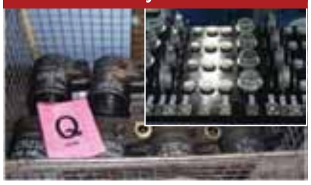
**Lean Machining**

- Cellular Manufacturing
- Flexibility and risk mitigation through low cost standard equipment

**Lean Intralogistics**

- Design of flexible Intralogistic Solutions
- Intralogistics and Zero Defect

**Lean Quality**



- From sampling and defect detection to mistake proofing
- Built-in quality

**Competency Development for the Continuous Improvement Processes**

- Learning Factory Design
- Development/evolution of the CiP curriculum
- Shop Floor Management and Problem Solving

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## 3. Research: Example Lean Machining – Overall Comparison Complete Machining and Cellular Manufacturing

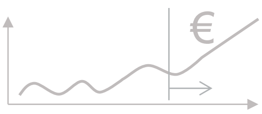
| | Complete Machining | Cellular Manufacturing |
|---|---|---|
| |  |  |
| Investment | ● (yellow) | ● (green) |
| Volume Flexibility | ● (red) | ● (green) |
| Mix Flexibility | ● (yellow) | ● (green) |
| Cost per Piece | ● (yellow) | ● (yellow) |
| Manual Work | ● (green) | ● (yellow) |



## Open question: "What does it cost?" vs. "What are the benefits?"

**competency development (short-term)**

Improved problem solving capabilities.




**competiveness (medium-term)**

Faster learning cycles increase productivity at higher rates.

**secure production location (long-term)**

Higher productivity and flexibility justify local wage level differences in the long run.

? ? ?

- Approach (which way to go?)
- Initial investment (time and financial resources)
- Return on investment uncertain (both: timeline and impact)

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## Future Challenge: Evaluation of Learning Factory Impact

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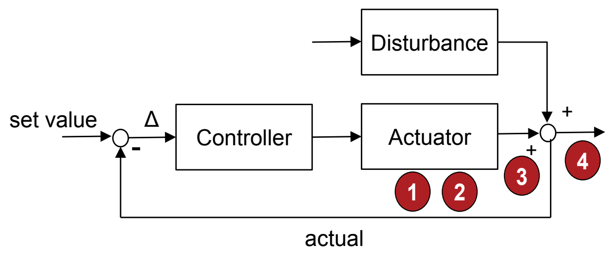


**Set-value vs. actual-comparison to adjust our approach?**

Source: Kirkpatrick, Donald L. (1994)



## Your contact persons at Process Learning Factory CiP

PTW TU DARMSTADT · CiP


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# **Session 2:** Qualification as an effective tool to support the implementation of lean

**Dipl.Ing., Dipl. Wirtsch.Ing. Werner Beauvais** has been involved in Schaefflers lean activities named MOVE for four years. As the head of the MOVE-Office he reports directly to Dr. Heiko Gierhardt who coordinates the lean activities at the Schaeffler Group worldwide.
After studying electrical engineering at the TU-München he added the AWA postgraduate studies also at the TUM.
He gained his work experience at Engel Machinery Austria as a projects engineer and later in the quality assurance. This lead him to work on the implementation of an ISO 9001 quality system at the Canadian subsidiary and later filling positions in production and sales. As a key account manager for automotive customers he was also responsible for the sales processes and the business side of a SAP implementation. After almost 10 years at Engel Canada he continued to work in the same fields at the Schaeffler Group in Herzogenaurach Germany. Since 2006 he has been involved in continuous improvement activities. When Schaeffler started the new MOVE initiative in 2008 / 2009 it was his part to start up the qualification end of the program with the first Schaeffler learning factory.

Schaeffler AG develops and manufactures precision products for everything that moves – in machines, equipment, and vehicles as well as in aviation and aerospace applications – with its INA, LuK, and FAG brands.
Schaeffler is a leading manufacturer of bearings worldwide and a renowned supplier to the automotive industry. The globally active group of companies, which is based in Herzogenaurach, Germany, generated sales of approximately 11.1 billion Euros in 2012. With approximately 76,000 employees worldwide, Schaeffler is one of the largest German and European industrial companies in family ownership.
With 180 locations in over 50 countries, Schaeffler has a worldwide network of manufacturing locations, research and development facilities, sales companies, engineering offices, and training centers. Customer proximity is important for the development of market-specific products, and for short delivery times and rapid service. All Schaeffler plants worldwide work to the highest standards of quality and environmental protection and are certified to internationally-applicable standards. Moreover, with its Code of Conduct, Schaeffler has committed itself to compliance with high social and ethical standards.

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# Qualification as an effective tool to support the implementation of Lean

3rd Conference on Learning Factories, Munich, May 7 2013

Werner Beauvais

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## MOVE Qualification

- **MOVE Academies**
- Leadership workshops
- Benchmark Seminars

1 May 2013 Schaeffler - MOVE Qualification - W. Beauvais

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## The MOVE System

The MOVE arrow symbolizes the principles of the MOVE System for all Schaeffler employees


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move

Excitement

## MOVE Academies

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Goal is not only to understand but to reveille emotion and enthusiasm for MOVE


- The main courses "Lean Enterprise" and "Lean Office" are meant mostly for management
- Trainings as "Value Stream Design", "Swimlane" and "Kanban" are for specialists

**"This is a great course, it is demanding and fun!"**

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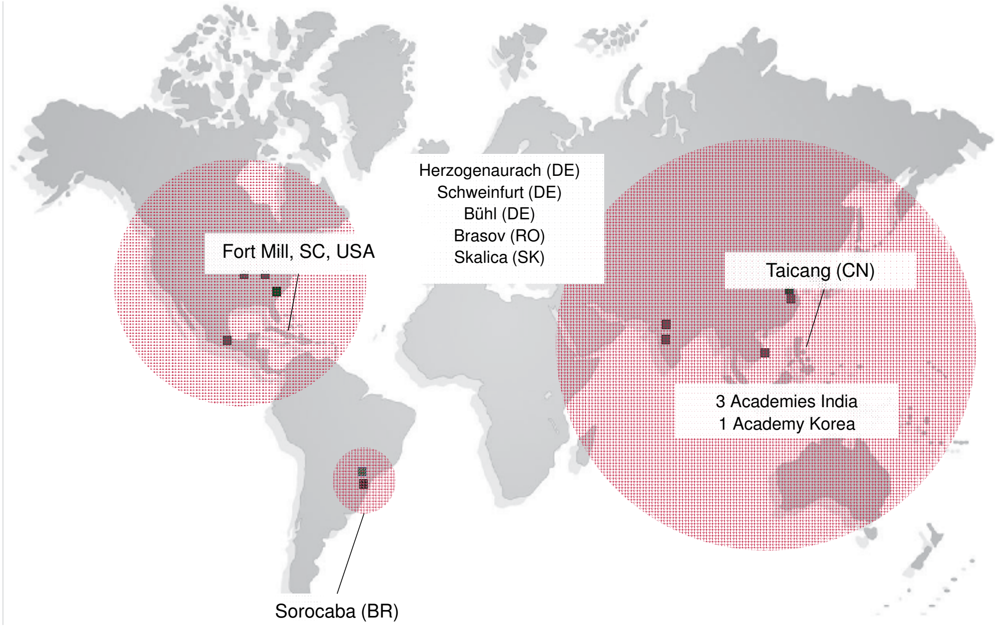
One concept worldwide

## 12 MOVE Academies worldwide

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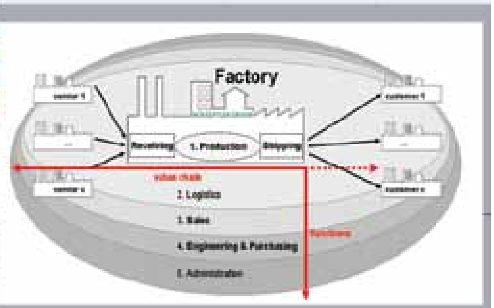
## Training -> Homework -> Application

A work shop should be scheduled shortly after the training

**MOVE Academy - Seminar Overview**

| Categories | Feb 28 2011 | Seminar No. | Duration |
|---|---|---|---|
| Basics | MOVE Learning Factory / Lean Office (Prerequisit for "Value Stream Analysis") | ST08020/22 | 2 days |
| Functional Improvement | MOVE Learning Factory "Light" | none[1] | 0,5 Tage |
| | MOVE Value Stream Analysis (Prerequisit for Flow-Oriented Prodn. & Logistics) | ST08040 | 2 days |
| Soft skills | MOVE Flow-Oriented Production | ST08050 | 3 days |
| | MOVE Logistics (Kanban & Tugger Route) | ST08060 | 2 days |
| Caption: | MOVE TPM (workshop on site) | ST08090[2] | 5 days |
| N = Not required | MOVE 5S (workshop on site) | ST08070[2] | 4 days |
| M = Mandatory | MOVE SMED (workshop on site) | ST08100[2] | 4 days |
| R = Recommended | MOVE Train-the-Trainer | ST08030 | 2 days |

| Target group | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **MOVE Organisation** | | | | | | | | | |
| MOVE Manager [3] | M | M | M | M | M | M | M | M | R |
| MOVE Trainer [3] | M | M | M | M | M | M | M | M | M |
| MOVE Coordinator | M | M | M | M | M | M | M | M | R |
| MOVE Office | M | M | M | M | M | M | M | M | R |
| **Production Areas** | | | | | | | | | |
| Manager Plant | M | N | N | N | N | N | N | N | N |
| Manager Segment | M | N | N | N | N | N | N | N | N |
| Manager Product Responsibility | M | N | N | N | N | N | N | N | N |
| Manager Function | M | N | N | N | N | N | N | N | N |
| Operator / Material Handler | N | M | N | N | N | N | N | N | N |
| **Administrative Areas** | | | | | | | | | |
| Manager | M | N | N | N | N | N | N | N | N |
| Specialist | R | R | N | N | N | N | N | N | N |
| Assistant | R | M | N | N | N | N | N | N | N |

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Impressions

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## MOVE Lean Enterprise and Lean Office

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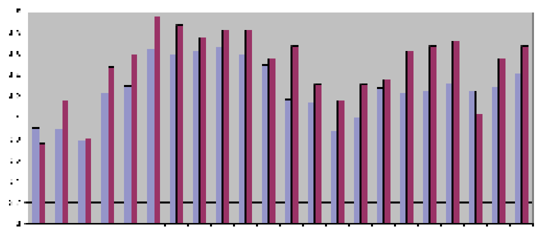
## Feedback: There is room for improvement

The courses are well received due to the high content of practical exercises

Feedback results



Main points for improvement:

- how to transfer the learned into the own environment?
- too much information packed into two days!

**Improvement to the system:**

**General lean training**

- Lean factory light (4 hours)
- Lean office light (4 hours)

**Specialized trainings**

Combine training session with subsequent work shop on the floor

- e.g. 2 days VSD training with adjacent values stream work shop

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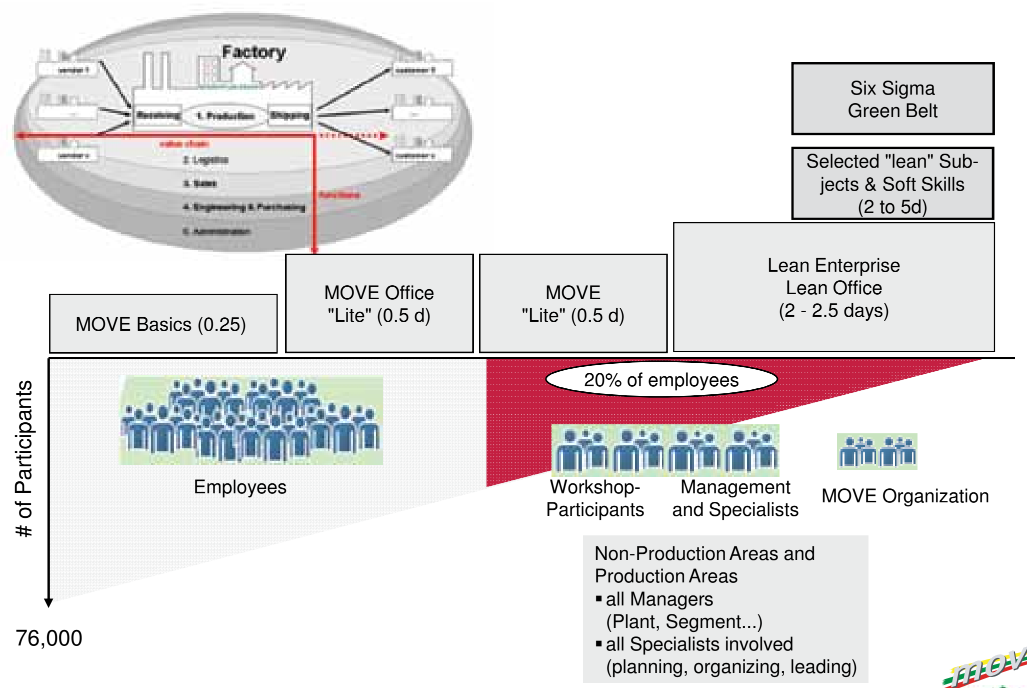
## MOVE Academy – Training concept




Page 8 May 2013 Schaeffler - MOVE Qualification - W. Beauvais

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## MOVE Qualification

- MOVE Academies
- **Leadership workshops**
- Benchmark Seminars

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MOVE Leadership Workshops

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## 5 days focused on MOVE for Top Management

The Team:
- BU Manager
- PL Manager
- Plant Manager
- Segment Mgr.
- MOVE Office

- to learn MOVE hands on
- to demonstrate MOVE to the employees

- to experience what can be achieved in 5 days
- to expect results in the future

- to live MOVE in the future
- **leading by example**

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Visible results

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## Qualification: MOVE Leadership Workshops

Examples

**Before**

- Large lot sizes
- Tow motors
- High number of handling steps

**After**

- Defined inventory level
- Defined replenishment rules
- Reduced number of handling steps

Reduction of space and through put times

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## MOVE Qualification

- MOVE Academies
- Leadership workshops
- **Benchmark Seminars**

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Qualification

## Benchmark Seminars: Learning from the best

Be open minded: Look out for the positive – avoid to criticize the negative

**Preparation**

- Training "see and evaluate"
- Meeting of the participants
- Definition of goals and categories to observe during the visits

**Benchmark Visit**

- Benchmark visit
- Take notes in the different categories (check list)
- reflect your experiences following the visit:
- What is important for my own department/area

**Post-processing**

- Workshop to prepare projects
- Transfer the seen to your own environment ready for implementation in other areas of the company
- Present results to management board

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Qualification

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## Benchmark Seminars: Example

**Implemented ideas coming from the benchmark seminars lead to measurable results**

***Benchmark Seminar "Machinery Department"***

**Japan**

- *Germany*
- *Slovakia*
- *China*
- *India*
- *...*

→ *"We will develop lean machining equipment"* → *manual assembly concept*

*→ Savings*

**Experience of real one piece flow**

***Benchmark Seminar Business Unite "Transmission Applications"***

**Europe**

- *Business unit*
- *plant management*
- *development department*
- *manufacturing engineering*
- *MOVE department*

→ *"Create flow from the raw material to the shipping department: A One-Piece-Flow-Pilot line"* → *improve assembly concepts*

*→ Savings*

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## Conclusion

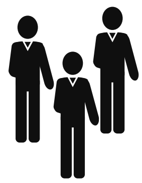
MOVE Campus: Qualification is a key element of our lean journey

**Academy trainings**

- Lean enterprise
- .......
- ........
- Lean methods

**Workshop trainings**

- Training on the floor
  - Value stream
  - TPM/5S
  - Kanban



**Employee**

- learn hands on
- lead by examples
- achieve results
- transfer

**Leadership workshops**

- learn to see
- evaluate and transfer
- develop and implement

**Benchmark seminars**

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Just start

## Let's do it

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# **Session 2:** Beyond lean learning factories – The model plant Ueberlingen as nucleus for the learning organization

**Dipl.-Wirt.-Ing. Marc Goldschmidt** is Director for Operational Excellence at MTU Friedrichshafen GmbH. After studying industrial engineering he started his career with Mercedes-Benz Technology Consulting GmbH. From 2005 to 2010 his focus was on the implementation of production systems and the development of lean production experts within the automotive sector, transportation as well as machine building industry. During the time as a consultant Mr. Goldschmidt deepened his practical knowledge within an International Lean Manufacturing Consulting – MBA program. In 2010 he started with MTU as Senior Manager Physical Logistics Series 1600. Mr. Goldschmidt was in charge of the logistics planning and – operations and one of the key drivers to build up a light house for the implementation of the MTU Productions System.

Tognum

With its two business units, Engines and Onsite Energy, the Tognum Group is one of the world's leading suppliers of engines and propulsion systems for off-highway applications and of distributed power generation systems. These products are based on diesel engines with up to 10,000 kilowatts (kW) power output, gas engines up to 2,150 kW and gas turbines up to 45,000 kW.

The product portfolio of the Engines business unit comprises MTU engines and propulsion systems for ships, for heavy land, rail and defense vehicles and for the oil and gas industry. The Onsite Energy business unit supplies distributed power generation systems carrying the MTU Onsite Energy brand. These comprise diesel engines for emergency power, prime power and continuous power, as well as cogeneration power plants based on gas engines and gas turbines that generate both power and heat. Tognum's product portfolio also features fuel-injection systems built by L'Orange.

In 2012, Tognum generated revenue of around €3.015 billion and employs more than 10,000 people. Tognum has a global manufacturing, distribution and service structure with 24 fully consolidated companies, more than 140 sales partners and over 500 authorized dealerships at approximately 1,200 locations. Since mid-March 2013, Tognum AG has been a wholly-owned subsidiary of Engine Holding GmbH, a joint venture of Daimler AG and Rolls-Royce Group plc.

Tognum
HOME OF POWER BRANDS
| ENGINES
| ONSITE ENERGY & COMPONENTS

# Beyond lean learning factories

## The model plant Überlingen as nucleus for the learning organization

*Munich, 15.05.2013, Marc Goldschmidt*

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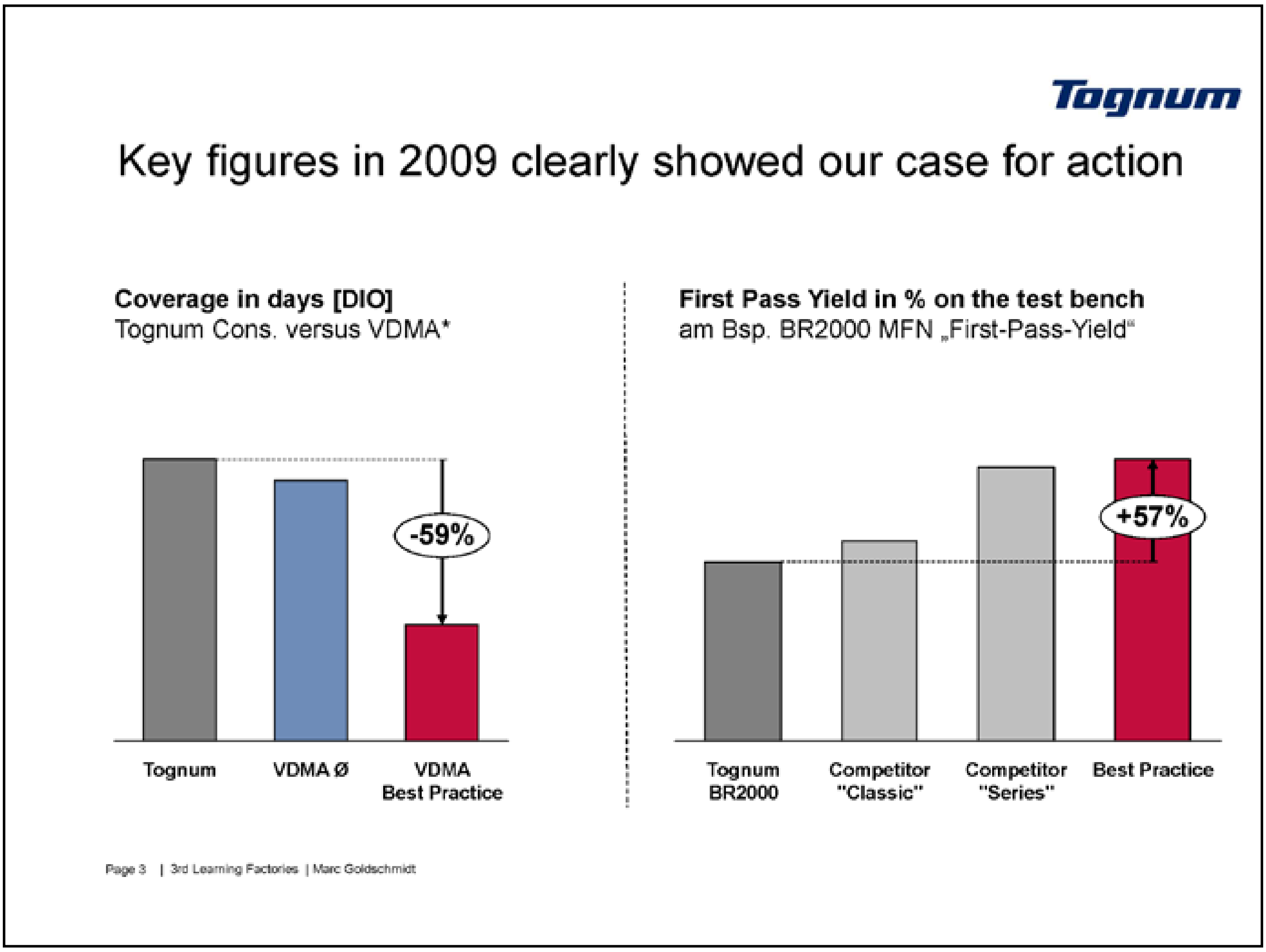
## Content


Tognum
Key figures in 2009 clearly showed our case for action
Coverage in days [DIO]
Tognum Cons. versus VDMA*
-59%
Tognum
VDMA Ø
VDMA Best Practice
First Pass Yield in % on the test bench
am Bsp. BR2000 MFN „First-Pass-Yield"
+57%
Tognum BR2000
Competitor "Classic"
Competitor "Series"
Best Practice
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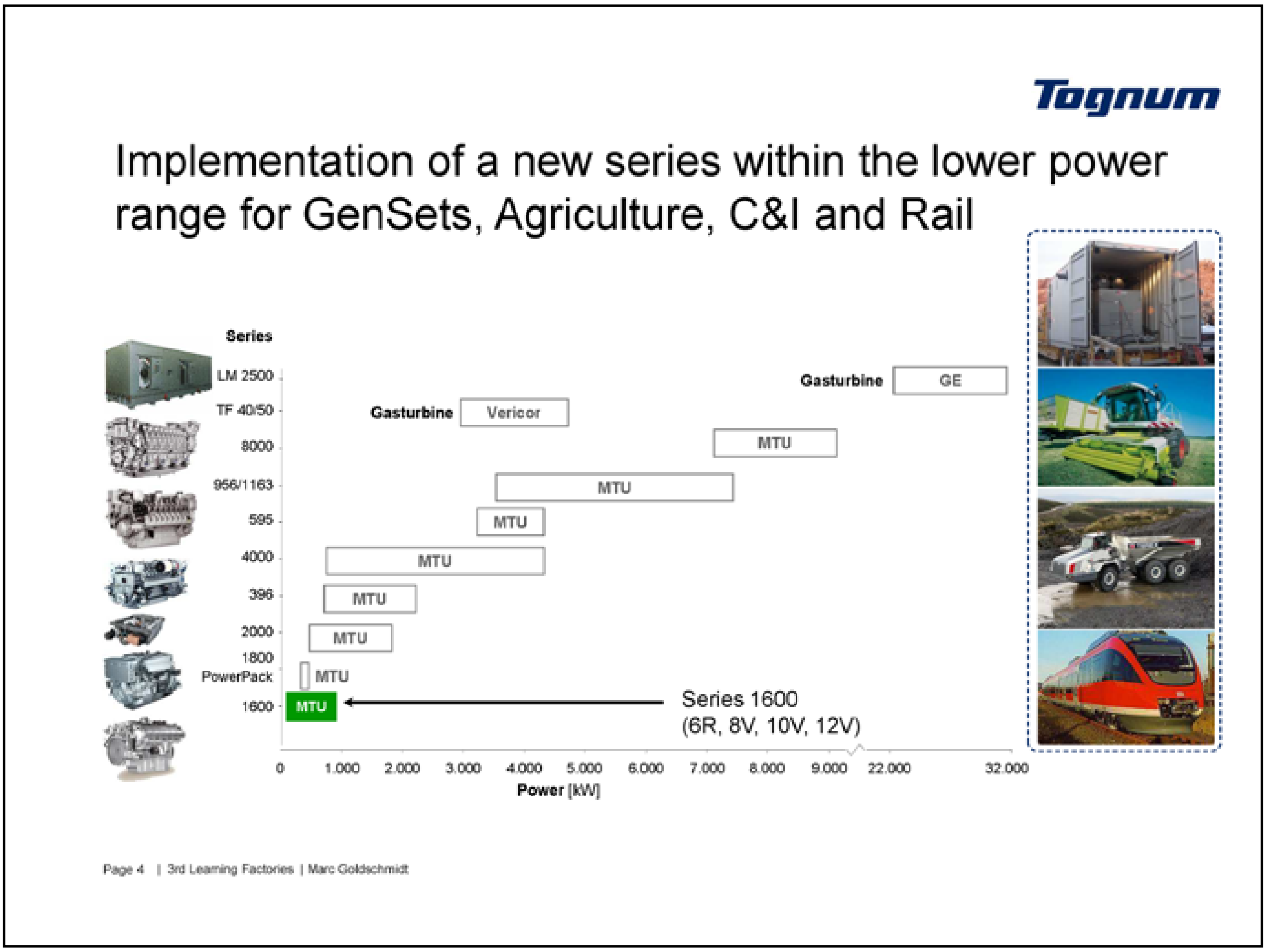
Tognum
Implementation of a new series within the lower power range for GenSets, Agriculture, C&I and Rail
Series
LM 2500
TF 40/50
8000
956/1163
595
4000
396
2000
1800 PowerPack
1600
Gasturbine
GE
Gasturbine
Vericor
MTU
MTU
MTU
MTU
MTU
MTU
MTU
MTU
Series 1600
(6R, 8V, 10V, 12V)
0
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
9.000
22.000
32.000
Power [kW]
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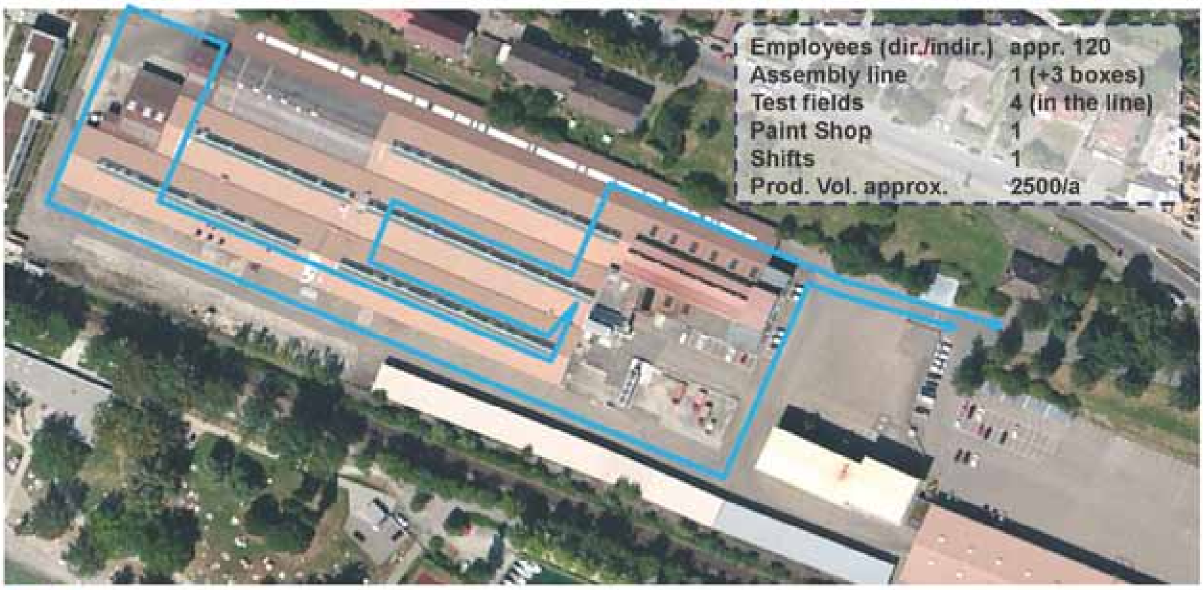
## For the build up of the new series 1600 we used an established plant structure




Material flow Copyright: googlemaps

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## Content

1 What was our case for action?

2 How was our change process?

3 What have we learned?

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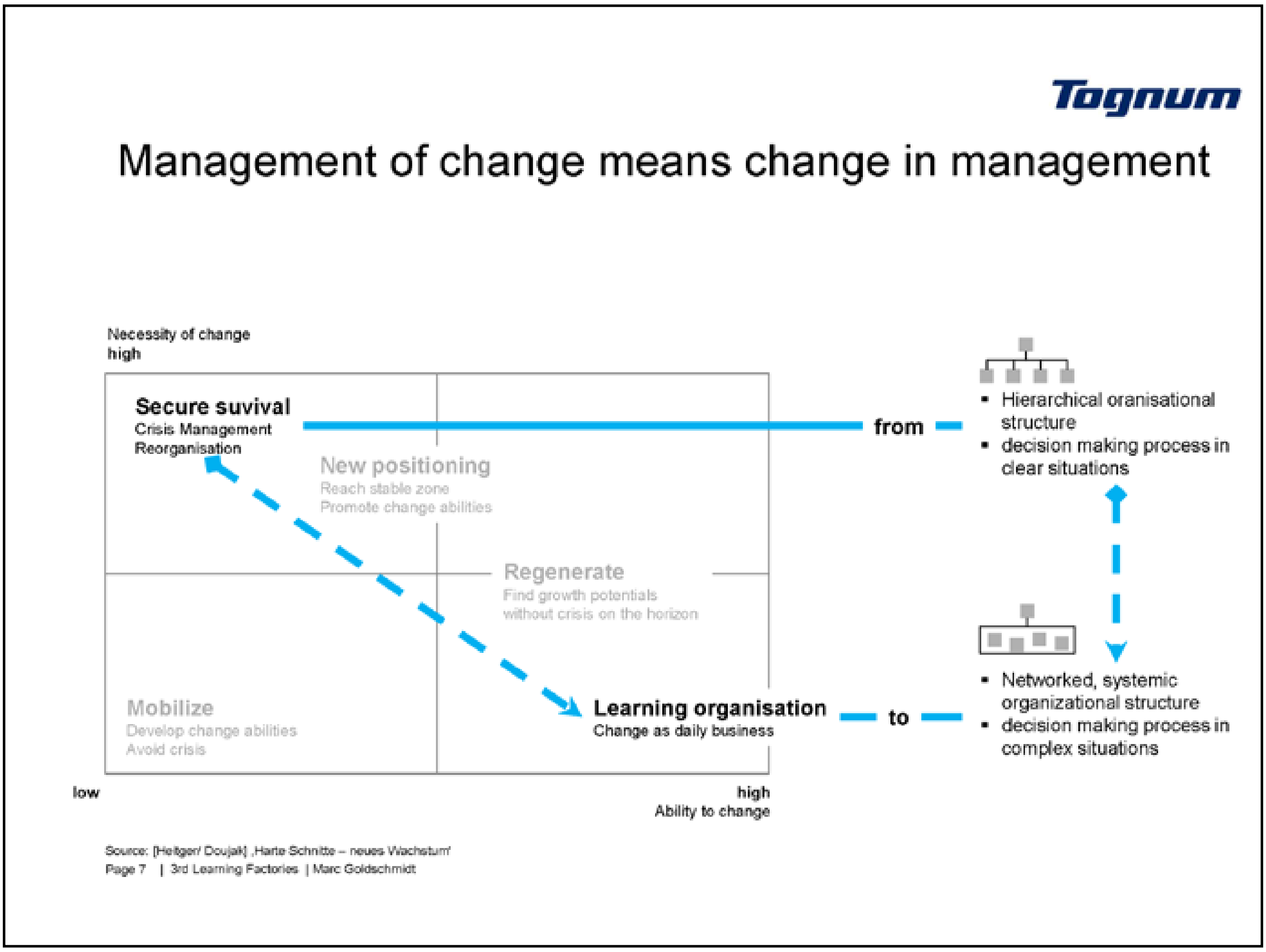
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Management of change means change in management
Necessity of change
high
Secure survival
Crisis Management
Reorganisation
New positioning
Reach stable zone
Promote change abilities
Regenerate
Find growth potentials
without crisis on the horizon
Mobilize
Develop change abilities
Avoid crisis
Learning organisation
Change as daily business
low
high
Ability to change
from
to
Hierarchical oranisational structure
decision making process in clear situations
Networked, systemic organizational structure
decision making process in complex situations
Source: [Heitger/ Doujak] ‚Harte Schnitte – neues Wachstum'
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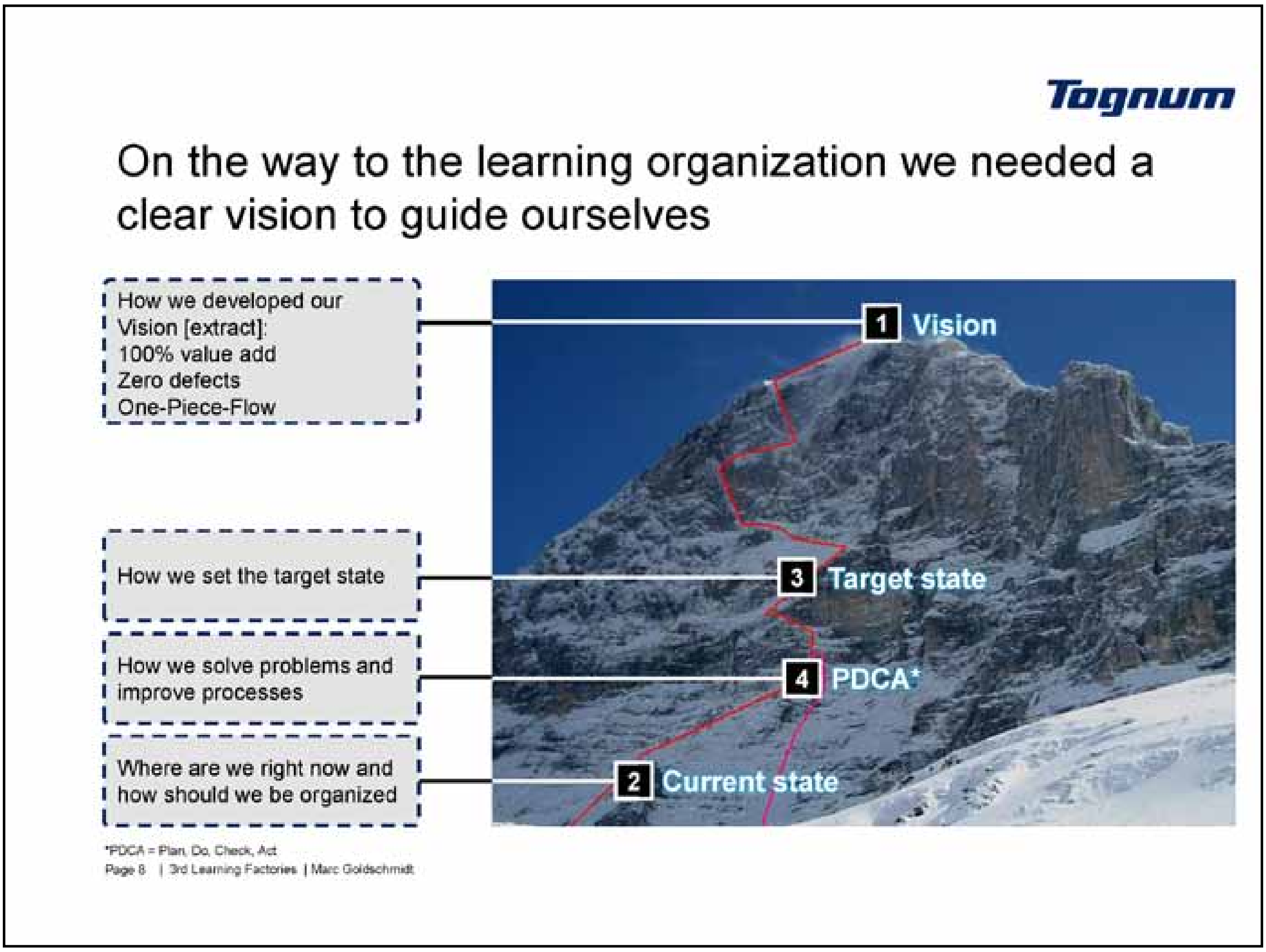
Tognum
On the way to the learning organization we needed a clear vision to guide ourselves
How we developed our Vision [extract]:
100% value add
Zero defects
One-Piece-Flow
How we set the target state
How we solve problems and improve processes
Where are we right now and how should we be organized
1 Vision
3 Target state
4 PDCA*
2 Current state
*PDCA = Plan, Do, Check, Act
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## Once a year we conduct a employee day – we focus on our vision and team building


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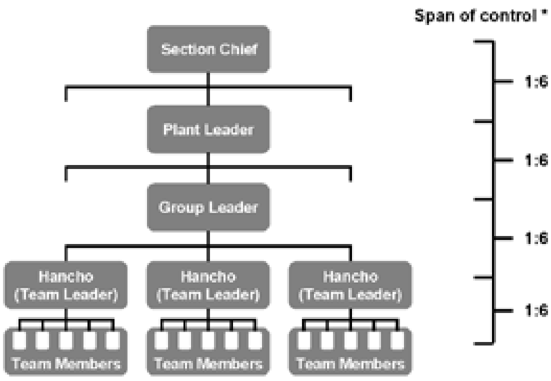
## Span of control max. 1:6 and management on the shop floor – it's clear what's important




**„Production team members appreciate management on the shop floor only when they see that we are out to help them to do there job, not as a part of command structure, bent on telling them what to do",**
Gary Convis, President, Toyota Motor Manufacturing, Kentucky

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## To understand the actual state, standards are necessary ...or „Where there is no standard, there can be no Kaizen.“

1 Plant

2 Dept.

3 Team

4 Worker

**Plant Board:**
- Value Stream
- Management Info Center
- KPI: Safety, Delivery, Quality, Efficiency, Cost

**Station Board:**
- Standard Worksheet
- Cycle time
- Easy Problem Solving

breakdown

Was it today a good or a bad day?

breakdown

* Taichii Ohno: Kaizen = Continuous Improvement

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## Based on the top-down targets the activities are planned in a yearly workshop with the Hanchos

1. Vision Development

2. Breakthrough Targets 3 to 5 years

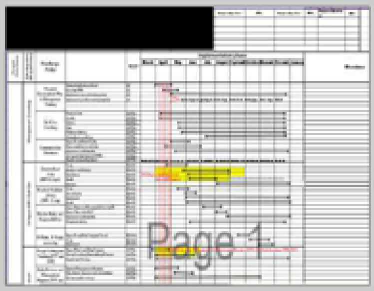
**1. Phase: long term company planning**

3. Target State plant

4. Target State groups / teams

**2. Phase: core process of setting the target state**

**Tactical implementation plan**
- Projects of the planning dep.
- Hancho improvements (Kaizen) with workgroups




5. Implementation

6. Operative planning review (1 month)

7. Annual review

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# Nothing can replace the detailed observation on the way to the learning organization

| | They report a problem !!! | I GO & SEE | I GO & STUDY | I GO & SOLVE | Learning Organisation |
|---|---|---|---|---|---|
| Management | ▪ Only Data<br>▪ Limited perception<br>▪ Influenced analysis<br>▪ Limited Interesst | ▪Feeling for the situation<br>▪Understanding of the environment<br>▪Visible interest | ▪Bottom-up decision making<br>▪Teamwork<br>▪Content based dialogue<br>▪Coaching / Example | ▪I learn<br>▪You learn<br>▪We improve<br>▪We celebrate | ▪Support of the workers in problem solving process |
| Worker | ▪ Big risk for a wrong desision and bad problem solving<br>▪ Lack of confidence zu succeed | ▪Motivation for the worker | ▪Understanding for 5x why<br>▪Trust in Management | ▪Big trust in cause and effect analysis and counter-meassures<br>▪Kaizen attitude by all employees | ▪Kaizen mindset and understanding by all employees |

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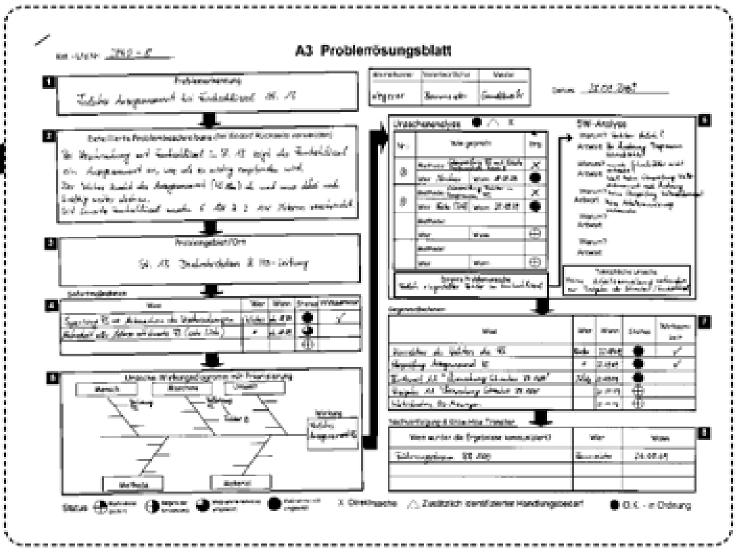
# The problem solving A3 paper to enable learning – or "no problem is a problem"

EXAMPLE




**The red cart in every Hancho Team shows the problems on the shop floor.**

**"Every problem is a treassure and gives us the chance for improvement".**

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## Content

1. What was our case for action?
2. How was our change process?
3. **What have we learned?**

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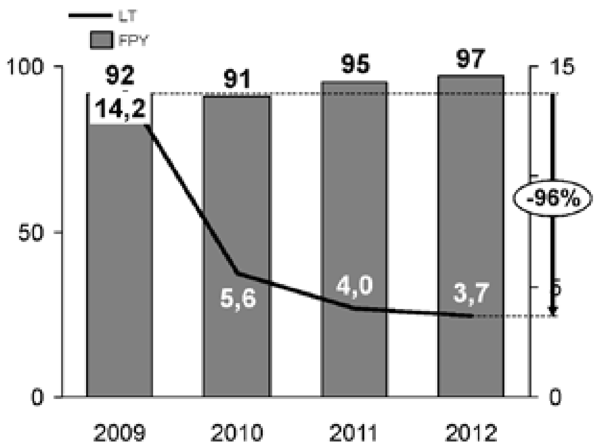
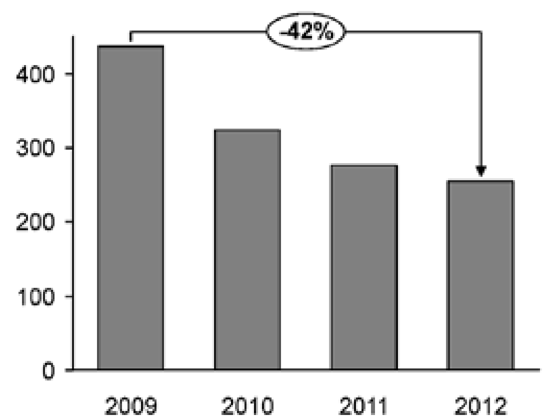
## The continuous improvement process shows significant effects in assembly and logistics

**Development of the lead time and first past yield in the assembly process between**
[LT = working days]; [FPY hot test = %]




**Development of the process time in the logistic process**
[min/engine]

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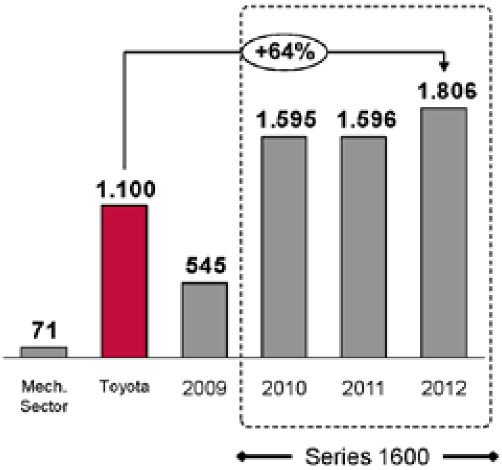
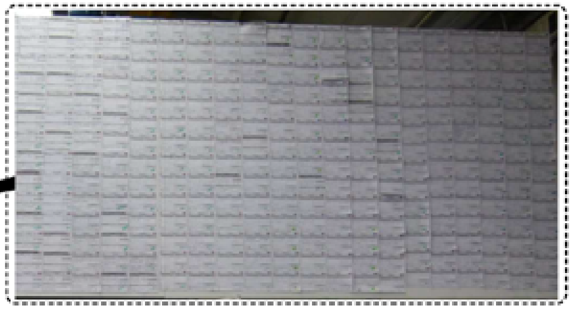
## "Living" a continuous improvement process means that every employee works on improving work flows every day




Visualization of "improvement-cards" in logistics



Source: dib-Report 2009, Dept. CPV/TMK, www.kanbanconsult.de/kaizen.htm



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## The lessons learned where formulated in the MPS – right now we are in the implementation phase


- Development in a small interdisciplinary team within 2 months
- Worldwide benchmarking and discussions with experienced professionals
- Continuous revision of the guiding principles
- Synchronization with the different departments and work council
- Definition of the pictures
- Production
- Roll-Out (approx. 2500 FTE trained)

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# Contact

A TOGNUM GROUP COMPANY


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www.mtu-online.com


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# SESSION 3:

## Creating the future with digital learning factories

# Session 3:
# Creating the future with digital learning factories

## Moderation: Prof. Dr. Gunther Reinhart

Prof. Dr. Gunther Reinhart is full professor for Industrial Management and Assembly Technology and director of iwb (Institute for Machine Tools and Industrial Management) at Technische Universitaet Munich (TUM). After studying mechanical engineering, he was research assistant at iwb from 1982 to 1988 with Prof. Dr. Joachim Milberg. After receiving the Ph.D. from TUM he started his industrial career with BMW Group, initially as head of the handling and welding engineering department and subsequently as director of the body paint shop. In 1993 he turned back to university to become professor and director of iwb.
From 2002 to 2007 Professor Reinhart took a sabbatical from university to become a member of the executive board of IWKA Corporation, a large German supplier with 13,000 employees worldwide. The he was in charge of Technology and Marketing.
2007 Professor Reinhart turned back to university and has served with Professor Michael F. Zaeh as co-director of iwb with more thand 100 employees. He is also the chairman of the Bavarian Cluster for Mechatronics and Automation and since 2009 head of the Fraunhofer IWU research-department for Resource-Efficient Converting Machines (RMV). Gunther Reinhart is member of multiple scientific societies and associations like acatech, WGP, WLT, CIRP and AIM. He has approximately 300 publications to his credit and is author or editor of ten books and two series. He has supervised doctoral theses of some 100 research associates.

The Insitute for Machine Tools and Industrial Management (iwb) of Technische Universitaet Munich is one of the major production technological institutes in Germany and consists of two chairs of the Faculty of Mechanical Engineering in Garching near Munich as well as a use centre in the area of production engineering in Augsburg. The two ordinariates, Institute for Industrial Management and Assembly Technologies and Institute for Machine Tools and Manufacturing Technology, define the focus of the research topics of iwb.

These are manufacturing processes, machine tools, handling, assembling and joining technology, control technology, robotics as well as industrial management, factory planning and logistics.
The staff of iwb dedicates itself to those fields in its reseach, teaching and industrial exchange.

# **Session 3:** XPRES - a digital learning factory for adaptive and sustainable manufacturing of future products

**Dr. Gunilla Sivard** is manager of XPRES Virtual Lab and manager of the research group Computer systems for design and manufacturing. She has previously worked at NASA in knowledge based representation, and Eurostep AB in information modeling and product life cycle management (PLM). She has been the project leader of several research projects concerning model based development of manufacturing systems and system neutral modeling of production resources and processes (ISO 10303). Further, she recently developed a new Masters course in Digital factories.

**Dr. Thomas Lundholm** is manager of XPRES. He has research and commercial development experiences in adaptive machining control, CNC system applications, manufacturing data acquisition and analysis, manufacturing system supervision and management, manufacturing resource modelling and gear manufacturing. He is involved in ISO standardization.

KTH VETENSKAP OCH KONST

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The Department of production engineering of KTH Royal Institute of Technology in Stockholm is the largest university department withing production engineering in Sweden. The department conducts research and teaching within the five chairs of Machine and process technology, Industrial metrology and optics, Evolvable production systems/Production systems, Computer systems for design and manufacturing and Sustainable manufacturing.
The Initiative for excellence in production research – XPRES with KTH Royal Institute of Technology as main contractor and Mälardalen University and Swerea Group research institutes as partners is a strategic research area funded by the Swedish government.
The Centre for design and managment of manufacturing systems – DMMS is a research and education centre mainly funded by the industrial partners. The focus is manufacturing of advanced, capital and knowledge intensive mechanical products, such as automotive powertrain parts.


Dr Gunilla Sivard
Dr Thomas Lundholm

Magnus Lundgren
Robert Romejko
Navid Shariat Zadeh
Emma Härdin

XPRES
initiative for excellence in production research

KTH ROYAL INSTITUTE OF TECHNOLOGY

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ROYAL INSTITUTE OF TECHNOLOGY

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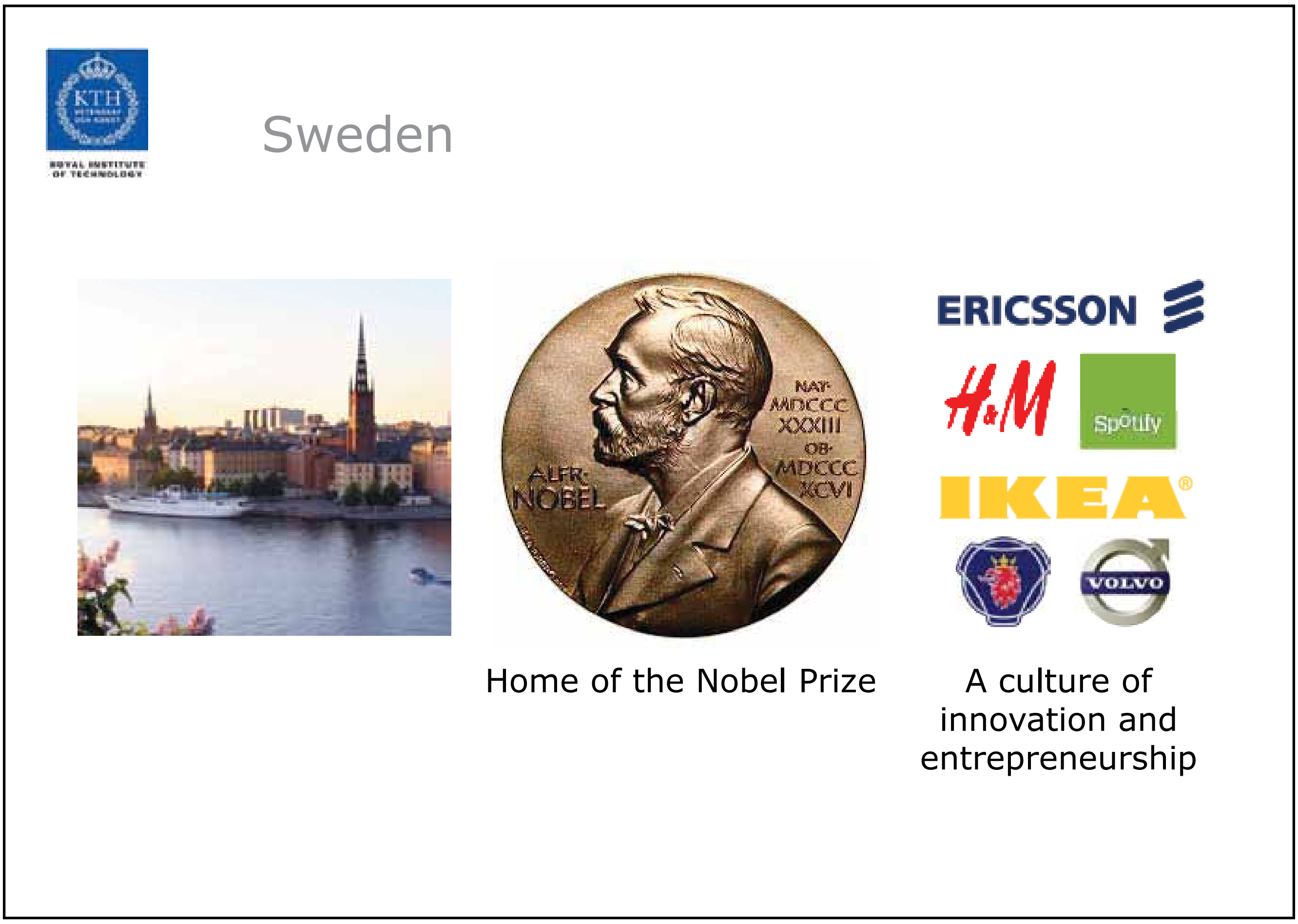
- Sweden’s largest, oldest and most highly regarded technical univeristy
- Leading research institution
- Maintains partnerships with international elite universities
- Hosts two EIT Communities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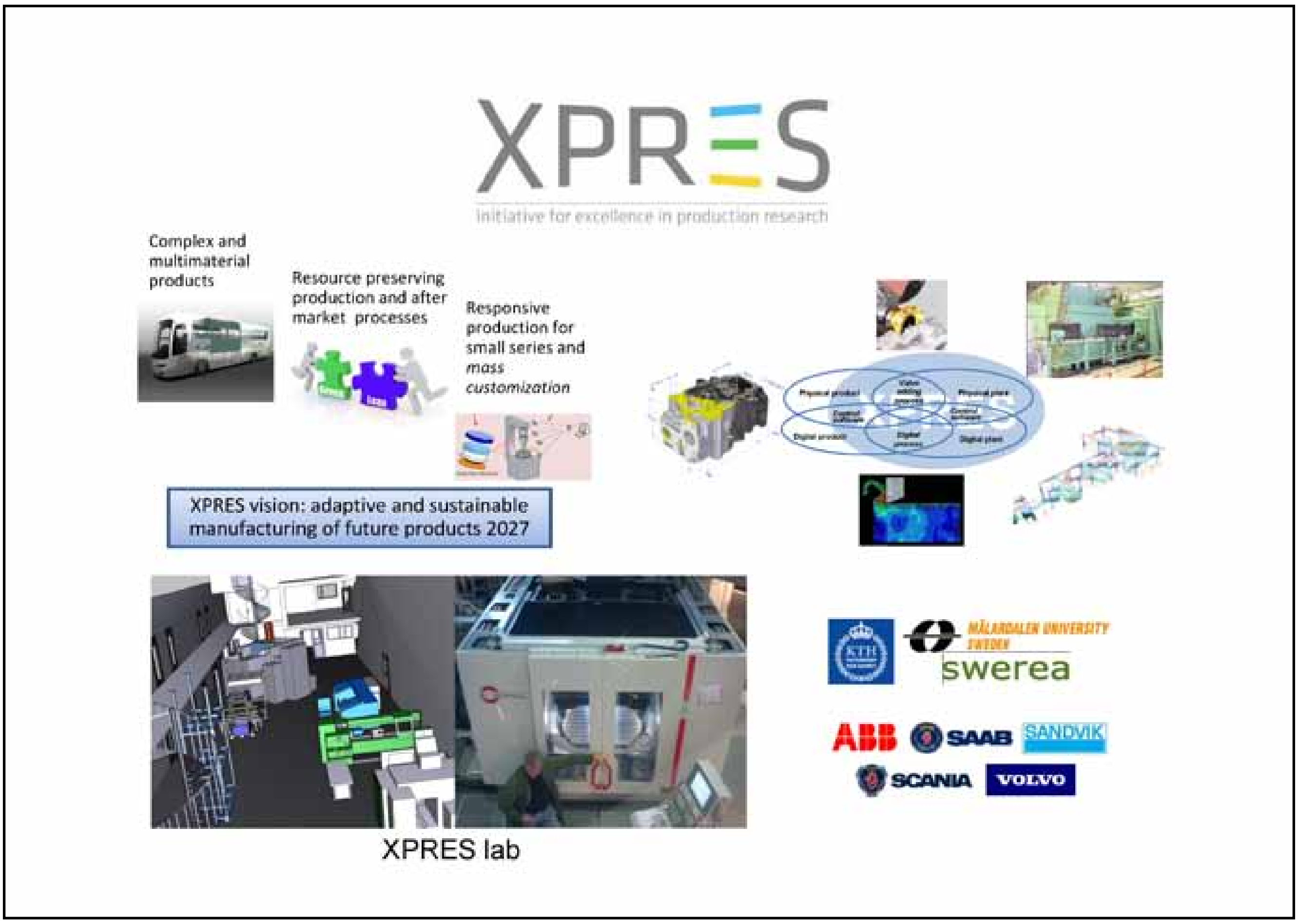
ROYAL INSTITUTE OF TECHNOLOGY
Sweden
Home of the Nobel Prize
A culture of innovation and entrepreneurship


XPRES
initiative for excellence in production research
Complex and multimaterial products
Resource preserving production and after market processes
Responsive production for small series and mass customization
XPRES vision: adaptive and sustainable manufacturing of future products 2027
XPRES lab
swerea

XPRES – a digital learning factory for adaptive manufacturing

1. Introduction
2. Learning factories at KTH today
3. Digital CiP learning factory
4. Q&A

Introduction

# Why a digital learning factory?

- Higher adaptivity through reduced development times with digital engineering
- Optimization of resources (time, energy and material) through simulation
- Increased industrialization of innovative products through early evaluation of disruptive manufacturing technologies

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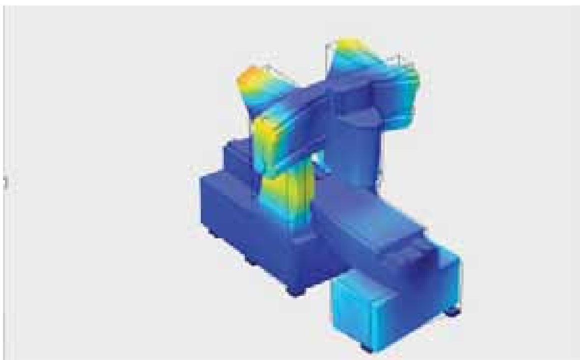
# Advantages of a digital learning factory

- Test various alternative scenarios
- Visualize what is invisible in reality and future solutions
- Exaggerate properties or speed up time
- Visualize and manage interdependencies in development workflow



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# Learning factory for different users – who will learn what?

- Engineering students
  - Basics in manufacturing
  - Utilization of digital factory
- Industry with limited experience in digital factories
  - New methods in manufacturing
  - Utilization of digital factory for their specific problems
- Industry interested in future possibilities
  - Possibilities with new technologies such as integrated, system neutral, information


XPRES initiative for excellence in production research | KTH Royal Institute of Technology | Mälardalen University Sweden | swerea swedish research

# Learning factories at KTH today

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# CIM line

XPRES · KTH · MÄLARDALEN UNIVERSITY SWEDEN · swerea

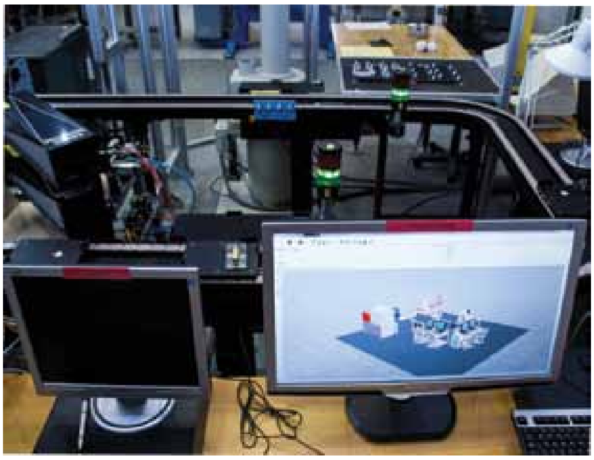
# Equipment

- Storage system
- Conveyor
- 3 IRBs
- 2 CNC machine tools
- Computers
- PLC

XPRES · KTH · MÄLARDALEN UNIVERSITY SWEDEN · swerea

# Exercises for students

- Analysis of control requirements
- Development of coordination strategies
- Programming of CIM manager system



# Project work

Implementation of

- new products
- new software
- new equipment

# Separate exercises

- Robots
  - Off-line programming
  - Vision
- Data communication
- CNC lathe
  CNC milling machine
  - NC programming
  - Machine evaluation tests

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# Modeling and simulation in factory development

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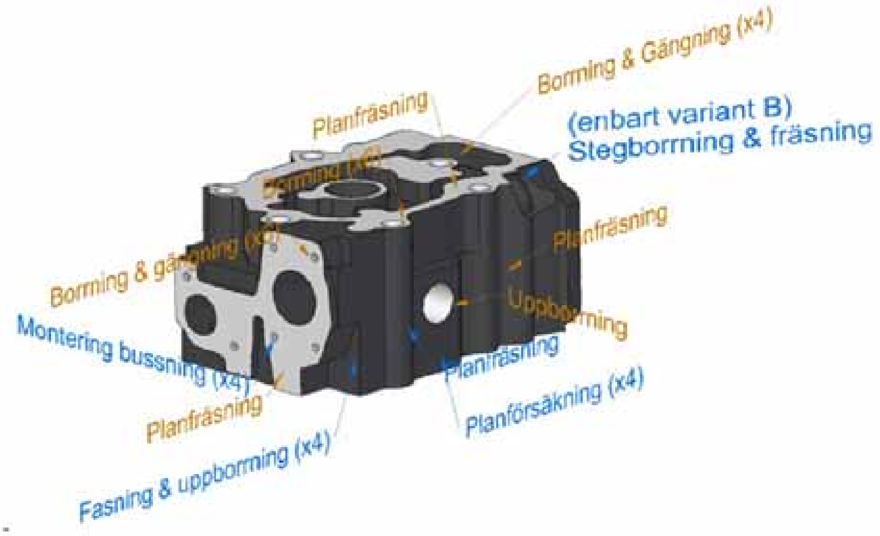
# Course task – machining of truck engine cylinder head

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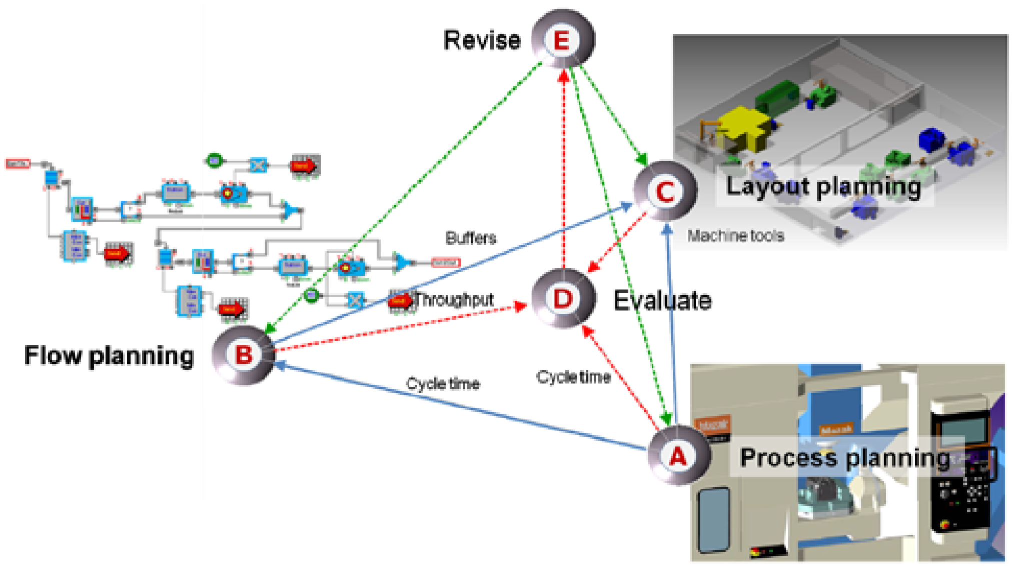
# Production development workflow – feedback loop

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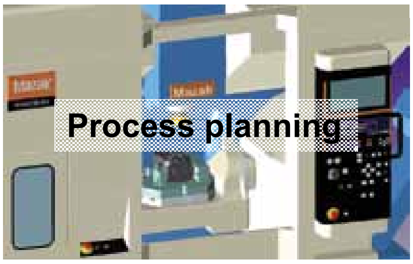


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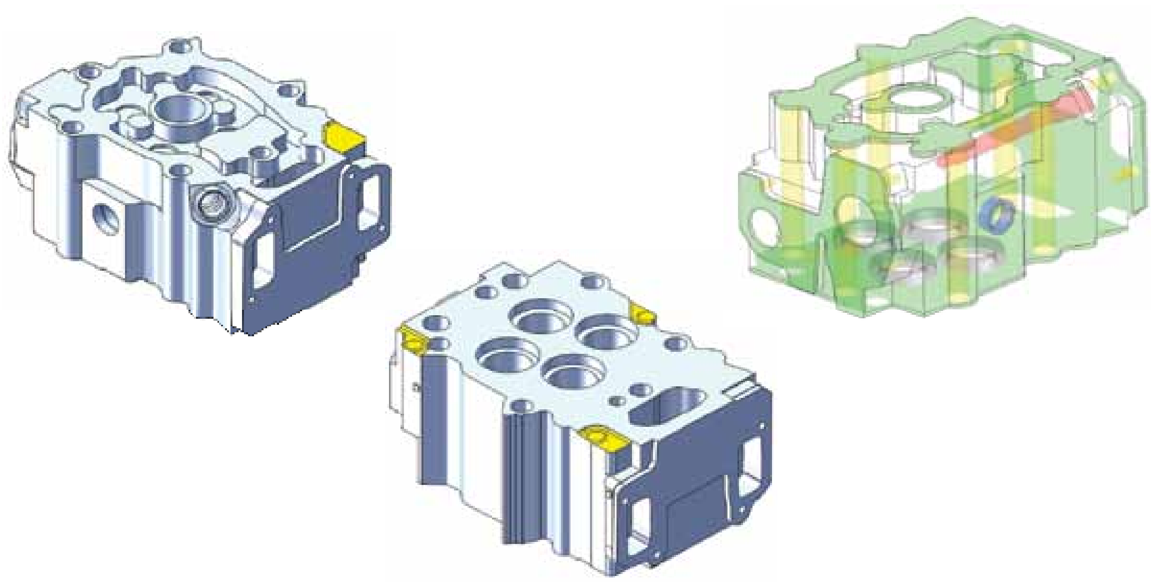
# Blank, workpiece and delta shape models



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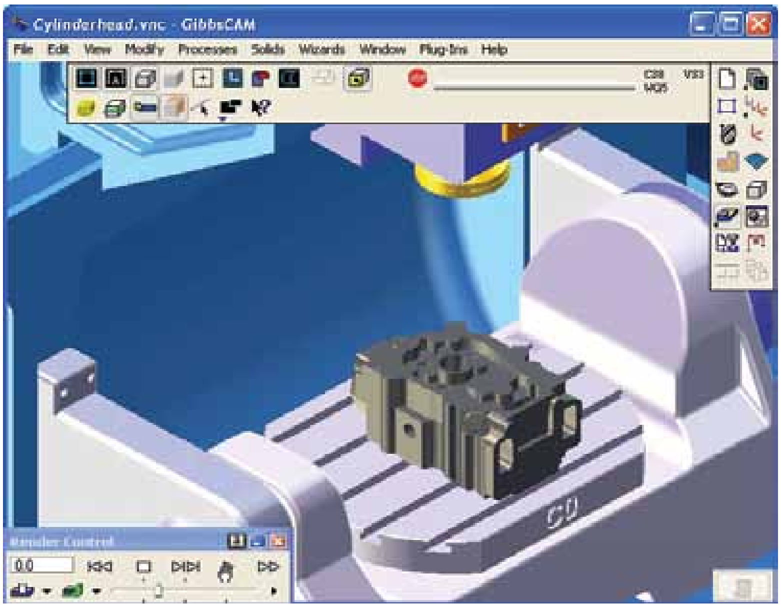
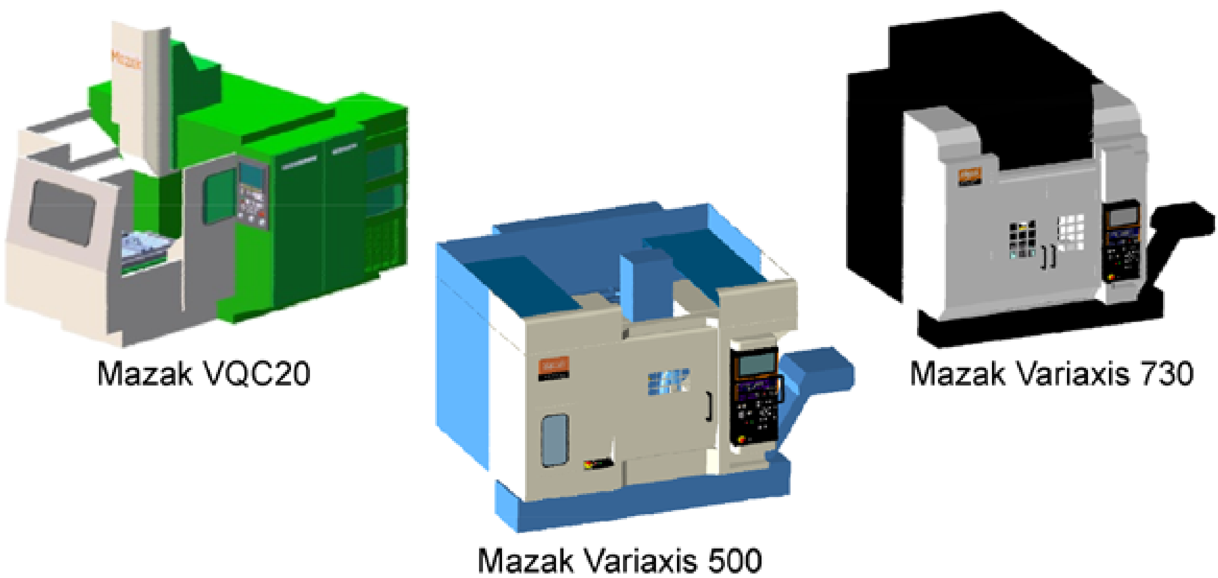
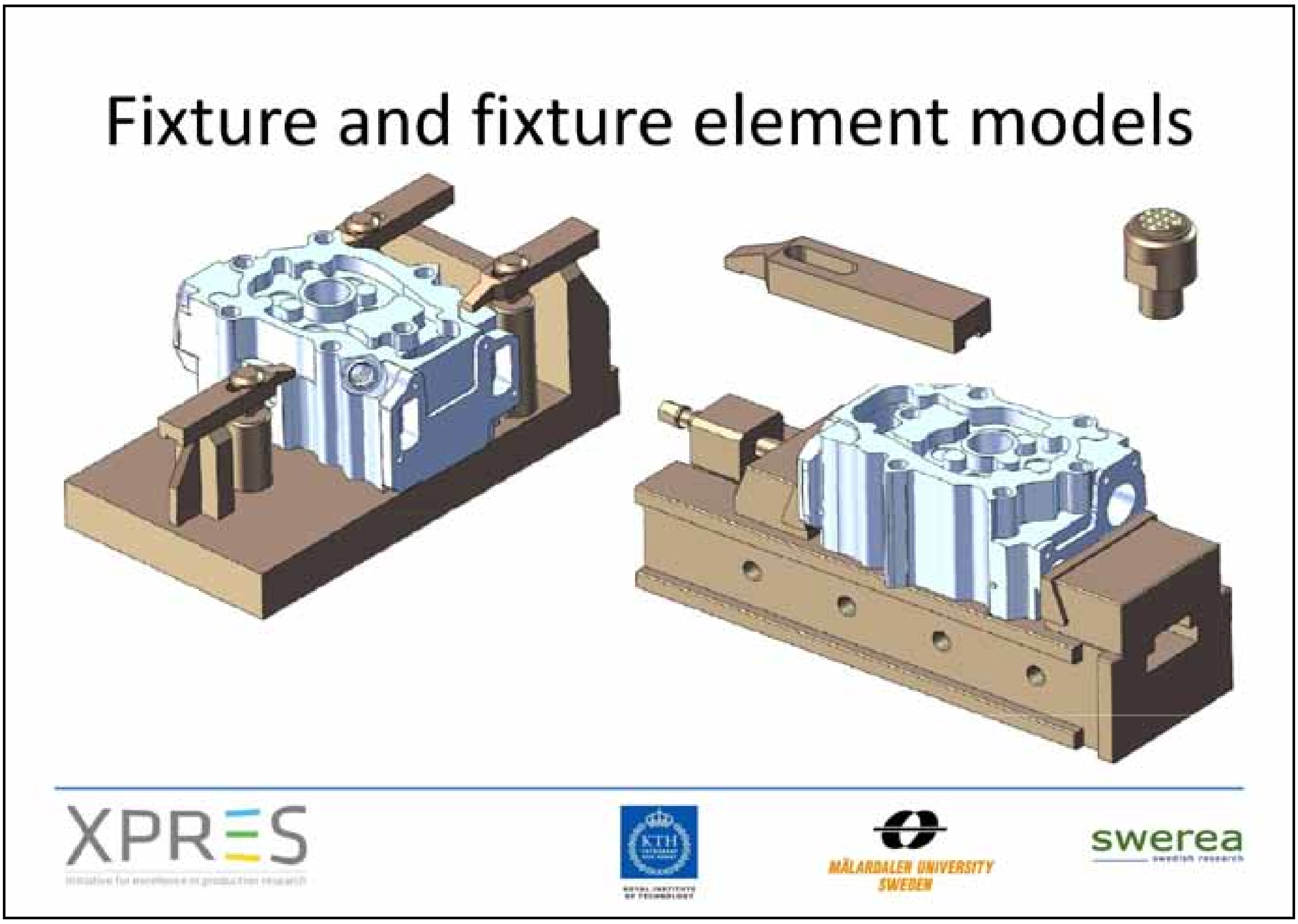
# Machining operations




# Machine tool models for simulation




Fixture and fixture element models
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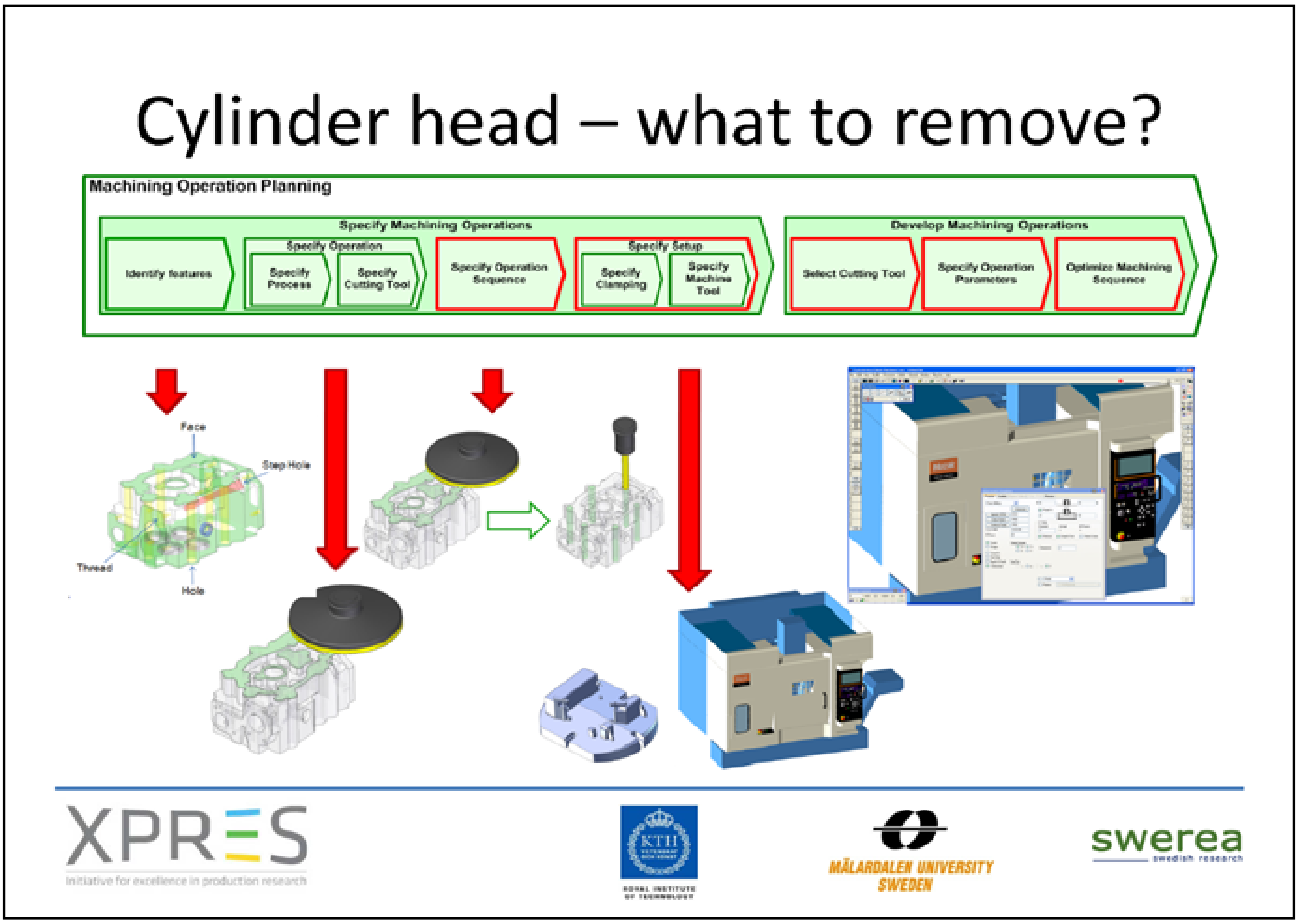
Cylinder head – what to remove?
Machining Operation Planning
Specify Machining Operations
Identify features
Specify Operation
Specify Process
Specify Cutting Tool
Specify Operation Sequence
Specify Setup
Specify Clamping
Specify Machine Tool
Develop Machining Operations
Select Cutting Tool
Specify Operation Parameters
Optimize Machining Sequence
Face
Step Hole
Thread
Hole
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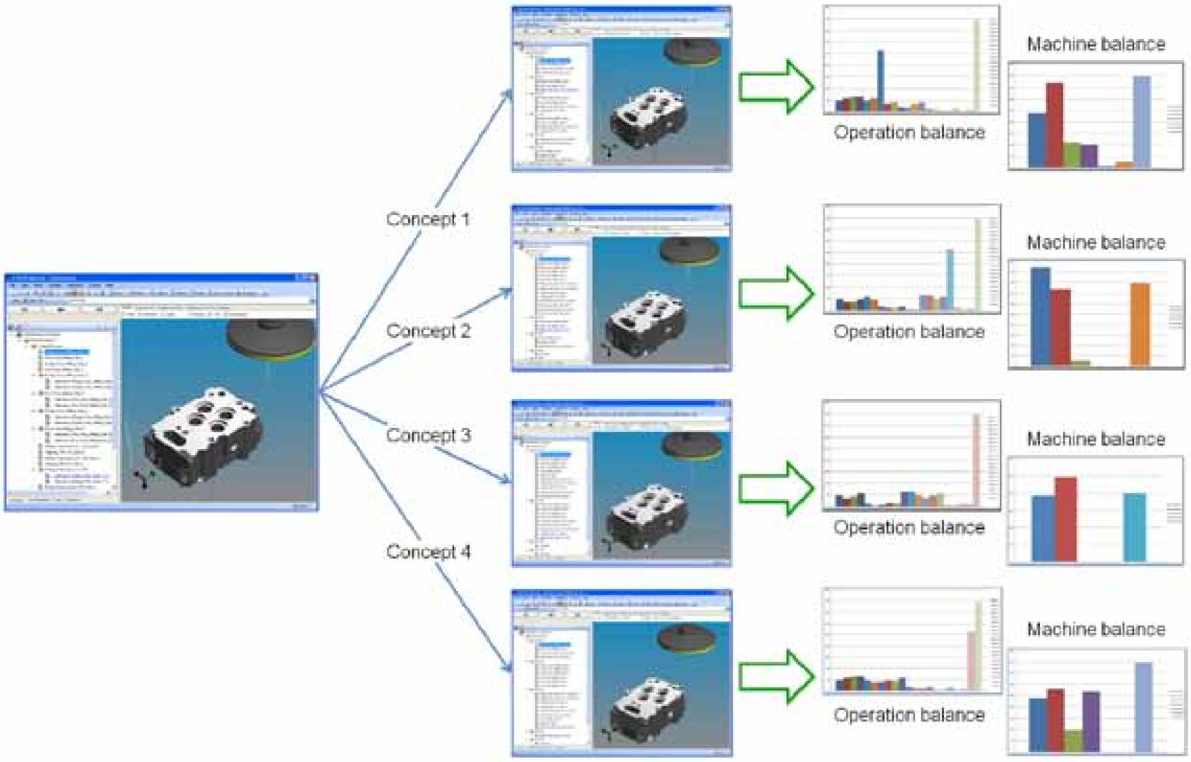


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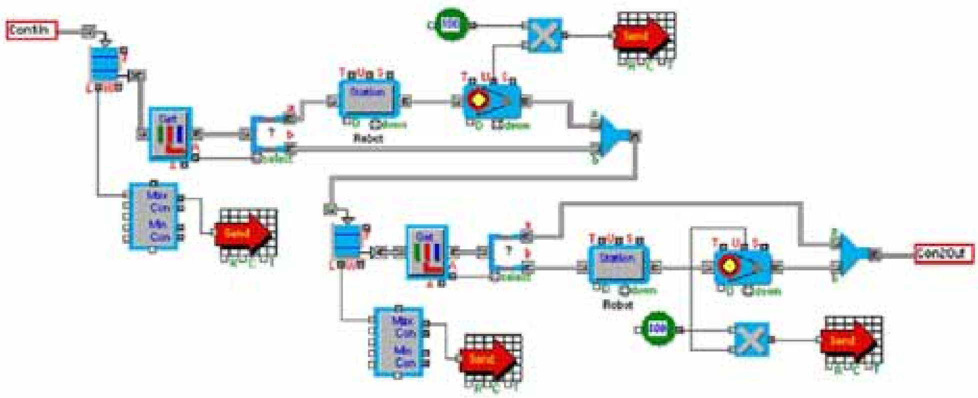
# Flow planning



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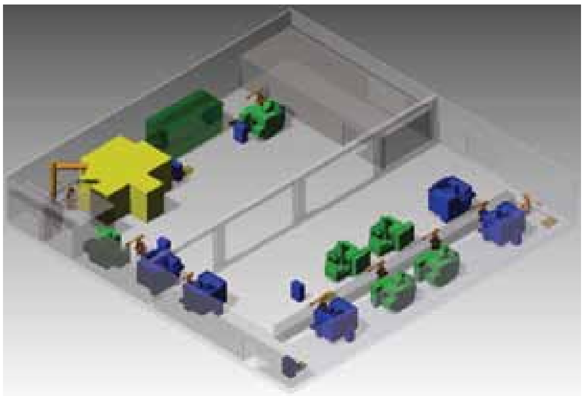
# Layout planning



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# Continuation

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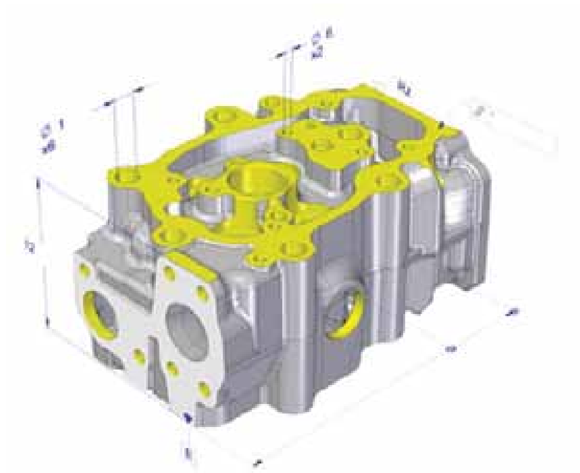
# Further development – model-driven production

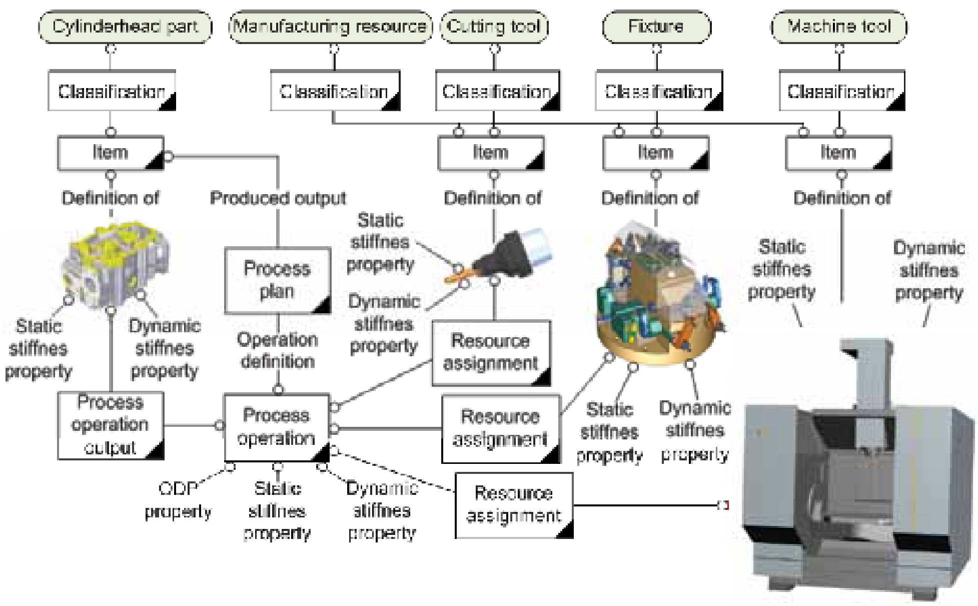
Based on information such as:

- workpiece material,
- machining features,
- geometrical dimensions & tolerances, datums etc

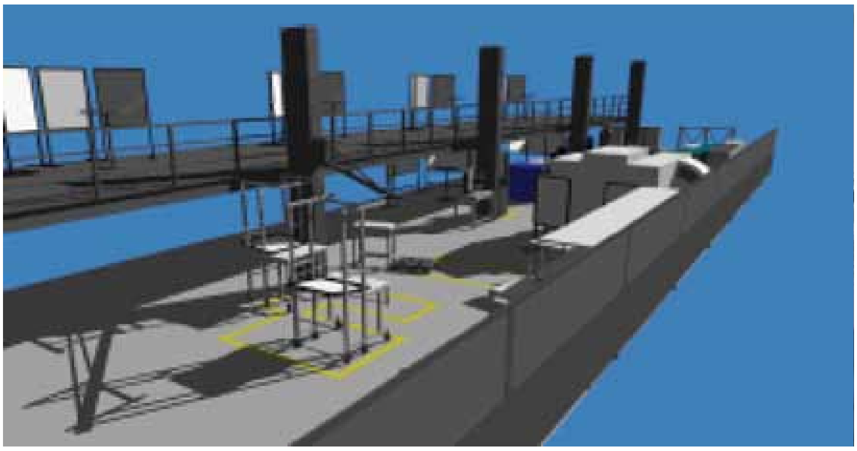
the digital part model can drive the selection of machining processes, cutting tools, cutting data, machining strategies, operation and setup sequencing.

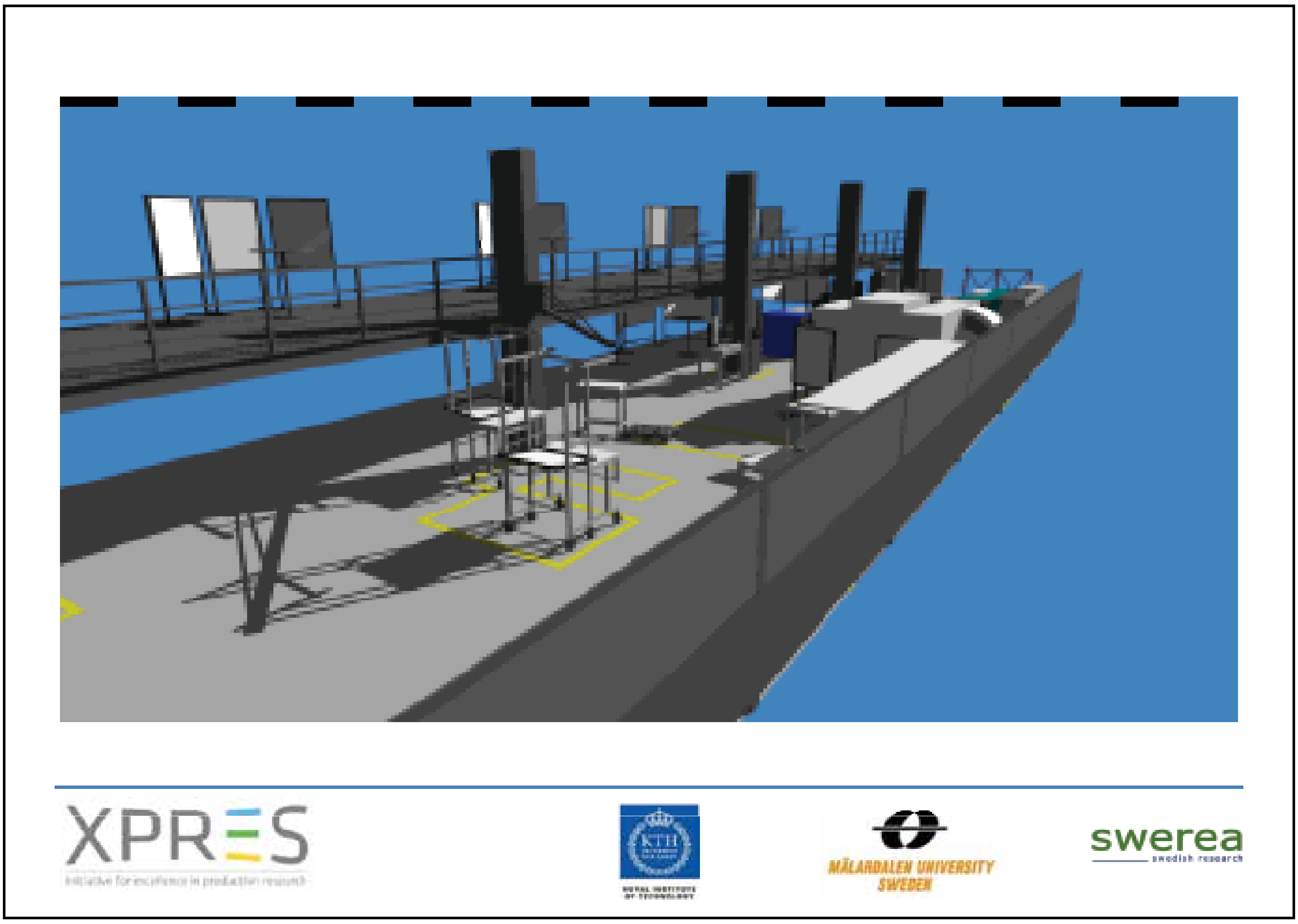


# ISO 10303 coherent models



# Digital CiP learning factory

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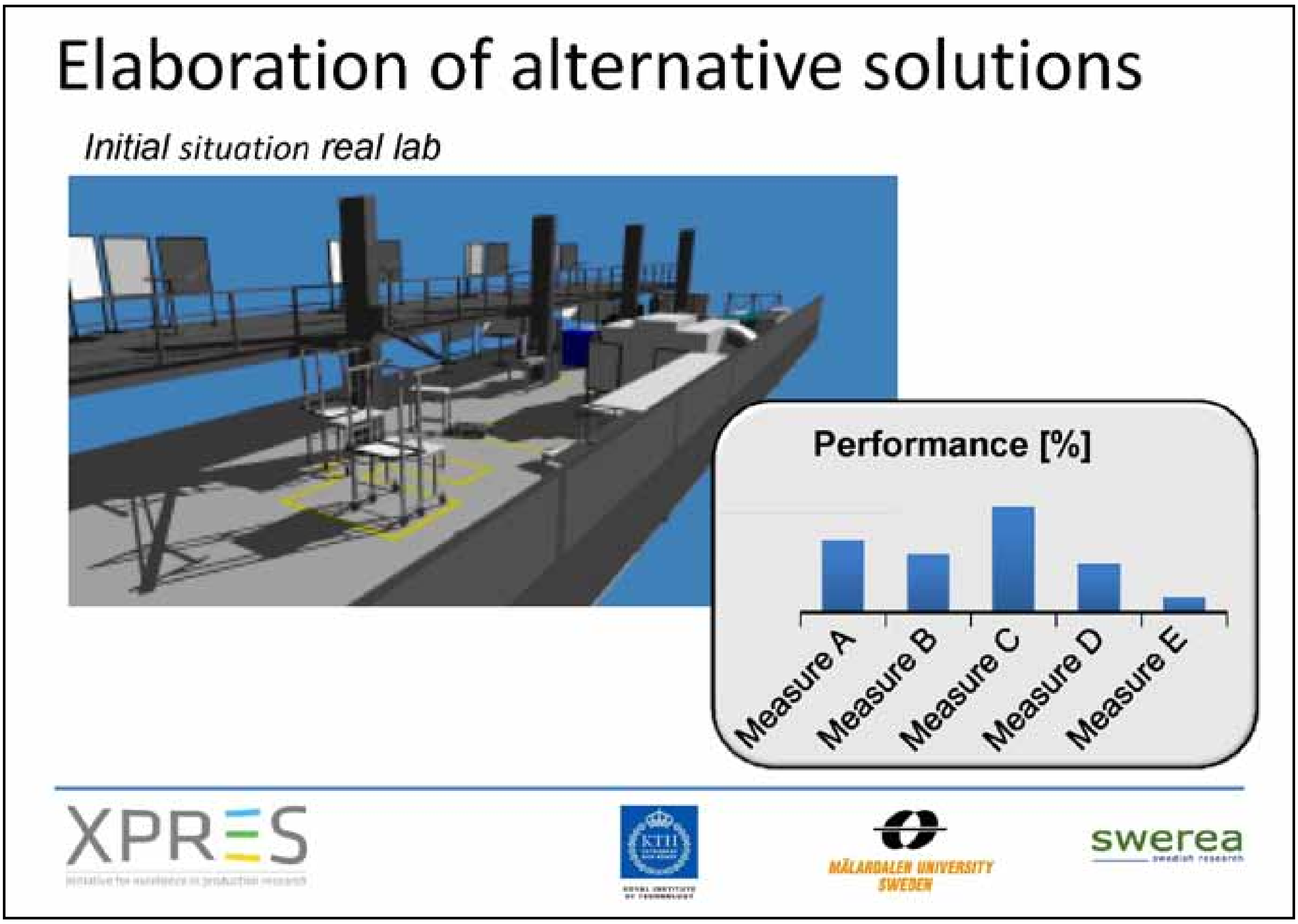
Elaboration of alternative solutions
Initial situation real lab
Performance [%]
Measure A
Measure B
Measure C
Measure D
Measure E
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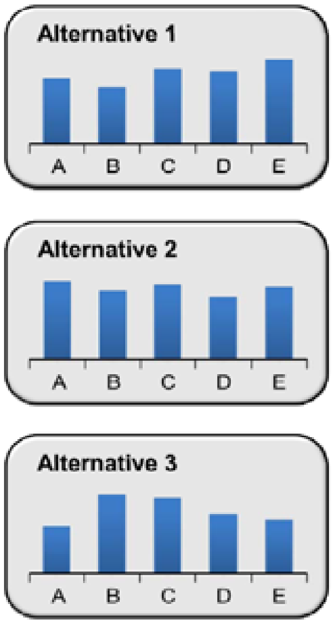
# Elaboration of alternative solutions

LAYOUT 1

LAYOUT 2

LAYOUT 3

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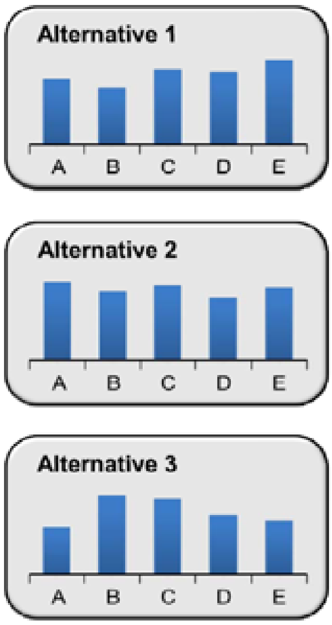
# Elaboration of alternative solutions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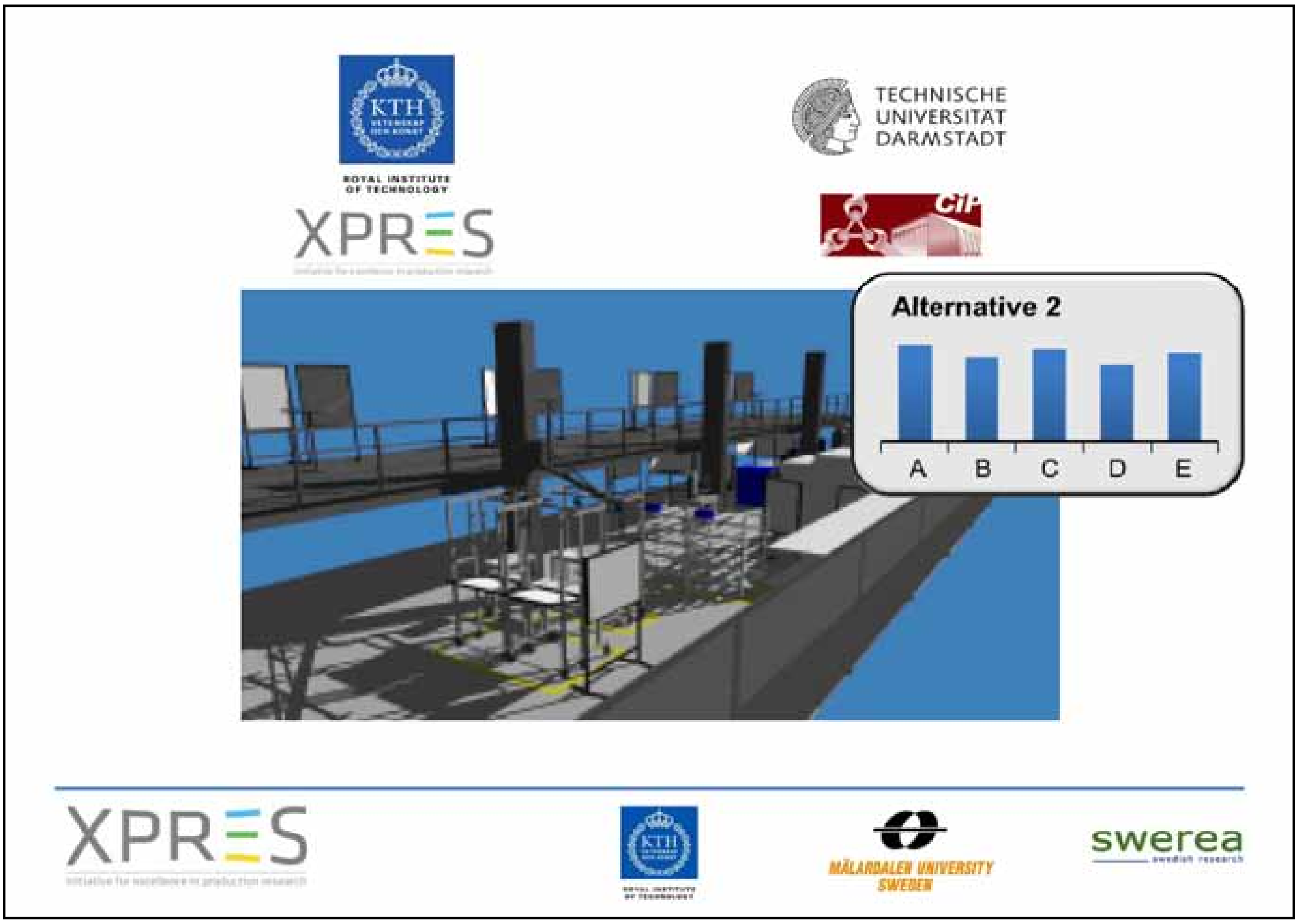
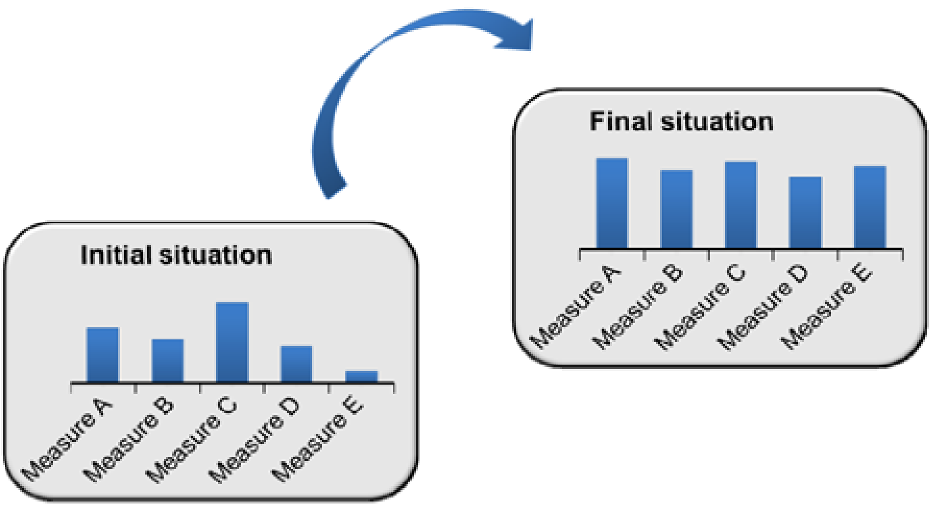



# Verification of results in the real lab

*Real factory vs digital factory*

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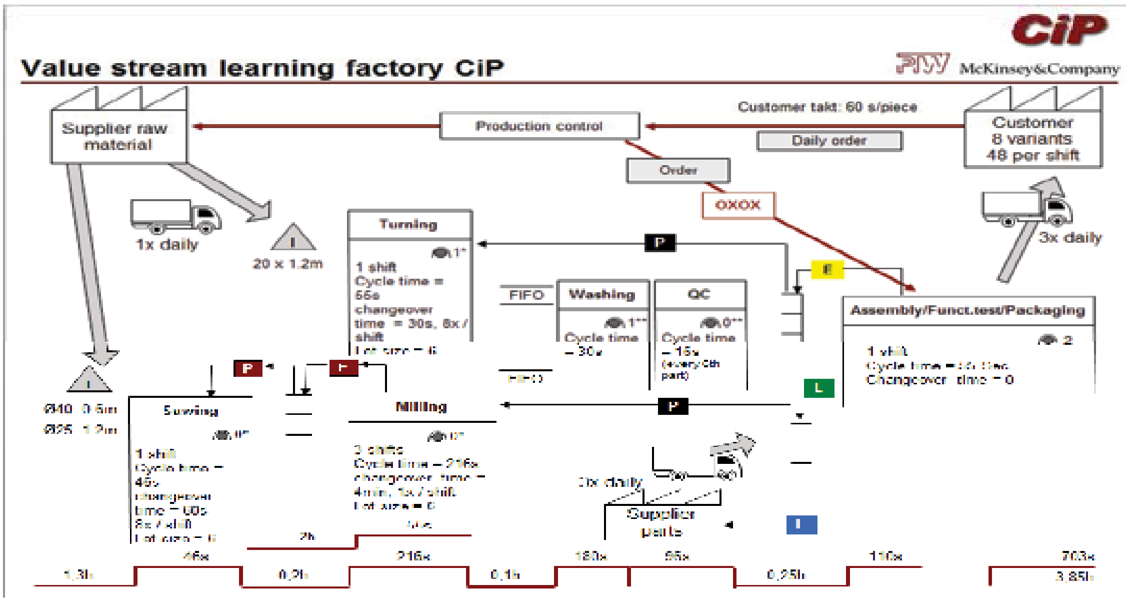
# Value stream mapping

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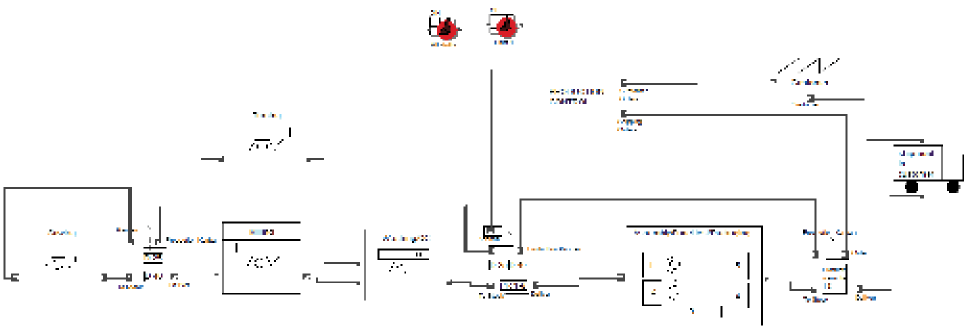
# Material flow simulation



- Capacity
- Throughput time
- Bottleneck
- Resource utilizations
- Cost
- Energy consumption

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# Thank you!

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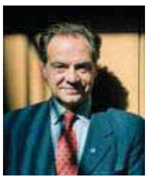

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# **Session 3:** Innovation of virtual commissioning solutions with the help of our Smart Automation research plant

**David Koch** is a research and development engineer at the Advanced Technologies and Standards department of Siemens Industry sector. He is responsible for several advanced research projects for the Industry Automation, Drive Technologies and Customer Services divisions.
David studied computer engineering with focus on closed-loop controls at TU Ilmenau. During his studies, he worked for Siemens Drive Technologies in the area of drive control and structural dynamics in Erlangen. After finishing his degree as an engineer, he joined Siemens Industry Automation at the Advanced Technologies and Standards department in Nuremberg. He has experience with research topics from Siemens Industry: e.g. CAD, CAM, machine tools, product lifecycle management, mechatronic engineering and virtual commissioning.

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Innovation of virtual commissioning solutions with the help of our Smart Automation research plant
3rd Conference on Learning Factories
May 2, 2013
Munich
David Koch
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Agenda
▪ Introduction
▪ Smart Automation
▪ Innovating virtual commissioning solutions
▪ Summary
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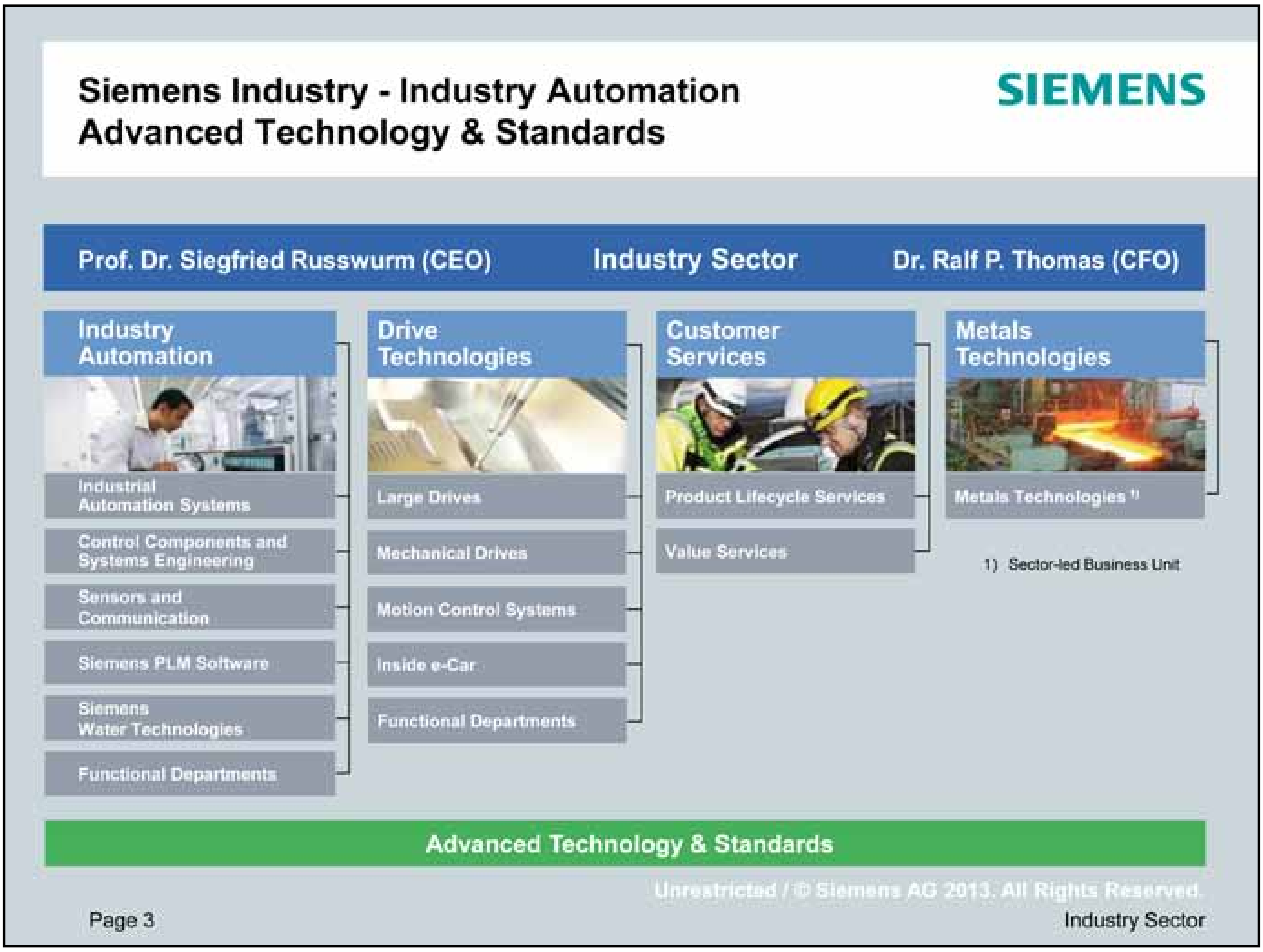
Siemens Industry - Industry Automation
Advanced Technology & Standards
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Prof. Dr. Siegfried Russwurm (CEO)
Industry Sector
Dr. Ralf P. Thomas (CFO)
Industry Automation
Industrial Automation Systems
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Siemens Water Technologies
Functional Departments
Drive Technologies
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Mechanical Drives
Motion Control Systems
Inside e-Car
Functional Departments
Customer Services
Product Lifecycle Services
Value Services
Metals Technologies
Metals Technologies [1]
1) Sector-led Business Unit
Advanced Technology & Standards
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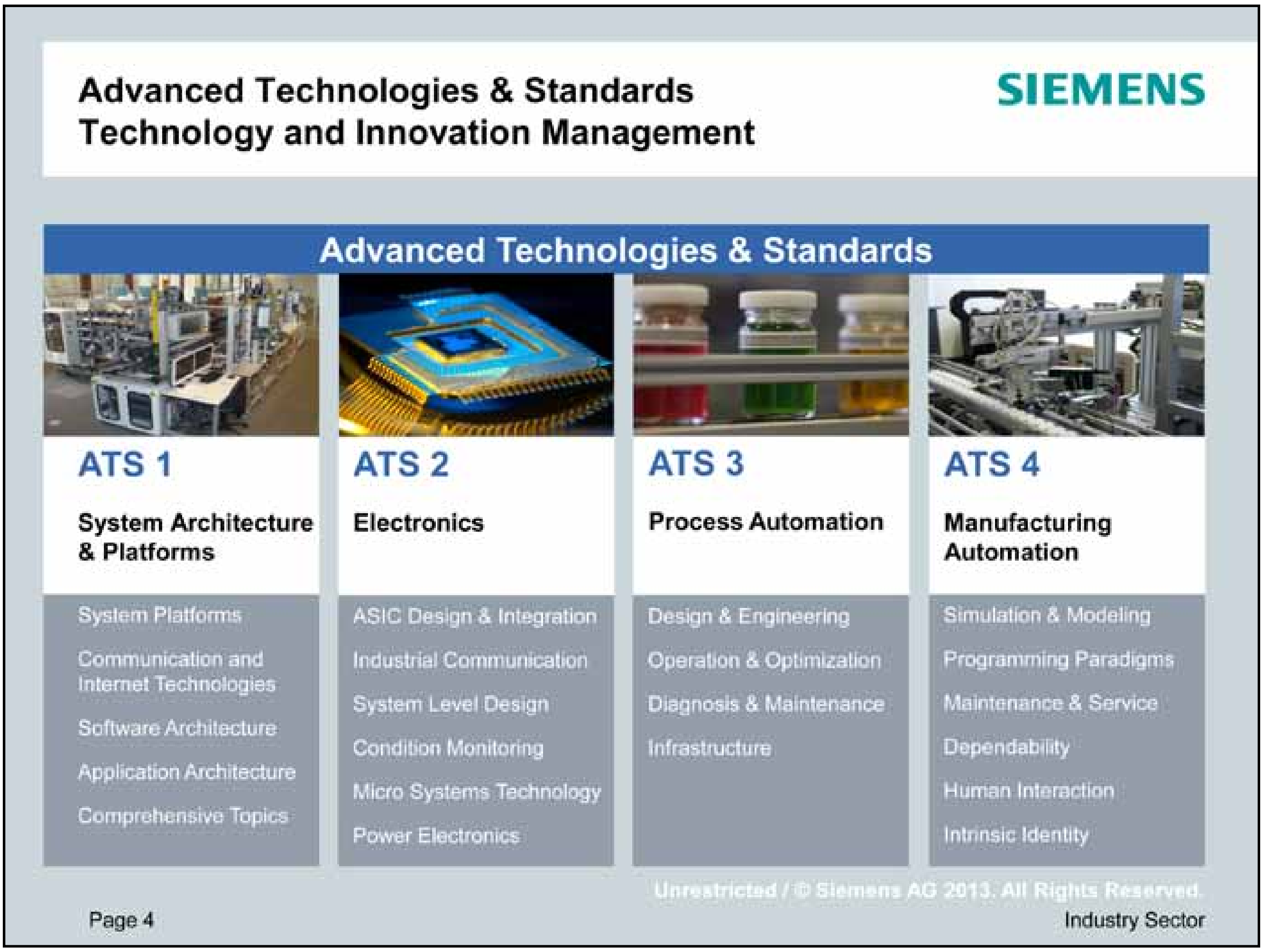
Advanced Technologies & Standards
Technology and Innovation Management
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Advanced Technologies & Standards
ATS 1
System Architecture & Platforms
System Platforms
Communication and Internet Technologies
Software Architecture
Application Architecture
Comprehensive Topics
ATS 2
Electronics
ASIC Design & Integration
Industrial Communication
System Level Design
Condition Monitoring
Micro Systems Technology
Power Electronics
ATS 3
Process Automation
Design & Engineering
Operation & Optimization
Diagnosis & Maintenance
Infrastructure
ATS 4
Manufacturing Automation
Simulation & Modeling
Programming Paradigms
Maintenance & Service
Dependability
Human Interaction
Intrinsic Identity
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▪ Smart Automation
▪ Innovating virtual commissioning solutions
▪ Summary
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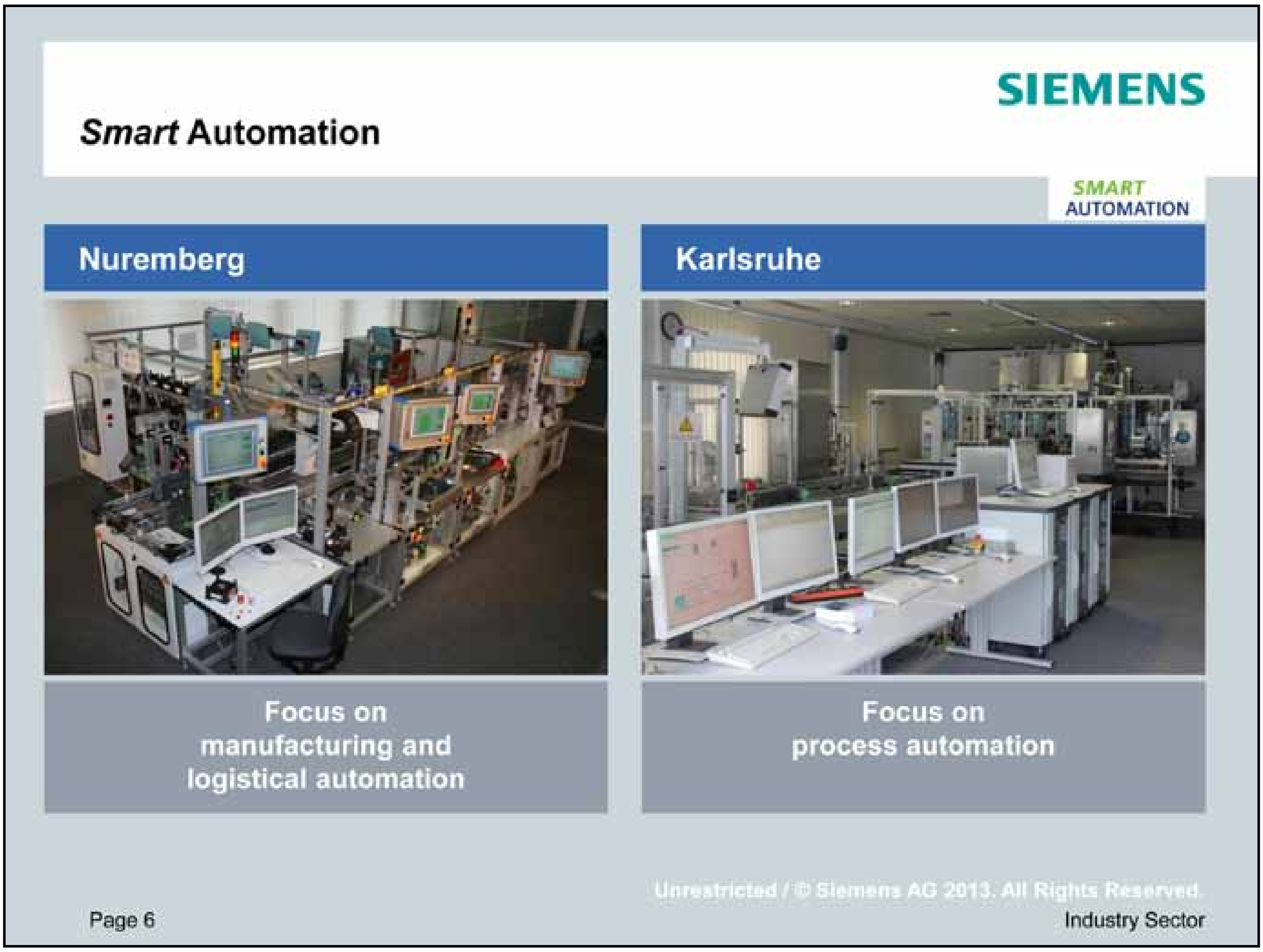
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*Smart* Automation
SMART AUTOMATION
Nuremberg
Karlsruhe
Focus on manufacturing and logistical automation
Focus on process automation
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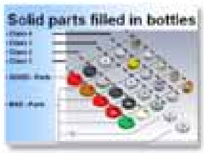
## History, facts, process

- Built in 2005 with project partner Festo Didactic GmbH & Co. KG
- Maximum automation complexity (11 modular stations with 12 different controllers, different fieldbus technologies, motion control…)
- 54 different ATS research projects since 2008 based on Smart Automation Nuremberg
- Closed manufacturing process


Capping → Picking & placing into trays (incoming and outgoing) → Uncapping → Recycling (emptying bottles)

Transportation

Quality check ← Filling bottles with solid parts

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## Central transport station

- Redundant bottle transport routes
- 18 single conveyor belts
- Bottle identification with barcode cameras
- Switches, separators and stopper
- Central station for safety functionality



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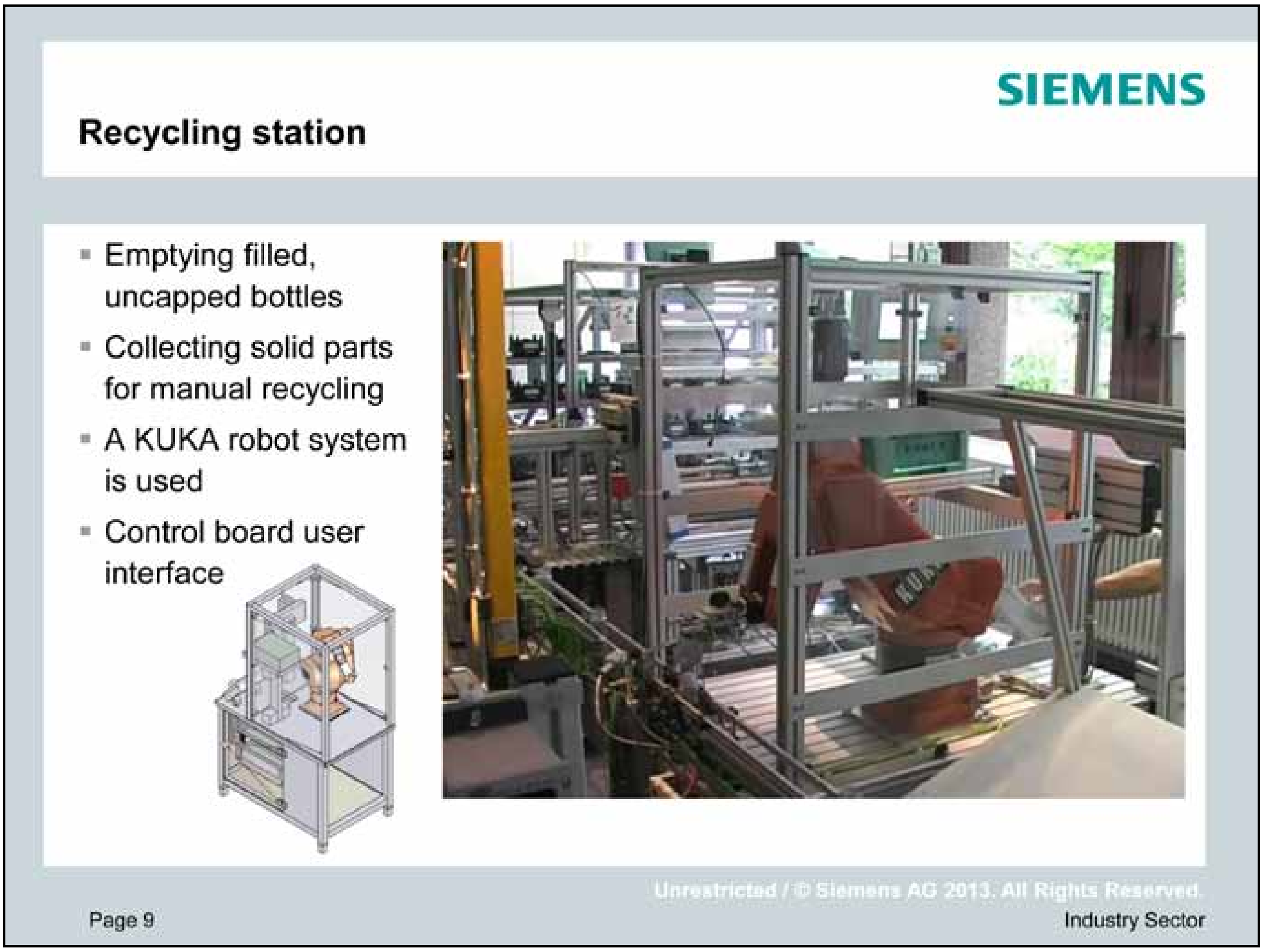
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Recycling station
Emptying filled, uncapped bottles
Collecting solid parts for manual recycling
A KUKA robot system is used
Control board user interface
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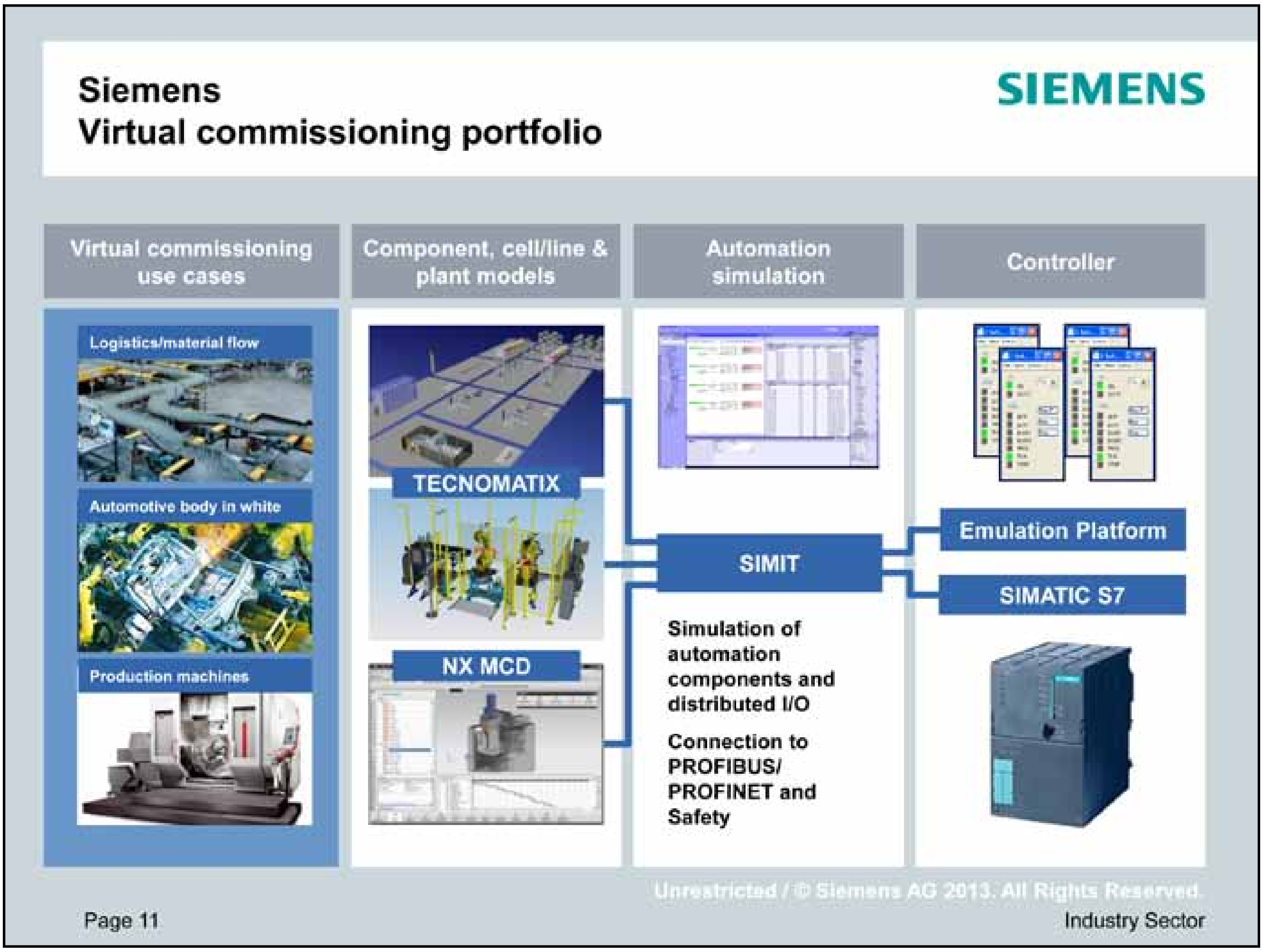


## Motivation for this *Smart* Automation project

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### Use of *Smart* Automation for promotion, product evaluation and innovations

Create a realistic virtual commissioning demonstrator for customers, sales personnel, management, workshops, etc.

Demonstrate customer use cases & failure scenarios

Verify following co-simulation tool chain for manufacturing plant:

- "SIMIT",
- "Emulation Platform" (SIMATIC Emulation) and
- "Process Simulate (Tecnomatix)"

Using new SIMIT conveyor library, co-simulation interface, time synchronization, etc.

Identify best practice model; separation between all tools

Identify limitations and analyze required modeling cost for further innovations



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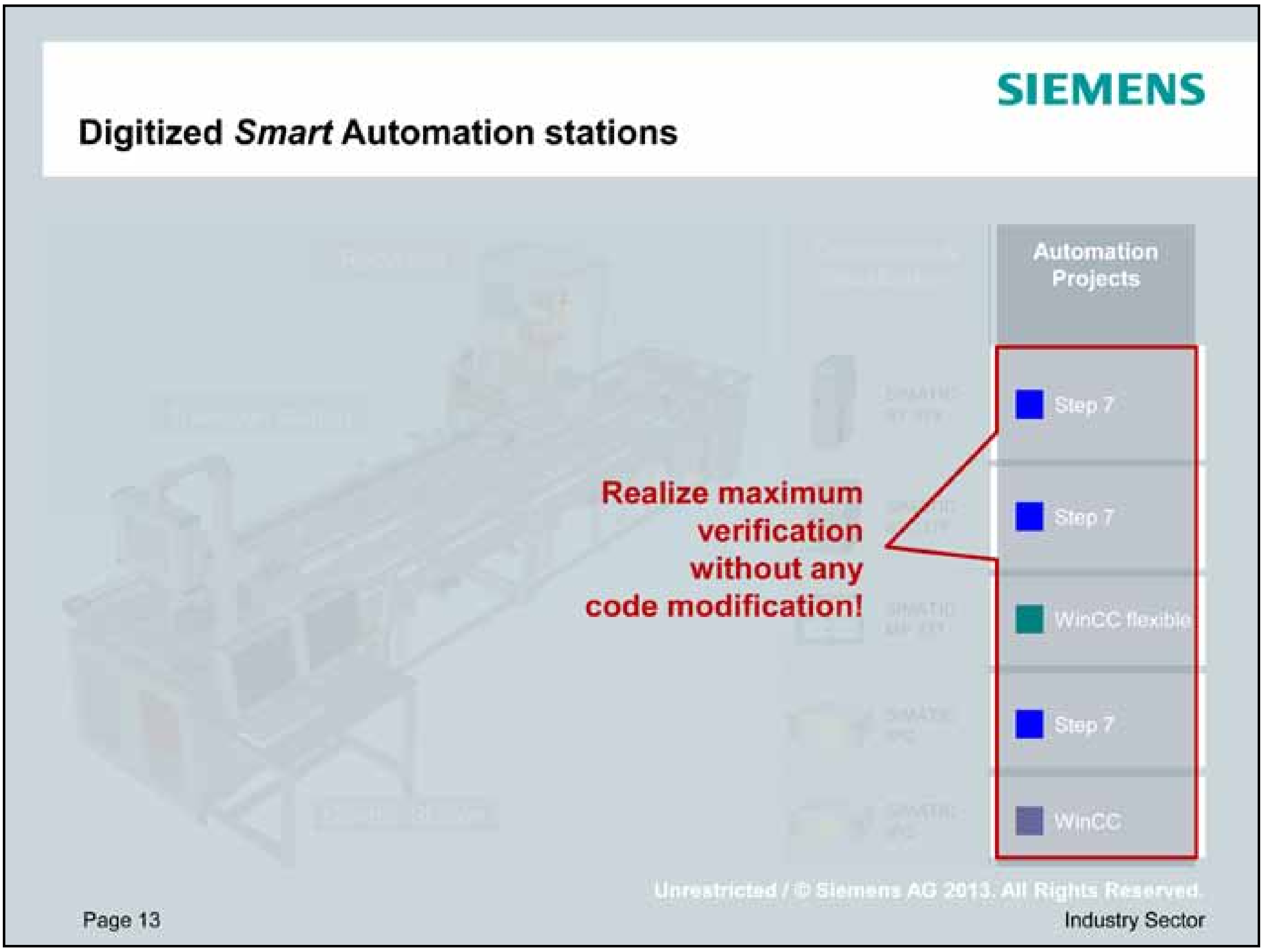
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Digitized Smart Automation stations
Automation Projects
Step 7
Step 7
WinCC flexible
Step 7
WinCC
Realize maximum verification without any code modification!
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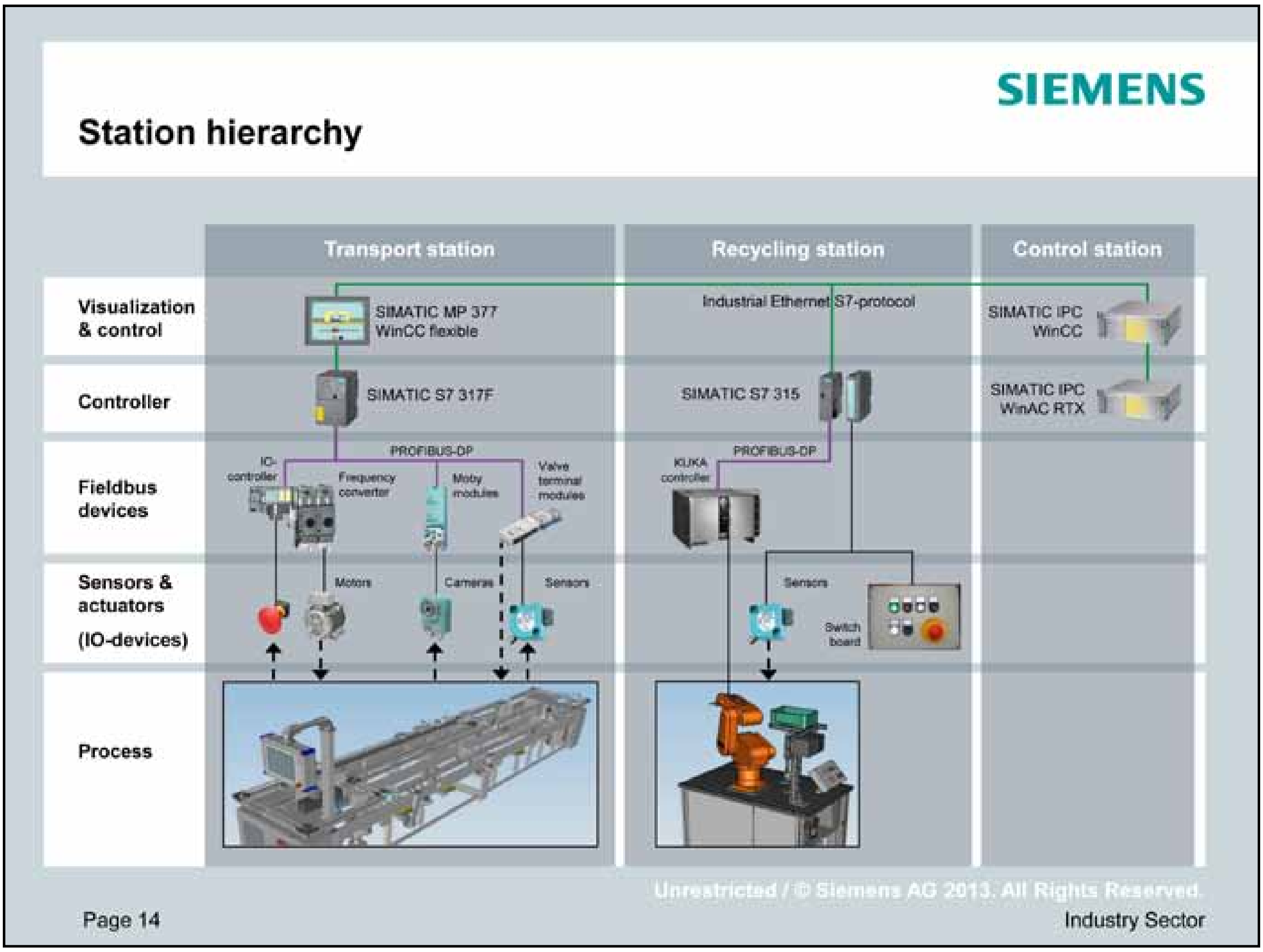
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Station hierarchy
Transport station
Recycling station
Control station
Visualization & control
Controller
Fieldbus devices
Sensors & actuators (IO-devices)
Process
SIMATIC MP 377 WinCC flexible
Industrial Ethernet S7-protocol
SIMATIC IPC WinCC
SIMATIC S7 317F
SIMATIC S7 315
SIMATIC IPC WinAC RTX
PROFIBUS-DP
PROFIBUS-DP
IO-controller
Frequency converter
Moby modules
Valve terminal modules
KUKA controller
Motors
Cameras
Sensors
Sensors
Switch board
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## Co-simulation framework (Windows based)

| | Transport station | Recycling station | Control station |
|---|---|---|---|
| Visualization & control | WinCC flexible | | WinCC |
| Controller | **PLC** (emulated SIMATIC S7) | **PLC** (emulated SIMATIC S7) | **PLC** (emulated SIMATIC S7) |
| Fieldbus devices | **Field devices** (emulated field devices model)<br>Emulation Platform | **Field devices** (emulated field devices model)<br>Emulation Platform | Emulation Platform |
| Sensors & actuators (IO-devices) | **IO-devices** (sensors & actuator model) | SIMIT<br>**IO-devices** (3D sensor & actuator model) | |
| Process | **2D process model** (2D material flow model)<br>SIMIT | **Robot** (3D robot model & controller)<br>**3D process model** (3D collision model)<br>Process Simulate | |



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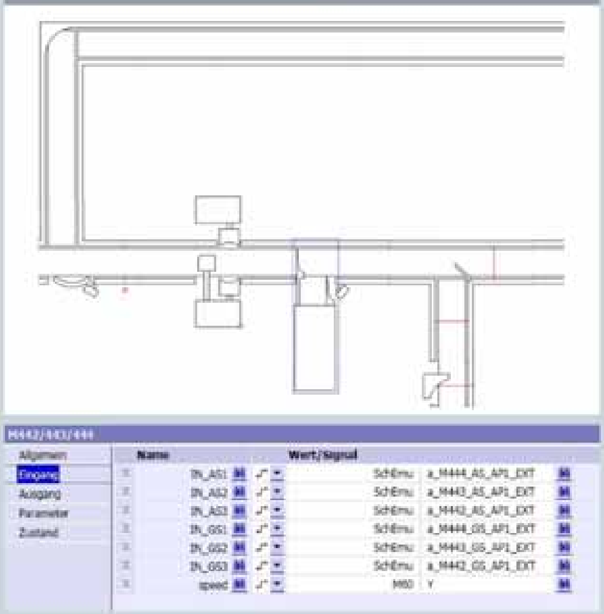
## Mapping real devices to virtual Bottle separator and stopper

### Real

### Simulation in SIMIT





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## Use cases & failure scenarios

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| Build new plant (no hardware) | Verify modified controller code | Verify hardware modification | Search for a complex bug | Operator training |
|---|---|---|---|---|
| | Minimum plant downtime | | | |

| | |
|---|---|
| **1. Broken hardware:** | Result of a broken sensor at transport station. |
| **2. WinCC HMI coding:** | Find WinCC configuration error in the project (data block address error). |
| **3. SIMATIC PLC coding:** | Find SIMATIC coding error in a function block (calling S7 communication). |
| **4. Check risky state:** | Verify controller programs (PLC & robot) to avoid risky states. |
| **5. Training:** | Operator training with original WinCC Project. |
| **6. Pre FAT-tests:** | Pre FAT verification of correct bottle routes depending an different states. |
| **7. Pre FAT-tests:** | Pre FAT verification of correct PLC behavior and HMI visualization when malfunctions occur. |
| **8. Time critical behavior:** | Test time critical behavior including process, communication and controller. |



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## Use case 4 "Risky states" Verify PLC logic to avoid risky states

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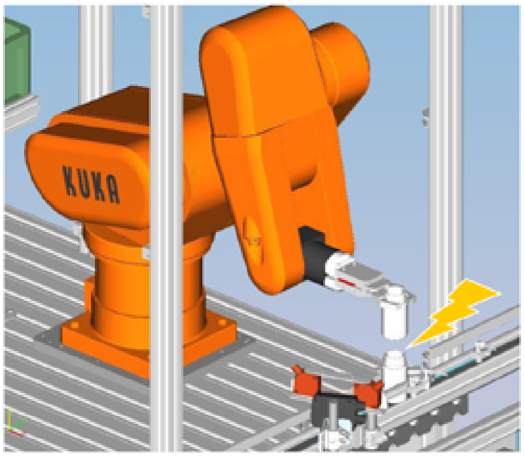
**Description:**

- The interface between recycling and transport station includes a risky state.
- Placing the bottle on top of a second bottle (due to wrong behavior or communication) will damage the plant, bottle and robot.

**Question:**

- Will both PLC controllers and robot program together identify and correctly avoid this risky state without damaging plant & bottle?
- How is this risky state visualized for the operator?



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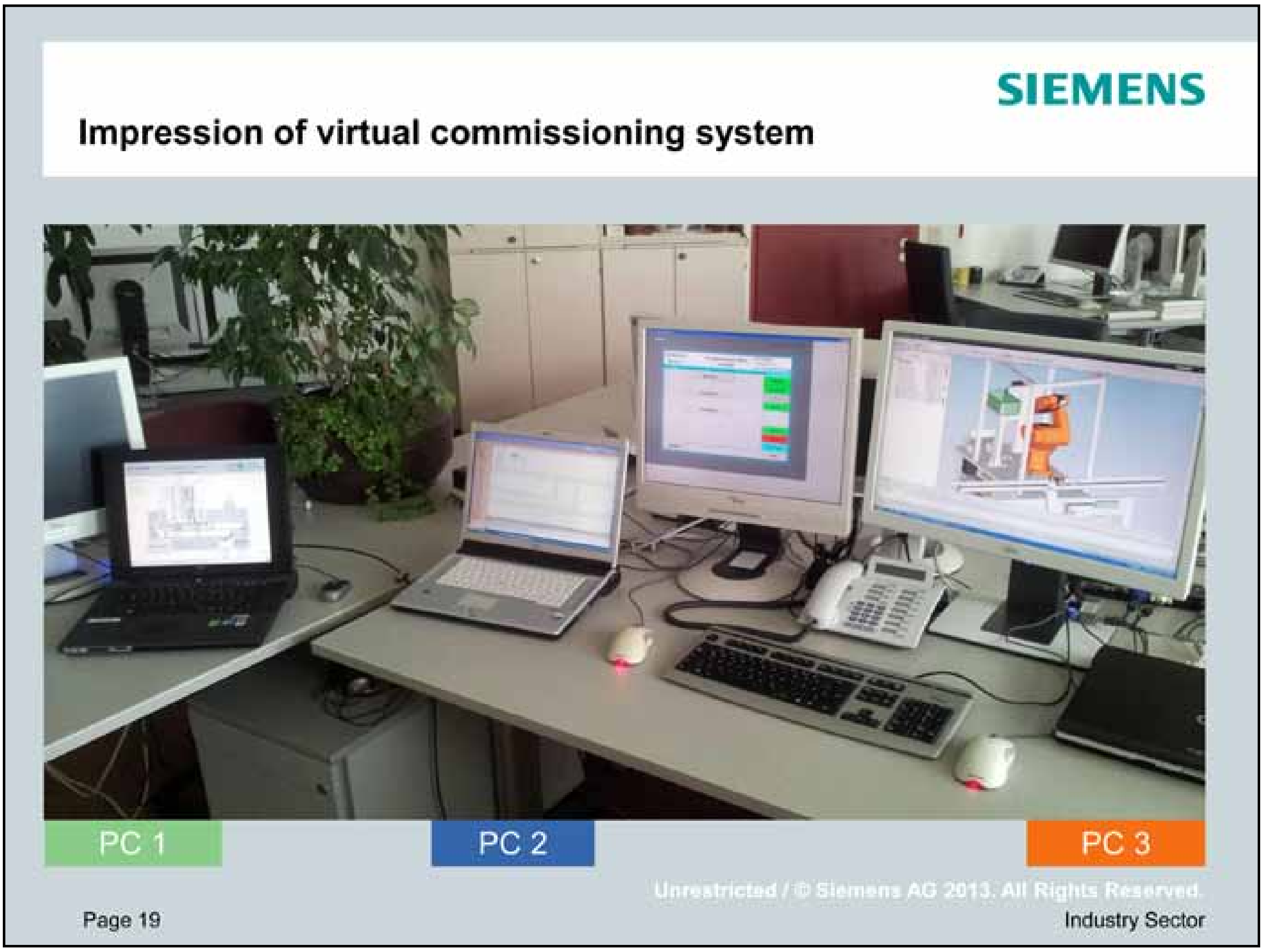
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Impression of virtual commissioning system
PC 1
PC 2
PC 3
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## Realization of complex virtual factories requires the following system features

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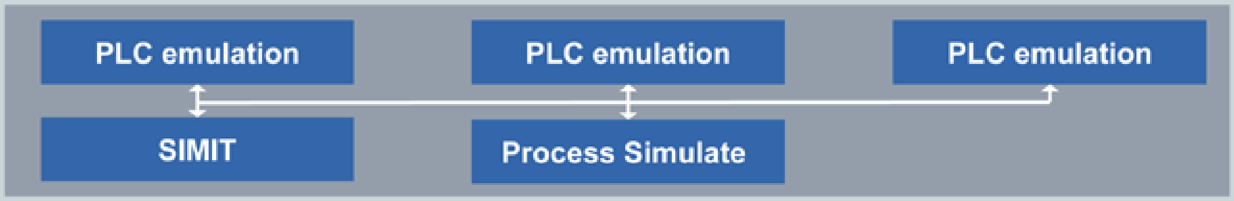


- Emulated controllers (software in the loop)
- Synchronized by virtual process time
- Simulation in real time (wall clock time) is not required
- Slow and fast mode simulation possible
- Complete and consistent system freeze (e.g. for detail view)
- No hardware required
- Commissioning on office PC
- Easy traceability, documentation, rerun, etc.
- Consistent on-the-fly snapshot of all components
- Avoid down time of real productive plant
- ...



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## Agenda

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- Introduction
- Smart Automation
- Innovating virtual commissioning solutions
- **Summary**

**Summary**
Virtual commissioning @ Smart Automation

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- We learned from the complexity of a real manufacturing plant
- Realized demonstrator is a starting point for many additional workshops
- Several improvements and feedback for current products
- Documented and analyzed modeling expenditure and costs
- Identification of several long-term product innovations (e.g. to reduce modeling expenditure and costs)



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**Summary**
Virtual commissioning @ Siemens

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- Unique portfolio of digital factory simulation models and automation simulation
- Supporting process and discrete industry applications for automation simulation
- Full re-use of machine, cell and plant level simulation models (no need to model "just" for virtual commissioning)
- Applications for early validation and training



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## Thank you for your attention!

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# **Session 3:** Digital – Real Learning Factory for manufacturing engineering

**Professor Dr.-Ing. Prof. E.h. Dr.-Ing.E.h. Dr.h.c. (mult) Engelbert Westkämper** is Director (em.) of FhG-IPA, IFF and GSaME at University Stuttgart Westkämper studied Mechanical Engineering at the RWTH Aachen. After his Dr. degree he worked in leading positions from 1977 to 1987 in aircraft (MBB) and in electronics industry (CAEG) with responsibilities for manufacturing technologies.
From 1988 to 1995 he was appointed as Professor and director of the Institute of Machine Tools and Manufacturing Technologies (IWF) at the University of Braunschweig. 1995 - 2011 he was head of the Institute of Industrial Manufacturing and Management (IFF) at the University Stuttgart and executive director of the Fraunhofer-Institute for Manufacturing Engineering and Automation (IPA) in Stuttgart, Germany.
He was founder and CEO of the Graduate School of Excellence for advanced Manufacturing Engineering (GSaME) in Stuttgart.
Westkämper was awarded by universities in Germany, Ukraina and Romania. He is Fellow of CIRP and ACATEC. He is one of the principal investigators and Member of the High Level Group of the EU Technology Platform Manufuture.
Westkämper was retired 2011. His successor in FhG-IPA and IFF is Professor Dr.-Ing. Thomas Bauernhansl. He is still director of the GSaME and Member of the Manufuture High level Group.

Fraunhofer IPA

Fraunhofer –Institute IPA is an application - oriented institute for Production engineering, technologies and automation in Stuttgart. Main fields of research are production management, robotics and robots application, material oriented process-technologies and coating.

Universität Stuttgart IFF Institut für Industrielle Fertigung und Fabrikbetrieb

IFF is an institute of the university Stuttgart with responsibilities for education in manufacturing technologies and management. Basic research areas are strategies and methodologies for manufacturing engineering and management and innovative manufacturing systems. Changeability of manufacturing, digital and smart factories were topics of development.

GSaME Graduate School of Excellence advanced Manufacturing Engineering in Stuttgart

The Graduate School of Excellence for advanced manufacturing Engineering (GSaME) is an interdisciplinary graduate school of the University Stuttgart. GSaME was foundet 2008 in the German universities excellence program. 75 doctoral students make their doctoral thesis in the fields of Factories of the Future strategies, global networking, ICT for manufacturing materials and technologies and intelligent production systems. GSaME follows a dual system in research and education. GSaME was awarded 2011 by Acatech for best practices in doctoral sytems.

# Digital – Real Learning Factory for Manufacturing Engineering

**The Learning Factory University Stuttgart**


## Engelbert Westkämper

Prof. Dr.-Ing. Prof. E.h. Dr.-Ing. E.h. Dr. h.c. (mult) i.R.
Member of the EU Manu*Future* High Level Group

Universität Stuttgart – Institut für Industrielle Fertigung und Fabrikbetrieb
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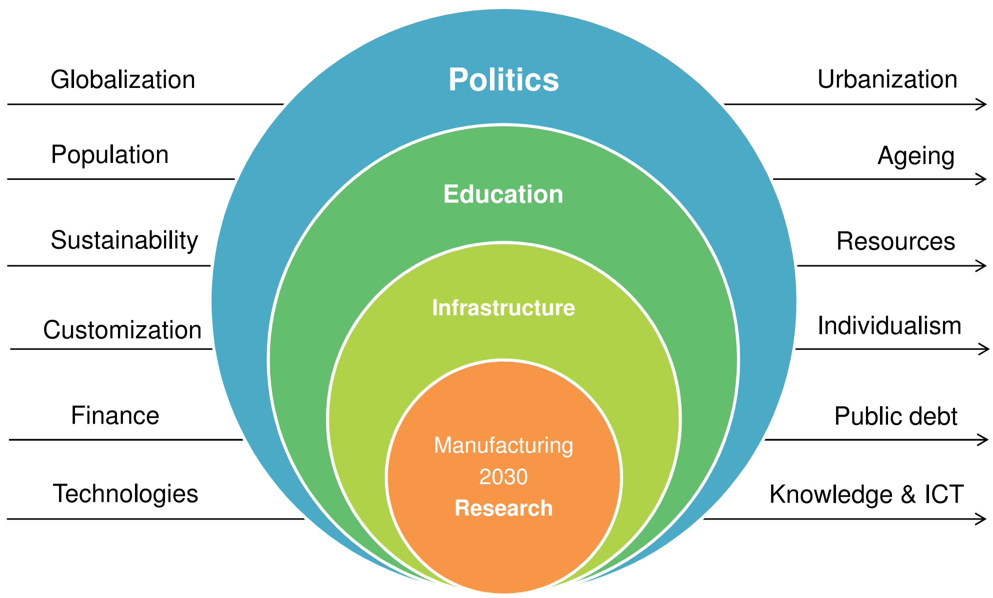
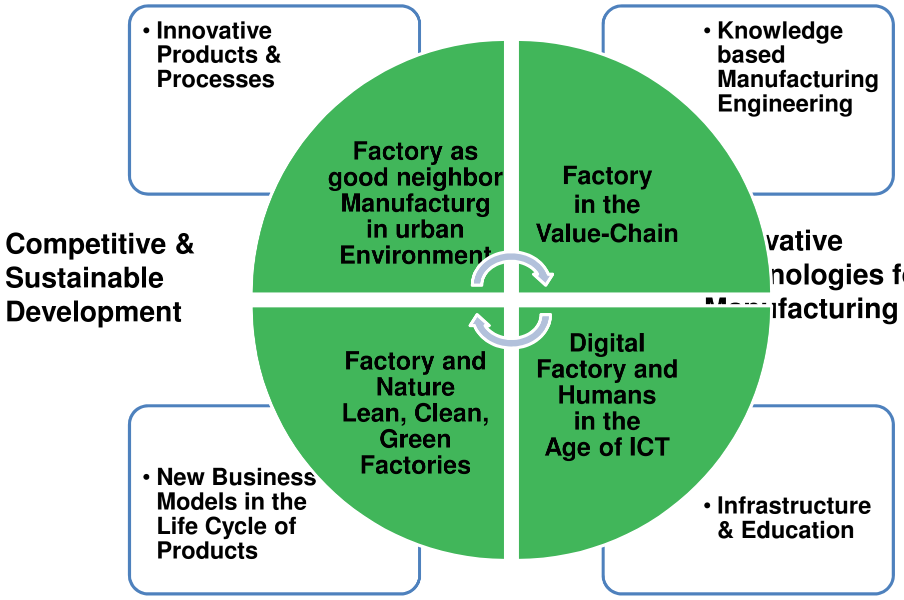
## Megatrends and Fields of Actions for Manufacturing Development towards Re-Industrialisation of Europe




Slide 2

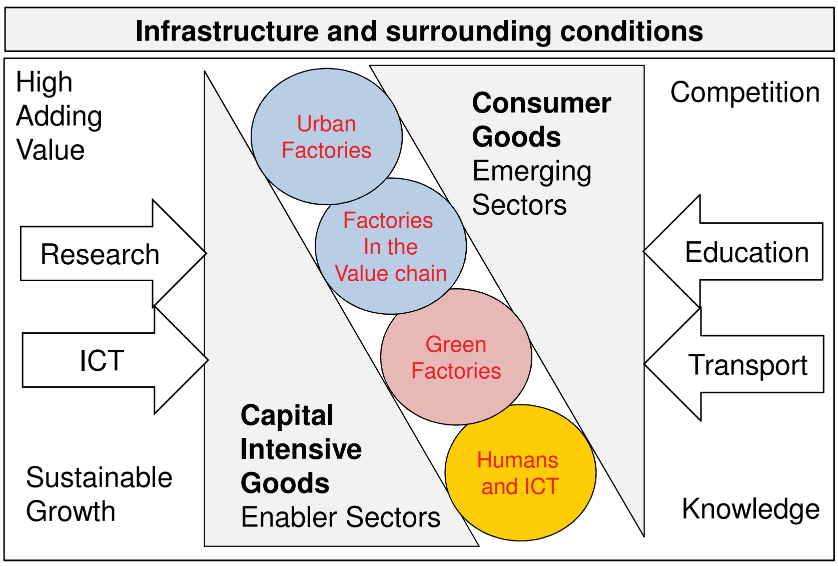
## Topics of the Strategic Innovation Agenda




Slide 3

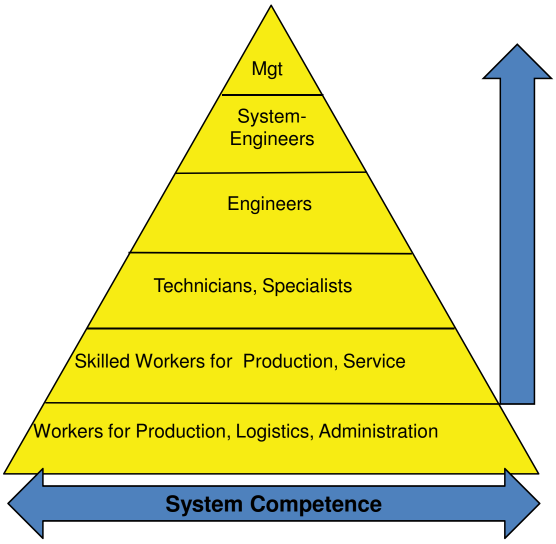


## Infrastructure for Sustainable and Global Growth




Slide 4

## Increasing Demand for Qualification at all Levels



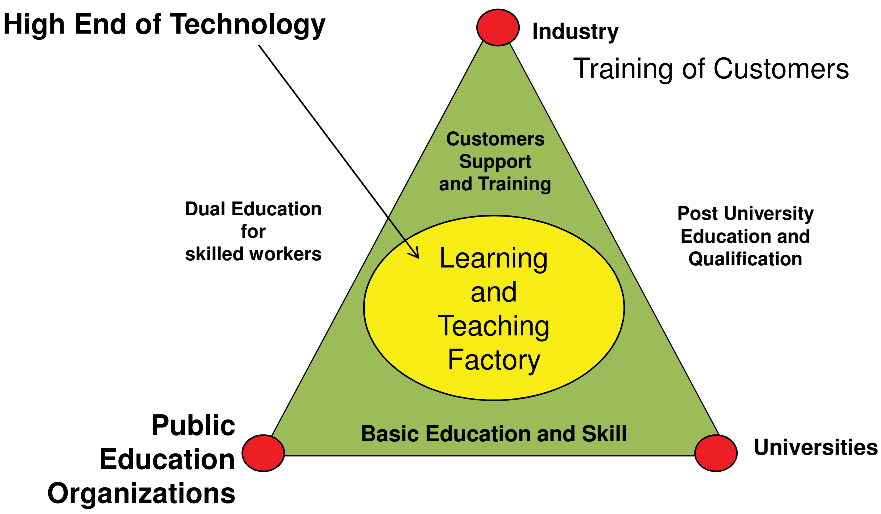

**Increasing Demand**
- Customization
- Adaptation
- Precision
- Complexity
- Reliability

**Cooperative Work**
- Working groups
- Team work (simultaneous)
- interdisciplinar
- networking
- Work in ICT environment

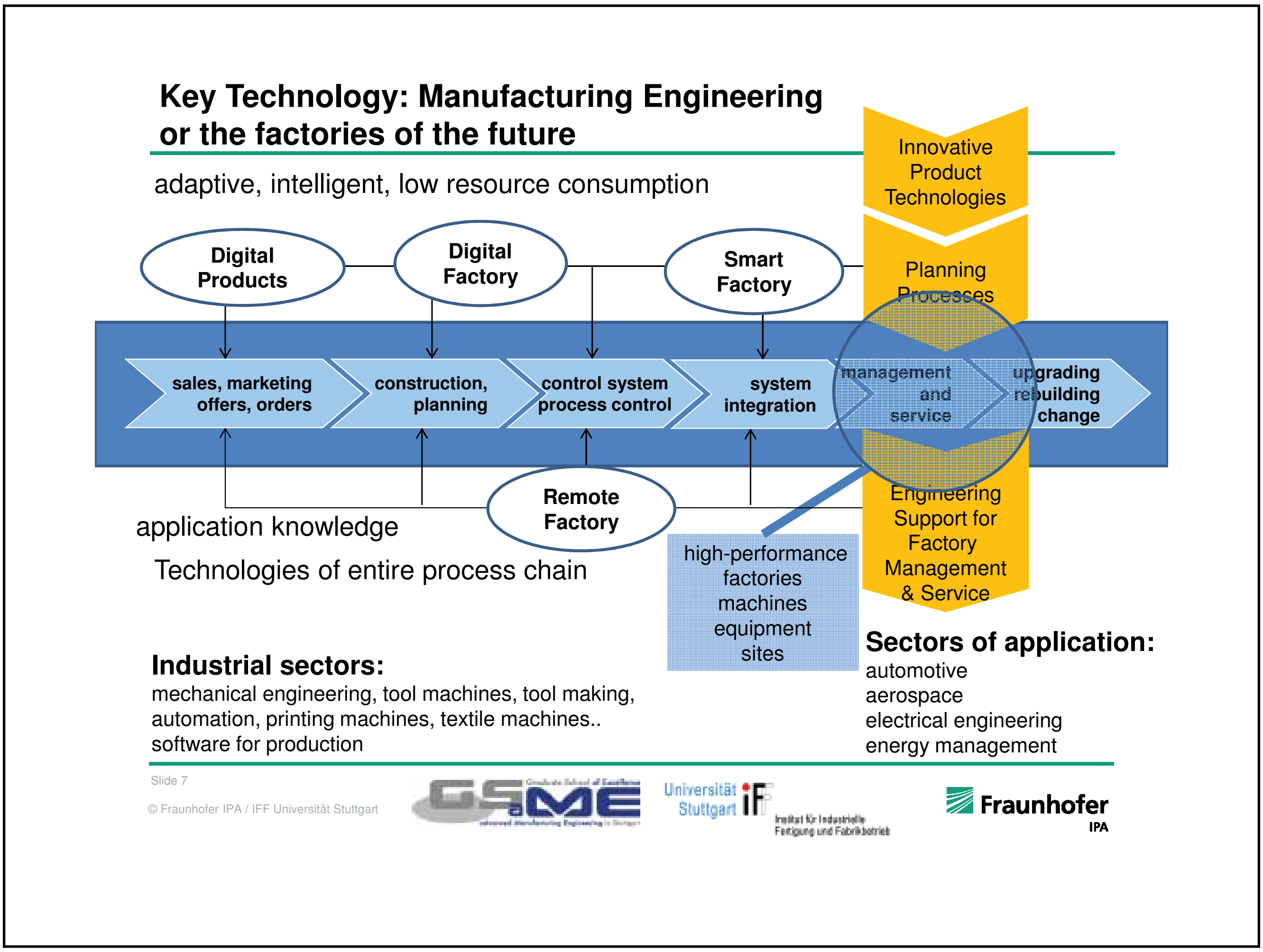
Slide 5



## Learning and Teaching for Qualification in the Triangle




Slide 6


Key Technology: Manufacturing Engineering
or the factories of the future
adaptive, intelligent, low resource consumption
Innovative Product Technologies
Planning Processes
Digital Products
Digital Factory
Smart Factory
sales, marketing offers, orders
construction, planning
control system process control
system integration
management and service
upgrading rebuilding change
Remote Factory
application knowledge
Technologies of entire process chain
high-performance factories machines equipment sites
Engineering Support for Factory Management & Service
Industrial sectors:
mechanical engineering, tool machines, tool making, automation, printing machines, textile machines..
software for production
Sectors of application:
automotive
aerospace
electrical engineering
energy management
Slide 7
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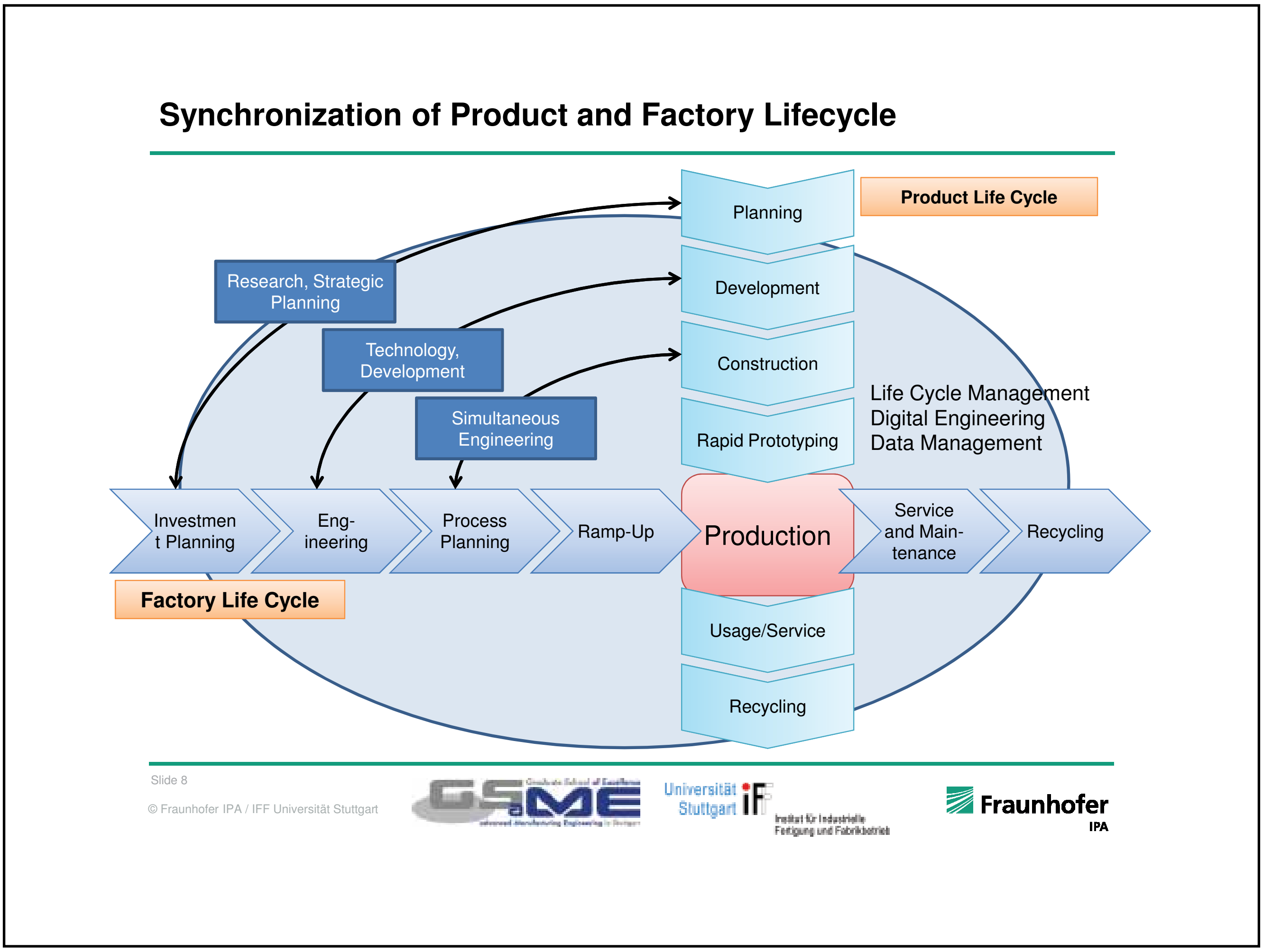
Synchronization of Product and Factory Lifecycle
Planning
Development
Construction
Rapid Prototyping
Production
Usage/Service
Recycling
Product Life Cycle
Research, Strategic Planning
Technology, Development
Simultaneous Engineering
Life Cycle Management
Digital Engineering
Data Management
Investmen t Planning
Eng- ineering
Process Planning
Ramp-Up
Service and Main- tenance
Recycling
Factory Life Cycle
Slide 8
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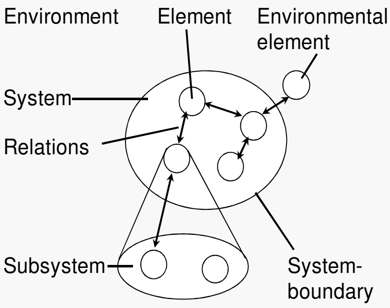
## System-View: the new Paradigma of Manufacturing

**Factories are complex socio-technical systems**
The **Efficiency** depends on the characteristics and properties of its elements and relations and structure of the systems

**Scalable Structure of Factories**




**System Levels of Factories**

- Manufacturing Network
  - Supply, Production, Distribution
- Locaction, plant, site
- Segments: Workshops, Technologies
- Manufacturing- / Assembly- Systems
- Subsystems: flow of…
  - Material, tools,
  - information, energy , air…
- Machines
- Workplaces
- Processes

Elements: Humans, Data, Information, Parts, Components, Products,…

Slide 9



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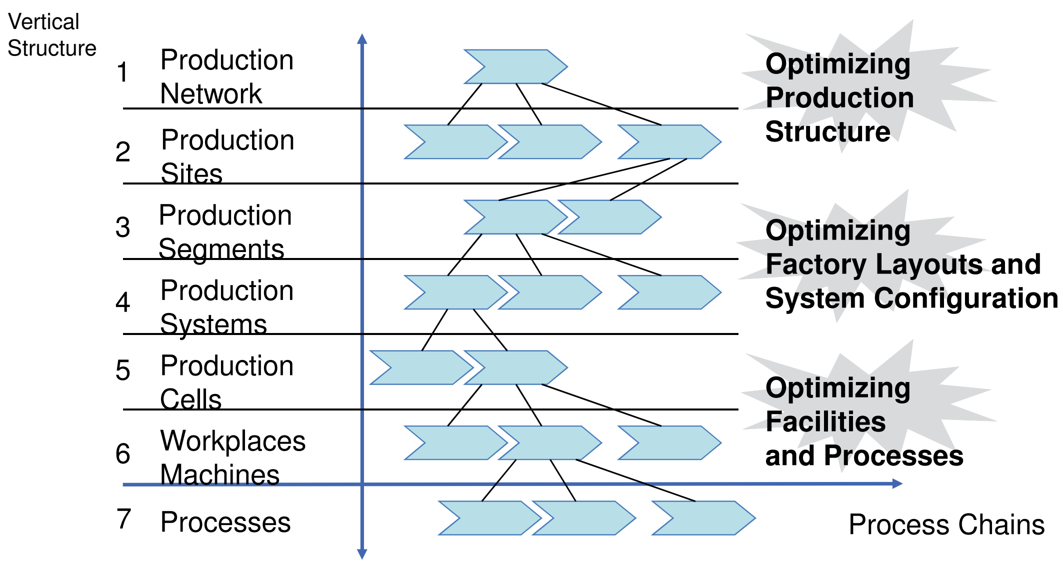
## Adaptation on all Scales: Every Time Optimized




Slide 10



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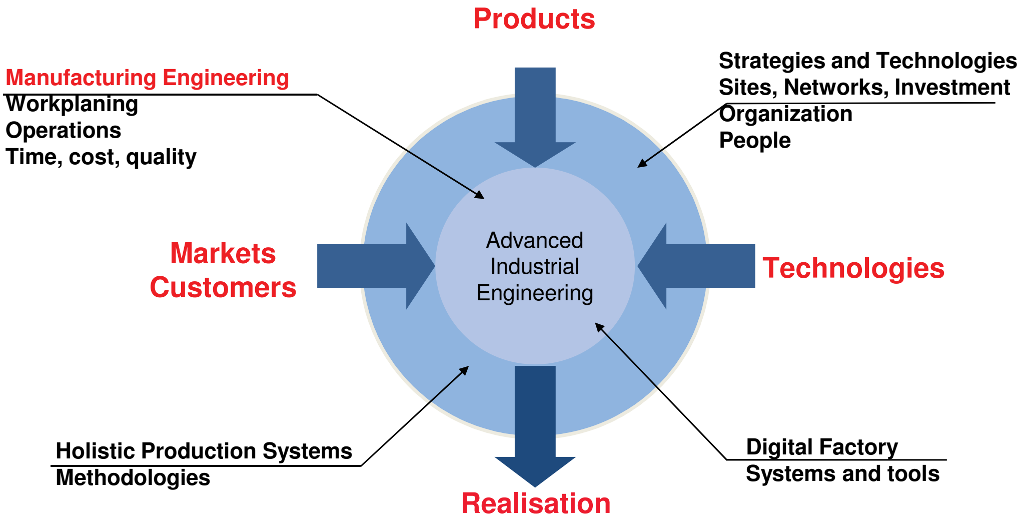
## The Role of Industrial Engineering




Slide 11



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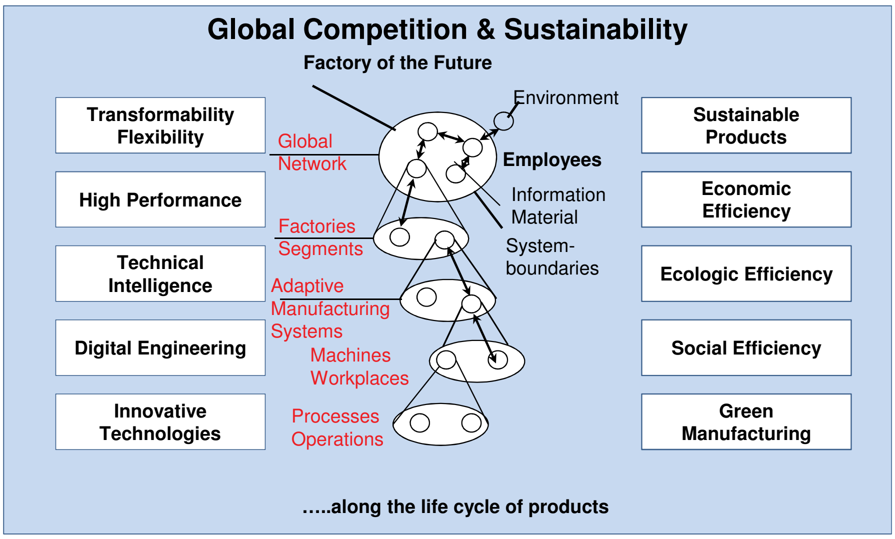
## Objectives of Manufacturing Engineering




Slide 12



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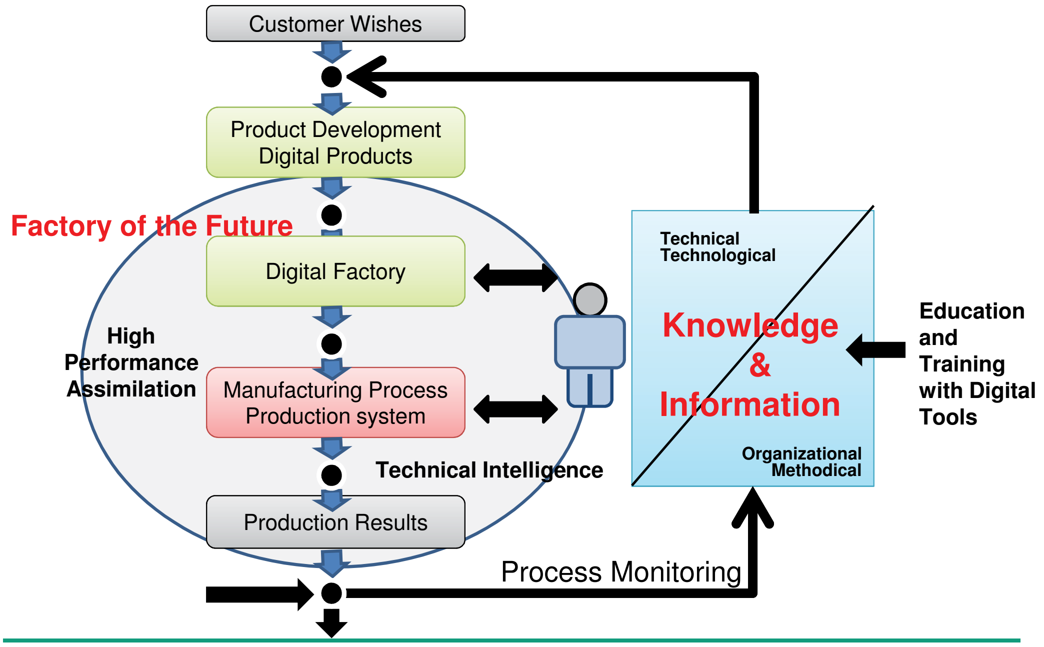
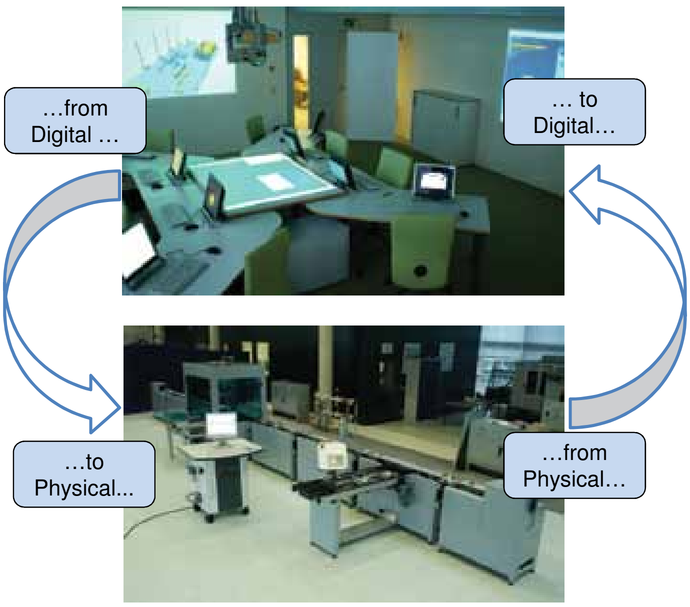
## Process of learning within industrial production




Slide 13



## Learning Factory for advanced Industrial Engineering




**Education**

*of management, engineers technicians and skilled people qualifying them for…*

- Changeability
- Planning and Optimization of factories, processes and workflows
- Application of digital tools and digital factory
- Adaptive manufacturing
- Learning Manufacturing

*In realistic Scenarios*

Slide 14

## Re-configurable Manufacturing System

**Standard Moduls**
- manufacturing
- Assembly cells
- robotcells
-manual work stations
- transport
- storage

**Standardised Interfaces**
- Mechanic
- Electric
- Electronic
- Air
- (Water, Fluids)
- Communication

Source: IFF, FESTO

Slide 15



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## Re-configurable Manufacturing System (FESTO) Learning Factory Stuttgart

Source: IFF, FESTO

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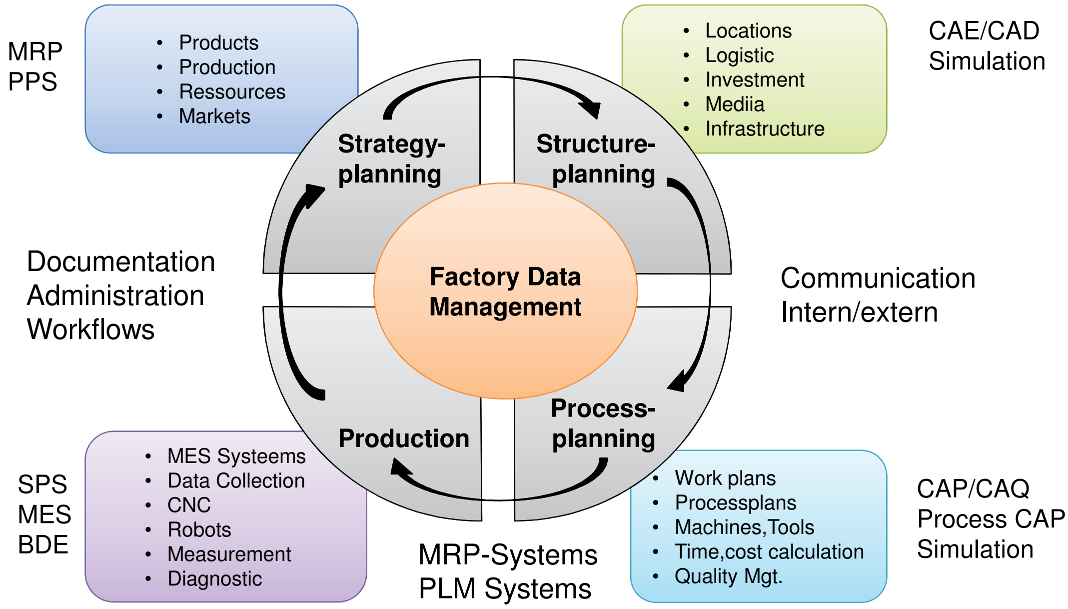
## Digital Environment in the Learning Factory

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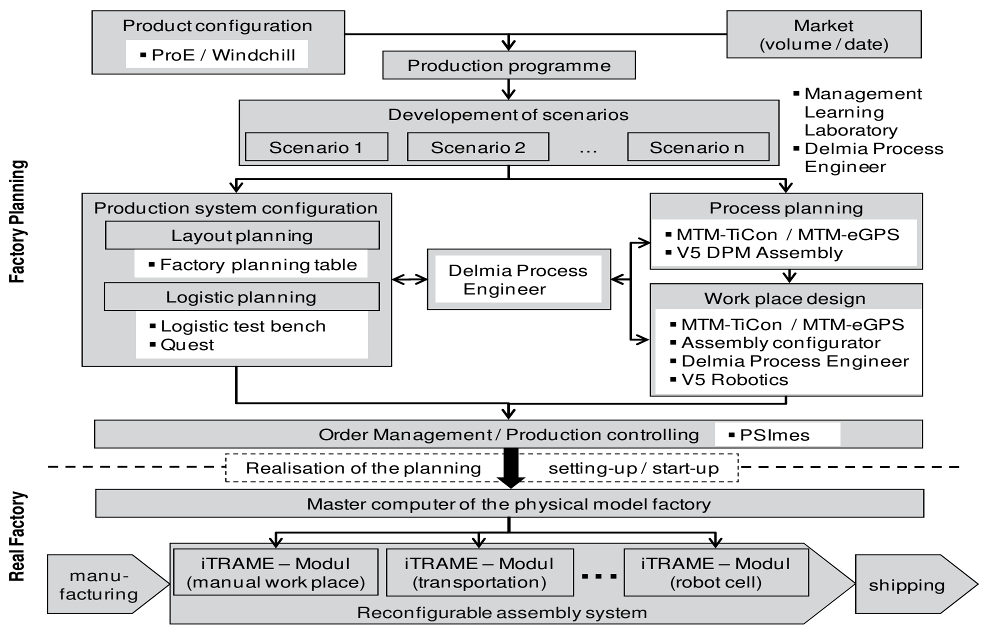
## Digital level of the Learning Factory

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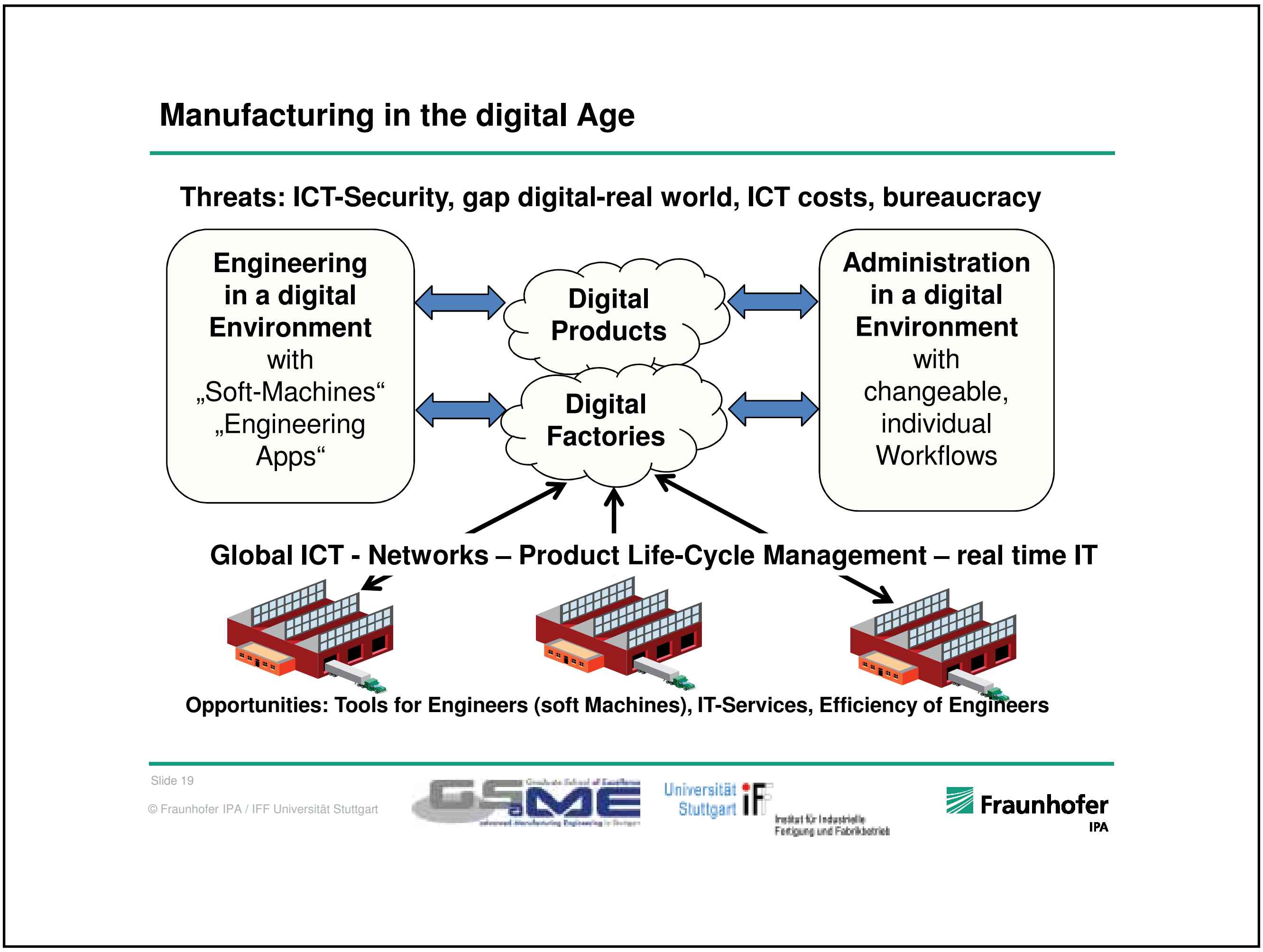
Manufacturing in the digital Age
Threats: ICT-Security, gap digital-real world, ICT costs, bureaucracy
Engineering in a digital Environment with „Soft-Machines“ „Engineering Apps“
Digital Products
Digital Factories
Administration in a digital Environment with changeable, individual Workflows
Global ICT - Networks – Product Life-Cycle Management – real time IT
Opportunities: Tools for Engineers (soft Machines), IT-Services, Efficiency of Engineers
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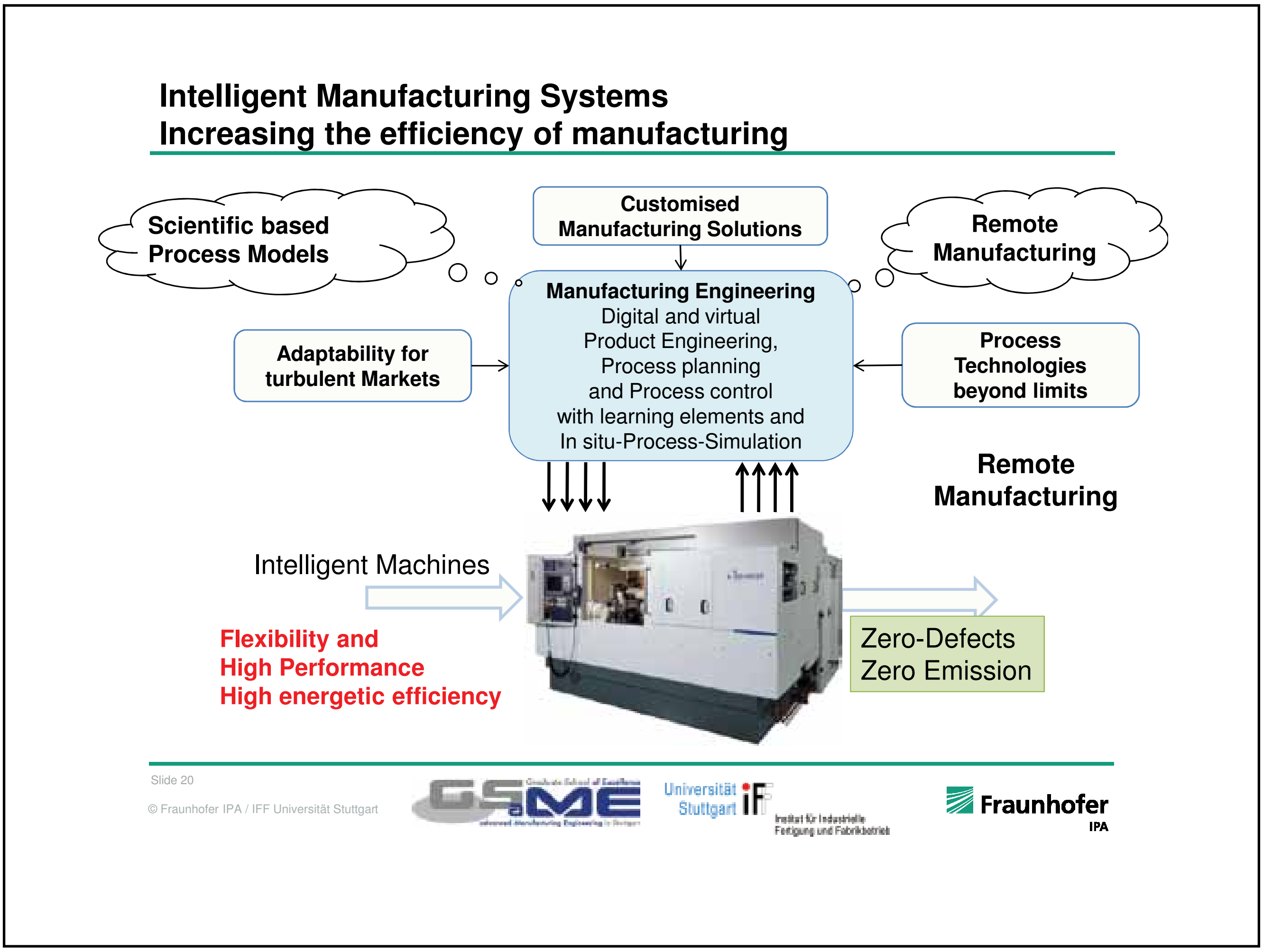
Institut für Industrielle Fertigung und Fabrikbetrieb
Fraunhofer IPA


Intelligent Manufacturing Systems
Increasing the efficiency of manufacturing
Scientific based Process Models
Customised Manufacturing Solutions
Remote Manufacturing
Manufacturing Engineering
Digital and virtual Product Engineering, Process planning and Process control with learning elements and In situ-Process-Simulation
Adaptability for turbulent Markets
Process Technologies beyond limits
Remote Manufacturing
Intelligent Machines
Flexibility and
High Performance
High energetic efficiency
Zero-Defects
Zero Emission
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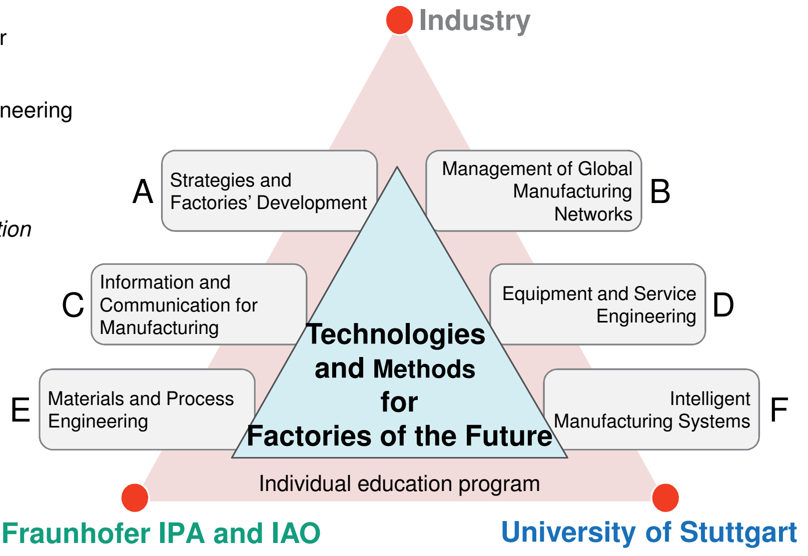
## Learning factory the Lab of The Graduate School GSaME

**GSaME**
Graduate School for
advancved
Manufacturing Engineering
University Stuttgart

- *Dual System*
- *Individual Education*
- *Learning factory*
- *Scientific Profile*

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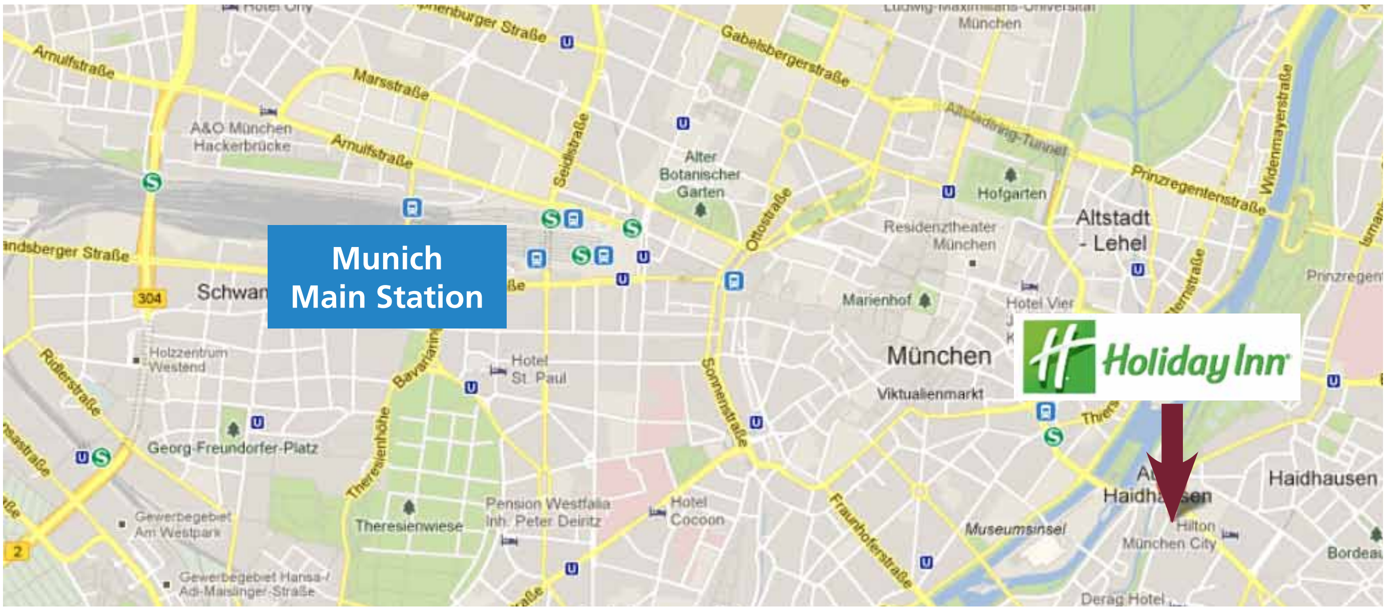
## Summary

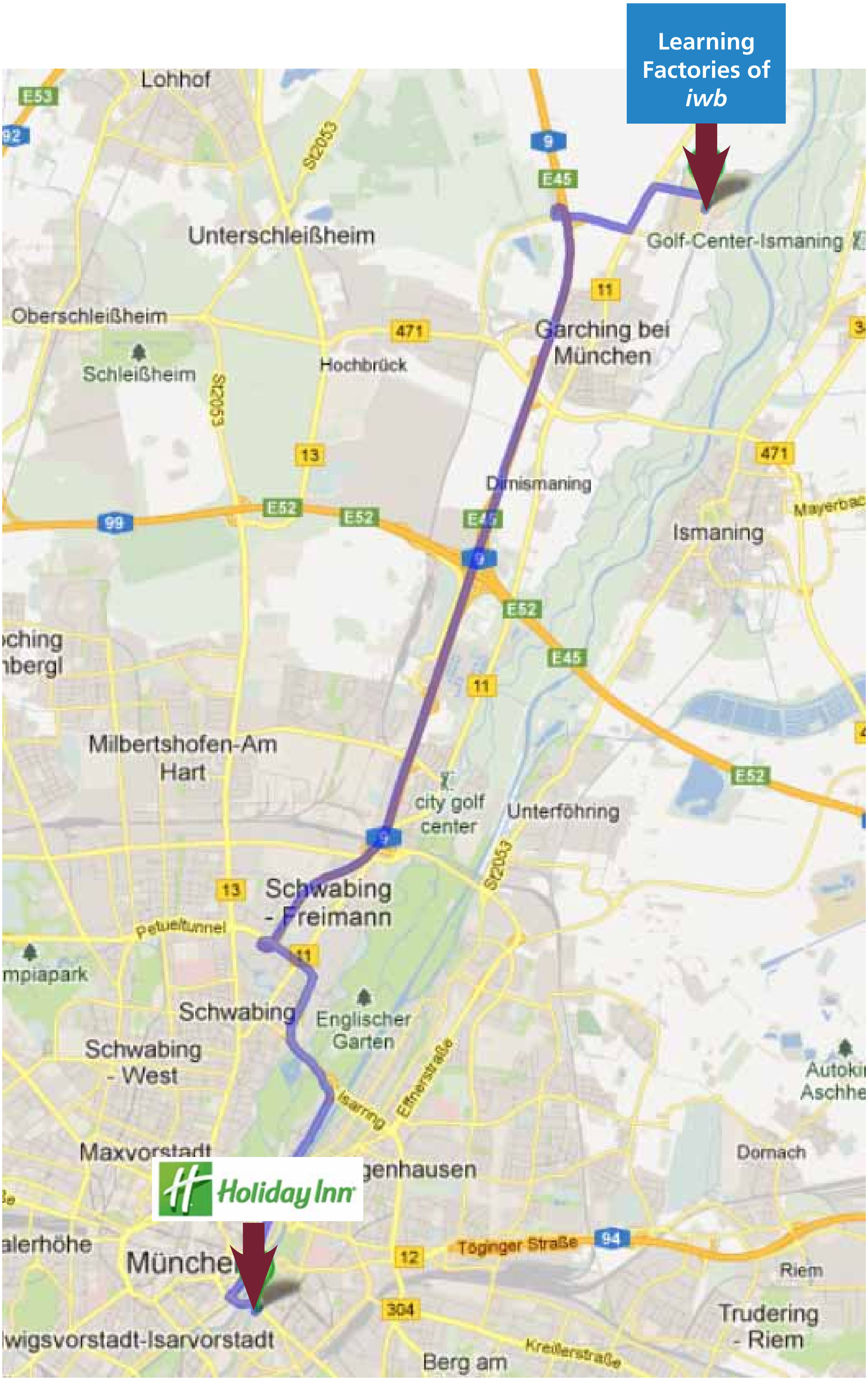
Digital-Real Learning Factory for Manufacturing Engineering

- Increasing demand for qualification & skill on all levels
- Manufacturing engineering has the key role for optimization and innovation
- The Learning Factory in Stuttgart was the result of a basic research project
  - Transfer from SFB to Practice – 2005
- Factory of the Future: Adaptability, permanent optimization of the system
- Technical environment digital factory and flexible manufacturing system
  - Reconfigurable
  - Link between physical shop and digital world (cyber physical system)
- Education programm for
  - Changeability and Management
  - Advanced industrial Engineering
  - ICT- Systems
- Future: Implementation of technical Intelligence

Slide 22

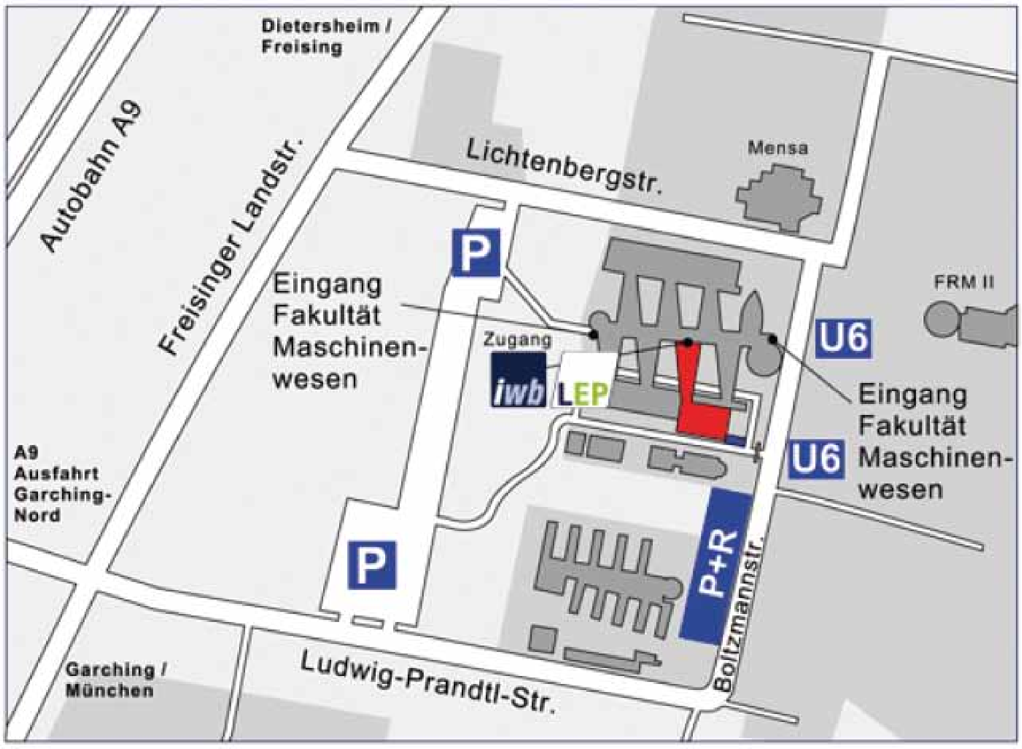
# Important Maps

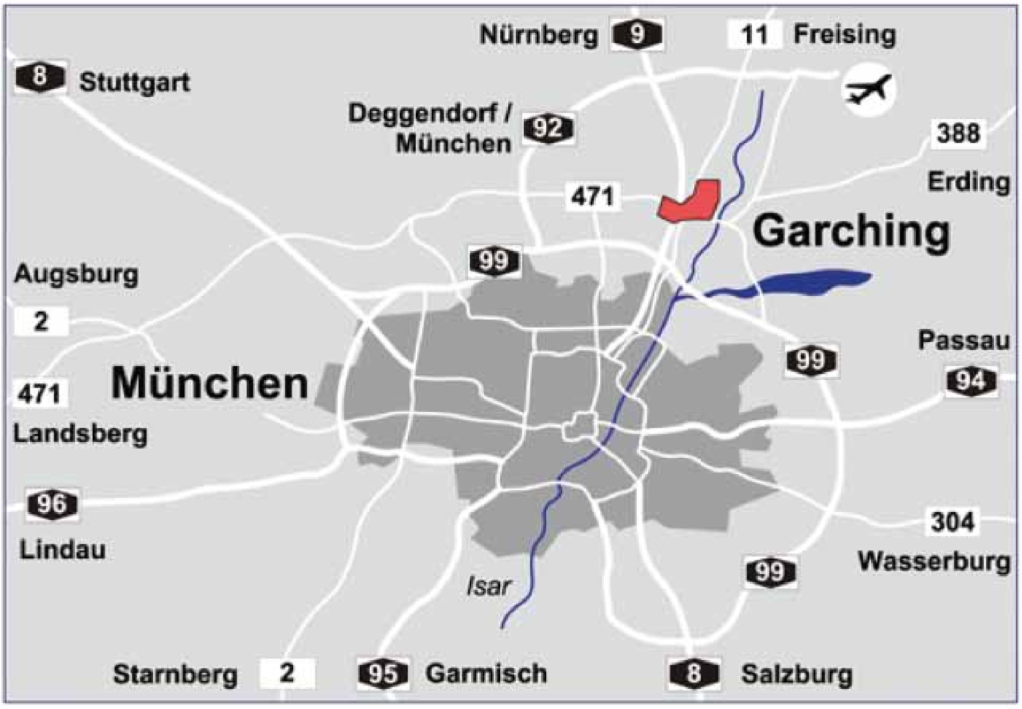




Learning Factories of *iwb*
Holiday Inn
Lohhof
Unterschleißheim
Oberschleißheim
Schleißheim
Hochbrück
Golf-Center-Ismaning
Garching bei München
Dirnismaning
Ismaning
Milbertshofen-Am Hart
city golf center
Unterföhring
Schwabing - Freimann
Petueltunnel
Schwabing
Englischer Garten
Schwabing - West
Isarring
Effnerstraße
Maxvorstadt
Dornach
Töginger Straße
München
Riem
Trudering - Riem
Kreillerstraße
Berg am
E53
E45
E52
471
St2053
9
11
13
99
12
94
304

# Access to LEP

LEP – Lernfabrik für Energieproduktivität
c/o iwb – Technische Universität München
Boltzmannstraße 15
85748 Garching



# Access to RMV | Augsburg

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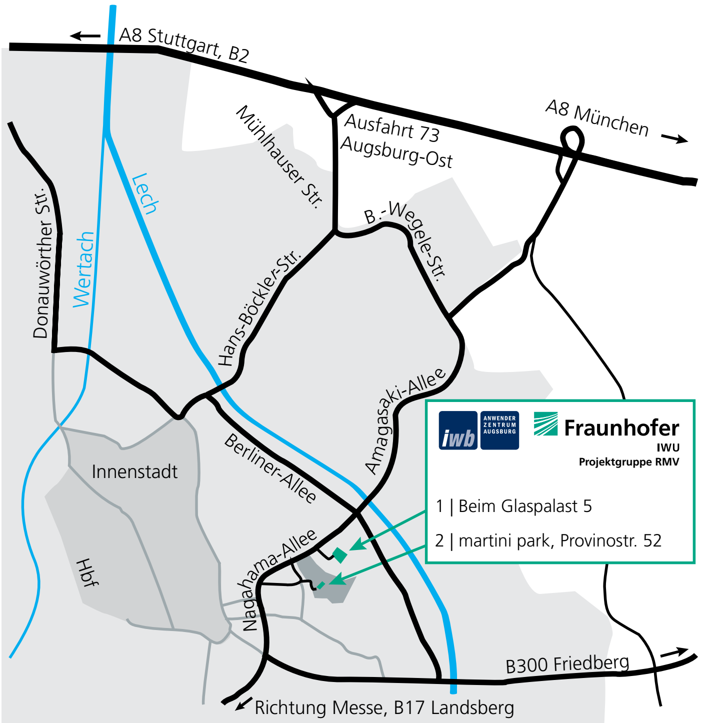
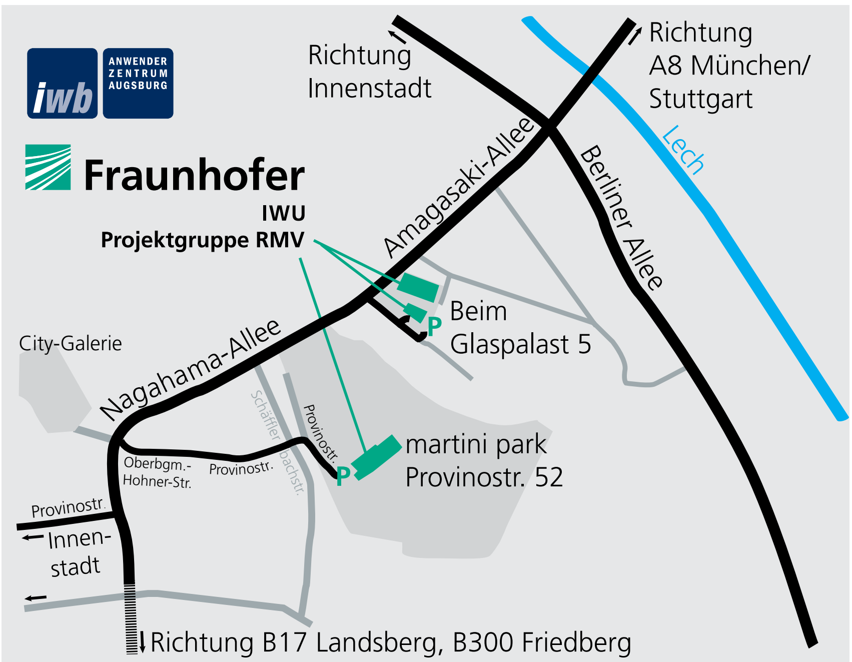
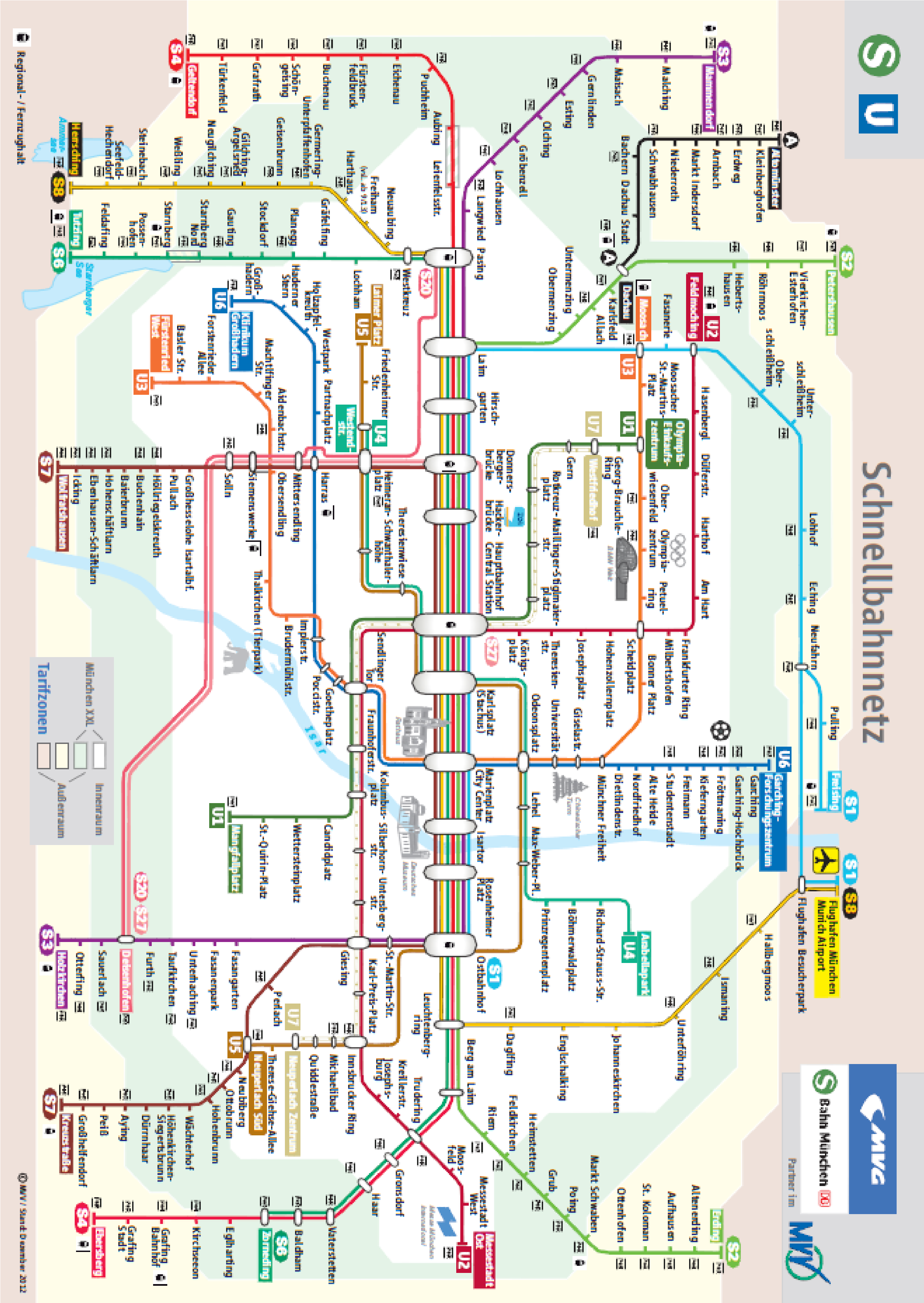


# Urban rail network



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