Industrie 4.0

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Outline

- Industrie 4.0 – Digitalization of Manufacturing Industry
- Industrie 4.0 Platform
- New Ecosystems for the digitized Manufacturing Industry
- How will this change manufacturing structures?
- Industrie 4.0 – Examples of Research and Development Activities
Foundation of digitalization of the manufacturing industry

Industrial Internet of Things - IoT enters the manufacturing domain

- 3 billion people used the internet in July 2014
- 3.8 billion things are connected via internet in 2014 (in 2020 it is estimated that 25 billion things are connected)
- The amount of services is countless, e.g. 1.3 million apps at the Apple Store have been downloaded more than 75 billion times (as of 2014)
- Major change in innovation process: ICT and the consumer market is more and more driving the development of manufacturing technology

source of picture: emc.com
Change of product architecture
The ability to manage complexity effectively becomes a key competitive advantage

- Minimum complexity, maximum personalization, and economies of scale at the same time
- Customer is part of the personalization process and pays for it
- Innovation focus: eco-system, user-friendliness, design

Digitization of Business Models

Everything goes smart and changes industrial branches

CPS: Cyber Physical System
RFID: Radio Frequency Identification

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XaaS drives new business principles
Value of Ecosystems is driven by economies of scale and economies of communication

**Success factors**

- **VaaS**
  - availability (access, use)
  - performance (service quality)
  - partner integration (e.g. prosumer)

- **MaaS**
  - Logic of modularization (SOA, SDK, MDK)
  - Logic of complementation (lotsize one, Additive Manuf.)

- **PaaS**
  - number and quality of users (flexibility)
  - reliability (safety)

- **IaaS**
  - Economies of scale

**Competitive structure**

- Innovation-intensive competition (open market)
- Capital intensive competition (Oligopol)

**Vision**

Democratization of markets through federative communities
Assessment of the Industrie 4.0 Readiness

Germany as Frontrunner has the best position in Europe

source: Roland Berger, Strategy Consultants, March 2014
²Adjusted for outliers Cyprus, Latvia, Luxemburg, Romania, Greece
Potential economic benefits by Industry 4.0
Possible increase in Gross Value Added from 15 % to 30 % by 2025*

- Bitkom/FhG IAO expects additional annual growth of 1.7% by 2025
- John Chambers, CEO Cisco: “… 2% of additional annual growth for the Germany economy…”**
- German businesses are planning to invest €40 billion over the next 5 years***

<table>
<thead>
<tr>
<th>Wirtschaftsbereiche</th>
<th>Bruttowertschöpfung [Mrd. €]</th>
<th>Potenzial durch Industrie 4.0</th>
<th>Jährliche Steigerung</th>
<th>Steigerung [Mrd. €]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2025*</td>
<td>2013-25</td>
<td>2013-25</td>
</tr>
<tr>
<td>Chemische Industrie</td>
<td>40,08</td>
<td>52,10</td>
<td>+30%</td>
<td>2,21%</td>
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<tr>
<td>Kraftwagen- und Kraftwagenteile</td>
<td>74,00</td>
<td>88,80</td>
<td>+20%</td>
<td>1,53%</td>
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<tr>
<td>Maschinen- und Anlagenbau</td>
<td>76,79</td>
<td>99,83</td>
<td>+30%</td>
<td>2,21%</td>
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<tr>
<td>Elektrische Ausrüstung</td>
<td>40,27</td>
<td>52,35</td>
<td>+30%</td>
<td>2,21%</td>
</tr>
<tr>
<td>Land- und Forstwirtschaft</td>
<td>18,55</td>
<td>21,33</td>
<td>+15%</td>
<td>1,17%</td>
</tr>
<tr>
<td>Informations- und Kommunikationstechnik</td>
<td>93,65</td>
<td>107,70</td>
<td>+15%</td>
<td>1,17%</td>
</tr>
</tbody>
</table>

| Potenzial der 6 ausgewählten Branchen | 343,34 | 422,11 | +23% | 1,74% | 78,77 |
| Beispielhafte Hochrechnung für die Gesamtbruttowertschöpfung in Deutschland | 2,326,61 | 2,593,06** | +11,5%** | 1,27%** | 267,45** |

* Bei den Hochrechnungen für 2025 wurde kein Wirtschaftswachstum berücksichtigt. Es handelt sich um eine reine Relativbetrachtung mit und ohne die Industrie 4.0-Potenziale für die sechs ausgewählten Branchen.
** Gesamtsumme enthält die Industrie 4.0-Potenziale für die sechs ausgewählten Branchen sowie die Hochrechnung der restlichen Branchen unter der Annahme, dass für diese ein Potenzial in Höhe von 50% des für die ausgewählten Branchen gilt.

sources: * Bitkom/IAO 2014, ** Sueddeutsche.de, *** PwC Studie 2014, wiwo.de

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Germany’s approach to digitalize the manufacturing industry
“Plattform Industrie 4.0”

Chair
Ministers Gabriel, Wanka

Representatives from business, trade union, academia
Political integration

Steering Committee (business)
- Led by businesses, with the participation of BMWi, BMBF
- Chairs of working groups and other guests/ambassadors

Development of industrial strategy, technical coordination, decision-making and implementation

Strategy Committee (Politics, industry associations, trade union, academia)
- Chair: Secretary of State Machnig, Secretary of State Schütte
- Representatives of the Steering Committee
- Representatives of the Federal Chancellery, BMI
- Representatives of the Federal States Working Group
- Representatives of the industry associations (VDMA, ZVEI, BITCOM, BDI, VDA, BDEW)
- Representatives of the trade union (IG Metall)
- Representatives of the academia (FhG)

Agenda-Setting, political steering, multipliers

Working Groups
- Reference Architectures, Norms and Standardisation
- Research and Innovation
- Security of Interconnected Systems
- Legal Framework
- Employment, Apprenticeships and Life-Long Learning
- Others, as needed

Working bodies with technical and practical competences; departments involved: BMWi, BMBF, BMI, BMJV, BMAS

Project office as service provider
Coordination of the network, organisation, project management, internal and external communication

Academic Advisory Board

Industrial consortia and initiatives
Market implementation: Testing, Use Cases

International standardisation
Standardisation bodies (DKE and others), consortia

Participation in the working groups is open for all interested and qualified representatives

source: Plattform Industrie 4.0
Industrie 4.0 – Definition

Industrie 4.0 is based on the integration of „Cyber-Physical-Systems“ (CPS) in production and logistics as well as the application of internet of things and services in industrial processes. This includes the resulting consequences for the adding value, the business models and the subsequent services and organizational structures.

Industrie 4.0 concepts and solutions will be applied to 5 main areas:

- **Horizontal integration** along the value chain
- Consistent integration of the digital engineering throughout the whole value chain
- **Vertical integration** and cross-linked production systems
- New social infrastructures of work
- Technology of Cyber-Physical Systems (IoT) for manufacturing

Source: Abschlussbericht Industrie 4.0, 8. April 2013
Results of former AG2 / ZVEI SG2
Reference Architecture Model Industrie 4.0 - RAMI 4.0

RAMI is based on the Smart Grid Architecture Model (SGAM) and adjusted to I4.0 requirements

- Vertical dimension: Implementation view for large information and communication systems
- Horizontal dimension: Live cycle / process view of the different objects (product & production) involved
- 3rd dimension: Hierarchical structure of overall manufacturing systems, incl. product, enterprise, and connected world

source: Plattform Industrie 4.0

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Results of former AG2 / ZVEI SG2
Industrie 4.0-Component Definition

Most objects in the manufacturing environment can become an Industrie 4.0 Component

- To do so, each component has to be clearly identifiable
- Each Industrie 4.0 component has an Administration Shell containing Meta Data about the component

An Industrie 4.0 component does not necessarily have a RJ 45 plug!

source: Plattform Industrie 4.0
Results of former AG2 / ZVEI SG2
Industrie 4.0-Component Management along the live cycle

Life cycle of the factory

Engineering Phases and Tools at Factory

IT- Infrastructure at Factory

Component of different vendors, system integrator

source: Plattform Industrie 4.0

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From factory to Eco-system
Platform based integration of front- and back end

Back End
Focus: Adding Value
(e.g. Industrie 4.0)

Front End
Focus: Value Creation
(e.g. Internet of things)

Value adding system
Production network
Factory
X
Prosumer
Platforms for Digitalization
From product to solution and from vendor to community

Product focus
Example: Car

Service focus
Ex: Autonomous driving

Solution focus
Ex: Mobility services

Degree of integration

Vendor-driven
Customer-driven
Community-driven

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Platforms for Digitalization
The winner takes it all?

Product focus
Example: Car

Service focus
Ex: Autonomous driving

Solution focus
Ex: Mobility services

Vendor A
Vendor B
Vendor C
Vendor D

Vendor
Vendor
Vendor
Vendor

Vendor
Vendor

Vendor
Vendor

Vendor
Vendor

Degree of integration
Interoperability

Vendor-driven
Customer-driven
Oligopoly-driven

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Why open Platforms for Digitalization

Shortcomings and risks of

- Vendor driven platforms
  - Vendor lock-in
  - Limited functionality
- Customer driven platforms
  - Loss of synergies
  - Loss of economics of scale
- Oligopoly-driven platforms
  - Strong dependence on platform operators
  - business model and technology

→ Platforms driven by active communities
  - Open access to platform possible
  - Open interfaces which support integration of other systems and migration
  - Transparent policies and privacy measures establish trust
Industrie 4.0 Service Platform – Virtual Fort Knox

Overview

- Secure federative platform for service-orientated applications in the domain of manufacturing-IT services for production companies
- The initial development founded by the state of Baden-Württemberg
- Strong involvement of SMEs from IT and manufacturing industry during the development
New way of cooperation in the Manufacturing Industry
Open, federative, and highly agile solutions provided by platforms

**Services**

**Provisioning of Services**
- Integration
- Interoperability between services
- Security concept
- Data privacy
- Business continuity

**Commercial**
- Contract management
- Service accounting and invoicing
- Service level agreements

**Future Development**
- Integration of standards and protocols
- New business models
- Community

**End User**
- Professional IT solutions for the factory
- Pay-per-Use
- Enables federative usage of data
- Protection of CAD, production and process data as well as knowledge
- Easy service implementation

**Equipment Manufacturer**
- Offering of completely new kind of services as well as accompanying services for products
- Improvements of service level, e.g. via preventive maintenance
- Usage of data for equipment or process improvements

**Software Vendor**
- Additional marketing channel
- Access to new customer groups and cross selling
- Lower risk due to close integration of customer during development
- Use of existing IT resources

**Virtual Fort Knox**
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ARENA2036 – Stuttgart Research Campus
Active Research Environment for the Next Generation of Automobiles

- PPP
- 15 years
- Research factory as integration platform
ARENA2036
Freely Accessable Process Modules for (Automotive)Production of the Future

Today

Challenge
- Decomposing traditional processing line without the disadvantages of classical workshops
- Changeability creates additional complexity
Objects in a Factory will become smart and very agile

Example: swarm intelligence for logistics

source: Fraunhofer IML, Prof. Dr. Michael ten Hompel
Software service as a skill (machine focus)
Bin-picking as cloud service

Advantage
- Externalization of skills, services, maintenance
- Lean robot workcell ("Lean Client")
- Centralized collection of data
  - Optimization by statistical learning
  - Optimization by big data
- Always latest version accessible

Diagram:
- Planner
- Operator
- Work piece
- CAD-model
- Service Bus
- Portal
  - System planning
  - Part teaching
- Bin-Picking App
  - Object localization
  - Task/Path planning
- Object Features
- Motion Data
- Actors
- Skills, Services
- Part models
- Sensor
- CAD-model

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All Entities of a Factory will have a Digital Shadow
Motion Capturing for feed-back of real processes into planning models
Outline

- Industrie 4.0 – Digitalization of Manufacturing Industry
- Why will there be a 4th Industrial Revolution?
- How will this change Information and Communication Technology for manufacturing?
- How will this change manufacturing structures?
- Industrie 4.0 – Research and Development Activities
Current research projects in the context of Industrie 4.0

- Actually the first 5 demonstration centers are being implemented incl. central coordination and evaluation
- Several 100 already implemented Industrie-4.0 use cases are identified, classified, and documented throughout the whole German industry

Foreseen budget for national research projects in the context of Industry 4.0: more than € 200 Mio. leading to more than 50 founded R&D Projects

Additional budgets for EC-internal and state research projects in the context of Industry 4.0 such as Horizon 2020,...
Plattform Industrie 4.0 – Scientific Advisory Board
The Industrie 4.0 R&D -Roadmap

Horizontal Integration along the value chain
- Framework for value chains
- Automation of value chains
- Integration of real & virtual world
- System Engineering

Consistent integration of the digital engineering
- Sensor data analysis and data-based process control
- Smart –Flexibility – Agility

Vertical integration
- multi-modal support systems
- Work place design

New social infrastructures at work
- MEMS and ICT
- WiFi
- Security and Safety

Core Technologies
- CPS – Plattforms and service-oriented Architectures

Migration Strategy
- 2015
- 2018
- 2025
- 2035

Expected funding by German government until 2020: more than €1 Billion
„It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change.“

Charles Darwin, 1809-1882
Thank you very much!