

# Industrie 4.0 in practice – Solutions for industrial applications



## Industrie 4.0 – Made in Germany

### Examples from the mechanical engineering industry



Hartmut Rauen

The German mechanical engineering industry has a key function in the context of Industrie 4.0. As the backbone of German industry, it is a guarantee for growth and prosperity in our society. More than one million people are involved in producing the future, day after day. The mechanical engineering industry is also the data source of smart production. Machine data get captured, recognized, interpreted and transformed into new innovations.

Given this position – and the sector's innovation and market leadership in many areas – the German mechanical engineering industry has an obligation to shape new developments in industrial production. Industrie 4.0 is, without a doubt, one of these new developments. At the smart and networked factory, decentralized self-organization replaces centralized controls. Smart products control their own production process individually. Moreover: Based on communication along the value chain, the product's life cycle is fully traceable. Completely new business models become possible.

Industrie 4.0 is thus not a parallel world, but rather an important trajectory on the way to the future of production. The examples in this brochure show that this development has already begun and implementation is well advanced. More than 50 VDMA member companies present solutions from the industrial practice that clearly illustrate the specific character of Industrie 4.0.

Yet, Industrie 4.0 is a topic for all companies – certainly for small and medium-sized companies, too. It is against this backdrop that the VDMA established the “VDMA Industrie 4.0 Forum”.

The forum comprises an interdisciplinary team of VDMA experts, who view themselves as partners of companies and service providers. Together with VDMA members, the key action fields research, norms and standards, IT security, production and business models, legal frameworks and employee qualification are advanced. VDMA's “IMPULS Industrie 4.0 Readiness Study” with its “Online self-check” as well as the “Guideline Industrie 4.0” support SMEs in mechanical engineering in developing their own Industrie 4.0 implementations. Moreover, numerous activities of the VDMA Industrie 4.0 Forum offer platforms for information sharing and knowledge transfer.

Use this network and join in – it really is worth it.

Hartmut Rauen,  
Deputy Executive Director of VDMA

## VDMA Industrie 4.0 Forum – Modules pave the way

**How can companies benefit from Industrie 4.0? Which aspects need to be taken into account in its implementation? What could the path to connected production look like? The VDMA Industrie 4.0 Forum provides answers.**

Industrie 4.0 heralds a fundamental change in production. IT and Internet technologies are being used more and more extensively in products and factories. Humans, machines and means of production communicate along the entire value chain. However, these changes do not just happen overnight. The development towards Industrie 4.0 is much more evolution than revolution. VDMA accompanies and supports its members in a number of ways to ensure successful implementation step by step.

### Control center for digitalized production

VDMA has pooled its internal know-how in the VDMA Industrie 4.0 Forum, an interdisciplinary team of VDMA experts. As partners and service providers, they offer practical support to the member companies and the VDMA associations and departments in the following areas of activity, which are particularly relevant to Industrie 4.0:

- **Politics & networks:** Important political conditions need to be agreed with stakeholders from politics and society.
- **Production & business models:** Intelligent production systems make organizations and processes more efficient. Automation and batch size 1 production are no longer mutually exclusive. Innovative business areas are created.
- **Research & innovation:** The results of research are a more decisive factor than ever in Germany's competitiveness as an industrial location. Funding instruments need to be reliable and the results of research need to be transferred into industrial practice quickly.
- **Norms & standards:** Consistent standards are the only way to ensure successful networking along the value chain. Participating in drawing up these standards and involving the relevant stakeholders in dialog is crucial.
- **IT security & legal affairs:** The automated exchange of data between networked production systems must be secure and reliable. In addition to protecting products, machines and plants, further development and new interpretation of existing legislation are important factors here.

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### VDMA Industrie 4.0 newsletter

VDMA has pooled the expertise within the federation in the VDMA Industrie 4.0 Forum. A regular newsletter provides information on the Forum's activities in the three core fields of information, knowledge transfer and networking.

If you wish to subscribe to the VDMA Industrie 4.0 newsletter, please contact Anita Siegenbruk at [anita.siegenbruk@vdma.org](mailto:anita.siegenbruk@vdma.org) or by calling +49 69 6603-1906.

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Many small pieces of the jigsaw come together to form the bigger picture. With the Industrie 4.0 Forum, VDMA is committed to transforming the vision of Industrie 4.0 into practicable recommendations for action for the mechanical and plant engineering sector

Quelle: iStockphoto / Webeye

- **IT technologies & software:** Modern software architectures are the key to modular and flexible systems. Suitable methods and the knowledge of various experts is needed to ensure that these systems meet modern standards in terms of quality, availability and usability.
- **People & work:** The activities in the factory of the future will become more challenging, from both the technological and the organizational perspective. Interdisciplinary competencies are becoming increasingly important. The education system and companies will need to adapt to this.

#### Support along the way

This way, the many small pieces of the jigsaw come together to form the bigger picture. With the Industrie 4.0 Forum, VDMA is committed to transforming the vision of Industrie 4.0 into practicable recommendations for action for the mechanical and plant engineering sector and to taking into account the perspective of users in particular. The goal is to build a network that enables the member companies to exchange experiences.

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Source: ABB

## Creating an automated future together

### Initial situation

The market, and our customers, required the flexibility to handle constantly changing products with life cycles on the order of several months and shrinking. The solution needed to be easily portable and re-deployable and able to fit into workspaces designed for humans. It also needed to employ innovative programming methods so intuitive that anyone can do it without special training. Above all, it needed to be safe enough to work side-by-side with humans.

That vision is what ultimately led to YuMi®.

### Solution

When talking about its vision of an integrated industry, ABB refers to the “Internet of Things, Services, and People”, or IoTSP. One of the most important dimensions of IoTSP is that technologies are accessible and easy to integrate across local factories or across global enterprises. ABB Robotics is helping to lower the entry barriers of IoTSP by enhancing the simplicity, integration and collaboration of robots with people.

YuMi® is a complete solution which includes flexible hands, parts-feeding systems, camera-based part location and state-of-the-art motion control. This combined with simpler programming can help get new production up and running in hours rather than days, and give manufacturers the flexibility to keep ahead of the market. Its ability to work side-by-side with people is shifting the definition of ‘what can be automated’, and will unlock many new assembly applications that could not have been imagined before.

### Benefits at a glance

- Lead-through programming
- DNA of safety with a lightweight, yet rigid magnesium skeleton covered with soft padding
- No pinch points
- Integrated IRC5 robot controller
- Servo grippers include options for built-in cameras



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Source: Arburg



## Individualised high-volume plastic products

### Initial situation

The demand for individualised plastic products is increasing. The production of small batches without impairing economic efficiency or availability is a genuine challenge. Combining injection moulding, additive manufacturing and Industrie 4.0 technologies should make it economically viable to individualise large-volume products in single-unit batches in a flexible, automated, cyberphysical production system.

### Solution

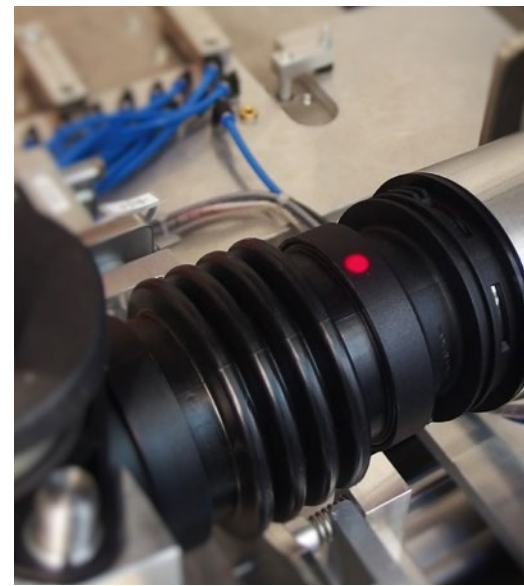
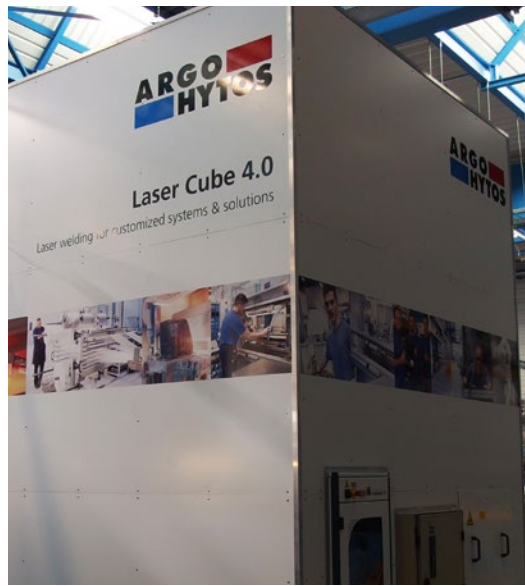
A fully networked and automated production cell will be used to demonstrate the manufacture of individualised office scissors in series, for example. An ALLROUNDER injection moulding machine and a freeformer for additive manufacturing are linked by means of a seven-axis robot. When entering their orders, users will create their own individual lettering on a tablet PC and choose from one of four types of scissors. The data will be registered in digital form and high-volume

production will start automatically. A data matrix (DM) code turns every product into an information carrier. In the next step, the freeformer will apply the 3D plastic lettering in an additive process. The ARBURG host computer system, ALS, plays a central role in registering the parameters and passing them on to a web server. The product, process and quality data can be retrieved from the product-specific website in the cloud by means of the code using mobile devices.

### Benefits at a glance

- Increased added value, production efficiency and process reliability
- A more flexible and efficient high-volume process for individual parts or multi-variant small-volume batches
- Online data archiving, documentation of quality assurance and traceability of parts





Source: ARGO-HYTOS

## When “customized” makes the manufacturing process exciting

### Initial situation

Successful machine manufacturers set trends and are developing dynamically. They specify the applied technology exactly according to the needs of the respective machine. In mobile hydraulics, annual purchase quantities of a few thousand pieces for highly integrated hydraulic, filtration and tank solutions are the rule.

### Solution

ARGO-HYTOS has recognized this trend and has followed the concept of “ZERO SET-UP TIME” for several years. Through the use of networked components, “production facilities 4.0” are developed in our own plant engineering. Such as the “Laser Cube 4.0” which has been put into operation at the factory in Kraichtal, Germany, in December 2015.

The “Laser Cube 4.0” has been optimized for flexibility and cost reduction in the manufacture of highly integrated plastic system and plastic tank solutions. The flexible configuration of the

system consists of interconnected core components which communicate with each other partly directly and partly via a machine controller. The on a moderate industrial robot mounted laser head can freely move in space and thereby weld even complex geometries in different welding levels. The sophisticated laser optics allows both the laser transmitted light welding as well as the quasi-simultaneous welding of plastic parts, sequentially in one welding operation. An in the plant control system integrated online monitoring and control of temperature in the melt ensures optimum welding results at maximum welding speed.

### Benefits at a glance

- Possibility to economically realize even small quantities of customized highly integrated plastic system and plastic tank solutions
- A maximum in flexibility and independence of component geometries
- Targeted tuning of the system functions



Source: AVENTICS

## Intelligent pneumatics pave the way for IoT

### Initial situation

The production of ever smaller quantities coupled with the need for greater system availability is one of the challenges of tomorrow's industry. This requires more flexible assembly and handling equipment and the capacity to plan required maintenance activities in advance. Therefore, networking and intelligent components are two key requirements of the Internet of Things (IoT).

### Solution

With its valve systems from the Advanced Valve (AV) series and matching valve electronics in the Advanced Electronic System (AES), Aventics makes a dedicated contribution to the development of the Internet of Things.

The ultra-light, compact valve systems in the AV series support modularization, since they can be mounted decentrally near the actuators. This makes it possible to preassemble entire function groups without a control cabinet.

AES valve electronics with their I/O modules offer the option of generating status and diagnostic information locally and communicating it via the Ethernet network. All pneumatic valves, sensors, or actuators connected to the valve electronics can be linked to the higher level control with just two cables for power and communication.

The AES supports all conventional fieldbuses and Ethernet protocols for a seamless flow of data. The data also enables preventive maintenance – for enhanced system availability.

### Benefits at a glance

- Lightweight, compact AV series valve systems facilitate modular engineering
- AES valve electronics meet demands for increased networking
- Enhanced system availability via condition monitoring





Source: AXOOM

## Making the transition to Industrie 4.0, step by step

### Initial situation

AXOOM, founded by machine tool manufacturer TRUMPF in 2015, addresses the problem of growing complexity in the manufacturing industry – for example, those caused by declining batch sizes. Modern machines turn out parts so quickly that they offer very little potential to reach greater productivity. The situation is entirely different when it comes to the processes that precede and follow the actual production of a part – from taking a customer's order, then to materials procurement and order scheduling, and through to invoicing – there are many opportunities to save time and expense.

### Solution

The key is an open business platform that is holistic in design and encompasses the entire value chain. AXOOM will be available to all customers, their suppliers and service contractors, as well as to other partners. Components made by different manufacturers within the

production value chain can be networked together and are thereby able to work together intelligently. This shall help to simplify process steps within production, synchronize them, and bring overall productivity to a new and higher level.

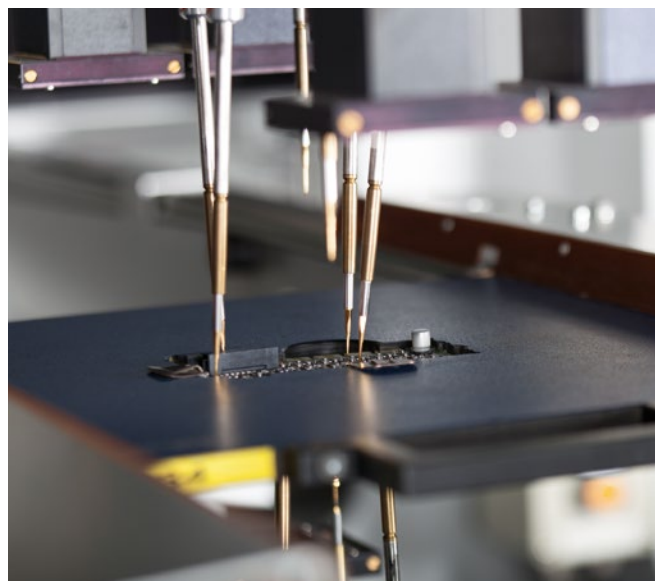
### Benefits at a glance

AXOOM makes consistency and transparency possible, along the entire value chain.

- Order Management enters orders digitally and manages them efficiently.
- Resource Management automatically reorders material – just when needed – and gives full transparency.
- The module Shop Floor optimizes productions paths for all orders.
- Logistics enables an efficient provider selection and processing.
- Reporting brings transparency in everyday business by providing all important data fast and at any time.



Source: B&amp;R Industrie-Elektronik



## Solutions for higher productivity in production

### Initial situation

Since B&R has introduced its X20 PLC series in 2005, both the number of available modules and their production quantities have risen drastically. This has been accompanied by demands for greater variety, lower cost, improved quality and smaller batch sizes. New production equipment was needed to achieve these goals.

### Solution

B&R developed new, fully automated production cells, which can now produce more than 200 different types of PLC modules.

The cells are controlled by B&R X20 PLCs that communicate directly with the ERP system. The assembly, testing and labeling stations check each serial number in the ERP system in real time to determine individual parameter settings and which tests are required for the given module type. Fractions of a second later the station performs the tests and sends the results to the ERP system.

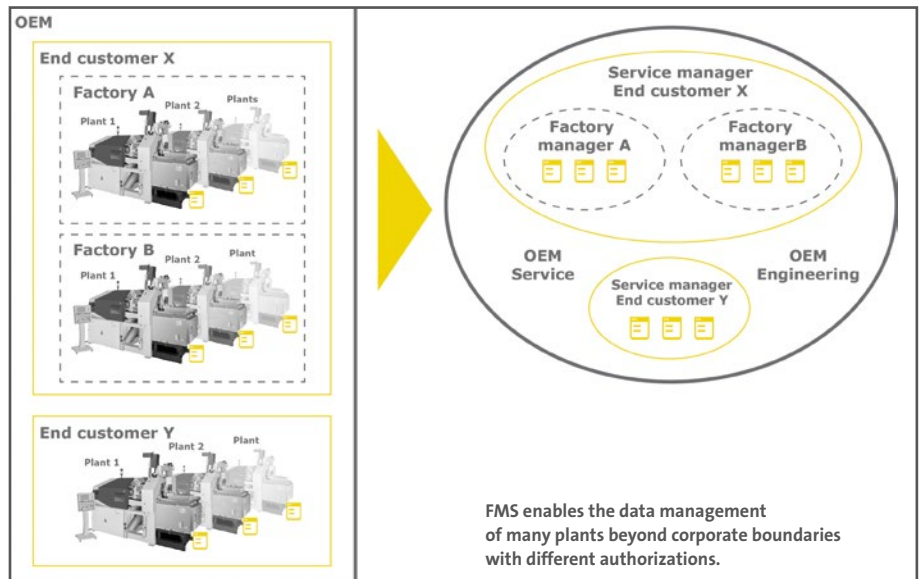
The cells communicate at the line level with B&R's APROL factory automation software. APROL records production data and evaluates it. Based on this data, predictive maintenance plans are created to minimize unplanned downtime and increase productivity. A variety of dashboards for OEE, production quality and cycle time data displays current and historical information about the state and efficiency of production.

### Benefits at a glance

- Increased productivity and profitability
- Improved transparency and quality with integrated production tracking
- Reduced unplanned downtime
- Time/cost savings through predictive maintenance based on condition monitoring



Source: Bachmann



## Software concept for the smart factory

### Initial situation

Bachmann is working continuously on new automation solutions which will bring the machine building sector a considerable way closer to the vision of the smart factory.

### Solution

Bachmann is focusing on automation solutions for optimizing the vertical data flow in order to optimize machine monitoring and service management, as well as to prevent unscheduled downtimes. This vision is now bearing the first ripe fruits in the form of the “Fleet Management System” (FMS) software module. A new concept which fetches data from the depths of the machine sensors and actuators and refines it into knowledge that can be used worldwide. On the global level this enables condition-based maintenance beyond the boundaries of plants and their owners.

FMS enables the quantity of the data collected worldwide as well as the quality of the information obtained to be considerably increased. This

method allows machine builders and end users to reduce unnecessary maintenance costs as well as minimize unplanned downtimes so that the operating costs of a machine are reduced. The ability to plan service operations with condition based maintenance not only reduces costs but also increases machine availability. This is because the software module detects faults and signs of wear early on and communicates this for proactive protection directly to the right places.

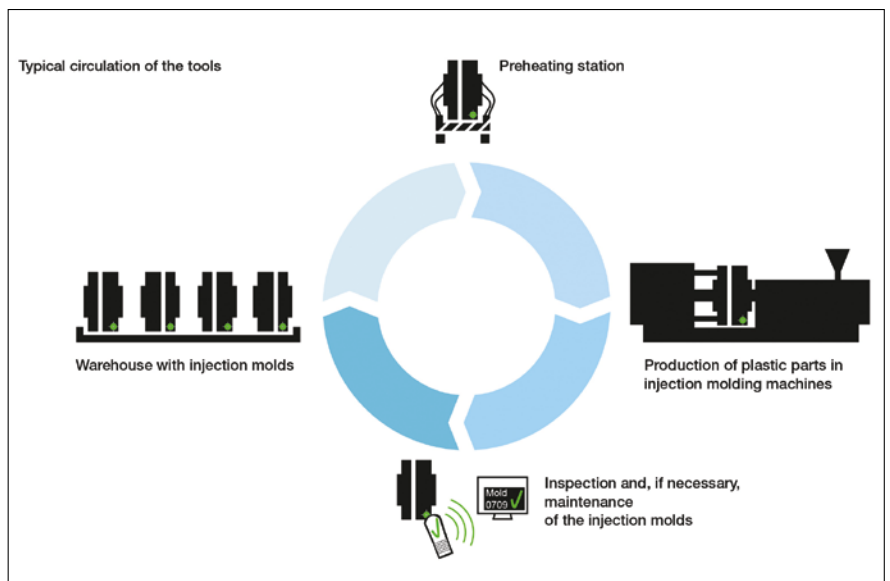
### Benefits at a glance

- Simple change from preventative to condition-based maintenance
- Feedback of real loads/data into development
- No corporate boundaries or geographical restrictions
- Use of existing sensor/actuator data
- Standard data aggregation – reduced for value addition
- Target-group oriented data management
- Limitless flexibility through the use of seamless web technology for in-house visualization





Source: Balluff



## Transparency in mold handling

### Initial situation

Molds from injection molding machines are subject to wear and tear and must be regularly maintained as a result. In many cases, maintenance and inspections are frequently carried out only if the produced components no longer meet the required standards or if the mold malfunctions.

### Solution

This is where Mold ID from Balluff comes in. Industrial RFID makes the use of injection molds traceable and provides an objective database for condition-based maintenance. This is an autonomous system which can be retrofitted anytime and anywhere in the world.

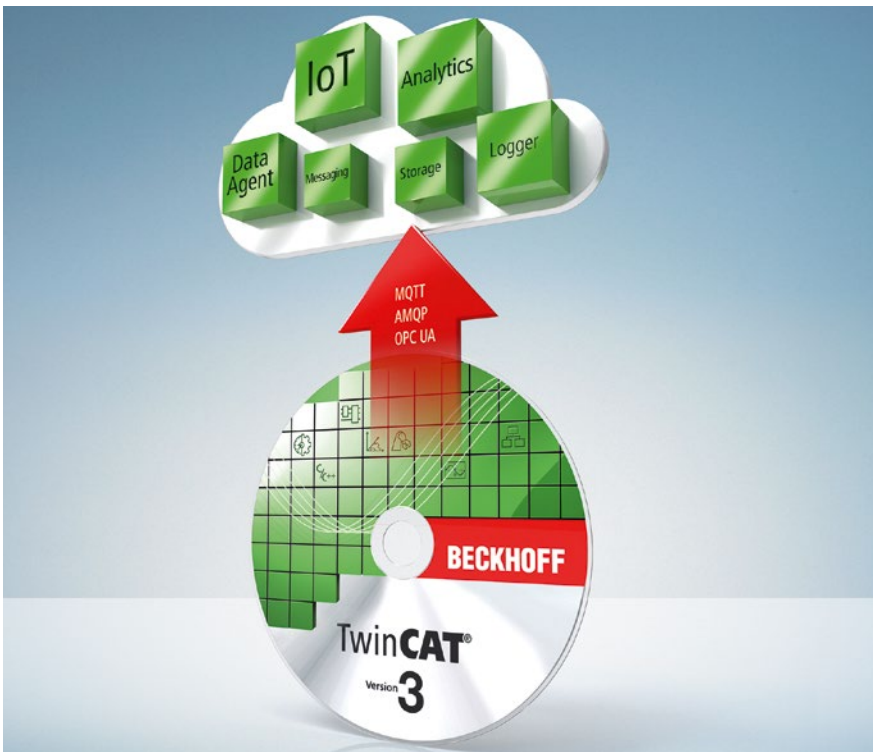
The added value lies particularly in the automated data acquisition directly on the mold and the ability to link with other data. This is because all Mold ID systems can be connected to the control level, an ERP system or an MES system via web services by means of LAN, Wi-Fi or Powerline.

The result is access to the data and processes from anywhere. This makes Mold ID a clear and practical example for how Industrie 4.0 easily finds its way into production.

Implementation: a rugged RFID data carrier on each mold stores the current shot count and various mold-specific process parameters in non-volatile memory without making contact. These data can be recalled at any time. The shot counter is implemented in the form of an inductive or optical sensor.

### Benefits at a glance

- Foolproof matching of the molds
- Complete recording of the production cycles
- Objective database for condition-based maintenance
- Integration into higher level systems
- Access to the data from anywhere in the world



Source:  
Beckhoff Automation

Based on comprehensive and cycle-synchronous data recording, the new TwinCAT Analytics solution enables seamless online and offline analysis of machines and production data.

## Machine diagnostics and predictive maintenance

### Initial situation

Implementation of Industrie 4.0 and IoT concepts comes with a wide range of requirements, particularly for machine diagnostics, including online and offline condition analysis, predictive maintenance, pattern recognition, machine optimisation or long-term data archival. As a result, seamless and cycle-synchronous data acquisition becomes a prerequisite for effective analysis and correction of processing errors in the machine. For this reason, Beckhoff has developed the TwinCAT Analytics tool to serve the growing needs of Industrie 4.0 applications.

### Solution

Processing errors in machines generally create excessive cost and lost production time. The situation becomes all the more serious if there is a lack of machine data and production parameters

for analysing processing errors and avoiding such errors in the future. The new TwinCAT Analytics tool can be used to rectify this information deficit by storing all process-relevant data in a cycle-synchronous manner. Data is stored in a standardised process data format with data compression, either locally in the controller, in a cloud-based solution on a server in the company network, or in a public cloud, as required.

### Benefits at a glance

- Seamless online and offline analysis of machines and production data
- Storage and analysis of data directly on the local control, in private networks or in the public cloud



Source: Bosch

## Sensors seamlessly monitor product quality in supply chain

### Initial situation

Whether, sensitive components or expensive finished products: although quality is monitored almost seamlessly during production, knowledge as to what happens during transportation and product use is frequently nebulous. For example, nobody knows for certain whether the specified transport conditions are really complied with, or whether vibration, excessive humidity, or shocks have caused invisible damage. In the worst case, components can no longer be used, resulting in high downtime costs.

### Solution

This is exactly the application field of a new Bosch Industrie 4.0 solution called "TraQ" (Tracking and Quality). The solution aims at the continuous monitoring of product quality along the entire supply chain. Transport packaging is furnished with integrated Bosch sensors that are connected to the Bosch IoT cloud. They continuously record data that are relevant for product quality, such as temperature, shocks or humidity. The sensors transmit this data to the cloud,

which means that the process can be smoothly integrated into the business processes. The Bosch IoT cloud evaluates quality-related incidents along the supply chain. Users are alerted in real-time, and the supply chain partners can initiate countermeasures in good time. Furthermore, the position data supplied during transportation allow the products' estimated arrival time to be determined. It is planned to launch this sensor solution, which has already been successfully tested in-house at Bosch, in 2017.

### Benefits at a glance

- Systematic incoming goods inspections improve quality management.
- Reduced costs: no error correction arising from rework, time-consuming tracking investigations, or compensation claims by customers.
- Continuous transport documentation allows conformance with compliance regulations, and enhanced complaints management.
- Real-time transparency along the supply chain for optimized transport and improved supply-chain risk management.





Source: CAS Software

## CRM + product configuration equal time savings of up to 90 percent

### Initial situation

When it comes to sales, time is of the essence. Manufacturers of variant-rich products are well aware of both this and the effort involved in creating customer offers. And when you consider that product data and customer information are often stored on different databases in different systems then you can appreciate the conflicts and losses of efficiency that result.

### Solution

GekaKonus GmbH from Eggenstein-Leopoldshafen is one of world's leading manufacturers of thermal oil heating systems and high-pressure steam generators. The company is now counting on the effectiveness of using the product configurator and CRM system in combination. This integration establishes the necessary connections between customers, sales and technical product knowledge. So despite countless possible combinations and product diversity, you can create customer offers at the touch of a button

and start producing the required equipment or systems immediately. The ease of operation and mobile access to both product and customer data using a tablet-PC is key to success. The combination of CRM and product configuration reduces the time required for creating an offer by up to 90 percent.

Faultless offers, tailored very specifically to your customers' needs, can be created in no time at all. Using our product configurator and CRM solutions you will enjoy the advantages of leaner processes and very happy customers.

### Benefits at a glance

- Professional customer management
- Configurator compiles your products optimally
- Individual and tailor-made offers
- Consistent sales and offer process
- More time where it counts – for sales and improved consulting
- Happy customers and long-term company success



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Source: Centigrade / SEW-EURODRIVE

SEW-EURODRIVE's Industrie 4.0 tradeshow exhibit 2015 is a blueprint for connected production and intralogistics.

## Industrie 4.0 HMIs for connected production and intralogistics

### Initial situation

How can connected production and intralogistics contribute to a product being manufactured, transported and stored more efficiently?

SEW-EURODRIVE aims to answer this question with a hands-on tradeshow exhibit. They want to develop a fully functional miniature production line in collaboration with Centigrade. This line serves as a metaphor and blueprint for large-scale connected production facilities.

### Solution

The exhibit consists of multiple stations. An intelligent production plan supports the user's order management, for example by incorporating real-time data on available production resources. Users can always modify the production plan on a touch display.

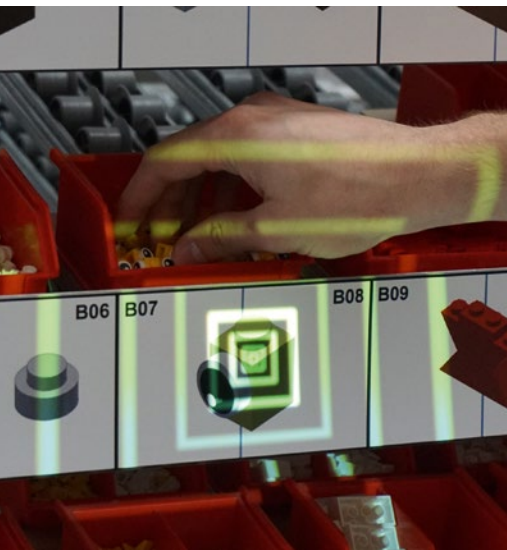
Intralogistics are updated as well: virtual 3D objects representing the actual products are overlaid on a video stream from a ceiling-mounted

camera. Using another touch display, the 3D objects can be selected and placed into boxes to trigger actual warehousing operations. This use of augmented reality gives users an unprecedented view and direct control over ongoing intralogistics processes.

The HMI of these stations uses the "Bring Your Own Device" principle and gamification elements. This enables and motivates users to always make decisions that improve production and efficiency.

### Benefits at a glance

- Optimal user support through „Bring Your Own Device“, augmented reality and gamification
- Decreased production risks
- Connected processes increase efficiency throughout the production line



Support for the assembler: At the manual workstation the mobile projection shows the user where to grab which part.



A 3D model showing the assembly instruction is projected onto the manual workstation and guides the user step by step through the assembly process.



The projection-based AR environment is tested in the versatile assembly system of the SmartFactoryOWL. Source: CIIT

## Mobile projections in industrial production

### Initial situation

In the research and development centre CENTRUM INDUSTRIAL IT (CIIT) researchers are working together on solutions for the Factory of the Future. A key technology for Industry 4.0 purposes is the so-called Augmented Reality (AR), the computer-assisted extension of reality. In Lemgo the CIIT researchers of Institute Industrial IT (inIT) of the OWL University of Applied Sciences and the Fraunhofer Application Centre Industrial Automation (IOSB-INA) developed cooperatively a technology promising more efficiency and convenience at the workplace without any tools such as data glasses, PC tablets or other mobile devices.

### Solution

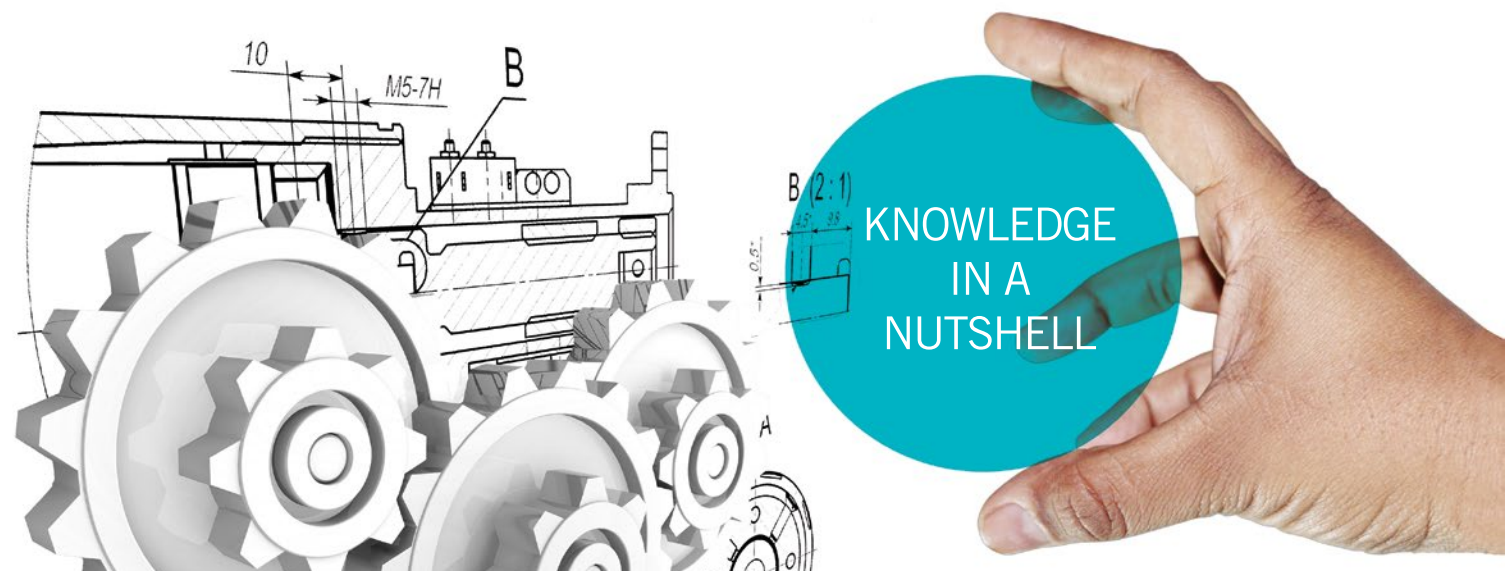
The vision behind the **projection-based AR environment** is to produce more efficiently and smartly by providing the right information at the right time and in the right place.

By combining a high-performance projector with a specific software it is possible to guide the user safely and efficiently through the assembly process on the manual workstation. All relevant information needed is directly projected on the assembler's working place – from an individual assembly part being virtually colour-highlighted to a complete 3D model showing the assembly instruction. The suggested approach is based on “pick-by-vision” or “pick-by-light”. A first demonstrator has been implemented successfully in a versatile assembly system by the inIT and IOSB-INA researchers.

### Benefits at a glance

- High benefit for the user
- Significantly more convenient and user-friendly
- Changes of locations/machines are no longer an obstacle
- The mobile projection is providing holistic and latency-free support to the assembler





Source: cognitas

## The CyberSystem Connector – intelligent technical documentation lifecycle services

### Initial situation

Machines, production plants and procedures became more and more complex during the last decades, and the timespans between changes due to changing requirements shorter. Manuals for manufacturing systems were mainly created for safety reasons, but today operating companies start to use them for their daily work. High quality solutions for manuals and information management are becoming a quality feature of manufacturers. The low-cost production of up-to-date documents becomes a main objective.

### Solution

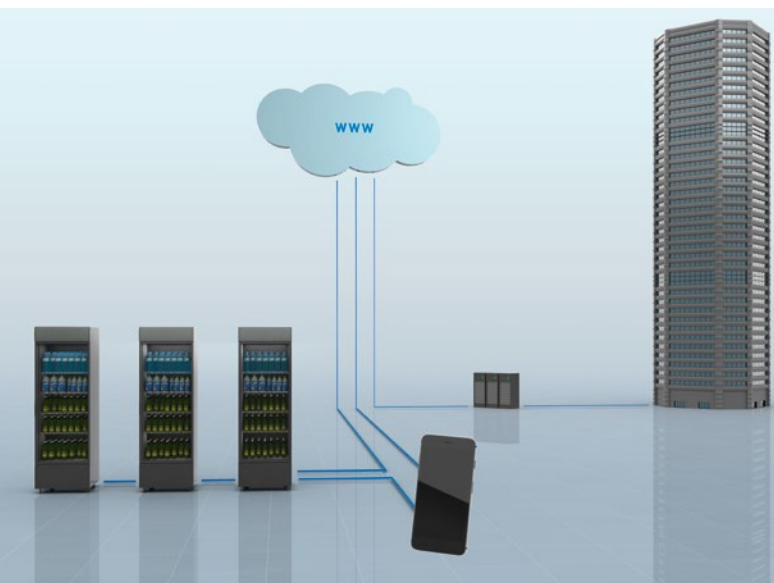
The CyberSystemConnector (CSC) Collaboration uses the growing networks among machine components to recognize relevant changes to the machines. cognitas and the collaborators develop a virtual image of the machine that mirrors its state at any time.

The file format <AutomationML/> is then utilized to prepare the virtual images for the exchange between companies. Thus, documentation content can be delivered taking into account the target group and the working situation of the users. Content delivered by suppliers can be integrated seamlessly.

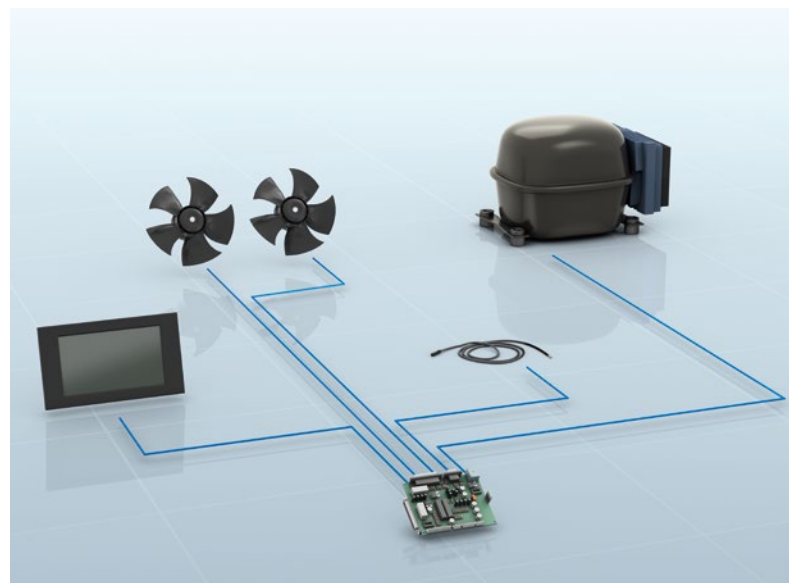
### Benefits at a glance

- Up-to-date documentation, anytime
- Increased safety
- Shorter maintenance and shutdown times
- Utilization of innovative documentation distribution channels like augmented reality
- Seamless integration of machine documentation into the users' workflows

The CyberSystemConnector project is supported by the German Federal Ministry for Education and Research (BMBF) and supervised by the PTKA.



Source: ebm-papst



## Intelligent and interconnected control systems for refrigerators

### Initial situation

There are over 50 million refrigerators in all the world's food retailing establishments and together they consume over 90 TWh of electricity per year. However, refrigerators are also used for cooling tooling and production machines, industrial electronics, medications, etc. to precise temperatures. In contemporary refrigerators, the individual components have power electronics and control units that function in isolation from each other.

### Solution

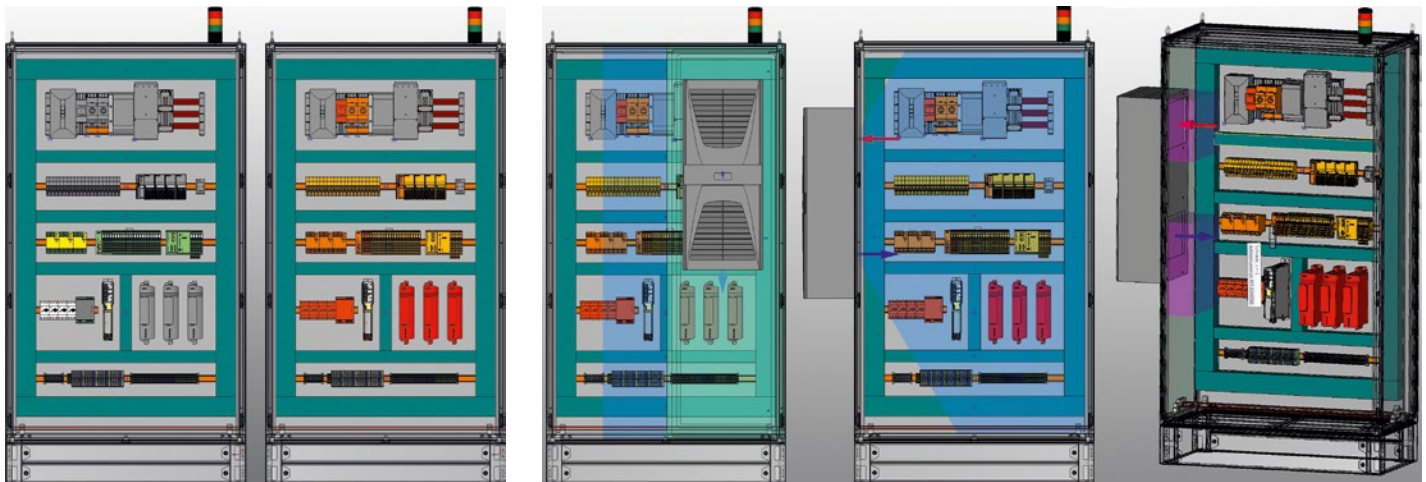
As a proactive solution to Industrie 4.0 and the Internet of Things, ebm-papst has developed in cooperation with an American refrigeration company an intelligent, interconnected control system for refrigerators in the industrial and consumer sectors that increases the efficiency of the overall system. With energy savings of over 30 %, the newly developed refrigeration cycle system also makes a contribution to climate protection. The project's technological creativity consists in the intelligent interconnection of all energy-

supplied units, optimizing output, energy and function in the process. The centrally controlled system solution with integrated data connection enables the cooling capacity to be adjusted according to need and in advance. This boosts the system's energy efficiency and permits it to be used under economical general conditions.

### Benefits at a glance

- Increases both functional and economic efficiency
- Energy savings of over 30%
- Automatic data transmission
- Monitoring, closed-loop control, control, remote maintenance and geographical location of the units
- Transfer to a variety of applications, e.g. electronics and switching cabinet cooling, precision cooling of tool and production machines, cooling of (perishable) food, beverages, etc.

Read more about another Industrie 4.0 solution of ebm-papst on page 44.



Source: EPLAN

Representation of the heat-loss distribution within a control cabinet. At left: enclosure as seen normally. At right: display of the heat-loss distribution. A component's colour corresponds to its heat-load density – the components shown in red are those that should preferentially be cooled.

At left: for door construction, the optimal climate-controlled area does not reach the cabinet wall. Middle: for side-wall mounting on the left, all the components are located in the optimally cooled area. At right: the spaces blocked off for air circulation are free from obstacles.

## „Thermal Design Integration“: Complete integration of digital data into product development and production

### Initial situation

Consistent virtual engineering is a precondition for Industrie 4.0. This is a principle followed by “Smart Engineering and Production 4.0” – the technology network from Eplan, Phoenix Contact and Rittal. “Thermal Design Integration” informs control cabinet designers about the functionality, performance limitations and integration options in climate control systems. Efficient solutions can then be developed in an intuitive and simple way while avoiding “hot spots”.

### Solution

Using “Thermal Design Integration”, components in Eplan Pro Panel are coloured differently according to their heat-load capacities. Designers receive information on how heat-load densities are distributed throughout the cabinet. All the required information is made available as device data through the “EPLAN Data Portal” – both for active components and connectors. Phoenix

Contact is the first manufacturer to provide device data – such as maximum heat loss, minimum spacing and flow directions – entirely within the portal as part of “Smart Engineering and Production 4.0”.

### Benefits at a glance

- Visualisation of functionality, performance limitations and integration options of different climate control systems
- Information on the air inlet/outlet for climate control components and the resulting air flows
- Quick identification of parts that require extra cooling to enable optimal positioning of climate control components
- Visualisation of the main device parameters to identify airflow-specific reserved areas.

More information available under:

**[www.SEAP40.com](http://www.SEAP40.com)**



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Source: Festo AG

## Energy transparency system at the Scharnhausen technology plant

### Initial situation

In tomorrow's production world, the sustainable treatment of natural resources will become increasingly important – energy efficiency is a key topic of Industrie 4.0. At the production plants of Festo, however, there has as yet been no energy transparency at machine level: the consumption data of buildings and production have largely been considered separately.

### Solution

At the new Technology Plant of Festo, an energy transparency system enables the holistic analysis of energy flows and consumption by locally recording data down to machine level where appropriate, and systemically analysing their interaction. It makes use of a flexible architecture with standardised, non-proprietary interfaces on the basis of OPC-UA. Software applications allow the consumption data to be visualised on mobile devices, thereby enabling direct access on the shop floor. The configuration has now been

completed in a pilot unit. It is scheduled to be introduced throughout the plant by mid-2017. The data is acquired by type SFAM flow sensors, among others. These are integrated as standard into all new systems; together with type CPX-CEC decentralised control blocks, they create the basis for Industrie 4.0 capable data monitoring. Modern automation components such as the energy efficiency module MSE6-E2M also enhance energy-efficient operations. This module has autonomous leakage detection and process monitoring capabilities; remote servicing and adjustment of the parameters can be carried out via fieldbus. When the compressed air supply is shut off, the module checks the system for leaks. If the pressure drops too rapidly, a leakage is reported.

### Benefits at a glance

- Transparent energy consumption in production
- Automated process monitoring and energy management
- Recognition of savings potential



Source: Festo Didactic

## Cyber-physical research and learning platform

### Initial situation

The enormous rise in the quantity of data and in the complexity of plant networks and company divisions makes it necessary to develop products that make the flow of data easy to project and to use – at production level, but also for training and developing workers' skills.

### Solution

The cyber-physical research and learning platform "CP Factory" provides educational institutions and companies with access to the technology and applications of Industry 4.0. The technologies and methods of digital production can be tested and demonstrated in a scalable, non-proprietary network of systems and components. The learning factory presents various stations of a real production plant as an emulation that integrates all relevant technologies from the fields of mechatronics and automation.

Part of the platform is an intelligent module for the communication of process data – the "CPS Gate".

The "CPS Gate" functions within the factory's workstations as the basic module for controlling the processes. It combines PLC, sensors, actuators and RFID/NFC technology in one product and communicates within the network with the connected IT systems (ERP) and the production management system (MES) as well as all the data relevant to production of the products being processed.

### Benefits at a glance

The "CP Factory" offers practice-oriented qualification for industry 4.0:

- Systems networking
- Application of open configurable systems
- Communication standards
- Energy efficiency
- Condition monitoring
- Data-based order processing
- RFID and NFC technologies
- Data acquisition via mobile devices can



Source: GE Digital

## Big data becomes smart data – thanks to cloud processing

### Initial situation

The digitalization of production marches on, and more and more companies are connecting machines, data, and people to create manufacturing networks. Information technology and operational technology are merging, controls and processes are being digitized, and the factory is now becoming the Smart Factory. At GE, it is the “Brilliant Factory”.

Smart factories produce billions of data bytes from production processes and critical assets. How can companies extract the most important information from these vast amounts of data? How can a factory convert all of this big data into smart data?

### Solution

The answer is cloud processing and analytics. GE has developed a secure, industrial-strength cloud solution, the “Brilliant Manufacturing Suite”. It uses smart analytics to evaluate data

and uncover actionable information that can be used to proactively manage brilliant machines and factories.

### Benefits at a glance

- The new cloud service from GE Digital enables companies to take full advantage of big data, using continual data analysis to optimize equipment performance.
- Data and applications are cloud-based, and every factory and user is connected through the cloud.
- Users only need a browser-capable device to connect to the cloud, and they have full access to applications, data, and communication with users and factories worldwide.
- The new cloud service from GE Digital can increase a factory's overall equipment effectiveness (OEE) by 20% or more.



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Source: HARTING

## Integrated Industry – from the product to complete solutions

### Initial situation

Integrated Industry combines automation technology and information technology to enable new business models, new products and services, as well as to increase reliability and productivity. HARTING has implemented a comprehensive raft of solutions in its own SmartFactory known as “HARTING Integrated Industry 4 You” (HAI4YOU). The challenge here is to use vertical integration to offer the customer solutions which are tailor-made to its specific requirements.

### Solution

The complete vertical integration from the customer through to the flexible manufacture of a modular connector demonstrates how business processes might change in the future. First, a Han-Modular® connector is configured and ordered in an online store, after which further processing takes place in SAP and production is then performed in a fully automated manner. Here, the customer has the option assigning its own labeling to the product, e.g. an item number.

Integration in SAP with the packages ERP, ME and MII was implemented by HARTING specialists. Production of the Han-Modular® connector is performed in three assembly cells in the HAI4YOU Factory. The cells are equipped with their own control systems and are guided by special flow charts that are assigned to each product as product memory.

### Benefits at a glance

- The identification during the process, together with vertical integration in a SAP environment, makes it easier to deliver customised solutions.
- The HAI4YOU application is demonstrating the HARTING Technology Group's competence in Integrated Industry at all levels, from the product all the way to complete solutions.





Source: Heidelberger Druckmaschinen

## Developing new business models

### Initial situation

Due to a consolidation in the print industry over the past 20 years, huge multinational companies and highly automated internet-printers took over a large part of the printing market. These companies require highest machine availability and performance from manufacturers like Heidelberg Druckmaschinen AG (Heidelberg).

### Solution

A modular range of services, developed and implemented, for ever increasing customer demands.

Basis for these new smart services is an IoT-platform for the transmission of machine log data as well as a high-tech big-data analytics system, which permanently analyses data of thousands of sensors of the printing presses. With this, indicators for approaching errors can be detected and handled early enough to prevent unplanned downtimes thanks to the expertise of our service specialists. The objective: highest machine availability.

Apart from technical data, the machines also transmit performance data which is used to analyze and monitor production processes. To improve the efficiency of the entire production system (people, machines and processes) the causes of losses in terms of time, speed and quality must be identified in order to find the best solution. Heidelberg covers all of this in a unique consulting service: Performance Plus.

### Benefits at a glance

#### For customers:

- Comprehensive and sustainable consulting service
- Designed for individual customer requirements
- Up to six-figure savings throughout the duration of the project
- Increased output by up to 40%
- Minimized risk thanks to performance-related fees

#### For Heidelberg:

- Growth in service business
- USP for Heidelberg compared to the competition



Source: Hologram Company

## Advantage of secure identification

### Initial situation

One of the principles of Industrie 4.0 is the secure and reliable identification of a product based on batch numbers or at best with an individual and unique serial number. This serial number has to be allocated and connected to a product. For logistics, authentication and customer interaction it is necessary that the serial number can be reliably read at any time.

### Solution

A smart identification label enables products to be easily and reliably individualised either on the product itself or on the packaging.

The RAKO Group is one of the foremost manufacturers of adhesive labels and, owning one of the largest HP-digital machinery plant, is one of the worldwide leaders in digital printing. This printing technique allows each single label to be completely individualised, e. g. with a unique serial number, either as a data matrix code, QR code or barcode. The labels can be combined

with RFID/NFC to allow electronic identification. Products which are optically verified with a Nanogram™ can be quickly and reliably recognised as an original.

### Benefits at a glance

The RAKO Group offers the label for Industrie 4.0. Digital / Smart / Secure:

- Digital printing technology offers variable data printing with 100% control including code verification.
- By combining RFID and NFC, the label can be read electronically.
- A Nanogram™ offers protection against forgery.



Source: AFS

## Just in time fuelling on international airports

### Initial situation

AFS Aviation Fuel Services GmbH of Hamburg assumes every step in the airplane fuelling process for their customers. The ultramodern vehicle fleet that has been designed by AFS itself comprises 165 vehicles for fuelling at more than 150 airports worldwide. Fuelling aircraft on international airports is a logistical tour de force from the refinery to the aircraft. For this challenge, a sophisticated system as well as reliable communication up to the fuelling vehicle are necessary.

### Solution

The so called fuel handling system (FHS) models all processes from the refinery up to fuelling. All vehicles are equipped with on-board computer, touch screen, printer, PLC and measuring system. FHS is connected with the ERP systems of the airlines and oil companies as well as the flight information display systems of the airports. This allows the AFS scheduler to ensure a fuelling to

the minute also for delayed aircraft. The programmable cellular routers MoRoS HSPA are used as UMTS gateway in the vehicles. These routers with integrated 4+1 port switch have two SIM card slots and are equipped with one Telekom and one Vodafone SIM card. This makes data communication redundant and allows using the included data volumes of the SIM card well-balanced. If no HSPA/UMTS network is available, the connection falls back to GPRS or EDGE automatically.

### Benefits at a glance

- Secure end-to-end data communication
- Redundant communication via two SIM cards
- Robust cellular routers for continuous operation in vehicles





Various attachments are attached to a B 40 scrubber-drier's tank (on the left).  
Pre-assembly of the control module (on the right).



The underside of a B 40 frame is being assembled. The pick-by-light system illuminates in green the parts to be installed.  
Source: Kärcher

## Advanced assembly line for floor cleaning machines

### Initial situation

A new Industrie 4.0 assembly line at Alfred Kärcher GmbH & Co. KG enables scrubber-driers in great variety to be manufactured on the basis of optimised processes. Floor cleaning machines are configured more and more individually, according to customer requirements more than 40,000 versions of a model are possible. With the previous assembly system the reliable production in batch size 1 could not be realized on the economic conditions of a large-scale production.

### Solution

A QR code generated at the start of production of a new machine can be used to retrieve all production-relevant information. This information is deposited on a RFID chip on the workpiece carrier on which the customer's individually configured machine will be made. The data is read out at every work station, following which detailed assembly instructions appear on a monitor at the particular work station. The individual parts required are delivered via a kanban material flow system. A pick-by-light system highlights for the

worker those components that are needed for the current production step.

In the event of malfunctions a defined escalation management is installed. Then, the worker can use any touchscreen to request help from the relevant contact persons. At the end of the line is the test bed. After making sure that the floor cleaner is in full working order, the tester scans the QR code and the system logs the machine as ready assembled and tested.

### Benefits at a glance

- Process-optimized production of a product in a large number of versions
- Economic implementation of batch size 1
- Enhanced functionality and flexibility of the assembly line
- A high degree of data transparency
- Modern communication media enable rapid support for workers





Source: KOMET GROUP

## Assistance system: Comprehensive Industrie 4.0 solution for use in machining

### Initial situation

In the machining industry, the full potential of machine tools is all too often not exploited. By monitoring and analysing machine, operating and process data, it is possible, amongst other things, not only to optimise processes and make them more reliable, but also to improve machining quality and productivity, and reduce consumption costs.

### Solution

The ToolScope monitoring system developed by KOMET® BRINKHAUS is a comprehensive assistance system for use in machining. It monitors and records the machine's internal signals while the process is under way, such as the torque of a spindle or the feed force of an axis. It also detects events such as tool changes and machine stoppage. Using its knowledge of process identifiers such as program, tool, sequence number, etc., which can be read from the control system, the software is able to make necessary adjustments

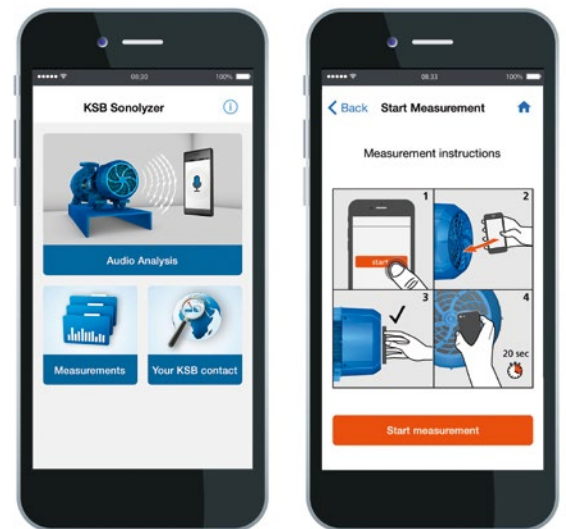
in the process and produce a range of documentation. In order to offer the customer an added benefit that works independently of the rest, KOMET® BRINKHAUS has developed a number of apps that can be simply licensed and activated; these apps can be called up on the user interface and perform a variety of services.

### Benefits at a glance

- Minimal hardware requirements, user-friendly software
- Activatable apps function as an automatic shift log or tool change log, perform adaptive feed control, provide an independent cloud database function, detect collisions, monitor processes, and much more besides
- Increased process reliability and productivity



Source: KSB Aktiengesellschaft



## Free energy efficiency check

### Initial situation

Flexible, transparent and reconfigurable production layouts need smart components that offer a host of functions, services and information in a networked environment in addition to meeting application-specific technical requirements. At KSB, target-oriented examples that have already been implemented underscore the way in which the digital pump will be integrated in future production settings.

### Solution

The free KSB Sonolyzer® smartphone app, for example, is a quick and easy way to analyse potential energy savings in pump systems. The app is intuitive to use: Simply select your pump type, enter the name plate data of the pump and the asynchronous motor, start the measurement, and hold the smartphone next to the fan hood of the motor for 20 seconds.

The fan noise is recorded and the noise spectrum is transferred to the KSB Cloud for analysis via a secure connection. The measurement result indi-

cates whether the operating point is inside or outside the part-load range and whether savings in operating costs can therefore be made. After the potential has been analysed, an application-specific detailed analysis is necessary, which – thanks to KSB Sonolyzer® – can be performed only on machines that show potential, making it cost-efficient. App users also have the option to contact KSB experts directly for support.

### Benefits at a glance

KSB Sonolyzer® hears whether energy can be saved in the pump system:

- Easy to measure – directly at the motor.
- Measures fast – in 20 seconds.
- Analysis result shows whether energy can be saved.
- If necessary, KSB experts can be contacted directly.



Source: KUKA

## Intelligent mobile assistant optimizes production processes

### Initial situation

KUKA offers advanced solutions in robot-based automation to its customers around the world. Industrie 4.0 is bringing the digitization of factories to the fore. The requirements on production are growing, and product life cycles are becoming shorter while product variety is increasing. This calls for flexible systems capable of communicating with one another and functioning autonomously. For the modernization of its own robot production in Augsburg using efficient lean manufacturing methods, KUKA has introduced just-in-sequence delivery of assembly material and automated logistics processes.

### Solution

In the in-line wrist assembly shop for the KUKA KR QUANTEC robot, the KMR iiwa mobile robot has the task of distributing screws and other production material. The KMR iiwa (KMR stands for "KUKA Mobile Robotics") is a mobile platform on which the sensitive LBR iiwa lightweight robot is mounted.

WÜRTH delivers the ordered KANBAN boxes to the central warehouse rack. At regular intervals, the sensitive KMR iiwa checks the individual shelves and removes the delivered boxes. It holds each box up to a QR code scanner mounted on the platform, enabling it to identify the individual target position. It then transports the boxes directly to the appropriate workstation.

The integrated KUKA Navigation Solution, combined with safety laser scanners, makes it possible for the KMR iiwa to detect obstacles early on and thus to safely and autonomously navigate through the production facility. In this way, it can share common paths with people and logistics trains.

### Benefits at a glance

- Maximum economic efficiency
- "Internet of Things": workpieces, materials and robots recognize where they are needed
- Human-robot collaboration combines the potential of humans and machines



Source: Lenze

## Smart solutions for resource-efficient intralogistics

### Initial situation

As the retail market becomes more globalised, with sales mainly taking place in internet shops, the flow of goods is changing dramatically. As a result the need for efficient logistic processes in the shape of highly productive and fully automated distribution centres has never been greater. In the light of the new climate targets of Paris, this trend poses new challenges, especially because of the energy-hungry electric drives used in intralogistics. As a result, there is a high potential for saving energy, precisely because a very large number of the same drives are deployed in running logistic centres.

### Solution

For this reason, the innovative project entitled “Smart drive and control technology for energy-efficient intralogistics”, which was initiated by Lenze and has now reached completion, focused on developing an intelligent, mechanically compatible modular set of efficient drive solutions.

The project, which was carried out within the “it’s OWL” technology cluster, used Industrie 4.0 mechanisms to combine energy-efficient motors, inverters and gearboxes with an energy-optimised motion control.

At the heart of everything are technical systems with inherent partial intelligence that can react to changes in conditions, automatically adapting their behaviour accordingly while communicating and cooperating with other systems.

### Benefits at a glance

- Self-optimising motion sequences adapt to the current level of capacity utilisation and yield energy savings of 15 to 40 per cent
- Easy replacement of existing solutions
- Reduce the systems energy consumption where a lot of energy is used
- No perceptible impact on investment costs or loss of productivity





Source: Fotolia

## Industrial cloud service platform

### Initial situation

Modern machinery and plants are producing more and more data. An important aspect is to not only collect these data, but also use this information profitably for both the manufacturer and the customers, for example for predictive maintenance or operator models.

Once the generated data have been collected, they must be processed accordingly and then displayed on different end devices. Analytical methods allow for obtaining valuable insights from these data. To make this possible, consistent and horizontally and vertically networked solutions are required to handle these large quantities of information.

### Solution

M&M Software's industrial cloud service platform is a key in solving this problem by providing for reliable and secure collection, storage, analysis and visualization of machinery and plant data.

The platform consists of a universal core system and individual web portals based on it that can be intuitively operated on both a PC using a browser and on mobile devices. Methods like data mining, real-time analytics and machine learning for recognizing interrelationships can be applied to the collected data.

M&M Software offers an "all-inclusive package" to customers. In addition to the development of customized OEM solutions the package also includes reliable operation, usage-based billing, continuous application monitoring, and end user support.

### Benefits at a glance

- Individual visualizations
- Flexible data connection – whether OPC, function blocks or extensions of machine controls and firmware
- Long-term archiving
- Real-time and historic data analysis
- Notifications and alarms
- Real-time and big data analytics



Source: Mayr Antriebstechnik

## Permanent overview of the brake operating condition

### Initial situation

In all areas of mechanical engineering, the focus is being placed more and more on the monitoring of electromagnetic safety brakes. In future, the increasingly complex processes will require permanent, targeted monitoring, as only in this way changes to the brake properties can be recognised immediately, and countermeasures initiated. However, not all brakes can be retrofitted with the microswitches or proximity switches generally required for condition monitoring. And the work involved in the assembly, wiring and adjustment of the switches is in part demanding.

### Solution

The intelligent brake control module, the ROBA®-brake-checker, can supply brakes and monitor them at the same time. It detects the motion status of the actuator, wear on the brake linings and cable breakage. The module works without a sensor; instead it evaluates amongst other things the current and the voltage.

In this way, the ROBA®-brake-checker can ascertain a possible wear reserve or, if applicable, unpermitted heat-up. The module thus detects safety-critical conditions prior to their occurrence and guarantees higher levels of operational safety for machines and systems. Microswitches and proximity switches and all their associated wiring are therefore no longer required. Users save money and wiring effort, and make their machines fit for the future.

### Benefits at a glance

- Sensorless switching condition monitoring
- Increased operational safety through the detection of safety-critical statuses prior to their occurrence
- Control and monitoring function in one
- Simple, fast and inexpensive, it can also be integrated into existing systems



Source: MPDV

## “Smart Factory” in four steps using an MES

### Initial situation

Numerous manufacturers must manage today's increasing requirements of their customers and still prepare their production for Industrie 4.0. The latter often presents an immense challenge. A uniform solution is hardly possible as the starting point differs from company to company. However, the aim is clear for all: an efficient, flexible and sustainable production – in short the “Smart Factory”.

### Solution

In order to transform any production systematically into a “Smart Factory” MPDV's MES experts suggest an easy “Four-stage Plan”:

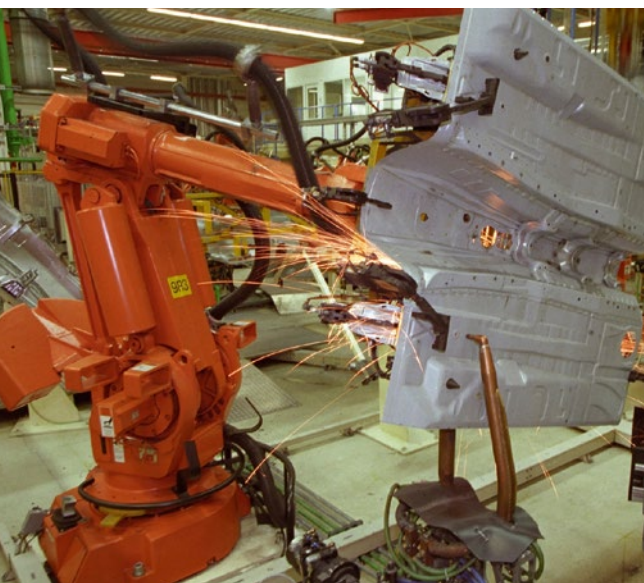
- Make your factory transparent by comprehensively collecting and evaluating data with a Manufacturing Execution System (MES) like HYDRA from MPDV.
- Transform your production planning and control into a reactive tool by integrating collected data into the MES planning process. Subsequently waste will be reduced.

- Incorporate your findings to create control cycles in production that lead to a self-regulating factory. MES HYDRA will support you.
- Functionally link all departments, resources and systems involved in the production process. This also requires product development to be directly connected to production.

### Benefits at a glance

- Systematical and targeted approach – even for medium-sized companies.
- You can start at any stage.
- You can utilize existing machinery and installations.
- Investment phases are predictable and clearly structured.
- All employees can manage the migration to Industrie 4.0.





Automated manufacturing processes can be optimized with 3D-based machine vision technology.



By using 3D Scene Flow autonomous pallet transporters can operate more securely in logistical processes.

Source: MVTec

## Perfect human-machine interaction

### Initial situation

Industrie 4.0 will change the processes by which manufacturers create value over the long term. The unstoppable trend toward automation goes hand in hand with this development. Thus the safe interaction between people and machines in automated production processes continues to gain in importance. Another goal should be to reduce expensive machine shutdowns and associated production interruptions as much as possible in order to save money. This requires technologies that can reliably detect and localize objects in three-dimensional space.

### Solution

“3D scene flow” from MVTec is a 3D vision technology that can be used not only to determine the position of objects but also their direction of movement and speed. This is achieved with the placement of multiple cameras that record the production situation from different perspectives.

MVTec’s standardized machine vision software processes the digital image information and turns it into a three-dimensional, real-time motion profile of humans and robots involved in the production process. The evaluation of 3D image data makes it possible to predict – early and accurately – the potential points of contact between employees and robots. This approach avoids collisions and makes production processes safer and more efficient.

### Benefits at a glance

- Optimizes human-machine interaction
- Increases safety and efficiency in production
- Reduces machine shutdowns and production interruptions
- Saves money

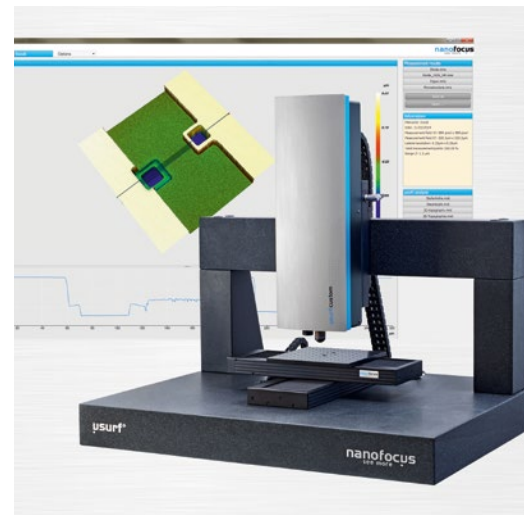




Fully automated wafer inspection with  $\mu$ sprint-technology  
Source: NanoFocus



Integration of the NanoFocus measuring technology into fully automated test systems for user-independent series measurements is possible.



Measurement data and analyses are permanently stored in an analysis library.

## Quality assurance with 3D surface measuring systems

### Initial situation

In industrial production there is a worldwide trend towards interlinked process chains summarized under the heading Industrie 4.0. Meanwhile the demands on product quality are increasing. In this context, user-independent and automatable measuring technology gains more importance in quality assurance. Reliable measurement data provides information about the product quality which is necessary for controlling production processes.

### Solution

Along with conventional 3D microscope systems NanoFocus offers surface metrology systems for inline use. With various options for automation they can be flexibly integrated into production-related control systems.

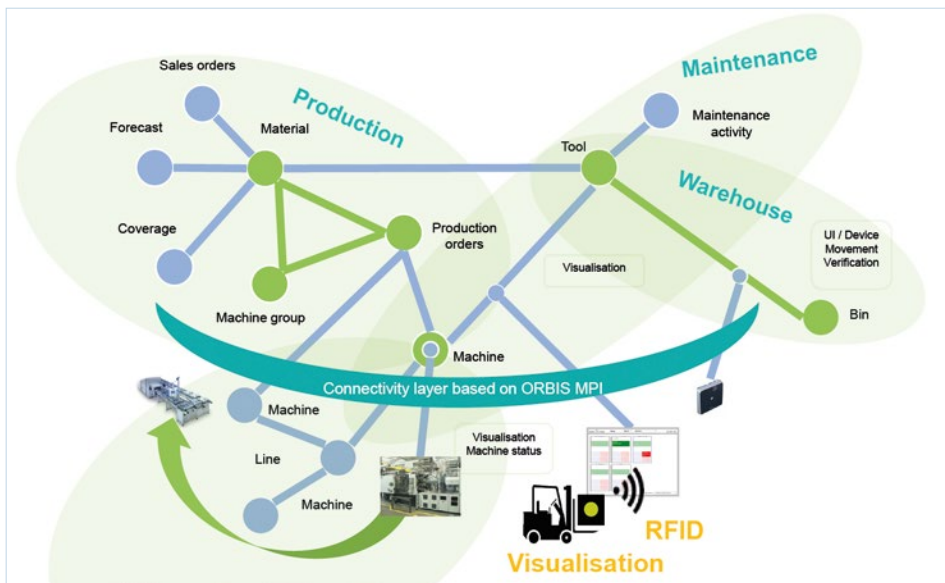
The fully automatable confocal 3D surface measuring systems can be integrated directly into production lines for 100%-control. They may also be implemented near the production lines for sample inspection (single or serial measurements). Customer-specific measurement strategies and complex evaluations can be easily configured

with the NanoFocus automation software.

Measurement results can be directly transferred to pre-defined evaluation protocols or exported to further relevant software via various data interfaces. Result data is available for nominal/actual comparison or can be exported for further analysis to q<sub>s</sub>-STAT, Matlab, various data bases or SPC-charts. Industrial requirements are fulfilled by functions such as wafer map import or OCR/DDM/Bar Code Reading. In serial measurements no user intervention is required thanks to features such as fiducial recognition, automated alignment and measurement range tracking.

### Benefits at a glance

- Inline-capable 3D surface measuring systems ready for integration into production plants
- Fully automated measurement process and data evaluation
- Reliable measurement data for quality assurance and controlling production processes
- Increased throughput and reduced downtime
- Non-contact and non-destructive measurement principle



Source: ORBIS

## “Digital Tool Management”

### Initial situation

The Hager Group is a leading supplier of solutions and services for electronic installations for residential, industrial and commercial properties. As part of the project “Digital Tool Management”, the company is automating logistics processes, replacing manual SAP posting processes, visualizing tasks, consequently implementing the “Internet of Things” and in future, will realize the preventative maintenance of injection tools. The result is an increase of process reliability in logistics and increased machine and tool availability based on consistent information transparency.

### Solution

By means of the ORBIS Multi Process Suite (ORBIS MPS) and the application of RFID technology, Hager is realizing the interlinking of injection tools, machines, forklifts and storage locations, based on SAP ERP. For this, each tool and each storage location receives an RFID tag for identification and individualization. Using the ORBIS MPS, tool data and movements are transferred in “real-time” to the SAP ERP system and at the

same time visualized on forklift terminals in a user-friendly and appealing way. This allows for continuous tracking of the tools in the factory. This transparency allows for the optimal use of tools in terms of production planning and maintenance – and thus also a reduction of costs. The project’s ROI will be achieved in about 2.5 years. In the fall of 2015, the Hager Group received the renowned “Digital Transformation Award” from the “Wirtschaftswoche” magazine for this innovative Industrie 4.0 project.

### Benefits at a glance

- Automated processes increase process reliability
- Automation of the entire tool management
- Optimized production control and maintenance
- Preventative maintenance of injection tools



Source: Parker

## Sensors for condition-based maintenance

### Initial situation

As a global supplier, Parker Hannifin has a range of sensors, electronics, drives and measuring technology for process monitoring and control in fluid technology as well as automation and control technology.

The desire to be able to quickly and easily access this sensor data, could only be realised in a limited fashion in the past using the existing fieldbus systems. Meanwhile, in addition to the sensors described, information technology has become so advanced and established.

### Solution

One feature that makes these sensors and systems Industrie 4.0 capable is the connectivity and intelligence in the component. In systems, gateways are used to make fieldbus sensors or analogue sensors networkable. With this, the sensor data is continuously available at all levels up to the office area and can be analysed on a PC or smartphone, or interpreted and saved.

With the SensoNODE system, Parker has developed a new intelligent system in which measurement data can be downloaded to an app wirelessly to assist the user in decision-making.

### Benefits at a glance

Benefits result, in addition to the pure recording of measurement data, from the application-specific, rule-based interpretation:

- Maintenance can be carried out on demand (Parker Total Health Management).
- Downtimes are minimised, maintenance can be planned and maintenance intervals optimised.

With the combination of a huge range of sensors and broad application know-how, Parker provides its customers with the basis for their own 'Predictive Maintenance' for their applications.



Source: Phoenix Contact



## End-to-end digital

### Initial situation

Phoenix Contact is the global market leader for components, systems, and solutions catering to the fields of electrical engineering, electronics, and automation. Phoenix Contact is a manufacturing company that builds many of its own machines and systems, so the firm knows all about the requirements of tomorrow's intelligent production processes. In order for people, machines, and products to come together into an intelligent and autonomous network, the systems involved have to be digital from end to end, meaning that they can be described in a machine-readable way.

### Solution

As part of the leading-edge "it's OWL" cluster, Phoenix Contact is working on the "Automation for Adaptable Production Technology" project ("it's OWL-AWaPro"). The customized placement of terminal blocks on mounting rails adjusts flexibly to changing manufacturing processes. Data consistency from the engineering tool through to quality control, as well as adaptable

production, makes all of the advantages of mass production available for individual product manufacture – even at a lot size of one.

Products and processes are first generated virtually and are fully transparent. The result of the engineering process is a digital article for the mounting rail fitted with components. In the modular production line, a robot places the individual components on the mounting rail. The labeling is produced and applied using a manual workstation further downstream. Then a camera checks the final product. Unique RFID identification enables the independent execution of single process steps and the association of additional data.

### Benefits at a glance

- Faster engineering
- Automated production programming
- Higher availability, flexibility, and speed of production
- Product manufacture at a lot size of one, at mass production conditions, and at market prices





Quelle: pi4

## workerbot – the humanoid factory worker

### Initial situation

The so-called “Internet of the Things” (IoT) introduced the era of “Industrie 4.0” as the 4th industrial revolution. Conversion of conventional factories into Smart Factories is now an unstoppable process, itself representing a new industrial and technological revolution.

In order to also work efficiently and with high productivity in the future, a robotic platform had to be created that permanently complies with requirements of efficiency in use of resources and capability to adapt, as well as with ergonomic design needs.

### Solution

With its workerbot, the Berlin company pi4 robotics has created an effective tool, which can be integrated in practical and highly flexible ways within modern production lines.

High flexibility in implementation of highly different communication and interface standards, as well as simplified human-machine communi-

cation have been essential aims in the design of the workerbot and the basic prerequisite for integration of the robot in networked factories.

The workerbot can also be adapted for future innovation, on account of its modular construction and control by an industrial PC. Its humanoid anatomy with two arms and a rotating upper body enables autonomous supply of parts. This is supported by camera and image processing systems allowing independent recognition of the position and characteristics of production parts.

### Benefits at a glance

- Fully networkable via Ethernet with Gigabit-speed data transmission
- Easy integration in existing machinery communication systems
- pi4\_controlV10 intuitively learning control software with a touch screen
- Optical recognition of part position and characteristics
- Integrated automatic force monitoring
- Mobile platform





Source:PILZ

## Control concepts for the future

### Initial situation

Modularisation and decentralisation are two of the key success factors on the road to the future of manufacturing automation. Centrally designed programmable logic controllers (PLCs) have a major disadvantage when compared with modular systems: changes in individual plant sections have far-reaching effects at control level, because program structures at central points of the control system need to be modified. That's why the automation of the future calls for solutions that are able to distribute control intelligence and guarantee that it will remain easy for the user to handle the necessary decentralisation and networking of multiple control systems.

### Solution

The Industrie 4.0 compatible automation system PSS 4000 allows the mechatronic approach to be transferred to the control level. PSS 4000 enables complex, distributed plants to be broken down into manageable, independently functioning units. Thanks to the mechatronic approach, the cost of engineering, commissioning and maintenance

is significantly reduced. The degree of standardisation of plant and machine components also rises, allowing them to be adapted rapidly and flexibly to changing customer requirements.

### Benefits at a glance

- Reap the benefits of a decentralised control structure, without making the hardware and software more complex to handle.
- Engineering can be significantly reduced by separating hardware and software development. Function blocks make it simpler to create automation programs, while also enabling programs to be organised and structured by function.
- Using the mechatronic approach to build plants enables complete modularisation in the form of machine elements. Functions can be standardised and re-used across a range of modules.



Source: PROXIA Software

## BDE software practically doubles production output

### Initial situation

Harburg-Freudenberger GmbH is a company in the HF MIXING GROUP specializing in the manufacturing of mixers for the rubber processing industry. It offers its customer complete end-to-end solutions from R&D, design, production and assembly to control technology and installation, to 24/7 service, training and after-sales support. This high standard, along with the success of the last ten years due to the merger, have presented the company with the daunting task of being ready for the fast pace and high volume of incoming orders.

### Solution

Since mid 2011, production has been networked with PROXIA software and terminals. Thanks to BDE, transparency has improved considerably and output has increased. Before the system was introduced, Harburg-Freudenberger was able to produce about three machines per month. Today, the plant produces eight machines per month. In addition, Harburg-Freudenberger has also been able to meet the agreed deadlines – despite the

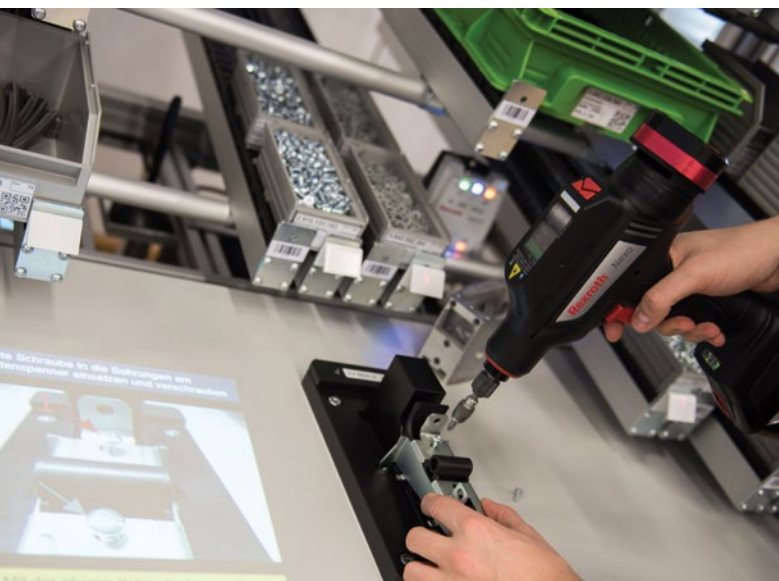
significant increase in orders. Production Manager Karl-Heinz Linke is especially proud of this accomplishment: “Customers hardly ever have problems due to delivery dates!”

The BDE software by PROXIA that was introduced helps machine and plant manufacturers maintain an overview of all the steps in the manufacturing process so they can use their resources in an optimal way, thus ensuring production growth.

### Advantages at a glance

- Greater production output – sales almost doubled
- More transparent processes – automated capture of operating data
- Faster feedback – production data available in realtime
- More economic planning – targeted use of resources and staff
- Better communication – immediate information on the current production status
- Easier application – easy to use, understandable display





Source: Bosch Rexroth



## A cost-effective way to implement assembly of multiple variations

### Initial situation

One of the aims of Industrie 4.0 is to ensure highly flexible assembly of many product variations, from small batch sizes to single units. This means greater requirements for manual assembly. Associates need to clearly identify several thousand versions, some of them with different materials, know the relevant work instructions, and implement them with reproducible quality.

### Solution

The modular, freely adjustable ActiveAssist worker assistance system from Rexroth for assembly of multiple versions offers a solution. It combines real-world assembly stations with the virtual world of information technology. The web-based software uses RFID to identify the work piece and loads the respective work plan via a connection with the overarching MES or ERP system. Digital assistance systems project work instructions and mark material crates or pick-to-light modules guide the associate. The language

and working depth for these instructions can be adjusted easily on an individual basis. Combined with the intelligent Nexo cordless screwdriver from Rexroth, screw sites are automatically located and the system automatically detects whether the screw is positioned correctly. Systems that can be integrated on a modular basis, such as 3D cameras and ultrasonic sensors, review the work steps and help the worker to take corrective action right away.

### Benefits at a glance

- Shorter training times and reproducible quality in manual assembly of multiple variations
- Web-based software with interfaces with MES and ERP systems
- Features a modular structure; can be supplemented with future technologies such as Augmented Reality





Source: ebm-papst

## Digitizing the production

### Initial situation

The principal objectives of fan and motor manufacturer ebm-papst (€1.6 billion annual revenue, 12,000 employees) are to continuously improve manufacturing operations and to establish the same quality standards in all plants worldwide. Well-aligned production processes are a must for meeting these requirements. The digitization of manufacturing plays a key role here.

### Solution

SAP Manufacturing Execution (SAP ME) helps ebm-papst, which is headquartered in the federal state of Baden-Württemberg in southwestern Germany, to network production more closely, both within the company and with suppliers and customers, as well as to simplify order processing and digitize production process. Data is exchanged autonomously between the production machines and SAP ME, and production steps are triggered automatically. The entire manufacturing process can be managed and monitored in one central system making it possible to trace back all the production steps.

### Benefits at a glance

- All relevant parts can be traced from the supplier to the customer. This also applies to all defined processes between order and delivery.
- Production performance can be analyzed and visualized at any time.
- A product is not shipped until it has successfully passed all the predefined quality gates.
- The software is implemented based on lean management principles such as poka-yoke (avoidance of human error) and jidoka (intelligent automation).
- Changes to manufacturing processes can be made using drag and drop.

Read more about another Industrie 4.0 solution of ebm-papst on page 18.



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Source: Schaeffler Technologies

## Innovative rolling bearing solutions

### Initial situation

In machine tools, rolling bearings and guidance systems transfer the machining forces from the tool center point (TCP) to the machine frame. They are decisive in determining the required dynamics, precision and rigidity and therefore secure productivity. The condition of the bearings and guidance systems during operation thus have a significant influence on the machining quality. Tool wear also substantially affects quality and interferes with the influence of the condition of the bearings and the machine. Today, these changes that occur over time are mostly recorded indirectly and not directly. On the workpiece itself, this is carried out, for example, by measurements as part of quality assurance. This means that changes in manufacturing are detected at a relatively late stage.

### Solution

Bearing systems with matched sensor systems are very suitable for determining the current condition of the bearings and for generating a virtual image of the machine condition and the

quality of the manufacturing process in real time. For this purpose, DMG Mori and Schaeffler developed "Machine Tool 4.0" – with components ranging from the sensors to the cloud. With over 60 sensors for measuring vibrations, forces, temperatures, and pressure, these milling and turning machining centers transmit a large volume of data to the Schaeffler cloud. Sensor data and therefore informed recommended actions are thus available to the user.

### Benefits at a glance

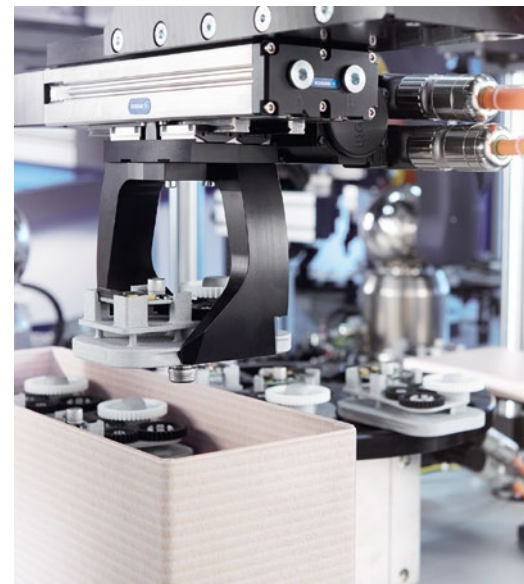
- Optimization of manufacturing and planning processes at constant high machining quality
- "One shot, one hit": Lot sizes of 1 part using machining methods
- Predictive maintenance: continuous calculation of the remaining basic rating life of each bearing position while taking the actual load spectrum into account facilitates the optimum operating life of the components and enables requirements-based maintenance to be planned using the data provided.

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Source: SCHUNK

## Smart assembly based on modular design

### Initial situation

Until recently, conventional high-performance assembly lines have usually only offered limited flexibility. Processes are normally rigidly defined and can often only vary with elaborate manual conversion of the line to a new spectrum of parts. The status and process monitoring takes place exclusively in the PLC. Process deviations are not recognized until relative late and require manual intervention.

### Solution

Adaptable SCHUNK gripper modules, efficient SCHUNK changing systems and highly dynamic, freely programmable SCHUNK linear motor drives allow the design of a flexible process with maximum productivity. With each new component and each prioritized order the assembly lines repeatedly invent a new choreography. In addition: SCHUNK mechatronic grippers with adjustable force and position as well as SCHUNK force-moment sensors enable precise condition monitoring. They allow decentralized intelligence in the individual process step and are suitable for

monitoring process parameters, for decentralized quality assurance and for documentation of quality criteria.

Before failures occur, the force/moment sensors detect even minimal deviations and therefore create the conditions for plannable and effective intervention with the framework of predictive maintenance or a necessary correction of the process parameters. Fieldbus compatibility enables immediate, barrier-free communication between the modules and line components.

### Benefits at a glance

- Flexible design processes at any time depending on the situation.
- Control takes place locally at the component level.
- All process steps can be monitored in real time.
- The recorded data provides an optimal basis for foreseeable service.



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Source: SEW-EURODRIVE

## Industrie 4.0 boosts productivity

### Initial situation

The growing speed of innovation has increased the pressure on German companies. Long-term strategies therefore need to be developed that go beyond the current status quo and set out a specific view of the future tailored to a company's own activities, history, image and portfolio.

### Solution

The solution is the close networking of industrial processes with cutting-edge IT technologies with the aim of creating a smart factory. What's new about this approach is that it is not just machines and integrated systems that will communicate with one another. All systems will be intelligently networked and will also exchange information with the products to be manufactured.

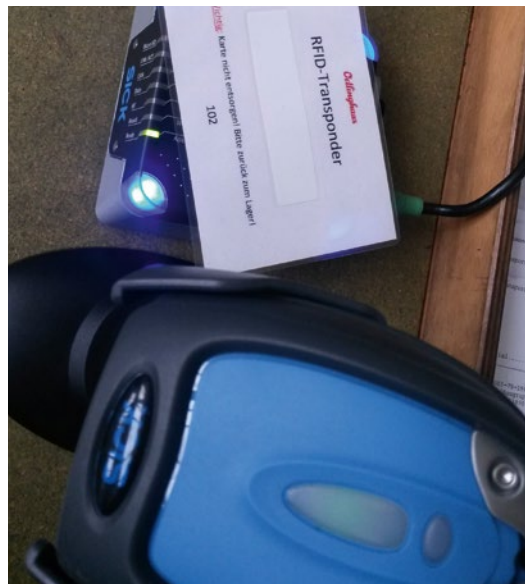
The solution is to perfectly implement the lean principles and technological approaches of Industrie 4.0 and thus create factories that follow the successful philosophy of "intelligently combining man and machine in a working process." This involves designing waste-free, flexible and moti-

vating working processes that are geared toward value creation and supporting these across all areas using embedded intelligent automation solutions. The Industrie 4.0 approach takes functions that were previously separate – such as production, assembly and logistics – and intelligently interlinks them into a single overall system.

### Benefits at a glance

- Employees are provided with support in carrying out their activities / key information is communicated to them (augmented reality).
- Innovative IT-based assistance systems foster creativity and learning.
- Workflow that supports the acceptance, performance, development, health and well-being of employees
- Profitable combining of people and technology in the complete assembly process
- Handling-, motion- and ergonomically-optimized material and tool supply





Source: SICK AG

## Production control based on intelligent sensors

### Initial situation

The entire industrial sector is seeing groundbreaking changes right now. The fusion of production, information, and communication technologies is at the heart of these changes. To respond to them, companies need a direct connection between actual production and a piece of software for production planning that is capable of mapping the complexity of material flows, machine and staff utilization, and the current status of all orders as close to real time as possible.

### Solution

Collaborating on a joint research project, SICK and Ortlinghaus-Werke GmbH have developed an innovative production information system that is capable of mapping many items of additional data. It is an identification solution for identifying materials based on RFID technology. One of these RFID systems has been installed at Ortlinghaus as an access gate on the way from the warehouse to the pre-completion zones. The system comprises an RFU63x RFID read/write device in

conjunction with an external RFA63x antenna. The components are simply installed above a transport route in the production area so that they do not affect production processes.

With the help of antennae, the read/write device reads the order data on the tag without making direct physical or visual contact and transmits this information to the new production information system using the intelligent functions integrated within the sensor. These intelligent sensors are capable of using measurement data to provide quantitative or qualitative information about the production processes they are monitoring.

### Benefits at a glance

- An updated overview of the status of all production orders can be called up and visualized at any time.
- The company is able to respond to disruptions in production as soon as they occur.



Source: Siemens / Fripa

## Customized solution

### Initial situation

Papierfabrik Albert Friedrich AG (Fripa for short) in the Lower Franconian town of Miltenberg manufactures hygiene tissues such as kitchen rolls, toilet paper, and tissue handkerchiefs. For the production of this kind of tissues a cellulose roll is dissolved and the paper suspension produced in this way is passed through a strainer. The solids content is less than one percent. Through dehydration, pressing and drying, this content is increased to 95 percent – within less than one second.

However, the long machine running times and the energy-intensive drying process consume a considerable amount of energy. Energy consumption during production is therefore a major factor for Fripa in order to be able to maintain its competitive position despite increasing cost pressure.

### Solution

To cope with this situation, Fripa is relying on energy-efficient Siemens technology. The paper

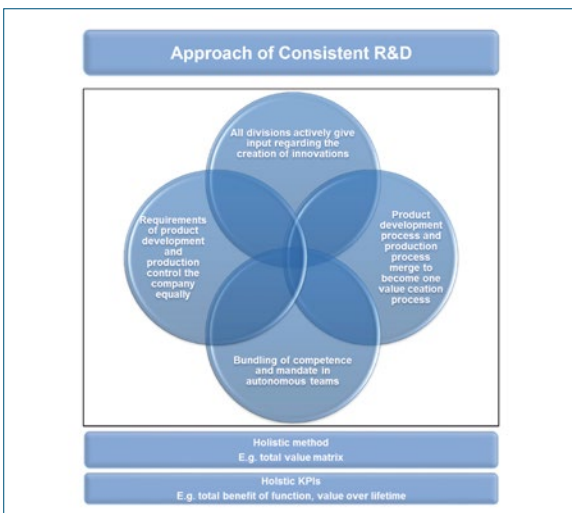
mill is using the plant-wide SIPAPER industry concept on its new PM7 hygiene paper line. This cutting edge solution has been customized to meet the requirements of the pulp and paper industries: high efficiency drive systems, specifically developed automation and process control systems, intelligent power distribution and industry-specific services. As a product and solution provider Siemens supports its customer along the entire industrial value added chain on its way towards the new era of digitalization in line with Industrie 4.0.

### Benefits at a glance

- Solution tailored to meet the specific requirements of the pulp and paper industries
- Reduced energy consumption despite increased production
- Higher throughput rates
- Secure investment in future-proof technology
- All-in-one solution from one single provider
- Very short project implementation thanks to long standing partnership

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Source: Techniciency Consulting



Source: Shutterstock

## “Consistent R&D” – Creating new processes in product development

### Initial situation

Many companies have optimized their production process by making continual improvements. But there is still a lot of untapped potential in product development. This applies both to the design of a systematic process as well as the quality of content when developing new products.

### Solution

Techniciency has developed a holistic approach that differs strongly from “Lean Development”. It enables companies to benefit in the future from “Industrie 4.0”. This process, which is called “Consistent R&D”, has the following features:

- All business units play an active role in development.
- Product development requirements and production requirements are weighted equally by corporate management.
- Development and production merge – the company becomes a “development factory”.
- Competence and authority are concentrated in small, freely operating teams.

Product development cycle times can be reduced drastically through the highly developed integration of information. Results can be incorporated directly. Greater amounts of information can be integrated into newly formed parts, for example.

### Benefits at a glance

- Shortens the development process by up to 25 %.
- Takes into account the additional revenue potential in holistic indicators (e.g. “Total Value Matrix”). Sustainability aspects are already incorporated during product development.
- Greatly increases flexibility, as the close integration of development and production promotes a new way of working.
- Supports corporate management to be product oriented, viewing the value added holistically.





Source: TRUMPF

## Technology for networked manufacturing

### Initial situation

Declining lot sizes and rising numbers of variations in items are constantly adding complexity to the manufacturing processes in the sheet metal processing industry. Here, in particular, the effort devoted to indirect processes is climbing. Keeping an overview of the activities and keeping costs under control have indeed become a challenge.

### Solution

TRUMPF helps to achieve individual optimization of business processes as a whole and to increase transparency and data consistency. Consulting that takes account of practical needs shows what the road to the Smart Factory might look like, which advantages it will bring about, and which concrete steps the customer has to take to this end. The customer's criteria are decisive here, what would he like to achieve: greater transparency, improved profitability, faster throughput, speedy response to changes, or a mix of several of those criteria.

For the implementation TRUMPF offers a wide range of modules that help expand the value addition process and, depending on the requirements, create an individualized Smart Factory. The spectrum of tools ranges from software packages for production control or automatic generation of bids, for instance, to monitoring tools and solutions for tracing parts, and far more.

### Benefits at a glance

- Increased productivity and process reliability with greater flexibility in production
- Consistent processes throughout the factory and individual processes that are easier to manage, as the systems work hand in hand
- Better collection and analysis of data and, as a result, transparency when it comes to performance data, costs and the current processing status





Source: Weidmüller

## Condition monitoring solutions

### Initial situation

Machine availability is a critical success factor for manufacturing companies, especially in industries where processes have to run continuously or where unscheduled maintenance tasks can only be carried out with a great deal of time and effort. Unscheduled downtimes are costly: indeed, breakdowns in steel production facilities or offshore wind turbines quickly lead to six-figure costs.

### Solution

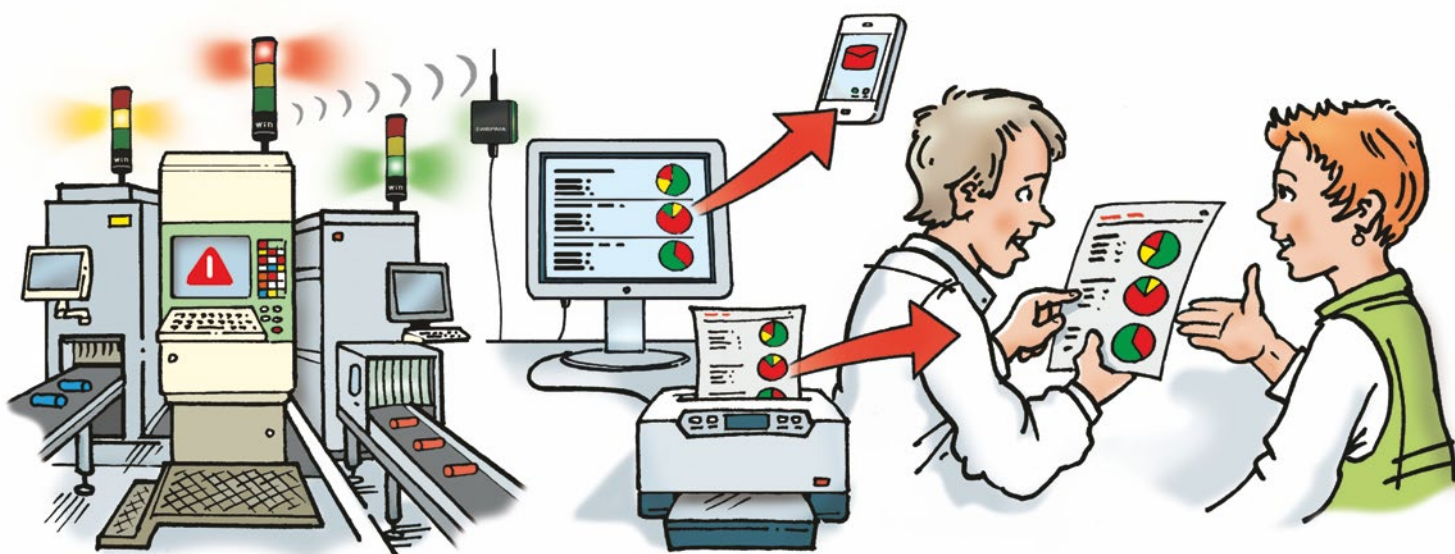
With condition monitoring solutions, Weidmüller is specifically endeavouring to identify and rectify any errors at an early stage. The customer's responsiveness is increased and expensive downtimes are thus reduced to an absolute minimum.

With regard to predictive maintenance, Weidmüller offers solutions that will ensure machinery is maintained in a proactive manner. It is complementing these with customer-friendly solutions for reliable remote maintenance. The products used include communication-capable

signal converters such as the ACT20, as well as routers and switches. Using these products, maintaining and monitoring critical variables based on particular conditions and identifying any anomalies is a doddle. The digitalisation and networking of process and condition data – with the u-remote remote I/O system, for example – forms the basis of this. Combined with the u-Link remote maintenance solution, the customer can also access systems distributed around the globe – from any location.

### Benefits at a glance

- Condition-based monitoring increases process reliability.
- Costs are reduced; delivery reliability is increased.
- Reliable remote access means simple maintenance routines can be performed at any time.
- Data analytics is used in a next step to optimize maintenance in the long term.



Source: WERMA Signaltechnik

## Transparency thanks to networked signal towers

### Initial situation

Increasing complexity prevents transparency in production and malfunctions reduce productivity. This is part of everyday working life for many companies. To uncover hidden potential in production, you need a system for measuring all unproductive times.

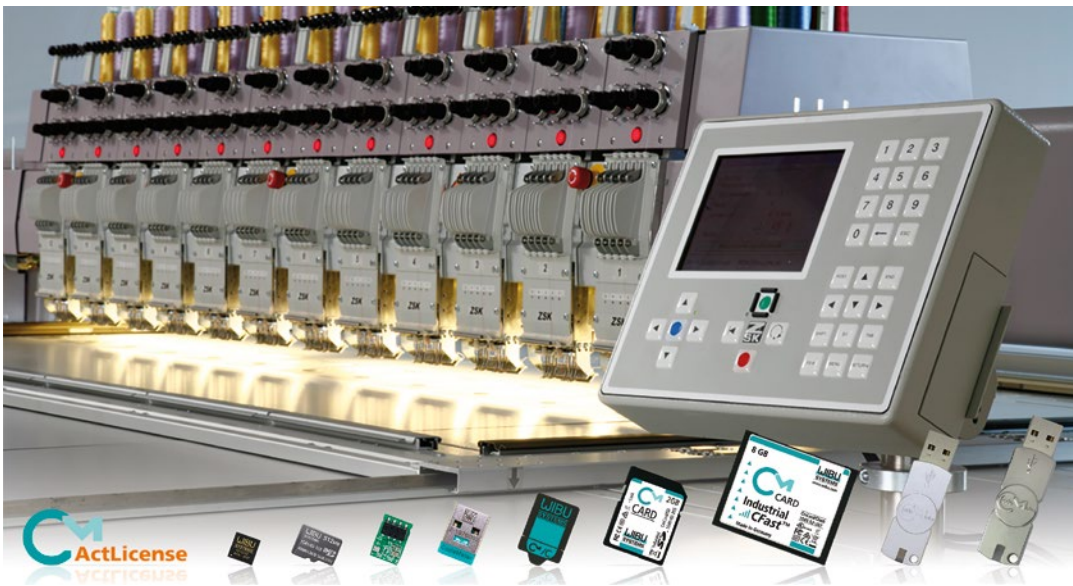
### Solution

Intelligent networking of signal towers creates a simple, low-cost and retrofittable alternative to conventional complex machine data collection systems – completely independent from the machine manufacturer. With the intelligent system based on networked signal towers, reliable data can be collected and the potential for sustainable cost optimization in production can be opened up. Weak points can be identified and processes optimized – based on these findings, thereby increasing productivity. The system can be retrofitted easily and is based on wireless technology. A signal tower acts as a shared interface. A transmitter is inserted in an existing KombiSIGN signal tower via plug & play. This

transmitter sends the statuses of the signal tower to a receiver. The data from all transmitters is saved completely and securely in the integrated SQL database. Further expansion also enables machines and plants to be controlled. Start or stop machines to achieve resource-efficient production, reduce energy consumption or to visualize the status of the entire production via the “head-of-line” function. An integrated logic module processes the recorded statuses of all integrated transmitters independently and supports you with the generation of the control commands.

### Benefits at a glance

- Recognize and react to stoppages immediately
- Uncover improvement potential in production
- Wide range of reporting and analysis functions included
- Transparency throughout production, irrespective of the manufacturer and age of the machines
- Integration of manual workstations
- Wireless-based retrofit solution removes the need for complex installation



Source: WIBU-SYSTEMS AG

## IP and data protection for intelligent manufacturing

### Initial situation

The valuable know-how of industrial manufacturers resides in their software and data. The transition to connected devices required by Industrie 4.0 specifications makes security by design a necessity.

### Solution

In terms of technical preventative solutions, CodeMeter meets all security needs in modern production environments. Its IP protection mechanisms prevent illegal copying and reverse engineering of software, theft of production data, and product counterfeiting; machine code integrity foils tampering and cyber attacks. Additionally, a hidden counter sitting inside the software license controls volume production, making sure only the mandated batches are produced. In networked environments, remote communication also needs special care: Using certificate chains combined with digital signature ensures end point security for sensors, devices, and machines. CodeMeter License Central offers an additional license lifecycle management platform that

promotes new business opportunities and consistent savings in logistic associated costs.

### Benefits at a glance

- Best-in-class encryption with industrial-grade hardware-based protection via CmDongle, a family of devices with built-in smart card chips
- Secure communication between sensors, devices, and machines enabled by using digital signature and certificates
- Higher software monetization rate with CodeMeter License Central for creating and managing flexible licensing models
- Faster back office automation with the seamless integration of CodeMeter License Central in all leading CRM, ERP, and e-commerce systems

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