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The right tools are essential for every system integrator who wants to be prepared for any situation that may arise

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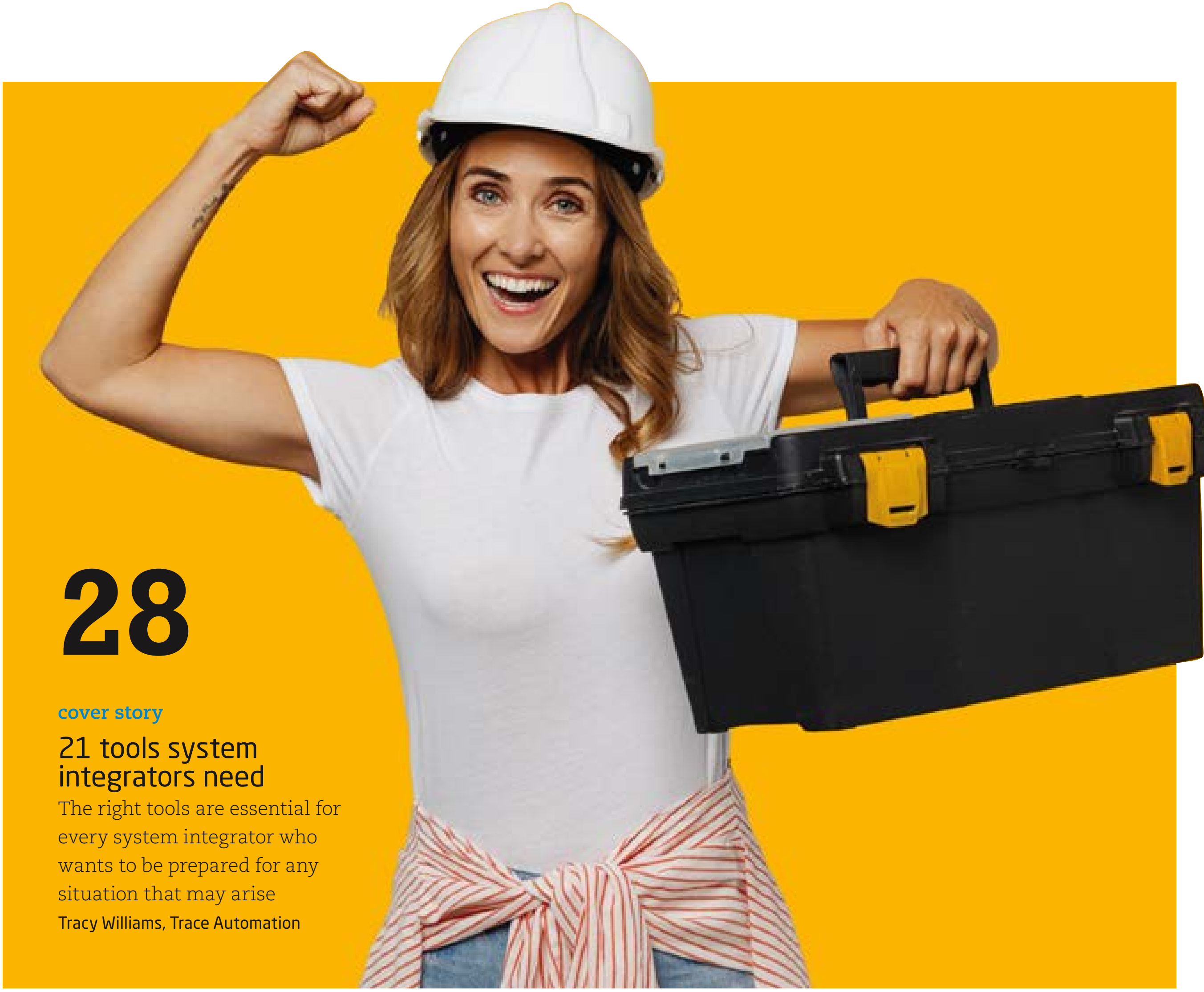

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ABB

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Put recession fears on hold

THE SKY IS NOT FALLING. The air quality is still a bit hazy in many parts of the United States, due largely to the Canadian wildfires burning through the countryside, but economically the second half of 2023 is off to a stable start. And the recession that was on the tip of everyone's collective mind for the past six months looks more like a worry wart on the end of Americans' collective nose.

One person who foresaw this months ago was Alex Chausovsky, vice president of analytics and consulting at Miller Resource Group. He explained the economic situation and reassured those in attendance at the Control System Integrators Association (CSIA) Executive Conference in New Orleans.

"Be a data-driven decision-maker in every facet of your business," Chausovsky advised. "Don't buy in to the hysteria. We've been hearing about a recession for more than a year. Real gross domestic product (GDP) is the most holistic economic indicator in the United States. It remains at a record high. We did have a recession in Q1 and Q2 of 2022, but we have been in positive GDP since then. A lot of the elements that fueled retail sales growth, such as the COVID shutdown, are starting to fade, so that growth is not sustainable. Economies do not accelerate forever."

> Many companies have been slow to increase prices, but now is the time.

Chausovsky indicated the U.S. economy is in a controlled descent. "The possibility of a soft landing—a mild recession—is likely," he said. Successful companies will capitalize on the growth before everyone else knows it's coming, he explained. "The face value of industrial production is we do not have any evidence of major contraction," Chausovsky stated. "Our highest level was in 2019, but we're not declining as of right now. We're seeing a fairly substantial slowdown in the volume of activity. A lot of you are still busy, but I believe that is backlog."

While year-over-year activity is still up slightly, Chausovsky expects it to dip into the negative but net around zero for the year compared to 2022. "Capital-goods new orders fuel the majority of your projects as system integrators," he noted, reminding the 400-plus attendees of their almost $900 billion record high, mostly due to price increases that have been passed on to customers. "Remember that you are in business not to grow revenue, but to grow profits." Many companies have been slow to increase prices, but now is the time. "As we get closer to a recession in the first half of 2024, it's going to become more difficult to raise prices," he cautioned. "You'll get pushback as recession nears. The odds of a recession in the next year are about 65%. The job market has remained consistent." cd

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How mobile is your workstation?

MOBILITY IS KEY. Laptops, notebooks and tablets all allow us to be free of physical encumbrances to do the work we need to do. And don't forget the cell-/smartphone, which is our everything.

So, why we are still considering desktop computers for the plant/factory floor. Human-machine interfaces (HMIs) and supervisory-control-and-data-acquisition (SCADA) nodes were all over the place in years gone by. I've written about interfaces before. From software and physical interfaces to the location of HMIs on any particular machine or process. It really had everything to do with visibility into the operation.

Normally the HMI would be fixed and mounted on a cabinet, possibly on a gantry arm or some articulated system to get the visibility needed.

Mobile workstation enclosures can be very useful, similar to having computers fixed in cabinets.

Part of the issue we face in the world of software licensing is the fact that it isn't inexpensive. Many companies are still using run-time protection such as USB security software or, heaven forbid, parallel-port dongles to protect intellectual property. Some are using token-based authentication for run-time protection.

Regardless, there may come a time in your day-to-day operation that an engineering workstation has all the programming and SCADA/HMI development software needed at various places in the plant.

Remember that not all devices reside on a network for many different reasons. Air-gap security is an obvious one. Legacy is probably the main one. Anything more than 20 years old falls into that category for the most part.

A workstation may be an all-in-one box with a 32-inch screen or a simple desktop with a 32-inch screen for specialized monitoring or development work.

In past years, we used a trolley to move these beasts around. It was an open concept, but the safety may have been in question. Hitting bumps and having things fall off was commonplace.

Mobile workstation enclosures can be very useful, similar to having computers fixed in cabinets. They protect the access to things such as USB ports, network connectivity and also have a place to store the mouse and keyboard. The screen would typically be behind a plexiglass cover for protection.

In the environment of a factory or plant floor, there may be multiple stations that have their homes in a corner and then are moved to the location where they will be needed. They may be fixed, but mobile, for machine cleaning and floor preparation, if you will. Environmental considerations would affect the enclosure's physicality. Dust-tight vs. water-tight creates different headaches for the specifier, but solutions are available. Does it matter what the desktop or workstation hardware really is? Probably not, but, with computer prices the way they are now, it's best to protect them as best as possible.

There is no doubt that a mobile laptop could be used for the same result. Their hardware specifications now rival high-powered desktops, except when it comes to graphics. If video, 3D, virtual reality (VR) or augmented reality (AR) is of concern, a laptop may not suffice. Connectivity may also be an issue if you need more than two high-speed USB ports.

I used a Hoffman enclosure for remote workstations in a national distribution center due to the high cardboard dust environment. Mobility wasn't as much of a big deal as the protection was. But if needed, it could be wheeled anywhere.

The need for these workstations without a doubt has diminished over the years. Heck, I can sit at home and connect to my client's network and have access to anything from an HMI or programmable-logic-controller (PLC) point of view. Anything graphically required may be a chore. This was especially true when I had broadband Internet service. The speed was very limiting, but a small price to pay to live in paradise with my sweets.

Now I have fiber—60 Mbps up/down symmetrical. With the proliferation of wireless in the plant environment, one wonders how mobility of technology will be defined even in the next two years.

Sensors have built-in wireless connectivity, as do many control devices. Wireless safety is even a thing. Mobility means access to data anywhere you can get it. Rolling a workstation to a location will become a thing of the past at some point. This point will come quickly I'm sure, but until that time we will need good robust enclosures to allow workstations to remain mobile. CD

JEREMY POLLARD, CET, has been writing about technology and software issues for many years. Pollard has been involved in control system programming and training for more than 25 years.

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Servo-driven devices expand capabilities

LOOK BEYOND THE BUZZWORDS. Augmented reality (AR) and artificial intelligence (AI) are familiar industrial terms. Augmented reality aims to use technology to enhance the interaction between human and machine, while artificial intelligence applies technology to expedite the ability to create control algorithms.

Both of these approaches to automation have a lot of visibility at trade shows and expositions. Manufacturers are spending a lot of money and resources on making these technologies work for the end user. Behind the bright lights and fancy user devices, manufacturers have also been busy making machines easier to design and program. With the enhancement of the user experience, vendors can now make their machines more intelligent without making the user interaction more complex. One key element in these super-charged machines is the increased use of servo-controlled devices.

> The use of servos usually means a lot fewer moving parts.

Traditional control systems on a repetitive-motion machine would rely on a central drive shaft with cam-driven accessories that perform patterned movement based on the position of the main cycle shaft.

The great thing about these early designs is the calculated behavior of the various accessory devices. Depending on the shape of the lobe on the cam, the device travels the same path every time the drive shaft makes a cycle.

An example of this type of machine would be a horizontal packaging machine. This machine takes a roll of paper or plastic membrane, converts it into a pouch, fills that pouch with product, seals the pouch and then discharges the pouch to further processing. A number of stations are defined on the machine that perform specific functions.

Each of these stations has an accessory that uses a cam mounted on a main cycle shaft that runs the length of the machine. Since each station/accessory moves relative to that central shaft, each motion is coordinated in such a fashion that adjacent stations can work in close proximity to each other.

The upside of this type of system is the secondary devices are always in position relative to the main cycle shaft. In most cases, the cycle shaft can be rotated in either direction while the accessory devices will remain in time, based on the cam relationship to the main shaft.

This is also the downside of this type of system as all functions are lock-step with the cycle shaft. If something goes wrong in the process, the machine must complete the rest of the machine cycle before the cam-driven devices return to their home position.

Another detraction from the physical cam system is speed. The cammed device depends on springs to hold the device against the cam. At high speeds, the device will tend to leave the surface of the cam due to centrifugal force, making the action of the station erratic.

With the advent of servo positioning, it became possible to operate each accessory station, independent of the main cycle shaft, through the use of accurate feedback and precision motor control. The control philosophy remains the same in that the secondary accessories, or axes, still follow the position of the main cycle shaft but without the physical contact of the cam lobe on the cycle shaft. All of this means a significant increase in speed and accuracy.

Additionally, recovery from a sudden stop can be handled in multiple ways. Slave axes can be individually recovered to match the position of the master axis, either prior to or during restart. By uncoupling the various stations on a machine from the master axis, not every station requires an adjustment during a restart; only the parts of the machine that are out of position will need to.

Servos give additional capabilities by allowing for changes in cam profile without having to physically change out a cam to a different profile. Electronic camming means nearly infinite profile possibilities.

On a packaging machine, for example, different package sizes will require different motion profiles to accomplish similar tasks. A large carton, with larger flaps, will need the tucking devices to move in different arcs with slight variances in timing relative to the master axis. This can easily be done by loading a different cam profile for each product as part of a recipe change.

To the end user, all of this is seamless and happens behind the scenes as they select the product from a list and the recipe is loaded into the machine.

On the design side of things, the use of servos usually means a lot fewer moving parts. On a more traditional machine, the main cycle shaft must be driven by a significantly

larger motor because it is responsible for moving all of the various assemblies for the entire machine.

By using a servo and decoupling the assemblies, not only is the main motive force greatly reduced, the various assemblies can be driven by smaller motors that only have to be big enough to drive the attached components.

The draw of many slave axes makes the physical design more compartmentalized but can also quickly add up on the controls side of the equation. Each slave axis needs its own servo drive, and the programmable controller has to be sized accordingly. Servo drives communicate via a network, and there are limitations as far as how many connected devices can be on each communications network.

The limitations have to do with the amount of information being transferred between master and slave and how those blocks of information constantly being transmitted and received will affect the performance of the devices themselves. Accurate motion definitely depends on rapidly confirming the relationship between commanded position and actual position.

On the software side, each servo drive is added to a hardware tree in the development environment. The software automatically creates unique tags for each drive and will notify the programmer if more axes are added than the processor is capable of controlling.

For this reason, it is a good idea to create the software version of the control application before finishing the actual control circuit design to make sure that the appropriate processor size is chosen early in the design process.

On the hardware side, servo systems have evolved greatly in the past few years. Not long ago, there was one servo drive for each servo motor. Connections to each motor required power, encoder feedback and sometimes brake cables. Each of those cables had to be routed from the enclosure to the motor on the machine.

On a multi-axis machine, that is an awful lot of cables to manage and might be a significant reason why a pneumatic device might be used in place of a servo, even if it is less accurate to do so. One recent trend is single-cable technology where power, feedback and brake are combined into a single cable from drive to motor. The benefits of routing a single cable versus two or three is obvious.

Another emerging trend is multiple axes in a single drive package. This technology significantly reduces the impact on the footprint in an enclosure. Two axes driven from a drive with the same footprint as a single-axis version can help greatly where footprint is an issue. Additionally, a common incoming power and protection circuit reduces that part of the circuit, as well.

The failure of one axis in the drive package means two axes are down as a result. Dual-axis drives will also cost a bit more, so, while we are saving room in the panel, the cost of replacement will be higher for the end user.

Yet another trend in servo technology is to put the drive in the motor. With this approach, servos can be daisy-chained

> **On a more traditional machine, the main cycle shaft must be driven by a significantly larger motor.**

for connections, as a single cable can be used for power and network, and each drive/motor becomes a node on the network. All the smarts are in the drive/motor device and communicate on the same trunk back to the programmable controller in the main panel. This technology can be likened to devices on a CANbus, but we are talking about more than just a sensor.

The advantages to these constantly improving technologies are making machine footprints more compact, controls packages smaller, more efficient and, as a result, easier to deploy and duplicate. Machine vendors are more likely to use servos in their control designs with the end user being the ultimate winner—faster processes producing widgets of a higher quality with more flexibility to alter the machine function down the road as trends and desired outcomes change.

The pushback to using new technology is always about the learning curve involved in taking the new gadget and incorporating it into our design. It is human nature to resist change, and we can come up with a million reasons why we can't or don't need to accept change. At some point in the journey, we either accept that change or we are forced to do so when our usual way of doing things is no longer available to us.

The trick is to navigate this path in such a way to stay on the leading edge of technology without having to reinvent the wheel. Happily, hardware vendors are making this task easier for us to do, and the results are well worth pursuing. cd

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The future of control: trends and predictions

TECHNOLOGICAL ADVANCEMENTS have revolutionized control systems, making them smarter, more efficient and transformative. Control systems have surpassed previous limits, offering unmatched precision and intelligent features. This progress has ushered in an era of automation, machine learning and interconnected intelligence, shaping a world of new possibilities.

Increasingly, AI usage in control systems is enabling fast and precise decision-making. Real-time data analysis empowers AI to anticipate issues and provide proactive solutions, enhancing safety, reliability and performance. Consequently, this approach reduces downtime and maintenance expenses.

AI, aided by sensors and data analysis, predicts maintenance needs, saving time and money. Adaptive control algorithms leverage AI to optimize real-time system performance, enhancing efficiency and reducing energy consumption. Integrating AI into control systems has transformative potential for industry. However, challenges in data accuracy and interpretability of AI decisions need resolution, as well as preventing bias and discrimination.

In control systems, the Industrial Internet of Things (IIoT) optimizes performance through data analytics, facilitates remote monitoring and control and enables predictive maintenance. IIoT devices enable real-time system monitoring and remote control. Rapid issue detection optimizes performance, improving system reliability, reducing costs and enhancing customer satisfaction. The Industrial Internet of Things has enormous potential in control systems, from increasing productivity and reducing downtime in factories to improving energy efficiency and security in building automation.

Machine learning can also optimize control system performance, improve safety and minimize downtime. By analyzing large volumes of data, machine learning tools such as predictive maintenance, anomaly detection and adaptive control identify patterns to boost system efficiency. Machine learning allows for automation of complex processes and data-pattern identification.

Due to the increasing number of cyber threats, control systems must implement efficient cybersecurity measures. Strong security protocols are crucial to have in place because these risks can gravely endanger critical infrastructure.

> **Control systems must implement efficient cybersecurity measures.**

Cyber attacks, data breaches and unauthorized access can all lead to system failures and serious safety issues in connected control systems. To safeguard control systems from cyber threats, network segmentation and encryption are effective cybersecurity solutions. Other recommended measures include regular security assessments, tight access controls and employee training to stay ahead of potential risks.

Advancements in human-machine interfaces (HMIs) have led to more intuitive and user-friendly control systems, improving operator productivity and reducing errors. These systems are more complex and require specialized training.

Intuitive and immersive interfaces like augmented reality (AR) and virtual reality (VR) have the potential to revolutionize the control-systems industry by providing operators with a more engaging and interactive experience. These technologies can enhance training, maintenance and troubleshooting processes. Improved HMIs can provide control-system operators with better situational awareness, allowing them to make more informed decisions. As a result, productivity may increase, mistakes may go down, and safety may go up.

Incorporating advanced technologies into control systems requires us to be mindful of several ethical concerns, centered around protecting privacy and ensuring security. They also raise the possibility that automation may eventually replace human operators. Therefore, proper consideration and regulation are necessary. The integration of technology into control systems also raises concerns such as algorithmic bias, privacy and accountability. Responsible design and governance ensure that ethical considerations are taken into account.

Emerging technologies have transformative potential for controls engineering. Continuous learning, adaptation and innovation are essential for harnessing this potential and driving progress forward in the field. CD

Shawn Cox is a licensed master electrician/PLC programmer. He was co-owner/operator of Bobby Cox Electric for 15 years and is currently employed by BMW Manufacturing as an ESA.

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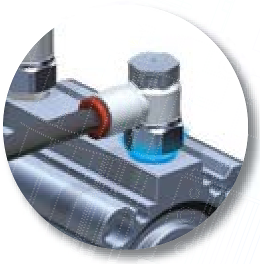
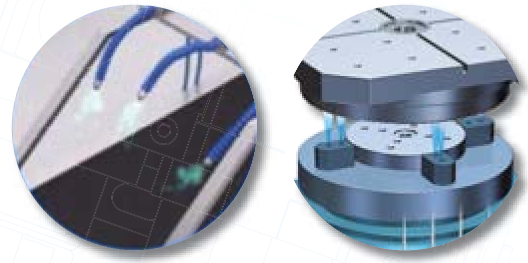


Leakage from piping connections due to poor piping installation

Leakage from cylinder due to worn seals



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Energize Your Efficiency

Data infusion enhances simulation software

Model accuracy, closed-loop behavior improve with deep-learning algorithms

by Mike Bacidore, editor in chief

SIMULATION SOFTWARE ALLOWS users to optimize designs of new product generations. From CAD to CAM, simulation leads the way. The software couples the virtual world with the real world, providing results from simulated processes that can be used to fine-tune operations and procedures.

Advancements in real-time simulation of mechanical systems enable the rapid evaluation of hardware, software and human-in-the-loop scenarios. And, with cloud-native tools, software can deploy CAD and simulation to an entire enterprise.

Testing specific loads and constraints that might have caused previous models to fail is a tried and true application of simulation software, but these five industry veterans foresee an expansive future where data-rich environments become hotbeds of virtual growth.

Prashant Srinivasan is director of AI products & applications at SymphonyAI Industrial.

Todd Kraft is CAD product manager at PTC.

Greg Brown is vice president of product management at Onshape.

Dean Palfreyman is senior director, Simulia strategy, at Dassault Systèmes.

Shankar Karanth is the head of global delivery at Axcend Automation & Software Solutions, a CSIA-certified member of the Control System Integrators Association (CSIA). Karanth is a seasoned solution consultant and a program management professional with about three decades of experience in various technology roles.

What have been the biggest improvements to simulation-software technology in the past five years?

Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: The biggest improvements we've seen in simulation-software technology is the powerful digital-twin concept with real-time data feed helping vastly in higher productivity, safety, response times, quality and utilization.

Coupled with powerful 3D visualization and multi-physics capabilities, the simulation tools power the digital twins to move beyond static models and simulate real-life functions and predictive actions.

Simulation tools have also become multi-faceted and integration-friendly in the recent years. In the past, there were dedicated tools for different simulations such as mechanical system simulations, control logic simulations including PLC signals and responses, and operations simulations.

With integration capabilities, some simulation tools can take in industrial engineering data and simulate mechanical parameters like replicating speeds, loads, temperatures, pressures and inertia for the given operations data. This has enabled manufacturers to understand machine loading, capacity planning far better than before and enhance the virtual commissioning process to give better and more realistic results.

Another area of improvement we've seen is the ease of use. Many simulation tools come with pre-built components and visual interfaces to build the models. This has accelerated complex model development without the need for expert knowledge and has eased up the process of changing the model parameters.

Dean Palfreyman, senior director, Simulia strategy, **Dassault Systèmes**: Certainly, there have been advances in simulation technology to solve a wide array of complex engineering problems related to advanced materials, structural integrity, electromagnetics, aerodynamics, acoustics and control systems. Additionally, advancements in process automation and optimization technologies make it possible for product-development teams to automate the process of evaluating hundreds or even thousands of design options using design-of-experiments (DOE) applications.

However, beyond the technology advances themselves, the integration improvements related to data management, 3D design, multiphysics simulation and manufacturing applications on a unified platform are providing the foundation needed for digital transformation in manufacturing organizations.

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: The biggest improvement has been the infusion of data into simulation software in many different ways to enhance the outcomes—for example, the integration of real-time data with simulation models to improve model accuracy, as well as simulate closed-loop behavior and plant operations in a more realistic manner. A powerful application of this is high-fidelity 3D virtual-reality simulations for operator training that integrate real-time data.

Integration of big data from the cloud can calibrate and validate simulation models for a wide range of scenarios, leveraging powerful and scalable hardware on the cloud and run very exhaustive what-if-analysis scenarios in a reasonable amount of time.

What's the most innovative or efficient simulation-software technology application you've ever seen or been involved with?

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: We have developed an AI digital-twin model and a real-time optimizer for optimizing energy, throughput and quality in melting furnaces. The real-time simulation is based on explainable deep-learning models that can accurately predict or forecast temperatures at various locations on the furnace, taking into account all major inputs and disturbances in the process. The explainability feature of the model can give operators an idea of what variables are impacting the model prediction the most and why a certain action is being recommended by the optimizer. This is third-generation AI and brings in more context, insight and trust in the results of the simulation model.

Dean Palfreyman, senior director, Simulia strategy, **Dassault Systèmes**: It's amazing to see the advancements in real-time simulation of mechanical systems, which enable the rapid evaluation of hardware, software and human-in-the-loop scenarios (Figure 1). This is unique as it enables engineers to model and couple the virtual world with the real world. It is enabling the use of driving simulators to evaluate and improve vehicle handling and control systems in response to changing road conditions and driver reactions (Figure 2).

Beyond manufactured products, the same modeling and simulation technologies are being used within the life-sciences industry to develop virtual twins of the human body to evaluate and improve medical-device designs. For instance, when

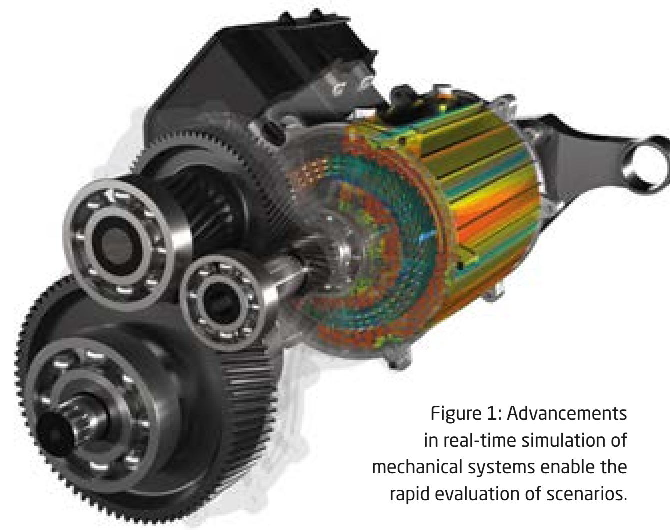


Figure 1: Advancements in real-time simulation of mechanical systems enable the rapid evaluation of scenarios.

Figure 2: The use of driving simulators can evaluate and improve vehicle handling and control systems in response to changing road conditions and driver reactions.

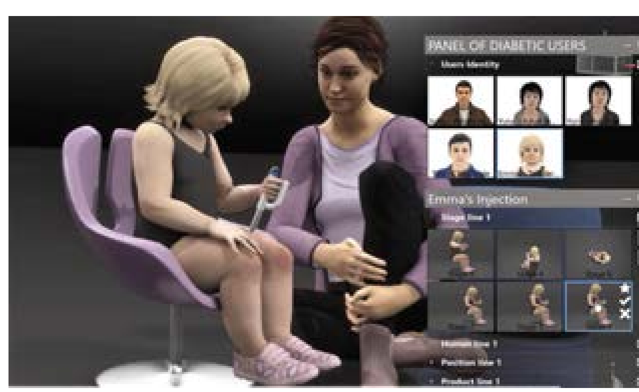
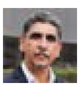


Figure 3: Designers can use a virtual twin of a human body to analyze the sizing and ergonomics of their device and the force required to insert a needle into the skin for various patient types, ranging from adults to children.

developing a drug-delivery device, designers can use a virtual twin of a human body to analyze the sizing and ergonomics of their device and the force required to insert a needle into the skin for various patient types, ranging from adults to children (Figure 3). Similarly, cardiac-implant makers can use a virtual twin of the heart to evaluate how an artificial heart valve will move during the cardiac cycle in a virtual patient before creating and testing a physical prototype.



Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: While we've developed many simulation-based solutions like virtual commissioning and process fine-tuning, a solution that we developed for an automotive-industry line builder to balance between performance and cost is what we would consider as an innovative solution using simulation tools.

We simulated an entire line to increase the throughput by 30% and reduce labor by 60%. We provided the user with what-if scenarios using various parameters like throughput, cycle time, equipment utilization and operator loading factor. This helped the line builder to recommend a smart line for the customer and take it forward for the actual commissioning process.

Another innovative solution we're building now is to combine artificial intelligence (AI) with discrete event simulation, which allows for better outcomes and predictability.

How has simulation-software technology benefitted from remote connectivity and networking?

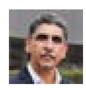
Greg Brown, vice president of product management, **Onshape**: Nothing is built by one person alone. We live in a highly connected world, where design, engineering and manufacturing teams are often globally dispersed. People have to communicate, especially finite element analysis (FEA) results, asynchronously off-line and collaboratively in person.

Remote connectivity and networking can only function with cloud-native simulation software.

There is not a more natural way to connect simulation with CAD than to unify it with the assembly. This allows users to co-edit a model in real-time with a colleague and watch the simulation results refresh interactively.

With cloud-native simulation, simulation is finally ready for a multi-user world.

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: Remote connectivity and networking have helped with seamless integration of data from manufacturing plants to simulation software via the cloud. It has also enabled remote collaborative development of highly complex simulation models accessing data from the cloud. Likewise, it has facilitated the smooth deployment of software updates/patches remotely. Finally, it has enabled running complex simulation models on the cloud, communicating data continuously with a manufacturing plant and providing rich insights and inferences to plant engineers and operators. Such solutions can easily be scaled to multiple similar plants across geographies, thanks to the power of networking and cloud.



Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: The main benefit we see for simulation software from the developments in remote connectivity and networking is access to simulations. This means empowering multi-plant simulations with centralized expert teams and better remote support which was helpful during the COVID-19 crisis. Another by-product of better networks and connectivity is the ability to upgrade the software remotely and faster.

Can you explain how improvements in simulation-software design and production have impacted industrial applications?

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: Improvement in simulation-software design and production have certainly increased the adoption and usability of industrial applications. It has also improved the productivity of the users in general.

Greg Brown, vice president of product management, **Onshape**: Many companies are just now returning to profitable growth after the economic downturn. Important industrial initiatives such as sustainability, which are often at the forefront, can become last in line due to budgets and resources. Product design, or computer-aided design (CAD), is one of the most critical technologies used to bring all kinds of industrial applications to life, and simulation goes right along with it, helping companies meet and exceed their goals.

Improving product design with simulation is how we build products with better materials, that reach longer lifespans and have better manufacturing techniques for a sustainable future that is economically realizable.

Simulation improves the quality of a product's design, the pace of the design team to market and the overall profitability of companies enabling teams to invest further into innovation and sustainability.

Dean Palfreyman, senior director, Simulia strategy, **Dassault Systèmes**: If you compare the cars of the 1980s to vehicles today, it's easy to see the improvements that occurred largely due to advances in computer-aided design and simulation technologies (Figure 4). Moreover, these performance and safety improvements are not just related to cars, but also aircraft, tires, toothbrushes, food packaging and just every product that we are using in our everyday lives.

However, product development and manufacturing organizations are facing ever-increasing challenges, ranging from a distributed workforce to disparate government regulations and sustainability mandates to increasing product complexity and the demand to lower costs and save time by eliminating physical prototypes.

Driver-assisted and autonomous vehicles are prime examples of the complexity and connectivity issues facing manufacturers across all industries. High-tech vehicles and products also require the integration of components and systems provided by suppliers. This added complexity makes it impossible to develop and manufacture in a siloed organization.

The only option is for manufacturers to leverage a platform that enables all stakeholders, including their suppliers, to manage their projects and data, design their products, simulate the functional performance of interdependent components and systems and collaborate on performance-based decisions efficiently and securely.

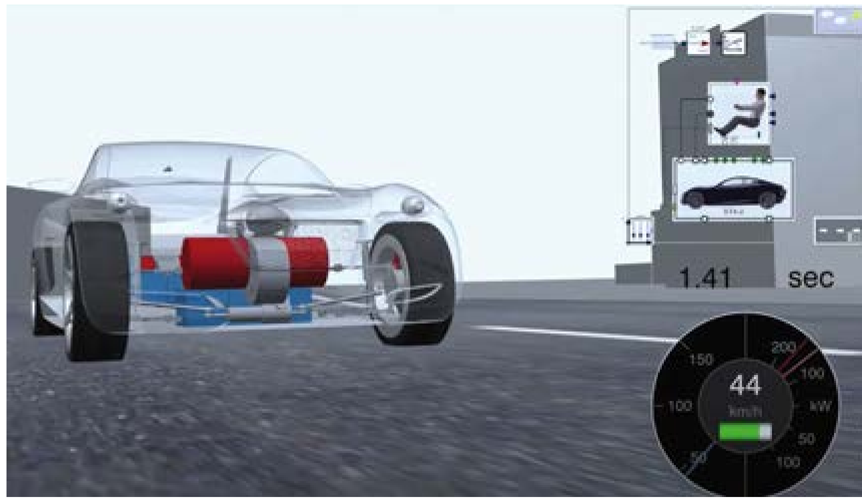
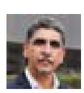


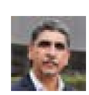
Figure 4: Automotive improvements have occurred largely due to advances in computer-aided design and simulation technologies.



Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: The ease of use and tools with pre-built components have impacted manufacturing positively. The improvements in simulation software have enabled better decision-making in several fronts and is not just limited to numerical modelling like in the past.

Also, simulation software is not just model-based but can be of several types and used in various stages within the industrial ecosystem. For example, from a product engineering and design perspective, simulation software has enabled industries to catch design defects much earlier than before, thus saving lots of cost to manufacturing enterprises. Similarly, in manufacturing and industrial engineering, the multivariate modelling in simulation software allows design of new processes, use of new materials and parts and the ability to see the impact of engineering and process changes much ahead of implementing them.

How do simulation-software technologies figure into digital-twin platform models being used by manufacturers?

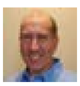


Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: Visual and 3D simulation tools have great potential to integrate and plug in with digital-twin platforms. There are some tools that do these already. Sophisticated models such as production processes, robotic simulation and test rigs can augur well for digital twin used by manufacturers.

On top of the simulated models, digital twin can include predictability by using real-time data from the operations.

Digital twin can also enable playback, which will allow manufacturers to see how a process was done in real life, so they can fine-tune the same where necessary.

A lot of improvement opportunities can be uncovered with the combination of simulation tools and digital twin.



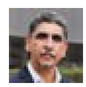
Todd Kraft, CAD product manager, **PTC**: For products that are constantly evolving and changing, simulation software can provide a means to test the design of the new generation of a product. A previous version of the product can be used as a benchmark to improve upon, and data collected by companies on how the previous model fared in the real world can be utilized to model these problems digitally. The goal here would be to optimize the new version now knowing the very specific loads and constraints that might have caused the previous model to fail.

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: Simulation-software models can be integrated into digital-twin-platform models in multiple ways, either by running as a compiled object or plugin within the platform and interfacing with the model or by running standalone remotely and pushing outputs into a cloud storage, which are then accessed by the digital-twin model. Sometimes a high-fidelity simulation model from the software may be used to provide operational boundaries and training data to extract a reduced order model that can be deployed as a component of the digital-twin model on a platform.

When will simulation-software technology become IT-friendly enough that engineers/ IT professionals are no longer required for installation and operation?

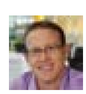
Dean Palfreyman, senior director, Simulia strategy, **Dassault Systèmes**: Design and simulation software can be installed on a personal computer or laptop without significant IT knowledge or support. Alternatively, the applications can be accessed through a cloud subscription with no installation or IT support required. Many startups and small- to medium-size businesses are taking advantage of this to minimize their computing hardware and IT infrastructure requirements.

However, large organizations, with high-security requirements or those who are developing complex products across a global team still use their internal IT operations and private networks. Due to this, there will continue to be a need for IT organizations to support networks and software installations. However, third-party cloud offerings are providing alternatives to in-house IT for installing and managing software, which is becoming attractive to many larger businesses who are under pressure to reduce overhead costs.



Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: With the prevalence of cloud, we believe simulation software will also lend itself to the cloud where only the manufacturing subject matter expert will be needed to create the simulation models without help from IT. Many simulation tools are beginning to have web-based options with no installation and configuration needs.

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: The focus in the industry on more intuitive user interfaces and user-friendly self-service capabilities, as well as infusion of artificial intelligence into software technology, are some steps being taken in that direction. We expect that the transformation will happen over the next decade in a gradual manner. There will always be some niche technical areas where engineers or technical experts are still required to help users out.



Greg Brown, vice president of product management, **Onshape**: Now. Today. We are already here at this milestone and doing more. With cloud-native tools, simulation software can deploy CAD and simulation to an enterprise with ease.

What future innovations will impact the use of simulation-software technology in manufacturing operations?

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: The following future innovations could make an impact on simulation-software technology in manufacturing.

Integration of diverse types of data sources—unstructured text/logs, images, videos, voice—and artificial intelligence in simulation software will provide more context and insight into the results.

Innovations in user experience and human interface with simulation software will make the experience more intuitive and interactive for operators and users.

Dean Palfreyman, senior director, Simulia strategy, **Dassault Systèmes**: There are a number of macro-innovations that are affecting the use and benefits of simulation technology. To name a few, artificial-intelligence (AI)/machine-learning (ML) technology is accelerating the process of creating and computing a simulation as well as providing deeper insight into data derived from simulation. The ability to create dynamic surrogate models providing real-time scenario-centric feedback to improve products in operation with a high degree of accuracy. This is particularly important for predictive maintenance. A continuing issue for product development teams is the ability to seamlessly—the operative word—unify their designs and multiple physics together to simulate complex product and system scenarios to gain deeper insight into their product and system behavior.

Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: Better graphical-processing and AI-processing engines will impact simulation software positively with the ability to model complex geometries that are closer to real-life. We believe the strides in this area will also make simulation tools more accessible and less expensive to propel usage in manufacturing operations. Another impactful innovation we foresee is the rise of concepts such as metaverse, which we envisage will make collaboration on simulation models easier and better.

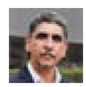
Greg Brown, vice president of product management, **Onshape**: The Internet. We are here at 5G and cloud, so what's next, 6G and Blue Sky?

The next generation, 6G, will likely bring applications with even higher throughput requirements including massive Internet-of-Things (IoT) machine-to-machine (M2M) communications, tactile Internet, and augmented-reality/virtual-reality (AR/VR) environments.

We are likely to see further connectivity of people, processes and data with continued investments in sophisticated automation. One example would be direct CAD to computer-aided manufacturing (CAM) connections for cloud product development and manufacturing, so more manufacturing as a service (MaaS), equipment as a service (EaaS), everything as a service.

In this case, we are also likely to see more consolidation on industry formats for cloud-native application-programming-interface (API) exchange so that cloud solutions can interoperate with each other efficiently.

Tell us about your company's state-of-the-art simulation-software technology.

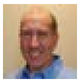


Shankar Karanth, head of global delivery, **Axcend Automation & Software Solutions**, a CSIA-certified member of the Control System Integrators Association: At Axcend, we've seen several innovative uses of simulation technology, especially with digital manufacturing becoming mainstream and with modern manufacturing becoming complex. The simulation tools we use depends upon the problem statement that we discover with our customers. Typically, simulation tools will be combined with other technology solutions to derive the best benefits for our customers.

For example, we've made a digital twin powered by simulation by using Visual Components software and combining it with our custom-built application to feed in real-time data from the shopfloor and compare actual progress with benchmark scenarios, thus being able to predict outcomes more realistically.

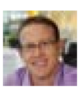
We also have experience in using other software tools such as Simul8, PlantSim and Process Simulate for developing digital-factory concepts and Industry 4.0 solutions for discrete event simulation, process validation and fine tuning, human ergonomics analysis and virtual commissioning.

Prashant Srinivasan, director of AI products & applications, **SymphonyAI Industrial**: SymphonyAI Industrial's Performance 360 software features simulation capability using a combination of data-driven AI/ML models and first-principles-based physics models. The data-driven models leverage deep-learning algorithms such as recurrent neural networks (RNN), long short-term memory (LSTM), transformers and deep-state space models, while the physics-based models cover thermodynamic simulations, heat and mass balance equations, and equations of state. This software has been applied across industrial assets such as compressors, turbines, pumps, heat exchangers and furnaces, as well as for system-level simulations including refinery pre-heat train and combined cycle power plant.



Todd Kraft, CAD product manager, **PTC**: Designed uniquely for the engineer, PTC has a robust arsenal of simulation software that has the familiar Creo user interface, engineering terminology and seamless integration with CAD and CAE data. You have at your fingertips an easy-to-use structural, thermal and vibration analysis solution with a comprehensive set of finite elements analysis (FEA) capabilities.

In recent years PTC has integrated Ansys technology into Creo to create two products. The first, Creo Simulation Live, provides design engineers instantaneous structural, thermal, modal and fluid flow design guidance, disrupting the traditional, time-intensive design process with instant feedback through real-time simulation. The second product, Creo Ansys Simulation, is a fully featured, high-fidelity simulation tool which leverages Ansys' capabilities for thermal, structural and modal analyses directly within Creo.



Greg Brown, vice president of product management, **Onshape**: Onshape is known to be the fastest-growing CAD platform, and the response to our new cloud-native simulation tool has been overwhelmingly positive.

Onshape Simulation will change designers' expectations and workflows: You can set up and solve full assembly-level static simulations in seconds, which is to say that Onshape Simulation is by far, the fastest and easiest way for CAD designers to get meaningful and timely decision support on the behavior of their designs under load.

Onshape serves many fast-moving industries that need a platform for agile product development, so having finite element analysis (FEA) built-in to the assembly environment just makes sense.

As part of the Onshape Doc, your assembly and your FEA analysis stay in sync throughout your design process, and FEA results can be simply refreshed as your design changes.

Users can do analysis as early and as often as needed, more quickly identifying the best- and worst-performing aspects of their models.

Furthermore, there are no steep learning curves required to benefit from this new analysis tool. If you know how to use Onshape, you already know how to use Onshape Simulation.

Dean Palfreyman, senior director, Simulia strategy, **Dassault Systèmes**: Dassault Systèmes' 3DExperience platform provides a unified, digital environment that enables manufacturing organizations to leverage applications from Dassault Systèmes' world-class brands including, among others, Enovia for planning and product lifecycle management, Catia for product design and systems engineering, Simulia for realistic simulation of virtual prototypes and Delmia for planning and simulation of manufacturing facilities and operations.

Global development teams are using the platform and applications to manage their product development lifecycles and collaborate on meeting business and functional requirements from research and concept phases to detailed designs, virtual testing, manufacturing and product retirement.

By bringing people, technology and processes together on the platform, manufacturing organizations are able to accelerate innovation and meet their business and sustainability goals.

Dassault Systèmes' 3DExperience platform enables our clients to leverage a geometry model to analyze a range of functional performance attributes and share the simulation results to collaborate on performance-based decisions and optimize their designs before committing to a physical prototype.

Remote working during the COVID-19 pandemic was a proving ground of the benefits and capabilities of remote connectivity. Dassault Systèmes has a long history of providing networked and on-cloud deployment options, providing access from anywhere, at any time, on any device.

However, remote connectivity is not just about connecting users to their software; it's also about connecting people to each other. All the required applications and associated data are available on 3DExperience on-cloud to multiple user types, such as designers, industry process specialists, simulation experts, and manufacturing teams so they can collaborate on their projects securely, in real-time and across global time zones.

Dassault Systèmes delivers a virtual twin experience through our 3DExperience platform. A virtual-twin experience lets you visualize, model and simulate sophisticated experiences. Starting with a 3D model that represents the shape, dimensions and properties of a physical product or system, simulations are run on that virtual model to explore how the product will behave when assembled, operated or manufactured.

The 3DExperience platform is built on a data model that combines a description of products' requirements, static and dynamic behaviors, logical and physical models. This drives model-based system engineering of virtual twins at every stage. From regulatory requirements, materials and functional design to manufacturing and the customer's experience, every stage can be modeled, simulated and manipulated. This capability extends into connecting a virtual twin of the factory with the real shop-floor operations for simulation, optimization and planning maintenance activities. cd

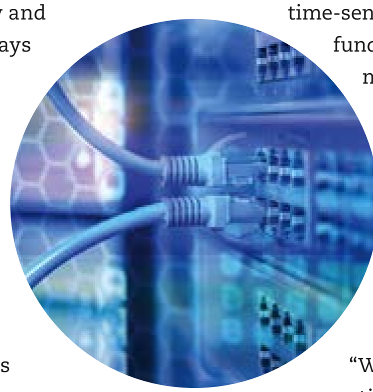
8 reasons Ethernet has endured for 50 years

Ethernet Alliance discusses the flexibility, adaptability and power of Ethernet

By Anna Townshend, managing editor

THIS YEAR ETHERNET REACHES ITS 50TH ANNIVERSARY. Designed to be adaptable and flexible, this has allowed Ethernet to mature and transform for decades. For more on how the Ethernet Alliance is celebrating Ethernet's beginning and the evolution of its global reach, read "Ethernet celebrates 50 years" on www.controldesign.com.

1 Ethernet is the technology that underpins the Internet.
"Ethernet has succeeded by building a comprehensive, open community that provides the technology that underpins the Internet. It specifies just enough to satisfy the customer need, maintains an intense focus on interoperability and adapts to changing needs and technologies," says Peter Jones, Ethernet Alliance chair and engineer at the Cisco Networking hardware team.



2 Ethernet is constantly evolving.
"Ethernet constantly evolves to address new use cases—moving data from the cloud to the edge to serve an increasingly smart and connected world," says Sam Johnson, Ethernet Alliance, Higher-Speed Networking subcommittee co-chair and manager of the link applications engineering team at Intel's cloud networking group.

3 Ethernet adaptability is not by accident.
"Ethernet is not constrained by cable or connection—hence, its use over myriad copper or fiber cables. This adaptability is not by accident; rather, it's a product of the combined efforts of engineers across the world who come together to maintain and innovate the underlying standards," says David J. Rodgers, Ethernet Alliance events and conferences chair and business development manager at Exfo.

4 Ethernet has brought about change at a global level.
"Ethernet and IEEE 802.3 in general constitute some of the world's best engineers and international organizational principals in work collaboration and development. The transformative nature of networking technology now impacts us and our communities for the better in countless ways," says John Calvin, Ethernet Alliance board member and strategic planner and DataCom technology lead at Keysight Technologies.

5 Ethernet will seamlessly power AI/ML.
"It is truly remarkable to see how Ethernet, born 50 years ago, is still going strong. As the data being generated in our digital life continues to grow, Ethernet technology will be the networking technology of choice for a seamless digital experience powered by artificial intelligence and machine learning," says Kishore Racherla, Ethernet Alliance board member and product manager at Broadcom.

6 Time-sensitive networking will change manufacturing.
"The Ethernet innovation that I am most excited about is time-sensitive networking. This emerging use case will fundamentally change transportation and industrial manufacturing by enabling unprecedented component synchronization and coordination. This could not be possible without the recent enhancements built upon Ethernet over the past few years," says Carl Wilson, Ethernet Alliance secretary and Ethernet silicon and technology planner at Intel's Ethernet products group.

7 Ethernet is the fabric of connectedness.
"We can solve large problems and get answers to questions through the virtue of being connected one to another—you to me, both of us to others and all of us to computers and storage. Ethernet is a key part to our interconnectedness. We are much more powerful and capable due to our interconnectedness, as well as more inclusive than ever before. Thank you, Ethernet," says Pavel Zivny, Ethernet Alliance, Higher-Speed Networking subcommittee co-chair and high-speed serial data domain expert at Tektronix's wide band oscilloscopes group.

8 Ethernet helps leverage information transparency.
"Ethernet will not only monitor/communicate/control connected assets but also will provide power delivery. As we approach a complete Ethernet footprint from cloud to edge, enabled by technologies like single-pair Ethernet, we'll further leverage the transparency and availability of information from all facets of the enterprise," says Bob Voss, Single-Pair Ethernet subcommittee chair, Ethernet Alliance and engineer at Panduit Corporate Research and Development. cd

What OEMs need when they need it

CHRIS WADSWORTH
Vice President and General Manager, Global OEM, Wesco

Wesco builds, connects, powers and protects the world. Delivering ingenuity and expertise to approximately 150,000 customers worldwide, Wesco helps businesses run smoothly by providing solutions that can increase profitability, improve productivity and mitigate risk. With nearly 1.5 million products and locations in more than 50 countries, Wesco delivers what companies need when they need it.

Q: In your opinion, what is the difference between the services offered by a value-added automation distributor and a system integrator?

A: That is a great question and can be confusing. I believe the biggest difference is where there is potential overlap in value-added services and in the handoff between the distributor and integrator. Each has unique capabilities and value propositions. An automation distributor brings franchise ownership and technical resources, as well as a deep supply-chain capability, but really stops at the point of installation. The integrator provides a much more technical value-added skill set, including commission, programing, customizing and aftermarket service for the solution. The value-adds are very vast from basic kiting all the way to integrated control design and even panel building. I see the automation distributor and the integrator as partners that complement the solution for the customer to optimize the success of the program or project.

Q: How much has the availability of components improved since the backlog of orders in previous years due to the global pandemic and supply-chain disruptions? What types of devices are still problematic?

A: The supply chain has definitely improved regarding both availability and improving lead times across the large majority of the supply base. As I say that, there are a number of problematic product categories that continue to keep supply from meeting demand and limiting potential sales growth and development. We all hear about the chip shortage as that gets daily press. What we have seen across the industry is that a number of legacy or older technology is not being invested in by manufactures which has forced many original equipment manufacturers (OEMs) to upgrade old technology and find alternate sources of supply.

This takes time and has created large backlogs and supply disruptions. What we do not hear as much about are the highly engineered products, such as switchgear that support both commercial construction projects but can also affect OEMs powering equipment. As products such as switchgear have long lead times, the balance of the system cannot be executed, which has been tying up working capital and revenue recognition and really slowing potential sales growth.

Transformers are another example. Lead times can be out 12 to 15 months. Manufacturers have not invested in capacity for a multitude of reasons. As we look to drive a hardened grid to support electrification, we find ourselves governed by the capacity and lead-time challenges. These facts are working against demand that is out there for us all to gain.

Q: How much of a shift have you seen toward data collection and transmission, whether it be for analysis at the edge, at the enterprise level or in the cloud? What sorts of smart devices have become more prevalent as a result of company's pursuit of digital transformation?

A: Everything is migrating to the cloud, including enterprise-resource-planning (ERP) systems and basic applications, as well as edge device data. The shift is in play for sure, but I have to say we are all figuring out how to leverage and monetize the opportunity both for our customers and ourselves. Many platforms and methods exist.

I would say that most companies are very active with initiatives and diverse investments to figure this out. Making decision based on all this data is critical to all of us, and we all have opportunities to come up with creative and value-based solutions for our companies. Wesco has made a significant set of strategic investments in digitalization, and the smart devices are just one aspect of the long-term strategy.

I find very interesting all the sources for collecting data from lighting to cameras to onboard machine sensing, as we see all devices becoming smart. The intelligent devices are actively using the data to optimize production and overall equipment effectiveness (OEE), as well as using it to reduce equipment downtime via predictive-maintenance applications. Software development is also a high-growth area as well to support the use of these devices. The future is bright but very developmental at this point in the industry space.

Q: The skilled labor shortage has often prompted manufacturers to look further up the value chain for ways to compensate. How has the democratization of technology helped to alleviate the pressure to find competent workers, and what can factories and plants expect to find?

A: Since COVID, the skilled labor shortage has improved, but our company as well as many others across a diverse set of manufacturing and distribution are still struggling to get back to pre-COVID labor stability. While this is a challenge, it also presents an opportunity for a step change across these same key performance indicators (KPIs).

Companies are at a very wide range in their journeys to automate their operations. As a distribution company with a large solution set across automation products and solutions, we have both an internal and external opportunity to capitalize on this transition to automation.

WESCO DELIVERS
Nearly 1.5 million products are available in more than 50 countries.

Internally, we are on a digital transformation that includes warehouse automation solutions. Externally, we have diverse OEM firms, that build and support the warehouse automation revolution. Our industrial division is driving automation solutions on the plant floor driven by our automation's supplier software, machine learning and component advancements.

Companies are really being forced to drive these changes as another factor is the aging skilled labor force that we have relied on to keep our factories running. Many of those domain experts will be retired over the next five to 10 years, and that skill set is not being replaced at the rate necessary, which will drive an even greater need for automation in factories and distribution centers.

The worker of the future will need more of a technology-driven bias, and technology and artificial intelligence (AI) will continue to close the gap in the experience that has been forming for years and continues.

Q: Safety has become an increasingly expected part of machinery's control system, especially now with the popularity of collaborative robotic systems. What sorts of trends are you seeing in the way safety is being designed and implemented in manufacturing equipment and production lines?

A: Our automation suppliers have a significant bias in safety in their product portfolios, and many have grown their product diversification through acquisitions of safety-device and automation technology. Engineers also have the same bias in their design thinking about the worker safety as they automate machines and plant-floor applications.

These two trends complement each other very well and provide opportunity to drive productivity, quality and safety at the same time.

Safety is really the top-priority measurement of manufacturing KPIs and is expected by company executives, which is translating into the product advancement and integration in the systems and controls.

For more information, visit www.wesco.com/oem.

21 tools system integrators need

The right tools are essential for every system integrator who wants to be prepared for any situation that may arise

by Tracy Williams, Trace Automation

cover story

Every week, engineers from our company, Trace Automation, travel to clients' sites to ensure they're getting the most out of their systems and troubleshoot problems that inevitably arise. We fly anywhere our customers need us, whether it's the United States or abroad, and that affects the tools we take with us.

I've been in systems integration for so long—more than 30 years—that I've come to realize the same tools are always needed, so I keep them in my trusty bag at all times (Figure 1). I usually know what I will be working on when I travel to a client, and those tools take care of most, if not all, of my needs.

Figure 1: The same tools are always needed, so keep them in a trusty bag at all times.

Here's a list of 21 tools system integrators need in their bags.

1 All-weather paper, pocket and regular sizes
Used for taking notes that won't get easily destroyed in the field.

2 Pencil and pen combo
Everything you could possibly need to write with, all in one! My favorite is the Cross Tech3+ with black ink, red ink, and 0.5 mm pencil, but the Mitsubishi Premium Multi-Functional Pen & Pencil is great, too.

3 Multiple RJ45 Ethernet cables
I use these to connect to any Ethernet device in the control network. I carry good quality cables in three to four different lengths ranging from 6 ft to 25 ft, just in case.

4 RJ45-M12 Ethernet cable
When I need to make an Ethernet connection to a device, such as IO-Link, with M12 connectors.

5 Every USB connector available
You never know what connector you might run into while working with programmable logic controllers (PLCs), robots or printers.

6 Safety glasses
Most facilities will require you to wear safety glasses at least some of the time, but my vision is bad, so I have to wear expensive prescription safety glasses.

7 Earplugs
Many sites with large machinery and equipment require earplugs, and I prefer corded ones with a case, so I don't lose them and they are kept clean and tidy during storage.

8 Multitool
Always handy to have, regardless of what you are working on. I have a Leatherman that hangs off my belt at all times.

9 Phone charger
I carry a USB wall base and a USB charger cable for when my phone runs low during work. I have used both Apple and Android phones for work, and like them both.

10 PLC Tools IP Explorer Professional
A great tool to find and assign IP addresses on any Ethernet device that you don't know the IP address of.

11 PLC Tools SIM-ALP2 4-20 ma simulator and 0-10 Vdc generator
When you need to simulate analog inputs or drive analog output signals on PLCs or a distributed control system (DCS). I don't always carry this, but I'll bring it along if I'm going to a job with many loop checks.

12 Multimeter
Get a good multimeter! Make sure you have a high-quality lead set with alligator clips, so you don't have to hold the leads while you work. Also, meters with a magnetic hanger are great because you can hang them on something metal instead of holding them. I prefer the Fluke brand, but these days there are a ton of acceptable ones. For the love of God, do not show up to a job site with a cheap meter from some retail chain store!

13 USB to Ethernet
I carry lightweight laptops that don't have an Ethernet port, so I need this to connect to Ethernet devices. I've used several different brands, but I'm partial to TP-Link. I usually carry at least two with me, just in case I misplace one, and the ones with both USB and USB-C connections in one are awesome!

14 Insulated screwdrivers
You need a good screwdriver set for electrical work. There are lots of acceptable alternatives, but I prefer a smaller set just because of the limited space in my bag.

15 Wire cutters/strippers
In my line of work, I don't need to strip and cut wires that often, so I carry inexpensive ones. But if you're banging wires out all day, get professional strippers.

16 Fiber optic trimmer
I carry the free ones that usually come with fiber optic cables, but trimmers you pay for will work just as well. Too many times, I've run into a situation where someone cut fiber cables with diagonal cutters, which damaged the end of the cable and degraded the optic signal.

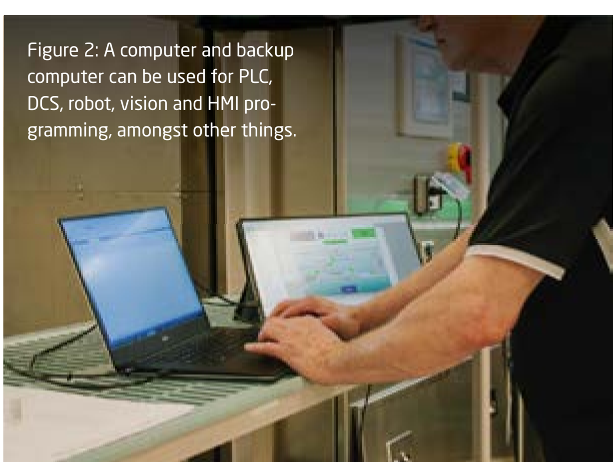


Figure 2: A computer and backup computer can be used for PLC, DCS, robot, vision and HMI programming, amongst other things.

17 Computer
It turns out a computer is not just for answering emails and searching for recipes! I use my computer for PLC, DCS, robot, vision and human-machine interface (HMI) programming, amongst other things (Figure 2). I mainly use a Dell XPS, but sometimes I use a gaming system when I need more graphics power. My current computer has an i7 processor, 32 GB of RAM, and a 1 TB solid-state hard drive.

18 Backup computer
I like the Microsoft Surface because it's lightweight and can double as a second monitor. My Surface has an i7 processor, 16 GB of RAM, and a 512 GB solid-state hard drive.

19 Portable monitor

I love that these give me more screen real estate. For example, I can view my PLC program on one screen and have the HMI program on the other. I've tried several of these, but I'm partial to ViewSonic. It's very affordable compared to the competition.

20 Portable switch/Ethernet splitter

I need this a lot because often there aren't enough available Ethernet ports on the equipment I work with.

21 Wireless router

Useful to plug into a network to give yourself wireless internet access. I've tried several different brands, but I found that a smaller one is easier to pack in the bag. Be sure to check with your client before using, however. Some companies have policies regarding internet access.

Figure 4: The right tools are essential for any system integrator who wants to be successful.

I carry all these tools in my beloved "bag," a Wenger SwissGear backpack (Figure 3). When I get to a job site, if I notice some items won't be needed, I'll lighten the load by moving those unnecessary tools to another bag I keep at the hotel. If I'm traveling for just a sales call, then I leave my big bag and laptop at home and use a different, smaller bag that my Surface tablet gets moved to.

Occasionally, I have to add something, such as cables or adapters, to the bag for specific jobs. Recently, I had to order a special programming cable for a client's old Mitsubishi FX series PLC before I traveled to the site. The job is now complete, and that item has since been sent back to the office for "safekeeping," meaning, if I need it again, it's unlikely we'll ever find it!

Figure 3: Carrying a well-stocked bag of tools will have you prepared for any situation that may arise.

On that note, I lose stuff all the time: Ethernet cables, routers, small hand tools. Something often gets left at a site whenever I visit. Sometimes, I leave things on purpose because multiple people have found a use for it, and I can't get it back without a fight! It's just become part of doing business and doing right by our clients.

Apparently, I'm a troublemaker, according to the Transportation Security Administration (TSA). I have so much stuff in this bag that causes issues with them these days that I put my bag in a suitcase that I check at the airport front desk. I'm not sure what's changed recently, but almost every time I open my checked bag, I find a TSA Notice of Baggage Inspection. I wonder what they must think!

The life of a system integrator is never without its challenges, but, with the right tools, we can tackle any problem that arises (Figure 4). The 21 tools listed here have proven their worth time and time again by providing convenience, improving efficiency and decreasing frustration. These tools have become my trusty companions and enable me to deliver exceptional service that exceeds our clients' expectations. In conclusion, having the right tools is essential for any system integrator who wants to be successful. cd

Tracy Williams is owner and principal engineer at Trace Automation. Contact him at tracy@traceautomation.com.

Terminate those connections

Terminal blocks and I/O systems ensure safe machines and operators

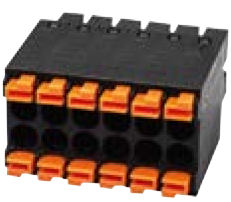
Weidmuller Klippon Connect

Weidmuller Klippon Connect Side Entry terminal blocks feature Weidmuller's patented lateral Push In technology, which is designed to reduce the connection times for terminal blocks by up to 50% and make connectivity tasks easier, faster, safer and more cost-efficient.

Weidmuller / www.weidmuller.com

Galco Terminal Blocks

Dinkle PCB connector plugs, connector sockets and terminal blocks are UL94V-0 flammability rated with an operating temperature of -40 to +120 °C (-40 to +248 °F). Available in pitch range from 2.54 mm to 10.16 mm, they are made from industrial grade (PA) with high tensile strength making them ideal for environments with extreme temperature fluctuations, intense vibrations and shocks. Connections actuation includes screw connection, push-in design, iron soldering, spring clamp and front screw and wave soldering designs are also available.



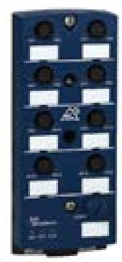
Galco / www.galco.com

Phoenix Contact XTV terminal blocks

Phoenix Contact XTV terminal blocks can accommodate the direct insertion of all conductor types: ferruled, solid or stranded wires. The XTV series features Push-X connection technology from Phoenix Contact. Push-X operates similarly to Phoenix Contact's Push-in Technology (PT) but uses a preloaded mousetrap design that keeps the leg spring depressed. As a result, the technician only needs to apply enough force to unlatch the spring and directly insert any type of wire. Tapping the inserted conductor triggers the preloaded contact spring and automatically establishes safe contact.

Phoenix Contact / www.phoenixcontact.com

Bihl+Wiedemann digital I/O

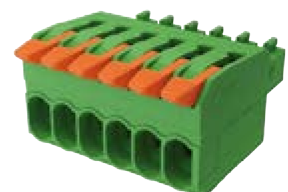


The BWU4230 is a self-configuring digital module with up to 16 digital input/outputs through ASi-5. Any digital signal can be used as an input or output, and the signal type can be changed without any additional software. Using the module is designed to help ease troubleshooting by offering channel-specific diagnostics. It can save up to 70% in wiring costs.

Bihl+Wiedemann / www.bihl-wiedemann.de/us/

Dinkle Push-in Lever UP

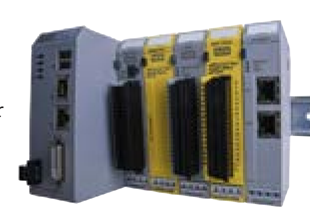
Dinkle Push-in Lever UP (P-LUP) product family PCB connectors accept bare stranded wire, bare solid wire or wires finished with ferrules. Solid wires and ferrules can take advantage of the Push-in connection features by being pushed into the terminal block for a rapid and secure connection, with no additional action needed. Users can choose to lift a lever to release the terminal tension so stranded wire, solid wire or ferrules can be inserted and then secured by pushing the lever. The 0256/0257 Series PCB Connector is designed for 100% tool-free operation, saving 70% wiring time.



Dinkle / www.dinkle.com

KEB America Safe I/O modules

KEB America Safety PLC, Safe I/O modules, and Safety PLC programming software is part of a full system solution designed by KEB. All safety products are TÜV Rheinland certified to IEC 61508 SIL3 and EN/ISO 13849-1 PL e. KEB's Safety PLC is a Fail Safe over EtherCAT (FSoE) master that is used in tandem with the machine PLC to execute and monitor the safety functions of the machinery. The Safety PLC connects with other FSoE slave modules like Safe I/O and Servo Drives with Safe Motion functionality. Each FSoE slave device has four safe inputs, two safe outputs and four OSSD outputs. One FSoE master can control up to 65,535 slave devices.



KEB America / www.kebamerica.com

product roundup

Advantech Slice IO expansion

The Advantech Ultra Compact Control Platform has Intel Atom Processor, 64GB eMMC, 2 x LAN, 2 x USB, 2 XxCAN, 2 x COM and Slice IO expansion. The AMAX-5570 is specially designed for machine and equipment builders, with Intel Atom 4 core

CPU series processors and optimized local expansion slots for general IT and OT applications. On board eMMC storage design minimizes the overall size and allows scalable local expansion with mPCIE and M.2 B key ports for further storage or wireless communication requirements. Extra Wi-Fi or cellular modules can be installed for uploading data to cloud servers.

Advantech / www.advantech.com

IDEC easy-stack terminal blocks

IDEC easy-stack terminal blocks are designed to provide flexible wire termination. BTBH-H surface mount terminal blocks provide any number of connection poles without special tools or fittings. These terminal blocks are designed to be stacked together or ordered preassembled to meet the needs of any commercial or industrial application. BTBH-H blocks are available in four different amp ratings—10 A, 15 A, 30 A and 50 A—and can be ordered as individual components or as complete assemblies by Amp rating for two to 30 poles. The terminal blocks are assembled in a twist- and snap-together fashion, without the need for special tools, connecting rods or DIN rails. Users can add or remove terminals at any time, as required by specification changes or maintenance work.

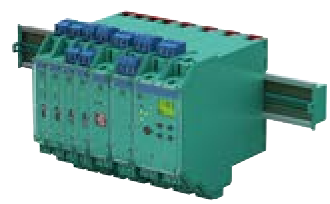
IDEC / www.idec.com/usa

Murrelektronik MVK Pro and Impact67 Pro

Murrelektronik MVK Pro and IMPACT67 Pro are part of Murrelektronik's collection of IO-Link master modules. Available for the Profinet, Ethernet/IP and EtherCAT protocols, each is equipped with eight multifunctional Class A/B IO-Link master ports allowing one module to serve as your choice of 16 DI, 16 DIO, 16 DO, 8 IOL. The two L-coded M12 ports in four- or five-pole options allow for daisy-chaining and provide up to 2 x 16 A power. By taking full advantage of IO-Link capabilities, these blocks are designed to get the needed input and output data from your machines and systems. Add in IO-Link hubs and analog converters, and you can connect digital and analog signals to this IO-Link master using a standard sensor cable.

Murrelektronik / www.murrinc.com

Pepperl+Fuchs K-System Intrinsic Safety Barriers



K-System from Pepperl+Fuchs offers a portfolio of isolators with a solution for any interface requirement. The power rail is designed to ensure simple, flexible mounting and power supply without complex point-to-point wiring. K-System offers an extensive range of more than 200 different intrinsic safety interface modules for many signals and applications, from simple isolators to highly functional modules. K-System is designed for a mixture of applications involving both Ex modules and non-Ex modules and they can be combined flexibly on the DIN mounting rail in a space-saving solution.

Pepperl+Fuchs / www.pepperl-fuchs.com

Siemens Failsafe I/O

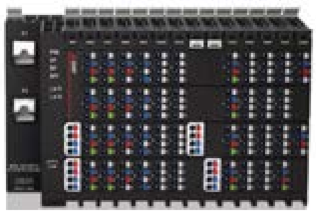
Siemens Failsafe IO, Simatic ET200 series, includes a variety of I/O systems, available for standard and fail-safe automation.

The modular design is designed to allow for scalability pf the ET 200 systems in small steps, for example, to expand with fail-safe I/O modules. Features include one system for standard and safety automation, uniform safety functionality for all Simatic devices, uniform operating capability of the TIA Portal enabling intuitive safety function engineering, compact design to reduce space required, seamless system for ease of use, and external safety solutions are not required

Siemens / www.siemens.com

Mitsubishi Electric Automation NZ2FT Series

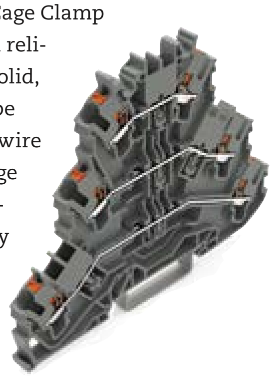
The Mitsubishi Electric Automation NZ2FT Series slice distributed I/O is compatible with the CC-Link IE TSN time-sensitive network. NZ2FT Series is a modular distributed I/O system that operates currently as a remote station for EtherNet/IP, Profibus DP, and Modbus TCP device-level networks. It offers a scalable architecture that accepts a range of mix-and-match I/O configurations. This type of remote I/O solution is designed for machine builders and manufacturing facilities seeking moderate concentrations of modular I/O. The product features the coupler module, power supply and compact I/O that assembles on a DIN rail to form a remote system or node.



Mitsubishi Electric Automation / https://us.mitsubishielectric.com/

Wago TopJob S triple-deck push button terminal block

Wago's TopJob S triple-deck push button terminal blocks is part of the TopJob S Series, featuring the Cage Clamp connection technology designed for a reliable, maintenance-free experience. Solid, stranded or ferruled conductors can be terminated simply by pushing in the wire or utilizing the easy-to-identify, orange push buttons. This comes with a variety of jumper types and has internally commoned terminals available, allowing six conductor landings in a footprint as small as 5.2 mm.



Wago / www.wago.com

Rockwell Automation on-machine distributed I/O

Rockwell Automation's Allen Bradley ArmorBlock 5000 I/O blocks are integrated with IO-Link technology. The distributed I/O is designed to offer smart capabilities that can help industrial manufacturers improve operational productivity with minimal cost. Manufacturers can deploy and maintain smart automation with the ArmorBlock 5000 I/O. With the highly integrated IO-Link capabilities, machine design complexity is designed to be reduced through simpler device configuration and better integration with Allen Bradley controllers.

Rockwell Automation / www.rockwellautomation.com

Beckhoff EPX Series EtherCAT I/O

Beckhoff EPX Series EtherCAT I/O offers a compact option for Ex i signal acquisition from zones 0/20, 1/21 and Div. 1 as an addition to the range of EtherCAT Box modules. With IP67 protection, they are designed to enable direct and decentralized installation on machines and systems, even in harsh environments. Interface options are available for the popular HART, NAMUR and FDT/DTM standards. The IP67-rated EPX modules are designed to enable reliable data collection, even in hazardous areas where no control cabinet or terminal box can or should be installed. The compact modular design leads to significant space savings. Furthermore, safety barriers are no longer necessary.

Beckhoff / www.beckhoff.com

Advantech WISE-4060LAN-B

The WISE-4000/LAN series is an IoT Ethernet I/O module which supports new RESTful web API for IoT applications. An HTML5 web configure interface enables users to configure WISE modules without a platform or operation system. The built-in data logger function logs data with time information, which can be retrieved in a bundle. Wide operating temperatures enable the WISE series to be implemented in more IoT data acquisition applications. The mechanical design can let users install the module and do diagnostics.

RS / us.rs-online.com

How to choose between a PLC and an IPC

A CONTROL DESIGN *reader writes:* I keep hearing about the great upsides of PC-based control platforms: lower cost and smaller footprint. Free product support is another upside, and the scan times are fractions of what a legacy programmable logic controller (PLC) or programmable automation controller (PAC) takes.

On the downside are the potential phase-outs of hardware and software that leave applications unsupported. A PLC's useful life is around 10 years, but industrial PCs are obsolete within three years.

Operating systems and hardware platforms are locked in step, and I've heard nightmares about the 32-bit/64-bit situation, as well as horror stories resulting from the retirement of Windows XP. Are the advantages of PC-based control worth the potential risks?

Figure 1: Good industrial computers incorporate different components to ensure machine builders a long availability.

Answers

Incorporate components that are available long-term

I believe that there is no right or wrong when distinguishing between traditional PLCs and PC-based control systems. Both have their pros and cons, and the choice of the right avenue might vary with the application and preference or direction of expertise.

While I do not want to comment too much on PLCs, as those seem to be a well-known architecture, I want to comment on the few points regarding the PCs—industrial PCs, to be precise.

When looking at commercial-grade personal computers, the statement about short product life is probably valid. Good industrial computers incorporate different components to ensure machine builders a long availability (Figure 1). The main processor—as the most critical component—should be, therefore, from Intel's long-term Embedded Roadmap, meaning that it is available somewhere between 7 to 15 years from its launch. Machine builders should consider buying an industrial computer that incorporates long-term available components and choose from new product families to benefit from the longest possible product life.

Similar is the topic with operating system. Industrial computers are often offered with long-term available operating-system distributions. While Windows 7, for instance, was taken off the market for the consumer and commercial market years ago, it is just phasing out for the industrial world now.

In terms of footprint/size comparison of a traditional PLC and an industrial PC, it probably depends on the application and the choice of hardware. I assume that the footprint can be in favor of each, depending on the platform and configuration. There are devices with particularly small footprints for both PLCs and for industrial computers.

What should be kept in mind are the benefits that come with each platform.

- Do I need hard real-time performance? A PLC might be the more solid choice, even though there are real-time-capable soft PLCs on the market.
- Do I need to store larger amounts of data locally? This is a clear benefit of an industrial computer, where storage space is easily scalable.
- Do I need an integrated human-machine-interface (HMI) screen? This is also a benefit for an industrial computer, where the machine builder can minimize the number of devices.

For product support, this is not a platform-specific question, in my opinion. There are manufacturers for both PLCs and industrial computers that charge for any kind of service or offer free service. This is rather a choice of the right partner—trusted vendor of industrial components. What is a true statement is that several components in an industrial computer are easily accessible and therefore serviceable or scalable, locally by machine builders or their customers.

BERND MATHIAS
operational manager—industrial PCs/ **Phoenix Contact**

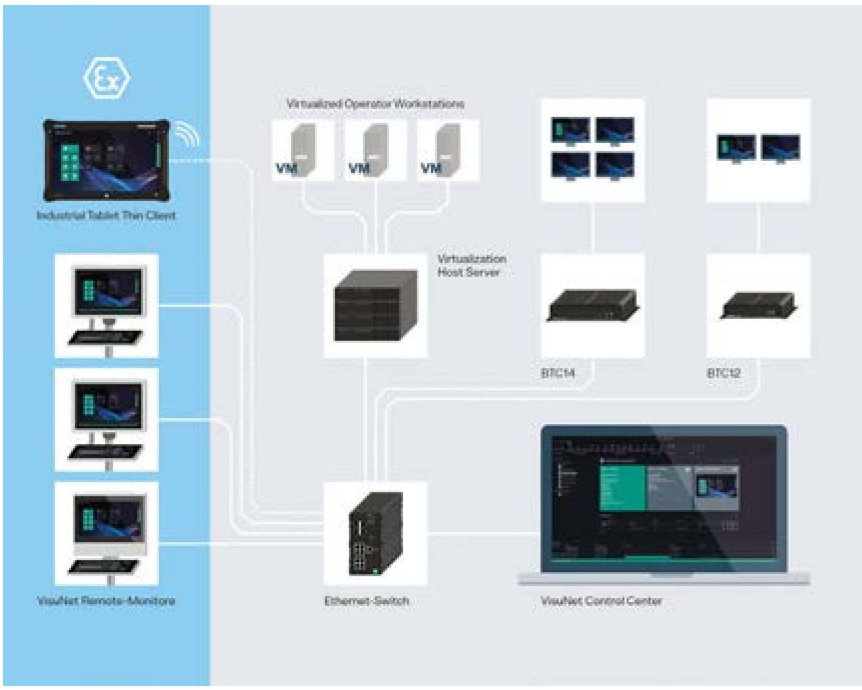


Figure 2: A thin client architecture, as opposed to running full PCs, would be connected back to the main server via a network protocol.

Thin-client architecture extends useful lifecycle

It honestly will depend on the specific application and the customer installation, but certainly there are benefits to using a PC-based control architecture that may outweigh any potential risks.

Windows versions will become obsolete over time; there is no question about that, but Microsoft does offer Enterprise long-term-servicing-channel (LTSC) versions, which have elongated support and patch releases along with other tools and features specifically for industrial customers. These versions can help ease the burden of software compatibly and extend the life of the used software platform.

PCs also tend to be a much more open architecture, which would allow for a variety of different software and hardware to be used depending on the application requirements. This is going to allow the user to be much more flexible in terms of designing and implementing the control system, especially if there are situations where the equipment must be located within industrial and/or hazardous classified areas.

Cost and scalability are also a topic that could be in favor of a PC-based solution. PCs will be easier to scale than a PLC-based application, as they can easily be updated to handle more data processing by simply adding more memory or processing power. Scaling a PLC in the same way is not always possible and could lead to additional costs and complexity.

An additional layer on top of the PC argumentation would be to implement a thin-client architecture as opposed to running full PCs. The thin clients would be connected back to the main server—virtualized or physical—via some type of network protocol, such as Microsoft Remote Desktop Protocol (RDP) or a virtual network computing (VNC) software, and allow for lower-cost hardware to be used within the industrial areas (Figure 2). Thin clients will ultimately have a longer useful lifecycle than traditional PCs due to their nature of design/usage and can save additional costs on installation, qualification and replacement over the course of five, 10 or 15 years.

AARON SEVERA

product manager–HMI, FieldConnex, remote IO /

Pepperl+Fuchs

Application-agnostic PCs embrace evolution more quickly

I suppose the answer here might depend on how quickly your company wants to be able to innovate. It's true that technologies, libraries, operating systems, protocols and everything else tend to move on more quickly toward obsolescence in the PC world than in the PLC world. But, to take another angle on this, those same factors moving more quickly in PC solutions also allow you to more readily embrace the rapid iterations and innovations that come along. Technology advancements are not done just for the fun of it.

There are deliberate motivations behind these changes. Each improvement is done with the intention of allowing users to do more, to do it on a greater scale and to do it with more efficiency. The same forces are applied in both PLCs and PCs, as, underneath it all, these share many commonalities. However, the fact that PCs are designed to be more application-agnostic and less hardware-oriented allows for evolution to take place more quickly.

Regardless of whether you take a stance that is more PLC or PC-centric, an important factor to consider is what dependencies your application has: is there a path forward, and does the vendor have a future-proof plan? The horror stories resulting from Windows XP's retirement weren't a result of the need for us to start building systems with a newer operating system.

These resulted from the plethora of software technology providers who had made no forward-looking plans for what comes next. No technology is going to be relevant forever. All will eventually face obsolescence. The key goal is to pick technology providers who have a vision and a plan for how to stay ahead of the curve and who can help carry you forward along the way.

JOTHAM KILDEA

solutions sales engineering supervisor / **Iconics**

Reduce the risk of choosing the wrong architecture

The breadth of applications for PC- and PLC-based control is increasing, and the line between PLC and PC is becoming more nebulous. Driven by the production pressures to reduce costs within manufacturing, increase finished goods part counts and establish a robust log of traceability data to clearly document quality, both PC- and PLC-based control architecture have their merits, many of which you have clearly articulated. The risks of choosing the wrong control architecture can be devastating, and you are absolutely correct in taking an objective perspective when comparing the two control-based architectures. Before we address the risks of PC-based control, two pieces of data should be gathered, the first being the prioritization of the facilities' objectives; the second are principles to compare each architecture's specifications to these objectives.

Each of the facilities' objectives, not only from the perspective of one department, but the facility as whole, should be paired with the facilities' pressures, which are incentivizing the achievement of the objectives, as well as the facilities' current challenges inhibiting the objectives from coming to reality immediately. This prioritization will help when guiding the selection between PC- and PLC-based control architectures and even between different PC and PLC manufacturers.

You are absolutely correct that phase-outs can become a source of risk. Moore's Law does limit the product lifecycle of specific PC models, and software development is continuing at an ever-increasing pace. When helping customers determine between PC- and PLC-based control, our team builds a rubric, focusing on machine performance, developing transparent and simple architecture and leaving future opportunities to easily harvest more data from the system.

Overlaying these three principles with the facilities' objectives can help focus the team on not only the obvious costs, such as hardware and software licensing, but also the hidden cost, such as first-pass yield or the opportunity cost of not pursuing other projects and training. Many vendors offer both PLC and IPC platforms for control as both have distinct value when helping facilities meet their production objectives. However, both control methodologies maximize machine performance, minimize architecture complexity without compromising robustness and allow for more data harvesting without incurring additional costs.

For the specific application, the value of a PC-based control system may be worth the risk, but it may not. Laying out your team's needs and future roadmap can offer both PC and PLC control the opportunity to create a solution, which not only generates returns, but also leaves the door open for sustaining that performance in change that is yet to come.

THOMAS KUCKHOFF

product manager—controller / **Omron Automation Americas**

Advantages and disadvantages of PLCs and IPCs

To begin, an important difference between an industrial PC and a PLC is the way it executes a program. A PLC is usually a scan-based program, whereas an IPC is event-driven. More businesses are wanting to make their operations more flexible and scalable, and PC-based control provides such capabilities. Understanding end users' needs and desire for continued growth and sustainability is vital to helping them select the right solution. Both PLCs and PC-based hardware have their place in modern facilities. You can combine them together to get the best of both worlds or look into PACs.

PLC advantages

- It's made for reliable operation in very harsh environments.
- Ease of programming and troubleshooting usually follows scan-based programmable software. See International Electrotechnical Commission (IEC) 61131-3 standard.
- Proprietary processors and unique operating systems are resistant to viruses and cyberattacks.
- It supports scalability with easy-to-add expansion modules and long lifecycles of 15 to 20 years.
- It is used in nearly every industry.

PLC disadvantages

- I/O options are limited since they're tied into the same manufacturer.
- It can be expensive.

An important difference between an industrial PC and a PLC is the way it executes a program.

IPC advantages

- New industrial PCs are even more resistant to harsh environments and extreme temperatures.
- It has enhanced programming capabilities and increased connectivity and investment value.
- It uses more widely known programming languages, such as C++, and is not tied to one hardware platform.
- It has communication between programmed controls and equipment.
- An IPC can control multiple functions on one platform and runs programs and applications that PLCs cannot.

IPC disadvantages

- They are difficult to upgrade when new Windows versions are released.
- Long-term product support is lacking.
- They are susceptible to hacking.

Gary Guess / product portfolio manager / RS

Built-in capabilities

Programmable logic controllers and PCs can be used to automate specific functions of machines, entire processes or even entire production lines. These processes can include timing, control, sequencing and starting and stopping motors, pumps and valves. The primary thing that sets PLC control apart from PC-based control is built-in or snap-on input/output (I/O). Many types of I/O can be combined in a PLC: analog, digital, thermocouple. While PC control systems have the same types of I/O available, the I/O is often distributed on a deterministic network.

Programmable logic controllers often need to be connected to other systems, typically PC-based, to complete tasks such as supervisory-control-and-data-acquisition (SCADA) and structured-query-language (SQL) database management. Often PC-based controls have these software features and network capabilities built-in.

Since IPCs use the same hardware and software as hundreds of millions of other PCs across the world, there are no shortages of new updates, products and technology to use. Industrial PCs are widely available, versatile and easy to implement into a system. When the hardware and software used in a system are so mainstream, it's guaranteed that users will always have state-of-the-art computing power at their fingertips. Industrial PCs often mimic a standard office PC in function, making them familiar to operate and maintain.

Industrial PCs may use Microsoft OS, Linux OS and other operating systems to control non-real-time tasks, which means IPCs can be used for multiple tasks beyond the cyclic control tasks. Additionally, IPCs can combine real-time operating systems with non-real-time operating systems. A real-time operating system is a computing environment that reacts to input within a deterministic time period. A real-time clock and turnaround reaction time can often be measured in microseconds. Industrial PCs also have easy connection to the network using Ethernet connectivity.

Industrial PCs are not a niche market. The cost to purchase and maintain these types of control systems are typically lower for a given processing speed or update rate. Industrial PCs also come in a wide range of sizes and power and can be purchased with options that include fanless or high IP ratings, such as IP67 or higher. Maintenance and replacement may be significantly easier and options to upgrade abound. Often, IPCs from one manufacturer can be replaced with an IPC from another. When processing or computing power becomes a limiting factor, there are usually options to upgrade the processor speed, memory, port options or number of network interface cards.

Industrial PCs have the capability to work with all controllers, including PLCs, and networks such as EtherCAT, Ethernet/IP and Modbus TCP/IP. This allows for a more streamlined, purpose-built control architecture that is flexible and scalable.

DANNY WEISS

senior product manager / **Newark**

The line between PC-based controllers and PLCs is blurred

I'm still a fan of traditional PLCs due to their longevity, long lifecycles and ruggedness. But many PLCs are, at their core, PC-based controllers, as they run a logic engine on a form of Linux or Windows IoT and offer many of the advantages typically associated with PCs, so the line between PC-based controllers and PLCs is becoming blurred.

However, a full-fledged PC can bring many advantages due to its sheer computing power. Industrial Internet of Things (IIoT) integration, databasing and higher-level languages are all very desirable in automation applications, and these are very achievable with PC-based controllers.

Take these precautions to mitigate some of the risks:

- Be sure to use an IPC rather than a standard PC in a cabinet. The ruggedness of the construction will result in a much longer lifespan.
- Be sure to work with a reputable manufacturer and discuss the expected lifespan and opportunities to extend the lifespan. I have worked with more than one company that manufactures IPCs, and they usually offer operating-system upgrades that can extend the useful lifespan of the hardware.
- When selecting a logic engine to run the control, consider a product that is hardware-independent and can be moved around. CoDeSys is a good example of a logic engine that runs on a vast array of operating systems and hardware platforms.

In conclusion, PC-based controllers offer a lot of value and should be considered; just do your homework and contingency planning.

TED THAYER
principal product marketing specialist—control / **Phoenix Contact**

PC-based control supports Industry 4.0

First off, you're right. PC-based control offers undeniable advantages compared to the legacy PLC approach. Industrial PCs (IPCs) offer an unbeatable price-to-performance ratio, and their scan times are incredibly fast (Figure 3).

Beyond that, PC-based control inherently supports the advanced functionality and communication needed to implement Industry 4.0 concepts. All these gains come with reduced hardware cost and footprint. A single IPC can incorporate the functionality of previously separate "black box" CPUs for motion control, safety, machine vision or robotic kinematics. And you can run advanced software—everything from analytics and machine learning to mechatronic transport systems and algorithms written with advanced model-based design toolboxes from MATLAB/Simulink—on one IPC along with the machine control logic.

It's also far easier to scale a PC-based platform. The ability to use modern version/source control via Git, GitHub or team foundation server (TFS) is another bonus. This allows programmers to maintain their code and collaborate between multiple programmers, while also drawing on a broad library of already developed options and examples. However, true support should go beyond that, and only some vendors offer free 24/7 support.

On a basic level that's really the answer to the concerns about PC-based control: You have to closely evaluate the vendor and understand what they're offering. An additional thought is that many of these past concerns are already resolved.

Figure 3: A mechatronics-enabled machine produces 200 varying stator hairpins for a major electric vehicle manufacturer. The combination of speed, power and flexibility, along with long-term availability, made PC-based control the optimal choice for the mission critical application. (Source: Beckhoff)

For starters, many IPC offerings in the market provide only around three years of "useful life" whereas industrial machines typically have a much longer lifespan. The shortened lifecycle of IPCs can be attributed to various reasons. One factor is the rapid changes made by vendors in terms of hardware and form factor, resulting in a lack of product consistency. Additionally, certain so-called "industrial" PCs are unable to withstand the harsh production environment adequately. Furthermore, operating system (OS) issues can render vendors' controllers outdated prematurely, even though they could have remained functional for many more years.

This is where you need to know your vendor and how they approach hardware and software. On the hardware side, some PC-based controllers provide a lifecycle of 10 years, plus another 10 years of service (Figure 4). And the vendor absolutely should guarantee, without conditions, that their IPCs and accompanying software can easily migrate to the next-generation CPU. Which, by the way, is not often guaranteed with PLC platforms, leading to total rip-and-replace scenarios of the controller, specialized I/O and more.

On the operating system side, look for options that can separate the PC-based control platform and OS. These don't have to be "locked in step" necessarily. That is, you shouldn't have to worry that Microsoft will make your machine control platform obsolete due to hardware upgrade restrictions. PC-based control means using standard PC CPUs and architecture for machine control, but this could mean many different operating systems.

With Windows, Microsoft sets the timeline and supported underlying hardware. Generally, vendors that have a long-term servicing channel (LTSC) with Microsoft can deliver the OS version, such as Windows 10, for a minimum 10-year lifespan. Windows works for many applications, and it will be offered by PC-based controls vendors far into the future. But it's not the only choice.

Alternative operating systems, such as TwinCAT/BSD based on FreeBSD, provide an opportunity for PC-based control manufacturers to have control over the supported operating system lifecycle on their hardware. FreeBSD is a Unix-compatible open-source operating system directly originating from Berkeley Software Distribution (BSD). These Unix-like options, including TwinCAT/BSD, offer several benefits, including enhanced system security and reduced image size, while still offering the flexibility to implement a hypervisor to run virtualized Windows or Linux when specific software is needed on those platforms. This opens up new possibilities and advantages for users seeking flexible and robust solutions for their PC-based control requirements.

Figure 4: Some PC-based controllers provide a lifecycle of 10 years, plus another 10 years of service. (Source: Beckhoff)

In regards to the 32-bit/64-bit situation, that has been resolved for over a decade. Around 2010, applications and operating systems had outgrown the 32-bit memory space and were migrating to 64-bit. This global transition included industrial controls—PLCs, PACs, IPCs and their engineering tools and runtimes (although lagging PLC vendors only supported 64-bit data types in the past couple of years). It also impacted user applications such as Microsoft Office and millions of others. The entire software and PC industry made the migration. From our perspective, that risk was mitigated long ago.

Despite the broad industry adoption and countless successes of PC-based control, the perception of "potential risks" lingers. Meanwhile, the PLC comfort zone faces some existential threats. Companies putting all their eggs in one basket will continue to have difficulty recruiting young engineering talent. New graduates, even from programs focused on controls and automation, are incredibly skilled in computer science technologies. And they're excited about these new STEM opportunities and modern controllers and programming languages, rather than struggling to get a dozen different black boxes to slowly execute in quasi-synchronized processes.

PC-based control creates a vast field of possibilities. There are plenty of considerations when comparing vendors, sure. But that's no reason to take a wait-and-see approach for the next decade to find there's no skilled labor left to complete your machine designs and programming on a slow, overpriced legacy platform. So we don't see it as asking you to make a supposedly "risky" investment in PC-based control. We're asking you to invest in your company's future.

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Safety first, or at least not last

INDUSTRIAL MACHINE SAFETY is a complex subject, as it deals with life and limb. Anyone who has designed the safety portion of an industrial machine quickly realizes that it can be a confusing ocean of rules, regulations, specifications and international standards, not to mention corporate rules.

This was probably why, at least in my first-hand experience, safety systems on prototype manufacturing equipment were typically defined and designed last. The typical safety systems of the not-so-distant past, and many present-day installations, were made up of a sea of hardwired single-purpose safety relays, electromechanical interlocks, e-stop buttons, light curtains and safety mats, all connected with seemingly miles of point-to-point 12-gauge wiring. The resultant number of terminations to the required relays and devices made troubleshooting wiring issues a difficult and time-consuming task. This is especially true on multi-zone safety implementations with layers of safety relays and associated wiring.

Additionally, the actual cause of any e-stop condition to the automation controller, and therefore communicated to the operator, could only be made through auxiliary contacts from the hardware devices, and there were not many of these built into the hardware safety devices. Determining the cause of the e-stop on a machine or production line could be a guessing game at best. Safety trumps system uptime every time.

In response, the early 2000s saw modifications to standards such as IEC 615081 and NFPA 792, which help to enable allowable safety networking requirements. As a result, multiple automation companies have introduced their own safety networking products that communicate safety data through standard fieldbus infrastructure. Similar to how fieldbuses originally replaced home-run wiring for control signals, safety networks also reduce a significant amount of the wiring complexity of a machine safety system.

Transmitting safety data over a standard fieldbus comes down to a black-channel approach. The safety data is segregated in its own container within the standard fieldbus communication telegram. The underlying packet of safety data does not rely on the physical or protocol layers of the fieldbus to be valid. The three ingredients for this approach are additional cyclic-redundancy checks (CRCs) in the safety data packet to detect corruption of safety data; data packet counters to detect missing packets of data; amd watchdog timers in the networked devices that are reset with each telegram. These three mechanisms allow the creation of the black channel. Additionally, no modifications are needed to the upper-level network, and the safety packet can be passed from protocol to protocol, as long as the three error-detecting parameters are satisfied. Safety devices now have a standard, simple fieldbus connection, and, internally, each device can service safety data into the black channel, while also copying the same or similar information for the automation controller, so the controller can indicate which e-stop is depressed.

> **Transmitting safety data over a standard fieldbus comes down to a black-channel approach.**

One additional major benefit is in the area of drives for rotating equipment, robotics and linear actuators. In 2006, IEC 61804-1 introduced a number of safe motion functions for drives, for example, to safely stop, go into a predefined safe-torque mode or move at a predetermined safe speed.

Initially, each of these commands was assigned to an individual hardwired input to the drive. This, again, required additional wiring, terminations and points of failure into the safety system. The market was quick to respond with drives that are themselves safety devices and can use the black-channel data to receive these safe commands via the same fieldbus connection that it receives motion data on. These same safety commands are being designed into additional devices such as stepper motors and variable-frequency drives (VFDs).

The definition of the safety schemes and selection of the safety devices can occur earlier in the design phase of a new machine line. Okay, maybe that's theoretical. At the worst, the safety team doesn't have to be the last in line in the design cycle, trying to figure out how to shoehorn in a safety system into a finished design. CD

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