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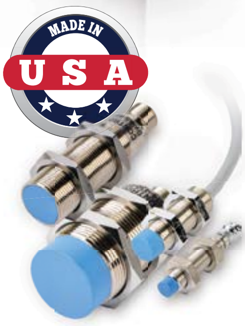

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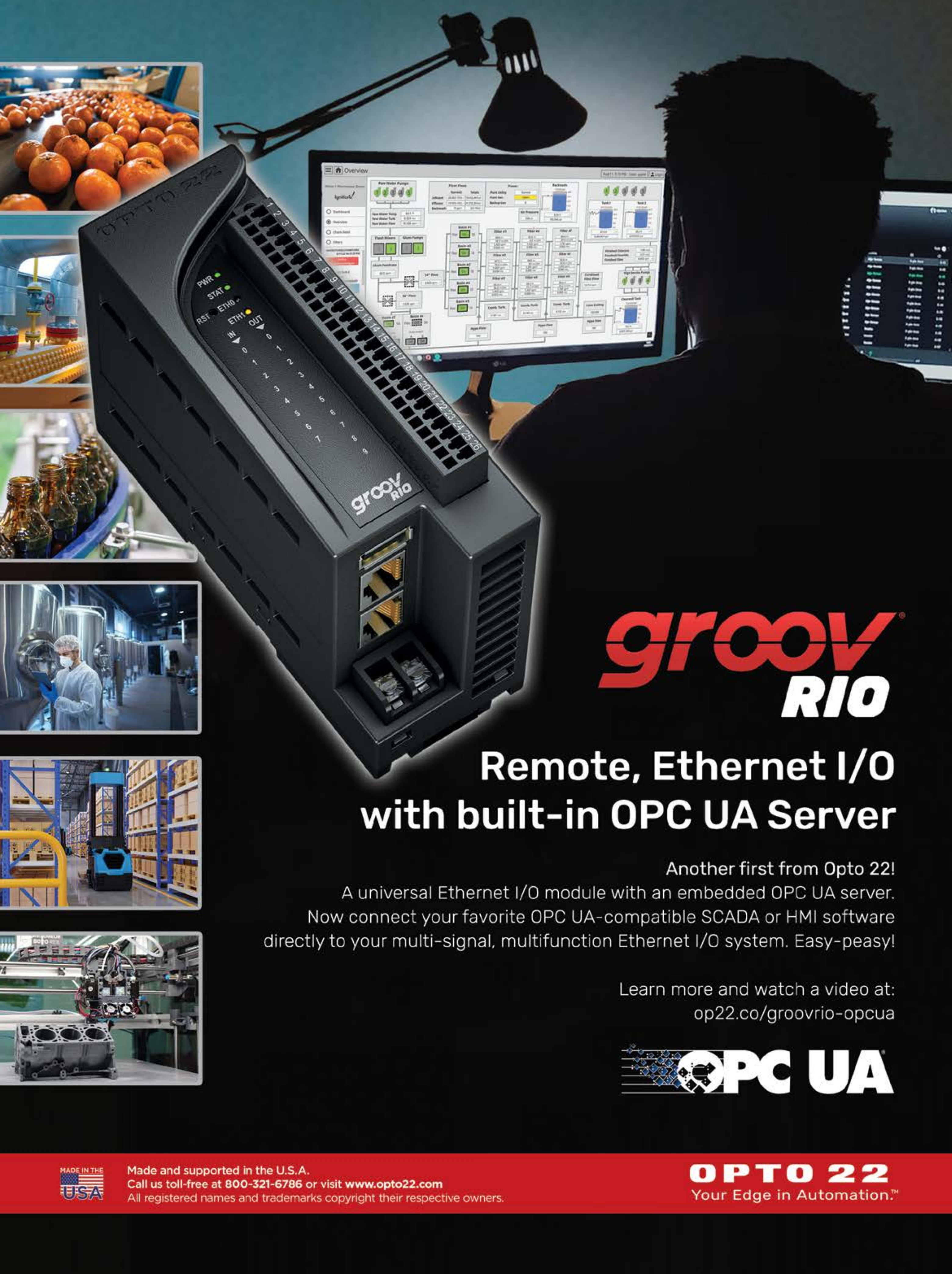

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FEATURES

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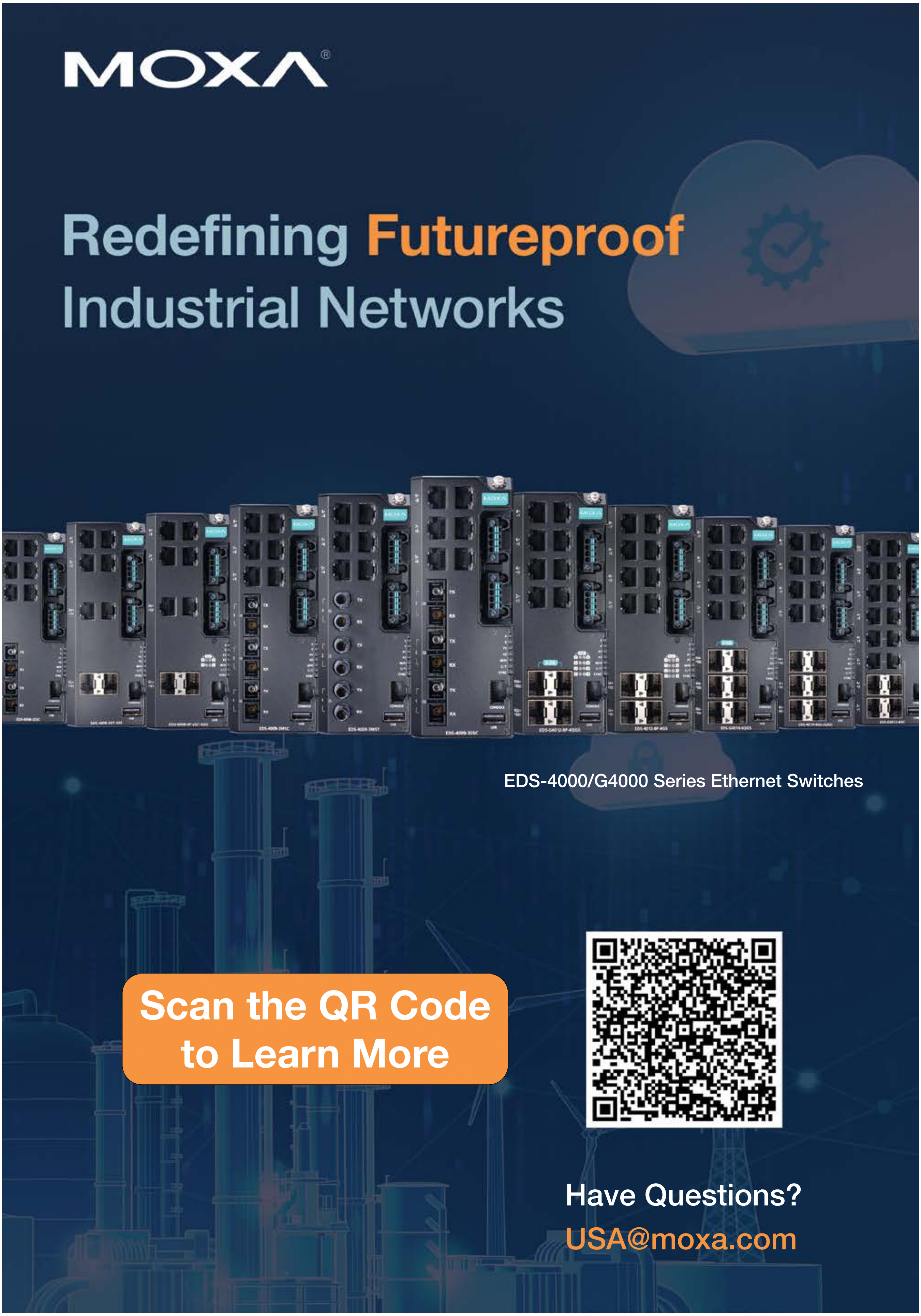
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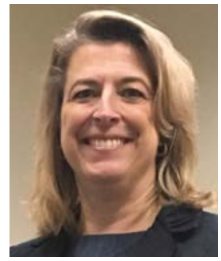

By Renee Bassett, *InTech* Chief Editor

Industry 4.0 and smart manufacturing aren't just for petrochemical campuses and automotive assembly plants. Digital transformation isn't just for food and pharma operations. Machine builders, job shops, and other midsize manufacturers may think they are too small, too specialized, or too ordinary for automation, but they are wrong.

Sure, all the case studies and proofs of concept for advanced manufacturing solutions seem to come from mega companies—or from lab-based startups that are somehow getting paid to fly drones or build BattleBots®. But 2022 may be remembered as the year when digital tools matured, and automation found its way to the masses. This very real Industry 4.0 revolution was on display at IMTS 2022, the biennial trade show and conference put on by the AMT – The Association for Manufacturing Technology.

Cancelled in 2020 by pandemic restrictions, IMTS 2022 came roaring back into Chicago in September to showcase digital manufacturing innovations by and for machine builders. More than 85,000 registered for the six-day show, whose theme "Digital Manufacturing. Implemented." was on display in more than 1 million square feet of exhibits.

Nine technology pavilions showed solutions such as multitasking machining centers, robots/cobots, and digital twin and manufacturing execution/work order software. The co-located Hannover Messe USA show and conference encompassed nearly 500 of the 1,800-plus exhibiting companies and highlighted industrial automation systems, wired and wireless networking, and much more.

The advances in digital manufacturing technology on display at IMTS 2022 put solutions within reach of small- and medium-sized businesses and should amaze even industry veterans, said Peter R. Eelman, chief experience officer at AMT. "For example, visitors can learn how to set up and run an entry-level automation solution in 30 minutes. Computed tomography inspection systems now operate with almost push-button simplicity, and digital twin technology is as easy to use as a favorite CNC control or CAD/CAM program."

Greater affordability and ease of implementation for cobots, pallet changers, Industrial Internet of Things (IIoT) devices, and manufacturing execution software means automation is not just accessible to job shops, original equipment manufacturers (OEMs), and small-to-medium-sized manufacturers; it is increasingly essential for these operations to staying competitive.

"If OEMs and job shops can digitize it, they should," said Eelman and others. "Digital tech is the best way to increase productivity with an existing talent pool, control costs, make reshoring/near-shoring more attractive, reduce time to market, and respond with agility to a volatile market."

My takeaways from four days of talking to IMTS 2022 attendees and exhibitors: Automation is power. Machine monitoring is smart. Software speeds setup and changeover. Cobots empower people, not just processes. Private wireless industrial networks are here. IIoT devices are essential and increasingly easy to implement.

The year 2022 may well become known as the year of industrial transformation. What are you doing today to make the jump to light speed when it comes to automation and innovation? Let me know. ■

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Practical IIoT and Wireless Network Practices for Modern Mining

By Bas Mutsaers, Mark O. Harris, Joanne Sun, and Robert Zwick

Modern metals and mining companies are sophisticated and often highly automated businesses with long histories. Current macroeconomic trends and business pressures increasingly demand that operations respond to technology advances, including faster and more reliable communications. The Industrial Internet of Things (IIoT), edge and cloud computing, 5G wireless communications, and other new technology promise increased functionality, but also require new approaches to security and daily governance to protect the investments needed to support them.

How wireless technology, IIoT, and good cybersecurity practices can support modern mining and metals facilities.

Here we share practical considerations about how wireless technology combined with good cybersecurity practices can support modern industrial facilities. Our examples come from mining and metals operations but apply to modern industrial operations of all types. Our focus is on wireless communication and IIoT, where practices are less mature, use and functionality are expanding quite rapidly, and security practices need to keep up with the growing risks that the sheer volume of additional endpoints will create.

Need for near-real-time data

With sustainability increasingly guiding the central decision-making processes, production functions, and the wider enterprise, businesses expect communication and processing to happen efficiently and with the lowest possible carbon production. This translates to producing with minimum energy consumption and with the least impact on water demands and water quality. Shareholders and the wider public are demanding sound environmental, social, and governance (ESG) and best practices for energy efficiency.

The efficiency of these processes can only happen with the right data. Tracking production to a level of trace metal specificity is being in-

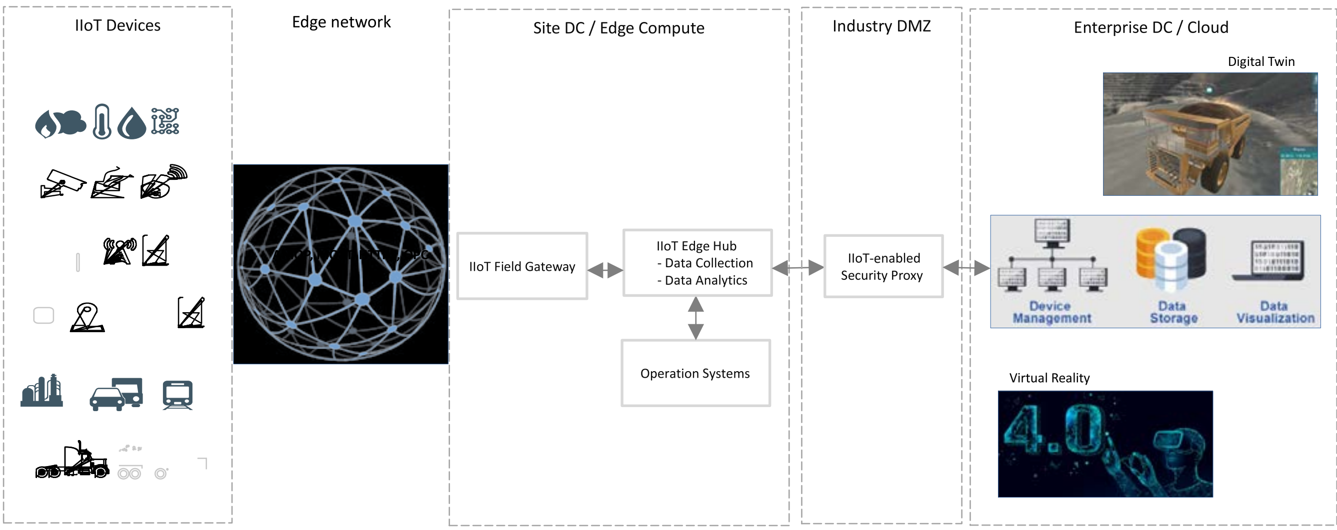

Figure 1. A common IIoT deployment architecture at a mining site

Source: MMID

creasingly requested for the related Scope 1, 2, and 3 reporting needs of the downstream production and purification companies. Companies can address requirements for such near-real-time data to support business needs separately or by a combination of wired and wireless solutions.

Communication can happen over hardware spread across the premise, or it can move wirelessly to the cloud for bulk data storage. IIoT devices deployed at industry sites communicate with field gateways/edge devices via an edge network (typically a wireless network). Data is collected from sensors and systems, analyzed at the edge hub level for real-time integration, or sent to a central cloud-based service. This data is aggregated with other data and delivered for advanced data analytics, such as digital twin, virtual reality, and value chain optimization (figure 1).

The edge network is critical communication infrastructure that enables fleet automation, decision automation, and optimization of production processes in the pit. Through the edge network, companies manage operations and maintenance with integrated planning and live fleet updates from drills, haul trucks, shovels, sensors, and unmanned aerial vehicles or drones.

Edge compute capacity is commonly achieved by deploying compute/storage hardware at the industry site data center close to the operation site. Data collected from IIoT devices can be processed quickly, and real-time integration with operational management systems takes care of hygiene, water management, energy and power quality, and product and assay management. Without IIoT, these processes would normally be manual, slower, and less accurate. With edge computing, the data reaches decision makers more quickly. Many workflows are therefore shortened, resulting in better decision making and overall plant efficiency.

Wireless trends in metals and mining

The use of wireless communication is already large and growing in mining and metals operations, often because the work is dangerous or spread over large areas. Steel is manufactured with very hot smelting processes, for example, and many operations use robotics for productivity and safety. There is a growing interest in autonomous robotic operations, including the management of in-process inventory, because these products are heavy and hard to handle.

ISA's Mining & Metals Division

The Mining & Metals Industries Division (MMID) is one of ISA's technical divisions. It focuses on leveraging automation functionality and technology solutions to enhance mining processes and metal production.

Who is best served by this division? Professionals concerned with economically and environmentally sound practices related to the extraction of metal ores, coal, cement, sand, gravel, and other minerals—and the handling, separation, processing, fabrication, related processes, and research and development for the production of finished mineral or metal products. The division also covers the iron and steelmaking industries, aluminum processing and other light metals, and the production and manufacturing of metals products. Find out more by visiting the division's page on ISA Connect (https://connect.isa.org).

In secondary steelmaking, requirements for speed and custom-made production volumes and grades are increasingly affecting efficiency, as these processes are added (through intelligent real-time scheduling) on top of brownfield applications and existing architectures, producing new safety scenarios and challenges. This strains existing wireless communications infrastructure.

Mines generally have similar challenges to efficiency, as well as multiple production- and safety-critical systems that are reliant on a consistent wireless connection. Mining continues to increase its levels of automation, and this includes the need for data connections to traditional (crewed) heavy mobile equipment (HME) and to autonomous or remote-controlled HME such as drills, haul trucks, excavators, and dozers.

The following mine systems are typically reliant on some kind of wireless connection:

- operations and fleet management
- remote HME operations
- collision avoidance for mobile equipment
- asset health monitoring and reporting
- ore and grade control, drill patterns
- high-precision GPS for GPS corrections
- geotechnical monitoring
- fatigue monitoring of personnel
- underground remote equipment operation
- electrical power equipment monitoring and control
- leaching field monitoring
- condition-based monitoring of intelligent instruments and control elements.

When it comes to cybersecurity, every industrial sector has its own requirements, but mining and metals companies are benefiting from the work of the ISA Global Cybersecurity Alliance (https://isa.org/isagca) to advance cybersecurity readiness and awareness in manufacturing and critical infrastructure facilities and processes. Secure communication is key, because mining and metals information also involves business information as products change hands across the value chain.

Another more local example of the need for secure communications happens when contractors who manage the pit fleet are moving material at the right grade from the pit to the owners of the plant: If trusted information is available for decision making, sites can realize the highest potential value of the ore based on specific productivity key performance indicators and other requirements.

Updating a 10-year-old wireless data network

Consider the situation facing a mining operation with a 10-year-old wireless data network. At this point, it is likely at its bandwidth capacity, which limits new technologies and upgrades to existing systems (e.g., collision avoidance, turn-by-turn dispatch directions). Besides the environmental challenges of dust, vibration, and other dynamics affecting operation of the current network, there is a risk of increased system failure as the network ages, demands for performance and data rate increase, and spare parts availability diminishes over time. Likely after 10 years, parts are no longer commercially available and must be procured through third-party sellers.

To mitigate the risk of unplanned system failure and therefore outage of several production- and safety-critical systems, management would have determined that the current wireless system must be upgraded or replaced with fit-for-purpose wireless technology that meets current and future bandwidth and cybersecurity needs. The new network must adapt to the current complexity of mine topography and evolve as the mine is further developed, either in an open pit or deeper and deeper underground.

Execution of the upgrade (modernization versus migration) also needs to accommodate new and updated wireless technologies to improve safety, such as systems for driver safety and collision avoidance, upgraded fleet management, and improved production and processing capabilities. Ideally systems are "future ready" for some of the expected innovation currently in pilot stages at the mine to prevent regret costs.

Given these requirements, the mine site has five options: run the existing network to failure; upgrade the current mesh network with no changes; replace it with a hybrid mesh/LTE network; replace it with a hybrid mesh/LTE network "as a service"; or install a site-specific 5G network. Here are considerations for each choice.

Run the existing network to failure. Pro: Low cost up front. Cons: Potential incidents because the current network supports safety-critical systems; increased maintenance on the existing network with no replacement components commercially available; estimated three-week production impacts due to network failure.

Replace with latest version of current mesh network hardware with no change. A typical wireless infrastructure provider offers fixed wireless and Wi-Fi to broadband service providers and enterprises to provide Internet access. An example of this is a Canopy network. Pros: Replacement systems support safety-critical systems and are often downward compatible; components are readily available; the overall system is supported by the vendor of choice; and the solution provides the easiest cutover without much additional training. Cons: Inflated cost, and the system may not provide as much bandwidth as a hybrid mesh/LTE solution.

Replace with a hybrid mesh/LTE network. Pro: The replacement system supports safety-critical systems and avoids production impacts from a network failure; addition of LTE provides additional bandwidth; components are readily available; and the system is supported by the vendor. Cons: Highest cost option; added complexity; unfamiliarity of LTE would require training and SLA setting with the vendor.

Replacement with a mesh OR hybrid mesh/LTE "as a service." Like many platforms, hardware as a service is also available. Pros: Lower up-front cost and in greenfield sites, often a plus; good option when capital is scarce; there is a replacement system to support safety-critical systems; and the approach avoids production impacts from failure. Cons: Requires a long(er) term support contract and expense; network as a service relies on a service agreement between the customer and vendor for network maintenance and managing a business-critical system. (For this it is best if the vendor is intimate with the challenges in OT and IT for the specific industry.)

Upgrade to site-specific 5G network. Pro: Site-specific 5G networks are up to 20 times faster than traditional LTE networks; the added speed allows the benefit of additional connections. Con: Additional connections means additional cybersecurity implications that must be addressed.

Additional actions/considerations for choosing among the five options:

- Give network components due consideration (for likely types of scenarios) and make sure the design receives a third-party review if safety and production rely on it.
- Identify all details to be included in the design.
- Conduct a constructability review for an initial state and a future state, as mines evolve over time.
- Calculate the current bandwidth requirements of all mine equipment and systems, and estimate bandwidth requirements for anticipated future technologies to produce a target bandwidth with a suitable safety margin.
- Perform a proof-of-concept test for each option or case under consideration to ensure the system functions as advertised in your environment. Test physical and electromagnetic functions, performance under additional security, performance beyond vendor default, and performance when adding potential overhead of various additional protocols (safety, functionality, or integration).

Consider the following major priorities when comparing the solutions:

- maximizing your bandwidth return relative to cost
- having a proven, established enterprise solution ready for mine deployment
- fulfilling cybersecurity requirements, default and specific to risk profile (such as for autonomous mining)
- having straightforward scope/implementation requirements to minimize schedule delays of the rollout
- having a low operating cost relative to the capital cost, but more importantly to the total cost of ownership
- minimizing reliance on the vendor for support for servicing as well as achieving a service level in response to the specific needs for the site. The Information Technology Infrastructure Library (ITIL) foundation provides a good framework to consider the details of service functions in IT and OT.

IIoT security considerations

IIoT devices leverage wireless technologies such as LTE, 5G, and Wi-Fi. They also leverage cloud technologies for analytics and storage, and low-power-consumption technologies for operational longevity. These technologies allow IIoT devices to be widely adopted in mining sites supporting autonomous mining or other processes. However, IIoT devices often have significant cybersecurity vulnerabilities to security threats.

Cyber threat actors frequently exploit security vulnerabilities in IIoT devices. A mining company faces different threat actors depending on its profile. Many mining companies have assets worth multiple billions of dollars, and many of these assets operate critical infrastructure, such as water and power supplies. Mining companies have exploration knowledge about future mining assets that, for example, influences decisions about adjacent infrastructure investments. Hence, various motivations attract intense interest from different cyber threat groups, including nation states, cyber terrorists, or even disgruntled employees.

Either external or internal threat actors can exploit a wide range of vulnerabilities in IIoT solutions, and the impact can seriously damage physical assets and risk the health and safety of people. For example, bad actors can hack the sensors used to monitor tailings dam water levels and maliciously change readings to be lower than the actual ones. This can delay or prevent an emergency response to a spill of the tailings water, resulting in damage to the environment and potential loss of human life.

Another example of an IIoT cyber threat target is the sensors used for stockpile slope monitoring. Sensors are commonly used to monitor the angle or stability of large stockpiles of different materials. If the stockpile slopes cannot be monitored correctly due to hackers intentionally changing the sensor data in the monitoring system, the stockpiles can collapse. This can cause production delays, financial loss, equipment damage, and loss of human life.

Common IIoT device vulnerabilities include:

- Hardware devices that are unmanaged: No device registration, tracking, compliance monitoring, or access control.
- Hardware and software versions that are out of date combined with versions of operating systems and applications that are no longer supported, leaving significant exposure.
- No endpoint protection, which makes the devices vulnerable to malware infection.
- Communication channels that are unencrypted or have no or weak authentication or are using unsecured protocols.
- Network IIoT devices connected to untrusted networks or the IIoT exposed to the Internet without proper security protections.
- Unprotected data in transit and storage, exposing sensitive or critical data either at rest or in transit.
- Unsecured IIoT services running either on premise or in the cloud.

- Increased exposure of critical IIoT through connected and converged IT/OT infrastructure.
- Software as a service (SaaS) with no segregation of customer data and unsecured cloud services. Vendor implementations have varying levels of security and are often open (not secure) by default.
- The supply chains are not well secured due to history and missing government practices on how third-party-supplied software/firmware/hardware should be secured.
- The lack of physical access control for installed IIoT devices.

Protecting the IIoT environment is only possible by minimizing IIoT vulnerabilities and reducing potential risks. Cybersecurity is not just a technology challenge. It is also a business issue that must be addressed comprehensively through people, processes, and technology. Every organization should consider following the National Institute of Standards and Technology (NIST) Security Framework. This framework provides guidance on balancing the effort to mitigate risks and provides processes where previously none existed.

Considering standards

Automation, IIoT, and wireless technologies are fundamental to current mining and metals companies. These technologies are evolving quickly, producing an exciting time of growth in data collection and data sharing, expanding capability, increasing efficiency, and supporting sustainability. At the same time, it is important to ensure strong cybersecurity controls and governance to keep functionality in place, safely. Companies can increase production and reduce costs through the deployment of connected technologies, but they can also lose significant value due to cyberattacks.

At first view, smaller companies seem less vulnerable to cyberrisks. They have lower profiles. However, they also have smaller budgets for protection and less to work with when it comes to the increasingly complex capability areas that cannot be fully performed through contractors. This is where standards can help ensure best-practice implementation of technology and cybersecurity protections at reduced cost.

Some internal function needs to exist for setting and auditing the best practices supporting mining and metals companies of the future. Our companies are continuously evolving their autonomous processes across the supply chain, supported by IIoT and sound cybersecurity practices. Simple steps like network segregation and training can provide additional protection.

We in ISA MMID believe it is worth sharing some of our experiences to motivate members using the standards ISA offers in this space (figure 2). From our personal experience, we believe we need to find the balance between production gains, risk exposure, and implementation cost. This can be tricky, but with a regular inventory of the risks and some good cybersecurity practices and related frameworks, most companies can solve these challenges. ■

ISA provides more information about this subject, particularly related to standards that are important to mining and metals operations:

ISA18, Instrument Signals and Alarms

ISA88, Batch Control Systems

ISA95, Enterprise-Control Integration

ISA99, Industrial Automation and Control Systems Security

ISA100, Wireless Systems for Automation

ISA101, Human-Machine Interface

ISA108, Intelligent Device Management.

Figure 2. ISA standards related to mining and metals

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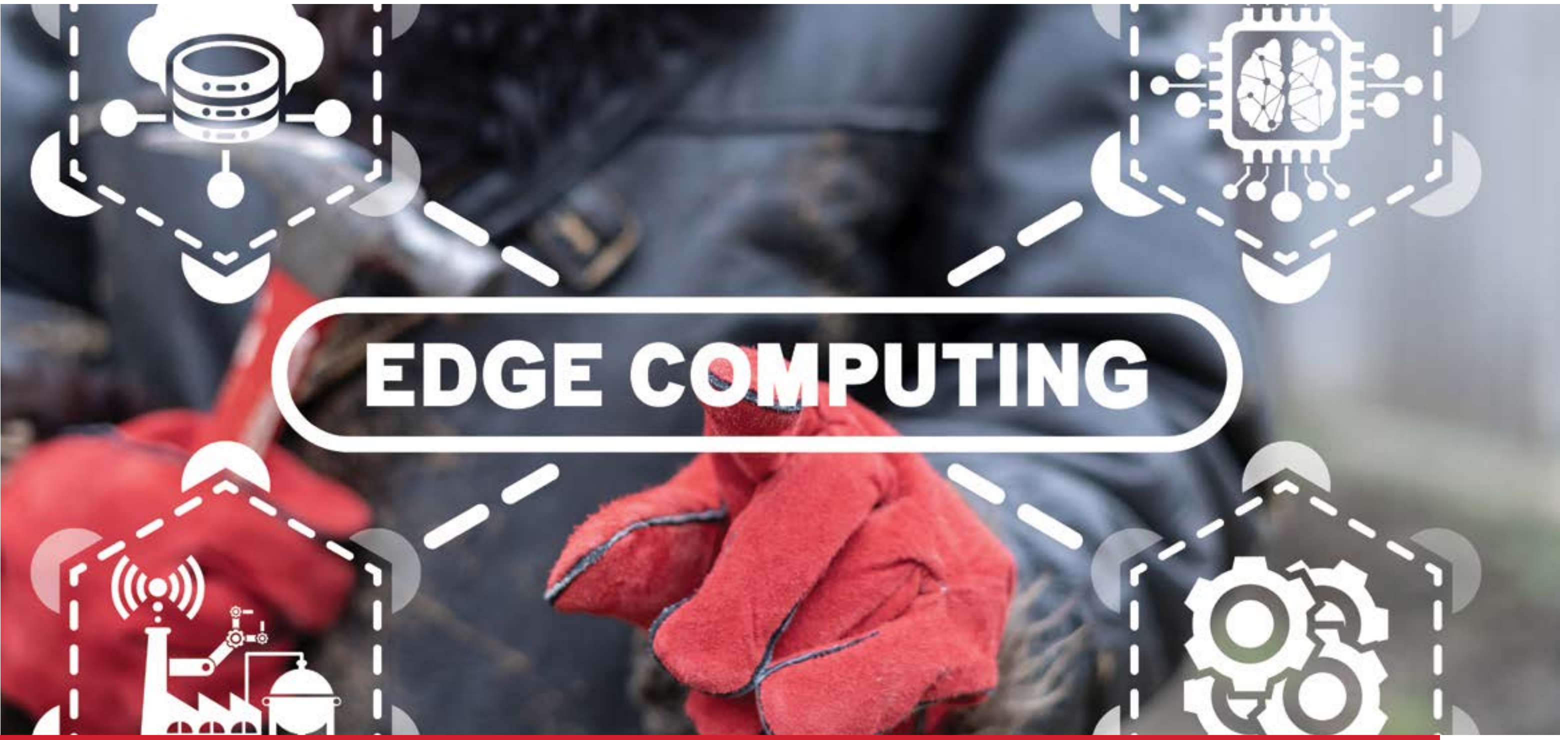
Increasing Edge Expectations



While the "edge" has existed since the beginning of industrial digitalization, a modern and comprehensive edge platform can create truly innovative solutions.

By Silvia Gonzalez

In the modern era of industrial automation, there has always been an "edge" where the physical, real world transitions into digital systems. Industry 3.0 involved the application of digital monitoring and control, while Industry 4.0 is marked by the expansion of connectivity and the Industrial Internet of Things (IIoT). The edge has existed throughout this progress, but it has grown in both size and capability to meet end user needs, especially in the area of data management and analysis.

These developments bring new possibilities for end users everywhere. In fact, there are so many opportunities it can be hard to know where to start, or to realize the extent to which barriers have fallen. Instead of just performing older tasks better, advances in edge connectivity and real-time control expand the horizons of what is possible. Users can start with certain practical goals, but they should also actively consider new and perhaps even unconventional approaches.

It is important for end users, original equipment manufacturers (OEMs), and systems integrators (SIs) to familiarize themselves with the necessary features of a comprehensive edge platform. The right edge platform will remove roadblocks to creating innovative applications, future proof installations, and provide a host of other benefits.

Edge platform basics

Edge applications bridge the gap between operational technology (OT) industrial systems and information technology (IT) resources. Organizations must be able to rely on OT implementations to run for years with minimal upkeep while effectively connecting with IT.

Part of the attraction of edge applications is the freedom users experience in choosing from an entire marketplace of hardware, software, and technologies to create a solution tailored to their needs. However, this extreme openness is more demanding than it might seem a first glance. A full-custom approach means the developer is responsible for ensuring the capability, performance, compatibility, cybersecurity, and supportability of all elements, in conjunction with each other.

Industrial applications call for greater assurances on each of these issues. Users will find that a complete edge platform (figure 1) from an experienced industrial automation supplier addresses each of these points by providing a coordinated, compatible, and wide-ranging portfolio that includes:

- scalable hardware
- flexible software
- extensive connectivity
- comprehensive cybersecurity
- mobile accessibility.

Scalable hardware

When developing an application, designers quickly discover there is no “one size fits all” when it comes to edge hardware. Not too many years ago, a traditional programmable logic controller (PLC) was a primary digital interface method for connecting with most field signals. Since then, field devices have become more intelligent, and some are directly IIoT capable, while real-time control and computing options have also multiplied. PLCs in small, medium, and large form factors remain relevant, although the larger versions are now often referred to as programmable automation controllers (PACs) because of their more extensive capabilities.

A key change at the edge has been the introduction of edge controllers. The best implementations of edge controllers perform real-time deterministic control just like a PLC—but add the onboard, general-purpose computing necessary to support IIoT applications. The most demanding applications may call for a full-fledged industrial PC (IPC).

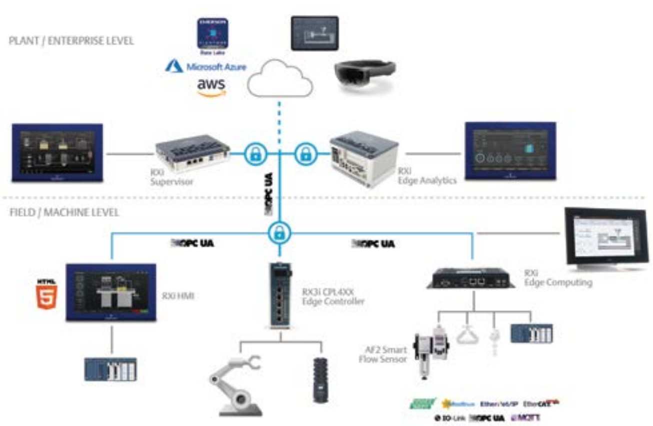


Figure 1. Edge projects are built from carefully coordinated hardware, software, connectivity, cybersecurity, and accessibility elements. An edge solution should provide a tightly integrated portfolio of these products, enabling users to create innovative applications hosted on proven edge platforms.

Flexible software

Edge applications can be diverse to meet specific needs. They can range from gathering PLC or intelligent sensor data, to performing more complex aggregation and computational roles. Therefore, edge software must flexibly meet the need for connectivity, computing, visualization, control, and analytics, which are all different but related (figure 2). Software also should follow industry standards, while being interoperable, open, and extensible.

Edge software must operate locally, while seamlessly connecting with higher-level on site or cloud-based resources. It may be called upon to gather field data, perform preprocessing, support local visualization, communicate information to other systems, execute local control, and carry out analytics. This is a tall order, and the software also must be easy to use, enabling end users to develop and deploy applications.

Connectivity

End users have a mix of control and edge application needs, but each solution relies on connectivity, which involves both hardware and software. From a hardware standpoint, connectivity includes hardwired input/output signals and serial

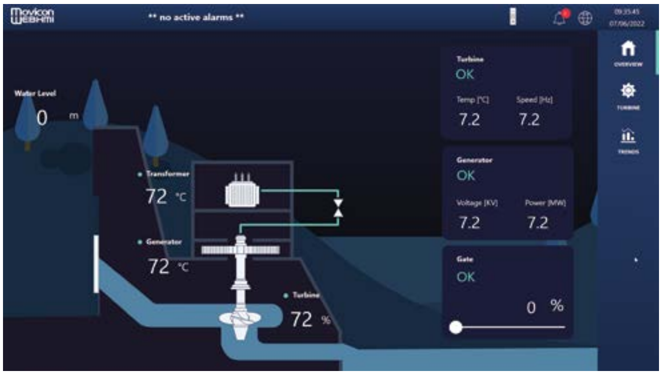


Figure 2. Edge software is called upon to perform many roles for connectivity, computing, and visualization. The web-based HMI shown here enables properly credentialed users to securely visualize process operations and analytics results from any location.

communications, along with support for industrial fieldbus and wired/wireless Ethernet protocols. Software provides the appropriate communications protocols, which need to be native to the edge platform, with the option to add support for more as needed. Complicating connectivity is the fact that both OT and IT have specific and different protocols unique to their implementations, so any edge platform must readily work with both.

Cybersecurity

Great connectivity demands equally capable cybersecurity. Edge platforms by their nature make OT equipment and operations potentially accessible to cyberattackers, who may steal or alter data, or cause improper system operations. Creating an edge solution using unrelated products from various suppliers means the developer needs to ensure not only the functionality and interoperability, but also the overall cybersecurity provisions. Instead, there is a case to be made for selecting products from a portfolio of industrial-specific options designed to comply with cybersecurity standards and best practices.

Mobility

Although there are many examples of edge solutions not needing a specific operator interface, it has become common for the edge to support local, remote, mobile, and browser-based visualization of direct field data and analytical results. Some applications may need all forms of these interfaces, supplied via industry-specific software and human-machine interfaces (HMIs), as well as more general open-source tools. A complete edge portfolio should support all these options.

Edge applications

For end users, OEMs, and SIs, most projects can succeed with the right mix of hardware, software, connectivity, cybersecurity, and mobility. Connecting with disparate data sources, performing computations, and communicating and visualizing the results are each unique but related tasks (figure 3). Following are a few examples where designers creatively pursued comprehensive solutions to meet their goals.

Figure 3. Users should approach edge applications with practical goals, but they will benefit by building these solutions upon a coordinated portfolio of hardware and software, efficiently merging the best of OT and IT technologies in a scalable manner.

An OEM provides connectivity and monitoring solutions specialized for supporting remote sites, such as oil wells. The OEM wanted to offer advanced capabilities—such as flare monitoring, adherence to security practices for personnel, and even vehicle license recognition—but this required a level of computing power that was previously impractical for field installation. However, by using an IPC and associated industrial-grade edge software, it built the exact edge computing solution needed to process data locally, which reduced the bandwidth needed for upstream communications to higher-level systems.

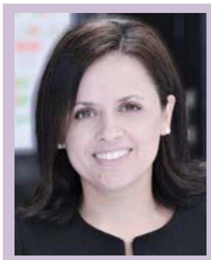
Another organization needed a way to monitor the health of Bitcoin server farms spanning multiple sites. It needed a simple way to monitor existing systems, add new sensors in parallel to existing devices, and enable remote access for a centralized view of all operations. Edge-capable hardware and software made it straightforward to add these robust capabilities to systems formerly limited to largely proprietary HVAC control and monitoring systems. The solution can incorporate external data, like weather, and perform analytics spanning many sites.

A third example is a manufacturing company that needed a better method for weld inspection. It developed a machine-learning algorithm that could be run for each weld to compare the actual results with what was expected or predicted by the model. Suspect situations could be indicated to users, and the system could even put a hold on the operation until the issue was fixed. Edge solution hardware and software selected from a comprehensive portfolio let the company create the system it needed, while minimizing concerns with respect to processing power, compatibility, and cybersecurity.

Expecting more from the edge

While the industrial edge has existed in the digital age, recent technological advances mean much more is possible at the edge than ever before, and by a large margin. This also suggests that implementers can think bigger and more openly than they are accustomed to by considering a wider range of options. ■

All images courtesy of Emerson



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OPERATIONS

Best Practices for Collaboration Between **Industry** and **Academe**

By R. Russell Rhinehart, ISA & AIChE Fellow

Better collaboration between academic institutions and industry practitioners can improve outcomes for industrial businesses and the schools, professors, and students they depend on.

Academic research about education is what substantially shapes higher education, which often leaves manufacturing and industrial businesses complaining about how new engineering graduates lack industry readiness. But if teachers had a better grasp of the applications and perspectives needed by industrial businesses, they could do a better job of creating an educational environment that generates fit-for-employment graduates. Additionally, with better collaboration, the creativity and expertise of academics could be a problem-solving resource for industry.

There is a need for industry to more effectively engage academic experts, and for more useful knowledge exchange. Although automation professionals and faculty are effectively working together in some places, there is a gap between what industry practitioners need and what academic experts provide. More frequent and influential collaborations can lessen that gap.

First, understand why a gap is there. Here are several reasons, categorized by contrasting terms:

Practicable-possible

Although industry requires what is practicable, faculty research is guided by what might be possible (and its mathematical demonstration). That means the knowledge being published in academic journals (like *ISA Transactions*) rarely affects the practice. Even if relevant, the journal articles require substantial cultural translation to become implementable. If academe is to support the practice, the practice needs to find a way to shape academic research.

Urgency-analytical
Academics work in a precommercial environment and have the investigative time to seek a clear and comprehensive system view of the fundamentals associated with a technical discipline. They want to discover nature and fundamentally defensible procedures. In contrast, practitioners tend to focus on immediate solutions for specific application cases, often using intuitive actions, workarounds, or a shotgun approach. Although true knowledge would be useful to them, situation urgency means practitioners often miss fundamentals that could become helpful.

Sufficiency-perfection
Industrial applications of technology are performed within a complex context, constrained by safety, regulations, human aspirations, and more; they are also applied on nonlinear processes. Such aspects are usually imprecisely quantifiable. Application success requires simple solutions, both mathematically and procedurally. By contrast, to achieve career goals, academics often seek complexity of mathematical analysis and proofs of certainty. These necessarily require an idealized context. One side is seeking perfection in an idealized context, while the other is seeking sufficiency in an ambiguous context.

Fruition-fundamentals
Industry wants to make things happen, to create and sustain a productive process or a marketable product. Academe seeks to discover the fundamental principles about nature. One focuses on how to do it, or the synthesis. The other focuses on defense of claims, or the analysis.

When people on one side read the publications of the other, they find little to nothing to address their needs. It is not that one side is doing it all wrong. Each side is doing what is right within its dissimilar environment. The gap between them—the differing goals, motivations, and measures of success—is what makes collaboration difficult.

About the survey
Collaboration, while difficult, is not impossible. In fact, the examples shown elsewhere in this article involving Miami University of Ohio, University of Michigan, and Purdue University are the results of successful collaborations. To bridge the gap in more places and for more institutions and industry practitioners, the International Federation of Automatic Control (IFAC) conducted a survey of best practices. (Read this article online [https://isa.org/intech] to see key survey result statistics, a glossary of terms, and additional articles related to this topic.)

ISA is one of nine professional societies in the American Automatic Control Council (AACC), which represents the U.S. to the IFAC Industry Committee (figure 1). An IFAC Industry Committee task force created the survey and analyzed the results, which are presented here.

The survey had 19 questions, about half of which solicited open text responses. The link to the survey was distributed within commercial publications, as well as via direct emails to the members of the IFAC Education and Industry Committees and ISA Divisions. Recipients were encouraged to further distribute the survey to their network of professional contacts. Approximately 260 individuals opened the survey, and 125 completed it.

Of those who provided geographical information, most are from Europe and North America. A total of 24 nations from six continents are represented, with the U.S. and France being the two largest contributors.

Most survey participants have experience in academia. In all, about 60 percent identify with academe and 40 percent with the practice; some claim significant experience in both. It is worth noting that many control practitioners are part of nonprofit, government, military, and even academic organizations, not just industry. So, we use the term “practice” to include all professionals who practice automation and control, regardless of their place of work. That is why we replaced the commonly used expression “university-industry collaboration” with the more inclusive “academic-practice collaboration” throughout the survey and this report.

The 12 academic disciplines represented in the survey were dominated by electrical, industrial, chemical, mechanical, and computer engineering. The 14 technology application domains were primarily represented by process, energy, and manufacturing. The nine practice sectors were substantially represented by industrial suppliers, industrial users, service providers, and vendors. The eight academic sectors involved were primarily research and graduate programs. Interestingly, most of the research entities listed their focus as application rather than pure science.

Understanding collaboration
Collaboration can take many forms, all of which can be mutually beneficial. Collaboration is an activity whereby individuals work together for a common purpose to achieve a common target benefit. Essential skills include trust, tolerance, self-awareness, empathy, transparency, active listening, and conflict resolution. Collaboration is not people working independently and following their own paths. Collaboration means accepting the experience of the others in the joint effort.

Examples of collaboration include industry practitioners helping in classrooms by providing guest lectures on topics and application perspectives often omitted in education. They could provide case studies for teaching examples or student projects. Industry could help in laboratory experiences by providing equipment and technical support.

With such collaboration comes many benefits: The teaching faculty comes to better understand the needs of the practice. Respectful relations are formed for possible future problem-solving benefit. Contact with students gives industry folks a recruiting advantage. Students benefit from the exposure and enjoy the real-world insight.

As a reciprocal, industry could host academic associates at invited seminars or short courses for employee continuing education and skills development. The experience shapes the academic focus, improving both teaching and research.

Another example is industry-sponsored research projects for undergraduate or graduate students. Preferentially, these are precommercial investigations designed to help practitioners answer their questions or explore a possibility that might seem promising. The sponsorship could be one on one or within a consortium, and the students and faculty would be allowed to publish the results.

There is a need for industry to more effectively engage academic experts, and for more useful knowledge exchange.

Industry also could hire faculty on an individual basis to solve a problem or to help develop a product, or it could engage equipment, faculty, and students to provide support through a university contract. Here, intellectual property (IP) concerns related to rights to inventions and patents would restrict academic publication. Myopic lawyers within both the industry sponsor and the academic institution seem to place IP possession above the benefit of collaboration and argue that their side should have exclusive rights. The IP impasse is often a barrier to collaboration, but when agreement can be reached, product and process development is enhanced.

The five players and their motivations

The survey reveals that five separate groups are involved in any academic practice collaboration. Each group must have an incentive to participate and to invest its resources to make a collaboration successful. The collaboration needs to be structured so each of the players experiences a benefit that justifies its investment. Each group also has its own culture and way of interacting. A collaboration must permit those diverse ways to synergize. The five groups are students, faculty, academic institutions, practitioners, and practice entities. Here is what motivates each to collaborate.

Students

Students are seeking practical knowledge and experience about the industrial context, which will lead to career and employment opportunities. Students are excited to work on real-world problems, to have access to state-of-the art hardware and software, and to relate the theory learned in class to specific practical situations. Students want to work with industrial mentors to gain in-depth understanding of the nontechnical side of practice, such as soft skills, project management, and market-driven decision making.

Faculty

Top incentives for faculty are professional development and funding. Professional development includes staying current with the state of the art in the field, selecting relevant research topics, validating ideas, having access to actual data, networking, and maintaining visibility through academic publications. Research funding is required to build a research group, support equipment and travel, and provide summer income. Industry-funded projects provide the means to support and sustain an academic group. Sponsored projects identify ideas faculty can use for their more science-oriented research.

Other incentives for faculty are practical relevance of the curriculum and personal satisfaction. Collaboration with practice makes faculty more comprehensive teachers and mentors to their students, due to exposure to first-hand knowledge about technology, practices, expectations, and opportunities. Industrial collaboration can provide a unique and advantageous perspective on the state of the art. The ability to steer the students in the right direction naturally leads to personal satisfaction.

Academic institutions

Academic organizations seek funding, reputation, and societal impact. Sustainable programs tied to the practice community attract high-quality students, which in turn brings more interest from prospective partners to collaborate. Student participants typically are offered employment in the partner organization, which elevates the reputation of the academic institution. Universities like displaying collaborative programs and societal impact in their messages to alumni and when reporting to legislatures. Secondary benefits are acquisition of facilities, networking, and education quality.

Practitioners

Top priorities for practitioners are professional development, career promotion, and better ability to hire qualified personnel. Professional development includes access to new ideas, technological surveillance, refreshers on theoretical fundamentals, engagement in fundamental research, and peer benchmarking. Incentives also include personal satisfaction as a mentor, attending conferences, publishing in scientific journals, and an opportunity to influence the education of the next generation.

Collaborative projects with academia also provide an opportunity to train and evaluate potential employees before extending a job offer. In addition, student allegiance to the corporate collaborator is a recruiting advantage for students who are familiar with the technologies and practices of the corporation.

Practice entity

Top incentives for industrial companies and other practice entities are new ideas, new product/process development, access to new knowledge, recruiting, and brand-name recognition. Even if the involved students accept employment elsewhere, they might have a preference to use a collaborator's product there, and their in-school affirmation of the experience will aid the sponsor's recruitment of other students.

Companies may view collaborations with academia as low-cost research and development initiatives, or as investments in workforce development. The benefit-to-cost ratio is often enhanced when government funding also supports the initiative. Demonstrating societal responsibility is another motivator, achieved by helping and stimulating academia to focus on real-world problems and opportunities.

Ensuring collaboration success

Collaboration is not a one-sided game. An erroneous industry view is that a company hires the academic to develop a solution, the same way it might hire a consultant. An erroneous academic view is to take the position and the money and run (in pursuit of scientific publication). Notably, people may claim their academic-practice partnership is a collaboration, but in a collaboration the individuals share, are flexible, and accept each other's perspectives.

Mutually beneficial collaboration requires all players to understand how the others perceive the initiative, and to help provide what the others will interpret as a win. It may require each player to give up on getting its primary "win" and to settle for a secondary benefit, so that other players also can experience a win. For example, faculty may primarily want to use industrial funding to support mathematical analysis and journal publications. This provides little value to an industrial sponsor. It is acceptable to pursue and publish mathematical analysis, but also seek to return the sponsor's interpretation of benefit.

Successful Collaboration: Miami University of Ohio

The Pulp and Paper program at Miami University of Ohio has a process control minor to prepare engineering graduates to supply industrial needs. To recruit students into this relatively unknown career, collaboration with industry partners offers both a three-week intersession course in the practice of process control and summer internship opportunities for students.

The course segments are offered by application-oriented faculty and practitioners, and the course topics are aligned with both industrial needs and engineering education criteria. The course and internships are attractive for students, and industry is happy that an academic program is supplying their workforce development needs. Visit https://www.miamioh.edu/cec/sasi.

Successful Collaboration: University of Michigan

The Reconfigurable Manufacturing Systems (RMS) program at the University of Michigan was established in 1996 with partial support from the National Science Foundation as an Engineering Research Center (ERC) to improve manufacturing productivity. It was funded by more than 30 company collaborators.

Benefitting industry, from 1997 to 2012, ERC-RMS produced more than 350 graduate students, most of whom are working in U.S. industry, and improved productivity in more than 69 production lines in 15 factories in the U.S. and Canada. Benefitting academe, application projects have been essential to the career development of many students and faculty and for bragging rights of the university. Although initial funding has waned, the legacy of collaboration, labs and courses, and relevant teaching continues. Visit https://erc.engin.umich.edu.

Successful Collaboration: Purdue University

The Center for Innovation in Control, Optimization, and Networks (ICON) at Purdue University explores innovative control solutions to challenges associated with manufacturing, transportation, supply chains, health care, power, communication, and social networks. These systems are rapidly growing in scale and complexity, driven by advances in autonomy and connectivity. ICON seeks to develop knowledge and techniques for control and optimizing, to customize curricula to meet emerging educational needs, to collaborate with industry to tackle priorities, and to provide employment-ready graduates. It was established in 2020, has about 70 faculty researchers from a dozen departments, has funding from both industry and government, and enjoys strong collaboration with Saab, Rolls-Royce, Northrop Grumman, and John Deere. Students provide biweekly reports to industrial partners who provide feedback direction, advice, and serve on dissertation committees. Visit https://engineering.purdue.edu/ICON.

As another example, industry may primarily want, in return for a bit of funding support for a student, to be able to claim all rights to the lifetime of knowledge that the faculty advisor has acquired. Alternately, industry should accept the workforce development benefit of their contribution. Success requires each entity to find a way to shape the process and outcomes to satisfy their values, while making it satisfactory to the other entity. To create a win-win (actually win-to-the-5th-power) means that the process and outcomes that generate success for all may be suboptimal for any one entity. Industry practitioners are familiar with this condition of suboptimally operating one process unit to maximize manufacturing.

Collaboration also means mutual respect for the viewpoints and experience that the other has acquired. Having acquired career success, key individuals on either side of the gap are strongly immersed in their way of doing things. They have their own terminology, symbology, values, and conventions and often do not understand the other's situation, ways, and needs.

Several survey respondents reported that players on either side belittled the "inferior" experience and context of the other, which alienates the other and effectively undermines collaboration. It is important for experts in one domain to respect and understand the viewpoint of those in the other domain, and to help the other acquire a comprehensive view. It is also important for experts in one domain to accept what the others would like them to understand.

As the survey results indicate, two aspects of collaboration are central to the success or failure of practice-academe initiatives: Give the other collaborator adequate wins and respect the other's experience. A summary of the top 10 ways to improve collaboration is listed in figure 2; full survey results are available online.

Read this article online (https://isa.org/intech) to see key survey result statistics, a glossary of terms, and additional articles related to this topic. ■

1. Address a common purpose, a shared vision.
2. Define success and deliverables (objectives, goals, schedule, milestones).
3. Build realistic expectations (compatible with skills and resources).
4. Define responsibilities.
5. Appoint a project manager/program director who can bridge the gap.
6. Ensure a commitment to share adequate resources (funding, data, time, staffing).
7. Gain support of leadership and participants (ensure all see their "win").
8. Stay engaged and connected.
9. Build mutual trust, respect, and personal relationships.
10. Partner with organizations where there are other beneficial interactions (workforce development, employee training, technical access). Synergize.

Figure 2. Top 10 ways to improve collaboration

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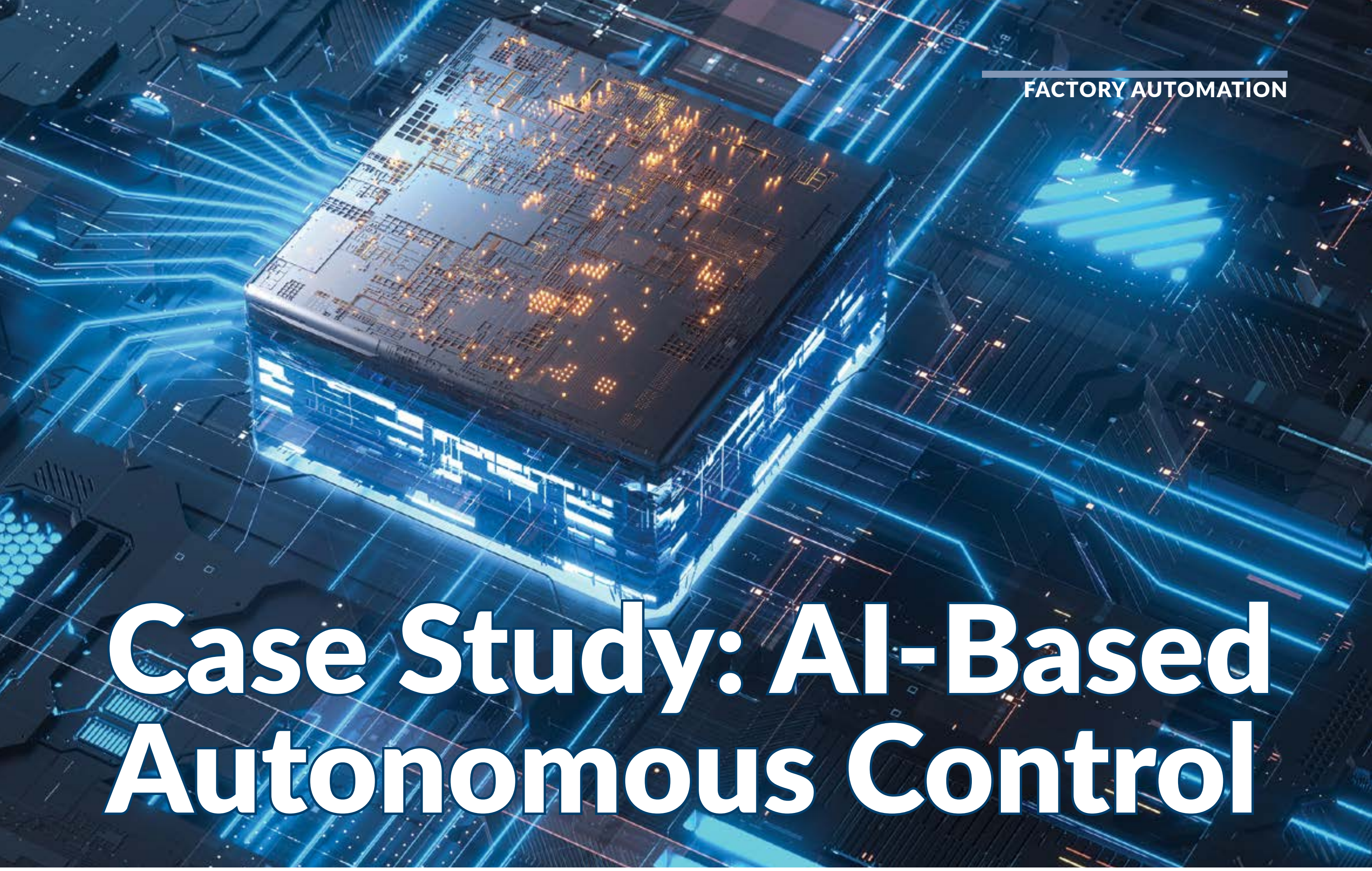
The International Federation of Automatic Control (IFAC) is primarily an academic organization seeking to share automation possibility, theory, and analysis worldwide. The American Automatic Control Council, a consortium of nine U.S. professional societies (of which ISA is a member) represents the U.S. to IFAC. The IFAC Industry Committee, established in 2017, has had a core task of promoting interaction between academia and automation and control practitioners in industrial, nonprofit, military, government, and other institutions by helping each side understand the culture and the motivation of the other.

The author greatly appreciates the members of the IFAC Industry Committee task force who created the 2021 survey of best practices and analyzed the data. They include:

David A. Anisi, associate professor, NMBU/UiA, Norway	**Philippe Goupil**, aircraft control system expert, Airbus, France	**Chris Manzie**, professor, The University of Melbourne, Australia	**R. Russell Rhinehart**, professor emeritus, Oklahoma State University, U.S.	**Tariq Samad**, director, management of technology, University of Minnesota, U.S.	**Bran Selic**, president and founder, Malina Software Corp., Canada	**Atanas Serbezov**, professor, Rose-Hulman Institute of Technology, U.S.	**Jaroslav Sobota**, control system engineer, Centrum LTD, Czech Republic

Figure 1. About the IFAC Industry Committee



Case Study: AI-Based Autonomous Control

A Japanese semiconductor plant shows how autonomous control based on artificial intelligence is becoming reality.

By Hiroaki Kanokogi, PhD

As process control technologies advance, one concept gaining prominence is autonomy. When contrasted with conventional automation, one of the main differentiators of autonomy is applying artificial intelligence (AI) so an automation system can learn about the process and make its own operational improvements. Although many companies find this idea intriguing, there is understandable skepticism. The system's capability is only as good as its foundational algorithms, and many potential users want to see AI in operation somewhere else before buying into the idea wholeheartedly. Those real-world examples are beginning to emerge.

Yokogawa's autonomous control systems are built around factorial kernel dynamic policy programming (FKDPP), which is an AI reinforcement learning algorithm first developed as a joint project of Yokogawa and the Nara Institute of Science and Technology (NAIST) in 2018. Reinforcement learning techniques have been used successfully in computer games, but extending this methodology to process control has been challenging. It can take millions, or even billions, of trial-and-error cycles for a software program to fully learn a new task.

Since its introduction, FKDPP has been refined and improved for industrial automation systems, typically by working with plant simulation platforms used for operator training and other purposes. Yokogawa and two other companies created a simulation of a vinyl acetate manufacturing plant. The process called for modulating four valves based on input from nine sensors to maximize the volume of products produced, while conforming to quality and safety standards. FKDPP achieved optimized operation with only about 30 trial-and-error cycles—a significant achievement.

This project was presented at the IEEE International Conference in August 2018. By 2020, this technology was capable of controlling entire process manufacturing facilities, albeit on highly sophisticated simulators. So, the next question became, is FKDPP ready for the real world?

Figure 1. Yokogawa's Komagane facility has complete semiconductor manufacturing capabilities, which must operate in clean room environments.

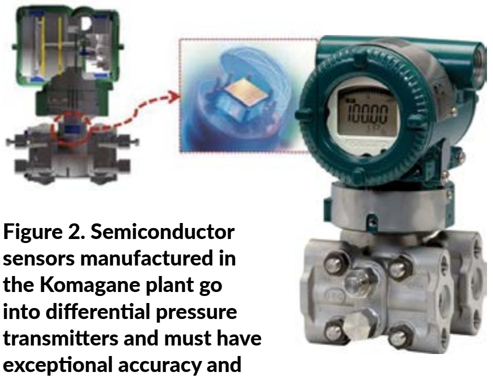


Figure 2. Semiconductor sensors manufactured in the Komagane plant go into differential pressure transmitters and must have exceptional accuracy and stability over time.

From simulation to reality

Yokogawa answered that question at its Komagane semiconductor plant in Miyada-mura, Japan (figure 1). Here, much of the production takes place in clean room environments under the tightly controlled temperature and humidity conditions necessary to produce defect-free products. The task of the AI system is to operate the heating, ventilation, and air conditioning (HVAC) systems optimally by maintaining required environmental conditions while minimizing energy use.

It is understandable that an actual application selected for this type of experiment would be of modest scale with minimal potential for safety risks. This conservative approach may be less dramatic than one at an oil refinery, but this does not reduce its validity as a proof of concept.

At first glance, operating an HVAC system autonomously might not seem complex. But the HVAC systems supporting the tightly controlled clean room environment account for 30 percent of the total energy consumed by the facility, and so represent a sizeable cost. Japan's climate varies through the seasons, so there are adjustments necessary at different times of the year to balance heating and cooling, while providing humidity control.

The facility resides in a mountain valley at an elevation of 646 meters (2,119 feet). It has a temperate climate and tends to be relatively cool, with an annual temperature between –9° and 25°C (15.8° and 77°F). The plant produces semiconductor-based pressure sensors (figure 2) that go into the company's DPharp pressure transmitter family, so maintaining uninterrupted production is essential. Even though this demonstration is at one of Yokogawa's own plants, the cost and production risks are no less real than those of an external customer.

The facility's location is outside the local natural gas distribution system, so liquified petroleum (LP) gas must be brought in to provide steam for heating and humidification. Air cooling runs on conventional grid-supplied electric power. Both systems work in concert as necessary to maintain critical humidity levels.

Complex energy distribution

Considerations surrounding energy use at Japanese manufacturing plants begin with the high domestic cost. Energy in all forms is expensive by global standards, and efficiency is paramount. The Komagane facility uses electric furnaces for silicon wafer processing, and it is necessary to recover as much waste heat as possible from these operations, particularly during winter months.

To be considered a success, the autonomous control system must balance numerous critical objectives, some of which are mutually exclusive. These objectives include:

- Strict temperature and humidity standards in the clean room environment must be maintained for the sake of product quality but with the lowest possible consumption of LP gas and electricity.
- Weather conditions can change significantly over a short span of time, requiring compensation.
- The clean room environment is very large, so there is a high degree of thermal inertia. Consequently, it can take a long time to change the temperature.
- Equipment in the clean room also contributes heat, but this cannot be regulated by the automated control system.
- Waste heat from electric furnaces is used as a heat source instead of LP gas, but the amount available is highly variable, driven by the number of production lines in use at any given time.
- Warmed boiler coolant is the primary heat source for external air. If more heat is necessary than is available from this recovered source, it must come from the boiler burning LP gas.
- Outside air gets heated or cooled based on the local temperature, typically between 3° and 28°C (37.4° and 82.4°F). For the greater part of the year, outside air requires heating.

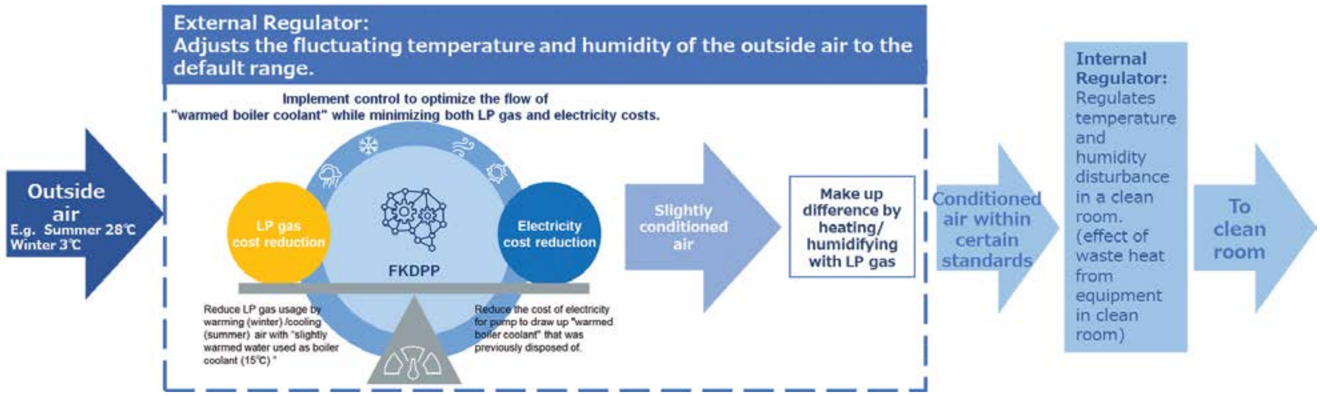


Figure 3. The HVAC system brings air in from outside nearly continuously to ensure adequate ventilation. The air must be conditioned to maintain tight temperature and humidity requirements in these critical manufacturing environments.

The existing control strategy (figure 3) is more complex than it first appears. Below the surface, the mechanisms involved are interconnected in ways that have changed over the years, as plant engineers have worked to increase efficiency.

There have been numerous previous attempts to reduce LP gas consumption without making major new capital equipment investments. These incremental improvements reached their practical limits in 2019, which drove implementation of the new FKDPP-based control strategy in early 2020.

The implementation team selected a slow day during a scheduled production outage to commission the new control system. During that day, the AI system was allowed to do its own experimentation with the equipment to learn its characteristics. After about 20 iterations, the AI system had developed a process model capable of running the full HVAC system well enough to support actual production.

Over the weeks and months of 2020, the AI system continued to refine its model, making routine adjustments to accommodate changes of production volumes and seasonal temperature swings. The ultimate benefit of the new FKDPP-based system was a reduction of LP gas consumption of 3.6 percent after implementation in 2020, based entirely on the new AI strategy, with no major capital investment required.

FKDPP-based AI is one of the primary technologies supporting Yokogawa's industrial automation to industrial autonomy (IA2IA) transition, complementing conventional proportional-integral-derivative and advanced process control concepts in many situations, and even replacing complex manual operations in other cases. Real-time control using reinforcement learning AI, as demonstrated here, is the next generation of control technology, and it can be used with virtually any manufacturing process to move it closer to fully autonomous operation. ■

All images courtesy of Yokogawa

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Hiroaki Kanokogi, PhD, is a general manager in the Yokogawa Products Headquarters. He joined Yokogawa in 2007 and is currently pursuing the development, application, and commercialization of AI designed for production sites. Kanokogi is one of the inventors of the FKDPP algorithm, and he was previously engaged in machine learning application R&D at Microsoft Japan. He has a PhD from the University of Tokyo.

Instrumentation Lessons: Selecting and Sizing Flowmeters

By John Davis and Graham Nasby

No two flow measuring applications are the same, and two nearly identical flowmeter products can differ in how the accuracy is measured.

Flow rates and flow totals are two of the key types of measurements used in process facilities around the world. No matter the process industry, there will always be a wide variety of flow measurements that must be made for monitoring, control, and regulatory purposes. However, the appropriate selection and sizing of flowmeters are not something we can always take for granted.

Like any piece of equipment, instrumentation must be carefully selected so the measurements will be as accurate and repeatable as possible. Flowmeters are no exception. In industries where low-bid design and construction services are commonly used, it is even more important that the main aspects of properly sizing flowmeters are taken into account. In this article, we explain key considerations of sizing a flowmeter from the perspectives of accuracy, repeatability, and rangeability, as well as common installation pitfalls to avoid.

The measurement goal

The first aspect to think about when sizing a flowmeter is the expected flow range. Whether a flow rate is expected to be a fairly consistent narrow range, or the rate is expected to vary widely has a substantial effect on how a flowmeter should be sized.

In general, when sizing a flowmeter, conditions to consider include:

- shutdown or rest state (and if the line will tend to drain)
- the normal startup progression
- the normal operating range (steady state)
- the extreme operating range (steady state)
- normal shutdown progression
- any expected possible abnormal conditions.

A way to do this is by estimating a flow envelope using a table such as the sample shown in table 1.

Accuracy versus repeatability versus rangeability

After the flow envelope has been determined for a flowmeter, the next aspect to consider is how well a proposed flowmeter can measure the flow. "Accuracy" refers to how close the flowmeter reading is to the actual flow value. "Repeatability" (also known as precision) is how consistent readings are over time. Accuracy and repeatability are not the same. The difference between accuracy and repeatability is shown in figure 1.

Another way to understand the difference between accuracy and repeatability is to imagine two archers shooting at a conventional archery target. Suppose one archer hit the bull's-eye consistently. Because he was always accurate, the shots were repeatable. Now imagine an archer who hit the target but consistently missed the bull's-eye. Although the archer had good repeatability, he was not accurate. Good repeatability does not guarantee accuracy. If you do not see a proper accuracy statement on equipment, (i.e., there is only a repeatability statement), be cautious.

A flowmeter with good repeatability (but poor accuracy) can be adjusted to read more accurately. However, a flowmeter with poor repeatability cannot be adjusted, because there is no consistency in the readings.

"Rangeability" is a measure of how accurate and how repeatable the flowmeter will be over the expected range of flow readings. Some flowmeters are better at turndown (being able to read very low flow rates) than others. Thus, whenever an accuracy claim is being made for a flowmeter, it is important to

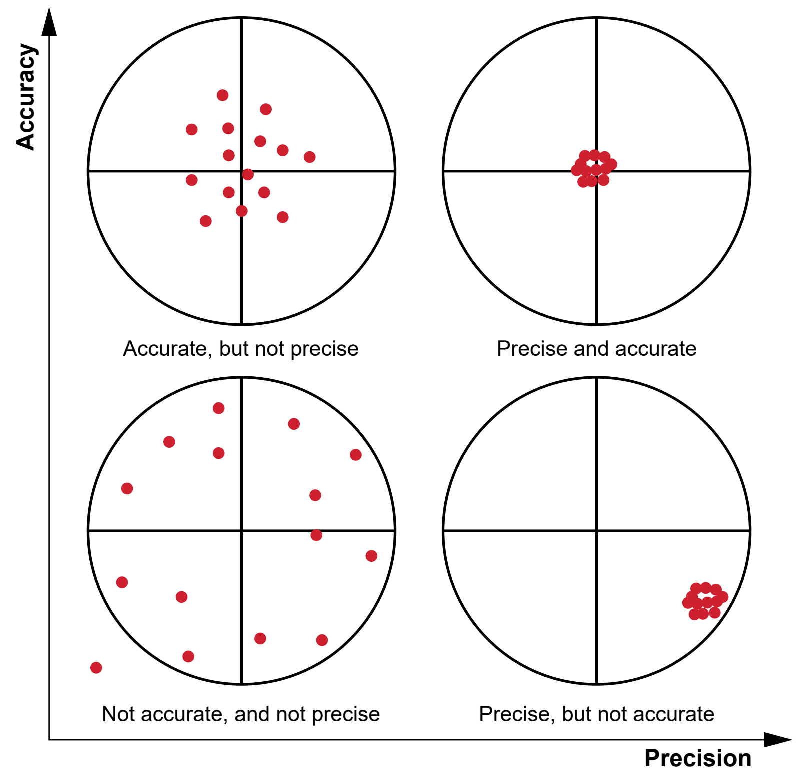

Figure 1. Measurement accuracy versus precision/repeatability

	Expected Value	Notes
Extreme high measurement	6500 gal/min (U.S. gallons/minute)	Initial pump startup, with discharge line empty
Extreme operating range – upper limit	5500 gal/min	
Normal operating range – upper limit	4000 gal/min	95% of the time in this range
Normal operating range – lower limit	2000 gal/min	95% of the time in this range
Extreme operating range – upper limit	1500 gal/min	
Extreme low measurement	0 to 1500 gal/min	
Shutdown/rest state	0 gal/min	Pumps off

Table 1. Sample expected operating envelope for a flowmeter

look at the expected flow range accuracy that the vendor is guaranteeing.

Before looking at some of the more common flowmeter selection/sizing pitfalls, here is a more detailed discussion about defining accuracy and repeatability.

Accuracy impacts

It pays to read the fine print when it comes to accuracy claims (or specifications) associated with instrumentation such as flowmeters. At lower flow rates, the accuracy often drops off significantly. For example, if an instrument has an accuracy claim of 0.5 percent of full scale, it is important to recognize that the actual accuracy diminishes as the operating conditions fall below the full-scale setting.

"Accuracy" refers to how close the flowmeter reading is to the actual flow value. "Repeatability" (also known as precision) is how consistent readings are over time.

Another way of stating accuracy is to define it in terms of the reading, such as ±0.5 percent of the reading over a certain part of the flowmeter's range. Depending on the range in which the flowmeter is used, this stated accuracy could be either negligible or a significant difference. On flowmeters used for billing or other revenue-related purposes, the meter's accuracy can have a major financial impact.

Imagine that a paddle-wheel flowmeter claims to have an accuracy of ±0.5 percent. Suppose further that it is a percent of the full range, and the full range is 50 feet per second (ft/s). If the flow range where you will use it is 6 ft/s, which is common in wastewater treatment plants, the actual accuracy is much different than you might expect:

$$0.005 \times 50\ f/s = \pm 0.25\ ft/s$$

If you apply this accuracy against a flow rate of 6 ft/s, the actual accuracy is:

$$\frac{\pm 0.25}{6\ ft/s}$$

$$= \pm 0.0417, \text{ or } 4.17\%$$

Comparing a magnetic flowmeter with an accuracy of 0.5 percent of reading to a doppler flowmeter with an accuracy of 0.5 percent of full range yields a similar result.

A common problem occurs when a city or municipality uses two different types of flowmeters. Imagine one meter is a highly accurate magnetic flowmeter located in a meter vault to monitor the plant's effluent flow, and the other is a doppler meter monitoring the influent flow. Doppler flowmeters tend to decline in accuracy as the flow rate drops. Even highly accurate magnetic flowmeters have both extremely high and low reading limits under which they will not operate accurately.

Case histories have shown that the plant appears to be generating wastewater, because the effluent is more than the influent, or something is evaporating the wastewater. We know in both cases that neither of these conditions really exists. What is happening is that the doppler meter is not matching the accuracy of the magnetic meter. The difference between 0.5 percent of 12 million gallons a day (Mgd) and 4.17 percent of 12 Mgd is substantial.

$$(.0417 - 0.005) \times 12\ Mgd =$$
$$0.44\ Mgd, \text{ or } 305\ gal/min$$

Matters are made even worse if the doppler meter is used for pacing chemical feed into the wastewater with the same inaccuracies; the results are either overdosing or underdosing. Water treatment plants have low, average daily, and high peak demand flows, and further, low and average daily flows occur more frequently. This demonstrates the importance of being cautious in choosing meter types for those flow variables.

Many types of flowmeters suffer in performance as the flows decrease and approach the lower end of their viable flow range. Therefore, pacing during low flow periods may be highly suspect. Chemicals are becoming more costly, analytical instruments for measuring the effects of these chemicals are becoming costly, and corrosion due to underdosing or overdosing wastewater can also be costly to equipment. All of these may contribute to effluent that is a danger to wildlife and, in extended cases, can be harmful to the health of people living in the area.

Repeatability

In many ways, repeatability is even more important than accuracy. If an instrument is consistently wrong (inaccurate, but repeatable), the instrument can be adjusted to read correctly. However, if an instrument is inconsistent with how it reads, no amount of calibration work can fix the poor readings it provides.

Today, many field instruments work on force-balance techniques (where a process reading is converted to a force that then impacts a force-based sensor) such as piezoelectric crystals, capacitance, and strain gauges. These work on the principle that if you put a force on an instrument, there should be no motion even though an electric signal is generated on the output of that instrument. There are still flow, level, and chemical measuring devices that do not work on the force-balance principle, and for these types, looking at the repeatability of that piece of equipment is still important. A steady widening of the repeatability is an indication that something is going wrong with the instrument.

While the accuracy of an instrument can be improved with calibration, repeatability is often something that the design of the instrument defines.

Rangeability and uncertainty

As previously noted, the rangeability of an instrument must be taken into consideration during the sizing and selection part of a plant design. It is important that installed flowmeters can read the various intended flow ranges specific to where they are installed. At a minimum, they must meet the needed accuracy/repeatability for each flow rate for the application.

One of the most common problems with a piece of instrumentation equipment is the exaggeration of its range. How many times have you heard that a meter can read flow rates at velocities of 1 to 100 ft/s, giving the impression that you can read flows accurately through that total velocity range?

What often goes unmentioned is that the particular meter's accuracy has a 10:1 turndown ratio. This means that a meter sized to measure a range of 0 to 30 Mgd has a true accuracy over the full range of 3 to 30 Mgd. Below 3 Mgd, the meter accuracy diminishes.

Additionally, different types of meters have different turndown ratios over their full range. It is common for a Venturi tube, for example, to have two transmitters measuring the flow. This is because a Venturi tube with one transmitter measures accurately with a 6:1 turndown ratio over the full range. So, if we look at a range of 0 to 30 Mgd, the meter's accuracy diminishes below 5 Mgd.

The range over which the instrument meets the stated linearity of uncertainty requirements is its "rangeability." "Uncertainty" is the range of values within which the true values lie with a specified probability. Uncertainty of ±1 percent at 95 percent confidence means the instrument will give the user a range of ±1 percent for 95 readings out of 100.

Another common error occurs during equipment sizing. In the municipal wastewater sector, it is a common practice to assume that solids in wastewater will settle out around a velocity of 2 ft/s. A magnetic flowmeter reads accurately if the minimum velocity is above 2 ft/s, but below this, settling is likely to occur—and then who can say what the accuracy really is?

Designing for now versus the future

Typically, designers size plants to handle increased flow capacities for 20 years. For this reason, designers often oversize pipes for early lifecycle flow, and there is a corresponding settlement inside the pipe. This settling can also occur in the inner liner of the meters. Because these meters are velocity-sensing devices with an assumed constant cross section, they will give a false reading if the inner liner becomes coated with sludge.

A solution may be to reduce the size of the meter to increase velocity by using a pipe reducer on the inlet side and a pipe expansion section on the discharge side of the meter. If possible, avoid connecting the reducer and expander directly to the meter. Manufacturers recommend that when you reduce the pipe, the flowmeter should be placed a minimum of six to 10 pipe diameters upstream from an elbow or valve and at least two pipe diameters downstream of a pipe elbow or valve. This provides a less distorted flow profile for the meter to read.

Good repeatability does not guarantee accuracy.

Be certain you can afford to lose the pressure head when you reduce the meter size. Maximum velocities should not exceed 15 ft/s. By maintaining a minimum scouring effect inside the pipe, your sludge buildup inside pipes and any inline equipment will diminish, helping avoid measurement errors and costly maintenance downtime.

Other common flowmeter traps and pitfalls

Some people ask for the accuracy of a certain flowmeter, level, or pressure-measuring device and, upon hearing a low number, think that everything involved with the flowmeter will be of the same accuracy. However, the meter accuracy is not the accuracy for the entire flow system. A mathematical equation known as the root mean square (RMS) correctly determines the accuracy of the complete system. Consider the case of a magnetic flowmeter that records flow locally, sending an analog signal to an operator's workstation via a programmable logic controller (PLC).

One must look at each component's accuracy:

- magnetic flowmeter (±0.5 percent)
- magnetic flowmeter transmitter (±0.5 percent)
- wire connection to the recorder (±0.01 percent)
- wire connection to a local control panel terminal block (±0.01 percent)
- the input/output (I/O) card of the PLC (0.4 percent).

Each component in the system has its own measurement errors and uncertainties that contribute to the overall accuracy of the complete system. In real cases, there could be more components attached to a control system.

To use the RMS method, first square each number, yielding 0.000025, 0.000025, 0.00000001, 0.00000001, and 0.000016. Second, add the numbers. Then find the square root of the sum. The entire system has an accuracy of approximately ±0.00813, or ±0.813 percent instead of 0.5 percent. This accuracy equation works for any individual chemical, pressure, level, temperature, or flow loop.

Looking ahead

Remember that no two flow measuring applications are the same. Each has its own unique flow characteristic, range, and accuracy requirements. It is always important to review the expected operating envelope to determine the normal and extended operating ranges to be measured before sizing any flowmeter.

Once the requirements are known, any accuracy, repeatability, or rangeability specifications for possible flowmeter products should always be carefully reviewed. Two nearly identical flowmeter products can have similar sounding accuracy and different details about how the accuracy is measured.

Regardless of the application, it is always recommended to carefully review the requirements and manufacturer literature regarding accuracy and to consider the range, repeatability, turndown ratio, installation requirements, and other aspects. These details make the difference between a well-specified flowmeter and a measurement system that has issues.

Also, depending on the application, it may be worthwhile to do more advanced simulations, to perform RMS error analysis, or to look at installed examples. Lastly, do not be afraid to make use of application engineering services offered by most leading flowmeter vendors.

Like many things in life, it is worthwhile to do some homework when it comes to sizing and selecting flowmeters. It always pays to do the background work up front to ensure that a flowmeter is able to measure the flow and meet the needs of the application. ■

ABOUT THE AUTHORS

John Davis (jack46davis@aol.com) is a retired instrumentation and automation professional located in Oldsmar, Fla. After working in both the industrial and municipal water/wastewater sectors for more than 50 years, he now writes technical articles to share his experiences.

Graham Nasby, P.Eng., PMP, CAP, CISSP, CISM has over 15 years of experience with instrumentation, SCADA, and operational technology in various industries, and is co-chair of the ISA112 SCADA Systems standards committee. He is based out of Guelph, Ontario, Canada.

Digital Transformation Training Series Debuts

ISA announced the release of its new Digital Transformation Training series, a set of courses covering emerging technologies associated with digital transformation. Designed for engineers, technicians, business leaders, and managers engaged in industrial automation and its related fields, the courses teach foundational concepts of digital transformation technologies and show how they can be applied to drive efficiency across multiple industries.

"The ISA Digital Transformation Training series will help organizations cross the chasm on adoption of digital technologies and upskill the workforce across their enterprise," said Prabhu Soundarrajan, ISA Executive Board member and president-elect for 2024.

"This training is different for two reasons," said Jeff Winter, director of ISA's Smart Manufacturing & IIoT (SMIIoT) Division and industry executive, manufacturing, at Microsoft. "First, it's modular and will keep growing over time. Second, it includes a mix of theory and strategy with hands-on, practical applications related to real-world controls that automation professionals are familiar with."

The training includes a mix of theory and strategy with hands-on, practical applications related to real-world controls.

The first course, *Introduction to IIoT – The Industrial Internet of Things (DT101)*, is available now. It helps automation, engineering, and business professionals understand the global Industry 4.0 movement and how it is driving businesses to shift toward digital transformation of conventional industrial and manufacturing processes. Trainees will learn about the basic concepts of the Internet of Things (IoT), how these concepts and underlying technologies have evolved, and how they are being applied to industrial applications.

The next two courses in the series, on the topics of big data and data visualization, are under development and are planned be released later this year. Learn more at https://www.isa.org/training-and-certification/isa-training/digital-transformation-training-series. ■

ISASecure Announces Certification for IIoT Component Security

The ISASecure program announced a new ISASecure certification for Industrial Internet of Things (IIoT) components based on the ISA/IEC 62443 series of standards. The IIoT Component Security Assurance (ICSA) certification was inspired by recommendations from a joint study published by the ISA Global Security Alliance (ISAGCA) and ISA Security Compliance Institute (ISCI).

The certification addresses the urgent need for an industry-vetted IIoT certification program. More information about the ISASecure IIoT Device and Gateway certification program and its basis in the ISA/IEC 62443 series of industry standards is available in a free webinar (https://register.gotowebinar.com/register/5775404052661694224).

Founded in 2007, the ISA Security Compliance Institute's mission is to provide the highest level of assurance possible for the cybersecurity of automation control systems. ISCI has been conducting ISASecure certifications on automation and control systems since 2011 through its network of ISO/IEC 17065 accredited certification bodies.

Details of the ISAGCA/ISCI study are available in the Learning Center section of the ISASecure website: https://isasecure.org/en-US/Learning-Center/Webinars/ISA-IEC-62443-IIoT-Certifications-Study-Review-(Oc. The full ISAGCA/ISCI study is available for download at https://gca.isa.org/iiot-component-certification-based-on-62443.

The Institute was established by major organizations in the automation controls community that wanted to improve the cybersecurity posture of critical infrastructure for generations to come. Prominent ISASecure supporters include Chevron, ExxonMobil, Saudi Aramco, Shell, Honeywell, Schneider Electric, TÜV Rheinland, Yokogawa, YPF, exida, GE Digital, Synopsis, CSSC, CSA Group, and IPA-Japan. The Institute's goals are realized through ISASecure compliance programs, education, technical support, and improvements in suppliers' development processes and users' life cycle management practices. ■

ISA and Industry IoT Consortium Partner to Help Companies Secure Industrial Automation Systems

ISA and the Industry IoT Consortium (IIC) announce the *IoT Security Maturity Model: 62443 Mappings for Asset Owners, Product Suppliers and Service Suppliers*. This new guidance adds the service provider role to the previously published *IoT Security Maturity Model: Practitioner's Guide*, explains Ron Zahavi, chief strategist for IoT standards at Microsoft and IoT SMM co-author. It "provides mappings to existing 62443 standards and specific guidance for the asset owner, product supplier, and service provider roles," he said.

The IoT Security Maturity Model (SMM) helps organizations choose their target security state and determine their current security state. By repeatedly comparing the target and current states, organizations can identify places to make further improvements.

The ISA/IEC 62443 standards are the basis for the guidance. The ISA99 committee developed the 62443 series of standards, which the International Electrotechnical Commission (IEC) then adopted. These standards address current and future vulnerabilities in industrial automation and control systems (IACS) and apply necessary mitigation systematically and defensibly. The ISA/IEC 62443 standards focus on maturity, but only on the maturity of security programs and processes.

"Achieving security maturity targets can be difficult to put into practice without concrete guidance," said Frederick Hirsch, co-chair of the IIC ISA/IIC Contributing Group. "These 62443 mappings enable practitioners to better achieve security maturity by relating IIC IoT SMM practice comprehensiveness levels to ISA/IEC 62443 requirements. In this way, IACS asset owners and product suppliers can achieve appropriate maturity targets more easily."

Eric Cosman, co-chair of the ISA99 committee, said, "While standards such as ISA/IEC 62443 are needed to codify proven and accepted engineering practices, they are seldom sufficient. Joint efforts such as this provide the practical guidance necessary to promote and support their adoption."

It is not about more security but about implementing the appropriate security measures. *IoT SMM: 62443 Mappings for Asset Owners and Product Suppliers* helps companies select the adequate security levels commensurate with their expected level of risk.

Pierre Kobes, a member of both ISA99 and IEC Technical Committee 65, said, "It is not about more security but about implementing the appropriate security measures. *IoT SMM: 62443 Mappings for Asset Owners and Product Suppliers* helps companies select the adequate security levels commensurate with their expected level of risk."

You can download *IoT Security Maturity Model: 62443 Mappings for Asset Owners, Product Suppliers and Service Providers* from the IIC (https://www.iiconsortium.org/wp-content/uploads/sites/2/2022/05/SMM-Asset-Owner-and-Product-Supplier-Mapping-2022-05-05.pdf) and ISA (https://www.isa.org/standards-and-publications/isa-standards/isa-iec-62443-series-of-standards) websites. You will find a complete list of the contributing authors in the document. Work is underway to add the service provider role to the document in a future revision. ■

Registration Opens for New Fall Conference

Registration is open for ISA's new event, which combines ISA's leadership conference with two days of technical presentations on trending industry topics including digital transformation, cybersecurity, IIoT, smart manufacturing, and process automation. Register at https://www.isa.org/events-and-conferences/alc.

Plan to attend the live event in Galveston, Texas, U.S. on 7–9 November 2022. You will have the opportunity to network with ISA leaders and automation professionals from around the world and talk to technical subject matter experts from the U.S., Canada, Middle East, Brazil, Malaysia, Spain, and India. For those who cannot attend live, the two-day technical conference will be available virtually. ■

In-Situ Proof Testing of Automated Valves

A vital element in process safety is assurance that safety-related devices, including automated valves, remain capable of performing intended safety functions at all times during plant operations. Government regulations, operating licenses and permits, technical specifications, and various industry standards specify requirements for testing automated valves used in process safety applications. To meet these requirements, automated valves are routinely subjected to in-situ proof testing at intervals determined by the importance of each valve, the recommendations of valve and actuator manufacturers, in-service performance experience, and other factors.

A new technical report, ISA-TR96.05.02, *In-Situ Proof Testing of Automated Valves*, provides guidance on the various criteria to consider when selecting the in-situ proof testing method—such as, for example, automated versus manual test execution, spurious trip potential, actuator force or torque output, and on-line maintainability. The document also addresses the capabilities and limitations of the various measurement, analysis, and acceptance criteria approaches used to assess in-situ proof testing results; and the accuracy of measurement and analysis methods employed by the various proof testing systems, sensors, and analysis techniques.

The document is one of several standards and technical reports developed by the committee ISA96, Valve Actuators. ISA96 will hold an all-day face-to-face meeting on 11 November 2022, in conjunction with the ISA Automation & Leadership Conference in Galveston, Texas, U.S. For information on the event, visit https://www.isa.org/events-and-conferences/alc. ■

ISA99 to Develop Security Profiles for Electric Energy Transmission and Distribution

ISA99, Industrial Automation and Control Systems Security, has established a new Working Group 14, "Security Profiles for Electric Energy OT Control Systems." The working group will focus on a cybersecurity work product utilizing the ISA/IEC 62443 series of standards for securing various control systems used in electric energy generation, transmission, and distribution operations.

This group will prioritize the development of multiple ISA/IEC 62443 security profiles for transmission and distribution applications. The initial priority will be on the control center and substations. These profiles should be adaptable or expandable to the control center and generation facilities. The third priority will be distributed applications. Profiles will provide ISA/IEC 62443 conduit requirements between the various process zones and mitigation requirements within a zone. The profiles will also provide mandatory and optional documentation requirements.

The intent is to provide a means for auditing and testing deployments with respect to the requirements set forth in the ISA/IEC 62443 standards.

The scope of the project will include interface and communication exchanges to and from external levels that are identified and within the levels or zones in the various application environments. ■

For more information:

- Access ISA standards and technical reports at www.isa.org/findstandards.
- For information on ISA99 and ISA/IEC 62443 standards and activities, visit https://www.isa.org/standards-and-publications/isa-standards/isa-iec-62443-series-of-standards.
- Participation in ISA standards committees is open to all who are interested. For information, contact standards@isa.org.
- Have an idea for an ISA standard, book, training course, conference topic, or other product or service? Send it to crobinson@isa.org.

ISA84 Launches New Projects

The ISA84 committee, Instrumented Systems to Achieve Functional Safety in the Process Industries, has recently approved two major new projects as it prepares for its upcoming semi-annual plenary meetings:

- A new working group will develop an ISA technical report providing guidance on how digital information can be applied during the operation and maintenance activities of the functional safety lifecycle, with a focus on the associated benefits. The scope will focus on the operation and maintenance phase but does not exclude the rest of the lifecycle. Lifecycle data that is derived from analysis and engineering is necessary to achieve operation and maintenance functional safety effectiveness. The technical report will identify how digital information can be used to facilitate timely collection, analysis, and visualization of functional safety information.
- The committee will also begin the development of a new standard to be titled *Functional Safety of Process Safety Controls, Alarms, and Interlocks (PSCAI) for the Process Sector*. This standard will set forth requirements for achieving functional safety using PSCAI as protection layers. The requirements for the design and management of alarms identified as part of PSCAI will be provided by ISA18, Instrument Signals and Alarms. The standard will apply to a range of industries within the process sector, including chemicals, oil and gas, pulp and paper, pharmaceuticals, food and beverage, and nonnuclear power generation.

These new undertakings add to several ongoing projects within ISA84 to write and update a series of technical reports to aid users in the understanding and application of the series, ANSI/ISA-61511, *Functional Safety – Safety Instrumented Systems for the Process Industry Sector*. ■

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 the 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

Austen Allgeier, U.S.
John Barrow, U.S.
Jeremy Bayer, U.S.
Derek Belkofer, U.S.
Daniel Blackstone, Xcel Energy-Monticello Nuclear Generator Plant, U.S.
Elijah Byard, U.S.
Jordan Cannon, U.S.
Arin Van Culin, Xcel Energy-Monticello Nuclear Generator Plant, U.S.
Eric Curtis, U.S.
Christopher Davidson, U.S.
William Gorman, U.S.
Chase Holsonbake, U.S.
David Hull, U.S.
Darrell Lee Huntoon, U.S.
Keith Ivey, U.S.
Jared Glen Jackson, U.S.
Cody Kell, Cobb County Water System, U.S.
Christopher Lanham, U.S.
Beau Louis Maciej, Xcel Energy-Monticello Nuclear Generator Plant, U.S.
Thomas Mackintosh, U.S.
Brandon McCranie, U.S.
Matthew Alan Morris, TC Energy, U.S.
James Morrissey, U.S.
Nicholson G. Mortejo, C2C Technical Services, U.S.
Daniel Aaron Moyers, U.S.
Scott M. Patterson, U.S.
Justin Pickard, City of Longview, Utility Maintenance & Technology, U.S.
Ronald Reed, U.S.
David Renz, U.S.
Anthony R. Robles, U.S.
Julian Salas, U.S.
James J. Santee, MSD, U.S.
Casey L. Schultz, U.S.
Stephen Shaffer, U.S.
Craig Sheets, U.S.
Ronald Simpson, U.S.
Kenneth Szuba, U.S.
Joseph Nganga Thuo, U.S.
Jared Turner, U.S.
Kyle Willett, U.S.
Gregory Wimsatt, U.S.
Michael Yentsch, Technical Systems Inc., U.S.

Level 2

Timothy Ronald Burgoon, U.S.
John L. Campbell, U.S.
Jared D. Harmon, U.S.
Gregory Koshollek, Fox Valley Technical College, U.S.
Christopher Ranta, U.S.
Todd Vannurden, Xcel Energy, U.S.

Level 3

Robert L. Hopkins, U.S.
Manuel Luis Lombardero, AES Corporation, Panama

CERTIFIED AUTOMATION PROFESSIONALS

Abdullatif M. Alsaad, Saudi Aramco, Saudi Arabia
Paramjit Singh Anand, India
Bijoy Balan, Kuwait
Oluwafemi Isaac, Chevron Nigeria Limited, Nigeria
Adnan Ahmad Khan, Saudi Aramco (Saudi Arabian Oil Company), Saudi Arabia
Aaron Maclennan, Canada
Tariq Mahmood, General Electric, United Arab Emirates
Heath Pritchett, S&B, U.S.
Renjith Rajendran, Wood plc, Saudi Arabia
Osama Elawad Salih Hussein, Bashayer Pipeline Company (BAPCO), Sudan
Caitlin Sharkey, Thermo Systems, U.S.
Joshua Welch, U.S.

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Mentoring: Paying It Forward Enriches You

By Bill Lydon

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.

Experienced automation professionals have an opportunity to mentor people entering industry, which is a way of "paying forward" your expertise. Paying forward is the idea of repaying what you gained in the past from others by sharing with someone else. In the context of automation professionals, the payment is in the form of using your know-how and hard-earned experience to help new people be more effective and efficient.

New automation people just out of college or technical schools have learned the "latest and greatest," but they lack the know-how and activity knowledge gained with years of experience. Know-how and activity knowledge are the practical understanding of how to get something done, as opposed to "know-what" (facts) or "know-why" (science). Experienced learnings are not obvious, and they are often difficult to transfer to another person by means of writing or verbalization. It is best experienced in the field with an experienced mentor as a guide.

An experienced, longtime ISA member and automation professional described mentoring as helping new people be more effective and avoid making the mistakes he had made early in his career. Without the benefit of a mentor, new people make old mistakes, spending a lot of troubleshooting time trying to fix errors that could be avoided with mentoring.

There are great advantages to pairing the veteran and the novice, beyond avoiding old mistakes. There is the potential for tremendous synergy from the combination of an experienced mentor and a person who has recently learned academically about some of the newest technologies. Synergy is defined as two or more things functioning together to produce a superior result not independently obtainable. Consider the potential, where knowledge of new methods and technology are combined with a deep and intimate understanding of the plant's automation and physical processes.

Mentor benefits

Mentor benefits include:

- The joy of seeing someone else progress and gain valuable skills due to your guidance.
- The satisfaction that comes from giving back by simply sharing your own learning, having a remarkable impact on a person's future.
- Giving your time and knowledge to someone who might not have previously had access to your level of expertise can be hugely rewarding.
- Gaining new perspectives as a mentor by viewing and understand a problem through the lens of your mentee.
- You might also surprise yourself and pick up a few tips and tricks from your mentee that you might not have otherwise thought about.
- Deeper appreciation for the unique knowledge and value you have to offer by sharing your experiences with someone else.

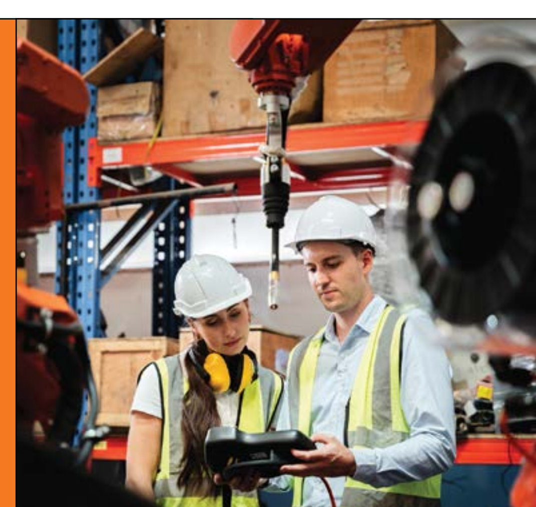
The longer-term result of a great short-term mentor-mentee match is often a lasting friendship and long-term contact.

ISA Mentor Program

ISA offers a unique opportunity to share your valuable experiences and perspectives by becoming part of the ISA Mentor Program (https://www.isa.org/professional-development/find-a-mentor-and-be-a-mentor). ISA's mentoring program connects early career professionals to more seasoned professionals who are willing to help coach, guide, and share expertise.

The program is conducted entirely online. There are no meetings to attend or travel to endure. Participants are from around the world. Relationships between participants can develop and progress at your convenience. The program is designed for practitioners, retirees, and educators whose goal is the best functional use of automation products that are not exclusive to an individual supplier and are not in any way promoting the sales of products from a particular supplier. If you are interested in becoming a mentor or mentee, just complete the brief online application form. ■

Synergy is defined as two or more things functioning together to produce a superior result not independently obtainable.

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Built For The Plant Floor
Build Mobile-Responsive HTML5 Applications
That Run Natively on Any Screen

Built For Everyone

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Add unlimited clients, screens, tags, connections & devices.

Cross-Platform Compatibility
Ignition works with any major operating system, even iOS and Android.

Instant Installs and Updates
Install on a server in just 3 minutes, push updates to clients everywhere, instantly.

The Value in Your Membership

ISA is a membership association, centered on offering you the community and tools needed to shape the future of automation. Our core values focus us on excellence, integrity, diversity, collaboration, and professionalism. ISA is a community built for professionals like you.

ISA Connect

Engage in technical discussions - both online and live - with professionals like yourself all around the world.

Career Center

Search job openings, build your resume, and plan your career path – all the tools you need to advance in automation.

Standards

Access over 150 standards that reflect the expertise of industry leaders from around the world.

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Enhance your network by connecting with professionals in your local community or in your technical specialty.

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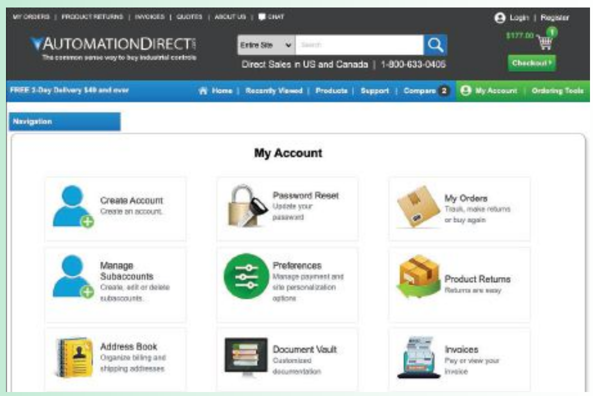

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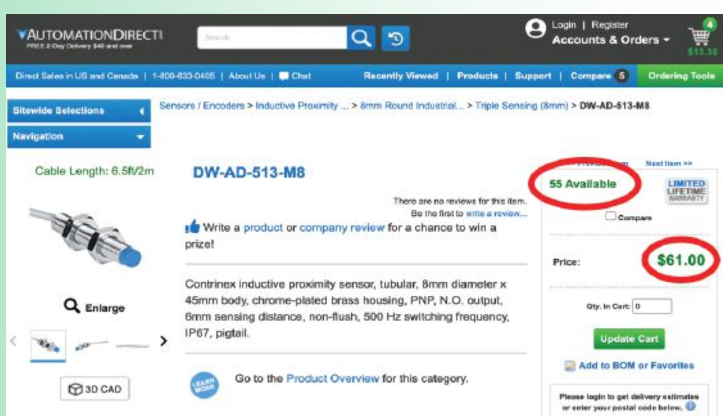

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