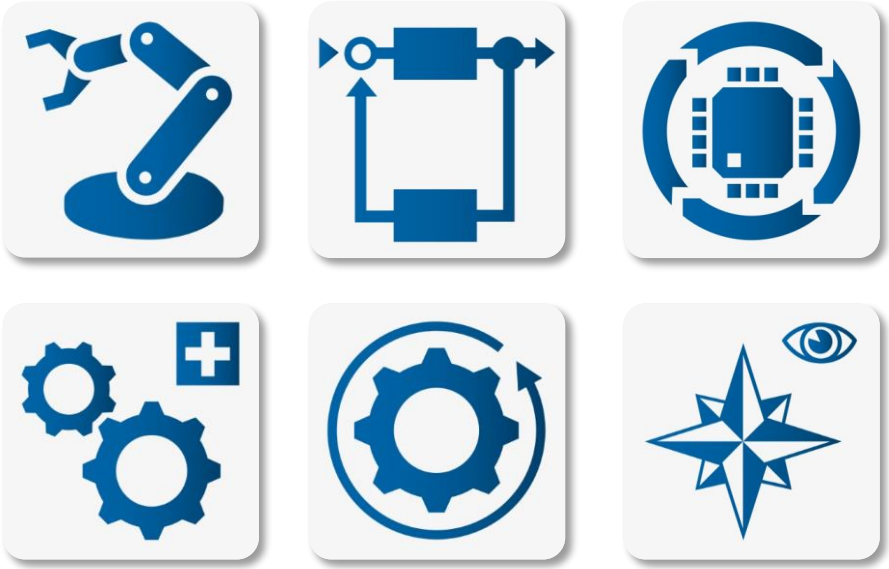
Mechatronics

Driving Force for

Industry 4.0



How cyber physical systems will change the way of future production

IMS
Institute of Mechatronic Systems
Applied Science in Mechatronics

The first international event on
Fourth Industrial Revolution Industry 4.0
Tehran 4th/5th August 2016
Iran International Exhibition Center

Prof. Dr.-Ing. Hans Wernher van de Venn
Head of Institute of Mechatronic Systems IMS
Zurich University of Applied Sciences, ZHAW

Outline

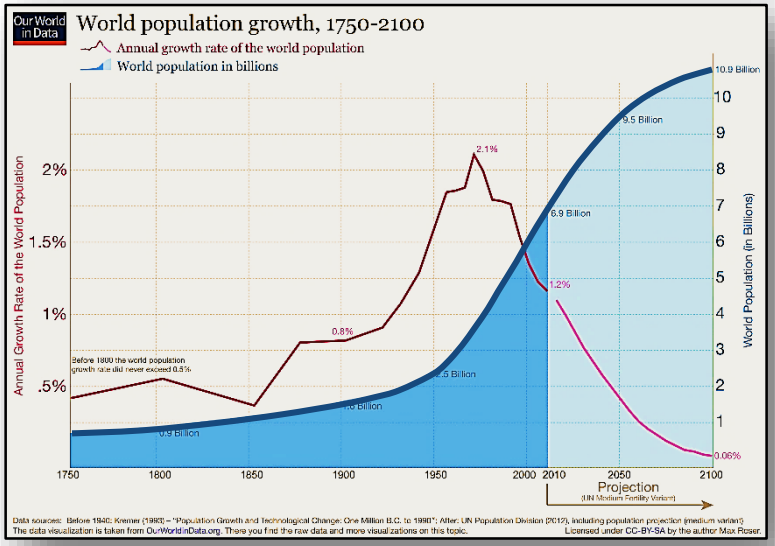
- Future challenges
- The way ahead for next generation production
- Mechatronics: Enabler for flexible Automation
- Form device to Cyber Physical System
- The Mechatronics Part in Industry 4.0
- How does Mechatronics influence the way ahead
- Some Examples
- Conclusion and Outlook

Future Challenges

Future challenges for production industries

Demographic development of world population

2011: 7 billon people
2024: 8 billon people
2045: 9 billon people



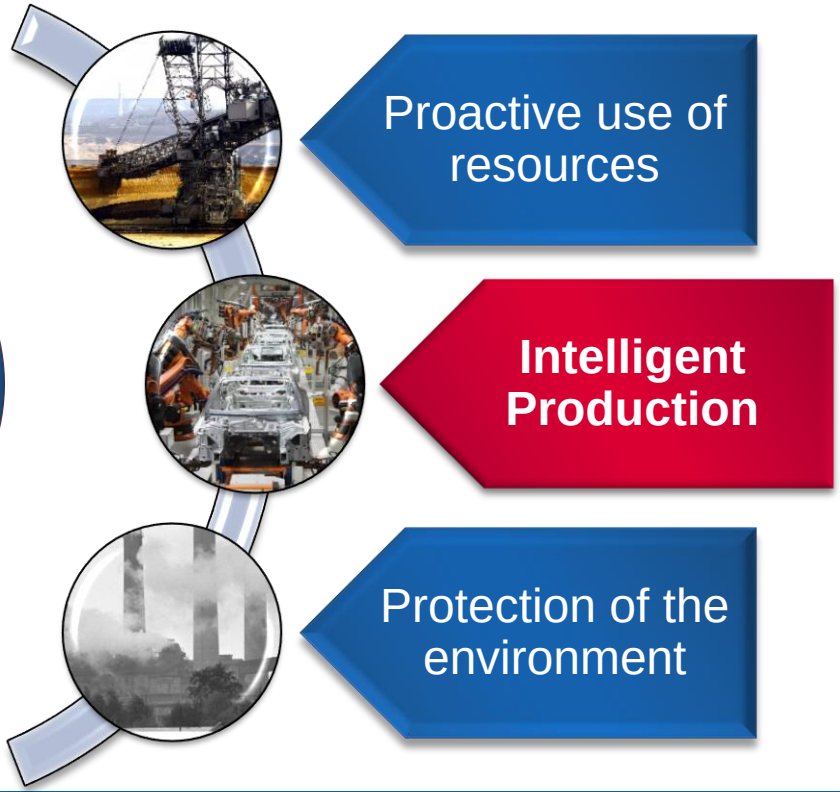
Source: Our World in Data, www.ourworldindata.org

Future challenges:

- Increase production by a factor of 10
- Reduce energy and resource consumption by a factor of 10
- Reduce pollution significantly

Future challenges: Are we able to…

- … Increase production by a factor of 10
- … Reduce energy and resource consumption by a factor of 10
- … Reduce pollution significantly



Future challenges require for new ways of thinking

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Today:

- Maximizing profit by minimal Investment

In the future:

- Added value by a minimum of resource consumption

Future Key Technologies in Production:

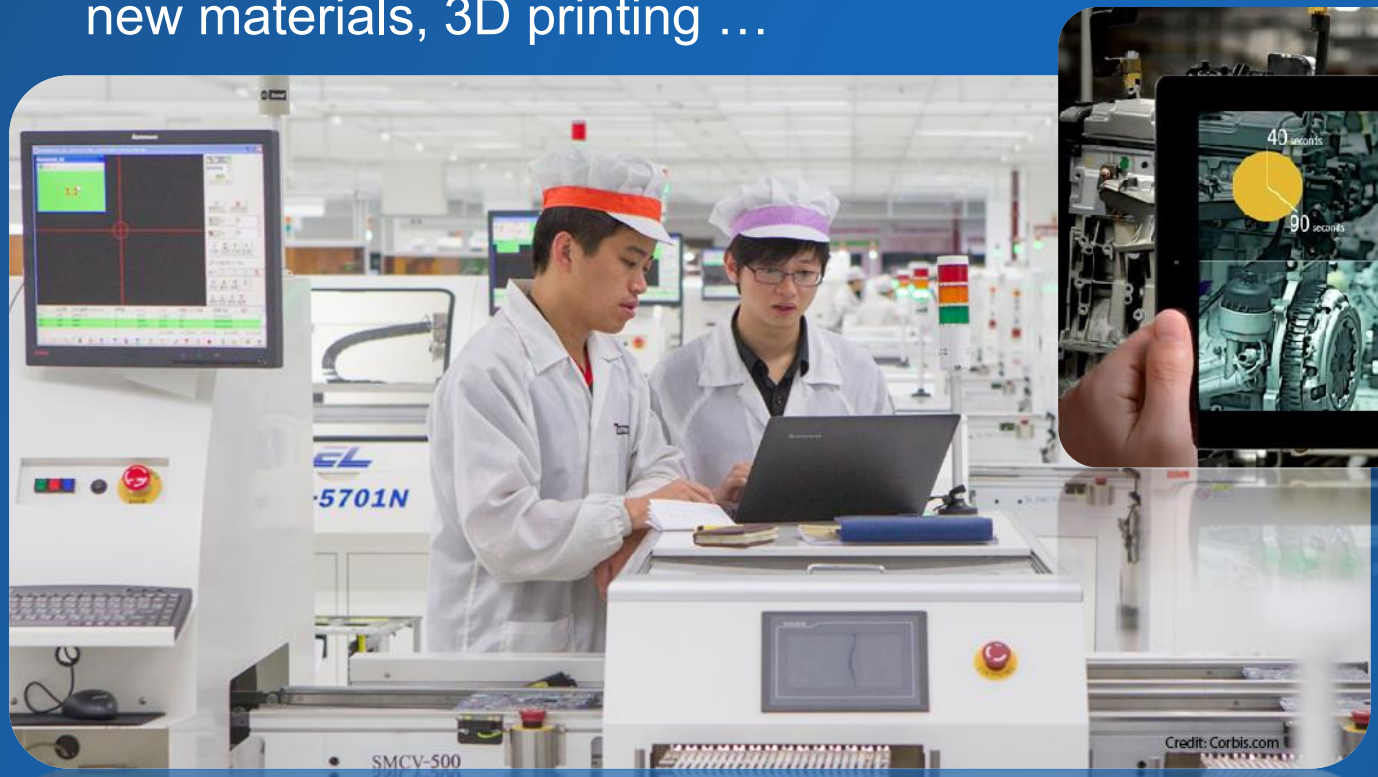
- Intelligent Mechatronic Systems, Cognitive Information Processing, Self-tuning, Self-configuration and Self-diagnostics, Networked Automation Systems

Image source: KUKA Robotics, Germany

The way ahead for next generation production

Internet goes factory: “Industry 4.0”?

- Digitally connected manufacturing is often referred to as “Industry 4.0” and most often simply described as “Internet enabled” factory.
- However Industry 4.0 encompasses a much wider variety of technologies, ranging from self-aware production systems to robotics, new materials, 3D printing …



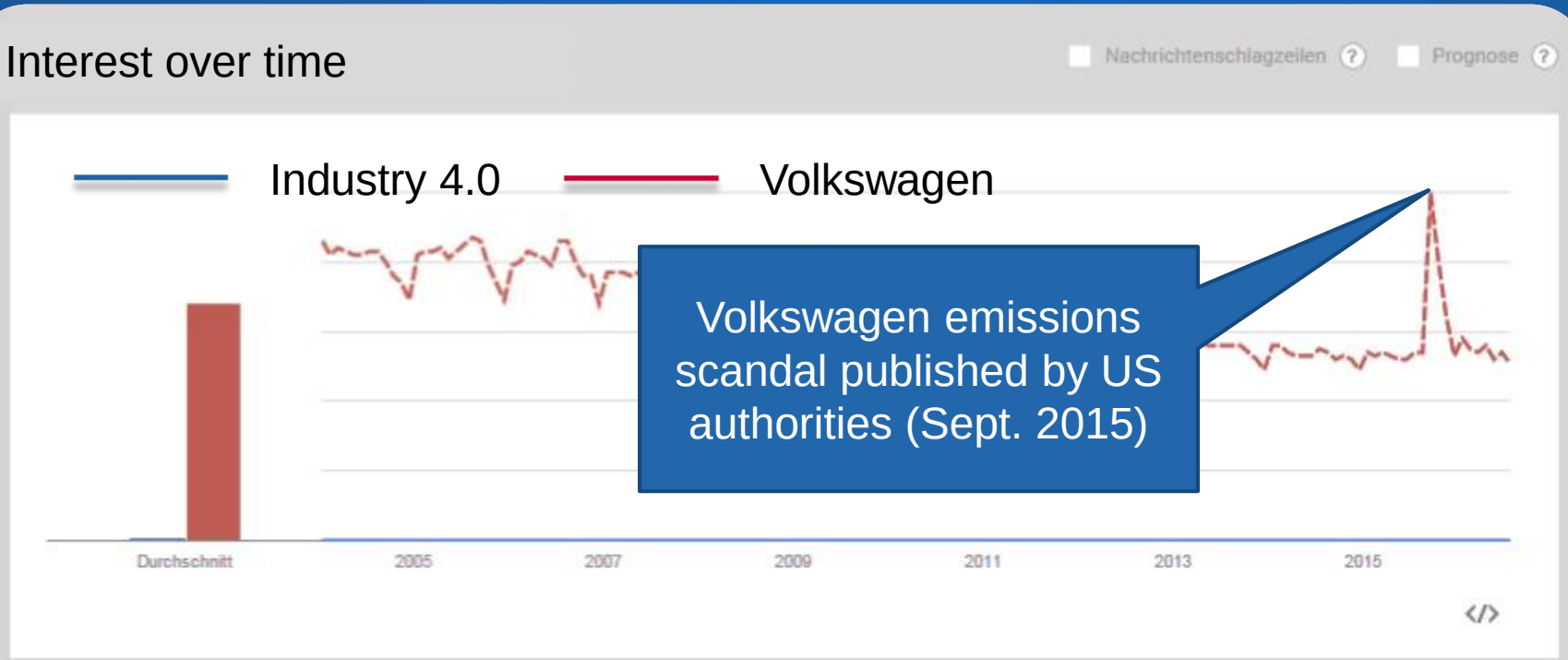
Still, most companies don't know…

- The Internet of Things is about to come. But many companies still do not know what to do with it and how to be prepared.
- One of two decision makers in industry in Germany, Austria and Switzerland has not heard of the term “Industry 4.0", ...
- Around a quarter recognizes the concept, but does not know exactly what it is all about.
- And only a quarter knows “Industry 4.0” and is aware of the future chances and challenges.

Source: Frankfurter Allgemeine Zeitung, February 2016

Google Trends

Result Google Trends for “Industry 4.0” and “Volkswagen”



- The importance of “Industry 4.0” as a future paradigm in production seems to be generally underestimated or still not recognised
- At present we have a more local occurrence in Europe (Germany) and surprisingly in Japan
- However, Industry 4.0 (Smart Factory, …) will have a worldwide impact to all economies

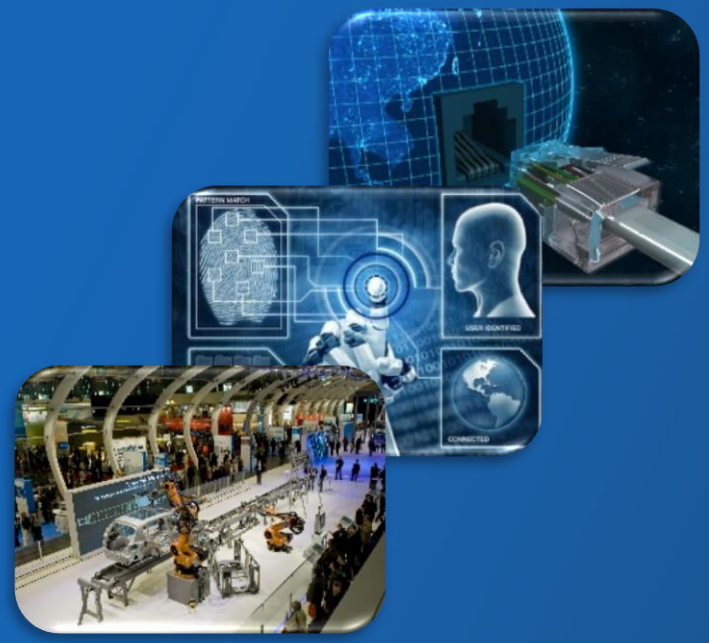
Source: Phoenix Contact

Mechatronics: Enabler for flexible Automation

Flexible automation, what is it all about?

When speaking about flexible automation today, terms like the following ones are common:

- Internet of things
- Cyber Physical Systems (CPS)
- Information Cloud / Fog
- Manufacturing 2.0
- Industry 4.0
- Smart Factory



Classification and delimitation is difficult. Is this just about new tags for known fields of action or is there really something new in it?

Mechatronics as building block to Industry 4.0

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1969

Mechatronics (Japan)

1988

Ubiquitous Computing (USA)

1999

Internet of Things (USA)

Ambient Intelligence (EU)

2006

Cyber Physical Systems (USA)

2008

Factories of the Future (EU)

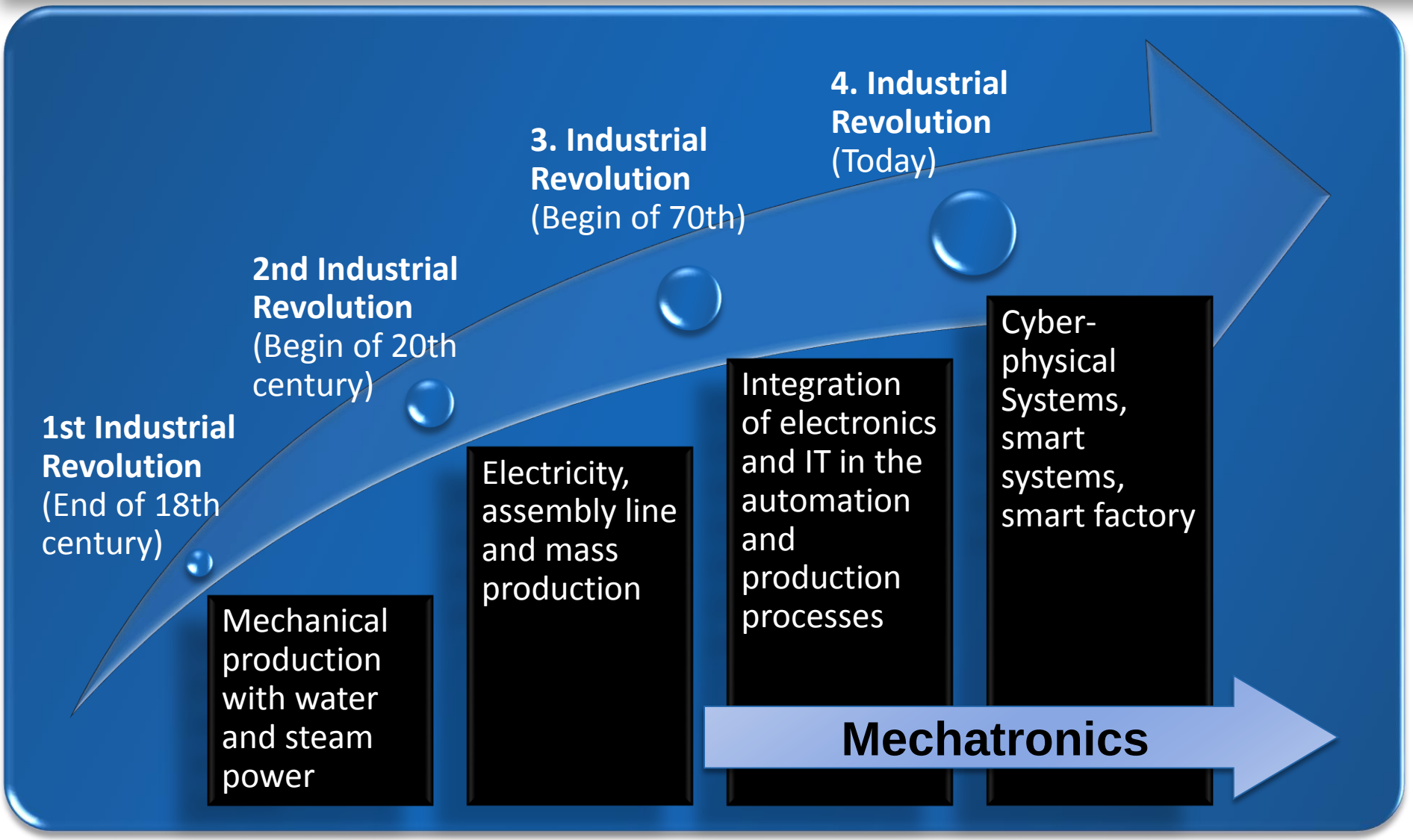
2010

Industry 4.0 (DE)

Manu-facturing 2.0 (EU)

Mechatronics can be regarded as a requirement to Industry 4.0

4th Industrial (R)evolution



Mechatronics enables flexible automation

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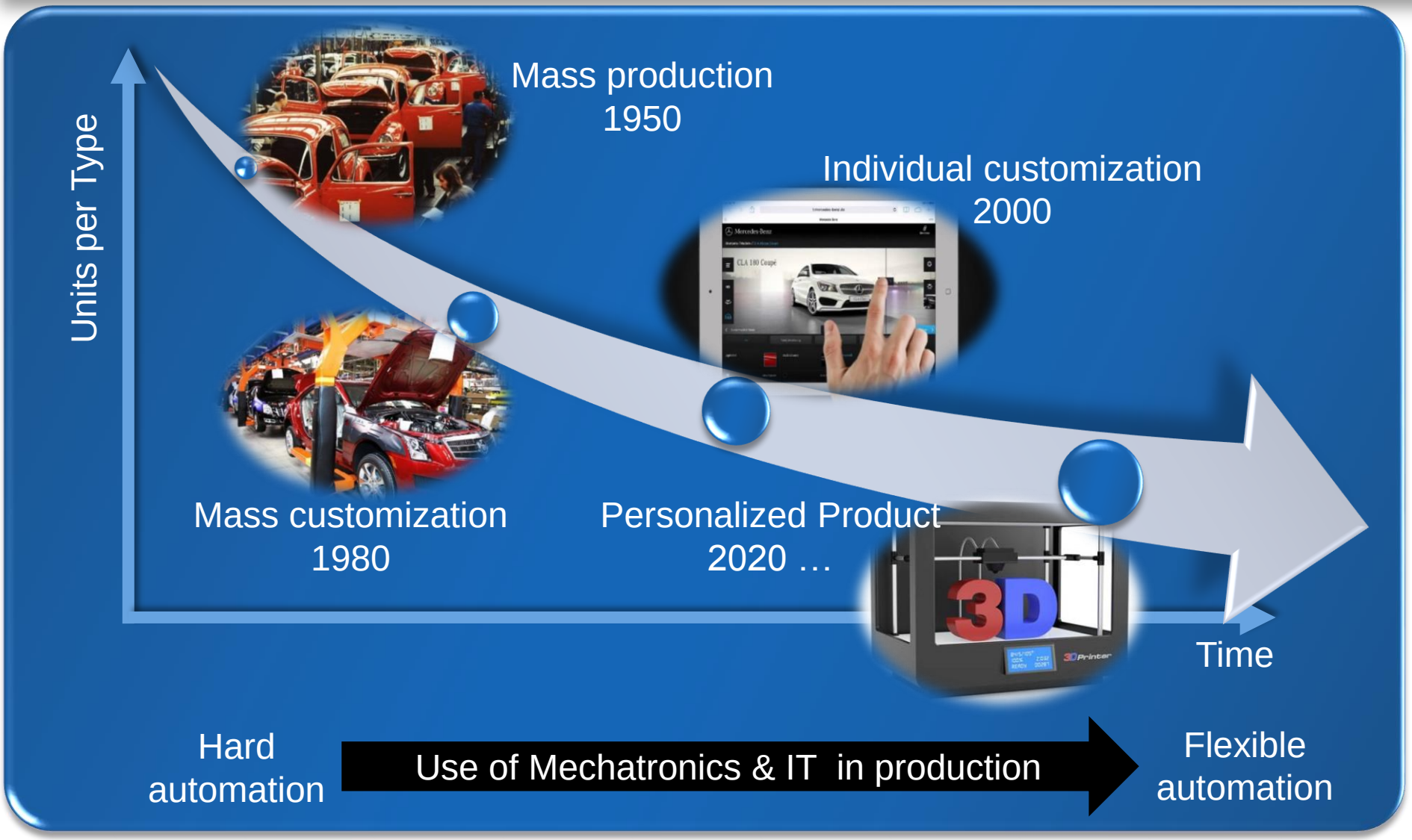

From device to Cyber Physical System

… its all about Mechatronics

Yesterday

Separated development cycles: mechanical engineering, electrical engineering, IT

Today

Integrated development cycles, communicating mechatronic systems

Tomorrow

Optimized mechatronic systems, energy-efficient, resource-efficient

Future

Mechatronic components as cyber physical systems, self-optimization

From embedded to Cyber-Physical System

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Cyber-Physical Systems (CPS)

Smart Factory, Smart Grid, Smart Home, Smart Traffic Systems

Networked embedded Systems

Autonomous operation, Cloud Computing, Machine-to-Machine communication, sensor networks for real-time data capturing

Embedded Systems

Machine control, vehicle control systems, household appliances, safety systems, medical systems

Elements of "Industry4.0"

Internet of things ⟷ **Internet of services and data**

+ IP-ability

Cyber-Physical Systems (CPS)

+ Internet Readiness
+ System to system com. (M2M)
  - Wireless communication
  - Semantic description

Embedded Systems

+ Sensors, Actuators
+ Integration of high-performance micro-computer

Physical objects, equipment, ...

Big Data
Cloud Computing
Smart Devices
1 user, many computers

Data Warehouses
Internet
PC
1 user, 1 computer

Mainframe system
many users, 1 computer

Grafik in Anlehnung an Prof. Dr. Henning Kagermann, acatech - DEUTSCHE AKADEMIE DER TECHNIKWISSENSCHAFTEN

From factory to cyber-physical Production

Cyber-Physical Systems

Embedded systems
(as part of machines, buildings, transport, roads, production facilities, medical processes, logistics, coordination and management processes)

+

Internet enabled

Indicators:

- Detecting physical data with sensors
- Using worldwide available data and services
- Analysing and storing data
- Using communication technologies (wireless / wired, local / global)
- Interacting with physical world via actuators
- Using multimodal human-machine interfaces (touch screen, voice control, gesture control, ...)

According to ACATECH 2012

The very heart of Industry 4.0
A converging development

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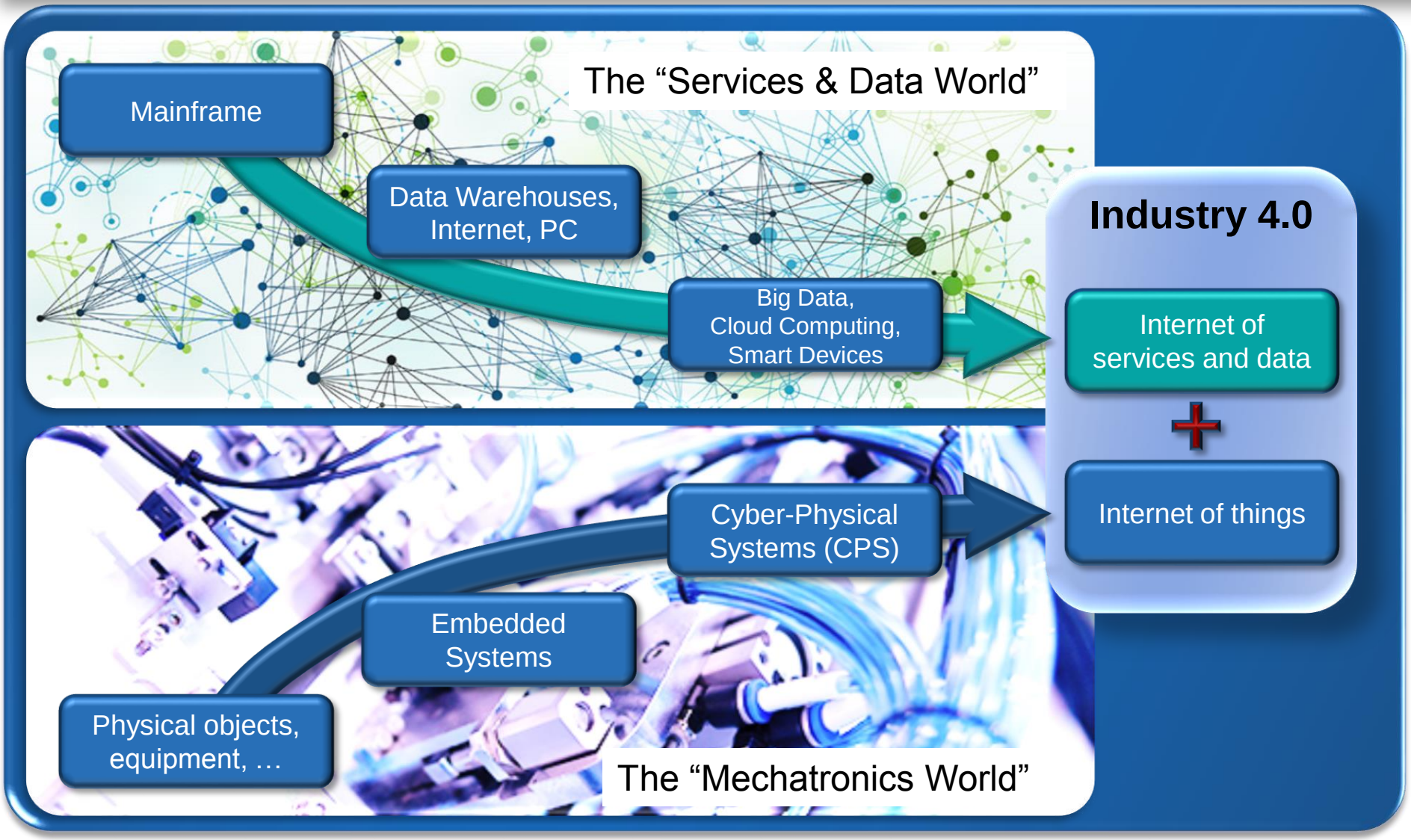
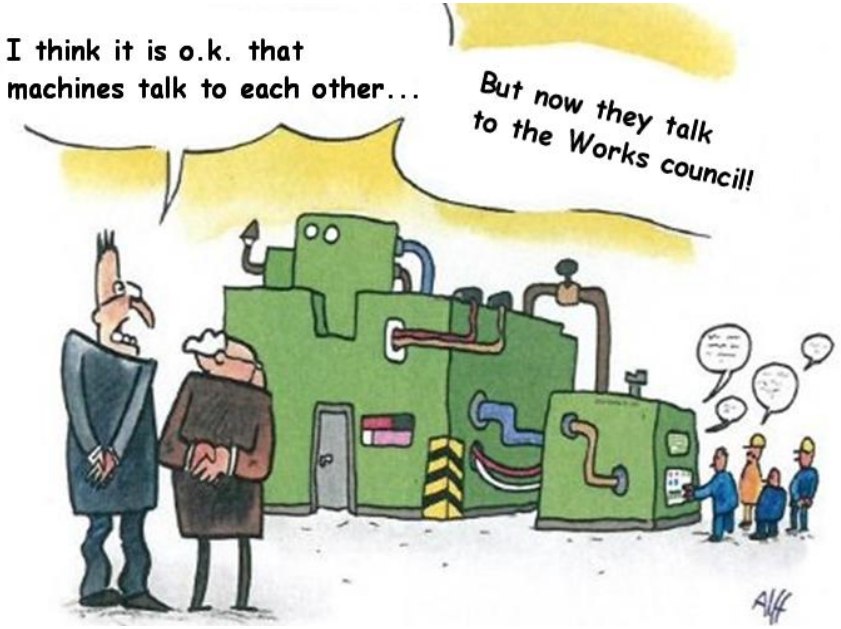
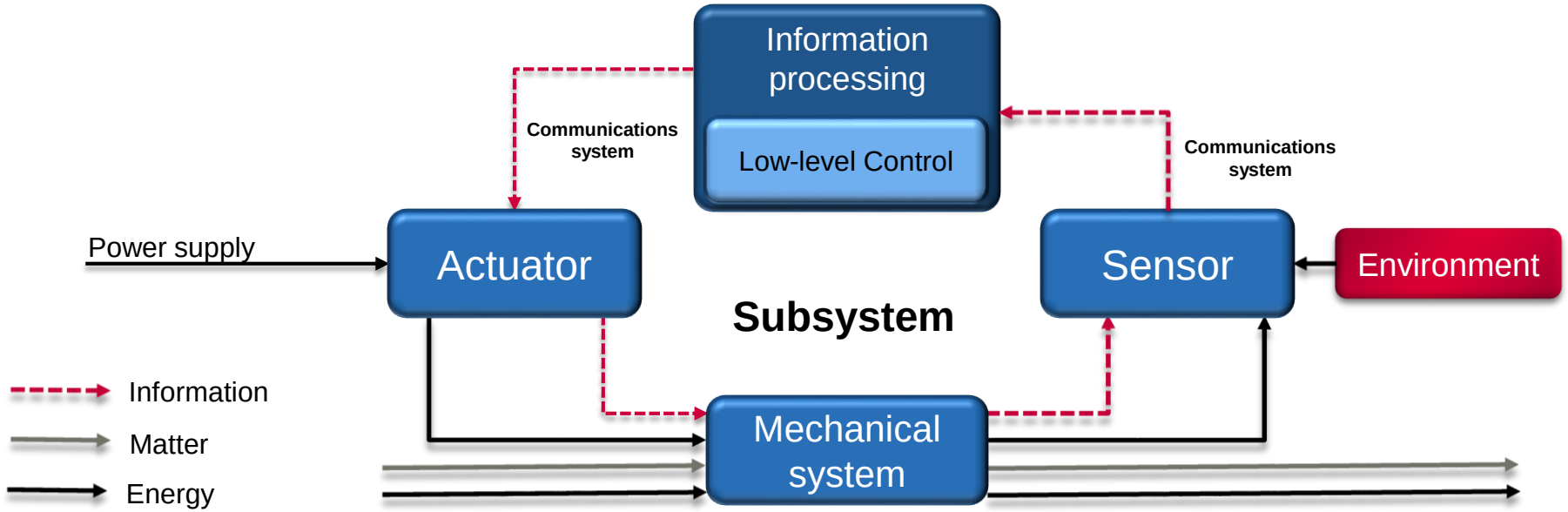




How does Mechatronics influence the way ahead

Mechatronic System

It all started by Mechatronics…



… Transformation into a Cyber-Physical System

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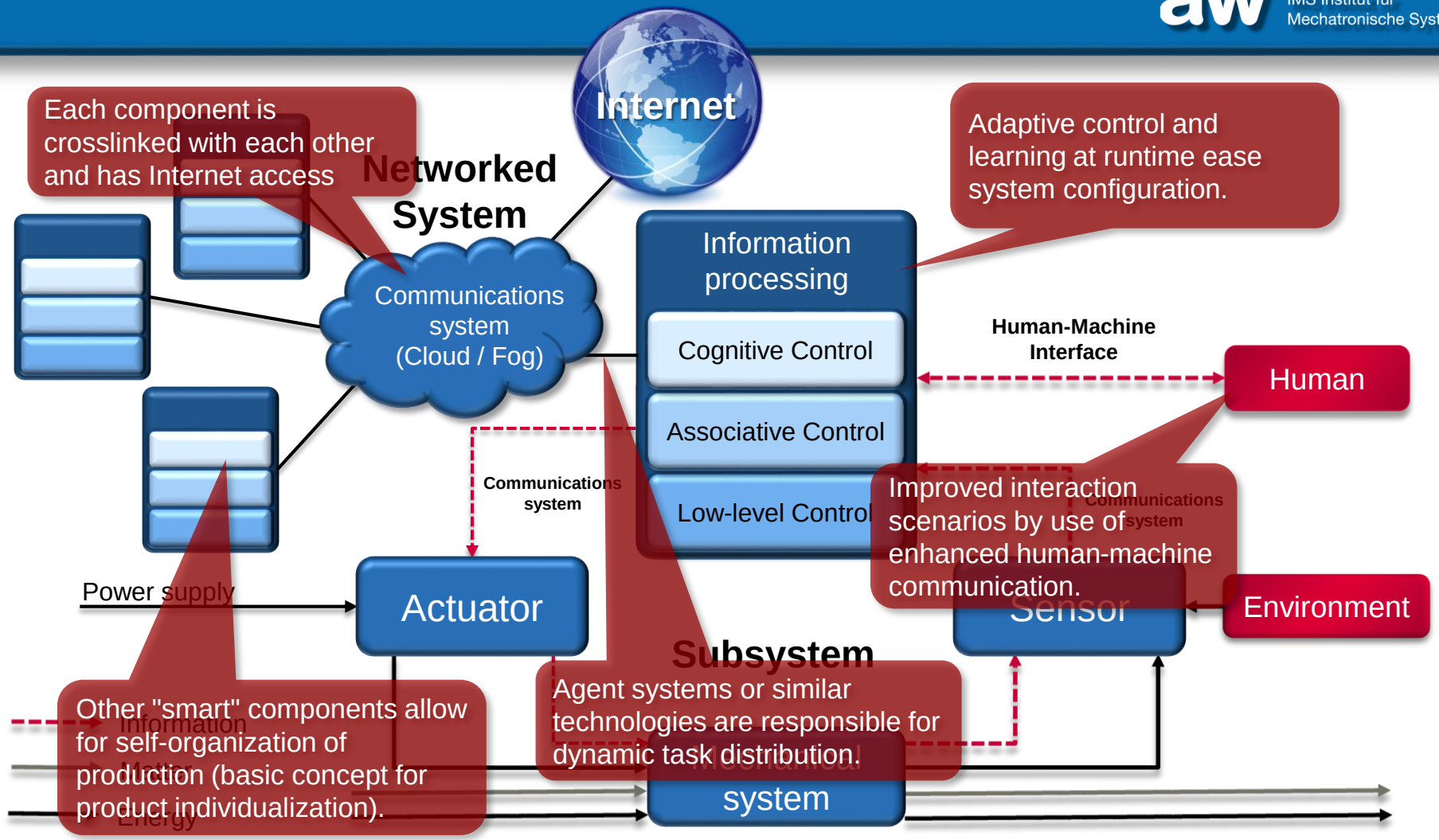

From Production to intelligent Production

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Mechatronics

Self-optimizing Production Systems

- Independent determination of quality and productivity goals of the individual process steps for a comprehensive optimization of the value chain

Context-sensitive cognitive Production Systems

- Dynamic adaption of production parameters depending on internal and external influences
- Consideration of knowledge about products and systems to optimize production by objectives

Adaptivity and Autonomy

- Independent configuration of the system at runtime
- Autonomous adjustment of machining processes according to objectives

Communication and distributed functionality

- The factory as a network of mechatronic systems and people
- Breakup of the conventional communication hierarchy
- Horizontal and vertical integration

Towards Intelligent Production

Today's Reality

Industry 4.0 Communication and self-organization in Real-Time

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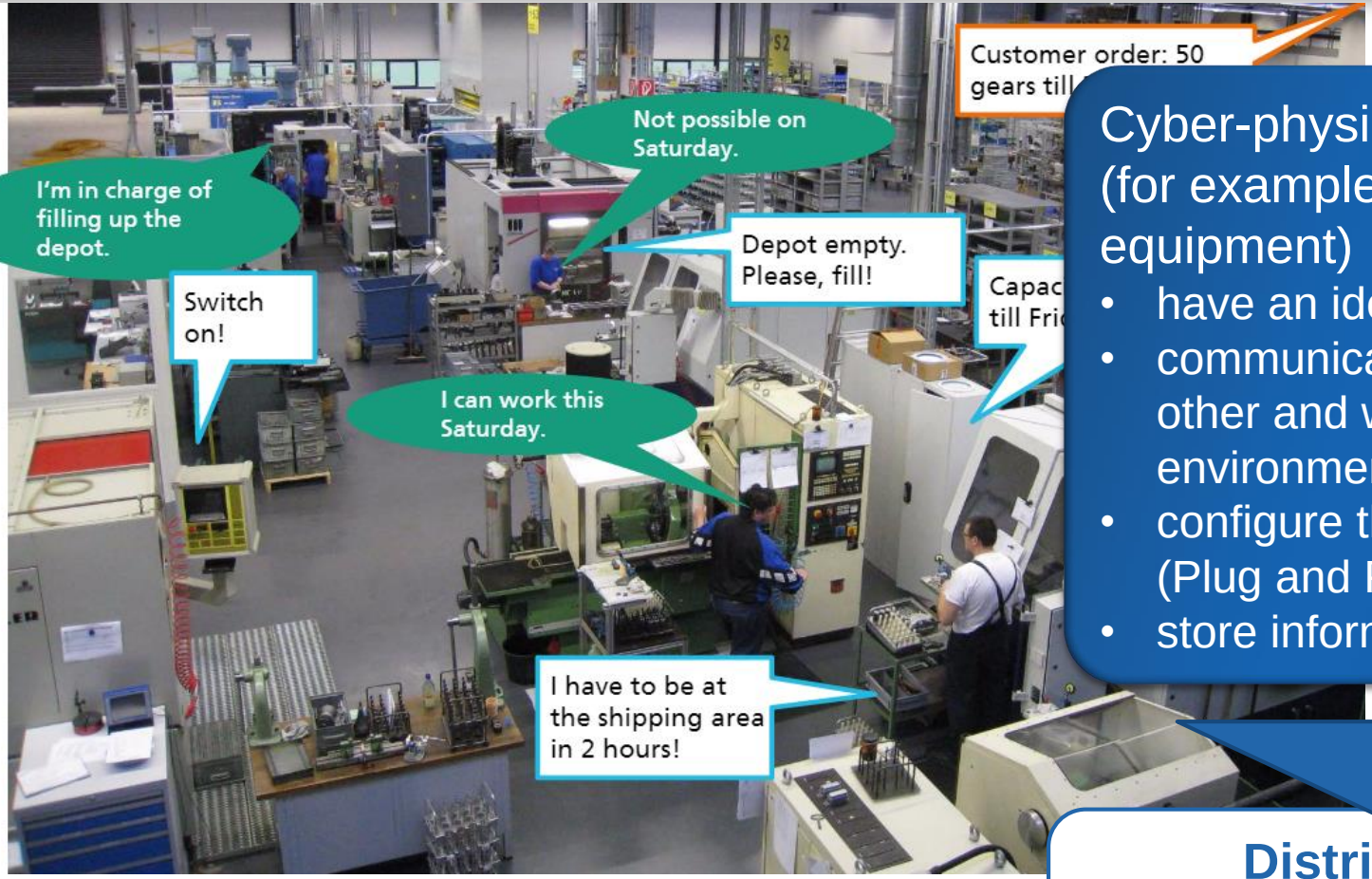

Cyber-physical systems (for example, machinery, equipment)

- have an identity
- communicate with each other and with the environment
- configure themselves (Plug and Produce)
- store information

Distributed Self-organization In Real-time

Source: According to Bauernhansl, IPA Stuttgart

Some Examples

Intelligent manufacturing system based on multi-agent control

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Plug and PRoduce Intelligent Multi Agent Environment

PRIME

Plug and produce intelligent multi-agent environment based on standard technology

SEVENTH FRAMEWORK PROGRAMME

Investigating new solutions for deployment of highly adaptive, (re)-configurable self-aware plug and produce assembly systems.

FP7-2012-NMP-ICT-FoF

www.prime-eu.com

PRIME Project partners

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asyril experts in mechatronics

csem centre suisse d'électronique et de microtechnique

INTROSYS Global Control System Designers

SIEMENS

Technology Transfer System®

SIMPLAN

UNINOVA Instituto de Desenvolvimento de Novas Tecnologias

Zurich University of Applied Sciences
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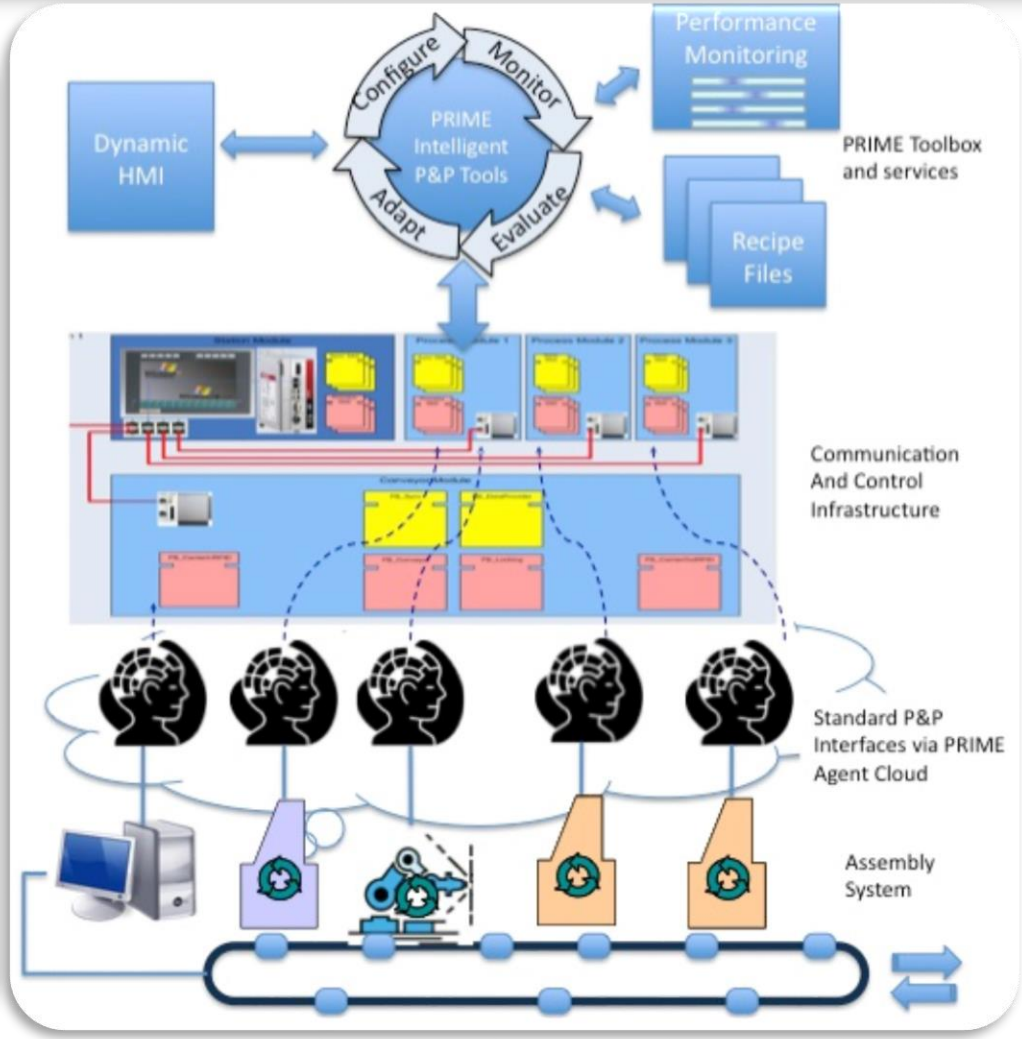
IMS Institute of Mechatronic Systems

Coordinator:

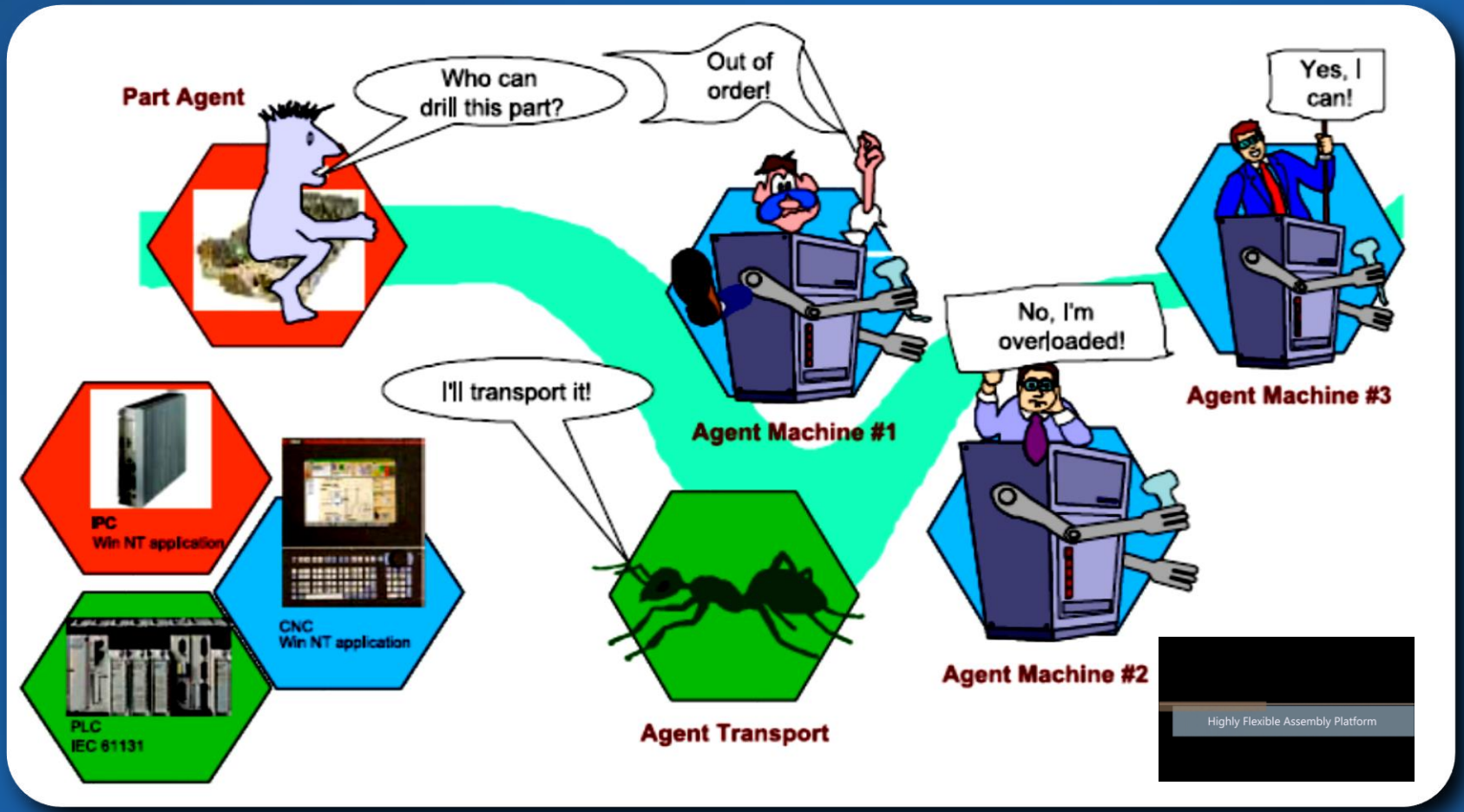
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

PRIME Concept

- Each component is a mechatronic system consisting of hardware, control, communication unit and software agent
- The agents take over the integration and control of all components.
- Agents communicate with each other, with the overall control and the product agent



PRIME Concept



PRIME and Industry 4.0

- PRIME is the implementation based part of a possible Industry 4.0 concept on factory level
- PRIME is a network of cyber physical systems
- PRIME implements Communication and Self-organization of complex assembly systems in Real-Time

Smart Collaborative Robots Lead the Way in Mass Customization of Consumer Goods

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Autonomous operation

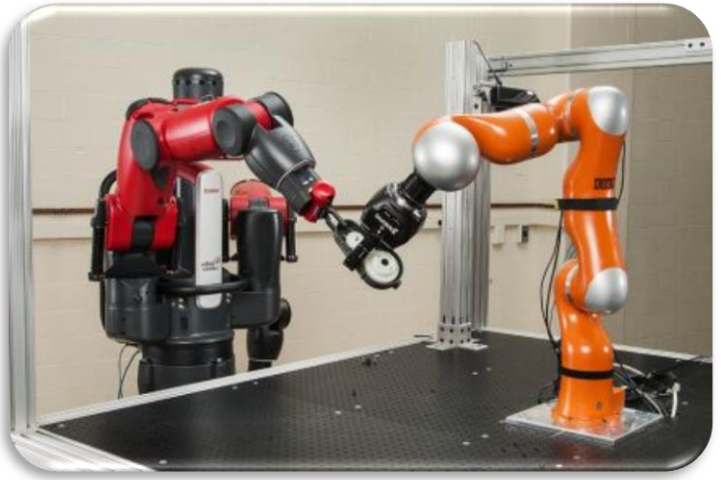
- Localisation and navigation in unstructured shop floor environments
- Robot / Robot cooperation

Learning and decision making

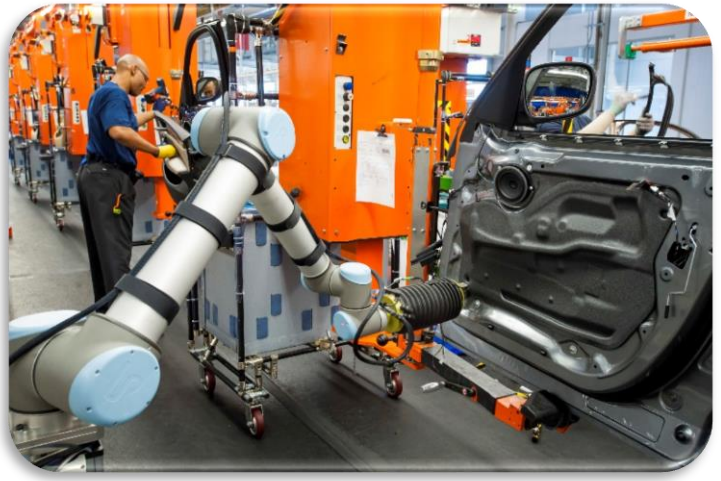
- Reduced factory setup and commissioning times

Perception of environment

- Sensor fusion (video, image, lidar, sound, haptic information)
- Safe human robot cooperation in shared workspaces



Source: The National Institute of Standards and Technology (NIST)



Source: BMW Group, BMW Werk Spartanburg

Systems for industrial Application

Baxter, Rethink Robotics

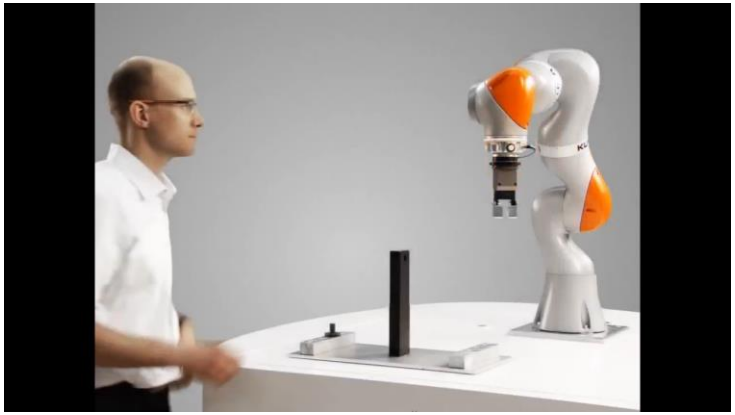
Source: Rethink Robotics

YUMI, ABB Robotics

Source: ABB Robotics

Kuka LWR iiwa

Source: Kuka



Kawada Industries "NextAge"

Source: Kawada Industries

Flexible Airplane Assembly

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Grasp the sidewall and move the component by hand

Exoskeletons as flexible production system

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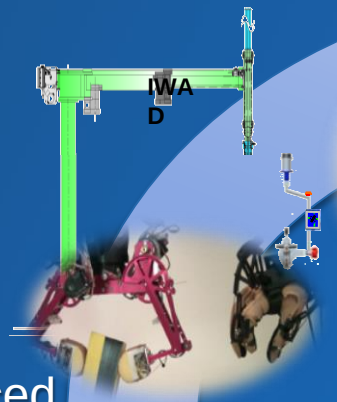
Haptic control



Exoskeleton

Human-robot collaboration

Human-Robot Co-working

Robot-Teaching

Advanced Manipulator

Industrial Manipulator

- **Safety & Productivity**
- **Direct physical interaction**
- **Human workload reduction**
- **Natural human-robot interface**

Project goals

EU FP7 Project RoboMate
Intelligent Exoskeleton for industrial Application

The aim
- Development of a user-friendly, intelligent and cooperative light weight wearable human-robotic exoskeleton for manual handling work support.

Application
- Manual production processes in industrial environments

Source: Robo-Mate Consortium

Consortium
12 partners form 7 countries

www.robo-mate.eu

Project Reference:
EU FP7 60897

RoboMate System and Applications

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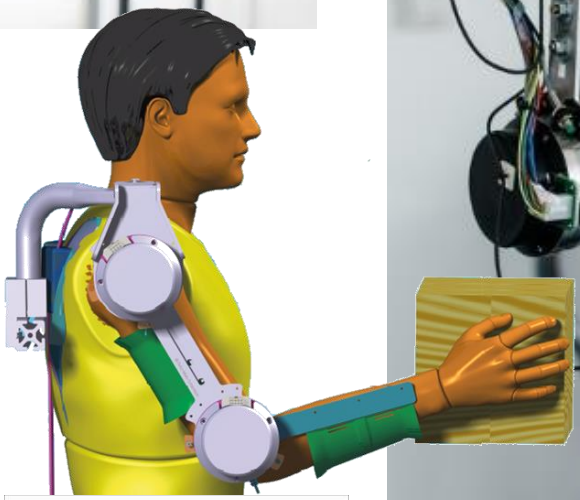
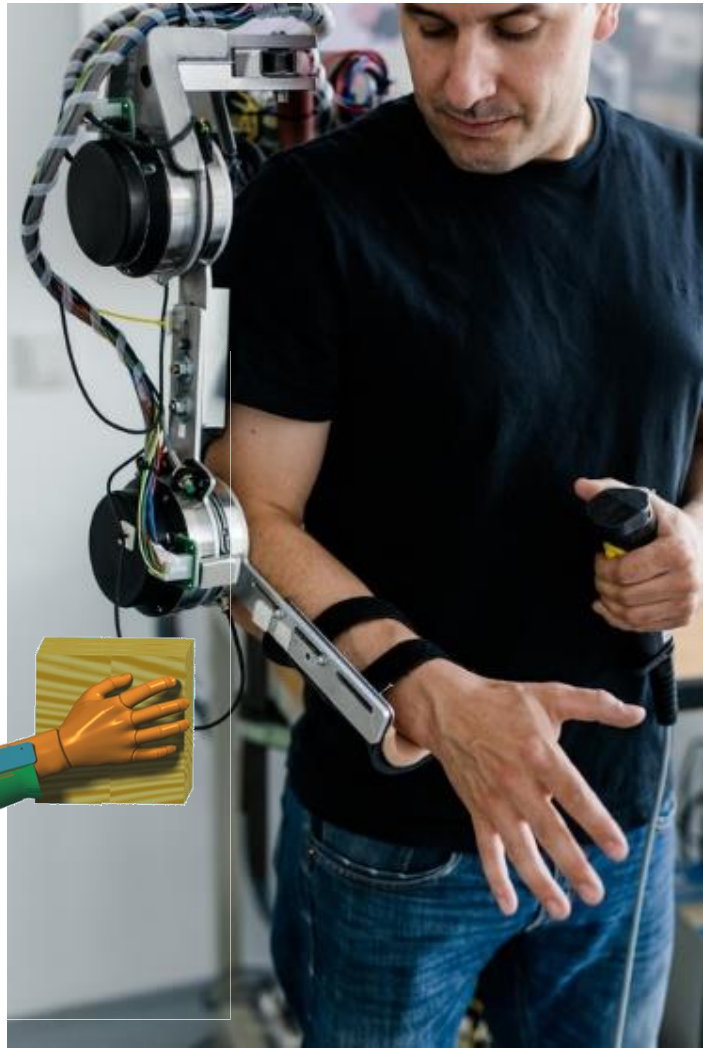
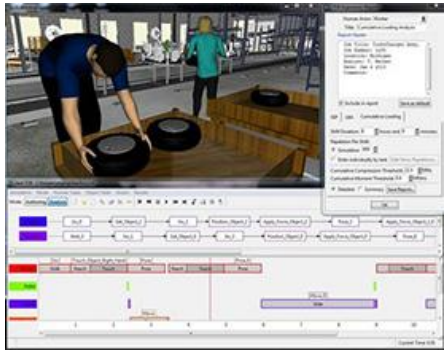




RoboMate

RoboMate's digital factory integration

RoboMate's digital twin is already part of the human and ergonomics simulation environment "JACK" from Siemens



Factory and work conditions

AnyBody
Biomechanical simulation of the impact of loads

CORRELATION
Match the AnyBody results with the digital factory model

JACK (SIEMENS)
Digital factory environment

Feasibilty and benefit analysis

RoboMate

RoboMate and Industry 4.0

- RoboMate implements a highly flexible production system for Industry 4.0 applications
- RoboMate is fully integrated into the factory communication system
- RoboMate distributes adaptivity, autonomy and context sensitive cognitive controlled behaviour between human and machine

Chances and Challenges

Mechatronics Driver for Industry 4.0

Mechatronic systems drive future I 4.0 developments

- Mechatronics will increase flexibility and allow for the economic production of small lot sizes.
- Robots, smart machines, and smart products that communicate with one another will provide this flexibility.
- Manufacturing processes will be enhanced through learning and self-optimizing by smart Mechatronic components that will add decision making on machine level.
- Cyber Physical Systems as future implementation of Mechatronic systems will enable fully integrated data and product flow within enterprises and will also drive horizontal integration between companies, suppliers and customers

Conclusion: Chances and Challenges

Industry 4.0

- Gains it strength by combining horizontal integration all over the value chain and vertical integration in interconnected production facilities
- Changes future work as human and objects will decide together
- Will be an enormous driver for competition and has huge economic potential
- Industry 4.0 is a concept, not something you can buy, so companies have to build up their technological base and implement their own specific business models
- International standards are missing at present
- University teaching on Industry 4.0 objectives has to be largely implemented with specific emphasis on cyber physical systems, IT-related skills and managing innovative business models

Thank you very much!

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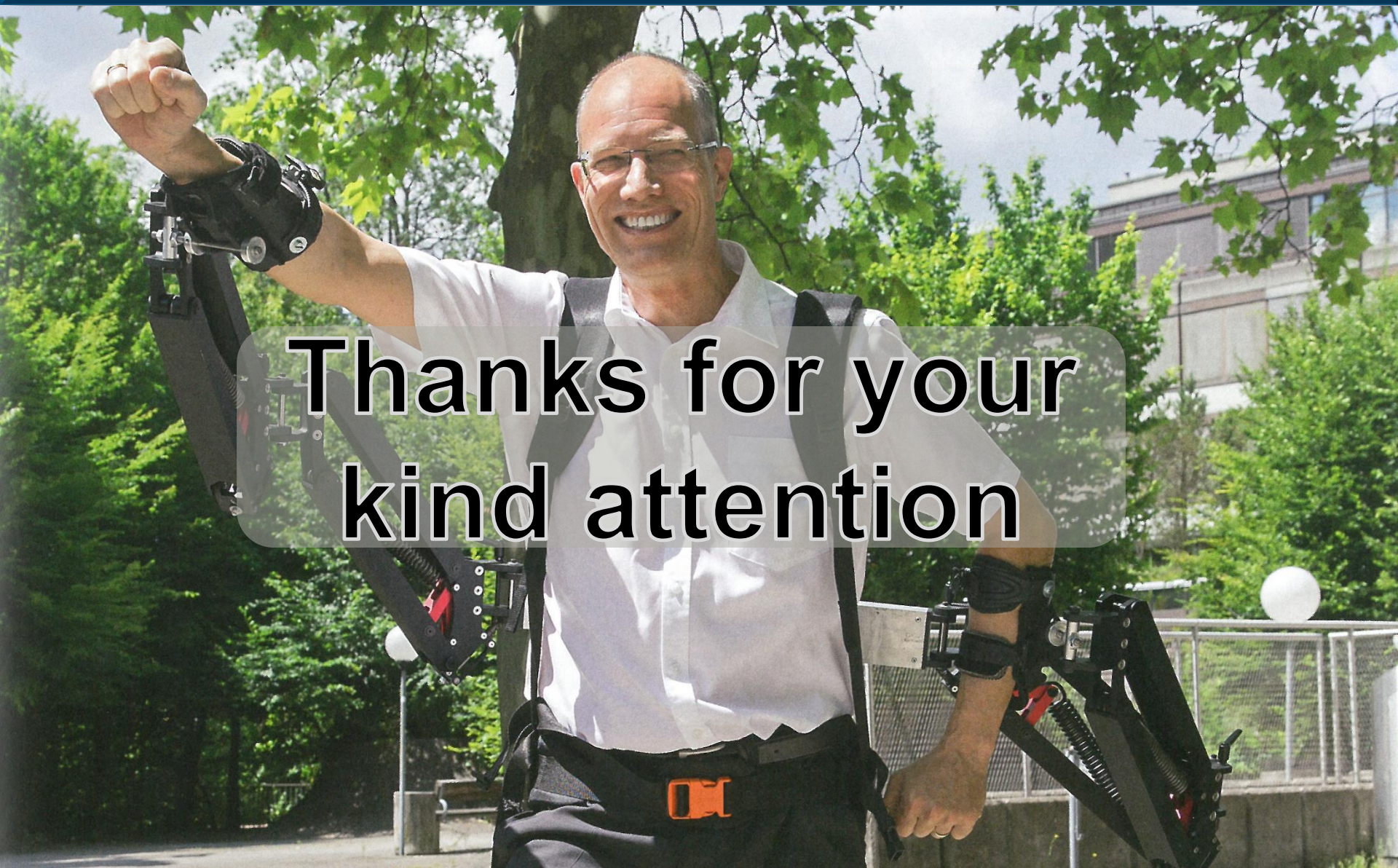

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ims Institute of Mechatronic Systems
We Apply Science

Institute of Mechatronic Systems
ZHAW Zurich University of Applied Sciences

Prof. Dr.-Ing. Hans Wernher van de Venn
Director Institute of Mechatronic Systems
Technikumstrasse 5
Postfach 805
CH-8401 Winterthur / Switzerland

Email: wernher.vandevenn@zhaw.ch
Phone +41 (0)58 934 77 89
Fax +41 (0)58 935 77 89
Website: www.ims.zhaw.ch

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