Country Profile USA

Stand: 17. Dezember 2015

Präambel:

Wir schreiben im Folgenden in der maskulinen Form, und zwar ausschließlich wegen der einfacheren Lesbarkeit: Wenn beispielsweise von Mitarbeitern die Rede ist, meinen wir selbstredend auch Mitarbeiterinnen.

Empfohlene Zitierweise:

GAUSEMEIER, J.; KLOCKE, F.: Industrie 4.0 – Internationaler Benchmark, Zukunftsoption und Handlungsempfehlungen für die Produktionsforschung. Paderborn, Aachen, 2016

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Summary

Customer value is key. **Industrie 4.0** will mostly see its **use** in those **applications** where it **can add to end customer experience** through **quality**, **individuality** or **service** rather than where it can simply save costs, since production off-shore is cheaper. **Solutions** will mostly be applied **targeted to specific business levers** rather than ensuring the use of consistent production concepts. U.S. **suppliers** will mostly **offer Industrie 4.0 solutions** where there is **potential to fundamentally change production paradigms**. **Market gaps** can be expected where **individual performance increases are possible** through the use of advanced technology **requiring large amounts of production domain knowledge**, but where **fundamental business model shifts are unlikely**.

Highlights

Business Model

Customer-focused business innovation trumps technology innovation. New technologies, ➨*business models* and products are piloted in start-ups and rapidly brought to market.

Standards, Migration and Interoperability

A pragmatic approach to standards (“done is better than perfect”) allows for quicker collaboration between different interdisciplinary actors. Competing standards are accepted and an emphasis is placed on ➨*interoperability* between standards.

User friendliness

Simplicity and pragmatics are key for Human-Machine Interaction: Focus is on single-purpose, simple, value-generating applications providing optimal user experience.

Map

Industrie 4.0 in the USA

Drivers/ Challenges

Drivers

- The **innovation system permits experimenting** with expensive innovations, with large funding for scale-up on success
- **Re-industrialization strategy** adopted by President Obama administration focuses on developing and applying advanced manufacturing technologies
- Large **innovation efforts on B2C applications for Internet of Things**, driven by high ICT competence, spill down to the B2B sector

Challenges

- **Low public perception of production** hinders talent acquisition
- **Investments are focused on specific productivity improvements** rather than on upgrading production systems as a whole
- **Technology transfer** from universities to companies outside of disruptive start-ups is **weak**, especially for production technology

Key Stakeholder

- **Industrial Internet Consortium (IIC)**
- **Smart Manufacturing Leadership Coalition (SMLC)**
- **Nationwide Network of Manufacturing Innovation (NNMI)**: Digital Manufacturing Design and Innovation Institute (DMDII)
- **National Institute of Standards and Technology (NIST)** – Standardization agency tasked with coordinating the NNMIs
- **President's Council of Advisors on Science and Technology** – Presidential advisory body releasing strategy recommendations for using advanced manufacturing in the U.S.
- **General Electric (GE), Cisco Systems –** Co-initiators of the Industrial Internet Consortium
- **Rockwell Automation –** Initiator of the Smart Manufacturing Leadership Coalition
- **U.S. Department of Energy, U.S. Department of Defense –** Government departments responsible for funding NNMI Institutes

Key Approaches

The Industrial Internet
GE- and IIC-driven approach for bringing Digitalization to Industry in general, focused on the product lifecycle.

Smart Manufacturing
Production process-oriented view on Industrie 4.0 used and promoted by the SMLC.

Internet of Things (IoT)
Product-centered view on using Internet technology for improving physical products.

Digital Manufacturing
Integrating product design, engineering and production processes using simulation and virtualization.

Technology (1/2)

Overview

On a national basis, the U.S. has a **high degree of technological know-how**, including in **ICT**, **production technology** and **automation**. Production technology **know-how** is **kept on-shore** despite off-shore production through the **demands of the military and government**, which requires very high-end produced goods made in the U.S. **Concepts related to Industrie 4.0** in the U.S. **derive from larger-scope digitalization** concepts such as ▸***Internet of Things*** and ➨***Cyber-Physical System*** concepts, developed for other applications such as **Smart Cities**, **Smart Grid** or **consumer applications** such as home automation. Nevertheless, ▸*Smart manufacturing*, ▸*Digital manufacturing* and the ▸*Industrial Internet* have caught on and the respective **consortia are strongly growing with industry partners**. **Advanced manufacturing** research has been **prioritized by President Obama** and the ▸*Nationwide Network for Manufacturing Innovation* has been created as a network of **public-private-partnership research** institutes, with a **high-level staffed** Advanced Manufacturing Partnership 2.0 as **steering board**.

Security

Industrial ➨*security* is a **key concern for the U.S. government**. ▸*NIST* has been **tasked with developing standards and frameworks** for cyber security for the ▸*Internet of Things* in general, and ▸*Smart manufacturing* in specific. U.S. **companies** demand security **foremost from government.** As reputation-damaging break-ins occur more frequently, companies are **starting to consider security a key business factor**. Corporate risk managers start to demand risk assessments of cyber security threats. Nevertheless, security is still **not a strong decision factor** when buying equipment. Companies are reluctant to connect machinery to the internet for connection to their supply chain or machine vendors to prevent IP theft, but are willing to do so for supporting processes not contributing to own IP. The ▸*IIC* as a private-sector-led organization is dealing with developing **consistent views on security requirements** for approaches for the ▸*Industrial Internet*. Companies **producing for the military or federal government** are furthermore **subject to strong cyber security requirements** as a condition of their supply contracts.

Standards, Migration and Interoperability

Standard-setting in IT-related fields is seen as a **natural process of consolidation** of initially competing standards. **Government-funded institutes** such as ▸*NIST* develop **metrics and KPIs** to measure aspects which can then be standardized by industry or defined in individual contracts. The ▸*Industrial Internet Consortium* and the ▸*Smart Manufacturing Leadership Coalition* form **private-sector-led collaboration fora** for joint development of testbeds leading to an eventual adoption of emerging best practices as standards. As long as conversion or adaption is possible, multiple **competing standards** for e.g. architectures or protocols are **not seen as an issue.** ➨***Interoperability* between major standards is demanded** for system integration solutions. Large buyers start to **impose requirements on open standards** for machinery and control systems to enable interoperability between heterogeneous systems. Government projects often require the use of open standards. Migration of and **interoperability with existing systems are demanded** for specific applications where economic benefits are clearly measurable. **Heterogeneousness** of systems and operating **systems with vastly different maturity levels side-by-side is not seen as problematic**.

Sustainability

Sustainability is a **strong driver for smart manufacturing** from the **government point of view**. The ▸*NNMI* institute for Smart Manufacturing is tendered with the explicit aim to promote **energy efficiency in manufacturing** and is funded by the ▸*Department of Energy*'s Office of Energy Efficiency and Renewable Energy. **Economic benefits of sustainability** in manufacturing (**resource and energy efficiency**) are main drivers for companies to use sustainable concepts. **Costs for toxic waste management** in **process industries** and **semiconductors industry** are one example where efficiency optimization potentials through **smart manufacturing** are **seen as a potential solution**. Economically or politically **hard to acquire materials** such as **rare earth minerals** also drive adoption of sustainability concepts reducing their use and waste. **Regulation** on sustainability is **state-dependent**, but generally **less stringent than in Europe**. California has very stringent sustainability requirements. Some **companies** are driven to **fulfill more stringent standards** when **exporting** to the EU or having **subsidiaries in the EU**.

Technology (2/2)

User friendliness

»**Simple is cool.**« **Simplicity** and **predictability** are seen as key factors for user friendliness. The customer-centered term **User Experience** has replaced the technology-oriented term **User Interface**. Information technology companies in the Silicon Valley use **integrated teams of engineers, product developers and designers** to engineer customer-centric products. When given a choice between simplicity and extra functionality or efficiency, simplicity is prioritized. Systems requiring **extensive operator decisions** are seen as **poorly designed** except when explicitly demanded. **Products** and systems should ideally serve **one well-defined function**, driving away complexity in a similar fashion to how lightweight apps replace complex software systems. **Advanced Human-Machine-Interaction technologies** are **extensively researched** by universities and **commercialized by start-ups**, but focus is on researching optimal **human-oriented interaction** concepts rather than on technological breakthroughs. **Consumer electronics devices** are used in industrial settings as they are **available, cheap and adaptable**, but demand for **rugged** input devices is recognized. **Ergonomic systems** are driven through constant **threat of litigation** rather than regulation.

Collection and Analysis of Field Data

In automated production lines **data is collected extensively**. Generally, a **challenge** is seen **more in the analysis** than in the collection of field data. Additional ➨***sensor* technology** is seen as **only needed in very specialized areas** of production. In areas where quality improvements are needed, companies are **starting to employ data scientists** on their own **to analyze and improve production processes**. Companies offering **general-purpose data analytics** also **exist**, but are generally **not regarded as fulfilling the needs of specific production systems**. **Specialized start-ups** improving specific production settings based on data also **exist**. Nevertheless, **skilled employees** understanding data science as well as having specialized domain knowledge on production are **in short supply**. **Privacy** or worker relations are **not** commonly **seen as challenges** regarding the analysis of field data. **Leveraging shorter innovation cycles** in data technologies for **capital-intensive goods** like lines and machines is seen as an **important challenge** to be overcome by **standards regarding downward compatibility** and **upgradeability** of equipment.

Material and Information Flow

Factories of **all degrees and competence** levels in **automation** exist in the U.S., with SMEs dominating the lower competence end of the spectrum. In unionized states and industries, **automation** is **still viewed negatively**. A **full spectrum of industrial IT** suppliers exists in the U.S. for **all layers** of the ➨*automation pyramid*. Companies have **started to integrate MES, ERP and PLM** solutions, but are **facing challenges** with **real-time** constraints and **heterogeneity of standards and architectures**. **High-end logistics** competences are driven by **online business platforms,** especially **Amazon**, since their ➨*business model* and customer service portfolio necessitates full transparency of material logistics **throughout the supply chain**. **Transparency** throughout the **supply chain** is also seen as **driven by sustainability and higher quality**, but is **not commonly used** yet.

People

Overview

While the U.S. is a **magnet for talent internationally** and has some of the **best universities in the world**, **talent in production engineering is in short supply**. Even **scarcer** are **specialists with skills in both ICT and production engineering**. One main reason for this shortage of talent is the **lack of reputation of production**. **Entrepreneurship is fostered and well-regarded**, and new ways of thinking are welcomed, yet many **manufacturing industries are still very traditional**. The value of highly **trained** and highly **capable operators** is **recognized by experts** in the field of production, **but generally not by corporate management**. **Specialized blue-collar workers** pose a **threat** for losing **knowledge** due to **high worker fluctuation**. **Lack of available skilled workers** on the job market mean **high investment costs**. As a result, **technology around blue-collar jobs is more used to reduce qualification need** rather than empower workers. Nevertheless, **in specialized industries such as Aerospace and Defense the value of skilled operators** is starting to be **recognized** and **training programs are piloted**. In **these industries**, technologies giving greater **flexibility** and **decision-power to operators** are **appreciated**, but **markets are still small.**

Training and Qualification

While **top-class universities** produce extremely skilled talents, **mid-tier education for companies is lacking**. Research in **top-tier universities** is **focused on basic research**, and application focus is not provided in university (except in internships). **Technical expertise** is **only valued** equally to managerial competence **in specific high-tech sectors including ICT, aviation and defense**. **Production** workers are **often not formally skilled,** and **no public system to train workers** exists**. Employees** not only **switch employers often**, but **tend to work in very different fields** of work during their working lives. **Companies** thus see a need for **using technology** such as smart manufacturing **to reduce training-on-the-job times** and reducing the **potential of human error**. **Interdisciplinary education** in production-relevant fields is **not focused in universities**, but it is common for people to return to universities for professional courses. **Employees are expected to learn new skills throughout their working life,** which is well-accepted. **Experience** gathered by **senior employees** is passed on in **mixed teams and training-on-the-job. Older employees** are routinely **kept in business** for reduced shifts and see **sharing their experience as fulfilling.**

Importance of »Production«

Differentiation is sought through the **product or service**, **not** through **production**. **Companies continue to off-shore manufacturing if it is more cost-efficient, despite reindustrialization** efforts by federal and state governments. **Working in production** is **not seen as an aspired career**, not even in managerial positions. **Operational positions** are **not** commonly **on a career track** to top management, rather **finance-oriented positions** commonly **lead to the top**. Cooperation between producing industry and universities happens at local level, but not widely with top-tier universities conducting basic research. **Production is perceived as “oily”** work with many factories still living up to this reputation. **Public calls for re-shoring** of production tend to be driven by **patriotic rather than economic** arguments. **Government initiatives** on **advanced manufacturing innovation** (Advanced Manufacturing Partnership 2.0, ▸*NNMIs*) **intend to change the reputation of production to give it a high-tech image**. However, the effectiveness of these measures is disputed, and **political change jeopardizes continuing** of ▸*NNMI* roll-out.

»Pioneering Spirit«

White-collar workers are expected to show a large degree of initiative and pioneering spirit in the U.S. Workers of all levels are expected to show **continued drive to learn new technologies**, e.g. the share of senior Americans able to use the Internet is very high. Especially in large companies **loyalty to one’s employer is low**, so is loyalty to employees. As a consequence, **companies fret on accumulating key knowledge in employees** for fear of losing the knowledge. Due to **high job fluctuation**, **entrepreneurship is not seen as much more risky** than employed work, and the **social standing of entrepreneurs is high**. **Failure is more acceptable than lack of initiative**. **Failure** in a business is **not** seen as a **mark of shame** but as **experience**. **Interdisciplinarity is valued** and outside opinion is sought.

Organization

Overview

Strong rule-of-law enables trust for cooperation between organizations. **However, anti-trust regulation and corporate culture impede collaboration of competitors** even on **pre-competitive development**. **Associations** are less important compared to Europe, and mostly **focus on shared infrastructures**, **platforms** for developing standards and forming a **voice of the industry** to media and government. **Collaboration** mostly takes place in **more informal networks and ➨*ecosystems*** such as the ones naturally formed in **regional clusters** around major universities. **Companies tend to focus on core competencies** and conglomerates are commonly seen as inefficient by shareholders. **Family-owned SMEs developing** significant **technologies** are comparatively **rare,** and **publicly traded companies** focus on **quarter-to-quarter profits**.

Business Model

Innovation means business. The innovation system in the U.S. is geared towards **implementing incremental improvements via market-pull** mechanisms and **pushing disruptive technologies to market through start-ups**. **Service** or ➨***business model innovation* is seen as equally innovative** as **technological break-throughs**. **Universities** have offices specifically **assisting students with founding start-ups**, and **large companies get access to new technologies by acquiring relevant start-ups**. The **focus of** these **acquisitions** tends to be on **getting the talent** working at the start-ups rather than the previously developed technology. In **smart manufacturing**, the **start-up** ➨***ecosystem* is much smaller** than in classic web development. However, **start-ups in production data analytics exist and are successful**. While **production equipment companies** do **experiment with novel** ➨***business models*** such as leasing machine frames, **production-as-a-service** ➨*business models* have **so far only emerged in consumer-driven additive manufacturing services**.

Corporate Culture and Flexibility

Organizations are flexible and **hierarchies are less relevant for preparing decisions**. **Taken decisions** are **executed very stringently**. **Interdisciplinary working is common**. In high-tech companies, **product-centered organizations** are used as opposed to function-centered organizations. **Technical expertise** is **valued less** than a vision on the **demands of the end customer**. To achieve **high speed of innovation**, companies **grow inorganically** by **acquiring start-ups or forming joint-ventures** when entering new technology fields. **Work modes** are **highly inflexible**, and **flexible working plans** are almost **exclusively used** in areas with a severe shortage of employees **to attract talent**. **Long hours and little vacation** irrespective of demand peaks **are the norm**.

Internationality

U.S. **workforce is highly diverse**, especially in **engineering and science**. Companies are **able to attract international talent**. **Standards** and **innovation** are also **seen globally**. Both ▸*SMLC* and ▸*IIC* are **internationally oriented**, and companies prefer **globally useful solutions**. Large **companies** based in the U.S. **see themselves as global** rather than American, and deploy technology and processes around the world interchangeably, demanding ➨***interoperability* with global standards**. This global view on standards is a recent development driven by a **previous focus** of U.S. companies **on the domestic market**, often using incompatible standards (e.g. the **U.S. measurements system**) and resulting barriers to enter international markets.

Business Environment

Overview

Off-shoring of production has happened to a large extent in recent decades and **government initiatives and public opinion would prefer manufacturing to return** to the U.S. driven **by advanced technology**. The **opportunity to re-build factories from scratch** is seen as an opportunity for **using the latest technology**. In contrast, **upgrading existing machinery is done only in specific spots** where productivity can tangibly be improved. **Capital for developing innovative solutions** is **widely available**, but **capital for investment-intensive enterprises,** including those setting up sophisticated production, **is scarce**. However, off-shoring has led to **large amounts of unused production infrastructure**. This infrastructure is **currently leveraged by start-ups** to cheaply access domestic production capacities, though **with old technology**. **Companies** see themselves as **acting in an international trade network** and operate both **globally in supply chains** and **locally in condensed clusters**, rather than focusing on national supply chains. **Government incentives exist**, but are **small in scope** for the task of re-industrializing the world's largest economy.

Political Will and Restrictions

Business as a whole **prefers politics to stay away** and let companies decides what is best. As a result, **few specific strategic R&D programs exist**. Rather, **corporate research can be credited** towards corporate income **taxes**, without a need to observe national priorities. **State-level** and local-level governments **set various incentives** for industry to settle, leading to a **competition of regional legislations**. This competition includes great **freedom for piloting novel and risky technologies** such as autonomous cars, and **restricting union access to certain states**. On a federal level **reindustrialization is driven by President Obama** through establishment of **advanced manufacturing research institutes (▸*NNMIs*)** loosely modeled after Germany's Fraunhofer Institutes. With **advanced sensing and control** as well as **digital manufacturing**, two core Industrie 4.0 topics are included in the NNMI program. **Effectiveness of the program** to drive a significant reindustrialization of the U.S. is **disputed**. Furthermore, **instability of political programs** especially on federal level **deters companies from making large investments** dependent on the continued existence of grants through the advanced manufacturing programs.

Access to Capital

Large amounts of ➨***venture capital*** exist for developing **risky technologies** and ➨*business models*. Venture capital is seen as a stronger driver for innovation than government grants. **Most venture capital** is used for ➨***business models* relying purely on software**. Venture capital for **investment-intensive** start-ups is still **rare**. **»Picking winners« by the government is disliked,** both in the sense of government subsidies to specific companies and in picking strategic technologies for development. **Strategic programs** are thus **focused** on technologies with relevance to **national security** or concerns such as **sustainability**. Capital is **not seen as a hindrance for consumer-oriented technologies** to move to market readiness. However, **consortia and associations undertaking precompetitive research** in supporting technologies like production and process technologies **are rare**. **Technology transfer** is mostly narrowly focused on IP transfer and is **seen as weak in production technologies**.

Access to Selling and Procurement Markets

Large companies are thoroughly **globalized** and sell globally. **SMEs** largely **focus on the domestic market**. There is comparatively **little support by state export promotion** and associations. The **need to adapt exported goods** and particularly software systems **to local demands is recognized** and accounted for. **Language barriers** are seen as more important. Manufacturing is considered a global business and not all required devices and components can be sourced locally for an efficient price. The **need to import** is **not seen as a challenge**. A **secondary supply market** of a large spectrum of components is **kept domestically** at high prices for **supply of the military**, with little opportunity for export due to **export controls**. **Regional cooperation and clusters** are strong around top-tier universities (e.g. Silicon valley, Massachusetts around MIT). Old **manufacturing centers** (e.g. Michigan) also **re-gain importance** through availability of unused infrastructure and breed new SMEs. **Value chains** are **global as well as regional. Outsourcing** both **production** (e.g. to China) and **development** (e.g. to India) common. Nevertheless, **tapping into regional cluster infrastructures** is also seen as vital and **worth higher costs** for being in such a cluster.