FRAUNHOFER AUSTRIA RESEARCH

Advances in Industrial Cyber-Physical Systems

Industrie 4.0 - Potentials, Opportunities and Roadmap

AIM Conference
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Industrie 4.0

Potentials, Opportunities and Roadmap

- **Fraunhofer Austria**
  Introduction
- **Industrie 4.0: Definition, Opportunities and Potentials**
  The connected Value Creation System of the Future
- **Roadmap to Industrie 4.0**
  Examples from the Industry and Demonstration Factory at TU Wien

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Short Introduction
Fraunhofer-Gesellschaft

The Fraunhofer-Society is the leading organisation for applied research in Europe.

Fraunhofer promotes and undertakes applied research in an international context, with direct utility to private and public enterprise and of wide benefit to society as a whole.

Fraunhofer-Gesellschaft

The leading organisation for applied research in Europe

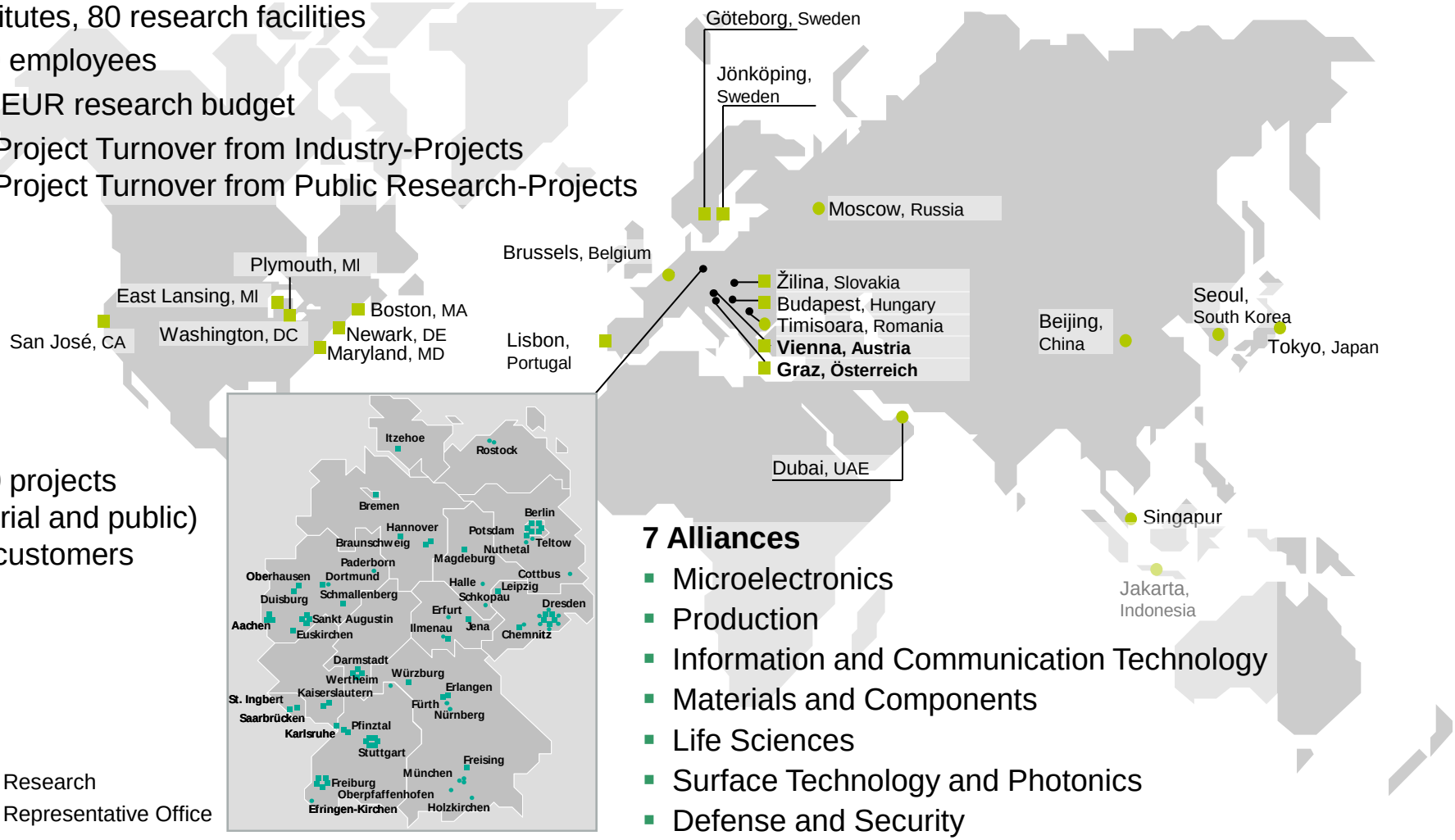
68 institutes, 80 research facilities

23 000 employees

€ 2 bn EUR research budget

2/3 of Project Turnover from Industry-Projects

1/3 of Project Turnover from Public Research-Projects



12.000 projects
(industrial and public)
3.000 customers

■ = Research
● = Representative Office

7 Alliances

- Microelectronics
- Production
- Information and Communication Technology
- Materials and Components
- Life Sciences
- Surface Technology and Photonics
- Defense and Security

Vienna University of Technology - Institute of Management Science

TU Vienna

- Rector: O.Univ.Prof. DI Dr. Sabine Seidler
- Founded in 1815
- Budget: >300 Mio. €
- 8 faculties, 54 institutes, 4.500 employees
- Students: ~ 27.000 (27% international, 26% woman)
- Degree programs: 18 Bachelor, 44 Master
- > 430 first enrolments in Industrial Engineering

Institute of Management Science

- Board: Univ.-Prof. Mag. Dr. Schwaiger
- 60 employees
- Industrial and Systems Engineering (Prof. Sihn)
- Ergonomics and Organisation (Prof. Köszegi)
- Financial Management and Controlling (Prof. Schwaiger)
- Property and Facility Management (Prof. Redlein)

Fraunhofer Austria Research GmbH : Linking Science and Industry

TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

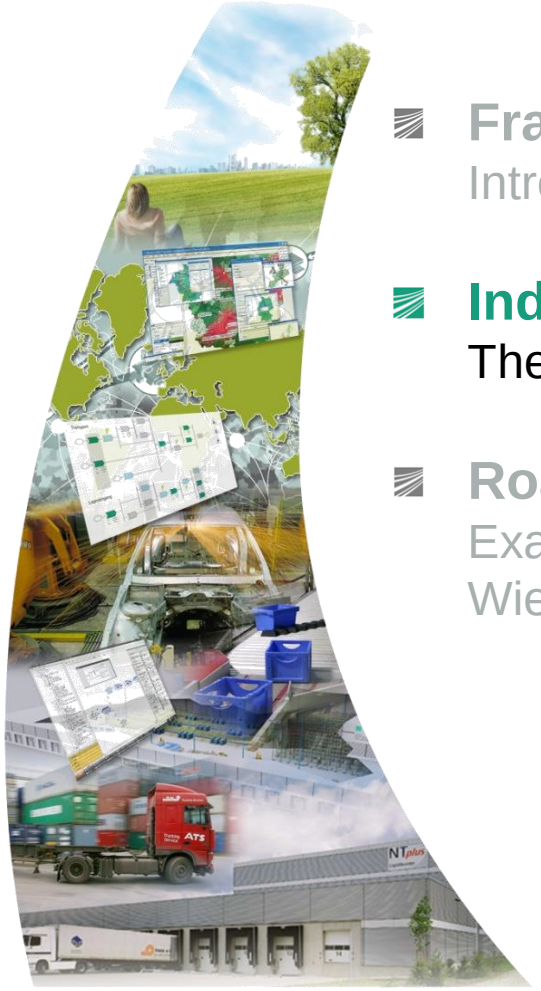
Fraunhofer AUSTRIA
Division Production and Logistics Management


Industry

Higher Education → Research → Development → Realisation → Application

Industrie 4.0

Potentials, Opportunities and Roadmap



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Paradigm Shift – Why do we need Industrie 4.0?

Complexity in Production and Logistics grows exponentially

Sources of Complexity

- **Complexity of Structure:** Globalization is still increasing and the degree of interconnection is growing exponentially.
- **Complexity of Data:** Information overload in production and logistics is growing disproportionately high – production-planning required on hourly bases.
- **Complexity of Products:** Wish for individuality is growing with its opportunities «batch size one» is getting reality.
- **Complexity through interaction:** Participation in virtual life is increasing due to more open systems and interconnectedness of all systems.

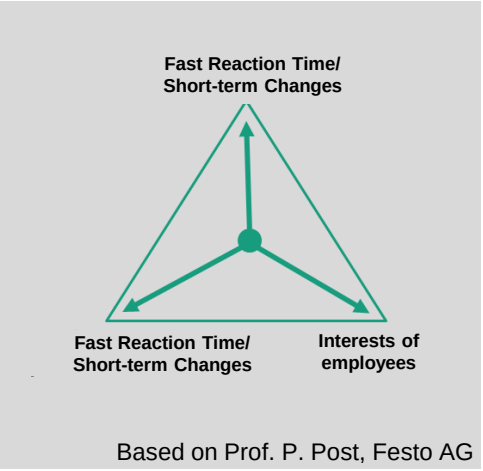
Based on: Hompel ten, Michael

Consequences

Consequences of Complexity

- **Complexity confronts the need for flexibility**
- **disproportionately high growth of complexity leads to instability**

➔ **Tension Triangle**



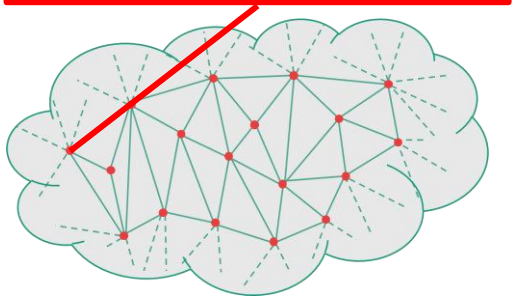
Based on Prof. P. Post, Festo AG

Industry 4.0

Paradigm-Shift

- **Transition to ad hoc interconnected, real-time, adaptive, decentralized and self-optimizing production- and logistic systems**

Single value creation chain is optimized as integrated part of the value creation system



What is Industrie 4.0?

The fourth Industrial Revolution

First mechanical weaving loom
1784

First assembly line, Slaughterhouses of Cincinnati
1870

First programmable logic controller (PLC), Modicon 084
1969

First Industrial Revolution
Through implementation of mechanical production-plants utilizing water- and wind power

Second Industrial Revolution
Through implementation of labor division in mass production utilizing electrical energy

Third Industrial Revolution
Through utilization of electronics and IT for further automization of the production

Fourth Industrial Revolution
On the basis of Cyber Physical Systems

Degree of Complexity

End of the 18th Century

20th Century

Beginning of the `70s 20th Century

Present

Time

(Source: DFKI, 2011)

Definition Industrie 4.0

- „Industrie 4.0“ represents the **“Fourth Industrial Revolution”**, a new level of **Organization und Control - ** concerning the whole value creation chain over the entire life cycle of products.

- The life cycle becomes orientated towards the **increasing individualism of costumer requirements** and encompasses: **the idea**, **the order for development and production, the distribution of products plus recycling,** and furthermore including all related Services.

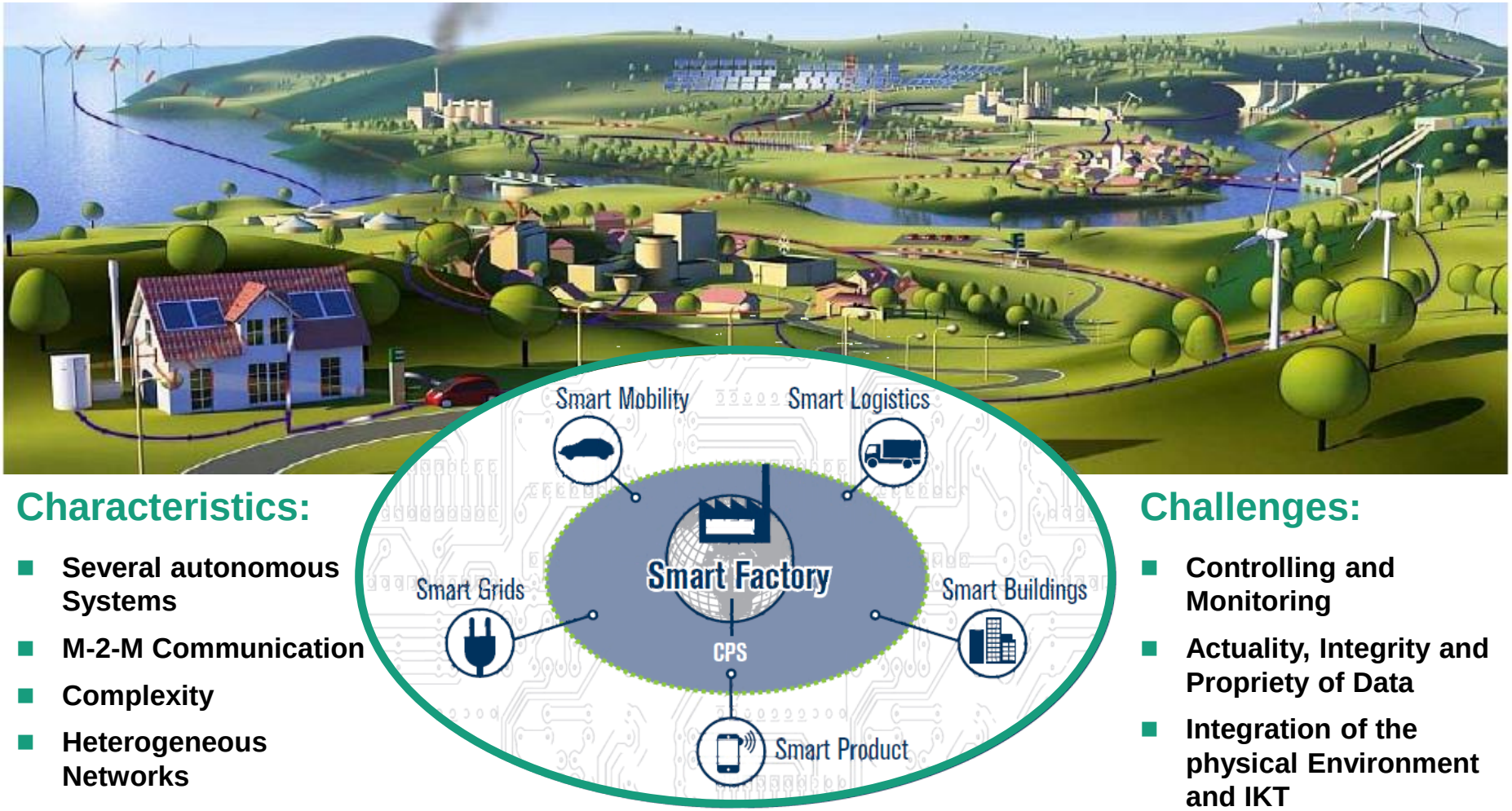
- Industrie 4.0 is based on the **availability of relevant data in real time through the interconnectedness of all instances related to the value creation process**, and moreover on the ability of deriving an optimized value creation process from the available data.

- **The interconnection of human beings, objects and systems leads to dynamic, real time optimized and self organized inter-company value creation systems** which are evaluated and optimized using criteria such as costs, availability and resource efficiency

Quelle: Plattform Industry 4.0

What is the Basic Idea of Industrie 4.0?

The Internet of Services – The Internet of the Things – Smart Everything



Characteristics:

- Several autonomous Systems
- M-2-M Communication
- Complexity
- Heterogeneous Networks

Challenges:

- Controlling and Monitoring
- Actuality, Integrity and Propriety of Data
- Integration of the physical Environment and IKT

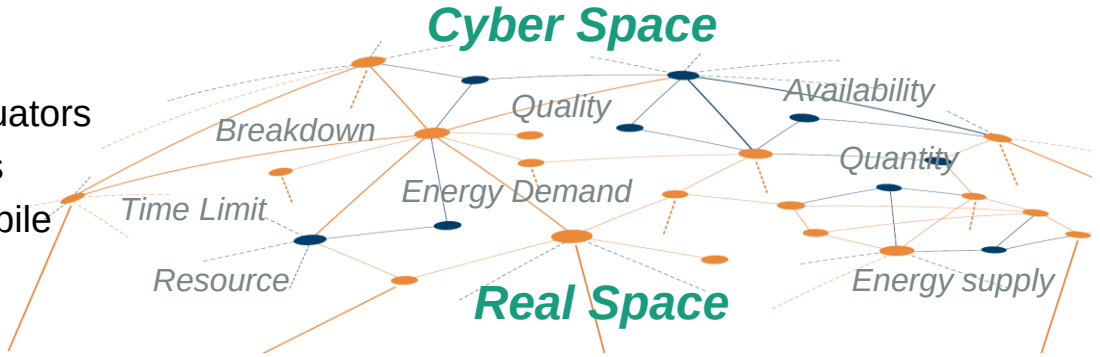
Source: Acatech, BMWT, TUWIn 4.0

How does Industrie 4.0 work?

As a Cyber-Physical Production System, connecting the material and virtual world

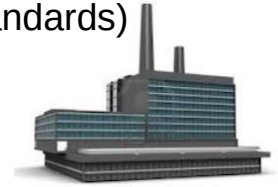
Technologies:

- Sensors & Actuators
- Cloud Services
- Wireless & Mobile Com.
- Self X
- (Standards)



Functions:

- Communicating & Negotiating
- Interpreting & Deciding
- Configuration & Adjusting
- Analyzing & Optimizing



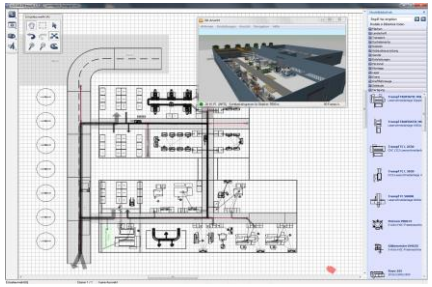
Supplier

Engineering

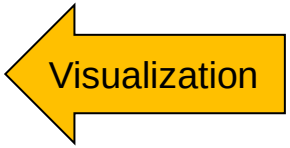
Production

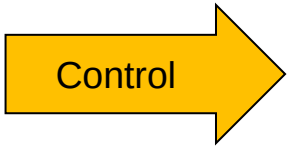
Costumer

Lifecycle (Production und Production system)



virtual/abstract



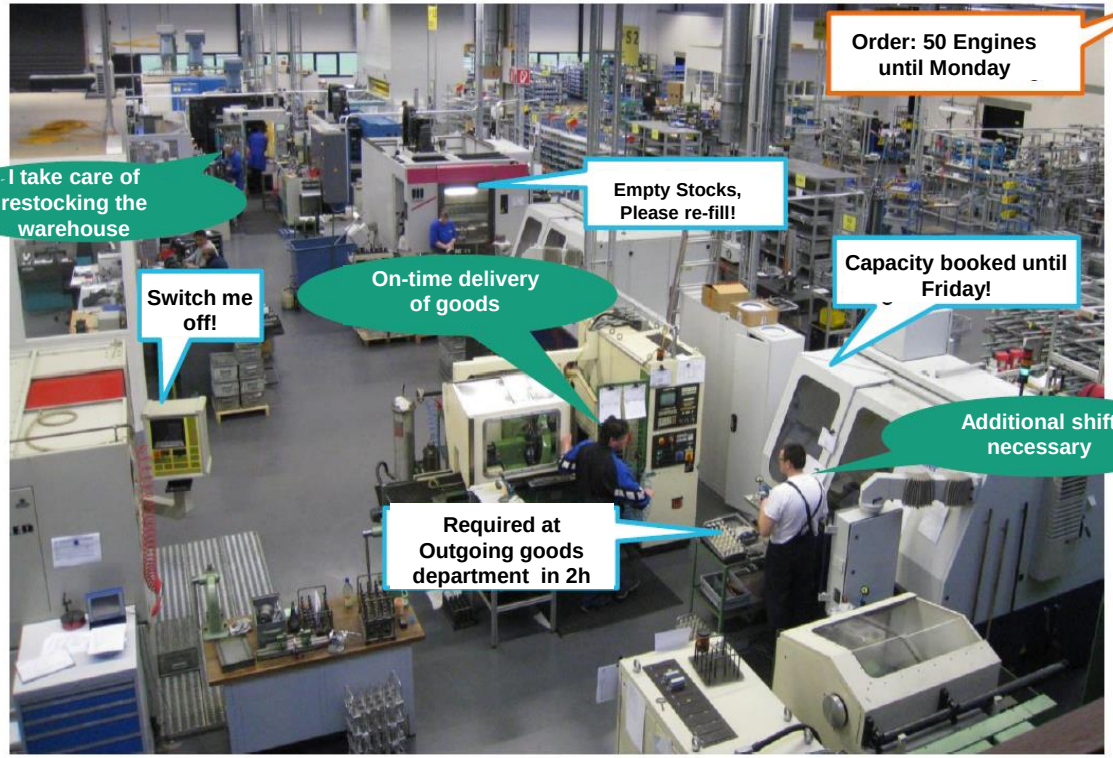


real/concrete

Source: TU Wien, Gerhard, 2014, TUWIn 4.0

How can we imagine Industrie 4.0 in Reality?

Smart Factory - Autonomous Organization in Real Time



Cyber-physical Systems

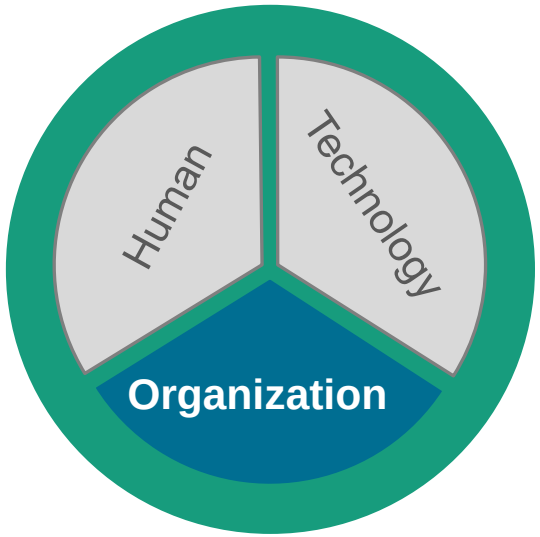
- do have an identity
- are communicating with each other and with the environment
- are configuring themselves (Plug and Produce)
- are storing information

De-centralized self-organization in real-time

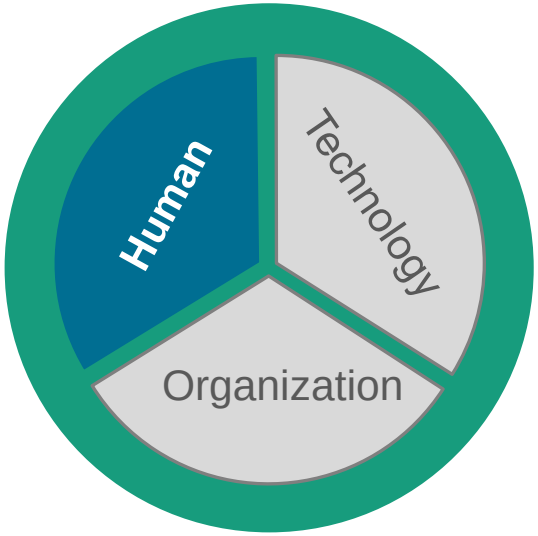
Industrie 4.0 - What should we pay attention?

Design aspects of Cyber-Physical Production Systems

Focus: Organiszation



Focus: Human

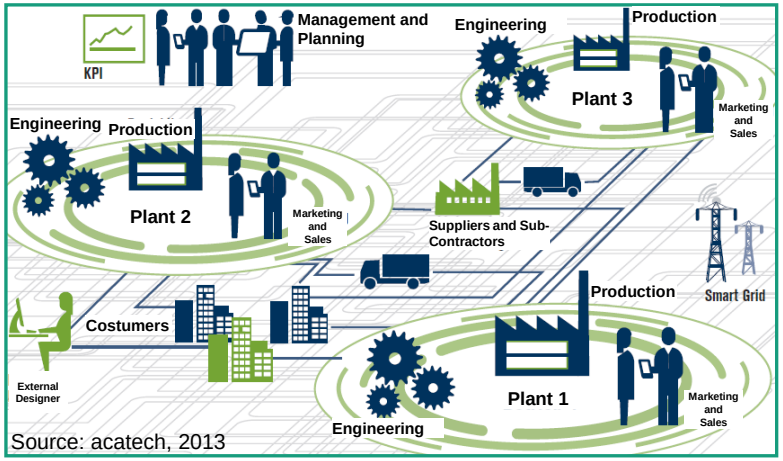


Focus: Technology

Implementation of the design aspects in Cyber-Physical Production Systems

What are the application fields of Industrie 4.0 in Production?

Selected Use-Cases



Source: acatech, 2013

General Characteristics:

- **Vertical Integration**
- **Horizontal Integration**
- **Consistency of the Engineering** along the entire life cycle
- **Human Beings interconnecting and cooperating** with Industrie 4.0
- **Technology Cyber-Physical-**(Production-) **Systems** (CPS/CPPS)

Interconnected Production
Flexible Sequences, intelligent PPS

Energy-Efficiency
Optimized use of Energy

Resource-Efficiency
Increase of Productivity and Efficiency-Factors

Increase of the productivity of Working-Systems
Employee-oriented Configurations

Integrated product- and process Development
Collaborative Planning-Platforms

Up-Cycling
Efficient Recycling-Strategies

Self-organizing and adaptive Logistics
transition to more flexibility of Logistic-Channels

Costumer oriented Engineering
transition to more flexibility of Products

New Business Models
Product-Service Systems

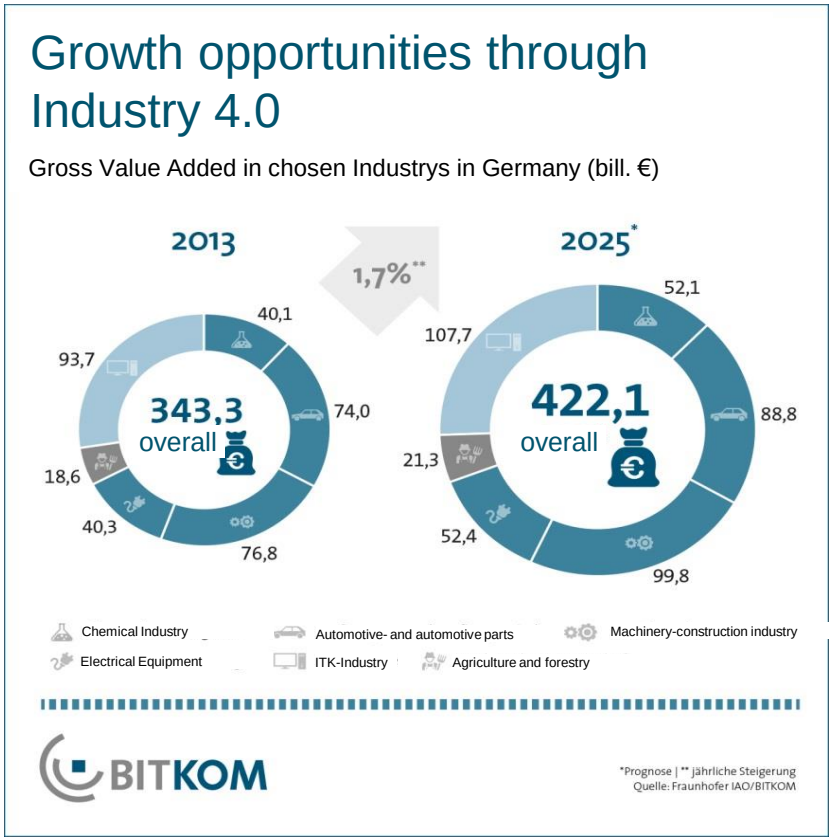
Resilient Plants
transition to more flexibility of Plant-Layouts

Knowledge-based Systems for extending the Product Lifetime
Interdisciplinary Cooperation's

Technology-Market Places
transition to more flexibility of technology

Industrie 4.0 – What are the Economic Potentials?

1,7% additional growth caused by Industrie 4.0



- The average growth of 1,7% per year and Industry is created through **innovative Products, new Services** & **Business Models** as well as **more efficient** operational **Processes**.
- The study investigated the potentials of 14 per cent of Germany‘s Gross Domestic Product (GDP)
  - Overall-effect are far reaching
  - Not all effects of interactional and systematic interconnections of different applications are assessable at the present

The application of Industrie 4.0 regards to the whole value creation chain:

Distribution/Sales → **Product development** → **Production** → **Logistics**

Source: BITKOM, Fraunhofer IAO

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Industrie 4.0 Examples

Collective Intelligence in Logistics

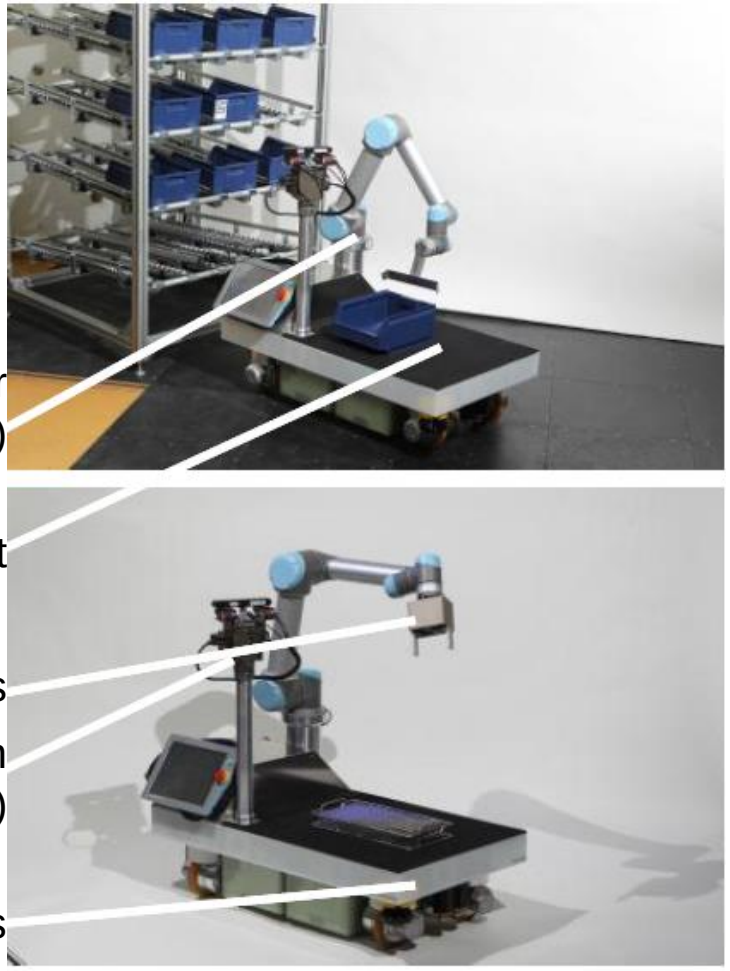
- Agent-based control of vehicles and orders
- Fusion of sensors for localization and collective control
- Replacement of conventional order-picking and handling of goods

Source: Fraunhofer IML

Industrie 4.0 Examples

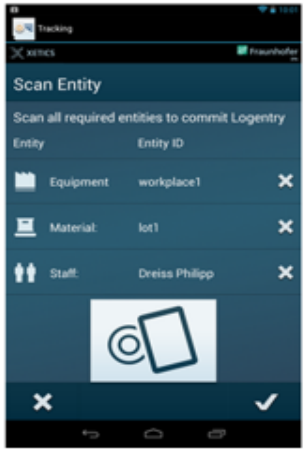
Mobile Helper for „Low Cost Jobs“

- Mobile robot for re-filling stocks at assembly workstations and removing empty storage-boxes
- Mobile Robot (with shipping space) operates in the super market and distributes goods to the desired storage-boxes)



Source: Fraunhofer IPA, IFF Universität Stuttgart

Industrie 4.0 Examples – Instant MES-Apps



Without Server Connection

Core Data App

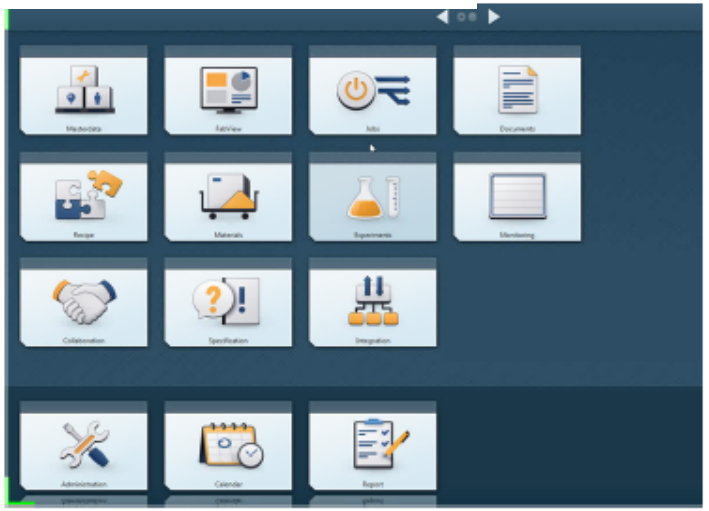
Administration of Resources e.g. Machinery, Worker, Working Plans

Tracking App

Monitoring of the product during production e.g. lot, machinery and Worker via NFC)

User- /Application specific Apps

Random combinations possible on mobile devices and the PC



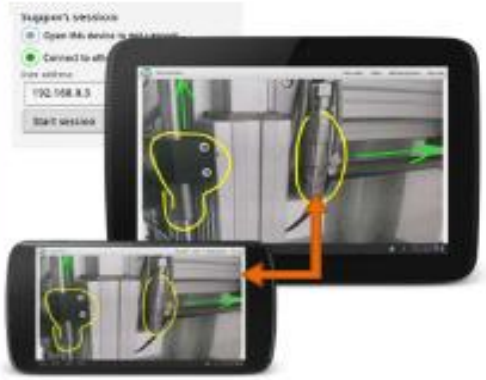
Industrie 4.0 Examples – Augmented Reality

Descriptions of Components and Systems

Staff training trough context-based descriptions and tutorials

Supporting the Error-Tracking Process

Connection of components with elements of the electrical cabinet



Remote-Support on Plant-Level

Image-transfer from tablets to smartphones

Support at Maintenance

Automized maintenance protocols
Evaluation of sensors

Industrie 4.0 Examples – Lean and Industrie 4.0

Optimized Assembly-Islands for Mounting Gearboxes

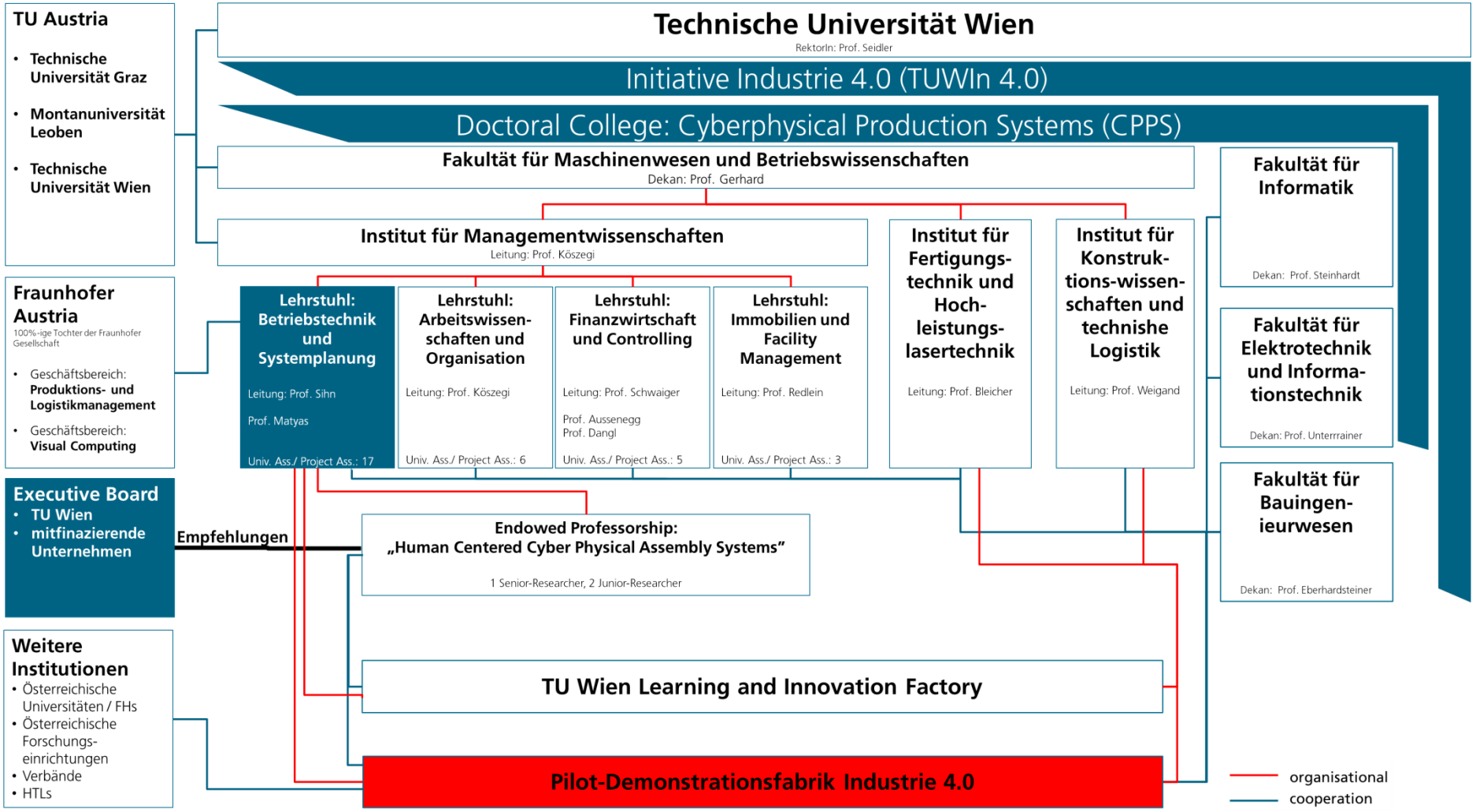
- Non-contact energy-supply
- Implementation of short-time-energy-storage-systems for an autonomous operation
- a compact and powerful load handling device
- Integration of navigation- and safety controllers as well as several autonomous reference-systems (can be activated selectively to fit the current conditions)
- Integration of Improved workplace-ergonomics

Automated Guided Vehicles

Source: Johann Soder, SEW Eurodrive

Industrie 4.0 and Cyber-Physical Production Systems

Interdisciplinary Research at TU Wien



Industrie 4.0 and Cyber-Physical Production Systems

Pilot-Demonstration-Factory at TU Wien

Focus: Human Centered Cyber Physical Production Systems

Human Centered Cyber-Physical Assembly-Systems

Human Centered Cyber-Physical Manufacturing- and Logistics-Systems

Smart Engineering of Human-Centered Cyber-Physical-Production-Systems

DEMONSTRATION



- Demonstraton of Industrie 4.0 - visual an tangible
- Industry-oriented and integartive training in respect to production work of the future
- Cross-themes, problem-based learning

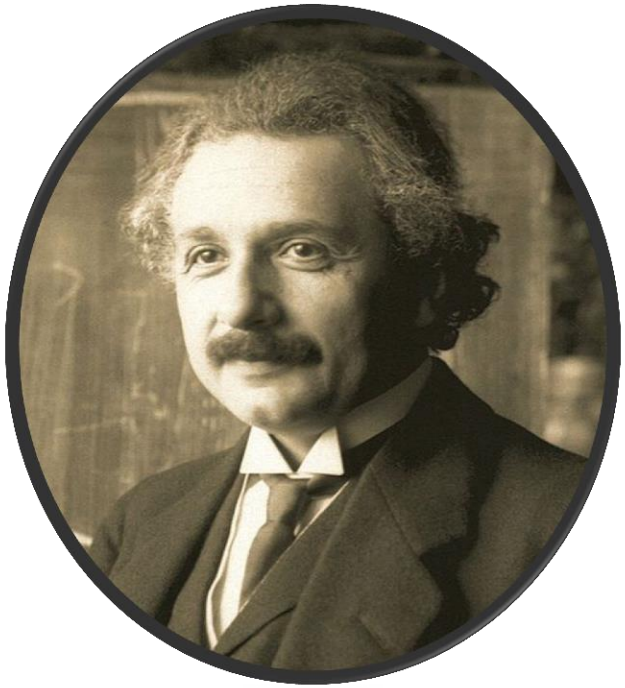
Demonstration of modern, forward-relevant technologies, processes and IT Systems

INNOVATION

- Practical test and implementation of
  - prototypes and product technologies
  - production technologies and processes
  - assistance, control, decision-makeing and support systems and methods
- Interdisciplinary, empirical research
- laboratory for controling, product, date and structure complexity


Interaction of product, production, engineering, IT, organization and human aspects

„Insanity is
to do the same things over and over
and expect different results .“



Albert Einstein,
Physiker
(1879 - 1955)

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We are looking forward to accompanying you in innovative projects…

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„Fraunhofer Austria – on behalf of the future“

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