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InTech

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Assessing the key players and strategies

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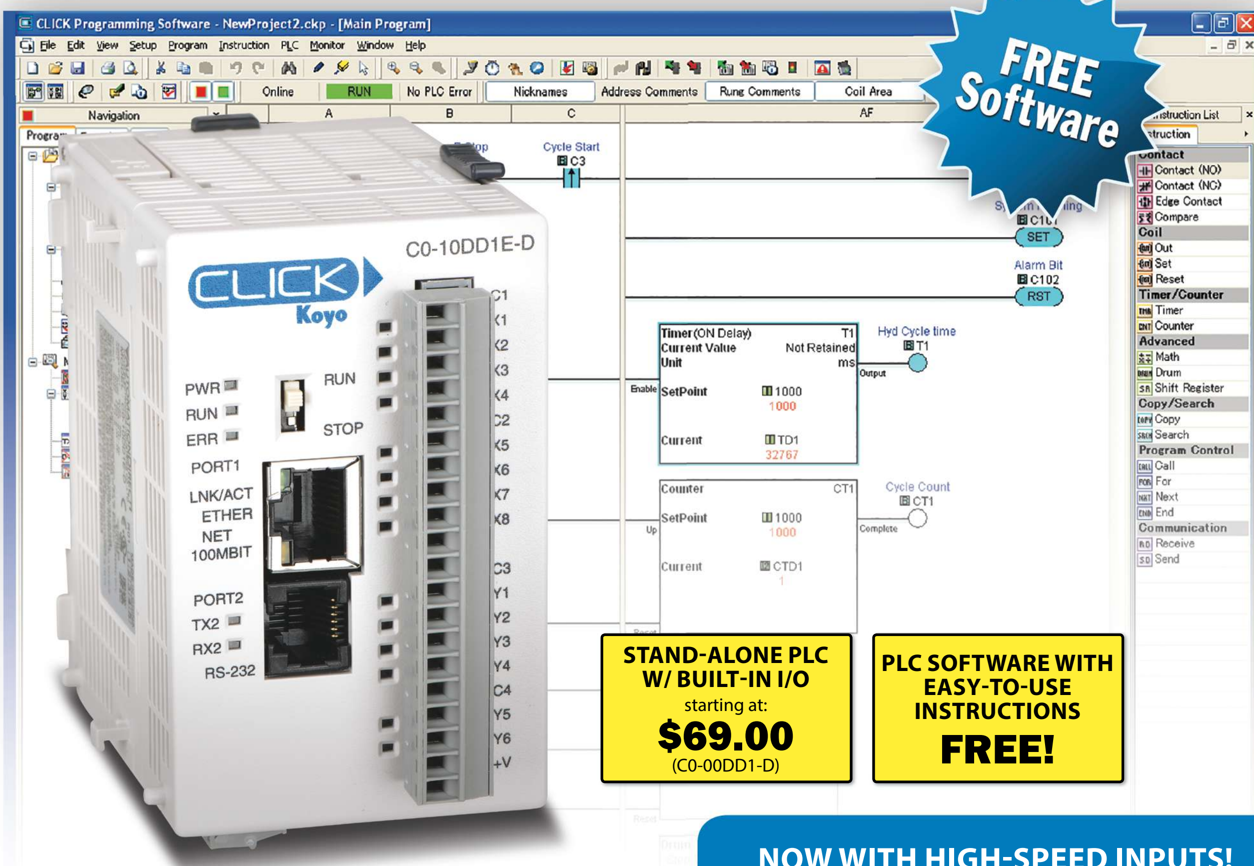

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InTech provides the most thought-provoking and authoritative coverage of automation technologies, applications, and strategies to enhance automation professionals' on-the-job success. Published by the industry's leading organization, ISA, *InTech*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

Squandering data today?

By Bill Lydon, *InTech*, Chief Editor

The continuing mantra is more data, big data, analytics, artificial intelligence, machine learning, and other suggestions, but are you squandering existing data today?

Attending many presentations at conferences and industry events about the cloud, big data, and analytics has brought to mind ways to use existing data that I was taught in the 1980s as an application engineer at a company sensitive to performance, energy, and maintenance. Certainly, there is value in the wide range of new sensing, analytics, and software technologies, but it may be worth considering what can be done with the data available in your system today. A question to explore is: What insights can you gain from information already in your systems?

These are some simple things I was taught that may not be obvious to new application engineers. They can typically be implemented in existing controllers, human-machine interface (HMI), or supervisory control and data acquisition:

Minimal start time/minimal stop time monitoring

Determine if a motor is short cycling to alarm or warn that there is a problem developing with the equipment that needs attention. This can indicate an issue that can be addressed before big problems develop and equipment totally fails to ensure that operations run efficiently. There are a wide range of applications, such as short cycling pumping systems, air compressors, and refrigeration compressors. These can lead to an understanding of root causes, such as dirty heat exchangers, sticky valves, and process issues.

Run-time and cycles monitoring

Actual equipment run-time hours can be easily monitored in a programmable logic controller, controller, or HMI to schedule maintenance, rather than simply using calendar time. Similar to run time, actual machine cycles in production machinery can be used to schedule maintenance instead of calendar time.

Run-time and cycle monitoring result in maintenance labor savings. Having three levels of alarms provides an even better way to schedule maintenance. The first alarm can be used before critical run time or cycles are exceeded, allowing time to schedule preventative maintenance. The second alarm can be set as a "yellow light" warning that preventative maintenance should be performed. The third alarm indicates that it is imperative to perform preventative maintenance.

Analog rate of change alarm

Rapid rate of change is an indicator of problems in many types of equipment, for example, monitoring when a water tank level is falling too rapidly.

Flow rate change monitor

Monitoring the rate of change can be used to identify problems, for example, an unusual rate of change used as an alarm for a pipe break. The flow rate in plant air compressor systems when production is down can indicate leaks in the piping systems.

Load

In many systems, the sensors are already on a unit or process to calculate load input versus load output. With these values, efficiency can be calculated. Changes in this value can be used as a general indicator to check equipment for problems when efficiency drops.

Leveraging existing sensors can provide a great deal of valuable information. Continually ask: What insights can you gain from information already in your systems that can yield benefits?

There are exciting opportunities with new technologies, including analytics, but it makes sense to leverage existing sensors and data. Figuring this out is why industrial automation professionals are valuable to their employers. ■

Industrial companies using safety to increase profitability

Industrial companies are using safety to not only mitigate risks, but also to improve productivity and profitability, according to a survey by LNS Research. The survey finds organizations are using the three core elements of safety maturity—safety culture, procedures, and technologies—to avoid safety incidents and improve business performance. In addition, risk management increasingly includes both safety and security risks.

From a culture standpoint, the survey found that organizations in which environmental health and safety (EHS), operations, and engineering collaborate to improve all aspects of safety reported a median incident rate 15 percent lower than those without this collaboration. Organizations with cross-functional safety collaboration also had a 12 percent better on-time delivery performance. On the technology side, 75 percent of industrial companies said they have seen operational improvements from the use of advanced safety technology. Similarly, 60 percent of respondents said they have seen financial improvements resulting from the use of advanced safety technology.

The survey results also support original equipment manufacturers building safer machines, as 20 percent of respondents said they are willing to pay a premium for increased safety performance.

While the survey results confirm that many industrial companies are improving safety maturity, they also identify areas where manufacturers are falling short.

Culture: About half of respondents (49 percent) claim that safety is viewed as a core value in all levels of their organization. However, only 19 percent said their organization has C-level commitment to make the necessary investments in safety. This disconnect indicates that many companies do not have a culture that is fully supportive of safety. Additionally, only one in four respondents said their EHS, operations, and engineering EHS teams effectively collaborate to improve all aspects of safety.

Technologies: Almost half of respondents said top challenges to improving EHS performance included disparate systems and data sources. Meanwhile, almost two-thirds (64 percent) of respondents said they have not implemented dedicated EHS software. This indicates there is a big opportunity for companies to use modern information-management technology to better manage safety performance.

Only 24 percent of respondents said they use lockout/tagout alternatives to improve operational performance. And even fewer (11 percent) said their organization is using industrial IoT technologies to holistically manage operations and safety. However, 20 percent said they will start using industrial IoT technologies this way in the next 12 months, and 17 percent said they will require that new equipment be smart and connected within that same time period.

Procedures: Widely adopted standards call for a life-cycle approach to risk management, which can help companies address risks in their equipment and production from design to retirement. However, only 28 percent of respondents said they use such an approach. What is more, only 27 percent of respondents said they use a life-cycle approach to safety-system management. ■

Increased industrial IoT sophistication this year

According to an IFS research study of 200 North American executives, industrial companies achieved substantial year-over-year gains in Internet of Things (IoT) usage. Executives at respondent companies, ranging from manufacturers to oil and gas companies, are collecting more data from connected devices, integrating it with other systems in new ways, and making IoT more central to their businesses. The study shows:

- There has been an increase of 17 percent in companies collecting IoT data on entire work cells or production lines rather than individual machines or machine components. This enables more advanced use cases, which helps explain a 30 percent increase in use of IoT to support asset performance management.
- Respondents using IoT to monitor their customer equipment saw a 10 percent increase, potentially signaling transformational approaches to field service management.
- Despite these advances, the percentage of respondents who have integrated IoT data streams with their enterprise resource planning software hovers at 16 percent. This reluctance may represent a barrier to leveraging IoT to deliver new business models or revenue opportunities. ■

Product registry and online repository

FieldComm Group has launched its product registry and online repository—updating the previously standalone HART and FOUNDATION Fieldbus product registries. It provides a unified tool to obtain the latest device files and provides online access to APIs that host system manufacturers can tap for built-in real-time access to the latest versions of EDDs and FDI Device Packages for field devices. The release comes as the organization simplifies the experience users have with industrial standards.

The product registry includes text search capabilities; advanced filtering by application and FDI; mobile-friendly functionality; a unified registry for FF, HART and FDI; and full device versioning support in EDD downloads (all registered versions provided in a single download).

The repository provides a cloud-based system with REST APIs, a single source for registered EDDs and FDI device packages irrespective of vendors and protocols, the ability to update hosts and handhelds automatically or by manual trigger through the cloud, streamlined device revision management, and push notifications for available updates. ■

Collaboration?

Yes, that's how we'll build a robust cybersecurity landscape

Assessing the key players and strategies

By Andrew Kling

Ten years ago, cybersecurity was a trend, a small but important issue industrial manufacturers were just aware of. But today, with the threatscape increasing exponentially in scope and scale, cybersecurity is completely revolutionizing industrial manufacturing around the globe. It is time for the industry as a whole to reassess how it will secure and protect its people, assets, and operations from attack.

Cheaper computing power and connectivity are why cybersecurity has become the problem it is today. The Industrial Internet of Things (IIoT) and other emerging trends (e.g., digitization) bring true business benefits, but reaping the most value from these initiatives requires manufacturers to unify their operations and business processes in some way. One common way is by bringing the information technology (IT) functions that have historically controlled the business closer together with the operational technology (OT) functions that have historically controlled the manufacturing process. More intelligent, connected devices empower better visibility and control of more than just real-time operations. Plant managers can begin to control other critical business variables in real time, too, including safety, reliability, and, especially, operational profitability. This is the culmination of closing the OT-IT divide.

The promise of that approach is that manufacturers gain better, real-time visibility and control of their business performance, but connecting the business layer with the operations layer increases the entry points for potential hackers. And because many—if not most—of the systems that control our most critical and volatile manufacturing operations were installed decades ago, long before cybersecurity was a consideration, we are never safe from an intrusion. What is more, many of today's progressively bold, innovative attacks are perpetrated by malicious actors, such as nation-states, who effectively have unlimited time, resources, and funding. Such attacks aim to disrupt industrial activity for financial, competitive, political, or social gain. When you put it all together, it means every connected system must be viewed and assessed within the context of a comprehensive cybersecurity program.

Last year, the world's first known cyberattack on a safety instrumented system occurred. Commonly referred to as Triton, this incident remains a call to action for the global industrial process and manufacturing industry. In the year since, the industry has taken a step forward in cyberattack preparedness. Plant asset owners are addressing cyberrisks with more vigilance, and vendors

FAST FORWARD

- Cybersecurity involves actors at many levels—each with a role to play.
- Better synergy between these actors is essential to combatting the risks inherent to today's hyperconnected landscape.
- We must encourage transparency, open communication, and ongoing collaboration. Now is the time; our future depends on it.

continue to harden their solutions with cybersecurity built directly into the products.

These are important, positive steps. But industry has a long way to go, and the focus must be on facilitating and increasing collaboration among everyone associated with it.

Industry collaboration

When any attack or attempted attack happens, it is easy to point the finger at whoever is deemed responsible or question what could have been done differently. This sort of examination, both internally and externally, is necessary so that we can learn lessons and mitigate the risks of other attacks.

But finger pointing does not get us very far. Cybersecurity in industry affects a wide variety of players, including plant asset owners, suppliers, designers, process engineers, plant operators, third-party providers, integrators, standards bodies, academia, and government agencies around the world. Suppliers regularly collaborate with their plant asset-owner clients and with standards bodies, and so forth. Too rarely, however, do competitors within the space—whether foreign governments, suppliers, end users, or integrators—pool best practices and provide guidance to (or seek it from) those vying for market share.

When it comes to cybersecurity in mission-critical facilities, lives are at stake, as are massive operations. Fifteen years ago, the cyberthreats of today were unimaginable. The spirit of open and honest collaboration must thrive for us to best address cybersecurity in the decades ahead.

Start with standards bodies

One does not become an industrial cybersecurity expert overnight. Fortunately, experts do exist—starting with standards bodies that set detailed guardrails and best practices.

Although regulation and legislation vary by country, cyberattacks are border agnostic. Attacks—both attempted and successful—targeting a facility in any one country can have detrimental consequences worldwide. Therefore, it makes sense to have in place international standards and agreements on cybersecurity best practices.

This includes initiatives from ISA, including IEC 62443, a set of standards developed by the ISA99 and International Electrotechnical Commission (IEC) committees to improve the safety, availability, integrity, and confidentiality of components or systems used in industrial automation and control. Adopted by many countries, these standards can be used across industrial control segments. There are also others, including ISO/IEC 27001, which provides requirements for an information security management system (ISMS).

These standards are not set in stone, either, but instead evolve to reflect a changing threatscape. They become stronger when the wide range of companies and organizations working within the industrial space share their experiences and insights, as well as actively participate in refining these standards. For end users, a strong security culture has its foundations in a close tracking of and adherence to evolving standards, protocols, and best practices.

However, standards bodies are just one piece of a broader matrix of organizations that set

Building resilient cybersecurity in a connected world

Urgent call for change

Triton was a wake-up call for collection action. As the world's first known cyberattack on an industrial safety system, the Triton malware attack on 4 August 2017 shifted the thinking of the entire industry. One year later, we examine what has changed and what is yet to do.

The system operated as designed and shut down the plant properly, averting disaster, but an immediate joint investigation uncovered an attack perpetrated by a state-sponsored actor exploiting on-site security lapses.

The incident led to the worldwide realization that similar attacks will likely be carried out and that they can happen at any time on any industrial safety system.

Thirty-five years after safety instrumented systems were first brought to market, the attack led many plant operators and suppliers to overturn the status quo, identify risks, and address them openly and collaboratively.

It is clear that no single entity can solve this global issue. Suppliers, engineers, standards bodies, government agencies, and others must collaborate to address the ongoing and ever-changing cybersecurity threats in both legacy and emerging technologies.

What now? Time for action

Governments, operators, designers, engineers, and suppliers must aggressively act to address the risks to industrial control and safety systems, especially those built before the notion of cyberwarfare.

Industry leaders must apply cybersecurity standards for industrial control and safety systems that consider the entire threatscape, while governments encourage adherence.

The industrial safety system supply chain must commit to hardening the cybersecurity of platforms, while plant operators and owners adopt (and educate on) practices to address cybersecurity risks.

guidelines and therefore must collaborate to address the monumental and ever-evolving task of cybersecurity. They must work hand-in-hand with government agencies.

Incorporate government

With many of today's attacks being perpetrated by nation-state actors, strategies and protocols set by government agencies can make an impact. In 2013, the U.S. government directed the National Institute of Standards and Technology (NIST) to develop a framework that would become an authoritative source for cybersecurity best practices. Other countries have similar standards or are actively working on local versions. In some countries, like France, these standards are even carrying the weight of law. These cybersecurity standards create an ordered, structured approach to addressing cybersecurity challenges. They can help translate vague, fear-based concerns into common-sense risk analysis, risk tolerance assessment, and risk avoidance.

In 2018, hundreds of cybersecurity bills were introduced or considered in the U.S. The bills range from addressing reform in consumer credit card reporting to how data is collected on connected devices.

Jurisdictional legislation and regulation such as this can be effective, but across all governmental organizations, the key lesson is that effective and lasting cybersecurity programs are codified via defined roles, responsibilities, authorities, and executive order. Such action is a clear indication of institutional support for cybersecurity efforts and helps to reduce friction and confusion.

But governments can do much more than rely on political leaders to introduce legislation. The many three-letter governmental agencies in the U.S. (e.g., NSA, FBI, CIA, and DHS) have a responsibility to actively share knowledge. This can happen via the normalization of a trust-based relationship with the private sector, such as in Information Sharing and Analysis Centers (ISACs). Involvement between government and private-sector partners enables timely information sharing and mitigates risk across the industrial world.

Governments can set the parameters, but it is a monumental job to try to enforce manufacturers and end users into compliance. That is why incentives can help, especially by giving guidance to regional policymakers and granting funding that is connected to national cybersecurity priorities. Such funding would encourage asset owners to take initiatives that strengthen their industrial assets from attack and otherwise improve their cybersecurity posture.

There is more than one way to keep equipment, software, and operating protocols regularly updated. While there are different schools of thought on what works best in the carrot-versus-stick debate, incentives can promote broader adoption of cybersecurity standards through the development of upgraded vendor solutions (instead of relying solely on regulations and harsh financial penalties).

When considering incentive-based programs that financially reward companies for regularly updating their equipment and software, staff should be trained to remain compliant with the latest standards and regulations. The government helps prevent potentially catastrophic events from occurring; the plant receives funding to encourage reinvestment in the latest secure technology, staff training, and funding of liability management initiatives. As with most aspects of cybersecurity prevention, a balance of regulation, standards, and incentives is often the best practice.

Sharing from public to private

Although communication between governmental bodies can be lacking, the framework for north-south communication between the public and private sectors is strong. This is where ISACs have an important role. ISACs are nonprofit organizations that serve as a central resource for gathering information on cyberthreats to critical infrastructure and providing two-way information sharing between the private and public sectors. They assist federal and local governments with information pertaining to cyberthreats. More than 20 exist within the U.S., Europe, and Canada. ISACs have verticalized, industry-specific expertise in a wide range of disparate segments: automotive, financial services, oil and gas, real estate, and even retail.

Each of these groups consists of industry experts who anonymously share cybersecurity intelligence vertically with government agencies. From there, the government disseminates this information to all relevant players in that specific industry. This model encourages vendors and other industry actors to share their experiences so that others can both benefit and advise.

While ISACs encompass the vertical, communities of interest (COIs) provide more horizontal guidance. COIs address communication among peers at the vendor and asset-owner level, not just with the government. An example of a COI is the SANS industrial control system (ICS) community, an initiative that equips security professionals and control system engineers with security awareness, work-specific knowledge, and hands-on technical skills for securing automation and control system technology.

In COI settings like this, companies within the industry can have open discussions with competitors around cybersecurity, without tipping their hands as to specific scenarios. By removing any sense of competitiveness, they instead instill a sense of community. For communities such as these to be most effective, they must include not only vendors, but asset owners, cybersecurity researchers, standards bodies, and even universities. There must be rules of engagement for discussion, but those with a vested interest and a part to play should be encouraged to participate. Otherwise it is not a true community. From public to private and across both levels, open and honest collaboration is essential to hardening our defenses against cyberattacks.

Where do we go from here?

Ongoing malicious attacks are our new reality. The good news is we have the means to confront them—as well as to build and advance a resilient "detect and response" cybersecurity strategy across all levels of an industrial enterprise—but only if we take immediate, collective action.

We should be encouraged by the progress made over the past year, but there is always more work ahead. In fact, building cybersecurity resilience is an ongoing pursuit. We all recognize that cyberattacks can be made against any industrial control and safety system anywhere in the world, no matter who designed, engineered, built, or operates it. That means no single entity can solve this global issue. Instead, end users, third-party suppliers, integrators, standards bodies, industry groups, and government agencies must work together to help the global manufacturing industry withstand assaults on the world's most critical operations, thereby protecting the people, communities, and environments we all serve.

In a pervasively connected world that is aggressively closing the IT-OT divide, it is up to us, the manufacturing and ICS experts, to ensure legacy, pre-IIoT critical infrastructure systems and assets are able to shut the door on future Triton-like attacks. To do that, we must encourage transparency, open communication, and ongoing collaboration—not just vendor to vendor, but across every layer of the industrial cybersecurity ecosystem. Now is the time. Our future depends on it. ■

ABOUT THE AUTHOR

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View the online version at www.isa.org/intech/20181201.

RESOURCES

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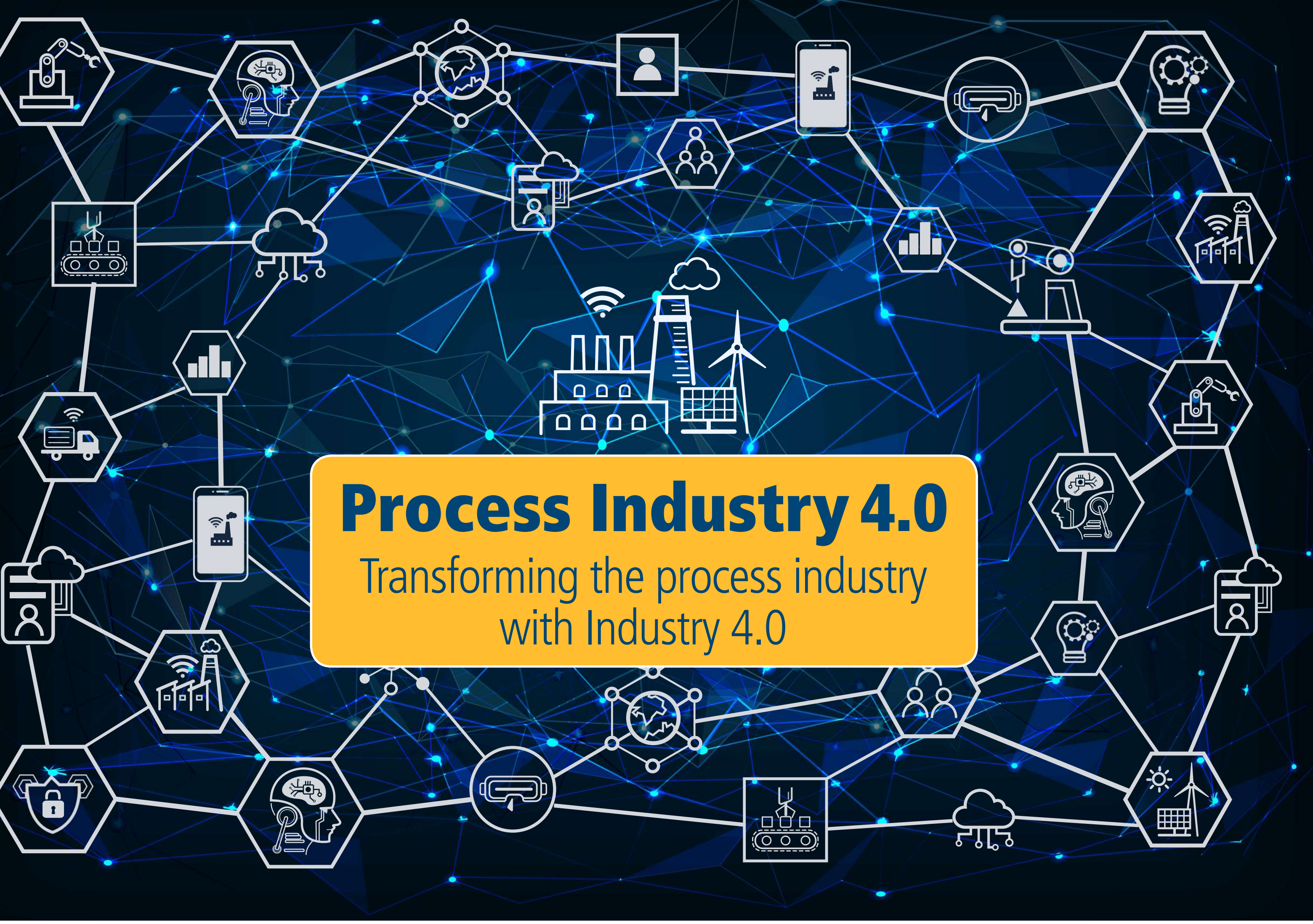


Process Industry 4.0

Transforming the process industry with Industry 4.0

By Stefan Zippel

When the Industry 4.0 working group presented its results at the Hannover Fair in 2013, it hardly made any impression within the process industry. Following my webinar, "Industry 4.0: A Blueprint for Achieving a Dynamic Smart Factory" (produced by Marcus Evans in partnership with Advantech in June 2017), two questions remained unanswered:

- What is the strategy and road map of initiatives in 4.0 for chemical or seeds facilities?
- Is there an Industry 4.0 standard for process industries like the chemical industry?

In my role as an Industry 4.0 architect, I still hear questions regularly. This shows that confusion still abounds.

FAST FORWARD

- The Industry 4.0 transformation of the process industry is a journey to become innovative, flexible, data-driven, and agile organizations.
- The right combination of legacy process industry systems and new Industry 4.0 technology is the foundation to enhance the availability of information and improve decision making.
- Industry 4.0 frees employees to use their creativity, innovation, imagination, and intuition to optimize processes, increase profits, lower costs, and minimize risks in the process industry.

Industry 4.0 and the process industry has a difficult past

The use of heavily automated production as well as centralized control and data collection dates back to the 1960s. The first such industrial control computer system was at the Texaco Port Arthur refinery in Texas in 1959. At that time, it was clear that industry standards were needed to ensure consistent terminology and operation models. Subsequently, the ISA-95 standard was established, from which IEC 62264 (DIN EN 62264) was formulated. The process industry was not the only one to follow the ISA-95 standard.

ISA-95 already widely used

With ISA-95, most process industry facilities achieve a nearly fully automated production process, where assets are connected to a central control system (e.g., distributed control systems [DCSs] and supervisory control and data acquisition [SCADA]) and historians/manufacturing execution systems (MESs) are often deployed. Although other industries also deploy automated assets, often with programmable logic controller (PLC) or computer numeric control, they

Level 5	Enterprise network, routing, access point for cloud services	Enterprise integration	Firewall
Level 4	PLM, ERP, CRM, HRM, PDES, QMS (time frame: months, weeks, days)	Site business planning and logistics DMZ	Firewall
Level 3	MOM/MES, WMS, LIMS/(QMS), CMMS (time frame: days, shifts, hours, minutes, seconds)	Site manufacturing operations and control	Firewall
Level 2	DCS server and client (SCADA, HMI), OPC server (time frame: hours, minutes, seconds, subseconds)	Area supervisory control	
Level 1	Batch control, discrete control, drive control, continuous process control, safety control, PLC, CNC (time frame: minutes, seconds, milliseconds)	Basic control	
Level 0	Sensors, drives, actuators, robots (time frame: minutes, seconds, milliseconds)	Process	

ISA-95 Reference Model: Many outside the process industry, and even those involved with Industry 4.0, are not aware of this important standard.

lack the interconnected environment we know from the process industry. There is a gap between the individual assets and higher-level functionality. As a discrete manufacturer, the Volkswagen Group demonstrates in the YouTube video, "Industry 4.0 in the Volkswagen Group," the long-established concept of the central control room as part of its Industry 4.0 strategy.

Looking at Industry 4.0 as a journey, the process industry is already flying, while other industries are only now checking in.

Industry 4.0 and existing standards

Conforming to ISA-95 is certainly an advantage for the process industry, but it has also been an obstacle when evaluating Industry 4.0. Strong biases toward existing standards warp the understanding of the value of Industry 4.0 to the process industry. It was unfortunate that most of the initial use cases for Industry 4.0 were in the automotive industry and did not represent the reality in the process industry.

Additionally, the hype around the Internet of Things (IoT) failed to look at the high connectivity already present in the process industry. Even the early data analytics models failed to highlight their advantages over principles like real-time optimization. In short, Industry 4.0 failed to show how it would raise profit margins, lower operating costs, and manage risks better than the existing standards used in the process industry.

It was not until 2015 that organizations like NAMUR (User Association of Automation Technology in Process Industries, www.namur.net/en) started exploring the first applications of Industry 4.0 in the process industry.

Not enough focus on people and processes

The focus of Industry 4.0 has been on the technology, connecting assets and collecting data. But similar technology has been used in the process industry for decades. Instead of trying to capture the attention of the process industry with tools, the focus should have been on using Industry 4.0 to make the right decisions, at the right times—optimizing processes, maximizing profits, and minimizing risks.

Technology is only an enabler. Industry 4.0 is about the processes and structure within an orga-

nization and across its value chains. It is about the human element and how our workers can truly add value with their creativity and innovation. This understanding of Industry 4.0 has gained significant traction since I first became involved in 2014.

New process industry use cases

Example use cases from the process industry (Covestry, Lonza, HPE and Texmark) were highlighted in several keynotes in the recent Industry of Things World conference in Berlin, illustrating how conforming to ISA-95 can quickly bring benefits from enhanced data collection. A few use cases showed how mobile devices brought real-time data into the field when checking critical assets, instead of keeping that information locked away in a control room. Others showcased how digitized dashboards improved on paper-based communication channels. All of these improvements were to processes. The benefits were realized by following the Industry 4.0 principles of improved communication and open information sharing.

Industry 4.0 has a future in the process industry

Until now, Industry 4.0 did not clearly show how it could benefit the process industry, because the focus appeared to be on the technology and the hype around how many jobs would be lost. However, Industry 4.0 is about establishing an active collaborative network, both within organizations and throughout their value chains: people and technology connected by digital threads and limitless information exchange.

The process industry is full of hierarchical organizations with isolated operational silos and information stored behind "locked doors." The way forward is clearly a solution-oriented network of people, tools, and shared information across boundaries, supported by the process industry's existing standards and technologies.

Implementing Industry 4.0

Why so many projects fail

In my experience, organizations do not start at the beginning, by understanding their processes. Instead, they start with reports or dashboards already in mind. But the solutions selected to deliver those outcomes rarely survive the first contact with reality. These projects fail, because they fall into a constant cycle of modifications and rebuilds, as each step in the processes throws up unforeseen issues, causing delays and increased costs.

Mismatch as a result of not starting at the beginning

Instead of a custom Industry 4.0 strategy based on the existing processes and system landscape within a company, many have a checklist of technologies they want to use, whether their processes require them or not: IoT/IIoT, AI/ML, mobile devices, augmented reality (AR)/virtual reality (VR), cloud, etc.

First steps for a successful implementation

Your experienced workforce is critical to identifying both low-hanging fruit and your biggest pain points.

- Map every step in every process and every system that is used. You need to understand what each step or system is used for, what is done, why it is done, and how it is done.
- See what works well and which standards are used. But more importantly, see what is not working and which standards are not used.

Common low-hanging fruit

Plant communication: Digitize paper-based plant data into dashboards to transform existing analog data into real-time information, so you can use this knowledge. This becomes a powerful asset for artificial intelligence (AI) and machine learning (ML) implementations. Dashboards on screens, laptops, and mobile devices not only let you make data-driven decisions in the moment, but also enable you to see what works and what does not.

Constant process optimization: Using collected data to drive plant optimization is not new. Data-driven methods like Six Sigma or Lean in combination with a data historian are a match made in heaven. A historian can provide ample data for your measurement and analysis phase, allowing you to quickly perform a comprehensive root-cause analysis and review sustainability. Real-time optimization applications are available, but the complexity, skills required, and cost involved mean they are not suitable for all situations.

Interfaces between systems: Many companies have a variety of systems in use, such as ERP, SCM, CRM, QMS, LIMS, WMS, MES, DCS/SCADA, and HRM systems. But most are isolated where data and information exchange is rudimentary—paper-based or via text email at best. Start creating your company's digital thread by setting up interfaces based on standards like OPC-UA, Message Queuing Telemetry Transport (MQTT), Rest, or Open Database Connectivity (ODBC) in combination with ETL (extract, transform, load) or ELT (extract, load, transform).

Predictive maintenance, or using machine learning to produce a maintenance model, is not a short-term project. In fact, one company admitted in its 2018 keynote that its machine learning project was yet to produce a working model, even after three years. Its machines are scheduled for replacement in two years.

Do not jump into a machine learning solution if you cannot solve the problem without it. Leverage your employee's experience first—mechanics often "know" whether their machines are running well, because they have a model in their head of what they need to keep an eye on. Tap into their experience and monitor what they suggest.

For example, a pump will break at some stage. We know how much pressure the pump generates at a given power consumption. An experienced employee keeps an eye on these values and knows that when power consumption rises, the pump will break in the near future. It is easy to monitor these two values (power and pressure) and trigger an alarm in your central control system to signal that maintenance is needed.

Looking forward: Will the process industry fully embrace Industry 4.0?

Industry 4.0 will free humans from having to compete with machines, especially on speed and quality in repetitive tasks. Instead, we can take advantage of human strengths like creativity, innovation, imagination, intuition, and ethics to full effect. But there are many small steps along this Industry 4.0 journey.

Work with existing systems and architecture

A form of IoT already exists in process industry plants, and even in discrete manufacturing assets like molding lines or die casting cells. "The Internet of Things (IoT) is the network of physical devices and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect, collect, and exchange data." (Wikipedia)

In the past, to record a new measurement, you had to purchase expensive hardware, wait for a shutdown, wire it in, rewrite the control program, test the code in simulation, load the new program, and hope that the change did not reduce productivity. Because of the costs and risks involved, updates like these were rarely done, resulting in many missed opportunities to optimize processes to decrease costs and increase profit margins.

Integrate IoT devices

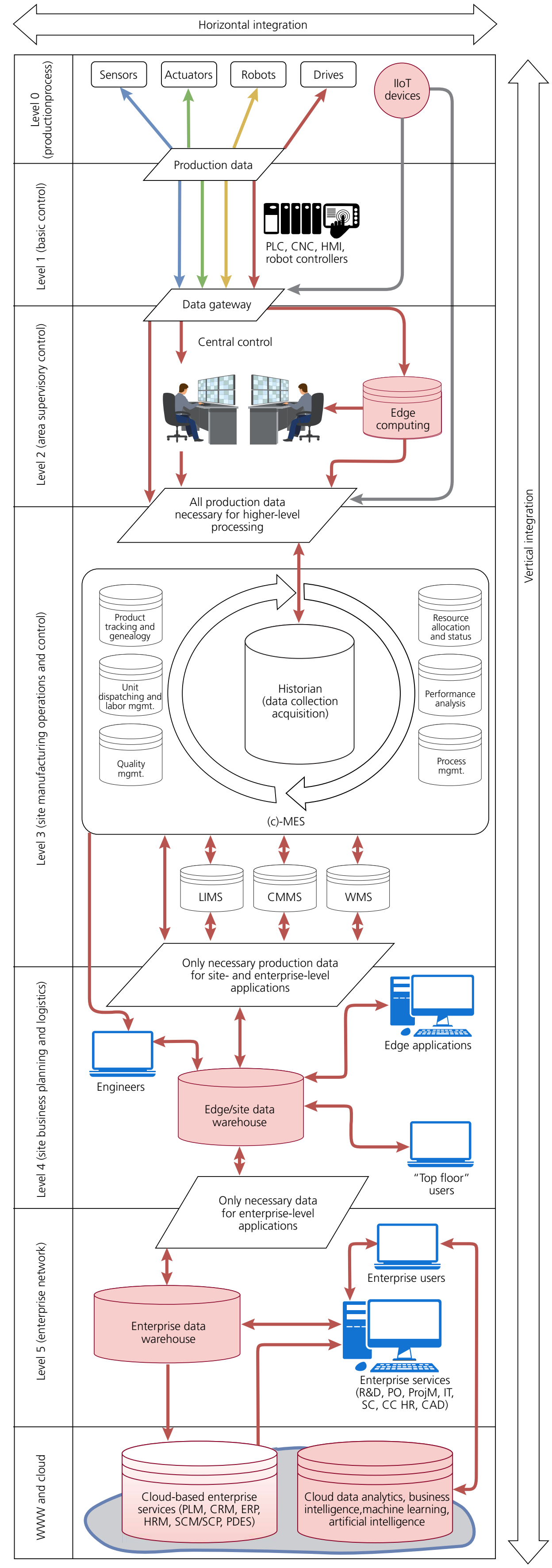
IoT devices are comparably cheaper and easy to install, customize, and update. They can communicate with data collection systems without the need to run cables and rework production lines. The true power of IoT devices is to enhance data collection capabilities without disrupting production.

Enhance existing data collection

In edge computing, computation is done by the device (the sensor or actuator) itself or by a nearby computer system and not in a remote data center or the cloud. You can use edge computing with existing technology like DCS/SCADA and historian/MES systems. Existing infrastructure like DCS/SCADA and historians is valuable, well designed, and reliable. They belong in any Industry 4.0 architecture, but they are not designed for real-time analysis of data to identify patterns. Edge computing working with these existing systems can analyze patterns and trigger actionable states, such as alarms.

Implement data analytics, AI, ML, and digital twins

As Greg Hanson, CTO and vice president at Informatica, put it, "If you put garbage [data] in, you'll get garbage [data] out." Too many companies fail to use data analytics effectively



Possible Industry 4.0 architecture based on ISA-95 in their quest to add value, minimize risk, increase profits, and lower costs. The TV series *Star Trek: The Next Generation* shows how employees can use data analytics to add value. When crew members need to make a decision, they ask their computer (AI) questions to leverage the vast amount of stored information and determine the best course of action or to phrase further questions. This open information exchange helps the crew make the right decisions at the right times, and the AI learns more about those situations.

Value of data analytics

There are many applications of data analytics in chemical plant engineering, product development, customer service, and service or product development. One concrete example is using AR/VR or mobile devices to guide and assist technicians. Here are some ways that data analytics can add value:

Predictive maintenance: Similar to predictive plant control, real-time data is used to predict when equipment will fail. Instead of performing maintenance on an arbitrary schedule, you do it only when it is necessary, guided by past experience. You are more likely to identify equipment failure before it happens and better manage the risks involved. The key to success here is the experience of your maintenance staff.

Real-time process optimization and predictive control: Deploying AI/ML can deepen the understanding of how a plant operates. Building upon your employees' past experience, predictive operational control and real-time process optimization enhanced by AI/ML will further improve quality, reduce safety issues, and optimize energy and raw material consumption.

Energy management: The process industry relies on utilities (e.g., electricity, steam, gas, and water), and energy management is necessary to limit costs. Today, energy management focuses on the collection of energy data to achieve certifications like ISO-50001, which are typically used for tax benefits.

If you combine this information with systems like MES, enterprise resource planning (ERP), and supply chain management, it becomes easy to predict the energy consumption based on the scheduled activities. You can use these predictions to negotiate shorter-term energy contracts—freedom to choose the best offers can bring significant savings. Plus, you can analyze process data together with energy data to optimize your production process to reduce your energy consumption.

Support at all levels

Developing your own custom Industry 4.0 architecture is one part of the picture. Industry 4.0 needs your support as it evolves to adapt to new challenges and use cases. Chief officers, such as CIOs, CTOs or CDOs, play critical roles in the transformation to Industry 4.0.

I agree with Nick Ismail in his recent article, "Artificial intelligence: Data will be the differentiator in the marketplace," where he said that the CIO is essentially responsible for the "support and sustain" side of things, while the CTO is responsible for translating the new business requirements to technical requirements. All parties involved should learn about existing standards and participate in the development of new or updated standards.

Support from evolving standards

ISA-95 is a cornerstone in an Industry 4.0 architecture, as underlined by Charlie Gifford and David Daff in "ISA-95 evolves to support smart manufacturing and IIoT." I am personally developing an ISA-95-based architecture as illustrated in the figure. This lets my organization reap the rewards of using an established standard, helps with the IT-OT convergence, and manages the flow of the data and information between the operational functions.

Quick wins give your Industry 4.0 project momentum:

- Analyze and document processes and infrastructure. Complete understanding is required before new technology or processes are introduced. Bringing employees onboard will be easier, and you may discover many easy optimizations.
- Build inexpensive interfaces between your existing infrastructure and processes to collect and share data.
- Create digital dashboards to streamline communication using the cost-effective edge computing and IoT technolo-

gies. Make this information available in real time everywhere to make better decisions.

- Monitor and optimize your energy use to achieve certifications and negotiate more appropriate energy contracts.
- Leverage your experienced employees' knowledge to improve upon or prevent expensive maintenance on equipment.

Gradual transformation

Advanced applications in data science will slowly become more common, working alongside existing systems, such as DCS/SCADA, manufacturing operations management, and enterprise resource planning, and Internet of Things devices will be used increasingly often to enhance existing data collection systems. If correctly deployed, they will fundamentally transform how the process industry operates in the long term.

Data models need to be trained over time before they can actually contribute positively. They also have to be validated and constantly improved and adjusted to stay relevant. So, they are not a quick fix to lower costs. Both the new technology and analytics require highly trained new workers, as well as your experienced staff who understand the "old world," the processes and technology that you use now.

Siloed responsibilities and old barriers must be destroyed and replaced with open collaboration for Industry 4.0 to succeed. Industry 4.0 is absolutely not going to reduce your workforce. To be effective, you will need to hire skilled personnel to keep your Industry 4.0 initiative alive and well and retrain your existing workforce, so they become an enthusiastic part of your Industry 4.0 strategy. This massive transformation will not happen overnight, but it is happening gradually in the process industry, right now. ■

ABOUT THE AUTHOR

Stefan Zippel (stefan@stefanzippel.com), with more than 10 years of experience in technology like MES and a deep knowledge of smart manufacturing, IoT/IIoT, and Industry 4.0, joined Georg Fischer Casting Solutions to lead the company's Industry 4.0 transformation. Zippel strongly believes that the biggest opportunity in the Industry 4.0 transformation is that employees can creatively and innovatively use information to make better decisions and make their company stand out from its competition.

View the online version at www.isa.org/intech/20181202.

RESOURCES

"ISA-95 evolves to support smart manufacturing and IIoT"
www.isa.org/intech/20171203

"Artificial intelligence: Data will be the differentiator in the marketplace"
www.information-age.com/artificial-intelligence-data-123475102

Additive manufacturing simulations

Any machine, any process, any material

By Subham Sett and Jing Bi

Additive manufacturing (AM) has witnessed tremendous growth as its focus has shifted from prototypes to end-use functional parts. However, the industry has a set of critical production challenges, including build repeatability, process stability, yield rates (and, perhaps, failure for critical components), and the ability to deploy in-service. Digital tools are helping resolve some of these issues: generative design, functional lattices, build planning with hardware integration, thermal distortions, and shape compensation. Some of these tools are very specialized for certain tasks while relying on others to complete the entire additive process. As a result, an organization often relies on a disparate set of applications connected together in a file-based approach. Such a system can lead to lost productivity as users work through multiple software packages. This makes it a challenge for production processes where version control, traceability, and data accuracy are critical.

A model-based approach (as opposed to a file-based one) that integrates design, materials, manufacturing, and production is paramount to the successful evolution of additive from a lab environment to a production environment. This is being addressed by software platforms that enable end-to-end digitalization of additive manufacturing while connecting additive to the rest of an organization's industrial processes.

Physics-based simulations of the additive process are crucial in assessing the finished part's quality. Much of the attention has been on powder bed metal processes, as industries—primarily aerospace, defense, and medical—work to bring certified parts to market. Mostly based on finite element methods, these simulations either rely on precalibrated libraries (based on scanning strategies) or thermal strains that serve as inputs to relatively fast computations of the part distortions. These methods are fairly simple to use and do not require the user to dive deep into the physics of the solutions.

To be successful with this method, users need to build these calibrated strain libraries, and in most cases, they are specific to a machine type or even a specific machine. Although it is an elegant and simple approach (also used in the welding community), issues with this method will arise as machines are retired, new machines are introduced into production, and the volumes of data and designs keep increasing over time.

The other approach relies on a fully thermo-mechanical solution to the process simulations. Scanning strategies can be used in lumped thermal models to predict the thermal profile as the part is being built, layer by layer (or multiple layers together). The thermal profiles then drive the mechanical simulations for a more accurate prediction of the distortions. The main advantage of this method is that the fidelity of the simulation can be controlled. At the lower end, running very accurate simulations in the micro-second level (or lower) can capture the physics behind the manufacturing process down to melt-pool levels, phase change, solidification, and microstructure evolution. These simulations are run on representative cube models (at mm level) and help get to accurately predicting residual stresses, voids, cracks, and so on, factors that will affect the service life of the functional parts.

At the higher end of the scale, at the part level, a multiscale approach is used to map the lower-level scales to predict overall part distortions and stresses. The drawback of this method is that a fundamental understanding of the physics is required to create simulation models. Often, these models are part of the company intellectual competence and as such mature over time. However, as hardware vendors bring to market machines with new processes, faster build rates, materials choices, and open frameworks, what works for metal powder bed processes may not apply to them.

In a powder bed fabrication process, thermal energy selectively fuses regions of a powder bed; in a binder jetting process, a liquid bonding agent is deposited to join the material powder. In a direct energy deposition process, a nozzle that is mounted on a multi-axis arm deposits molten material, and in photo polymerization, liquid photopolymer is selectively cured by light-activated polymerization. While each process family uses a different raw material supply form (i.e., powder, wire feed, liquid resin, ink), each process family manufactures parts consisting of different material types. For example, powder bed fabrication produces metallic and plastic parts; binder jetting produces metallic, plastic, and ceramic parts; material extrusion produces plastic and composite.

Adding to the complexity is the fact that each process family includes many subprocess types that are differentiated by technical details and patents, such as close or open system, input/output formats, how raw material is included, how raw material is selectively heated, different types and sequences of heating and cooling sources, and how machine manufacture and environmental conditions are controlled. Under powder bed fabrication alone, there are a number of subprocess types, e.g., selective laser sintering (SLS), selective laser melting (SLM), electron beam melting (EBM), and direct metal laser sintering (DMLS). Under directed energy deposition, there are laser cladding, direct

FAST FORWARD

- Most digital tools address some of the critical additive production challenges but rely on others to complete the entire process—causing loss in production.
- An organization needs a model-based approach that integrates design, materials, manufacturing, and production to successfully evolve additive from the lab to a production environment.
- An unbiased public benchmark is crucial to building trust in the additive community.

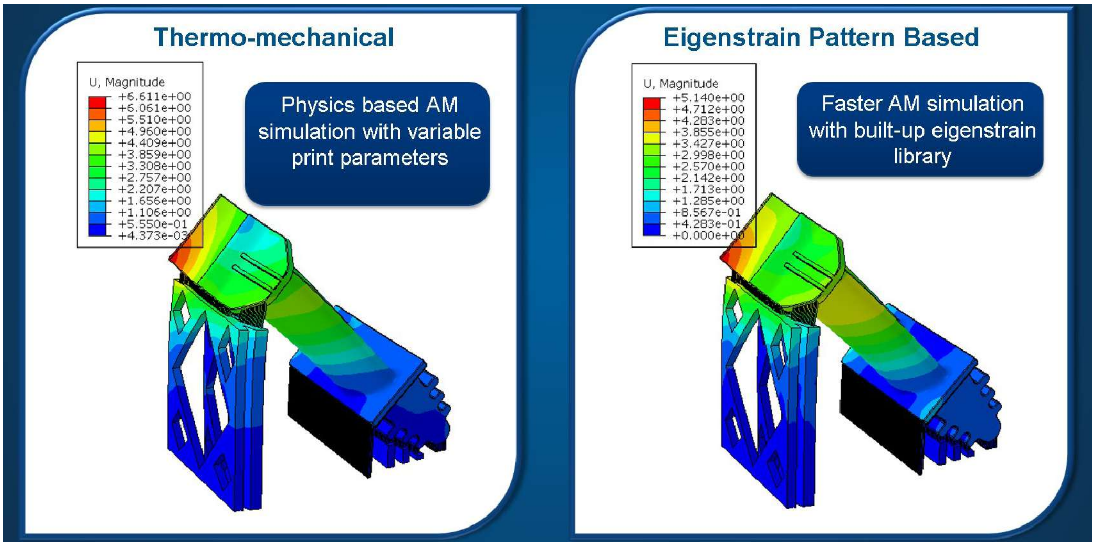


Figure 1. Thermo-mechanical and eigenstrain approaches for process simulation

energy deposition (DED), laser metal deposition (LMD), laser engineered net shape (LENS), and laser or electron beam wire deposition.

Furthermore, with many of these burgeoning processes, it is premature to predict if a single process or a multitude of processes will be in a company's tool kit. All indications point to the latter, where companies have a variety of machines at their disposal as they plan their additive road map. Herein lies the issue that could inhibit a true end-to-end digital thread.

General framework

Do I have to acquire another specialized simulation software, develop another set of techniques, maintain libraries for individual parts and machines? What if the process parameters change? What if a set tool path for polymer extrusion does not get me the right part strength? Do I go back to the drawing board? One way to address this concern is to be rigorous in the management of the AM simulation chain: machines, processes, and materials. If not planned with care, chances for drowning in the data lake are high.

There is a better way to address this issue, though, by providing researchers and analysts with a general-purpose simulation framework designed from the ground up to handle any machine, any process, and any material. In other words, a framework agnostic of the process, but driven at a deeper level by the science of energy and material handling. Energy decides how the material evolves during the process. For metal powder, the laser sources fuse the powder, and as it solidifies, the as-built material properties decide the part strength and quality. For polymer extrusion, the energy source to fuse the pellets is the extrusion process. Each process inputs this energy as a series of events that are distributed in space and time, predetermined as part of the manufacturing process.

The other issue is material handling. While material handling is machine specific, the simulation framework only needs to know when and how the material is handled. Again, these can be treated as distributed events in space and time. For powder bed, it is the roller laying down a new layer of powder. For multi-jet, it is the ink that gets deposited before the lamp provides the fusion energy. As before with energy, these events are determined a priori by the planning algorithms (figure 2).

Taking these independent events as inputs and automatically solving for dependent events, such as powder melting, liquid metal solidification, cooling surface evolution, temperature history, build stresses, and distortions, the simulation framework can proceed with the computations and predict the outcome of a certain manufacturing process or material. We also need to mesh the part and the underlying support structures in a regular finite element sense—both at a geometry and voxel level—while intersecting it automatically with collected events (energy and material).

This technique makes the simulations more efficient, as it can handle multiple layers of manufacturing events while still using a regular mesh. This open simulation framework not only addresses the multitude of existing processes but can help accelerate the maturation of new processes: a new thermal mechanical physical process, a new chemical agent application method, a new UV light polymerization process, or even a new machine that uses a number of different heating devices simultaneously or sequentially to preheat and fuse the parts!

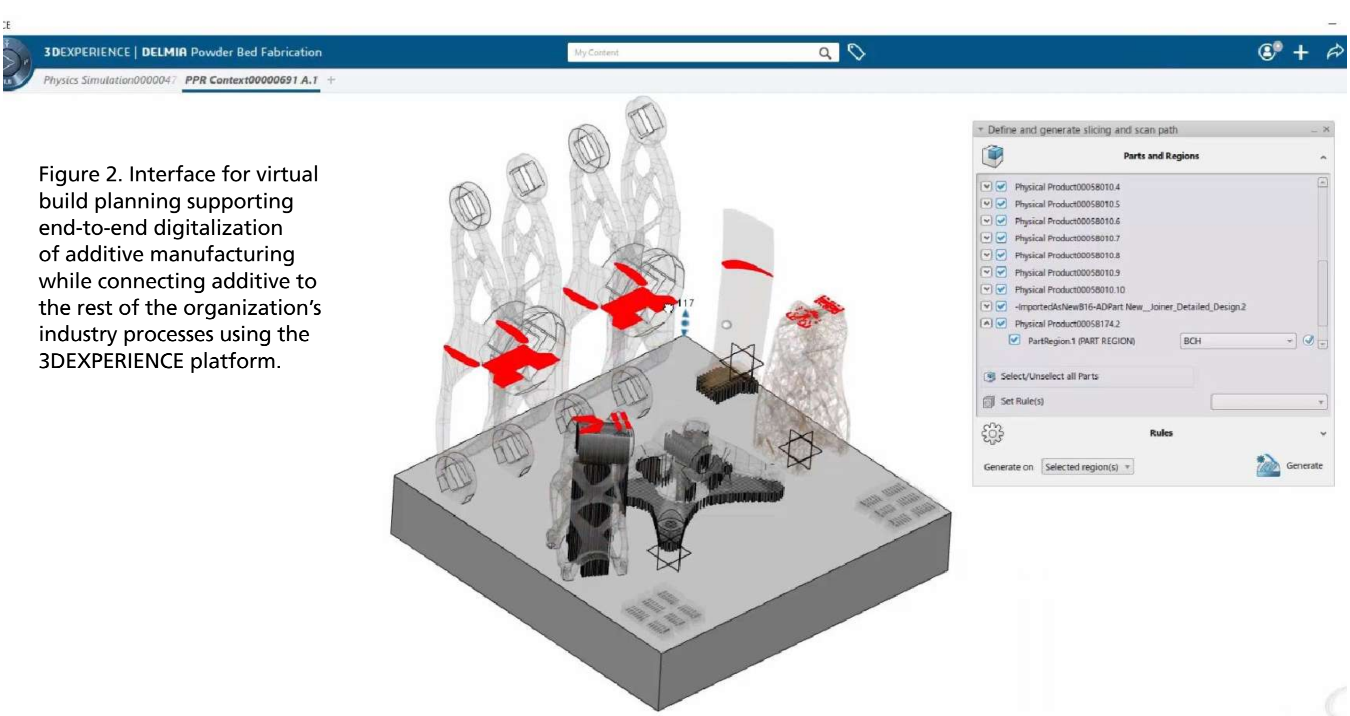
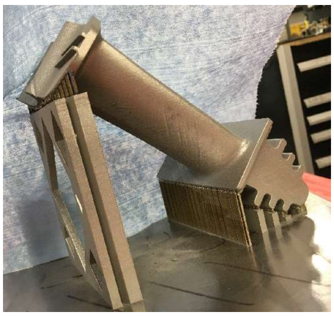
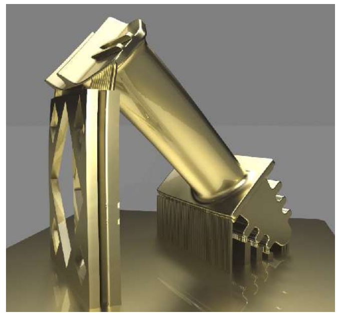


Figure 2. Interface for virtual build planning supporting end-to-end digitalization of additive manufacturing while connecting additive to the rest of the organization's industry processes using the 3DEXPERIENCE platform.

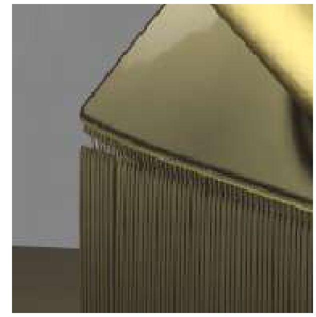
Powder bed fusion additive manufacturing (PBF-AM) process simulation



a. Physical print of a turbine blade



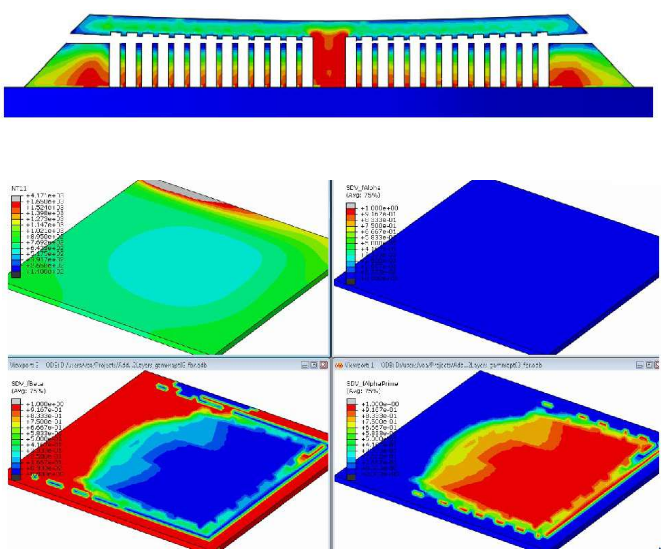
b. Process simulation of a turbine blade



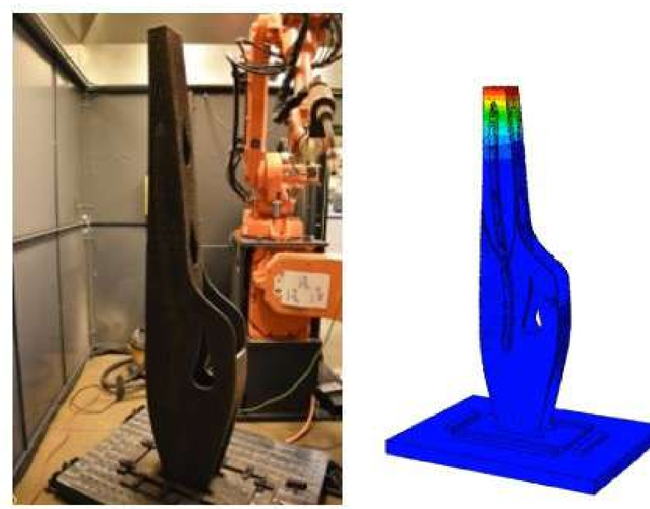
c. Crack observed in a physical print

d. Crack observed in a process simulation

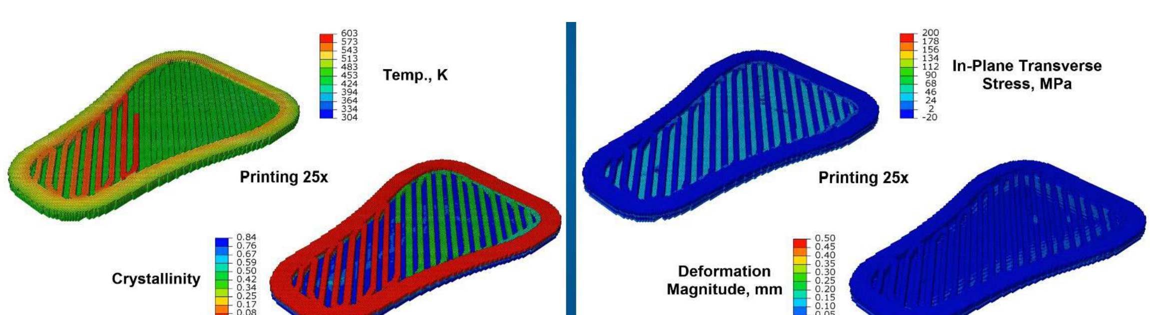
Figure 3. Examples of different processes using the same simulation framework



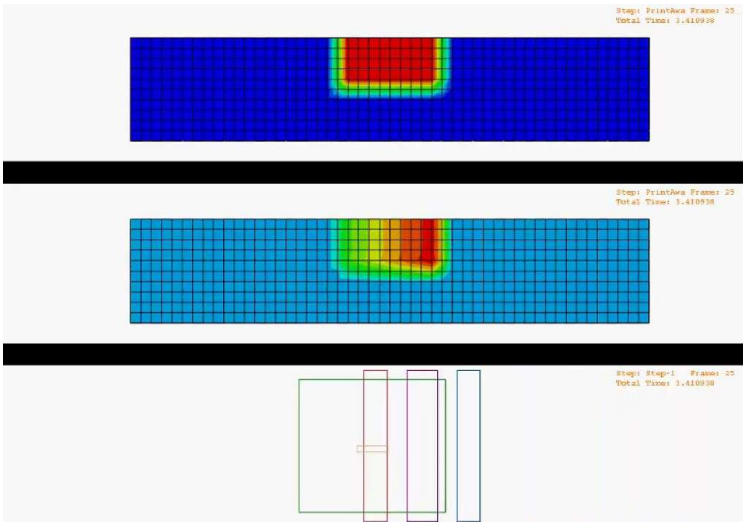
Selective laser melting process simulation at part and detail levels
London et al. (2017, 2018). *Science in the Age of Experience*



Metal big area additive manufacturing (mBAAM) process simulation
Simunovic et. al. (2017). NAFEMS World Congress (NAFEMS is the International Association for the Engineering Modelling, Analysis and Simulation Community.)



Extrusion deposition additive manufacturing (EDAM) process simulation
Favoloro et al. (2017, 2018). *Science in the Age of Experience*



Multi-jet fusion (MJFTM) process simulation
Fradl et al. (2017, 2018). *Science in the Age of Experience*

Seamless deployment

Making this simulation framework integral to the model-based digital thread allows for seamless deployment to the end users within an organization. A part designer can quickly evaluate part distortions and compensate for the shape (with the tedium of file export and import), so that the final part is within manufacturing tolerance.

The machine operator and build planner can then determine optimal part orientations or quickly verify the entire build plate by running the fast simulations, already preconfigured by the experts. They can change support strategies, and scan strategies and the simulation models are updated automatically, with a full history of updates stored—so they can revert to old scenarios with ease.

The analyst, who is responsible for signing off on the part's functional quality, can do so by incorporating the additively manufactured part—let's say a bracket—in her product configuration and running it across multiple loads and fatigue scenarios, since the residual stresses and material behaviors are inherently part of the part model she is provided with. If yields are being affected, the researcher can diagnose the issues off of the same digital thread, building highly detailed models to investigate defects, porosities, or crack propagation. All of the above feed into a data lake that continually enhances an organization's intellectual competence. It decreases its time to market while learning from past experiences to accelerate future production targets.

Figure 4. TWI and Dassault Systèmes won first place in best modeling results predicting the residual stresses within an as-built IN625 bridge structure in the NIST AM Benchmark Challenge (www.nist.gov/ambench/awards).

A final thought on simulations: it is imperative that simulations be validated with reality. As control settings for tests lead to variances in experimental data, the same applies to simulations. Modeling assumptions, physics approximations, and boundary settings all impact the simulation outcome, so verification of what you do is key. Furthermore, establishing wide, unbiased benchmarks is critical. The entire simulation community should come together and validate their methods against a common set of tests. The AM-Bench from the National Institute of Standards and Technology is an excellent step in that direction, as it will build trust in the additive manufacturing community of the role simulation has in helping them move additive from a niche manufacturing technique to a mainstream one (figure 4).

For more information on additive manufacturing, visit http://go.3ds.com/print2perform. ■

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Please send any questions or comments to: 3ds@racepointglobal.com.

View the online version at www.isa.org/intech/20181203.

OPC

Interoperability standard for industrial automation

In today's complex economy, information is the key to business success and profitability

By Thomas J. Burke

The OPC Foundation is working with consortia and standard development organizations to achieve the goals of superior production with digitalization. The year 2018 has been an interesting, record-breaking year, with end users, system integrators, and suppliers focused on maximizing their engineering investments and increasing productivity. End users are capitalizing on the data and information explosion. Consortia and standard development organizations (SDOs) are helping suppliers to exceed expectations.

Integration opportunity

Information integration requires standards organizations to work together for interoperability with synergistic opportunities to address convergence and to prevent overlapping complex information model architectures. The standards organizations have been working independently, and now it is time for them work to together to harmonize their data models with other standard organizations. The criteria for success for an SDO should be measured by the level of open interoperability provided.

When OPC UA was first conceived, it focused on developing a strategy for platform independence and a solution that allowed the operational technology (OT) and information technology (IT) worlds to communicate, have seamless interoperability, and be able to agree on syntactical and semantic data exchange formats.

The OPC Foundation started developing a service-oriented architecture, recognizing the opportunity to separate the services from the data. It consciously developed a rich, complex information model that allowed the OPC data to be modeled from the OPC classic specifications.

OPC Foundation

The mission of the OPC Foundation is to manage a global organization in which users, vendors, and consortia collaborate to create standards for multivendor, multiplatform, secure, and reliable information integration interoperability in industrial automation and beyond. To support this mission, the OPC Foundation creates and maintains specifications, ensures compliance with OPC specifications via certification testing, and collaborates with standards organizations.

OPC technologies were created to allow information to be easily and securely exchanged between diverse platforms from multiple vendors and to allow seamless integration of those platforms without costly, time-consuming software development.

This frees engineering resources to do the more important work of running the business. Today, there are more than 4,200 suppliers who have created more than 35,000 different OPC products used in more than 17 million applications. The estimate of the savings in engineering resources alone is in the billions of dollars. The OPC Foundation strategy is:

- rules for OPC UA Companion Specifications developed together with partners
- predefined process for joint OPC UA companion specifications
- templates to ensure standardized format and potential certifications
- compliance
- intellectual property
- working processes

The OPC Foundation is focused on evangelizing the OPC UA information framework and collaborating with standards organizations and consortia to incorporate data models that reflect the knowledge of their subject-matter experts.

Information models

OPC UA, beyond being a secure, interoperable standard for moving data and information from the embedded world to the cloud, is an open architecture for a wide range of application information models that add meaning and context to data. Information modeling allows organizations to plug their complex information models into OPC UA. This brings information integration and interoperability across disparate devices and applications. Using the common OPC UA framework was a way for all standards organizations to seamlessly connect their data between the IT and OT worlds. This greatly simplifies the end user's task of digitalization.

Service-oriented collaborative architecture

The OPC Foundation collaboration across many organizations is a very important part of the OPC UA service-oriented architecture that lets other organizations model their data and have it seamlessly and securely connected. The concept is simple. An organization develops its data model, mapping it to an OPC UA information model. Vendors can build a server that publishes information, providing the appropriate context, syntax, and semantics. Client applications or subscribers can discover and understand the syntax and semantics of the data model from the respective organizations. An OPC UA server is a data engine that gathers information and presents it in ways that are useful to various types of OPC UA client devices. Devices could be located on the factory floor, like a human-machine interface, proprietary control program, historian database, dashboard, or sophisticated analytics program that might be in an enterprise server or in the cloud.

The initial collaboration that the OPC Foundation engaged with was called OpenO&M, which was a cooperation between OPC Foundation, MIMOSA, ISA95, and OAGIS. This first collaboration resulted in several OPC UA companion specifications that were focused at the IT world and integration with the factory floor. The graphic shows the logos of the numerous standards organizations that the OPC Foundation has partnered with. These specifications allow generic applications to connect to different devices and applications to discover and consume the data and information.

Fast forward to late 2018, and the OPC Foundation has now partnered with more than 40 different

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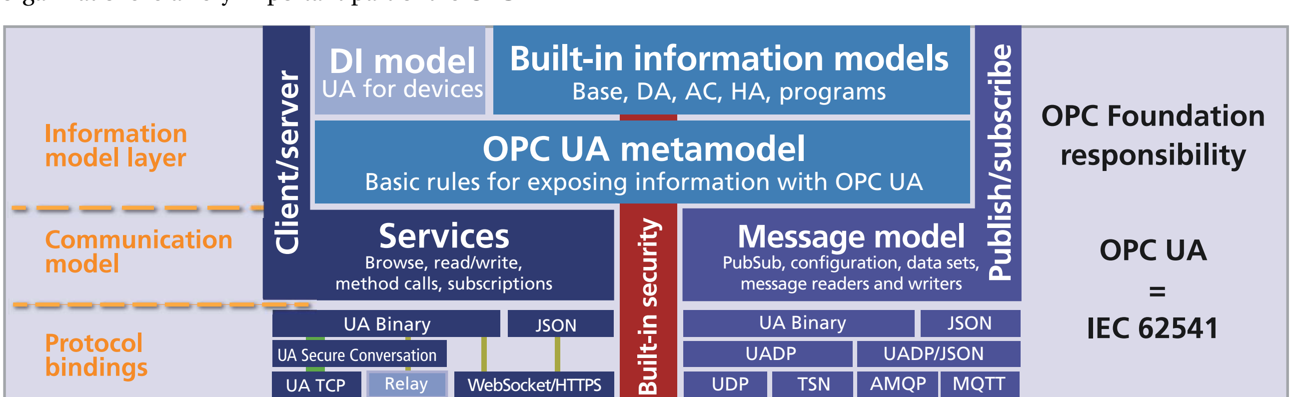
- Information integration requires standards organizations to work closely together for interoperability to address digitalization and convergence.
- The OPC Foundation is working with consortia and standard development organizations to achieve superior production with digitalization.
- OPC UA provides a secure, interoperable standard for moving data and information from the embedded world to the cloud using application-oriented data models from other organizations.



OPC UA Model diagram

standards organizations. These organizations include every major fieldbus organization, robotics, machine tools, pharmaceutical, industrial kitchens, oil and gas, water treatment, manufacturing, automotive, building automation, and more. All of these organizations are now developing or have already released OPC UA companion specifications, and these organizations can take advantage of the service-oriented architecture of OPC UA.

Some of the more important consortia that are predominantly end-user driven include the oil and gas industry, pharmaceutical NAMUR, and VDMA (the Mechanical Engineering Industry Association). There is also a lot of energy being "energized" in the energy industry (no pun intended). There are exciting trade shows in the machine tool industry and the packaging industry. Significantly, suppliers and end users are realizing the volume of data from all the devices and applications that needs to be turned into useful information.

One of the most exciting organizations that the OPC foundation has collaborated with is VDMA, representing more than 3,200 companies in the subject-matter-expert dominated mechanical and systems engineering industry in Germany and the rest of Europe. It represents the breadth of the manufacturing industry developing and leveraging standards across multiple industries.

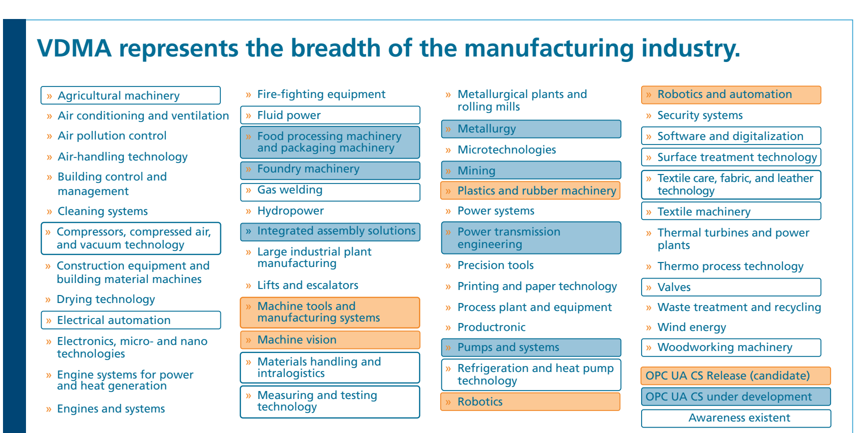
The OPC Foundation activities include collaborations with a number of industries and applications, including automotive, building automation, energy, oil and gas, robotics, welding, pharmaceutical serialization, transportation, machine tools, product life-cycle management.

Governments

Governments and regulatory agencies are now becoming actively engaged in the standard-setting process. Industrie 4.0 started in Germany and has spawned a number of regional equivalents throughout the world that are accelerating standards development and adoption for complete system-wide interoperability. Examples include Industry 4.0 concepts being adopted in countries with various initiatives that include Made in China 2025, Japan Industrial Value Chain Initiative (IVI), Make in India, and Indonesia 4.0. Clearly there is a future for the holistic automation, business information, and manufacturing execution architecture to improve industry with the integration of all aspects of production and commerce across company boundaries for greater efficiency.

A lot is happening in the world of open standards. The OPC Foundation is tightly engaged in collaboration with a multitude of organizations and is reaching across to other verticals beyond the domain of industrial automation.

OPC Foundation collaboration examples



VDMA standard activities cover many industries, and VDMA has more than 3,200 member companies.

Vertical integration

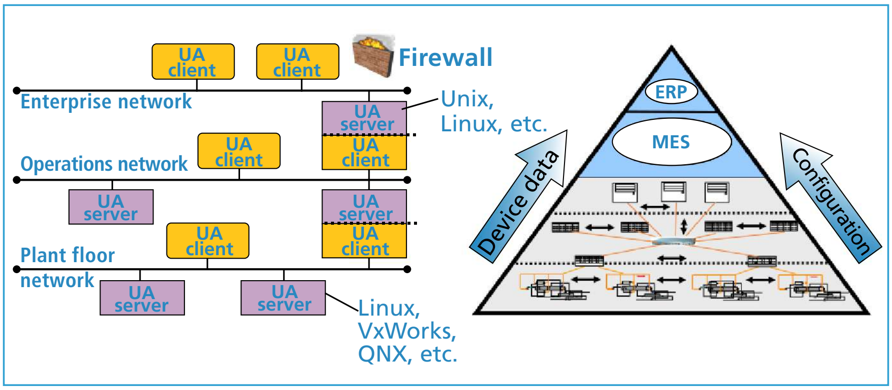
The whole concept of IT and OT convergence is very important to the suppliers and even more important to the end users, because they want a strategy and a vertical integration from the plant floor (sometimes called the shop floor) to the top floor or enterprise. What is most important in this equation of vertical integration of data from the plant floor's variety of field devices can be consumed and then turned into useful information as it goes up the food chain to the enterprise. Essentially, data becomes information as it is converted in the different layers of the vertical integration architecture.

Integration is bidirectional between sensors and controllers and the enterprise/cloud, communicating all types of information, including control parameters, set points, operating parameters, real-time sensor data, asset information, real-time tracking, and device configurations. This architecture creates the basis for digitalization with intelligent command-and-control to improve productivity, drive make-to-order manufacturing, improve customer responsiveness, and achieve agile manufacturing and profits.

OPC collaboration process

The OPC Foundation strategy is pretty simple. It has an established set of processes, so organizations can work together to develop OPC UA companion specifications complete with templates for the standardized format of the data to be understood and consumed generically. It establishes working groups and protects the intellectual property. All of the companion specifications become open standards to facilitate the whole vision of success measured by the level of adoption of the technology.

The OPC Foundation also has the certi-



Vertical integration

fication program, which allows the companion specifications to be certified for interoperability.

Digitalization

The industrial and process manufacturing industries have realized they can improve production by using data to gain insights and to optimize. This is leading to the movement toward digital manufacturing, which is the topic of many new conferences all over the world on big data, machine learning, artificial intelligence, Industrial Internet of Things (IIoT), IoT, cloud computing, edge computing, and the fog. End users and suppliers are overwhelmed with all these new innovations and are sorting out what makes sense to leverage from a business value perspective to maximize their effectiveness in daily production operations. Collaboration between the OPC Foundation and a wide range of other industry organizations is bringing clarity. ■

ABOUT THE AUTHOR

Thomas J. Burke (Thomas.Burke@OPC-foundation.org) is the OPC Foundation president and executive director. Burke has a BS in theoretical mathematics from John Carroll University and an MS in computer engineering from the University of Dayton. For the majority of his career, he has developed hardware, software, and firmware for industrial automation, mostly at Rockwell Automation. Burke is the founding father of the OPC Foundation (started in 1995) and has spearheaded the vision of OPC for multivendor, multiplatform, secure, and reliable information integration interoperability.

View the online version at www.isa.org/intech/20181204.

AI equipment health monitoring and prediction technology

Smart manufacturing seeks to make equipment downtime a thing of the past

By Stewart Chalmers and James Na

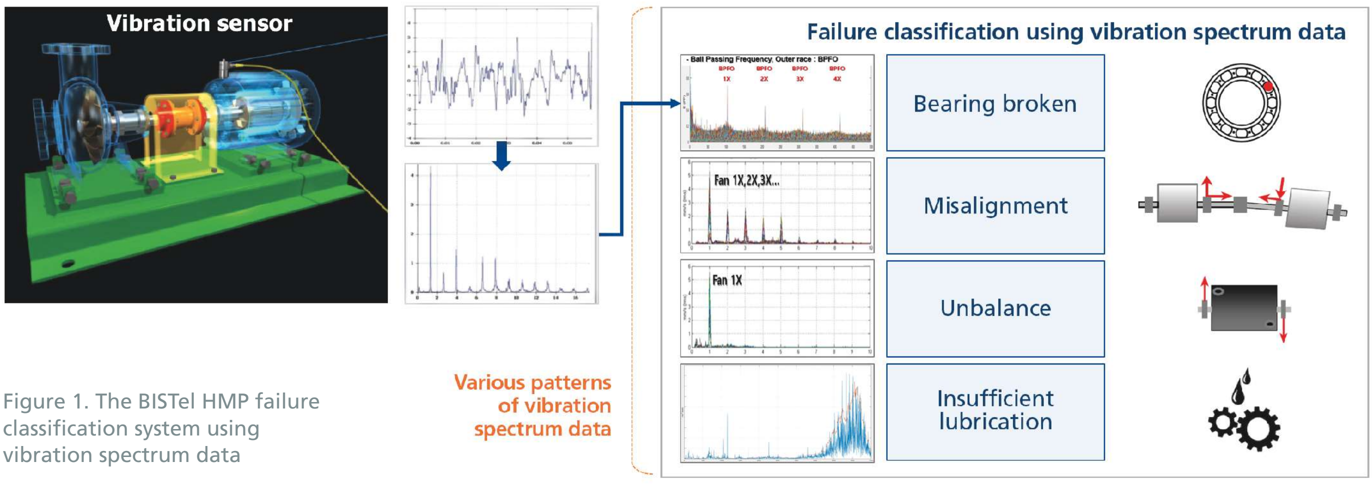


Figure 1. The BISTel HMP failure classification system using vibration spectrum data

New real-time, equipment health monitoring and prediction (HMP) systems are the first of many exciting AI-based applications that combine embedded human knowledge and advanced engineering automation. They help factories to better detect, analyze, predict, and prescribe solutions to complex, everyday manufacturing problems in real time.

In today's connected world, manufacturers who do not take advantage of the Industrial Internet of Things (IIoT) will soon find themselves left behind. IoT is fueling a wave of new artificial intelligence–based, adaptive intelligence applications for smart manufacturing. They offer the potential for massive reductions in manufacturing costs and eliminating machine downtime. How? Manufacturers are sitting on a wealth of data. Until recently, providing engineers and other stakeholders with access to this data at the right place and at the right time was not possible. Now, however, in the age of IIoT, the cloud, and big data, smart manufacturing is making this goal achievable, so employees in engineering, supply chain, and management can make more informed decisions in real time. To meet the demands of the fast-growing smart manufacturing sector, equipment HMP technology has AI-based applications that combine embedded human knowledge and advanced engineering automation to help factories solve problems.

The equipment health monitoring and predictive technology saves manufacturers time and expense by reducing two of the leading losses for the manufacturing industry: equipment failure and downtime.

Where there's a sensor there's a way

AI-based equipment HMP creates a way to not only take the risk out of manufacturing, but also to reduce risk for all industrial manufacturers, including those in the electronics, energy, automotive, steel, and pharmaceutical sectors. Through the use of sensors for each step of the production process, equipment and outputs are monitored in real time by an adaptive intelligence (AI) that provides a fault detection system, early warning alarms to prevent failure, and remaining useful life (RUL) calculations for all manufacturing equipment. Downtime is drastically cut, because maintenance is only performed as needed and where needed. In addition, of course, the equipment HMP system is highly adaptable to a wide range of industries, enabling smarter manufacturing from the steel and automotive sectors to semiconductors and energy. Manufacturers across all sectors are catching on to this trend. According to a 2017 Gartner Group study, the number of IoT devices installed across the world was 8.4 billion. By 2020, that number will more than double to 20.4 billion IoT devices deployed in the market.

AI-based equipment HMP learns the user's unique configurations and processes to identify anomalies. In steel manufacturing, for example, users are seeing an average lead time reduction of 95 percent and cost reductions of 3 percent. In one study, a top-five global steel maker using a real-time HMP system in a cold-rolling steel mill minimized surface quality issues, such as dents, scratches, and impurities, and solved the root causes of coil contraction. This was accomplished by feeding process data from a plethora of sensors throughout the manufacturing process to an adaptive intelligence. In addition to the process improvements enabled by HMP, accurate predictions of equipment failures avoided costly breakdowns and service disruptions.

Predictability in assembly manufacturing

Equipment HMP has been helpful with overhead hoist transports, ubiquitous in manufacturing spaces of all types. Users often have hundreds of overhead hoist transports on each assembly line, where they are prone to belt cutting, motor speed reductions, and other errors that lead to failure. More importantly, downtime can cause losses of millions of dollars. Monitoring vibration data allows the HMP system to send an alarm one full hour before failure, preventing accidents and saving money. Additionally, equipment HMP enables the user to easily set gold standard hoists for the entire factory floor. That ensures all transports are operating to that standard after any maintenance, and that the user is notified of any deviation from that standard. The RUL of each individual overhead hoist transport can be monitored to maximize maintenance efficiency.

Auto industry and equipment HMP

In addition to the benefits with overhead hoist transports, the HMP technology has enabled auto industry users to dynamically detect faults in real time. In studies with two top auto makers, sensor data was fed directly into the HMP system, where it was collected, analyzed, and compared to both

FAST FORWARD

- AI-based equipment health monitoring and prediction systems save time and expense by eliminating equipment failure and downtime.
- With IIoT, the cloud, and big data analytics, AI-based HMP systems help factories to better detect, analyze, and predict solutions to everyday manufacturing problems.
- By using sensors at each step of the production process, adaptive intelligence monitors equipment and outputs in real time.

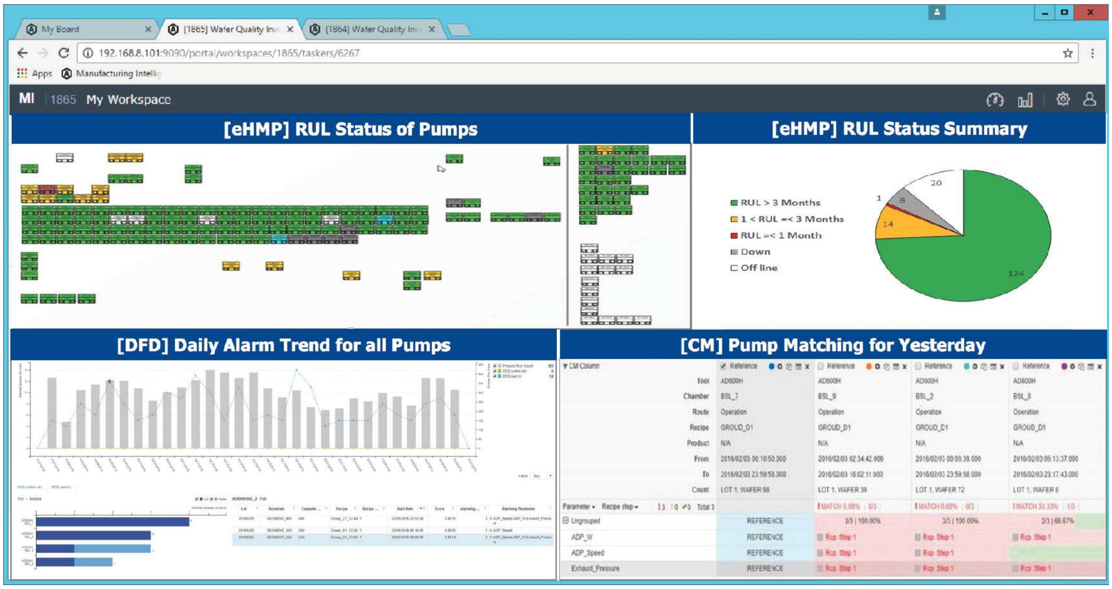


Figure 2. An example of the user-customizable dashboard to monitor equipment

historical data traces and other real-time traces to best identify anomalies. In figure 1, HMP used vibration data to identify faults in a drivetrain and to classify them in real time, saving engineers the trouble and time of diagnosing faults, which can often take weeks or months. When testing the drivetrain or other vital automobile parts, HMP allowed problems to be narrowed down quickly to specific causes, such as broken bearings, misalignment, imbalances, and lack of lubrication.

Golden chamber

The highly automated semiconductor industry has also seen great success with the implementation of HMP systems. In chip manufacturing, there are typically thousands of vacuum pumps on each process line, each producing their own data traces. HMP's adaptive intelligence can monitor all the data simultaneously, in real-time, to detect anomalies and send alarms for faults. Additionally, HMP enables the user to easily set gold standard pumps for chamber matching to ensure that all of the wafers are being produced in the same environment. The RUL of each individual pump can be monitored to maximize maintenance efficiency.

View performance

Users of equipment HMP can customize their dashboards to monitor their equipment, from the entire floor at once down to the individual sensor data on a single machine. In the dashboard image (figure 2), a top semiconductor company implemented the HMP system to monitor its vacuum pumps. The individual RUL of each pump can be viewed on the floor map or as a chart, as seen in the top two windows. The bottom left window shows the alarm trends for all pumps as recorded by the dynamic fault detection system, and the last window shows how select pumps are comparing to the golden pump (top performing reference pump) established by the user.

Foundation for prescriptive, self-healing applications

Equipment HMP takes advantage of full trace data. Unlike most traditional fault detection systems, which compare summary data from equipment to thresholds set by engineers, HMP's fault detection analyzes the full spectrum of data being generated—equipment sensor data and output quality data—and uses it to create dynamically defined control limits.

This means that subtle shifts in equipment functionality and yield quality are identified and investigated. In addition to the data already generated by each piece of equipment, sensors can be placed throughout a manufacturing process, creating a rich mine of information for the adaptive intelligence to learn from and discover patterns in. Remember, smart manufacturing is event driven, meaning that you address issues before they occur and only take machines offline when absolutely necessary.

No more scheduled-based maintenance?

As HMP technology adapts to each unique production environment, it can predict failures and create a smarter alternative to routine maintenance for vital equipment—one based on sensor feedback, big data, and machine learning rather than on-hours and use-time. HMP is the beginning. The next phase for HMP is developing a next-generation, artificial intelligence–based solution that builds a dynamic knowledge base. This will enable machines and systems to detect patterns that they have seen before and prescribe solutions to these problems in real time. For now, though, equipment HMP technology can help bring sizeable improvements in equipment utilization, yield, engineering productivity, and cost reduction to semiconductor, flat panel, display, big pharma, steel, and other manufacturing sectors. ■

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Stewart Chalmers (stewart.chalmers@bistel.com) is a senior strategic marketing executive and advisor to CEOs and smart manufacturing technology companies worldwide. He is currently an advisor to BISTel, where he is helping launch artificial intelligence–based manufacturing applications.

James Na is senior director of research and development at BISTel.

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Time-Sensitive Networking in automation

Where are we now?

By Volker E. Goller

Today, those working in the industrial communications industry are destined to confront Time-Sensitive Networking (TSN). TSN is coming, and while there are questions about when and in what form it will come, it is unquestionable that the technology will have a profound impact on industrial communications and automation. However, for many, the advantages of TSN are not clear.

History

Introduced to offices in the early 1980s, Ethernet quickly became popular due to its (at that time) high throughput of 10 Mbps. However, this iteration of Ethernet was not practical for real-time applications, because it used a party line, and collisions occurring at high utilization rates caused problems in office settings.

Collisions were eliminated in the next stage of development through the introduction of switched networks. Additionally, quality of service (QoS) brought Ethernet datagram prioritization. However, even with QoS, standard Ethernet can only guarantee latencies up to a certain point, especially with high network utilization—making it unsuitable for industrial applications, which rely on guaranteed latency.

For high-priority datagrams for industrial applications, there must be guaranteed available bandwidth and buffer space. Standard Ethernet cannot provide that, because of the store-and-forward strategy commonly used in commercial multiport switches and the impossibility of reserving bandwidth.

Store and forward means that a switch receives a complete datagram before forwarding it. This has advantages in terms of processing in the switch, but also brings potential problems that can negatively affect latency and reliability:

- When going through a switch, a datagram is delayed by an amount depending on its length. If switches are cascaded, the effect is magnified.
- Because a switch does not have an infinite storage capacity, it can reject datagrams if the network is experiencing overutilization. This means that datagrams—even those given higher priority—can simply be lost.
- Long datagrams can block a port for relatively long times.

From the beginning, switch cascading posed a challenge in industrial environments. Apart from the star topology used in the information technology (IT) field, line, ring, and tree topologies are frequently used in automation. These adapted topologies significantly reduce Ethernet installation wiring requirements and costs. Therefore, in industry, two-port switches employing a cut-through strategy, where datagrams are forwarded before being completely received, are integrated into field devices.

One size fits it all

Because standard Ethernet did not have sufficient bandwidth reservation capabilities, automation experts began developing their own Ethernet extensions in 2000. However, paths diverged during development. There is differentiation between the following approaches:

- Protocols using Ethernet as a transport medium for a fieldbus: These protocols claim complete control over the Ethernet medium for themselves. Classic TCP/IP communications are only possible in piggyback style via the fieldbus (EtherCAT and POWERLINK) or through a channel assigned by the fieldbus (Sercos). Bandwidth control is firmly in the hands of the fieldbus.
- Protocols that guarantee bandwidth reservation through a time-slicing procedure on the Ethernet: PROFINET IRT should be mentioned here. IRT enables hard deterministic, real-time data transmission on the same cable on which soft real-time or background traffic is operated. A precise timing model for the transmission paths is necessary for planning the time slices.
- Protocols based on sharing of the Ethernet cable: These protocols use QoS and are at home in factory and process automation applications. PROFINET RT and EtherNet/IP are noteworthy examples. These protocols are limited to the range of soft real time (cycle time greater than or equal to 1 ms).

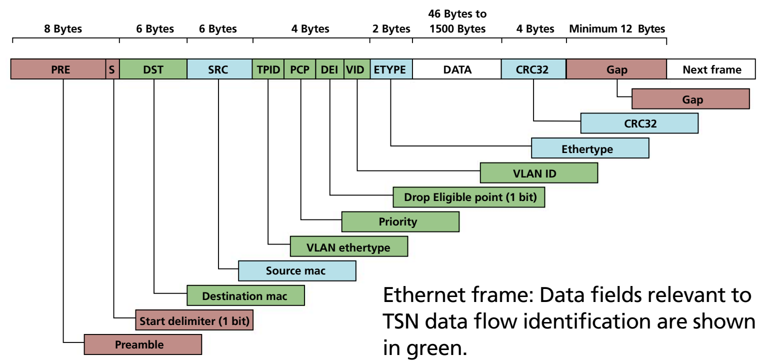
For these standards, special hardware support and, thus, special ASICs are needed. Because PROFINET RT and EtherNet/IP are also based on the embedded two-port switch with cut through, they are not exempt here. Flexible, hardware-based multiprotocol solutions solve the problem in an elegant manner.

Enter TSN

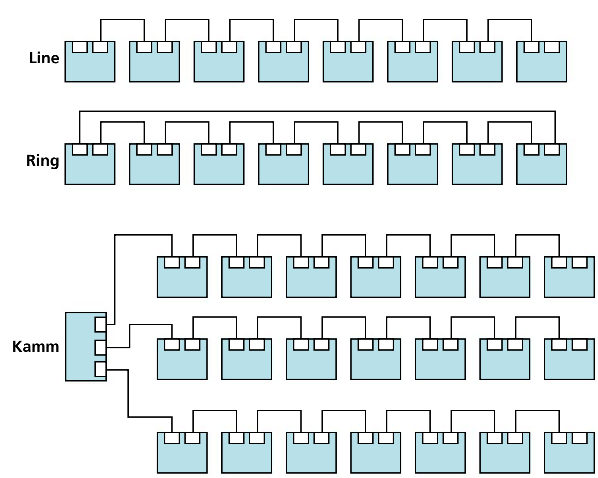
Breaking free of past limitations, TSN extensions for standard Ethernet in accordance with IEEE 802.1 have successfully been developed. Thus, there is now a standardized layer 2 in the ISO seven-

FAST FORWARD

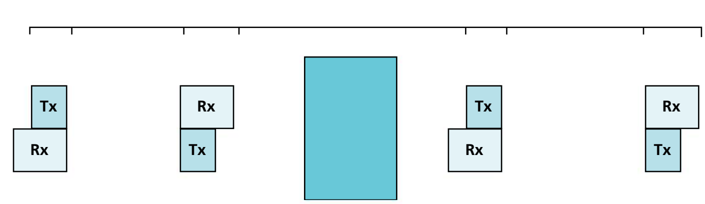
- Time-Sensitive Networking in accordance with IEEE 802.1 overcomes the limitations of today's Ethernet and delivers deterministic and highly scalable real-time data transmission.
- TSN creates a single network to meet all requirements, including audio, vision, and data with guaranteed speed and determinism for all applications.
- TSN is network-protocol agnostic and can be used simultaneously to transport industrial automation protocol traffic, IT data, OPC UA, video, and all other network traffic.



Ethernet frame: Data fields relevant to TSN data flow identification are shown in green.



Topologies



Timing model: PHYs, cables, and switches contribute to delays in data transmission. This must be considered with the time-slot method (PROFINET IRT and TSN time aware shaper [TAS]).

layer model with upward compatibility to the previous Ethernet and hard real-time capability. With 802.1AS-rev, TSN also defines an interoperable, uniform method for synchronizing distributed clocks in the network. Because best-effort communication always takes place with TSN, the common use of a cable is possible for hard real-time applications, as well as all other applications (e.g., Web server, SSH). TSN is not dissimilar to PROFINET IRT in that regard, and it also has comparable performance.

New with TSN is the need for more extensive network configuration. Centralized or decentralized configuration is possible, and both are currently being discussed and implemented. Interoperability between the two configuration mechanisms is a future development goal.

Practical advantages of TSN?

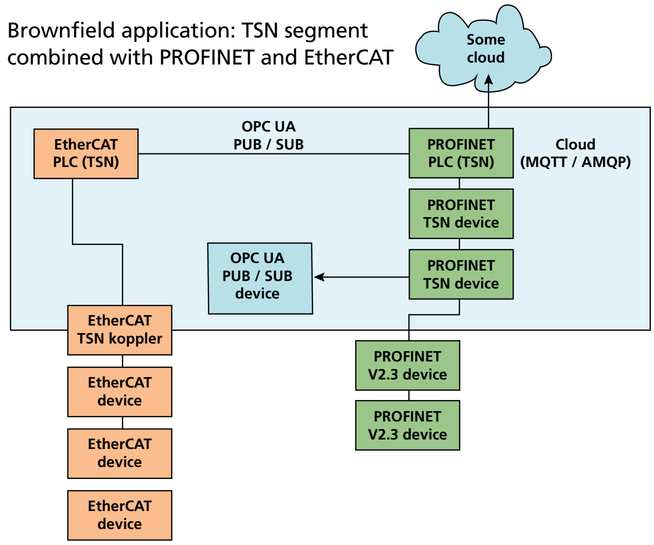
TSN will be used in building automation and the automotive industry in the future. As a matter of fact, the market for embedded TSN solutions is expected to be significantly bigger than the current market for all industrial Ethernet solutions put together.

This is because the greatest technical advantage of TSN over previous industrial Ethernet methods is its scalability. Unlike current industrial networks, TSN is not defined for a specific transmission rate. TSN can be used for 100 Mbps just as for 1 Gbps, 10 Mbps, or 5 Gbps. It also optimizes topologies, because adapted data rates can be selected for various segments. Whether it is Gbps, 100 Mbps, or 10 Mbps, a unified layer 2—IEEE 802.1/TSN—is used.

A uniform network infrastructure also helps personnel tasked with setting up and maintaining the network, because TSN solutions can now be used in sectors other than automation: building, process, and factory automation and energy distribution alike.

Training with TSN is underway to prepare the technology workforce for its pending widespread adoption. TSN is already a topic at many universities,

Brownfield application: TSN segment combined with PROFINET and EtherCAT



mostly in the research stage. However, technical and vocational colleges are already showing interest in this topic. TSN will become basic knowledge for engineers, technicians, and skilled workers. Retraining for different fieldbuses will no longer be necessary.

Brownfield, or what will happen to today's protocols?

There is a recurring theme in nearly all TSN-related working groups: How do we safeguard the transition to TSN and the supply to existing installations, such as brownfield applications? Emphasis is being placed on making the transition to TSN easy for customers. Existing industrial Ethernet protocols are not just going to vanish overnight. Companies using PROFINET, EtherNet/IP, EtherCAT, or a similarly widespread industrial Ethernet protocol today can safely assume they will also be able to operate networks with these protocols—and receive support and replacement parts—in 10 years' time.

All industrial Ethernet organizations have models that describe how existing plants can cooperate with new TSN-based devices. The interface to the existing industrial network is made by a gateway (Sercos), with a coupler (EtherCAT), or without any special hardware (PROFINET RT). Especially PROFINET and EtherNet/IP plan to make their complete protocols available right on TSN as layer 2. This makes stepwise transition to TSN possible.

TSN as an opportunity

TSN will be found in new installations everywhere, as well as in the form of islands or segments introduced incrementally into existing installations. However, with TSN, there will be new players in the industrial Ethernet field. OPC UA, with the new transport protocol PUB/SUB, in conjunction with TSN, is already viewed as a competitor to the classic protocols. For the manufacturers of field devices, this means that the classic industrial Ethernet solutions, as well as TSN and the new players will have to be supported.

TSN makes it possible to create a uniform basis for all industrial communications. Once TSN is introduced, layers 1, 2, and 3 of the ISO seven-layer model will be unified in industry. Completely new levels of scalability and performance will be possible. ■

ABOUT THE AUTHOR

Volker E. Goller (volker.goller@analog.com) is a systems application engineer with Analog Devices and has more than 30 years of experience with a diverse set of industrial applications, ranging from complex motion control and embedded sensors to TSN technology. A software developer by trade, Goller has developed a wide variety of communication protocols and stacks for wireless and wired applications while actively engaging in fielding new communication standards through involvement in industry organizations.

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Don't wait for the standards to be finished before implementing smart manufacturing

By David A. Vasko

ABOUT THE AUTHOR

David A. Vasko (davasko@ra.rockwell.com) is the director of advanced technology at Rockwell Automation. He is responsible for applied R&D and global product standards and regulations and is charged with developing and managing technology for future industrial automation products.

Smart manufacturing is called different things: Manufacturing USA (U.S.), Industrie 4.0 (Germany), China 2025 (China), or Industrie du Futur (France). The U.K., Sweden, Japan, Korea, and India also all have country-specific efforts, and new initiatives are emerging daily. Consortia such as Industrial Internet Consortium, OPC Foundation, and Open Process Automation Forum also have initiatives underway. What do they have in common? They all are:

- creating a vision for smart manufacturing
- using digitalization to help manufacturers reduce capital expenditures, improve time to market, reduce inventory, and improve productivity
- working to use and extend existing standards to realize the vision

The last point is an important distinction. These initiatives are not creating new standards but determining how best to use or extend existing standards. That means the groundwork for smart manufacturing and other initiatives is being done in standard-developing organizations like IEC, ISO, ISA, IEEE, and the OPC Foundation. That is where the influence starts, and leadership takes hold.

Countries and companies around the world are eager to adopt digitalization strategies. It levels the playing field for smaller companies that can gain the same benefits as bigger companies and remain globally competitive and relevant. What this means is if you look only at one initiative, you will have a limited view of the global movement. You must look at global standards to understand global impact. So rather than the name of the initiative differentiating the work, it is the standards behind that initiative that make the difference.

The time to start is now

For organizations waiting to start their journey to smart manufacturing until new standards are complete, I have to say, do not wait for them all to be finished. You can start now. Industrial Internet of Things standards (I4.0) will take decades to come to the ideal state where data flows seamlessly among multivendor applications and devices. But rather than see that as a reason to delay, I see that as a reason to *start now*.

Industry is slow to adapt to new technologies, mostly because it can take decades to replace existing assets with new, smart manufacturing versions. The transition should take place in phases. Smart manufacturing is not a moment in time. A good strategy thinks about how to use current standards to facilitate change that matters today—and support future evolution.

Why it matters

The Connected Enterprise uses the best of the international standards defining smart manufacturing. National initiatives and industry consortia are monitored and enhanced, so the Connected Enterprise can use the best international standards as they emerge. That is going to be important when we talk about another aspect of smart manufacturing: speed.

Speed is a challenge for everyone. International standards that support operations technology (OT) are mature and can take a few years to evolve. In information technology (IT), the timing is in months. Like apps on your phone, there is always something new. By the time a standard can form around it, there is something newer.

Initiatives need to be agile enough to address emerging trends and technology. Right now, that is not the case. Industrie 4.0, for example, plans to release yearly updates on its interfaces and relevant standards, but it is probably many years from describing the requirements for compliant products. We do not know what our IT landscape will be in a year, much less years from now. There are applications in the IT space that will evolve, gain acceptance, and become obsolete within five years.

It is smart to continually look for and implement improvements. The goal is to sort through standards, apps, and services to find the right ones for right now and to constantly assess them using a cost-versus-benefit analysis. That is how you determine where you can make the biggest impact for manufacturing—and find the next opportunity for improvement.

In just the past few years industry has harnessed never-before-seen levels of processing power, mobility, and visualization. We can now get any information we need, from anywhere, and at any time.

Standardization is working behind the scenes, and we must continue to align with those standards to support smart manufacturing in whatever terms you want to use: Manufacturing USA, Industrie 4.0, China 2025, or Industrie du Futur.

For more information on the future of smart manufacturing, tune in to the "State of the Industry" podcast. It explores the impact of disruptive technologies, workforce issues, and global business trends. ■

Systems integrators add to the success of automation projects

By William Pollock, PE

The large manufacturing expansion underway is driving a surge of plant upgrades and capacity expansions that manufacturers are understaffed to implement. Most manufacturers have cut staff to the bone, so that maintenance people can only carry out minimum levels of plant maintenance and in-plant engineering. Because of this, many companies trying to engineer or manage large upgrades or plant expansions by themselves are unsuccessful and frequently over budget. At times, they do not get production ready until far beyond the planned start-up date. Independent systems integrators are fundamental to making these projects successful.

Manufacturers are using professional system integration companies for plant upgrades and expansions with Control Systems Integrators Association (CSIA) members. In 1994, we were founding members of CSIA, the professional trade association of more than 600 control systems integrators with activities including certification, annual conferences, industry-specific business insurance, and an industry best practices manual. For the most part, members are independent organizations that use their automation and project management expertise to design and integrate manufacturing lines for industrial clients.

Manufacturers using CSIA systems integrators improve the probability of project success because integrators:

- have specialized knowledge of manufacturing software and current industry standards
- are trained in the implementation of capital projects and have project management systems for effective time and expense management
- have decades-long industrial experience that helps bring innovative solutions

System integrators eliminate the stress and risk of putting project burdens on the plant staff and provide manufacturers with low-risk, successful applications of automation technology.

Lessons learned by others

We have seen many examples of projects undertaken by our clients that were not successful. A company in the food production market decided to use its in-house production engineering team to work with a design-build firm to build a $400 million greenfield plant. The production engineers were so busy doing their regular engineering jobs that they had no bandwidth to undertake the additional responsibilities of designing a completely new facility. The food production company blindly relied on the design-build firm that wanted to improve its bottom line in the build aspect of the project.

Without proper oversight by a dedicated engineering staff, the design-build firm did not adequately engineer the facility. There were many deficiencies in the utilities, as well as in the structural integrity of the building. Other shortcomings were caused because the facility was built in the New York State snow belt, and the design-build firm was centered, and serviced clients, in Georgia. There was no engineering for elements like snow loading on the roof, roof lines that allowed more than 10-foot accumulations of drifting snow, freezing condensate lines from roof-top HVAC units, or planning for winter snow removal from parking lots.

To keep the project on budget, the client compromised the specifications of the facility and paid the price in loss of production when outdoor temperatures were extreme, or certain production runs, or combination of production runs, demanded utilities greater than the newly installed infrastructure could provide. Had the manufacturer or the design firm collaborated with a systems integrator, many of the shortcomings would have been identified in design or during design reviews, and problems avoided.

A dairy company finished a $2 million plant expansion using local vendors and contractors. It installed new and used equipment that was sourced online. No preliminary engineering or detailed engineering was carried out to complete the project. Unfortunately, the project was completed so far behind schedule that it missed the market for the product it was manufacturing. The company ended up with an overbudget project, and production significantly less than planned. Its attempt to save money caused a very low return on investment and a failed and lagging facility.

A chemical plant decided to do an expansion. Its initial plan was to manage the project management itself and have outside consultants and engineers do specific tasks. Its project management was ineffective, and the project went over budget. The initial project scope and definition were underengineered and because of the underdefined and incorrect scope, there were additional costs and delays. Ultimately, the project cost more than it should have, and production and return on investment began much later than they should have.

Often the manufacturing staff does not have the time, resources, or expertise to carry out the project. At times they are not equipped to adequately define scope and estimate the costs. Most of the members of the CSIA work with clients using a gated project methodology. If a company comes to us at the beginning of the project, we can help it create a piping and instrumentation drawing, as well as a preliminary project cost. It can use this cost as a basis to get capital funding approval in the company. Once approved, we can complete detail design and engineering, write automation software, procure equipment, install, and commission the new line. Outsourcing project engineering and project management to an independent systems integrator can be a great way to leverage internal resources and drive manufacturing forward. ■

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William Pollock, PE (Bill.Pollock@Optimationtech.com), is the CEO of Optimation Technology, Inc., in Rush, N.Y. He has had a varied career in the controls industry that has included design engineering, as well as a period as associate professor at the State University of New York.

New CAPs and CCSTs

Certified Control System Technicians

Name	Company	Location
Level 1		
Eric L. Miller	None	U.S.
Bromekas L. Gibson	Dominion Energy	U.S.
Thomas B. Rabel	None	U.S.
Jeremy M. McGough	None	U.S.
Gary O. Christian	None	U.S.
Sergio Guevara Oserio	Flowserve	Mexico
Kendall S. Kildow	None	U.S.
Donald W. Jenkins	None	U.S.
Jeffrey L. Keaton	None	U.S.
Bret T. Maloy	None	U.S.
Brent R. Mattfeld	None	U.S.
Brand M. Shonk	None	U.S.
John M. Kruse	MillerCoors	U.S.
April A. Brower	MillerCoors	U.S.
Keith A. Randell	None	U.S.
Troy D. Carter	None	U.S.
John B. Langer	None	U.S.
Bruce B. Alexander	None	U.S.
Norman L. Wagoner	None	U.S.
Anthony J. Freyta	None	U.S.
Adam P. Loveless	MillerCoors	U.S.
Jason L. Palmer	None	U.S.
Shannon T. Young	Alyeska Pipeline	U.S.
Charles A. Rickman	None	U.S.
Thomas L. Dechant	Alyeska Pipeline	U.S.
Walter C. Clymer	None	U.S.

Level 2		
Chad M. Schaner	Flint Hills Resources	U.S.
Pedro Antonio Herrera	None	U.S.
Luke J. Landaiche	None	U.S.
Jeremy J. Rican	None	U.S.
Michael E. Cervi	None	U.S.
Kyle J. Turner	None	U.S.
Antonio S. Johnson	None	U.S.
Rasel Ahmed	None	U.S.
David B. Kenner	None	U.S.
Nathaniel Paul Green	None	U.S.
Tugger C. Raymond	None	U.S.
Justin R. Minchew	None	U.S.
Richard T. Henman	None	U.S.
Von R. Watson	None	U.S.
Cody B. Bond	None	U.S.

Level 3		
Benjamin A. Penick	BP	U.S.
Charles D. Neel	None	U.S.

ISA 2018 author awards

Winners are recognized for their editorial contributions to a wide range of ISA publications, including ISA books, *InTech*, and *ISA Transactions*. The awards and award recipients are:

This year's Raymond D. Molloy Award recipient is **William L. Mostia, Jr.**, for his book, *Troubleshooting: A Technician's Guide, Second Edition*, which outsold all other ISA books published in 2017. Mostia has more than 45 years of experience in the process industries, primarily at petrochemical companies. Selected as an ISA Fellow in 2013, he has published more than 100 articles and papers on instrumentation subjects.

The Keith Otto Award was presented to **Peter Fuhr, PhD**, and **Sterling Rooke, PhD**, for their article, "Is it time for a change in cybersecurity?" (*InTech*, November/December 2017 issue). Fuhr has been involved in industrial wireless, sensors, and secure systems as a NASA space optical physicist, professor, entrepreneur, and a U.S. National Laboratory researcher. Sterling is a cyber operations officer in the U.S. Air Force Reserve, supporting USCYBERCOM and Defense Innovation Unit Experimental (DIUx). He is also director of ISA's Communications Division.

The recipient of this year's Nels Tyring Award is **Dean Ford, CAP**, for his article, "We have a demand problem with the automation profession" (*InTech*, September/October 2017). Ford, an active senior member of ISA, participates in many ISA standards committees and serves on the Automation Federation's Government Relations and Workforce Development committees.

The recipients of the *ISA Transactions* Best Paper Award are **Julian Barreiro-Gomez, PhD**, **Carlos Ocampo-Martinez, PhD**, and **Nicanor Quijano, PhD**, for their paper, "Dynamical tuning for MPC using population games: A water supply network application" (*ISA Transactions*, Vol. 69, pages 175-186, July 2017). Barreiro-Gomez is a post-doctoral associate in the Learning and Game Theory Laboratory at the New York University in Abu Dhabi (NYUAD), U.A.E. Ocampo-Martinez is associate professor of automatic control and model predictive control at the Technical University of Catalonia. Quijano is a full professor at the Universidad de los Andes in Colombia. ■

Certified Automation Professionals

Name	Company	Location
Victor Ezeano	None	Saudi Arabia
Sunilkuma Bharatkumar Vora	McDermott Middle East	U.A.E.
Douglas R. LeVasseur	None	U.S.
Keith D. Wilson	None	U.S.
Junaid Arshad	Intech Process Automation	Pakistan
Bilal Munawar	SMEC Oil & Gas Pvt Ltd.	Pakistan
Daniel R. Sturgeon	Syngenta	U.S.
Adekunle Akani	None	U.S.
Esakki Raj Mariappan	None	India
John Flynn	ESB International	Ireland
Virgil E. Sutton	None	U.S.
Shabir Khan	None	Pakistan

ISA Certified Automation Professional (CAP) program

CAP question

Which of the following procedures would NOT be included in an instrument commissioning testing matrix?

A. loop checks and loop tuning
B. calibration
C. receipt verification
D. justification analysis

CAP answer

The correct answer is *D*, "justification analysis." In an instrument commissioning testing matrix, activities are listed that are involved in the verification that the instrument installation is properly received and installed according to the specifications. First, a receipt verification is performed to verify that the instrument received is the correct item, including vendor, model number, size, and process connection type.

The item is then typically bench calibrated and installed in the process according to the piping and instrumentation drawings and installation drawings, including loop drawings. When construction is complete, loop checks are performed. During initial startup, loop tuning is performed, and all instrument readings are verified for consistency and reasonableness. Any deviating instruments may be recalibrated in the field.

Justification analysis was not included in the above discussion. Justification is typically performed during the feasibility phase of a project, or in the case of late scope additions, before purchase in the detailed design phase.

Certified Automation Professionals (CAPs) are responsible for the direction, design, and deployment of systems and equipment for manufacturing and control systems.

Reference:

Trevathan, Vernon L., *A Guide to the Automation Body of Knowledge, Second Edition*, ISA, 2006.

ISA Certified Control Systems Technician (CCST) program

CCST question

The ________________ process confirms that a company (1) documents what it does, (2) does what it documents, and (3) documents that it did it.

A. ISA12.11
B. ISO 9000
C. NFPA: 70-84
D. CENELEC

CCST answer

The answer is *B*, "ISO 9000." ISO 9000 is a family of international quality management systems standards designed to help organizations ensure that they meet the needs of customers and other stakeholders while meeting statutory and regulatory requirements related to a product or service. In short, this standard verifies that a company has a set of written procedures for manufacturing its product or service, that it follows these procedures 100 percent of the time, and that it documents that these procedures have been followed.

ISA12 is a group of standards relating to electrical equipment in hazardous (classified) locations. NFPA: 70-84 is the National Electrical Code (NEC). CENELEC is the European Community for Electrotechnical Standardization electrical standard.

Certified Control System Technicians (CCSTs) calibrate, document, troubleshoot, and repair/replace instrumentation for systems that measure and control level, temperature, pressure, flow, and other process variables.

Reference:

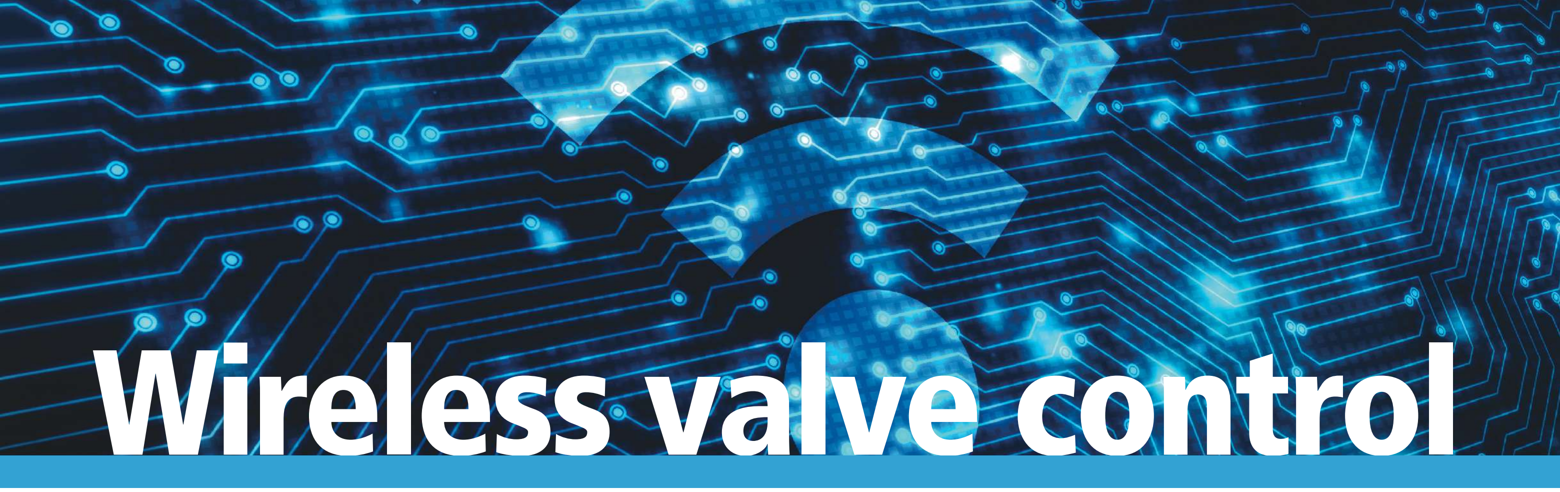
Goettsche, L. D. (Editor), *Maintenance of Instruments and Systems, Second Edition,* ISA, 2005.

In memoriam

Former ISA president **David Nolan Bishop** passed away 19 September 2018 at the age of 78. Bishop, who had a master's degree in electrical engineering from Mississippi State University, retired from Chevron after 35 years as an electrical engineer. He was a member of ISA from 1971–2018 and served as president in 1991–1992. In addition, he was named Mississippi State Engineering Alumnus of the year in 1990 and served on the MSU Engineering Advisory Board. During his professional career, he logged 12,000 student hours teaching electrical installations in hazardous locations. Bishop was a problem solver who gave his all to any project he encountered. As one of the many young professionals he mentored said, "He was a great inspiration and role model to me and many, many others." ■

In memoriam

Paul Whitfield Murrill, chemical engineer and former chancellor of Louisiana State University, died 2 April 2018. Receiving a Naval ROTC scholarship, Murrill earned a degree in chemical engineering at the University of Mississippi. After a time in the Navy and working as a chemical engineer at Columbia-Southern, he returned to academic life. Murrill completed his master's degree and PhD at Louisiana State and began working as a professor in 1963, later moving into leadership positions. Murrill wrote and edited many books, including seminal texts on process theory still in use today. He also worked with Cecil L. Smith on early research in digital system tuning methods. In 2003, ISA named him one of the 50 most influential people in history in the fields of automation, instrumentation, and control technologies. ■



Wireless valve control

By Shuji Yamamoto

It took many years, but wireless technology has become accepted by skeptical instrument engineers worldwide. When ISA100 Wireless instrumentation first appeared in 2010, engineers were nervous about reliability and noise immunity. Since then, millions of hours of successful operations have been recorded, and wireless is now often the first choice for new plant construction and revamps.

One major reason is cost. Wired transmitters require a wired infrastructure, which can include a power supply, cabling, conduit, and cable trays to bring the signal to a field junction box or marshalling cabinet, along with I/O devices at the control and monitoring system to accept the transmitter's 4–20 mA or fieldbus signal. This can make a wired transmitter installation a very expensive and difficult undertaking. Battery-powered wireless transmitters do not need the wired infrastructure or power supply, so they can be installed quickly and inexpensively.

Although few engineers now hesitate to use wireless for monitoring purposes, wireless valve control has not enjoyed such success, often due to latency, along with the safety and reliability required for closed-loop systems.

Overcoming latency

In a 4–20 mA wired system, the signal is always present. The control system can read a level transmitter, determine that a valve needs to close, send the appropriate signal to the valve controller via a 4–20 mA signal, and the loop is closed almost immediately. Not so with standard wireless.

A wireless level transmitter is typically battery powered. To save battery life, the transmitter normally is set to send a wireless signal every second, or less frequently depending on the application. The wireless signal is relayed by other wireless transmitters in a mesh network arrangement until it arrives at a gateway. There, it is added to the plant's network and arrives at the control system.

The control system determines that the valve should close and sends the appropriate signal over the network. The network delivers it to a wireless router, which transmits it to the valve controller. Total time elapsed is probably a minimum of 1 or 2 seconds depending on the signal frequency, but it could be much longer—perhaps 10 seconds or more, depending on latency in the type of mesh network. In particular, mesh networks with auto reconstruction of communication paths can substantially delay signal propagation. For a control or safety valve, 10 seconds is entirely too much time. A tank could overflow while the valve awaits a close command. Fortunately, there are ways to address this issue, starting with selecting the right wireless mesh network.

Mesh methods

Three types of wireless mesh systems are used in the process industries:

- *Fully automatic:* In this system, the path through the mesh is automatically determined and can vary. If, for example, a tractor-trailer parks so as to block a transmitter or gateway, the mesh automatically routes around it. It may require routing through three or four additional transmitters or repeaters, and it can take time to complete this rerouting. Advantages of an automatic system are that instrument engineers do not have to set the mesh route, and the system can automatically compensate for equipment failures and temporary blockages.
- *Semi-automatic mesh:* In this otherwise automatic mesh system, engineers can set the mesh path for some transmitters.
- *Fixed mesh:* The mesh path for every transmitter is determined manually.

An automatic mesh may be unsuitable for wireless valve control—and many other real-time control functions—because the latency cannot be determined beforehand. It frequently varies because of interference or noise on the path of signal propagation. Therefore, fully automated meshes often degrade real-time performance.

A semi-automatic or fixed mesh system enables reliable, real-time communication and near instantaneous discovery of path failure. With a fixed mesh system, the latency for a specific transmitter can be calculated during the design stage. Ideally, for a control valve application, engineers will set paths so the critical components in real-time control (the sensor, such as a level or pressure transmitter, and the valve controller, for example) will have direct, line-of-sight paths to gateways, eliminating any "hops" and minimizing latency.

Although some applications require lower or higher performance, the ISA100 Wireless standard aims to ensure systems can transmit command signals within 1 second. This is because it was primarily developed under the principle that 1-second latency covers a reasonable range of applications without involving painful trade-offs or asking the user to apply unproven control concepts. Maintaining and supporting these existing operating principles is one of the key benefits of using ISA100 Wireless technology.

One-second transmission times and reliable communication

Safety operations are already exploiting the ability of ISA100 Wireless to provide 1-second transmission times, with safety systems set up in numerous refineries and process plants using ISA100 Wireless networks. For example, an ISA100 Wireless adapter can be installed on an on-off valve (figure 1), so the control system can shut a valve in a minimum of 2 seconds, but the total response time will depend on the publication period of the control signal. For example, the device shown in figure 1 accepts signals once every 2 seconds, but other devices may introduce longer delays.

A monitoring example is a PROFIsafe system using ISA100 Wireless to connect a gas detector to a safety programmable logic controller. In gas detection, sensor data must be quickly transmitted to a safety system when hazardous gases are detected. Using the PROFIsafe protocol over ISA100 Wireless ensures correct message sequencing, message content, device address, and parameterization. The implementation relies on the low latency, reliability, error handling, and security intrinsic to ISA100 Wireless to meet SIL 2 standards.

In these kinds of applications, response speed is critical, but must also be accompanied by a high level of reliability. Organizations can achieve this by using ISA100 Wireless's automatic retransmission feature.

The packet arrival rate is an indicator of the certainty of data transmission. A packet arrival rate of 90 percent means packets will arrive nine times in 10 transmissions. The calculation of the packet arrival rate with retransmissions is shown below.

- In the case of one actual transmission + one retransmission: (1 – 0.1 • 0.1) = data arrival rate 99 percent
- In the case of one actual transmission + three retransmissions: (1 – 0.1 • 0.1 • 0.1 • 0.1) = data arrival rate 99.99 percent

As the calculations show, when the number of retransmissions increases, the reliability of communication rapidly increases.

Doubling reliability

The ISA100 Wireless Duo-cast system is a redundant fixed mesh (figure 2) that provides extremely high reliability by delivering data to the controller in a predetermined time, even if the wireless communication and the wireless access point have a single failure. Essentially, critical measurements are sent directly to two gateways simultaneously, ensuring that one of them will get through. This has the reliability needed for both wireless valve monitoring and control and for other critical real-time control applications.

With its 1-second latency time and reliability from automatic retransmission and Duo-cast, a well-designed ISA100 Wireless instrumentation network can operate as dependably as wired I/O in most critical applications, including valve control. ■

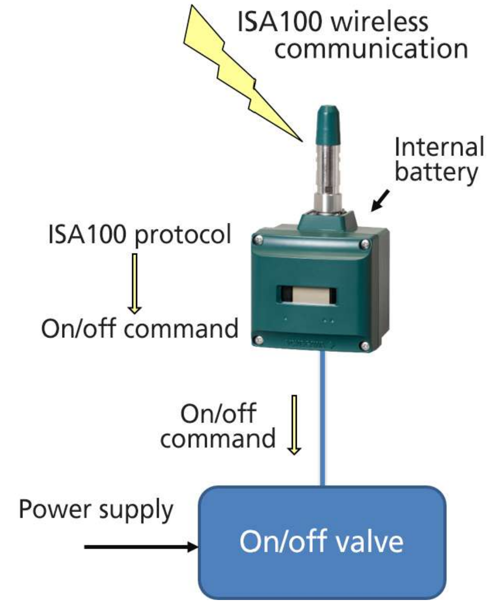


Figure 1. With proper project application engineering considering system dynamics, a simple ISA100 Wireless adapter allows this on/off valve to be reliably and quickly controlled.

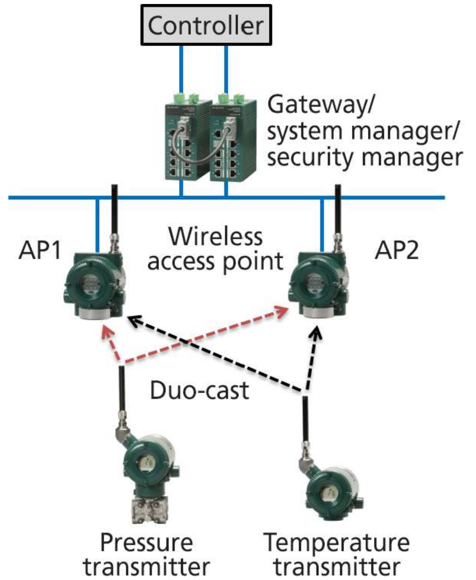


Figure 2. The ISA100 Wireless Duo-cast function gives a critical wireless transmitter a redundant path to a gateway.

ABOUT THE AUTHOR

Shuji Yamamoto (Shuuji.Yamamoto@jp.yokogawa.com) is the wireless promotion manager in Yokogawa's New Field Development Center. He joined Yokogawa after completing a master's degree in electronic engineering from Shinshu University with a specialty in high frequency research. He has had a variety of responsibilities with the company over his career, all primarily related to wireless networking and Industrial Internet of Things.

ISA to provide end-user perspective in new smart manufacturing program

In early November, the Geneva-based International Electrotechnical Commission (IEC) held the first meeting of a new IEC systems committee on smart manufacturing in Frankfurt, Germany. An IEC systems committee is intended to set high-level interfaces and functional requirements that span multiple work areas across the IEC and its partner, the International Organization of Standardization (ISO), to achieve a coordinated standards development plan.

The definition of smart manufacturing to be used by the IEC systems committee is:

Manufacturing that improves its performance aspects with integrated and intelligent use of processes and resources in cyber, physical, and human spheres to create and deliver products and services, which also collaborates with other domains within an enterprise's value chain.

Performance aspects within that definition can include agility, efficiency, safety, security, sustainability, or other indicators. Enterprise domains, in addition to manufacturing, can include engineering, logistics, marketing, procurement, or sales.

Major supplier and government organizations from across the globe were well represented at the Frankfurt meeting, but participation from end users in industrial processing and manufacturing was noticeably low. ISA's long-standing focus in its consensus industry standards on end-user performance, safety, and security, however, will be important in filling that void, as evident already in widely used IEC standards that are based on original ISA standards:

- ISA-99/IEC 62443: Industrial Automation & Control Systems Security
- ISA-95/IEC 62264: Enterprise-Control System Integration
- ISA-88/IEC 61512: Batch Control
- ISA-84/IEC 61511: Functional Safety
- ISA-18/IEC 62682: Management of Alarms
- ISA-100/IEC 62734: Wireless Systems for Automation

ISA's participation will be facilitated through an organizational liaison with the IEC by which ISA standards and technical reports, both published and in development, can be directly circulated and reviewed within the systems committee as appropriate.

For information about participating in ISA Standards or on the IEC Systems Committee on Smart Manufacturing, contact Charley Robinson, ISA Standards, crobinson@isa.org. ■

2018 ISA Standards Department award winners

Over the past year, ISA has published 10 new consensus standards and technical reports that improve the safety, cybersecurity, and efficiency of industrial processes. Prominent among these are several additions to ISA's standards on industrial automation and control systems cybersecurity and enterprise-control system integration.

At the ISA Annual Leadership Conference in Montreal, Quebec, ISA's Standards & Practices (S&P) Department presented annual awards in recognition of outstanding technical contributions and leadership in the development of these standards. The awards were presented by the 2017–18 vice president of the S&P Department, Maurice Wilkins, PhD, of Yokogawa, to the following:

- **Andrew Kling**, director of cybersecurity and software practices, Schneider Electric, and **Alex Nicholl**, senior industrial security architect, Rockwell Automation, for their technical expertise and contributions within the ISA99 standards development committee to the development of ISA/IEC 62443-4-2, *Security for Industrial Automation and Control Systems – Technical Security Requirements for IACS Components.*
- **Bill Thomson,** IoT secure development lifecycle technical leader, Cisco Systems, and **Paul Forney,** chief security architect, Schneider Electric, for their technical expertise and contributions within ISA99 to the development of ISA/IEC 62443-4-1, *Security for Industrial Automation and Control Systems – Product Security Development Life-Cycle Requirements.*
- **Brad Keifer,** senior manager, BHP Billiton Ltd, and **Bill Poole**, CTO, Manufacturing Intelligence, for their expertise and major contributions within ISA95 in the updating of the ISA-95 Parts 2, 4, and 5 standards on *Enterprise-Control System Integration.*
- **Koji Demachi,** marketing manager & technical coordinator, Technical Marketing Department, Yokogawa Electric Corporation, and **Andre Britz**, product manager – integration, RPMGlobal, for their technical expertise and contributions within ISA95 to the development of ISA-95.00.08, *Enterprise-Control System Integration – Part 8: Manufacturing Operations Management Information Exchange Profiles.*

Alex Nicholl (left) receives award from Maurice Wilkins, PhD, 2017–18 ISA S&P Department vice president

- **Stan Hale**, senior director, MRC Global, for his contributions to the development of ISA-TR96.05.01, *Partial Stroke Testing of Automated Valves.*
- **Fred Cain**, a long-time ISA75 standards participant and leader who retired last year from Flowserve Corporation, for his decades of leadership and expertise in the advancement of control valve standards.

For more information about ISA standards, please visit www.isa.org/standards. ■

E/P pressure-regulating valve

The subbase-mounted, EV03 electro-pneumatic (E/P), pressure-regulating valve has low energy consumption and can guarantee pressure control during a power loss. Depending on the version, maximum power generation is between 160 mA and 220 mA. The EV03 also has hysteresis as low as 0.7 psi, and flow up to 0.88 Cv (880 l/min) at 10 bar of pressure. The valve is available in models with an LCD display or with only LED indication. Configurable with the LCD display are pressure range, regulator behavior, actual value output, and switch output control.

The valves are externally piloted and operate via a poppet valve for response. They have pressure ranges from 0–145 psi (1–10 bar). The electrical connection is an M12, five-pin A-coded connector, and electrical protection is IP65. Operating voltage is 24 VDC. Standard output values are 0–10 volts or 4–20 mA. The design has a subbase with G1/4 connections for input and output, and G1/8 for exhaust.

Aventics, www.aventics.com/us/en

SV22, SV26, and SV102 product lines

A designer and manufacturer of solenoid valves and control components for liquids and gases has released the SV22, SV28 and SV102 product lines. The SV102 is a precision pressure regulator, and the SV22 and SV28 are high-flow electronic valves.

The SV102 is suitable for a variety of industrial applications, including pressure control of inks and tones in printing applications, inert gas pressurization of reaction vessels, flow control of process gasses in packaging applications, and varied other uses in the food processing, pharmaceutical, and manufacturing fields.

The SV22 comes in two-way and three-way configurations and can be used in many applications, including inert gas controls in packaging applications, BP cuff inflation control, CPAP devices, seal inflation control, air pilot control, weld shielding gas control, filling and dispensing, reagent control, rinsing/CIP applications, and process fluid control.

The SV28 uses technology to provide gas flow control. The operator can vary the output flow based on the current input to the solenoid. This valve has consistent gain and low hysteresis and may be controlled using DC current, open or closed-loop control, and even pulse width modulation to cover a range of applications.

Valcor Engineering, www.valcor.com

Industrial valve platform

The AxisPro industrial valves are now available in two-stage D05 (NG10) and D07 (NG16) designs, and they have the same performance and closed-loop control capability as the company's single-stage AxisPro valves, but in a higher flow package. The portfolio of valves includes single-stage and two-stage valves that accommodate flow rates up to 375 LPM.

The Pro-FX Configure, the programming software for AxisPro valves, has also been updated. With parameter-based tuning and a setup wizard, the Pro-FX Configure 2.0 enables users to configure and tune AxisPro valves by following a step-by-step graphical workflow. With onboard motion control, sensors, diagnostics, and communication, the valves are available in three performance levels to suit a variety of applications.

Eaton, www.eaton.com

PV4 and PV6 piston valves

The PV4 and PV6 piston valves for isolation purposes are available in NPT and SW versions, in sizes from ½ inch to 2 inches, in either forged carbon steel or forged stainless steel. These valves are designed to Class 800 and provide tight shutoff. They are suitable for steam, condensate, and other liquid systems. The PV4 and PV6 have been developed for use in the oil, gas, and chemical industries.

Spirax Sarco, www.spiraxsarco.com

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datafile

Datafiles list useful literature on products and services that are available from manufacturers in the instrumentation and process-control industry. To receive free copies of this literature, please contact each manufacturer via their provided contact information.

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The HM-USB-ISO USB HART modem meets industry standards for USB and HART connectivity. The small size, light weight, and durability of the HM-USB-ISO make it ideal for portable use. Operating power is derived from the USB connection. An easily installed Virtual Serial Port driver allows use in any Windows-based application.

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Automation and process control engineer

DuPont: This engineer in the Circleville, Ohio, plant will provide control systems technical support, identify and work with technical personnel to develop best practices for processes and equipment, help train operators and mechanics, and lead troubleshooting and root-cause analysis for complex control system issues. A technical degree (BS or MS) in electrical, mechanical, or chemical engineering is required. The company prefers a demonstrated ability to apply technical knowledge to solve equipment or process issues, demonstrated knowledge of key PSM technology elements, and DCS experience . . . see more at Jobs.isa.org.

Design engineer

Port of Seattle: The engineer will serve as the technical specialist in the application of advanced concepts, principles, and methods. He or she will support other port departments and the Northwest Seaport Alliance with engineering and technical knowledge and will coach, mentor, and train engineers on how to successfully design and deliver projects. Advanced theoretical and practical design knowledge of engineering and design principles for marine, airport, commercial, and industrial facilities in demanding sites is required. The position also requires demonstrated leadership skills, knowledge of capital budgeting, scheduling, and resource management . . . see more at Jobs.isa.org.

Lead manufacturing engineer

General Electric: This position in Lynn, Mass., is responsible for projects of moderate complexity. The engineer will meet day-to-day short-term objectives, resolve issues through immediate action or short-term planning, and support longer-term goals and objectives for the business and for personal professional development. A bachelor's degree in mechanical or industrial engineering and a minimum of three years of experience in production process and equipment is required. Prior experience with machining, welding, and nondestructive testing is also desired . . . see more at Jobs.isa.org.

Entrepreneurial orientation and the survival of the 21st century manufacturer

By Shari L.S. Worthington

ABOUT THE AUTHOR

Shari L.S. Worthington (sharilee@telesian.com) is president of Telesian Technology. She has more than 25 years of experience developing marketing programs for technology and manufacturing firms. She launched Telesian Technology to work with technology-based startups and Fortune 500 firms creating new ways to find and connect with B2B customers. Worthington is also a professor of practice and PhD candidate at Worcester Polytechnic Institute.

Today's manufacturers live in a hostile environment that is unpredictable, precarious, filled with intense competition, and often lacking exploitable investment or marketing opportunities. As if that is not enough, many manufacturers recognize they work in a hostile environment, but operate as if they were in a safe, benign space. As a result, they stick with rigid, mechanistic organizational structures and conservative strategic postures. Their competitive profiles are characterized by conservative, risk-averse financial management; a short-term financial orientation focused on profitability; an emphasis on product refinement versus innovation; and a willingness to rely heavily on single or small numbers of customers. That does not bode well for the long-term survival of these firms.

Research has shown that the types of organizations that survive and thrive in a hostile environment have more of an entrepreneurial orientation. That means they embrace an organic organizational structure that can respond faster to changing external forces. They have an entrepreneurial strategic posture and a competitive profile characterized by long-term, goal-oriented management, high product prices, and a concern for maintaining awareness of industry trends.

Entrepreneurial orientation is the entrepreneurial strategy-making processes that key decision makers use to put their firm's organizational purpose into action, sustain its vision, and create competitive advantages. In entrepreneurial firms, top managers are inclined to take business-related risks. They favor change and innovation in order to obtain a competitive advantage for their firm, and to compete aggressively with other firms. These managers are proactive, innovative, and willing to take calculated risks. Conservative firms are those in which top managers are passive, risk-averse, not innovative, and reactive.

It is time for manufacturers to do more than give a nod to flexibility and creativity in their mission statements. This needs to be an organization-wide change in attitude. We need manufacturers who are innovative, risk-taking, and proactive.

Innovativeness is an organization-wide mindset that encourages engagement in creativity and experimentation. This can be through the introduction of new products and services, as well as through technological leadership via research and development in new processes.

Risk taking involves taking bold actions by venturing into the unknown, borrowing, or committing significant resources to ventures in uncertain environments. Note that these are calculated risks. Many think that entrepreneurs take wild risks that sane people would avoid. The reality is that entrepreneurs take more risks because they see risks differently. They are able to assess limitations, apply creativity, and find a reasonable path to constructing something new.

Proactiveness is an opportunity-seeking, forward-looking perspective. It means introducing new products and services ahead of the competition and acting in anticipation of future demand.

There is some good news. According to the Federal Reserve Bank, manufacturing is a growing contributor to the U.S. economy, even when manufacturing job numbers are shrinking. Manufacturing contributed $2.33 trillion to the U.S. economy in the first quarter of 2018. Small-to-medium enterprises (SMEs) are responsible for a large and growing share of that added value. In fact, about three-quarters of the 250,000+ firms in the manufacturing sector have fewer than 20 employees.

While SMEs are often more specialized and flexible than their larger customers, there are gaps in the productivity and R&D investments of small manufacturers compared to large manufacturers. SME manufacturers face a number of obstacles: scarce resources, lack of skills, skepticism toward formal training, and the need for flexibility to compete against larger manufacturers.

The Boston Consulting Group found that a majority of U.S.-based manufacturing executives at companies with sales of at least $1 billion are investing in additional automation or advanced manufacturing technologies (AMT) with the expectation that this will improve productivity and competitiveness when compared to products made in low-cost countries. At the same time, low-cost countries are making significant and sophisticated investments in AMT. This creates an increasingly competitive climate, especially for SME manufacturers, many of whom are reluctant to make the major technology investments needed to keep pace. Small firms are also less likely than larger firms to train employees due to concerns about high employee turnover, high failure rates, and perceptions that training is costly.

What SMEs can do is embrace a more entrepreneurial orientation. This will lead to more opportunity recognition, more innovation, as well as more new products, processes, markets, and business models. ■


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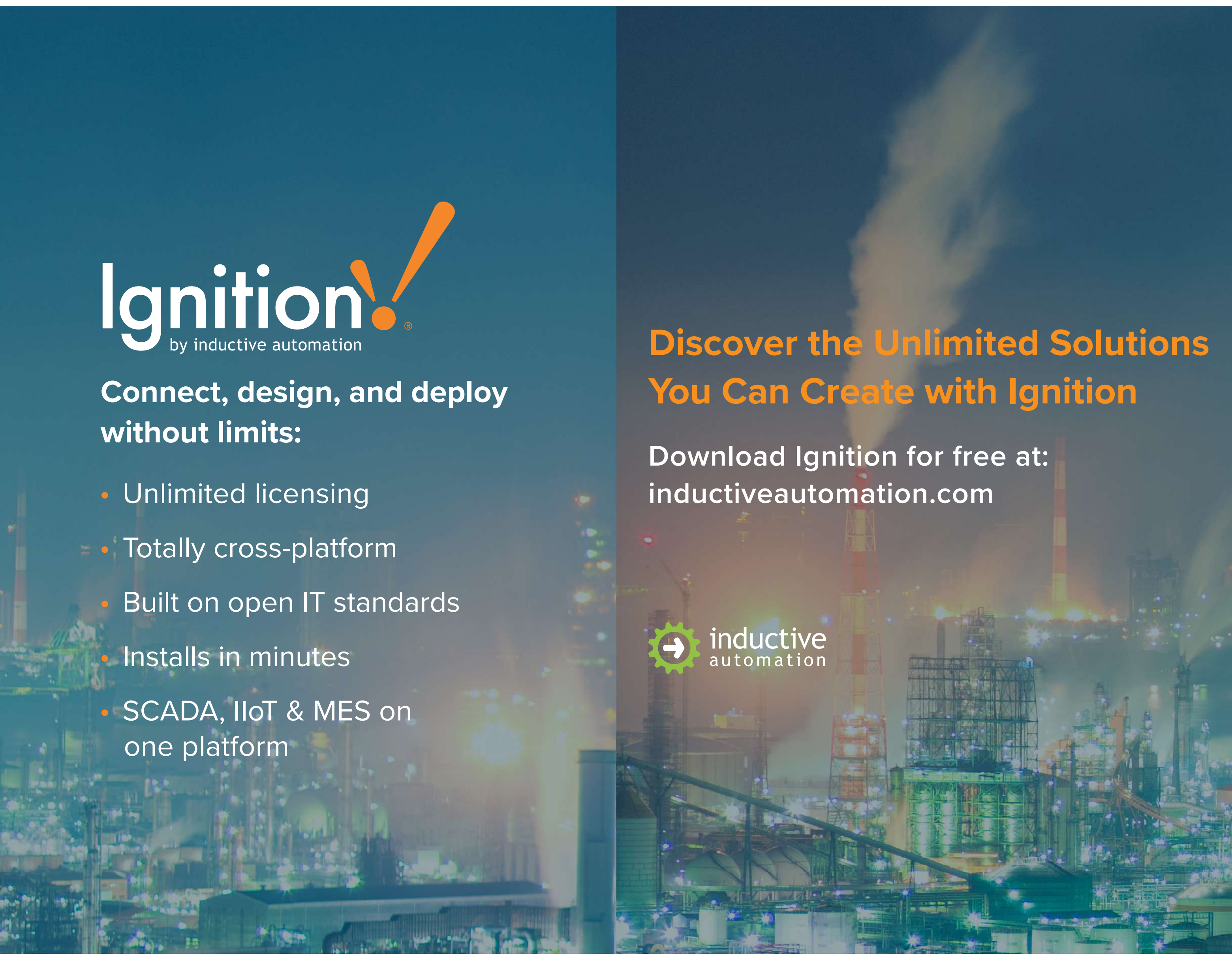
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Valves spotlight

Simplifying Edge Computing
from the Plant Floor to Remote Sites

Processor	Intel Core i7, 4 hyperthreaded cores
System Memory	32 GB
Storage	512 GB SSD
System I/O	HDMI Ethernet: 4 x 1 GbE (2 available for user applications) USB: 8 x USB 2.0
OS	Stratus Redundant Linux (with virtualization)
Temperature	–40 to +60 °C (0 to +50 °C if using provided AC adapter)
Humidity	10% to 95%, non-condensing
Vibration	3 Grms (5-500 Hz: X, Y, and Z directions)
Dimensions	280 mm (11.02 in) x 190 mm (7.48 in) x 76 mm (2.99 in)
Weight	4.6 kg (10.2 lbs.)
Certifications	CCC, CE, FCC, ICES, RoHS, UL, VCCI
Installation	DIN rail, wall, or table top
Power Input	9 to 36 VDC
Power Consumption	35W

OT and IT pros prefer ztC Edge because it's:

- **Simple** with built-in redundancy and virtualization software
- **Protected** with seamless failover and single button restore
- **Autonomous** with self-monitoring and remote management

Learn more or request a demonstration today.

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