

INDUSTRIE 4.0

Smart Manufacturing
for the Future



Foreword



One of 10 "Future Projects" identified by the German government as part of its High-Tech Strategy 2020 Action Plan, the INDUSTRIE 4.0 project represents a major opportunity for Germany to establish itself as an integrated industry lead market and provider.

At Germany Trade & Invest we have been monitoring developments in the intelligent manufacturing and production sector as part of our ongoing "GERMANY. SMART SOLUTIONS. SMARTER BUSINESS." international marketing campaign. We are delighted to present in this brochure the first fruits of our own INDUSTRIE 4.0 labors as part of our commitment to helping establish Germany as a lead market and provider of INDUSTRIE 4.0 solutions and services. We would like to extend a heartfelt thank-you to our science and industry partners without whom this publication would not have been possible.

We now invite you to join us on a journey which will effectively reinvent industrial production as we know it; one in which value chains become value networks; and in which countless new markets and market opportunities are created. We now move into the age of integrated industry.

A handwritten signature in black ink, appearing to be 'B. Bunse', written in a cursive style.

Dr. Benno Bunse

Chairman/CEO Germany Trade & Invest



INDUSTRIE 4.0 is the German strategic initiative to take up a pioneering role in industrial IT which is currently revolutionizing the manufacturing engineering sector. INDUSTRIE 4.0's strategy will allow Germany to stay a globally competitive high-wage economy. Hence, cyber-physical systems (CPS) improve resource productivity and efficiency and enable more flexible models of work organization. Companies that use CPS will have a clear advantage when it comes to recruiting the best employees, since they can offer a better work-life balance. Germany has the potential to develop its position as a leading supplier and to become the leading market for INDUSTRIE 4.0 solutions - thereby strengthening the German economy, intensifying international cooperation and creating new, internet-based markets.

Professor Henning Kagermann

President acatech –
National Academy of Science and Engineering

Spokesperson of the Communication Promoters Group of the Industry-Science Research Alliance and Co-Chair of the INDUSTRIE 4.0 Working Group



The Internet of Things is finding its way into production. Semantic machine-to-machine communication revolutionizes factories by decentralized control. Embedded digital product memories guide the flexible work piece flow through smart factories, so that low-volume, high-mix production is realized in a cost-efficient way. A new generation of industrial assistant systems using augmented reality and multimodal interaction will help factory workers to deal with the complexity of cyber-physical production and enable new forms of collaboration by digital social media. Since on-demand production of highly individualized products like cars or kitchens requires short logistic chains in the markets where they are used, production is guaranteed to remain the backbone of Germany's economic performance.

Professor Wolfgang Wahlster

CEO and Scientific Director of DFKI
(German Research Center for Artificial Intelligence)

Member of the Industry-Science Research Alliance and Chair of the INDUSTRIE 4.0 Working Group on Human Factors

Industry: Where we have been, where we are going

The world as we know and experience it today has been shaped by three major technological revolutions. The first Industrial Revolution, beginning in Great Britain at the tail end of the 18th century and ending in the mid-19th century, represented a radical shift away from an agrarian economy to one defined by the introduction of mechanical production methods.

The second period of radical transformation – with the advent of industrial production and the birth of the factory at the start of the 20th century – was no less precipitous; ushering in as it did an age of affordable consumer products for mass consumption. In the late 1960s the use of electronics and IT in industrial processes opened the door to a new age of optimized and automated production.

Today we stand on the cusp of a fourth industrial revolution; one which promises to marry the worlds of production and network connectivity in an “Internet of Things” which makes “INDUSTRIE 4.0” a reality. “Smart production” becomes the norm in a world where intelligent ICT-based machines, systems and networks are capable of independently exchanging and responding to information to manage industrial production processes.

The conditions which make the fourth industrial revolution or INDUSTRIE 4.0 possible are unique to Germany. It is no idle boast to claim that nowhere else in the world do the required conditions necessary for the fourth industrial revolution exist. This brave new world of decentralized, autonomous real-time production being pioneered in Germany has its basis in two things: Germany’s continued role as one of the world’s most competitive and innovative manufacturing industry sectors; and the country’s technological leadership in industrial production research and development.

Germany’s position as an embedded systems technology leader gives birth to enabling cyber-physical system (CPS) technologies which ingeniously marry the digital virtual world with the real world. Cyber-physical production systems (CPPS) made up of smart machines, logistics systems and production facilities allow peerless ICT-based integration for vertically integrated and networked manufacturing.

One of 10 “Future Projects” identified by the German government as part of its High-Tech Strategy 2020 Action Plan to pursue innovation objectives over a 10 to 15-year period, INDUSTRIE 4.0 represents a major opportunity for Germany to secure its technological leadership role and establish itself as an INDUSTRIE 4.0 lead market and provider.

Germany has the ideal conditions to become a global leader in innovative, internet-based production technology and service provision. Technological leadership and vision in the fields of manufacturing, automation and software-based embedded systems, as well as historically strong industrial networks, lay the cornerstone for the long-term success of the INDUSTRIE 4.0 project.

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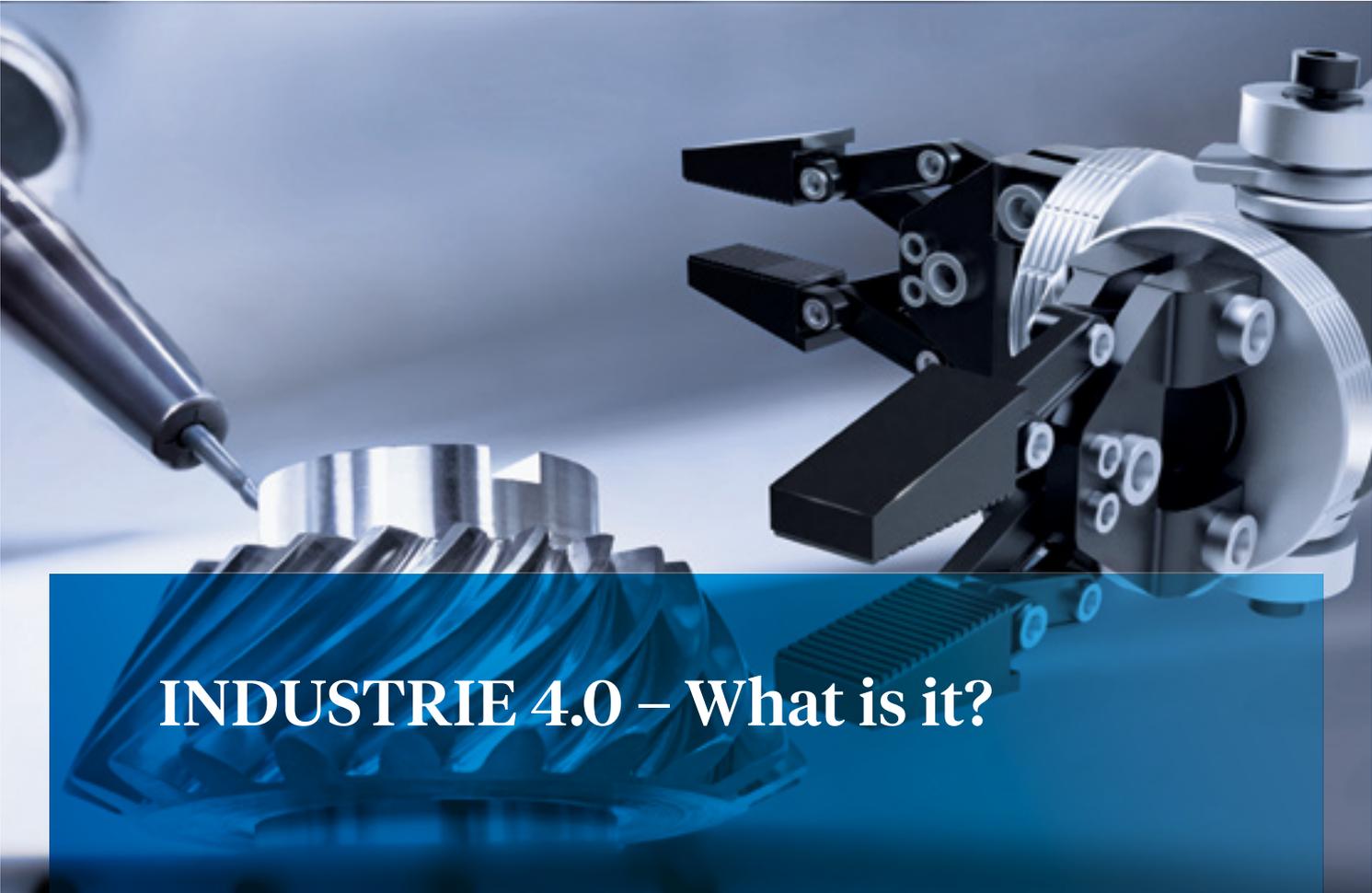
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INDUSTRIE 4.0 – What is it?

INDUSTRIE 4.0 connects embedded system production technologies and smart production processes to pave the way to a new technological age.

What is smart industry and what does “INDUSTRIE 4.0” mean exactly? Smart industry or “INDUSTRIE 4.0” refers to the technological evolution from embedded systems to cyber-physical systems. Put simply, INDUSTRIE 4.0 represents the coming fourth industrial revolution on the way to an Internet of Things, Data and Services. Decentralized intelligence helps create intelligent object networking and independent process management, with the interaction of the real and virtual worlds representing a crucial new aspect of the manufacturing and production process. INDUSTRIE 4.0 represents a paradigm shift from “centralized” to “decentralized” production – made possible by technological advances which constitute a reversal of conventional production process logic. Simply put, this means that industrial production machinery no longer simply “processes” the product, but that the product communicates with the machinery to tell it exactly what to do.

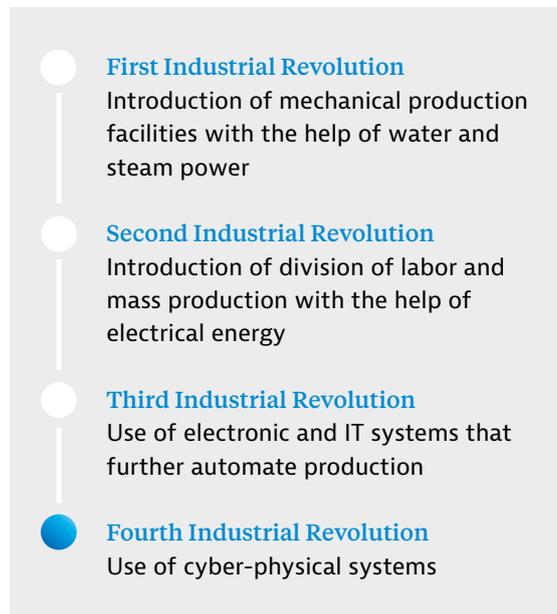
INDUSTRIE 4.0 connects embedded system production technologies and smart production processes to pave the way to a new technological age which will radically transform industry and production value chains and business models (e.g. “smart factory”).

Technological Background: Embedded Systems and Networks

Information and communication technologies (ICT) form the bedrock upon which tomorrow’s innovative solutions are built. Embedded systems and global networks – like the internet and the data and services found there – are two major ICT motors driving technological progress. Embedded systems already play a central – if almost hidden – role in all of our lives.

More than 98 percent of all processors produced worldwide are deployed in regulator, control, and monitor functions in devices for all facets of daily life. For instance, they are there in everything from vehicle ABS and ESP systems, smart phone communication and information services and ordinary domestic household devices to industrial production plant systems. Embedded systems are the intelligent central control units at work in most modern technological products and devices. They typically operate as information-processing systems "embedded" within an "enclosing" product for a set range of device-specific applications. These "connect" with the outside world using sensors and actuators; allowing embedded systems to be increasingly interconnected with each other and the online world.

From Industry 1.0 to INDUSTRIE 4.0



Source: DFKI 2011

Germany – Embedded Systems Leader

Germany is an international leader in embedded systems and also enjoys a leading position in security solutions and business enterprise software. Germany also boasts an enviable engineering reputation in matters system solutions-related and can call upon considerable semantic technologies and embedded systems know-how.

Germany's embedded system market currently generates around EUR 20 billion annually, a figure which is forecast to rise to more than EUR 40 billion by 2020. The applications sector alone generates annual turnover in the region of EUR 4 billion, with an estimated value added factor of approximately EUR 15 billion. As such, Germany's embedded systems market is the third biggest in the world behind the USA and Japan.

National Roadmap Embedded Systems

In 2009 a group of more than 40 decision makers from important companies, research institutes and relevant industry associations came together to create the National Roadmap Embedded Systems for the further development of embedded systems technology.

Representatives from a number of industry sectors – including auto construction, automation technology, and machine and plant manufacturing – will spend more than EUR 2.5 billion in six research areas over the ten-year lifetime of the project.

Cyber-Physical Systems

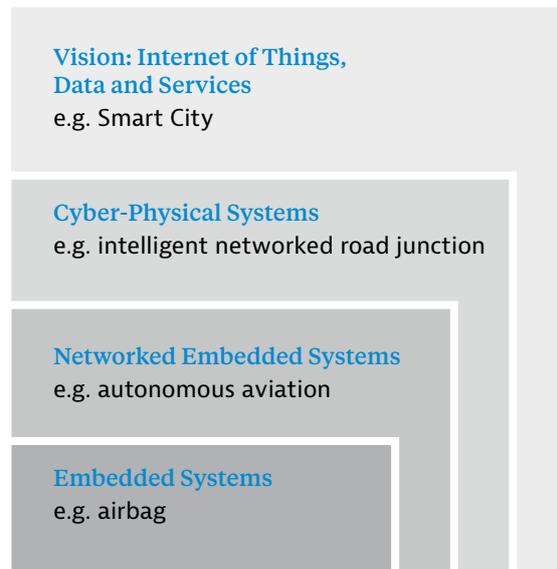
Cyber-physical systems (CPS) are enabling technologies which bring the virtual and physical worlds together to create a truly networked world in which intelligent objects communicate and interact with each other. Cyber-physical systems represent the next evolutionary step from existing embedded systems. Together with the internet and the data and services available online, embedded systems join to form cyber-physical systems.

Cyber-physical systems provide the basis for the creation of an Internet of Things, which combines with the Internet of Services to make INDUSTRIE 4.0 possible. They are “enabling technologies” which make multiple innovative applications and processes a reality as the boundaries between the real and virtual worlds disappear. As such, they promise to revolutionize our interactions with the physical world in much the same way that the internet has transformed personal communication and interaction.

The interplay between high performance software-based embedded systems and dedicated user interfaces which are integrated into digital networks creates a completely new world of system functionality. Modern mobile telephones are perhaps the most obvious example of this, offering as they do a complete bundle of applications and services which completely outstrip the device’s original telephony function. Cyber-physical systems also represent a paradigm break from existing business and market models, as revolutionary new applications, service providers and value chains become possible.

Industry sectors including the automotive industry, the energy economy and, not least, production technology (“INDUSTRIE 4.0”) for example, will in turn be transformed by these new value chain models. Global megatrends of globalization, urbanization, demographic change and energy transformation are the transformative forces driving the technological impulse to identify solutions for a world in flux. In the future, cyber-physical systems will make contributions to human security, efficiency, comfort and health in ways not previously imaginable. In doing so, they will play a central part in addressing the fundamental challenges posed by demographic change, scarcity of natural resources, sustainable mobility, and energy change.

The Evolution of Embedded Systems into the Internet of Things, Data and Services



Source: acatech 2011

Cyber-Physical Systems and the Internet of Things, Data and Services

The “The Evolution of Embedded Systems into the Internet of Things, Data and Services” illustration depicts the vision of a global “Internet of Things, Data and Services” through the evolutionary development of embedded system as a result of their being networked over the internet. Closed embedded systems (e.g. airbags) represent the starting point. Recommendations for the next step to locally networked embedded systems were already made in the National Roadmap Embedded Systems 2009. acatech’s “Agenda CPS” study extended the spectrum to global networking (one example being the intelligent networked road junction that makes use of traffic jam information). Cyber-physical systems represent the next stage on the road to the creation of smart cities through the creation of an Internet of Things, Data and Services.

What does INDUSTRIE 4.0 mean for the software sector – ERP or MES?

INDUSTRIE 4.0 has sparked a debate within the German software industry as to whether enterprise resource planning (ERP) or manufacturing execution systems (MES) will establish themselves as the dominant software system force in production environments. Some industry voices believe that ERP software will be directly linked to process control systems (PCS) at the production level, thereby eliminating the need for ERP software. Conversely, a significant contingent considers MES software to be excellently situated for the implementation of INDUSTRIE 4.0.

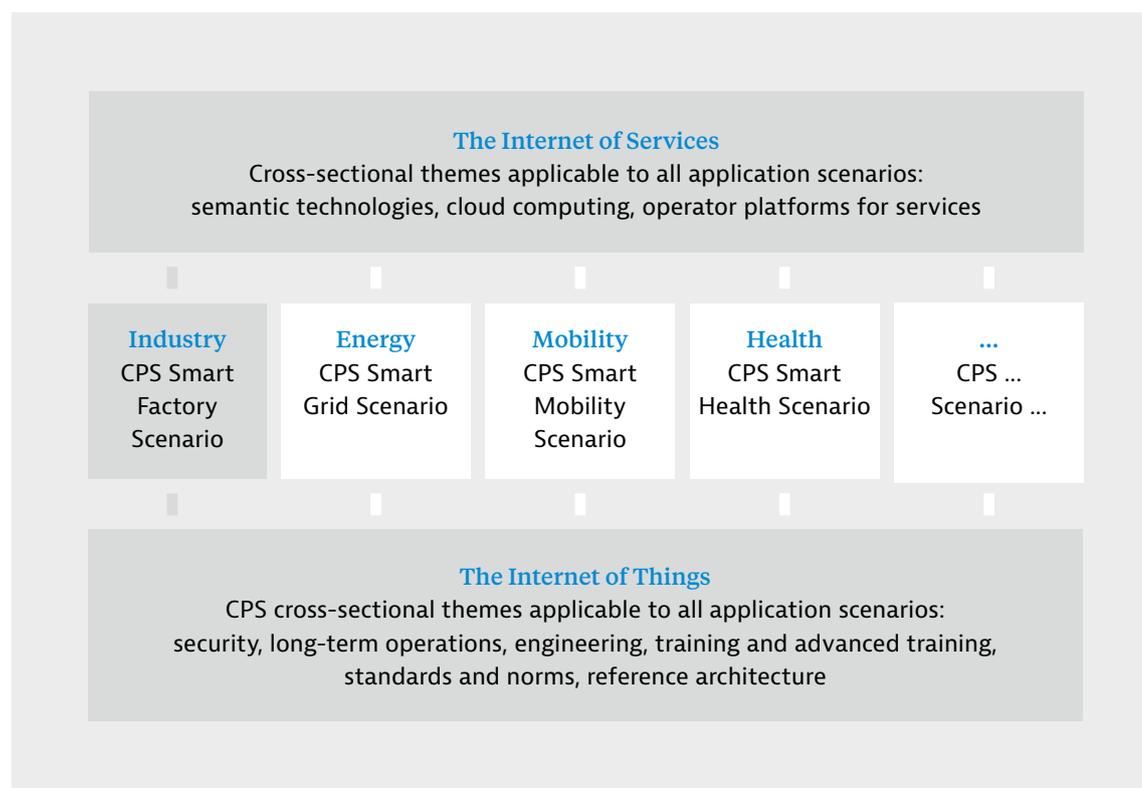
In reality, the answer is not as clear cut, as INDUSTRIE 4.0 will also cause significant transformation in the field of production management software.

However, because both traditional ERP and MES functionalities remain indispensable to production management, it remains unlikely that one software system will replace the other.

A more likely scenario is the increasing convergence of the two systems, with the line dividing corporate IT and production IT becoming blurred. This scenario matches the essence of interdisciplinary integration and the different stages of the product cycle foreseen in INDUSTRIE 4.0 (e.g. idea, development, production, service, and phasing out). Software systems utilized in INDUSTRIE 4.0 will also have to address new challenges including, for example, data correlations, as a result of ever more semantic networks and learning applications and the need to manage ever larger and more complex amounts of data.



ICT as Innovation Motor for all Fields of Demand – Relevance of the Internet of the Future



Source: Germany Trade & Invest 2013 (based on "IKT als Innovationsmotor für alle Bedarfsfelder – die Relevanz des Internets der Zukunft" in "Bericht der Promotorengruppe Kommunikation – Im Fokus: das Zukunftsprojekt Industrie 4.0, Handlungsempfehlungen zur Umsetzung", Forschungsunion 2012)



The Smart Factory – The Future of Automated Manufacturing

The merging of the virtual and the physical worlds through cyber-physical systems and the resulting fusion of technical processes and business processes are leading the way to a new industrial age best defined by the INDUSTRIE 4.0 project's "smart factory" concept.

The deployment of cyber-physical systems in production systems gives birth to the "smart factory." Smart factory products, resources and processes are characterized by cyber-physical systems; providing significant real-time quality, time, resource, and cost advantages in comparison with classic production systems. The smart factory is designed according to sustainable and service-oriented business practices. These insist upon adaptability, flexibility, self-adaptability and learning characteristics, fault tolerance, and risk management.

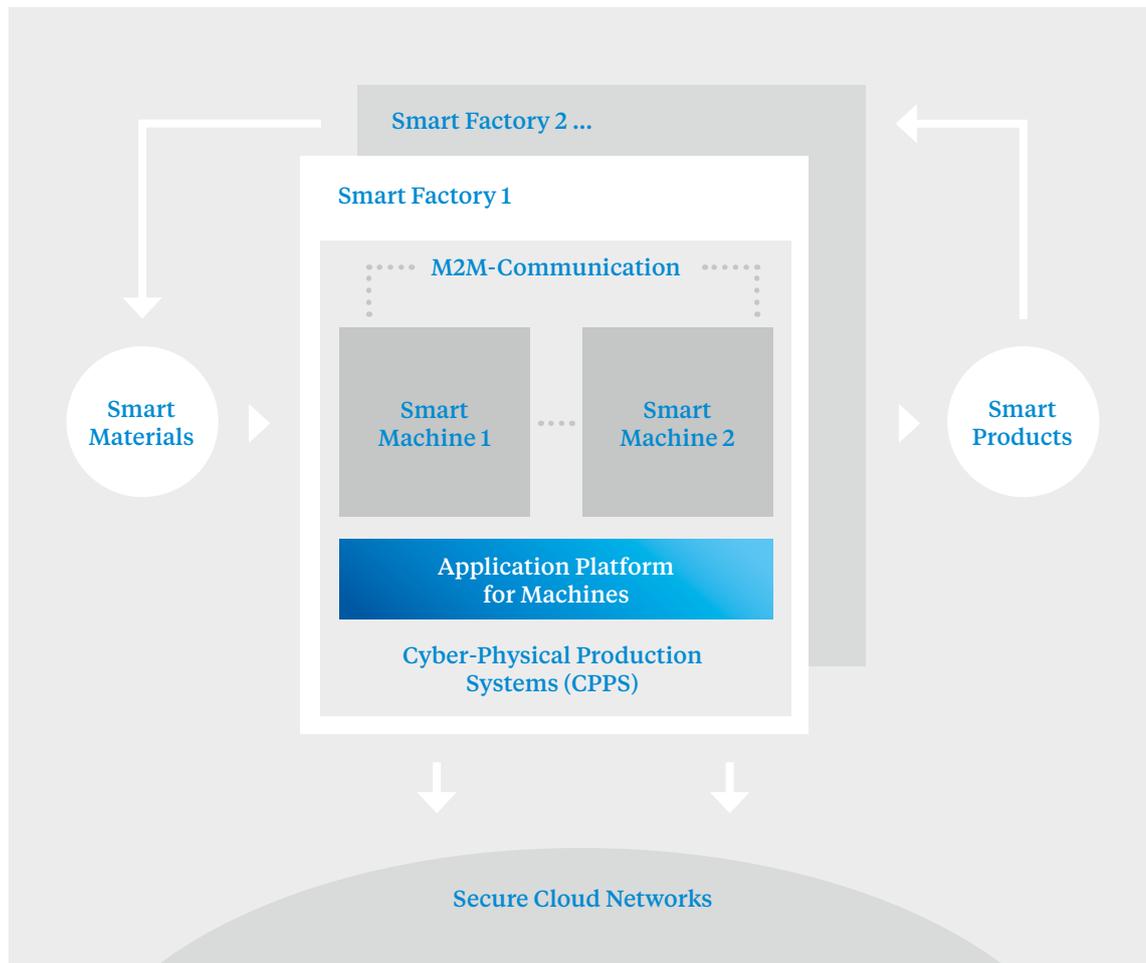
High levels of automation come as standard in the smart factory: this being made possible by a flexible network of cyber-physical system-based production systems which, to a large extent, automatically oversee production processes. Flexible production systems which are able to respond in almost real-time conditions allow in-house production processes to be radically optimized. Production advantages are not limited solely to one-off production conditions, but can also be optimized according to a global network of adaptive and self-organizing production units belonging to more than one operator.

This represents a production revolution in terms of both innovation and cost and time savings and the creation of a “bottom-up” production value creation model whose networking capacity creates new and more market opportunities. Smart factory production brings with it numerous advantages over conventional manufacture and production.

These include:

- CPS-optimized production processes: smart factory “units” are able to determine and identify their field(s) of activity, configuration options and production conditions as well as communicate independently and wirelessly with other units;
- Optimized individual customer product manufacturing via intelligent compilation of ideal production system which factors account product properties, costs, logistics, security, reliability, time, and sustainability considerations;
- Resource efficient production;
- Tailored adjustments to the human workforce so that the machine adapts to the human work cycle.

INDUSTRIE 4.0 Smart Factory Pipeline (cloud-based secure networks)



Source: DFKI 2012

A photograph of the Reichstag building in Berlin, Germany, featuring its iconic glass dome and classical architecture. The building is reflected in a body of water in the foreground. The image is partially obscured by a dark blue overlay containing text.

Policy Framework and Programs

A comprehensive package of complementary policy and funding programs and activities has been put in place in order to establish Germany as a lead market and provider of cyber-physical systems by 2020.

The High-Tech Strategy

Launched in August 2006, the “High-Tech Strategy” represents the first national concept to bring key innovation and technology stakeholders together in a common purpose of advancing new technologies.

The initiative combines the resources of all government ministries, setting billions of euros aside annually for the development of cutting-edge technologies (R&D projects can also count on generous financial support in the form of R&D grants).

High-Tech Strategy 2020

The objectives set out in the High-Tech Strategy were continued and extended within the framework of the “High-Tech Strategy 2020” launched in July 2010. Building on the initial successes of the High-Tech Strategy, this successor initiative intends to create lead markets, further intensify partnership between science and industry, and continue to improve the general conditions for innovation. The High-Tech Strategy 2020 exists to establish Germany as a lead provider of science and technology-based solutions in the fields of:

- Climate/Energy
- Health/Nutrition
- Mobility
- Security
- Communication

High-Tech Strategy 2020 Action Plan

The German government passed the High-Tech Strategy Action Plan in March 2012 for the further implementation of the High-Tech Strategy. The Action Plan identifies 10 "Future Projects" – including INDUSTRIE 4.0 – which are considered as being critical to addressing and realizing current innovation policy objectives as the focus of research and innovation activity. Within these lighthouse projects, specific innovation objectives will be pursued over a 10 to 15 year time frame. The INDUSTRIE 4.0 project has been allocated funding of up to EUR 200 million within the High-Tech Strategy 2020 Action Plan. The coalition agreement for the 18th legislative period signed by the newly constituted CDU-CSU-SPD coalition government of December 14, 2013, identifies the INDUSTRIE 4.0 future project as an important measure in consolidating Germany's technological leadership in the mechanical engineering sector. The coalition government plans to push ahead with the digitalization of traditional industry with expansion into the area of "Smart Services" foreseen, as well as the strengthening of projects and activities in the "Green IT" sector.

Germany – Lead Market for Cyber-Physical Systems 2020

As part of the country's INDUSTRIE 4.0 project, Germany aims to be the lead provider of cyber-physical systems by 2020. In marked contrast to many other industrialized nations, Germany has maintained a stable manufacturing labor force while integrating new technological developments into industrial products and processes at an early stage. A bridge between the real and virtual worlds is being created with the digital refining of everything from production facilities and industrial products to everyday products with integrated storage and communication capabilities, radio sensors and intelligent software systems. Boundaries between the real and virtual worlds are collapsing to create an Internet of Things. Germany's superior embedded system and cyber-physical systems know-how represents a major opportunity for industry in Germany to help shape the fourth industrial revolution (INDUSTRIE 4.0).

Agenda CPS

The objective of the Agenda CPS project led by the German National Academy of Science and Engineering (acatech) on behalf of the Federal Ministry of Education and Research (BMBF) is to establish an integrated CPS research agenda that allows Germany to shape this technological revolution as a lead market and provider in competition with other industrial and technological players.

Agenda CPS has identified four major fields of application up to the year 2025. These are "Energy" (cyber-physical systems for the smart grid); "Mobility" (cyber-physical systems for networked mobility); "Health" (cyber-physical systems for telemedicine and remote diagnosis); and, of course, "Industry" (cyber-physical systems for industry and automated production).

ICT 2020: Research for Innovations – IT Systems for INDUSTRIE 4.0

Innovative ICT research (including IT systems for INDUSTRIE 4.0) is provided by the Federal Ministry of Education and Research (BMBF) in its "ICT 2020 – Research for Innovations" program within the framework of the High-Tech Strategy 2020 and the federal government's "Digital Germany 2015" ICT strategy. Particular ICT research focus is concentrated in the area of ICT in complex systems (e.g. embedded systems), new business processes and production methods as well as the Internet of Things and Services. Research activities conducted in the area of IT systems for cyber-physical systems, the Internet of Things and Services, and INDUSTRIE 4.0 are all eligible for funding.

Software systems and knowledge processing research funding is divided into three specific categories:

- Embedded systems focusing in particular on software-intensive embedded systems with links to electronics, communication technology and microsystems technology;
- Simulated reality for grid applications and infrastructure, virtual/augmented reality and ambient intelligence, simulation, information logistics and software development for high-performance computing;
- Human/machine interaction with language and media technologies, bioanalogous information processing, service robotics and usability.

The three category research areas are complemented by the cross-sectional technologies of software engineering, reliability and security due to their specific focus on the strategic priorities of software-intensive embedded systems, grid applications and infrastructure as well as virtual/augmented reality. Applicant projects should be business-oriented and include cooperation with either university or non-university research institutions. Calls for applications are published on a case-by-case basis.



Autonomics for INDUSTRIE 4.0

The AUTONOMIK für INDUSTRIE 4.0 – Produktion, Produkte, Dienste im multidimensionalen Internet der Zukunft (“AUTONOMICS for INDUSTRIE 4.0 – Production, Products, Services in the Multidimensional Internet of the Future”) technology program contributes to the implementation of the goals set out in the High-Tech Strategy 2020.

Priority areas include developing the next evolutionary steps for machines, service robots and other systems able to deal with complex tasks autonomously as the transition from ICT-based control mechanisms to autonomously acting components and systems ushers in a new age in which efficiency, cost effectiveness, and quality increase in new and flexible production infrastructures.

The technological development of the Internet of Things has already been covered in the Federal Ministry for Economic Affairs and Energy (BMWi) next generation media (new technologies and ubiquitous computing) and AUTONOMIK (autonomous, simulation-based systems for small and medium-sized enterprises) precursor projects which provided significant impulse to new products, services and business models in different application scenarios. Important developments in the field of semantic technologies applicable in the Internet of Applications and Services were also established in the BMWi THESEUS R&D funding project. The successor AUTONOMICS for INDUSTRIE 4.0 project has made EUR 40 million in funding available to companies and research institutions in order to advance intelligent interacting between ICT and industrial production in the areas of future-oriented production systems and production logic; future-oriented premium products (including service robots); and future-oriented, knowledge-intensive electronic services.

CyProS (Cyber-Physical Production Systems)

The CyPros (Cyber-Physical Production Systems) research project consisting of a consortium of actors from science and industry led by Wittenstein AG was initiated in 2012 in order to research and develop a representative spectrum of cyber-physical system modules for production and logistics systems for industrial use. Together with the underlying reference architecture, also to be developed during the course of the three-year project, these system modules will allow the manufacturing industry to realize a significant increase in productivity and flexibility which will also equip Germany to become the lead user and provider of such systems.

This will allow the complexity of increasing competition to be controlled, but also lead to a sustainable and significant increase in productivity and flexibility of manufacturing companies through the development and introduction of cyber-physical production systems (CPPS). The resulting CPPS technologies will allow Germany to increase its competitiveness as an international production location as a result of improved productivity and flexibility, while simultaneously allowing CPPS to be introduced to the market as marketable products, thereby establishing the country as a lead CPPS provider.

CyPros follows three separate goal stages:

- Development of a reference architecture and a representative spectrum of cyber-physical system modules for production and logistics systems;
- Provision of universal practices, support tools and platforms for the introduction of cyber-physical production systems;
- Technical and methodological basis for the commercial operation of cyber-physical production systems and their implementation in the real production environment of a showcase factory.

RES-COM

Launched in June 2011 and funded by the Federal Ministry of Education and Research, the RES-COM project addresses automatized conservation of resources through highly interconnected and integrated sensor-actuator systems in an INDUSTRIE 4.0 context. Prototype scenarios for context-activated resource efficiency are being implemented. RES-COM adopts a completely new type of core technology based on active digital product memory and software service agents with embedded sensors and actuators. The project is overseen by the German Research Center for Artificial Intelligence (DFKI) in partnership with partners including SAP, Siemens, IS Predict, and 7x4 Pharma.



Actors and Institutions: A Selection

A number of important research and trade actors and institutions are working closely together to realize Germany's INDUSTRIE 4.0 vision.

Industry-Science Research Alliance

Initiated by the Federal Ministry of Education and Research (BMBF) in 2006, the Industry-Science Research Alliance is an advisory group which brings together 19 leading representatives from science and industry to accompany the High-Tech Strategy of interministerial innovation policy initiatives.

In January 2011, INDUSTRIE 4.0 was initiated as a "Future Project" of the German Federal Government by the Communication Promoters Group of the Industry-Science Research Alliance. The Industry-Science Research Alliance, in partnership with acatech – National Academy of Science and Engineering, established the INDUSTRIE 4.0 Working Group co-chaired by Dr. Siegfried Dais

(Robert Bosch GmbH) and Professor Henning Kagermann (acatech president and spokesperson of the Promoters Group).

The Communication Promoters Group of the Industry-Science Research Alliance (Prof. Dr. Henning Kagermann, acatech; Prof. Dr. Wolfgang Wahlster, German Research Center for Artificial Intelligence – DFKI; and Dr. Johannes Helbig, Deutsche Post AG) in cooperation with acatech published the "Securing the future of German manufacturing industry: Recommendations for implementing the strategic initiative INDUSTRIE 4.0 – Final report of the INDUSTRIE 4.0 Working Group" report supported by the BMBF in April 2013.



acatech – National Academy of Science and Engineering

acatech – the National Academy of Science and Engineering – represents the interests of the German scientific and technological communities, at home and abroad. It is autonomous, independent and a non-profit organization. As a working academy, acatech supports policy-makers and society, providing qualified technical evaluations and forward looking recommendations. Moreover, acatech is determined to support knowledge transfer between science and industry, and encourage the next generation of engineers. acatech works to

promote sustainable growth through innovation. Its work focuses on four core areas. Scientific recommendations: acatech advises policy-makers and the public on future technology issues based on best-in-breed research. Transfer of expertise: acatech provides a platform for exchanging excellence between the sciences and business. Promotion of young scientists and engineers: acatech is involved in the promotion of young scientists and engineers. A voice for science and engineering: acatech represents the interests of scientists and engineers at national and international levels.



www.acatech.de/uk

What role does your organization play in Germany's INDUSTRIE 4.0 project?

acatech – the National Academy of Science and Engineering – supports policy-makers and society by providing qualified technical evaluations and forward-looking recommendations. In 2010, acatech initiated a research project on cyber-physical systems – the technical core of INDUSTRIE 4.0. Initial implementation recommendations were formulated by the INDUSTRIE 4.0 Working Group between January and October 2012 under the coordination of acatech.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

INDUSTRIE 4.0 marks a fundamental paradigm shift towards decentralized and individualized production cycles which will enable new, internet-based services and business models. INDUSTRIE 4.0 offers Germany the chance to further strengthen its position as a manufacturing location, manufacturing equipment supplier and IT business solutions supplier. All the stakeholders in Germany are now closely cooperating through the Plattform INDUSTRIE 4.0 in order to push implementation. Germany is well placed to become a global pacesetter in the area of INDUSTRIE 4.0.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

Germany's global market leaders include numerous "hidden champions" who provide specialized solutions – 22 of Germany's top 100 small and medium-sized enterprises (SMEs) are machinery and plant manufacturers, with three of them featuring in the world's top ten. INDUSTRIE 4.0 will also result in new ways of creating value and novel business models. In particular, it will provide start-ups and small businesses with the opportunity to develop and provide downstream services.

What impact will INDUSTRIE 4.0 have beyond Germany?

The fourth industrial revolution is a global trend. Many of Germany's competitors have also recognized this trend of using the Internet of Things in the manufacturing environment and are promoting it through a range of institutional and financial measures.

How can international companies profit from INDUSTRIE 4.0?

First, INDUSTRIE 4.0 will involve increased networking and cooperation between several different partners in international networks of value creation. To realize INDUSTRIE 4.0, a close international network between science, industry and universities is needed. INDUSTRIE 4.0 will address and solve some of the challenges the world is facing today such as resource and energy efficiency, urban production and demographic change.





German Research Center for Artificial Intelligence – DFKI

The German Research Center for Artificial Intelligence (DFKI) was founded in 1988 and has research facilities in Kaiserslautern, Saarbrücken, Bremen and a project office in Berlin. In the field of innovative commercial software technology using artificial intelligence, DFKI is the leading research center in Germany.

Based on application-oriented basic research DFKI develops product functions, prototypes and patentable solutions in the field of information and communication technology. Research and development projects are conducted in fourteen research departments and research groups, ten competence centers and five living labs. Funding is received from government agencies like the European Union, the Federal Ministry of Education and Research (BMBF), the Federal Ministry for Economic Affairs and Energy (BMWi), the German Federal States and the German Research Foundation (DFG) as well as from cooperation with industrial partners.

Apart from the state governments of Rheinland-Pfalz, Saarland and Bremen, numerous renowned German and international high-tech companies are represented on the DFKI supervisory board. The DFKI model of a non-profit public-private partner-

ship (ppp) is nationally and internationally considered a blueprint for corporate structure in the field of top-level research.

DFKI is actively involved in numerous organizations representing and continuously advancing Germany as an excellent location for cutting-edge research and technology. Far beyond the country's borders DFKI enjoys an excellent reputation for its academic training of young scientists. At present, 413 highly qualified researchers and 272 graduate students from more than 60 countries are contributing to more than 232 DFKI research projects. Over the years, more than 60 staff members have been appointed professors at universities in Germany and abroad.

DFKI is on the forefront of INDUSTRIE 4.0 research. The SmartFactory Living Lab performs operation and testing of the latest technologies in process engineering and piece goods under industrial conditions. The project "RES-COM" examines the vision of an automatized conservation of resources through highly interconnected and integrated sensor-actuator systems.

"SmartF-IT" is looking at cyber-physical IT systems to master complexity of a new generation of multi-adaptive factories due to the intensive use of high-networked sensors and actuators, overcoming traditional production hierarchies of central control towards decentralized self-organization. Both projects are funded by the BMBF establishing Germany as one of the leading pioneers in the field of the Internet of Things.



www.dfki.de
www.facebook.com/DFKI.GmbH
www.smartf-it-projekt.de
www.res-com-projekt.de

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location? What impact will INDUSTRIE 4.0 have beyond Germany?

The Internet of Things is finding its way into production and revolutionizing existing manufacturing logic through high-resolution networking and extreme flexibility in the value chain. German mechanical engineering and plant manufacturers, who are international leaders, will profit from INDUSTRIE 4.0 as providers, as of course will the IT sector which is tasked with making production and business processes in real-time capable enterprise software solutions. On the INDUSTRIE 4.0 user side we primarily see auto manufacturers and suppliers as well as manufacturers of agricultural equipment, the packaging industry, and companies from the logistics sector. There will be no stand-alone solutions in the globally networked economy, but instead opportunities for global business innovation – with Germany preparing the path ahead.

What role does your organization play in Germany's INDUSTRIE 4.0 project?

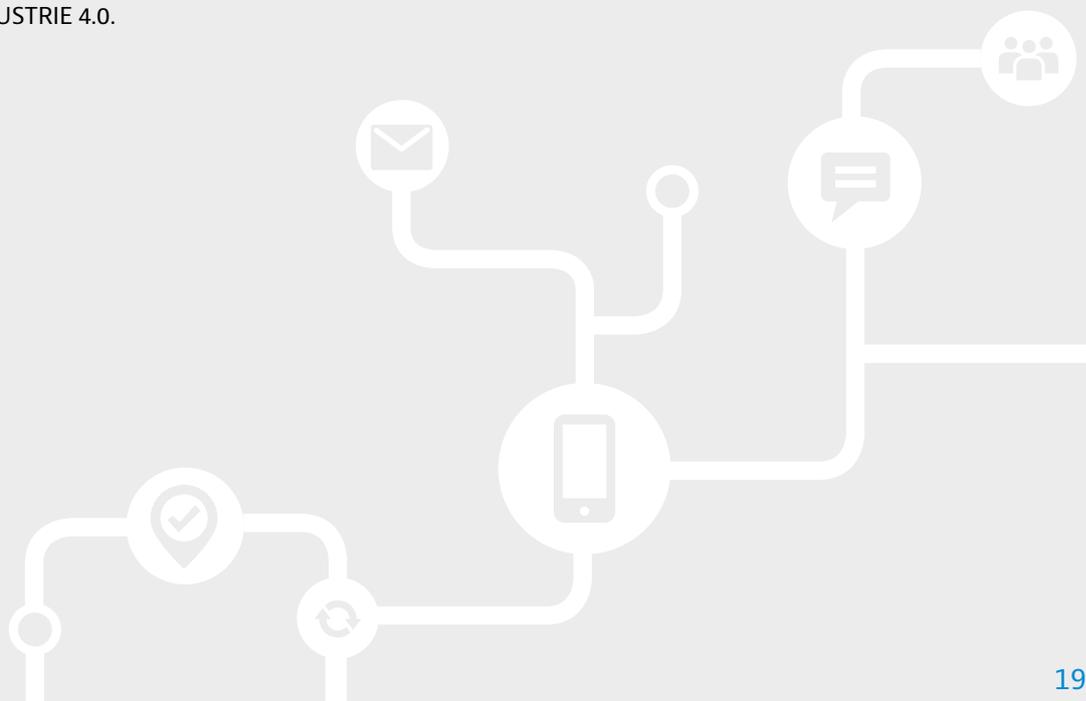
The DFKI has already worked on the initial concepts for INDUSTRIE 4.0 as part of the Industry-Science Research Alliance advisory group. The partners work with policy makers on an equal footing in order to design and practically implement joint project of real societal importance. For several years the DFKI has, together with leading plant manufacturers, been operating the world's first so-called "smart factory" as a living lab which serves as a reference architecture for INDUSTRIE 4.0.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

INDUSTRIE 4.0 will be of paramount importance to small and medium-sized enterprises (SMEs). Flexible value chains will transcend departmental, business and company boundaries. As a result, SMEs can become temporary production networks with precisely calculated value added contributions. Continuous networking of course presents a challenge for security technology, but INDUSTRIE 4.0 allows client series and personalized products to be produced at unit costs previously only possible in mass production.

How can international companies profit from INDUSTRIE 4.0?

INDUSTRIE 4.0 is an industrial not a political revolution. That is to say, there will be no single defining event that takes place, but rather a period of dynamic development. New resource-efficiency optimization processes make environmentally friendly and urban production at acceptable costs possible in the near future – not only in Germany but across the world. INDUSTRIE 4.0 will therefore make a significant contribution to the biggest problems facing society; be it climate change, energy transformation or mega-city management.





Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 66 institutes and independent research units. The majority of the more than 22,000 staff are qualified scientists and engineers, who work with an annual research budget of EUR 1.9 billion. Of this sum, more than EUR 1.6 billion is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and federal state governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.



www.fraunhofer.de

What role does your organization play in Germany's INDUSTRIE 4.0 project?

The Fraunhofer IAO* has been helping shape the INDUSTRIE 4.0 project since as early as 2011 as part of activities carried out by the Industry-Science Research Alliance. Since 2012 we have been working with industry partners in the area of highly flexible, self-organized capacity management as part of the publicly funded "KapaflexCy" (www.kapaflexcy.de/) INDUSTRIE 4.0 lead project. The current Produktionsarbeit der Zukunft – INDUSTRIE 4.0 ("Production of the Future – INDUSTRIE 4.0") pilot study lays the foundations for the Innovationsnetzwerk Produktionsarbeit 4.0 ("Innovation Network Production 4.0") in which Fraunhofer IAO is developing new applications and business models for INDUSTRIE 4.0 with industry and trade association partners.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

With its innovative and leading mechanical engineering, automotive and electrical industries, Germany is a country with deep industrial roots that is already a world leader in embedded systems (the technological basis for INDUSTRIE 4.0). This provides the German manufacturing sector with the opportunity of following a dual strategy for the future. On the one hand, Germany can continue to build on its competitive position as a production country thanks to innovative factory concepts and INDUSTRIE 4.0 applications. On the other hand, Germany can become the global technology supplier for INDUSTRIE 4.0 factories.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

The German manufacturing environment is characterized by a large number of small and medium-sized enterprises (SMEs). These SMEs often produce highly innovative products for the rest of the world. New market segments will open up for these companies domestically and internationally with INDUSTRIE 4.0. Moreover, SMEs in particular stand to benefit from the standardized networking of their own production resources as many still work with proprietary systems. This will allow SMEs to drastically reduce production management efforts and respond in significantly faster fashion to market requirements.

What impact will INDUSTRIE 4.0 have beyond Germany?

INDUSTRIE 4.0 is not an issue that is limited just to Germany. There are similar approaches being carried out across the world which are being promoted under the names of "Internet of Things" and "Industrial Internet" for example. As well as manufacturing, these highlight many more everyday and routine fields of application for networked systems. However, the full potential of INDUSTRIE 4.0 can only be fully exploited through the global networking of production resources and the use of globally functioning applications. The identification and introduction of uniform standards is especially important in this respect.

How can international companies profit from INDUSTRIE 4.0?

Global sourcing and distributed processes are always associated with considerable coordination and management time and effort. INDUSTRIE 4.0 allows information to cover long distances in close to real time. International companies will therefore be able to quickly react to client requirements in globally distributed production systems as well as provide their customers with a current picture of production progress at all times.

What significance does INDUSTRIE 4.0 have for the future employment market? What impact will it have on the education and training of the workforce?

The operation of a factory according to the INDUSTRIE 4.0 principle requires workers with the relevant production and IT know-how. For the future it is important to create certified training courses in order to take interdisciplinarity to a new and highly innovative level. By means of just-in-time learning and just-in-time training, workers can be equipped for dealing with short-term, unplanned ad-hoc work activities with changing content on the job, thereby becoming qualified to solve problems as they are dealing with them.

* The Fraunhofer IAO is a member institution of the Fraunhofer-Gesellschaft. Fraunhofer IAO activities include applied research and development in the fields of engineering, IT, economics, and social sciences.



it's OWL

In February 2012 the German Federal Ministry of Education and Research (BMBF) announced the "it's OWL" (Intelligent Technical Systems OstWestfalenLippe) high-tech strategy as one of the winners of its Leading-Edge Cluster competition.

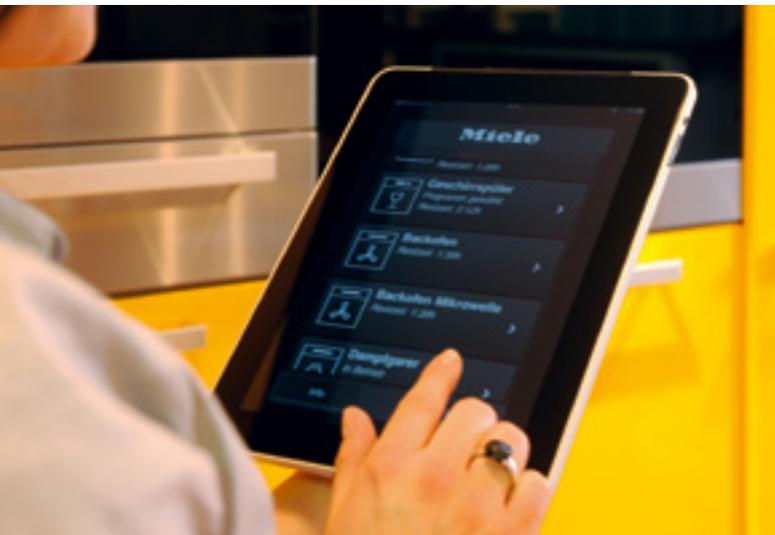
it's OWL is a science and industry technology network which intends to set international standards in the field of intelligent technical systems. The cluster is helping pave the way to the fourth industrial revolution and makes a significant contribution to the competitiveness of manufacturing and production in Germany.

Tomorrow's technological systems will be intelligent and connected. This applies to the products of mechanical engineering sector and related industries such as the automotive industry, electrical engineering and medical as well as their corre-

sponding production systems. Intelligent technical systems arise from the interplay of engineering and information technology. They interact with their environment and adapt to it autonomously. They also deal with unexpected situations in a dynamic environment and are able to anticipate the future effects of different influences thanks to experiential knowledge. Moreover, they also adapt to individual user behavior.

Within the it's OWL technology network, 174 companies – including world leaders such as Beckhoff, Claas, DMG MORI Aktiengesellschaft, Harting, Lenze, Miele, Phoenix Contact, WAGO, Weidmüller, and Wincor Nixdorf – and research institutions are carrying out pioneering work in this area. Intelligent products and production systems are being developed in 45 projects: from automation and drive solutions for machinery, automats, vehicles and household devices to networked production facilities. Examples include self-correcting manufacturing processes, digitalization of work planning, energy efficient intralogistics for warehouses, resource-efficient industrial laundry as well as energy management in smartgrids.

The development, deployment, maintenance and life cycle management of products, machines and systems will be improved by it's OWL technologies and solutions. Their reliability, resource efficiency, and user friendliness will also be optimized, with individualized and adaptable production processes becoming reality.



www.its-owl.com

What role does your organization play in Germany's INDUSTRIE 4.0 project?

Mr. Roman Dumitrescu, chief executive of OWL: The OWL (Intelligent Technical Systems Ost-WestfalenLippe) leading-edge cluster is currently the largest INDUSTRIE 4.0 project. Our intelligent technical systems provide a strong boost to Germany's competitiveness as a production location and pave the way to the fourth industrial revolution. INDUSTRIE 4.0 solutions are being developed in 45 different projects with a budget of around EUR 100 million. We see our strengths as being in industrial automation, human-machine cooperation and the realization of so-called 'self-x capabilities' like, for example, self-optimizing production systems.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

The project clearly strengthens machine engineering as well as the electronics industry; industries which are thankfully still very strongly represented in Germany. In recent times these industry sectors have been dismissed as "old economy," with countries like Great Britain fully focusing on the service sector – something we now know to be a mistake. I believe that with INDUSTRIE 4.0 we have a unique opportunity to combine and play off our strengths to become not only the lead provider for production in the future but also to remain an important production location.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

The current state of affairs is that the subject seems a little far off for SMEs. I say "seems" very deliberately, as there are also companies who are already very successfully active in the INDUSTRIE 4.0 area. For example, MSF Vathauer Antriebstechnik – an OWL cluster member – won the Industry 2013 prize for its decentralized drive solutions for INDUSTRIE 4.0 application. SMEs certainly play a key role in Germany. That's why we have set up a EUR 5 million technology transfer project specifically for these companies in order to pass on INDUSTRIE 4.0 solutions.

What impact will INDUSTRIE 4.0 have beyond Germany?

It has certainly not gone unnoticed by other countries that Germany has fared comparably well despite the financial and economic crises of recent times. The reason for this is that we are still a strong production location. For instance, even the European Institute for Innovation and Technology (EIT) will invite tenders for a Knowledge and Innovation Community (KIC) in the area of "Value Added in Production" in 2016. I don't think this would have been the case without Germany's INDUSTRIE 4.0 initiative.

How can international companies profit from INDUSTRIE 4.0?

Quite simply: by buying our solutions. Because here they can access all of the components for future-proof production. International companies can of course also profit from these innovations. We should not forget that Germany has invested enormously in research and development for this success. That is the only reason why we now stand on the threshold of a fourth industrial revolution.





Plattform INDUSTRIE 4.0

The Plattform INDUSTRIE 4.0 is a joint initiative of the industry organizations BITKOM (Federal Association for Information Technology, Telecommunications and New Media), VDMA (German Engineering Federation), and ZVEI (Electrical and Electronic Manufacturers' Association) and acts as a central point of contact for companies, employee representatives, politics and science in matters INDUSTRIE 4.0 related.

Officially launched at the Hannover Messe in April 2013, Plattform INDUSTRIE 4.0 will continue the work of the Federal Government's "Future Project INDUSTRIE 4.0" in order to strengthen Germany as an industry location. The main objective of the Plattform is the development of technologies, standards, business and organizational models and their practical implementation. The three industry

organizations believe that INDUSTRIE 4.0 is of significant importance to the continued competitiveness of German industry.

The central office of the Plattform organizes and coordinates all Plattform INDUSTRIE 4.0 activities, informs on the progress made by the cooperation and serves as a main point of contact for business, politics and the media.



www.plattform-i40.de





What role does your organization play in Germany's INDUSTRIE 4.0 project?

Together, three leading industry associations are pushing the INDUSTRIE 4.0 theme forward. BITKOM, VDMA and ZVEI founded the Plattform INDUSTRIE 4.0 partnership which started operations in April of this year. The Plattform is based in Frankfurt am Main with a joint information portal and "virtual office" set up online. Plattform INDUSTRIE 4.0 will continue the work of the Federal Government's "Future Project INDUSTRIE 4.0" within the framework of the High-Tech Strategy. The main objective is the development and expansion of knowledge and understanding as well as the distribution of research results and their practical application in INDUSTRIE 4.0. The Plattform is intended as the central point of contact for all matters INDUSTRIE 4.0 related and, as such, will actively involve and/or participate with all relevant actors.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

The INDUSTRIE 4.0 project builds bridges between manufacturing companies, providers, science, and politics. Cross-industry exchange of ideas and information help accelerate knowledge transfer for innovation in Germany. From the point of view of the three industry associations, INDUSTRIE 4.0 is of tremendous importance to the competitiveness of German industry. The term stands for networked – often with the internet over and beyond company borders – and connected industrial production. As a location we are strong in the development and application of production, automation, and embedded software-intensive IT and have longstanding and established industrial networks.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

From an overall economic perspective, SMEs in particular account for a significant share of employment and value creation in Germany and, as such, are of central importance to the economic structure. INDUSTRIE 4.0 is also of relevance to small and medium-sized enterprises: the next industrial revolution will be characterized by networking and the internet. Value chains become value networks. ICT, automation and production technologies will

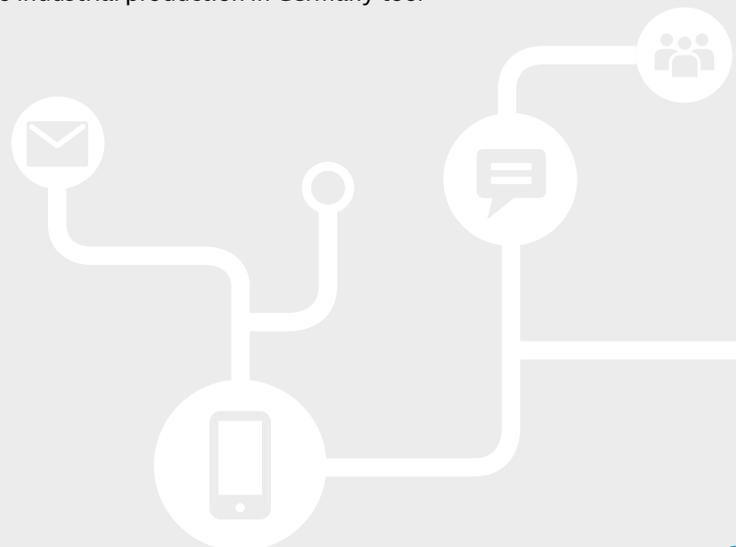
be more intertwined than ever before as a result of INDUSTRIE 4.0. The change process of INDUSTRIE 4.0 and the transformation it represents can be arranged with new opportunities. Examples already exist where INDUSTRIE 4.0 provides real added value to daily operations as well as strategic orientation for agile business behavior.

What impact will INDUSTRIE 4.0 have beyond Germany?

It is important to defend and expand the traditional core of German industry and its excellent international position with the advent of internet technologies. As an export nation, machines and plants are not only sold, maintained and operated worldwide, but also produced in branch factories and by licensees. The concepts at play in INDUSTRIE 4.0 do not observe national borders. The paradigm shift in industrial production and intelligent products creates the opportunity to increase productivity, flexibility and quality in many different economic regions.

How can international companies profit from INDUSTRIE 4.0?

Further improvements in the implementation of industrial processes in manufacturing, engineering, supply chain and life cycle management insist on new ideas, algorithms, technologies, reference architectures, standards, and business models. Germany has the ideal conditions to fulfill these tasks in order to play an internationally leading role in INDUSTRIE 4.0. Numerous standards, like the internet protocol, will be used internationally by foreign companies, thus allowing a swift entry for the Internet of Things and the Internet of Services into industrial production in Germany too.



smartFactory^{KL}

SmartFactory KL

The SmartFactoryKL technology initiative, located at the German Research Center for Artificial Intelligence (DFKI) in Kaiserslautern, is the first European vendor independent demonstration factory for the industrial application of state-of-the-art information and communication technologies. The venture has the purpose of supporting the development, application and propagation of innovative automation technologies in different sectors as well as providing a basis for their extensive usage in science and industry.

Founded in 2005, the SmartFactoryKL initiative is a successful example of public-private-partnership; being a cooperative venture between vendors and users (manufacturers) of modern automation technologies as well as representatives of public interests. The common projects range from fundamental work on basic technologies to the development of marketable products. Members, sponsors and promoters create a living partnership in order to realize the vision of a future industrial landscape with modern and innovative means.

SmartFactoryKL works as a pioneer for the technology transfer of key aspects of INDUSTRIE 4.0 into practice. By operating several modular pilot plants, both state-of-the-art technologies and cutting-edge research results can be implemented and evaluated.

Within these plants, the key aspects of INDUSTRIE 4.0 are demonstrated in an intuitive and accessible way. The central research and demonstration platform of the SmartFactoryKL is its hybrid demonstration plant which can produce a customized product (soap bottles) in the batch size one to customer specification. Terms of requirements, structure and complexity of the laboratory system with industrial production in practice is absolutely comparable. Functional electrical components (i.e. controllers, sensors, actuators) from different vendors are flexibly networked. Communication systems operate wirelessly, both within the system as well as for overall control levels.

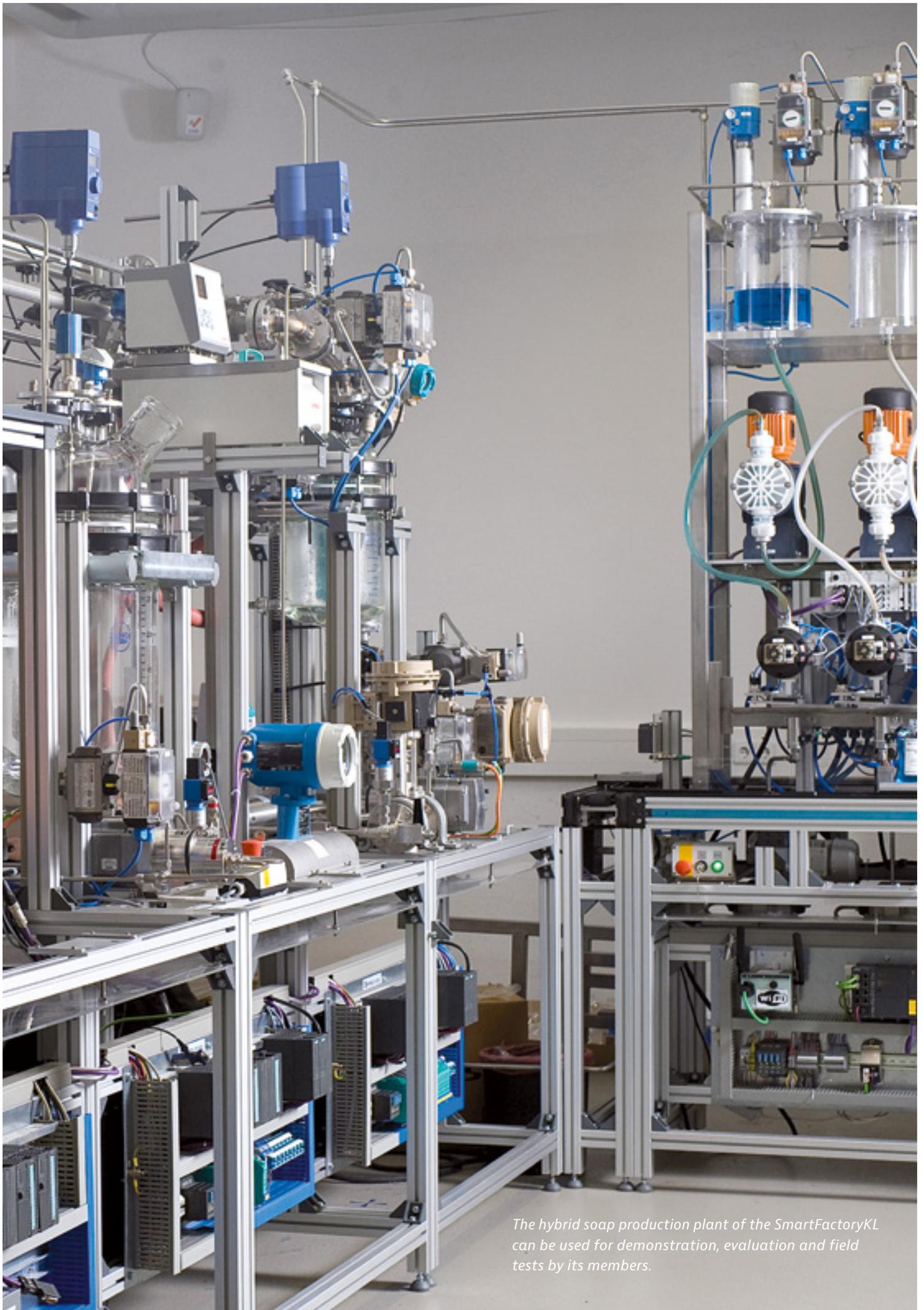
The mobile production line showcases the flexible production of an exemplary product whose components (i.e. case cover, case base, printed circuit board) are handled, mechanically machined, and assembled. The product is able to control its own production process as it has all of the necessary information available in its digital product memory stored on an RFID tag. The process is not controlled by a standard programmable logic controller (PLC), but by a service-oriented, decentralized control system consisting of distributed microcontrollers communicating using internet standards. Human workers are supported with innovative mobile device and augmented reality-based assistance systems.



The mobile production plant of the SmartFactoryKL demonstrates the key aspects of INDUSTRIE 4.0: smart product, collaborative machine and augmented operator.



www.smartfactory-kl.de



The hybrid soap production plant of the SmartFactoryKL can be used for demonstration, evaluation and field tests by its members.



Industry Voices: A Selection

A number of companies in Germany are already developing and implementing INDUSTRIE 4.0 technologies for use. A selection of companies provide their INDUSTRIE 4.0 perspective.



BOSCH

Invented for life

Robert Bosch GmbH

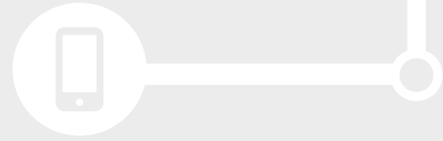
The Bosch Group is a leading global supplier of technology and services. In 2012, its roughly 306,000 associates generated sales of EUR 52.5 billion. Since the beginning of 2013, its operations have been divided into four business sectors: Automotive Technology, Industrial Technology, Consumer Goods, and Energy and Building Technology.

The Bosch Group comprises Robert Bosch GmbH and its roughly 360 subsidiaries and regional companies in some 50 countries. If its sales and service partners are included, then Bosch is represented in

roughly 150 countries. This worldwide development, manufacturing, and sales network is the foundation for further growth. Bosch spent some EUR 4.8 billion for research and development in 2012, and applied for nearly 4,800 patents worldwide. The Bosch Group's products and services are designed to fascinate, and to improve the quality of life by providing solutions which are both innovative and beneficial. In this way, the company offers technology worldwide that is "Invented for life."



www.bosch.de



What role does your organization play in Germany's INDUSTRIE 4.0 project?

Bosch finds itself in a dual role on the way to networked and integrated industry ("INDUSTRIE 4.0"). The company itself deploys technologies and software in order to network its own manufacturing base. On top of this, the company also develops solutions in this area. Bosch Rexroth provides numerous solutions for the Factory 4.0. Bosch Packaging Technology is already building intelligent equipment for intelligent factories in the pharmaceuticals and foodstuff industries. A software suite developed by Bosch Software Innovations also optimizes the complete equipment maintenance process.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

The advent of Web 3.0, i.e. the Internet of Things and Services, in industrial production provides Germany with enormous opportunities in two ways. On the one hand, German companies will develop, sell and export technologies and products for networked industry. On the other hand, the use of these technologies will improve the efficiency, and therefore competitiveness, of German industry.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

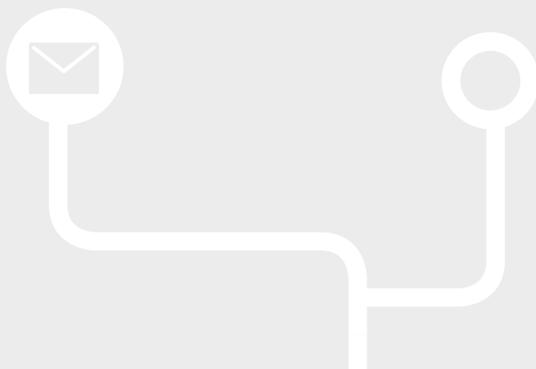
German companies are – notwithstanding the increasing competition from Asia – leaders in plant and mechanical engineering. German companies also have considerable know-how and a competent workforce in the fields of IT, embedded systems and automation technology. The framework for a concentrated implementation of networked production has been established with the creation of the BITKOM, VDMA, and ZVEI-funded "Plattform INDUSTRIE 4.0." German companies must actively shape the way to networked production and not lose sight of what is required.

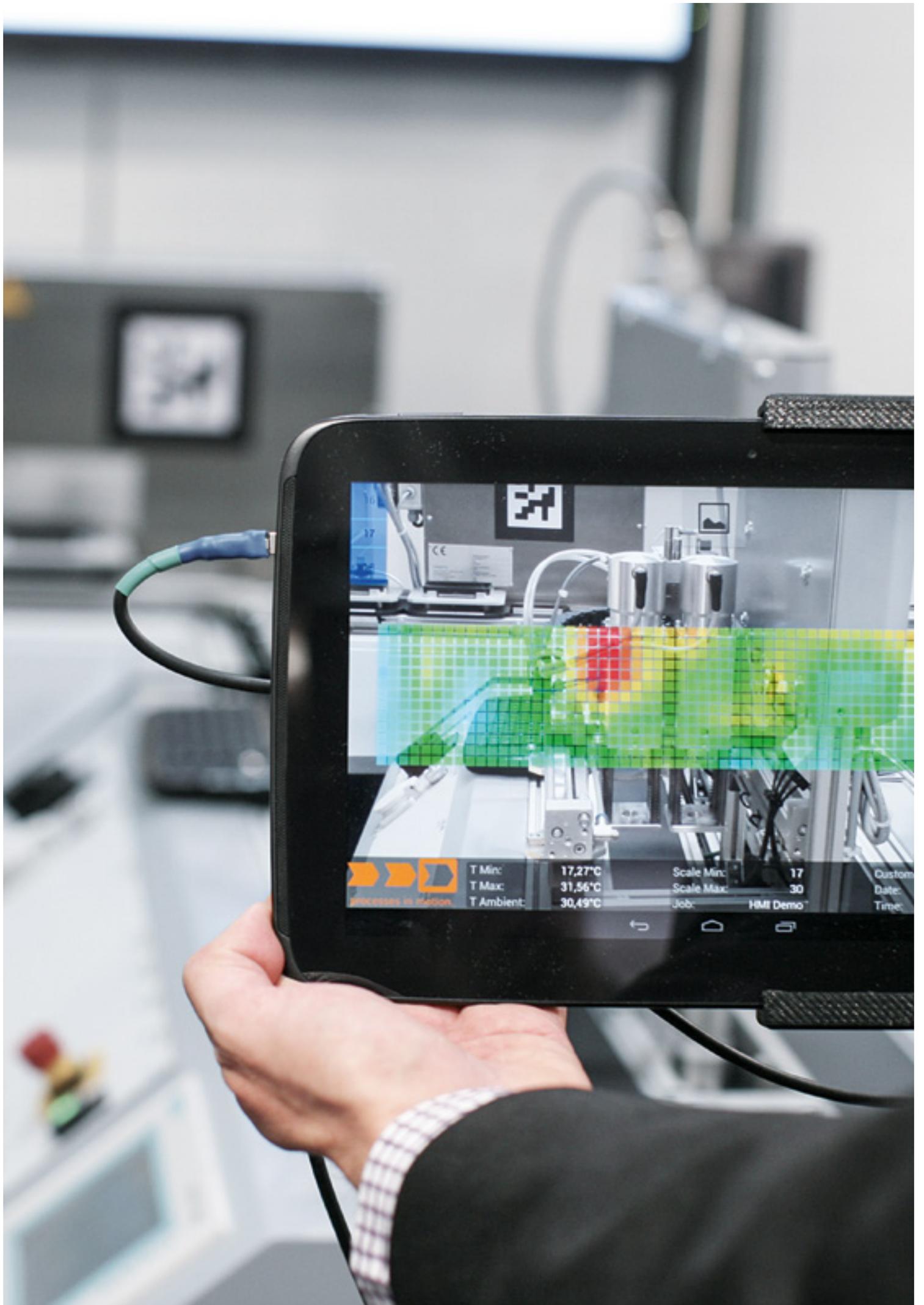
What impact will INDUSTRIE 4.0 have beyond Germany?

The ideas behind INDUSTRIE 4.0 will change existing value chains – even across national borders. Value chains in which companies and business processes are horizontally integrated will emerge. This means that business processes – including their engineering – will be consistently designed across the whole value chain. Production systems are conceived in networks – from the supplier to the customer. These highly dynamic business networks provide potential for innovation and new business models. The same also applies to better data generation and evaluation.

How can international companies profit from INDUSTRIE 4.0?

Digitalization and networking help to optimize the value chains: customers are no longer obliged to choose from a fixed product spectrum set by the manufacturer, but instead are able to individually combine single functions and components. The range of variety will become profitable for companies. This can consequently increase the size of the market and turnover. At the same time, customer satisfaction increases as the internal operative costs sink as a result of increased value chain digitalization.





FESTO

Festo AG & Co. KG

Festo is a leading international supplier of automation technology for factory and process automation. A globally oriented and independently run family business based in Esslingen, the company has established itself as a performance leader in the sector thanks to its innovations and problem-solving competence in the field of pneumatics. Today the company provides pneumatic and electric drive technologies for factory and process automation to more than 300,000 customers in 200 industry sectors across the world. Together with partners from science and industry, Festo is conducting research into new solutions for merging modern information and communication technologies with classical industrial production processes. The trend towards increasingly individualized products in smaller quantities and increased variety requires technologies that are able to continuously adapt to changing production conditions.

Festo recognizes intelligent components which organize themselves and process requests from higher level control systems as the basis for tomorrow's production systems. Festo is actively developing precision engineering and microsystem technologies in order to realize fully networked overall systems. Festo also conducts research into solutions which allow the human workforce to directly interact with new machine and robot technologies. To this end, the company is also extensively concerned with the proper provision of education and training for the next generation of workers in the new production world.



www.festo.com

What role does your organization play in Germany's INDUSTRIE 4.0 project?

Festo contributed to the recommendations made by the Industry-Science Research Alliance. Within this context, a "Resilient Factory" application case – with systems that are tolerant to disruptions – was introduced. These activities have subsequently been transferred to the Plattform INDUSTRIE 4.0 in which Festo is also very much actively involved.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

From a European perspective it is important to ensure that production in high-wage countries, of which Germany is one, remains competitive in the long term. INDUSTRIE 4.0 activities will contribute to achieving this. The perspective merging of manufacturing technology with IT can be carried out in especially efficient manner in Germany in particular, as public funds are also in operation. This special situation allows the attractiveness of Germany to be significantly increased with INDUSTRIE 4.0.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

The creation of commonly defined standards with widespread effect is an important part of

INDUSTRIE 4.0 activities. Continuous and open standard architectures are also clearly more advantageous for small and medium-sized enterprises (SMEs) than closed concepts from major concerns that shape the market themselves. It is therefore worthwhile for SMEs to force non-proprietary solutions within an INDUSTRIE 4.0 context.

What impact will INDUSTRIE 4.0 have beyond Germany?

Activities are being closely followed, for example, in Great Britain and the USA. Horizontal networking in value chain networks is not limited to just one company or country. Successful concepts which are developed will also be accepted internationally.

How can international companies profit from INDUSTRIE 4.0?

As already alluded to in the answer to the previous question, economic concepts are not applied nationally. International companies will be able to benefit just as much where technological and commercial advantages arise from the implementation of INDUSTRIE 4.0 concepts.





SAP AG

As market leader in enterprise application software, SAP helps companies of all sizes and industries run better. From back office to boardroom, warehouse to storefront, desktop to mobile device – SAP empowers people and organizations to work together more efficiently and use business insight more effectively to stay ahead of the competition.

As manufacturers face increased cost pressure and market volatility, product life cycles and test cycles are getting shorter. Products are becoming more complex and customized. Manufacturers find that moving production to emerging countries with cheap labor costs is no longer a path to success as they must balance customization with mass production. Production must increasingly be local, e.g. with 3D printers, to meet rapid changes in demand. Other factors also rise in importance – taking advantage of low energy costs as well as co-locating R&D and manufacturing to accelerate time-to-market.

Today, the manufacturing industries undertake a new and profound shift as business and technology trends converge in an unprecedented way. Manufacturers can now add sensors and microchips to tools, machines, vehicles, buildings, and even raw materials to make products “smarter.”

These smart items will provide a wealth of data that can be used to better understand products and potential issues around them. The ongoing digitalization of products and services is also freeing manufacturers and their customers from fixed locations. In the future, spare parts might be produced at the locations where original parts fail, saving significant costs related to transportation and inventory. As technology fosters stronger vertical integration between shop floor and global business strategies (as well as greater horizontal integration across design, planning, production of products and service provision), manufacturers are increasingly more responsive and efficient than before. They also benefit from agile, self-organized business networks that allow local execution of global business plans.



Companies need to be aware of the current business and technology trends and prepare for the upcoming transformation. SAP offers a holistic framework to align business models, technology platforms and solutions on the way forward. To integrate the industrial value chain and product lifecycles, business IT must seamlessly integrate processes: from product design to supply chain management, production, aftermarket service, and training. SAP's “Idea to Performance” initiative helps manufacturers seize new business opportunities using Big Data, 3D Visualization, Cloud and Mobility solutions to create new insight and connect with partners and customers. SAP's “Idea to Performance” concept covers the following areas:

- Sustainable innovation
- Responsive manufacturing
- Operational excellence
- After-market service

Solutions within the “Idea to Performance” portfolio enable intelligent process execution, resourceful operations, and intuitive user experiences. They help customers become smarter, faster, and simpler.



www.sap.com



Smarter

Provide intellectual power and insightful decision support



Faster

Enable quicker time-to-market and improved brand recognition



Simpler

Improve adaptability, consumability, and flexibility

What role does your organization play in Germany's INDUSTRIE 4.0 project?

SAP has been engaged in several public research projects and initiatives in the context of INDUSTRIE 4.0 and contributed to the recommendation paper issued by acatech – the National Academy of Science and Engineering. SAP provides technologies and solutions that help companies to embrace the upcoming changes in the manufacturing industries. SAP follows a holistic approach called "Idea to Performance" enabling companies to develop new business models and a roadmap for implementing INDUSTRIE 4.0 scenarios.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

For highly industrialized countries like Germany, INDUSTRIE 4.0 is a great opportunity to keep manufacturing jobs in the country and secure long-term growth and innovative strength. German manufacturers are often highly specialized global leaders in their field. With INDUSTRIE 4.0, they can further enhance their competitive advantage by becoming more efficient and responsive to market changes and introducing new service offerings based on a wealth of data from smart products and machines.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

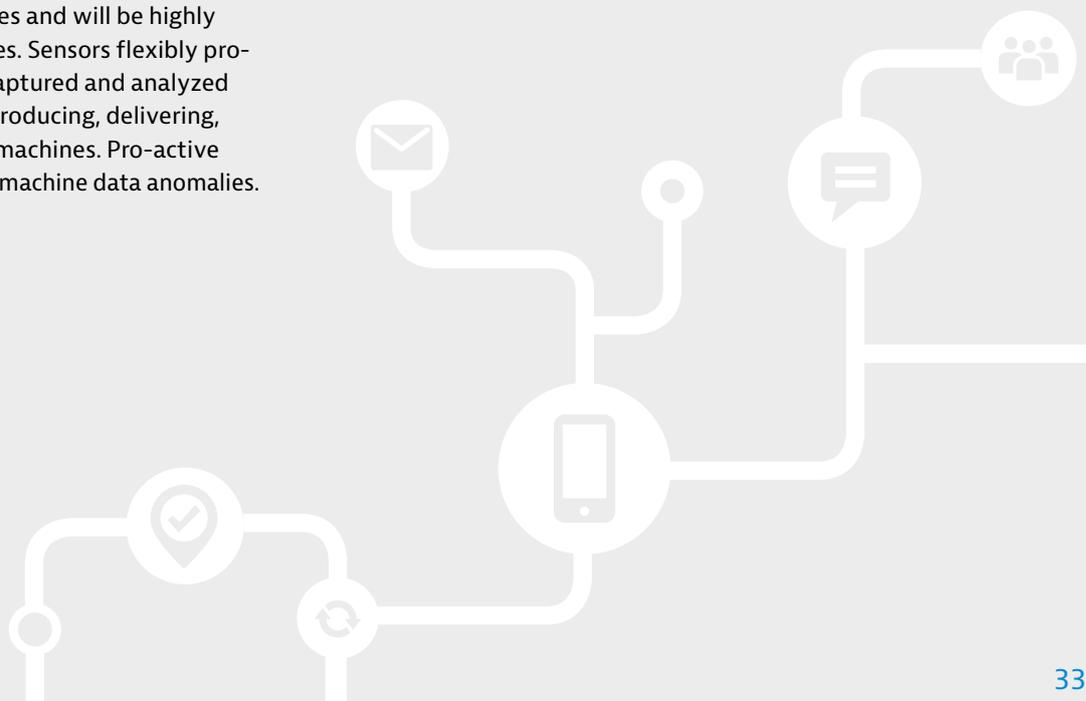
With INDUSTRIE 4.0, supply chains will evolve into highly adaptive networks. Small and midsize companies will play an important role in such value-add networks. By integrating INDUSTRIE 4.0 concepts and technologies, they can provide individualized products and services and will be highly adaptive to demand changes. Sensors flexibly provide machine data that is captured and analyzed while the manufacturer is producing, delivering, assembling, and operating machines. Pro-active services for example trigger machine data anomalies.

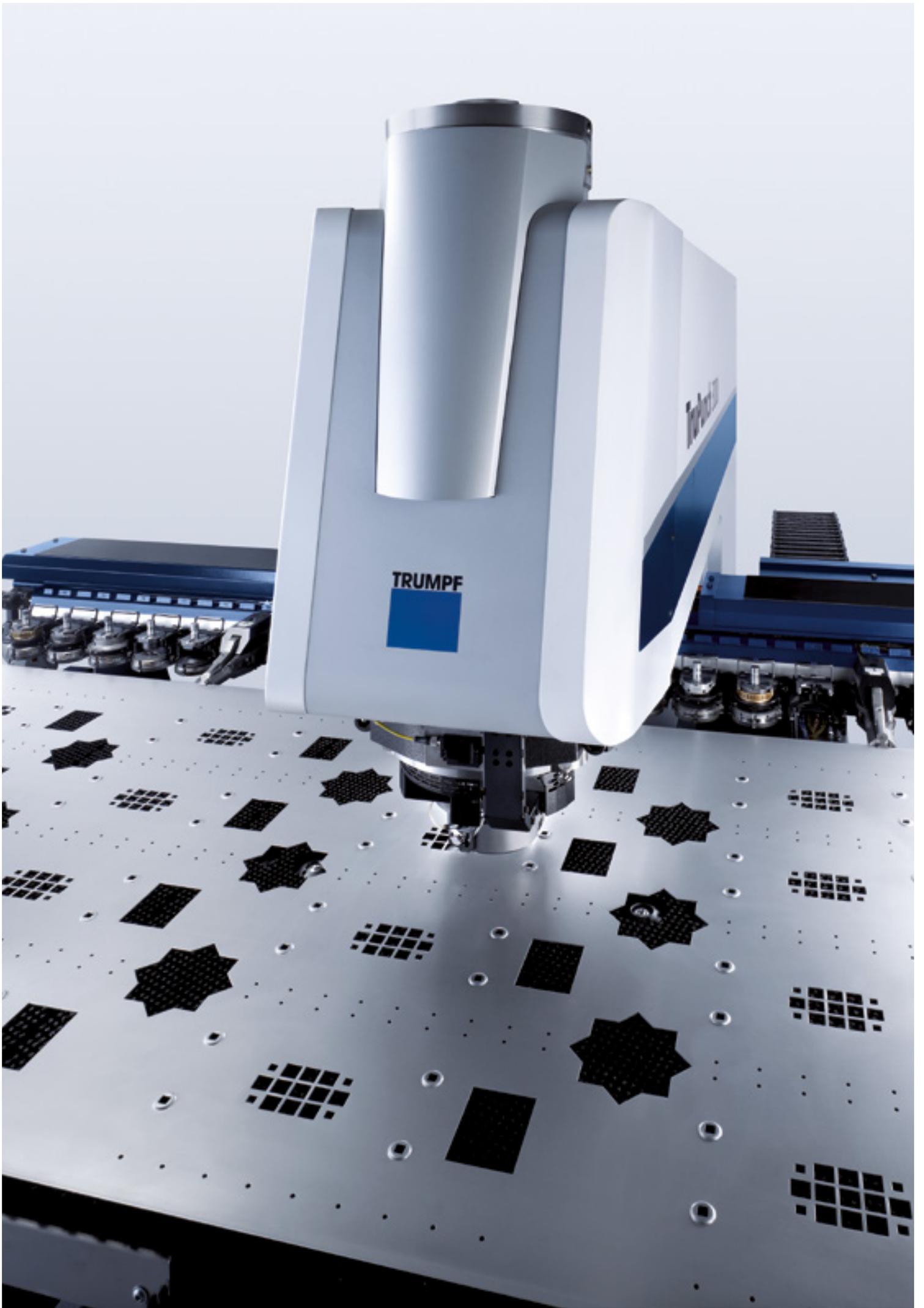
What impact will INDUSTRIE 4.0 have beyond Germany?

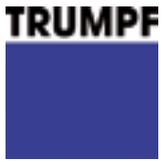
Manufacturers all over the world face increased cost pressure and market volatility. Product life cycles are getting shorter and products are becoming more complex and customized. Manufacturers must find ways to balance customization with mass production. Production will increasingly be local to meet rapid changes in demand. Many countries are aware of this trend and launched programs similar to INDUSTRIE 4.0. In addition, INDUSTRIE 4.0 addresses some of today's biggest challenges such as resource and energy efficiency.

How can international companies profit from INDUSTRIE 4.0?

INDUSTRIE 4.0 is a global topic, encompassing fast-growing markets like China or India as well as traditional manufacturing countries such as Germany, US, Korea, or Japan. Wherever they are based, companies can use INDUSTRIE 4.0 scenarios to prepare for upcoming changes and lead this new industrial revolution. With SAP's holistic "Idea to Performance" approach, our customers can position themselves and start implementing INDUSTRIE 4.0 scenarios to work smarter, faster, and simpler.







TRUMPF GmbH & Co. KG

TRUMPF is a leading global technology company with machine tools, laser technology, electronics and medical technology as its business fields. Products manufactured with the company's technology can be found in almost every sector of industry. TRUMPF is the world technological and market leader for machine tools used in flexible sheet metal processing, and also for industrial lasers.

In 2012/13 the company – which has approximately 9,900 employees – achieved sales of EUR 2.34 billion. With more than 60 subsidiaries and branches, the TRUMPF Group is represented in almost all the countries of Europe, North and South America, and Asia. It has production facilities in Germany, China, France, Great Britain, Japan, Mexico, Austria, Poland, Switzerland, the Czech Republic and the USA.



www.trumpf.com

What role does your organization play in Germany's INDUSTRIE 4.0 project?

TRUMPF has been a member of the federal government initiated INDUSTRIE 4.0 Working Group since 2011 and has already provided a decisive contribution to the definition of the "smart factory." As well as this, TRUMPF is also active in the Plattform INDUSTRIE 4.0 management board and steering group set up by the VDMA, BITKOM and ZVEI industry associations. Alongside projects like CyProS – in which 20 partners are conducting research into the implementation of cyber-physical production systems – TRUMPF is also working to create solutions for more productive and efficient production processes.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

The INDUSTRIE 4.0 vision is one of networked systems in which no capacity bottlenecks or available resources remain undetected. They are transparent, can react to variations flexibly and allow humans to intervene as intelligent decision makers according to the situation. These systems will allow individual products to be produced in an efficient and swift manner normally associated with mass production. The INDUSTRIE 4.0 project creates the conditions for the implementation of such production networks in Germany.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

Small and medium-sized companies in particular must react quickly to changes – for example short-term customer orders. The networked manufactur-

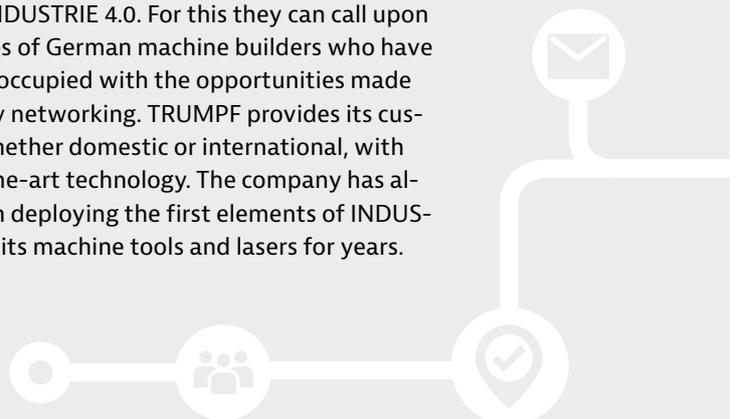
ing foreseen in INDUSTRIE 4.0 allows all production processes to be transparent and easily influenced. INDUSTRIE 4.0 provides the companies with the flexibility which allows them to remain internationally competitive.

In your opinion what impact will INDUSTRIE 4.0 have beyond Germany?

The "Global Facility" is one of the five elements of the Smart Factory. Production systems are already often internationally networked – with INDUSTRIE 4.0 this networking will continue to increase. Moreover, the new technological opportunities are not only available in Germany. The advantages that the Internet of Things for example brings to manufacturing won't go unnoticed in other countries. The different elements of INDUSTRIE 4.0 will therefore also affect production in other countries.

How can international companies profit from INDUSTRIE 4.0?

Just as is the case for German companies, international companies will be able to more efficiently shape their own production according to the principles of INDUSTRIE 4.0. For this they can call upon the services of German machine builders who have long been occupied with the opportunities made possible by networking. TRUMPF provides its customers, whether domestic or international, with state-of-the-art technology. The company has already been deploying the first elements of INDUSTRIE 4.0 in its machine tools and lasers for years.





WITTENSTEIN

WITTENSTEIN AG

With an international workforce of around 1,700 and turnover of EUR 241 million in 2012/13, WITTENSTEIN AG stands for innovation, precision and excellence in the world of mechatronic drive technologies – both nationally and internationally. The group, with headquarters in southern Germany, covers eight innovative business fields with respective subsidiary operations: servo gearheads, servo drive systems, medicine technology, miniature servo units, innovative gearing technology, rotary and linear actuator systems, nanotechnology as well as electronic and software components for drive technology. With around 60 subsidiary and representative operations in approximately 40 countries, the company is represented in all important global technology and sales markets, WITTENSTEIN focuses on innovation – without limiting itself solely to technological innovations and products but also

applying itself to new processes. The company intends to merge the terms “innovation” and “factory” in order to bring the new thinking to the fore: innovative products need innovative production. Together with partners from science and industry, WITTENSTEIN has set out on the path of making its own production INDUSTRIE 4.0 capable. INDUSTRIE 4.0 use cases will be carried out at the “Urban Production of the Future” showcase factory established in Fellbach near Stuttgart. A WITTENSTEIN innovation factory and production facility, which brings together development, sales and production of the different mechatronic company units together at one site, is currently being built at the company headquarters in Igersheim-Harthausen.



www.wittenstein.de



What role does your organization play in Germany's INDUSTRIE 4.0 project?

Dr. Manfred Wittenstein, chairman of the WITTENSTEIN AG board, is certain: INDUSTRIE 4.0 will most likely only become a reality in the next decade. However, companies who want to internationally profit from the new technology wave must lay the proper foundations today. New answers are required in the world of production in order to master the challenges of the future. As one of the INDUSTRIE 4.0 driving forces, WITTENSTEIN, together with its partners, is seeking out the smart answers in order to meet future production requirements. This also has something to do with corporate responsibility in terms of society and the environment.

How does the INDUSTRIE 4.0 project contribute to the attractiveness of Germany as a location?

As a high-performance location, Germany is well equipped to meet global challenges. Should German industry set the pace for the fourth stage of the industrial revolution, then developments made in INDUSTRIE 4.0 will also help contribute to secure Germany's position. Important and necessary for success here is the integration of science and industry – the major location advantage of German mechanical engineering companies since time immemorial. German companies have a great opportunity to help shape new standards across the entire value chain in a pioneering role.

What advantages does INDUSTRIE 4.0 have for small and medium-sized companies?

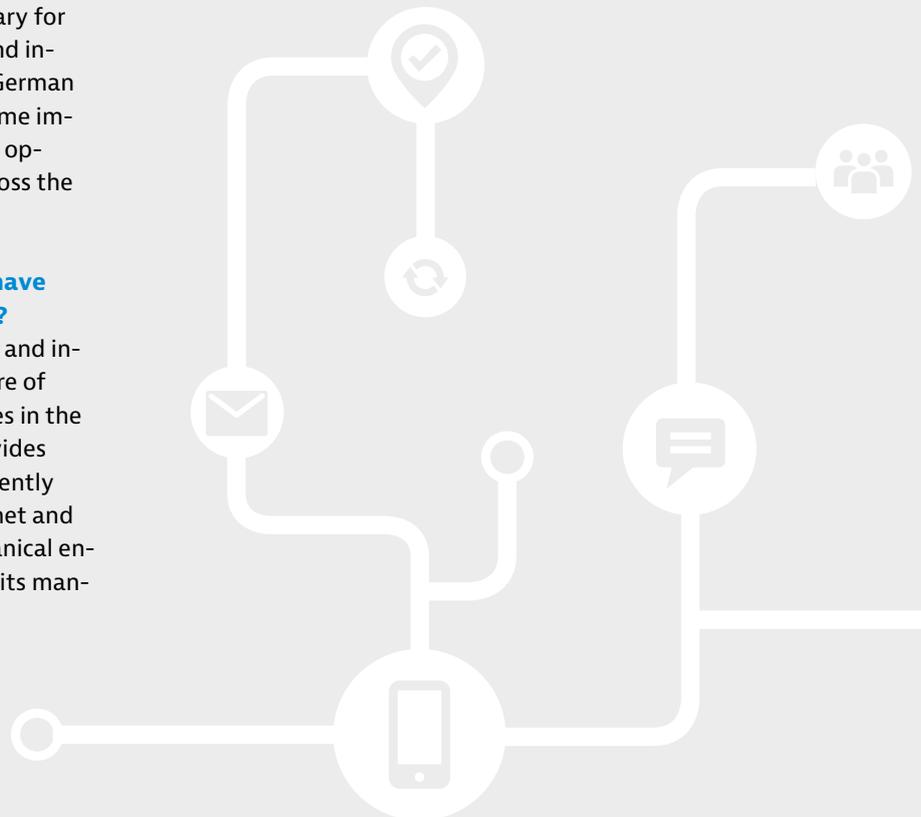
Germany's Mittelstand is used to including and integrating new skills. In fact it is the structure of many small and often family-run businesses in the machinery and equipment sector that provides the ideal conditions for quickly and intelligently mastering the way to the merging of internet and production technology. The German mechanical engineering industry could be a pioneer with its manufacturing and technology.

What impact will INDUSTRIE 4.0 have beyond Germany?

"INDUSTRIE 4.0 will become the global language of production." Hartmut Rauen, VDMA (Verband Deutscher Maschinen- und Anlagenbau – German Engineering Federation)

How can international companies profit from INDUSTRIE 4.0?

INDUSTRIE 4.0 will yield a new generation of automation technology and production systems. The goal for German companies is to become the lead provider in the future market for such systems. For foreign companies, the opportunity exists to profit from the technological achievements of INDUSTRIE 4.0 as well the integration and application know-how of German providers of highly productive systems in this market.



Our Services

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Imprint

Publisher

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Print

Asmuth Druck & Crossmedia GmbH & Co. KG,
Köln

Notes

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July 2014.

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Order Number

20750

Germany Trade & Invest would like to
thank the following organizations and
companies for their invaluable support in
making this publication:

- acatech – National Academy of Science
and Engineering
- DMG MORI AG
- German Research Center for Artificial
Intelligence – DFKI
- Fraunhofer-Gesellschaft
- it's OWL Clustermanagement GmbH
- Plattform INDUSTRIE 4.0
- SmartFactory KL
- Robert Bosch GmbH
- Festo AG & Co. KG
- SAP AG
- TRUMPF GmbH & Co. KG
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Supported by:



Federal Ministry
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All investment services and related publications are free of charge. Germany Trade & Invest is supported by the Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag.

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