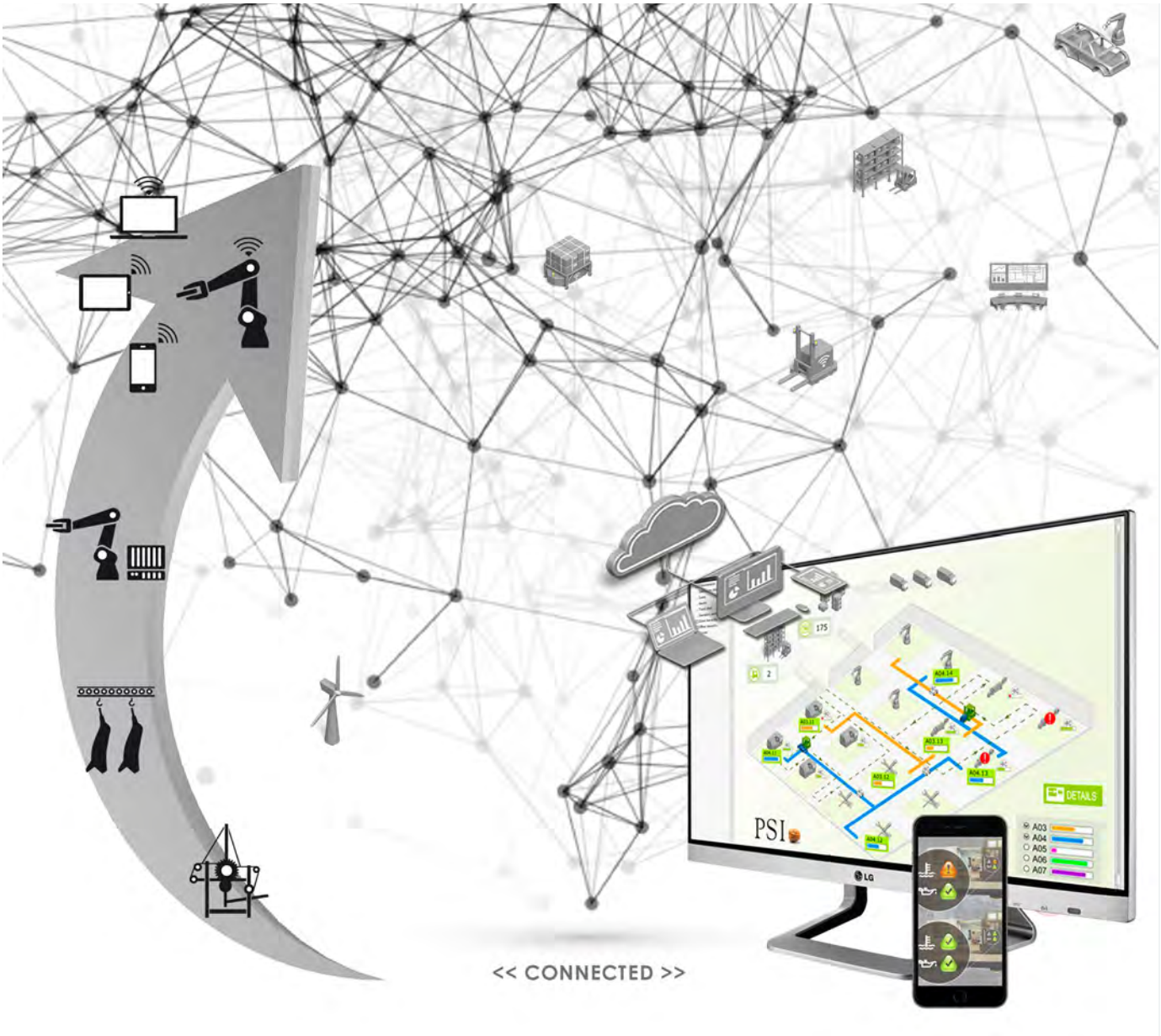
2016

industrie 4.0 magazin

Magazine for integrated production processes



Smart Production – Only in the Future?

A look into the current practice shows that digital transformation is in full progress. Technical platforms set new standards, offer open interfaces and possibilities of wide data transfer. New business approaches are discussed and implemented. PSI software enables these ground-breaking business processes.

PSI

HANNOVER MESSE: Digital Factory solution centre

Dr. Jochen Köckler | Member of the Board of Management of Deutsche Messe AG

For years, Industry 4.0 has been presented, publicised and discussed at the HANNOVER MESSE; but not without scepticism: Is it just hype? Does it have a real connection to industrial practice?
In 2016, the question is no longer if the manufacturing industry should go digital, but when and how quickly. Practical solutions are therefore at the forefront. More than a hundred use cases are presented at the HANNOVER MESSE. It is the only place in the world to do so.
The German initiative Industry 4.0 is making an impact. Many industrial countries have taken it as an example to start similar campaigns. In the USA, the Industrial Internet Consortium (IIC), which has similar objectives, was founded in 2014. This year, the USA is not just a partner country of the HANNOVER MESSE .The US exhibitors have the second largest area in the exhibition area of the Digital Factory after the German companies, including Autodesk, Microsoft and AT&T and IBM – two of the five founding members of the IIC.
The Digital Factory will therefore take centre stage in many respects – as the central point of the most important software solutions that are urgently needed for the path to Industry 4.0.
Discover the solutions of PSI Automotive & Industry there too. Faithful to the theme of this year's fair:
Integrated Industry – Discover Solutions!

Greeting

Dear readers,

Software companies buy robot manufacturers, machine manufacturers integrate with software vendors and highly competitive automotive companies cooperate when purchasing a digital map service. In the onward march of digitisation, it is clear that both established industries and new industries are increasingly growing together. Whilst web-based companies announce new business areas, traditional industrial corporations are looking to create new and integrated solution offerings that make them more independent as manufacturers and more compatible with the outside world. What this shows is that IT is important, but it is not the be all and end all.

Last but not least, the products and services of the real economy are our bread and butter. Digitisation is now forcing companies to question or radically change their business models and to rethink their IT landscape in the process. These present both opportunities and challenges. „Sheer driving pleasure“ has to be redefined in the context of the self-driving car. At the same time, people need to be increasingly mobile, without wanting to own a car themselves.

In this magazine, we will look at the significance of digitisation for the value chains in production, explain our areas of focus and consider how we are researching, cooperating and working together with PSI customers on the processes for ‘Factory 4.0’. Motivated by the theme of this year’s Hannover Messe, “Integrated Industry – Discover Solutions”, we present our integrated solutions on the basis of our own technologies.

Immerse yourself in the subject and enjoy reading.

Peter Dibbern
Director of Business Development
PSI Automotive & Industry GmbH

From Practice

Everyone is talking about the Smart Factory, but what about the implementation? The following articles show that Industry 4.0 already exists.

The Software Behind It

Software is seen as the key to implementing Industry 4.0 projects. Find out how PSI solutions already support the industry.

Research for the Future

Particularly in production, the possibilities of process optimisation have not yet been exhausted. Companies and research institutions are working together on future solutions.

About the magazine

The third edition of the Industry 4.0 magazine addresses aspects of the fourth industrial revolution.
Explanatory articles, practical examples, but also critical and scrutinising articles inform readers about current developments and trends. The magazine focuses on the software products from the PSI Group. Under the leadership of PSI Automotive & Industry GmbH (formerly PSIPENTA Software Systems GmbH), cross-industry PSI solutions are presented.

Found an interesting article?
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www.psipenta.de/en/industrie-40

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100 places Industry 4.0
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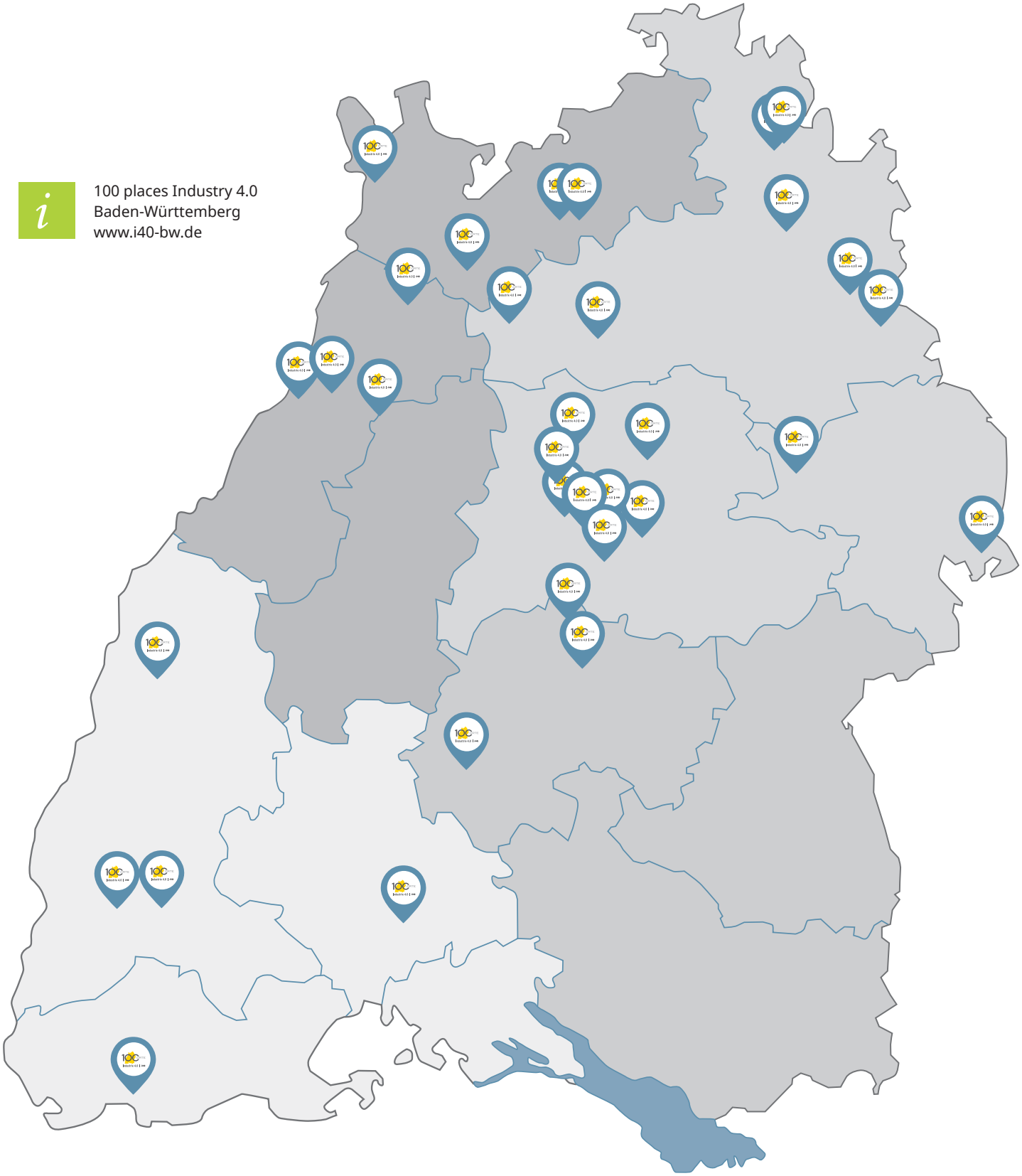


From Practice

A „Place for Industry 4.0“ – the excellent data collection and communication system by Felss

For many companies, „Industry 4.0“ is currently no more than a vision for the future or a topic of research. It is lacking in time, nerve and perhaps also references or testaments to success. In order to encourage small and medium-sized enterprises in particular in the state of Baden-Württemberg to present ideas or make the idea become reality, the „Industry 4.0 Baden-Württemberg Alliance“ launched the competition „100 places for Industry 4.0“ and honoured the first companies in November 2015. The Felss Group was one of the winners, receiving recognition for its innovative data collection and communication system (DEKS), amongst other things.

➲ **Felss Holding GmbH**
Contact info.felss-holding@felss.com

State Secretary Peter Hofelich (right) presents Wolfgang A. Hagg Müller (Business Development, Felss Holding GmbH – left) and Dennis Beihofer (Project Manager Development, Felss Systems GmbH – centre) with the competition document. (Source: Felss)

The DEKS by Felss allows integrated component collection and networking of the process parameters. This information is saved centrally in the cloud and can be retrieved whenever needed. Each component is equipped with a data matrix code (DMC). Using this code, status and process data are collected, stored, and processed centrally. The code on the component is scanned before each work step. The machine then requests the necessary parameters from the Finite Capacity Scheduler module and displays the green signal for the work step. When the procedure is complete, the machine sends all quality and process data back to the Manufacturing Execution System (MES). If the MES identifies problems, such as defective components, these are logged and are automatically separated.
In addition, DEKS provides many other functionalities, such as the connectivity of the different machines in a process chain.

Transparency – shorter lead times – satisfied customers

The system makes the entire production process transparent by providing and networking extensive data related to components and process parameters collected via the value chain in the production process and making this available for central reporting. The DMCs permit fully transparent tracking of the processes a particular component goes through. The storing of individual parameters saves on resources like changeover times and tool costs. Unique component identification also permits shorter processing times.

Thanks to seamless traceability, the customer can understand exactly which work steps a component has gone through. This transparency is especially important for safety-relevant components because, in the event of damage, it is easy to determine whether the component was produced without faults and according to the specified parameters.

The solution serves as a beacon for the further path towards Industry 4.0: In the future, intelligent components will drive the manufacturing process and convey relevant information about themselves to the machine via RFID chip and allow the process to be controlled.

Alliance & competition

The Industry 4.0 Baden-Württemberg Alliance has been jointly developed by the State Government of Baden-Württemberg and the Association of German machine and plant engineering (VDMA) launched, to combine the various competences from manufacturing, information and communications technology, to connect all major actors and through innovative transfer offers to support the industrial medium-sized companies towards industry 4.0.The goal is to establish Baden-Württemberg as the leading supplier for Industry 4.0 (for more information, visit: www.i40-bw.de).

Through the competition „100 places for Industry 4.0“, the Alliance is looking for innovative concepts from business which have been successful with the intelligent networking of production and value creation processes. In addition to the degree of innovation, the panel of experts also evaluates the specific practical relevance for Industry 4.0. „We particularly want to encourage small and medium-sized enterprises within the state to present their ideas.“ said State Secretary Peter Hofelich. „[…] With the award ceremony, we want to publicise great ideas from the state and also motivate other companies and institutions to become active in Industry 4.0.“ The winning solutions have shown that, even today, Industry 4.0 is no longer an abstract vision of the future, but a living reality in many places. This has made it clear that digital solutions are increasingly asserting themselves in medium-sized enterprises and also create specific added value. i4.0

Each component is equipped with a data matrix code, which collects, saves a
(Source: Felss Holding GmbH)

nd centrally processes information such as processing status or process data.

FELSS GROUP

- **Headquarters:** Köngisbach-Stein, Germany
- **Other locations:** Bretten-Gölshausen (Germany, Nesselwang (Germany), Wujiang (China), New Berlin (USA), Triengen (Switzerland)
- **Turnover:** approx. 100 million EUR
- **Employees:** 580 worldwide (330 Germany)

The Felss Group, under the brand name Felss Shortcut Technologies, produces both machines for metal processing as well as components for various sectors such as the automotive industry. Technically, the focus is on the cold forming process, swaging, axial forming, bending, autofrettage and tube end machining.
Felss has favoured PSI software solutions since the start of the 1990s, and uses PSI*penta* ERP and MES modules to support both order manufacturing and series production.

IT-STECKBRIEF

- **PSI*penta* customer since:** 1990
- **Licences at start:** 130
- **Current licences:** 240
- **Languages:** German, English
- **Software used:** Order Management, Cost Accounting, Shop-floor data collection, graphical Finite Capacity Scheduling, Mobile, Personnel Time Management, multiple plant management/ Multisite, Electronic data exchange (EDIFACT & myOpenFactory)

From Practice

Real time as a strategic factor

What do digitisation, Industry 4.0, Internet of X and Smart X have in common, and which investments can really be justified under these headings? Many practitioners are asking themselves this in light of the numerous buzz words, visions and technology perspectives, but genuine implementation examples are often lacking. The changes to be expected are often difficult to understand in the already partially digitised working world of industrial companies of various sizes and industries. Unique Europe-wide answers can be found in Aachen.

➲ **Dr. Rupert Deger** | CIO of e.Go Mobile AG & Managing Director of the European 4.0 Transformation Center at the RWTH Aachen Campus

Contact rupert.deger@e4tc.de

i For more information on the digital transformation, visit: www.europeantransformationcenter.eu

The second electric vehicle start-up has already been founded in Aachen. The first was StreetScooter, which was set up in 2010. StreetScooter initially competed in the market with a compact car, but then, thanks to very streamlined and fast development processes and production methods, quickly responded to market demand for cost-effective and customer-specific battery-operated short-distance transporters. StreetScooter was completely taken over by Deutsche Post/DHL at the end of 2014 and since then has manufactured exclusively for the Bonner Group. Since the beginning of 2015, Aachen is also home to e.GO Mobile AG, which concentrates on cost-effective compact electric vehicles for private and commercial use. The motivating factor behind the launch and business model of e.GO is a firm belief that the market for electric vehicles today is still only small because the right products are lacking. Instead of expensive and subsidised fast battery-powered cars, e.GO is very cost effective despite initially producing only small quantities. It offers dynamic and practical electric driving fun, so that anyone with a suitable trip profile can afford a battery-powered vehicle as a „best possible second car“. The e.GO prototype workshop also provides technology carriers for connected mobility and partially autonomous driving.

End-to-end digitisation

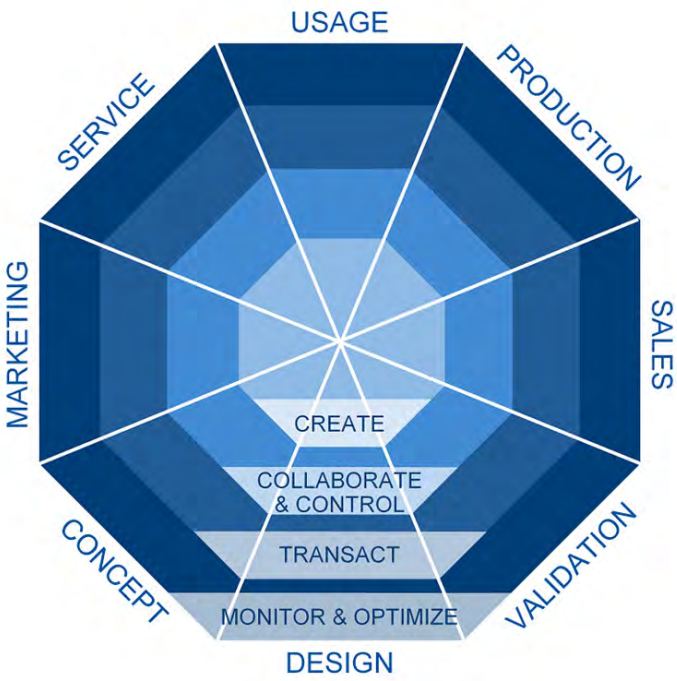
What these two start-ups have in common is not just the basic product architecture, but also the fact that they have had end-to-end digitisation from the start (something that is easier to realise as a new company). Products are digital and modular in design and therefore can have agile iterations between all main processes. For example, there is full continuity between the development data and the assembly planning as well as the associated work instructions on a Single Source of Truth with overarching change processes and conditions and handovers to the PSI*penta* ERP system. Even during the testing stages, the prototypes are networked as connected cars and transmit their performance data. Professor Achim Kampker, co-founder

e.Go Mobile AG focuses on the production of cost-effective compact electric vehicles. (Source: Demonstration Factory Aachen)

and CEO of StreetScooter, reports of a high „return on engineering“: half the normal development time for a tenth of the usual budget.

Partners in E4TC

The necessary technical and methodological skills are provided and holistically implemented at the RWTH Aachen campus as part of the European 4.0 Transformation Center (E4TC) by partners such as PSI Automotive & Industry GmbH, PTC and EPLAN using the e.GO products, production systems and processes. They are therefore not only available to the electric car start-ups but also for industrial projects. The Smart Logistics Cluster at the Aachen Campus, to which the E4TC also belongs, currently sees over 20,000 trade visitors a year. The two primary focuses of the E4TC are the holistic digital architecture model and the resulting orientation toward real-time capabilities in company processes on different levels. Real time is therefore also the driving force for the return on investment from the digital transformation of products, processes and business models in the manufacturing industry. Groups of experts, seminars and consulting projects support this transfer to operational practice. i4.0



The holistic architecture model of the European 4.0 Transformation Center includes the business processes as an octagon, allowing them to interlock agilely and recursively, and also describes handling digital assets. These are created, managed, included in transactions and coupled with monitoring and optimisation values (shell model). (Source: e.Go Mobile AG)

From Practice

Is everyone going digital? Online map shows the everyday reality of Industry 4.0 in German industrial companies

Digitising production and business processes, and developing business models that accommodate this present a major challenge for many small and medium-sized enterprises (SMEs). The competitive advantages and benefits for the individual company are something that always have to be considered. To find and evaluate solutions, SMEs need information and support. The Industry 4.0 platform is making an important contribution here. The Industry 4.0 online map (currently only available in German), for example, provides real-life use cases from companies around Germany and shows why it makes sense to invest in networked production.

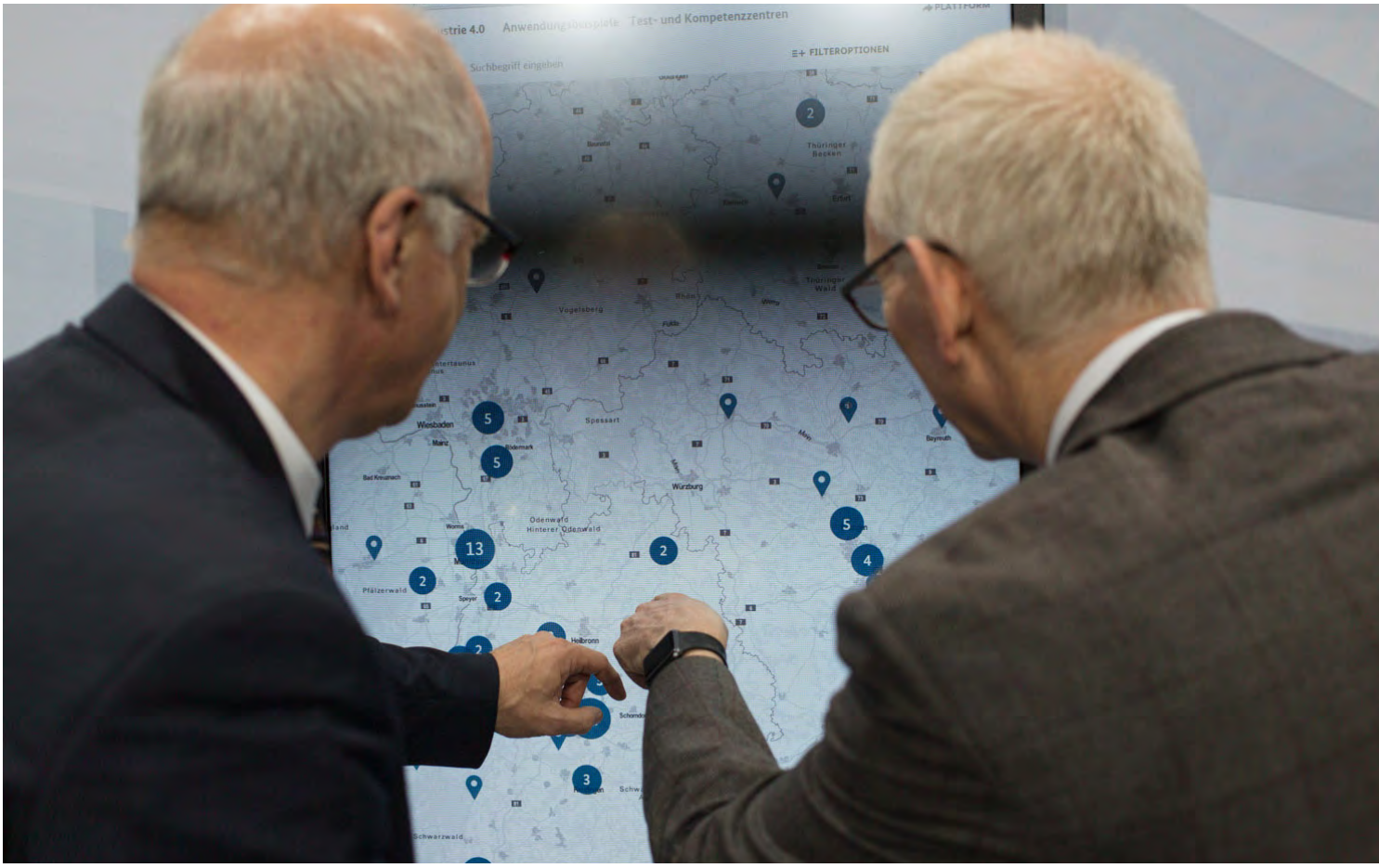
➲ **Henning Banthien** | Head of the Industry 4.0 platform office, IFOK GmbH
Contact geschaeftsstelle@plattform-i40.de

More than one in five machine and plant construction companies are currently implementing Industry 4.0. 75 percent, however, have still not taken any systematic steps in this direction – although many Industry 4.0 applications and technologies are essentially ready for use in SMEs[*1].
Often, reasons behind the wait-and-see attitude include concerns about the data security of assistance systems and a lack of information about the associated potential and possibilities[*2].
SMEs in particular need support here because they too have to adjust to the digitisation of the economy and introduce the right steps for their particular company. Otherwise, they run the risk of becoming disconnected from the international competition[*3]. The Industry 4.0 platform (www.plattform-i40.de) was established to advance digital transformation within Industry 4.0. The platform is operated as a joint initiative by representatives from business, science, associations and unions as well as under the leadership of the Federal Ministry of Economics (BMWi) and the Federal Ministry of Research (BMBF). This ensures that all relevant issues are tackled and the various social perspectives are illuminated and taken into account. This is achieved through five working groups, which are responsible for developing operational problem-solving proposals for companies and recommendations for action on various issues.

Over 200 use cases throughout Germany

The Germany-wide online map „Industry 4.0“ is visited frequently[*4]. There are over 200 use cases, illustrating

*1 *Study „Industry 4.0 Readiness“ by the VMDA, October 2015; study „Erschließen der Potenziale der Anwendung von Industrie 4.0 im Mittelstand“ (Exploiting the potential of Industry 4.0 in SMEs), commissioned by the BMWi, June 2015*
*2 *Study „Exploiting the potential of Industry 4.0 in SMEs“, commissioned by the BMWi, June 2015*
*3 *Study „Exploiting the potential of Industry 4.0 in SMEs“, commissioned by the BMWi, June 2015*
*4 *www.plattform-i40.de/I40/Landkarte*



The Industry 4.0 platform presented the first Germany-wide online map „Industry 4.0" at the national IT summit in November 2015. (Source: BMWi/Espen Eichhöfer)

companies and production processes in which Industry 4.0 is already part of everyday life. It also provides links to the company, allowing them to be contacted for more information. The map also refers to test beds, in which applications can be researched, tested and further developed.

For more information and use cases, visit:
www.plattform-i40.de

Holistic production system in the Bender final assembly plant

One such successful use case is the Bender final assembly plant in Grünberg, Hesse, Germany. In an interview with Head of Production at Bender, Mr Manfred Nicklas, visitors will discover the added value of the holistic production system.

Central networking hub

Through its various activities, the Industry 4.0 platform has established itself as a central networking hub. The relationships maintained with various associations, state departments and regional initiatives are an important part of this. These various bodies jointly organise information and qualification events, which are important for reaching companies throughout all regions of Germany. For example, the platform contributes its experiences and working results as a partner in the Chamber of Commerce and Industry event series „Industry 4.0@SME", which was launched in February in Berlin.

Three questions to…
Manfred Nicklas, Head of Production,
Bender GmbH & Co. KG

Mr Nicklas, you have introduced a holistic production system in your final assembly plant. What added value does this system offer your company in respect of Industry 4.0?

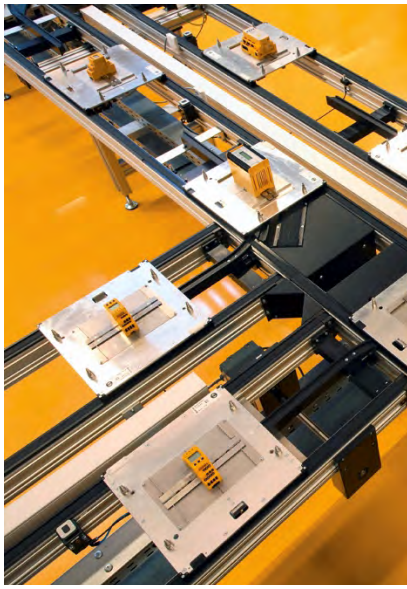
We use the new system to produce many different standard and customised products in an intentionally chaotic order with the shortest lead times. Batch sizes of one piece per year are also possible without setup costs, as is the production of several tens of thousands of parts of the same type – an important competitive advantage.

What does the system actually look like?

We use the Manufacturing Execution System (MES) coupled with Enterprise Resource Planning (ERP) to control a transfer system with manual and automatic workstations. An information system automatically provides the workers with important information on the products and workflow during the production run. The system has a tracking system that makes the entire production process transparent. We have also improved processes to minimise non-value-adding activities.

What was the biggest challenge in the implementation? And what advice would you give other companies considering a move to digitised production?

One of our biggest challenges was configuring the production system to meet current and future production requirements; another was ensuring that our employees were fully on board with the move from the old to the new production method. It is therefore important to involve the employees at an early stage in the design of the processes. One piece of advice I would give is to try and take a holistic view of Industry 4.0, and derive your own objectives from it. i4.0

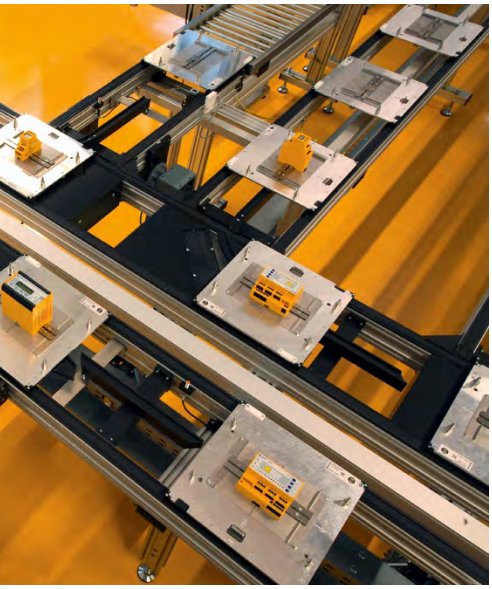


BENDER
The Power in Electrical Safety©

Bender final assembly plant

- **Location:** Grünberg | Hessen (Germany)
- **Use case:** Manufacturing industry
- **Value adding area:** Production & supply chain
- **Stage of development:** Market maturity/ productive use
- **Company size:** 250-5,000 employees

Please scan the QR code for more information!



At the Bender final assembly plant, standard and customised products are produced in an intentionally chaotic order.
(Source: Bender GmbH & Co. KG)

The Software Behind It

Quality control in production with SCADA system

SCADA systems are used to monitor and control technological processes. In this case, data is collected and analysed in real time. PSI AG has successfully provided SCADA systems in sectors such as the energy industry. The „PSIjscada for Production“ product introduces a principal, functional solution for production processes, which plays a great role to the Internet of Things (IoT) technologies.

➲ **Michał Wisniewski** | Manager of Research and Development at PSI Polska Sp. z o.o.
Contact mwisniewski@psi.pl

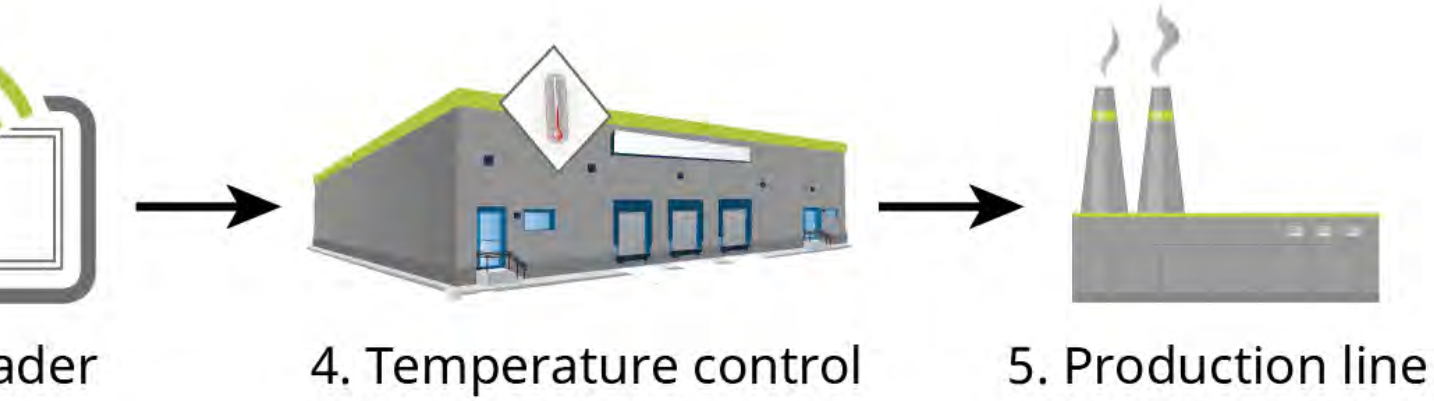
PSI*jscada* monitors production processes and collects data related to the production process and status of machines. The factory is visualised in real time, allowing timely intervention, for example, in the event of a defective machine part. In addition, programmable logic controllers (PLC), microprocessor-based control units and other automation devices can be integrated. For Industry 4.0 processes, the data collected using PSI*jscada* can be directly integrated into IoT applications.

SCADA systems for Industry 4.0 processes

In the subject of Industry 4.0, PSI*jscada* offers requirements control or quality assurance, for example for traceability. It is also used in a wide variety of business sectors. Together with an IoT platform, PSI*jscada* system monitors and makes multiple specifications for a single product, for production equipment and production environments (product-related process parameters) available. Based on data trends, process flows can be analysed within a certain period of time.
This way, in conjunction with IoT technologies, PSI*jscada* allows a fully digitalized material flow control including quality control. All materials for a specific production process are stored in separate containers. Each of these containers is equipped with a single IoT device that is registered in the SCADA system and transmits data such as GPS position, ambient conditions (temperature, humidity, CO_2 level, light intensity) or RFID signature. All material containers are stored in a warehouse. Upon receipt of a material delivery order the selected containers are transported to the production facility. In the process the system monitors the current specifications in each individual container and determines whether the requirements for storage and transport are met (based on a progress analysis). PSI*jscada* is using RFID technology to collect the specific container from the large number of containers in the warehouse. Thanks to the IoT technology, ordered materials and their quality can be automatically checked in order to minimise number of errors, determine the position and prompt the appropriate action (see figure below).

Simple specifications control

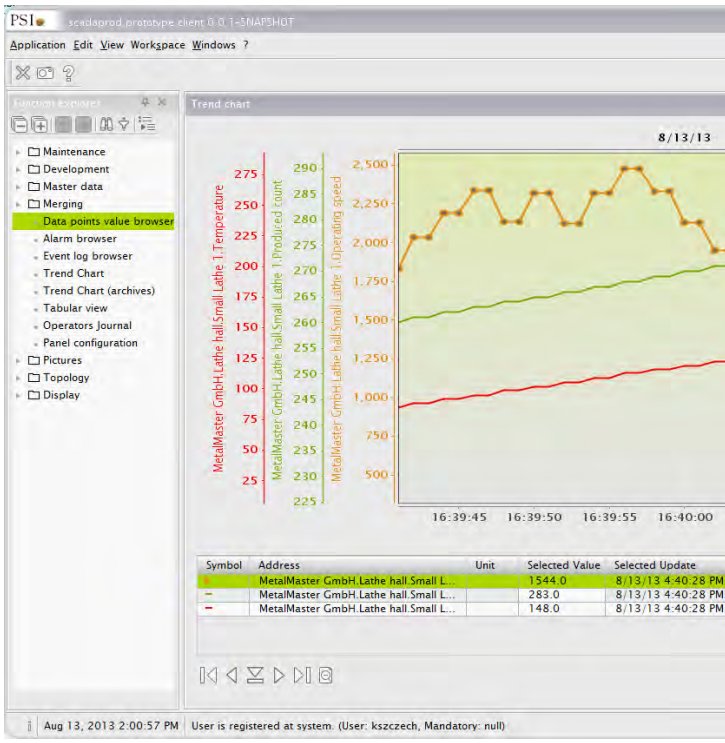
The example shows how PSI*jscada* enables the specifications control of materials and products in conjunction with IoT enabled applications. Irregularities in the process are identified more easily with the help of the automatic control and can be corrected immediately. Areas in which the specifications and parameters for raw materials and semi-finished products must be observed cautiously can be easily and reliably controlled. The compliance of production pa-

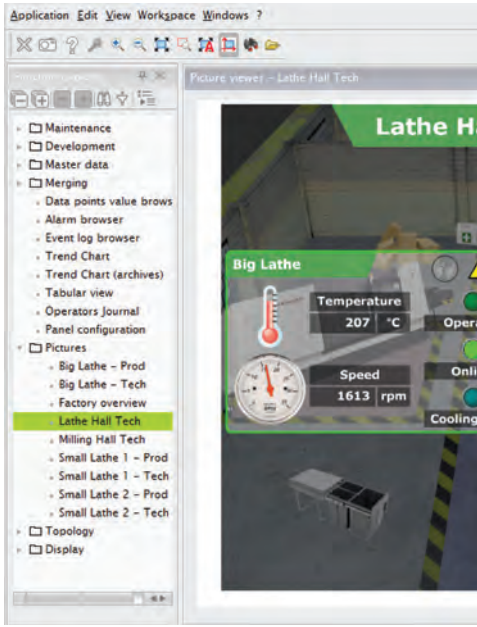


Specifications control in production: The requirements for the storage of semi-finished products in the warehouse are controlled. Before the semi-finished product can be delivered to the temperature-controlled room, first it must be checked using RFID. The required residence time in the temperature-controlled room can be precisely determined in accordance with the storage conditions of the semi-finished products in the warehouse. As soon as the semi-finished product has reached the right temperature, it can move on to the next production step.
(Source: PSI Polska Sp. z o.o.)

rameters is monitored in real-time. In addition, continuous checks help to discover irregularities in the production environment. If problems occur with a product, traceability and the specifications control identify other products which are subject to the same production specifications and which may also be affected.

Investments in the optimisation of production processes as well as the quality assurance are of great importance for Industry 4.0 processes. Accurate data collection and a system that enables informed decisions based on summarized data are the decisive factors for production quality. Comprehensive IT solutions by PSI contribute to improving quality of the product through the monitoring and control of production processes. i4.0

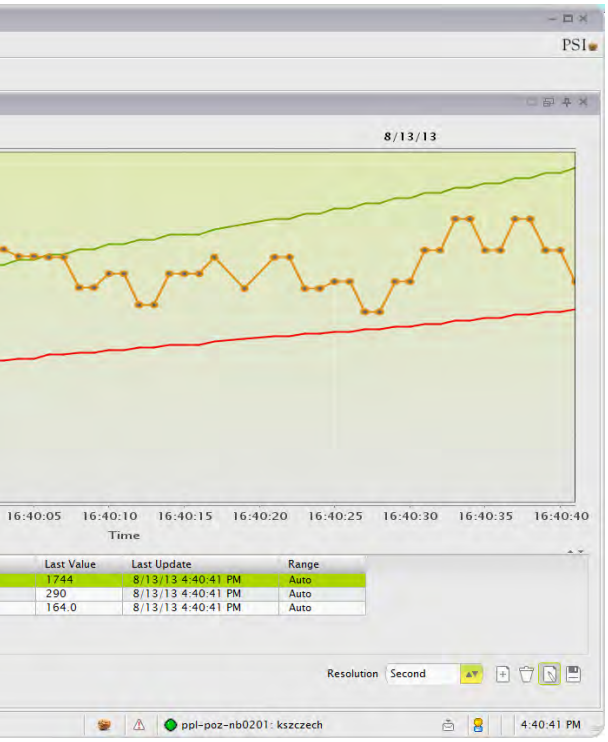




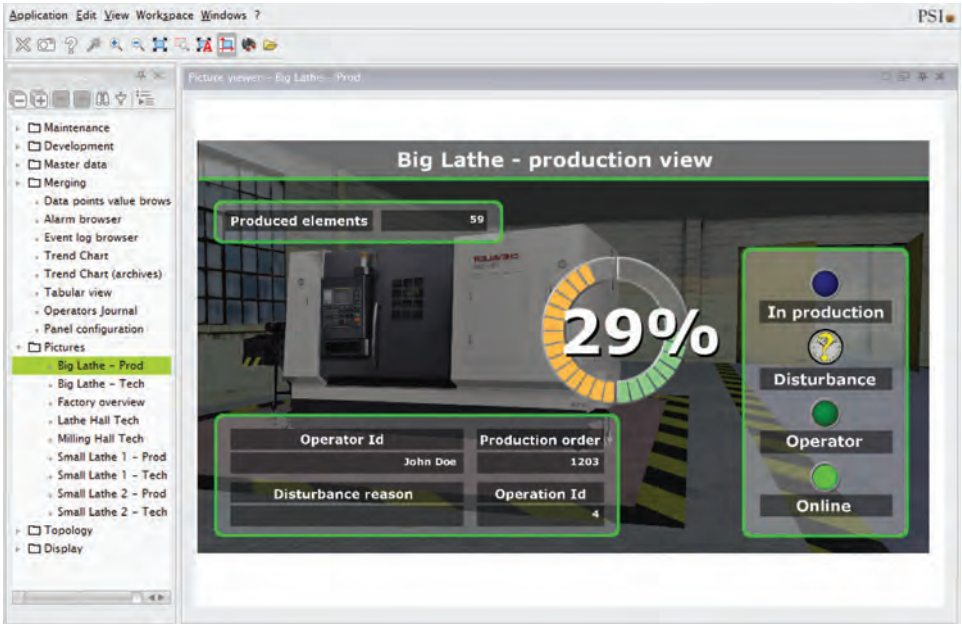
PSI*jscada* – *SCADA solution for the Smart Factory*

The PSI*jscada* application is highly configurable and expandable, and it can be used across different business sectors. As a so-called HMI SCADA (Human Machine Interface SCADA) it serves as an interface between man and machine. It combines the advantages of a small, compact and flexible system with the functionalities of a modern SCADA system. The system incorporates the functions of the operating control technology in accordance with ANSI/ISA-95 Part 1 and 2.

PSI*jscada* belongs to the PSI product portfolio and therefore can be easily integrated into other software solutions from the company.



For more information about the PSI SCADA solution for production processes, see: www.psipenta.de/en/mes/scada/



Visualisation of the production status in PSIjscada (source: PSI Polska Sp. z o.o.)

The Software Behind It

Future-oriented software functions for Industry 4.0 projects

The Industry 4.0 magazine met with Dr Rudolf Felix, Managing Director of F/L/S Fuzzy Logik Systeme GmbH, and Dr Hans-Thomas Nürnberg, Head of Technology at PSI Logistics GmbH, to discuss new technologies as well as changes in production processes.

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Dr Hans-Thomas Nürnberg | Head of Technology at PSI Logistics GmbH
Contact hnuernberg@psi.de

Industrie 4.0 Magazin: *Dr Nürnberg, manufacturing companies have begun to focus on the requirements of Industry 4.0 with increasing automation and networking. What do the software systems contribute in this context?*

Dr Nürnberg: The software is clearly the enabler for tackling the challenges that lie ahead. The future projects „Industry 4.0“ and „Internet of Things“ (IoT) proclaim „digitisation“ as the basis for process optimisation and future competitiveness, and for good reason. Digitisation and in turn the processing, networking and availability of information across the entire supply chain, is our daily business as a developer of software-standard products.

Industrie 4.0 Magazin: *So to what extent can you be proactive in the field? Don‘t you have to constantly chase the developments in flanking technology fields?*

Dr Nürnberg: The question embarrasses me a little. Of course, software developers must respond to developmental leaps in other areas of technology, currently, e.g. close-range communication, sensor systems or image capturing. On the other hand, modern IT architectures, especially in the field of mobile applications, apps and cloud services, currently drive the technological change.

Industrie 4.0 Magazin: *Can you give us an example?*

Dr Nürnberg: With our numerous future-oriented PSI features we have a unique selling point in the market. To name a few current examples, the spectrum ranges from the comprehensive observation and combinatorial optimisation of production and logistics processes with our PSI-*global* module to applications (apps) on our Mobile Service Solutions (MoSS) IT platform. We therefore make an important contribution to an effective IT infrastructure for the future projects Industry 4.0 and IoT.

Industrie 4.0 Magazin: *What does that mean in practice?*

Dr Nürnberg: By that I mean applications with MoSS applications, e.g. for IoT chips. They recognise status points and autonomously control handling and supply processes, as well as the routing, through logistics networks. These

are precisely the requirement profiles that are of great importance for Industry 4.0 and IoT projects. For applications with IoT chips we have already launched specific solutions, for example, for shipment tracking, for which we have coined the term „Smart Parcel", which is already being piloted, or for the areas of localisation, indoor navigation, motion detection and filling level monitoring.

Industrie 4.0 Magazin: *What are these IoT chips for?*

Dr Nürnberg: We see these as a basic technology for future processes and their control, especially in logistics. The so-called iBeacons, small Bluetooth transmitters, are cost-effective, active chips that have such low energy consumption that they function autonomously for years. These chips not only transmit their individual identification. They can also record motion and environmental data, such as temperature or changes in position, using integrated sensors. The iBeacons can be read out from up to 30 metres and offer exciting additional applications in comparison with an RFID transponder infrastructure. Based on our recent development work in the field of IoT chips, our standard systems can already include these properties in their scope of function.

Industrie 4.0 Magazin: *Does this mean that you are also applying these new technologies?*

Dr Nürnberg: We are working to operate the iBeacons in a useful way, to read out their information and integrate them in intelligent utilisation concepts. To do this, we must understand and configure how supporting technologies work. In the understanding and development processes, we use the technology transfer in the PSI Group. We work closely with our sister company F/L/S Fuzzy Logik Systeme GmbH, with which we have developed the QBeacons.

Dr Felix: That's right. The QBeacons allow high-quality decisions to be made, even in difficult data situations in real time, and are used for positioning applications. It is impressive how the hardware of the IT systems is becoming more and more powerful and miniaturised. With a performance previously offered by personal computers, nowadays tiny IT systems can not only be carried around by people in their coat pocket in the form of smartphones, but they can even be attached to objects. Of course, this has consequences for the planning and control of business processes.

Industrie 4.0 Magazin: *You mean that these developments will change the production processes?*

Dr Felix: Take the example of the automotive industry. The order principle of the assembly line is determinative

With PSI*global* and the applications on our Mobile Service Solutions (MoSS) IT platform, we make an important contribution to an efficient infrastructure.

Dr Hans-Thomas Nürnberg | Head of Technology, PSI Logistics GmbH

of the scope in assembly. The structure of the assembly line is designed once in the planning of the production structure for a model, and then „cast in iron“. Even if the model properties of the vehicles change, the assembly line essentially remains as it was once designed. It is orderly. However, the scope for action, from the perspective of changing orders when it comes to competition for resources and for „participation“ in production, remains very limited.

Industrie 4.0 Magazin: *What will be done differently in the future concerning this?*

Dr Felix: In a self-organising production process of an Industry 4.0 scenario, the process and the decision-making processes could be organised differently. There is no longer the fixed physical structure of the assembly line. Instead, assembly is organised by moving the semi-finished vehicles, as orders, on driverless transport systems. Depending on the situation, the orders themselves determine the workstation they wish to move to next. From the local perspective, the workstations are supplied with material and parts autonomously, where their needs requirements determine when they are supplied by the likewise driverless transport systems.

Industrie 4.0 Magazin: *If there will be flexibly arranged and usable assembly areas in the future, which component will then set the direction in the production process?*

Applications with „Mobile Service Solutions“ applications recognise status points and autonomously control handling and supply processes, as well as routing, through logistics networks.
(Source: PSI Logistics GmbH)

Dr Felix: Nowadays, production processes are already controlled by key data-oriented optimisations. Qualicision®-based KPI-optimisation is used worldwide in over 50 automotive factories, in the planning and control of production through to intercepting fault situations. Generally, the KPIs are still mostly focused on the physical structure of the assembly lines with their technical scopes. They are based on minimum gaps between orders with specific properties in the assembly sequence, or on desired groupings of orders such as colour or body type.

Industrie 4.0 Magazin: *And you want to replace these? Are you not afraid that this would be associated with too many sudden changes in the organisation and in the management of production processes?*

Dr Felix: Something like that certainly won‘t happen overnight. Industry 4.0 is often referred to as a revolution. But I much prefer the term ‚evolutionary revolution‘. Seemingly a contradiction and yet reality.
The latest, already productively tested trend in the KPI-based optimisation with Qualicision® is that order sequences are no longer mapped to physical order properties as before, but according to the scheduled capacity properties of the resources. An evolutionary paradigm shift is already taking place.

Industrie 4.0 Magazin: *What does this paradigm shift mean?*

Dr Felix: For the first time, the resource properties are used in the form of their working capacities as KPIs to optimise order sequences. The order sequence reflects the KPI dynamics of the capacity utilisation of resources by the orders. The KPI dynamics reflect the negotiation between the resources and the orders as „things“. That is a big contrast to previous KPIs.
If, as envisioned by Industry 4.0, there are no more assembly lines in the future, but instead flexibly arranged resources and semi-finished orders that move autonomously on driverless transport systems, then the Qualicision®-based optimisation of order processing can simply be supplied with other KPIs.

Industrie 4.0 Magazin: *That sounds simple. What makes you so sure?*

Dr Felix: Optimisations with the widest range of KPIs now work in a range of PSI tools. For example, depot management for public transport control technology has been implemented within the framework of PSI*traffic*, and workforce management within the framework of PSI*command*. The Industry 4.0 relevance of the solutions is immediate once the optimised business processes are equipped with IoT hardware. This is only a matter of time, or the evolution of IoT technology, if you will. We know how to develop Industry 4.0-relevant KPIs with the customer.

Industrie 4.0 Magazin: *Are you already working directly on this development?*

Dr Felix: The direct testing of such a scenario of the Industry 4.0 vision in automotive production has already been worked on for two years. For this, we are involved in the SMART FACE project, as part of the ‚Autonomik 4.0 of the BMWi' program, alongside industrial partners and research institutions. The project is about the organisation of the production of small series of electric vehicles without using an assembly line as an order principle. The evolution of the aforementioned paradigm change is already taking place here.

Dr Nürnberg, Dr Felix, thank you for this interesting insight. i4.0

> **The Industry 4.0 relevance of the solutions is immediate once the optimised business processes are equipped with IoT hardware.**
>
> *Dr Rudolf Felix | Managing Director, F/L/S Fuzzy Logik Systeme GmbH*

The software behind it

Augmented reality in metal production

The motives behind the Industry 4.0 initiative may be relevant for a number of industries in Europe today, but none more so than the metal production industry; especially with respect to safeguarding the competitiveness of industrial production in high-income countries. Cheap imports from China, tightened CO_2 laws and an investment backlog in infrastructure are just a few of the obstacles to turning a profit, especially in the steel industry.

➲ **Raffael Binder** | Marketing Director at PSI Metals GmbH
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Worker 4.0? PSI is exploring the possibilities of smart glasses in the production environment. (Source: PSI Metals)

Companies in the metal industry are increasingly coming to see the opportunities offered by Industry 4.0 as a means of increasing profits and reducing production costs. While on the subject, it is worth noting that in the area of information technology, the metal industry – which is often erroneously considered conservative – already enjoys a more highly advanced level of IT integration than almost any other industry today. Without a fully integrated, end-to-end IT landscape (from production through to sales), hardly any steel plants would be able offer the required quality within such tight delivery time frames.
This is also the reason why the metal industry and associated IT and system suppliers have to consider very carefully which concepts from the Industry 4.0 movement will help them to secure and subsequently improve competitiveness. Particularly in an environment where systems can be in use for several decades, approaches aimed at system networking and autonomy do not offer short-term solutions. Many of the players do agree on one thing, however: the vast potential in the area of data. While some of this potential has already been tapped through the high level of automation, its true value remains unknown. In view of this, PSI Metals, the world market leader for production management systems in the metal sector, is focusing on „data-driven production“ in the development of future scenarios with its customers.

Important topics for the near future

The most important question is, what advantages will the ideas and concepts associated with Industry 4.0 bring manufacturers? Nobody invests millions due to a pure infatuation with technology without considering the risk associated with converting production-related systems. PSI has therefore identified five key topics for the special requirements of the metal industry, which manufacturers are already discussing today, but will be more even more relevant in the near future:

1. New business models
2. Generation and use of information
3. Flexible IT architectures
4. Adaptive corporate structures
5. Work of the future

PSI is now channelling all of its efforts in the area of product development on these five topics for the future and researching new concepts with a focus on these topics.

Joint development with customers

To ensure that it is not operating without due regard to the market, PSI is inviting customers and experts from academia to participate in the concept development process. An example of this was the customer event in December 2015 in Dresden, which was dominated by Industry 4.0 and offered customers and partners a platform for active exchange. As part of a panel discussion, representatives of the aluminium sector (Dr. Werner Aumayr, AMAG), the steel industry (Ralf Damitz, thyssenkrupp), academia (Prof. Dr. Christian Ramsauer, TU Graz) and the IT sector (Jörg Hackmann, PSI) presented on current developments, experiences and trends associated with Industry 4.0. The attention that this placed on the industry trends was particularly well received. The implementation of new ideas and projects, which IT experts in the industry would be required to do anyway, is being given new momentum – thanks in no small part to the availability of government funding. However, a warning was also given about potentially disruptive business models: With regard to the new technical possibilities, it would be naive and even dangerous to think the metal industry immune to the innovative spirit affecting other sectors. Even today, e-business platforms are pushing into supply chains and 3D printers are threatening established procedures. Big data is always mentioned in this context and the potential benefits, which in many cases are difficult to determine at the present time. However, the industry considers itself open and ready for change, even if, from today's perspective, its enthusiasm is dampened somewhat by the security (or lack of) of IT systems. It is expected, however, that this risk will also be overcome.

Work of the future – Worker 4.0?

Production plants of the future will also place completely new requirements on production employees. Big data and the insights it provides offer excellent decision-making opportunities from executive level right down to the shop

floor. But how to deal with this wealth of information? How will the worker of tomorrow be able to exploit these new assistance systems to turn these mountains of data to their advantage, and derive precisely the information they need? The issue of user friendliness has been raised to a completely new dimension and thus also the requirements of software suppliers.

From consumer goods to industrial tools

Another aspect of modern technology is a reversal in the way products are launched. In the past, technical advances would first be used by industry and then introduced to the masses at a later time. Today, however, we are seeing the opposite. While smartphones and tablets have become ubiquitous in our homes, they have yet to achieve widespread use in an industrial working environment. Serious IT security issues are just one of the reasons.
In addition to the devices mentioned, a new class of device is also slowly feeding into production: known as wearables – technical devices that are worn on the body in the form of watches, eyewear or even integrated in clothing.

Industry experts on Industry 4.0: Ralf Damitz, Jörg Hackmann, Prof Dr Christian Ramsauer, Raffael Binder (from left to right) and Dr Werner Aumayr (not in the picture) (Source: PSI Metals)

PSI decided to investigate the extent to which, in principle at least, these devices could already be used for technical purposes at PSI and, above all, how users would respond to them.

Google Glass in industry

After an initial market analysis, PSI started by examining the Google Glass smart glasses more closely. It is interesting to note that even Google itself identified industry as a potential market for its product after it initially came up against a brick wall with the general public due to data protection concerns. Two use cases were quickly identified:

- Material movements in a coil warehouse
- Material inspection in a coil warehouse

In both cases, connecting the glasses to the current PSI*metals* platform turned out to be very simple. The final test took place at the Metec international trade fair last year, where interested visitors were given the opportunity to experience the new possibilities of human-computer interaction for themselves. The response was overwhelming. After a little training, the visitors were already able to use Google Glass to perform operations such as moving steel coils from one storage location to another. They were also able to identify and instantly classify damage to the material without problems using the in-built camera. The information about the procedures performed, which was transferred from Google Glass to the PSI*metals* systems, was displayed without issue. Although this was only intended to be an initial test of the technical possibilities and acceptance of new input forms, it generated immediate customer interest.

Future technologies for the customer

Some development work is still necessary to turn consumer goods such as Google Glass into tools that are a fit for industrial use. However, the PSI tests have demonstrated the potential in this area and that it is already perceived as very positive by the market today. PSI will therefore continue to work on the integration of these future technologies and making them accessible to the customer. i4.0

The Software Behind It

A software interface for multimodal interaction and context-adaptive procedures

The developments by PSI AG on the subject of Responsive Design and Click-Design make the future user interfaces of software products flexible and more efficient in design. Within the framework of Industry 4.0 the software Group must meet the demands for multimodal interaction and context-adaptive procedures.

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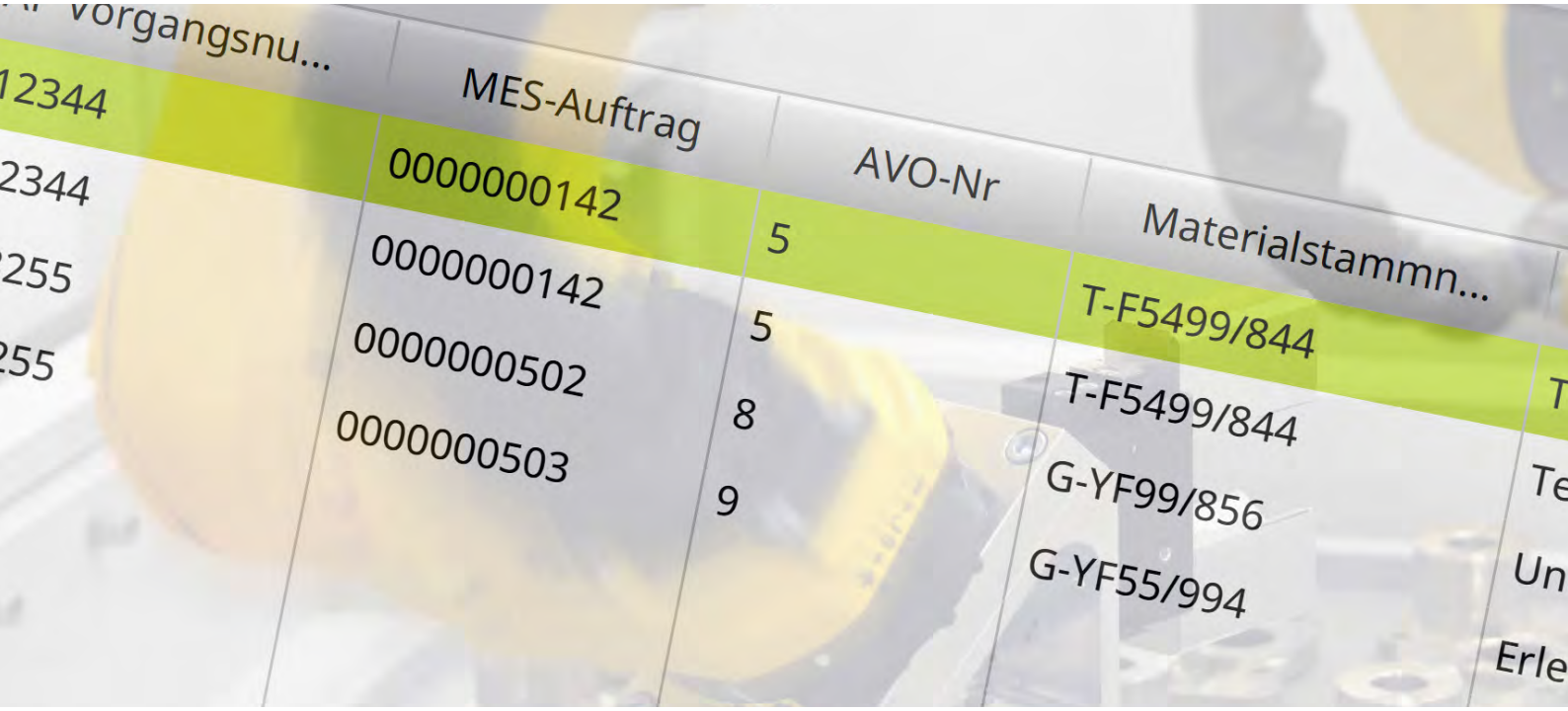
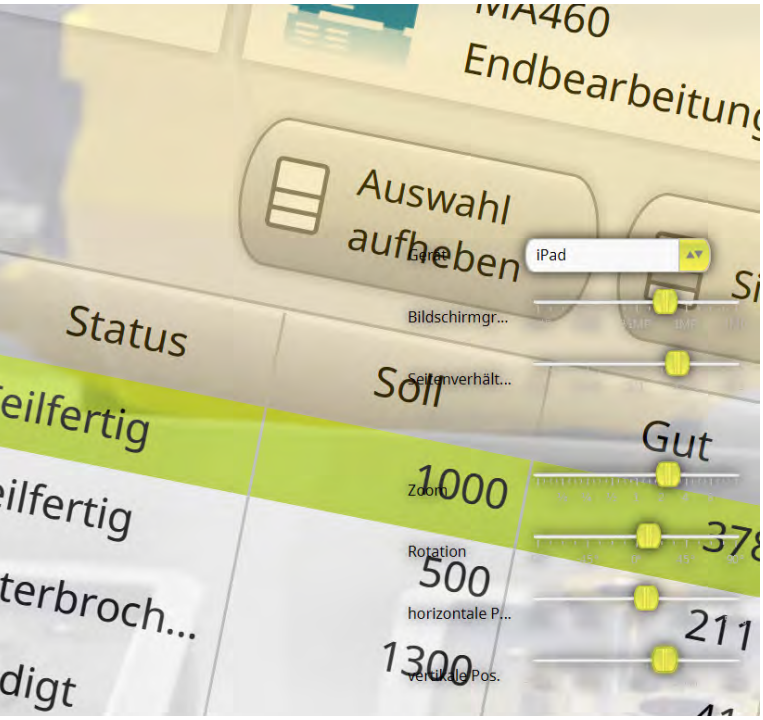


In recent years, PSI AG has adapted the design of user interfaces and made them configurable. The flexibility of the used graphical components was ensured, in order to respond cost-effectively to customer requirements in programming and system development.

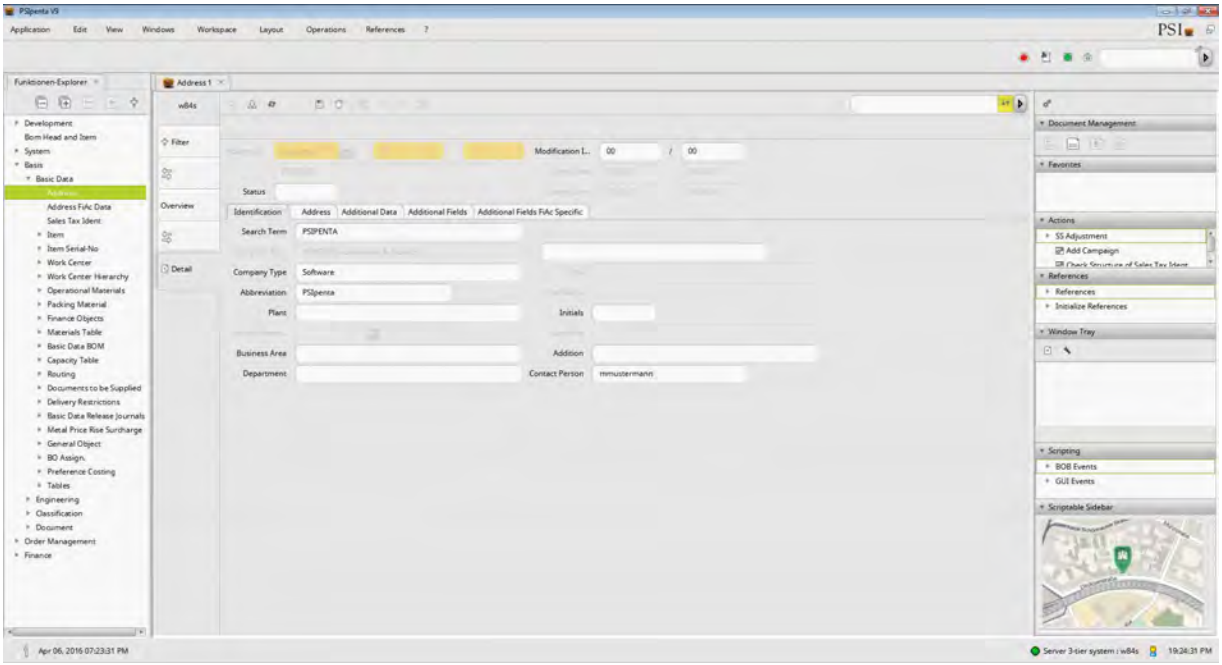
PSI Click-Design and context-adaptive procedures

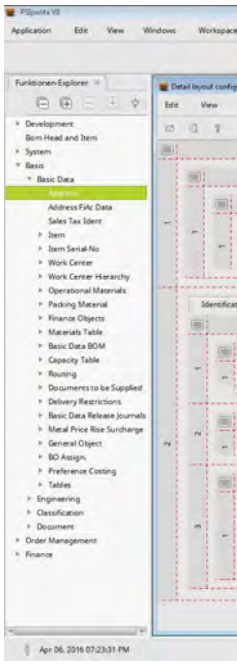
Newer mechanisms enhance the flexibility in the direction of configurability, which – even for customers, system integrators or users – is directly usable. This is done at the run-time of the system with additional simple dialogue functions; in a way with a „click“. As a result, this configuration technology is called „PSI Click-Design“. The resulting specific configurations, also called „profiles“, are stored separately in the database and can be used by individual workstations, users, user groups, or as a global default setting.
Within the framework of Industry 4.0, PSI Click-Design means a breakthrough in the implementation of context-adaptive procedures. This is primarily due to the consistency of the configurability.
Configurable schematic graphics have been available for some time via the PSI*visu2D* components. Any graphical elements and their link to data and statuses can be freely adjusted by a smooth switchover to the edit mode. This particularly benefits warehouse management systems, visualisation systems for production processes and general SCADA systems, such as PSI*jscada*, which is fully realised in Java™ (you can learn more about PSI*jscada* in the „Quality control in production“ article on pages 16-19).
List and table dialogues are used in all applications. The completeness of the aspects that can be configured using PSI Click-Design is comprehensive. The most basic design options affect the purely visual aspects such as Show/Hide, formatting, and fonts as well as column-by-column of colouring of the foreground or background. Some of the less trivial features include the content-based design, such as the cell-specific colouring of the background depending on data content and thresholds.
Beyond pure design options, structural aspects such as sorting, filtering and grouping with summation or other aggregation functions are easily configurable. For individual views and editing dialogues, other configurable features are added to the formatting aspects that are already supported for tables. The individual input fields can be freely arranged in a dialogue matrix. Field labels, field positions in the row and column, field groups and field links can be intuitively arranged using „drag and drop“.



Complete design freedom

But PSI Click-Design is not limited to simple dialogue components. The configuration of a complex dialogue from existing elementary dialogues allows complete design freedom for user-adaptive, task-adaptive and context-adaptive applications. With PSI Click-Design more detailed views (master/detail dialogues) can be quickly switched on in an overview list. In addition to the mere arrangement and implementation of individual dialogues, PSI Click-Design also settles the important issue of accurate data supply, keyword: dialogue linking, using automatically customised filters. If another data record is then selected in the superordinate master dialogue, the subordinate detail dialogue automatically adapts and directly displays all detail records relating to the superordinate data record. Of course, this is done without any development, programming or new system generation, simply live in the operational system. The „cost of change“ is significantly reduced.
The context-adaptive procedures required within the



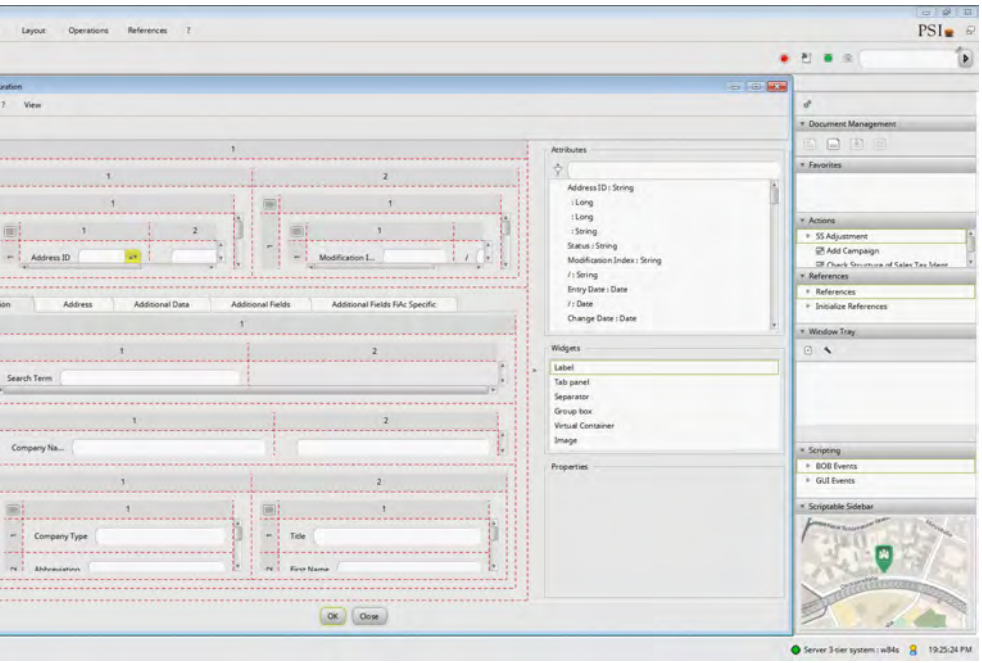


PSI Click-Design: Adjustments occur live in the operational system. In the left screenshot an input mask can be seen, in the right screenshot the editor appears, with which the dialogue boxes can be freely arranged. (Source: PSI Automotive & Industry GmbH)

framework of Industry 4.0 are supported by the functional components of the PSI software and their flexibility. The applications based on the PSI Click Design are „Ready for Industry 4.0“, thus opening up a high degree of investment security.

Responsive Design for multimodal interaction

In the „Stone Age“ of user interfaces, applications were developed for character-oriented terminals with, for example, 40 lines of 80 characters.
For decades, fully graphical data display units have been state-of-the-art and have largely replaced the character-oriented technology. Thus it became possible to integrate textual information as well as graphics and diagrams in the user interface. But the development of such interfaces for processing character or number-oriented data has not been revolutionised. Dialogues were presented in a graphically appealing and slightly more space-saving way, but the division of the screen area was still fixed, dialogue for dialogue, as specified by the application at the time of development. A typical minimum requirement for the graphics card or the monitor was e.g. „Resolution 1027 x 768 pixels“. A lower resolution was not supported and a higher resolution remained unused.
The emergence of the Internet and web browsers presented developers with major challenges. It was no longer possible to simply demand minimum requirements from – often anonymous – users. This problem has been exacerbated by the triumph of mobile data processing on smartphones and tablets. To date, the development effort is multiplied if user interfaces are specifically adapted for different resolutions.
The „Responsive Design“ technology has been established for some time, specifically for web developments. The texts and control elements of a website are automatically wrapped so that the available width of the screen is optimally used.
Analogue design paradigms are also developed by PSI for rich client environments, where there are some challenges to overcome. Unlike many web pages, with user interfaces it is rarely a matter of editorial content in which text paragraphs and images can be easily wrapped. In addition, it is not desirable to use excessive screen scrolling when operating smartphones. Therefore, different adaptive mechanisms can be combined to allow „Responsive Design“



To the PSI Click-Design video. Experience customisable user interfaces at: www.psi.de/en/psi-group/technology/

for different application scenarios. The graphical implementation can be done simply and efficiently with the existing capabilities of JavaFX™ in the PSI Java™-based framework.

The example of a dialogue for shop-floor data collection shows that one and the same dialogue definition is suitable both on normal monitors with widely differing aspect ratio and on tablets and much smaller mobile devices (see figure „Responsive Design“). The run-time environment rearranges components and scales infinitely for all resolutions and intermediate sizes.

In future releases PSI will concurrently incorporate these adaptive mechanisms, in order to better meet the demand for the support of multimodal interaction. i4.0

Responsive Design: In the PSI Java™-based framework the automatic adjustment of dialogues can be shown at different resolutions. (Source: PSI AG)

Research for the Future

The future of Enterprise Resource Planning

As co-founder of the Enterprise Resource Planning Centre, FIR e.V. at RWTH Aachen is involved in networking and intensive cooperation for Industry 4.0 projects. The Center represents an interest group that has been set up to identify and implement potential. The activities of the Enterprise Resource Planning Center are based on the four stages of the „Industry 4.0 Roadmap“.

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Dipl.-Wirt.-Ing. Jan Meißner | Head of the Enterprise Resource Planning Center
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The production and labor world is currently facing or undergoing a fundamental transformation. This change is driven by the digital networking of industry and the economy. This means that existing value systems are increasingly being penetrated by an unprecedented scale of information and communication technologies in order to realise significant productivity gains. Operational application systems that guarantee the efficient planning, control and allocation of corporate resources are integral to this. To keep up with the speed associated with Industry 4.0, industry and research must network even more strongly than before and work together intensively. The interest group identifies the potential of Industry 4.0 and defines the roadmap to achieving this in four specific stages.

Industry 4.0 goes beyond digital process mapping

The reason behind this is that a full implementation of Industry 4.0 in one move is almost impossible for companies. Both the terminology and progress in the implementation of Industry 4.0 are defined and perceived very subjectively. Companies should therefore rid themselves of the notion that Industry 4.0 has been achieved as soon as the majority of processes have been digitally mapped. The idea of Industry 4.0 goes far beyond that. The starting point for the outlined Industry 4.0 roadmap is the achievements of the third industrial revolution („Industry 3.0“). Based on this, companies plan and control their processes and use operational application systems to support the order handling process.
The route from there to Industry 4.0 is broken down into four main stages:

1. **Transparent production system**
   Digital mapping of all business processes
2. **Forecast-enabled production system**
   Identification of patterns and practices to realise a good and reliable forecast
3. **Control-enabled production system**
   Targeted counteraction to identified and anticipated deviations
4. **Self-learning production system**
   Learning from decisions made for sustainably efficient and productive business management

Tasks for future-oriented production planning and control systems

The disruptive change processes, which go hand in hand with Industry 4.0, affect in particular operational application systems such as the ERP system. However, there is an increasing focus on MES and platform/cloud solutions

ERP innovation lab in the Smart Logistics Cluster at the RWTH Aachen campus. (Source: © JRF e.V.)

for cross-system storage and use of relevant planning data. The classic division of tasks in this context is likely to lose its importance. Solutions must therefore be more intensively networked and enable the exchange of relevant data and information with other applications. Because of this, ERP manufacturers must adapt to the new framework conditions. Furthermore, they must let go of the idea that all applications can be functionally assigned to a level of the automation pyramid. In future, it will be much more the case that the application systems can no longer be functionally differentiated, but companies link or bundle functions from different systems to fulfil their tasks – as a kind of modularisation/app creation. The data and information will be exchanged via a central hub. The Enterprise Resource Planning Center, which is run by founders FIR e.V. at RWTH Aachen, Trovarit AG and MyOpenFactory Software GmbH, offers an ideal platform for this, facilitating an interdisciplinary exchange of interests and providing an opportunity to tackle bigger issues in joint projects.

For this purpose, the Center offers its partners a unique infrastructure, including innovation labs (see image 1), which are used interactively, the theme park (see image 2), which serves as a simple demonstration of the results as well as the conference centre for networking or specialist events.

PSI Automotive & Industry was one of the first companies to enrol at the RWTH Aachen campus in 2010. As a leading industrial partner of the Smart Logistics Cluster, PSI's production solutions, among other things, are represented at the Enterprise Resource Planning Center. Read more about the activities of the ERP provider in the article „Modular systems for the creation of smart hybrid prototypes – on the path to cyber-physical production systems" on pages 34-37. i4.0

Theme park at the Smart Logistics Cluster at the RWTH Aachen campus. (Source: © JRF e.V.)

Research for the Future

Modular systems for creating smart hybrid prototypes – on the way to cyber-physical production systems

In an Industry 4.0 context, the challenges for mechanical and system engineering companies lie in the provision of so-called cyber-physical production systems and in the support of decentralised production control at system level. At this point, virtual technologies can provide important assistance. The“Virtual Commissioning with Smart Hybrid Prototyping“ (VIB-SHP) research project develops modular systems for creating these prototypes.

➲ **Jörg-Uwe Zuchold** | Head of Research at PSI Automotive & Industry GmbH
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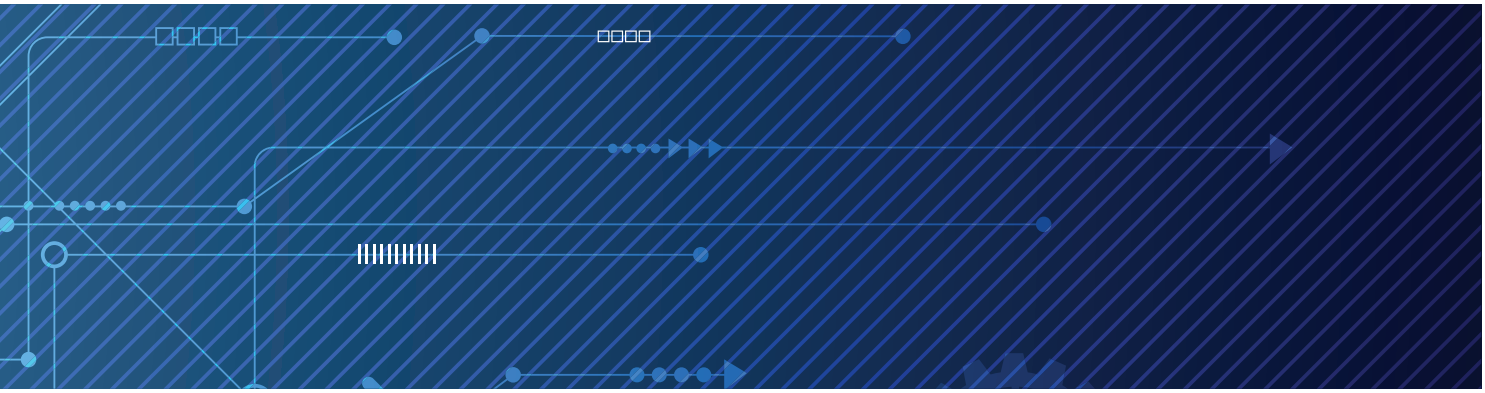


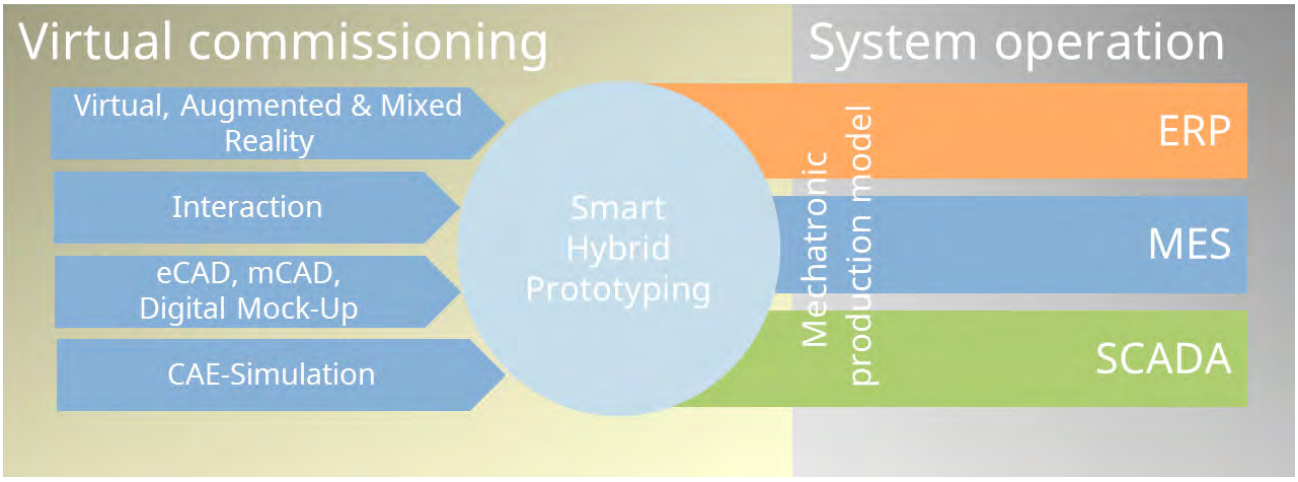
The future vision of Industry 4.0 summarises different approaches in the industrial landscape, which are characterised by new and predominantly networked technologies. Thereby, the core elements are decentralised and autonomous system controls and the use of the Internet of Things in the industrial/production-related environment. In this context, the Internet of Things is represented by cyber-physical systems (CPS).

Starting point and vision of the research project

Today's production facilities are usually firmly integrated in the automation pyramid. However, by implementing the Industry 4.0 core elements, a gradual dissolution of the classic automation pyramid and a replacement by networked, decentralised or partially self-organising services is expected (see figure on page 37). The high degree of networking and the ubiquitous availability of data and services creates new and promising perspectives for automation.
It results in the vision of adaptive, self-configuring and partially self-organising, flexible production systems. This leads to more cost-effective and efficient production, e.g. characterised by shorter set-up times and optimised energy and resource use.
Within the framework of the future project Industry 4.0 from the federal government, this vision is denoted by the keyword cyber-physical production system (CPPS). In CPPS, data, services and functions are maintained, retrieved and executed there, where it brings the greatest benefit in terms of flexible, efficient development (including design and engineering) and production. And that will not necessarily be at the classic automation levels. In fact, process data could also be obtained through services in an automation cloud, instead of through sensors at field level. This allows self-organisation of production, in which the workpieces themselves, precisely those cyber-physical systems (CPS), communicate with the machines, production systems and equipment (CPPS) and determine which processing steps are carried out by which machines.
However, initially, it is likely that real-time-critical controls and regulations will primarily remain close to the process at field level. But in the future it is also conceivable that real-time-relevant requirements will be met by new distributed architectures in CPPS.

Smart Hybrid Prototyping

In this context, Smart Hybrid Prototyping is the integration of virtual and real (physical) elements of a production system in a hybrid overall experience. Here, for example, the tangible (haptic) elements of an existing system are supplemented with virtual elements and partially overlaid. For this purpose, virtual reality (such as Oculus Rift) and augmented reality technologies (such as Google Glass or Microsoft HoloLens) are used.



Services and mechatronic production model for VIB and system operation (Source: PSI Automotive & Industry GmbH)

Modular systems for the tangible protection of production systems

The VIB-SHP project proposal mainly aims to support small and medium-sized production system manufacturers in the development process of CPPS using virtual technologies. It represents an important step in ensuring connectivity and capacity for innovation in comparison to companies that have already established virtual reality and virtual commissioning technologies.
For this, all interdisciplinary parties involved in the development process, such as planners, clients, designers, automation engineers and system programmers, but also future users, are much more involved in the development of production systems and processes than they were previously.
In early development phases of the product engineering process, Smart Hybrid Prototyping (SHP) methods are used to capture aspects that were previously limited in terms of display, such as haptic and acoustic, but also experience-oriented usage properties. For this, a modular system is defined and developed to significantly simplify SHP production. Further potentials of virtual technologies include:

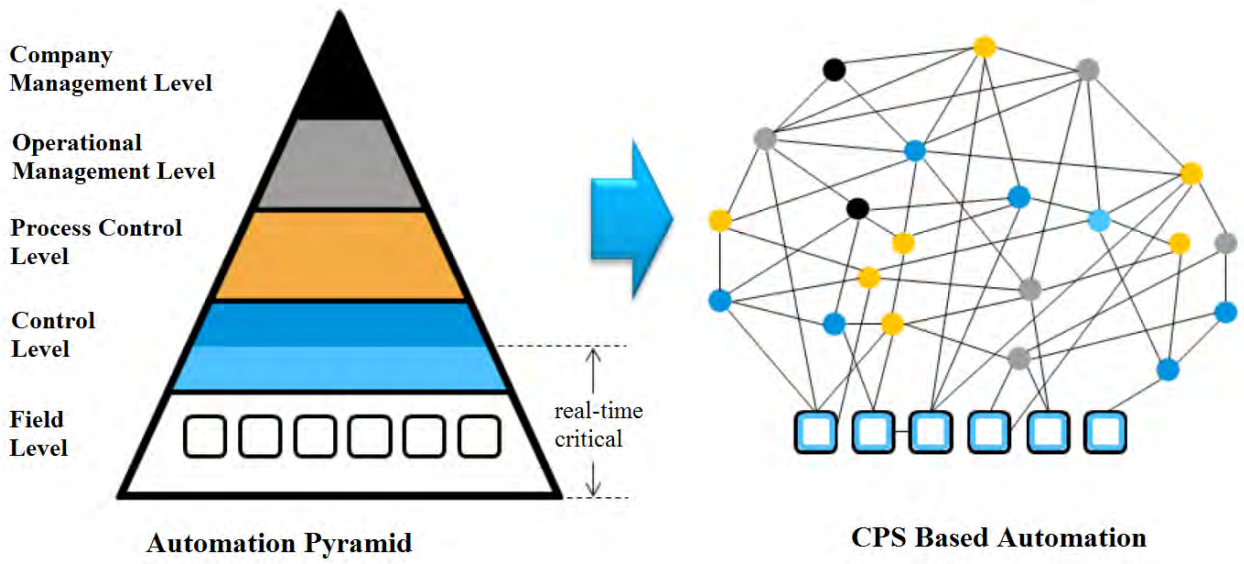
- The networking and interconnection of the system behaviour with higher-level systems such as ERP, MES and PLM
- Protection of the system concept in ergonomic aspects
- Perceptibility of the system behaviour in the context of CPS
- Training, coordination with the client or the validation of planning results (simulation)

Digital Factory Planning and flexible configuration options

In the context of the VIB-SHP research project, PSI Automotive & Industry GmbH is working on solutions for networking and interconnecting the system behaviour with the PSI*penta* ERP and MES system. For this, PSI is continuing to develop the product portfolio in respect of using the results for Digital Factory Planning and for flexible configuration options in the Smart Factory. The main objectives are to increase the planning flexibility of ERP and MES components as well as the automated configuration of MES components in the context of virtualised factory planning. An important prerequisite for this is the design and development of standard data models and standardised interfaces.
Relevant parts of the mechatronic product data model of CPPS are thereby stored in the ERP system and replaced with a central PLM system using enhanced interfaces. However, for a comprehensive system simulation, the product models of the goods to be produced, the CPS, must also be incorporated in the simulation. This means that the relevant model information across the entire supply

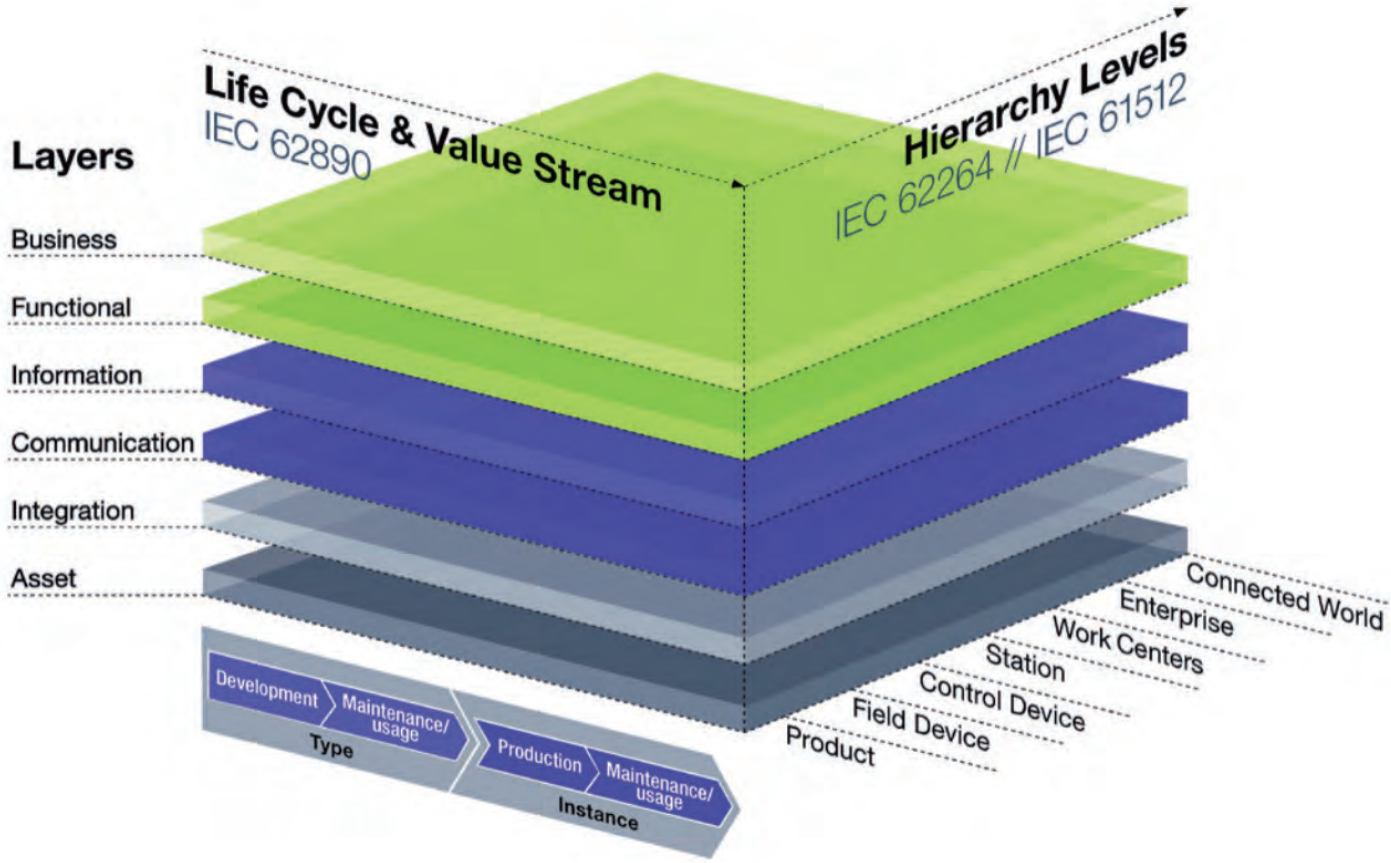
chain must be replaced using advanced ERP-ERP interfaces.

The virtualised system represents the basis for the virtual commissioning. This arises from the functionally relevant data of a technically planned system or a system that has already been partially implemented. This requires model data from electronic and mechanical CAD systems (eCAD and mCAD) which is aggregated with other data into a mechatronic overall model. Thus, the virtualised system is a model, which accurately reproduces the functional behaviour of the system compared to a control system. On the one hand, this model information can be transferred for the subsequent operation of the planned systems in the MES and SCADA systems, thus allowing, for example, an automatic configuration of MES components as a result of factory planning. On the other hand, the integration of systems into operational production control systems is already ensured as part of the simulation using virtual technologies (see figure p. 36). i4.0



Transformation of the automation by Industry 4.0: from the automation pyramid to the CPS-based automation processes. (Source: https://www.vdi.de/uploads/media/Stellungnahme_Cyber-Physical_Systems.pdf)

Information about the Industry 4.0 project can be found in the Industry 4.0 platform as well as from the BITKOM, VDMA and ZVEI organisations.



Reference Architecture Model Industry 4.0 (RAMI 4.0): The three-dimensional layer model illustrates the key aspects of Industry 4.0 and enables the consideration of complex correlations through manageable portions.
(Source: www.zvei.org/Themen/Industrie40/Seiten/Das-Referenzarchitekturmodell-RAMI-40-und-die-Industrie-40-Komponente)

Research for the Future

Business software and the Industry 4.0 architecture concept – contexts and perspectives

After the establishment of the Industry 4.0 platform, it became quickly very clear to the different study groups within the platform that a reference model was needed to ensure a common understanding among all partners for the transformation process lying ahead of the German economy. Therefore it launched the project „Reference Architecture Model Industry 4.0 – RAMI 4.0“ which is a multi-layered model showing the different perspectives on objects in an industrial environment.

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The RAMI 4.0 project considers the complete value streams from product development to use, operation and disposal. Therefore, the focus is the integration of all processes in a „connected industry“. RAMI 4.0 provides a complete yet complex approach to describe an architecture of the components and applications for future production systems and value-added networks. The analysis is formed of products and their life cycle (X-axis), the role of the products in the process (Y-axis) and the different views on the assets in the digital factory (Z-axis).
As an ERP and MES provider, PSI Automotive & Industry is involved in this project to create future software systems for order processing.

RAMI 4.0 – X-axis: product overview and life cycle

RAMI 4.0 looks at products (under the general term: Assets) under various aspects. On one hand it is about the appearance (material, immaterial) and on the other hand it is about the life cycle. The two dimensions of „appearance“ (material/immaterial) and „life cycle“ are represented by different types of assets or the transitions of the assets. Intangible assets in the „type“ category could be Meta models such as standards, procedures, formulas or other general rules. Material assets are understood to be the physical representations of the immaterial assets. These assets may be products, systems, tools, software, systems, programs or even people.
Today‘s order processing systems (ERP, MES, quality management, etc.) are based mainly on the material physical product. Life-cycle aspects come into play through the integration of these applications with PLM (Product Lifecycle Management) systems.
In the future it will be important to continue to deepen the integration (based on the type) and to include particular usage data (the instance) in the further development and maintenance.
In addition, further profound changes to these order processing systems (ERP and MES) are expected. It is about the integration of another IT system (which was scarcely or not at all considered previously) in these software systems: the Industry 4.0 component. This „smart product“ has communication skills and capabilities for data processing. It may be a product in use (in the field) or a stationary system in the production. Thereby continuous data is supplied, which is to be considered by the order processing systems in a different context or first placed in a context (semantics, ontology).

RAMI 4.0 – Y-axis: the role of the products in the process

The assets can take on or represent different roles in the course of a manufacturing process. On one hand, there are products that undergo various processes in the course of production and, on the other hand, there are systems that are used for this purpose.
The starting point is the consideration of the different levels of planning and control in manufacturing companies. The processes are basically divided into four areas:

- Production (Production Operations Management)
- Maintenance / Servicing (Maintenance Management)
- Quality Management
- Inventory Operations Management

The main difference with the existing descriptions of the structures are the extensions in the direction of the production process by Field Device and the (smart/intelligent) product and upwards in the direction of the corporate management level by the Connected World. These extensions accommodate the Industry 4.0 basic concepts of „smart product“ and „value-added network“.
The introduction of the structural level „Connected World“ illustrates the appeal of the widespread networking of partners in the value-added networks. This networking not only affects the traditional software systems and tools known today, but also more and more machines and systems with superior automation functions in the future.
The „Enterprise“ level essentially corresponds to the corporate management level. From a process point of view, the local (company-specific) planning and control takes place here. The standard of horizontal networking in the Industry 4.0 environment therefore mainly concerns the location integration and creates opportunities for the standardisation of processes. At the level of the ERP and MES systems, that affects the ability to control multiple plants, it must go far beyond today‘s current client concepts. Logistical and commercial aspects have to be considered equally here.
The automation and production technology is reflected at the level of „Work Units“ or „Field Device“. The requirements of the higher levels result in advanced demands on the production technology. This relates to two main aspects: steering of intelligent products through the production and monitoring functions of the production technology itself.

RAMI 4.0 – Z-axis: the layers

The third dimension of the reference architecture is based on the different views of the assets (products, systems), and their role within the digital factory. The three layers of business, function and information are of particular importance for the order processing systems. The layers provide the context for the consideration of the X- and Y-axis (assets and their life cycle as well as the role in the digital factory).
The business layer includes overall information relating to the assets and their use. In addition to this cluster of information, information about business partners, contracts, agreements or other provisions and guidelines is also located here. This includes, for example, information on communication channels and other overall information.
The functional layer describes the functional components and their linking to business processes. The specific functions strongly depend on the orientation of the company, the markets they serve and the services offered by the company.
The information layer forms the persistence layer for the data from all layers of a production system and the data exchanged with business partners. This layer provides the data basis for big data analyses or simulations of production plans with the help of the „digital twin“.

Make good use of existing data and information obtained

With the gradual implementation of the concepts, the penetration of production with IT technologies will increase. More and more people will have to interact with software systems. The efficiency of order processing is (must be) further enhanced by mobile solutions in the production environment. The automated communication capabilities of machines and systems, but also business partners, are a critical success factor for the implementation of Smart Factory concepts.
Ultimately, Industry 4.0 requires integrated software so-

lutions (in the field of production and logistics) that provide all existing data and information obtained in a user-friendly interface. The resulting data is visualised and used for the continuous optimisation of production (sequences, drift compensation, etc.) and for product improvement. Obvious fields of action or goals are:

- Increase the availability of production systems and reduce the costs for maintenance and repair work
- Stable production processes and consistently high quality of products and reduce the failure costs
- Timely deliveries in the right quantity

These objectives can be achieved by measures in the field of predictive maintenance, machine data acquisition and continuous monitoring of production and quality data. With the progressive implementation of Industry 4.0 concepts, continuously new requirements for software solutions are expected to arise in the industrial environment. It will be important that users and solution providers come together and jointly develop pioneering solutions based on relevant use cases. i4.0

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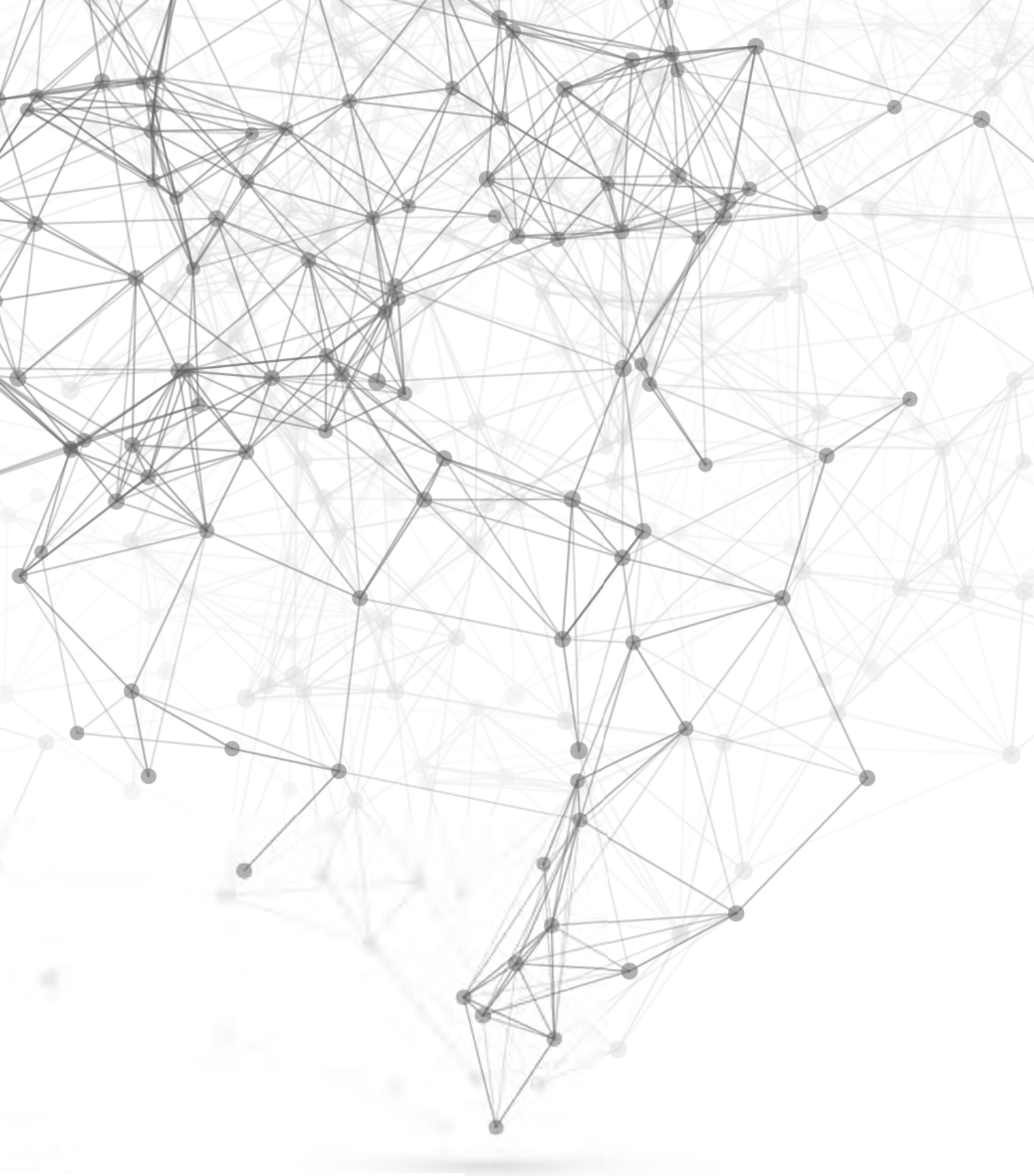

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