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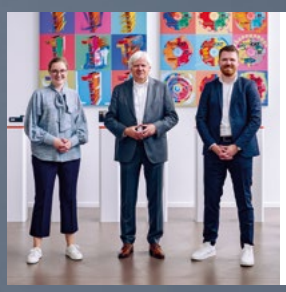
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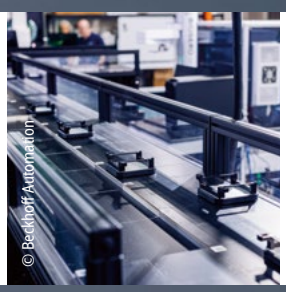
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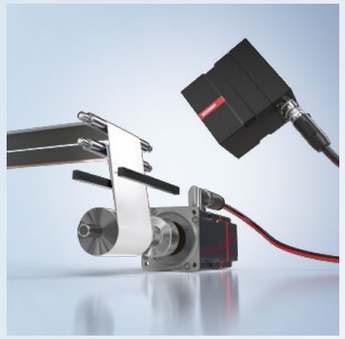


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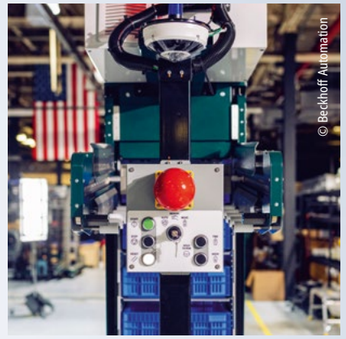


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The B.R.E.A.K. research project brings automation to life through play

High tech meets the joy of play

A student project has turned into an impressive example of the practical support offered to nurture young talent. Four students from Beckhoff Automation have developed the fully automated B.R.E.A.K. billiard robot as part of their work-integrated study program in mechatronics/automation at the Gütersloh campus of Bielefeld University of Applied Sciences and Arts (HSBI). In German, the letters in its name stand for “billiard robot for the autonomous execution of ball shots.” The machine analyzes game situations independently, plans the best shot, and implements it autonomously.

The impetus for the project came from a personal enthusiasm for billiards and a fascination to connect a tactical game with precise automation. Ben, Antoine, Michael, and Niklas came together to form a team to develop B.R.E.A.K. as a functioning mechatronic system. Their goal was clearly defined. A fully automated billiard robot was to recognize, analyze, and play the 8-ball game independently, while being precise, safe, transportable, and user-friendly. The result lives up to this aspiration. With a hit rate of around 80 percent, the system plays at a level above that of a good billiard player.

Image processing for precise positioning

The technical quality of the billiard robot is demonstrated by the seamless interplay of image processing, intelligent software, and precise control technology. The first step is the optical recording of the field of play. An industrial camera from Beckhoff captures the table in three individual images under different colored light pulses. The system then uses these images to reconstruct a color image, creating the basis to position all the balls reliably and precisely.

The subsequent analysis is performed by software developed in Python. A trained model recognizes and classifies the balls, determines their exact position on the table, and, at the same time, compensates for optical distortions to ensure a reliable data foundation for further processing. Based on this information, the system calculates the most suitable playing strategy and the optimum next shot in a fraction of a second. B.R.E.A.K. therefore translates a game situation that people often assess intuitively into precise data, algorithms, and motion profiles. The resulting target and movement data is transferred to the Beckhoff control system via ADS. TwinCAT is used for automation and motion control. There, the students implemented the machine logic in such a way that the system aligns itself safely, highly precisely, and without collisions, and executes every shot in a controlled and reproducible manner.

The result is a complete system that is not only impressive in terms of its technical performance, but also due to the consistent integration of all key disciplines – from optical detection to intelligent data processing and precise execution of movements.

Industrial control at the core

The technological basis of the project is provided by PC-based control technology from Beckhoff. The team built on this to implement the integration of TwinCAT, drive technology, and image processing – including industrial camera and illumination – to create a seamlessly coordinated complete system. Components from other sponsors in the local Ostwestfalen-Lippe region were also used. The result demonstrates the high practical relevance of the project. The robot brings together different technologies into a functional application and shows how industrial automation solutions can be implemented in an efficient, scalable, and application-oriented manner.



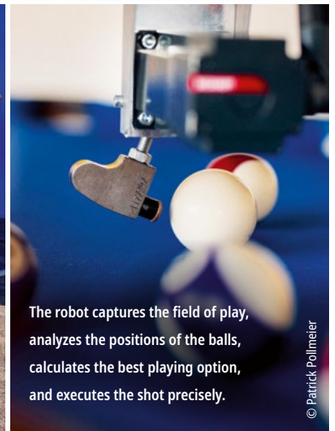
Four students have developed the fully automated B.R.E.A.K. billiard robot as part of their work-integrated study program in Mechatronics/Automation.

© Beckhoff Automation



The billiard robot impressively demonstrates how exciting, practical, and future-oriented the work-integrated study program at Beckhoff is.

© Patrick Pollmeier



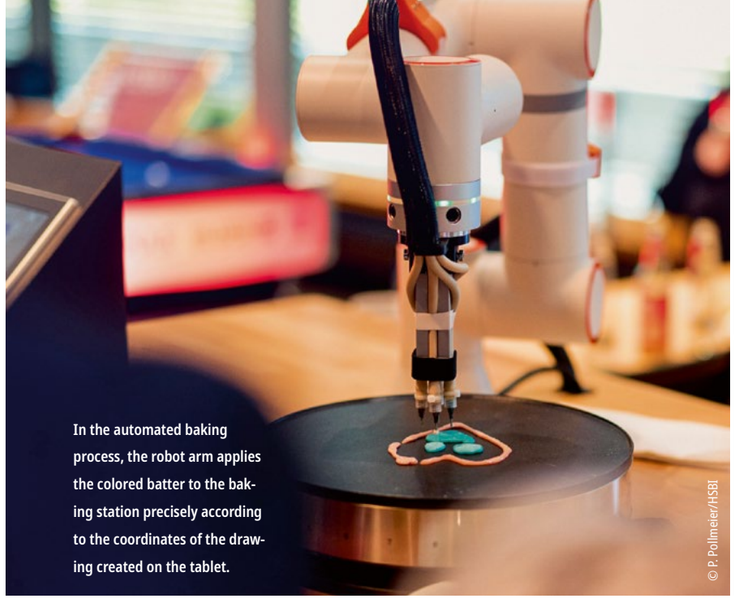
The robot captures the field of play, analyzes the positions of the balls, calculates the best playing option, and executes the shot precisely.

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More information:

www.hsbi.de/en

www.beckhoff.com



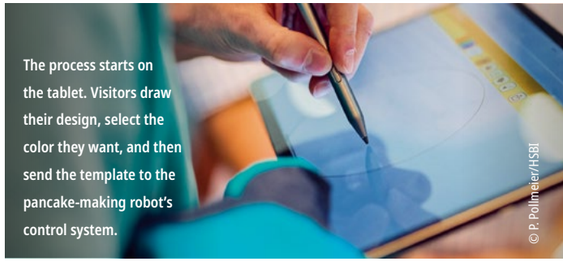
In the automated baking process, the robot arm applies the colored batter to the baking station precisely according to the coordinates of the drawing created on the tablet.

© P. Pollmeier/HSBI



The Beckhoff Control Panel displays key status data, such as the temperature of the baking plate and the pump speed, and allows the user to choose the next pancake design.

© P. Pollmeier/HSBI



The process starts on the tablet. Visitors draw their design, select the color they want, and then send the template to the pancake-making robot’s control system.

© P. Pollmeier/HSBI

Students build automated pancake-making robot

Turning a drawing into a pancake

Five students from Bielefeld University of Applied Sciences and Arts (HSBI) developed “PanCasso”, a pancake-making robot, at the Gütersloh campus. They completed their work terms at Beckhoff Automation – and used this project as an opportunity to translate a creative idea into a practical automation application with automation technology.

The idea for PanCasso originated in the “Documentation of Mechatronic Systems” course and was implemented one semester later in the “Mechatronic Systems” module. The project went well beyond a traditional student research project. The objective was to develop a technically sophisticated system that would showcase modern automation at exhibitions, university open days, and information events in a clear, interactive, and understandable way. The pancake-making robot demonstrably and practically meets this requirement. Users draw a design on the tablet, watch as the robot brings the design to life, and ultimately end up holding a custom-designed pancake in their hands.

A complex mechatronic system

Behind it all lies a complex, integrated mechatronic system. The team developed the drawing application for the tablet, programmed the control system, calculated the robot’s travel paths, and adapted the hardware to cater for the requirements of the baking process. The to-do list also included electrical engineering, design, documentation, project planning, and finding sponsors.

The students were thus able to go through the key phases of a real-world engineering project – from initial idea through technical implementation to commissioning. For Beckhoff, PanCasso also demonstrates the value that work-integrated training creates for both universities and industry. The students combined their theoretical knowledge directly with real-world industrial applications and took on responsibility for their own development project at an early stage. The project has produced a technology demonstrator that not only allows users to experience the fascination of automation first-hand but also highlights the value of hands-on training in a real-world setting.

From tablet to robot path

Visually, PanCasso presents itself as a mobile functional table that combines modern industrial components in a compact space. On top, the baking station is the hub of activity. Working directly alongside it is the robot arm, which applies the batter precisely onto the hot surface. The integrated process technology is located beneath the work surface. A cooling unit keeps the batter fresh, while controlled pumps deliver the various colors to the robot’s application head as required. Interaction starts intuitively on a tablet. This is where visitors can create their own custom designs, with a choice of up to four different batter colors, or use geometric templates. With a tap of the finger, the drawing is digitally captured and transmitted to the integrated Beckhoff control system. The software translates the drawn image directly into standardized G-code. This list of coordinates is interpreted by the control system so that the robot can trace the outlines precisely. The design is displayed directly on the control panel. The sequence control takes over as soon as the operator starts the process, coordinating the robot’s axis movements and simultaneously controlling the dispensing of the batter from the individual pumps. The change of color is also controlled automatically. The desired design then gradually takes shape on the baking surface.

More information:

www.hsbi.de/en

www.beckhoff.com



At SPS 2026, Beckhoff will demonstrate how all automation functions work together within a holistically integrated architecture.

Beckhoff at SPS 2026

All automation functions – one integrated architecture



Hands-on technology: In direct discussions with Beckhoff experts, the system concept becomes clear in context with specific applications.



At this year's SPS in Nuremberg, Beckhoff will once again be located at its usual spot in Hall 7, Booth 406.

Software-defined automation, the convergence of IT and operational technology (OT), and further advances toward physical AI are all coinciding with shorter development cycles and increased cost pressures. With Beckhoff, however, all of these technology trends and requirements can be integrated into a single architecture. The foundation for this is PC-based control, an integrated approach that was first formulated 40 years ago. Today, it is no longer just the availability of individual functions that matters: how they work together is of prime importance. Visitors to the Beckhoff booth at SPS 2026 will be able to see exactly what this means in a live demonstration.

In 1986, Beckhoff ushered in a new era with its first PC-based machine control system. This was motivated primarily by one observation: if users have IT standards as a basis for their control technology, they become part of those standards' innovation cycles and are no longer tied to proprietary development paths. The key to this, however, involved more than just integrating a PC into a machine. Abstracting the control function from proprietary hardware was vital as well. Since 1996, the TwinCAT automation platform has served as the software foundation that unifies everything – from logic and motion control, communication, HMI, safety, and measurement technology all the way through to image processing, robotics, and AI tools, all in a single environment.

So, the abstraction of software and hardware actually started out as a design decision that Beckhoff already made a quarter of a century before Industrie 4.0 came about. Since then, numerous technological advances have contributed to this progress. The implementation of PC technology has allowed machines to be linked easily with databases, ERP systems, and IoT systems via standardized IT protocols. No separate devices were needed for edge applications because of the inherent data transmission capabilities provided by the PC. With EtherCAT, the growing computing power of control systems can be harnessed for the machine process through fast, deterministic communication and precise synchronization. Multi-core processors have provided sufficient performance for tasks that previously required additional hardware, and web technologies have replaced proprietary user interface concepts. Each of these developments has addressed new requirements that have arisen over time. Today, the goal is to provide a wide range of necessary properties and functions simultaneously and consistently through one automation solution.

Software-based automation

Modern machines need to be precise, dynamic, and capable of handling variation, interact safely with people, record process conditions, provide data, remain intuitive to operate, and undergo continuous development over the years. None of these properties is new in and of itself; however, in order to remain competitive in the future, it will be essential for machine builders to

ensure that all functions work together within the same project, under the same engineering framework, and throughout the same lifecycle.

Software-defined automation shifts a machine's adaptability from its mechanics to its architecture. Motion profiles, process sequences, and variants are described in the software. This opens up new degrees of freedom, but can only be effectively managed if the control logic, motion, safety technology, operation, and process data are all coordinated. The convergence of IT and OT brings together two worlds with different types of logic: control systems require deterministic responses within defined time frames. Analysis, visualization, and higher-level services operate using different time references and data models. The two worlds have to share a single architecture without compromising the machine's reliability.

Added to this is significant economic pressure: project timelines are getting shorter and budgets are becoming tighter. At the same time, machines should be able to respond as flexibly and adaptively as possible to new requirements or variants throughout their lifetime. A closer look reveals just how closely these areas are intertwined. A change in motion affects safety functions, process times, and operating sequences. An image feature only becomes usable information when combined with data on the workpiece, position, process step, and time reference. Furthermore, any additional data connections must be designed so they don't compromise real-time capability, safety, or long-term manageability.

Between detection and action

This is most evident in physical AI – that is, when artificial intelligence interacts with the physical world. In this case, AI is not limited to data analysis, but establishes connections with image data, process values, motion states, and signals from the field. The critical transition lies between detection and action: a model can evaluate a deviation – but whether and how the machine responds to it is determined elsewhere. Which process step is currently running? What kind of movement is allowed? Which safety function is active? Does a person need to be involved?

This leads to a conclusion that contradicts a common assumption: AI does not replace the fundamentals of automation; rather, it raises the bar for how these elements must work together. Vision and measurement technology provide information from the real-world environment, the control system establishes a connection between this information and the current process, motion control executes movements precisely, safety technology defines the permissible scope of action, and the HMI makes states, decisions, and options for intervention transparent. This kind of coordination is essential for generating tangible benefits. On a technical level, this means that TwinCAT distributes applications, real-time tasks, and modules across multiple CPU cores and coordinates them all without compromising the deterministic execution of critical processes. A machine's performance is able to scale within a shared architecture without needing to set up standalone, isolated solutions for each new function.

That is exactly what the Beckhoff portfolio is designed for. Its scalability ranges from compact embedded PCs to high-performance industrial servers. This openness allows various programming languages to be used, easy incorporation of trained machine learning models, and integration of components and solutions from other manufacturers. Through distributed clocks, EtherCAT provides a precise time reference for the connected I/Os, drives, and measurement technology components.

The big picture

At SPS 2026, Beckhoff is dedicating a centrally located area to its system-based approach. Themed displays will explain the key tasks of modern machine automation – from sequence and motion control to operation, safety technology, measurement technology, image processing, artificial intelligence, and connectivity. These displays are not product overviews: instead, each will explain what the machine is being tasked with, which hardware and software technologies are available for that purpose, and how the solution fits into the overall system. Hardware and software will be considered in tandem in each of these contexts.

Visitors to the Beckhoff booth will be able to see how this translates into practice live. An actual machine, like the ones used in Beckhoff's in-house I/O production, will provide the central reference point and combine all the technologies from Beckhoff's modular automation system – from PLCs, communication, and motion control to measurement technology, robotics, AI tools, and XPlanar's floating movers. The combination of functions and technologies on display at SPS will clearly demonstrate why the system-integrated approach is making a real difference in today's environment. Visitors will be able to see its story from two different perspectives: either starting with a specific machine requirement and moving to the technology solution, or starting with technology and moving to how it is used with a machine.

From unconventional to standard

When PC-based control technology was introduced in 1986, it was initially met with skepticism, and continued to be thought of as an unconventional approach for some time. Over the past forty years, the importance of open and standardized interfaces has increased significantly. As a result, PC-based control has evolved from an alternative option to an established automation approach – not only in machine and system engineering, but in many other fields and industries.

What was once a vision has long since become a measurable benefit: with fewer interfaces, lower latencies, integrated engineering, a common control platform, and coordinated communication and time references. These are properties that require a significant amount of integration work to implement retroactively. Situations that handle control, motion, safety, measurement technology, and data systems as separate technology domains present the user with an integration challenge – requiring additional interfaces, specialized tools, and custom solutions whose costs increase over the course of their lifecycle.

This shifts the basis on which manufacturers can gain a competitive advantage. It is not the number of technologies available to a machine that determines how competitive it is, but rather its architecture's ability to incorporate new functions.

More information:
www.beckhoff.com/sps/



At the Beckhoff booth, visitors can experience how PLC, motion control, communication, safety, measurement technology, vision, robotics, and AI work together seamlessly.



The benefits of software and hardware abstraction in automation will be clearly demonstrated through numerous examples at the booth.









Beckhoff hosted the Motion Days in Marktheidenfeld and Hagenberg with the aim of bringing the versatile world of Beckhoff Drive Technology to life.

Pure drive technology, twice over

Bringing the versatile world of Beckhoff Drive Technology to life in a single day – with a focus on real-world applications. It was with this goal in mind that Beckhoff hosted the Motion Days in September at its locations in Marktheidenfeld, Germany and Hagenberg, Upper Austria. The fact that the plan worked is evidenced not only by the considerable number of participants in attendance but above all by the in-depth discussions that took place during the networking breaks.

Following welcome remarks and a brief introduction, a keynote address marked the start of the technical element of the event. The key message: Motion doesn't stop at the drive shaft. PLCs, motion control, I/Os, and sensors work together seamlessly, ensuring precision throughout the entire signal chain. A real-world example from the pharmaceutical industry featuring a 129 m XTS travel track incorporated in a single machine demonstrated the capabilities of this architecture.

Participants shared their own challenges during the subsequent discussion with customers, before breaking out into three workshops. "Precision in motion" focused on the portfolio of rotary and linear servo motors, ranging from the AM1000 economy motors to the water-cooled AM8300 and the AM8800 stainless steel models in hygienic design. "Think modular, drive decentralized" demonstrated how the AMP8000, AMI8100, and ASI8100 motors, along with the MX-System, can drastically reduce control cabinet footprints and wiring effort. The third workshop focused on intelligent transport solutions with XTS and XPlanar alongside typical real-world customer questions.

After the lunch break, which was put to good use for in-depth discussions with experts from Beckhoff, the "One system for all applications" presentation covered everything from the ELM72xx I/O-integrated servomotor terminal to the AX1000 and AF1000 economy drive series and even the AX8000 multi-axis servo system. A project case study traced the journey from initial idea to finished solution, and the concluding presentation on TwinCAT 3 Motion Control illustrated how multi-core and multi-task support can make complex motion sequences manageable without limiting the number of axes. "Motion Days was a resounding success," concludes Michael Pfister, senior product manager for motion. "Our customers don't just want to see drive technology depicted on a data sheet. They want to understand it within the system – from motor to amplifier to software. And that's exactly what we accomplished over these two days."

More information:
www.beckhoff.com/motion

TwinCAT bundles a complete motion engineering solution in a free toolchain

Three tools for each axis

Designing, commissioning, and optimizing drive axes – three tasks that, in practice, are usually carried out using very different tools, multiple data collection processes, and expert knowledge; but it doesn't have to be that way. Beckhoff maps the entire workflow consistently within a single toolchain using the TwinCAT Motion Tools: from sizing – including DC link analysis – through axis commissioning to fully automated, iterative controller tuning.



Advanced machines and systems require precise, efficient, and perfectly harmonized drive systems. At the same time, the number of axes, dynamic requirements, and variety of models are increasing, while project timelines are shrinking and there is a shortage of experienced commissioning personnel. As a result, the focus is shifting more and more toward engineering. The motor, gearbox, servo drive, and accessories must be thermally and dynamically compatible with one another; the power supply and braking resistor must be matched to the total load response of all axes; and the controller parameters must be tailored to the specific mechanical system. Traditionally, this means using spreadsheets for design, manual parameter lists for commissioning, and a time-consuming trial-and-error process for tuning – with discontinuities between the individual steps.

What used to be time-consuming and resource-intensive can now be implemented easily, quickly, and consistently using Beckhoff's free engineering tools. The tools are deeply integrated into the TwinCAT software platform, but remain open. That is why the Motion Designer can also be used as a standalone solution.

Predefined mechanical configurations reduce the drive/motor selection in the TwinCAT 3 Motion Designer to simply entering the application-specific parameters.



Step 1: The right design

The dimensioning of the drive axes, combined with the optimal selection of motors, gearboxes, drive controllers, and accessories, forms the foundation for efficient machine design. The TwinCAT 3 Motion Designer (TE5910) supports the designer in the configuration of typical mechanical systems such as rack and pinion, ball screw nut, winder, or crank drive. Load cases and mechanical models are already defined; the designer simply enters the application-specific parameters.

It takes just a few clicks to define the motion: Rough design calculations for simple load cases using the ½ or ⅓ rule or as a 7-segment profile are covered, as are multidimensional problems, kinematics, and cam plates according to VDI 2143. The multi-axis design is crucial for systems with many axes. The Motion Designer views the machine as a whole, takes into account all load cycles in terms of their temporal dependence and their impact on the common DC link, and thus ensures the selection of the appropriate power supply module or common braking resistor. This allows power supply capacities to be configured realistically rather than additively – for example, between the AX8620 (20 A DC) and AX8640 (40 A DC) power supply modules in the case of the AX8000 multi-axis servo system. Compatible cables and other accessories are also tested.

A major benefit lies in documentation and reuse – at the click of a button, design documentation, technical data sheets, 3D models, and bills of materials are generated. Export functions transfer the configuration directly to TwinCAT without having to re-enter the data. Planetary gear units illustrate just how closely hardware and design are intertwined. The tool calculates inertia ratios, required torques, and the adaptability of the motor and gearbox in a single step. The Motion Designer even includes suitable drive solutions for hygiene-sensitive applications in the food, beverage, and pharmaceutical industries.

Step 2: Getting it up and running quickly

The TwinCAT 3 Drive Manager 2 (TE5950) serves as the commissioning foundation for virtually the entire Beckhoff drive portfolio. This includes servo drives and variable frequency drives, decentralized 48 V DC drive solutions, and I/O components. It is integrated as a project into an existing TwinCAT solution and allows for the separate viewing of power supply modules, axis modules, and axis channels.

The time savings for the user result from automated parameterization: the Drive Manager 2 automatically reads the motor and associated parameter data from the electronic nameplate and uses this information to generate a startup list for each axis. Using One Cable Technology, which transmits power and feedback through a single cable, an axis can be up and running in less than two minutes. The integrated Scope View provides an immediate snapshot of the motor operated by the NC control system, allowing you to fine-tune the axis and minimize the tracking error directly. For axis control, TwinCAT retrieves the necessary parameterization directly from the tool. Engineering dialogs and PLCopen-compliant function blocks are available for further commissioning. The stage is set for the next generation of motion control as well, with the Drive Manager 2 automatically creating configurations and axes using standard parameters.

Using the electronic nameplate, the TwinCAT 3 Drive Manager 2 automatically collects motor and parameter data and generates a startup list for each axis.





Amplitude and phase progression in the Bode plot: The automated tuning process remains transparent to the drive engineer at all times.

Step 3: Fine-tuning

Optimizing the servo axes is crucial for precision, smooth operation, and service life. A key component of every machine commissioning process, it is time-consuming and sometimes requires extensive experience on the part of the technical personnel. Until now, the ability to interpret stability criteria and parameters for phase and amplitude has generally been the domain of drive experts.

TwinCAT 3 Autotuning (TE5960) automates this very step. At the push of a button, the servo drive determines all essential parameters of the application. The iterative tuning procedure identifies the mechanics and determines the load inertia, controller parameters, and filter settings. In addition to the gain factors Kp and Kv, the integration time constant Tn, and the load inertia JL, it is possible to calculate and implement current-setpoint filters that stabilize the system. Without compromising transparency for experts, the results are displayed with amplitude and phase progression in the Bode plot graphic. The calculated parameters can be loaded directly into the servo drives via the Drive Manager 2. For designs with many servo axes, the time saved increases in line with each servo axis.

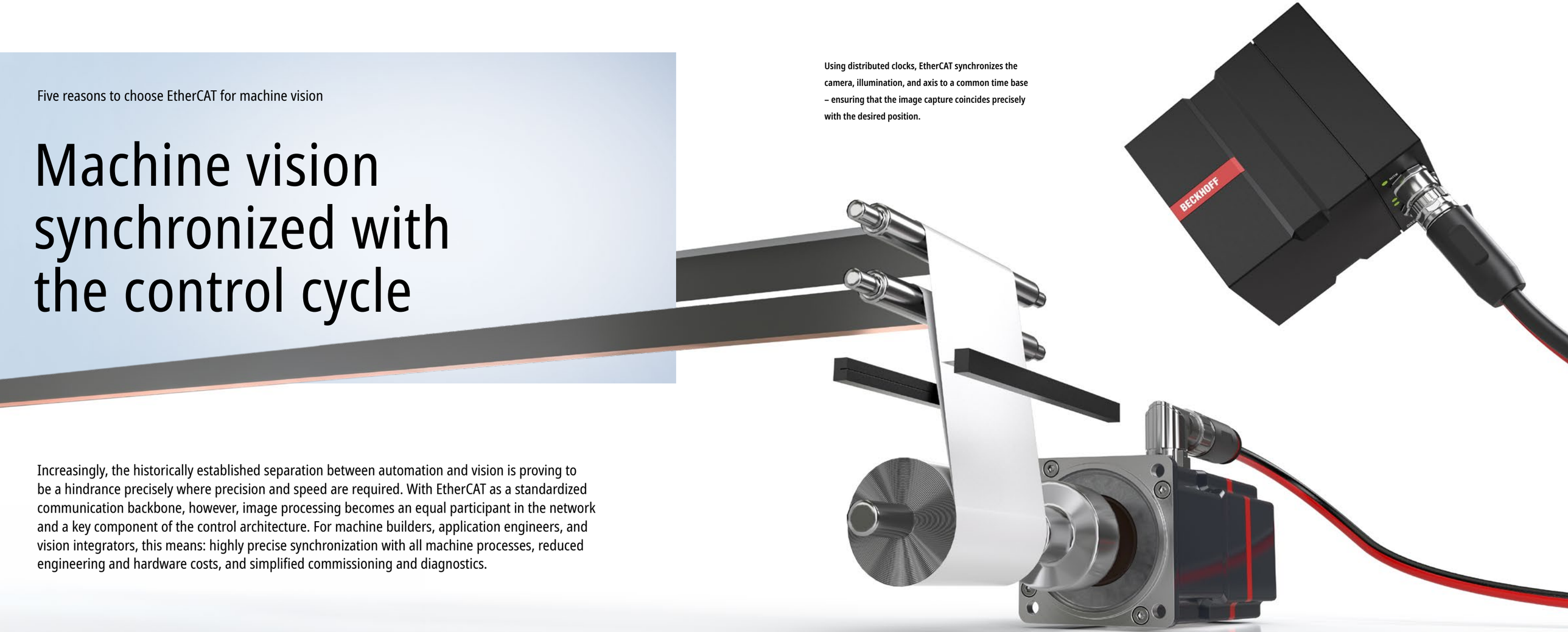
End-to-end rather than piecemeal

The three tools are positioned not as a toolbox but as a toolchain: Design data from the Motion Designer feeds into the TwinCAT configuration; the Drive Manager 2 uses an electronic nameplate to turn this into a fully operational axis; and Autotuning ensures the best possible control performance – and writes the parameters back via the same channel. For machine and system engineering companies, this means reproducible designs backed by robust documentation, shorter commissioning times, and less reliance on specialized knowledge. For operators, the optimized control system pays off in the form of fewer vibrations, greater precision, and a longer service life.

More information:
www.beckhoff.com/motion-software

Five reasons to choose EtherCAT for machine vision

Machine vision synchronized with the control cycle



Using distributed clocks, EtherCAT synchronizes the camera, illumination, and axis to a common time base – ensuring that the image capture coincides precisely with the desired position.

Increasingly, the historically established separation between automation and vision is proving to be a hindrance precisely where precision and speed are required. With EtherCAT as a standardized communication backbone, however, image processing becomes an equal participant in the network and a key component of the control architecture. For machine builders, application engineers, and vision integrators, this means: highly precise synchronization with all machine processes, reduced engineering and hardware costs, and simplified commissioning and diagnostics.

Anyone integrating an inspection task into a design today rarely struggles with the algorithm – they struggle with the interfaces. Separate vision controllers are connected to their own network, exchange status words with the PLC via a gateway, and operate on an uncoupled time base. A flash controller triggers the illumination via a third signal chain, while another engineering tool manages the camera parameters. Each of these limitations costs installation space in the control cabinet, terminal points, commissioning time – and, above all, determinism. Until now, communication between image processing and the control system has been complex and difficult to manage because latencies arising from network stacks and operating system factors cannot be reliably calculated. A twofold problem: The system runs more slowly than necessary, and it requires specialist knowledge in two disciplines at the same time.

“The separation of image processing and control was never a technical necessity, but rather the result of two engineering cultures that developed independently,” emphasizes Bernd Stöber, Senior Product Manager for Vision at Beckhoff. “Anyone who still maintains two separate worlds today pays the price in complexity – the most expensive ‘material’ of all in machine building.”

Reason 1: A standardized time base

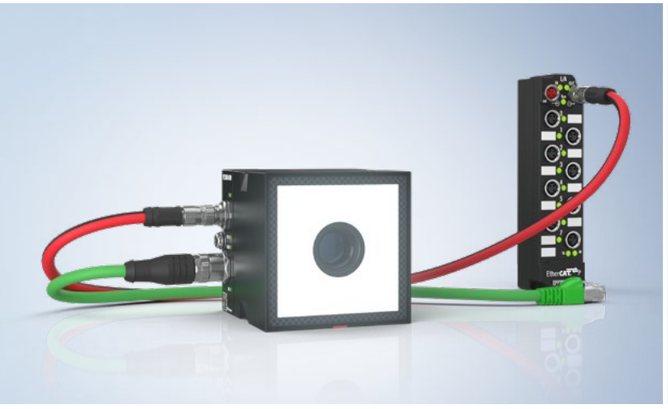
The technical basis for integrating PLCs and vision systems is EtherCAT’s distributed clocks (DC) mechanism. Unlike purely synchronous communication, distributed clocks operate with a high tolerance to jitter. Synchronization is entirely hardware-based: The time of the first DC-capable slave is distributed cyclically to all other participants; the propagation delay in the network is measured and compensated for during start-up – and, if required, continuously during operation. The resulting jitter is well below 1 µs, typically in the double-digit nanosecond range. The absolute system time is stored with 64-bit resolution; time measurement is carried out with a resolution of 1 ns.

This is the key factor in image processing: Cameras and illumination are operated at precisely defined times in relation to all other machine processes – both relative to the devices on the network and absolutely relative to a higher-level reference time. This allows image capture to be triggered deterministically based on a conveyor belt position or an axis position, rather than being initiated via a photoelectric sensor and an undefined software handshake. Track and trace applications and precise product tracking in EtherCAT-synchronized applications thus become standard practice.

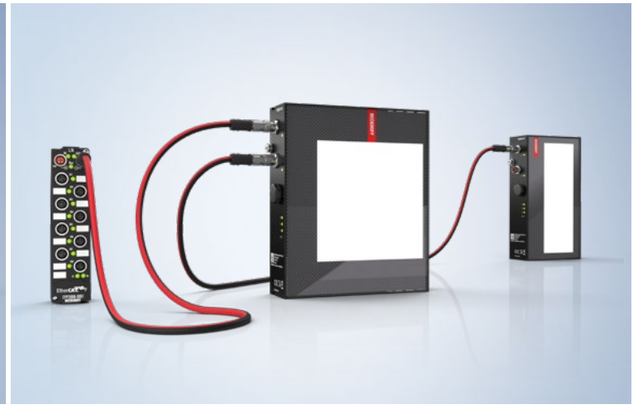
Reason 2: Triggers and lighting in real time

Consequently, the light also originates from the same time base. The EL2596 LED strobe control terminal contains a flexible power supply unit that supplies the illumination with the required current and voltage – ranging from continuous light to short light pulses in the kHz range. Each individual flash is triggered in a controlled manner by the control system via the distributed clocks/timestamp function. The terminal has a trigger output for triggering the camera and fast current and voltage control, so that even line scan cameras, for example, also benefit from constant illumination. Comprehensive real-time diagnostics of the input and output currents and voltages enable detailed monitoring of light intensity. If the load falls outside a specified range, the terminal switches off – a function that can be reset – to protect the LED. The timestamp-based EL2262 output terminal is also available to send a hardware trigger signal with microsecond accuracy to the camera.

Beckhoff’s multicolor LED lighting – in area, ring, and bar lighting designs – produces constant illumination conditions and creates the best possible contrast between the inspection feature and its surroundings in spectrally adjustable pulse mode. As synchronization via distributed clocks does not require an external trigger loop, pulse operation can be implemented without the need for additional hardware or software interfaces. In effect, very high



EtherCAT P combines power supply and synchronization in a single cable, significantly reducing cabling work and costs.



With EtherCAT P, participants such as cameras and their associated illumination systems can be connected in a cascaded configuration to a single power supply unit.

light intensities freeze movement without causing thermal overload in the illumination system. Components no longer need to be decelerated and then accelerated again for testing, which saves space in the system. At the same time, power supply requirements, cooling demands, and energy consumption decrease, while the service life of the LEDs increases and the sensitivity to ambient light is reduced.

Reason 3: Shorter reaction times

The fact that vision results immediately translate into action is, first and foremost, a property of the bus. EtherCAT overcomes the drawbacks of standard Ethernet through its operating principle: As a rule, a single frame is sufficient to update the output data in all participants and to read in the input data using the same frame. Each participant reads the data addressed to it "on the fly" and places its input data into the forwarded frame; the telegram is delayed only by the hardware processing time. There is no store-and-forward latency caused by switches, no protocol stacks at the intermediate layer, and no unpredictable delays, because only the master is allowed to transmit actively.

Image processing therefore does not run alongside the control system, but within it. With no time lost due to interfaces, it is possible to react directly to the results – literally in the very next line of PLC code and with instant communication to the motion components.

Reason 4: Reduced effort and costs

This integration has a positive financial impact on the parts list. There is no longer any need for a separate vision controller, flash controller, or the associated interfaces. All vision hardware components are configured via EtherCAT in an engineering environment. Equally important is the freedom in system layout: EtherCAT allows for a free choice of topology and combines line, star, and tree structures, so that cameras and illumination systems can be positioned where the process requires them, rather than where a switch infrastructure permits.

EtherCAT P takes this concept all the way to the camera: communication and power are transmitted via a standard four-wire Ethernet cable. All the properties of EtherCAT are retained, such as the free topology, on-the-fly processing of telegrams, high-precision synchronization, and extensive diagnostics. Unlike with traditional Power over Ethernet, participants such as cameras and their associated illumination systems can be connected in a cascaded configuration to a single power supply unit. The result is reduced engineering and hardware costs, simplified commissioning, and a significantly smaller system footprint. This is particularly evident in Beckhoff's vision units, which combine a camera, multicolor LED illumination, and focusable optics with liquid-lens technology in a sealed IP65/67 housing. The PLC uses EtherCAT to control all the settings of the functional components at runtime – focus position, light color, intensity, and pulse width, as well as the camera parameters.

Reason 5: Consistent diagnostics

Vision benefits directly from the bus's inherent diagnostic capabilities. In each participant, the EtherCAT Slave Controller checks the passing telegram using a checksum; only telegrams received without errors are made available to the application, while those containing errors increment a counter and are flagged for subsequent participants. By reading these error counters, the master pinpoints the exact location of the error – a significant advantage over traditional fieldbuses, where malfunctions propagate along the shared line and the source remains unknown. Rare sources of interference are detected and pinpointed before they affect machine operation. Even a loose plug can be quickly identified using the Link-Lost-Counter. Additional features include scanning and verification of the network topology during start-up, as well as diagnostic mechanisms across all ISO/OSI layers specified in the fieldbus standard. Because machine data and image data are aligned on the same timeline, and images are saved with reliably traceable timestamps, root cause analysis can then be conducted across axis profiles, I/O signals, and recordings. Unlike a conventional GigE Vision camera, in which fixed user settings are preprogrammed, EtherCAT-controlled hardware always remains open to the parameters specified by the PLC at runtime. This not only makes replacement easier in the case of service, but also eliminates the need to search for faulty parameters in the connected devices.

Conclusion: From an add-on to an integral part of the machine

It is not automation technology that lays the foundations for efficient vision integration, but the underlying communication technology. EtherCAT is standardized as an open standard – including the application layer and device profiles – and is being further developed by the EtherCAT Technology Group as the official standardization partner of the IEC. It is precisely this standardization that makes a camera an equal participant in the automation system: It is assigned the same 64-bit system time as the servo axis and digital terminal, it resides in the same cyclic process image, and it is monitored using the same diagnostic mechanisms. Where there used to be a gateway between the vision controller and the PLC, there is now a frame that is processed as it passes through. EtherCAT typically requires just a single telegram for the entire network, making it more streamlined and faster than other fieldbus or Industrial Ethernet technologies. Vision thus evolves from an add-on to an integral part of the machine, without the designer having to maintain a second system environment.



Bernd Stöber, Senior Product Manager Vision, Beckhoff Automation

> "The separation of image processing and control was never a technical necessity, but rather the result of two engineering cultures that developed independently."

With PC-based control from Beckhoff and EtherCAT, image processing transforms from a complex add-on into an integrated automation module



More information:
www.beckhoff.com/vision



From floppy disk drive to machine brain

Beckhoff Automation is celebrating two technological milestones in 2026: 40 years of PC-based control and 30 years of TwinCAT. In this article, Hans, Frederike, and Johannes Beckhoff speak with Ronald Heinze, editor-in-chief of trade magazine Open Automation, about the economic situation and the next stage of development for the Beckhoff automation architecture – from new computing platforms and AI in engineering to the vision of the M-Brain, an AI-based machine brain.

Things are changing again at Beckhoff – while other things are remaining surprisingly consistent. While the business is once again experiencing significant growth, new computer architectures are emerging, and artificial intelligence is becoming increasingly integrated into engineering and machinery, the company remains committed to a core principle that is now 40 years old: to consolidate as many automation functions as possible onto an open, high-performance, software-based platform. What began in 1986 with PC-based control and was expanded significantly ten years later with TwinCAT is taking on a new dimension in the age of AI. In a conversation with Managing Director Hans Beckhoff, Frederike Beckhoff (Corporate Development), and Johannes Beckhoff (Product Management), one thing becomes clear: While the individual technologies may be changing rapidly, the underlying systems philosophy has changed surprisingly little.

But first, it's worth taking a look at the economic situation – and it looks much more positive than it did a year ago. "We estimate that we will generate approximately €1.5 billion in sales, representing solid growth," says Frederike Beckhoff, in reference to the current financial year. "Compared to 2025, that represents growth of about 20%." Hans Beckhoff is optimistic: "We're even hoping for more than 20%." The outlook is also very positive when it comes to new orders. Frederike Beckhoff therefore considers "solid double-digit growth" to be a realistic prospect for 2027.

The focus is on growth

What is particularly noteworthy is the breadth of this development. At Beckhoff, sales in China are currently up by around 50%, in the U.S. by around 30%, and in Europe (excluding Germany) by 20 to 25%. Germany comes in at about 8%. From an international perspective, the latter seems rather low, but given the state of the domestic machine building industry, it is nonetheless respectable. "We're growing in almost every country; there are positive trends everywhere," says Frederike Beckhoff.

Hans Beckhoff has been observing this turnaround since the fall of 2025. "Someone must have flipped a switch back then," he says. Since then, new orders have risen significantly. There is now considerable evidence, in his view, that the recent downturn was, at least to a large extent, a classic cyclical crisis rather than solely the major structural crisis of European industry, and particularly German industry, that some observers had predicted. However, he does not want to dismiss the structural problems entirely: New competitors are emerging, cost structures are shifting, and certain industries must undergo a fundamental realignment.

Among the company's key growth drivers are the semiconductor industry in Asia and the U.S., as well as the PV industry. Johannes Beckhoff is also seeing a significant upturn among traditional mechanical engineering customers: "Packaging machines in Germany and Italy, as well as machine tools from Switzerland, are once again showing encouraging growth." He considers this breadth to be a particular strength of the company. Beckhoff automation technology is designed not to serve just a single industry, but to address a broad range of markets. "From semiconductors, packaging, and machine tools to power plants and stage automation – we're active in every field," says Frederike Beckhoff.

However, this strong growth is bringing back an issue that the automation industry thought it had left behind: supply bottlenecks and price increases for electronic components. Memory chips, in particular, have become significantly more expensive, and delivery times are also starting to increase again. Johannes Beckhoff believes, however, that the company is well prepared. Based on the lessons learned from the previous supply crisis, the company has established very long planning horizons and continues to maintain close relationships with its suppliers. Beckhoff plans more than two years ahead in certain areas and maintains large inventories. "Strong growth naturally places demands on the supply chain," says Hans Beckhoff. However, thanks to its inventory management strategy, the company is in a good position.

Between AI hardware and cable production

Beckhoff also remains committed to expansion when it comes to investments. A new Austrian headquarters has been built and opened in Vorarlberg. Near its headquarters in Verl, the company has leased additional office space in neighboring Gütersloh, providing room for around 180 employees. Virtually

For 40 years, Beckhoff has relied on PC-based control as the fundamental architecture for its broad range of automation solutions.





Frederike Beckhoff, Corporate Development

> **“We’re growing in almost every country; there are positive trends everywhere.”**

all departments are expanding. The company’s in-house cable production has moved to a 4,000 m² facility. Compared to the progress regarding large language models, high-end CPUs, and neural networks, that sounds remarkably down-to-earth at first. Nevertheless, Hans Beckhoff considers this area to be strategically important: “The demand for high-quality pre-assembled cables is on the rise, particularly for the MX-System, but also in traditional machine architectures.”

The subsidiary Schirmer Maschinen also plays a particularly interesting role. The machine builder is getting a new building with approximately 20,000 m² of manufacturing space and around 4,000 m² of office space. For Hans Beckhoff, Schirmer isn’t just any investment: The company was his first customer in 1980. Today, Schirmer employs around 300 people, generates approximately €80 million in sales, and manufactures high-performance machines for profile machining. For Beckhoff, the machine builder serves as both a testing ground and a valued technology partner. Schirmer was among the first users to implement a complete machine with the MX-System. “New hardware and software concepts can be evaluated there under real-world mechanical engineering conditions,” says Hans Beckhoff.

The company is also making substantial investments in AI, including its own training hardware for neural networks and large language models. At the same time, the development team continues to grow. Johannes Beckhoff does not regard this as a contradiction: “AI is not meant to replace software and hardware developers – it is intended to increase their productivity.”

A seamless system

Around 70% of Beckhoff’s customers opt for extensive or complete systems from the company. Does that mean the company is increasingly shifting from being a component supplier to a solutions provider? Hans Beckhoff interprets the concept somewhat differently. “We regard the solution as a component,” he says, which may initially come as a surprise. What he means is that Beckhoff develops specialized hardware and software products for specific industries, such as interfaces, software blocks, control algorithms, and user interface concepts. All of this remains part of a comprehensive modular hardware and software system that customers can draw upon. “We provide our customers with extensive support so they can develop the actual solution themselves. Because our customers have the process expertise and can use it to implement the best possible control system.”

It is true that Beckhoff Systems Engineering, a unit with a staff of around 400, operates as a system integrator. However, it is organizationally independent. The global automation business takes a different approach: offering the broadest possible range of hardware and software components, providing support for the application, but leaving the actual machine expertise in the hands of the customer.

Johannes Beckhoff therefore prefers to describe the company as a component manufacturer as well as a system provider. The systems approach is particularly crucial in every new product development. No industrial PC, I/O module, or drive is intended to be developed as an isolated entity. “No matter what product we develop, it is of the utmost importance that it does not stand alone, but is perfectly integrated into the Beckhoff system portfolio.” At the same time, according to Johannes Beckhoff, each individual component should be the best of its kind when compared directly to others on the market. A drive system should therefore not be considered attractive simply because it integrates particularly well with TwinCAT; it must also hold its own against any competition on its own merits.

“Our whole offering should still remain open,” Hans Beckhoff emphasizes. “We don’t lock customers in.” Third-party products can still be easily integrated, just as Beckhoff products can be integrated into third-party systems. Beckhoff thus caters to two types of customers: those who want a comprehensive automation system from a single source, and those with a high level of in-house system expertise who deliberately choose only individual components.

In 1986, Industrie 4.0 began with a floppy disk

The first major anniversary of the year – 40 years of PC-based control – shows just how long this systems philosophy has been part of the Beckhoff DNA. The first PC-based machine controller was delivered in 1986. “The machine wasn’t exactly spectacular – just a single-axis double-miter saw,” recalls Hans Beckhoff. “What made it revolutionary was the fact that it had a floppy disk drive.”

Today, this technical equipment evokes little more than a sense of nostalgia. At the time, however, it solved a very real digitalization problem: Data could suddenly be transferred between the office and the machine with relative ease. “That solved the data communication problem between the office and the production floor,” Hans Beckhoff emphasizes. For him, this example still illustrates one of the key advantages of PC-based control: establishing a connection between IT technologies and machine control.

In retrospect, choosing the PC as the underlying technology platform also proved to be an exceptionally future-proof decision. Beckhoff opted for the PC or x86 architecture developed by Intel and C as the programming language – at a time when neither the PC’s eventual dominance nor C’s future significance was yet apparent. The VME bus, Motorola® architectures, and other computing environments and programming languages – such as Pascal and Turbo Pascal – were considered serious alternatives at the time and were in some cases even



At Beckhoff, every new development is based on a systems approach – all products are seamlessly integrated into the overall portfolio.

more widespread. “We chose the technology that proved to be the right choice for the market,” says Hans Beckhoff with conviction. “It is particularly important that our customers have been able to follow the underlying architecture for decades without having to start from scratch time and time again.”

What began as a revolution turned into a process with remarkable continuity. And after four decades, Hans Beckhoff allows himself a measure of satisfaction that much of the automation world now follows the same basic principle. That is, he says, “a source of pride and honor.”

It should really be called “software-based control”

For Hans Beckhoff, the term “PC-based control” no longer does justice to the concept: “What ‘PC-based’ really means is ‘software-based’ control technology.” The principle behind it is simple: functions that used to be embedded in specialized hardware or intelligent peripheral devices are increasingly being shifted into software running on a powerful central CPU.

Motion control is a classic example. In the past, some drive manufacturers tried to integrate as much intelligence as possible directly into the drive. In modern architectures, however, a central computer can better coordinate complex motion sequences and handle many specialized functions through software. It is precisely the rise of artificial intelligence that is making this approach particularly relevant right now: The more machine functions are software-defined and centrally accessible, the easier it will be in the future for AI to generate, modify, and orchestrate them. “The centralized approach to control technology therefore provides an excellent foundation for AI concepts as well,” explains Hans Beckhoff.

Johannes Beckhoff therefore sees the decision his father made 40 years ago as a significant advantage. Making TwinCAT AI-ready will naturally require effort, but it’s by no means a Herculean task, he explains. The basic architecture is already in place. This gives the second anniversary of the year – 30 years of TwinCAT – a remarkable outlook for the future. “The fact that TwinCAT is no longer tied to Windows fits this overall picture: The runtime now also runs on Linux® and can be operated in container-based environments, all the way through to a virtual PLC,” Johannes Beckhoff points out.

TwinCAT evolves into M-Brain

Beckhoff is currently taking a multi-stage approach to the use of AI. The first is already highly tangible: AI as an engineering tool. TwinCAT CoAgent and associated interfaces help developers generate, analyze, and configure automation software. At the same time, Beckhoff is working to make TwinCAT itself even more AI-friendly. In the future, development data and structures must not only be understandable to humans, but also be interpretable as effectively as possible by software agents. The motto is: “Agentic First!”

The next stage goes much further: Artificial intelligence is making its way into the machine. Hans Beckhoff uses the term “M-Brain” to describe this: “We are no longer supplying customers with a PLC – to use the old term – but rather a ‘machine brain.’”

TwinCAT provides users with a software platform that combines all automation functions – from PLCs, motion control, and HMIs to measurement technology, image processing, robotics, and AI.



This M-Brain combines classic TwinCAT functions – such as PLC, motion, CNC, measurement technology, control, and vision – with a local large language model. Through standardized interfaces such as the Model Context Protocol (MCP), this model gains access to machine functions. The key word here is “local”: The LLM is part of the machine. It understands its context, can evaluate information and, in the future, will not only be able to process language but also see and respond to its environment. For Hans Beckhoff, this is a very concrete manifestation of physical AI.

Of course, a machine brain like this requires significantly more computing power than a traditional PLC. High-performance GPUs are thus becoming a key resource in machine building as well. For a high-quality production machine, the additional cost of such a computing platform can quickly be justified if, in return, the machine becomes more productive, more flexible, or easier to operate.

And Beckhoff is already thinking about the third stage. At some point, users may no longer write traditional control programs at all, but instead primarily describe tasks and rules. AI will generate the required application from those instructions, while a deterministic runtime will continue to ensure that creative artificial intelligence does not result in creative machine movements. Machines can do many things, but hallucinating should not be one of them.

Anyone who creates programs must also be able to test them

This automatically increases the importance of simulation. An AI system that generates or modifies an automation program must be able to verify that its output works as intended. Johannes Beckhoff distinguishes between several levels of validation: “The first step is to check whether a project is formally and syntactically correct. More interesting is the question of whether the machine actually does what it is supposed to do with the generated program, and, in particular, whether any collisions occur.”

To this end, the AI needs a simulation path that is as complete as possible. Beckhoff is therefore working to integrate logical and physical simulation more closely with the world of automation. As a result, simulation is evolving beyond a tool for virtual commissioning and digital twins and, in the future, could become a critical validation mechanism for AI-generated automation.

Over the next ten years, this could significantly change the appearance of machines. Hans Beckhoff anticipates more complex robot kinematics and a greater convergence between traditional machine building and robotics. His vision becomes particularly tangible when discussing cameras. Today, machine vision systems typically perform precisely defined tasks: checking positions, identifying colors, or measuring distances. In the future, a camera might simply be able to see. A multimodal model would interpret the situation and derive appropriate actions from it.

Then the physical machine becomes integrated with local AI, vision, simulation, motion, and robotics. Suddenly, the journey from the floppy disk drive to the machine brain amounts to little more than 40 years.

Hardware is also becoming more diverse

For this vision to work, suitable computing platforms are needed. Here, too, the PC world is becoming more diverse. Beckhoff continues to rely on



Johannes Beckhoff, Product Management

> “AI is not meant to replace software and hardware developers – it is intended to increase their productivity.”

high-performance x86 processors, but is increasingly expanding its portfolio to include Arm®. "Modern Arm® CPUs are now so powerful that they are finding their way into applications that were long reserved for x86 systems," explains Johannes Beckhoff. The TwinCAT Runtime for Linux® plays an important role here because Linux® runs very well on Arm® platforms.

At the upper end of the market, meanwhile, GPU performance is becoming increasingly important. If local LLMs, machine vision, and other AI technologies are to run directly on the machine, the graphics card will evolve from a visualization component into a genuine automation accelerator. It is precisely this spectrum – ranging from energy-efficient Arm® systems to high-end industrial PCs equipped with GPUs – that is likely to shape the industrial PC market in the years ahead.

MX-System: The terminal evolves beyond its original purpose

Development is also continuing on the MX-System. "The modular system is being expanded continuously. One module after another is being completed," says Hans Beckhoff, describing the work. This is essential: If control cabinet-free automation is to become a genuine alternative, it must cover as many of the functions familiar to machine builders from the traditional control cabinet world as possible.

At the same time, the MX-System is becoming increasingly integrated with the other Beckhoff systems. Drives, decentralized components, and existing IP67 solutions are being incorporated more closely. For Hans Beckhoff, the MX-System is ultimately the logical continuation of the modularization concept that the company originally pursued with the bus terminal system, only now combined with power electronics and functions that traditionally resided in the control cabinet.

Hans Beckhoff, Managing Director and owner

"What 'PC-based' really means is 'software-based' control technology."







In addition to high-performance x86 processors, Beckhoff is increasingly expanding its portfolio to include Arm® CPUs – for example, in the devices of the Next multi-touch panel generation.

The electrical architecture is also interesting. Large parts of the MX-System already operate internally with DC voltage. This could make it an attractive option for applications in which DC distribution systems are becoming increasingly important. The growing discussion around DC grids in industry and infrastructure therefore opens up additional opportunities.

Software makes XPlanar more accurate – and more economical

XPlanar demonstrates just how valuable software has become, even beyond traditional control functions. Beckhoff continues to simplify its use, for example through auto-tuning and more convenient graphical configuration. At the same time, the company is improving the properties of existing hardware through new algorithms.

Johannes Beckhoff cites impressive figures: A software update alone improved the accuracy of the existing hardware by around 25%. At the same time, power consumption was reduced by up to 20%, depending on the application. No new mechanics, no new motor, no new tiles – just software.

Similarly, XTS is also undergoing continuous development. New software features are being added, while Beckhoff continues to work on optimizing costs and performance. According to the company, the Eco module, which has already been introduced, has been well received. Meanwhile, preparations are underway for the series production launch of the ATRO modular industrial robot system. This system, too, fits neatly into the company's strategic vision, particularly if complex robotic kinematics become an increasingly standard feature of conventional machine concepts in the future.

Security without a hasty architectural overhaul

Alongside AI and new hardware, regulatory requirements remain a key consideration. With regard to the new Machinery Regulation, Johannes Beckhoff believes the existing safety portfolio is well prepared. In coordination with TÜV, the relevant products can continue to be used under the new regulatory framework.

With regard to the EU Cyber Resilience Act (CRA), Beckhoff is continuing to analyze and strengthen its product portfolio. In doing so, the company benefits from two properties of its architecture: A large proportion of its devices communicate via EtherCAT and can build on the security mechanisms provided by that technology. In the case of industrial PCs, many of the security measures familiar from the world of IT can be adopted directly. After all, a Beckhoff Industrial PC is still a PC. Johannes Beckhoff sums up the situation calmly: "We're not panicking because there is no need to fundamentally redesign our entire product portfolio."

Perhaps that sentence sums up the strategy rather well: no revolution for revolution's sake, no hasty replacement of the existing architecture. Instead, established concepts are further developed, more tightly integrated, and enhanced with new technologies.

Ironically, the very idea that Beckhoff embraced ahead of its time 40 years ago now seems remarkably modern: standardizing computing power, shifting functions into software, and bringing IT and automation together as closely as possible. In 1986, that meant giving a machine a floppy disk drive. In 2026, it means giving a machine a brain.

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More information:
www.beckhoff.com



The dawn of a new era: With the first PC-based machine control systems, the control functionality was decoupled from inflexible dedicated hardware.

The range of products, services, and applications offered by PC-based control

How an idea became a global standard

The particular strength of PC-based control does not lie in individual products or functions. It lies in the ability to implement a wide variety of automation tasks on a common, open, and scalable platform. Over the course of more than 40 years, the idea of using an industrial PC for machine control has evolved into a comprehensive automation system: with a broad product range, a wide spectrum of performance capabilities, and a wide variety of applications.

The story of this development began in 1986. At a time when industrial automation was dominated by traditional, hardware-based PLCs and rigid device architectures, Beckhoff delivered the first PC-based machine control system. This marked the beginning of a decisive shift in perspective. The control function was decoupled from dedicated hardware devices, and the power of IT was harnessed for use in machine and system engineering. Since then, PC-based control has evolved into an open, end-to-end platform that integrates a wide variety of automation functions. The particular strength of this approach is evident on three levels:

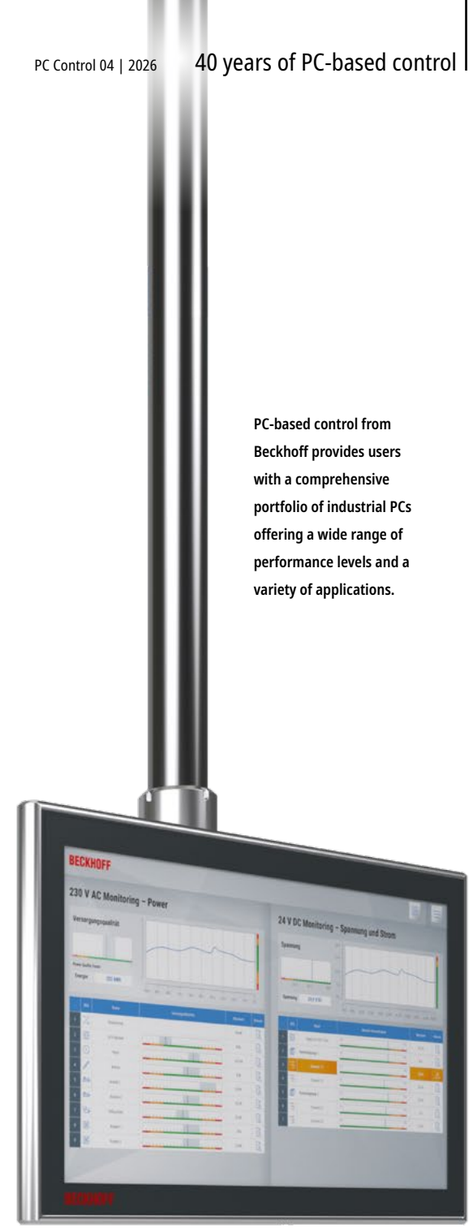
- in the product range, comprising a comprehensive, coordinated portfolio;
- in the performance range, extending from compact controllers to high-performance multi-core control systems;
- and in the range of applications, spanning from individual machines to complex, connected production and infrastructure systems across a wide variety of industries.

PC-based control is therefore not a single control technology, but a scalable foundation for automation tasks on virtually any scale.

The product range from industrial PCs to automation systems

The breadth of the product range offered by PC-based control is evident in the variety of system and automation components available. The product range covers the main areas of industrial PCs, I/O and fieldbus components, drive technology and automation software, supplemented by control cabinet-free automation and hardware for machine vision. Coordinated product ranges are available for all areas, which can be used as individual components or combined to form a complete control system.

What began in 1986 with relatively large computers has developed into a versatile range of industrial PCs designed to meet the demands of industrial environments. Over time, the range of traditional control cabinet PCs has been



PC-based control from Beckhoff provides users with a comprehensive portfolio of industrial PCs offering a wide range of performance levels and a variety of applications.



expanded to include multi-touch control panels and panel PCs, which enable modern and intuitive operation even in industrial applications. An important step forward was the integration of PC technology with the form factor of a hardware PLC. With the fanless CX series embedded PCs, which can be mounted directly on a DIN rail, PC-based control has become a very attractive option even for compact applications. The ultra-compact IPCs of the C60xx series also require very little space and can handle automation and edge computing tasks in a minimal footprint.

However, the hardware only reaches its full potential when used in conjunction with suitable software. TwinCAT automation software transforms the industrial PC into a real-time control system that combines engineering and runtime in a single, integrated platform. The integration of TwinCAT into Microsoft Visual Studio® has not only strengthened IT/OT convergence but also made it easier to incorporate IT methods and high-level languages into automation. Today, TwinCAT offers well over 100 Functions, making it an ideal foundation for solutions of all sizes and levels of complexity. Users can use these to put together exactly the automation solution their application requires – from a single machine module right through to a connected production line.

A high-performance communication system is required to ensure that control data can be transmitted quickly and in real time right down to the field level. As early as 1995, Beckhoff made a significant contribution to simplifying sensor and actuator integration with its electronic terminal block, the bus terminal. In 2003, the company introduced EtherCAT, an Ethernet-based real-time system that fully harnesses the capabilities of modern industrial PCs. Precise synchronization using distributed clocks and short cycle times in the microsecond range now form an important basis for high-performance automation tasks.

With TwinCAT and EtherCAT, individual components come together to form much more than just a broad product range. The result is a consistent, integrated automation architecture. The PC-based control product range makes it possible to design tailor-made solutions, minimize the number of interfaces, and further develop machine concepts throughout their entire lifecycle.

The performance range: scalability as a principle

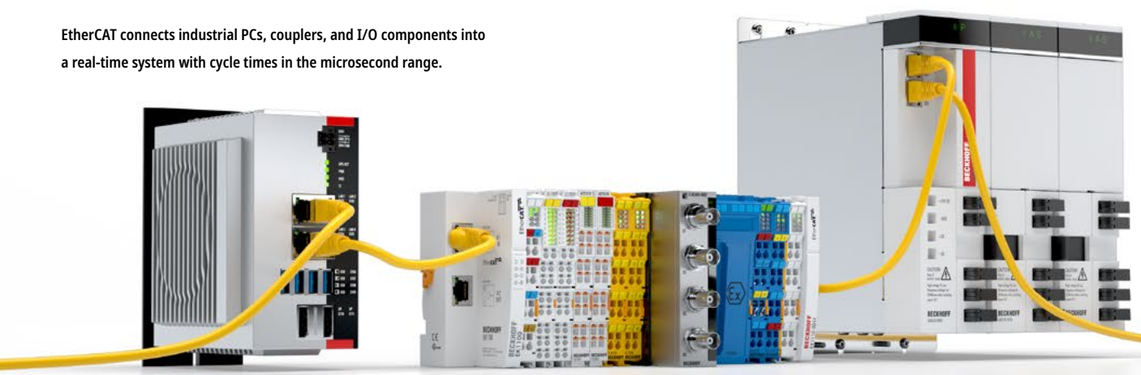
The range of services is also exceptionally wide. PC-based control scales from small control tasks right through to high-performance, data-driven applications – offering both economic efficiency and future-proofing. A key competitive advantage of PC-based control technology lies in its direct connection to the rapid innovation cycles of the IT industry. While proprietary control systems are often tied to longer hardware lifecycles, Beckhoff capitalizes on the continuous development work of tech companies such as Intel, AMD, and Arm.

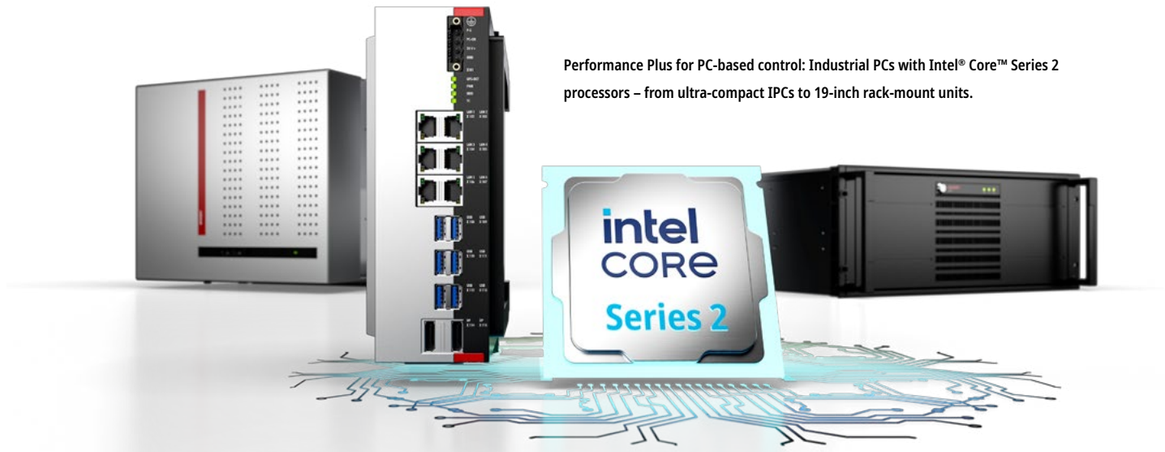
The fundamental premise of Moore's Law – the continuous increase in available computing power – has thus been adapted for use in machine building over the decades. The use of the latest standard IT processors means that automation benefits from ever-increasing performance. This results in consistent scalability across the market. Users do not have to choose between completely different system environments as a machine's requirements grow. TwinCAT runs just as well on a compact embedded PC as it does on a multi-core industrial PC with over 60 cores. This "right-sizing" makes it possible to provide exactly the computing power that an application requires.

As a result of this performance capability, traditional hardware silos within the control cabinet are eliminated. Whereas separate modules were previously required for PLCs, axis control, safety systems, or image processing, PC-based control allows all functions to work together within the same control architecture. Multi-core technology in TwinCAT allows tasks to be distributed specifically across available processor cores. Instead of having to communicate with each other via external interfaces, the functions can exchange data directly within the same control platform. This also provides significant protection for your investment. Hardware becomes outdated, but software remains. As performance requirements increase, it is sufficient to replace the control hardware with another industrial PC. The existing application software, on the other hand, can continue to be used. This ensures that the machine logic developed over the years, the engineering expertise, and the proven software blocks are retained.

The range of applications is particularly evident in the field of motion control. TwinCAT covers everything from applications with just a few axes right through to the control of more than 1,000 axes. With TwinCAT MC3, motion tasks can be distributed across multiple CPU cores, allowing a single industrial PC to synchronously control even machines with a large number of axes. The drive hardware ranges from the cost-effective servo drives and variable frequency drives of the economy drive system (AX1000/AF1000) to the high-end servo drives of the AX8000 series.

EtherCAT connects industrial PCs, couplers, and I/O components into a real-time system with cycle times in the microsecond range.





Performance Plus for PC-based control: Industrial PCs with Intel® Core™ Series 2 processors – from ultra-compact IPCs to 19-inch rack-mount units.

The range of applications, one platform for all sectors

Added to this is a wide range of applications across various industries and fields of use. As a versatile, cross-industry control approach, PC-based control forms the foundation for automation solutions in a wide variety of machine designs and industrial environments, ranging from CNC-controlled machine tools to intelligent building control systems.

The spectrum ranges from machine building, packaging, and plastics technology to intralogistics, the process industry, and semiconductor manufacturing, as well as wind power, the building industry, and the entertainment industry. This breadth is made possible by integrating control, motion control, safety, measurement technology, condition monitoring, robotics, and image processing onto a single platform. Mechatronic systems such as XTS and XPlanar are available for adaptive production and transportation tasks. Openness to fieldbuses, protocols, and IT standards also makes it easier to integrate heterogeneous systems and third-party components.

When Beckhoff shipped its first PC-based machine control system in 1986, the focus was on traditional machine building. Today, it is clear that the underlying philosophy can be applied across various industries. Whether a system is packaging, milling, generating power, or operating stage and set equipment, the core technology is based on the same fundamental principles: a scalable PC platform, real-time-capable software, and end-to-end communication all the way down to the field level.

For Beckhoff, traditional machine and system engineering continues to play a central role. Communication performance and precise synchronization via EtherCAT lay the groundwork for dynamic, precise, and tightly synchronized machine processes. The available computing power also makes it possible to integrate robot kinematics and other motion tasks directly into the machine control system.

Beyond discrete manufacturing, PC-based control also opens up new possibilities in energy, process, and building automation. In power generation and distribution, PC-based control systems provide a connection between precise control functions and the collection, analysis, and transmission of operational data. In the process industry, the right I/O components are available to meet requirements even in hazardous areas. In building automation, the platform integrates various systems, communication standards, as well as functions for control, visualization, and energy monitoring into a single architecture.

This versatility is particularly evident in the entertainment industry. When stage platforms, amusement rides, or kinetic installations need to be moved with precision, dynamism, and safety, PC-based control technologiy combines high computing power, integrated safety technology, and industry-specific communication protocols.

The range of applications is therefore not based on separate industry-specific solutions. It is based on an open and scalable platform that can be adapted to the requirements of each specific application.

Ready for the next 40 years

Looking back over 40 years of PC-based control reveals one clear constant. The decision taken in 1986 was not a short-term trend, but the starting point for a future-proof architecture that can be continuously developed. The combination of industrial-grade hardware, open software architecture, and IT standards lays the foundation for future requirements. These include the greater integration of artificial intelligence into machine control systems, data-driven functions, connectivity with edge and cloud infrastructures, and new mechatronic concepts. PC-based control, therefore, does not offer a one-size-fits-all solution, but rather an open and scalable foundation for automation in the coming decades.

More information:
www.beckhoff.com/pc-based-control

A look back at the C2000 from Beckhoff

The first compact industrial PC with a display

The year is 1990. “Total Recall” is playing in theaters, Nintendo and Sega game consoles dominate kids’ wish lists, and the first personal computers are appearing in living rooms. And in factories? Technological progress is making ever greater inroads there too, as demonstrated by the C2000, which was launched this year. It set an important milestone as the predecessor of the range of industrial and panel PCs available from Beckhoff today.

Back then, real-time machine control was a closed world: a handful of manufacturers, proprietary systems, dedicated processors, and dedicated programming environments. Anyone who needed more control performance simply inserted additional PLC modules into the module rack. Logic control, motion control, and the user interface usually required separate devices – three systems, three engineering domains, and limited scalability.

Traditional PLC CPUs processed binary logic in a flash. However, they reached their limits when it came to interpolated movements or complex calculations. Simple displays, often just two lines wide, were built into the control cabinet door or the control panel for operation and monitoring. The visualization was carried out line by line. Every diagnosis turned into a time-consuming search. The systems were closed and only evolved at the pace the manufacturers deemed appropriate.

Beckhoff teaches the PC how to control systems

Beckhoff delivered the first PC-based machine control system as early 1986. The idea behind it was simple: to decouple hardware and software. The PC provided the computing power, while the software enabled real-time control. Computer peripherals and interfaces could be utilized effectively. Beckhoff developed a real-time kernel for PC operating systems – initially for DOS, and later for Windows. The S1000 software for PLC/NC followed in 1988. This marked the first time that PLC, motion control, and visualization functions had been combined on a single hardware platform, paving the way for the wide range of integrable functions available today.

The x86 processors from the PC world offered significantly more computing power than PLC CPUs. The key advantage, however, lay in the pace of further development. With every generational change in mainstream applications, Beckhoff was able to integrate newer chips, and thereby increase control performance. The evolution of standard IT and Moore’s Law thus also became the driving force behind automation.

Furthermore, a processor’s instruction set acts as an interface between the CPU and the software. The high level of backwards compatibility of the x86 architecture paved the way for PC-based control systems to evolve from 16-bit to 32-bit and on to 64-bit – and thus to more addressable main memory, more modern operating systems, and new software applications. Existing code and knowledge remained usable. For users, this means long-term protection of their investment.

The first compact industrial PC with a screen

“In 1986, we built the first PC with an integrated color screen in a 19-inch housing,” recalls Hans Beckhoff, managing director and owner. “The commercial designs at the time were not particularly well suited to industrial use, however, which is why we started to develop our first in-house motherboard in 1989. With this, we then launched the first compact Industrial PC with LCD screen in 1990 with the C2000.”

The C2000 PC-based control system featured a 10-inch LC display as its graphical user interface. The display was available either as a passive-matrix LCD – including in color – or as a TFT display; it represented the cutting edge of technology at the time and offered the same level of clarity as was customary in consumer electronics. The membrane keyboard with 3D-effect keys was modern, suitable for industrial use, and easy to clean. It included function keys, a numeric keypad, cursor keys, control keys, and special keys, most of which were assigned PLC functions. This made it easy to navigate through the user interfaces and enter values. The user interface and the peripherals adopted from the PC brought about significant gains in productivity, for example through the use of a hard disk – which was very large for its time – as mass storage, and the loading of machine data or programs from floppy disks. Like a consumer PC, the C2000 featured an optional floppy disk drive and a port for a standard external keyboard.

With its slim design, the C2000 was suitable for integration into the control cabinet front. In this sense, it can be described as the first panel PC from Beckhoff. The design stood out clearly from the purely functional PLC devices of the time and was very attractive for its era.

Years later – the same concept, a new dimension

Across all subsequent models, the slim design with a lower depth and integrated display technology continued to evolve. And so the product family grew steadily: Control panels were introduced in 1998, with multi-touch control panels and panel PCs following from 2012 onward. Today, the CP22xx multi-touch Panel PC, for example, is a contemporary device for installation in a control cabinet front. A comparison with the C2000 clearly illustrates how industrial PCs have evolved in terms of performance.

Scalable range of industrial and panel PCs

The C2000 has evolved into a comprehensive portfolio: Panel PCs for control cabinet integration and mounting arm installation, plus explosion-proof versions suitable for zone 2/22 and control panels as remote operating units – with screen sizes ranging from 5.7 to 24 inches, in aluminum or stainless steel. In addition, there is an equally diverse range of industrial PCs, from embedded PCs, compact and ultra-compact industrial PCs right through to industrial servers. A wide range of processors covers every performance class. Last but not least, the company’s in-house produced motherboards, a proprietary BIOS, and the TwinCAT automation platform carry on the strengths that already set the C2000 apart.

More information:
www.beckhoff.com/ipc



The C2000 is regarded as the first compact industrial PC with a screen from Beckhoff.

	C2000 (1990)	CP22xx-0040 (today)
Device type	Built-in Panel PC	Multi-touch built-in Panel PC
Processor	Intel® 386SX, 16 MHz	Intel® Celeron® 6600HE, 2.6 GHz, 2 cores – up to Intel® Core™ i7-11850HE, 2.6 GHz, 8 cores
Storage	640 Kbyte of RAM	4 to 64 GB DDR4-RAM
Display	10-inch, 640 x 480, passive LC or TFT display	12 to 24 inches, up to 1920 x 1080, multi-finger touch screen
Operation	membrane keyboard, cursor keys	multi-touch, gestures
Mass storage	floppy disk, up to 16 MB hard disk	2½-inch hard disk, 1 TB; optional SSD, CFast; onboard RAID-1
Operating system	MS-DOS with Beckhoff real-time extension	Windows 10/11 IoT Enterprise, Windows Server 2022, TwinCAT/BSD
Real-time control	S1000	TwinCAT 3
Communication	Lightbus, 2.5 Mbaud	EtherCAT, 100 Mbit/s
Operating temperature	5…45°C	0…55°C
Protection rating	front side IP65, rear side IP20	front side IP65, rear side IP20



The CP22xx multi-touch Panel PC is a typical example from today’s industrial PC range.

40 years of PC-based control: A paradigm shift that made history

Faces of innovation

PC-based control is celebrating a milestone anniversary. What began as a technological paradigm shift has developed into a genuine success story over the past 40 years. But this story is not only about innovative technology and the courage to do things differently. It is also about remarkable people who have been passionate about automation for years – and in some cases decades. As pioneers, they share their insights in PC Control and explain how the success story of PC-based control is reflected in their own areas of work.



Johannes Beckhoff, Product Management

Ideal foundation for physical AI
PC-based control is based primarily on three properties. First, the approach employs a centralized control architecture: An industrial PC controls the entire machine and all of its functions and consolidates relevant data. Second, PC-based control is entirely software-based. Our TwinCAT automation software runs on the industrial PC; it is where the intelligence behind the machine functions resides – not in specific hardware. Therefore, new features can be integrated in software form and developed alongside the existing automation system. Third, PC-based control provides a connection between IT and OT at both the hardware and software levels. Modern CPUs and GPUs provide the necessary performance reserves. At the same time, novel software technologies can be employed directly for use in control engineering. All data from logic control, motion control, I/O, vision, and other machine components is readily available for this purpose within a common architecture.

It is precisely these properties that have made PC-based control a cornerstone of innovation in automation for 40 years. New processor architectures, software methods, and emerging technology trends from the IT sector can be quickly integrated into the machine context. At the same time, this approach provides the performance reserves and the end-to-end data infrastructure required to meet new demands from the machine building and manufacturing industries – such as for the levitating movers of the XPlanar, advanced machine vision applications, or highly integrated robotic solutions.

This end-to-end database is also a crucial prerequisite for industrial AI and physical AI. AI models require computing power, access to machine and process data, and close integration with real-world operations. PC-based control combines these requirements: The AI can run directly on the industrial PC and access the data available there. Information from drives, cameras, measurement technology, or robots does not need to be consolidated from separate subsystems via additional interfaces. This is how AI becomes an integral part of automation and can not only analyze data but also have an impact on actual movements and processes within the machine. That is precisely where the potential of physical AI lies.

> “PC-based control provides the foundation for quickly translating new technologies into actual machine functions. That was true 40 years ago for the first PC-based controls, and it’s true today for AI and physical AI.”



Gerd Hoppe, Corporate Management

No longer a unique path
When I joined Beckhoff in 1994 as one of three sales colleagues, I was looking for something exciting in the region – and found a company that had just decided not to remain focused on control cabinet design, but to grow into an automation manufacturer using its own technology.

At first, PC-based control was an adventure every day. The S1000 soft PLC ran on MS-DOS, was ten times faster and significantly more deterministic than the market leader’s PLCs – yet it soon reached the memory limits of DOS. The move to Windows NT, which was spurred by a customer who, of all things, wanted to use it to control a blast furnace, was the leap that changed everything. Real time processing on Windows was considered black magic: An oscilloscope for measuring tick and jitter was standard equipment in the sales department and a central element of every demonstration. Seasoned development managers tried every trick in the book to throw our control system off course – mostly to no avail.

As a result, the industry has come to recognize that PC-based control is very well suited for challenging tasks. In this segment, we often had an easier time of it because, back then, hardly any competitor could match our price levels. PC-based control has long since ceased to be a niche solution and is no longer limited to the high-end market. Not only have our customers recognized our approach as effective, but so have our competitors. Nearly every player in the market now offers fast industrial PCs and a versatile software platform. That is why it is so important to be more than just a supplier to our customers – to be their true partner.

We remain committed to the strengths that have distinguished Beckhoff since its very beginnings: direct, close contact with our customers and a commitment to solving their problems quickly and easily. This continues to shape my area of responsibility to this day. Even when technology has such extraordinary potential as PC-based control, it often has its limits. From there on, our outstanding team at Beckhoff makes all the difference.

> “Seasoned development managers tried every trick in the book to throw our control system off course – mostly to no avail.”

Andres Oetken, Sales, Process Industry

The ideal platform for the process industry
The process industry places very high demands on automation: long plant lifecycles, high availability, precise and stable control, and the ability to reliably collect, analyze, and transmit large amounts of data.

PC-based control offers an ideal platform for this. Support for standard protocols and interfaces enables seamless integration into existing control systems and IT infrastructures. High-performance hardware and real-time-capable software ensure precise control and fast response times. Its scalability allows for use in applications ranging from compact process modules to large-scale connected plants.

The combination of industrial ruggedness, long-term availability, and easy expandability makes PC-based control particularly well-suited to the requirements of this industry. For users, this represents investment security, high operational efficiency, rapid adaptability, and the ability to easily integrate innovations such as data-driven optimization or AI-supported process analysis.



> “For users, PC-based control represents investment security, high operational efficiency, rapid adaptability, and the ability to easily integrate innovations.”



Dr. Ursula Frank, Project Manager, R&D Cooperations

PC-based control gets researchers' hearts racing

PC-based control is in high demand in education, training, and research, giving universities, educational institutions, and research organizations the opportunity to explore innovative, complex, and real-time-critical approaches in theory, and also to implement them in practice. Using a standard PC and TwinCAT, automation skills can be taught in a practical way – from traditional sequence control to motion control, image processing, data analysis, and AI. Students develop their own applications in a very short time and implement precise real-time requirements in projects.

Decoupling automation functions from proprietary hardware enables students and researchers to use the comprehensive PLC, NC, CNC, motion, and measurement and analysis functions in TwinCAT flexibly and as needed. Thanks to the openness of PC-based control, programming can be carried out both in IEC 61131-3-compliant PLC languages as well as in C and C++. MATLAB® and Simulink® can be integrated via an interface, allowing the control system to be optimized in parallel. High-performance industrial PCs equipped with the latest processors are used to ensure highly deterministic real-time execution of the resulting software. In addition to the established Windows operating system, Linux® now also provides a foundation for containerized software architectures. Combined with the openness and scalability of PC-based control, these possibilities are bound to inspire researchers.

> "PC-based control offers the opportunity to explore innovative, complex, and real-time-critical approaches in theory, and also to implement them in practice."

Uwe Prüßmeier, Senior Product Manager Drive Technology, XTS, XPlanar

High dynamics? No problem!

Mechatronic systems such as XTS and XPlanar combine mechanics, hardware, and software to create something entirely new. In this context, "new" means more functionality and greater customer value than ever before.

However, complex relationships and nonlinear physical laws can only be made usable for the user through comprehensive software. In practice, this means a high demand for computing power, which can only be met by PC hardware at reasonable prices. The XTS and XPlanar systems, with their time-constant cyclic processing in just 250 µs, present another challenge that only an industrial PC can handle.

Twenty years ago, systems such as XPlanar would likely not have been economically viable. It wasn't until about ten years ago that the performance threshold was exceeded. Today, PC-based control allows a large number of movers and more advanced motion-control applications within a single machine to be controlled using just one industrial PC.

Executing various time-critical processes within a single industrial PC simplifies the integration of different motion control applications for the programmer, since no data needs to be transferred via interfaces. As a result, coordination between a robot and an XTS poses no problem for PC-based control, even under highly dynamic conditions.



> "The high demand for computing power of XTS and XPlanar can only be met by PC hardware at reasonable prices."

Tilman Plaß, Automotive Industry Manager



Operating complex machines efficiently

The automotive industry has always been one of the most demanding sectors in automation technology. High production volumes, maximum equipment availability, short cycle times, and consistently high quality place special demands on the control platform. The shift to e-mobility brings additional challenges. The manufacture of battery cells, battery systems, and electric motors requires highly dynamic, precise, and tightly synchronized production processes involving a large number of axes and complex motion sequences.

This is precisely where PC-based control technologically really shines. By integrating PLCs, motion control, robotics, measurement technology, and IT functionality onto a high-performance central platform, complex machines and production lines can be operated efficiently. The high computing power of modern industrial PCs enables short cycle times, precise synchronization of multiple axes, and the execution of complex control and automation tasks in real time. This boosts productivity, quality, and the output.

What's more, automotive manufacturers and system engineering companies benefit from the openness and scalability of PC-based architecture. The same technology platform can be used for everything; from individual production cells to large-scale body or battery manufacturing facilities. New functions, process optimizations, or software updates can be quickly implemented and rolled out. As a result, PC-based control offers the flexibility and future-safety that are crucial for the transformation of the automotive industry and the successful ramp-up of emerging e-mobility production lines

> "PC-based control offers the flexibility and future-proofing that are crucial to the transformation of the automotive industry."

Daniel Rostan, Packaging Industry Manager

Extreme speed, maximum flexibility

Every day, we see the balancing act that machine builders in the packaging industry must navigate: Their end customers demand extreme speed and precision, coupled with the greatest possible flexibility – even down to a lot size of one. The machines must be able to adapt to new formats or delicate, sustainable materials without lengthy mechanical modifications, while taking up as little space as possible on the shop floor.

Our PC-based control concept provides the ideal foundation to implement this. By integrating PLC, motion control, robotics, and image processing into a single, centralized automation platform, we eliminate complex interfaces and simplify the engineering process for machine builders. Using TwinCAT and the ultra-fast EtherCAT communication standard, all processes on the packaging line run in perfect synchronization, which increases output and ensures product quality.

In addition, the high-performance control system provides the perfect foundation for our intelligent transport systems, XTS and XPlanar. Thanks to individual mover control, complex format changes can be accomplished with a single click in the software. Open IT standards and the direct integration of AI ensure maximum future-proofing; our customers can continue to build the most innovative machines.



> "Open IT standards and the direct integration of AI ensure maximum future-proofing."

Daniel Siegenbrink, Product Manager MX-System



The result of 40 years of evolution
The MX-System is a revolutionary development for the market. For Beckhoff itself, it is also the result of 40 years of evolution in PC-based control. This development stems from the idea of using standard PC technology as the central platform for PLC, motion control, and visualization. Over the years, Beckhoff added more and more functions. I/O, safety, drive technology, and diagnostics, for example, were integrated into a single platform.

It is precisely this principle that forms the foundation of the MX-System today. The MX-System integrates a wide variety of automation functions directly into a modular, control cabinet-free system. To ensure that such a concept remains flexible and manageable, it requires powerful central intelligence – and this is where PC-based control really shines. The openness and scalability of PC-based control technology are a perfect match for the scalability of the MX-System. From compact machine modules to complex systems, control, motion, safety, and communication can be integrated onto a single, end-to-end platform.

The MX-System thus clearly demonstrates how PC-based control has evolved over the past 40 years: from traditional control systems in control cabinets to a fully integrated automation platform located directly on the machine.

> **“The openness and scalability of PC-based control technology are a perfect match for the scalability of the MX-System.”**

Nils Johannsen, Industry Manager, Electrical Power and Energy Systems



The right answer for an industry in transition
In the field of electrical energy systems, PC-based control is the right solution for an industry undergoing fundamental change. The energy transition is dramatically changing the demands placed on automation. Synchronous generators are being replaced by converter-based generators; system inertia is decreasing; grids must respond to faults within milliseconds, maintain frequency, and actively shape voltage. Power generation is becoming volatile and renewable; consumers are transforming into fast-charging infrastructure, data centers, and prosumers, alongside microgrids and off-grid networks. Plants are ranging from individual inverters to hybrid power stations, battery storage farms and HVDC interconnectors, each with their own grid connection rules and lifecycles of between 20 and 40 years.

PC-based control is already celebrating its 40th anniversary, yet it meets today’s requirements perfectly. Multi-core CPUs deliver hard real-time performance in the microsecond range, while EtherCAT with distributed clocks synchronizes distributed nodes in the nanosecond range. This is a prerequisite for distributed grid monitoring, phasor measurement, and grid-forming control.

Distributed measurement systems, phasor and power quality data acquisition, fault recorders, certified EZA (energy generation plants) control, and energy management all run on an industrial PC. This saves on hardware, cabling, and engineering. From the grid operator via IEC 61850 and IEC 60870-5-104, to the industrial plant via OPC UA, to the inverter via CAN or Modbus, and to the cloud via MQTT or HTTP – all on a single open platform. TwinCAT Target for MATLAB® and Simulink® seamlessly integrates model-based development and control models into real-time systems. Development, testing, and production all share the same code.

> **“PC-based control is already celebrating its 40th anniversary, yet it meets today’s requirements perfectly.”**

Conclusion on the anniversary

Four decades – and a story that continues …



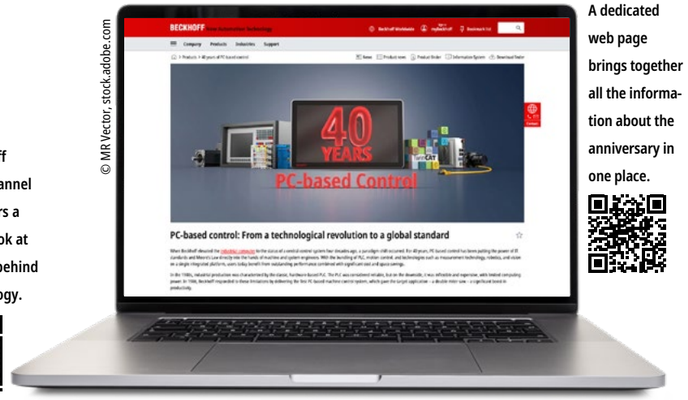
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On LinkedIn, news, insights, and analyses encourage direct discussion.



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The Beckhoff YouTube channel gives viewers a firsthand look at the people behind the technology.



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A dedicated web page brings together all the information about the anniversary in one place.

The “40 years of PC-based control” anniversary is more than just a date on the calendar. After all, it’s not really about the specific date when Beckhoff shipped its first PC-based machine control system. At its core is the technological development that has shaped automation ever since – and will continue to do so. With that in mind, the story continues, even though this issue of our customer magazine marks the conclusion of our special series on PC-based control.

Highlighting this anniversary is important simply because it shows how an idea that was initially met with skepticism became a global standard. Even more important, however, is that the fundamental principles from back then – the separation of hardware and software, the consistent use of open IT standards, and Moore’s Law – still form the foundation for technological leaps in factories today, such as IT/OT convergence, software-defined automation, and physical AI. Therefore, this anniversary is less of a look back than an assessment of where we stand.

One year, many perspectives
Accordingly, the editorial team covered the topic extensively over the course of an entire year in special features in the customer magazine. The event kicked off with a concise news segment that traced the evolution from the inflexible hardware PLCs of the 1980s, through the company’s founding in 1986, to Lightbus, the bus terminal, TwinCAT, and EtherCAT – all distilled into the recipe for success that Hans Beckhoff himself sums up as follows: “A powerful industrial PC, an equally powerful fieldbus interface, peripheral devices for sensors and actuators, and real-time control software for motion and logic – that’s all you need.” This was followed by in-depth technical articles on the technology and background reports, as well as a multi-part series of statements in which pioneers from all areas of the company share their own perspectives.

And the story goes on …
This series of articles is coming to an end – but the story is far from over. After all, PC-based control provides, now more than ever, the ideal foundation for leading-edge automation solutions. For those who want to dive deeper and stay up to date, there are various digital channels to choose from:

- A dedicated web page brings together all the information about the anniversary in one place: the ten biggest advantages of PC-based control, an interactive timeline of milestones from the past 40 years, statements from the people behind the success of PC-based control technology, and links to products and industries. A reference work that’s always available! Explore it at your own pace and delve deeper into the technology with each click.
- On LinkedIn, where Beckhoff has been closely covering the anniversary, the conversation continues: News, insights, and analyses reach an international audience of industry professionals and encourage direct dialogue with experts.
- Automation technology comes to life, both visually and audibly, on our YouTube channel. Watch as Hans Beckhoff explains how his idea became a global standard and what role PC-based control plays in implementing industrial AI solutions. The videos explain concepts that are difficult to convey in words and give viewers a direct glimpse into the lives of the people behind the technology.

Four decades of PC-based control demonstrate that innovation and openness are fundamental pillars of the Beckhoff identity. In this spirit, the same principle applies to the coming years as it did in 1986: The revolution continues!

More information:
www.beckhoff.com/pc-based-control

XTS on a flexible packaging platform for the pharmaceutical and cosmetics industries

Compact and exceptionally gentle filling of a wide variety of product containers

Rotzinger PharmaPack designed its VarioFill filling and capping platform to meet three key customer requirements: high flexibility to accommodate a broad product range, a highly compact machine design, and especially gentle, impact-free handling to ensure even the most sensitive containers can be filled. The core element – and foundation for this high-performance system concept – is the XTS linear transport system from Beckhoff.

Two precisely synchronized XTS movers combine to form a gripper that enables especially gentle container transport.

© Thomas B. Jones

Rotzinger PharmaPack in Waiblingen specializes in turnkey packaging systems for the pharmaceutical industry and increasingly for the cosmetics industry, too. As Product Manager Michael Gensheimer explains, “Our new VarioFill system in particular is especially well suited to filling creams and lotions, thanks to the exceptionally gentle product handling provided by XTS.” As a member of the Rotzinger Group, the company also benefits from the Group’s broad application expertise across a wide range of projects. If required, VarioFill can moreover be expanded with the pickFeeder container infeed and unscrambling system from Spanish sister company Packfeeder, which is likewise based on XTS.

VarioFill was designed with a highly flexible platform in mind for filling a wide variety of products and capping the corresponding containers. It is designed for non-prescription, non-aseptic pharmaceuticals such as nasal sprays and eye drops, as well as for liquid and solid products from the cosmetics, personal care, and food industries. Michael Gensheimer highlights one particularly important aspect, “VarioFill combines a very high degree of flexibility with the smallest footprint currently available in this segment of primary packaging.”

Complex process sequences in an ultra-compact design

The process begins with container supply, integrated as the appropriate infeed solution for the application in question – for example, upright glass bottles or plastic bottles in bulk. This is followed by an air-rinsing module that uses filtered air and vacuum suction to ensure thorough, hygienic cleaning inside each container to be filled – usually small bottles. The containers are then filled either with liquids or with products in solid oral dosage form:

- For precise filling of liquid products with viscosities ranging from low to high and fill volumes from 1 to 160 ml, the filling station can be equipped with various dosing technologies, such as rotary piston or hose pumps, using tool-free quick-change nozzles. To ensure maximum product integrity, the containers are also purged with nitrogen before filling, reducing oxygen exposure and thereby preventing oxidation and spoilage.
- For products in solid oral dosage form, such as tablets, coated tablets, and capsules, one or more counting modules can be integrated. Fast, tool-free format changes are also possible here, and multiple capping units can be incorporated while maintaining the same compact footprint.

The filling process is fully monitored by in-process control. As Michael Gensheimer explains, the XTS linear transport system also allows a check-weighing function to be integrated in an exceptionally compact design: “XTS transfers the containers to a short conveyor belt with an integrated weighing function both before and after filling. This makes it possible to reliably verify the correct fill quantity for each individual container. It also highlights a major advantage of XTS, in that the movers remain uniquely identifiable in the control system throughout the entire product transport process. This means that each individual container and its correct filling can also be traced reliably. XTS also enables precise synchronization with the conveyor belts of the weighing unit, making it possible to implement an extremely compact scale.”

Once the containers have been filled correctly, they can be fitted with the appropriate type of caps or lids at one or more freely configurable capping stations, depending on the application – including snap-on, screw, pump, and crimp closure. Here, too, flexible product transport with XTS offers clear advantages according to Michael Gensheimer, since the movements of the capping head are significantly more efficient than with conventional container infeed systems such as screw conveyors. XTS is the heart and pace-setter of the system, he adds, because it allows the individual machine modules to be operated in the optimum way for each filling order. This results in high overall efficiency and, in turn, maximized system output.

Together with the special capping process, which is based on one capping station each for placement or snap-on application and for additional crimping or screw-on closing, XTS makes it possible to achieve a machine design with a minimal footprint. As Michael Gensheimer explains, “A system in conventional design would be about twice as long as our VarioFill.”

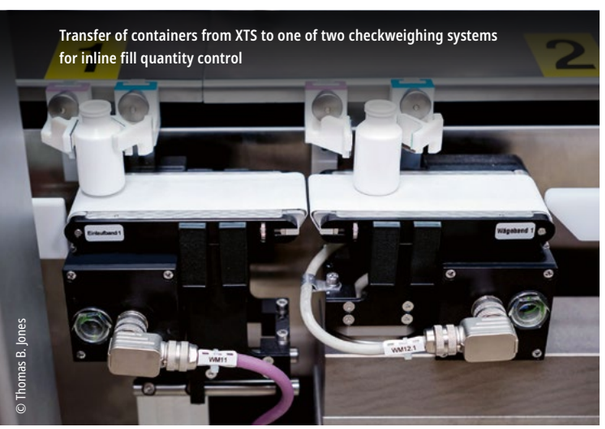
Flexible and gentle container handling with XTS

The modular transport system from Beckhoff allows VarioFill to be tailored precisely to specific customer requirements. Configured as a closed oval, the system can be extended to the required length in increments of 50 cm – with twelve movers per segment – typically ranging from 1.5 to 4 m. Beyond this flexibility, Michael Gensheimer sees another major advantage in the fact that XTS enables impact-free and therefore exceptionally gentle transport of a wide variety of container geometries, “Conventional handling via conveyor belts or screw conveyors would pose a risk of scratches and other damage, especially with glass vials, due to the containers bumping into one another. XTS eliminates this completely, because the containers are picked up gently and with defined pressure by the gripper – implemented with two synchronized movers – and reliably separated.”



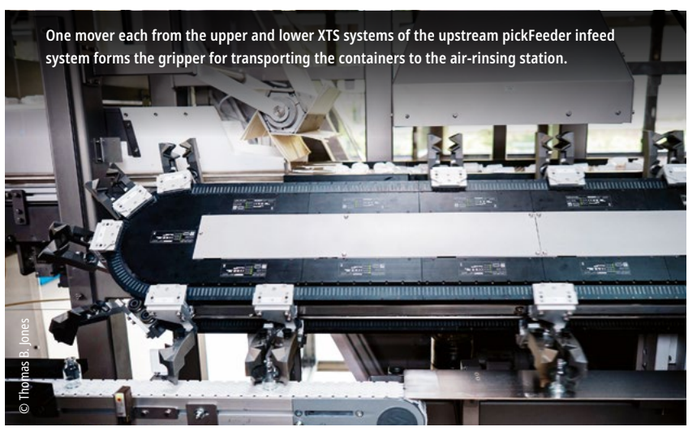
© Thomas B. Jones

Customer-specific configuration of the VarioFill filling and capping system with a 3.5 meter XTS system



© Thomas B. Jones

Transfer of containers from XTS to one of two checkweighing systems for inline fill quantity control



© Thomas B. Jones

One mover each from the upper and lower XTS systems of the upstream pickFeeder infeed system forms the gripper for transporting the containers to the air-rinsing station.

Michael Gensheimer adds that changeovers for product switches are much faster than with conventional systems, since they can be implemented easily via software and, if necessary, only the gripper elements need to be replaced. He also sees a further advantage in Beckhoff’s PC-based control technology, in that it simplifies the database integration used to store the comprehensive process data in a monitoring database.

PC-based control as a modular, integrated system

As Michael Gensheimer explains, PC-based control gives Rotzinger PharmaPack the advantage of being able to integrate all required functions in a modular way, “In addition to universal PLC and motion control, TwinCAT also enables real-time communication, TwinSAFE, and data acquisition and analysis in one consistent, high-performance, and highly flexible system. This modularity and system openness also extend to the broad range of control hardware.”

A CX2072 Embedded PC serves as the control system for VarioFill, complemented by a C6030 ultra-compact Industrial PC and a CP3918 multi-touch Control Panel for HMI functions. If requested by the customer, a C6015 ultra-compact Industrial PC can also be used where a separate device for remote access to the system is required. At the I/O level, Michael Gensheimer highlights the IP67 EP series I/O box modules, which can be used decentrally and, with their wide signal variety, cover all I/O requirements.

The AX8000 multi-axis servo system controls the rotary servo axes via Beckhoff AM8000 servomotors featuring One Cable Technology (OCT) designed to save space and materials. Depending on the system configuration, this makes it possible to implement around 20 to 40 axes, for example for rotating the containers during air rinsing, operating the grippers, and performing other movements within the various workstations.



© Beckhoff Automation

Michael Gensheimer, Product Manager at Rotzinger PharmaPack, explains, “XTS is the heart and pace-setter of the VarioFill filling and capping system.”

More information:
www.rotzinger-pharma.com
www.beckhoff.com/xts

Intravenous compounding automation with the XPlanar system

A paradigm shift enabled by magnetic levitation

Tylent Technologies has developed an innovative system for the automated preparation of injectable drugs in patient-specific doses. At the core of the project lies the XPlanar system from Beckhoff, which has opened up new application horizons for system designers.

© Tylent Technologies

The intelligent XPlanar transport system with magnetic levitation technology forms the core of the new system.



© Tylent Technologies

The XPlanar movers are used as mobile workstations.

The preparation of infusion drugs in personalized doses is one of the most complex and critical processes in the clinical environment. Dosing accuracy, microbiological safety, end-to-end traceability and operational continuity are essential requirements, particularly for high-criticality therapies such as oncology, biologics and patient-specific treatments.

Over the past twenty years, intravenous compounding automation solutions have largely relied on architectures derived from traditional industrial automation: monolithic systems, highly serialized processes and extensive use of anthropomorphic robotic arms. In many cases, pneumatic solutions have also been adopted to simplify actuator complexity and motion control. While well established, these design choices introduce structural limitations in terms of scalability, process parallelism, fine motion control and operation in environments where airborne particulate control is critical and regulated, resulting in bottlenecks that are difficult to eliminate. It is from this legacy industry design approach that the Lyvra™ project was born. Developed by Tylent Technologies, a company of the GPI S.p.A. Group, Lyvra™ aims to rethink the architecture of automated compounding systems from the ground up.

End-to-end automation, safety and traceability

The entire system is designed as a fully automated, end-to-end process, from initial material loading to the final packaged product



The team of experts at Tylent Technologies

© Tylent Technologies

ready for administration, without missing steps or manual interventions to complete the workflow.

Each preparation is seamlessly and uniquely identifiable tracked throughout the entire process. Information relating to the drug, dosage, patient and ward is automatically marked on the final product, while waste handling is managed through self-sealing containers, reducing operator exposure and contamination risks.

This approach delivers concrete and well-established benefits: reduced drug waste, increased safety for both patients and operators, and a significant reduction in pressure on highly qualified human resources, which are still often engaged in manual activities or supported by partial or outdated automation technologies.

Modularity and parallelism as architectural principles

Tylent's approach is based on a key principle: moving beyond serial automation towards a natively modular architecture, composed of replicable and reconfigurable workstations capable of operating in parallel and dynamically adapting to different workloads, priorities and preparation types.

The enabling element of this paradigm is XPlanar, Beckhoff's intelligent transport system with magnetic levitation. The contactless and independent movement of movers on a two-dimensional plane makes it possible to decouple the process flow from fixed paths and rigid sequences, allowing dynamic routing of individual carriers and the simultaneous execution of multiple operations.

"XPlanar allowed us to design a truly parallel system, in which each process unit can be managed and routed independently, without the constraints typical of linear architectures," explains Alessandro Jurman, R&D Manager at Tylent Technologies.

Fully electric system design with broad wireless communication

In intravenous compounding automation, the use of pneumatics has often represented a design shortcut to reduce the complexity and number of required actuators. However, this approach introduces significant challenges in terms of calibration, stability and contamination management, especially in applications requiring high precision and repeatability.

Tylent Technologies has instead adopted a fully electric architecture, in which all movements are handled by integrated electromechanical solutions and deterministically controlled via EtherCAT. In particular, the use of two Beckhoff motor families with integrated drives and absolute multiturn encoders has made it possible to significantly reduce the number of sensors, optimizing system components with both design and economic benefits. These include the ASI8100 compact integrated stepper motor drive for low-speed, space-constrained applications, and the AMI8100 compact integrated servo drive with integrated brake for vertical movements. Thanks to these design choices, the Lyvra™ system implements sophisticated motion functionalities while maintaining compactness, reliability and ease of integration.

This approach is complemented by a broader concept of wireless system design. Not only does the surface formed by planar motor modules eliminate mechanical connections and friction, but the electronic equipment itself is also distributed in an innovative way.

Tylent Technologies has developed original electronic solutions, currently patent-pending, integrated directly on board the Beckhoff movers. As a result, the movers evolve from simple transport elements into intelligent mobile workstations, capable of executing process functions, acquiring data, interacting with vision systems and actively contributing to overall process orchestration.

This design significantly increases system efficiency, scalability and reconfigurability, while reducing cabling, critical connection points and overall integration complexity.

PC-based control architecture and functional integration

Managing a high variability of formats, volumes and dynamic behaviors – ranging from small-volume syringes to flexible bags exceeding one liter – requires tightly integrated control of motion, vision and process logic. Tylent Technologies has selected a Beckhoff PC-based architecture, in which motion control, vision, safety and HMI are integrated within the single development and runtime environment TwinCAT. In particular, the CX2062 Embedded PC and C6032 ultra-compact Industrial PC, running TwinCAT, control the entire machine, while EtherCAT ensures deterministic real-time communication between the XPlanar system, the integrated drives, vision systems and field devices.

This level of integration enables adaptive motion profiles, safe handling of partially filled loads and variable geometries, while maintaining precision and safety even under complex dynamic conditions. Variability, which is intrinsic to clinical compounding, is therefore addressed not through dedicated solutions or process exceptions, but as an integral part of the control architecture. To fully exploit the flexibility offered by the mechatronic system, Tylent Technologies is complementing the conventional control software with an orchestration platform based on machine learning and artificial intelligence algorithms, designed to coordinate and optimize every process step. The goal is to maximize overall system performance by dynamically adapting operational flows to different clinical and production scenarios, while maintaining rigorous control over safety, traceability and process quality.

A new generation of intravenous compounding automation

The project developed by Tylent Technologies represents a substantial evolution in intravenous compounding automation. "The capabilities of XPlanar and the TwinCAT automation system, together with collaboration with a partner like Beckhoff – strongly focused on research and development – were decisive in our choice of solution," concludes Alessandro Jurman.

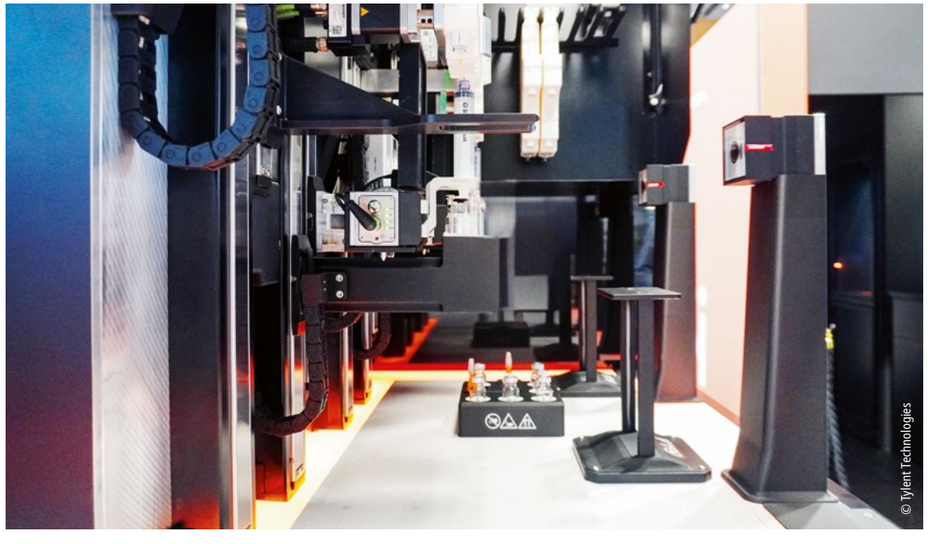
The combination of native modularity, process parallelism, intelligent mobile workstations and deep integration with the Beckhoff ecosystem makes it possible to overcome the limitations of traditional architectures and to address the complexity of modern clinical compounding in a structured and scalable way.

More information:

www.gpigroup.com

www.beckhoff.com/xplanar

The Lyvra™ system also utilizes Beckhoff's Vision Units Illuminated (VUI, shown on the right) – compact units comprising a camera, illumination, and focusable optics with liquid lens technology.



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The Lyvra™ system for automated intravenous compounding



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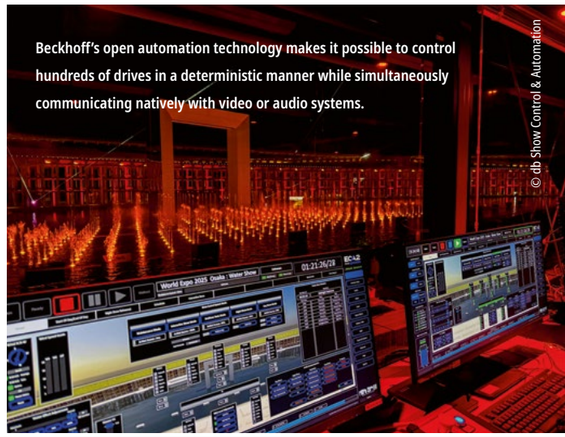
Orchestrated by PC-based control, the multimedia water show "Under the Midnight Rainbow" at Expo 2025 captivated up to 2,500 spectators every evening.

© Ralph Larmann

Spectacular multimedia water show networked in real time with PC-based control

Ultimate choreography of elements

At the 2025 World Expo in Osaka, a spectacular multimedia water show brought each evening to an emotional finale for up to 2,500 spectators. Production company ECA2 relied on the expertise of db Show Control & Automation for the precise and reliable synchronization of 300 water fountains with 30 flame effects across 8,800 square meters, as well as laser, video, and audio technology. Beckhoff provided the underlying automation technology: automation, safety, and the entire AV system were seamlessly integrated by converging PC-based control and specific entertainment protocols on a unified platform.



Beckhoff's open automation technology makes it possible to control hundreds of drives in a deterministic manner while simultaneously communicating natively with video or audio systems.

© db Show Control & Automation



Control of the 30 flame effect stations is integrated directly into the main control system via a safety PLC and EL1918 TwinSAFE Terminals.

In the entertainment market for large-scale facilities and attractions, audience expectations are constantly on the increase. So, production companies like ECA2, which specializes in creating spectacular signature shows, have to keep on pushing the boundaries of technology with every project. “Under the Midnight Rainbow”, the evening show at the Water Plaza at Expo 2025 in Osaka, illustrates this perfectly.

Achieving this type of installation requires an automation architecture that goes far beyond conventional applications. British company db Show Control & Automation has been responsible for the technical design, programming, and construction of turnkey control systems for ECA2 projects for around 15 years. “Today, we need to deliver systems that can control hundreds of drives in a deterministic manner while simultaneously communicating natively with video servers or Q-SYS® audio systems”, says CEO and company founder David Birchall. “It’s Beckhoff’s open PC-based control technology that enables us to achieve this protocol convergence. Other industrial control systems don’t support this feature.”



© db Show Control & Automation

Operators have a centralized view of all sensor and system data, as well as the status of the safety circuits, via the CP2907 Control Panel and TwinCAT HMI.

Distributed systems and strict time windows

280 straight water jets, eight 3D water jets with dynamic kinematics, two huge water screens, one cascade screen, and 30 flame effect stations were arranged across a sprawling water park for the six-month season in Osaka. In addition, there were fog machines, video mapping, projection equipment, and the central audio system.

Craig Pow Chong, Director of Engineering at db Show Control & Automation

> “We control nearly 300 variable frequency drives via EtherCAT. The cycle times and the synchronicity we achieve here are essential for accurate choreography.”

The key to the success of this type of outdoor application lies in mastering all the media and effects involved – in real time and while taking environmental factors into account: strong winds must not cause the water jets to interfere with the flame effects or reach the spectators in the stands. Conventional architectures typically rely on separate control systems for show playback as well as sensors and actuators, resulting in interface losses, latency, and significant engineering work. “To evoke and sustain an emotional response in 2,500 people, the technology working behind the scenes cannot falter at any point,” says Aurelien Bouvier, Technical Director at ECA2. “So, we needed an automation platform that would orchestrate the magic of our water show invisibly, reliably, and with absolute precision.”

Topology and sensor processing

To meet these requirements, db Show Control & Automation implemented a specialized automation topology. At its heart is a CX5240 Embedded PC, which serves as the show controller in the main control room. Field distribution is handled by eleven control racks, which are located at various locations around the water park. EtherCAT and standard UDP/TCP Ethernet are used throughout for networking. EK1100 EtherCAT Couplers collect signals from the decentralized I/O levels in nine decentralized control cabinets. “The key advantage of the Beckhoff architecture is the seamless integration of automation and IT,” explains Craig Pow Chong, Director of Engineering at db Show Control & Automation. “We control nearly 300 variable frequency drives via EtherCAT. The cycle times and the synchronicity we achieve here are essential for accurate choreography. At the same time, we can easily interact with the AV systems via TCP/IP. If necessary, the system could be scaled almost indefinitely by adding more EtherCAT Terminals.”

A key unique selling point of the solution is its software-based environment monitoring, which is integrated directly into TwinCAT. Sensors located across the site continuously measure parameters including temperature, humidity, wind speed, wind direction, and water depth. All sensor data acquired is consolidated in the CX5240 in real time. TwinCAT analyzes the data streams and intervenes in the show’s sequence whenever necessary. If, for example, the sensors detect a critical gust of wind heading toward the spectator stands, the control will shut down the affected inverters in a fraction of a second or deactivate specific flame effects. Functional safety is also an integral part of automation. TwinSAFE Terminals are used to manage the emergency stop circuits and implement the flame effects. Since the safety controller communicates via FSoE on the EtherCAT network, there is no need for any parallel wiring.

A paradigm shift for playback

Complex DMX recordings and audio synchronizations usually require large, dedicated server racks. db Show Control & Automation broke new ground in this area by developing its own recording and playback platform based on TwinCAT. The hardware platform consists of two C6017 ultra-compact Industrial PCs, one of which is configured as a master system and the other as a backup system. The initial programming for the show was created using established entertainment tools including GrandMA and Medialon. The resulting Art-Net™ signal was then recorded by the master industrial PC. The system receives highly precise timecode by means of integration into the Q-SYS® network. During live operation, the C6017 units handle the parallel playback of the 32 DMX universes independently without the need of GrandMA.

“Reliably recording and playing back a complete, time-coded show sequence using an industrial PC that fits in the palm of your hand is a real paradigm shift,” emphasizes Craig Pow Chong. “Without the performance of the Beckhoff IPCs and the flexibility of the TwinCAT software architecture, we would have had to budget for significantly more installation space and hardware costs.” The operator on site has full local access to the application via the connected CP2907 multi-touch Control Panel.

IT convergence: Data logging and diagnostics

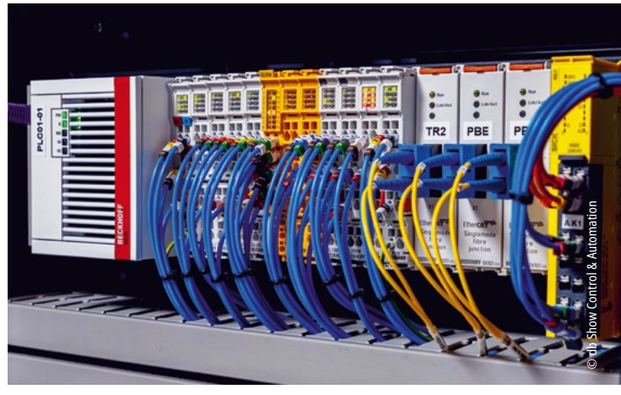
Thanks to its IT capabilities, TwinCAT is also used for data handling in addition to pure machine control. The TwinCAT TCP/IP (TF6311) and TwinCAT Modbus TCP (TF6250) software modules are used for communication with third-party components and UPS systems, for example. To ensure high system availability, all system and sensor data is logged in a database via the TwinCAT Database Server (TF6420). This allows operators to monitor the entire site in real time via the HMI front end, in addition to performing in-depth diagnostics. If any anomalies occur in pump performance or environmental conditions, the exact same parameters from past shows can be retrieved and analyzed down to the second. ECA2 benefited directly from this continuity: during the World Expo, approximately two million people attended the show without a single technical hitch that would have disrupted proceedings.

The successful implementation in Osaka underscores the importance of open automation standards in the entertainment industry. “In our view, Beckhoff is the only control system manufacturer that combines industrial-grade hardware with native support for protocols like DMX, sACN, and QSC® integration,” concludes David Birchall. Close collaboration with Beckhoff, particularly in the area of support, ensures that db Show Control & Automation benefits from the responsiveness required for global projects. Work is already under way on a follow-up project on a similar scale.

More information:
www.davidbirchall.com
www.eca2.com
www.beckhoff.com/entertainment



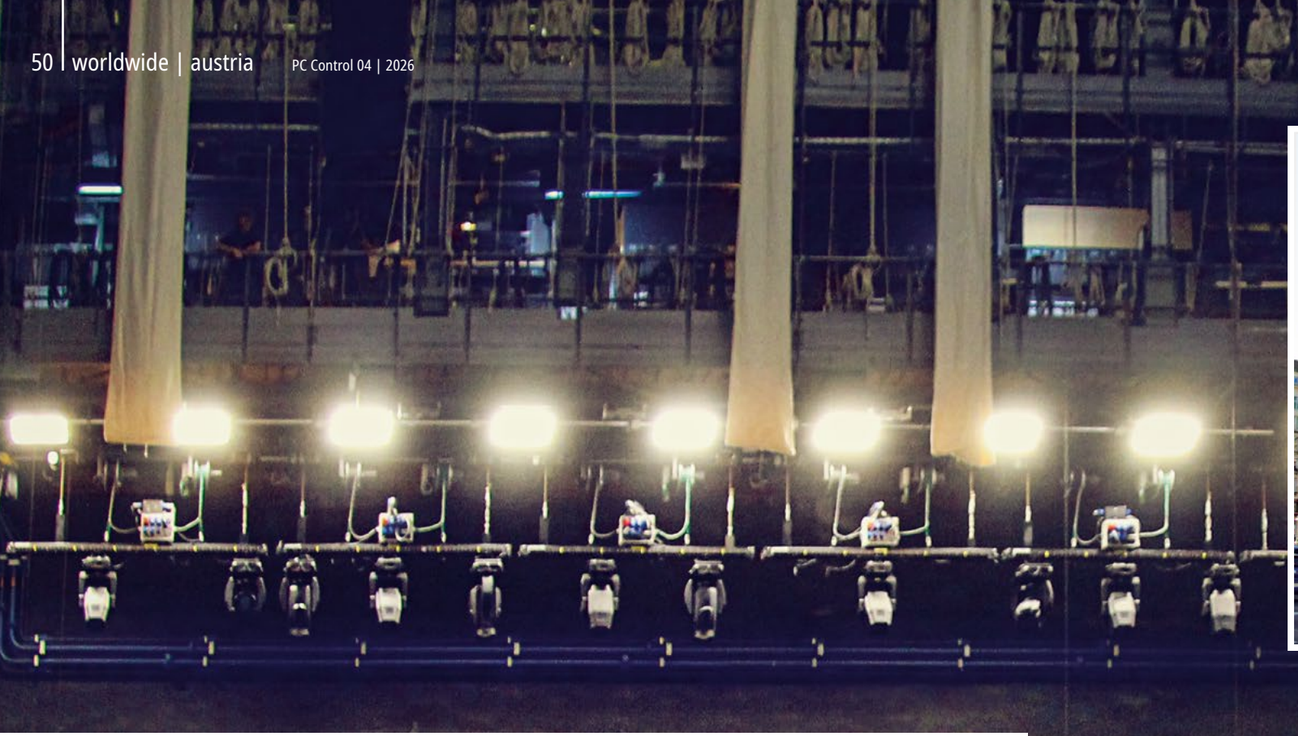
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Above: db Show Control & Automation uses two C6017 ultra-compact Industrial PCs for its in-house recording and playback platform, avoiding the need for bulky server racks.

Below: The CX5240 Embedded PC serves as the central show controller and synchronizes nearly 300 water fountain drives in real time via EtherCAT.





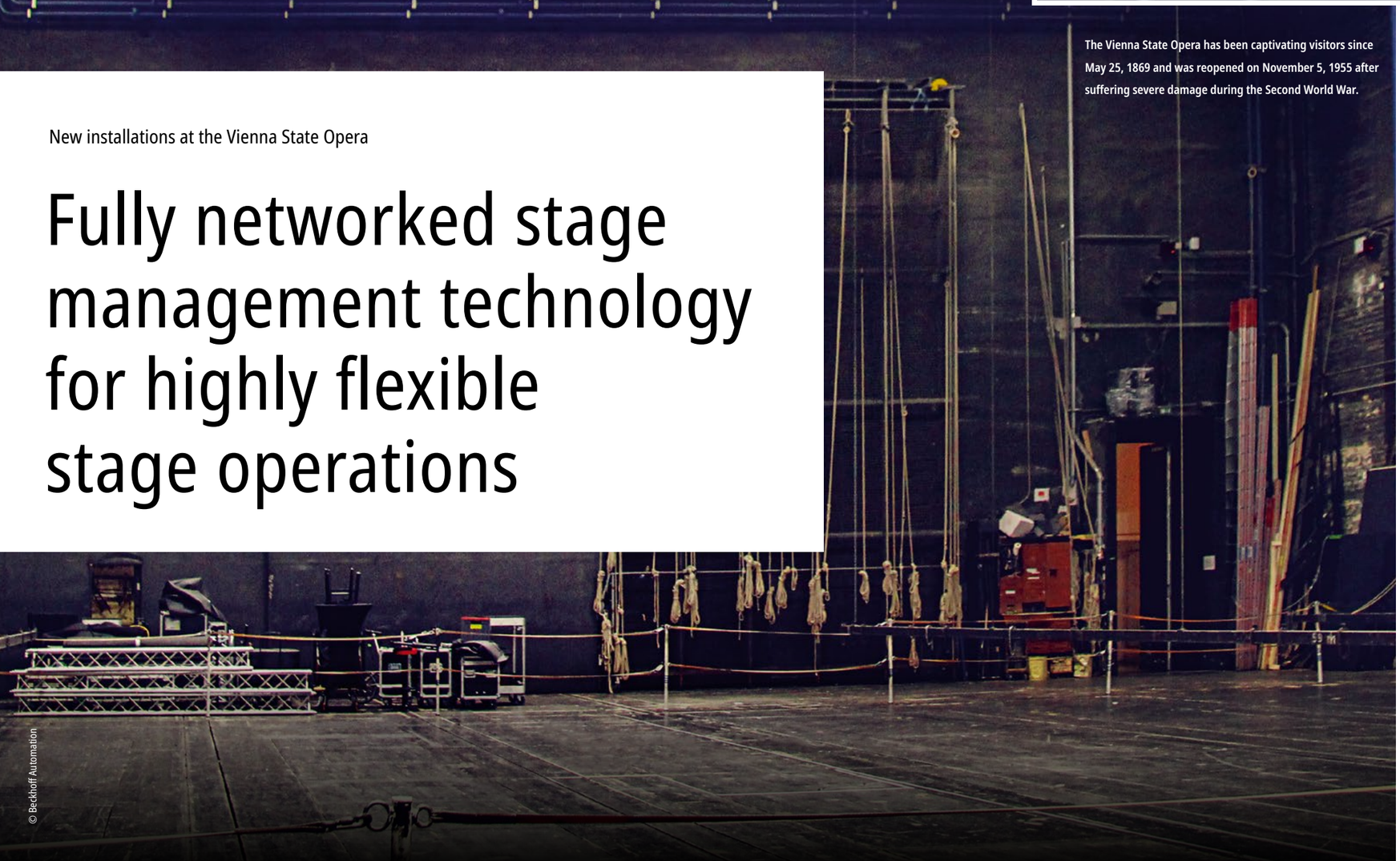
The Vienna State Opera has been captivating visitors since May 25, 1869 and was reopened on November 5, 1955 after suffering severe damage during the Second World War.



Salzgeber project engineer Tino Pfeifer in front of the stage manager's desk, which is used to coordinate the almost 200 people involved in each performance.

New installations at the Vienna State Opera

Fully networked stage management technology for highly flexible stage operations



The Vienna State Opera is one of the world's leading opera houses, supported not least by its continuously evolving event technology. Following a successful collaboration with the Vienna-based specialist Salzgeber and Beckhoff Austria to renew the sound and video control room, another project has now been completed. This was based on end-to-end system communication using EtherCAT and TwinCAT 3 TCP/IP, enabling the seamless integration of systems such as those from Riedel Communications.

Each season, the Vienna State Opera presents more than 60 different opera and ballet works in around 350 performances – an immense program that must not be disrupted, even by extensive modernization measures. Athanasios Rovakis, Head of Audio & Video Technology, explains: "There was only a small window of opportunity to replace the 20-year-old technology. So it was a very demanding undertaking, especially since errors during live performances are simply not an option. Even the first dress rehearsal before the opening performance had to run flawlessly. This meant that the integration period was only six weeks, including hardware processing as well as the complete programming and commissioning of all audio DSP call circuits and the lighting and video switching. The time available for commissioning and testing was less than two weeks." Tino Pfeifer, Senior Project Engineer at Salzgeber IT-Revolutions, adds: "The aim was to use new functions to make it easier for the stage



Project experts Christian Henke, Beckhoff Austria, and Athanasios Rovakis, Head of Audio & Video Technology at the Vienna State Opera, and Tino Pfeifer, Senior Project Engineer at Salzgeber (from left to right)

manager to coordinate the almost 200 people involved in a show. In addition, the existing components – such as pushbuttons and signal lamps for switching video and audio sources, as well as for displaying director controlled scenes – had to be integrated seamlessly."

Diverse communication requirements

The stage manager's desk is the central point from which all actions on stage and all technical processes are managed. A wide range of communication methods are used here: from audible announcements and light signals as color codes to number indications for the scenes to be called. This requires both 1:1 point connections and 1:n connections as well as bidirectional wireless communication – in other words, classic intercom functions. This is supplemented by the management of around 30 cameras, which allow, for example, singers waiting for their entrance to be observed from various perspectives or the movements of stage lifts and scenery to be monitored.

Tino Pfeifer, Senior Project Engineer, Salzgeber IT-Revolutions

> "Linking the stage management systems makes it possible for everything to run synchronously on a central controller."

Implementing all of this in a sufficiently dynamic and flexible way to meet the varying requirements from one production to the next – while also integrating the previously renewed sound system seamlessly – offers many advantages. Tino Pfeifer explains: "Linking the stage management systems makes it possible for everything to run synchronously on a central controller – in this case, a C6030 ultra compact Industrial PC from Beckhoff. The prerequisite is that all integrated devices can be fully controlled. The remote I/Os, pushbuttons, light signals, and serial interfaces are EtherCAT capable, ensuring very fast data transmission and comprehensive network diagnostics. Rather than implementing classic product combinations with certain predefined functions, we are using the C6030 as a central core that enables any logic or communication between all network participants. This results in an agile system that will allow future ideas and customizations to be implemented in a highly flexible manner."

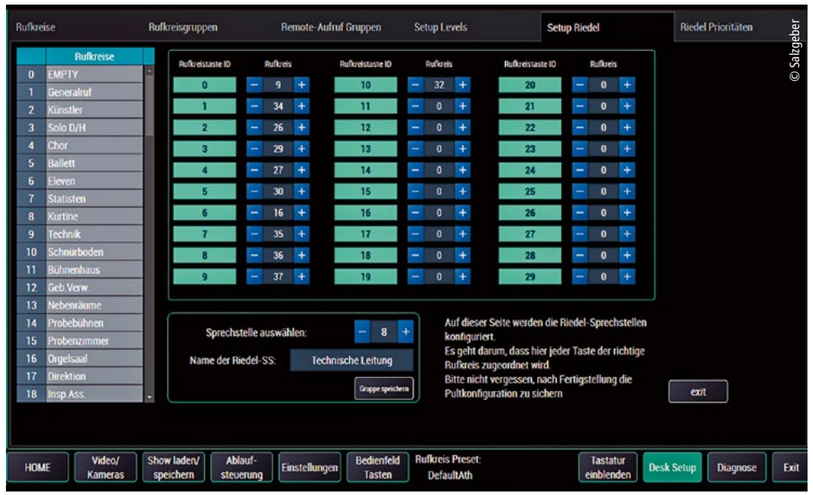
The Beckhoff TwinCAT software also offers a high degree of flexibility; for example, via the TwinCAT 3 TCP/IP function (TF6310), which is used to implement one or more TCP/IP servers and/or TCP/IP clients in the TwinCAT 3 PLC. This made it possible, for example, to implement the established Telnet network protocol as well as string transmission via TCP/IP. In total, there are around 25 network participants – i.e., TCP/IP connections – that must be maintained simultaneously in order to communicate with all buttons, video controllers, audio DSPs, etc. The communication systems from Riedel Communications, Wuppertal, can also be integrated via TwinCAT 3 TCP/IP. For this purpose, the essential parts of the RRCS protocol from Riedel are supported in TwinCAT on the basis of TwinCAT 3 TCP/IP, enabling communication with Riedel's Artist and Bolero systems as well as the use of Riedel SmartPanels. The combination of the Riedel system and TwinCAT 3 is what sets it apart from conventional stage management systems.

User-oriented operating philosophy

The stage manager's desk contains numerous intuitive controls, including a CP29xx multi-touch built-in Control Panel from Beckhoff with TwinCAT 3 HMI as a modern and convenient user interface. According to Athanasios Rovakis, it is precisely this connection between seemingly old technology – with buttons and rotary potentiometers – and modern touch screen technology that results in optimum operability: "A purely touch-based interface is not feasible, not least because you can't locate individual touch fields by feel when you also need to keep an eye on camera feeds or follow the score. Reactions are often required within milliseconds, and in some cases you even have to hit several buttons intuitively and correctly at the same time. The right haptic feedback is also very important, which is why selecting the hardware buttons required an extensive search process. The actuation point and response speed are crucial here."

Added to this is the cross disciplinary communication approach: the stage manager's desk brings together all departments – from mechanically movable stage elements to the lighting technicians, wardrobe staff, and performers, all the way through to sound and video. This is also reflected in the visualization implemented with TwinCAT HMI on the control panel, as Tino Pfeifer explains: "The visualization offers all the functions required for stage operation and device communication. Nothing was implemented in a static way, so everything remains dynamic and parameterizable, and can be easily configured via TwinCAT HMI. Each button on the desk has an ID and a defined function. Behind this is a PLC structure that can be copied at any time within these button fields – for example, to bypass defective buttons or to create an entirely new show configuration." Athanasios Rovakis adds: "This has enabled several functions that are not available as standard. Examples include a technical assistant for an overview of light signals, as well as the ability to display user specific views – including on tablets or mobile devices via a web browser."

Tino Pfeifer sees specific advantages for engineering in the TwinCAT 3 event logger and the EtherCAT diagnostics integrated into TwinCAT. With the event logger, any initial operating errors can be tracked quickly and easily – on a day with rehearsals and a performance, the log file can contain up to 10,000 events. EtherCAT diagnostics can be used to quickly locate open connections, for example. However, with the exception of defective network cables, there have been no failures in this project so far. "The entire system can be expanded to accommodate any future ideas and user requirements," adds Athanasios Rovakis.



As an example, the call system stored in the "Desk Setup" area illustrates the high complexity of the processes at the Vienna State Opera.

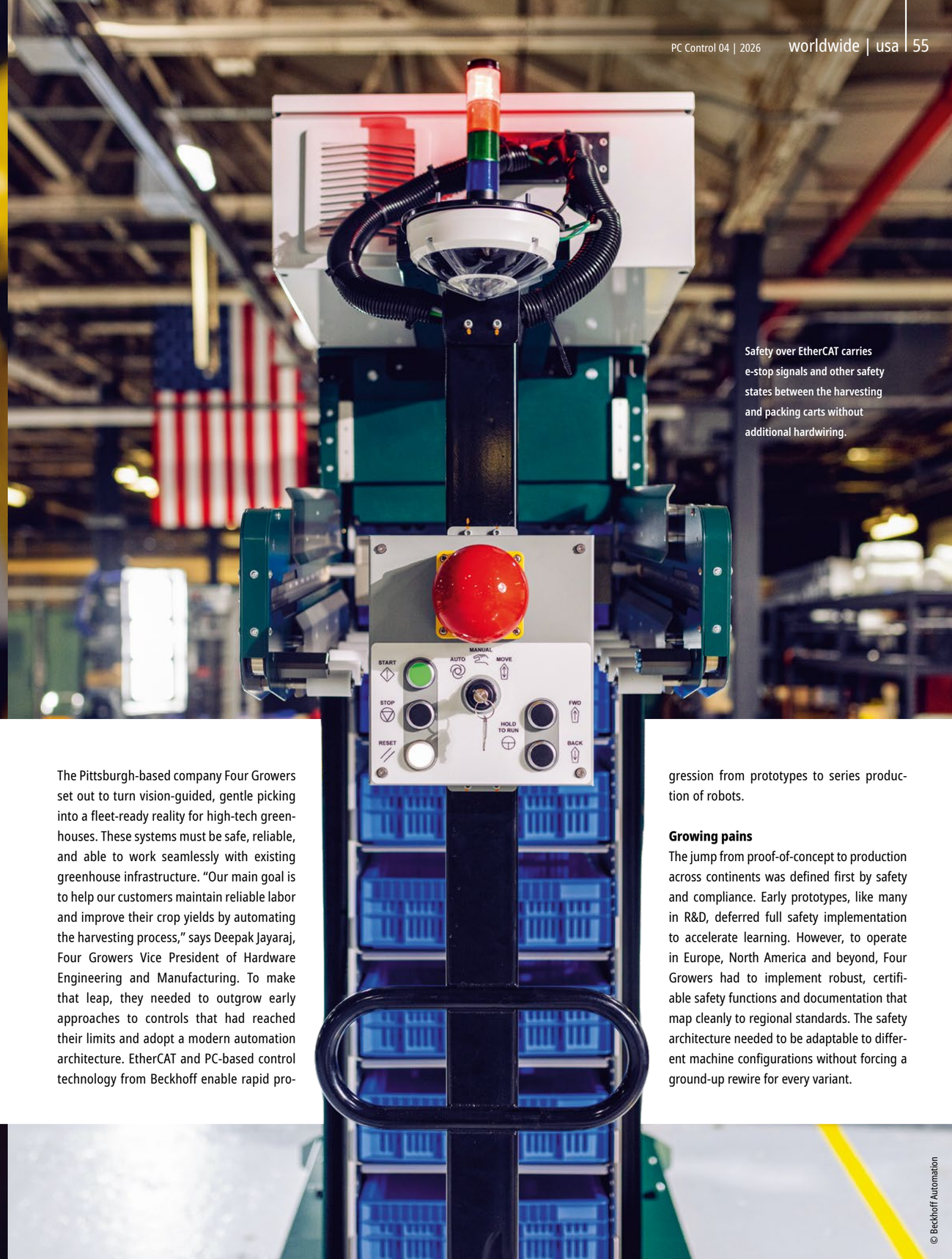


The CP29xx multi-touch built-in Control Panel ensures clear visualization and convenient operation of the various functions that can be called up via the stage manager's desk.

More information:
www.wiener-staatsoper.at
www.it-revolutions.com
www.riedel.net
www.beckhoff.com/entertainment



Vacuum suction at the end of the robot arm enables gentle handling of the tomatoes and ensures consistently high fruit quality.



Safety over EtherCAT carries e-stop signals and other safety states between the harvesting and packing carts without additional hardwiring.

Greenhouse automation with EtherCAT and TwinSAFE

Modular safety concept for autonomous harvesting robots

Commercial agriculture in most industrialized countries is under growing pressure to deliver consistent yields of high-quality crops with fewer hands-on deck. At the same time, delicate crops like on-the-vine tomatoes demanding rapid harvesting without damage. Using advanced image processing, robotics, and Beckhoff automation technology, autonomous harvesting is shifting from R&D labs to fleet-scale ready robots for the field.

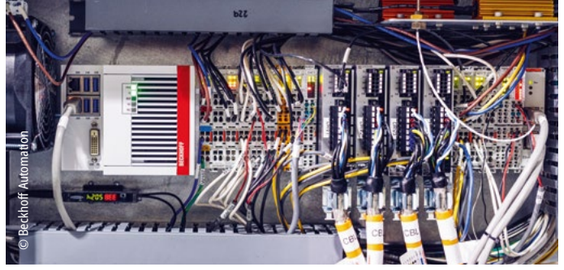
The Pittsburgh-based company Four Growers set out to turn vision-guided, gentle picking into a fleet-ready reality for high-tech greenhouses. These systems must be safe, reliable, and able to work seamlessly with existing greenhouse infrastructure. “Our main goal is to help our customers maintain reliable labor and improve their crop yields by automating the harvesting process,” says Deepak Jayaraj, Four Growers Vice President of Hardware Engineering and Manufacturing. To make that leap, they needed to outgrow early approaches to controls that had reached their limits and adopt a modern automation architecture. EtherCAT and PC-based control technology from Beckhoff enable rapid progression from prototypes to series production of robots.

Growing pains

The jump from proof-of-concept to production across continents was defined first by safety and compliance. Early prototypes, like many in R&D, deferred full safety implementation to accelerate learning. However, to operate in Europe, North America and beyond, Four Growers had to implement robust, certifiable safety functions and documentation that map cleanly to regional standards. The safety architecture needed to be adaptable to different machine configurations without forcing a ground-up rewire for every variant.

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A single Beckhoff CX5230 Embedded PC running TwinCAT automation software serves as the control platform for all sensors, drives, and safety functions.

"One of the biggest technical demands is reliability. All the GR-200 components, movement, suction, crate shuffling, must work together smoothly, especially in hot and humid environments," says Peter Beauregard, Four Growers Senior Electrical Engineer. Narrow greenhouse aisles and frequent obstacles demand predictable reactions to safety laser scans, emergency-stop presses and other potential triggers. In this context, the robot still needs to coordinate suction picking, arm motion, and crate shuffling with deterministic timing to ensure high throughput with gentle handling. This requires tight integration across the harvesting and packing carts, with clean handoffs to the robot arm. Any ambiguity translates into downtime or damaged product.

Mechanical constraints on a mobile platform raised the stakes further. The controls had to fit in a compact envelope and mount directly on the robot's backplate, without sprawling external cabinets or long runs of cabling that are vulnerable in tight aisles. Power consumption needed to come down compared with earlier iterations to extend uptime and reduce heat dissipation. And because most growers already rely on pipe rails for irrigation, the robot needed to ride on the same infrastructure without damaging it. That meant the control hardware and motion technology had to be rugged, space-efficient, and easy to service in the field.

Today, the GR-200 delivers reliable harvesting in challenging greenhouse conditions. Vacuum suction provides gentle handling compared with traditional pick-and-place approaches, ensuring consistently high fruit quality. In testing, peak measurements reached 2.79 s per tomato, with average speeds dependent on crop density and ripeness distribution. The dual-cart workflow mirrors established greenhouse practices but with far less manual labor: the robot harvests forward and back along the row, manages crate changes automatically and alerts staff only when unloading is required. Deterministic real-time control across suction, arm motion, and crate handling translates into consistent throughput and predictable behavior in the face of obstacles or safety triggers.

Safety for autonomous mobile robots

A single Beckhoff CX5230 Embedded PC running TwinCAT automation software – and TwinCAT/BSD for the operating system – integrates sequence control for all sensors, drives, and safety. A separate high-performance vision system identifies ripe fruit and sends harvesting targets to the controller.

Fast, real-time EtherCAT communication synchronizes tomato suction timing, robotic arm motion, imaging triggers, and crate handling with high precision. Modular I/O terminals make it straightforward for the Four Growers team to add signals as the design evolves. This currently includes digital and analog I/O, safety inputs and outputs, encoder feedback, brake choppers, and RTD temperature sensors for thermal monitoring. "As a standard EtherCAT I/O terminal, an EL6224 IO-Link master connects smart field devices as needed, opening the door to plug-and-play sensors and actuators." says Ola Roberts, Four Growers Electrical Engineer. "Built-in EtherCAT diagnostics streamline commissioning and troubleshooting, allowing us to scan the network, discover devices and pinpoint cabling issues quickly."

The team of experts (from left): Keith Beadle, Sales Engineer (Beckhoff USA) along with Christine Morgan, Chief of Staff, Peter Beauregard, Senior Electrical Engineer, Deepak Jayaraj, VP of Hardware Engineering and Manufacturing, Meara Murphy, Robotics Engineer, Ola Roberts, Staff Electrical Engineer, Nikil Ranade, Manufacturing Manager (all from Four Growers), and Steve Giannotti, Applications Engineer (Beckhoff USA)





Four Growers GR-200 robots are designed for use in greenhouses, harvesting at 2.79 s per tomato at peak production.

Safety technology moved to the center of the design through TwinSAFE and Functional Safety over EtherCAT (FSoE). Pre-certified function blocks and the TwinCAT Safety Editor helped the team implement and validate safety logic efficiently, with clear mapping to required performance levels. FSoE carries e-stop and other safety states between the harvesting and packing carts without additional hardwiring, simplifying the dual-cart architecture and reducing points of failure. Safety laser scanners, physical e-stop devices and other protective inputs connect through TwinSAFE I/O, and safe-state handoffs to the robot arm occur via the standard EtherCAT network along with all other communications. The result is a unified automation and safety system that's both robust and adaptable.

Motion control is also consolidated onto the CX5230 Embedded PC to drive six axes, replacing multi-controller setups from earlier iterations. Compact ELM7231-9018 EtherCAT servomotor terminals connect with AM8100 series servomotors with One Cable Technology (OCT) to reduce wiring and fit neatly inside the robot. This eliminates bulky external cabinets while improving serviceability.

The TwinCAT automation software toolchain accelerates configuration and quality assurance for greenhouse fleet deployments. Automatic hardware scanning with TwinCAT and EtherCAT reduces the chance of misconfiguration. Engineers can code in familiar, modern PLC programming languages within TwinCAT, including structured text. TwinCAT also integrates Microsoft Visual Studio, which further eases development work for team members with C++ and Python backgrounds. Project comparison tools support code reviews and controlled changes across the fleet, helping maintain consistency while enabling rapid software iteration.

Rooted in results

With the Beckhoff automation and control platform in place, Four Growers achieved safety compliance and validation across regions, unlocking market access while reducing wiring complexity through EtherCAT, FSoE, and modular TwinSAFE logic. The safety design is now a core, fully integrated asset rather than a bolt-on system: it maps cleanly to standards, documents easily for audits and scales across configurations without redesigning the machine. That, in turn, shortens the path from prototype to production for new variants.

The control architecture is simpler and more resilient. A single embedded PC now handles all motion axes that previously required multiple controllers, cutting complexity and reducing points of failure. "The greenhouse operator can put the system in the row, enter a few configurations, and hit start, and the robot will begin its harvest and notify when done," says Robotics Engineer Meara Murphy. Compact ELM series servomotor terminals with One Cable Technology (OCT) bring the motion stack inside the robot's footprint, improving robustness in tight aisles and reducing power consumption.

Perhaps most importantly, the GR-200 system automated by Beckhoff scales. TwinCAT's unified environment, Drive Manager and project comparison tools make it faster to configure, replicate and maintain robots across the fleet. The modular I/O enables Four Growers to add features and devices without redesigning the control platform and EtherCAT's built-in diagnostics reduce time spent chasing wiring faults in the field.

More information:
www.fourgrowers.com
www.beckhoff.com/twinsafe

Gentle product handling in research labs with XPlanar

Maintaining sample quality using levitating transport



With its magnetically levitating movers, the intelligent transport technology XPlanar provided the combination of delicate handling, determinism, and openness Biosero required.

© Beckhoff Automation

Over the past few years, biotechnology has advanced at a remarkable pace. In scientific research, automation plays an increasingly important role – from developing new virologic cures for persistently hard-to-treat diseases to pushing the limits of cancer immunotherapy and genetic medicines. The San Diego-based specialist Biosero applies their lab automation expertise to add a new level of flexibility using the XPlanar transport system.

In 2024, the engineers at Biosero sought out a transport solution that could move fragile samples across tightly packed lab cells without vibration, noise, or compromise to material and data integrity that could get in the way of the next big medical discovery.

The company's Green Button Go orchestration software was already being used to coordinate robots, lab instruments, transport systems, and schedulers as part of a single, predictable workflow environment in many automated laboratories around the world. As the orchestration layer, Green Button Go enables new technologies to be integrated into that environment while maintaining a consistent approach to workflow execution, data flow, and system management. What Biosero still needed now was a highly flexible and intelligent handling system. XPlanar, the intelligent transport system from Beckhoff, together with the TwinCAT automation software platform and fast EtherCAT communication, provided the combination of delicate handling, real-time control, and openness Biosero required.

"I first learned about XPlanar through conversations and demos at the SLAS trade show with Beckhoff representatives," recalls John Canty, Senior IT Architect at Biosero. Canty and his Biosero colleagues recognized that XPlanar could replace the heavier, more intrusive transport systems they were using.

For Biosero customers – from small research labs experimenting with new cancer assays to large production environments running population-scale DNA tests – the stakes are high. A single disrupted microplate, a poorly timed pick, or inconsistent handling can force rework, delay critical research timelines, and complicate regulatory submissions to the FDA. This is where XPlanar plays a role. "Together, Green Button Go and XPlanar ensure that movers and robots transport test plates efficiently and consistently throughout the process," John Canty explains. "This protects sample quality and traceability for our customers."

Consistency is key

Biosero engineers stress that consistency is not just "nice to have"; it is a prerequisite for downstream analytics, audit trails and, ultimately, for successful submissions to regulatory authorities. XPlanar answered a parallel set of needs here. The technology's magnetically floating and flying movers glide silently in any direction across motor tiles, enabling plates and carriers to be delivered to robots and other instruments without the shocks and vibration of alternative

handling systems. The XPlanar motor tiles can be arranged in any lab layout. The movers enable 2D product transport with up to six degrees of freedom in motion, they lift up to 5 mm, rotate 360°, tilt up to 5°, and can speed along at velocities up to 3 m/s.

"We work with XPlanar because of its smooth and near silent operation," says Evelyne Ploquin, Solutions Architect and Team Lead at Biosero. "Our applications require very gentle handling throughout our processes, and the XPlanar movers don't shake compounds or samples." For assays sensitive to agitation – cell work, delicate proteins, or sample preparations – that stability can improve results by eliminating a major source of variability. For lab engineers and scientists, the value is clear: fewer repeats, clearer signals, and a low likelihood that a seemingly minor handling event will have ripple effects that lead to costly delays.

Selecting XPlanar was not merely a material handling decision; Biosero required a complete automation architecture that could coordinate the control of movers, robots, vision systems and instruments with µs reliability. A C6032 ultra-compact Industrial PC with an 8-core Intel® Core™ i7 processor provided the processing power for deterministic real-time control and EtherCAT supplied the speed. Beckhoff supplied prebuilt control cabinets for the XPlanar system, which simplified on-site work.



Biosero applies lab automation expertise into R&D processes to accelerate discovery and adapt to the evolving needs of biotech researchers.



The team of experts (from left): Michelle Talarico (Biosero), Charles Usher (Beckhoff USA), Lucius Kemp (Biosero), John Canty (Biosero), Mathew Garcia (Beckhoff USA), Evelyne Ploquin (Biosero), and Asmaa Abid (Beckhoff USA)

TwinCAT provides an ecosystem for automation, where XPlanar, PLC, general motion control, and safety functions coexist in one platform. As Biosero's engineering staff is highly proficient in C# and Visual Studio, TwinCAT's deep integration with Microsoft's development environment flattened the learning curve and enabled reuse of engineering practices across projects.

Changing course without losing direction

Rather than a monolithic machine where conveyors and large robotic arms do everything, Biosero uses modular work cells that are coordinated by Green Button Go and connected through adaptive automation technologies such as XPlanar. Individual cells perform instrument-specific tasks while XPlanar continuously carries well plates between stations without disturbance to material integrity. The arrangement is compact, reducing the machine footprint compared to traditional conveyor or puck-based systems for labs. It's also far more flexible: reconfigurations for new assays or plate formats are software-driven rather than engineering-intensive mechanical and electrical changeovers.

That flexibility matters not only for throughput and quality but also for real lab economics. Biosero customers in biotech and pharma industries often need rapid changeovers between experiments or must support large SKU counts across many consumable formats. The combination of XPlanar's dynamic path planning and Biosero's orchestration software makes changeovers faster and less disruptive. In practice, this reduces downtime between production runs and shortens validation cycles when new formats or instruments are introduced. For labs under pressure to scale R&D or clinical diagnostics, that flexibility helps reduce disruption when workflows, formats, or system requirements change over time.

The Biosero software aggregates machine state, event logs, and diagnostic data in a structured way that enables downstream analytics and AI applications. TwinCAT CoAgent from Beckhoff, an emerging software extension to help accelerate programming and development, is directly integrating AI technologies into a standard automation software platform. "The biggest advantage I see with AI is with troubleshooting," John Canty says. "TwinCAT CoAgent takes that further by providing contextualized troubleshooting recommendations and deep code-generation support directly in the engineering environment."

Operationally, the choice of Beckhoff system with XPlanar has already delivered several recurring benefits. The gentle product transport helps minimize sample agitation and supports more consistent handling throughout the workflow. EtherCAT's diagnostic capabilities and TwinCAT's integrated software toolchain simplify root cause analysis and shorten troubleshooting time. The modular approach enables tailored deployments – from benchtop cells to production-scale orchestrated lines – while keeping the core control architecture standardized. All of this contributes to a lower total cost of ownership over the life of a machine, a critical consideration for capital-constrained labs or for organizations rapidly scaling diagnostic capacity.

A formula for success in the future

For Biosero, the work carries deeper meaning beyond project milestones. Michelle Talarico, Biosero's CFO, shares a personal perspective: "It's amazing to see how new technologies like these support scientific advances that ultimately contribute to improved healthcare outcomes and literally save patients' lives."



A C6032 ultra-compact Industrial PC provides the processing power required for the XPlanar-equipped lab automation systems from Biosero.



Together, the software Green Button Go and the intelligent transport system XPlanar ensure that test plates are handled efficiently and consistently throughout the process.

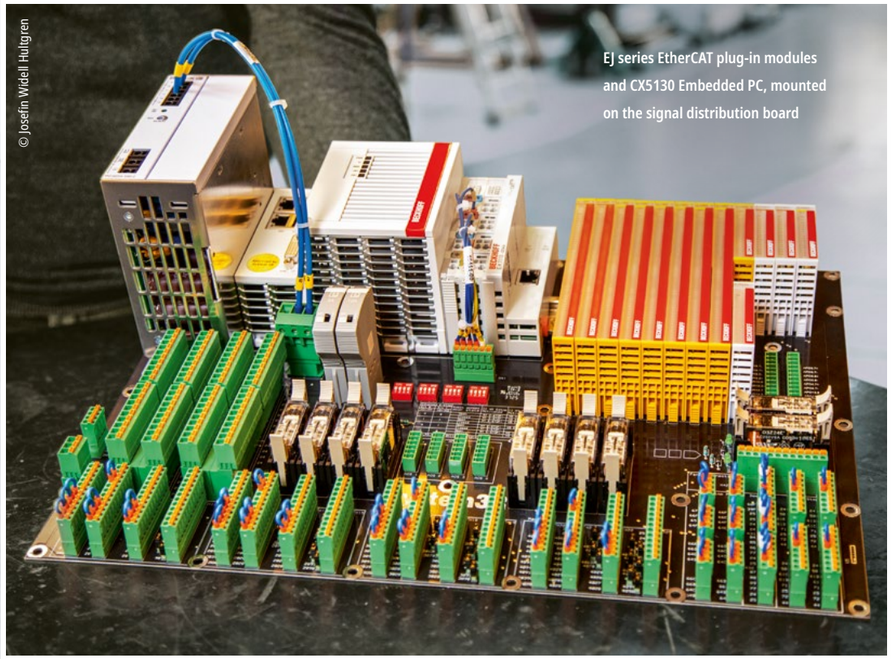
Looking ahead, Biosero and Beckhoff will continue improving validation workflows to ensure that orchestrated systems meet the documentation and audit demands of regulated biotech manufacturing and clinical environments. automation designs.

More information:
www.biosero.com
www.beckhoff.com/xplanar

A return to in-house control cabinet manufacturing with EtherCAT plug-in modules

Faster builds, fewer errors

By redesigning its electrical cabinets with Beckhoff's EJ series EtherCAT plug-in modules, System 3R has eliminated wiring errors, shortened build times and brought cabinet manufacturing back in-house. The result is a faster, more predictable production setup that supports high-volume machine manufacturing without compromising quality.



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EJ series EtherCAT plug-in modules and CX5130 Embedded PC, mounted on the signal distribution board



WorkPartner 1+ for palletized handling automation

© System 3R

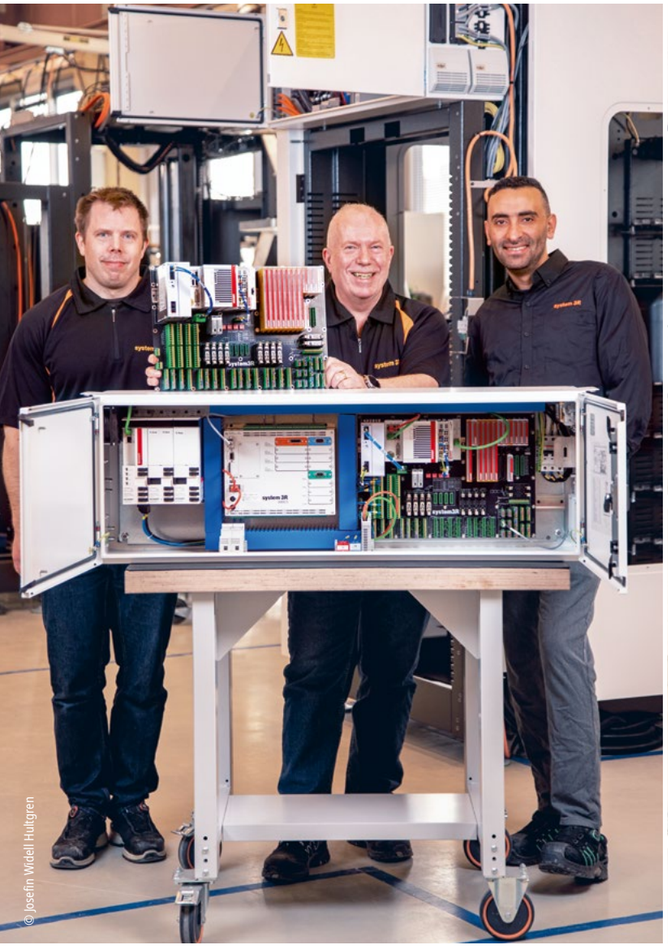
Headquartered in Stockholm, System 3R is a global specialist in automation, tooling, and software for precision manufacturing. 95% of the company's solutions are exported worldwide alongside EDM machines, laser texturing systems, additive manufacturing equipment and advanced milling operations. A defining principle behind System 3R's portfolio is openness. The company designs its automation around a neutral architecture, ensuring compatibility with virtually any machine tool, regardless of brand or underlying technology.

At the heart of many installations is the in-house production control software, WorkShopManager 5. Connected directly to the customer's ERP system, the software distributes programs, coordinate systems and configurations to individual production cells. Automated handling systems then supply machines with the correct tools and workpieces, log production data during machining and move finished parts onward in the process. The result is a tightly orchestrated, highly automated production flow with full traceability.

Outsourcing became a bottleneck

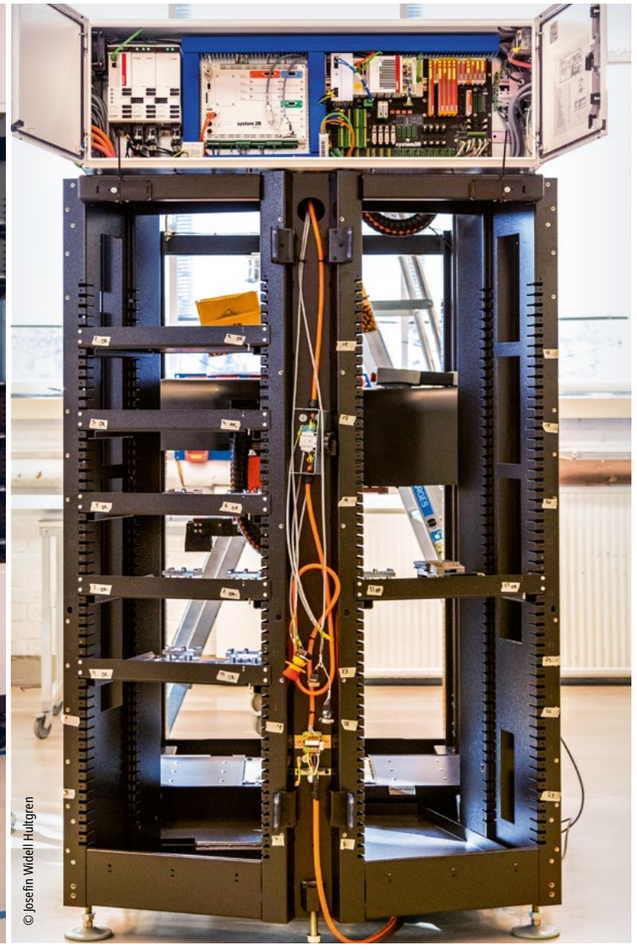
System 3R produces around 200 equipment-handling machines every year. That volume makes production speed and repeatable quality critical success factors. Over time, however, one part of the production setup increasingly stood in the way. For years, the electrical cabinets used in the company's handling systems were built externally. While outsourcing offered flexibility, it also introduced problems that grew more severe as volumes increased. Lead times were long, delivery schedules difficult to predict and, most critically, wiring errors were frequent.

The System 3R team of experts, featuring Magnus Carlquist (center)



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Installation of a WorkPartner 1+ with the control cabinet mounted on top to house the AX8000 multi-axis servo system (left) and the signal distribution board (right)



© Josefin Widell Hultgren

According to Magnus Carlquist, Manager for Electronics Development at System 3R, wiring errors were not just an irritation; they were a structural risk: "Correcting those errors required significant manual troubleshooting once the cabinets arrived at the factory. We spent extra working hours rechecking connections, fixing faults and validating safety functions. For a company like ours, where on-time delivery is non-negotiable due to the impact delays have on our customers, managing deviations came with substantial cumulative costs and made production planning unnecessarily complex." Eliminating the risks required a fundamentally different approach to cabinet design.

A different approach to building electrical cabinets

Together with Beckhoff, System 3R set out to rethink how its cabinets were built. Rather than relying on traditional terminal blocks and extensive manual wiring, the two companies developed a new architecture based on Beckhoff EJ series EtherCAT plug-in modules mounted directly on a signal distribution board. In this design, all internal connections are integrated into the printed circuit board (PCB). Sensors and actuators are connected using pre-manufactured cables, eliminating the need for manual internal wiring.

The cabinet architecture combines AX8000 multi-axis servo system with fast-connect technology, CX Embedded PC series running TwinCAT 3, and EtherCAT with integrated safety (FSoE). "From a control perspective, the solution is deliberately straightforward. Motion control, I/O and safety are handled on a single, coherent platform. The innovation lies in removing complexity," Magnus Carlquist says.

Faster builds, cleaner testing, and zero wiring errors

The impact on production was immediate. By eliminating manual wiring inside the cabinet, System 3R effectively removed the most common source of assembly errors. The cabinets themselves are smaller and lighter, as terminal blocks and internal wiring are no longer required. "Most importantly, cabinet build time has been dramatically reduced from 25 to 4 hours per cabinet. Faster assembly, fewer components, and simplified testing have, in combination, removed a major bottleneck in our machine production," Magnus Carlquist says.

Instead of labour-intensive manual checks, System 3R implemented a dedicated test station. Test cables are connected directly to the backplane, and software quickly and reliably verifies all I/O points. What had previously been a time-consuming validation step is now a short, standardised procedure.

Further, bringing cabinet manufacturing in-house has strengthened System 3R's ability to respond to late configuration changes driven by evolving customer requirements. Because both assembly and testing are already simplified and standardised, adjustments can be implemented quickly without disrupting production flow or quality. This added flexibility ensures that customised solutions can be delivered even when specifications change late in the process.

Magnus Carlquist,
Manager for Electronics Development at System 3R

> "Motion control, I/O and safety are handled on a single, coherent platform. The innovation lies in removing complexity."

From a technical standpoint, the solution supports highly modular machine designs, enabling a single handling system to serve from 1 to 20 machines. Integrated safety over EtherCAT simplifies system architecture while meeting stringent requirements. The wide voltage range of the AX8000 multi-axis servo system also enables System 3R to deliver machines globally without the need for additional transformers, further simplifying logistics and reducing system complexity.

Magnus Carlquist's conclusion: "Because of Beckhoff's innovative approach, we were able to bring electrical cabinet manufacturing back in-house – after 30 years of outsourcing. We could not achieve this with conventional automation components. In-sourcing has given us full control over quality, reduced dependency on external suppliers and significantly shortened lead times. For a company building hundreds of similar machines each year, insourcing has translated directly into higher throughput and lower total production costs."

A partnership built on experience

System 3R has worked with Beckhoff since 2020, and the long-standing relationship played a key role in the project. "We have a very close partnership with Beckhoff Automation, and we truly appreciate our direct connection to Beckhoff's specialists, as well as their quick responses and reliable counselling. Beckhoff has contributed with deep and valuable technical expertise and support," Magnus Carlquist says.

Key production impact

The cabinet design based on a signal distribution board eliminates internal wiring, removes a major source of errors and enables System 3R to build electrical cabinets in-house. Faster assembly, simplified testing and higher repeatability support the production of approximately 200 machines per year with consistent quality.

More information:
www.system3r.com
www.beckhoff.com/ethercat-plug-in-modules

EtherCAT hits another milestone: 5000th Vendor ID assigned

The EtherCAT Technology Group (ETG) has issued its 5000th Vendor ID, marking continued growth and geographic diversification among manufacturers building on EtherCAT technology. The Vendor ID (VID) is a globally unique identifier that enables controllers and tools to recognize EtherCAT devices reliably and ensures correct communication across networks.

Manufacturers producing EtherCAT hardware are required to obtain a Vendor ID from the ETG and embed it in every product before bringing it to market. Companies that simply integrate off the shelf EtherCAT modules into machines do not need their own ID. Vendor IDs are tied to ETG membership, are allocated free of charge, and can be requested online. A key element of the Vendor ID policy is mandatory conformance testing: products carrying a Vendor ID must demonstrate compliance with the EtherCAT specifications using the official EtherCAT Conformance Test Tool (CTT). Those tests are intended to make devices from different suppliers interoperable and predictable in real world installations.

Oliver Fels, who manages Vendor ID administration at ETG, sees the milestone as a sign of trust and ecosystem maturity: “This shows manufacturers are choosing a common technical foundation. Open access combined with rigorous verification lets vendors innovate while giving users confidence in interoperability.”

For system designers and integrators, the 5000th Vendor ID underlines growing supplier choice coupled with more reliable integration — a clear advantage for complex automation projects. More information on membership, Vendor ID registration and conformance testing is available at ethercat.org.



Oliver Fels is responsible for the allocation of Vendor IDs at ETG.

EtherCAT Compendium now also available in Chinese

The EtherCAT Technology Group has published a Chinese-language edition of the EtherCAT Compendium, providing members in China with practical, structured guidance on EtherCAT applications. The new edition was introduced to regional automation professionals at the exhibition IAS Shanghai in October 2026.





Left:
Florian Essler, lead author and originator of the EtherCAT Compendium.

Right:
ETG releases Chinese edition of the EtherCAT Compendium.

China accounts for approximately 20% of ETG’s global membership, making it the association’s largest national membership base. Companies in Asia represent 44% of total ETG membership worldwide.

The EtherCAT Compendium provides a comprehensive and coherent description of EtherCAT. It covers technical details as well as system design, implementation and user aspects. The publication complements the formal EtherCAT specifications by presenting the technology in an accessible, easy-to-read format. It supports engineers and users in understanding how EtherCAT components and systems interact in real-world automation applications. The Compendium is organised into several sections. Its chapters introduce EtherCAT and address key technology topics, including the physical layer and cabling, process data communication, and the SubDevice Information Interface (SII).

The Compendium will continue to grow, chapter by chapter, into a complete reference work. ETG publishes new chapters on an ongoing basis. Members can download the latest version from the ETG website; a member login is required. The publication date indicates the respective version of the EtherCAT Compendium. Florian Essler, Conformance TWG Chair, EtherCAT Technology Group, explains: “ETG’s extensive EtherCAT documentation is highly recognized and valued throughout the EtherCAT community. The EtherCAT Compendium closes the gap between detailed specifications, which can be challenging to read, and more practical, knowledge-base-style content. Written in clear yet precise language, it explains every layer of the EtherCAT protocol and combines theoretical knowledge with a functional understanding of the technology. The Compendium is unique in covering all aspects, from hardware and application protocols to diagnostics, providing readers with genuine practical know-how. It supports engineers in translating theory into the implementation and operation of EtherCAT devices that integrate seamlessly into an interoperable EtherCAT ecosystem. The demand for a Chinese translation confirms both the importance of this publication and the significance of the Chinese EtherCAT market.”



At the ETG Technical Committee Meeting in September 2026, 27 participants gathered at the Mövenpick Nürnberg Airport Conference Center to learn about the latest progress made by the Technical Working Groups.

ETG Technical Committee Meeting focuses on cybersecurity and configuration tools

The EtherCAT Technology Group held its Fall 2026 Technical Committee (TC) Meeting on Wednesday, September 30, at the Mövenpick Hotel at Albrecht Dürer Airport Nürnberg, Germany. The full-day meeting was conducted in a hybrid format, with 27 participants attending on site and a further 21 joining remotely.

The chairmen presented current results from the Technical Working Groups (TWGs), including TWG Safety, TWG Device & Network Description (DND), TWG Conformance and the Semiconductor TWG. Among the announcements was the release of Version 2.8.2 of the EtherCAT Conformance Test Tool (CTT), which includes updates to the FSoE conformance test cases. Cybersecurity was a key topic of the meeting. The security capabilities of the EtherCAT Device Protocol (EDP) have been assessed and certified against IEC 62443-3-3 in three application scenarios, referred to as blueprints. In addition, the draft versions of Parts 1 and 2 of ETG.1800, the EtherCAT Security Profile, have been published and are now available for review to ETG members.

Florian Essler, Chair of the Conformance TWG, presented practical ways for configuration tool providers to use existing EtherCAT features.



This meeting’s focus topic, “Configuration Tool Provider: Let Your Users Benefit from Existing EtherCAT Features,” examined practical implementation considerations for configuration tool providers. The EtherCAT specification supports a range of advanced configuration features, including SCI, modules and slots, and diagnostic-history functions. Although these capabilities are optional, they are increasingly used by EtherCAT SubDevices. Configuration tools for EtherCAT MainDevices therefore need to support these features to enable flexible integration of current and future SubDevices.

The Fall 2026 TC Meeting underlined the importance of coordinated technical development within the EtherCAT ecosystem. By advancing conformance testing, cybersecurity and interoperable configuration capabilities, the ETG supports the continued adoption and reliable implementation of EtherCAT technology.

More information:
www.ethercat.org

PCcontrol
The New Automation Technology Magazine

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