March/April 2019

# InTech

A PUBLICATION OF THE INTERNATIONAL SOCIETY OF AUTOMATION

ISA

Process analytical technology
Machine control
Plantwide wireless
RAMI 4.0
Flow spotlight

# Cybersecurity insights

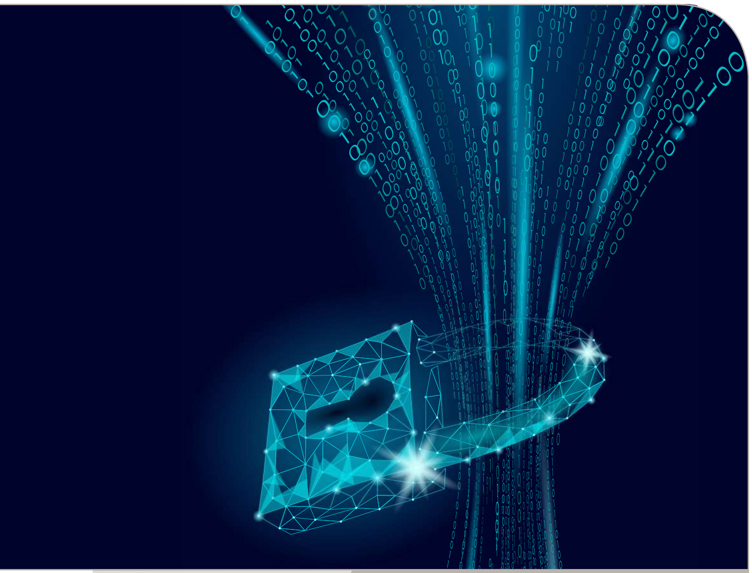
Industry experts provide perspectives on cybersecurity issues and challenges

*Setting the Standard for Automation*™
www.isa.org/intech

March/April 2019 | Vol. 66, Issue 2

www.isa.org

# InTech



COVER STORY

# www.isa.org/InTech

*InTech Plus* is ISA's online eNewsletter that connects automation professionals to all things automation. *InTech Plus* has technical content, educational training and videos, industry-related Q&A excerpts, and the latest and greatest on industry technology and news. *InTech Plus* focuses on a variety of topics, such as fundamentals of automation and control, certification, safety, cybersecurity, the Internet of Things, wireless devices, human-machine interface, pressure, level, temperature, and batch. All editorial content comes from a variety of sources, including ISA books, training course videos, and blogs and bits from ISA's cast of subject-matter experts. *InTech Plus* is powered by Automation.com, ISA's premier electronic publisher of automation content. Automation professionals can subscribe to *InTech Plus* at www.automation.com/subscribe.

Are you up to date on instrument calibration, cybersecurity, system migration, and industrial communications? Would you like to find out more about ISA events, training, membership, and more? ISA's YouTube channel is your resource for how-to videos on all facets of automation and control, and a great way to hear members talk about their real-life plant experiences and membership networking benefits. **www.isa.org/isa-youtube**


ISSN 0192-303X

***InTech,* USPS # 0192-303X, is published bimonthly in Research Triangle Park, NC by the International Society of Automation (ISA), 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709. Vol. 66, Issue 2.**

Editorial and advertising offices are at 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709; phone 919-549-8411; fax 919-549-8288; email info@isa.org. *InTech* and the ISA logo are registered trademarks of ISA. *InTech* is indexed in Engineering Index Service and Applied Science & Technology Index and is microfilmed by NA Publishing, Inc., 4750 Venture Drive, Suite 400, P.O. Box 998, Ann Arbor, MI 48106.

**Subscriptions:** For ISA members, 8.65% of annual membership dues is the nondeductible portion allocated to the *InTech* subscription. Other subscribers: $175 in North America; $235 outside North America. Multi-year rates available on request. Single copy and back issues: $20 + shipping.

Opinions expressed or implied are those of persons or organizations contributing the information and are not to be construed as those of ISA Services Inc. or ISA.

**Postmaster:** Send Form 3579 to *InTech*, 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709. Periodicals postage paid at Durham and at additional mailing office.

Printed in the U.S.A.

**Publications mail agreement:** No. 40012611. Return undeliverable Canadian addresses to P.O. Box 503, RPO West Beaver Creek, Richmond Hill, Ontario, L48 4RG



**To order REPRINTS** from *InTech*, contact Jill Kaletha at 219-878-6068 or jillk@fosterprinting.com.

**List Rentals:** For information, contact ISA at info@isa.org or call 919-549-8411.

PRINTED WITH SOY INK

*InTech* magazine incorporates *Industrial Computing*® magazine.

*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.

# Manufacturing tipping points: Evolution or revolution

By Bill Lydon, *InTech*, Chief Editor

Increasing numbers of manufacturers are investing in transforming manufacturing and applying Industry 4.0 and digitization to achieve top competitive positions in their industries.

This was evident at the 23rd Annual Automation Research Corporation (ARC) Industry Forum in February themed "Driving Digital Transformation in Industry and Cities." A significant number of users expressed plans and actions to transform manufacturing based on opportunities enabled by new technology to ensure they remain competitive. Larry Megan, PhD, director – Praxair Digital at Praxair, Inc., made an important point in his presentation that the focus is understanding your path to creating more value for customers, and a major challenge is to get from the hype to reality.

Users are also asking, "To achieve digitalization, should installed industrial automation be improved through evolution or revolution?"

Existing suppliers promote evolution, modernizing industrial automation through incremental add-ons, rather than through core control and automation hardware at the edge. This can be an incumbent supplier trap if your key suppliers are out of step with the application of technology. Incremental changes can make your manufacturing company less competitive.

Should the application of installed automation be continually improved or moved to newer automation technology? This discussion repeatedly happens in all areas of technology, and over the years there are different factors to consider, leading to various answers. Personally, many of us have made this value judgement when changing smartphones or computers to be more productive. Answering this question is not simple and should be based on a number of factors, including the knowledge and know-how of automation professionals. Automation professionals need to contribute to the management and investment discussion at their company to build winning plans.

Life-cycle cost analysis can help justify new automation investments, but selection of all the factors—including the competitive manufacturing environment—is vital for a reliable prediction. This is particularly important today with many new manufacturing and production competitors throughout the world that are leveraging new technology to take market share from traditional suppliers.

The competitive manufacturing landscape is changing, and new technology is enabling manufacturers to defend their competitive position or create new opportunities.

History many times repeats itself; consider Andrew Carnegie, who is known as a successful man of business, but he was also an innovator. In a desire to make steel more cheaply and more efficiently, he successfully adopted the Bessemer process at his Homestead Steel Works plant, resulting in greater efficiency and throughput, which contributed to major success.

"My interest is in the future because I am going to spend the rest of my life there."

*—Charles Kettering, American inventor, engineer, businessman, and head of research at General Motors from 1920 to 1947*

## Tipping points

The influx technology, combined with competitors applying new methods and technologies, is driving us to a manufacturing industry tipping point. A tipping point is the critical point in an evolving situation that leads to a new and irreversible development. The shifts from stand-alone controllers to PID to DCS and relays to PLCs drove industry to tipping points.

## Challenge

I think in this environment a key question to explore is, if you apply superior application and project engineering to existing industrial automation, can you surpass your competitors that will be deploying newer and superior technology? ■

### Survey insights

First of all, I really enjoyed and appreciated the article "The pay raise engineers have been waiting for," based on the results from the 2018 salary review [September/October 2018 *InTech,* www.isa.org/intech/20181001]. This information is very interesting and the type of content that will interest all of the readers who are involved in automation, instrumentation, and control. It is well done, and I applaud the effort to put out the survey and to analyze the input.

I would like to bring up one point with respect to both the survey and the "recipe" on page 15. This includes some ingredients that will help professionals to maximize their salaries and expand their income. You include some excellent points—most of which I included in my career path and salary adjustments.

However, there is one major area that is not explicitly included that can have a major impact on a person's role with the company and the future income. It may not even be included on the survey, and if it is not, it should be added. That factor is "professional credentialing," such as obtaining a legal license to practice engineering (PE), qualifying for a professional certificate as a Certified Automation Professional (CAP), becoming a Certified Control Systems Technician (CCST), or some other professional certification (CSFE, safety, etc.).

These are all achievements following some professional education or degree that add to the status and reputation of the individual, while making him or her more employable. The individuals find that these credentials not only increase their salaries, but also open new doors of opportunity for advancement in the company leadership roles. I speak from experience. My company gave an automatic salary increase for obtaining a PE license, which opened up new salary grades, and was required for a person to become a department manager.

In fact, ISA is a major supporter of the legal license to practice engineering and offers many certifications in our professional field of practice. This is a prime activity for the professional development department of ISA and a key to many of the educational efforts of the society. ISA also offers many


books, manuals, standards, training classes, and seminars as preparation for these credentials to expand the professional development of people in this profession.

Please consider including "credentialing" in future salary surveys and using the data in the analysis—I think you will find a difference in the salary of a licensed engineer as compared to someone with the same experience level, but not licensed.

**Gerald Wilbanks, PE**
**ISA Fellow**

### Author's response

Thanks so much for the kind words. We actually did include professional licensing in the survey, but opted not to include it in the article, which now I see was a mistake. It will be included in future articles.

Looking at the raw data, you are absolutely correct. Of the roughly 1,600 respondents that answered the licensed professional engineer question, 23.8 percent said they were licensed and reported a $22,000 increase over those who were not.

For the ISA certifications question, 30.1 percent of respondents answered that they had been certified. Their salaries averaged $2,460 more annually than those who were not.

Thank you so much for sharing these insights and experiences; they are incredibly helpful and very, very much appreciated. These points will definitely be implemented in articles going forward.

**Cory Fogg**

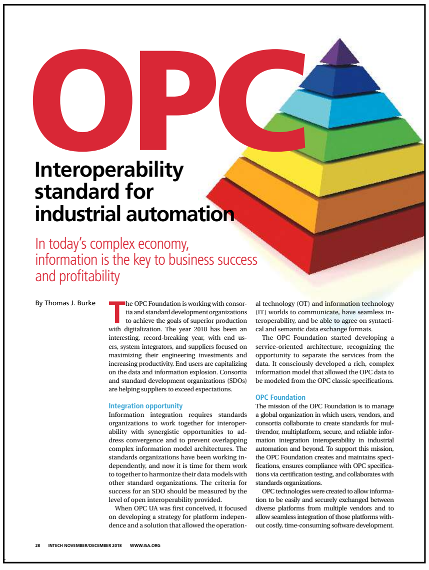
### Alarm management

While the ["OPC: Interoperability standard for industrial automation"] article [November/December 2018 *InTech,* www.isa.org/intech/20181204] is generally excellent, I kept hoping, while reading it, that the major challenge in trying to achieve information integration and OT standardization in the many industrial situations (e.g., many pharmaceutical plants) involving a plant's use of numerous diverse packaged automation systems from different vendors might be included as an example.

As Mr. Burke may be aware, the national standard (ANSI/ISA 18.2), originally published in 2009, and the similar international standard (IEC 62682) address alarm management in the process industries. The issues involved in achieving effective alarm management in the process industries, which include information integration and OT standardization, are so significant for plants using distributed packaged automation systems (e.g., different PLCs from different vendors controlling different plant operations) that ISA commissioned a committee to develop a formal technical report addressing this topic. The ISA18.2 WG7 worked for about five years on this issue, publishing their results (ISA-TR18.2.7) over a year ago. Their TR is titled "Alarm Management when Utilizing Packaged Systems."

Anyway, alarm management is one of several topics that has received significant attention in recent years regarding some of OPC's objectives. I was hoping some of this effort might be mentioned in the article.

**Joe Alford**


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.

28 INTECH NOVEMBER/DECEMBER 2018 WWW.ISA.ORG

# Cybersecurity insights

## Industry experts provide perspectives on cybersecurity issues and challenges

By Bill Lydon

**FAST FORWARD**

- Cybersecurity threats to manufacturing and process plants are coming from a widening range of attack vectors.
- The digital transformation of manufacturing to increase efficiency and productivity will increase the number of connected IIoT devices and the cybersecurity attack surface.
- The digital transformation requires integrating control and automation, which can create many new vulnerabilities that have to be addressed and mitigated.

Cybersecurity threats to manufacturing and process plants are coming from a wide range of attack vectors, including supply chain, logistics, enterprise computing, remote connections, operator stations, programmable logic controllers, distributed control systems (DCSs), smart sensors, and new smart devices. Many emerging Internet of Things (IoT) and communications technologies offer greater connectivity, but they make the cyber landscape more complex. This article explores aspects of these issues with cybersecurity experts Andy Kling, senior director of cybersecurity and architecture at Schneider Electric, and Marty Edwards, director of strategic initiatives at ISA and managing director of the Automation Federation (AF). I asked these recognized industry experts for their thoughts and opinions on a number of items:

## Edge-to-enterprise communications

IoT communications technology not only follows traditional information technology (IT) routes, but also connects to process, machines, material handling, and factory floor devices to close the IT/OT divide.

### How do you characterize new challenges created by direct edge-to-enterprise communications, and do you have any advice for users?

**Kling:** Without a doubt, the digital transformation will increase the number of connected IIoT [Industrial Internet of Things] devices. Enterprise business is constantly seeking new, better ways to get closer to operations. This is generally a very good thing, because as the speed of business accelerates, you need to be able to control your business variables and risks in real time. The natural result of all this new connectivity is a wider attack surface. To take advantage of the value the IIoT promises, organizations must expand connectivity amongst people, assets, and systems, which allows them to extract and make data work for them. To protect these new connections, you first need to understand the risks associated with moving to an IIoT environment: Will all the new information and data from the edge provide business benefits that exceed the risks it takes to retrieve and apply it? It is a simple question, and if you cannot answer, it is likely because you do not yet know and understand the full risk landscape. So get expert advice. Once you determine the value is there, then focus on data integrity. One compromised input device can poison the data repository. Cybersecurity can no longer be an afterthought. There is too much at stake, financially and operationally.

**Edwards:** There are a number of issues to consider here, I think. Firstly, just due to the sheer volume of new devices coming on the market, which might mean having to work with new manufacturers and vendors, we should expect to have a bunch of new vulnerabilities that will need to be addressed and mitigated. End users will have to contend with that and understand the implications and risks these new vulnerabilities will have on their operations.

It then depends on how you bring in the data. If your application vendor is backhauling all of the device data into the cloud through a service provider network like 5G and all you are getting is the data through the same vendor, then "device security" really becomes a vendor problem. At the opposite end of the spectrum is that if all of these devices are interconnected to your own control networks, then you really need to take a look at bringing the data in via a protected enclave, i.e., a section of an internal network that is subdivided from the rest of the network, much like we do with roaming Wi-Fi-enabled operator-interface solutions, for example.

## 5G wireless

A digital transformation requires increased connectivity and data transference, and 5G wireless can satisfy this demand. Process automation systems today primarily rely on hardwired networks for communications, particularly Ethernet, but to achieve the goals of new digital initiatives, like Industry 4.0 and IIoT, there are increasing bandwidth requirements. In addition to plant automation, 5G wireless capabilities are suited for linking process sensors and instruments to business enterprise systems.

Previous generations of mobile networks predominantly addressed consumers for voice and SMS in 2G, Web browsing in 3G, and higher-speed data and video streaming in 4G. The transition from 4G to 5G will better serve consumers and industries alike. New 5G wireless technologies provide the network characteristics manufacturing requires, including high bandwidth, connection density, low latency, and high reliability to support critical applications. Mobile 5G technology will allow higher flexibility, lower cost, and shorter lead times for factory floor production reconfiguration, layout changes, and alterations.

It is not necessary to wait for commercial wireless carriers to implement 5G before manufacturers can take advantage of these benefits. Production plants are already implementing 5G for in-house communications.

A number of 5G industrial applications were demonstrated at the 2018 Hannover Fair, including an extremely impressive concept of deterministic, high-speed coordinated motion over 5G wireless communications. The 2019 Hannover Fair will have multiple pavilions showcasing 5G in manufacturing applications and educational sessions on the topic.

### How do you characterize new cybersecurity challenges created by 5G, and do you have any advice for users?

**Kling:** When it comes to industrial operations, 5G feeds the IoT beast. In part, the definition of IoT is a connected device. With the increased bandwidth and security of coming 5G networks, there is a promise of many new vertical solutions. As a result, availability (resist jamming), integrity (protect from signal corruption and man-in-the-middle replays), and confidentiality all bear a heightened importance. 5G will be in places not really thought of previously. Yes, the SCADA [supervisory control and data acquisition] pipeline examples already exist, but imagine 5G-enabled drones running continuous thermal imaging of a plant. They could quickly isolate problems that would have been difficult to locate previously.

Uniquely, everybody has access to this transport layer. In 3G/4G technologies, jamming or "smart" jamming was always a concern. 5G has attacked this problem, making the wireless standard more resilient to jamming. The bottom line is that when it comes to 5G—similarly to the IoT ramp up—5G will enable many new solutions. Like IoT, its use must be tempered with an appropriate understanding of the risks involved. Our challenge will be to use it securely and appropriately.

**Edwards:** I pretty much agree with what Andy has said. I hadn't thought of a lot of those things, but from a security perspective, I view 5G as just another transport layer. If the 5G vendors "get it right" with security and bake it into the implementations from the beginning, then it will be less of an issue for the end user.

## Cloud computing

Cloud computing using third-party off-site providers is growing in popularity as a technology beneficial for industrial automation. The origin of the term "cloud computing" is unclear. In some sense, it is descriptive of something off in the distance over the Internet. We are just not sure where or what is storing information and performing computing. Some claim the term was used in internal documents at Compaq Computer in 1996. Others suggest the term was first commercially used in 2006 when Google and Amazon began using "cloud computing" to describe the new approach to access software, computer power, and files over the Web instead of from local servers or a desktop computer.

Whatever the history, cloud computing, or "cloud" for short, is now a common term. Pictures of local computers networked to the image of a cloud in presentations and literature have become popularized. The National Institute of Standards and Technology (NIST) defines cloud computing as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." NIST also defines essential characteristics of cloud computing:

**On-demand self-service**

A user can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

**Broad network access**

Capabilities are available over the network and accessed through standard mechanisms (i.e., Web services) that promote use by various platforms (e.g., mobile phones, tablets, laptops, and workstations).

**Resource pooling**

The cloud provider's computing resources are pooled to serve multiple consumers using a multitenant model, with different physical and virtual resources dynamically assigned and reassigned according to user demand. There is a sense of location independence in that the customer generally has no control over or knowledge of the exact location of the provided resources. Examples of resources include storage, processing, memory, and network bandwidth.

**Rapid elasticity**
Capabilities can be automatically provisioned and scaled to rapidly meet computing and storage needs based on user demand. To the user, the capabilities available often appear to be unlimited and can be appropriated in any quantity at any time.

**Measured service**
Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, applications, and active user accounts). Resource use can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

The application of cloud computing has the potential to change industrial automation system architectures that have been traditionally on-site systems requiring capital investment to add functions. In contrast, the cloud computing model provides significant storage, computing, and application software on demand with engineers only paying for what they use. Cloud computing and on-demand analytics are also being developed for a much broader range of applications outside of industrial automation, providing powerful and more cost-effective new capabilities for automation engineers.

## How do you characterize new cybersecurity challenges created by cloud services used in industrial automation applications, and do you have any advice for users?

**Kling:** The cloud brings so much promise, it is hard to ignore its potential. Several supporting technologies—improved communications, virtualization, improved compute power—make the cloud happen. All of this supporting infrastructure brings, in turn, its own set of cybersecurity challenges. So, it is not enough to just ask about cloud security-related challenges. You must also be aware of all that surrounds the use of the cloud. Each of these technological elements brings new challenges.

**Edwards:** Love it or hate it, the cloud is here to stay. There has been some fear, I think, in the adoption of cloud techniques in the control system space and rightly so. We need to look at significant change in our systems design very carefully. As far as cybersecurity, you can get the best and the worst. In some ways cloud services let you bundle security services onto something in a very easy way, but like anything, if you don't configure your containers and the like correctly, you can introduce security issues very easily.

Here's an interesting story to prove the point. I saw a wide geographic SCADA application in which the user had moved their entire SCADA environment—front end servers, comms, etc.—into the cloud, which surprised me. Their rationale, which was very well thought out, was that the uptime of the cloud provider's infrastructure was guaranteed contractually to be much higher than what they could accomplish with their own infrastructure. By the time they looked at maintaining the communications and all the servers, the cloud implementation looked very attractive and has performed very well for them.

## Fog computing

Fog computing, also known as fog networking or fogging, is a decentralized computing infrastructure in which data, compute, storage, and applications are distributed in the most logical, efficient place between the data source and the cloud. Fog computing essentially extends cloud computing and services to the edge of the network, bringing the advantages and power of the cloud closer to where data is created and acted upon.

## How do you characterize new cybersecurity challenges created by fog computing, and do you have any advice for users?

**Kling:** Similar to cloud, fog brings a unique set of security challenges. Applications become virtualized, which makes them fluid. That means they can move east to west (device to device) and north (to cloud) or south (closer to the cyber/physical edge). As a result, security features must "follow" the application. For example, certificates that might traditionally be stored in hardware will have to find a way to become more fluid as virtualized applications move between platforms.

Fog bridges the gap between edge computing and cloud computing and comes with its own unique challenges. Your first step is to understand those challenges: It demands virtualization, and it is often required to be more performant to run IACS [industrial automation control system] solutions than traditional cloud technology.

Make sure that, as a bridging technology, your security solution does not fall to just the lowest common denominator between the layers but maintains a robust set of security features unique to large amounts of virtualization.

**Edwards:** Fog is essentially an "on-premise cloud infrastructure." If that is the case, then end users will have many of the same challenges they confront when enabling a cloud infrastructure.

## Edge computing

IoT is creating a flood of new technology and driving communication and computing to the edge of system architectures. The number of connected IoT devices worldwide will increase 12 percent on average annually, from nearly 27 billion in 2017 to 125 billion in 2030, according to new analysis from global information provider IHS Markit. This is particularly the case with smart sensors that have embedded processing and communication to controllers, enterprise, and cloud servers. These IoT devices are uniquely identifiable electronic devices using Internet "data plumbing," including Internet Protocol, Web services, and cloud computing.

An example of this trend is the Industry 4.0 for Process Automation initiative started by NAMUR. Industry 4.0 and IoT concepts are being applied to process automation to achieve a holistic integration of automation, business information, and manufacturing execution function to improve all aspects of production and commerce across company boundaries for greater efficiency.

### Does edge computing pose any unique new cybersecurity challenges, and do you have any advice for users?

**Kling:** With more powerful processors, embedded sensing technologies, increased abilities to communicate, lower power consumption, smaller footprints, and mobile applications, we can start to take an application that used to run on a server and run it where it makes the most sense. At the end of the day, what we are talking about is pushing control further toward the periphery of the plant, right down to the equipment asset level. With more connectivity and computing power, these smarter, connected assets, like pumps, for example, will be able to control, monitor, and secure themselves in real time. And if we take the next step, it is easy to imagine extending this level of real-time control upward to the enterprise. It will revolutionize how companies improve the profitability and performance of their operations and assets. But regardless of what it looks like, be it cloud, fog, or edge, a robust cybersecurity strategy will have to be in place, because, as we said, all this new connectivity broadens the attack surface. Every new connection has to be secured. This will be the challenge.

**Edwards:** The scale we are going to see with these deployments creates a massive asset-management problem. I mean, if today we can't even identify what devices are currently on our ICS networks, what will it be like when we have two orders of magnitude more devices? Seems like an opportunity for a robust "management of change" type system.

## Virtualization

In the traditional architecture of digital services, applications are tightly bound to the platform on the operating system (OS). Virtual machines began a revolution to loosen the tight binding between OS and platform. Containers are taking that one step further. Now services are becoming loosely bound to their guest OSs. This unbinding allows for an increase in computing fluidity. It becomes far easier to leverage cloud, fog, and edge computing platforms as the application can move easily between environments.

### Does virtualization pose any unique new cybersecurity challenges, and do you have any advice for users?

**Kling:** Virtualization means we can now use applications we no longer have to install and customize to fit their platforms. Applications, services, and microservices are preinstalled on a virtual machine. Essentially, they are their own platforms. Isolated from their neighbors, they inherently bring security improvements. Maintaining the VM [virtual machine] repositories securely and using them in a secure fashion by ensuring integrity is a somewhat new challenge. But with these new challenges comes an incredible amount of value.

Once we see network convergence, network virtualization, and application and service virtualization, paired with traditional IoT and sensors, we will witness automation solutions that carry a lighter physical footprint. You can take advantage of these virtual resources on premise or off premise. It is entirely conceivable to imagine a rack of virtualized computers replacing control, I/O processing, and other applications. Think of a rack of compute power tied to an array of edge-based sensors and actuators. But once again, you must execute your applications where it makes the most sense, i.e., where it drives the most value within your risk threshold. A new vision is coming, one that leverages value from virtualization. With it comes the challenges unique to the technology being used. For example, know and understand how network convergence places higher importance on confidentiality and integrity. Be ready for communication prioritization schemes to rise in importance to help ensure critical traffic is treated appropriately to maintain availability.

**Edwards:** Virtualization presents similar issues as the cloud, fog, and other advancements we have discussed. Something I really like about virtualization is the ability to separate the software from specific hardware dependencies. As an old DCS guy coming from "the software only works on this specific hardware version," that is a huge benefit, and gives end users enormous flexibility and redundancy. But yes: You need to be aware of new vulnerabilities that come with virtualization. My advice here would be don't mix security levels on the same VM hardware. You need a unique set of hardware for each security level.

## Analytics, machine learning, and artificial intelligence

The application of technology to improve and optimize production operations has been an ongoing industrial automation journey over the years. Cloud, fog, and edge computing and software developed for a wide range of IT, Internet, scientific, and business applications have become easier to use and more cost effective for industrial automation applications. This does, however, connect production processes directly to a broader number of networks and computers.

### Does the broad application of analytics, machine learning (ML), and artificial intelligence (AI) pose any unique new cybersecurity challenges, and do you have any advice for users?

**Kling:** Absolutely. In traditional DCS or discrete applications, the control algorithms have a precise understanding. Control engineers have been trained in these algorithms. Machine learning and artificial intelligence bring a new level of discerning patterns from data and offer new ways to improve the safety, efficiency, reliability, and even profitability of the operation and the business. But before a single operator decision is made, time must be taken to understand these new algorithms and to ensure the integrity of the data being fed into them, so they can explain their results. Only then can confidence be found.

From a security standpoint, as mentioned in the cloud discussion, the integrity of the data is paramount. The convergence of data availability via an increase in sensor technology, our ability to move that data, and now the compute resource made available to act upon that data have reached a point where ML/AI are viable. Securing the acquisition at the lowest levels and ensuring the integrity of that data is essential to using it securely.

**Edwards:** Access to powerful computing platforms is a big win for advanced control. The industry will continue to see unique optimization opportunities that we could only dream of before. Having that much data in one place for the algorithms to eat for breakfast, though? That could pose a challenge from an intellectual property perspective, so I think even these applications have to be thoughtful from a security perspective or you might get into trouble.

## Collaboration

Cybersecurity is big and getting bigger, and the level of complexity is rising. One way to overcome the complexity of securing disparate systems from multiple vendors is to join together and collaboratively share knowledge. This is one of the primary ways we as an industry can grow to be more effective.

**Kling:** Taking on new and increasingly dangerous cyberthreats can't be limited to a single company, industry, or region. That's why everyone associated with industrial manufacturing—suppliers, end users, third-party providers, integrators, standards bodies, and even government agencies—must come together. We need to collaboratively develop new ways of ensuring legacy and emerging technologies alike can withstand sophisticated cyberattacks.

On the whole, our industry is generally pretty conservative, but we have to change that culture when it comes to cybersecurity. The most effective way to do this is to encourage a collaborative, three-pronged approach that focuses on people, processes, and technology.

First, we have to work together to make sure everyone—everywhere—knows they are responsible for cybersecurity. This includes ensuring everyone is trained, with defined, clearly understood roles, responsibilities, and procedures to prevent, mitigate and, most importantly, respond to cyberattacks.

Second, we have to work together to establish best processes, practices, and policies, especially as it relates to performing regular risk and threat assessments and gap analyses. That approach is proven to identify holes in our systems and our overall security posture. Additionally, there is an opportunity for industry to work together to help end users contain, mitigate, and even prevent the spread of any virus and malware via network segmentation, the application of zones and conduits, and the establishment of other processes. This includes strengthening an industrywide commitment to adhering to best practices, especially a drive to remain compliant with prevailing, most-current industry standards, like IEC 62443.

Third, we need to find ways for suppliers to work together to strengthen their products with today's threats in mind. Keep in mind that end users are frequently using a mix of systems from various vendors and vintages. Can we collaborate and evolve our technology to help them address cybersecurity issues in their frequently complex operating environments? The answer is yes, but it requires a cultural shift and a strong commitment from industry leaders.

It really is time for industry as a whole to step up. By collaborating openly and transparently, we increase our collective ability to protect the world's most critical operations and the people and communities we all jointly serve. Let's get it done.

**Edwards:** This is an area that can really help advance cybersecurity. We are all in this together, and cybersecurity should not be a competitive differentiator between vendors. If we could truly come together as an industry and share the information about threats and attacks with each other in an open yet safe environment, then I think we could all advance our capabilities to defend against these things. This is sort of a hot button for me, coming from my ICS-CERT background. I am optimistic that we will follow some of the trends of other industries, such as the financial services industry, where this type of information sharing is very well accepted and functions with a very high level of success. ■

## Author's note

Thank you to Andy Kling and Marty Edwards for sharing their knowledge and thoughts on industrial cybersecurity. The International Society of Automation has a wide range of industrial cybersecurity training resources (see www.isa.org).

### ABOUT THE AUTHOR

**Bill Lydon** (blydon@isa.org) is *InTech*'s chief editor.

### ABOUT THE EXPERTS

**Andy Kling,** CSSLP, is industry automation product security officer and senior director of system architecture at Schneider Electric. He has more than thirty years of software development experience in multiple industries. Kling has ushered the company's process automation development organization to compliance with IEC 62443 standards at the process, product, and system levels. Kling is a participating senior member of ISA, primarily contributing to the ISA/IEC 62443 cybersecurity standards.

**Marty Edwards** (medwards@isa.org) is director of strategic initiatives at ISA and managing director of the Automation Federation. He was previously director of the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT), an operational division of the National Cybersecurity and Communications Integration Center.

View the online version at www.isa.org/intech/20190401.

**RESOURCE**

**"Number of Connected IoT Devices Will Surge"**

https://technology.ihs.com/596542/number-of-connected-iot-devices-will-surge-to-125-billion-by-2030-ihs-markit-says


# Empowering an effective PAT methodology

## Operationalizing advanced analytics for data-driven decision making

By Lisa Graham, PhD, PE

Leveraging process analytical technology (PAT) advancements helps companies derive value by combining data from process and analytical instruments with advanced analytics to:

- empower subject-matter experts (SMEs)
- augment process development and scale up
- optimize the globally connected system
- realize the potential of the Industrial Internet of Things (IIoT/Pharma 4.0)
- reduce manufacturing cycle time

The concept of PAT has grown into a broad field encompassing process analysis, chemical engineering, chemometrics, modeling, process automation and control, and knowledge and risk management. This approach is consistent with the FDA's document titled *Guidance for Industry PAT,* which is "written for a broad industry audience in different organizational units and scientific disciplines" and "discusses principles with the goal of highlighting opportunities and developing regulatory processes that *encourage innovation.*"

From an innovation perspective, a strong PAT methodology includes a plan for connection to disparate data sets, advanced analytics, and the culture change required to actively implement insights through improved workflows. This is important, because PAT should ultimately support data-driven decision making, which requires a firm grasp of measurements, data science, and analytics workflows—along with a plan for summarizing and disseminating the knowledge gained (figure 1). Further, the value of the outcome should demonstrate a return on investment whether the analyses are using an effective PAT methodology for diagnostic, predictive, monitoring, prescriptive, or descriptive views (figure 2).

**FAST FORWARD**

- Reasons to implement PAT include reduced cost, improved reliability, and better quality.
- Leading challenges are changing company culture and accessing and analyzing data.
- Two case studies show the results of applying advanced analytics to PAT projects.

In this article, case studies will illustrate an effective use of a PAT methodology for optimizing the facility operations and active pharmaceutical manufacturing processes required to produce quality medicines for patients. But first, let's look at why PAT is important for improving pharmaceutical manufacturing processes.

## Background: Why PAT?

The demand for new therapies, loss of revenue from biosimilar and generic competition, and the rapid growth of emerging markets are forcing manufacturers to be more productive. To meet these challenges, pharmaceutical companies must capture process parameters and real-time measurements of critical quality attributes using analytical techniques and data analysis/modeling techniques, often referred to as PAT. A robust PAT methodology is essential to achieve:

- cost effectiveness:
  - —increase system automation and control
  - —reduce or eliminate production of waste
  - —enable the use of alternative or less expensive raw materials
  - —reduce production cycle times
  - —reduce energy use
  - —support a semi- to fully continuous processing approach
- reliability:
  - —achieve target quality consistently
  - —prevent rejection of batches
  - —reduce time from manufacture to product release
  - —demonstrate confidence in product quality
- productive system performance:
  - —simplify and shorten development cycles through increased process understanding
  - —enable extended automation capability
  - —achieve greater throughput with minimal additional time or resources
  - —incorporate real-time release to reduce or eliminate many testing requirements

PAT can help achieve these goals through process analysis, including the application of field-deployable instrumentation and chemometrics to monitor chemical or physical attributes, and the detection of events that cannot be derived from conventional physical measurements like temperature or pressure. Process analytical instrumentation can be organized into many categories: (1) physical property analyzers measuring attributes like viscosity, refractive index, and thermal conductivity, (2) combustion analyzers, (3) electrochemical analyzers measuring voltage or current that correlates with concentration, and (4) spectrophotometers that measure an attribute via electromagnetic interactions.

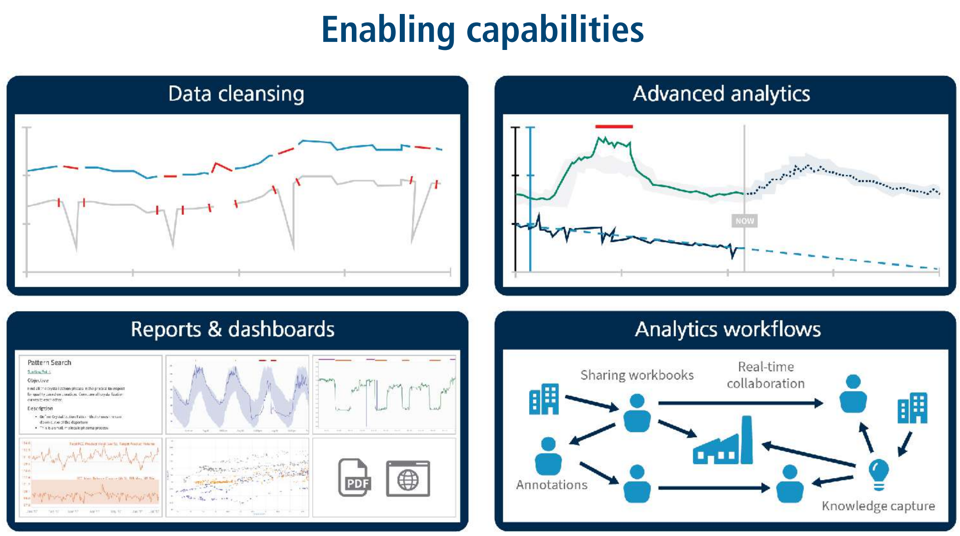



Figure 1. Major elements of an effective PAT methodology include data cleansing, advanced analytics, reports and dashboards, and analytics workflows.

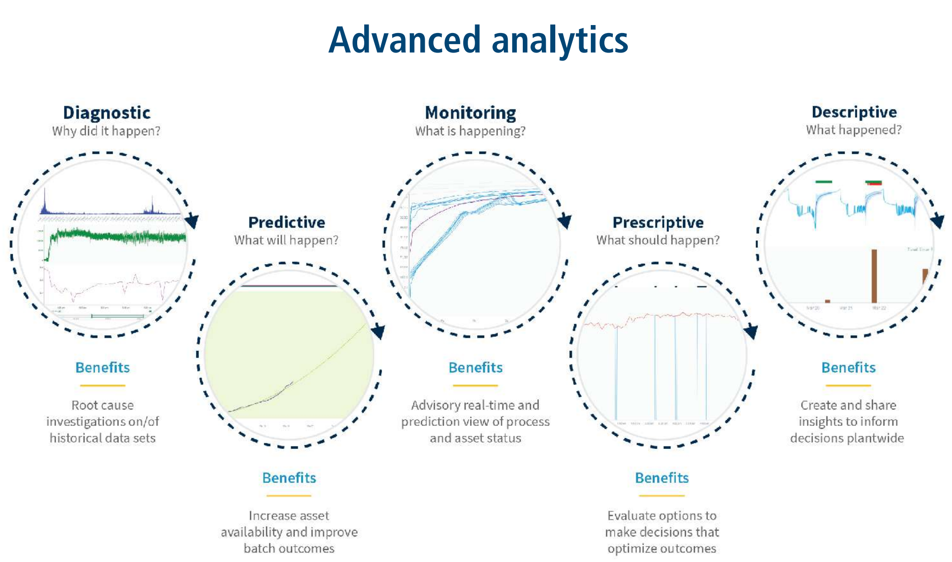



Figure 2. An effective PAT methodology can be used to provide diagnostic, predictive, monitoring, prescriptive, and descriptive benefits.

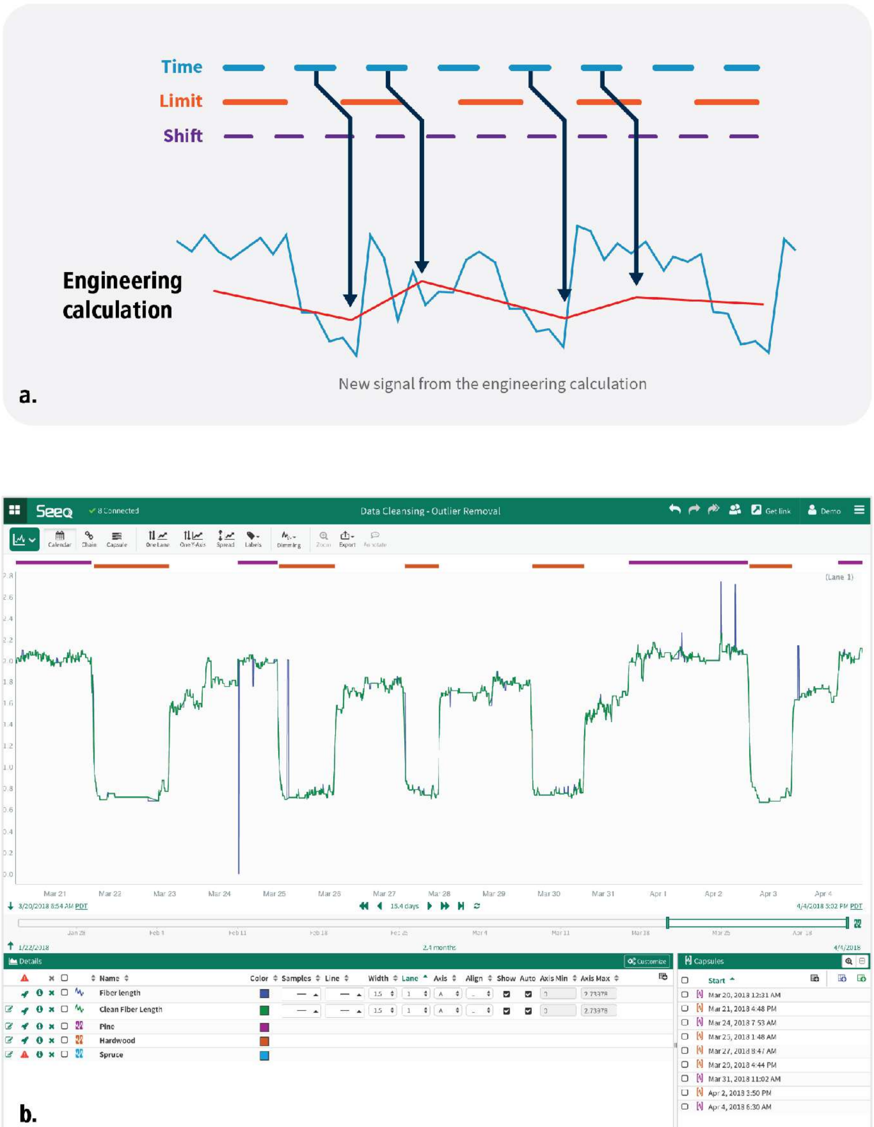



Figure 3. Use capsules to easily identify periods of interest during a run, from which predictive models can be quickly developed. (a) Overview of using capsule logic to isolate specific conditions (e.g., by time, limit, pattern) to create combined conditions, and (b) Seeq helps identify only the periods of time where the process analytical instrument is functioning properly, and the process is in the proper mode of operation.

Examples of using spectroscopic technologies for determining material characteristics *in situ* for traditional pharmaceutical processing include the determination of drug content uniformity during powder blending and tablet manufacture, and drug-layering during pellet coating. Active pharmaceutical ingredient manufacture in reactors and cell growth/protein expression in bioreactors use *in situ* methods like focused-beam reflectance and dielectric spectroscopy, respectively, to monitor product attributes in real time.

Another example of innovation in process analytical instrumentation and methodology is the recent implementation of a mass spectrometry-based approach to simultaneously monitor the extensive array of product quality attributes present with therapeutic molecules. This approach has successfully enabled the real-time monitoring of bioreactors and quality control release, and it has the potential to replace several conventional electrophoretic and chromatographic methods currently used to release therapeutic molecules. The development of this new method is a prime example of proactively reevaluating the desired data source, and then transitioning away from using earlier PAT measurements that are less directly connected to the protein attributes.

Deploying these and other types of process analytical instrumentation to gather data is the first step. The second is using advanced analytics software to derive insights and improve operations. This data analytics component of a strong PAT methodology consists of empirical, multivariate, and first-principles modeling techniques, including mechanistic modeling, chemometrics, and statistics packages.

## Challenges: Data access, ease of analysis and company culture

Although not always accurate, historical data can often bring insight into the future performance of a process. In development, for example, identifying which unit operations are robust and which are not, along with the effect on quality metrics, is key for defining the required work to shorten the scale-up process while ensuring a quality-by-design approach ready for filing.

For example, the relationships of the process inputs to the respective critical quality attributes must be determined to define the design space of a process. General challenges in using PAT effectively include:

- Access to all the relevant data: Data connectivity continues to be a tremendous source of frustration for getting the most value out of PAT. For example, an important aspect of PAT is its role in supporting an effective quality-by-design approach for therapeutic molecule manufacturing, which requires a deep, molecular-level understanding of the attributes crucial to the safety and efficacy of the medicine. Quite often, these datasets are either maintained off-line or trapped in a process data historian. In either case, it takes extra effort, often in the form of spreadsheet gymnastics, to bring the datasets together and make them available to the engineer or scientist performing the data analysis. Applications that connect to and present data from a multitude of disparate data sources, including process historians, should be a core element of the PAT implementation strategy.

- Ease of data analytics and visualization: The ability to view data from both the process instrumentation and the process analytical instrumentation together in one place during select times of operation is crucial for performing investigations and monitoring, and for developing accurate models. Analytics techniques, including multivariate- and first-principles-based modeling, only work well when the PAT methodology provides:
  - —a centralized, single location to overlay multiple experiments or multiple conditions from within an experiment
  - —automated file transfer from off-line instruments to eliminate cutting and pasting various data files into spreadsheets
  - —handling samples from different time intervals, including analysis when a sample may have been missed or skipped
  - —easy batch definition with the ability to search by key metadata about the experiments
  - —automated templates to apply standard data views and calculations for quick routine analysis, tied in with report generation

Figure 3 illustrates how engineers can selectively query data to identify stages of operation. For example, when an analytical instrument is being tested or recalibrated, the data signal no longer represents the actual process. To develop a robust model, the engineer should be able to exclude these periods of bad signals from the analysis. Further, the best data analytics application can support the engineer in developing a model to predict what the values should have been if the sensor had been operating properly.

- Ensuring a dynamic culture that is ready to embrace change: Realizing the full potential of the PAT methodology often requires a fundamental change in company mindset from the top down and the bottom up. This is especially true in groups that have not already implemented agile data collection and an analysis methodology in their manufacturing process. In these cases, the group needs to review workflows to understand the existing obstacles for collecting and accessing the right data, and then use the right data analytic software. This software must be able to perform the required analysis and be implemented so subject-matter experts can use it, as opposed to only data scientists. A successful PAT methodology is evidenced by a system that the full organization can use (figure 4), but this often requires the adoption of new workflows.

## Leveraging PAT throughout an organization to enable continuous improvement

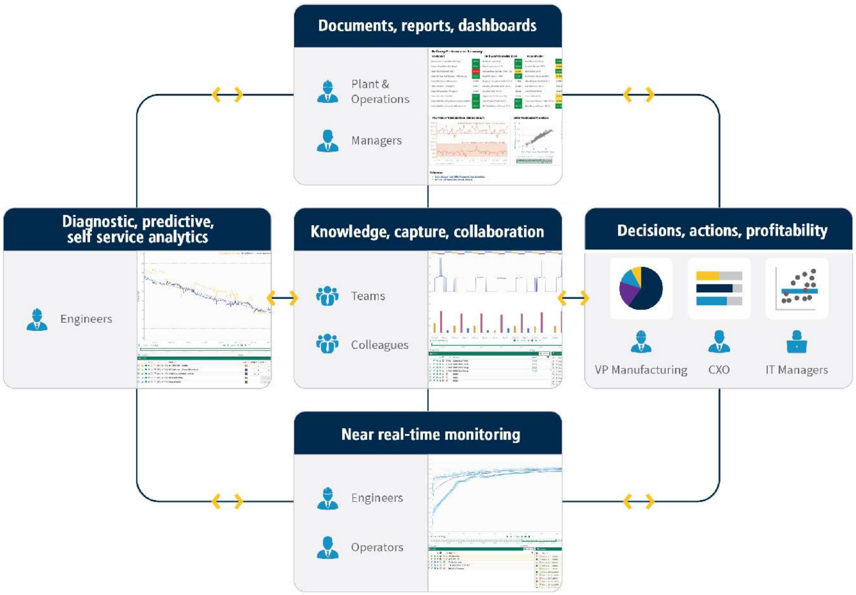



Figure 4. Leveraging an effective PAT methodology for continuous improvement benefits SMEs and the entire organization.

### Advanced analytics in action

For robust, quality products, facilities operations and product manufacturing processes must both run smoothly. On the facilities operations side, examples of unit operations include water purification, filtration, heating, and cooling. On the product manufacturing side, examples of pharmaceutical unit operations include:

- crystallization in reactors and protein expression in bioreactors
- filtration and purification (e.g., chromatography)
- lyophilization
- feeding and blending
- granulation
- tableting
- tablet coating

Both areas are subject to the inherent challenge of enabling engineers to apply their domain expertise to optimize the operation of equipment such as pumps, valves, compressors, and heat exchangers.

The following case studies illustrate the effective implementation of a complete PAT methodology. These case studies showcase both the facility operations and active pharmaceutical manufacturing processes required to produce quality products. For each case study, the PAT methodology being followed employs the following aspects:

- Proactive data type selection: Installing instrumentation to deliver the required data

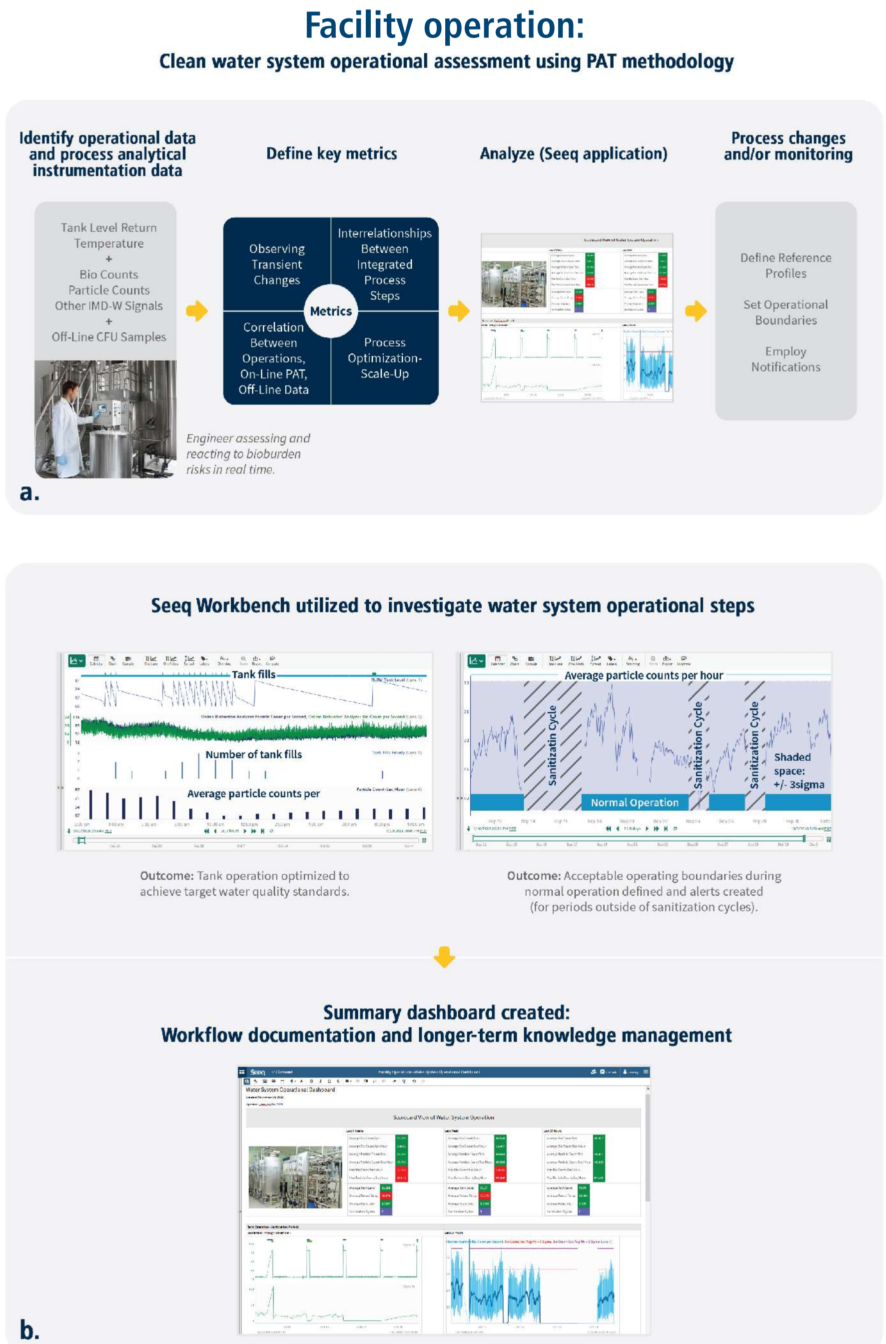



Figure 5. Water system operation case study showing (a) an overview of how the PAT methodology is applied to a facility's water system operation and (b) key outputs from an analysis illustrating an optimized water system, including the use of Seeq Workbench for analysis and Organizer Topics to summarize and share learnings with the broader organization.

- Connecting disparate data sources: Encompassing all relevant information, including process operations data and process analytical instrument data
- Investigation: Having the full range of data signals available for each process, batch, or asset readily available to:
  —cleanse data
  —add and remove datasets of interest
  —define periods of interest using capsule logic
  —perform profile searches to teach and find similar performance
- Advanced analytics to analyze and develop models: Using built-in and user-friendly tools for initial calculations and immediate application to new batches
- Construction of a full process train view: Comparing multiple different unit operations side by side to understand the effect of upstream changes on downstream operations
- Workflow documentation: Using journaling, annotation, and lab notebook functionalities to capture critical steps in the workflow
- Knowledge management: Communicating key results in a report containing a dashboard of current or previous batches or runs.

## Case study A: Robust facilities operation

When operating a pharmaceutical-grade water system, it is imperative to have a direct line of sight to the current data and the historic trends. This requires continuous availability of process operations data and real-time particle and biologic counts. Benefits of using a well-defined PAT methodology in this case study include:

- enhanced quality assurance
- improved risk management
- energy savings
- reduced resource and labor requirements
- extended facility and equipment life

In this example, an online water bioburden analyzer was the primary process analytical instrument. This online and real-time technology simultaneously detected particles and determined biologic counts without requiring staining or reagents, or export of the data for upload into a process data historian.

With connection to all relevant data established, the organization performed analysis using advanced analytics software to quickly identify time periods outside sanitization cycles and tank filling cycles to assess the impact on bioburden and particle counts (figure 5). From these observations, statistical models were built, and 3 Sigma boundaries created to represent a robust operating space. To share the results, the organization documented workflows in Seeq Journal and created a dashboard in an Organizer Topic.

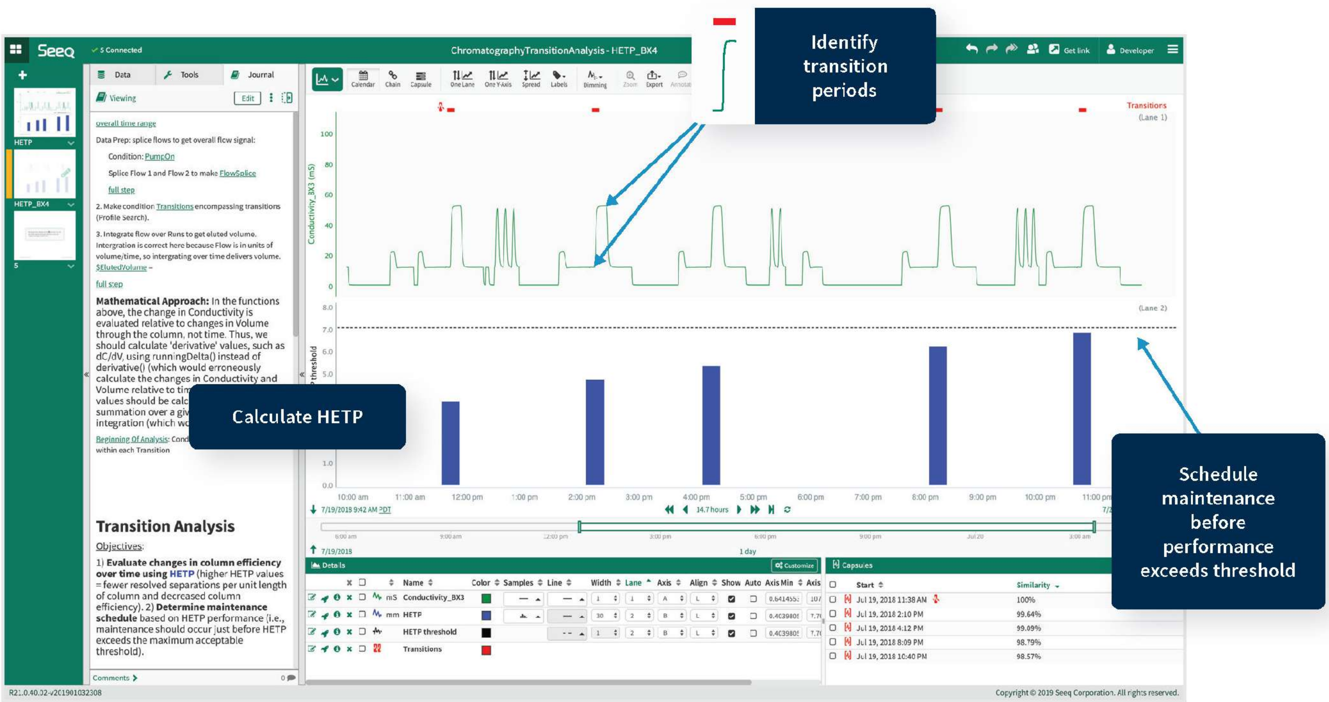



Figure 6. Pharmaceutical process example illustrating how a PAT methodology can be applied in production-scale chromatography to track column efficiency degradation using Workbench and Journal.

## Case study B: Column maintenance in production-scale chromatography

A PAT methodology can be applied in production-scale chromatography to track column efficiency degradation using, for example, transition analysis and the calculated height equivalent to the theoretical plate (HETP), so engineers can optimize column maintenance. This example shows conductivity and volume signals spanning a variety of production, downtime, regeneration, and transition analysis periods (figure 6).

First, the organization uses Seeq's Profile Search tool to identify all of the transition analysis periods, enabling calculation of the HETP during each transition. The HETP increases, indicating fewer resolved separations per unit column length (i.e., lower efficiency), with total volume through the column, as might be expected. This calculation is refreshed as the connected data sources are updated, allowing engineers to continuously monitor column efficiency and schedule maintenance before the HETP exceeds the desired threshold, which would decrease product purity.

Similar analyses could be used to optimize flow rates and eluent composition, increasing productivity and reducing maintenance costs. Further, this information can be captured as part of a continuous improvement process through workflow documentation in Journals and Organizer Topics.

## Recipe for success

In a world currently trapped in unfocused data collection and time-consuming, complicated, nontransferable spreadsheets, there is a path forward. Data in and of itself is not useful unless one has an approach to derive insights from it. Fortunately, there is a recipe for success.

The keys are implementing an advanced analytics solution where the datasets are gathered strategically with an end use in mind upfront, and then providing a way for these datasets to be easily accessed and analyzed within a user-friendly interface. With this approach in hand, organizations can more fully realize the knowledge management practices essential to achieving business value within a PAT framework. ■

### ABOUT THE AUTHOR

**Lisa Graham, PhD, PE** (lisa.graham@seeq.com), leads the analytics engineering team at Seeq Corporation. Her PhD is in chemical engineering, and she has 20 years of experience across many industries—including pharmaceuticals and life sciences and specialty chemicals. Graham was previously COO and SVP at Bend Research (now Lonza) and Alkemy Innovation, which she founded. Graham was director of the Oregon governor's STEM Investment Council and chair of the Oregon Board of Trustees for Oregon Tech University.

View the online version at www.isa.org/intech/20190402.

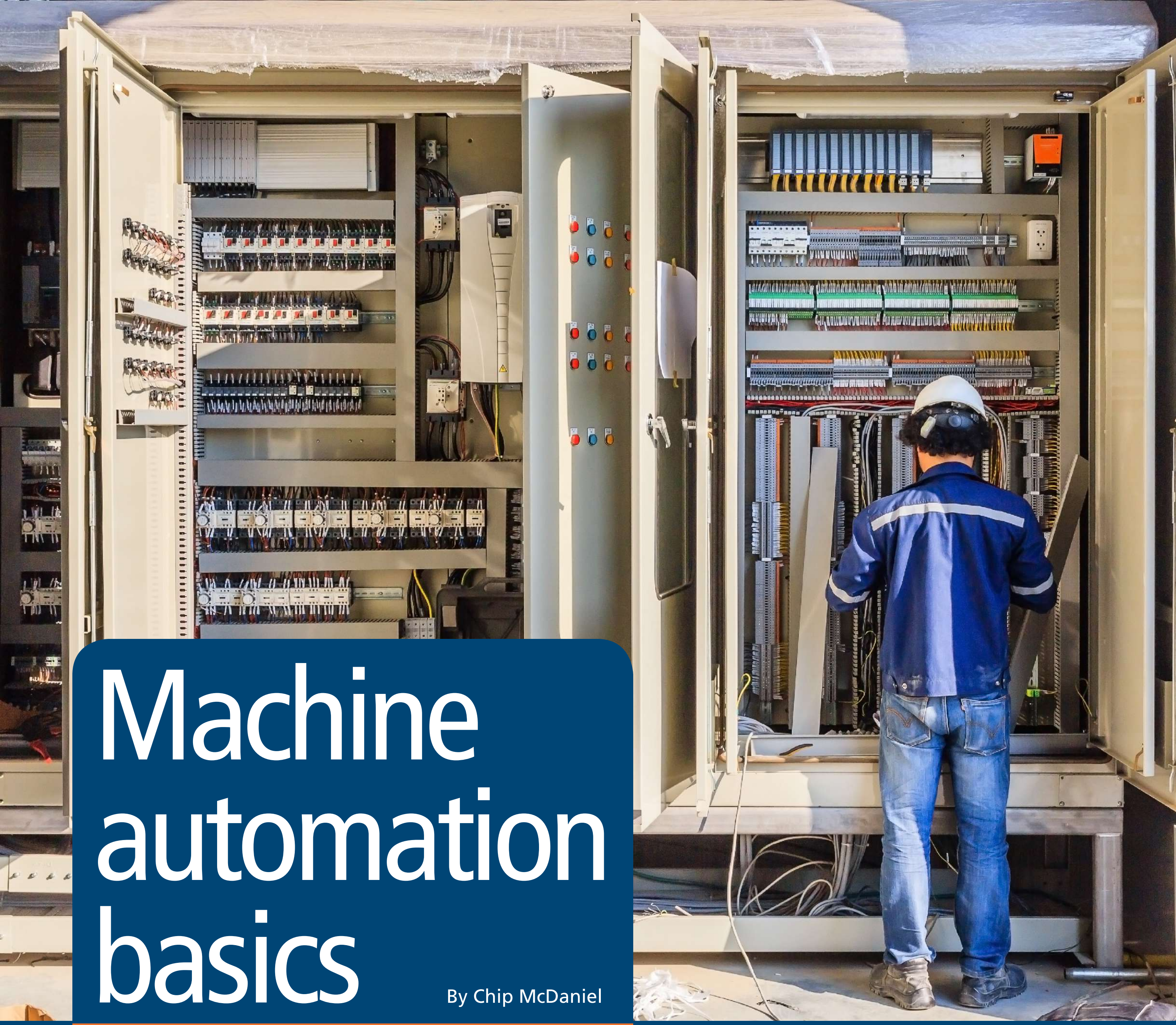
### RESOURCES

**"It's the right time for PAT"**
www.isa.org/its-the-right-time-for-pat

**"What's next for big data in process manufacturing"**
www.isa.org/intech/20180601

**"Big data analytics need new solutions"**
www.isa.org/intech/20170204

***Guidance for Industry PAT — A Framework for Innovative Pharmaceutical Development, Manufacturing, and Quality Assurance***
www.fda.gov/downloads/drugs/guidances/ucm070305.pdf



# Machine automation basics

By Chip McDaniel

## Systems must integrate multiple power and control subsystems and components into a coherent whole

Faced with ever-increasing cost pressures and demands for improved performance, machine builders are actively seeking new automation solutions with improved cost/performance ratios. In response to these demands, vendors must often incorporate commercial off-the-shelf components and other technologies to deliver more performance at lower costs in smaller form factors.

This article shows how machine builders and vendors can work together to deliver the automation systems demanded, and how to successfully integrate the multiple power and control subsystems and components.

**FAST FORWARD**
- Power needs to be distributed to a machine's motors, drives, controllers, and other components.
- The machine's safety system must remove motion-causing energy when called upon, including both electrical and fluid power.
- It is a good practice to have multiple Ethernet and serial ports available to integrate to a variety of equipment, computers, HMIs, and business and enterprise systems.

## Components and subsystems

A machine's automation system primarily consists of power and control components. For a smaller machine, these may be housed in one panel (figure 1); whereas larger machines may require multiple panels, often one for control and another for power. The main subsystems and components of a machine automation system are:

- power distribution
- motor control and drives
- safety system
- programmable controllers
- discrete and analog I/O
- communication systems
- human-machine interface (HMI)

The power distribution subsystem feeds power to components, such as motors, drives, and controllers. The control subsystem primarily consists of safety systems, programmable controllers, discrete and analog I/O, communication systems, and HMIs. Let's look at each of these areas in more detail.

## Power distribution

The National Electric Code (NEC, also NFPA 70) has much to say about using electricity properly to safeguard persons and property. The code comes into play well before the power source connects to the machine control enclosure through a plug, disconnect, or terminal block. At the machine, the NFPA 79: *Electrical Standard for Industrial Machinery* is the benchmark for industrial machine safety related to fire and electrical hazards. Some of the major requirements in machine control power distribution discussed in these standards include using proper disconnect means, protecting personnel from contact with electrical hazards, and protecting equipment from overcurrent and overloads.

The disconnect—whether a switch, circuit breaker, or cord with a plug—must be provided for any control enclosure fed with voltages of 50 VAC or more. It should be properly sized, positioned, wired, labeled, and, in some cases, interlocked to the enclosure door.

Protecting personnel from contact with electrical hazards is always needed, both inside and outside a machine power or control panel. All conductors must be protected from contact by personnel. Most power distribution devices are designed to facilitate this level of protection, but live components, such as power buses, distribution blocks, and other power terminals, should be covered with a nonconductive, see-through cover.

Protecting equipment from overcurrent is critical to reduce the chance of fire. Conductors and electrical components must be protected from overcurrent related to short circuits. Overcurrent protection devices, such as fuses and circuit breakers, must be sized based on conductor current-carrying capacity, device interrupt rating, maximum fault current, system voltage, load characteristics, and other factors.

For power circuits, branch-circuit-rated devices must be used to meet current-limiting and ground fault protection requirements. Supplemental overcurrent protective devices are not suitable for use in these circuits but work well in downstream control circuits tapped from the load side of the branch circuit.

## Motor control and drives

Motors have special needs in machine control. For every motor, a proper form of electrical control is required, from simple on/off to more complex variable speed applications. Motor control devices include manual motor starters, motor contactors and starters with overloads (figure 2), drives, and soft starters.

A motor circuit must include both overcurrent (short circuit) and overload protection. This typically consists of branch-circuit protection, such as properly rated fuses, and a motor starter with overload protection devices, such as thermal overloads, but additional protection may be needed.

Additional protection to consider for machine control components includes loss of cooling and abnormal temperatures. Ground fault protection is also needed, so a proper ground connection is important. Over, under, and loss of voltage must also be considered. Protection from lightning, overspeed, and loss of a voltage phase in three-phase supplies are additional considerations for proper machine control.

Some motor controllers, such as drives and combination controllers, are self-protected. If this is the case, the device's rating or manufacturer's instructions will clearly note it is suitable for output conductor protection.

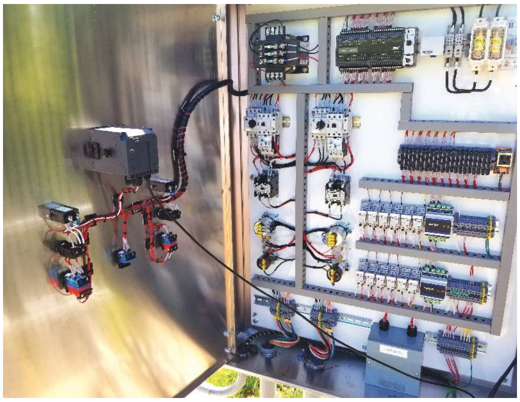


Figure 1. For smaller machines, a single panel is often used to house both the power distribution system and the control components.

Figure 2. These Fuji manual motor starters and contactors from AutomationDirect have high switching capacity and integrate the functions of a molded case circuit breaker and a thermal overload relay.

## Safety system

A risk assessment drives the safety system design as needed to remove motion-causing energy, including electrical and fluid power, to safely stop the equipment for protection of both personnel and machines. Many safety standards come into play for proper machine control at both a mechanical and electrical level. Proper mechanical machine guarding and access points, as well as elimination of identified hazards, is a starting point. Safety relays or safety-rated controllers must be used to monitor safety switches, safety limit switches, light curtains, and safety mats and edges.

In small machine control applications, a safety relay is probably the simplest way to integrate safety functionality for emergency stop, monitoring a guard door, or protecting an operator reaching through a light curtain. In more advanced machines, safety-rated controllers provide the same functions, but can simplify the integration of multiple safety devices. Safety-rated controllers reduce hard-wired safety logic by providing a platform to program the safety functions needed for proper and safe machine control.

## Programmable controllers and I/O

Available in form factors from small to large, the machine controller can be a programmable logic controller (PLC), a programmable automation controller (PAC), or a PC. The complexity of the machine control application, end-user specifications, and personal preference drive controller selection. Many vendors have families of controllers to cover a range of applications from simple to complex, allowing a machine builder to standardize to some extent. Often three or more physical configurations—small, medium, and large form factors—are available from the controller manufacturer.

Using the same software platform to program a family of controllers is becoming the norm. This allows the designer to first program the system, and then select the right controller based on its capacity to handle the number of I/O points needed, as well as special functions such as proportional, integral, derivative control and data handling. Required capabilities like extensive communications and high-speed control should be carefully evaluated, as these are often the main factors driving controller selection.

Discrete and analog inputs and outputs connect the controller to the machine sensors and actuators. These signals can originate in the main control panel through a terminal strip with wiring to field devices, but a distributed I/O architecture is often a better solution. Distributed I/O reduces wiring by moving the input or output point closer to the field device, and by multiplexing multiple I/O signals over a single cable running from the remote I/O component to the control panel.

For distributed I/O at a smaller scale, IO-Link is a point-to-point serial communication protocol where an IO-Link-enabled device connects to an IO-Link master module. This protocol communicates data from a sensor or actuator directly to a machine controller. It adds more context to the discrete or analog data by delivering diagnostics and detailed device status to the controller.

## Communication systems

Another important part of machine control now and for the future is extensive communication capability. It is a good practice to have multiple Ethernet and serial ports available to integrate to a variety of equipment, computers, HMIs, and business and enterprise systems (figure 3).

Multiple high-speed Ethernet ports ensure responsive HMI communication, as well as peer-to-peer and business system networking. Support of industrial Ethernet protocols, including EtherNet/IP and Modbus TCP/IP, is also important for scanner/client and adapter/server connections. These Ethernet connections enable outgoing email, webserver, and remote access communication functions—all important options for machine control.

Machine control often benefits from the availability of legacy communication methods, such as serial RS-232 and RS-485. Modern controllers often also include USB and MicroSD communication and storage options.

A big part of machine control communication is cybersecurity. Consider a layered defense where protection includes remote functions that are only enabled as part of the hardware configuration. For further protection, all tags should be protected from remote access unless the tag is individually enabled for that purpose.

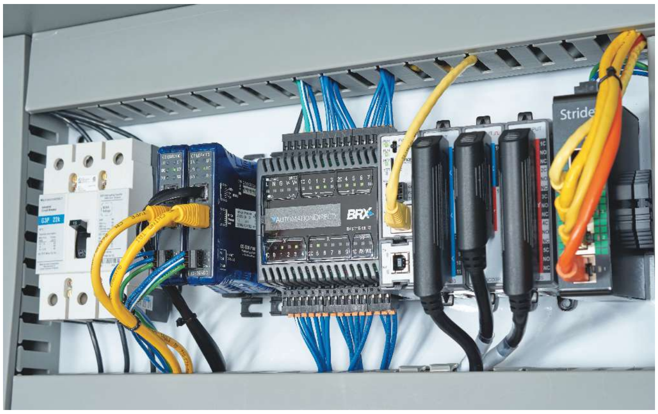



Figure 3. In addition to the multiple communication ports on this BRX controller, additional ports are added using a STRIDE Industrial Ethernet switch and a GS drive serial-to-Ethernet adapter.

## Human-machine interface

The HMI shows vital information about machine conditions using graphical and textual views. HMIs can be in the form of touch panels, text panels, message displays, or industrial monitors. They are used for monitoring, control, status reporting, and many other functions.

The purpose of the HMI must be clearly defined. Some machines may only need a fault message display with few control functions. Other machines may demand a detailed view of machine status, access to system parameters, and recipe functionality. Clearly defining the need of the machine will help determine HMI size and capabilities, and this should be done early in the design process.

HMIs can also act as data hubs by connecting to multiple networked devices. In some machine control applications, multiple protocols may be used, and often HMIs can be used for protocol conversion. This functionality can be used to exchange data, such as status and set points, among different controllers and other smart devices.

Some HMIs can also send data to the cloud or enable remote access functionality through the Internet, given proper user name and password authentication.

**RESOURCES**

**"Start with risk assessment to enhance safety"**
www.isa.org/intech/20181003

**"Explaining AC drives"**
www.isa.org/intech/201806basics

**"Remote access to automation system components"**
www.isa.org/intech/20180205

## Work together

Machine automation systems consist of multiple subsystems and components to provide the required power distribution, safety, and real-time control. Each of these subsystems and components must work together, and many are often networked to each other via either hardwiring, or increasingly via digital communication links. Careful design, selection, integration, and testing will ensure the automation system performs as required, both initially and throughout the life cycle of the machine. ■

**ABOUT THE AUTHOR**

**Chip McDaniel** (mcdaniel@automationdirect.com) works in technical marketing for AutomationDirect and is a graduate of Georgia Tech. His 33 years of experience in the industrial automation field include designing, building, and commissioning multi-axis servo systems, as well as marketing a wide range of automation products.

View the online version at www.isa.org/intech/20190403.

# Striking a balance for plantwide wireless

## Advantage of two industrial wireless technologies; one for operations and one for infrastructure

By Shuji Yamamoto

Real life has a way of demonstrating that it is relatively rare to find a case where the phrase "one size fits all" truly applies. Many times, this assertion can be translated as "one size imposes compromises on all," and so it is with industrial wireless networking. Several options are available, and engineers scrutinize the right combination of installed cost, connectivity, and power consumption to select the winner. However, in many cases choosing two winners may be the best answer.

**FAST FORWARD**
- ISA100 Wireless is already established for critical process automation operations.
- IIoT sensors are often numerous and widely distributed but have low required polling rates and are typically used for noncritical maintenance and environmental sensing.
- LPWA, specifically the LoRaWAN protocol, is a low-cost wireless technology suited for connecting to many IIoT devices over a wide area, powered only by long-life batteries.

A primary reason for moving to wireless sensors is to minimize installation cost, because home-run conduit and wire are removed from the equation. But even among wireless options, there are sustaining cost considerations, such as how often batteries need to be replaced.

Some industrial wireless standards, such as ISA100 Wireless, are already established wireless local area networks in many process plants for critical operations like monitoring and control of equipment, or even safety-related automation. This type of industrial wireless must have extremely high reliability and operate in a close to real-time manner for process control and safety applications.

By comparison, the use of Internet of Things (IoT) and Industrial IoT (IIoT) devices throughout facilities is quickly expanding for monitoring and even controlling noncritical infrastructure relating to maintenance and environmental management. For these types of applications, there are many reasons to select a protocol within a networking class known as low-power, wide-area (LPWA) networking. A prominent protocol in this area is LoRaWAN.

Implementing LPWA for IIoT devices in conjunction with a protocol like ISA100 Wireless for process devices lets end users strike an optimal balance between price and performance to achieve advanced, efficient, and safe plant operations. This article examines why LPWA is a compelling choice within a sitewide wireless network architecture for implementing IIoT devices.

## Operations and infrastructure overlaps and gaps

When designing or expanding sitewide wireless network architectures, users must categorize the desired service for various field devices. Typical plant or factory wireless needs can be roughly divided into one of four types: safety, operation, maintenance, and environment (figure 1). The first two are considered operational, while the last two are infrastructure related.

Safety is usually considered the most critical application, followed closely by operation. Maintenance and environmental monitoring are most likely somewhat less critical, but important, nonetheless. With this in mind, wireless networking technologies should be selected based on these roles.

To do this, it is helpful to review some specific requirements for operational networks in comparison with infrastructure networks. Weighing these requirements drives the network technology selection, since sometimes the choices are gray rather than black or white. For instance, some characteristics such as "reliability" are always desirable. However, high reliability may be crucial in some applications, while lesser reliability may be acceptable in others.

Operational networks, such as ISA100 Wireless, must directly operate process devices and safety systems. Therefore, these networks are expected to deliver:

- real-time monitoring and command with less than 1-second response
- high reliability of communication infrastructure
- high integrity of data transmission
- excellent security
- medium-range communication
- flexible topologies (redundancy, backbone, mesh, star)
- coexistence with wired systems
- robustness within typical industrial environments

Infrastructure LPWA networks, on the other hand, typically monitor equipment and the environment. Therefore, these networks are expected to have:

- wide-area coverage, kilometers or tens of kilometers
- ultra-multipoint connections, up to 1,000 or even 10,000 points
- variable communication cycles ranging from 60 seconds to 60 minutes to three days
- easy physical installation to minimize field costs
- a possibility for data sharing by multiple top-level systems
- a focus on long-term data as opposed to instantaneous values
- suitability for use in multiple operating conditions
- relatively low cost per point

Based on the listed criteria, almost any conceivable field device can be logically categorized. Setting aside cost and technical details, a significant deciding issue is the poll time required for a signal.

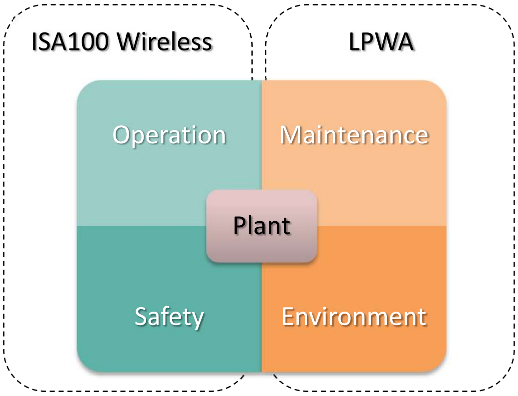



Figure 1. Typical plant wireless categories: Process plants usually have safety, operational, maintenance, and environmental networking needs. The first two are best served by an operational network like ISA100 Wireless, while the last two find a better fit with LPWA networking.

Operational devices are associated with immediacy and quick action, while infrastructure devices are often trended over a much longer time base.

A closer look at wireless networking technologies reveals why different types are best suited for certain roles.

## Power struggle

One consistent and common-sense bottom line when evaluating wireless technologies is the trade-off between power consumption and range (figure 2). Common consumer Wi-Fi is a large power consumer with relatively short range, although it delivers massive bandwidth. Low-power networks like Zigbee are finding a place in home automation scenarios, but their extremely low range limits them to personal area network applications. Industrial wireless networking such as ISA100 Wireless occupies a balanced region somewhere in the middle.

This leaves LPWA residing by itself in the low-power, wide-area position indicated by its name. For IIoT implementations, this is the sweet spot for two main reasons. The first is that low-power enables IIoT devices to be operated with just batteries, only needing replacement after years of service. No additional local power conduit and wire, or a local power source such as solar cells, are required, making these devices very convenient for hard-to-reach locations. The power constraint is not about saving power strictly for consumption costs, it is instead about enabling the device to be installed as a truly wireless physical island requiring minimal maintenance.

The second reason is that IIoT devices tend to be widely scattered around a site, so long-range communications are necessary. This also means it is far easier to add future sensors as funding allows without requiring additional components.

At the end of the day, power consumption, range, and the resulting available bandwidth determine where an industrial wireless network technology fits best.

Conventional industrial wireless network efforts were originally focused around supporting the operational type of applications, mostly due to the available underlying technologies at the time. To achieve sufficient performance that results in responsive control (action time less than about 1 second), the design of operational wireless networks is necessarily more heavily engineered up front.

Sometimes this involves specifying redundancy options. In cases where operational wireless networks are used in conjunction with classically wired systems, a well-engineered system will handle the two similarly, although of course they would be distinguishable.

There are ways to leverage operational wireless networking to monitor infrastructure-type signals, but the end user would be overpaying for hardware and design efforts every step of the way. Instead, it makes more sense to select a networking technology targeted for infrastructure applications.

## Focused on infrastructure

Contemporary LPWA networks have become available as the core technologies have improved, often based on consumer electronics breakthroughs. Advances in reduced power consumption (such as with handheld devices and consumer Bluetooth wireless) and maximized wireless network bandwidth have translated into similar benefits for industrial applications.

LPWA implementations, such as LoRaWAN, have now reached a practical level where they can be used to integrate thousands of sensors at a site. Additionally, LPWA is extensible beyond an on-premises solution to connect over the cloud, which effectively makes the transmission distance unlimited as long as Internet access is available.

It is worth noting that 3G/4G/5G mobile networking systems are a form of LPWA but are not considered here for industrial networking use due to relatively high service provider costs. This is because they are more aligned as the backbone of commercial communication networks at this time, as opposed to being considered workable for general wireless sensor networks. Also, end users would likely be concerned about building their sensor networks on systems that make them beholden to outside network providers.

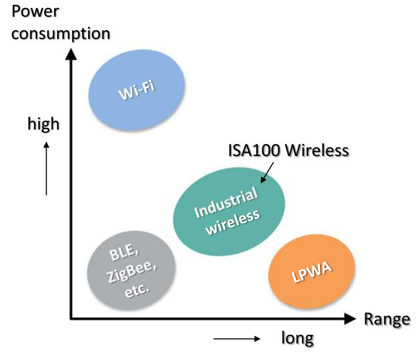



Figure 2. Wireless balancing act: When comparing power consumption against communication range, it is easy to see why LPWA networking occupies the sweet spot for IIoT implementations.

For these reasons, LPWA networks and small field devices are an excellent fit for infrastructure monitoring applications. They can easily be used to retrofit existing equipment with instrumentation to support preventive maintenance efforts, and they can minimize personnel exposure by being installed in areas that formally required operator rounds.

The data delivered by IIoT devices in a LoRaWAN system can be used by analytical applications in parallel with operational systems, or it can be cross-connected to operations (figure 3). Many times, IIoT data

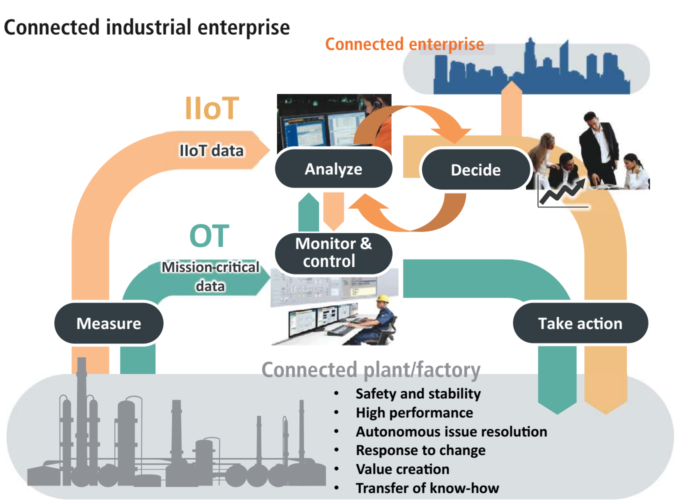



Figure 3. Benefits of wireless: Industrial wireless technologies, whether for operations or IIoT infrastructure, should be used where they fit best to sense conditions, initiate controls, and empower decision making.

is processed offline and separately from live operational data, such as to determine when rotating equipment is experiencing increased temperatures or vibration and should undergo preventive maintenance.

When engineers have gained confidence in the IIoT platform, they may choose to use the information to proactively modify active control strategies. This overarching concept of using all available data to produce optimal actions is the ultimate goal of any completely connected industrial enterprise. Next, let's look at a typical application.

## Applying small sensors

IIoT sensors for infrastructure are generally small sensors, easily installed even in remote or difficult physical locations. This allows extremely granular installations, providing condition-based sensing exactly where needed, as opposed to a wired installation where it is more important to centralize devices to minimize the wired infrastructure installation effort.

This granular nature also makes wireless infrastructure monitoring systems very scalable. Users can initially install sensors anywhere to meet immediate needs, and then add more sensors later as funding allows or where experience proves valuable.

Figure 4 depicts a basic IIoT installation and integration. Numerous IIoT field devices are installed as needed in the field and report over a LoRaWAN system to a plug-and-play gateway. This gateway in turn transmits the field data up to an on-premises or cloud-based system, where the data becomes available to any higher-level host or supervisory system. In fact, the cloud connectivity also means there are options to publish the data directly to portable devices, so field personnel can monitor the data from anywhere, especially near the equipment.

Host systems could be one or more of the following: the operational control system, a database and trending package, analytical software, or possibly even a system offering advanced machine intelligence algorithms. IIoT systems provide just the kind of "big data" that analytical software needs to do its work. In fact, the cloud implementation means that applicable data from multiple sites can be aggregated to

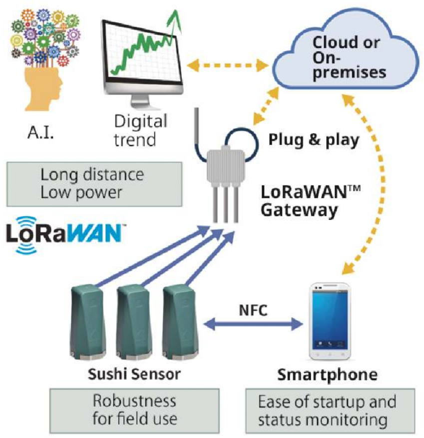



Figure 4. LPWA LoRaWAN in action: This diagram depicts a basic installation where many field-located Yokogawa Sushi Sensor devices connect through a plug-and-play gateway. The data is transmitted to an on-premises or cloud-based system for use by a higher-level host system or portable devices. NFC connectivity enables local configuration and monitoring of the sensors with a smartphone.

look for larger trends, or to compare the different facilities against each other.

Process controls have always been the domain of operational technology (OT) personnel, but infrastructure monitoring in recent years has often been dependent on information technology (IT) staff. Although IT staff are proficient at networking and databases, they are often less experienced with industrial concepts and the nature of time-series process data.

Implementing infrastructure condition monitoring with LPWA plug-and-play functionality puts the maintenance and environmental monitoring tasks squarely in the hands of OT personnel, who are best equipped to use it. This results in a far more efficient integration.

One other note is that some IIoT sensors offer near-field communications (NFC) wireless capability. This very short-range (just a few centimeters) wireless link is not useful for ongoing data transmission but does enable common smartphones to act as local configuration and monitoring tools for sensor status. This is yet another case where IIoT devices can save end users money.

## Just right wireless

Conventional industrial wireless operational networks, such as ISA100 Wireless, will continue to experience a growing presence in automation systems for high-performance control and monitoring. However, to truly take advantage of widespread IIoT advancements, it is important to adopt LPWA networking technology such as LoRaWAN to economically integrate multitudes of sensors on a sitewide basis.

LPWA is a just-right fit of cost, power consumption, range, and bandwidth for monitoring infrastructure conditions such as temperature and vibration. This data is key to preventative and predictive maintenance programs. The nature of LPWA devices means they are economical to install initially, since no wiring is required, and they are also cost effective on a long-term basis due to minimal maintenance requirements.

Operational and LPWA infrastructure wireless networking work especially well in conjunction with each other, because the combination covers such a wide range of wireless needs. Used together in a sitewide industrial wireless network, they deliver a comprehensive balance of immediate and proactive plant operations. ■

### ABOUT THE AUTHOR

**Shuji Yamamoto** (shuuji.yamamoto@jp.yokogawa.com) is the wireless promotion manager at Yokogawa's marketing headquarters for External Affairs & Technology MK 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 IIoT.

View the online version at www.isa.org/intech/20190404.

### RESOURCES

**"Essential wireless network layout concepts"**
www.isa.org/intech/201708basics

**"Getting IIoT to live up to the hype"**
www.isa.org/intech/201702web

**"Convergence and commercial momentum"**
www.isa.org/intech/20170404

# RAMI 4.0

# Reference Architectural Model for Industrie 4.0

## Three-dimensional map showing how to approach Industry 4.0 in a structured manner

By Bill Lydon

The RAMI 4.0, Reference Architecture Model Industrie 4.0 (Industry 4.0), was developed by the German Electrical and Electronic Manufacturers' Association (ZVEI) to support Industry 4.0 initiatives, which are gaining broad acceptance throughout the world. Industry 4.0 (also termed Industrie 4.0) is a holistic view of manufacturing enterprises, started in Germany, with many worldwide cooperative efforts including China, Japan, and India. Industry 4.0 concepts, structure, and methods are being adopted worldwide to modernize manufacturing.

### Effective manufacturing

Throughout the world, there is a recognition that to be competitive, manufacturing needs to modernize. The Industry 4.0 movement in particular continues to accelerate defining the pattern of how all industrial automation can achieve the goal of holistic and adaptive automation system architectures. A driving force behind the development of Industry 4.0 is the realization that pursuing low labor rates is not a winning strategy. Remaining competitive and flexible can only be accomplished by leveraging advanced technologies, centering on automation to enable a successful transition. Germany's Industrie 4.0 initiative has ignited cooperative efforts in China, Japan, and India.

Industry 4.0 is interdisciplinary, where the standards applicable in mechanical engineering, electronics, electrical engineering, and communications and information technology need to be combined with the respective technologies needed for their implementation.


### Discrete and process industries

The development of RAMI 4.0 focused on industrial production as the primary area of application, including discrete manufacturing to process industries. Industry 4.0 concepts are being applied to process industries to achieve a holistic integration of automation, business information, and manufacturing execution function to improve all aspects of production and commerce across process industry value chains for greater efficiency. The "Process Sensor 4.0 Roadmap" initiated by NAMUR and VDI/VDE, in collaboration with several prominent leaders in the industry (including ABB, BASF, Bayer Technology Services, Bilfinger Maintenance, Endress+Hauser, Evonik, Festo, Krohne, Lanxess, Siemens, and Fraunhofer ICT), reflects the intent of creating fundamental building blocks to advance process automation system architectures. A number of NAMUR working groups are part of Working Area 2 (WA 2), Automation Systems for Processes and Plants.

Related to this activity, the OPC Foundation and FieldComm Group have an initiative to create a protocol-independent, process automation device information model (PA-DIM) specification based on the industrial interoperability standard OPC UA. PROFIBUS/PROFINET International is now participating in this vision, which is supported by NAMUR as part of its Open Architecture (NOA) initiative. The goal is enabling end users to dramatically reduce time to implement advanced analytics, big data projects, and enterprise cloud solutions that rely on information from thousands of geographically dispersed field devices using multiple process automation protocols.

## RAMI 4.0 definition

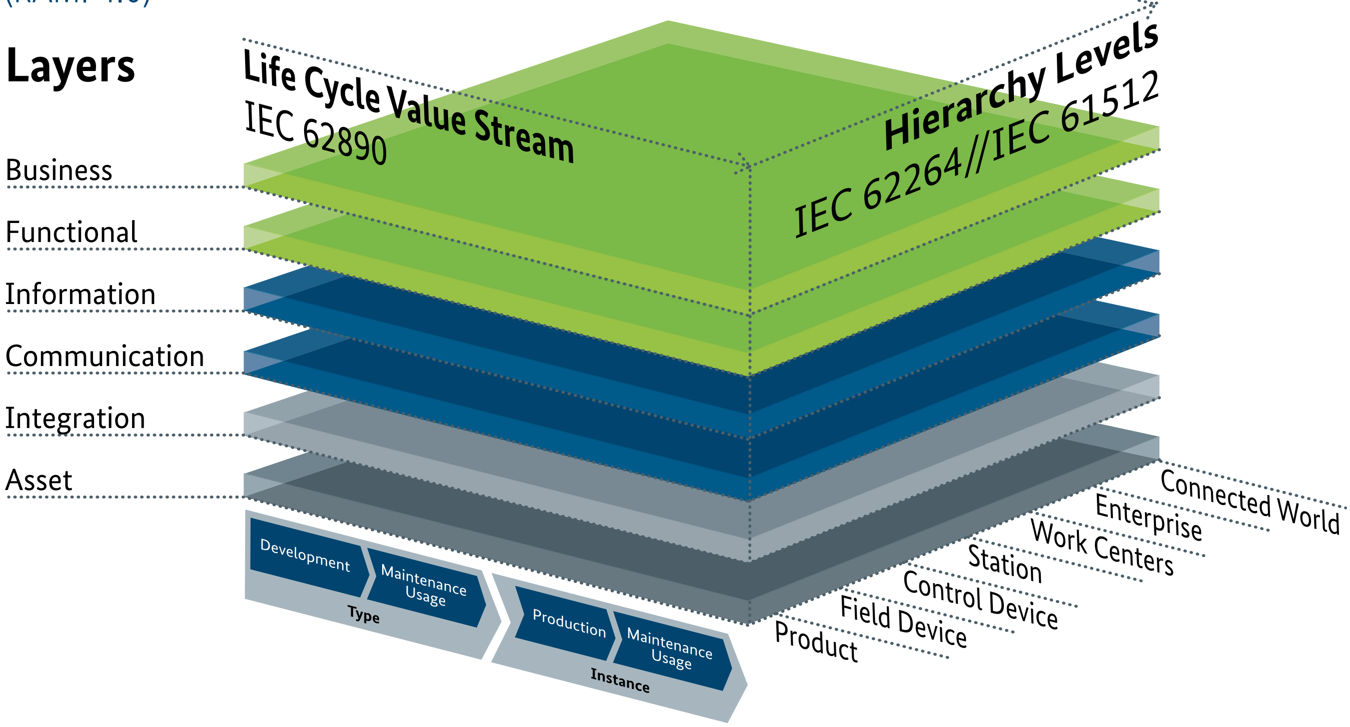
The RAMI 4.0 Reference Architectural Model and the Industry 4.0 components give companies a framework for developing future products and business models. RAMI 4.0 is a three-dimensional map showing how to approach the deployment of Industry 4.0 in a structured manner. A major goal of RAMI 4.0 is to make sure that all participants involved in Industry 4.0 discussions and activities have a common framework to understand each other. The RAMI 4.0 framework is intended to enable standards to be identified to determine whether there is any need for additions and amendments. This model is complemented by the Industry 4.0 components. Both results are described in DIN SPEC 91345 (Reference Architecture Model Industrie 4.0). DIN (www.din.de) represents German interests within the International Organization for Standardization (ISO). Today, roughly 85 percent of all national standard projects are European or international in origin.

Putting the RAMI 4.0 model in perspective, in the glossary of the VDI/VDE-GMA 7.21 Industrie 4.0 technical committee, a reference model is defined as a model that can be generally applied and can be used to derive specific models. There are many examples of this in the field of technol-

**FAST FORWARD**

- RAMI 4.0 ensures that all participants involved in Industry 4.0 discussions and activities have a common framework and terminology.
- RAMI 4.0 focused on industrial production as the primary area of application, including discrete manufacturing to process industries.
- The Industry 4.0 movement continues to accelerate defining the pattern for all industrial automation to achieve the goal of holistic and adaptive automation system architectures.

## Reference Architectural Model Industrie 4.0
(RAMI 4.0)




RAMI 4.0 is a three-dimensional map showing the most important aspects of Industrie 4.0. It ensures that all participants involved share a common perspective and develop a common understanding," explains Kai Garrels, chair of the working group Reference Architectures, Standards and Norms at the Plattform Industrie 4.0, and head of standardization and industry relations at ABB (www.plattform-i40.de).

ogy. The most well known is the seven-layer ISO/OSI model, which is used as a reference model for network protocols. The advantage of using such models is a shared understanding of the function of every layer/element and the defined interfaces between the layers.

## Important characteristics

RAMI 4.0 defines a service-oriented architecture (SOA) where application components provide services to the other components through a communication protocol over a network. The basic principles of SOA are independent of vendors, products, and technologies. The goal is to break down complex processes into easy-to-grasp packages, including data privacy and information technology (IT) security.

ZVEI characterizes the changing manufacturing systems. The current "Old World Industry 3.0" manufacturing system characteristics are:

- hardware-based structure
- functions bound to hardware
- hierarchy-based communication
- isolated product

The "New World: Industry 4.0" manufacturing system characteristics are:

- flexible systems and machines
- functions distributed throughout the network
- participants interact across hierarchy levels
- communication among all participants
- product part of the network
- RAMI 4.0 structure

RAMI 4.0 consists of a three-dimensional coordinate system that describes all crucial aspects of Industry 4.0. In this way, complex interrelations are broken down into smaller and simpler clusters.

**"Hierarchy Levels" axis**

On the right horizontal axis are hierarchy levels from IEC 62264, the international standards series for enterprise IT and control systems. These hierarchy levels represent the different functionalities within factories or facilities. (Note that the IEC 62243 standard is based upon ANSI/ISA-95.) To represent the Industry 4.0 environment, these functionalities have been expanded to include work pieces, labeled "Product," and the connection to the Internet of Things and services, labeled "Connected World."

**"Life Cycle Value Stream" axis**

The left horizontal axis represents the life cycle of facilities and products, based on IEC 62890, *Life-cycle management for systems and products,* used in industrial-process measurement, control, and automation. Furthermore, a distinction is made between "types" and "instances." A "type" becomes an "instance" when design and prototyping have been completed and the actual product is being manufactured. The

The German ZVEI (www.zvei.org) industrial association, founded in 1918, represents the interests of the high-tech sector with a wide portfolio. ZVEI is committed to the common interests of the electrical industry in Germany and internationally. This commitment is supported by about 160 employees in the main office and 5,000 employees from the member companies in an honorary capacity.

ZVEI is based in Frankfurt with offices in Berlin and Brussels. Through its EuropeElectro working group, ZVEI also has an office in Beijing. More than 1,600 companies, which employ about 90 percent of the staff of the electrical industry in Germany, have opted for membership in ZVEI. Its members include global, medium-sized, and family-owned companies. The sector has 868,000 employees in Germany, plus more than 736,000 employees all over the world.

The basis of the association's work is the exchange of experience and views between the members about current technical, economic, legal, and socio-political topics in the electrical industry. From this exchange, common positions are drawn up, including proposals on research, technology, environmental protection, education, and science policy; ZVEI is a pacemaker of technological progress. It also supports market-related international standardization work.

The association works with national business associations and organizations, European industry and trade associations, and international organizations. It is divided into 22 trade associations that comprise all member companies, each operating in the same market segment. In addition, ZVEI maintains nine state offices in Germany that represent the interests of the electrical industry in the country. Since June 2014, Michael Ziesemer, vice chairman of the board of the Endress + Hauser Group, has been president of the ZVEI. Klaus Mittelbach has been the executive director of the ZVEI management since 2008. ■

model also combines all elements and IT components in the layer and life-cycle model.

**"Layers" axis**

The six layers on the vertical axis describe the decomposition of a machine into its properties, structured layer by layer, i.e., the virtual mapping of a machine. Such representations originate from information and communication technology, where properties of complex systems are commonly broken down into layers.

Within these three axes, all crucial aspects of Industry 4.0 can be mapped, allowing objects such as machines to be classified according to the model. Highly flexible Industry 4.0 concepts can thus be described and implemented using RAMI 4.0. The model allows for step-by-step migration from the present into the world of Industry 4.0.

## Benefits of RAMI 4.0

The model integrates different user perspectives and provides a common way of seeing Industry 4.0 technologies. With RAMI 4.0, requirements of sectors—from manufacturing automation and mechanical engineering to process engineering—can be addressed in industry associations and standardization committees. Thus, RAMI 4.0 brings a common understanding for standards and use cases.

RAMI 4.0 can be regarded as a map of Industry 4.0 solutions. It is an orientation for plotting the requirements of sectors together with national and international standards to define and further develop Industry 4.0. There is a refreshing interest with Industry 4.0 initiatives for various organizations to work cooperatively and overcome the compartmentalization of the national standardization bodies.

## The challenge

The influx of technology is starting to dramatically improve manufacturing. However, to do this effectively takes planning, and the RAMI 4.0 model is a focal point for understanding the entire manufacturing and supply chain. ■

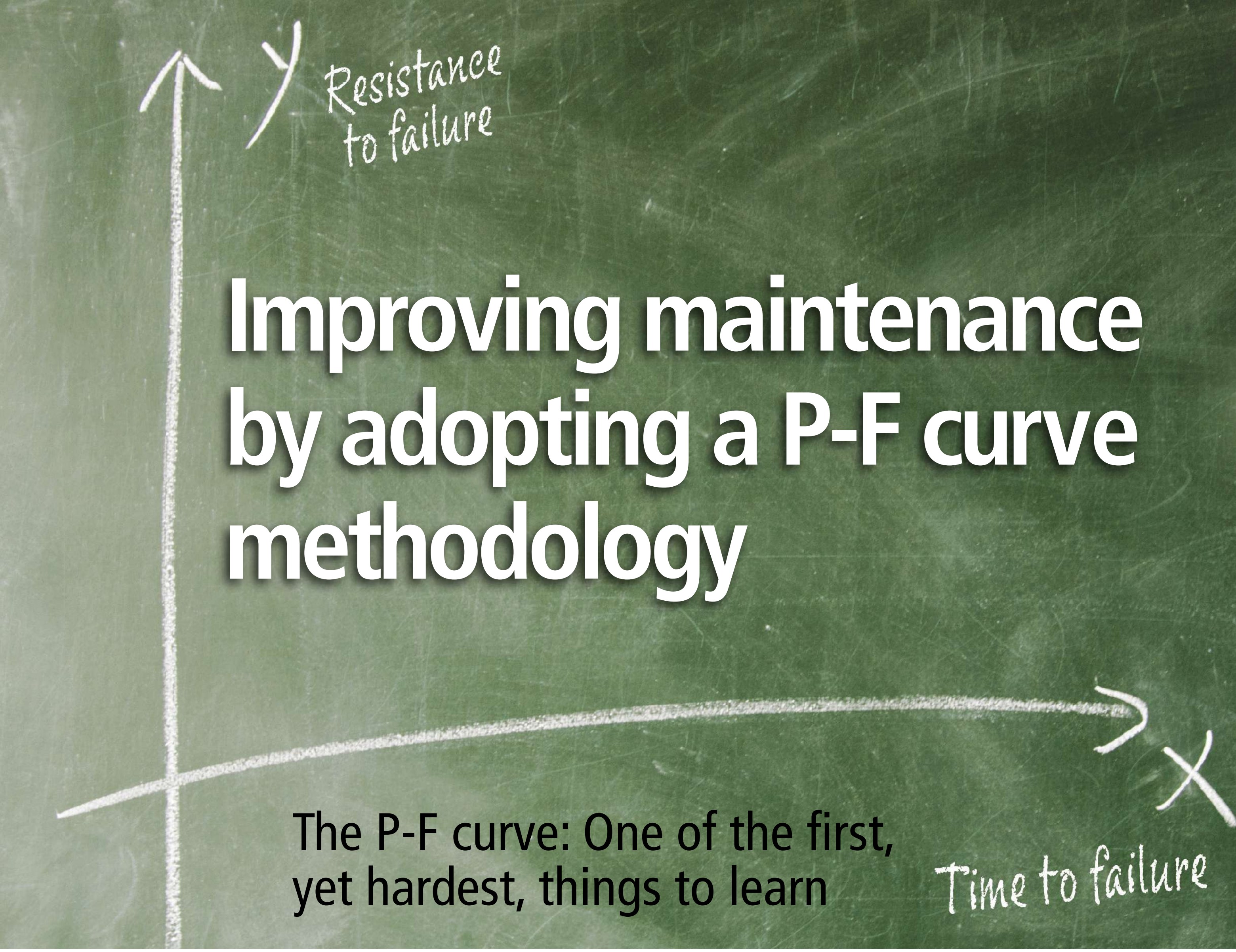
**ABOUT THE AUTHOR**

**Bill Lydon** (blydon@isa.org) is chief editor of *InTech*. Lydon has been active in manufacturing automation for more than 25 years. In addition to experience at various large companies, he co-founded and was president of a venture-capital-funded industrial automation software company.

View the online version at www.isa.org/intech/20190405.

# Improving maintenance by adopting a P-F curve methodology

## The P-F curve: One of the first, yet hardest, things to learn




By Kevin Clark, CMRP

The P-F curve is a way of representing an asset's behavior or condition before it has reached a failed state. It illustrates an asset's progression toward failure. On the chart, the x-axis represents the time to failure, starting with an asset's installation, and the y-axis represents an asset or component's resistance to failure.

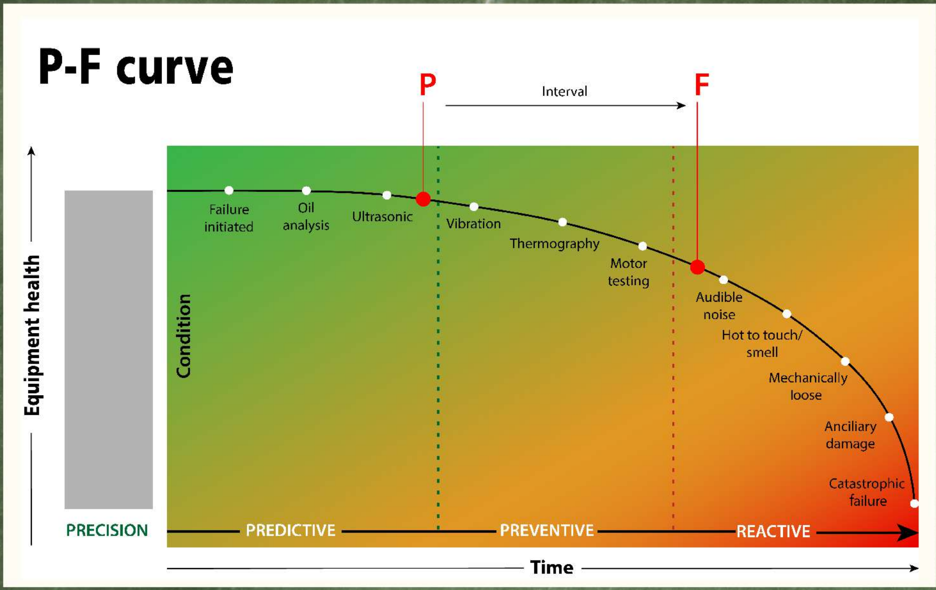
Potential failure (PF) indicates a detectable state of failure, or the point at which degradation begins. Functional failure (FF) is when the asset or component has reached a failed state or no longer performs satisfactorily. The most important part of the P-F curve is the P-F interval, which represents the time between when potential failure is detected in an asset and when it reaches the failed state. The length of the P-F interval is largely determined by the technology used to detect failure.

### Highly dependent on patterns

"Most assets follow a curve in their life cycle, from good to progressively worse, until they completely fail," says John Bernet, a product application specialist at Fluke with decades of experience in vibration monitoring. "The P-F curve is a conceptual representation only and does not have any units or scale."

The P-F curve is highly dependent on patterns. For example, if one motor ramps up to a specific rpm during operation, then an identical motor used on another asset should behave in the same way. The P-F curve is something that we—those of us in the maintenance and reliability space—depend on from a mature standpoint. As reliability engineers using the P-F curve, we have gotten to the point of trying to design out failure, of trying to indicate failure, rather than simply waiting for it to happen.

The way motors are built today, they have onboard diagnostics indicating how they perform—but not how they feel. Similarly, our human bodies are built to take care of themselves—but when things go wrong, we need doctors to help us determine what is wrong and




**FAST FORWARD**

- Used in conjunction with condition monitoring, the P-F curve improves maintenance by allowing staff to do more than just react.
- Detecting failures when they are actionable but still early allows organizations to plan the best time to take corrective action.
- Using P-F and condition monitoring tools improves productivity and uptime.

what needs to be done to fix it. A motor takes care of itself. It knows how to run, and it knows how to deliver power and energy to whatever it is attached to. But when something starts to go wrong, it needs a diagnosis to determine the repair required.

The method and frequency of detection essentially determine the length of the P-F interval. The more often assets are inspected and the more sensitive the method of inspection, the more time there will be between detection of potential failure and when failure actually takes place.

## Modalities of the P-F curve

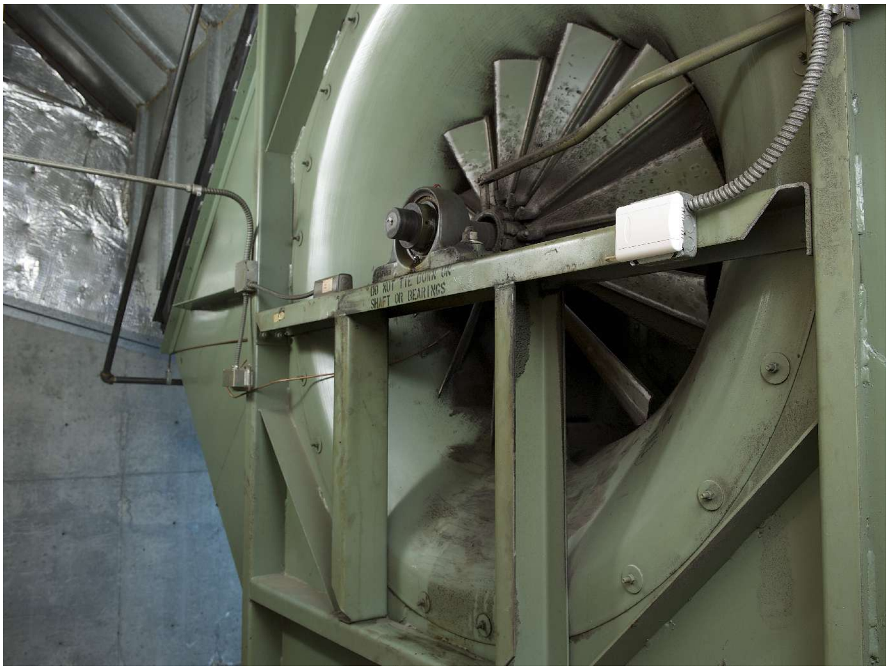
Technologies and tools used to detect failure can include (earliest to latest):

- oil analysis
- ultrasound
- vibration
- thermography
- motor testing
- physical inspection

Each of these methods of testing has something specific to say about an asset's operation, and the timing information has even more to say about the future of the asset. Using these modes of inspection and methods of detection can provide an early warning of decreased performance.

"Early indicators, like oil analysis and ultrasound, may just be a signal for additional maintenance actions, such as lubricating bearings, or beginning to plan and schedule maintenance to avoid surprises," Bernet says. "Late indicators, like thermography, may not be soon enough to prevent damage to the shaft, bearings, and components of the rotating machine."

The cost of maintenance commonly increases the closer you get to the failed state, as there is less time to mitigate or eliminate failure. And, at a certain point, there is no potential failure anymore—the asset has reached failure and must be repaired or replaced. It is also true



that the further away from the failed state you detect potential failure, the more sophisticated (and thus expensive, considering both equipment and training) the detection technology.

## Importance of timing

Sometimes taking corrective action too soon can have bigger consequences, such as higher costs or more downtime, than not acting. If you are repairing things too quickly, you are going to be spending money on changing out components more often than necessary. In such cases, you either have inaccurately identified the actual point of failure or have your parameters set incorrectly.

By detecting failures when they are actionable but still early, you are able to plan the most advantageous time to take corrective action. When used in conjunction with condition monitoring, the P-F curve improves maintenance by allowing you to do more than just react.

Oil analysis is one of the first indicators of potential failure. It tells you a lot about what is going on with a piece of equipment by indicating what kind of particles are in the oil. But not all assets have oil, so you cannot use oil analysis for everything. Vibration is typically the next earliest indicator. The most common thing to use the P-F curve on is equipment with rotating assets, which makes vibration a perfect technology to use. Rotation is something that is fairly consistent. When you have a consistently behaving piece of equipment, using the P-F curve makes a lot of sense.

## P-F curve and vibration monitoring

All machinery vibrates, but excess vibration in rotating equipment can make potential issues known early on. Vibration monitoring can measure changes in the amplitude, frequency, and intensity of forces that can cause damage to rotating equipment.

“Compared to other technologies—like ultrasound, oil analysis, and thermography—vibration is kind of like Goldilocks,” says Bernet. “Thermography can be too late, while ultrasound and oil analysis can be too early, but vibration is just right. With vibration, we can see indications of faults 12 to 18 months in advance—when there is still life left in the components—and not react too soon.”

The four most common vibration faults are imbalance, looseness, misalignment, and bearing wear. Rare machine faults do happen, but almost all vibration faults fall into these four categories. “Vibration is especially effective in diagnosing mechanical faults,” Bernet continues. “Even a healthy machine is going to have vibration, so it’s easy to identify what is normal for a good rotating machine and then to be able to look for patterns in the change in the vibration.”

## Why condition monitoring pairs well with the P-F curve

Condition monitoring is the use of continual screening technologies to detect changes in the operation of assets, which means you are alerted to potential issues well before failure or downtime occur. It gives you real-time situational awareness of your operation and enables you and your team to schedule maintenance and corrective actions in advance. Furthermore, condition monitoring can provide a longer P-F interval than other maintenance methods.

“Reactive maintenance is all based on failures that have already occurred. Planned or calendar-based maintenance is based on taking some kind of corrective action globally but not having any indication of which machines actually need it,” Bernet said. “Condition monitoring is based on knowing that a fault is coming—but has not occurred yet—and gives you some prewarning and the ability to schedule corrective repairs before the efficiency or capability of a machine is reduced.”

Identifying anomalies before they result in damage, downtime, or disruptive repairs decreases costs, unexpected downtime, and production loss. Other benefits include extended equipment life and smaller spare parts inventories. And, when you have sufficient lead time to order parts on an “as needed” basis, you can even eliminate expedited costs.

Other maintenance methods, such as calendar-based maintenance, simply do not fit as well with the P-F curve. The real-time data provided by condition monitoring lets you stay on top of where each critical asset is on the P-F curve.

## Tools to optimize

Maintenance is neither about fixing everything the moment potential failure is detected nor about waiting until everything fails before replacing it. It is about finding the right balance between taking action at the most opportune time for each asset and allocating your resources in the right way.

One way to manage the trove of data and insights you will get from condition monitoring is with a computerized maintenance management system (CMMS). This software maintains a database of information on an organization's assets and maintenance operations.

In addition to software like a CMMS, each organization should go through the process of performing a criticality analysis. This crucial assessment evaluates and classifies all of an operation's assets to provide a clear understanding of which require immediate attention, which can wait, and even which can run to failure. This evaluation will help clarify and inform your maintenance decisions and efforts. From a dollars and cents standpoint, the P-F curve applies more to critical assets.

A criticality analysis helps you identify how pivotal each asset is to the business. Think about it this way: You have two identical motors on different pieces of equipment, and they have two totally different rankings. That is because a criticality analysis considers the impact an asset has on product quantity and quality, on the environment, on safety, and on how that particular machine affects everything else.

**Identifying anomalies before they result in damage, downtime, or disruptive repairs decreases costs, unexpected downtime, and production loss.**

When you do a criticality analysis, you are looking at every factor surrounding each asset and how integral they are to the process. Any time you start to analyze, you are likely to hear from your team that, "It's all critical. If I don't have any of these assets, then I can't produce products." It is not until you start breaking it down in detail that they start seeing how assets truly differ in importance. In general, assets are broken down into three different categories: A, high criticality; B, medium criticality; and C, low criticality.

Typically, 10 to 20 percent of assets are highly critical. Between 20 to 30 percent of assets are in the medium range. And the rest, up to 40 to 60 percent, are low criticality. The criticality analysis helps you understand how each asset affects your operation, and that helps you see where you need to spend your time, money, and energy.

## The future of maintenance

Emerging technologies, namely artificial intelligence and machine learning, promise to take that kind of focus to the next level. With pattern recognition capabilities beyond human capacity, they will advance and enhance your maintenance operations.

Data is one of the most valuable things in the world—if you know what to do with it. One of the biggest benefits of condition monitoring is that, as you learn exactly how your assets perform and fail over time, you will be able to sharpen and refine your maintenance program. And by taking advantage of emerging technologies, you will have extremely powerful software watching for patterns and learning more every day.

For a long time, maintenance was seen as just a cost to doing business. Now, with the concept of reliability engineering gaining traction and new technologies becoming more widely used, companies are recognizing ways to achieve operational excellence and gain strategic advantage. Maintenance can help companies carve out a competitive edge, especially once they have started using the P-F curve. ■

### ABOUT THE AUTHOR

**Kevin Clark, CMRP** (kevin.clark@fluke.com), vice president, Accelix, Fluke Digital Systems, joined Fluke in December 2016. He has more than 30 years of industrial experience, working with both Fortune 500 and smaller start-up manufacturing/technology companies in various leadership capacities. He currently maintains his conference board position with the Society of Maintenance & Reliability Professionals and is on the advisory board with Pumps & Systems. Clark has a BS, computer-integration in manufacturing, from Purdue University and an MBA from Colorado State University.

View the online version at www.isa.org/intech/20190406.

# ISA Energy and Water Automation Conference

The ISA Energy and Water Automation Conference, scheduled for 7–8 August 2019 at the Omni Championsgate Resort in Orlando, Fla., will have interactive sessions led by ISA's power generation, alternative energy, municipal water, and industrial water experts. The conference program will cover technologies and best practices that apply to multiple infrastructure sectors.

Challenges the industry faces today include using data analytics in a meaningful way, navigating the new world of Industrial Internet of Things with safety and cybersecurity in mind, and applying the insights of recent "Smart Cities" initiatives to improve operations.

"Part of ISA's mission is to increase technical competency by connecting automation professionals, and this event is a perfect example of how that can benefit our industries," said ISA Executive Director Mary Ramsey. "Technology applications that are working in one sector can often translate to another, but users and solution providers have to engage in meaningful dialogue to find those synergies. ISA can be a venue for those discussions in multiple ways, from standards development to content creation to in-person events."

ISA's Water/Wastewater Industries Division will bring expertise and content focused on effective utility management, water/wastewater operations and maintenance, IT/OT coordination, engineering best practices, integration/programming, supervisory control and data acquisition, programmable logic controllers, instrumentation, cybersecurity, and asset management related to the treatment and distribution of water and the collection and treatment of wastewater.

ISA's Power Industries Division plans to host sessions covering automation and control solutions for oil and gas exploration, processing, and refining with a focus on power generation methodologies, including harnessing wind and solar energy.

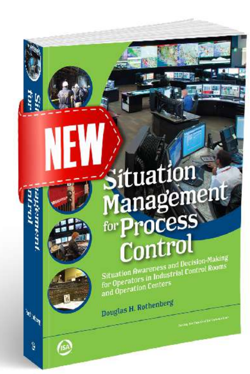
Many industries rely on sourcing, transporting, handling, recycling, and disposing industrial water as a core element of their power generation strategies. Infrastructure that supports both power and water are also at the heart of the "Smart Cities" initiatives.

For more information about the event, visit https://isaautomation.isa.org/ewac2019. ■

**"Part of ISA's mission is to increase technical competency by connecting automation professionals, and this event is a perfect example of how that can benefit our industries."**

—Mary Ramsey

## New book on situation management available




The new book, *Situation Management for Process Control* (www.isa.org/situationmgmt), is intended to unify industry understanding of how to deliver real value to control room operations. Written by Douglas H. Rothenberg, PhD—an expert in alarm management and operator support technology—the book explores control room management as a discipline, focusing on the applicable tools, technology, and methodologies that foster safer, more effective control room functioning and improved industrial production.

Situation management is the sum total of the real-time decisions and actions that the operator makes to determine whether or not the enterprise operates safely and productively. These include accurately and appropriately assessing the current operating environment, transforming that assessment into needed action for proper management of abnormal situations, and validating the effectiveness of the action.

"Properly understood and executed, it is a game changer in safe and effective operation of industrial plants and operations," states Rothenberg. "It advances a firm technical framework that ties together all of the traditional individual aspects (e.g., procedures, the human-machine interface, control room design, and more) into a technology to understand and design effective control room management operations. This is a unified approach with explicit tools to deliver situation management to control room operators. The tools to see problems are followed by the tools to manage them."

New contributions, Rothenberg points out, are the concepts and technology of weak signals and their use to supplement the alarm system and cover situations that alarms are not intended or able to manage.

"Weak signals are small indicators of things that don't appear quite right," he explains. "They can be discovered everywhere; understanding and exploiting them will lead to valuable clues and the ability to confirm something likely going amiss."

Rothenberg emphasizes the importance and relevance of the book to managers, supervisors, operators, human-factors engineers, safety personnel, and technicians in industrial enterprises and operation centers. It will also be useful for regulators, specialists, engineers, system designers, and trainers at commercial firms who create monitoring and controls hardware, software, and technology for end users. ■

# ISA Certified Automation Professional (CAP) program

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

### CAP question

**Why must voltage be reduced along with frequency in a variable frequency speed controller?**

A. to let the motor cool off
B. because of capacitive reactance
C. to maintain the volts/hertz ratio
D. to keep the motor from overspeeding

### CAP answer

The correct answer is *C,* "to maintain the volts/hertz ratio." The speed of the motor is controlled by changing the frequency applied to the motor:

RPM = (Frequency • 120) / (# of poles in the motor)

Varying the frequency affects both the motor speed and the strength of the magnetic field. When the frequency is lowered (slower motor speed), the magnetic field increases, and excessive heat is generated. When the frequency is increased (higher motor speed), the magnetic field decreases, and lower torque is produced.

In order to keep the magnetic flux constant, the V/Hz ratio must remain constant. This keeps torque production stable, regardless of frequency. As frequency changes, we want to maintain a constant flux density to maintain the torque developed by the motor.

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

# ISA Certified Control Systems Technician (CCST) program

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.

### CCST question

**If the proportional band on a controller is 100 percent, then the controller gain is equal to:**

A. 0.50
B. 0.20
C. 1
D. 100

### CCST answer

The correct answer is *C,* "1." The proportional band is defined as the amount of change in input (or deviation), as a percent of span, required to cause the control output to change from 0 percent to 100 percent.

Gain is a unitless number that defines the ratio of the change in output, due to proportional control action, to the change in input, in percent of span.

From the above definitions:

$$PB = [\Delta \text{ INPUT} / \Delta \text{ OUTPUT}] \times 100 \quad (1)$$

and

$$GAIN = \Delta \text{ OUTPUT} / \Delta \text{ INPUT} \quad (2)$$

Combining equations 1 and 2:

PB = 100 / GAIN
or
GAIN = 100 / PB

For a PB = 1:

GAIN = 100 / 100 = 1

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

## New CAPs and CCSTs

### Certified Control System Technicians

| Name | Company | Location |
|---|---|---|
| **Level 1** | | |
| David M. Gwin | None | U.S. |
| Geoffrey B. Rousseau | None | U.S. |
| Randy A. Dugger | None | U.S. |
| David N. Jones | None | U.S. |
| James E. Anderson | None | U.S. |
| Robert G.W. Whalen | None | U.S. |
| Hiram G. Page | None | U.S. |
| Russell Daniel Reed | Holly Frontier | U.S. |
| Evan B. Williamson | None | U.S. |
| Travis D. Russell | None | U.S. |
| Brandon Weibley | Prime Controls | U.S. |
| Angel J. Hernandez | None | U.S. |
| Joel M. Martinez | None | U.S. |
| Marco A. Venegas | Orange County Sanitation District | U.S. |
| Henry Ng | Orange County Sanitation District | U.S. |
| Albert Navarro | None | U.S. |
| Gholamrezaei Reza | Orange County Sanitation District | U.S. |
| Ryan M. Raiford | Orange County Sanitation District | U.S. |
| **Level 2** | | |
| Timothy C. Secrest | None | U.S. |
| Joshua A. Smith | None | U.S. |
| Matt A. Hayes | None | U.S. |
| Justin M. Kovalski | None | U.S. |
| Jason W. Gerard | None | U.S. |
| Rick M. Mirolla | None | U.S. |
| Edward V. Keen | None | U.S. |
| Dominic D. Duffert | None | U.S. |
| Pedro N. Gulbe | None | U.S. |
| Jeffrey P. Campbell | None | U.S. |
| Jan A. Gramley | None | U.S. |
| Joseph D. Davis | None | U.S. |
| Robert C. Davis | None | U.S. |
| Benjamin J. Smith | None | U.S. |
| Mitch E. Maloof | None | U.S. |

### Certified Automation Professionals

| Name | Company | Location |
|---|---|---|
| Saad Rehman Hashmi | Qatar Chemical Co. Ltd. | Qatar |
| Servio Uribe | None | U.S. |
| Michael J. Bartlett | None | U.S. |
| Sudhakar Rajendran | WorleyParsons | Abu Dhabi |
| Arthur Eugene Nichols | None | U.S. |
| Tom J. Hilty | None | U.S. |

# The mobile revolution invades the controls space

By Steve Hechtman

Mobile computing has now surpassed desktop computing in the consumer space, but as we all know, operational technology (OT) trends tend to follow information technology trends by up to 10 years. However, the OT space is now seeing a proliferation of mobile devices and applications that leverage them well, affording the space a tremendous opportunity (with a few caveats).

When considering mobile computing, there are three important design concepts to understand: mobile responsiveness, mobile adaptiveness, and mobile first.

"Mobile responsiveness" refers to the design of applications that are suitable for mobile devices. This is done by using a dynamic layout that automatically renders information to any screen size, resolution, or orientation in a highly usable manner. For example, text and images can change from a three-column display to a single-column display, with unnecessary images hidden so they do not interfere or compete with more important information on a mobile device's smaller screen.

One can test any website for mobile responsiveness by using a desktop browser and resizing it to see how the text and images flow. Mobile-responsive design reflows and adapts to almost any size, while still presenting the most important information in a usable form.

"Mobile-adaptive" design is similar to mobile-responsive design, except that it uses different layouts, each suited to a particular range of screen sizes and resolutions. Such a design detects the type of device being used and presents the appropriate layout for that device. For example, if a PC is detected, one layout is used, and if a mobile device is detected, another one is used that can better utilize the available screen space.

Application design in the past focused on optimal desktop presentation, and mobile design was an afterthought. "Mobile-first" design reverses this and makes mobile a first-class experience, with desktop design a secondary consideration. In most cases, within the context of OT, both desktop and mobile need to be first-class experiences, so blending the mobile-adaptive and mobile-responsive approaches is usually the better choice. Another term for this is "mobile-also." This widens the skill set and understanding required of the control system integrator, whose user interface design concepts need to evolve to fully leverage mobile-device capabilities—all without abandoning prior workstation design concepts, which are still fully applicable.

Speaking of fully leveraging mobile-device capabilities, the real win comes by leveraging the wide range of sensors available in mobile devices. Today's mobile devices are packed with nearly 14 sensors that produce raw data for motion, location, and other things concerning the environment. This could include using the camera for reading barcodes or using Bluetooth LE (low energy) for determining the general location inside a plant, and of course there is also GPS. How useful would it be to record the location of events or navigate to applicable screens or data based on location? Or how about using a mobile device's accelerometer for vibration analysis—a way of predicting rotating equipment failure—with nothing more than your mobile phone?

Being out of range of cellular towers or Wi-Fi should not be a limitation, because applications can be built to work in untethered mode. In this case, the recording of mobile sensor data or manual data entry is done offline, with the data being automatically uploaded or synchronized when signals are back in range.

But there's more! Today most mobile (and many desktop) applications can run as JavaScript inside the browser. In essence, the browser has become the operating system. This is good news, because nearly every device has a browser. This means applications can be written once and can run on any device or operating system.

This can reduce plant downtime immensely. Whereas the failure of a typical plant floor human-machine interface (HMI) or touchscreen PC can take down a line for hours or more, browser-based applications can be restored using any device with a browser in a minute. One could even imagine using a tablet device in a ruggedized protective housing in lieu of proprietary HMI screens.

**Whereas the failure of a typical plant floor human-machine interface or touchscreen PC can take down a line for hours or more, browser-based applications can be restored using any device with a browser in a minute.**

We are just now starting to see viable mobility in action on plant floors and in the field. This opens whole new vistas of what is possible and can make plant operations far more efficient. ■

### ABOUT THE AUTHOR

**Steve Hechtman** (info@inductiveautomation.com) is the president, CEO, and founder of Inductive Automation. Before starting the company in 2003, Hechtman had 25 years of experience as a control system integrator, including at Calmetrics Company, which he cofounded in 1988. After years of frustration with expensive and impractical industrial software, he created a better solution. He formed Inductive Automation, which has brought up-to-date technologies to the controls business with web-based, database-centric products, and sensible licensing models.

# UL panel upholds ISA appeal of UL cybersecurity standard

An appeal panel formed by Underwriters Laboratories (UL) has ruled in favor of an ISA appeal against a UL cybersecurity standard. ISA's appeal was brought against UL 2900-2-2, *Standard for Software Cybersecurity for Network-Connectable Devices, Part 2-2: Particular Requirements for Industrial Control Systems*, for which UL was seeking approval as an American National Standard. ISA's successful appeal means the UL standard will not gain that status at this time.

ISA's appeal was driven by an underlying principle of standards development—to avoid burdening users with overlapping and duplicating standards from different standards developers. Based on reviews by cybersecurity experts, ISA was concerned about UL overlap with the ISA/IEC 62443 series of standards, which are developed by the ISA99 standards committee as American National Standards with simultaneous review and adoption by the Geneva-based International Electrotechnical Commission (IEC). ISA99 draws on the input of cybersecurity experts from across the globe in developing the widely used standards, which are applicable to all industry sectors and critical infrastructure.

ISA's successful appeal asserted that UL failed to follow a key clause in the UL accredited standards procedures that is intended to prevent duplication and overlap. Prior to the appeal, UL had acknowledged that it missed earlier opportunities to identify potential overlap and duplication.

Without approval as an American National Standard, the UL standard will not be eligible to become an internationally recognized standard through the IEC. IEC leaders from TC65, the primary IEC committee working with ISA99, had previously indicated that the UL standard would have a very low chance of achieving that status in any event.

The ISA/IEC 62443 series is cited throughout the U.S. NIST Cybersecurity Framework. In late 2018, the United Nations Economic Commission for Europe confirmed it will integrate the ISA/IEC 62443 series in its Common Regulatory Framework on Cybersecurity, which will serve as an official UN policy position statement for Europe.

For information on the ISA/IEC 62443 standards and related training and learning resources, contact Eliana Brazda, ISA Standards, ebrazda@isa.org. ■

# ISA76 seeks user input on sample probe design


The ISA76 standards committee, Composition Analyzers, has undertaken a first step in the process of creating a possible new standard or modifying an existing industry standard for the safe design of sample probes. The committee is investigating the mechanical design of sample probes and injection quills in response to concerns by industry users about a possible gap in current best practices. Several industry standards are currently used, including ASME PTC 19.3, *Thermowells,* and IEC/TR 61831, *On-line Analyzer Systems – Guide to Design and Installation.* However, current practices either specifically exclude sample probes or do not reflect the most recent practices and industry knowledge.

As a first step in the process of creating a new standard or proposing changes to an existing standard, ISA76 is seeking input from the wider industry, including manufacturers, EPCs, and end user companies. ASME PTC 19.3 is believed to be the most comprehensive standard in terms of understanding the static and dynamic stresses on a probe (with the current restriction that the thermowell standard specifically eliminates probes from its applicability).

ISA76 is seeking to determine if any users have designed a sample probe according to ASME PTC 19.3 2010 and/or 2016 and have experienced probe failure due to static or dynamic loads. It is expected that this information will enable ISA76 to understand the extent that the nuances between a probe and a thermowell impact the overall structural performance on a practical level. At this time, ISA76 is asking users to indicate, anonymously if desired:

1. Do you design, or have you ever designed, a sample probe according to ASME PTC 19.3?
2. Have you ever had a mechanical failure of the probe designed to ASME PTC19.3 (which could not be disregarded due to an engineering error such as material choice or corrosion)? If your answer to the second question is yes, would you allow ISA76 leaders to follow up to understand the application and failure?

Any additional information on quantities, current company design practices, and other related information and any questions that could be considered by ISA76 will also be greatly appreciated.

Please send your responses to Charley Robinson, ISA Standards, crobinson@isa.org, with the subject line "Sample Probe Survey," and indicate clearly if (a) you would like to remain anonymous, and (b) if ISA76 leaders may follow up with you to better understand your experience. ■

# How multivariable DP flowmeters can improve performance

## Using a DP flowmeter to measure additional variables beyond basic flow measurement increases precision and reduces costs

By Connor Oberle

Differential pressure (DP) is a common and well-understood technology for measuring the flow of process fluids for several reasons:

- Versatility: It can measure virtually any type of fluid: liquid, gas, or steam.
- Scalability: Installations can be any size.
- Precision: When designed and executed well, DP has very high accuracy.

Another attribute is the ability of DP flowmeters to measure multiple variables using sophisticated transmitters. Let's unpack this idea and consider what flow is and how it is measured.

### Uncompensated versus compensated flow

When measuring flow, simple DP flowmeters provide a reading using just a DP measurement. Using a simple formula, the DP value can be used to determine a flow rate. For many processes, such as liquids where the density

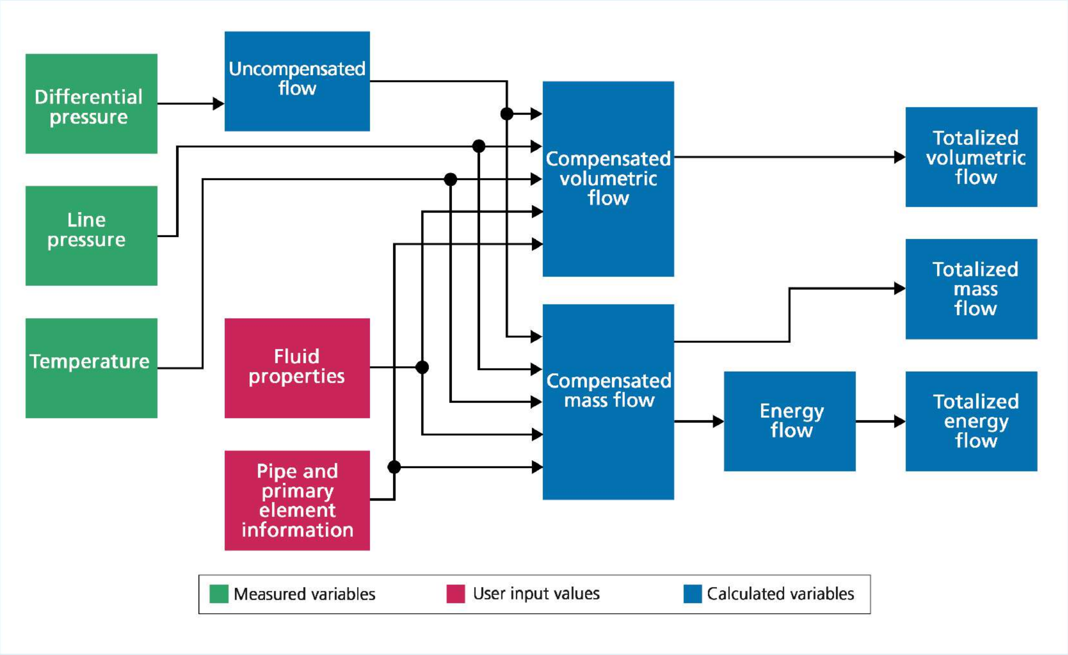



Figure 1. Using a mix of measured and configured variables, a DP flowmeter can provide a variety of different readings.

and other properties can be reasonably assumed, this is what is required. However, there are many applications where steam or a gas is the process fluid, and an uncompensated reading does not deliver much useful information. A compensated flow reading is required for steam or gas, or a mass flow measurement may be required for feeding liquids to critical chemical reactions for custody transfer and other applications.

Some flowmeter technologies, such as Coriolis, measure mass flow natively. This technology can provide a different range of variables than DP flowmeters, so depending on the needs of the process, it might be a more appropriate selection. For example, this technology can calculate specific gravity of a fluid along with solids content.

If a mass flow measurement is required for the process, the flow measurement available from a DP flowmeter (figure 1) can be conditioned by using multivariable technology. Multivariable DP flowmeters are capable of providing additional process measurements and process information, including process temperature, line pressure, fluid properties, and specifics about the pipe geometry and primary element. When this information is available, a compensated flow measurement will correct for changes in density, viscosity, and other dynamic fluid properties, allowing DP flowmeters to be used with more challenging fluids or in critical applications.

As a case in point, if the DP flowmeter using multivariable technology takes input from a temperature sensor, it will be able to improve its flow accuracy by using the temperature value in its flow calculations. If the transmitter has been programmed with the density value versus temperature curve for the process fluid, it can perform all the calculations necessary for a compensated flow reading for any process liquid in real time. We will talk about steam and gases in a moment.

When temperature and other variables are used to compensate the flow value, precision can be improved to ±1 percent or better, depending on the conditions. Because sophisticated DP flowmeters have a high degree of accuracy, this can be a very useful improvement.

## Pressure matters too

DP transmitters are designed to measure the difference between two points in a process. In the case of a DP flowmeter, the pressure on the upstream side of the primary element is higher than on the downstream side. For the sake of example, say the pressure drop at a given flow condition is 1.35 psi. This is an accurate reading, but it does not say anything about the pressure in the line. It could be 20 or 200 psi, and there is no way to know without an additional pressure measurement. Or is there? Some DP transmitters can also measure the line pressure in gauge

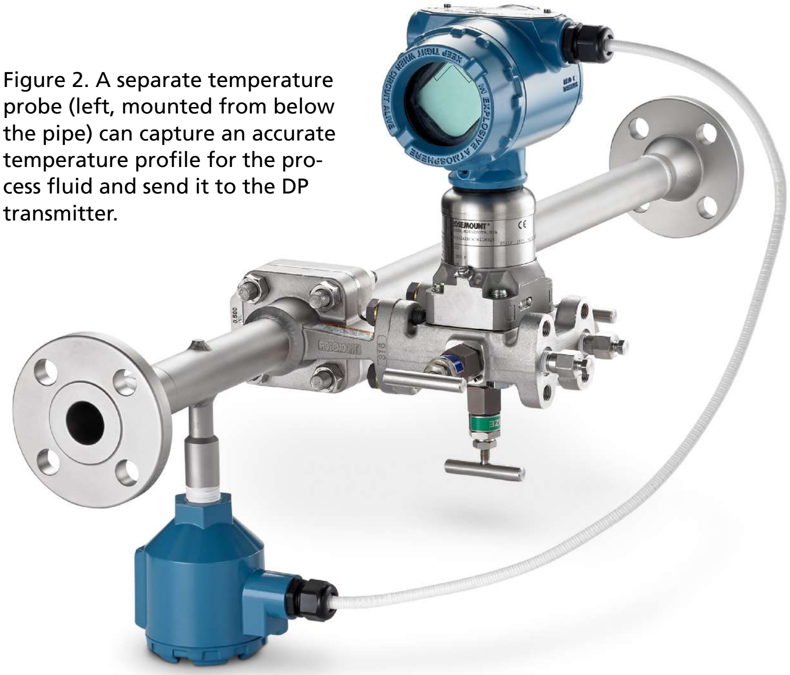


Figure 2. A separate temperature probe (left, mounted from below the pipe) can capture an accurate temperature profile for the process fluid and send it to the DP transmitter.

or absolute terms. By using the differential and line pressure measurements together, the pressure on either side of the primary element can be determined. In this example, the high side is 64.92 psig, and the low side is 63.57 psig.

Knowing the high and low line pressures when working with a gas or steam is enormously important for generating an accurate flow measurement, and the DP transmitter can monitor changing conditions and make sophisticated calculations in real time.

## Precision and cost

Two elements were mentioned in the opening of this discussion: precision and cost. So far, we have talked about the mechanics of measurement and how they affect precision. A sophisticated DP transmitter provided with the process fluid's characteristics combined with a temperature and line pressure measurement can very precisely measure mass or volume. Such a transmitter can go through the calculation routines 20 times or more per second to ensure a true real-time measurement.

Where does cost come in? The type of DP flowmeter described performs the function


Figure 3. A HART interface extracts the extra variables and presents them as if each were coming from a discrete point.


Figure 4. A WirelessHART adapter can send multiple variables via the wireless network without affecting the primary wired I/O connection.

of several individual instruments: a DP-producing element such as an orifice plate, a DP transmitter, a gauge or absolute transmitter, a temperature transmitter, and a flow computer. Using a single, multivariable DP flowmeter with its sophisticated transmitter and ancillary measurements eliminates the need to install all these additional devices, at least in most situations.

Some process engineers may be reluctant to use a secondary variable for a critical measurement. For example, the DP flowmeter can provide its own temperature reading, but perhaps not with an update rate as fast as a stand-alone temperature sensor and transmitter. Of course, it is probably a small number of situations where temperature changes occur so rapidly, and if a critical loop is based on temperature, it will certainly require its own instrument.

## Practicality of additional measurements

The practicality of using the extra measurements as part of a larger process automation strategy will depend on how they are extracted. The DP flowmeter has access to the measurements we have already mentioned—along with any additional information, such as fluid density characteristics and line size, embedded in the configuration. The transmitter uses this information constantly for its own internal calculations.

If the DP flowmeter or any other type of multivariable instrument is used in a Foundation Fieldbus or HART-enabled I/O environment, capturing the additional data is very simple. The distributed control system (DCS) simply needs to be programmed to access the data and on how to use it in larger control efforts.

In a conventional analog I/O environment, accessing the extra functions and variables is more complicated. HART multiplexers tend to take a long time to cycle through all the transmitters they service, so the additional readings will not have a fast update rate. A HART interface (figure 3) can work with a single multivariable instrument, breaking out the additional readings and turning them into separate 4–20 mA signals. This works well, but the DCS has to treat them as separate tags just like individual instruments, adding to wiring costs.

WirelessHART may be the best approach for retrofits in a simple wired I/O environment, or for new installations. Many plants now have WirelessHART networks operating for a variety of purposes and adding an adapter (figure 4) to a DP flowmeter is a simple matter. It can then send all its data through the network to any point in larger systems where it needs to be used. No additional wired I/O slots are necessary.

## Advantages of multivariable instruments

Today's multivariable instruments are possible thanks to advances in transmitter electronics. The little circuit board inside the housing is truly a powerful computer able to perform calculations with remarkable speed. When applied to DP flowmeters, these capabilities provide exceptional accuracy across a huge range of fluid types and characteristics.

Where useful, secondary variables can deliver process information without additional instruments or process penetrations. This double benefit of performance and cost advantages can help optimize the process while reducing the cost of gathering the data necessary for effective decision making. ■

ABOUT THE AUTHOR

**Connor Oberle** (www.linkedin.com/in/connoroberle) is a global pressure product manager for Emerson Automation Solutions in Shakopee, Minn., responsible for Rosemount™ MultiVariable™ transmitters. He has a BS in mechanical engineering from the University of North Dakota.

# Digital transformation creates new opportunities for system integrators

By Jose M. Rivera

There is limited value in discerning between smart industry, Industrial Internet of Things (IIoT), Industry 4.0, digitalization, and digital transformation, to name a few trendy terms. They are all pulling in the same direction and represent a powerful disruptive force. These initiatives are much more than a mere technology play. Technology is important and a key enabler, but only one of the several complexities to be addressed to achieve success. Viewing these concepts as buzzwords or as an effort to place new labels on past concepts comes with the grave risk of missing immense opportunities.

All you have to do is look around you to see the disruption—the use of mobile smart devices, connectivity, and new business models has exploded. Uber and Lyft have disrupted the taxi industry, while Airbnb is giving the lodging industry a run for its money.

Manufacturing digital transformation is not far behind; in fact, many industry experts tell you it is well under way. Digital transformation creates an enticing proposition for manufacturers; leaders among them understand that this is vital for their survival. Some are planning their initiative, starting their journey, or scaling pilot programs. Most have struggled, because the transformation collides with cultural (organization), technological, and application complexities that may not have been properly addressed.

This digital transformation will, in turn, disrupt system integrators (SIs). Their ways of adding value will evolve into new areas, creating three basic segments: product-centric SIs, solution-centric SIs, and transformation-centric SIs.

## Product-centric SIs

For product-centric SIs, ingenuity and deep product knowledge are paramount and, most likely, their value proposition to date. They often bridge platforms from various vendors to deliver solutions that manufacturers demand. On its own, this is a big accomplishment. Although this core function is still valuable today, standardization and smart tools are simplifying and automating the process and reducing the value-add at this level. On the other hand, the solution scope delivered by SIs is growing to meet the demand for ever-more interconnected systems. This, in turn, increases the need for more comprehensive cybersecurity systems. New technologies come into the mix and need to be mastered. All of this means SIs will be kept busy.

## Solution-centric SIs

Next are the solution-centric SIs. From the perspective of their manufacturing clients, the value added by the SIs grows with the expertise in their vertical and, sometimes, in a specific application within that vertical. New technology, e.g., digital twins, requires not only mastering the tool and the approach, but also gaining a deep understanding of the client's underlying assets and applications. When SIs are regarded as the experts, they become trusted advisors to their clients, and their involvement can start earlier in the process. Geographical proximity, important in the past, becomes secondary.

## Transformation-centric SIs

Digital transformation brings the opportunity for value creation to a new level. SIs can use their solid technical and vertical application expertise to complement a front-end consulting engagement that also tackles the other complexities, particularly those related to the human element (culture and organization). This creates immense value to those manufacturers joining the digital transformation. These are brand new areas of expertise for SIs. To achieve this level, many SIs will turn to partnerships or outright acquisitions to complement their capabilities. The information technology/operational technology (IT/OT) convergence could also take place at the system integrator level. In December 2015, Accenture (IT SI) closed its acquisition of Cimation, an OT SI in oil and gas, pipeline, chemicals, metals, and mining. Similar deals could become more common.

By successfully delivering on the digital transformation opportunity, SIs can address several of their own current challenges:

- core business commoditization and competition from equipment vendors
- thinning tech pool at manufacturers and frequent changes in their organization affecting established relationships
- competing market entrants (e.g., IT) to the acquisition, development, and retainment of talent, increasing pressure on wages

Digital transformation gives SIs the following options:

- Stay ahead of the curve to create differentiation.
- Develop stronger links to manufacturers through deeper expertise and ongoing services.
- Offer new and valuable business models that reduce plant capital expenditure and demand on the client's thinning tech pool.
- Update their culture, work environment, and pay grade to attract and retain next-generation talent.

The need to support manufacturers in their digital transformation is real. Those SIs able to do this will have an immense opportunity and competitive advantage in the coming years. Will SIs step up and seize this opportunity? This challenge comes at a time when business for SIs in the U.S. has been very strong. More than half of Control System Integrators Association (CSIA) members indicated that their current order activity was somewhat or significantly stronger compared to six months ago, according to a survey of CSIA members in the spring and fall of 2018 conducted by the CSIA and JP Morgan. In a less formal survey on business sentiment from December

*Continued on p. 46*

*Continued from p. 45*

2018, 92 percent of participating CSIA SIs reported "things are looking good," while only 8 percent "saw trouble ahead."

Clearly, SIs in the U.S. are busy with their current, conventional business approach. Digital transformation requires diverting some of the thinly stretched resources to develop new capabilities—not an easy request. This is the classic tradeoff between focusing on today versus investing for tomorrow.

Throughout their history, SIs have adapted to important technological changes and gone on to thrive. This time will be no different. I am confident that forward-thinking SIs will take advantage of this unique opportunity and create a sustainable competitive advantage. Whether it is through partnerships, mergers, or some other means, these SIs will raise the bar for the entire SI industry. Some SIs will follow; others will never change and continue to deliver their traditional approach to a contracting market.

As the CEO of CSIA, I strive to maximize the number of SIs pursuing and thriving in the opportunity provided by digital transformation. This way, CSIA can achieve its mission to advance the control system integration industry for the benefit of its members and their manufacturing clients. ■

### ABOUT THE AUTHOR

**Jose M. Rivera** (ceo@controlsys.org) is the CEO of CSIA. His career in the automation industry, which includes Emerson, Schneider, and Siemens, has spanned six countries, most often with regional or global leadership roles. Rivera has an MBA from Kellogg School of Management at Northwestern University, and Lic (MS) and BS degrees in electrical engineering from the University of Costa Rica.

Founded in 1994, CSIA (www.controlsys.org) is a not-for-profit professional association of more than 500-member companies in 40 countries advancing the industry of control system integration.

# Biogas flowmeter


The thermal mass ST51A biogas flowmeter is designed specifically for dirty, potentially hazardous biogas processes. It gives system operators an accurate and repeatable mass flow measurement to facilitate system control, log gas production data, and provide mandated safety and environmental reporting information.

To survive in biogas processes, the ST51 flowmeter comes standard with 316 stainless-steel body construction and Hastelloy-C22 thermal sensors. It has no moving parts and is nonclogging, which eliminates the need for constant cleaning in wet, dirty biogas conditions. The ST51A meter comes with full global Division 1, Zone 1, Ex safety approvals.

The meter's electronics are housed in a durable NEMA 4X, IP67 dust/water ingress-protected and all-metal (aluminum or 316L stainless-steel) enclosure with dual conduit ports in either NPT or M20 threading. The transmitter can be integrally mounted with the flow element (probe) or can be remote-mounted for installation flexibility. The instrument comes standard with dual 4–20 mA, NAMUR NE43 compliant outputs and a 500-Hz pulse output.

The model adds digital communications via the HART, Version 7, protocol. It provides plant staff with digital data on flow rate and temperature parameters, the instrument's health, fault diagnostics, and asset management information. It can also make field configuration changes if needed by using standard HART portable communicators.

**FCI, www.fluidcomponents.com**

# Profinet interface


The IN-FLOW mass flowmeters and controllers are made according to IP65 (i.e., dust- and waterproof). The instruments are available for flow ranges from 0.05-1 mln/min up to 200-10000 $m^3/h$ air-equivalent. In addition to the optional ATEX approval for use in Category 3, Zone 2 hazardous areas, the series is now offered with FM approval for Class I, Division 2, which is important in North America.

A Profinet fieldbus interface is also available on the company's industrial mass flowmeters and controllers for gases (for this new fieldbus, the FM and ATEX approvals are pending). The flexible architecture with its scope of functions enables machine automation: maximum performance and precision, flexible address assignment and modular design, fast commissioning thanks to open access, and defined interfaces and optimal diagnostics of devices and the network.

**Bronkhorst, www.bronkhorst.com**

# Laminar flow sensor

The EE660, designed for laminar flow monitoring and clean room applications, measures low air velocity. The transmitter is now also available with an RS485 interface. The EE660 is suitable for measurement of low air velocity down to 0.15 m/s (30 ft/min). It features an E+E hot film sensing element. Furthermore, the sensing element is resistant to contamination and has a low angular dependency.

In addition to current and voltage outputs, the device now has an RS485 interface with Modbus RTU or BACnet MS/TP protocol, which allows for integration into a bus system. The EE660 is available for duct mount or with remote probe. The enclosure with external mounting holes facilitates installation with a closed cover. The measured data is also available on the optional display. Backlight and 180° rotatability allow reading in any mounting conditions.

The EE660 is user configurable with jumpers on the electronics board or via software. The adjustment and the display setup can be performed with an optional configuration adapter and the free EE-PCS product configuration software.

**E+E Elektronik, www.epluse.com/en**


# Flow sensors


The company's flow switches alert users to potential failures due to a reduction in necessary fluid flow. The recently released BFF series of flow sensors, which are available in both thread-in and inline versions, provide a switching output that is activated when the flow falls below a user-defined rate. This makes it possible to notify users of system problems, such as the failure of a pumping system, a clogged filter, or leaks, before they cause critical issues or system shutdowns.

The completely solid-state calorimetric sensing technology measures temperature differential on each side of the sensing probe and has no moving parts. They are resistant to failures caused by dirt or foreign object buildup. The devices also have continual flow monitoring and visual display of flow with integrated light-emitting diodes.

The BFF series of flow sensors complement the company's existing line of temperature sensors and are an addition to the line of process-oriented sensor products.

**Balluff, www.balluff.com**

# Coriolis mass flowmeter

The Promass A flowmeter measures substances drop for drop. The flowmeter measures values with repeatability, even in cases where process and ambient conditions fluctuate. The measuring device is suited for installation, for example, in modular process facilities and skids.

The sensor system is mounted on a base plate that acts as a "shock absorber," effectively shielding the Coriolis measurement from outside interference, such as from pipe vibrations. Other contributing factors are the oscillation frequency of the measuring tube and its completely balanced oscillation behavior. At a specified maximum measured error of ±0.1 percent, high-precision measurements down to 8 g/min are possible, or—if the maximum error is permitted to be ±1 percent—even a quantity of less than 1 g/min can be measured.

Because of the variety of device options, such as nominal diameter, material, process connection, certification, transmitter type, or degree of protection, Promass A can be used in numerous applications. It is a small measuring device with a nominal diameter DN 1 (1/24"), so the flowmeter can also be installed in extremely tight spaces, such as in skids. A multitude of process connections are available, such as flanges, lap joint flanges, couplings, internal threads or Tri-Clamps. The flowmeter can be used at process temperatures between –50 and +205°C (–58 and +401°F).

**Endress+Hauser, www.us.endress.com**

# Process flowmeter

The Rosemount 9295 helps end users streamline procurement, installation, operation, and maintenance. Design and purchasing consists of specifying and buying one assembly. Most field welding, cutting, fabrication, and other tasks are not required, because all components are fully assembled and leak checked. The Rosemount 9295 is a single assembly, but individual components can be replaced while it is in service.

This integrated DP flowmeter assembly withstands the challenging environments and piping requirements found in refineries, chemical processing, and other heavy industrial plants. The device also has a welded spool section for drop-in installation, an all-welded design that meets piping requirements for hydrocarbon applications, roddable impulse lines for removal of impulse line blockages without shutting down the process, optional integral RTD for critical temperature reading to assist mass flow calculations, dual-tap configurations that support fully redundant DP transmitter assemblies for safety instrumented systems, and isolation valves that meet API 602 requirements and are designed to operate through years of continuous service. The flowmeter uses the Rosemount 3051S DP transmitter to deliver flow readings and device diagnostic information via HART.

**Emerson, www.emerson.com**

*InTech* advertisers are pleased to provide additional information about their products and services. To obtain further information, please contact the advertiser using the contact information contained in their ads or the Web address shown here.





## Contact *InTech* today:


**Richard T. Simpson**
Advertising Sales Representative
Phone: +1 919-414-7395
Email: rsimpson@automation.com

**Chris Nelson**
Advertising Sales Representative
Phone: +1 612-508-8593
Email: chris@automation.com

**Kelly Winberg**
Advertising, Classifieds Section
Phone: +1 267-718-8197
Email: kwinberg@comcast.net

**Chris Hayworth**
Advertising Materials Coordinator
Phone: +1 919-990-9435
Email: chayworth@ISA.org


View and download the InTech media planner at **www.isa.org/intechadkit**

## Reprints

**Foster Reprints** will work with you to create a customized reprint package, including hard copy reprints, eprints, and mobile-friendly products.

Contact Jill Kaletha at 219-878-6068 or jillk@fosterprinting.com.

## 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.

### USB HART MODEM

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.

It is the lowest cost USB Modem certified by the FieldComm Group to meet the HART communication specifications.

**ProComSol, Ltd,** Process Communications Solutions
Tel. 216.221.1550; Fax 216.221.1554
**sales@procomsol.com; www.procomsol.com**
Toll Free 877.221.1551



## Sample of Jobs Available at Jobs.isa.org

*See more at Jobs.isa.org, where you can search for available jobs or advertise positions available within your company. ISA Members post resumes at no charge.*

### Senior process engineer

Pacira Pharmaceuticals: The successful senior process engineer will provide technical support to operations, automation, facilities engineering, product development, quality, and regulatory affairs. The engineer will focus on leading projects for improving and optimizing operations through implementing new technology. A minimum of 25 percent travel from San Diego is required based on project timelines. The position also requires at least 10 years of relevant cGMP and technical experience and a BS in engineering. Knowledge of Bulk, Fill, CIP, and SIP processes is preferred . . . see more at Jobs.isa.org.

### Senior scientist technical transfer

Translate Bio: This Lexington, Mass., company is seeking a highly motivated and scientifically rigorous individual to join the CMC team. The scientist will focus on drug substance and drug product manufacture and on regulatory and analytical support (including development, validation, and data review) for drug substances and products. He or she will assist in the development of scalable and robust formulation processes for drug substance and drug products in addition to serving as the process knowledge link between process development and manufacturing. The position requires a BS in chemistry, biochemistry, or chemical engineering with 10 or more years of experience. A master's degree with six or more years of experience is preferred . . . see more at Jobs.isa.org.

### Strategic sourcing lead

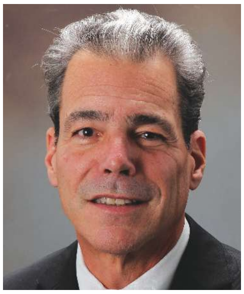
Polaris Industry Inc.: The strategic sourcing lead in Minneapolis, Minn., is responsible for strategy development and implementation for assigned categories in alignment with the broader commodity strategy. The lead will manage the supply base to ensure all suppliers meet the priorities of delivery, quality, new product integration, and cost competitiveness. He or she will also lead cross-function teams. A bachelor's degree in supply chain, business administration, or a technical area; six or more years of purchasing or relevant experience; a proven track record of strong leadership; and a high level of critical thinking and analysis is required. APICS CPIM or ISM CPM/APP is desired . . . see more at Jobs.isa.org.

### Cybersecurity threat analyst

HP: The cybersecurity threat intelligence analyst, located in Austin, Texas, is charged with advancing our knowledge of adversary intent, opportunity, and capability to cause harm to the company's global business. The analyst is responsible for the collection, analysis, and dissemination of intelligence, enabling internal cybersecurity teams to focus their prevention efforts and the business to make better decisions. An extensive knowledge of standards of intelligence collection and analysis tradecraft; experience tracking and reporting on cyberespionage, crime, and malicious cyberactors; extensive knowledge of standard signature and information-sharing data formats and exchange protocols; and familiarity with automation concepts and proficiency in scripting languages such as Python, Perl, Ruby, and JavaScript are required. The position also requires a BS or higher in computer science or information security and five or more years of experience in a cybersecurity function . . . see more at Jobs.isa.org.

# Evolve or become irrelevant

By Paul Gruhn, PE, CFSE



**ABOUT THE AUTHOR**
**Paul Gruhn, PE, CFSE** (paul.gruhn@aesolns.com), is the 2019 ISA society president and a global functional safety consultant with aeSolutions in Houston, Texas.

No one likes change, yet change is inevitable. The noted quality guru W. Edwards Deming was known for saying, "It is not necessary to change. Survival is not mandatory."

There is no doubt that change is disruptive and often painful. Some people complain that automation is displacing workers. It has for hundreds of years. The printing press did away with scribes, who could then move on to bigger and better things. Factory robots have done away with jobs, but the same thing happened in the first industrial revolution long ago. Did those displaced workers not move on to bigger and better things? The automobile did away with an entire industry that had to pick up and dispose of horse "products." And how many people wanting to remain in that job might have fought against the automobile? Automation simply moves people into new and better-paying roles.

The only constant in life is change. Many have written that we cannot even think of most of the jobs, products, or services that will exist in 20 years. So just how does one know what service, product, or organizational structure to develop or change?

**ISA's vision and mission statements were updated last year. I believe they will help guide us in the future and help us remain relevant. Our vision statement is: "Create a better world through automation." Who wouldn't want to be part of that?**

Customers do not always know what they want or what they might need in the future. People once could not conceive of—let alone ask for—the automobile, airplane, television, personal computer, iPhone, or programmable logic controller. Surveys will not always reveal such desires, either. Henry Ford said that if he had asked people what they wanted, they would have said "a faster horse." (Well, that is essentially what he gave them!)

Yet ISA, like any organization, must be data driven in order to understand its markets and the interests of its members and customers. We cannot simply rely on the whims or personal opinions of leaders. What one leader may consider important, another may consider irrelevant, and neither may be of real interest to actual industry professionals. Also, what a professional with two years of experience wants is different than what a professional with twenty years of experience wants. What an employer wants may be different than what an employee wants.

ISA has been evolving continuously since its inception in 1945. Our leaders have not always agreed over the years. Early on, there was not complete agreement regarding the composition of the society, the requirements for membership, or on holding an annual exhibit. In the late 1960s, six long-range planning committees published a 300-page report with hundreds of recommendations on ISA's future direction. All in an effort to remain relevant. It is the same today.

ISA's vision and mission statements were updated last year. I believe they will help guide us in the future and help us remain relevant. Our vision statement is: "Create a better world through automation." Who wouldn't want to be part of that? Our mission statement is: "Advance technical competence by connecting the automation community to achieve operational excellence." We are advancing people's knowledge to help companies be more successful. What employer wouldn't be interested in that? But how will we accomplish that?

An organization's high-level strategies should not change year after year. It is better to have one five-year plan than five one-year plans. ISA's Executive Board sets ISA's strategic direction. Our high-level strategic priorities are to: (1) be recognized as a standards authority, (2) be the global source for automation, (3) go through a content and digital transformation, (4) further education advocacy, and (5) review our governance and leadership culture. I doubt anyone would question the appropriateness of those goals. They do line up with our vision and mission statements.

The question then becomes what specific programs and actions will we put in place to accomplish those goals? Some of the programs we are discussing and fleshing out to accomplish our priorities are: (1) market awareness and sponsorship, (2) membership development and engagement, (3) technical education and certification, and (4) leadership and professional development. The Executive Board has broken into four smaller working groups to address these issues. We are working to make these programs and goals specific, measurable, and timely. These working groups will include other society leaders as needed. After all, we're all in this together.

If you care about the society, where it is going, and how it can better help you and your employer accomplish your goals, please get involved. After all, the world is run by people who show up. Don't abdicate your responsibility to others. ■

March/April 2019

# InTech®

A PUBLICATION OF THE INTERNATIONAL SOCIETY OF AUTOMATION

Process analytical technology

Machine control

Plantwide wireless

RAMI 4.0

Flow spotlight


*Setting the Standard for Automation™*

www.isa.org/intech

The #1 Value in Automation
AUTOMATIONDIRECT.com
1-800-633-0405
WARNING! SEPARATOR TANK 2 OVERFILL
P2-550 CPU
P2-16NE3
GET MORE THAN YOU PAY FOR... FROM AUTOMATIONDIRECT.COM
FREE shipping - orders over $49
2-day Shipping
Order Today, Ships Today
30-day Money-Back Guarantee
30 day
FREE Technical Support
Located in USA
FREE software and manuals
Voted Best in Service - 15 years straight
VOTED Best in SERVICE 15 YEARS
99.7% of orders ship complete same day

# AutomationDirect: much more than just a ".com"

AutomationDirect is a non-traditional industrial controls company using the best ideas from the consumer world to serve the automation market. Because of that approach, we can deliver quality products to you for much less than traditional suppliers. See below . . .

## AutomationDirect.com HQ, Developmen


## You need quality products at great prices.

Since 1994 our prices have been typically 50% less than traditional suppliers.

| Product | AutomationDirect Price/Part Number | VS. | Competitor Price/Part Number |
|---|---|---|---|
| Proximity sensor, 18 mm, 3-wire PNP DC shielded, with quick disconnect | $14.50 PBK-AP-1H | | $89.04 A-B 872C-D5NP18-D4 |
| AC Drive, 5 hp, 460V | $416.00 GS2-45P0 | | $1,627.50 A-B 22B-D010N104 |
| NEMA 12 Enclosure, steel, wallmount (20" x 16" x 8") | $256.00 N12201608 | | $459.11 Hoffman A-201608LP |

*All prices are U.S. published prices, subject to change without notice. AutomationDirect prices as of 12/19/2018. Hoffman prices are taken from www.alliedelec.com 11/21/2018. Allen-Bradley prices are taken from www.wernerelectric.com 11/21/2018. Prices may vary by dealer. Many other part numbers are available from vendors.

For decades we've been offering a better value on industrial controls by running our business efficiently and passing the savings on to our customers.

www.AutomationDirect.com/price

## You don't want to wait for your order.

FREE shipping - orders over $49

We have same-day shipping, it's even FREE if your order is over $49.*

AutomationDirect has always maintained a huge inventory, allowing us to ship 97.5% of orders complete the same day.

*Order over $49, and get free 2-day (transit) shipping within the U.S. and Puerto Rico. (Certain restrictions apply; Canadian orders may take longer based on destination)

## You want to be confident you're buying quality products.

30-day Money-Back Guarantee

We stand behind our products and guarantee your satisfaction.

We want you to be pleased with every order. That's why we offer a 30-day money-back guarantee on almost every stock product we sell, including our software. (See Terms and Conditions online for exclusions.)

## You insist on getting and you want it FREE

Voted Best in Service - 15 years straight

Our technical support ha voted best in service for in a row. And it won't cos

Many independent industry magazine reader surv the top of their lists for service. In Control Design m tops in service for multiple product categories fifte

www.AutomationDirect.com/service

## You want complete p to make the right pu

FREE software and manuals

We have FREE documen of FREE videos, FREE soft FREE CAD drawings avai

Whether you're deciding on purchasing our proc you buy, why should you have to pay for the ma

**Download the manuals - no purchase necessa**

We have **hundreds of videos online** for you to g and learn about our products. When shopping on looking at has video, it will be available right there

We also provide FREE online PLC training to anyo interested in learning about industrial control. A **www.automationdirect.com/plc-training**

Programming software for a complex product ca help you out by offering **FREE fully enabled sof** popular products, including the Do-more PLCs, P CLICK PLCs and C-more Micro HMI. No license or and **our support is free too**!

In addition to software and documentation onlin **drawings** for the majority of our product lines.

www.AutomationDirect.com/support

**99.7% of orders ship comp**
**See for yourself at www.Auto**

## nt Center and Warehouses

ouses

d about 45 minutes north of Atlanta, GA, USA. r sales and technical support teams, purchasing, e our huge warehouses and speedy logistics team.

## better service E.

as been 15 years st you a cent!


eys have placed us at nagazine alone, we've been voted en years in a row.

## product information rchase decision.

tation, hundreds ware, and lable 24/7 online.

ducts or learning our products after nuals? That doesn't make sense.

**ry.**

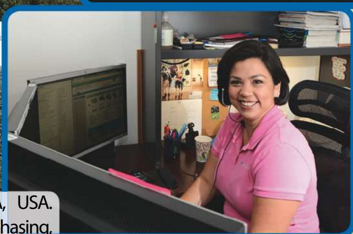
et up to speed quickly line, if a product you're e for you to view.

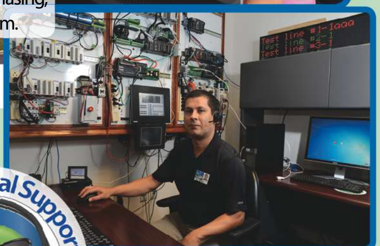
one vailable 24/7:

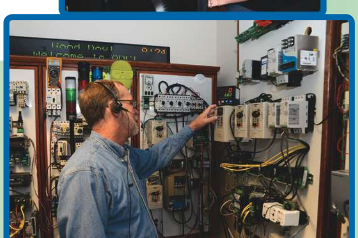

n be costly, so we try to **ftware** for a number of our most Productivity series controllers, upgrade fees to deal with,

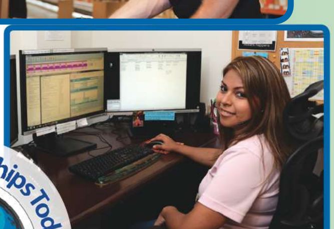
ne, we have **FREE CAD**


**plete same day!**
**omationDirect.com**









# This ".com" is powered by ".awesomepeople"!

For over twenty years our sole focus has been customer service. That takes many forms: great prices, fast delivery, and quality products. But regardless of our product selection and other tangibles like pricing, the intangible value of customer service is something that cannot be faked, automated or glossed over.

Our team members here at AutomationDirect.com approach every day with this one goal in mind - serve the customer. It's a simple philosophy that many companies forget or make too complex and fail. If the answer to any decision is **"Yes, this is good for our customers"**, then we do it.

### It's common sense.

**"Should we have real upfront pricing online and realtime stock availability?**
Yes, this is good for our customers."

**"Should we have FREE tech support before, during, and after any sale instead of charging yearly fees for tech support?**
Yes, this is good for our customers."

**"Should we offer FREE software on many products instead of charging licensing fees?**
Yes, this is good for our customers."

**"Should we have all our documentation online for FREE so people can access anytime, even before they choose to purchase?**
Yes, this is good for our customers."

**"Should we offer more selection by consistently introducing more new quality products with great prices monthly, sometimes weekly?**
Yes, this is good for our customers."

**"Should we offer FREE shipping for orders over $49?**
Yes, this is good for our customers."

**"Should we be fiscally responsible and run an efficient business so customers can rely on us decade after decade after decade?**
Yes, this is good for our customers."

All these are discussions we've had internally and all have had certain aspects of "can we do that?", "that will be hard to accomplish", "no one else is doing that, how can we?". But if you bring it back to the simple answer, "Yes, this is good for our customers", then the perceived obstacles really don't matter.

Our company has evolved dramatically since 1994 and it's this type of decision making by all our team members over the years that keeps our customers coming back and new customers checking us out daily.

If you're a current customer, we sincerely thank you for your business. We wouldn't be here if it wasn't for you and promise to do our best for you every day. If you're new and checking us out for the first time, we hope you give us an opportunity to serve you.

AUTOMATIONDIRECT.com