October 2021

# InTech

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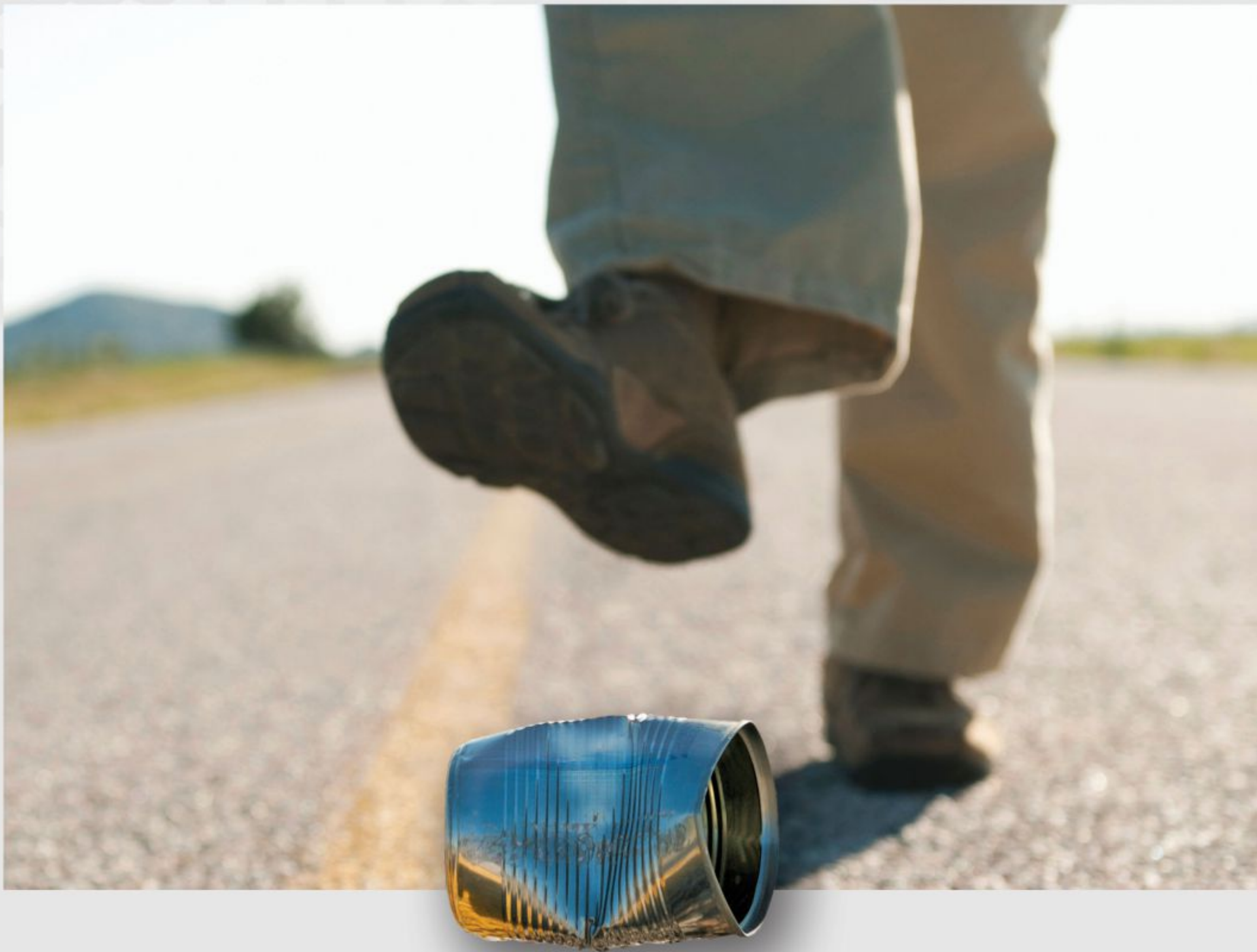

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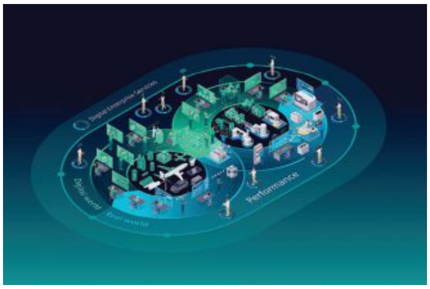

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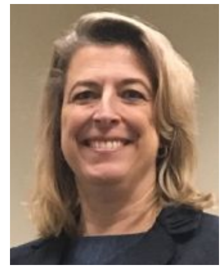
*InTech* provides thought-provoking and authoritative coverage of automation technologies, applications, and strategies to enhance automation professionals' on-the-job success. Published by the industry's leading organization, ISA, *InTech* addresses critical issues facing the rapidly changing world of industrial automation.

# The Essential Skill of Mastering Virtual Worlds



By Renee Bassett, *InTech* Chief Editor

Nowadays, "virtual" tends to mean online—that is, experienced through a desktop computer or handheld device. We use it to describe an interaction that does not take place in an in-person physical environment, like a virtual conference or virtual classroom. But the other meaning of the word is as an antonym to "actual." So when we say something is virtual, we are also saying that it is essentially not actual—that is, not "real."

The industrial virtual environments that are emerging, however, are real—and are very useful—thanks to the Industry 4.0 technologies being applied. Getting comfortable with and even mastering these virtual worlds might be the latest essential skill for industrial automation, control, and instrumentation professionals.

Work life has changed in the wake of the COVID-19 global pandemic, and many things may never go back to how they were. A recent Bloomberg article notes how business travel, for example, has been "forever changed"; 84 percent of large-business executives from the U.S., Europe, and Asia say they plan to spend less on travel by cutting both internal and external in-person meetings.

Manufacturing companies cited by Bloomberg note that technology is enabling them to do remotely what they had not dreamed of before. French tire maker Michelin used a drone so its top manufacturing executives could virtually visit its Campo Grande plant in Brazil. "We start machines remotely, have used drones to visit factories, and train people from home," said CEO Florent Menegaux.

Royal Dutch Shell Plc created online control rooms with interactive 3D simulations of oil platforms and plants to give engineers virtual access from home. Aptiv Plc, a former car parts unit of General Motors Co. based in Troy, Mich., used drones and Oculus augmented-reality headsets to show customers the manufacturing run rates of plants in Mexico, Hungary, and China.

In this issue of *InTech*, a closed-loop digital twin combined with programmable logic control and human-machine interface simulation enables off-site development and virtual commissioning (p. 36). The wireless networking of Industrial Internet of Things sensors (p. 32) is eliminating walk-by machine monitoring, especially for far-flung equipment. And augmented reality has become "authentic reality" for Jaguar Land Rover and ThyssenKrupp (p. 48).

As the CTO of Dell noted in a recent post about the shift to "visceral virtual experiences," soon "a no-frills video call interrupted by deeply irritating Internet lags won't cut the mustard. Hence, businesses should be actively investigating how they can build customer loyalty and affinity by providing a more sensory experience online." Make the virtual world more real, he says. "In fact, in this on-demand (online-services driven) world, businesses should be looking to create end-to-end environments rather than discrete, transactional substitutes."

I agree and contend that it will be the automation engineers who can best wrangle, as Dell puts it, "the emergence of immersive technologies, underpinned by a next-generation connective fabric, to more cogently, powerfully, and viscerally access virtual experiences."

Dell asks, "In this remote-first working world, what follows Zoom and Microsoft Teams?"

The answer, in the industrial space, may be the digital engineer who has mastered virtual worlds.

What do you think? Talk to me via LinkedIn or ISA Connect. ■

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# Understanding IIoT Application Programming Interfaces

By David Schultz

**ABOUT THE AUTHOR**

**David Schultz** has 25 years of automation and process control experience and currently helps manufacturers with digital transformation and asset management. He is president of the Milwaukee Section of ISA and actively involved in ISA's Digital Twin and AI/ML technical committees. He is also a member of the Society of Maintenance and Reliability Professionals (SMRP) and Project Management Institute (PMI).

Application programming interfaces (APIs) have been used for many years to allow computer programs to exchange information, but they are not as commonly used in manufacturing systems. As more systems are connected through Industry 4.0 initiatives, APIs will be more commonly used. It will be critical for control systems engineers and technicians to be able to make requests and parse the responses from APIs. Here is how APIs can be used for smart manufacturing and Industrial Internet of Things (IIoT) applications.

An API is a set of definitions and protocols that are used for building and integrating different application software so that they can communicate with each other. It can be thought of as an agreement between an information provider and consumer. The consumer will make a call or request (ask for information), and the provider will provide a response (give the information). The API defines how to formulate the question to get the desired answer. The API also defines how the answer will be provided.

**Within the context of Industry 4.0, manufacturing systems connected using APIs could include a SCADA system connected directly to a CMMS for creating and managing work orders.**

There are many types of APIs, but Representational State Transfer (REST), or RESTful APIs, are the most common. They are a defined structure using common Web protocols and data formats. When a consumer application wants information, it will make a Hypertext Transport Protocol (HTTP) request to the provider, which responds with the formatted data. Like APIs, there are many data formats that can be used, but JavaScript Object Notation (JSON) is the most popular due to its simple data structure. It should be noted that while it has Java in its name, JSON is language-agnostic, taking advantage of how data is assembled.

Another API that is sometimes used is a Simple Object Access Protocol (SOAP). Unlike REST, SOAP is much more structured, and little needs to be known about the request and response format. When using SOAP, the information provider uses a Web Services Description Language (WSDL) file to facilitate the data exchange. While this might seem easier, it has specific requirements that often make it slower and heavier.

## Types of applications

Within the context of Industry 4.0, many more manufacturing systems will be connected using APIs. For instance, a supervisory control and data acquisition (SCADA) system will connect directly to a computerized maintenance management system (CMMS) to create and manage work orders. Quality information, like instrument calibration data, will be historized along with process data. Data from disparate systems will be easily visualized from a common platform.

A typical scenario includes a line operator and a downtime event. Traditionally, when the event occurs, the operator attempts to fix the problem. If the situation requires a maintenance person, the contact is usually made through a radio or telephone. The technician arrives at the line and makes the repair, and the line starts running again. Only the line stop-time and start-time events are captured in real time. Other events (such as the work order, dispatch, arrival at the line) would not be known.

Using an API, the operator can generate a work order or work order request directly from the control system. The maintenance person is dispatched through the maintenance system. The technician logs into the control system, makes the repair, and then updates the status of the work order at the line. In this case, the work order generation, dispatch, and arrival times are all captured along with the downtime and start events.

APIs are not just limited to software systems. As more data is available from edge devices, such as instruments and sensors, the hardware that is used to connect these devices will use APIs. For instance, using a similar scenario to the one described above, a programmable logic controller controlling a remote asset like a compressor will use an API to make the request directly to the work order system based on operating conditions and states. The upside is that APIs are used to connect disparate devices and systems so that they can function more effectively and efficiently. ■

*A version of this article originally appeared on the ISA Interchange blog (https://blog.isa.org/application-programming-interfaces-in-iiot).*


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# Pandemic Casts Long Shadow as Labor Shortages Plague Manufacturers

The September update of the Manufacturing Industry Output Tracker from Interact Analysis looks at global industry as it moves into a post-COVID phase. "But perhaps use of the phrase "post-COVID" is to some extent premature, as the virus is still presenting challenges . . . and swathes of global industry are still suffering a hangover from the pandemic, with a number of negative factors playing out: vaccine hesitation, semiconductor shortages, and labor shortages being three major drags on sustained recovery," says CEO and research director Adrian Lloyd.

**The U.S. Bureau of Labor Statistics reports over 800,000 vacancies in manufacturing. Meanwhile, Germany has close to 150,000 job vacancies in the manufacturing sector, and the U.K. has 68,000.**

The struggle to recruit into manufacturing is unexpectedly hitting some big players, says Lloyd. "According to the latest available data, specific regions have been hit hard by labor shortages. The U.S. heads the list, with the U.S. Bureau of Labor Statistics reporting over 800,000 vacancies in manufacturing alone. Meanwhile, in Germany there are close to 150,000 job vacancies in the manufacturing sector, and 68,000 in the U.K. France, on the other hand, reported a mere 5,995 vacancies."

The temptation is to look at the U.S. first, where vacancies have skyrocketed, but Germany is perhaps more interesting. Traditionally the manufacturing powerhouse of Europe, Germany is currently struggling to reboot its manufacturing sector following the COVID shock. A recent report describes Germany (population 83 million) as a country with an aging population, a low birth rates, and a desperate need for skilled immigrant labor—much as it was at the time of the Gastarbeiter (guest worker) program in the 1960s.

The Federal Labor Agency chairman Detlef Scheele recently said that Germany must attract 400,000 skilled immigrants annually to keep up with demand across all sectors, including industry. This is in spite of the fact that, according to the Organisation for Economic Co-operation and Development (OECD), the country has one of the best-performing vocational education and training systems in the world. Scheele said that the country would have 150,000 fewer working-age residents this year alone. The pandemic had a major part to play, slowing migration and significantly reducing the numbers of skilled immigrants entering the workforce.

Across the pond from Europe, in the U.S., those 800,000+ job vacancies reported in May and June 2021 constitute double the number of vacancies for a similar period going back to 2011. This problem has been exacerbated by the high use of unemployment insurance benefits rather than job retention schemes. But pandemic unemployment benefits are scheduled to stop in quarter four of 2021, so we expect many vacancies to be filled. However, as in Germany, there has been a historical shortage of skilled manufacturing labor owing to an aging workforce. That is because the U.S. has had difficulties in attracting younger people into this sector.

The U.K. is the third major economy where job vacancies are high. The twin shocks of COVID and Brexit have taken their toll here. For either or both reasons, many E.U. workers have left the U.K. and do not intend to return, or cannot return owing to new post-Brexit immigration policies. There has been a resultant serious shortage of haulage drivers—100,000 being an oft-quoted figure, including 25,000 E.U. drivers—and a shortage of factory workers. The result has been a disruption of supply chains, particularly in the food and beverage sector. The Confederation of British Industry (CBI) has reported that general stock levels are at the lowest they have been for 40 years.

Other regions, such as the Asia-Pacific countries, have not suffered from the challenge of labor shortages in the same way as these three, but low vaccination rates and rising COVID infections have continued to slow production. The pandemic is casting a long shadow. ■


Autonomous operations come to the open ocean with Sea Machines' SM300 system, which uses computer vision and augmented reality. See page 13.

# Goal: Net Zero Emissions of Heavy Industrial Machinery

ABB has signed a memorandum of understanding with MEDATech to jointly explore ways to decarbonize mining operations through charging solutions and optimized electric drive systems in battery electric vehicles for heavy-duty applications. The two companies will share expertise and collaborate to reduce the greenhouse gas emissions associated with heavy machinery in mining.

Mining customers require approaches specifically designed for heavy industries so they can electrify their fleets and facilitate the transition to net zero emission transport across mining operations. Electric vehicles and matching charging infrastructure solutions must meet demanding requirements, including high power, automated and safe operation, ruggedized designs for harsh environmental conditions, and approved standards.

Mining operators require solutions specifically designed for heavy industries to enable the electrification of their fleets.

ABB launched ABB Ability eMine, an integrated portfolio of electrification and digital systems, to accelerate the decarbonization of the mining sector. MEDATech, located in Ontario, Canada, provides drive train technology to original equipment manufacturers and end users while developing optimization tools to efficiently and cost effectively implement electric fleets.

The ABB Ability eMine offerings can electrify mining equipment used for hoisting, grinding, hauling, and material handling and are integrated with digital applications and services to monitor and optimize energy use. eMine FastCharge will provide high-power electric charging for haul trucks and is currently in the pilot phase. It also incorporates the ABB Ability eMine Trolley System, which can reduce diesel consumption by up to 90 percent. ■

# Emerson Celebrates 75 Years of Welding Technologies

Emerson is celebrating the 75th anniversary of its Branson brand, a name said to be synonymous with ultrasonic technologies for plastics and metal welding, and precision cleaning. The Branson portfolio expanded beyond ultrasonics over the years with nine other material-joining technologies including laser, vibration, and infrared welding.

Emerson marked the anniversary at a new $49 million global headquarters for welding and precision cleaning technologies that opened in January. The new facility will focus on innovation in advanced design, engineering, and joining technologies for complex and fast-growing industries such as medical devices, existing and new bio-based plastics packaging, electric cars, and next-generation batteries.

The Branson brand traces its history to Norman G. Branson, a research engineer who founded a company in Danbury, Conn., in 1946 to harness the power of high-frequency ultrasonic energy for cleaning and degreasing applications as well as nondestructive testing and gauging. But it was ultrasonic welding—developed in 1963 at Branson Sonics and Materials, which was acquired by Emerson Electric Co. (Emerson) in 1984—that represented the real breakthrough for the company and for manufacturing.


"It set in motion a monumental change in the way plastics, and later metals, were joined," said Vernon Murray, president of Emerson's assembly technologies business. "We are extremely proud of our history and how we revolutionized the use of ultrasonics in so many remarkable ways." ■

# Jumpstart Fellowship Program Targets Girls for Robotics Careers

Following a successful pilot run of the MassRobotics Jumpstart Fellowship Program, applications for the second cohort are now open through 1 November. The Jumpstart program provides opportunities for diverse Massachusetts high school girls to learn about careers in robotics. It exposes them to technical skills and develops their professional networks through direct engagement with industry professionals.

This cohort will run from 8 January through 14 May 2022, and will meet on Saturdays, alternating between in-person meetings at the MassRobotics office and virtual sessions. It will also include a full week of sessions and field trips to robotics companies during the February school vacation week.

MassRobotics is the result of the collective work of a global group of engineers, rocket scientists, and entrepreneurs with a shared vision to create a strong, vibrant robotics and Internet of Things ecosystem. The Jumpstart curriculum exposes young women to the many technical skills needed within the robotics industry, from programming to design and simulation, to hands-on building, prototyping, and testing. A key part of the program is making sure these young women feel confident and empowered to enter the STEM field. Students will learn directly from mentors about the different types of robotics jobs and how to leverage their studies into a career in robotics through lab and company visits.

The curriculum includes expertise from MassRobotics' partners and the Massachusetts robotics ecosystem including SolidWorks, MathWorks, Lightspeed Manufacturing, and GreenSight. The first Jumpstart cohort was made possible through funding and support from The Boston Foundation, Dassault Systèmes' La Fondation, and Mass Tech Collaborative. ■

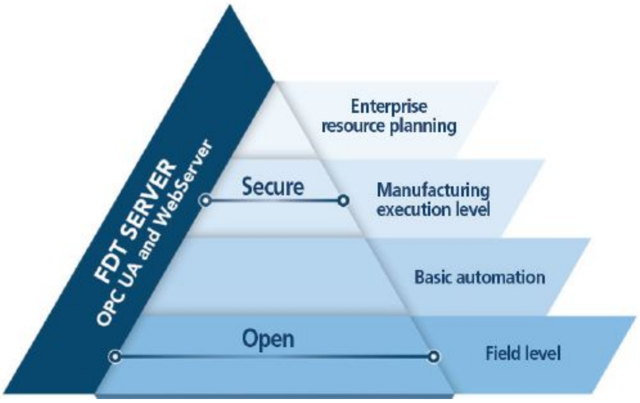
# FDT Group Evolves FDT 3.0 Toward Greater Openness

FDT Group continues to evolve its open standard for enterprise-wide network and asset integration as a data-centric platform with its updated FDT 3.0 standard. FDT 3.0 enables an ecosystem of FDT-based solutions to meet demands for Industrial Internet of Things (IIoT) and Industry 4.0 applications by supporting universal device integration, mobility, and remote access.

FDT 3.0 provides the industrial enterprise with native integration of the OPC Unified Architecture (OPC UA), as well as control and web services interfaces for mobile applications. The technology also employs multilayered security to safeguard critical automation information and operating data.

According to FDT Group, FDT 3.0 became platform independent by evolving the fundamental technology on which it was built, moving from a Windows-based .NET Framework to an open .NET core as well as to HTML5 and JavaScript. The use of HTML5-based development will allow FDT to be deployed on a much broader range of devices than in the past.

At the core of FDT 3.0 technology is the new FDT Server, which natively integrates an OPC UA Server for enterprise-wide data access and a web server mobilizing remote operations. FDT 3.0 is closely aligned with the NAMUR NE 175 Open Architecture initiative, which addresses asset monitoring and optimization requirements in industrial processing facilities. ■




FDT 3.0 provides the industrial enterprise with native integration of the OPC Unified Architecture (OPC UA), as well as control and web services interfaces for mobile applications.

# U.S. Manufacturing Technology Orders Up in July

New U.S. manufacturing technology orders totaled $472.6 million in July 2021, according to the latest "U.S. Manufacturing Technology Orders" report published by AMT–The Association for Manufacturing Technology. July 2021 orders saw a slight decrease of 5.6 percent from June but a 41.5 percent increase over July 2020 orders. The year-to-date total was just shy of $3 billion, a 48 percent increase from the total through July 2020.

"The amplified pace of orders over the past several months has injected a degree of confidence into manufacturing not seen since before the pandemic. Increased onshore capacity and diversified supply chains have made lead times more predictable and inventories more consistent, allowing manufacturers closer to end-use customers to justify the capital expenditures we are seeing in this month's USMTO orders," according to the report.

"While this is the general trend in manufacturing, there still are industries where supply chain issues remain an impediment, particularly industries whose products rely heavily on computer chips," the report said. ■

# Autonomous Operations Come to the Open Ocean

Autonomous vehicles navigating warehouse aisles are getting ever smarter at planning their own obstruction-free routes, but a new project named The Machine Odyssey–"harkening to Homer's *Odyssey* and the courage to undertake a voyage of discovery and adventure"—plans to take autonomy and remote control to a whole other level. A modern tug, the *Nellie Bly,* was scheduled to take a 1,000 nautical mile autonomous and remotely commanded journey around Denmark in September and October on a voyage designed to prove that the world's waterways are ready for long-range autonomy.

American venture-backed, deep-tech startup Sea Machines is providing full onboard vessel control managed by autonomous technology, while operating under the authority of commanding officers located in the U.S. The project intends to show that operators can integrate autonomous technology into their vessel operations, gaining benefits ranging from enhanced safety and reliability to "leaps in productivity and new on-water capabilities."

The Sea Machines SM300 autonomy system, which has long-range computer vision, uses advanced path planning, obstacle avoidance replanning, vectored nautical chart data, and dynamic domain perception, all to control a voyage from start to finish.

The SM300 will reportedly provide the remote human commanders with an active chart environment of live augmented overlays showing the mission, state of vessel, situational awareness, and environmental data, as well as real-time, vessel-born audio and video from many streaming cameras. Of course, Sea Machines also will stream 24/7 live updates from the sea, the crew, the command center, and more on a dedicated website (https://sea-machines.com/odyssey). ■

# Rockwell Automation Acquires ASEM

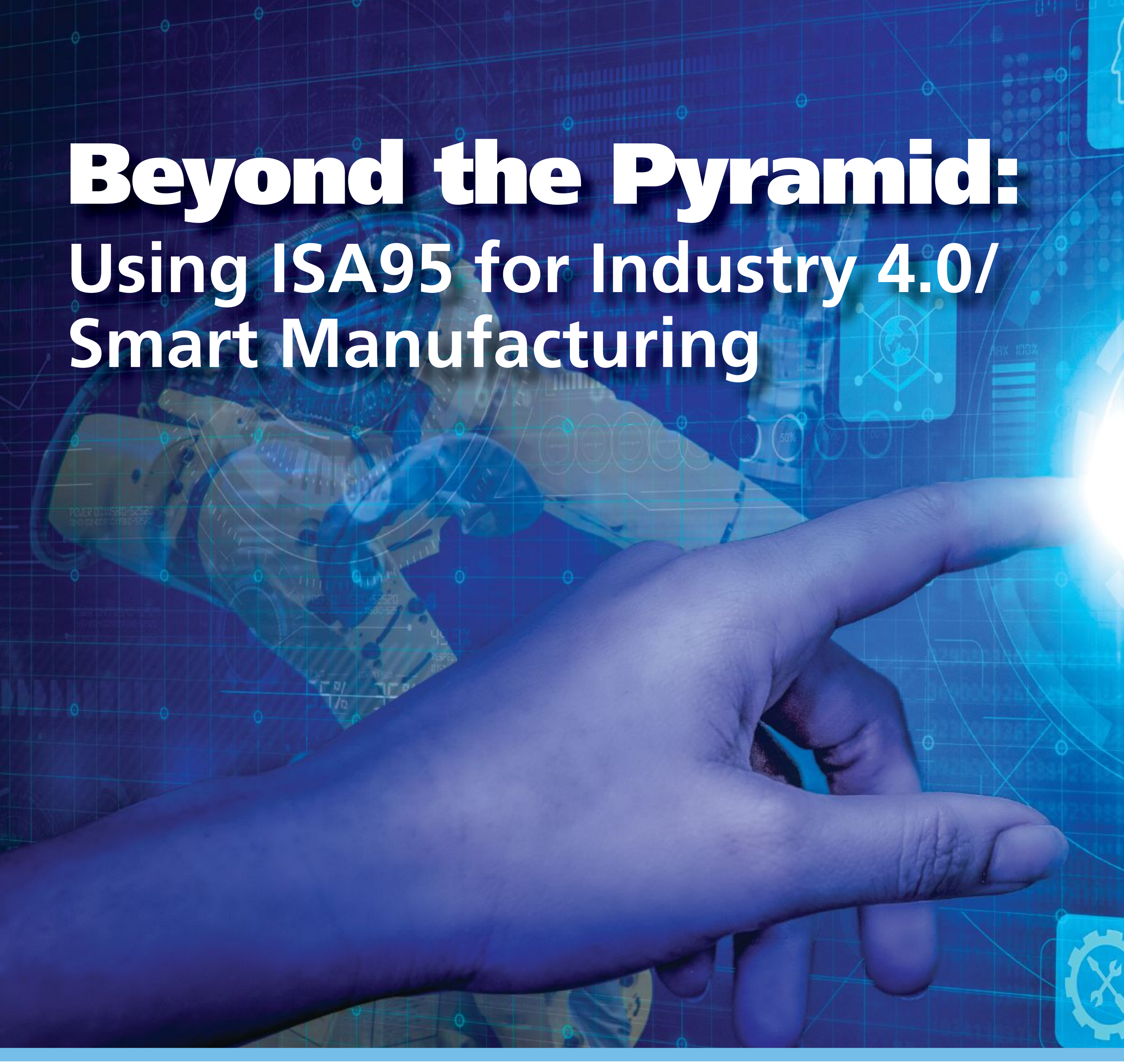
Rockwell Automation chairman and CEO Blake Moret and his team are transforming the company through acquisition. Moret recently announced the acquisition of ASEM, based in Artegna, Italy, with the goal of combining ASEM's human-machine interfaces, controllers, remote assistance, and IIoT gateway solutions with software from Rockwell Automation's open industrial digitalization software platform partner, PTC.

The ASEM acquisition continues the pattern Moret discussed at Rockwell Automation's annual investor meeting in 2019. "Seamlessly connecting all levels of a business and turning raw data into powerful insights happens when devices are integrated and data is standardized," said Moret. "No one vendor can do this alone. Instead, companies need an ecosystem of proven partners."

Deploying PTC software combined with ASEM hardware and software provides a modern distributed control and automation architecture for digitalization and Industry 4.0 projects. The ASEM HMI and edge computers come with CODESYS SoftPLC, delivering IEC 61131-3 open automation systems. ASEM offerings also include Ubiquity, an IEC 62443 certified compliant offering providing secure communications over the Internet. These are open-architecture, intelligent, edge-device building blocks that can be used for Industry 4.0 digitalization.

"Under Blake Moret's leadership, Rockwell Automation is evolving in many ways, reinventing itself, and pivoting toward new open architectures, system integration business, material handling components, and lifecycle services. It will be quite a cultural change," says Automation.com's Bill Lydon. ■

# Beyond the Pyramid:
## Using ISA95 for Industry 4.0/ Smart Manufacturing



By Dennis Brandl and Charlotta Johnsson

The ISA95 (IEC 62264) standards have an important place in the Industry 4.0 smart factories of the future. The key is an extended ISA95 activity model.

From their inception 20 years ago, the ISA95 Enterprise-Control System Integration standards have sought to solve an important industrial business issue: normalizing integration practices between isolated enterprise and control systems. Now well-established and well-adopted, ISA95 continues to provide, among other things, a functional hierarchy defining activities within a manufacturing organization. That hierarchical model has traditionally taken the form of a pyramid.

More recently, Industry 4.0 and smart manufacturing have arrived. They aim to advance manufacturing through the establishment of


**FAST FORWARD**

- ISA95 is a well-adopted series of standards for enterprise-control system integration.
- Industry 4.0/smart manufacturing is often presented as the fourth industrial revolution.
- Industry 4.0/smart manufacturing aims at advancing today's manufacturing, and the architecture of tomorrow's manufacturing systems will be fundamentally different from today's.

intelligent products and smart production processes, as well as through vertically and horizontally integrated manufacturing systems. Can the well-accepted pyramid be changed for another architectural design, such as a modern network-structured architecture, without losing compliance to ISA95? Absolutely. Here is how to leverage your ISA95 knowledge to build an Industry 4.0/smart manufacturing platform to support industrial advances.

## ISA95 modeling

Today's manufacturing activities can be organized into various lifecycles that have at their center a "Make" or "Operate" step (figure 1). These lifecycles, which include supply chain, product, asset, order to cash, and security management, converge in operations. There are other intersections of lifecycles in manufacturing organizations; however, this article focuses on the "operations" intersection.

The ISA95 functional model (figure 2) divides the activities required by a manufacturing system into five levels depending on the time horizon of the functionalities—without consideration of the systems supporting the functionality. Some functions are time critical, such as real-time control with cycles in micro- or

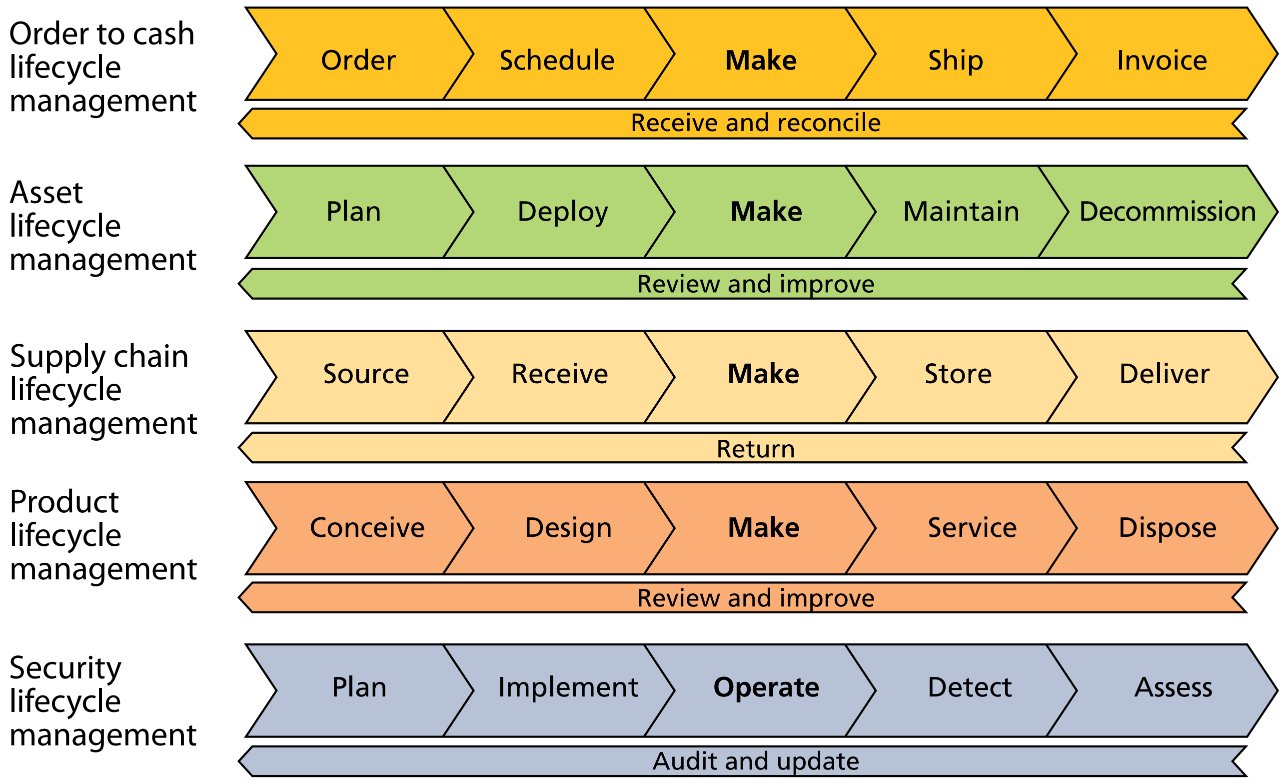



Figure 1. Manufacturing lifecycles converge in operations, in the "Make" stage.

milliseconds, and others are less time critical with resolution in weeks or days.

Even though it is not imposed by the ISA95 standard, one traditional implementation of the ISA95 functional model into a physical architecture is a pyramidal network-and-system architectural structure. Placing the functional model pyramid where the lifecycles intersect at operations, we get the diagram shown in figure 3.

## Tomorrow's manufacturing

Industry 4.0/smart manufacturing is often presented as the fourth industrial revolution, coming after steam-powered mechanical machines, electrically powered mass production, and electronically/IT-powered automated manufacturing. This fourth revolution promises similar advances in efficiency and will be powered by intelligent products and smart production processes, as well as by vertically and horizontally integrated manufacturing systems.

The improvements are explained by the following definition of smart manufacturing (from ISO resolution 114/2017): "Manufacturing that improves its performance aspects with integrated and intelligent use of processes and resources in cyber, physical and human spheres to create and deliver products and services, which also collaborates with other domains within an enterprise's value chains."

**To successfully implement a network-structured architecture, it is helpful to have an extended ISA95 activity model as well as a smart manufacturing reference model.**

The fourth industrial revolution emerges from major recent advances in technology:

- Data storage is no longer a barrier (cloud storage).
- New algorithms for processing are being developed (machine learning and artificial intelligence).
- Computational power is fast enough to process large amounts of data in reasonable amounts of time (big data).
- Devices, items, and things can actively send and receive data, and can be equipped with Internet connections (Internet of Things [IoT]).
- Wireless data transfer is possible with the same or better performance as wired data transfer (5G).
- Standards are being developed that enable interoperability (ISO, IEC, and ITU).

These improvements will make tomorrow's manufacturing systems more advanced than today's systems. Ultimately, Industry 4.0/smart manufacturing should result in more rapid product development, facilitated customized production, improved handling of complex production and testing environments, more efficient supply chains, better use of production resources, and more holistic lifecycle management.

Holistic lifecycle management is a central concept; the interoperability between the phases in each respective lifecycle is vital; and the feedback within and between lifecycles is crucial. For example, smart order-to-cash management will

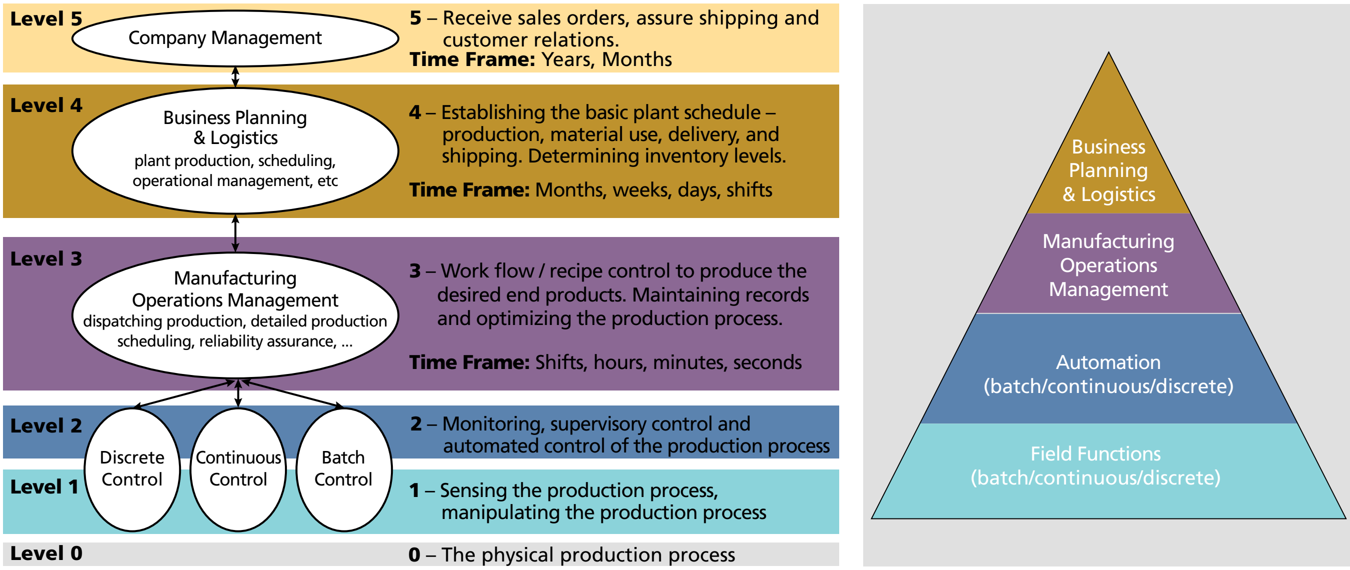



Figure 2. The ISA95 functional model (left) is more traditionally presented as a pyramid.

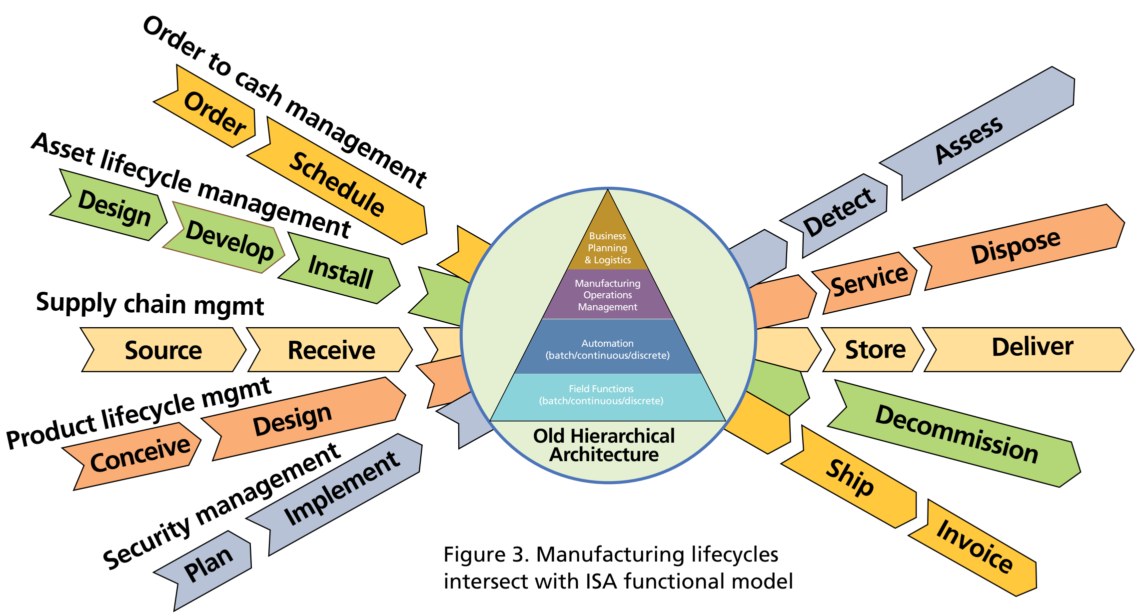



Figure 3. Manufacturing lifecycles intersect with ISA functional model

interact seamlessly with smart supply chain management; smart personnel management will work seamlessly to provide just-in-time training with smart product lifecycles; and smart security will work seamlessly with smart manufacturing assets.

## Evolution of models

Because Industry 4.0/smart manufacturing will result in such profound advances, it makes sense that tomorrow's manufacturing systems will look fundamentally different from those of today. One assumption is that traditional architecture—the hierarchical pyramid—will be replaced by a network structured architecture (figure 4).

Can the concepts of ISA95 that have been well understood and accepted in industry be used in the context of Industry 4.0/smart manufacturing? Yes, by "simply" replacing the hierarchical pyramid with the networked activity model that is also defined in the ISA95 Part 3 standard (figure 5).

The ISA95 activity model defines the specific activities that must occur in a manufacturing organization, but without reference to systems that implement the activities. For example, a smart physical asset may include sensors, actuators, real-time control, recipe management, optimized scheduling, internal data analysis, and reports. An alternate implementation architecture may support these activities in separate devices. The activities are consistent, while the systems that support them will change and evolve over time.

Therefore, to successfully implement a network-structured architecture, it is helpful to have an extended ISA95 activity model as well as a smart manufacturing reference model. Smart manufacturing reference models are used to describe

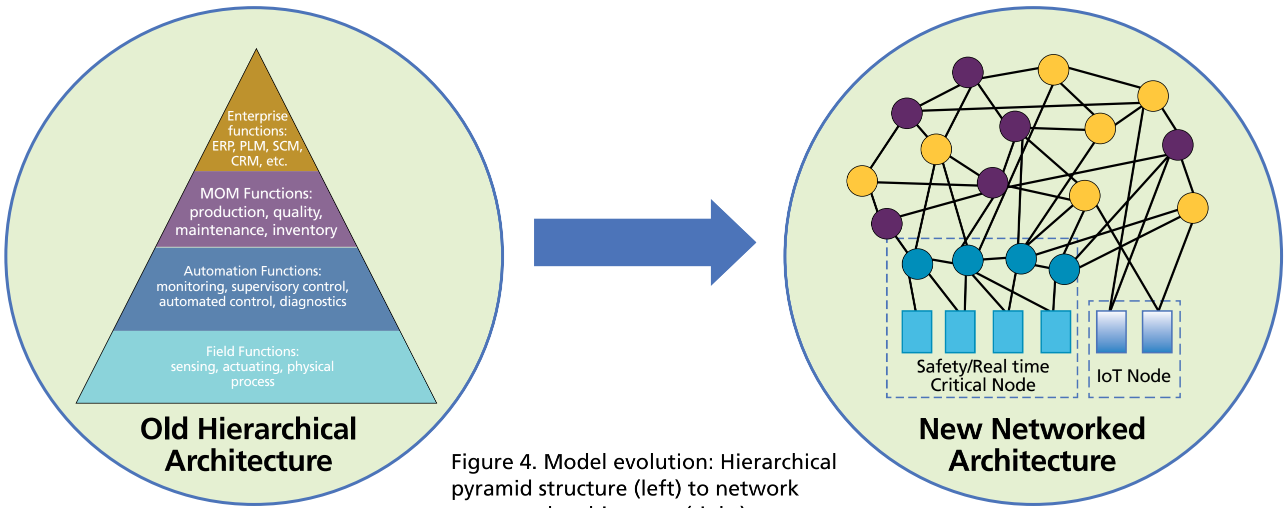



Figure 4. Model evolution: Hierarchical pyramid structure (left) to network structured architecture (right).

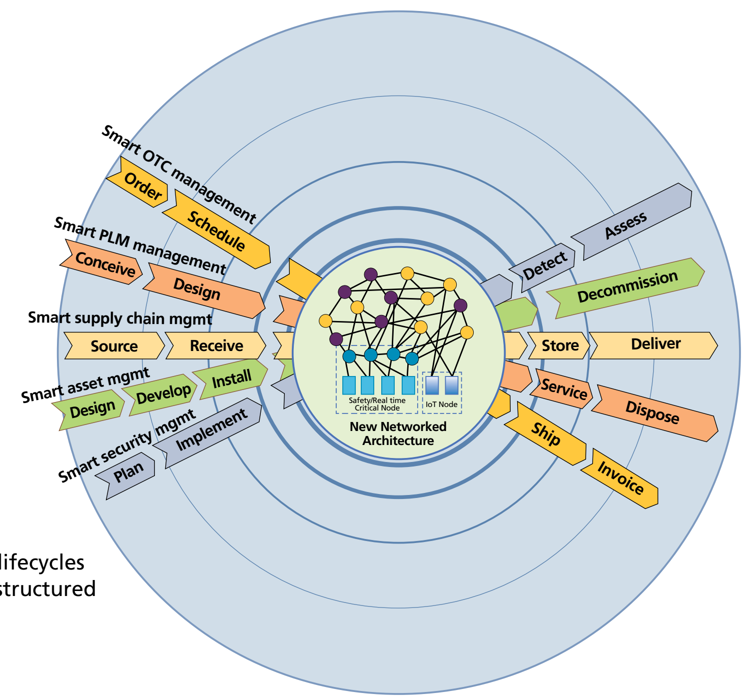



Figure 5. Manufacturing lifecycles supported by a network structured architecture.

crucial aspects of Industry 4.0/smart manufacturing and indicate how the aspects relate to each other.

The reference model RAMI 4.0 from Germany consists of a three-dimensional coordinate system and includes aspects from ISA95. Other models, originating from other nations, include the Scandinavian Smart Industry Model (Sweden-Norway), Smart Value Chain Initiative (Japan and China), and the NIST-model (U.S.).

## Extended ISA95 activity model

The "activity models" shown in figures 6 and 7 illustrate an extension of the ISA95 activity model, which covers all the activities that must occur from the sensors and actuators used to control the physical equipment to the activities that interface with order-to-cash and supply-chain management activities. Each oval in the figures represents an activity as a set of tasks that need to be performed. These can be performed manually, or they can be automated in a smart manufacturing environment. There may be multiple devices and systems implementing some, all, part, or even overlapping parts of the activities in a network of systems and devices.

The physical systems supporting the activities operate in the "new networked architecture" illustrated in figure 4. That networked architecture includes edge devices that implement the fast response activities, and may also support other, less time-critical activities. The devices communicate using accepted and robust communication standards that enable plug-and-play interoperability.

## Final thoughts

This article aims to provide information concerning the use of ISA95 in an Industry 4.0/smart manufacturing context. The ISA95 standards provide users with a functional hierarchy defining the specific activities that must occur in a manufacturing organization. The hierarchy indicates the relative time horizons for the activities but gives no indications of how they should be implemented nor what architectural structure should be used.

Traditionally, the activities have been implemented through a hierarchical pyramid architecture, but this could be changed for another architectural design, such a modern network-structured architecture, without losing compliance to ISA95.

Our belief is that, through the ongoing global collaborations spanning companies, organizations, and nations regarding both the ISA95 standard and smart manufacturing reference models, it will be clear how users can leverage ISA95 knowledge to build Industry 4.0/smart manufacturing platforms. ■

## More information

For more about ISA95, smart manufacturing, and Industry 4.0, refer to these resources:


- Acatech (2016) "Industrie 4.0: International Benchmark, Options for the Future, and Recommendations for Manufacturing Research"
- Dotoli M. et al. (2018) "An overview of current technologies and emerging trends in factory automation," *International Journal of Production Research*
- IEC (2015) "Factory of the future" whitepaper
- ISO/IEC (2013) "ISO/IEC 62264-1:2013 Enterprise-control system integration Part1: Models and terminology" ISO standard
- Johnsson C. (2004) "ISA95 – How and where can it be applied?" whitepaper
- Johnsson C. and Brandl D. (2017) "Introduction to Smart Manufacturing/Industry 4.0" whitepaper
- Lu Y. et al (2015) "Current Standards Landscape for Smart Manufacturing Systems" NIST, NISTIR8107
- MESA (2016) "Smart Manufacturing: the landscape explained" whitepaper #52

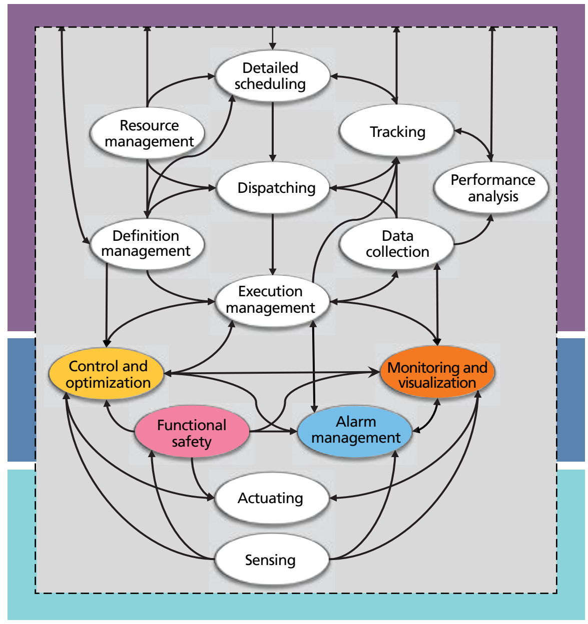




Figure 6.
This networked reference architecture for operations in a manufacturing organization is an extension of the ISA95 Activity model. Each oval represents an activity as a set of tasks.

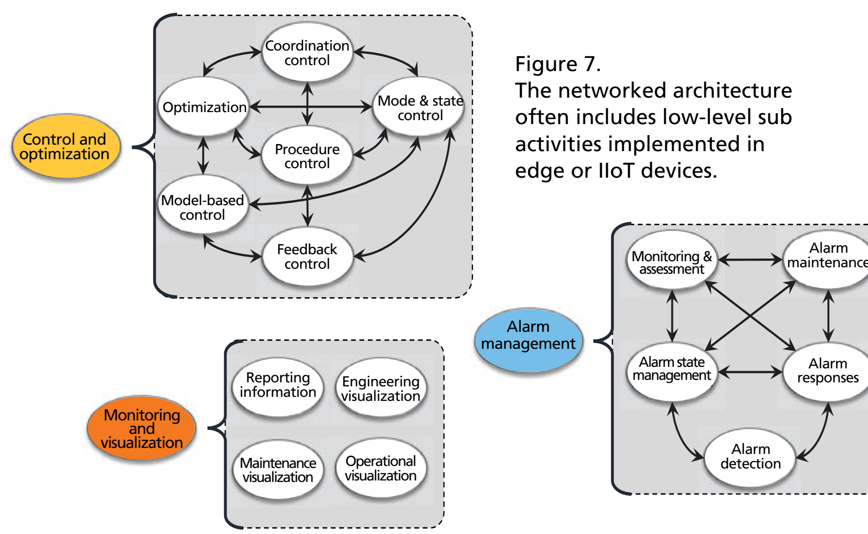



Figure 7.
The networked architecture often includes low-level sub activities implemented in edge or IIoT devices.

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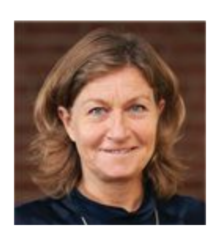

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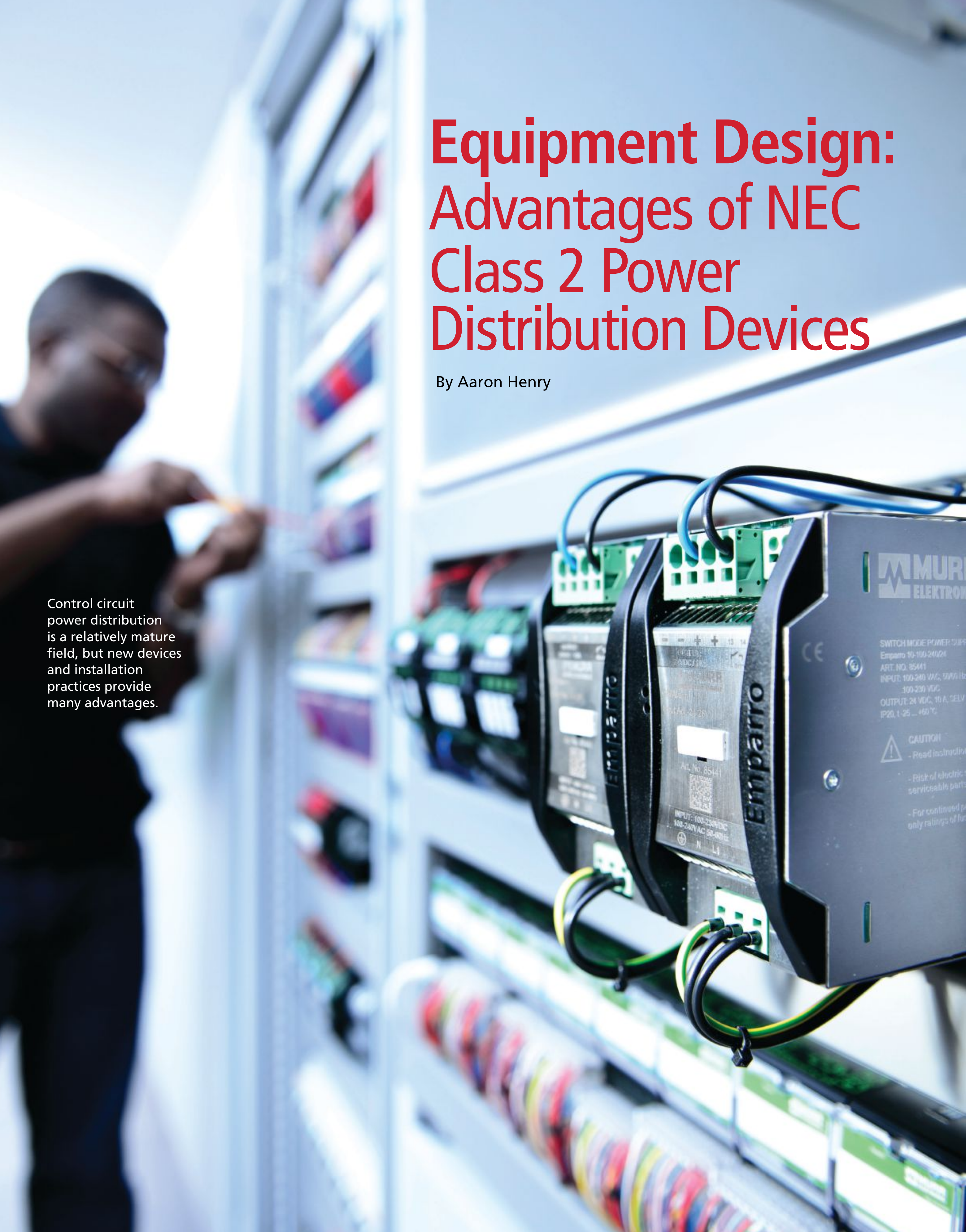
# Equipment Design: Advantages of NEC Class 2 Power Distribution Devices

By Aaron Henry




Control circuit power distribution is a relatively mature field, but new devices and installation practices provide many advantages.

# A new type of device provides designers of automated installations for North America with performance, cost, and safety benefits.

**FAST FORWARD**

- Class 2 devices and wiring methods are a specific type of energy-limited control circuit defined in the NEC.
- Designs using Class 2 products and methods have improved protection performance, better safety, and other installation and operational benefits.
- Electronic circuit protection operates faster and more accurately than fuses and traditional circuit breakers while providing features for intelligent distribution of bulk DC power.

Industrial machinery and equipment system designs typically rely on proven materials and methods to ensure reliable and effective end results. This is especially true when it comes to electrical power branch circuit distribution and control circuits, where the products available on the market are mature and design practices are largely guided by codes. But every so often, a new option becomes available to improve performance, reduce cost, and increase safety.

Such is the case with respect to a relatively new type of power distribution device built to take advantage of a special National Electrical Code (NEC) classification called a "Class 2" circuit. For automated equipment and systems destined for the North American market, Class 2 has many benefits for low-voltage control circuits.

Traditional control circuit power distribution designs use fuses, circuit breakers, and conductors to meet standards and requirements. Although complying with all codes is essential, this classic circuit protection approach is inefficient in some ways for the relatively small amounts of power involved.

Class 2 recognizes the low energy levels associated with many control and signaling applications, and it provides an improved option for designers to use specific materials and methods for these situations. Implementing Class 2 principles with the right devices brings functional benefits, lowers the total installed cost, and improves safety for users and equipment.

## Understanding requirements

Different global regions adopt specific directives, codes, and standards that must be observed for electrical design, products, and installations. Correspondingly, electrical products are typically made to comply with one or more of these requirements. Following are some relevant documents for power supplies within industrial equipment:

- Europe and International
  - International Electrotechnical Commission (IEC)
  - European Standards (EN)
  - IEC/EN 61204-1: Low-voltage power supply devices
  - IEC/EN 61439-1: Low-voltage switchgear and controlgear assemblies
- North America (U.S., Canada)
  - National Fire Protection Association (NFPA)
  - NFPA 70: National Electrical Code (NEC)
  - NFPA 79: Electrical Standard for Industrial Machinery
  - Underwriters Laboratories (UL)
  - UL 508A: Standard for Industrial Control Panels
  - UL 1077: Standard for Supplementary Protectors for Use in Electrical Equipment
  - UL 1310: Standard for Class 2 Power Units
  - UL 2367: Standard for Solid State Overcurrent Protectors

Designers and engineers must be familiar with applicable guidance for the final location where equipment will be installed and inspected. European and North American standards are not necessarily harmonized, adding complexity.

Standards related to power supply and distribution are generally intended to protect personnel, and to prevent fires, or any other unsafe or damaging conditions. The design principles and applicable products are well understood, but sometimes the standards are updated, or newer products become available, providing options for improvement.

## Class 2 considerations

In the simplest terms, a Class 2 circuit is of such low voltage and current, and therefore low power, that it does not present a fire hazard or a shock hazard to personnel. Designs that ensure available energy is limited have many engineering, regulatory, installation, and operational benefits.

Traditional hardwired devices like motor starters often draw too much power for Class 2 circuits to be practical. But low-power digital devices, which are increasingly prevalent—such as programmable logic controllers (PLCs), human-machine interfaces (HMIs), and other intelligent components—work well when powered by Class 2 circuits. Also, much of the associated communication, networking, and input/output signaling can be supplied by Class 2 circuits.

In North America, the NEC is the primary standard for electrical installations. Control panels and the circuits within them are addressed by UL 508A, while UL 1077 and 2367 are directed at branch circuit protection.

The NEC specifically defines a Class 2 energy-limited control circuit in article 725-121 as:

- not to exceed 60 VDC (although they are most commonly operated at 24 VDC or 24 VAC for industrial and commercial purposes)
- load side power potential must be limited to less than 100 VA (although adhering to these limits with standard fuses or circuit breakers is not acceptable)
- supplied by a Class 2 power source device specifically UL listed as such.

These conditions must be maintained even in the event of a short circuit or during fault conditions. There are also restrictions on what classes of circuits may be routed together. Generally, Class 2 circuits must be routed separately from other classes of circuits in control panels and raceways. Note that Class 2 is only applicable within North America.

## Class 2 advantages

There are many benefits when product suppliers and designers comply with Class 2 requirements. Circuits and downstream devices operating under Class 2 require no further protection from shock or fire hazards. From a practical standpoint, this means Class 2 devices and conductors can be smaller, and circuitry is often simplified for these reasons. Field wiring methods are less demanding, because the materials are easier to procure, install, and maintain. These benefits combine to reduce the expense of design, materials, installation, and support.

Manufacturers submit their devices to UL for investigation to receive NEC Class 2 certification. Once a device is Class 2 certified, it is easier for designers to use it compared with using most other types of electrical components. For example, within UL 508A–listed control panels, any Class 2 circuits and the components connected to them need not be evaluated for UL compliance, greatly minimizing the panel design effort.

There are a few points to know for properly implementing Class 2 designs. Some downstream devices may be certified as requiring a Class 2 power source, so designers must be aware of this and make sure they provide the proper Class 2 source. Also, while Class 2 wiring methods are generally easier to use, the Class 2 circuits must be routed independently of other circuits, both within a control enclosure and in field raceways. Perhaps the biggest concern with Class 2 designs is the limited amount of power available for each circuit, constraining the number of downstream devices that can be supplied.

## Class 2 implementations

There are a few options for implementing Class 2 power sources. Small transformers can be designed to convert 120 VAC to 24 VAC in a current-limited manner to meet Class 2 requirements. These are often used for residential and commercial signaling applications, e.g., heater and air conditioner thermostats or other building automation. However, typical industrial control systems commonly use 24 VDC.

Some component suppliers originally developed power supplies specifically for Class 2 applications. These power supplies were designed, tested, and certified to meet Class 2 requirements (figure 1). This is a workable approach, but these power supplies were often limited to a nominal 4 A or less output current at 24 VDC. Many control panels needed a greater amount of control circuit current, which therefore required multiple power supplies. Or perhaps several Class 2 power supplies could be used, but were not fully utilized. Both situations eroded some of the expected benefits.

Some suppliers responded to customer needs for a better way to deploy Class 2 designs by creating a new category of device called an electronic circuit protector (ECP). ECPs are a smarter family of Class 2 devices, performing intelligent power distribution and making it much easier to gain the benefits, while providing many standalone and modular options for distributing bulk 24 VDC power from standard power supplies (figures 2 and 3).

Using ECPs, it is possible to distribute up to 40 A of bulk upstream power to many individual Class 2 downstream circuits. Designers can therefore choose fewer, but larger, upstream power supplies as needed, perhaps even incorporating redundancy or an uninterruptible power supply. ECPs also have many other benefits.

## More intelligent power distribution benefits

Because intelligent power distribution devices perform their ECP function using digital methods, the protection reacts faster than other physical methods, such as fuses or traditional circuit breakers. The response is more reliable than the trip curve of a standard breaker or fuse, and it is much closer to the desired protection level selected. For example, if 2 A protection is desired, the ECP trip curve is nearly 2.1–2.2 A, while it may be as high as 6 A for a breaker. This ECP responsiveness provides accurate overcurrent selectivity with other circuits, and it helps prevent voltage drops, and even cable fires.

An ECP monitors the current on each individual output channel, and it provides users with the ability to turn each output channel on and off individually, for example via remote signaling from control systems. Upon startup, the output channels are automatically started in


Figure 1. Suppliers like Murrelektronik created power supplies such as the Emparro67 shown here to meet Class 2 requirements, although this approach is typically limited to less than about 4 A power supply.


KEEP IT SAFE
STZ SAFETY HART TEMPERATURE TRANSMITTER
DUAL SENSOR
SST SAFETY SIGNAL ISOLATOR
SPAN
ZERO
READY INPUT TRIP 1 TRIP 2 FAULT
132.68
PSIG
COM UP DOWN SELECT
STA
SRM SAFETY RELAY MODULE
POWER
INPUT
OUTPUT
SSX SAFETY SIGNAL ISOLATOR
SPAN
ZERO
MOORE INDUSTRIES
WORLDWIDE
Demand Moore Reliability

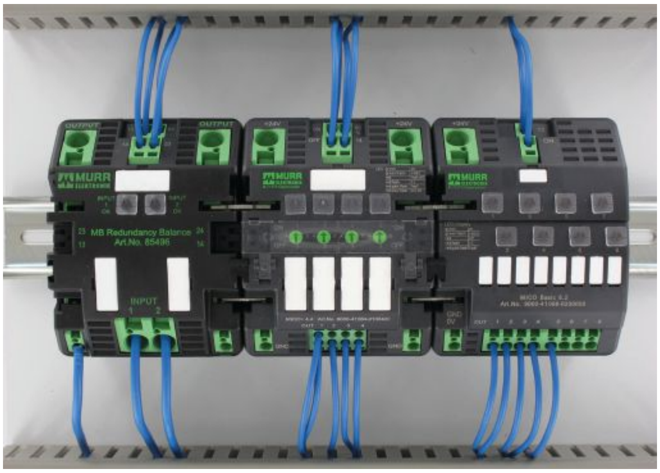


Figure 2. Individual ECP modules, like the three devices from the Murrelektronik MICO line shown here, enable bulk 24 VDC control panel power to be distributed to one, two, four, or eight individual Class 2 circuits.

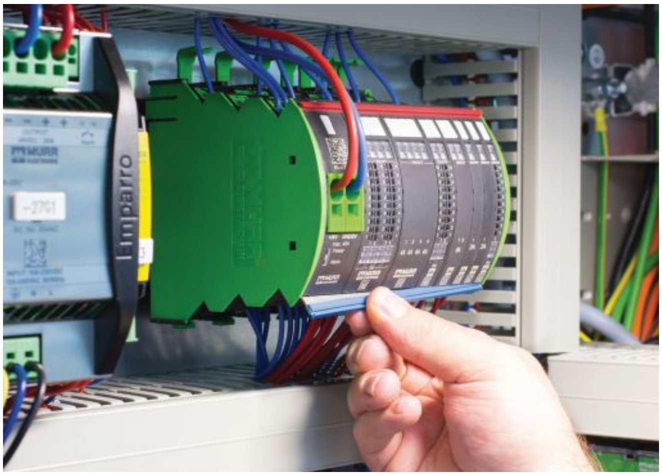


Figure 3. ECPs available in an expandable form factor with convenient bussing make it easier to design and fabricate control panels with many Class 2 circuits.

a cascade manner to reduce the system inrush and minimize the chance of upstream overcurrent trips.

Some ECPs have a visual indication of channel loading, such as a steady green LED for less than 90 percent, blinking green for 90 percent to 100 percent, and red for greater than 100 percent. Also, a group alarm contact allows the ECP to be monitored by supervisory PLCs. Control actions can be taken if necessary, and HMI alarms can be triggered. The control and diagnostic capabilities far exceed what a tripped circuit breaker or blown fuse can provide, significantly easing startup, factory acceptance testing, and troubleshooting efforts.

Many ECPs offer compact form factors, and versions supporting higher channel numbers can take up less DIN rail space than fuses or circuit breakers. A line-side bridging system facilitates bulk power distribution, while compact form factors and clear labelling make it easier to design, fabricate, and maintain control panels.

Note that ECPs are not only for Class 2 installations. Some general ECP models may allow adjustable current limits per channel, while specific Class 2 models are necessary for true Class 2 installations. Therefore, ECPs can be used for many control circuit applications where Class 2 is not needed, but other intelligent power distribution benefits are desired.

Modern ECPs are the best choice for distributing bulk 24 VDC control panels to Class 2 circuits in control panels, and they also provide substantial benefits for distributing standard 24 VDC circuits. Implementing ECPs allows proactive monitoring, often precludes any need for personnel to open electrical cabinets, and unlike a fuse, does not require replacement after a trip.

## ECPs deliver

Class 2 circuits are a very specific configuration, unique to the North American market and defined by the NEC. There are many safety, performance, regulatory, and economic benefits associated with implementing Class 2 control circuits.

Certain power supplies are rated to provide Class 2 circuits, but there are power constraints, so sometimes many such devices are needed. ECPs are the best and most flexible way to distribute multiple Class 2 circuits from the bulk 24 VDC power supplies typically used in control panels. ECPs also provide many benefits for distributing general power circuits.

For projects and equipment destined for North America, designers should familiarize themselves with the requirements, products, design methods, and installation practices associated with Class 2 control circuits, so they can take advantage of this compact, economical, and feature-rich solution. ■

### ABOUT THE AUTHOR

**Aaron Henry** is vice president of strategic development at Murrelektronik, where he is responsible for the company's product road map. Henry has extensive industry experience with electric and automation products, and he also served as a petty officer in the U.S. Coast Guard for four years. He has an associate's degree from Georgia Perimeter College, a bachelor's degree from the University of Georgia – Terry College of Business, and a master's degree in industrial distribution from Texas A&M University.

Images courtesy of Murrelektronik

### RESOURCES

**"Power protection at the edge: How industrial batteries are evolving"**
www.isa.org/intech-home/2020/may-june/columns/power-protection-at-the-edge-how-industrial-batter

**"Troubleshooting"**
www.isa.org/intech-home/2018/may-june/features/troubleshooting

**"Don't rush to startup by passing the factory acceptance test"**
www.isa.org/intech-home/2017/march-april/columns/bypassing-the-factory-acceptance-test

# FDI Certification Enables Smoother Digital Transformation


Digital sensing devices built on open standards can significantly expand data visibility and improve an organization's asset management process.

By Anna Velena

Plants rely heavily on their sensing devices, as timely delivery of measurement and process information allows personnel to operate in a controlled and consistent manner. As more plants evolve on their digital transformation journeys, intelligent field devices are playing an even more critical role in enterprise-level process visibility to improve performance across the organization.

Plant personnel typically manage hundreds or even thousands of devices in a single facility, requiring them to keep track of differing technologies and a wide range of device files. Updates, cybersecurity, and management all require significant knowledge of several technologies—ultimately slowing digital transformation by reducing the pace at which plants can perform device selection, installation, updates, and repairs.

To address these and other issues, an emerging technology—FieldComm Group and Profibus & Profinet International's Field Device Integration (FDI)—is changing the way plants manage devices. FDI simplifies installation and management by supporting device and system interoperability. There is a single device package per protocol that is compatible with all host systems.

Manufacturers are finding it easier to innovate, and end users will soon have a simpler path to implementation. FDI-registered solutions will significantly improve an organization's asset management process, moving them closer to their digital transformation goals.

More devices will bring more asset management responsibility. Adding tens, hundreds, or even thousands of new sensing devices to a plant will increase management and calibration tasks, as well as the cost of engineering.

Much of this new responsibility will fall upon operators, technicians, and engineers—each of whom are already very busy. With retirements across industries creating a shortage of skilled workers, organizations will need to find ways to enable increased efficiency for available personnel. By staying ahead of the curve and beginning to work today with the systems that will be fully FDI registered soon, plants can reduce the amount of training and work necessary to gain the full benefits of FDI.

With this foundation in place, organizations can rapidly eliminate data silos, increase security, and streamline daily tasks—not only laying the groundwork for the plant of the future—but also readying the workforce for a new paradigm of operation.

## What is FDI?

FieldComm Group is a global, standards-based, nonprofit member organization focused on digital open standards in the process industries. It has collaborated with industry foundations and suppliers like Emerson to develop FDI, an internationally

**FAST FORWARD**
- Manufacturers need a better way to connect field devices to higher-level systems.
- EDDL and FDT/DTM will be supplanted by a single FDI standard to deliver improved connectivity and other benefits.
- Higher-level systems, such as those used for asset management, should be made ready to work with the new generation of FDI devices.

standardized solution for process automation device and systems integration (figure 1). The standards FDI is based on include ANSI/ISA-62769-109-1, *Field Device Integration (FDI) – Part 109-1: Profiles – HART and WirelessHart*.

A single FDI device package includes the device definitions, user interface plug-ins, certificates, and useful documentation. This information simplifies integration with field devices and FDI-enabled plant, enterprise, and cloud-based host systems. It also simplifies the selection, installation, and configuration of all field devices.

## FDI support versus FDI registration

Manufacturers of host systems can build in the level of support for FDI they deem appropriate. As more manufacturers enable this support, users will have access to a wider range of devices and functionality in their device manager applications. However, because manufacturers can choose which individual features to implement on their FDI host systems, it is possible that some applications will support certain elements of FDI but not others.

To get the full benefits of FDI, standards orga-

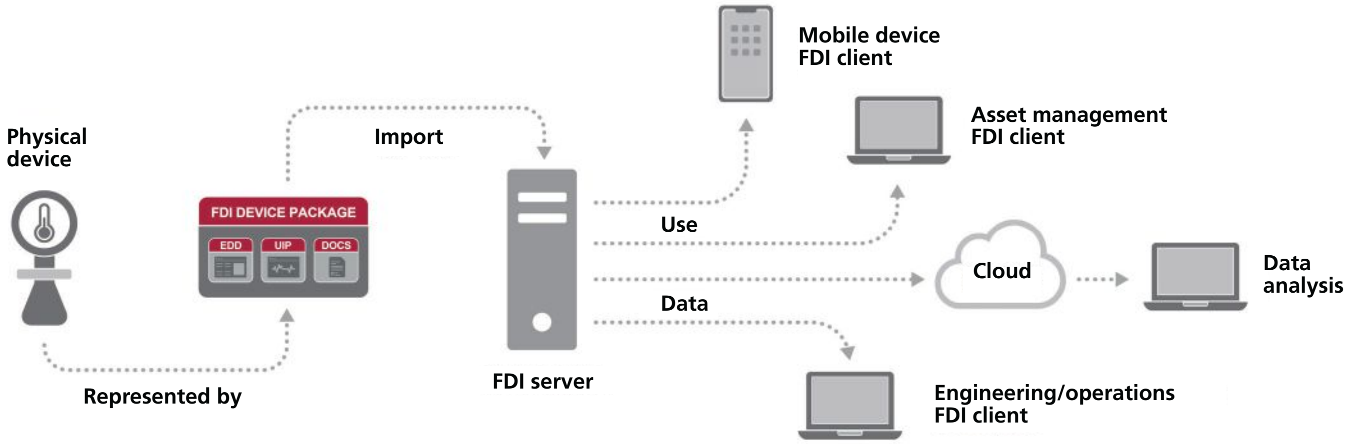



Figure 1. FDI takes the best features of EDDL and FDT packages and combines them into a single common standard, simplifying installation and reducing or eliminating device compatibility concerns.

nizations are supporting FDI-registered applications. FDI-registered hosts have implemented all the FieldComm Group's specifications and passed a rigorous testing process to ensure that required features are supported by the software.

## More devices, fewer hurdles

Field devices are critical to digital transformation and Industry 4.0, because they provide the data required to help key personnel keep a finger on the pulse of the plant. As more devices arrive on the market and the number of digital devices in a plant increases, companies realize the advantages of Industry 4.0. To begin with, users enjoy new and better forms of visibility across the plant. As advanced analytics technologies, such as artificial intelligence and machine learning, become more prevalent, plants will need to add more specialized sensors, resulting in even more devices and data, all of which must be managed.

Organizations will need a seamless way to manage these field devices. Currently, two host technologies, EDDL and FDT/DTM, are available, forcing plant staff to double up on training, time, and effort.

Doubling up on effort is expensive and time consuming, and it also tends to create data silos, which make it more difficult for operators and technicians to quickly find the data they need. These data silos create obstacles for effective predictive maintenance and limit visibility at the enterprise level, making it harder to take steps to improve operational efficiency.

An FDI device package removes the need for plants to choose between EDDL and FDT/DTM technologies. All FDI devices use a single software package incorporating the best features of both technologies. The single package contains device drivers, management applications, guides, diagrams, and manuals (figure 2). With a single FDI device package, plant personnel can find all the functionality they need in a single source file. They do not have to search for multiple files in different formats.

Organizations can prepare for FDI by choosing an FDI-registered asset management system that can handle all the devices that are in—or will be in—the plant. The ability to support all a plant's devices will enable the asset management system to act as a central repository for instrument information, eliminating data silos and increasing operational efficiency. In addition, organizations can seek out an FDI-registered asset management system with connectivity to enterprise systems (figure 3).

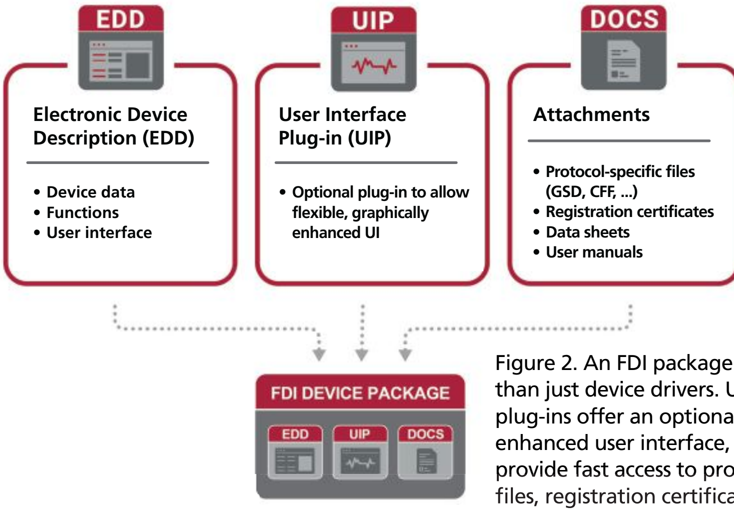



Figure 2. An FDI package contains more than just device drivers. User interface plug-ins offer an optional graphically enhanced user interface, and attachments provide fast access to protocol-specific files, registration certificates, data sheets, and manuals.

Figure 3. FDI-registered device management software, like Emerson's AMS Device Manager, simplifies installation and management of devices, and improves system interoperability.

These asset management systems provide data to enterprise-level applications such as data lakes, where the organization can perform higher-level analytics to ensure the entire operation is running at peak efficiency.

## Encapsulating security

Today, plant personnel may need to download drivers to configure, diagnose, and troubleshoot each device added to a plant. These files can be hosted in many places, with no guarantee they are uncorrupted (either before or after the download) due to intentional tampering or inadvertent changes. Insecure files introduce potential security and safety risks, making the plant more vulnerable to a cyberattack.

An FDI device package provides increased security through digitally signed certificates. If the application is FDI-registered, it will provide an essential baseline of security, regardless of the plant's device manager software security features. Before beginning the installation of an FDI device package, an FDI-registered host system server will check the software's certificate to ensure the files are authentic and complete.

Moreover, because all a device's necessary files (device descriptors, advanced

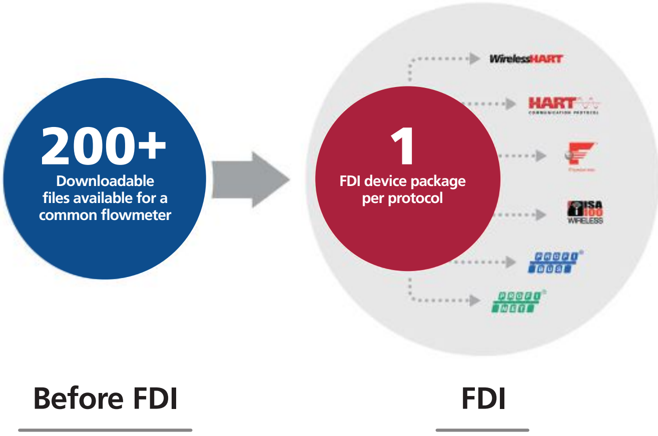



Figure 4. Instead of scouring the Internet for hundreds of necessary files, users can simply download a single FDI package from a secure repository to obtain everything necessary for integration.

management applications, and documentation) are contained in one package, users will not need to search multiple places for the required files, reducing the risk of downloading compromised files from an unreliable source. Plant personnel can instead rely on one trusted repository (figure 3).

Knowing the move to FDI is on the horizon, plants can gain even more advantage from evaluating the cybersecurity features available in their asset management software. Implementing or upgrading to an asset management application that will be FDI-registered in the future, but that also contains out-of-the-box security features today, will improve the plant's cybersecurity posture over the long term. Plants gain the immediate security improvement of signed files and can upgrade to further increases in security when they move to FDI.

## Automated daily tasks

Adding additional devices to the plant should make asset management easier, and not overburden already busy personnel. Device management tasks, such as calibration, audit trail management, commissioning, and testing, will all be essential for the many new assets that will become available with FDI.

For example, the calibration management tools available in some device management systems will reduce the need for manual work, refining and speeding calibration procedures. This type of software helps users build calibration routes to establish ordered groups of devices for calibration.

Once calibration is complete, all data stored in the calibration tool is synced with the device manager software, and users can easily access and print reports. Technicians do not need to keep written notes, and they do not have to remember to copy data to the system manually. The device management system automatically documents, trends, and reports calibration data—preventing data drift and providing reliable audit trails.

The benefits of FDI-registered device management software will also extend beyond daily operations into capital project execution. Using a single host package with FDI will increase efficiency by reducing the time spent selecting the right devices and searching for files.

FDI registration assures project teams that every element of the FDI package they use will be compatible with the device manager system—eliminating late-stage surprises that complicate projects, limit flexibility, and increase engineering time and costs. In addition, existing device management tools—such as smart commissioning—will increase this efficiency by speeding device binding, configuration, loop checks, and documentation, and help to take device installation off a project's critical path.

## Drive digital transformation

FDI will unlock a wide array of new device technologies in the coming decades, just as many plants will be ramping up their digital transformation initiatives. But control and sensing devices do not operate in a vacuum. The devices delivering critical data across the plant and across the enterprise rely on a solid system of support, and the backbone of the system is the personnel who keep it running at peak performance.

Taking steps today to build a solid foundation of support for new and existing digital technologies will help ensure everyone in the plant has the tools they need to keep devices and their associated assets running at peak performance across the plant's life cycle. ■

### ABOUT THE AUTHOR

**Anna Velena** is the product manager for AMS Device Manager and has been with Emerson for 16 years. She has gained extensive knowledge of distributed control systems and asset management systems through progressively responsible positions in Emerson. Velena earned her BS degree in chemical engineering from the University of the Philippines.

All figures courtesy of Emerson

### RESOURCES

**"Product registry and online repository"**
www.isa.org/intech-home/2018/november-december/departments/automation-update

**"Is your automation asset management out of sync?"**
www.isa.org/intech-home/2019/september-october/columns/is-your-automation-asset-management-out-of-sync

**"HART, FDI, and OPC UA collaboration simplifies applications"**
www.isa.org/intech-home/2018/january-february/features/hart-supports-industrial-digitalization

# LoRaWAN: A Clipboard Killer for Condition Monitoring

## Optimizing automated equipment condition monitoring calls for a different wireless network protocol than that used with process instruments.

By Haruka Yamada

Manufacturers of all sorts have long sought a balance between tasks best done by automation and those best done by human beings. In recent years, this has shifted in favor of automation due to more capable technologies coupled with a decline in the availability of qualified people. One area where this has been particularly visible is the traditional practice of sending out humans on manual inspection and data collection rounds.

In these activities, an operator with a clipboard or a more sophisticated recording device follows a route through a facility with stops along the way to read a gauge, examine a sight glass, or perform a similar check related to a process directly, or to verify equipment condition. This may be simply a mechanistic recording of a reading, but could also include a more subjective component. After reading and noting the gauge, another step may call for an evaluation. Does the compressor sound normal? Is the centrifugal pump vibrating more today than yesterday? Is the seal leaking? Is there a faint aroma of burning lubricating oil? Some operators may be highly qualified to make such judgements based on extensive experience, but how many of those people are around today? A generation of skilled workers is quickly fading into retirement.

In many industrial plants and facilities, the reality is changing, because these rounds tend to be tedious and time consuming. Also, they may not add much value to the operation, as the result is usually simply confirmation of any obvious signs of abnormality. Insightful observations are waning, leaving little potential for detecting a slowly developing problem. These characteristics make routine rounds prime candidates for automation, especially for far flung equipment (figure 1).

Fortunately, there is no shortage of appropriate instruments capable of measuring relevant variables. The larger problem is gathering data efficiently and bringing it to a central host system. Often the equipment that needs to be monitored is spread over a large area, potentially in places that are difficult to access or are hazardous. Distance calls for a wireless solution, and there are many choices. For the balance of this article, we will examine one practical way to solve the overall challenge.

**FAST FORWARD**

- The traditional practice of sending out humans for manual inspection and data collection rounds is over.
- There is no shortage of appropriate instruments capable of measuring relevant variables. The problem is gathering data efficiently.
- LoRaWAN is a wireless protocol suited for the specific requirements of condition monitoring.

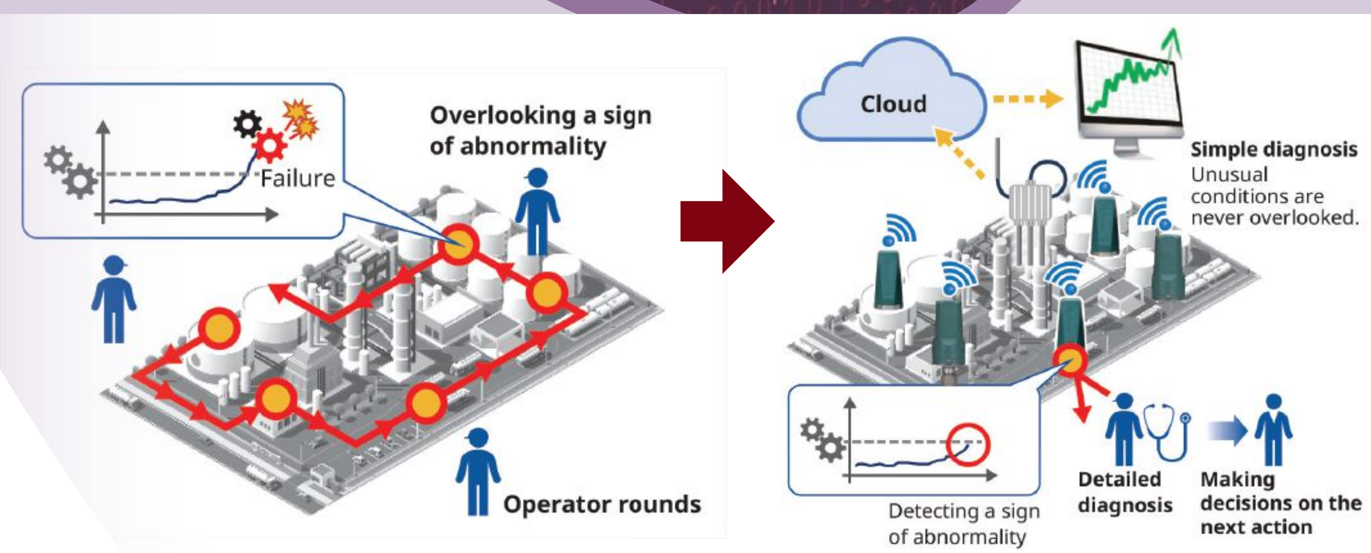



Figure 1. An operator following a prescribed route to check equipment is costly and time consuming, and not nearly as effective as automated condition monitoring.

## Wireless deployments

Although there are few hard statistics, it is safe to say that the majority of process manufacturing facilities have deployed wireless networks in some capacity. Wi-Fi networks, first set to cover offices, now extend into production areas to facilitate mobile workers and a wide variety of other purposes, but few support instrumentation or field devices of any kind.

Many progressive companies have deployed other types of wireless networks specifically for device-level support, such as ISA-100.11a and WirelessHART. These networks are well suited for process instruments and actuators involved in process control, supervised by a distributed control system (DCS), and serving similar functions as wired counterparts. Although these two protocols are incompatible, they share many functional similarities:

- Similar communication distances, for example up to 500-m line-of-sight for ISA-100.11a.
- Extremely high signal reliability.
- Ideal for high-density installations.

So, what is the answer for an engineering team that wants to deploy temperature and pressure sensors in condition-monitoring rather than process-control applications? Either of these device-level networks is better than Wi-Fi, but there are still drawbacks:

- Condition-monitoring instruments do not need frequent updates.
- Data from a condition-monitoring instrument will have to be separated from the process instruments on the same network so it can be sent to other people.
- Equipment needing condition-monitoring instruments will likely be more spread out, so longer communication distance coverage is desirable.
- Battery life is often insufficient.
- Most installations require repeaters.

The answer is choosing a wireless protocol suited for the specific requirements of condition monitoring, rather than trying to make it fit in a less optimal solution. What does that look like?

## Alternative wireless protocol

The requirements for a wireless protocol supporting condition-monitoring instruments are different from those for a network supporting process devices:

- Longer distances may need to be covered.
- Lower update rate is typical, often hourly as opposed to every few seconds for a process device network.
- Lower signal reliability is tolerable.
- Long battery life may be needed.

This can be satisfied by a different wireless protocol, originally designed for smart city and other industrial purposes: LoRaWAN. This low-power, wide-area networking protocol (figure 2) is supported by the LoRa Alliance and used by 500 IoT-related companies globally.


Figure 2. LoRaWAN is well suited to supporting a wide-area network of condition-monitoring sensors, concentrating all the relevant data in one place.

The protocol communicates via a license-free 920-MHz band, which works well for communication over a radius of 1 km from the gateway, with no repeaters required. These distances are possible even where buildings, pipes, and other obstructions are present. Battery life for LoRaWAN sensors is longer, with thermocouple or pressure sensor batteries lasting up to 10 years.

## Combining sensor and LoRaWAN transmitter

Since the introduction of WirelessHART and ISA-100.11a about 13 years ago, the range of native process instruments has grown enormously, but sensor selections have been largely limited to devices with low power consumption. Offerings designed for equipment condition monitoring tend to focus on tell-tale variables, including temperature, pressure, and vibration. Let's look at how the first two can be applied.

Temperature sensors are designed to work with various types of thermocouples, including B, E, J, K, N, R, S, T, and C. The transmitter can support the full measuring range of each type, so low as well as high temperature measurements are possible. The actual temperature sensor can take any typical form and be mounted separately from the transmitter, or it can be attached directly. This allows monitoring anything from gases and liquids flowing through a pipe to electric motor bearings.

Pressure sensors for condition monitoring tend to be basic in-line gauge pressure measuring devices, which can be mounted directly like a mechanical gauge or connected to the process via impulse lines. Frequently, the new wireless transmitter can be mounted in the same location as a mechanical gauge it is replacing. Typical applications might include monitoring the output pressure of a pump or compressor, back pressure of a reverse-osmosis membrane to detect clogging, or pipeline pressure.

When installed in a plant environment, it is often possible to install a single LoRaWAN gateway in a central location capable of covering the whole facility, thanks to its 1 km radius range.

Naturally geographically large facilities, such as a tank farm or well head site, may need more than one gateway. Because this network only serves the condition-monitoring sensors, data can be routed to the appropriate users, such as maintenance or reliability teams.

## Examples of automated condition monitoring

Returning to the earlier discussion about manual rounds, let's look at how condition-monitoring sensors improve on traditional practices, including:

- Inconsistent timing: Manual rounds are effective only when operators perform them consistently. If an emergency or other assignment causes a skipped visit, a problem has that much more time to escalate.
- Inconsistent data retention: If data has to be collected and transferred to a host system manually, there is high potential for errors and missing data.
- Inability to spot trends: With gaps in data, it is difficult to recognize trends and steadily escalating problems.

Automated data collection ensures consistency on all sides. There are no gaps in performance and no errors. If there are trends, they are easy to spot. Because all the data comes in through a single gateway, or at least a single network, all data can be directed to the right individuals for evaluation and appropriate action. Here are some brief examples of how companies have put this capability to work.

**Dust collector:** A process that generates dust, such as a lime or cement kiln, must capture dust from a flue gas stream via a dust collector or baghouse. These items of equipment can become problems if they are too full, reducing throughput, or begin leaking due to a broken bag. Placing a pressure sensor on the outlet ahead of the induced draft fan can diagnose both conditions.

**Pressure-relief valves:** Any pressurized equipment in a process unit must have pressure-relief valves (PRVs). These are notorious for leaking due to malfunction or inadequate reseating after a pressure event. A slow but continuous leak over a long period can waste an enormous amount of product. Since most processes operate either above or below ambient temperature, it is possible to detect leaks by installing two temperature sensors, both tied to a single LoRaWAN transmitter, upstream and downstream of the valve. If there is no leakage, the downstream sensor should show a reading equal to ambient conditions. If the downstream sensor moves closer to the upstream reading, it is due to fluid coming through the valve. The difference between the two readings can indicate the amount of leakage.

**Coal storage:** Companies that store bulk coal (e.g., power plants, steel mills) can experience spontaneous ignition from heat buildup deep in piles. If temperature sensors are inserted into the piles, it is possible to detect a temperature increase and respond with pile agitation before it gets hot enough to ignite.

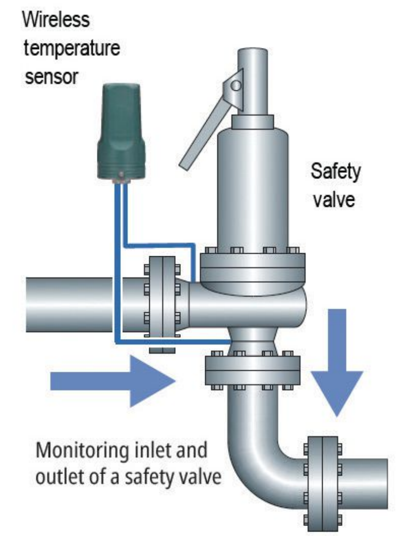



Figure 4. Measuring the temperature differential on both sides of a PRV with a Yokogawa Sushi Sensor communicating via LoRaWAN can indicate when it is firmly closed or is leaking.

When condition monitoring is automated, it can facilitate data sharing within a company from unit to unit and plant to plant. Maintenance and reliability teams can learn from each other and become more efficient and effective. Plants and even entire companies can improve output and profitability due to more reliable production through greater plant availability. All this can be achieved without tedious and time-consuming inspections by using a wireless protocol optimized for use with process instruments. ■

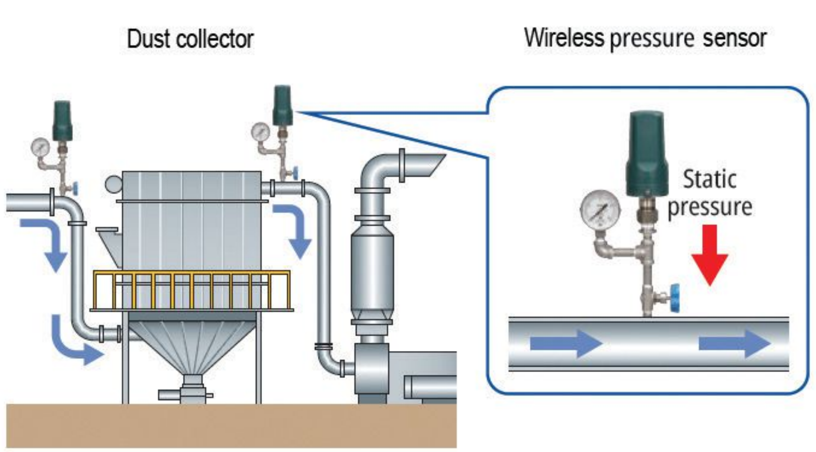



Figure 3. Sensors like Yokogawa's Sushi Sensor can provide a pressure measurement via LoRaWAN at the outlet of a bag house to indicate if it is clogged or if it is leaking due to torn bags.

**ABOUT THE AUTHOR**

**Haruka Yamada** is a member of Yokogawa Electric Corporation's Internet of Things wireless promotion team. She joined Yokogawa Electric after earning a master's degree in mechanical engineering, specializing in robots controlled by wireless, from Shibaura Institute of Technology. Yamada first worked as a software engineer for ISA100 Wireless, and she is now in charge of marketing and promotion of Sushi Sensor.

All figures courtesy of Yokogawa

# Digital Twins Calibrated Data Drive Efficiency

## By deploying a closed-loop digital twin throughout a system's entire lifecycle, machine builders and end users can reduce costs and optimize efficiency.

By Colm Gavin


As digital trends evolve throughout industrial automation, more individuals and organizations are realizing the benefits of modeling and simulation on their production systems. These practices can lower design and development costs and reduce time spent troubleshooting equipment in the field during commissioning. Perhaps less well known is an equally important benefit: simulation can also help continuously optimize operational efficiency, especially when production data is used to calibrate the model. This methodology is known as a closed-loop digital twin (CLDT).

A digital twin is a virtual representation of a physical asset. The CLDT expands on digital twins by using historical data to improve accuracy over time. Particularly in material handling and manufacturing, it is difficult to determine labor and machine utilization, and a CLDT can identify and provide insights and recommendations to improve the efficiency of these systems. CLDTs also provide benefits during the design and commissioning stages of a system's lifecycle, but this article focuses on their usage during operation. While a system is in service, a CLDT helps users make informed decisions to adjust operations on the fly for improved efficiency.

### Old models stagnate

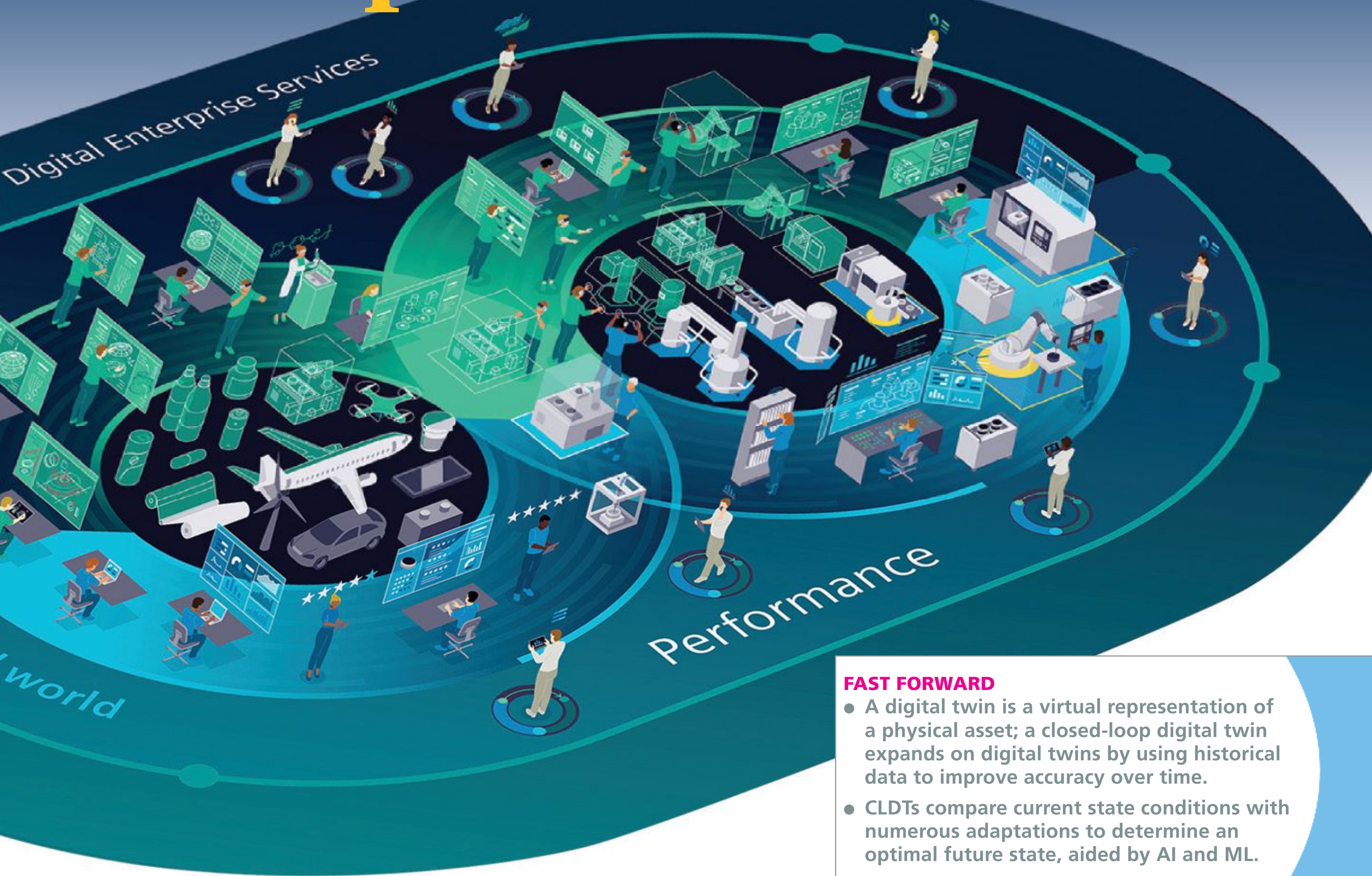
In manufacturing and intralogistics environments, facility managers are faced with the difficult task of maintaining optimal key performance indicators (KPIs) despite daily and unplanned changes in employee numbers; large unexpected incoming or outgoing orders; and package-handling bottlenecks.

Facility models can help staff identify critical production points to achieve aggressive operational targets, but many of these models are rigid at best or inaccurate at worst. To maximize efficiency and productivity, staff need a model that can be tuned, but most facilities do not have the trained personnel or the time to manually perform these adjustments. Additionally, with so many control variables, it is difficult to know what to even simulate in a model. Models guided with artificial intelligence (AI) and machine learning (ML) can bring answers to these and other problems.

### Insight-bearing digital twins

The digital twin methodology provides precise insight for optimizing parameters to meet and maintain KPIs. Expanding on this concept, a CLDT creates an accurate replica of the assets' current states to forecast accuracy beyond that of a standard digital twin without feedback. CLDTs compare current state conditions with numerous adaptations to determine an optimal future state, aided by artificial intelligence and machine learning.

# with Operational




**FAST FORWARD**

- A digital twin is a virtual representation of a physical asset; a closed-loop digital twin expands on digital twins by using historical data to improve accuracy over time.
- CLDTs compare current state conditions with numerous adaptations to determine an optimal future state, aided by AI and ML.
- CLDTs can accurately forecast capital and operating expenditures and throughput to provide a baseline from which to increase operational efficiency.

In this process of generating and evaluating potential future states, cloud computing power is immensely useful for simulation and data ingestion. In an ideal scenario, a machine builder or system integrator develops a CLDT to aid in the development process, and they then deliver it with their product, giving end users the ability to continue using it. As detailed below, CLDTs have benefits for machine builders and end users during the design, commissioning, and operation phases of the machine lifecycle.

## Design phase

During the design phase, CLDTs empower machine builders and system integrators to persuasively demonstrate the effectiveness of their design to potential customers, equipped with statistics and visual interfaces to monitor virtual machine performance. These models and simulations can be used to convincingly predict the outputs end users are looking for, increasing confidence in designers' proposals, and enabling them to win more bids.

By delivering a CLDT with their systems, machine builders can leverage the investment beyond the design phase, creating additional revenue streams through an ongoing services model. This gives them the ability to follow up and support products deployed in operation, and it extends and strengthens the relationship between machine builders and end users.

For end users, these digital twins increase profit margins by accurately forecasting capital and operating expenditures—along with throughput—providing a baseline from which to increase operational efficiency. They can do this through informed decision-making with the aid of a CLDT.

## Commissioning phase

During development and commissioning, a digital twin combined with programmable logic control (PLC) and human-machine interface (HMI) simulation helps engineers spot bugs and inefficiencies in a machine before physical equipment and moving parts come into the picture. The addition of a digital twin to PLC and HMI simulation is a clear link between the automation programming logic and machine performance, complete with a virtual visualization of the machine. This setup makes it easy to find problems early on.

By identifying potential issues virtually and early in the commissioning phase, these tools limit unexpected and costly project changes. Additionally, greater virtual troubleshooting and testing abilities shorten required physical commissioning time, while reducing labor requirements and costs for integrators.

Shorter and more effective commissioning benefits end users because systems start up and enter production on time, with reduced chances of costly change orders late in the commissioning phase. And unlike classic commissioning processes, hands-on digital twin plant simulation enables end users to begin operator training and equipment tuning programs well ahead of physical commissioning.

## Operations phase

Throughout operations, a closed-loop system brings its greatest value with cloud collectors that ingest production data, providing continual fine tuning for optimal operational states. Simulation with a digital twin provides:

- experimentation of multiple states, modeling hours of production and estimating results in a matter of seconds.
- prediction of important KPIs—like throughput, utilization, and idle time.

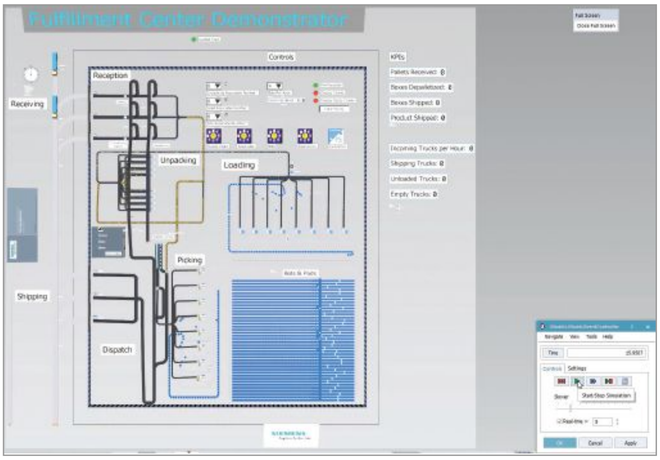



Figure 1. Users can adjust control parameters in software like Siemens Plant Simulation to visualize and determine effects on throughput and other KPIs.

Closing the loop and supplying a simulation with historical data greatly improves simulation accuracy.

The resulting CLDT enables fine tuning of operations by providing reports with optimal parameters, such as machine settings, manpower allocations, and shipping/receiving capacities, through a combination of simulations and AI/ML. Facility staff can set up automatic report generation at specific time frames—for example, before or during shifts, or in preparation for a daily staff meeting.

When human-based analysis is required to augment a decision-making process, easily understood model visualization provides insights into the way a facility operates. Visual simulation helps staff identify production bottlenecks and areas where excess resources are allocated. It enables staff to simulate multiple scenarios to answer situational questions—such as “What happens if there are fewer associates at a picking station?” or “What if too many robots are being sent to one area (e.g., picking) versus another (e.g., loading)?” CLDT software gives users the capability to adjust control variables and visualize their effects on operations (figure 1), quickly resolving these and other issues.

Visual elements help users better understand the numbers and point out where changes need to be made. These software tools evaluate the best utilization of machines and labor—for instance, ensuring a warehouse has enough trucks available at the loading bay to handle outgoing shipments, but not too many, to avoid sending away unloaded trucks.

In situations involving a large number of parameters and theoretical combinations to experiment with, automated software helps eliminate redundant or impractical experiments by intelligently identifying those that are feasible. This can reduce thousands of combinations to tens or fewer, ultimately identifying the best set of parameters (figure 2).

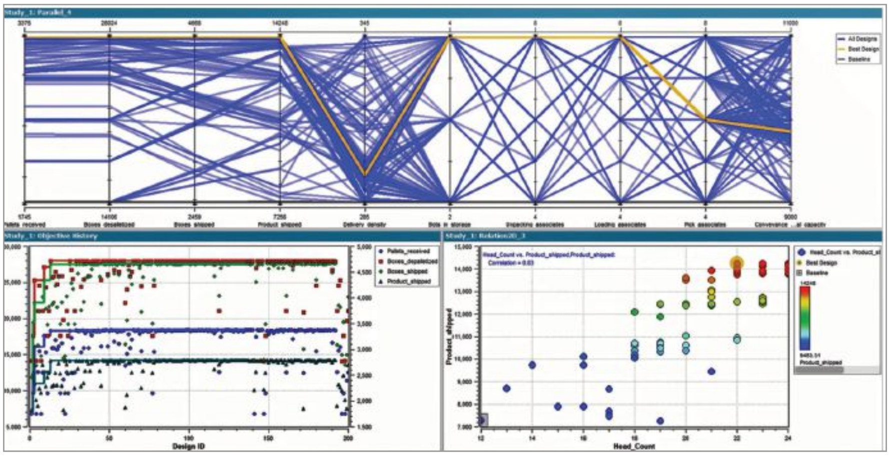



Figure 2. Software helps eliminate examples that are not useful. Siemens Plant Simulation software—with the HEEDS design exploration and optimization engine—determines suitable variants and the best design.

## Creating the calibrated CLDT

To calibrate the CLDT, the first step is connecting the digital twin with the automation equipment to feed data to the model. Edge devices are prime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Get an overview of your process at a glance.
Control your SCADA with a swipe.
Ignition
Perspective
See the live demo now.
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interfaces for data collection because they can preprocess machine data before sending it to the cloud for synchronization with the CLDT's historical data-based optimization algorithm.

Users can build, operate, deploy, and maintain software solutions across multiple edge devices using managed edge apps. Numerous apps are available for analyzing machine data. Their ecosystem—including patch and version control—is managed through a central system deployed in the cloud or on premises.

Using industrial edge controllers reduces the number of devices connecting to machines on the plant floor. They also provide the means for an on-premises simulation solution, or advanced analysis in a cloud-based simulation.

With a simulation in the cloud on an open Internet of Things (IoT) cloud platform, users can map data from the plant floor to the digital twin model. This data is used to create insights for optimizing conditions and control variables on the production lines to maximize throughput and other KPIs. Some cloud platforms include a dedicated app for preparing and aggregating time series data into a simulation application (figure 3).

The model accuracy improves over time, as more data is collected and aligned with control variable inputs and predictions. In advanced AI- and ML-enabled configurations, the models can manipulate PLC parameters to improve operational efficiency, in addition to generating reports with suggested resource and asset reallocation. This type of calibrated CLDT is created as a turnkey system, specific to a machine or facility.

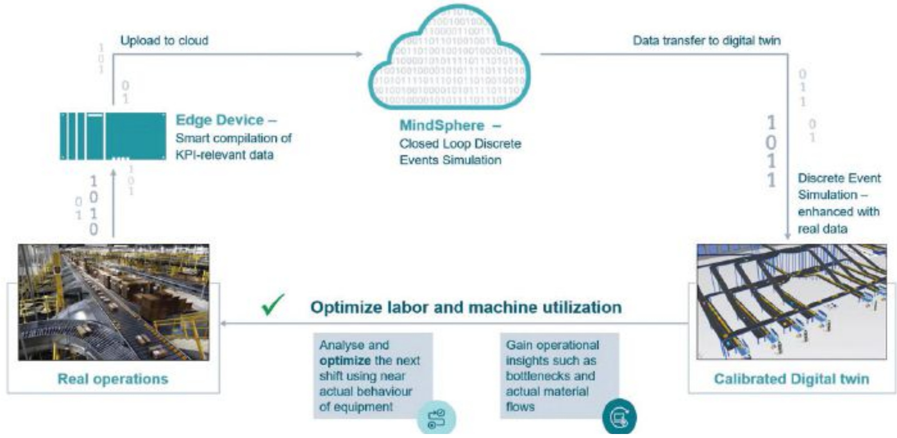


Figure 3. An open IoT cloud platform, such as Siemens Industrial Edge and Cloud native apps, empowers users to calibrate their digital twin with historical production data.

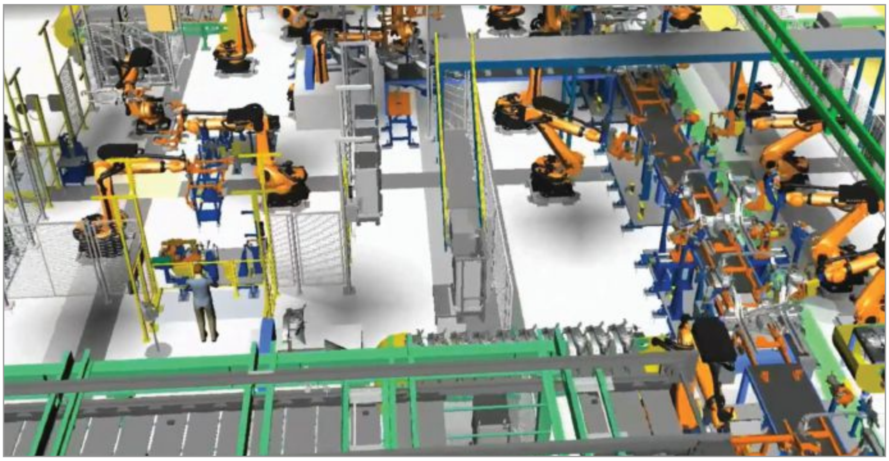

Figure 4. One manufacturing company optimized operations and predicted throughput with more than 99 percent accuracy using Siemens digital twin methodology with Plant Simulation and MindSphere applications.

## Results

A manufacturing company recently added a high-volume production line at its facility, containing 75 machines, 25 pick-and-place robots, and conveyor belts to perform complex material handling operations. Coordinating the vast amount of equipment required careful planning to implement and optimize operations after commissioning. The project team developed a digital twin to aid design and commissioning efforts, and closed the loop once machines were installed, creating a calibrated CLDT (figure 4).

Following calibration, the model predicted 105.26 jobs per hour for a certain shift. The actual shift yielded 105 jobs per hour, achieving model production accuracy of 99.75 percent.

## CLDTs streamline operation

Digital twins are already widely accepted for identifying potential issues early in design and development, reducing error occurrence, and speeding up physical commissioning. Their potential value multiplies during operation.

A calibrated CLDT reduces the time required for manually monitoring production data, and eliminates human guesswork involved in planning procedural changes and resource reallocation to increase efficiency. This translates to streamlined operation and higher profit margins, empowering manufacturers and intralogistics companies to become more competitive in demanding markets. ■

### ABOUT THE AUTHOR

**Colm Gavin** is the portfolio development manager for Siemens Digital Industries Software. With more than 21 years at Siemens, he uses his experience in discrete manufacturing to help companies take advantage of Industry 4.0 innovations.

All figures courtesy of Siemens

# Meet 2021 ISA Fellow David Strobhar

David Strobhar has worked in the area of human factors in automation for the past 37 years. He founded a human factors consulting company, helped develop the ISA-18.2 (IEC 62682) standard, wrote the book *Human Factors in Process Plant Operation* and more than 25 papers, and established the Center for Operator Performance. Now, as a 2021 ISA Fellow, Strobhar is being honored for his long-time contributions.

In 1984, Strobhar started the company Beville Operator Performance Specialists, Inc., (www.beville.com) to provide alarm rationalization, which is the process of evaluating the purpose and value of each alarm. Before these services were offered, alarm systems were often impeding—rather than helping—operations because operators were dealing with alarm floods (too many alarms going off at once).

Strobhar said getting the company off the ground involved about six months of cold calling to determine if there was a market for human factors in the refining and chemical business. Eventually, he did some projects for free to demonstrate what he could do. Now, 38 years later, about 75 percent of Beville's work is with refineries, and 25 percent involves chemical plants, pipelines, and production facilities.

"We were doing alarm rationalization before anyone else had a term for it," said Strobhar. "There was a definite need for it. Now, a whole slew of other organizations have popped up to try to meet that need."

Strobhar became active in ISA around 2005 when ISA-18.2, the ISA standard about alarm rationalization, began development. Strobhar helped with the formation of the standard; he also assisted in editing the rationalization clause and reviewed the rest of the document. Ultimately, ISA-18.2 was adopted by the international community.

> **"Step forward to your supervisor and ask to address issues. That really helps you get noticed and advances your knowledge base."**

Strobhar said working on the ISA-18.2 standard has afforded him credibility in the field. "When people ask who you are, and you say you're on ISA's alarm management committee, they're going to think, 'I guess you know something about alarms!'" he said.

In 2007, Strobhar helped launch the Center for Operator Performance (https://operatorperformance.org), a diverse group with representatives from industry, vendors, and academia addressing human capabilities and limitations with research, collaboration, and human factors engineering. "The group brings data to the discussion so that people can make more informed choices," he said. "It meets twice per year but funds research throughout the year at various facilities."

Strobhar recommends that young engineers get involved in things outside their normal job functions to learn about and improve the company. "Step forward to your supervisor and ask to address issues," he said. "That really helps you get noticed and advances your knowledge base. It shows you have the ability to not only do what you're supposed to do but also see opportunities to improve the company's performance."

Find out more about ISA Fellows and other awards at www.isa.org/members-corner/isa-honors-and-awards. ■ *–By Melissa Landon*

## Most Popular Posts on ISA Interchange Blog

ISA's official blog, ISA Interchange, has many perspectives from ISA members and industry contributors. The staff recently compiled the five most popular posts from the first half of 2021. See what your peers are reading here, and visit https://blog.isa.org for more.

### 5 Increases in Instrument Application or Installation Issues

In this post by Greg McMillan, who represents the ISA Mentor Program, Mike Laspisa, a 37-year veteran in the instrumentation and control discipline, asks ISA Mentors a question: "Has anyone noticed an increase in installation-related issues over the past 10 years related to either device selection or improper installation?"

### 4 Construction Automation and its Humanitarian Applications

Author Zachary Liollio says that within wartime humanitarian efforts, automation has removed humans from the line of fire, and the construction industry is adapting these new technologies as well. He mentions how one international nonprofit, Bomb Techs Without Borders, is tackling demining operations and explosive ordnance disposal (EOD) with expedited completion times and incredible precision.

# ISA Introduces Automation Project Management Specialist Certificate Program

ISA announced a new professional certificate program covering the unique challenges of project management in the automation industry. The program is designed for project managers who want to gain a deeper understanding of how to execute automation projects effectively, as well as for automation professionals who wish to acquire an understanding of core project management principles.

The Automation Project Management Specialist Certificate Program is based on "real-world, practical lessons that you can apply to your job today," said project management veteran Hunter Vegas, who helped develop the program.

"The first third of the course covers the basics of project management so that the entire class is up to speed on project management terms and project execution methods," said Vegas. "The last two-thirds of the course specifically cover automation projects and the various issues/challenges they pose."

Vegas, who has engineered and managed automation projects for most of his 35-year career, has a BS in electrical engineering from Tulane University, an MBA from Wake Forest, and Professional Engineering licenses in Control Systems and Electrical Engineering in six states.

"Automation is not well understood by others, and the requirements are usually poorly defined. The challenges associated with automation project management are legion," said Vegas in an interview with Christina Ayala for the ISA Interchange blog.

"This course is not a theoretical course on project management," Vegas added. "It is a 'been there, done that, and got the scars to prove it' type of course that points out potential pitfalls and provides practical advice about how to address a whole host of issues and gotchas."

Topics include:

- integration of multiple engineering disciplines (software, computer systems, networks, and instrumentation)
- high dependency on user requirements of disciplines outside of automation
- integration of requirements from many areas (business, engineering, safety, environmental)
- delays in other project areas that propagate over the automation area
- new technology or technology constraints.

An impressive list of project managers from around the world—including Simon Lucchini, Andre Michel, Steve Mustard, Nick Sands, and Scott Sommer—helped put together the new certification. Some of the developers routinely worked with 100+ million dollar projects, and others usually worked on smaller projects, so everyone involved contributed different management techniques to the program.

No prerequisites or applications are required for the Automation Project Manager Certificate Program. Choose from several formats, including classroom (MT01) or self-paced modular (MT01M). You can try module one of MT01M for free.

ISA also offers a host of other certification programs, such as the Certified Automation Professional (CAP), various cybersecurity certificates, and several safety certificates. To find out more about all the ISA certification programs, visit www.isa.org/certification/certificate-programs. ■ *–By Melissa Landon*

## 3 Why are 5G and IoT a Game Changer for Manufacturing?

Emily Newton tackles the topic of 5G telecommunications technology, describing how it may soon revolutionize how companies use IIoT devices to increase efficiency, enable predictive maintenance, enhance data collection, and improve robotics capabilities.

## 2 Bridging the Gap Between Education and Industry

Elena Rios describes the skills undergraduate engineers will need for the digital economy. She elaborates on the technical skills, such as data analysis and software development, and the soft skills, including complex problem solving and analytical thinking. She also touches on how a looming talent shortage is causing many countries to import employees and may lead to a new focus on skills development.

## 1 Cyber-Physical Systems: The Core of Industry 4.0

Rajabahadur V. Arcot penned the most-read post in the first half of 2021. He describes a key element in the implementation of Industry 4.0: cyber-physical systems (CPS), or smart systems that include engineered interacting networks of physical and computational components. He explains how industrial firms plan to leverage the tenets of CPS to achieve operational excellence. ■

# ISA Transactions Names PID Advanced Control Article Best of 2020


*ISA Transactions,* the journal covering the science, mathematics, and engineering of measurement and automation, has announced the best of its 450 papers published in 2020. The editorial board of the journal annually highlights its best article based on its expected impact on the research, development, or practice of industrial automation and measurement, among other criteria.

"The task of selection of the best paper involves a tedious process," said Ahmad Rad, editor-in-chief, *ISA Transactions.* "The objective was to select the best from a list of 450 papers published in 2020 in twelve volumes (96–107)."

The paper "Controlling industrial dead-time systems: When to use a PID or an advanced controller" won the nomination from the editorial advisory board. Lucian Ribeiro da Silva, Rodolfo Cesar Costa Flesch, and Julio Elias Normey-Rico wrote the article, which appears in Volume 99 of *ISA Transactions,* published April 2020, on pages 339–350.

"This work presents a comparative analysis of PID, DTC, and MPC strategies when used to control SISO processes with dead time considering characteristics commonly found in industry, such as noisy measurements in the process output and modeling error," the authors, who are affiliated with the Universidade Federal de Santa Catarina, write in the abstract. Editors and editorial board members were asked to cast their votes based on the following criteria:

- quality and clarity in the manuscript
- degree of utility and applicability of the technique
- completeness and comprehensiveness of the work
- input from the review process
- expected impact of the work on the research, development, or practice community.

ISA partners with Elsevier to make the content of *ISA Transactions: The Journal of Automation* available through Science Direct, a searchable online database of the full text of all articles since 1989. Non-members and institutions may access ISA Transactions at www.sciencedirect.com/journal/isa-transactions. ■ *–By Melissa Landon*

# A Diversity Message from ISA President Steve Mustard


**Steve Mustard, PE, C.Eng., CAP, GICSP**

Diversity and inclusion are core ISA values, along with excellence, integrity, collaboration, and professionalism. We strive to be a global, diverse, and welcoming organization.

But what do we mean by diversity and inclusion? Diversity is the representation of different people in an organization; inclusion is ensuring that everyone has an equal opportunity to contribute to and influence that organization. Author and thought leader Verna Myers explained it this way: "Diversity is being invited to the party. Inclusion is being asked to dance."

I feel that equity goes right along with diversity and inclusion, ensuring that processes and programs are impartial, fair, and provide equal possible outcomes for everyone. Why does ISA have diversity and inclusion as core values? Does the inclusion of new people create a zero-sum game, with the exclusion of those who are already there? Does equity give preference to some more than others?

Businesses are already aware of the benefits of being diverse, equitable, and inclusive, experiencing better financial performance and higher customer satisfaction. Companies in the top quartile for gender diversity in executive teams are 21 percent more likely to have financial returns above their industry's national median than companies in the fourth quartile.

Organizations that successfully create an inclusive culture have 39 percent higher customer satisfaction scores than those that do not. Inclusive cultures also reduce turnover rate and increase innovation.

**"There can be no better example of how diversity and inclusion is not a zero-sum game than tackling this skills gap. I believe this must be a priority for all engineering societies."**

The Royal Academy of Engineering also released a case study toolkit on increasing diversity and inclusion in engineering. Case studies from engineering companies such as IBM, Airbus, Atkins, BAE Systems, bp, Rolls Royce, and CH2M are included, showing how diversity and inclusion have become a core focus, and with good reason.

The engineering skills shortage has been debated for many years. The *2020 Global Engineering Capability Review* provides a very stark view of this shortage: "Today, there is a severe lack of such engineering and technical capacity; a skills gap that is exacerbated by the introduction of new and emerging technologies, and by infrastructure developments that do not include and involve local workforces. So, without intervention, the pattern of increasing occupational accidents and fatalities is likely to continue."

There can be no better example of how diversity and inclusion is not a zero-sum game than tackling this skills gap. I believe this must be a priority for all engineering societies. ISA can help lead the way, embracing people from all underrepresented groups and giving them a place and a voice so they are part of the solution.

The Executive Board established a volunteer diversity review task force this past year, asking it to specifically look at our policies and opportunities to improve diversity, equity, and inclusion in our leadership. We also have groups reviewing processes in hopes of increasing diversity of some of our recognition programs.

We are all able to and should strive to contribute to our diversity and inclusion values:

- Be role models internally and externally to promote opportunities for all groups to progress in the society.
- Communicate and advocate diversity and inclusion.
- Use data to raise awareness, measure progress, and support diversity in our volunteer groups.
- Identify, address, and eliminate unconscious bias/challenging bias. Try out the implicit association tests at Harvard's Project Implicit.
- Implement and follow guidance on how to respond to unacceptable or unhelpful behavior in the society.
- Mentor individuals from underrepresented groups, in ISA and in our day jobs.

As always, feel free to contact me if you have any thoughts or comments. Share with me any ideas on how to make ISA a more diverse, equitable, and inclusive society. Diversity, equity, and inclusion is a win-win game for the society and the wider profession. Now more than ever we all need to work together to build a better world through automation. ■

## ISA Certified Automation Professional (CAP)

Certified Automation Professionals (CAPs) are responsible for the direction, design, and deployment of systems and equipment for manufacturing and control systems. For more information, visit www.isa.org/training-and-certification/isa-certification/cap.

### CAP review question

**For a resistance temperature device, the term "alpha" in the equation below is typically called?**

$$R = R_0 ( 1 + \alpha \Delta T )$$

A. temperature coefficient of resistance
B. temperature inverse scaling factor
C. RTD normalization constant
D. coefficient of heat transfer

### CAP answer

The answer is *A,* "temperature coefficient of resistance." Resistance temperature device (RTD) elements can be characterized by their temperature coefficient of resistance (TCR). This constant is also referred to as the alpha constant for the RTD. RTDs can be manufactured from different metals, and each RTD specification has its own alpha value. For example, the IEC 60751 standard defines the platinum Pt100 RTD as having a resistance of 100 ohms at 0°C with an alpha coefficient of $\alpha = 0.00385$. Using the equation in the problem statement with $R_0 = 100$ ohms, a Pt100 RTD will change resistance by 0.385 ohms/°C.

References: Sands, Nicholas P. & Verhappen, Ian, *A Guide to the Automation Body of Knowledge, Third Edition*, ISA Press, 2019.

## ISA Certified Control Systems Technician (CCST)

Certified Control System Technicians (CCSTs) calibrate, document, troubleshoot, and repair/replace instrumentation for systems that measure and control level, temperature, pressure, flow, and other process variables. Visit www.isa.org/training-and-certification/isa-certification/ccst.

### CCST review question

**Each controller in the plant has instructions as part of the device that affects the controller output based on the error signal. These are preset based on the dynamic loop response and are referred to by which of the following terms:**

A. algorithm
B. reverse band
C. process lead lag
D. error compensation

### CCST answer

The answer is *A,* "algorithm." An algorithm is a set of instructions or equations that are used to evaluate process inputs, such as sensor values, and determine the desired output. There are multiple algorithms that can be used. The familiar proportional, integral, derivative (PID) algorithm uses the difference between the sensor input and the set point (error) to calculate an output based on magnitude of the error, persistence of the error, and the rate of change of the error.

Reference: Goettsche, L. D. (Editor), *Maintenance of Instruments and Systems, Second Edition*, ISA, 2005.

# New CAPs and CCSTs

The following individuals have recently passed either ISA's Certified Automation Professional (CAP) exam, or one of the three levels of Certified Control Systems Technician (CCST) exam. For more information about either program, visit www.isa.org/training-and-certification/isa-certification.

## Certified Control System Technicians

### Level 1

Justin Adkins, U.S.
Abdullah Al Mesbah, Saudi Arabia
Juan Manuel Albelo, U.S.
Ibrahim Almajnouni, YASREF, Saudi Arabia
Lucas Scott Ancell, University of Missouri-Columbia, U.S.
Mason Armstrong, U.S.
Ren Babin, Total Petrochemicals USA Inc., U.S.
Jason Bertacchi, Dublin San Ramon Services District, U.S.
David Burns, U.S.
Matthew Nick Cahoon, 3M Co., U.S.
Jack Carter, U.S.
Jorge Castillo, U.S.
Nok Chanthasaly, U.S.
Stephan Cook, U.S.
Christopher P. Criblez, U.S.
Van Danh, U.S.
Ephraim Jesugbemi Eniayekan, PIVOT-GIS, Nigeria
Samuel Ferguson, U.S.
Willard Dale Ferguson, U.S.
Micah Graves, Prime Controls LP, U.S.
Jack Hoit, U.S.
Aaron Horn, U.S.
Joseph Hurm, U.S.
Benjamin Johnson, Xcel Energy, U.S.
Brandon T. Kanouff, U.S.
Daniel Kilerciyan, Koch Modular, U.S.
Kevin Lacar, U.S.
Carlos LaLuz, U.S.
Adam Lucas, IBEW Local 82, U.S.
Brian Maki, U.S.
Jorge Maldonado, U.S.
Joseph McDaniel, Southern Gardens Citrus, U.S.
Nathan Daniel McNamee, MKD Electric, U.S.
Anibal Meraz, U.S.
Noel Montesano, U.S.
Luke Motycka, Hikma Pharmaceuticals, U.S.
Jason Nelson, City of Roseville, U.S.
David O'Leksy, TAI Engineering, U.S.
Justin Palensky, Huffman Engineering, U.S.
Bradley L. Perry, U.S.
Joseph C. Petronglo, Complete Control Services, Inc., U.S.
Minh Phat Le, U.S.
Starlena Phillips, U.S.
Kurtis Ptolemy, EPCOR Water Services, Canada
Christian G. Ransdell, U.S.
Scott D. Rathbun, City of Ann Arbor WWTP, U.S.
Amancio Rodriguez, U.S.
Anish Sargath, Saudi Aramco, Saudi Arabia
Javid Tarlan Semavi, Micron Technology, U.S.
John Shepherd, U.S.
Christian M. Smith, U.S.
Charles A. Thompson, U.S.
Zachary Weber, Eagle River Water and Sanitation District, U.S.
Lonnie S. White, U.S.

### Level 2

Guillermo Aguilar, Metropolitan Water District of Southern California, U.S.
Ali Alsaidi, Saudi Aramco, Saudi Arabia
Michael K. Ayoub, U.S.
Daniel J. Caffery, Eagle River Water and Sanitation District, U.S.
Adam Dittbenner, U.S.
Jude Chinedu Esumobi, U.S.
Thomas Faughn, Lincoln Electric System – TBGS, U.S.
Daniel Abata Ferrer, Metropolitan Water District of Southern California, U.S.
Arturo A. Flamenco, Denka Performance Elastomer, U.S. Dalton Landwehr, U.S.
Eric E. Holden, U.S.
Cameron Kardel, Honeywell UOP, U.S.
Gary D. Lucas, U.S.
Christopher J. Meier, U.S.
Michael D. Moriarity, U.S.
Nathan Murphy, U.S.
David Payne, Flint Hills Resources, U.S.
Bradley L. Perry, Stepan, U.S.
Roberto Rolando Ramirez, U.S.
Daniel Schoess, U.S.
Matthew W. Scott, U.S.
Kevin J. Vokey, Canada

### Level 3

Colette Cook, Tecpro, U.S.
Robert C. Davis, U.S.
Ryan R. Funk, Xcel Energy, U.S.
Michael R. Glass, U.S.
Matt A. Hayes, U.S.
Brett Eugene Holuby, U.S.
Kenneth R. Lane, Telstar Instruments, U.S.
Timothy A. Majewski, Chevron, U.S.
Jeff E. Scott, U.S.
Joshua A. Smith, Blue Racer Midstream LLC, U.S.
Brian Trent, BAE Systems, U.S.

## Certified Automation Professionals

Hafiz Muhammad Abdullah Arif, Pakistan
Ravindar Arumugam, Qatar Aluminum, Qatar
Saad Ather, Pakistan
Shreyas Bhandare, Malisko Engineering, U.S.
Deeparnak Bhowmick, Mitsubishi Hitachi Power Systems, India
Ben Bosch, U.S.
Girard R. Bourque, U.S.
Trey Buechler, Poet, U.S.
David Burns, U.S.
Philip V. Chandra, U.S.
Analyn C. Corcuera, U.A.E.
Aaron Doxtator, Canada
Tushar Kanti Dutta, India
Kenny Eichler, Tecpro Ltd., U.S.
Ahmed Abdulmuttalib Elzaki, Petro-Energy E&P Co. Ltd., Sudan
Denis Maulini Guncet, U.S.
Gaurav Gupta, ADNOC Onshore, U.A.E.
Faisal Hayat, Lalpir Pvt. Ltd., Pakistan
Mohamed Saifeldeen Hemeadh, ASGE Group, Saudi Arabia
Carlos Hernandez, VIAVI Solutions, U.S.
Bryan Highland, Wunderlich-Malec Engineering, U.S.
Woong Jung, Republic of Korea
Ryan William Kershaw, Litmus Automation, Saudi Arabia
Vsevolod Krasnoperov, U.S.
Jerahmeel Andrew Layco, Maynilad Water Services Inc., Philippines
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Stephen Marshall, Bechtel Nuclear, Security and Environmental, U.S.
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Saqib Rehan, Intech Process Automation, Pakistan
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Muhammad Waseem Shahzad, ATSYS, Australia
Cedric Sindjui, Intech Process Automation, Cameroon
Justin Philip Singree, Automation Plus, U.S.
Harry Stafford, Chevron USA Inc., U.S.
Michael Stafford, Canada
Tijo John Thomas, Yokogawa Middle East and Africa B.S.C, Bahrain
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Seth White, U.S.
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# ISA84 to Hold October Plenary

The ISA84 standards committee, Instrumented Systems to Achieve Functional Safety in the Process Industries, will meet virtually throughout the week of 25 October 2021 as it continues developing and updating a comprehensive set of technical reports. The technical reports provide guidance and practical examples for applying the widely used ISA/IEC 61511-2018 standards, *Functional Safety – Safety Instrumented Systems for the Process Industry Sector*, Parts 1–3. Those ISA/IEC standards, the first version of which was completed by ISA84 in 1996, set forth requirements for the specification, design, installation, operation, and maintenance of a safety instrumented system (SIS) so that it can be entrusted to achieve or maintain a safe state of a process.

The ISA84 objectives for the week include:

- Complete work on a technical report revision, ISA-TR84.00.02, *Safety Integrity Level (SIL) Verification of Safety Instrumented Functions*, which serves as a tutorial on the fundamentals of data selection and the reliability calculations. The technical report was recently approved by ISA84, but with submitted comments that will be reviewed and responded to during the meeting.
- Continue work on updating ISA-TR84.00.05-2009, *Guidance on the Identification of Safety Instrumented Functions (SIF) in Burner Management Systems (BMS)*. Focus is on providing BMS-specific guidance and clarity to all phases of the safety lifecycle, updating unit operation examples based upon the latest governing standards/practice (e.g., NPFA 85, API 556), and updating based on end-user feedback from using the current edition of the document.
- Discuss ideas for updating ISA-TR84.00.07-2018, *Guidance on the Evaluation of Fire, Combustible Gas and Toxic Gas System Effectiveness*, which addresses detection and mitigation of fire, combustible gas, and toxic gas hazards in process areas.
- Continue work on updating ISA-TR84.00.09-2017, *Cybersecurity Related to the Functional Safety Lifecycle*, which provides guidance on integrating the cybersecurity lifecycle with the safety lifecycle as they relate to safety controls, alarms, and interlocks, inclusive of safety instrumented systems.

ISA standards participation and meetings are open to all interested parties, and experts from any country are welcome to join ISA84 or any ISA standards committee. For more information, contact Charley Robinson, ISA Standards, crobinson@isa.org.

For information on viewing or obtaining the ISA technical reports described above, visit www.isa.org/findstandards. ■

# ISA Standards Leader Wins Major IEC Award

Nicholas P. Sands, an ISA Fellow and long-time leader within ISA's Standards & Practices Department, has been awarded the IEC 1906 Award by the International Electrotechnical Commission (IEC) in recognition of his leadership and technical expertise as the lead editor of an IEC team in the development of IEC 62682, *Management of Alarm Systems in the Process Industries*. The standard is the IEC version of the ISA-18.2 standard of the same title. It was originally developed by the ISA18 standards committee, of which Sands serves as co-chair with Donald Dunn.

The award, which commemorates the founding of the IEC in 1906, honors technical experts around the world whose work is fundamental to the international standardization mission of the IEC. ISA is a major participant in and contributor to IEC standards, with original ISA standards serving as the basis of several widely used IEC standards.

Sands is currently a senior manufacturing technology fellow working for DuPont's Tyvek® business and the global alarm management leader for DuPont, supporting plants in Virginia and Luxembourg. In his more than 30 years with DuPont, he has been a business process control leader, site process control leader, process control consultant, and plant control engineer in several different businesses. He has worked on or led the development of several corporate standards and best practices in the areas of automation competency, safety instrumented systems, alarm management, and process safety.

Sands is a past vice president of ISA's Standards and Practices Department and, in addition to serving as co-chair of ISA18, is the managing director of ISA101, Human-Machine Interface, and ISA84, Instrumented Systems to Achieve Functional Safety in the Process Industries. He is also a past vice president of ISA's Professional Development Department, and a volunteer in the development of ISA's Certified Automation Professional program.

Sands has written over 40 articles and papers on alarm management, safety instrumented systems, and professional development, and is the co-editor of ISA's *Guide to the Automation Body of Knowledge, 3rd edition.* He is an ISA Certified Automation Professional and a licensed professional engineer in the state of Delaware. He has a BS in chemical engineering from Virginia Polytechnic Institute and State University. ■

# Augmented reality becomes authentic reality

By Percy Stocker

**ABOUT THE AUTHOR**

**Percy Stocker** is SVP AR Americas for TeamViewer, a global mobile technology company. He has 15 years of consulting, sales, and operations experience and a master's degree in computer science from Technical University of Munich and the National University of Singapore.

Every Boeing 747-8 Freighter contains at least 130 miles of wiring. There are wires overhead, under the floor, through the walls, around the cockpit, and down into the wheel wells. Depending on the customer's needs, Boeing's cargo planes are also available in multiple configurations, each with its own distinctive wiring scheme. Getting all those planes wired correctly is critical, and for years the plant's assembly technicians used heavy printed manuals—their so-called "phone books"—and intricate laptop diagrams to guide them in their work. It was a tedious job.

Several years ago, the company found a better way. It equipped its technicians with Google smart glasses that use augmented reality (AR) software to superimpose wiring diagrams and related information from a remote computer onto real-time images of the plane's wiring harnesses. And they do it without requiring the workers either to break visual contact or use their hands. The instructions they need are projected directly onto their field of view, and by using voice commands, they can change the display as required.

Boeing is not alone in using AR to find novel ways of improving quality and saving costs. A growing list of leading manufacturers are finding that AR can be applied to a variety of industrial issues.


Thyssenkrupp, for example, uses Microsoft HoloLens, a system that overlays high-definition holograms onto real-world images, to custom design and help customers visualize home stair lift systems. Data from those images is then transferred to the company's manufacturing facility, dramatically shortening delivery times.

Jaguar Land Rover designed an AR system that uses iPad cameras to train new employees how to recognize the location of wiring and electronic devices obscured behind the vehicle's dashboard. It uses an app that shows diagrams of concealed wire connections, simply by pointing to the dashboard. The system teaches trainees whatever they need to learn without the time or cost involved in disassembling an actual vehicle.

Caterpillar is using an AR app to help its technicians do maintenance. It gives them step-by-step instructions of how to perform various service and maintenance checks, and it can connect them with experts all over the world. It also helps newly hired mechanics learn tractor maintenance much more quickly. Airbus is using AR in its inspection work, which has enabled it to speed up the assembly process by 40 percent. And Porsche is working on developing a system that uses AR for quality control.

Augmented reality is still a nascent technology, and its capabilities are constantly being expanded. But forward-looking companies are already finding valuable ways to apply the power of low-cost, wearable, voice-activated technology to augment the strengths of their workers, improve plant productivity, increase safety, enhance quality, cut costs, and train personnel more effectively. In fact, by 2025 it is estimated that approximately 14 million workers will be using various types of headsets in their workplaces, blending the power of data with real-world scenarios.

Among its emerging uses are inventory management, prototyping, security, and real-time analysis. But for manufacturing organizations and on the plant floor, it is the company's industrial engineers, skilled operators, technicians, and machinists whose training and work stand to benefit most immediately from this transformational technology. ■

*This article (www.automation.com/en-US/Articles/August-2021/Augmented-Reality-Authentic-Reality-manufacturersfirst) appeared on Automation.com in August 2021.*

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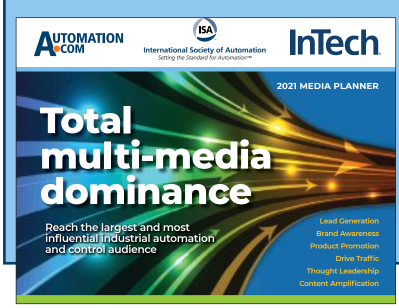


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### INDUSTRIAL CYBERSECURITY QUICK START GUIDE

The ISA Global Cybersecurity Alliance's Advocacy and Adoption work group's guide to the ISA/IEC 62443 series of standards includes lists of specific standards documents applicable to various roles within the security environment. The ISA Global Cybersecurity Alliance is a collaborative forum to advance industrial cybersecurity awareness, education, readiness, and knowledge sharing. Membership is open to any organization involved in industrial cybersecurity.

**To download a PDF copy of the whitepaper, visit https://gca.isa.org/isagca-quick-start-guide-62443-standards. To talk about how your company or organization can join ISA GCA, contact Rick Zabel at rzabel@isa.org.**

# Enhancing Virtual Events

By Bill Lydon

**ABOUT THE AUTHOR**

**Bill Lydon** (blydon@isa.org) is an *InTech* contributing editor with more than 25 years of industry experience. He regularly provides news reports, observations, and insights here and on Automation.com.

Due to the pandemic, we have entered a virtual world, replacing physical events with Zoom calls, webinars, and electronic chat rooms, but we can enhance them by reaching out and touching someone.

My more-than-30-year industrial automation career has benefited from learning and meeting people at ISA symposiums, trade shows, and other face-to-face events that, unfortunately, have been canceled during the pandemic. Fortunately, Internet technology allows us to attend virtual events that are productive under the circumstances. But these virtual events lack valuable informal human interaction.

Logically I know events must be virtual during these times, but they do not have the added dimension of face-to-face attendee discussions. Mingling at exposition areas, breakfasts, breaks, lunches, social hours, dinners—and just bumping into people—I gained highly valuable information: knowledge, new ideas, insights, and know-how. These informal interactions at events also foster greater camaraderie in the automation community. As a result, you make long-term professional connections and friendships, and these become your personal ecosystem of automation resources. Your professional life is enhanced by a diverse group of people in a way that goes beyond formal training and book learning.

## Reach out and touch someone

The lack of informal interaction due to virtual symposiums and events has led me to think about the 1970s AT&T advertising slogan, "Reach out and touch someone," encouraging people to make long distance calls to friends and family. This campaign was highly successful, touching a fundamental need for human interaction not always possible at a distance.

**Informal interactions at events also foster greater camaraderie in the automation community. You make long-term professional connections and friendships, and these become your personal ecosystem of automation resources.**

Feeling the sense of loss of face-to-face events for several months, I started making a conscious effort to reach out and connect with people using emails, LinkedIn messages, ISA Connect, and phone calls to say hello, how are you doing, and what's happening? The reception to these efforts has been very good, because I think people feel the same need to connect. Phone calls particularly have been well appreciated, with many resulting in serendipitous conversations about meaningful challenges and solutions.

Industry is faced with rapid change and challenges, and the diversity of automation professionals throughout the world is a great resource for dealing with these changes in the automation industry. In Judith E. Glaser's book, *Conversational Intelligence,* she describes how conversations actually rewire our DNA and brain chemistry for mutual success. In my experience, asking people in my ecosystem for ideas and thoughts has proven invaluable for solving automation control problems and improving operations.

The broader ecosystem outside your organization is important for protecting yourself and your company against the dangers of becoming inwardly focused and not changing with the times.

Whether you are a young person just entering the workforce, new to the industry, or an experienced veteran, your ecosystem can help you navigate industrial automation challenges and new technology. ■

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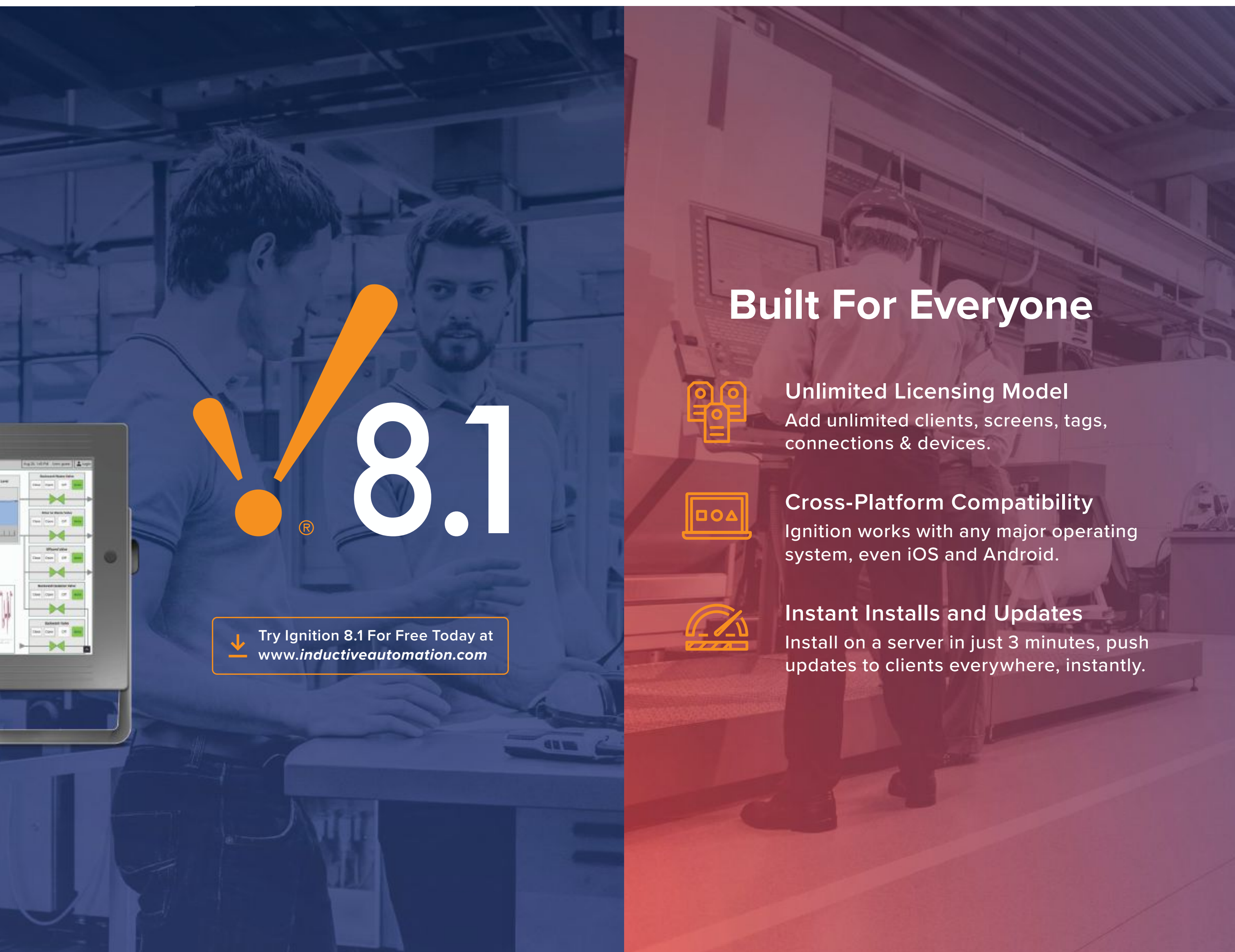
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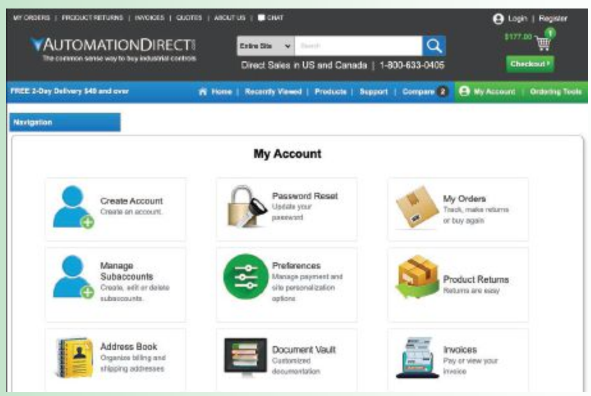


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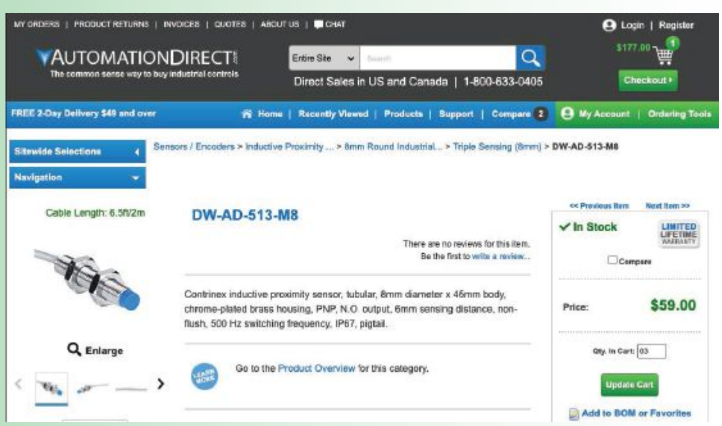


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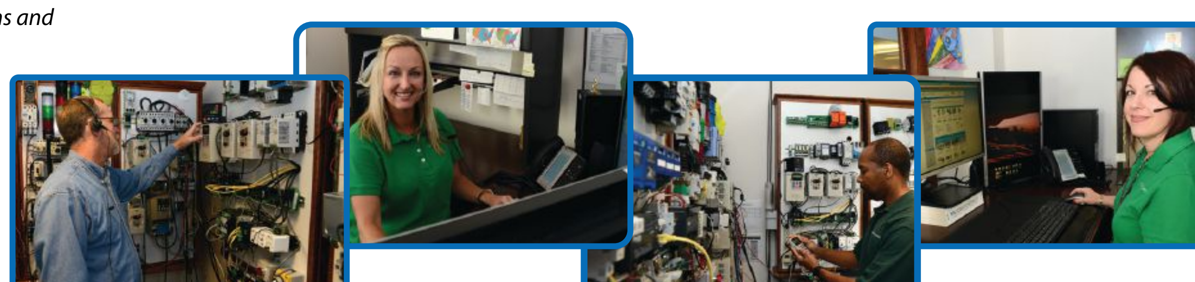

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