Industry 4.0:
Exemplars of best practice in Germany
Meeting the needs of Industry 4.0
Limerick, March 31st, 2016

Agenda

- Industrie 4.0 background
- relevant organizations
- industrial implementation
- best practice examples
- conclusion
Timeline of „Industrie 4.0“

- 2010: idea created by a working team inside a research project, funded by the German Federal Ministry for Research
- 2011: idea presented to the public on the Hannover Industry Fair
- 2012: promotor group (chair Robert Bosch GmbH and acatech – German National Academy for Science and Engineering) presented recommendations for industry 4.0 implementation. Supported by ABB, Bosch, Detusche Telekom, Festo, Harting, HP, IBM, Infineon, Lenze, MAN, Pepperl+Fuchs, Phoenix Contact, SAP, Siemens, T-Systems, Volkswagen, …
- since 2013: continuous work within “Plattform Industry 4.0”, a joint initiative between
  - Bitkom (Germany’s digital association)
  - VDMA (German engineering federation for capital goods)
  - ZVEI (German Electrical and Electronic Manufacturers' Association)
- dialogue with unions, other industrial associations, companies, science and politics
Basic concept of Industrie 4.0: the fourth industrial revolution

- cyber-physical systems and internet-of-things applied to the industrial context
- smart factory, including smart operations and smart workers
- smart products, including data-driven services
- digital integration of process chains, including mass customization
Relevant organisations: Plattform Industrie 4.0

- "Plattform Industry 4.0" now headed by German Federal Ministry for Research and German Federal Ministry for Economic Affairs
- goal: recommendations for industry and politics; standardization
- five working groups of representatives from business, science, associations, trade unions and federal ministries
  - Working group 1: Reference architectures, standards and norms
  - Working group 2: Research and innovation
  - Working group 3: Security of networked systems
  - Working group 4: Legal framework
  - Working group 5: Work, education and training
 Relevant organisations: Allianz Industrie 4.0 Baden-Württemberg

- Baden-Württemberg is (together with Bavaria) the strongest country in Germany in terms of economics
- home to companies like SAP, Daimer, Bosch, Porsche, Kärcher, Stihl, Trumpf, Index, Chiron, Würth, Zeiss, …
- main industries: automotive, machining, IT
- self-understanding as the world’s supplier for factory equipment
- idea of the I4.0 alliance: bring together local partners, primarily networks and association (-> multipliers)
- foster technology transfer, enabling to learn one from each other
- alliance as central platform for events, practical demos/realizations, competence map, match making, …

http://www.i40-bw.de/
Relevant organisations: Cross Cluster Industrie 4.0

- joint initiative between
  - bwcon: network for ICT in Baden-Württemberg, main applications in mobility and manufacturing
  - microTEC Südwest: network for sensors and smart systems
  - Virtual Dimension Center: network for virtual engineering, VR

- idea: cooperate in the I4.0 field, especially in integrated engineering process chains, smart sensors/systems and cloud solutions

- common initiatives, common events, match making between members of these 3 networks

- [www.x-cluster-i40.de](http://www.x-cluster-i40.de)
Industrial implementation

- awareness is there – everywhere
- we are not at industry 3.0 – we are at 3.6 / 7 / 8?
- the point is not to think about green field industry 4.0 factories – we have to upgrade, to refit, to convert existing facilities
- big technology leaders and smart SMEs, especially technology providers and suppliers started activities
- the majority of the SMEs remains awaiting what’s coming
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Expected main benefits of Industrie 4.0

- improved planning and control (e.g. in manufacturing, logistics)
- increased customer satisfaction
- more flexibility in manufacturing
- faster time-to-market (in product design)
- quality improvements
- individualized products
- new business models

Companies’ expectations

- Improved planning and control (e.g. in manufacturing, logistics): 80% huge, 15% medium, 5% low
- Increased customer satisfaction: 67% huge, 27% medium, 6% low
- More flexibility in manufacturing: 62% huge, 27% medium, 11% low
- Faster time-to-market (in product design): 54% huge, 32% medium, 14% low
- Quality improvements: 49% huge, 35% medium, 16% low
- Individualized products: 46% huge, 34% medium, 20% low
- New business models: 46% huge, 34% medium, 20% low

Note: The numbers in parentheses indicate the level of importance (4.5 for huge, 3 for medium, 1.2 for low).
Barriers for Industrie 4.0 implementation

- economic barriers
  - equipment expensive
  - ROI too far away
  - missing operator models
  - no need to change
  - more potentials in Industrie 3.0
- processes
  - missing will to integrate
  - missing resources
- acceptance
  - data safety
  - consultants not welcome
  - missing support from management
  - open questions on data property
- technological limits
  - networks (capacity, real-time ability)
  - availability of I4.0 upgrade equipment, sensors
  - low maintainability
- legal barriers
  - labor law
  - role of unions
- knowledge
  - I4.0 concept too huge
  - missing knowhow measurement engineering, sensor fusion
  - data property
Mittelstand 4.0-Kompetenzzentren

- 11 competence centers for digitalization within SMEs
- 1 competence center for digitalization within crafts enterprises
- founded & financed by German Federal Ministry of Economic Affairs
- distributed over Germany
- located at research institutes and universities
- tasks:
  - inform & consult SMEs
  - publications supporting tech transfer
  - collect and translate good I4.0 examples to be used in SMEs and crafts enterprises
- http://www.mittelstand-digital.de/DE/Foerderinitiativen/Mittelstand-4-0/kompetenzzentren.html
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Mittelstand 4.0-Agenturen

- 4 agencies focusing on certain aspects of digitalization
  - cloud computing solutions (Stuttgart)
  - process and resource management (Dortmund)
  - communication, knowledge management, eLearning, innovation management (Berlin)
  - trade, e-billing, virtual enterprises (Cologne)
- founded & financed by German Federal Ministry of Economic Affairs
- located at research institutes and universities
- tasks:
  - [equivalent to competence centers]
- [link to website]

I4.0 readiness online self assessment

- established by VDMA and Aachen university
- idea: find out own ability and preconditions to make use of I4.0
- analysis of 6 main I4.0 dimensions
  - strategy and organization
  - smart factory
  - smart operations
  - smart product
  - data-driven services
  - staff
- time: 15-30 minutes
- https://www.industrie40-readiness.de
I4.0 discussion guideline

- established by VDI/VDE Technik and VDC
- actually testing guideline prototype
- idea: find first feasible steps for entering into I4.0
- pose questions in a 12-fields matrix

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<th>Logistics</th>
<th>Development</th>
<th>Manufacturing</th>
<th>ICT</th>
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<td>company (internal processes)</td>
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- get into details in 1 or 2 field of that matrix
- identify discreet fields of possible activities
Plattform Industrie 4.0

map “Landkarte Industrie 4.0”
- shows where industry-ready solutions in practical use can be seen
Allianz Industrie 4.0 Baden-Württemberg

- 100 locations for I4.0 in Baden-Württemberg
- short descriptions about I4.0 in practical application (challenge, method/technology, outcome)
- contact details of responsible persons in companies (-> arrange visit)

http://www.i40-bw.de/100_places/__100-Orte.html
Example: assembly line design

- **challenge:** highly individualized products (40,000 variants) with connected manufacturing and logistics processes, material and production planning

**solution:**
- generation of QR code and RFID, latter at workpiece holder
- RFID code is read at each assembly station: detailed manufacturing information if provided to the workers at screen, coming from a digital data base
- end of assembly line: booking of product via QR code (finished assembly)
Example: predictive maintenance of injection molding machines

- challenge: injection molding machines are subject to deterioration
- documentation only available – if ever – as manual paper work

solution:
- each production cycle is documented via RFID directly at the tool
- this autarkical system counts all cycles, processes relevant information and supplies it either to a signal lamp (shop floor) or to a web browser
- via web services this information is furthermore forwarded to high level manufacturing control systems
Example: intelligent container iBin

- challenge: detection of stock of C-parts (screws, nuts, washers, …)

solution:

- an intelligent bin, that detects its own content using a camera
- initialization: first photo showing 100% filling degree
- then: calculation of filling degree by regular photos
- communication of filling degree via safe radio transmission
- trigger new order
Examples: driver-less transport systems

- **challenge:** flexible production lines, changing lot sizes, individual assembly amounts per car
- **solution:**
  - autonomous transport systems (ATS)
  - driving order for ATS per WiFi
  - integrated sensors (also RFID) for navigation
  - energy supply for ATS via boostcap technology (charging stations in the shop floor)
Example: individual plastics series products

- challenge: automized, flexible manufacturing at lot size 1 keeping efficiency of mass production

solution:

- combination of injection molding and additive manufacturing
- data matrix code on each product: product becomes data carrier
- product controls its own way through “3 factories”: injection molding, individualizing (3D print) and quality check
- central MES for order entry, injection molding, additive manufacturing, quality check, packaging
- all process and quality data in a cloud archive
Example: digital shift planning

- challenge: short term reaction on extra demands regarding staff
- solution: a “shift doodle”
  - the shift planner sends out requests for extra work via a smart phone app (when, capacity demand, qualifications)
  - all relevant employees are notified via their smart phones; they can decide to join the respective shift
  - if no smart phone available: terminal at the shop floor
Example: digital translator

- challenge: fast reconfiguration of production processes due to new products

solution: “industrial USB”, Plug and Work
- machine-to-machine communication
- new components of a production line can communicate their skills and their configuration framing to the control software
- control software integrates this information automatically, creating a new production process
- no programming of additional interfaces and drivers
- use of open standards like CAEX (Computer Aided Engineering Exchange) and AutomationML™
Example: smart worker - augmented automation

- challenge: ease complex processes
- solution: smart worker
- data glasses, communication electronics, web based server portal
- data glasses: display, camera, microphone, loudspeaker
- remote collaboration between shop floor worker and specialist at desk
- send data sheets, circuit diagrams, maintenance instructions, …
- record own work (e.g. maintenance) for documentation
- access to machine control
Example: smart worker – industrial data glove

- **challenge**: save time of bar code scanning (car: ~ 1,000 bar codes in assembly)
- increase process quality
- **solution**
  - smart gloves, integrating bar code scanning unit, any sensors (e.g. for temperature, layer thickness measurement, voltage, …)
  - smart watch to supply worker with information, e.g. feedback from scanning or orders
  - sensors to create motion profiles (to detect inefficient work place design, un-ergonomic activities)
Recent developments

- trend: cloud platforms by tooling machine manufacturers
  - many special purpose machinery manufacturers and automation suppliers now develop their own cloud solutions
  - idea: storage of machine & process data (equivalent to jet engine manufacturers)
  - problem 1: process data could be core knowhow of client company
  - problem 2: a manufacturing company uses e.g. 5 tooling machines from 4 suppliers with 3 different cloud solutions: how to integrate?

- cooperation agreement between Platform I4.0 with Industrial Ethernet Consortium (2.3.2016)
  - strong point of discussion: Reference Architecture Model Industrie 4.0 (RAMI 4.0) vs. Industrial Internet Reference Architecture (IIRA)
Conclusion

- Industrie 4.0 is a mega trend
- I4.0 is a good integration initiative to bring together our industries, especially manufacturing and ICT
- A good initiative to address SMEs (due to German wording)
- Transfer to the masses difficult: big expectations have been created, some SMEs expected solutions earlier, now disappointed
- Some SMEs are scared of the big vision of I4.0
- Some critics say, too much paper has been produced and not enough practical realizations, whereas standardization has started in the USA
- There is a lot of public support in recommendations and consultancies – however, many need to be convinced by the market rather than by public authorities – hopefully that will be still in good time.
Thank you very much for your attention