Dear customers and those interested in the digital factory,

At Hannover Messe 2016, Siemens will not only be showcasing new products. We will demonstrate how our core products for the digital transformation of industry, such as our Digital Enterprise Software Suite, are growing and coalescing. In this context, I would like to draw your attention to three solutions in particular.

One of the greatest challenges for industry remains that of uniting all the specialist disciplines in parallel in the same data model for each mechatronic product. At Hannover Messe, we will be presenting Integrated Mechatronics Engineering. Mechanics, electrical systems, and software, supplied by a library with mechatronics components, provide data for automation, simulation, and virtual commissioning – if required, combined with the Mechatronics Concept Designer.

The second challenge is merging product and production system development with the world of production planning and control – in other words, Manufacturing Operations Management (MOM) – in a single data model. Often, when we speak of integration we are referring to PLM (product lifecycle management) and MES (manufacturing execution system). And indeed that is another of our highlights at Hannover Messe: Closed Loop Manufacturing.

The third topic is one we had in the pipeline last year, and now its moment has arrived. With MindSphere – Siemens Cloud for Industry, we are providing the first cloud infrastructure that will allow our customers to offer services using worldwide data collated from their applications. The Internet of Things is becoming a reality.

Digitalization and Industrie 4.0 in practice: In recent years, we have invested billions and hundreds of engineers have literally worked around the clock – and now, for the first time, you can see for yourself the whole picture.

Anton S. Huber,
Chief Executive Officer of Siemens AG
Digital Factory Division
The future began yesterday

The digital revolution in industry is unstoppable. Companies in the manufacturing and processing industries benefit from increased productivity and flexibility and shorter times to market, thereby increasing their competitiveness. Their customers benefit from more personalized, high-quality products. And end users can order their very own merchandise, tailored to their needs. Batch sizes of one are becoming the new normal.
Technology people” – that is the nickname that Schwäbische Werkzeugmaschinen GmbH (SW) has given to its employees. This refers to people who enjoy exploring processes, manufacturing solutions, and technologies in the broader sense – not only individual machines. The term reflects a fundamental attitude: It is no longer enough to sell technologically flawless products. Customers now want maximum flexibility, short innovation cycles, and innovative business models that give them true added value.

SW has fully embraced this mind-set – and this is evident not only in the term it uses to describe its approximately 500 employees. In addition to providing personal customer advice and technologically outstanding multispindle processing centers and automation and assembly solutions, the Swabian company has won the appreciation of customers all over the world for its online services in particular.

A couple of years ago, SW also introduced an online solution to analyze machine statuses in its PULSE (Productivity and Lifecycle Services) portfolio. This allows experts from the SW headquarters in Baden-Württemberg or the subsidiaries in the United States and China to identify and solve problems online, for example, meaning that service technicians are usually not required. And if spare parts are needed, shipment can be arranged immediately. Even maintenance work can be planned with this technology according to actual needs. This significantly reduces unplanned downtime and enables maintenance work to be carried out at suitable times.

Moreover, the online tool offers an additional valuable benefit to the customer: SW can assess the productivity of its machines at the customer’s site online at any time, compare it to the target figures, and, taking this as a basis, provide recommendations on how to optimize maintenance, servicing, and production processes. “Without the transparency guaranteed by such a tool, it is almost impossible to find out why the production output volume is too low or fluctuates and eliminate the cause, especially when it comes to networked machines,” says Jochen Heinz, head of industrial data services at SW. “Here the cause might just as well be found in an individual machine as in the workpiece feed, for example.”

The technological foundation for PULSE is the Siemens online solution Machine Tools Analytics Services. With this solution, customers can benefit from innovative services based on the digitalization of all processes and from the development of new business models.

Core components for the Digital Enterprise

Such companies include four core areas: First, a Digital Enterprise requires industrial software solutions for end-to-end processes, from development to production and services (see page 11). Moreover, it needs an efficient communications infrastructure for networked data exchange. A Digital Enterprise also needs reliable security solutions to ensure protection of trade secrets in this networked, online world. Finally, a Digital Enterprise must offer industrial services that increase its own real net output ratio by means of digitalization.

Digitalization makes it possible to merge all stages of the value chain. The first attempts to do so occurred as early as the 1980s, in the form of computer-integrated manufacturing (CIM). At the time, however, the planned integration of computer-aided design (CAD) and computer-aided manufacturing (CAM) could not be fully carried out. “The technology simply wasn’t far enough advanced for that yet,” says Uwe Grundmann, European chief executive officer of the American market research company ARC Advisory Group, headquartered in Düsseldorf. “Back then, only 56 kbit/s could be transmitted over the telephone lines, which was much too slow.” Today,
speeds of up to 10 Gbits/s are possible – about 180,000 times as much! In addition, today we have much more powerful methods of capturing, transferring, storing, and evaluating large quantities of data. The technological advances have an effect not only on the volume of data (Big Data) but also on its analysis and practical application (Smart Data).

**Customers drive progress**

Technological progress, however, is not the only thing that drives the development of the Digital Enterprise. “Customers are instrumental in this development. They want to be supported on their path toward the Digital Enterprise and ask for the corresponding solutions and products,” states Peter Weckesser, chief operating officer of the Siemens Product Lifecycle Management business unit in the Digital Factory Division.

So it comes as no surprise: “Short time to market is becoming increasingly important,” affirms Weckesser. Achieving this requires holistic, digitalized processes. Furthermore, customer needs are becoming more individual and have to be met flexibly. “Our target is a batch size of one. At Nike, for example, customers can have their names stitched onto their athletic shoes in the factory,” Weckesser reports. In the end, it is about increasing productivity, making more efficient use of human resources and machines, and reducing the consumption of energy and raw materials.

**3D printing is gaining ground**

The new possibilities offered by 3D printing will make a significant contribution toward more individualized, flexible production. 3D printing, based on CAD files, can create components out of metal, plastic, or ceramics that, in the past, were not possible to make or could only be manufactured with great effort. This printing method will be particularly successful in creating small batches of products that need to be light but very strong and that must be delivered quickly because their design undergoes constant changes – for example, in the aerospace or automotive industries.

For the Porsche 919’s steering system, for example, components will be printed and subsequently finished in the same machine by the supplier. From concept to manufacturing, it used to take several weeks to produce such components. Today, this can be done in only a few hours. Airbus uses 3D printing to produce supporting components out of titanium for its A350 model. In the past, these parts had been milled out of aluminum and weighted 30% more.

Because factory digitalization inevitably goes hand in hand with powerful communications infrastructures, IT architectures need to change as well. From a bilateral, hierarchical exchange of information, the trend is moving toward broadly networked, distributed systems.

**The five stages of the Digital Enterprise**

Digital Enterprise operations can be subdivided into five stages: product development, production planning, production engineering, production execution, and services. But unlike in traditional approaches, these stages are seen as a holistic, fully integrated system instead of a chain of processes in chronological order. All the relevant data are captured, transmitted, and analyzed in each stage, and also in all interactions among the stages.

Already from the very beginning, during product development, innovations must be designed, tested, and modified digitally. Long before the first physical product comes into being, the developers have already created a digital twin. With this twin, virtual tests can be performed to determine whether and how the product works. Ideally, designers will not need to make any further changes to the real end product. “The goal is that the first prototype built is already fit for sale,” explains Weckesser.

This digital approach also stretches to production planning and production engineering, because even production can be completely planned with digital means – all the way to the virtual sources and machines, and reducing the consumption of energy and raw materials.
Interview with Peter Weckesser, chief operating officer of the Siemens Product Lifecycle Management business unit in the Digital Factory Division.

The vision of Industrie 4.0 is based on a digital value chain – from product development, production planning, and production plant design to production and customer service. Is the data stream aligned to these stages of the value chain?

Peter Weckesser: The value chain has many interactions between all stages – the data stream is not aligned to them. Customer service passes customer requests on to development. Production planning receives information on improvements in the production sequences. Production collects data that help increase the precision of production planning and production efficiency.

Does the digital value chain go beyond the company itself?

Weckesser: Industrie 4.0 enables completely new customer relationships. Here, Siemens offers Lifecycle Analytics, an analysis software solution for predictive remote maintenance. With this software, manufacturers can access and evaluate operational data that can help them improve their products.

Development, production, and service often work with very different IT systems and data sets. How can this problem be solved?

Weckesser: Indeed, a consistent, shared database is indispensable – for example, our software solution Teamcenter. As a collaboration platform, it serves as the basis for all programs and tools used in our Digital Enterprise Software Suite that are compatible with each other during the entire lifecycle of the product. In the development stage, this includes the software programs from our product lifecycle management portfolio with which new products can be developed and optimized virtually. This includes, for example, our Tecnomatix development software and the NX CAD tool. In the actual production phase, our automation tools, such as Totally Integrated Automation (TIA) in combination with TIA Portal, come into play to allow all automation components to work together.

What can you tell us about software compatibility once the products are with the customer?

Weckesser: In this phase, it is mainly about the services, which should provide considerable added value to all those involved. We are therefore now introducing a further development of our existing and time-tested solutions for online services: the open platform MindSphere – Siemens Cloud for Industry. In the context of Big Data, industrial companies can use this platform to offer their own digital services, for example, in the area of predictive maintenance, energy data management, or resource optimization. This can also lead to innovative new business models.

Many companies use control systems and software solutions created by other manufacturers with their machines. How do you intend to better reach out to these companies?

Weckesser: Together with a connector box, MindSphere can also be used for devices and control systems from other manufacturers. Compared to the proven online tools used today, MindSphere offers the additional advantage that the platform is designed for larger data volumes and the data can be made available in a more user-friendly and comprehensible way. In this sense, the solution provides immediate added value to the management level as well.

How secure is this cloud technology?

Weckesser: The MindSphere platform has strong encryption and offers the greatest possible protection against cyberattacks.

In manufacturing, 3D printing is an important topic for the future.

Weckesser: It is also an important topic for Siemens. These manufacturing methods can be integrated into our software environment. We recently initiated a pilot project with one of the major machine tool manufacturers that uses laser melting to produce solid metal, 3D workpieces.
commissioning of a new plant or an entire factory with all its production processes. And as soon as the specifications for a new product are available, for example, computers can create the bills of materials for the required parts and components themselves.

When the product goes into the manufacturing stage, the design data are seamlessly transferred to production in the Digital Enterprise. That may seem obvious, but in practice things can often be very different. Since many software solutions are incompatible, the data usually need to be printed out and then keyed in again manually. This is usually a complex and also error-prone process.

Finally, digitalization includes all the services that help the customer achieve maximum productivity, reduce operational costs, and generally get the most out of the delivered product. This usually goes hand in hand with new business models and customer relationships (see interview on page 9).

Just like at SW, machine manufacturers have an online link to the delivered devices and plants, from milling machines and wind power turbines to jet engines. This makes it possible to automatically gather, transfer, and analyze the operational data to monitor the machines. It also enables preventive maintenance and servicing before the machines become damaged and malfunction.

The challenge of data security
Process digitalization and the disclosure of data to service providers entail security concerns. Without cybersecurity, many strategic concepts of the future will fail to gain traction, emphasizes the German Electrical and Electronic Manufacturers’ Association (ZVEI, Zentralverband Elektrotechnik und Elektronikindustrie), which has set up its own working group on the topic. Although many security technologies in various industries are already working quite well, these often cannot be applied to other sectors. “For example, when it comes to IT issues, financial service providers are mainly concerned with data security. In industrial companies, on the other hand, plant availability is the main priority,” explains Grundmann. These two very different premises require different solutions.

SW has demonstrated how many of the challenges of modern industry can be solved with digital solutions. Currently, the Swabians are working on the next evolutionary stage of digitalization. “We want to create full digital transparency for our machines using the new IoT platform MindSphere. Of course, we are talking about a completely different scale than what we are used to when it comes to data volume,” says Heinz. However, that takes time and the involvement of customers with respect to the requirements they have regarding the data and the necessary security when handling them. “You cannot simply impose such a strategy on existing processes. It has to become a central component of product development, manufacturing, and services,” explains Heinz.

It is an effort that in theory will pay off for SW, but also for others. For one thing, it opens up new service and business model possibilities. For another thing, effective digitalization strategies are of vital importance for one very important factor: the future viability of the company itself and that of its customers.

How will Industrie 4.0 affect your competitiveness?

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Source: McKinsey & Company

Source: McKinsey & Company

Source: McKinsey & Company
In recent years, Siemens has invested a great deal in the integration of software that companies can use to digitalize their value chains. The results are the focus of Siemens’ presence at this year’s Hannover Messe. Three topics will draw visitors’ attention above all: Closed Loop Manufacturing, Integrated Mechatronics Engineering, and MindSphere – Siemens Cloud for Industry.

Those who have followed the discussion regarding Industrie 4.0 and the Internet of Things in recent years have not always had an easy time separating the wheat from the chaff. What is talk only and what is actually feasible? What exactly will intelligent industrial value creation look like? Siemens does not have all the answers. But now the company is offering solutions that address central challenges facing industry during its digital transformation – solutions that allow customers to start the implementation step by step, with quickly noticeable results.

One of the greatest challenges – as all experts agree – is overcoming the format discontinuities between the main areas of the technical value chain: between the engineering of products, the associated planning of production systems and processes and the production execution itself. All this supported by an efficient coupling of the technical value chain with the relevant commercial processes. This challenge calls for a solution so urgently because Industrie 4.0 simply does not work with the isolated IT solutions that are customary today. At its core, this vision counts on the future development and manufacture of even highly complex and smart products, customized to individual customer wishes, at almost the price of mass production. How is that supposed to work if it takes weeks to find out where the requested product can be manufactured with what adaptations?
However, this is the level of technology today: With CAx – at Siemens with NX – product models are developed whose data ultimately lead to a parts list, known as a bill of materials. Then machines, equipment, and plants are developed for the production (all the way to the simulation of production and of the material flow) with systems for digital manufacturing – at Siemens with Tecnomatix. The result is a digital process description, called a bill of process. With product lifecycle management (PLM) software – at Siemens with Teamcenter – these data can be linked and the connections kept up to date. However, the data regarding the product structure and the operating machinery and equipment describe only the theoretical process. The actual control of a certain machine or production line requires more.

Starting with the order planning, the specific requirements for an individual order now need to be linked with the technical data. And they need to be supplemented by vendor parts and plant-specific data, including the layout of the plant. This is the job of the manufacturing execution system (MES), which speaks a different language from the technical systems of engineering. In many cases, it is necessary to reenter data and program processing steps.

Closing the value chain
With Closed Loop Manufacturing, Siemens is now offering a single data model that saves numerous processing steps and allows for a bidirectional flow of data. The data available from the PLM system can be used directly for controlling the specific production line. And the data from production are available to engineering.

It is precisely this data consistency that creates the preconditions for fulfilling the requirements of Industrie 4.0. Within minutes, it is possible to find out whether and where a product can be manufactured exactly as ordered and, if changes to previous products or processes are necessary for this, how quickly and at what price they can be made – because the data from production at all sites can be called up centrally to be matched with engineering. And once the order is placed, it can be executed with an automatic trigger from the enterprise resource planning (ERP) side in no time at all and at minimal cost. The NX, Tecnomatix, Teamcenter, and
Simatic IT systems are all involved in the Closed Loop Manufacturing data model.

The cause of the second challenge faced by the digital transformation of industry is found in another format discontinuity: Today, all the specialist disciplines needed for the development and manufacture of smart manufacturing plants work with different systems and data models. The 3D model of the mechanics is not compatible with the logic schematic of the electrical systems. The behavior model of software development does not know any of the engineering details of the mechanics and electrical engineering. When a simulation model exists – created, for example, by Process Simulate – then its data are not usable for other models without additional processing.

Siemens has now ensured that the software tools involved in Integrated Mechatronics Engineering understand each other. And the approach goes even beyond that.

**Multidisciplinary items from the library**

Whether in general machine building, machine tool manufacture, or a production facility, many components have been unnecessarily reinvented again and again. Now a mechatronics library of components and modules such as motors, drives, valves, pumps, and other parts can be developed that contains the detailed information from all the disciplines involved. The elements can now be easily imported as finished parts in the development of a machine because the data are centrally managed in Teamcenter. And since even automation with TIA Portal understands this language, engineering data can be used directly for the generation of PLC software and virtual commissioning. This integration eliminates data reentry, but more importantly it eliminates interfaces and their maintenance, which have historically cost a great deal of time and money. This is the automation of engineering in the literal sense.

Of course, the processes and procedures within the company and with suppliers also change with this simplification. The implementation of these new processes must therefore not be confused with the implementation of an IT project. But it is exactly these kinds of changes to operational processes that characterize the transformation into a Digital Enterprise. In the long run, it is precisely these changes that will distinguish a company from competitors that have shied away from the cost and effort of the transformation or that do not consider it necessary.

The situation is similar with regard to the third topic that Siemens is focusing on in its trade fair appearance in Hannover this year. Quite a few company executives, above all in Germany, are very cautious when it comes to the industrial use of cloud technology. This is surprising, because virtually everyone agrees that already in the medium term there will be no getting around it, if data from industrial processes are to be used for a wide variety of services via the Internet. Several companies are therefore working on implementing solutions such as predictive maintenance and intelligent logistics systems. With the consent of the customer, machines, mechanical equipment, and other products will be linked with the Internet and their data collected and analyzed.

Not every company can set up its own cloud for this, and not every cloud platform is suited for industrial applications. Security – of data, but above all of processes – is one of the challenges that differ significantly from those of clouds used for personal communication or e-commerce. In addition, the issue of real-time capability is defined completely differently in the industrial context as opposed to personal use of the Internet. In the control of a production facility, network interruptions lasting only a millisecond can result in damage worth millions. In using a browser, they do not matter.

This is why Siemens has decided to offer its customers a secure cloud infrastructure. Initially, this infrastructure is available as MindSphere – Siemens Cloud for Industry, based on SAP HANA. Additional platforms are to follow.

Siemens’ trade fair appearance in Hannover signifies a break this year. From the discussion of the future possibilities of a Digital Enterprise, a large step has been taken toward the merging of digital and real processes, with the Digital Enterprise Software Suite. The investment of a great deal of effort in the integration of crucial IT components now differentiates Siemens from other suppliers. ■

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**References**

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Data platform for the Digital Enterprise

Processing large volumes of data is especially important for networked companies with software-based production, also known as Digital Enterprises. With the open MindSphere – Siemens Cloud for Industry platform, there now is an inexpensive, virtualized data management system available.

Reducing cycle times, increasing flexibility, enabling individualized mass production, and minimizing the consumption of energy and resources – these are the challenges manufacturing companies face today. To remain competitive, they need to improve their entire value chain, from design and production planning to engineering and services. This also means that in order to make the right decisions early, a vast quantity of captured data ("Big Data") must be analyzed, and it must be determined which of all these data are truly necessary.

MindSphere – Siemens Cloud for Industry brings real production into the virtual world. First, all company data defined by the customer are collected and transmitted to MindSphere at determined time intervals. Then the data are analyzed, and those that are relevant for optimization are made available. These Smart Data make it possible to increase production efficiency and tap the full potential of the plant.

Open cloud with many possibilities
Because MindSphere has been conceived as an open IT ecosystem, it is not only possible to exchange data outside the company itself, but the system can also link to a wide variety of products. "Open standards and interfaces make it possible to obtain data from industrial devices from a wide variety of manufacturers and analyze them in MindSphere with their own algorithms – for example, for online monitoring of machine tools that are distributed all over the world," explains Dr. Florian Beil, head of technical sales and mobilization at Siemens. This means that manufacturers, especially
Guaranteed data protection

For Siemens, it goes without saying that only the most advanced security and encryption technologies are used when it comes to capturing, transmitting, storing, and processing data, and the company has also made additional efforts to guarantee data security. For example, data are hosted on German servers in the SAP server farms, where the same strict security and data protection standards apply to all customers. An on-premise solution is even envisaged for the future. With this solution, the data remain on each customer’s company premises and are processed in MindSphere from there. Finally, with Plant Security Services, Siemens offers holistic solutions that help minimize risks. In addition to these technological measures, it is also important to the users of MindSphere, whether plant operators or machine manufacturers, that whoever creates the data also owns them. Only the creator of the data can decide which data are transferred to MindSphere and who has access to them.

Future potential

“MindSphere helps customers generate added value with data and is the basis for providing digital services.”

Dr. Florian Beil,
Head of Technical Sales and Mobilization, Siemens AG

From data to added value

Visualisation and recommendations
Increase availability of components

Data analysis and simulation

Optimize power consumption

Secure data management and transmission

Maximize process efficiency

Data collection

MindSphere helps customers to generate added value with data and is the basis for providing digital services.”

Dr. Florian Beil,
Head of Technical Sales and Mobilization, Siemens AG