Progress within the network
Demonstrator 2020
Production Level 4 –
Our vision of production in the future

First introduced in Kaiserslautern in 2005, the term Industrie 4.0 has since radiated around the world. Originally, Industrie 4.0 primarily described the digital networking of machines. Over time, many other nuances have become common, for example, Vacation 4.0, Administration 4.0, and Labor Law 4.0.

In 2018, we began a series of intensive discussions focused on the further development of Industrie 4.0. In addition to engineers and technology-oriented researchers, we brought economists, physicists, and social scientists on board. For us, Industrie 4.0 describes a period of development, an era. In the beginning, we networked cyber-physical production systems. Currently, our efforts center on cognition and the use of AI. The years ahead are devoted to agile, autonomous production structures. However, the term autonomous has a bitter aftertaste, because it connotes fully automated functions without human interaction on factory floors devoid of people. That is a view of future development that we do not share. We decided to look for a new, more appropriate term and came up with Production Level 4.

Production Level 4 is an agile concept, subject to further development as new insights arise. The Corona virus has shown us the potential of using digital tools to support humans at work. Meetings are held in virtual spaces, remote working from home is a reality for office colleagues. For those working on the factory floor, remote work also becomes a tangible possibility when access, control, and monitoring of machines is possible from anywhere. This saves the commuting time and eliminates compulsory presence. Members of the younger generations, in particular, want more family and leisure time and expect flexible work hours. Production Level 4 provides an initial concept that recognizes these implications for the factories of the future.

In this brochure, we present the companies that have actively contributed to our Production Level 4 demonstrator. Included are the findings from multiple research projects that find practical application in the development of the demonstrator.

Our experts lead joint working groups that encourage the active participation of our members and the results are made available to the companies. Interesting contacts and lucrative business ideas are one of the end results. If you are interested in cooperation or membership, please contact us.

In closing, I hope you enjoy further reading and thank you for your support in building the world’s first Production Level 4 demonstrator!

Sincerely,

Prof. Dr. Martin Ruskowski,
Chairman of the Board at SmartFactoryKL
Why is it called Production Level 4?
The term Production Level 4, with the number 4, is a continuation of Industrie 4.0. We see Production Level 4 as a kind of update to Industrie 4.0. The number 4 also refers to a level of autonomy. In autonomous driving and manufacturing, Level 5 is defined as the absence of human involvement. That is not our vision. Production Level 4 emphasizes the importance of people to production.

What is the aim of Production Level 4?
Production Level 4 means using Artificial Intelligence to gain the agility to respond to external influences and increase the reliability of production. Production systems will become more flexible, more robust, and highly reliable. We want to achieve this through autonomous processes. In the new, extensively autonomous production, people are employed according to their specific abilities and assisted by intelligent processes.

What does the future of manufacturing look like?
Production that only produces goods that have been ordered is flexible production. Future production will resemble an online marketplace, where smart machines are equipped with intelligence and offer services and make simple decisions. In parallel, a higher-level system addresses other problems. In the smart factory, the individual product independently finds its way through the manufacturing process. Keywords such as cooperativeness, resource adaptation, self-learning, decision-making and explanatory skills will become routine.

What roles will humans play?
At Production Level 4, we see fully automated production stations on the factory floors taking over more and more of the routine and repetitive tasks from people in the future. The more complex activities, especially those involving customization, cannot and should not be left to automation. People will concentrate on their strengths in the factories of the future: complex operations, strategic choices, and the continuous search for product and process improvements.
The new demonstrator reflects the technical implementation of our current research results and is a practical example of what Production Level 4 is all about. We intend to continue development of the demonstrator until 2025. The current version already incorporates four innovations.

1. **Use-Case**

The use-case is simple: A customer orders an individually configured USB memory stick. The visual appearance as well as the data to be entered on the stick is selectable. However, the specific memory stick is not the key focus. What we exhibit is a new vision of production!

2. **Module exchange**

If the customer selects the option „Save quality control photos to USB,” the demonstrator must rely on a special quality module. The activity of the plant is based on function or abilities. If a required ability is missing, an automatic reconfiguration of the plant systems is initiated. The operator is instructed to install the required module. Currently, the two existing quality modules are provided by different manufacturers and work together in the system without any problem. When a new module is docked, an automated release process begins.

3. **GAIA-X**

The digital connection of the system to other production locations via the European cloud system GAIA-X is new. The Cloud, still under construction, enables secure data connections and exchange. This feature can be used to trigger production at other locations or to perform simultaneous data updates on the machines.

4. **AI Methods**

A special adaptable artificial intelligence tool is implemented in the quality control module of the system. The AI algorithms work on three levels: in the module itself, in a higher-level plant system, or in a Cloud, for example, like GAIA-X.

5. **System architecture**

The innovative system architecture is of a modular design. The system can be easily extended with new features.
EPLAN offers software engineering and services in the fields of electrical engineering, automation and mechatronics. The company develops one of the world’s leading software solutions for machines, plant systems, and switch cabinet design. Standard and custom ERP and PLM/PDM interfaces ensure consistent data along the entire value chain. EPLAN was established in 1984 and belongs to the Friedhelm Loh Group.

**Contribution to the demonstrator:**
The new SmartFactory® demonstrator is 100% planned with EPLAN. The EPLAN portfolio and its products EPLAN Electric P8 (ECAD), EPLAN Fluid (fluid engineering), EPLAN Pro Panel (control and switching unit engineering) are ideally suited for the job. The entire system is configured with EPLAN and stored in the cloud after completion via EPLAN’s eVIEW. Project data is shared and Cloud-to-Cloud connections are implemented via eVIEW.

HARTING provides hybrid sensor connectivity to and from the Cloud. The company’s digital solutions link classic connectivity with software-based solutions and services. The company also produces hardware and software for customers and applications in the fields of automation technology, mechanical and plant engineering, robotics, and transportation.

**Contribution to the demonstrator:**
HARTING is responsible for a module that demonstrates edge computing solutions. The connectivity used provides a unified interface for the power and communication infrastructure. Intelligent plug connectors are equipped with additional functions that contribute to system safety: for example, to avoid risk, the concept ensures that unlocking is only possible when the system is disconnected from the power supply.
IBM supports companies as they transition towards Industrie 4.0. Our customers’ success is based on vertical and horizontal integration, data-based optimization of manufacturing, services, and products as well as more efficient business processes in all areas of operation. IBM offers consulting, design, and implementation as well as the necessary software components, such as platforms/infrastructures, analyses, cloud, security, and edge technologies as well as cognitive – learning – systems. A commitment to platform independence, data sovereignty, reliable AI, and the cooperative approach of SmartFactory™ enables IBM to contribute significantly towards the implementation of Production Level 4 by 2025.

**Contribution to the demonstrator:**
As the AI technology partner of SmartFactory™, IBM supplies the foundation for successful achievement for the vision of Production Level 4. The years of experience has shown SmartFactory™ to be a test lab and showcase for Industrie 4.0 systems, which IBM then implements for its customers. SmartFactory™ is an integral part of IBM’s presentation of value-adding solutions - from shop floor integration and analytics, AI and IoT, productivity improvement options, to OT-IT Security and GaiaX Integration.

Consumers are shaping the trend towards customized products. Our pioneering technologies can achieve the same production speeds in lot size 1 operations as previously expected in mass production.

Markus Sandhöfner,
General Manager, B&R Deutschland

On July 6, 2017 B&R became a business unit of ABB. B&R supplies its customers with perfectly integrated products for machine and plant automation, drive and control systems, visualization, and integrated safety systems. Communication solutions for industrial IoT – in particular, OPC UA, POWERLINK, and standard open-SAFETY – round out B&R’s service portfolio.

**Contribution to the demonstrator:**
ACOPOStrak is the B&R transport system with high speed switching and, thanks to absolute design freedom and intelligent system software, it provides the flexibility required for Production Level 4. B&R introduces the ACOPOStrak system in a simulation environment using a digital twin. The integrated vision system from B&R built into the QA module shows the advantages of intelligent sensors. The camera’s microsecond synchronization with the process controller enables real time process evaluation.

SmartFactory™ is an ideal classroom and factory showcase for IBM. With active partner involvement, we all learn from each other in this creative lab while implementing the current trends – IoT, edge computing, predictive analytics, machine learning, AI for production with our Watson technology, and currently, also GAIA-X and safety solutions. What we put into practice at SmartFactory™ is, in fact, a litmus test for our customers of what will be possible in the future.”

Ralf Bucksch,
Technical Executive Watson IoT Europe

More information at: [www.ibm.com](http://www.ibm.com)

More information at: [www.br-automation.com](http://www.br-automation.com)
Digital twins and artificial intelligence are the key enabling technologies in the understanding of machine data, the intelligent provision of knowledge, and the right recommendations for action during optimal interactions between man and machine at Production Level 4.  

"Empolis and service management products for cloud solutions from Empolis bundle artificial intelligence technologies. These enable a completely new quality of service, customer approach, digitalization „as a service” and business model software – from signal to action. The Knowledge Graph technology from Empolis provides an ideal tool for displaying industrial knowledge, showing the digital twin of the machine with all components, functions, symptoms and sources.

Contribution to the demonstrator:
The Empolis Service Express allows trade visitors to completely reconfigure an industrial production line autonomously. AI-based tools guide the user step-by-step through the process – independent of the end device, with optional AR support, both online and offline. Empolis software supports modular and agile Production Level 4 structures, in which operator, machine, and software function as one unit.

"By bringing ONCITE to the new demonstrator, we highlight our private Edge-Cloud infrastructures, data analysis products, and industry-specific AI-applications."

André Tholig,  
Head of Corporate Development

German Edge Cloud is a start-up that belongs to the Friedhelm Loh Group and is the developer of the first, real-time capable, AI Edge Cloud for industrial use cases. The company offers AI enabled, managed edge solutions for the manufacturing sector in collaboration with affiliate company Innovo Cloud and partners like IoTOS and Fraunhofer Gesellschaft. German Edge Cloud provides private edge-cloud infrastructures (IaaS), data analysis software (PaaS), and industry-specific AI applications (SaaS) that make data available quickly and easily in networked factories, while allowing data sovereignty for the customer.

Contribution to the demonstrator:
An industrial edge data center is implemented in the form of ONCITE, the all-in-one solution for the new demonstrator. ONCITE enables SmartFactory® to significantly increase the internal value creation by using the existing internal factory IT-infrastructures as data sources while, at the same time, fully meeting the future data sovereignty requirements of digital production systems.
HUAWEI is a leading global supplier of Information and Communication Technology (ICT). Using integrated solutions in four core areas — telecommunication networks, IT, smart devices, and Cloud services — our aim is to offer a digital, networked, intelligent world to every person, every home, and every company.

**Contribution to the demonstrator:**
Using 5G and LTE connectivity, Huawei is meeting the increasing demands for mobility, real-time, and data rates in flexible, autonomous production plants. Advanced edge computers are equipped with special AI chip elements to enable real-time, machine-based AI applications such as machine vision for quality control. The TSN technology supports deterministic data transmission between infrastructure and server.

More information at: www.huawei.com

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The Pilz Group is a global supplier of products, systems and services for automation technology. With 42 subsidiaries and branches the family-owned company provides safety for man, machine and the environment worldwide. The technology leader offers complete automation solutions comprising sensor, control and drive technology - including systems for industrial communication, diagnostics and visualisation.

**Contribution to the demonstrator:**
Pilz safety solutions protect physical and digital access to the machine or process. By combining machine safety components (safety gate system, emergency stop) with an operating mode selection and access permission system plus a firewall solution, a coherent machine access concept is created, which takes into account not only the safety of your machine but also its industrial security.

More information at: www.pilz.com

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MiniTec Smart Solutions is a tech startup that develops interactive assistance systems for manual assembly processes. We implement various software and hardware components that communicate and cooperate with each other, with connected devices, and with the production IT to produce a tailor-made solution at low cost for the customer. The company was established early in 2017, as the result of many years of cooperation between MiniTec GmbH & Co. KG and the technology initiative SmartFactory³.

**Contribution to the demonstrator:**
For the trade fair, MiniTec Smart Solutions is creating user interfaces between the demonstrator system and the operator. Touchscreens are used to query important operating parameters, control the integration and removal of modules in the production process, and to support specific work steps. The interface design includes a dedicated graphical editing tool that allows quick and iterative changes.

More information at: www.minitec-smart-solutions.de

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proALPHA has been supporting small and medium-sized companies in various industries for more than 25 years. About 1,200 employees support more than 4,500 customers worldwide in their digital transformation. Our integrated ERP software forms the digital backbone that controls the systems and processes along the entire value chain. Other modules, such as plant data collection and data analysis, as well as those from certified partners can easily be connected.

**Contribution to the demonstrator:**
proALPHA serves as the interface between business management and the manufacturing level. It is easy to design a customized USB memory stick using the integrated product configurator – even browser-based and with an interactive 3D preview. The communications interface is based on technologies such as REST and MQTT and ensures the synchronization of order data and feedback to and from the ERP system.

More information at: www.proalpha.com
TÜV SÜD provides focused consulting, training, testing and certification services related to Industry 4.0. More than 24,000 employees work at over 1,000 locations in about 50 countries to continually improve technology, systems and expertise. They contribute significantly to making technical innovations such as Industry 4.0, autonomous driving and renewable energy safe and reliable.

**Contribution to the demonstrator:**

As a member of technology initiative SmartFactoryKL, TÜV SÜD is providing support and consulting for the world’s first vendor-neutral production facility under Industrie 4.0. The TÜV SÜD experts have developed a modular certification system for supplying interactive and real-time-capable machinery safety evaluations. In doing so, their focus was on designing a catalogue of methods and a framework of rules for developing and evaluating Industrie 4.0 components, machine modules and systems.

More information at: [www.tuvsud.com/de](http://www.tuvsud.com/de)

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Research Contributions to the trade fair demonstrator 2020

An industrial use case involves LBAM machines (Laser Based Additive Manufacturing) in an integrated, multi-process production station [cell] that includes additive and subtractive processes. The concept of hybrid production cells was introduced as a pre-competitive demonstrator and implemented in a real production environment, validated by the production of metallic workpieces.

**The HyproCell and PERForM project**

Development and validation of integrated multiprocess HYbrid PROduction CELLS for rapid individualized laser-based production and

Production harmonized Recconfiguration of Flexible Robots and Machinery (October 2015 to September 2018)

The HyproCell project integrates the earlier work of PERForM, the project that developed new strategies and methods for the implementation of a new generation of flexible and smart production networks. For example, Information and Communication Technologies are now being developed to facilitate the transformation of existing systems into flexible Plug & Produce production systems. Project HyproCell is currently testing production processes for the integration of hybrid cells.

Relevance to SmartFactoryKL and priority research areas:

- Define a modular system architecture for two pilot plants
- Implement prototype of architecture elements in SmartFactoryKL
- Test and validate system architecture

Contribution to the trade fair demonstrator:

The system architecture elements are integrated into the design of the trade fair demonstrator. For example, the trade fair demonstrator orchestrator uses the findings from HyproCell and code segments for connecting and monitoring system modules. The integration layer of the trade fair demonstrator was adapted using the concepts from HyproCell.

Detailed information at: [www.hyprocell-project.eu](http://www.hyprocell-project.eu)
Relevance to SmartFactoryKL

Relevance to SmartFactoryKL's priority research areas:
- SmartFactoryKL serves as a manufacturing testbed for cyber-physical production systems and the safe use of the developed architecture and components.
- Reference architecture development and an operating system of distributed control.
- Edge server development for a system capable of production decisions (e.g., predictive maintenance, real-time communication and calculation) even without a central server.

Contribution to the trade fair demonstrator:
Concepts and solutions for safe data transfer between plant components are incorporated in the system architecture of the new demonstrator. For example, the secure ordering process for products via the Internet is based on software components from FarEdge.

Detailed information at: www.faredge.eu

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FAR-EDGE

Factory Automation Reference Implementation Edge Computing Operating System

The FAR-EDGE project implements an edge computing architecture for factory automation, specifically, for the virtualization of the automation pyramid. The aim of the project is to implement highly scalable, flexible, and re-configurable products, as well as a reference operating system for future factory automation with open and safe standards. Validation in mass-customization and resourcing use cases is also included.

Relevance to SmartFactoryKL's priority research areas:
- FAR-EDGE serves as a manufacturing testbed for cyber-physical production systems and the safe use of the developed architecture and components.
- Reference architecture development and an operating system of distributed control.
- Edge server development for a system capable of production decisions (e.g., predictive maintenance, real-time communication and calculation) even without a central server.

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Detailed information at: www.faredge.eu

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BaSys

Basic Industry 4.0 system

The BaSys 4.0 project and the follow-on project BaSys 4.2 work with Fraunhofer IESE and 18 other partners from research and industry to study the use of BaSys middleware to develop the corresponding components in the context of Industrie 4.0. A major focus here is on the versatility of manufacturing, which is sometimes achieved using model-based, skill-related descriptions of the product, process, and resources, as well as a decentralized level of decision making, the so-called controller components.

Contribution to the trade fair demonstrator:
Alas, two concepts from the project have been successfully put into practice in the SmartFactoryKL demonstrators. The controller concept from BaSys is further developed as the basis for the skill-based OPC UA interfaces of the new modules of SmartFactoryKL.

The asset administration shell was also implemented and validated, especially, in connection with the plug-and-produce process for the safety case. The new modules are added to the production line after the appropriate validation and release of potential risks.

Detailed information at: www.iees.fraunhofer.de/de/innovation_trends/industrie4_0/basy42.html

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AUTOWARE

Wireless Autonomous, Reliable and Resilient Production Operation Architecture for Cognitive Manufacturing

AUTOWARE is a project that helps to develop cognitive autonomous production systems and put them into practice. Production technologies based on robotics, smart devices, and cloud services are expanded for use in an Industrie 4.0 environment. At the same time, the structures for the development of business models are tested, e.g., services for automation.

Relevance to SmartFactoryKL's priority research areas:
- Technology development for manufacturer independent pilot plants.
- Development of a new digital product memory.

Contribution to the trade fair demonstrator:
The project resulted in the new digital product memory, which is used in the new trade fair demonstrator. In addition, it was possible to use artificial intelligence that had already been tested and proven. This approach is seen in the optical quality control as well as other AI-based algorithms and implementations.

Detailed information at: www.autoware-eu.org
Technologie-Initiative SmartFactory KL e.V.
Trippstadter Straße 122
67663 Kaiserslautern, Germany

P +49 (0) 631 / 20575-3401
F +49 (0) 631 / 20575-3402
M info@smartfactory.de

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Executive Board
Prof. Dr. Martin Ruskowski (Chairman of the Board)
Dr. Haike Frank, SCHOTT AG
Andreas Huhmann, HARTING AG & Co. KG
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Management
Rudiger Dabelow, DFKI GmbH

Source for images
Christopher Arnoldi
A. Sell