

## CP Systems

Learning factories for teaching and research



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## Research in Production

### Pioneering work for industry

#### Progress through research

Industrial production continues to develop rapidly, driven by global megatrends. In hardly any other sector do the new requirements and opportunities of digitalization, globalization, ecology or individualization come together in such a concentrated way as in the factory of the future. What this future may look like is determined not only by change processes in companies, but also significantly by targeted research and development activities.

#### Research institutions in focus

Through their dual function for teaching and research, the opportunities for national and international networking, and the established paths of knowledge transfer to industry, universities play a decisive role for driving these developments. This is exactly where the excellent solutions of tomorrow are being researched and developed, for example in the areas of machine learning, flexible, energy-efficient production, the use of big data approaches or secure networking, right through to the industrial Internet of Things.





# Applied research needs the right tools

## The interplay of model factories and simulations

### The importance of „real world“ equipment

Learning factories provide a basis, a platform to approach the new challenges experimentally and to implement solutions and ideas practically. In contrast to production facilities in the ongoing operation of companies, model factories allow research topics to be considered independently of location, time and running production, as well as with an unbiased perspective independent of product or technology.

### The role of simulation

Nowadays, the right mix of real and digital elements is crucial. Simulations allow learners, students and researchers to analyze scenarios away from what can be implemented in practice, whereas real facilities of production technology, control technology, networking or human-machine interaction can usually only be considered as a simplification in the digital model. In the realistic factory environment of the CP learning factories together with their digital representation in the corresponding simulation software, both perspectives can be combined.

### Factory Simulation with CIROS

Simulation and virtual commissioning save time and money during machine construction and offer a clear and effective training and testing tool. Students can work in groups to program and simulate models using real programming languages and then use these in the hardware environment provided. We supply CIROS, which is a powerful, industry-tested platform for 3D simulation modules in automation technology.





# CP Systems

Our comprehensive offer for applied research and training

## Cyber-Physical Systems

In our Cyber-Physical Systems, we combine communication networks and physical systems to form a single entity – an important characteristic of Industry 4.0.

We follow a modular and flexible design approach to provide the perfect solution for various customer requirements with regards to space and budgets. Therefore, our learning and research platforms range from the compact and flexible CP Lab, right up to an authentic and integrated replication of the real stations of a production system, the CP Factory. A wide range of application modules can be flexibly mounted on either the CP Lab pallet transfer systems or the CP Factory stations to vary the training or research content. With Robotino or the branch module CP Lab and CP Factory can be connected to form one common system.

**Magazine**      **Measuring**      **Pick-by-Light**      **Output**      **Labeling**      **Press**      **Camera Inspection**

All application modules can be mounted on both, CP Lab and CP Factory

Learn more about CP Lab

**CP Lab**  
The Cyber-Physical Lab is the professional and compact Industry 4.0 learning system that allows for modular expansion. It can be used as a stand-alone workstation or set up in various layouts via the pallet recirculating system as a tabletop solution or mounted on trolleys.

Get to know CP Factory for your research projects:

**CP Factory**  
The Cyber-Physical Factory represents the practical implementation of digital production. This comprehensive, modular and expandable factory model for Industry 4.0 can be used to model many parts of the value chain, including robot assembly stations, ASRS, or logistics. Therefore, CP Factory embodies an authentic smart factory basis system par excellence for various research purposes.



# CP Factory

## The universal Industry 4.0 research and learning platform

**Cyber-physical systems (CPS) permit intelligent networking of people, products, and production equipment.**

**They fulfill the prerequisites for digital production by integrating Internet-based communication networks with physical production systems.**

The Cyber-Physical Factory is the apex of our progressive, modular learning system for training and research in Industry 4.0. It authentically replicates the stations of a real production system, integrating relevant mechatronic and automation technologies. With its flexibility and expandability, the CP Factory represents numerous aspects of the Industry 4.0 value chain, including:

- Integration of manufacturing divisions into digital production
- Automated and manual assembly
- Logistics in autonomous systems
- Production planning and production control/MES
- Lean production as a basis for Industry 4.0
- Smart maintenance to monitor systems and system states
- Quality assurance in Smart Factories

Research can be expanded further by topics such as systems networking and the use of open, configurable systems, communication standards and data-based job control, RFID and NFC technologies, as well as the acquisition of information via mobile devices.

You can customize the CP Factory for concentration on the topics most relevant to your needs in industrial automation technology, configuring in minutes your preferred factory layout.





# Adaptable layout for flexible manufacturing with the latest Industry 4.0 applications

## Modular system varies training and research content

The arrangement flexibility of the individual modules, as well as the ability to add a variety of applications, are at the core of the CP Factory and determine the content of the various stations. Processes such as drilling, press-fitting, and heating can be replicated, as can logistics processes, i.e., storage and withdrawal of materials and material transport with autonomous robots.

## Open interfaces for quick changeovers

The CP Factory addresses the real-world experience of the changeable factory. Standardized interfaces allow application modules to be exchanged and uniform, preassembled system cables permit fast layout changes and commissioning. Thus, one or more production lines focusing on the desired areas of automation, are created very quickly.

## Industry 4.0 applications in actual practice

Key issues such as RFID, near field communication, professional cloud, and the step-by-step introduction of CPS, as well as plug & produce methods can be imparted in a highly practical manner with the CP Factory.

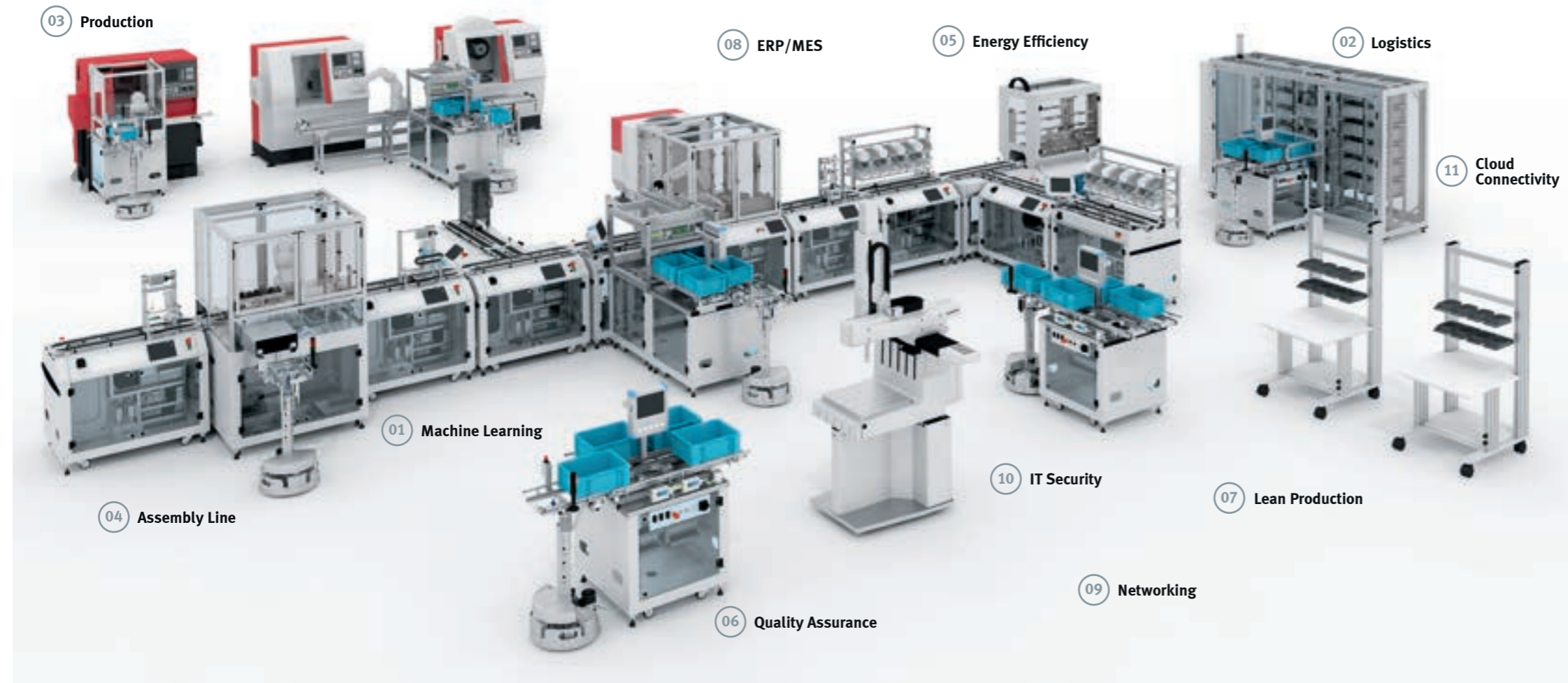
All production data are brought together in the MES4 production control system, which has been developed in accordance with Industry 4.0 requirements. Open databases with transparent interfaces fulfill the prerequisites for learning and experimentation.





# CP Systems

Ready for your research application



## The universal Industry 4.0 learning factory

A value chain not only includes assembly lines but also other areas such as production, lean production, logistics and quality assurance.

Our CP Systems therefore incorporate comprehensive facilities for these areas and integrates them with an MES (Manufacturing Execution System) developed to meet the needs of Industry 4.0. This creates a comprehensive, modular and expandable factory model that provides a networked starting point for various research applications.

**01 Research Area Machine Learning**  
Machine learning or deep learning based on neural networks has proven to be particularly promising for the automated analysis of data. Due to the increasing computing power, it is possible to analyze and classify huge amounts of data and to derive profitable conclusions.

With our CP camera module, ready-made neural networks can be used, trained and further developed.

**02 Research Area Logistics**  
An intelligent flow of materials and networked logistics are important drivers for Industry 4.0. The CP Factory offers a versatile training and research platform for numerous different logistical problems:

- RFID
- MES
- Automatic warehouses
- Production stores and magazines
- Pallet transfer systems with deflectors
- Autonomous transport robots, including the transfer of materials

**03 Research Area Production**  
CNC machines and flexible production systems play a major part in the creation of customised products down to the level of one-off production.

The CP Factory integrates CNC technologies for use in industrial training projects and scenarios.

It therefore adds:

- Robot integration
- CAD/CAM products
- Simulation

**04 Research Area Assembly Line**  
One-off production and the assembly of product variants place demanding requirements on production in accordance with Industry 4.0. To meet these requirements, the CP Factory offers:

- Modularity
- Mobility
- Short setup times
- RFID technology
- Plug & produce
- Standard interfaces
- Service-oriented program architecture
- Pick-by-light

**05 Research Area Energy Efficiency**  
Integrated energy monitoring with web-based visualizations permits the analysis of electrical and flow-rate data. This allows to address research topics such as energy-efficient and energy-flexible production.

The “Smart Grid” learning software EiSLab® enables the CP Factory to be reintegrated into a virtual smart grid and displays the relationships between the various load devices, storage devices and power generators. As a perfect use case for IIoT communication, energy data can be sent to cloud platforms via the IoT Gateway.

**06 Research Area Quality Assurance**  
From a caliper gauge to a fully-automatic 3-D measuring machine – all standard measuring devices can be integrated into the CP Factory as a quality laboratory.

The SPC module in the MES4 is used both to enter setpoints and carry out evaluations.

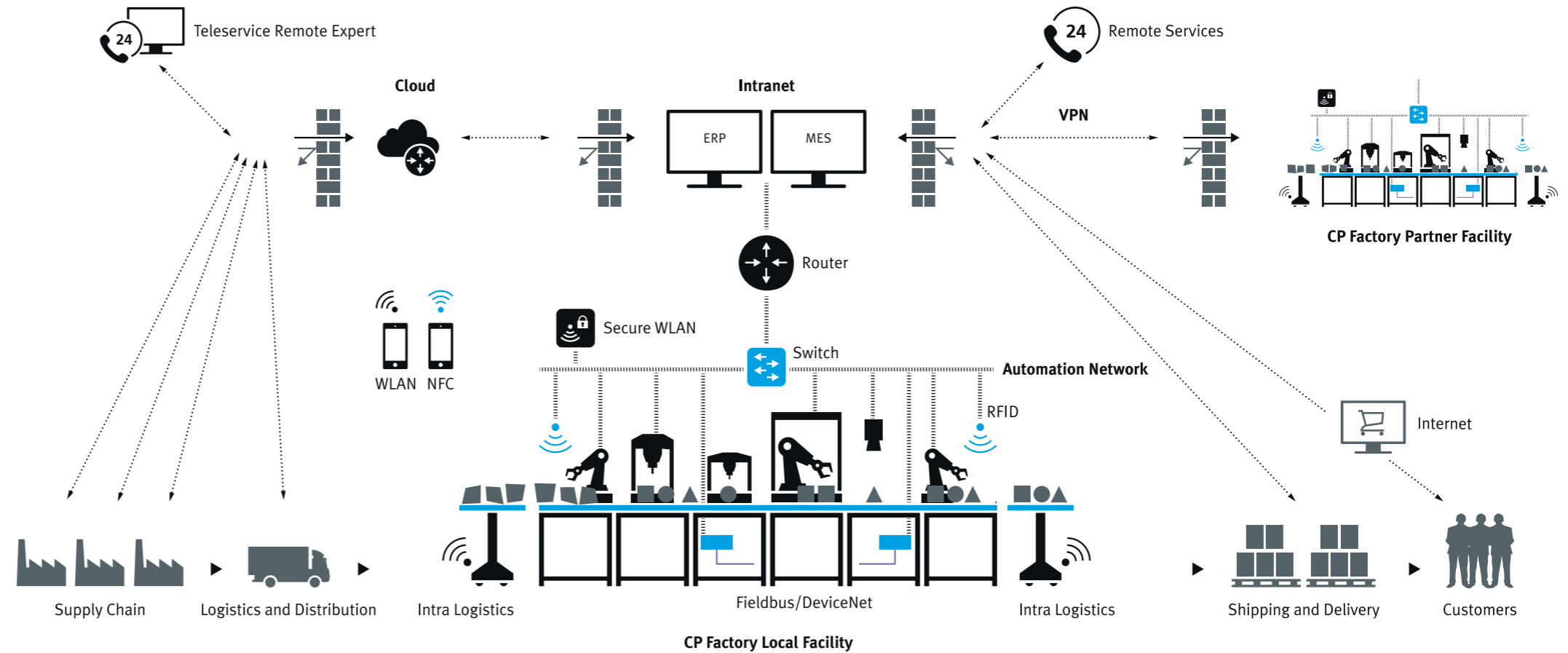
# CP Systems

## Applied research for the production of the future

### Global networking

Each factory and its components form part of a large network. This applies to both physical objects such as semi-finished and finished products and also a variety of data.

Industry 4.0 delivers a clear benefit by optimising and intensifying networking at all levels. What's more, networking and data management generate additional business opportunities based on big data and non-location-specific cloud applications.



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#### Training Area Production Planning and Control/MES

In a modern factory, intelligent machines and workpieces communicate with each other and with the IT systems ERP (enterprise resource planning) and MES (manufacturing execution system) both inside and outside the factory, up to cloud level. MES4 is Festo's MES for a smart factory, working with an open database and open interfaces. We are able to produce further MES and ERP links on request.

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#### Research Area ERP Systems

ERP systems such as SAP are widely used in many companies. For the CP Factory, a direct interface for SAP was created in consultation with SAP. This extends the possible applications of the CP Factory to cover business management topics.

Festo and SAP offer a curriculum for Industry 4.0 and SAP which is available via the SAP University Alliance and Festo Didactic.

**SAP**  
University  
Alliances

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#### Research Area Networking

A major prerequisite for the implementation of Industry 4.0 is the seamless networking of machines and plants together with all relevant IT systems, up to and including the Internet. The CP Factory covers all relevant communication systems and thus allows a comprehensive simulation of industrial reality:

- Fieldbus (sensor/actuator level)
- Automation Network
- OPC UA (PLC communication)
- LAN (local area network/MES)
- WLAN (wireless local area network/mobile devices, Robotino)

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#### Research Area IT Security

Machines and plants must be protected against unauthorized access. As with increasing digitalization hackers resort to ever more sophisticated attack methods, research in the field of IT security is of immense importance, for example:

- VPN for non-location specific communication
- Network security (layer 2 and layer 3)
- WLAN security
- Secure remote access
- Firewalls and VLAN

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#### Research Area Cloud Connectivity

Direct communication paths from subsystems with servers in the company or the cloud are increasingly replacing rigid communication in the automation pyramid.

The IoT Gateway for CP systems addresses:

- Industrial cloud connectivity
- MQTT applications
- Edge computing capabilities
- Cross-location networking



# CP Systems for teaching and research at a glance

## What our model factories can do for you



### Didactical implementation of top topics

Festo Didactic specialists are passionate about integrating future top topics into our model factories. The scenarios developed for machine learning, for example, not only enable the use of current deep learning algorithms for classification, localization and detection, but also offer the possibility of understanding, adapting and further developing the algorithms step by step through didactic software and learning materials.

### Data source for Big Data

Modern digitalized production facilities are a source of countless and diverse data. Much of it is essential for maintaining production operations, such as order data and process parameters, while some can help increase efficiency and optimize processes, such as energy consumption or machine data. Some data even up to now has no specific use but can still be logged to potentially use it for optimizing production in the future with algorithms developed at a later stage, e.g. based on machine learning.

Our learning factories are capable of transferring, storing and evaluating this full variety of data – for all current tasks and for everything that is yet to come.

### The perfect basis to get started right away

Developing everything yourself? Possible, but unnecessary. Technologies in production environments are becoming increasingly complex. The development of an entire learning factory is extensive and lengthy.

Our recommendation? Start directly with a fully functional learning factory and focus your development capacities on your top research topics.

### Hardware platform for own modules

Our learning factory modules kit already includes a wide range of applications, topics and designs, be it production with CNC machines, additive manufacturing steps, or quality assurance with laser or camera sensors, only to name a few. But also for individual development projects, CP Systems lay the perfect foundation. Many of our customers develop their own intelligent applications based on single-board computers and integrate them into the overall system directly or via the optional CPS Gate, which already contains the essential basic functions for system integration.

### Preconfigured software platform

Software is a central and integral component of our learning factories. The Manufacturing Execution System MES4 is where all the threads of order control come together. Energy consumption can be monitored and optimized via the Energy App. The AR app provides essential live information about the plant, and the preconfigured web store rounds off the processes in the direction of the ERP and customer front end. All software components are pre-configured and therefore ready for immediate use.

### Software interfaces for own applications

Our software applications already offer a wide range of didactically prepared functions. Nevertheless, you will find special areas for which you might want to use other software tools or develop new software yourself. That's perfectly fine. Our systems are equipped with open and extensible software interfaces such as OPC UA, TCP/IP, MQTT or MariaDB (MySQL). In project work, our customers use these to develop individual solutions, such as the connection of an alternative web store or a cloud platform for visualization.



### CPS Gate – enabling your own applications

The CPS Gate integrates a stopper with RFID, a controller, communication to applications and the MES, web based human machine interface and an IIoT edge controller with Node-RED. It is perfectly prepared for smart retrofit projects or advanced plug-and-produce scenarios.

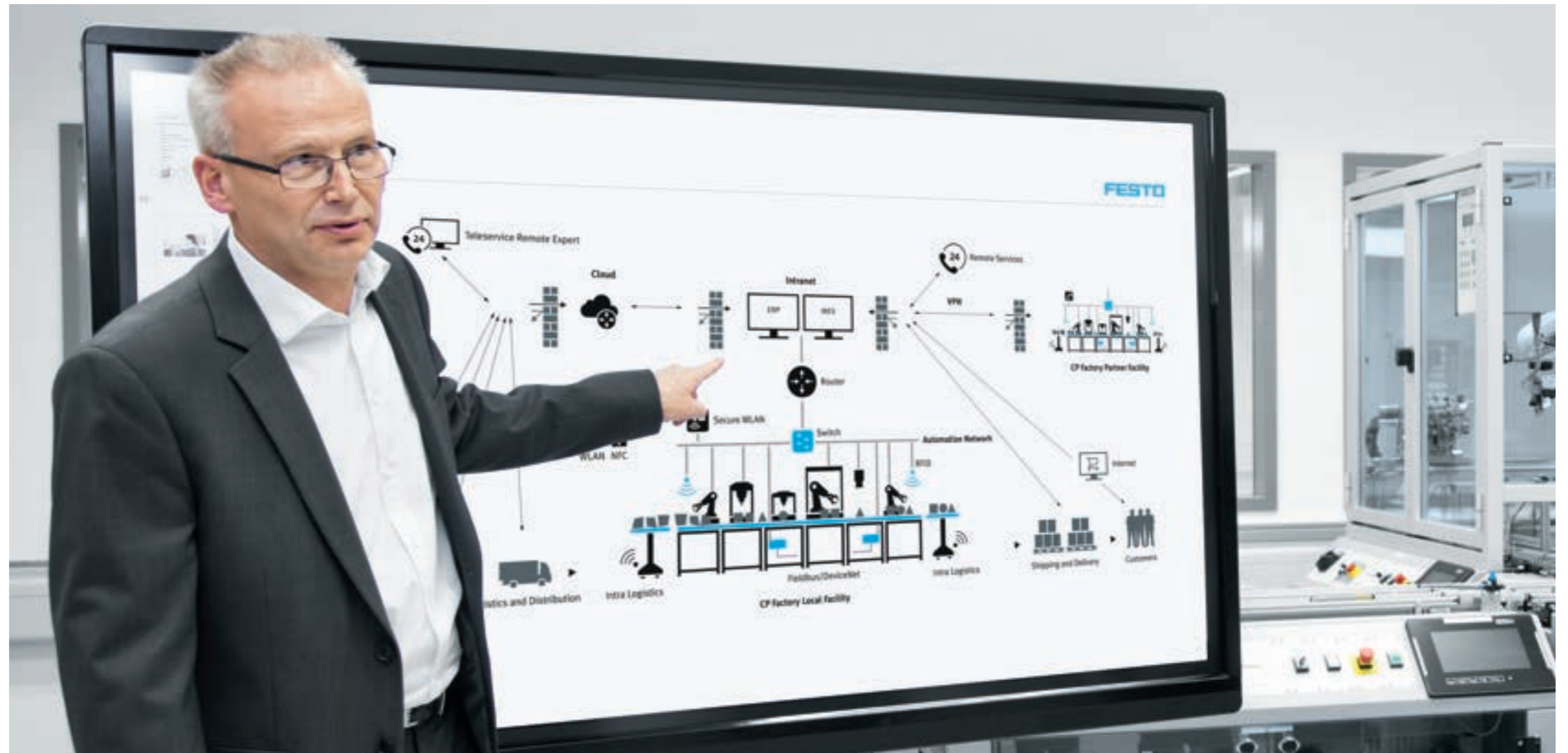


# Festo Didactic

## A reliable partner for your research endeavors

### From industry for industry

can, as your partner, address two needs at once: on the one hand, we work very closely together with industry and know its needs, which we incorporate directly into our learning and research factories. On the other hand, we are part of many Industry 4.0 committees such as SmartFactory-KL and the Plattform Industrie 4.0. We are thus able to play an active part in shaping this project and integrating the latest trends in our learning systems. Profit from this experience! This allows you to use your capacities optimally for your teaching and research tasks!



### Festo's involvement in the Plattform Industrie 4.0

The "Plattform Industrie 4.0" initiative is sponsored by the VDMA, ZVEI, and BITKOM associations. Various companies from business and science are working together on the development of technologies, standards, and business models for Industry 4.0, as well as their implementation in actual practice. Festo is part of this initiative and sits on the board of directors as well as in the steering committee – [www.plattform-i40.de](http://www.plattform-i40.de).

### Research projects

Festo is actively organizing future production and is involved in numerous Industry 4.0 research projects which are subsidized by the German federal government. Together with partners from industry and science, highly promising solutions are being developed, such as an open engineering platform for autonomous, mechatronic-automation components, autonomics for Industry 4.0, and energy self-sufficient sensors for the optimization of resource efficiency in the OPAK, ESIMA, MetamoFab, APPSist and SOPHIE projects.

### European innovation cooperation

We are part of Europe's largest network for innovation, the European Institute of Innovation and Technology (EIT). EIT Manufacturing is a partnership of over 50 corporations, companies and organizations and supports startups and SMEs to strengthen their competitiveness and expand European markets and business models. As a partner company and expert for digital transformation in production and education, we play an essential role in several joint research and development projects.

### Labs Network Industrie 4.0

Festo is member of the Labs Network Industrie 4.0 (LNI 4.0), an association founded to experience and test new technologies on the path towards Industry 4.0. In testbeds, new technologies like TSN (Time-Sensitive-Networking) are evaluated while always taking into account Industry 4.0 characteristics as well as standardization approaches.

### Benefit from the community

As a CP System customer, you can access existing documentation and learning materials – offline, via our InfoPortal or the Festo LX learning experience portal. In addition, our CP Community offers the opportunity to network with other users and exchange ideas.