Engineering Leaders Under 40, p.30

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SEPTEMBER 2018

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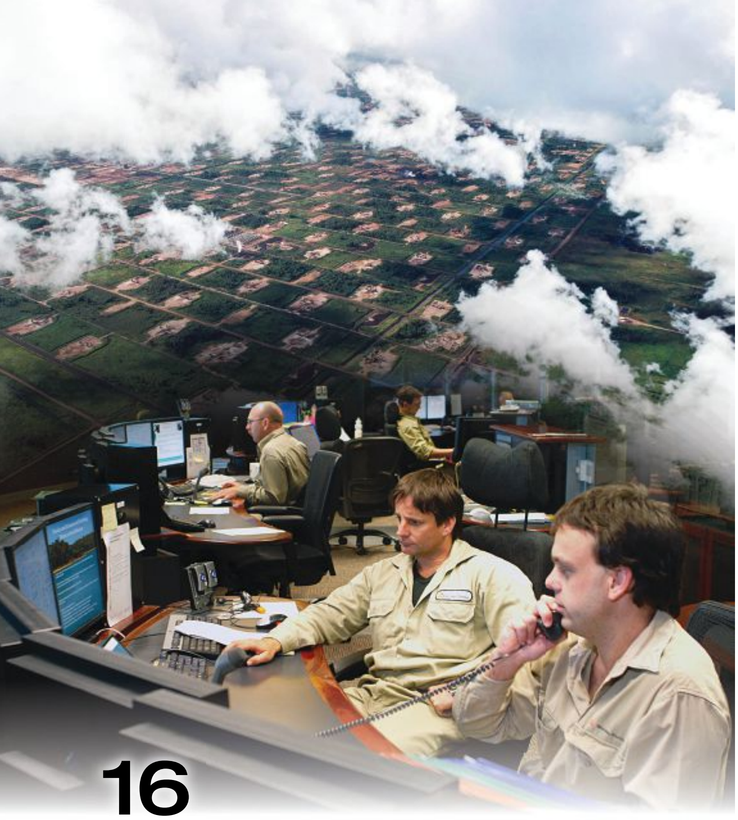



**COVER IMAGE:** Automation and control systems must be more flexible and agile. An on-process production system for remote SCADA applications where the user wants to monitor and/or control geographically dispersed assets. A virtual engineering plant provides an off-process way to develop, test, and validate the process control system. It helps process or control engineers improve or add to an existing SCADA or control system. Courtesy: Honeywell Process Solutions

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## ANSWERS



## INSIGHTS



## INNOVATIONS



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# INSIGHTS
RESEARCH

2018 PROGRAMMABLE CONTROLLERS STUDY:

## Five industrial controller findings

The *Control Engineering* 2018 Programmable Controller Software & Hardware Study showed what end users expect and how they purchase or specify industrial controller software and hardware.

**1. Usage of industrial controller software, hardware:** Programmable controller software or hardware is most commonly used for continuous manufacturing (24%), discrete and continuous manufacturing (23%), or continuous and batch manufacturing purposes (20%).

**2. Applications:** 63% of end users already use industrial controllers to help with remote monitoring tasks; another 54% use these products for maintenance, 41% for simulations, and 25% as a mobile interface for alarming.

**3. Justifications:** The top situations in which end users purchase new industrial controller software and/or hardware are an automation upgrade (68%), a new installation (53%), and an operations/engineering upgrade (40%).

**4. Cybersecurity:** 71% of respondents reported that their companies restrict access to controllers in an effort to protect these devices; 55% have increased password protection procedures.

**5. Looking ahead:** 82% of end users expect to buy industrial controller software or hardware in the next 12 months; end users expect to use/purchase an average of 21 industrial controllers in this time. **ce**

*View additional findings at www.controleng.com/2018ControllersReport.*
***Amanda Pelliccione** is the research director at CFE Media, apelliccione@cfemedia.com.*

**More RESEARCH**

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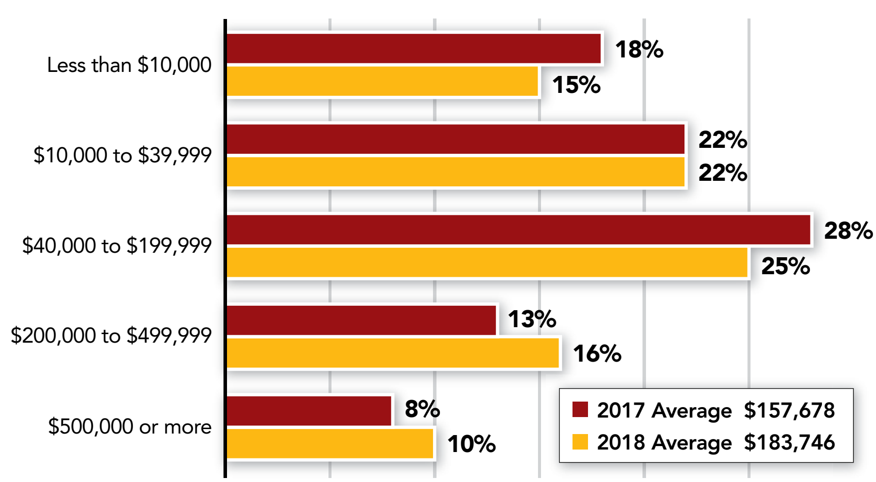
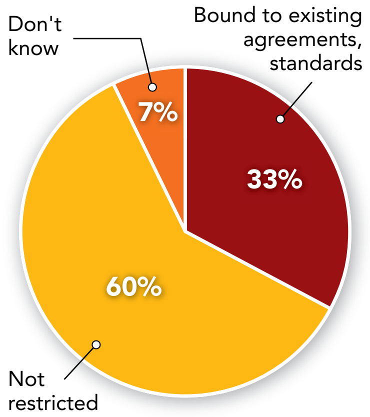
### Annual spend on controller hardware, software




**Over the past 12 months, the average respondent's company was estimated to have been spent $184,000 on industrial controller software and hardware—an increase of 17% over 2017 data. Source: *Control Engineering***

### HMI software, hardware purchases




One-third of end users are bound to existing purchase agreements or company standards when buying HMI/SCADA software or hardware. Source: *Control Engineering* 2018 HMI Software & Hardware Study

**$10,091:** The average non-salary (bonus, profit sharing, etc.) compensation received by end users in 2017. Source: *Control Engineering* 2018 Career & Salary Study

**75%** of end users' industrial controllers use the 4-20 mA/0-10 V dc communications protocol. Source: *Control Engineering* 2018 Programmable Controllers Study

**71%** of end users agree that accurate positioning is highly important when evaluating servo and/or stepper drives. Source: *Control Engineering* 2017 Motor Drives Study

### More research

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All reports are available at www.controleng.com/ce-research.

**Brian Clifford,** Faegre Baker Daniels

# Avoid engineering litigation 5 ways

Remember, it could be worse: To avoid engineering-related litigation, consider these five alternative dispute resolution mechanisms.

An actual or threatened claim by a customer is always bad news, but the good news is very few disputes rise to the level where a court battle makes much sense. But system integrators know long-term success and growth means that, eventually, some disputes will arise that need to be resolved.

A customer may have an issue with the quality of work performed, or may quarrel over whether call-back services should be billed at normal support rates or should be covered by a warranty. A subcontractor or supplier may object to delivery requirements or schedules, or may contest the scope of work included in a fixed-price order. There may be unpaid amounts that seemed to be properly invoiced.

“**A fresh set of eyes** can break through the emotional frustration associated with many disagreements.”

When a disagreement must be settled, several mechanisms can be used to keep everyone away from the courthouse:

**1. Direct negotiations:** When the project team members have reached an impasse, a solution can often be found by escalating the discussions to the executive level. A fresh set of eyes can break through the emotional frustration associated with many disagreements. The executives may have a better opportunity to take “the long view” of the parties’ business relationship and their strategic vision for the future—not just one invoice or one deliverable.

**2. Initial decision-maker:** For long-term projects, it can make sense to appoint a neutral third-party at the start of the work. This person can give the parties a quick, unbiased decision on their respective positions in the event of a future dispute. Choosing someone with experience in the control systems industry can save time and allow for a more credible early decision. If either party is unhappy with the determination of the initial decision-maker, more formal proceedings can be initiated.

**3. Dispute review boards:** A take-off on the initial decision-maker concept, a dispute review board (DRB) is a panel (generally) made up of industry professionals and established at the start of a large-scale, long-term project. The DRB can make timely (either non-binding or binding at the parties’ option) decisions on all claims that may arise during the complex project. Since it is unbiased and experienced in the relevant field, its decisions are often accepted by the parties as a fair resolution of the dispute.

**4. Mediation:** Professional mediators—who are often, but not always, attorneys—have long been successful in getting parties to bridge the gap between positions and in resolving claims through voluntary settlement. Usually through a process of shuttle diplomacy, mediators can point out the strengths and weaknesses in each of the parties’ arguments in a confidential setting in an effort to reach a mutually-agreeable resolution.

**5. Arbitration:** Arbitration is not too different from litigation. It involves appointing a person or a panel—commonly attorneys with experience in litigation in the relevant field—that the parties agree is empowered to make a binding decision on a claim. Arbitration rulings generally can be enforced like a court order and are not appealable.

Compared to litigation, arbitration has the advantage of being more customizable—the parties can agree in advance to procedural rules and can appoint an arbitrator who knows their businesses. A judge, on the other hand, may have to handle a criminal trial or a custody dispute in the morning before turning their attention to your case in the afternoon.

The advantages of arbitration come at a cost—arbitrators do not work for free, and the time, money, and effort expended in going through the arbitration process can be very similar to litigation.

Alternative dispute resolution mechanisms have successfully resolved many disputes before the parties truly “made a federal case” out of an issue. To avoid the question of “what happens next” after a dispute arises, include language in the project agreement that sets out a specific dispute resolution process, perhaps using one of these options. **ce**

*Brian Clifford is a partner in the automation and robotics practice of Faegre Baker Daniels. Edited by Mark T. Hoske, content manager,* Control Engineering, *CFE Media, mhoske@cfemedia.com.*

## More INSIGHTS

**KEYWORD: Arbitration**

**Alternative dispute** resolution: binding or not.

**Taking a wider view** often can be an option.

**CONSIDER THIS**

**Do your contracts** name ways to avoid litigation?

**ONLINE**

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**Nate Kay, PE,** MartinCSI

# Understand network security: Public key encryption and industrial automation

Remove unnecessary fear; take a proactive approach to industrial network security.

Public key encryption is used for internet security and is being used increasingly in industrial automation applications.

Most people are familiar with encryption, which essentially involves scrambling data and making meaningful data appear as a random sequence of bits, bytes, or characters.

It is a simple process by which data is encrypted, transmitted, and then decrypted using a shared private key. Because the same key is used to both encrypt and decrypt the data, this is referred to as symmetric key cryptography. Also, since the key is kept hidden from the public, it also is known as private key encryption.

Why not use such a simple and secure method? Because there is a problem with this model. Both the sender and receiver must share a copy of the key. If they are far apart, say halfway around the world, exchanging keys will be difficult.

Of course, the sender could "mail" the receiver a copy of the key, but then someone could intercept that key, make a copy for themselves and start "spying" on the conversation. This is where public key encryption comes into play.

## Public key encryption

To explain public key encryption, consider the example of a letter and a safe.

Let's pretend Alice wants to send Bob a secure letter. She could lock the letter in a safe and send the locked safe to Bob. Bob could then unlock the safe and read the letter. This is essentially symmetric (private key) encryption. However, how can Alice and Bob securely share a copy of the key?

Is there a way Alice can securely send her letter to Bob without exchanging a copy of the key? Sort of. The solution involves creating two keys, a public key which is used only to lock the safe and a private key used to unlock the safe. Continuing the example, Bob takes the unlocked safe and creates two keys, a private key (that he keeps) and a public key (which he gives to Alice). Bob next takes the public key and the empty, unlocked safe and sends them both to Alice. Alice puts her letter in the safe and then uses the public key, that Bob sent, to lock the safe. Alice mails the safe back to Bob, and Bob uses his private key to unlock the safe and read the letter. Suppose someone makes a copy of the public key that Bob sent to Alice. He cannot unlock the safe and read the letter. The public key that Bob gives to Alice can only be used to lock the safe, not unlock it.

## Authentication alternatives

Alice can securely send her letter to Bob regardless of who has access to the public key. What if Charlie intercepts the public key and unlocked safe and pretends to be Alice so that he can send Bob counterfeit information? This is where another benefit of public key encryption comes into play, authentication.

Bob created the private and public keys. However, to illustrate how authentication works, let's take a new example. Bob still creates a private key and a public key. However, Alice also creates her own private key and public key. Next, Bob and Alice exchange their public keys. Alice sends her public key to Bob, who sends his public key to Alice. As before, Bob sends the unlocked safe to Alice. Alice places her letter in the safe and locks it using the public key that Bob provided.

However, this time, Alice does something else. She also takes her own lock, applies it to the safe and locks it using a private key she created. Alice then mails the safe back to Bob. This time, before Bob unlocks the safe with his private key, he first takes the public key that Alice sent to him and tries to remove the lock Alice applied. If Bob can use the public key to remove the lock, which Alice applied and locked using her private key, then Bob knows the letter came from Alice. This process is called authentication. The lock that Alice applied to the safe can be thought of as the signature (see Figure).

More industrial automation equipment is incorporating public key encryption. Additionally, many web

M More INSIGHTS

**KEYWORDS:**
**Encryption, cybersecurity**
**Public key encryption** is helping industrial automation.
**Tutorial explains** how it works.

**ONLINE EXTRA**
See 2 more diagrams, Footnotes 1-3.

**CONSIDER THIS**
**How are your** industrial network communications protected?

**Public key encryption** helps when it comes to selecting secure devices and configuring them.

browser-based SCADA systems are starting to incorporate HTTPS web page support, which also is based on public key encryption.

## Selecting equipment

In the real world how do we create public key cryptography? One method is related to an interesting and very difficult problem in mathematics, factoring large numbers into prime numbers.

As an example, consider the following simple encryption algorithm: $m^e \bmod N = c$ [1]

In this equation m is the message to be encrypted, e is the public key used to encrypt the message, N is the product of two prime numbers ($N = P_1 * P_2$), and c is the encrypted message. In our example Bob selects prime integers $P_1$ and $P_2$, multiplies these to calculate N. He also selects the public key e. Bob then sends e and N to Alice, although he keeps $P_1$ and $P_2$ to himself. Alice plugs in her message m as well as the numbers Bob sent, e and N, into the above equations to generate her encrypted message c, which she sends back to Bob. Once Bob receives the encrypted message c from Alice he just needs to decrypt it using the following equation: $c^d \bmod N = m$ to get the original message back.

In this equation, instead of using the public key e that he sent to Alice he uses his private key d to decrypt the message. If Bob, and only Bob, can figure out what d is, then this will work. It just so happens that d can be computed using Euler's totient function φ(N), where $d * e \equiv k\,\varphi N + 1$[2] The important property of Euler's totient function φ(N) is that it's what is called a trap door function. What this means for our example is that it is easy to calculate $\varphi(P_1 * P_2)$ provided $P_1$ and $P_2$ are known, but it is very difficult to calculate φ(N), if $P_1$ and $P_2$ are not known, but N is. [3]

Someone seeking to decrypt the message may consider taking N (since N is public information that Bob already sent to Alice), factoring N into the two prime numbers $P_1$ and $P_2$ and then decrypting the message. However, it's very time-consuming to factor a large number N into prime numbers. In fact, it's so difficult it is not even practical to solve using super computers. This is where the real power behind public key cryptography lies. Bob can multiple $P_1 * P_2$ to generate the number N which Alice can use to encrypt the message. But it doesn't matter if N is known publicly. Decrypting the message also requires knowledge of $P_1$ and $P_2$. Bob kept those numbers private.

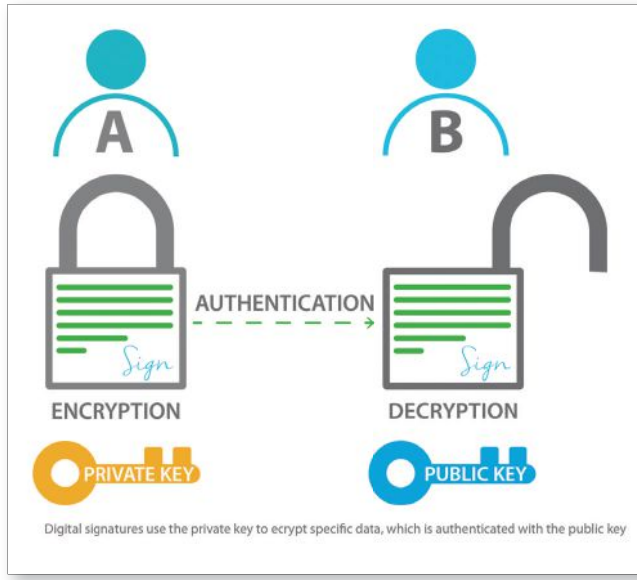
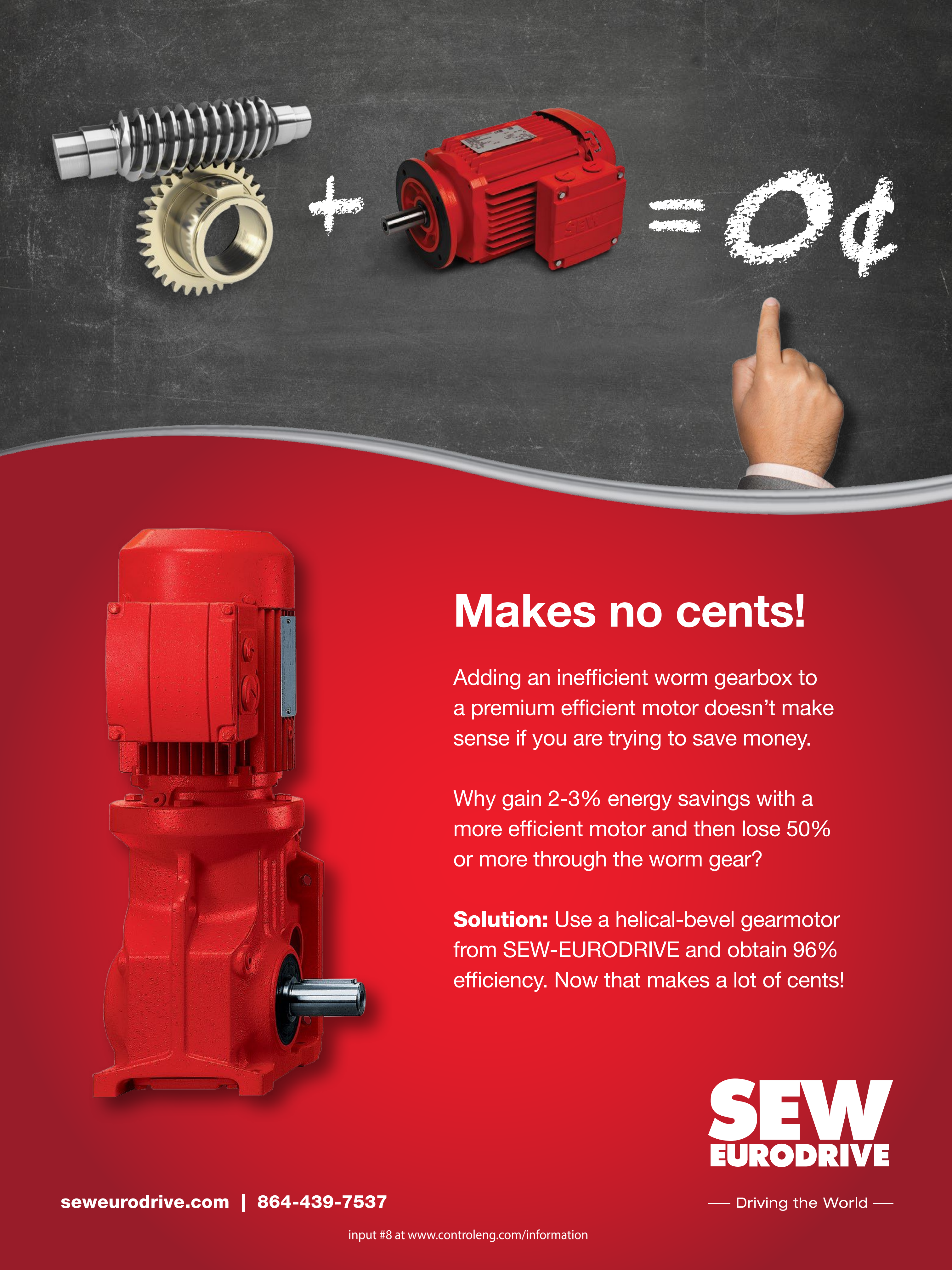



**Figure: Digital signatures use the private key to encrypt specific data, which is authenticated with the public key. Courtesy: MartinCSI**

## Stay secure

An understanding of public key encryption also helps when it comes to selecting secure devices and configuring them. Understanding security helps separate out unnecessary fear. Instead, a more proactive approach can be taken to network security. **ce**

*Nate Kay is a project manager with MartinCSI. Edited by Kevin Parker,* IIoT for Engineers *content manager, kparker@cfemedia.com.*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# Move past customized vendor equipment

A key cause of the high costs, detailed and lengthy processes, and the large number of resources involved in procurement is the customization of vendor standard equipment. This requires detailed specifications; lengthy request for quotation (RFQ) packages; unique proposals from every bidding supplier; detailed and lengthy proposal reviews; new designs developed by the suppliers; multiple recycle of drawings for review and approval by the engineering-procurement-construction (EPC) contractor and the users; modified manufacturing processes; frequent factory inspections; and lengthy factory acceptance tests (FATs) witnessed by the owners and EPC contractors.

While the process has been followed for decades and works by delivering the equipment specified, it also consumes a lot of time and resources, which incurs significant costs and extends the time for delivery of the equipment.

This historical process, however, is not necessary to deliver the necessary goods.

Eliminating the costly and time-consuming customization steps requires every user to sit down with their key suppliers to agree on a set of requirements for design, quality assurance and quality control (QA/QC), and documentation that will become the standard for each supplier. This can include each supplier designing new requirements or the users accepting differences from their historical requirements. This "standardization" process can consume a lot of time of the users and their suppliers, but it is done once and not on every project.

Agreeing on a standard package of features and options with each supplier and equipment can be bid and ordered with completed datasheets and eliminates the need for lengthy specifications. This leads to a much simpler and more streamlined system for all parties.

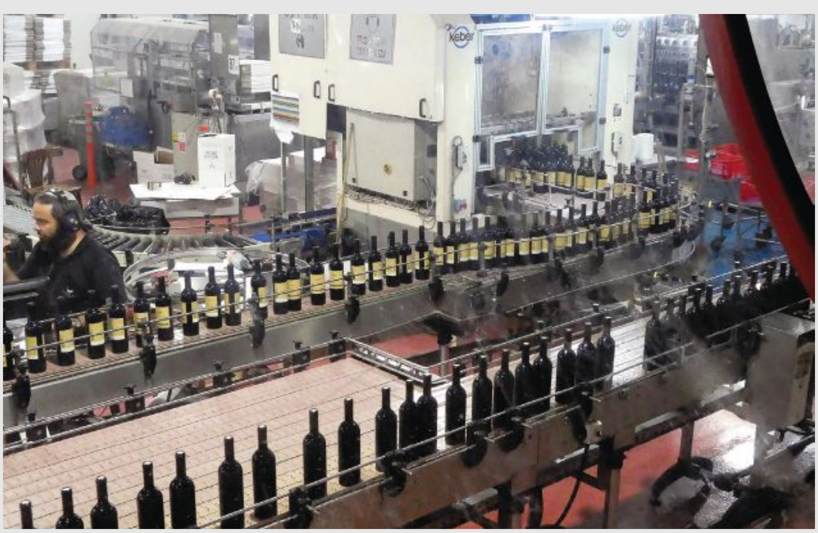
### Procurement saves 30 to 50%

Developing completely standard solutions with key suppliers can reduce the cost of the equipment by 30%, reduce the cost of the necessary engineering by 50%, and shorten the delivery of the equipment by 30 to 40%. The investment of time and resources by the users and the suppliers one time outside of a project to develop the standard vendor solutions will result in significant savings on every project.

***Sandy Vasser*** *is retired from ExxonMobil. Edited by Mark T. Hoske, content manager,* Control Engineering, *CFE Media, mhoske@cfemedia.com*

## Winery automation in northeast Israel

Bottle filling is part of the packaging process in this wine bottling line at Golan Heights Winery (GHW) in Katzrin, Golan Heights, Israel. The tour of the facility featured the winemaking process from aging the wines in barrels in a computer-controlled temperature environment to an automated bottling line. Various brands of packaging systems—a Keber bottling machine, a Kosme adhesive labeler, ABB ac variable-speed drives for powering the conveyor line, and a Yaskawa Motoman robot palletizer—were evident in the plant layout. Image courtesy: Frank J. Bartos



## Artificial intelligence for machine vision

Artificial intelligence (AI) technology is making its way into vision applications in a wide range of industries, expanding on existing capabilities and opening new possibilities in machine vision.

A primary reason for AI use in machine vision systems is the rise of the Industrial Internet of Things (IIoT). The IIoT features machine-to-machine communication in an automated environment dependent upon machine vision to identify a wide range of objects within the factory and throughout the process of the flow of goods.

AI can be used in numerous ways along with vision systems. As mentioned above, inspection applications are some of the first jobs that AI has been profitable in, specifically when leveraging machine learning algorithms for defect detection and classification. The cost of acquiring and labeling large datasets has decreased in the past few years due to advances in IIoT, making machine learning more accessible than ever for inspection applications. AI also is used in vision systems is for continuous improvement in recognition applications.

*This article originally appeared on the AIA website. The AIA is a part of the Association for Advancing Automation (A3), a CFE Media content partner. Edited by Chris Vavra, production editor,* Control Engineering, *cvavra@cfemedia.com.*

# Wireless group expands IoT network, improves power

The Zigbee Alliance announced a certification program designed to create new business opportunities for members and make it easy for new entrants to join the growing ecosystem of certified products that work with major consumer and commercial Internet of Things (IoT) platforms. The program permits members and non-members to adopt, sell, and market certified products under their own brand while maintaining those products' certified status. The program offers an avenue to implement certified products from alliance participant and member companies, and then market those products under their own brand.

The alliance also announced Zigbee PRO 2017 mesh networking technology, which is designed to connect and facilitate interoperability between smart devices. Zigbee PRO is the underlying network technology that supports full-stack interoperable devices certified under Zigbee 3.0. It is capable of operating in two ISM frequency bands simultaneously: sub-GHz 800-900 MHz for regional requirements and 2.4 GHz for global acceptance. This dual-band option enables flexibility and design choice for manufacturers, municipalities, and consumers wanting to connect products across buildings, cities, and homes.

The network specification also provides key advantages including longer range, reduced power consumption, and lower operating costs for low-data-rate applications ranging from home security and automation, to smart metering and connected lighting.

*- Edited from a Zigbee Alliance press release by CFE Media.*

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# Digital advantages for design, automation

Digitalization benefits include speed to market, flexibility, efficiency, consistent quality, cybersecurity, and lower lifecycle costs.

Digital technologies are helping companies in industrial sectors to gain wider edge over competitors, explained Raj Batra, president of the digital factory division of Siemens USA, at the Siemens Automation Summit event in June. Batra, speaking to attendees from discrete and process industries, recognized Ann Cooney, head of the process automation division of Siemens USA, early in his comments. He also noted the generational diversity among attendees, there to evolve and do better at their jobs, and thanked end-users for guiding more than 50 user conference sessions.

Mark T. Hoske, Content Manager

The focus on digitalization in this decade follows attention to automation and design and engineering over the prior two decades, Batra explained. Creating a digital twin in the value chain drives flexibility, expands efficiency and quality, and lowers time to market across process, discrete, and hybrid industries.

Combining the real world with the virtual world, through seamless integration of automation and software is complex, Batra said, but there's a lot to gain by putting design and manufacturing environments on a common digital model.

While the automotive industry is leading, others also are improving products, production, and performance. Benefits include shorter times to market, fewer prototypes with simulation, end-to-end data management, programming of automation systems, simulation of production processes offline prior to start of construction, analysis of process data, and preemptive fault detection in product lines.

## Digitalization examples

Examples of digitalization providing competitive advantages include:

Hendrick Motorsports has 36 product launches a year, one for each NASCAR race. Expediting the innovation process is key because with an open garage policy, new ideas only remain new for a couple of weeks. Data mining and information sharing across the shop produces answers, beyond data, with nearly every component subject to finite element analysis.

Food and beverage applications need a higher level of flexibility to address greater demands for wider product variant diversity, while maintaining a consistently high standard of quality. Holistic plant simulations enable faster commissioning and new data transparency enables consistently high-quality products. When brewing and packaging 240 million cases of Corona and Modelo beer per year (part of Belgium-based Anheuser-Busch InBev), consistency is key.

Chemical industry applications need more flexibility and smaller batches. Merck, the oldest pharmaceutical company, dating to 1668, wants to be first in organic light-emitting diode (OLED) materials for displays. In a smart automation test lab, modules dock like a space station to quickly enable plug-and-produce applications.

Think again about how digitalization benefits can be applied: Speed to market, flexibility, efficiency, consistent quality, cybersecurity, and lower lifecycle costs. **ce**

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# The Leading MRO & Automation Solution

Goran Novkovic, MESA

# Manufacturing in the cloud

Overcome challenges and maximize cloud computing benefits by understanding different cloud service models and their risks.

Cloud computing is revolutionizing the way manufacturing organizations are implementing information systems and using critical assets. It promises better and more efficient use of resources and virtually unlimited scalability and greater flexibility—at an attractive cost. Adopting cloud computing models carries a number of technical and business risks. Risks are not new. Every manufacturing organization already has its own risk management methodology.

The manufacturing organizations should analyze the negative impacts of things with a business impact analysis (BIA), which represents the systematic process of determining and evaluating the potential effects of an interruption to a business operation. A manufacturing organization should do a BIA as part of a cloud service adoption process.

Those putting data and software application into the cloud place a certain level of trust to cloud service providers (CSPs). Manufacturing organizations can lose some control over critical assets, and there is risk associated with that. To mitigate risk, all security requirements must be clearly defined, analyzed, and communicated to ensure that if assets move to the cloud, they adhere to applicable laws and regulations.

For widespread adoption of cloud computing services, manufacturing organizations must ensure that CSPs are trustworthy and are doing everything possible to protect data and software applications of the manufacturing organizations. CSP has to be carefully selected based on well-defined business requirements. Adopting manufacturing organizations must be confident that the services outsourced to the CSP, including important assets, will not be disrupted and compromised. Even a small cloud incident can negatively impact a manufacturing organization.

## CSP expectations

Cloud service models have different controls and security risks that are related to critical data assets and software applications in the cloud. Models include:

**Infrastructure as a service (IaaS)**: With an IaaS model, the CSP provides an underlying infrastructure (computational capabilities, storage, and network management) and the manufacturing organization uses these resources to manage its data and software applications. An IaaS provides the greatest control over resources and presents the lowest security risk for the manufacturing organization.

**Platform as a service (PaaS)**: With a PaaS model, the CSP provides the infrastructure and the application development platform. The manufacturing organization has fewer infrastructure elements to manage and retains control over some system administration. This reduces the responsibility of the manufacturing organization, but translates into less control over resources, and thus creates a higher security risk to the organization.

**Software as a service (SaaS)**: Using a SaaS model, the CSP controls the infrastructure and development platforms, and controls over administering the software applications. Even so, manufacturing organizations still may be responsible for securing the data that are produced by SaaS applications. Although this may help manufacturing organizations reduce costs and speed time to market, a SaaS model is associated with the least control over resources and the highest risk for the organization. ce

*Goran Novkovic is a member of MESA, a CFE Media content partner. Novkovic has a formal education in electrical engineering and project management and has a master's degree in information technology. Edited by Emily Guenther, associate content manager,* Control Engineering, *CFE Media, eguenther@cfemedia.com.*

## More ANSWERS

**KEYWORDS: Cloud computing**
**Types of cloud** service models
**Expectations** and risks

**CONSIDER THIS**
**What cloud service** model would pose the least amount of risk to an organization?

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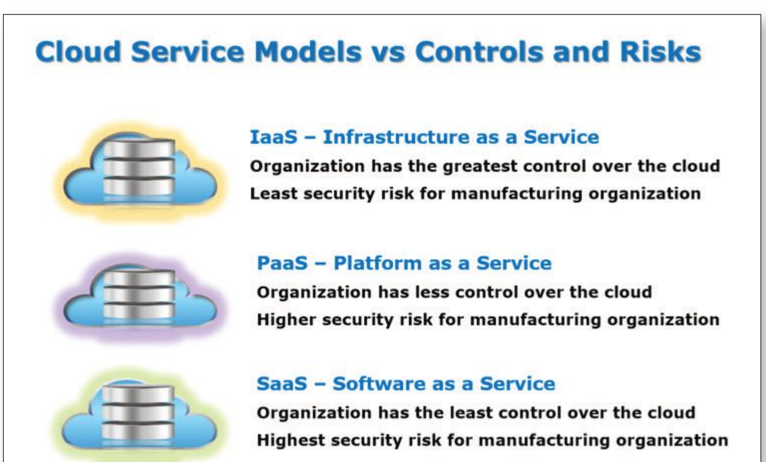


**Cloud service models vary in amount of control and risk available to the organization involved. Courtesy: MESA**


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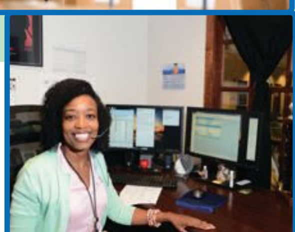

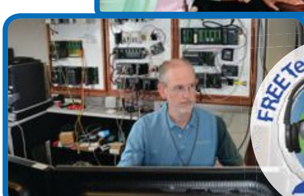



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**Chad McGraw,** Honeywell

# Cloud-based software for industrial applications

Choosing cloud-based software or a combined approach with an on-site strategy may result in cost savings, improved operational efficiencies, and enhanced security.

A growing number of technology suppliers are offering cloud-based software for automation, control, and instrumentation applications. It remains the responsibility of end users to decide where automation software should reside. Should they "own" the software in a traditional sense, or does software-as-a-service (SaaS) or platform-as-a-service (PaaS) make more sense for particular applications?

Many industrial control systems (ICSs) run for 30 or more years with minimal changes to hardware or software. The use of Ethernet, in various mediums, for plant networks have the potential to expose automation systems in any location—whether in the cloud or on-site—to unauthorized access. (On-site architectures also frequently are called on premises or on prem for short.)

**Cover image, bottom, figure 1: Honeywell's Open Virtual Engineering Platform (Open VEP) provides an off-process way to develop, test, and validate an Experion PKS process control system. It helps process or control engineers improve or add to an existing SCADA or control system. Graphics courtesy: Honeywell Process Solutions**

## Rise of cloud computing

Significant benefits associated with cloud computing such as:

- The availability of a standardized development and test/simulation environments cuts costs for setting up and configuring the infrastructure.
- The flexible use of distributed engineering resources permits multi-project and multi-user configuration, independent of location.
- The freedom to focus on core competencies in running the assets while reducing on-site physical footprint, hardware, software and maintenance.
- Expertise available for keeping the system up to date, and applying the right cybersecurity solutions to keep it safe and protect intellectual property.
- A demand-oriented pricing model reduces investment costs to the actual use.

A growing number of manufacturers are tapping the potential of cloud computing—including SaaS and PaaS—for design and operation of ICSs.

## Growth of Saas, PaaS services

SaaS is a software distribution model in which the developer hosts applications and makes them available to customers over the internet. Incorporating SaaS in the process control world means adding data collection, integration, and/or distribution capabilities beyond the limits of most existing in-house systems.

SaaS can expand access to plant data, which supports real-time monitoring of processes. It also delivers Big Data needed to drive predictive maintenance programs. It enables facility-wide or enterprise-wide visibility of real-time key performance indicators (KPIs) and dashboards, which focus attention to what's important, and otherwise leverage the value of new or existing supervisory control and data acquisition (SCADA) investments.

When properly implemented, SaaS can mean significant cost savings over the traditional approach of software ownership. This cloud service model offers minimized hardware and software setup costs even as it delivers redundancy and high availability, which allows maintenance on running applications. End users are freed of managing and controlling the underlying information technology (IT) infrastructure. Security, networking, computing, and all software licenses are packaged into a monthly or annual fee, eliminating or greatly reducing capital expenditures (CapEx). Instead, there is a one-time cost to access any desired services. Organizations pay for what they use and often have the flexibility to add or delete services as needed.

Another benefit of SaaS is the automation services provider usually includes updates software applications. The provider will work with the customer to coordinate the installation of appropriate software release updates and patches to all installed software, as appropriate to the applicationn and ensure they function correctly. The provider takes on this added responsibility because it helps when customers use the newest software to lower support costs while improving security.

PaaS is ideal for efficiently providing programming environments and developer tools to industrial organizations that develop and test software and database applications. It provides a complete and centralized development environment that is accessible on demand.

Some cloud-based environments will include sophisticated simulation environments for fully testing project applications before moving them to the production system. Software and database applications can be custom applications industrial organizations have used in the past, but are now deploying on virtual machines (VMs) in the cloud. They also can be applications built from scratch in the cloud using the platform and tools provided by the automation service provider.

In some cases, the same software can be used for SaaS and PaaS applications. Control and process engineers might use a PaaS model to develop the application and SaaS for their production environment. For instance, automation, process control, and SCADA software, traditionally only offered in the customer's facility, are available as an off-process development and simulation environment

**Cover image, top, figure 2: Automation and control systems must be more flexible and agile. Honeywell Process Solutions Experion Elevate is an on-process production system for remote SCADA applications where the user wants to monitor and/or control geographically dispersed assets.**

(Open VEP) or as SCADA software optimized to provide enterprise-level reliability and security to monitor and control widely distributed assets.

Putting such software into a data center with direct high-speed connectivity to the telecoms and internet enables high-speed and reliable connectivity to all remote devices and visualization of the overall business.

## Cloud-based SCADA systems

The traditional approach to SCADA has been wholly owned and on-site, requiring dedicated support staff with heavy capital and operational expenditures (OpEx). These costs cover security and firewalls, networking equipment, as well as physical computer servers and software. However, the on-site approach offers limited flexibility and ties up valuable resources better used elsewhere. Perhaps more importantly, these on-site solutions need to be updated every 4 to 5 years. Migrating existing solutions to new hardware is often more difficult than the initial installation—especially if they were not initially virtualized.

To help customers meet operational and business challenges, leading automation suppliers have developed SCADA software for a hosted cloud environment. New cloud-based SCADA systems represent the natural progression of software in the era of the IIoT. Locating functionality in the cloud means end users can move from a capital model to a predictable OpEx model. They can have a functioning SCADA system within days.

## Implementing a cloud service model

Manufacturers must ask if it makes sense to move part of the control and monitoring software to a cloud environment, or if it should remain on-site. Implementing a cloud service model might not be imperative for organizations with one production

M More ANSWERS

**KEYWORDS:** **Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), cloud, SCADA**

**Benefits of** implementing cloud-based software for industrial applications

**Factors to conside**r when choosing on-site or cloud-based software

**Growth of** cloud computing for industrial facilities.

**CONSIDER THIS**

**Would an on-site,** cloud-based, or combined strategy help optimize your facility's operations?

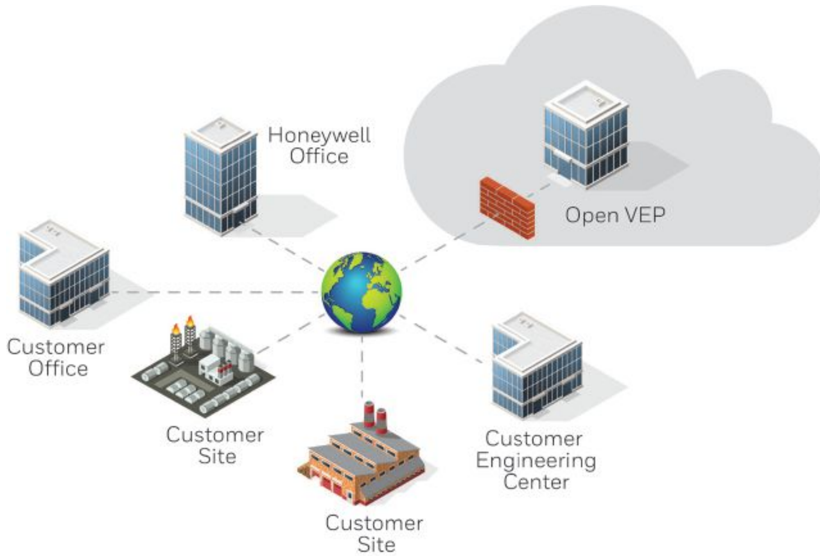



**Figure 3: Global access: Honeywell's PaaS can be accessed anywhere, on an automation system at any release, configuration, and size, with security, firewalls, networking, and licenses, to cut architecting, hardware and software purchase, and maintenance.**

site. However, manufacturers with multiple facilities can collect data from different locations as part of an overall cloud approach. Some manufacturers might deploy it as a supervisory system to visualize the current status of the company's priorities to coordinate resources and make better enterprise-level decisions.

Traditional on-site hosting has the advantage of speed and simplicity. The cost of a remote services license also is eliminated. On the other hand, cloud hosting allows for increased collaboration and anywhere access to control data without having to manage software licenses on individual computers. Employees can do their jobs from anywhere, yet still be secured to their unique scope of responsibility. Others can see progress done on a particular project so they can continue working on the current version.

The flexibility of using distributed engineering resources facilitates breaking the automation task up between specialists focusing on their areas of expertise; regardless of location. Companies can greatly reduce travel costs while by enabling personnel to work remotely to bring new products to market more quickly. This also allows experts to be involved in supporting any facility to reduce downtime while building consistency across multiple facilities.

The cloud versus on-site decision often hinges on what is being controlled and where it is located. There is a growing need for employees to be coordinated in their work processes, as opposed to operating autonomously with software on their own computers—often with poorly orchestrated backups of critical programming. Manufacturers running facilities in one state or country will likely want their cloud-based solution to be hosted within their geographical region. But, if it is necessary to monitor assets that are widely or globally distributed, it may make sense to use several cloud strategies with failover from one location to another.

As cloud computing continues to gain popularity, major automation suppliers are offering cloud hosting and on-site control software. One reason for having both is to comply with regulations and meet critical data needs. There are pros and cons to each approach.

Customers can partner with an automation technology vendor to choose the right path based on operations and business requirements. The overall strategy might be a mix overall. Automation knowledge and experience is crucial to making the best decision for the company.

Perhaps the greatest opportunity for cloud technology is remote monitoring for enterprise operations. For instance, a cloud solution employing SaaS is appropriate when corporate management wants to monitor the status of all plant locations and remote assets. This approach provides one set of dashboards, key performance indicators (KPIs), and other reporting capabilities to help understand the situation across the enterprise. It enables a consistent view of the current situation and allows data from hundreds of facilities to be aggregated and presented in a visual graphic to direct the attention of stakeholders throughout the organization and help them make better decisions.

## Layered cybersecurity strategies

Despite concerns about the security of cloud-hosted data for the industrial plant environment, major technology providers have deployed rigorous defense-in-depth strategies to protect software deep within multiple layers of physical and cybersecurity. This gives security experts time to recognize and eliminate intrusions before they impact crucial control assets.

Flexible solutions incorporating additional firewalls and advanced encryption to maintain secure access to the customer's control infrastructure and intellectual property also can be developed to enhance security.

Industrial organizations can now use the same software—on-site or in the cloud—to realize all the benefits for control or automation applications. Cloud service models offer significant advantages for collaboration and mobile access, but the end user must consider specific requirements when choosing a control software or platform approach. **ce**

***Chad McGraw*** *is the hosted solutions marketing manager/open VEP product manager, Honeywell. Edited by Emily Guenther, associate content manager, CFE Media, eguenther@cfemedia.com.*

**Bob McIlvride,** Skkynet Cloud Systems Inc.

# Control in the cloud: How much?

Cloud computing is gaining ground as industrial plants become more efficient, but it's important to recognize where computing is needed and where it should be taking place.

Many process engineers would be happy to apply the mantra "What happens in Vegas stays in Vegas" principle to their systems, meaning, "What happens in operations stays in operations." To process engineers, all automation, control, and instrumentation applications should stay in the plant. It's more reliable and secure that way. And that's the way it was until a few years ago. A shift is taking place.

In a drive for efficiency and having a competitive advantage, companies are turning to cloud computing as a way to gather production data, crunch the numbers, and feed selected results to management, to analysts, to suppliers, to vendors, and in some cases, back to the plant. Call it the Industrial Internet of Things (IIoT), Industrie 4.0, or enhanced supervisory control and data acquisition (SCADA), but the digital transformation of industrial production is well underway.

Because this radically departs from the way things have been for decades, many questions arise like: What about security? Are the connections reliable? Isn't this just what we've always been doing, with a new name?

As companies move beyond the pilot stage and begin to implement full-scale IIoT and Industrie 4.0 systems, another question often coming up is: How much control goes to the cloud? Or, how much data processing should be done in the cloud (Figure 1)?

## Cloud computing for industrial systems

Some cloud-computing proponents assert that the more computing that can be done in the cloud, the better. However, that approach does consider the realities of industrial control systems (ICSs). It would be foolhardy to attempt low-level or time-sensitive control from the cloud, as well as most types of supervisory control. The security, latency, and reliability of an internet connection can't match an in-plant network. Also, the volume and rate of data pouring in from a typical industrial system would consume enormous amounts of cloud resources, resulting in a much higher cost.

One of the latest trends in cloud computing isn't in the cloud at all, but at the edge. Edge computing can mean different things to different people. From the viewpoint of an IIoT cloud, the edge is often considered to be the border of the industrial system, such as the gateway that connects to the cloud. From within an industrial control system itself, the edge could be a device, like a sensor, actuator, or perhaps a remote terminal unit (RTU) out in the field that collects data from a number of devices. However, the edge is defined, the idea is if processing power is inserted there, a lot of time and money can be saved by filtering, conditioning, and aggregating data before it is passed on to the next level of analysis.

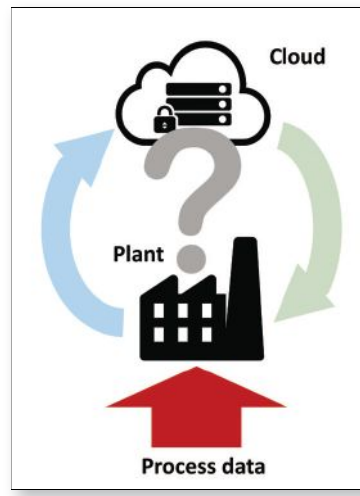



**Figure 1: How much control should go to the cloud? All graphics courtesy: Skkynet Cloud Systems Inc.**

Everything doesn't have to be done in the cloud. In fact, most automation engineers would agree it's better to put computing power where it is needed. Local computing keeps responses closer to real-time, cuts bandwidth, and reduces the uncertainties of network connections. Consider these four areas where processing can take place:

**1. Device:** Adding computing power at the device level can help reduce the amount of data that needs to be sent to the plant's upstream applications and the cloud by filtering or conditioning the data at the source. In addition, processing at the device can abstract the data from the different field protocols into a common protocol. This means upstream applications do not need to know the specific protocols of the field devices providing them with information, which makes the data available to a wider range of clients.

**2. Plant:** Traditionally, this is where most industrial computing has taken place, with SCADA and human-machine interface (HMI) systems providing supervisory control and visualization. Now, to satisfy new requirements, these systems are increasingly being used to create metadata, such as device status, connection status, and system health scores, as well as target production tracking.

**3. Gateway:** Computing at the gateway is an effective way to apply the cost savings of data reduction and conditioning to established infrastructure

More ANSWERS

**KEYWORDS: cloud computing, industrial analytics**

**Cloud computing** for industrial systems

**Areas where** computing power takes place for industrial systems.

**CONSIDER THIS**

**How does** your facility balance and analyze data at each step to optimize operations?

**ONLINE**

**Read more** about cloud computing online at www.controleng.com.

that may not be able to support added computing resources themselves. If an organization doesn't want to disrupt the legacy system, adding data processing at the point where the data leaves the plant makes sense (Figure 2).

**4. Cloud:** When proper steps to reduce, manage, and enhance the quality of the data from plant systems and remote devices is done at the source, cloud computing resources can be used more effectively to aggregate data from multiple locations, store and analyze the data, and present it in a form best suited to the client needs.

The latest generation of IIoT cloud services also provides secure, bidirectional connections, which allows the cloud to send data and analytics back to authorized end users at any location. Not all cloud services offer this, but the benefits can be significant. Cloud services can store data on a scale that can't be matched by in-house systems. Combining that with a broad range of cloud analytics shows how integrating plant data and cloud services can enhance process knowledge and guidance.

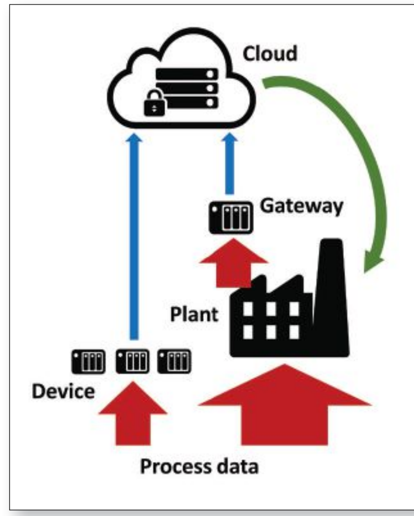



**Figure 2: Balance the data load at each step of the process.**

## Control, cloud services

Making the most of the new era of cloud services for industrial control will depend on how the cloud data needs to be managed and the data that needs to be received from the cloud. Applying resources at the appropriate level to condition and optimize the data sent to the cloud will reduce costs and generate a quicker round-trip time for analytical data supplied back to the plant. Abstracting the data from multiple source protocols will make it available to more client applications in the plant and in the cloud.

The days of "what happens in the plant stays in the plant" are numbered. Driving process data into the cloud and getting meaningful answers back is the goal of many integration projects. Balancing the data load at each step in the process seems to be the key to a successful implementation and adding edge computing where it is needed will pull things together. **ce**

***Bob McIlvride*** *is director of communications at Skkynet Cloud Systems Inc., a CSIA member. The CSIA is a CFE Media content partner. Edited by Emily Guenther, associate content manager,* Control Engineering, *CFE Media, eguenther@cfemedia.com.*

# In a class by themselves

## An educated, diverse group have remarkable achievements beyond manufacturing

By McKenzie Burns, Production Coordinator; Amanda Pelliccione, Research Director; and Bob Vavra, Content Manager

The 2018 CFE Media Engineering Leaders Under 40 are in a class by themselves, but they also have plenty of experience in a class. These 30 manufacturing professionals are by far the best educated group we've recognized since the program began almost a decade ago. They've taken that formal education and turned it into groundbreaking improvements on their plant floor and in patented product development. The seven women and 23 men honored this year range in age from 25 to 39. All have university degrees, including several from foreign institutions. More than half have a master's degree, and two have PhDs. Their degrees include 10 in mechanical engineering, seven in chemical engineering, and two each in industrial engineering and electrical engineering.

The 2018 Engineering Leaders Under 40 class also has a wide range of capabilities outside the manufacturing plant that add to their resumes. Two of this year's group contributed in ways that transcend engineering and manufacturing.

Kyle Shipp, the MEP coordinator for DPR Construction in Morrisville, N.C., served two tours of duty in Iraq, is a staff sergeant in the U.S. Army Reserve, and the senior vice-commander of his local VFW Post.

Sheikh Rafik Manihar Ahmed is a control systems engineer and innovation catalyst for Fluor Daniel India Pvt. Ltd. in Gururam, India, and the only member of this year's Engineering Leaders Under 40 group from outside North America. Besides his professional skills, his involvement in improving health care in his region led to his donation of O+ blood platelets to help save the life of a 15-year-old girl who was about to undergo surgery. He did this even though the donation caused him to break his fast during the holy season of Ramadan.

"I will keep the fast later to compensate, but human life can't be compensated," he said.

More remarkable stories follow.

Meet the 2018 Engineering Leaders Under 40.

### Sandesh Amberkar, 36

Principal Process Engineer

*GS Engineering & Construction, Mumbai, Maharashtra, India*

*BE Chemical Engineering, Mumbai University Institute of Chemical Technology*

Sandesh was recognized as upcoming talent and promoted as lead level process engineer at the age of 30. Considered a team player, good motivator, and trusted leader, he has already handled a team of 15 process engineers. In 2016, he was recognized as a best process engineer. Sandesh feels that being a chemical engineer in EPC industry helps in his process engineering, but in other aspects of his career as well.

**FUN FACT:** Sandesh enjoys touring different countries and recently took time to travel to Seoul, South Korean, and Muscat, Oman.

See more details in images and profiles at **www.controleng.com/EngineeringLeaders**

### Jon Breen, 31

Founder

*Breen Machine Automation Services LLC, Madison, WI, United States*

*MS Mechanical Engineering, University of Wisconsin-Madison*

After graduating Summa Cum Laude in the Honors Program from University of Wisconsin-Stout, Jon attained a Master's degree in mechanical engineering from University of Wisconsin-Madison. He has more than 10 years of experience with various manufacturers, OEMs, and engineers from across the world. Jon chose a career in engineering because he enjoys exploring and creating solutions to real problems, and he's enjoyed working with people in industry to improve their automation. Now in its third year of operation, Jon created Breen Machine Automation Services, offering fast, friendly, and tailored automation solutions to the global manufacturing industries.

**FUN FACT:** In his spare time, Jon enjoys engineering biological systems in the yard (gardening).

## Nathan Butler, 27

Controls Engineer

*RedViking, Plymouth, MI, United States*

*BS Electrical Engineering, Kettering University*

Nathan tried a lot of different things when he was younger, but quickly picked up on his talent for mathematics. He has led the software development and integration of the two largest inductively powered automated guided vehicles (AGVs) conveyers in the world and led a group of eight controls engineers during the integration of four AGV assembly lines across the U.S. and Canada. Quickly becoming the go-to engineer in the group, he has shown incredible talent at resolving complex issues. Nathan also is assionate about electronic design and microcontroller programming; he's created an RGB/HSV LED light controller and used it to teach his two-year-old daughter her colors.

**FUN FACT:** Nathan has been working on programmable logic controller (PLC) software programming and has about a dozen modular blocks of code.

## Raniel Camacho, PE, 33

Project Manager

*San Francisco International Airport (SFO), San Francisco, CA, United States*

*BS Mechanical Engineering, California Polytechnic State University, San Luis Obispo*

Growing up, Raniel enjoyed playing with LEGOs because he loved being creative and building things. As he got older, Raniel realized engineering would allow him to do just that on a larger scale while helping people in his community. While at SFO, he has been assigned projects such as a major upgrade to all utility meters and consolidation of multiple building management systems across the airport. Raniel has been a part of a 2-person team to create, develop, and implement SFO's $76 million energy management control system project and co-developed planning, design, and construction aspects to upgrade, integrate and standardize gas, water, electricity, and building management systems in more than 100 SFO buildings into one system.

**FUN FACT:** Raniel is an active volunteer at Habitat for Humanity, an organization that helps build homes for low-income families in his community.

## Christopher Christie, 36

Refinery Process Control Lead — GEOS NA & SA

*Cargill Inc., Wayzata, MN, United States*

*BS Chemical & Process Engineering, University of the West Indies, St. Augustine*

*MS Chemical Engineering, Virginia Tech*

*PhD Chemical Engineering, Virginia Tech*

With more than 15 years of experience in process systems engineering and process control, Chris has been able to apply his expertise across a broad range of industries including mineral refining, metals trading, agricultural food processing, and biological control systems. At Cargill, Chris has developed best-practice control strategies for standardizing vegetable oil processing operations across the company's global fleet of oil refineries. Chris was responsible for the evaluation, procurement, and deployment of a continuous control-loop performance monitoring solution at more than 40 Cargill manufacturing sites.

**FUN FACT:** Chris, a native of Jamaica, loved exploring the island's mountains, beaches, and other wonders, as a youngster.

## Adam Cleary, 26

Automation and Controls Technician

*Crofter's Organic, Parry Sound, Ontario, Canada*

*AAS Electrical Engineering Technology, Conestoga College*

Over his career, Adam has been recognized as not only a very skilled electrical and controls engineering technologist, but also a very dedicated team player. His calm demeanor helps to critically analyze issues during high-pressure settings, helping him conquer challenges that arise. In college, Adam was selected as a representative for a controls and automation industry showcase. In the past two years, he has been the only constant employee at Crofter's through their electrical and controls development projects. Adam's involvement has been critical to projects such as implementation of wastewater treatment plan controls, installing new equipment supplied from outside companies, and developing controls systems for cooking and auxiliary equipment.

**FUN FACT:** Adam was selected to represent his college class at a controls and automation industry showcase.

## **Nick Clute,** 35

Business Development Manager

*Turck, Minneapolis, MN, United States*

*BS Electrical Engineering, Kettering University*

Nick chose a career in controls engineering because of his curiosity to find solutions. He excels at viewing a customer's challenge as part of an entire system and understanding the impact that one change can have on other areas. Specific to the automotive industry, Nick was involved in developing radio frequency identification bolt tags, programming AGVs, and implementing field logic controllers using a programming environment to improve control processes. His engineering contributions extend into his community. He volunteered as one of the first ISO auditors for Turck and also has been instrumental in introducing training programs and communication tools to help sales reps and employees better understand company offerings.

**FUN FACT:** Nick is very involved in volunteering for the activities his children participate in and has since become the rookie director for the local racing club.

## **Vryan Constantino,** 30

Lead Engineer

*Panacea Technologies Inc., Montgomeryville, PA, United States*

*BS Chemical Engineering, Mapua Institute of Technology, Philippines*

*BS Chemistry, Mapua Institute of Technology, Philippines*

*BS Biotechnology, Mapua Institute of Technology, Philippines*

For Vryan, the original plan was to major in accounting. Instead, he ended up triple majoring in Chemistry, Chemical Engineering, and Biotechnology. During his career, when Vryan saw a need to better automate operating system patches to prevent malware attacks, he took it upon himself to build what is now the Panacea Update Manager, a first-of-its-kind standalone Microsoft Patch Manager that supports cross-compatibility between multiple automation systems. He has helped develop alarm standards in the industrial gases space that were used to contextualize, justify, and track alarms leading to better informed operators and safer plants.

**FUN FACT:** Vryan is a big foodie and makes it a point to try a local dish wherever he goes.

## **Nicole Dyess,** 35

Director, Client Solutions

*ValuD Consulting & Motors@Work, Dallas, TX, United States*

*BS Mechanical Engineering, North Carolina State University*

*MS Mechanical Engineering, North Carolina State University*

*MPA, University of North Carolina*

Nicole showed an aptitude for science at math at an early age and has a passion for the environment. She began her career at Advanced Energy by testing motors, consulting with OEMs on motor design, and identifying motor management best practices for the U.S. Department of Energy. In 2003, she received a Young Consultant Award from the American Council of Engineering Companies' NC chapter for her work at Advanced Energy. Later on, she managed statewide energy efficiency programs for the NC Energy Office (NCEO). In 2012, the U.S. Environmental Protection Agency bestowed NCEO with "Leadership in Housing" and "Excellence in Brand Promotion" awards for Nicole's programs. The constant in Nicole's diverse career is a passion for finding energy savings for her employers and clients.

**FUN FACT:** As a DIY-er, Nicole uses her engineering experience to help her husband, John, with full-gut house remodels.

## **Kyle Elam,** 32

Process Engineer

*3M, Quapaw, OK, United States*

*MS Chemical Engineering, University of Oklahoma*

Kyle loves being a chemical engineer because it is a perfect combination of creative thinking, science, technology, and math. During his undergrad, he led and assisted projects on microwave-assisted synthesis and siderophores. As a graduate student, he led and assisted projects on biofuels, primarily focused on the production of diesel fuels from natural plant oils. He works as a 3M process engineer, developing, supporting and/or directing projects throughout the 3M Quapaw facility. He was a lead process designer on a large $25 million safety and plant optimization capital project. In 2017, he was given the Pollution Prevention Pays award for LSS, and nominated for both the 3M Process Improvement & Maintenance Conscious Engineering awards. In that same year, Kyle and his wife started a garden that covers more than 2,000 sq ft. In just a year, the garden project is expanding into composting, rain collection, canning, and raised garden beds.

**FUN FACT:** Kyle enjoys rebuilding classic cars.

## Vincent Errichiello, 25

Process Lead

*Ingredion, Bedford Park, IL, United States*

*BS Chemical Engineering, University of Illinois at Chicago*

Growing up with two engineers for parents, Vince felt destined to become one himself. In school, Vince was a Division I swimmer at University of Illinois at Chicago for four years while completing his degree in Chemical Engineering. He also earned the 2015 McCormack Outstanding Senior award. Only three years out of school, he has been promoted twice to a process lead position and continues to tackle any problem he comes across. He is presently working on his Lean Six Sigma Black Belt project targeting 30% reduction in packer supply shortages due to poor flowability of the upstream hydrate dextrose supply, increasing margins by $980,000 per year

**FUN FACT:** Vince enjoys weightlifting and in the past year accomplished a sumo deadlift exceeding 500 lbs.

## Nate Fossell, 39

Senior Project Manager

*Interstates Control Systems Inc., Sioux Center, IA, United States*

*BS Civil & Environmental Engineering, South Dakota State University*

*MS Engineering, Emphasis in Civil and Environmental Engineering, South Dakota State University*

Nate's career began after college when a mentor told him the best engineers can communicate, manage projects, solve problems, and transfer information efficiently. Since then, Nate has become a mentor himself, helping teams focus on what is needed to need and exceed client expectations. While at Interstates, he helped the project management team in refining processes and has been involved in helping improve overall client experience. He has worked to become Project Management Professional certified with the Project Management Institute and is actively involved with the local chapter. Nate has led several internal task forces to improve Interstate's internal process, such as the new functional specification development process.

**FUN FACT:** Nate loves being active outdoors, primarily enjoying hunting and fishing.

## William Kidd, 32

Mechanical Team Lead

*RedViking, Plymouth, MI, United States*

*BS Mechanical Engineering, Cornell University*

Bill has been considered instrumental in the rising success of RedViking over the past 5 years. He and his team have developed groundbreaking technical advancements that are changing the powertrain test system and jet engine industries, including the most powerful helicopter transmission test stand in the industry with over 17,000 hp of capacity and a rotor head connection that can test every torque, thrust, shear, and moment that a transmission would see in flight. He has also been instrumental in the development of a dual input planetary gear set that varies the drivetrain gear ratio, enabling one flexible four-square test stand to test five helicopter transmissions. Bill recently took on the role of Mechanical Team Leader and made an immediate impact by leading his team to successful execution of their projects with proper planning, tracking, and reporting on all projects within his group.

**FUN FACT:** For the past three years, Bill has been creating wood and metal artwork and furniture at a local makerspace.

## Niranjan Kulkarni, 37

Director, Operations Improvement

*CRB, Medford, MA, United States*

*BS Mechanical Engineering, University of Mumbai*

*MS Industrial Engineering, Binghamton University*

*PhD Industrial Engineering, Binghamton University*

*Lean Six Sigma Master Black Belt*

Niranjan has more than 10 years of experience in construction and design industries supported by knowledge in operations improvement for pharmaceutical, chemical, food and beverage, semiconductor, and financial industries. After starting as CRB's first industrial engineer, Niranjan leads a group several industrial and process engineers. Other accomplishments include increasing annual revenue for an active pharmaceutical ingredient manufacturer by $8 million, capital cost avoidance exceeding $15 for an oral solid dosage manufacturer, and developing a strategic plan and increasing revenue by $10 million annually for a ready-to-eat food producer.

**FUN FACT:** Niranjan is working on a script that he hopes will become a movie one day.

## **Catsy Lam,** 37

Material Sciences Technical Leader

*Victaulic, Easton, PA, United States*

*BS Chemical Engineering, Polytechnic Institute of New York University*

*MS Chemical Engineering, Lehigh University*

Catsy has always had a passion for innovation. Being born and raised in Hong Kong has given Catsy a unique understanding of cultural diversity, competitive challenges, and continuous improvement. During her 13 years with Victaulic, Catsy has been looked at as one of the company's most valued engineers. In her current role, she serves as a technical leader in developing sealing materials including elastomers, thermoplastics, engineering polymers and polymer composites for Victaulic piping solutions used worldwide. Her recent success includes developing a proprietary fire-resistant gasket for maritime and oil and gas markets. According to her manager, she is dependable and self-driven, putting her a step ahead of everyone else.

**FUN FACT:** Catsy has been working with her husband to design an energy efficient custom home.

## **Devon MacNeill Guglietta,** 31

Project Engineer

*Applied Control Engineering Inc., Newark, DE, United States*

*BS Chemical Engineering, University of Maryland*

Devon began her career interning at NASA Goddard Space Flight Center, where she validated aerosol data from MODIS satellite instrument through analytical comparisons with ground-truth data, determined factors affecting aerosol data, and corrected for bias with neural networks and support vector machines. Devon has an associated publication titled: *Machine Learning and Bias Correction of MODIS Aerosol Optical Depth* (IEEE Geoscience and Remote Sensing Letters, Vol. 6. No. 4., October 2009), which won the 2010 IEEE Geoscience and Remote Sensing Society Letters Prize Paper award. She strives to use existing infrastructure to improve system data integrity, reduce project expenses, and deliver high-quality control systems. Devon's technical skills make her a positive role model for younger engineers.

**FUN FACT:** Devon hiked the 32.5 mile, 9,510 ft elevation gain Pemigewasset Loop in New Hampshire over three days while fighting unpredictable weather.

## **Sheikh Rafik Manihar Ahmed,** 26

Control Systems Engineer & Innovation Catalyst

*Fluor Daniel, New Delhi, India*

*AAS Innovation Management, Erasmus, University Rotterdam*

*BE Electronics & Instrumentation, Chhattisgarh Swami Vivekanand Technical University*

Sheikh Rafik Manihar Ahmed has supported instrumentation engineering across the oil, gas, and petrochemical industries. As Fluor's New Delhi office Innovation Catalyst, he leads a team to improve project execution. He is deeply involved in plant digitization and was honored by 2018 Design Thinking Personality of the Year Award and also a finalist for India's Innovator Under 35 in 2018. During a workshop, he put his safety training and knowledge to use when a short circuit prompted a fire at the hotel where he was staying. Being certified in first aid, he saved his own life as well as many others who were staying with him in the same hotel. In June 2018, Ahmed saved the life of a 15-year-old girl by breaking his Ramadan fast to donate his O+ blood platelets for her heart surgery.

**FUN FACT:** Ahmed chose engineering as a path to help solve complex problems and best impact people's lives.

## **Sean Murphy,** 36

Engineer

*Applied Control Engineering Inc., Danbury, CT, United States*

*BS Chemical Engineering, University of Delaware*

Sean became a chemical engineer after being inspired by his grandfather. He has since completed control system projects on Honeywell, Siemens, DeltaV, Rockwell Automation, and Bailey Controls in a wide range of industries, including power generation, pharmaceutical, specialty chemical, prisons, and food and beverage. Sean uses these skills to help his company acquire new customers in a competitive marketplace. Sean is a leader at the office in Danbury, CT. Due to the small office space, having Sean's "Swiss Army knife" abilities allows the office entrance into new regional industries and clients when opportunities arise. Sean takes it upon himself to train new employees in the technical aspects of being a process control engineer. Young engineers learn from Sean how to configure new application software and what their roles and responsibilities are in the automation industry.

**FUN FACT:** Sean loves participating in volleyball leagues and tournaments.

engineering
# leaders<40

## Steven Murray, 29

Engineering Manager

*Dennis Group, Duluth, GA, United States*

*BS Industrial Engineering, Georgia Institute of Technology*

Steven began his career at Dennis Group as a Packaging Engineer and has quickly risen through the ranks. In fact, he was the fastest engineer in the office to be promoted to project manager. His multi-discipline engineering expertise has been further expanded to include processing, packaging, material handling, and building utilities. He has been the sole engineering resource covering all disciplines concurrently executing multiple $20 million capital projects. In 2016, he received employee of the year award from the company. Steven designed and installed high-speed ready-to-eat cereal packaging systems across four sites for one food processing company. Steven has managed multi-disciplinary architectural and engineering studies for complete brownfield and greenfield food processing facility designs.

**FUN FACT:** Steven has been to 42 of the 50 states.

## Paulina Olesinska, 28

Engineering Lab Manager

*Victaulic, Easton, PA, United States*

Paulina is always listening to what is being said, which helps her arrive at solutions faster than most. She is currently working on her second master's degree and has authored a patent and served as a secondary author for another. Within the company, Paulina has worked closely with the Victaulic Intelligent Roll Grooving tool and has augmented its features. She also has had the opportunity to mentor three interns, which has been incredibly rewarding. She hopes to impress upon others that she is an engineer at heart (thus her passion for creating new ideas) who is always looking to shape the next big innovation, which can only be done through clever outside-of-the-box thinking and collaboration with others.

**FUN FACT:** Paulina enjoys working on her house as well as gardening in her spare time.

## Adwait Palsule, 39

Project Manager

*Panacea Technologies Inc., Montgomeryville, PA, United States*

*BS Industrial Engineering, Veermata Jijabai Technological Institute*

*MS Computer Integrated Manufacturing, Rochester Institute of Technology*

Adwait embodies everything it means to be an engineering leader. He showcases problem-solving skills, technical know-how, and strong work ethic. Adwait helped develop the OpenBIO system at Panacea, which won a 2018 innovator award. He helped develop and implement a process analytical technology system for a pharmaceutical company that would feed real-time data back into the process control system for real time parameter changes to improve batch quality and product purity. Adwait's passion for automation extends into home. He was one of the first people in the United States to install an automatic lawn mower at home. The mower, which he named Trevor, became a cornerstone of his home automation hobby after having made upgrades to his lighting, speaker, and garage door systems.

**FUN FACT:** After moving to the United States, Adwait became a die-hard Philadelphia Eagles fan.

## Ryan Queen, 36

R&D Sr. Mechanical Engineer of Advanced Technology

*Siemens, Norwood, OH, United States*

*BS Mechanical Engineering, The Ohio State University*

Ryan's patented ideas on technologies like high-speed yet low-vibration motors have allowed the industry to realize higher process efficiencies and provide a greener plant environment. He is also a strong advocate of engineering through his participation in global technical conferences such as IEEE-PCIC. Ryan holds one patent, has two pending patents, and has two disclosed inventions. As an active IEEE member, he has written two technical papers for the IEEE-PCIC conference, and his work on projects has been recognized in magazines like *Plant Engineering*. He is a member of the Siemens Global Network of Competency (NOC) and contributes to the Rotor Dynamics & Noise and Machine Vibration groups. Ryan also leads and supports the U.S.-based NOC for Rotor Dynamics and Finite Element Analysis groups.

**FUN FACT:** Ryan enjoys spending time with his family and volunteers at the YMCA as a soccer coach.

## Ramona Schindler, 30

Digitalization Business Development Manager for Machine Tools

*Siemens Industry Inc., Elk Grove Village, IL, United States*

*BS Mechanical Engineering, Friedrich-Alexander University of Erlangen-Nuremberg*

*MS Mechanical Engineering, Friedrich-Alexander University of Erlangen-Nuremberg*

Ramona is responsible for pioneering work in the area of digitalization for machine tool builders. She has an active patent on "Digitalization: Data analytics for technological workflow steps" in the area of big data and analytics. She is a part of "Women in Engineering" group, a named "Future Maker" for Siemens and is pursuing a bachelor's degree in mathematics to widen her knowledge in data analytics. Ramona spent a year in South Korea working on a project for the South Korean government that explored what digitalization means for global and local users. There, she contributed to the development of the global aspect of the project for the machine tool builders.

**FUN FACT:** Ramona tutors students in math.

## James Shaw, 38

Founder & Managing Director

*Fastway Engineering LLC, Chicago, IL, United States*

*BS Mechanical Engineering, University of Pittsburgh*

*MBA, F.W. Olin Graduate School of Business | Babson College*

Jim runs Fastway Engineering, a two-pronged business providing world class computer-aided design/computer-aided engineering (CAD/CAE_ training and in-demand CAD/CAE consulting services. The training arm of Fastway helps engineering teams of all sizes stay competitive by teaching powerful and profitable finite element analysis (FEA) skills to all levels of employees. Jim has more than 16 years of high-level engineering experience and is a leading expert in the application of CAD, FEA, and computational fluid dynamics (CFD). As a trainer and consultant, Jim has enriched the careers and capacities of hundreds of students and raised the bottom line of dozens of companies. At the helm of his own company, Jim provides training and consulting services for Fortune 500 companies, mid- and small-sized engineering firms, academic institutions, and CAD/CAE software companies.

**FUN FACT:** Jim is an avid motorsports fan and active supporter of the Formula SAE Collegiate Design competition.

## Robert Shields, PE, 32

Performance Engineer 3

*Lakeland Electric, Lakeland, FL, United States*

*BS Mechanical Engineering, University of South Florida*

*MS Mechanical Engineering, University of South Florida*

Robert had in interest in STEM activities from a young age. His work on McIntosh Unit 3, allowing it to burn lower quality coals, yet maximize efficiency, helped save 100 jobs and saved ratepayers more than $10 million. Bobby began post-college career 2011 as an entry level performance engineer and has since become a Performance Engineer 3, and earned his Professional Engineering license. He received a Process Improvement Award Level 1 and Level 2 for projects that have saved the rate payers more than $200,000. He is responsible for tuning and optimizing the combustion of the boiler post outage. Bobby received an award for his work during the outage work in 2016. Work in tuning McIntosh Unit 3 has been key to allowing it to burn lower quality coals, saving more than $12 million in fuel costs.

**FUN FACT:** Bobby enjoys mountain biking and often rides with his 3-year-old son.

## Kyle Shipp, 34

MEP Coordinator

*DPR Construction, Morrisville, NC, United States*

*MS Manufacturing, Kettering University*

Kyle started building and programming robots in high school and has progressed steadily into leading an automation group at a construction company. Currently, he manages a control system scope for 2.5 million sq ft of data center space in multiple states. In addition, Kyle has led control system design-assist effort for new-build 2.8 million sq ft corporate headquarters, developed and commissioned control systems for data centers throughout North America, and trains co-workers on automation concepts in formal classes and project specific cases. Outside of work, Kyle serves as the senior vice commander of a VFW Post to support local veterans. He also serves on the town planning board to help direct future development. Kyle is actively pursuing a green-certification for a renovation on a 100-year-old house to prove it can be done.

**FUN FACT:** Kyle was a staff sergeant in the U.S. Army Reserve with two deployments to Iraq.

## Mary Frances Stotler, 33

Project Manager

*Dennis Group, Duluth, GA, United States*

*MBA, Duquesne University*

*MS Sustainability, Duquesne University*

Since becoming Dennis Group's first sustainability hire in 2012, Mary Frances has started and grown the department, which now is a source of new revenue streams for the company. She is currently managing one of the largest projects in the company's history—a $190 million greenfield bakery facility. Mary Frances is LEED AP BD+C and O+M certified and now oversees a group of LEED accredited professionals. While they were originally aiming for LEED Silver, Sabra earned the distinction of being the first LEED Gold Certified New Construction facility in the state of Virginia. Mary Frances is overseeing a new 430,000 sq ft facility for the J.M. Smucker Co., which will double the capacity to produce frozen sandwich line. This $190 million facility is pursuing LEED certification. Mary Frances loves the opportunity to demonstrate that doing good and doing well aren't mutually exclusive.

**FUN FACT:** Mary Frances' honeymoon was in Egypt.

## Justin Sturek, 37

Manager of Continuous Improvement

*The Raymond Corp.*

*Greene, NY, United States*

*BS Business Management, HRM, Binghamton University*

*MS Systems Science, Binghamton University*

*Executive MBA, Binghamton University*

Justin believes in sharing his passion for the profession with local youth and has participated in numerous Manufacturing Day events at The Raymond Corp. As manager of continuous improvement and a Lean Six Sigma Black Belt, Justin manages the strategic plan of the Toyota Production System (TPS) initiative. He facilitated and advised 10 continuous improvement initiatives focused on creating standardized work for installation and scheduled maintenance processes for more than 2,500 technicians. The average results reduced cycle time by 30% and resulted in $2.7 million in savings. There has been a 50% reduction in defects, 30% reduction of backlog work, and more than 1,500 kaizens submitted for savings of $1.4 million.

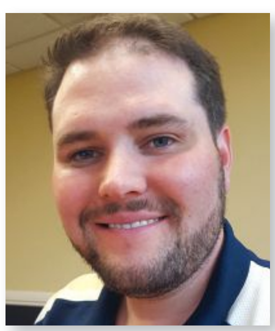
**FUN FACT:** Justin enjoys running marathons.

## Thomas J. (TJ) Swistro Jr., 34

Industrial Engineering Manager/CI

*Albea Metals America Inc. (AMA), Watertown, CT, United States*

*MBA, University of Hartford*



TJ has more than 10 years of manufacturing and industrial engineering experience and has used those skills to spearheaded a number of projects for AMA including the robotic loading of aluminum lipstick caps on to anodizing racks, the automation of silk screened aluminum jar covers, and repurposing a robot to auto load plastic jars into a silk-screening machine. In addition to the success of these projects, TJ also has undertaken the role of maintenance manager for AMA's three facilities. He is focused on several new projects that will help improve AMA's overall productivity, the largest of which is the refurbishment of a 22-year-old anodizing line. This major project will require new mechanical, electrical, and software infrastructure improvements on a running production line, which cannot be shut down for an extended period of time.

**FUN FACT:** TJ is an avid off-road motorcycle racer.

## Liz Walls, 39

Head of Research & Development

*One Energy Enterprises LLC, Findlay, OH, United States*

*MS Mechanical Engineering, University of Massachusetts Amherst*

Liz has worked on a wide range of engineering topics, including software design and development; turbine blade, tower, and foundation loads measurement using strain gauges; and wind measurement campaigns. Her combination of programming skills and development of a new wind flow modeling algorithm led to her creation of Continuum, a wind flow modeling software used around the world. For her work, Liz was recognized as one of Windpower's 2016 Innovators of the Year. She played a role in the development and testing of Vaisala's Triton SODAR and has presented several podium and poster presentations at AWEA conferences. In addition, Liz co-founded Cancalia Engineering & Consulting LLC in 2014, which was then acquired by One Energy at the end of 2016.

**FUN FACT:** To date, Liz has completed six half marathons, one marathon, a sprint triathlon, numerous 5Ks, and, soon, a Spartan race.

**Daniel E. Capano,** Gannett Fleming Engineers and Architects

# Wireless propagation tips

Reliability wireless controls depends in part on the type of wireless signal transmission and potential obstructions and impairments during the design process.

One of the most important factors in designing a wireless system is how the radio frequency (RF) signals will propagate between the transmitter and receiver. A clear line of sight (LOS) between two end points is the desired goal, but this is impractical, particularly in an industrial setting. Rural areas present unique seasonal problems that affect propagation. Non-LOS (NLOS) and beyond-LOS (BLOS) are other cases of propagation that can be successfully dealt with to provide a robust and secure link.

## Visual LOS versus radio LOS

Line of sight is exactly what it states; the transmitter can see the receiver, or at least, the antennas of each can see each other. It is the visual line of sight. The shortest signal wavelength is several thousand times longer than the longest optical wavelength. This means a visually clear LOS does not necessarily translate into radio LOS, and vice versa.

To achieve a reliable RF link, careful planning, including a radio path study must be performed, along with an informed selection of equipment and antenna locations. The transmitter may use an omnidirectional antenna that is transmitting in all directions. The receiving antenna also may be an omni, but in many cases, and to increase the likelihood of receiving a usable signal, a directional antenna may be used.

For a dedicated link between two points—a point-to-point link will use a directional antenna to narrow the beam-width to avoid interference and increase the effective strength of the signals. All of these factors must be considered prior to final system design. Designers also should be aware of several possible impairments.

## Fresnel Zone

The first possible impairment is the Fresnel Zone (pronounced Fren-nel), which is a football-shaped area between the two tapered link end points that must be kept clear of obstructions to ensure a quality link. Area of concern here is the first Fresnel Zone; technically the area is a "prolate ellipsoid" that surrounds the transmitter and receiver and the area between them.

Obstructions in the first Fresnel Zone are not necessarily in the LOS between the end points, but they will cause a degradation of the signal strength and intermittent impairment. Signal behavior will differ based upon antenna polarization: a vertically polarized signal encountering an object in the first Fresnel Zone will invert and arrive at the antenna out of phase, degrading the signal. The opposite will happen with a horizontally polarized signal. The distance between the link endpoints and the wavelength of the transmitted signal determines the area of the Fresnel Zone.

## Ground, water RF reflections

The next impairment to LOS are the reflections from the ground or water local to the transmitter. The reflections from what is essentially a ground plane cause multipath interference and degrade the signal. In short range microwave transmission, the multipath phenomenon is dealt with by using diversity antennas and complex algorithms to combine or reject signals based on whether they are received in or out of phase (constructive and destructive multipath). For longer-range links, raising antenna height is the most common way to deal with reflections from the ground plane. Signal quality improvement is "height gain."

## Earth, atmosphere

One other parameter affecting LOS propagation is the Earth's curvature. The rule of thumb is a transmitter at sea level has a LOS of seven miles if unobstructed, which is referred to as an "Earth bulge." Another factor is the effect of atmosphere on propagation. Since the signal does not travel at a uniform height above the Earth, the effects of varying atmospheric conditions will affect LOS. The most pronounced effect of declining atmospheric pressure is the signal will be bent toward the Earth, effectively increasing propagation by a factor of around 4/3, or about 15%.

## Wireless obstructions

NLOS describes a link without a clear line-of-sight. Obstructions are in the path of the link or within the first Fresnel Zone. The effect of an obstruction in a NLOS situation can range from negligible to complete obstruction. Radio waves are considered "plane waves" in that the magnetic and electric fields propagate in two distinct planes perpendicular to each other. Plane waves are affected by obstructions in several ways and the effect is dependent upon wavelength.

More ANSWERS

**KEYWORDS: Industrial wireless, wireless propagation, RF**

**Wireless reliability** depends on understanding signal propagation.

**Radio path** study early can save resources later.

**CONSIDER THIS**

**Understanding signal** propagation can save money in a wireless control implementation.

**ONLINE**

This article online has more about dealing with NLOS/BLOS.

www.stamfordwpca.org

**See wireless tutorials:** www.controleng.com/blogs

Obstructions fall into three broad categories: Smaller than the incident wavelength, the same size as the incident wavelength, and larger than the incident wavelength. When an obstruction is smaller than the incident wavelength, there is negligible, if any, interference. When an obstruction is the same size as the incident wavelength, the plane wave will diffract around and through it with minor attenuation.

If an obstruction is larger than the incident wavelength, the signal will be obstructed to varying degrees depending upon the obstruction's materials and their electrical characteristics.

### BLOS, beyond NLOS

BLOS propagation is a special case of NLOS often encountered in very long-distance communication links blocked by Earth bulge, terrain, or other obstructions. Methods for overcoming these conditions use the same technology to achieve stable communication links. The most common method for medium to long-range links are passive and active repeaters, which receive the signal from the originating transmitter and repeat it to increase range.

### Do a radio path study

The first step in determining the quality of the link between the endpoints is to conduct a radio path study. This study is done by specialists who use a variety of resources to accurately map the path between endpoints to determine the best path, the Fresnel Zone obstructions and their effect on propagation, the need for, and location of, any ancillary equipment such as repeaters, the required signal strength at the transmitter, and receiver sensitivity.

The report typically contains visual depictions of the path on a topographic map and identifies any potential obstructions. When designing a link, it is advisable to contact the local building department to determine if any new high-rise buildings for other towers are being planned for the area within the path.

Planning for a communication system cannot be done on the fly or by putting components together without a plan or professional guidance. As with most things, one dollar spent on proper planning will save many dollars later. **ce**

***Daniel E. Capano*** *is senior project manager with Gannett Fleming Engineers and Architects, based in New York City. He is also the vice-chairman of the Stamford Water Pollution Control Authority (SWPCA) and chairs the SWPCA Technical Committee. Capano is a member of the* Control Engineering *Editorial Advisory Board. Edited by Mark T. Hoske, content manager,* Control Engineering, *CFE Media, mhoske@cfemedia.com.*

**Paul Dillien,** High Tech Marketing

# Wireless IIoT gateway design

Software-defined radio (SDR) hardware and open-source programming software provides an alternative to proprietary wireless communications systems, helping improve Industrial Internet of Things (IIoT) networks.

Despite many discussions about how the Industrial Internet of Things (IIoT) will change factory automation, no unifying technology exists to connect various "things" together, which results in incompatibility among systems. Connections among disparate industrial wireless standards can be made with open-source software-defined radio (SDR) technologies. Compatibility issues can be best illustrated by looking at IIoT, an application subset where pervasive connectivity offers significant benefits. A leading communications equipment vendor estimated over 90% of industrial machinery is not currently connected to any network.

### Incompatible wireless standards

The primary barrier to greater interconnectivity is the likelihood that multiple vendors supply machinery on most sites. Each vendor is likely to have a different approach to adopting IIoT, which includes wireless for maximum flexibility, but without interoperability among standards among wireless links and protocols. These include Wi-Fi, NB-IoT (also called Cat-NB1), LTE MTC Cat M1, Long Range (LoRa), Sigfox, Ingenu, WirelessHART, Weightless, 2G in the form of Extended coverage GSM IoT (EC-GSM-IoT), 3G, Bluetooth Low Energy (BLE), and ZigBee.

Each technology has advantages and limits and the use case may dictate the selection. Low Power Wide Area Networking (LPWAN) schemes, such as LoRa, NB-IoT, and Sigfox, are better suited to longer range links with low data rates, while radio access via Wi-Fi and Bluetooth are very popular, but the range is limited. A new Wi-Fi variant called HaLow is being added to the mix. It uses IP packets and lower frequencies that give greater range and penetration.

Incompatible systems are a drawback for any factory information technology (IT) department seeking to move to Industrie 4.0, as it might require multiple hubs and gateways to collect and collate data for analysis.

An SDR can support a vast range of wireless technologies, is compact, programmable, open source, full duplex, and "app-enabled," meaning it can be configured after downloading code from an app store.

Such a radio requires a means to communicate and a controller, such as a dual transceiver field programmable radio frequency (FPRF) device and a field-programmable gate array (FPGA) chip. The board plugs into a suitable processor, which would typically be a PC unit, via a USB 3.0 connector or PCIe interface.

A processor running Linux can be enabled with open source apps from the SoapySDR project, which can be used "as is" or modified to provide the exact requirements. Open-source Ubuntu-based apps are available for GSM and LoRa, with an active eco-system working on a raft of new applications. Hardware designers can use the Intel FPGA on the board to encode and decode the data for the various wireless standards; open-source software is becoming available. The FPGA also could be used to encrypt the data to avoid transmitting "in the clear."

Open-source material's major advantage is functionality can be modified to match application needs. Documentation allows the software designer to understand code operation. In addition, forums and blogs can answer many frequently asked questions, and the open-source community can help sort out

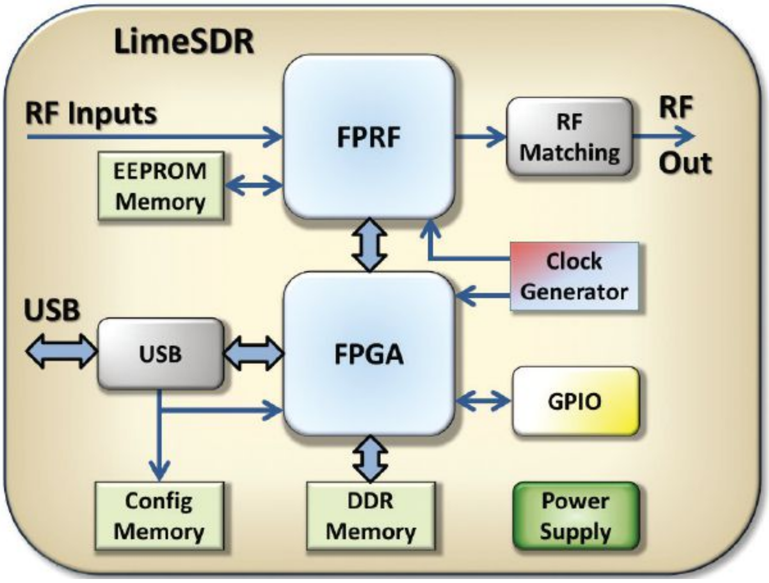



**Figure shows the LimeSDR software-defined radio board block diagram. LimeSuite is free open-source software to program LimeSDR boards. The graphical-user-interface (GUI)-driven design environment allows control over radio-frequency (RF) chip functions, such as bandwidth and frequency. Courtesy: Lime Microsystems**

issues and answer questions. A software engineer might start by downloading the LoRa files and then enhance the system on the SDR to support other technologies.

Options are available for modifying the system. SoapySDR supports a vendor neutral support library where a designer can access C++ APIs, C wrappers, and Python bindings. Data includes detailed explanations of code operation, which can form the starting point for the new design.

Free open-source software is used to program SDR. The graphical-user-interface (GUI)-driven design environment allows control over aspects of the RF chip, such as the bandwidth or frequency.

This is achieved using the FPGA to load data via the serial peripheral interface (SPI) connections to set the required wireless standard. Downloads onto the board can be performed in real time and the system performance can be checked with hardware-in-the-loop (HIL). When RF design is final, the FPRF settings can be saved for use in the final system.

## Control logic in FPGA

The control logic for the SDR is handled in the FPGA, and commands can be downloaded into the module via the USB port. FPGA functions can be modified, a task previously allocated to the hardware design team with specialized skills needed for device design. This is recognized as one of the biggest barriers to wider adoption of FPGAs in electronics by the vendors. As a result, they have made significant efforts to simplify design flows to the software or non-specialist community.

The IIoT is integral to the drive to higher levels of industrial automation, and wireless connectivity must hold a place in the overall IIoT strategy. Some options exploit unlicensed spectrum LPWANs while others might deploy emerging cellular standards. It is unlikely one wireless communication technology will cover all requirements, which creates the need for a configurable gateway designed to cover many options. Open-source SDR hardware and software communications provides an alternative to proprietary wireless communications systems. **ce**

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### More ANSWERS

**KEYWORDS: Industrial wireless, gateway**

**Software-defined radio** (SDR) can communicate among wireless standards that are not interoperable.

**Open-source tools** and apps ease communications programming.

**CONSIDER THIS**

**Among applications,** how are industrial wireless protocols exchanging data?

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**Kinichi Kitano,** Yokogawa

# Self-organizing versus managed industrial wireless networks

ISA 100.11a and WirelessHART standards reflect contrasting attitudes toward network management and these standards impact operational effectiveness.

A plant or facility considering a wireless network to connect field devices, such as instruments and actuators, to control and monitoring systems has two main wireless protocol choices: ANSI/ISA 100.11a and WirelessHART. Both were adopted by the International Electrotechnical Commission (IEC) as global standards (IEC 62734- Wireless communication network and communication profiles and IEC 62591-Industrial networks- Wireless communication network and communication profiles, respectively) and have been used for about a decade.

The two approaches have many similarities. (For example, they use the same low-power IEEE 802.15.4 radio. WirelessHART's mesh is a self-healing and self-organized network. ISA100.11a is also self-healing, and each node can have redundant paths, with users specifying these paths to organize the network. However, the ways in which the networks are organized differ significantly. Much hinges on the way the networks form communication paths and use meshing technology, which governs how individual field devices communicate bi-directionally with each other.

## WirelessHART self organizes

Both protocols came out of the early 2000s when automation technologies for process manufacturing were undergoing significant changes. The fieldbus wars of the earlier decade had subsided, leaving the impression on many automation suppliers that if a technology was too complex to operate, it could reduce the commercial viability in spite of its technical advantages.

WirelessHART came on the market promising simplicity and fast setup, perhaps hoping to avoid the main complaints related to Foundation Fieldbus and Profibus PA: they were too complicated to easily implement by typical industrial plant personnel. WirelessHART adopted many of the tools and techniques of traditional HART for wired instrumentation and applied them using wireless communication.

WirelessHART has a self-organizing capability so the devices on a network can automatically determine how to communicate with each other to exchange data. An individual instrument's transmitter can send data to neighboring devices, which will pick up and pass the data on to one another until it gets to the gateway. This causes some latency, but it's usually a minor consideration. The self-organization capabilities of the network are dynamic and adjustments can be made on-the-fly in response to changing conditions. The technology works and has benefits, but challenges exist:

- Making WirelessHART self-managing eliminates most tools for external management. The network creates its own communication paths, and there is no mechanism to override them manually.

- The self-organizing characteristic of WirelessHART means scalability can become an issue. Any gateway will have a maximum number of devices it can handle (up to 100 devices, for example). Self-organizing does not always mean self-optimizing. It can find a communication path for a given device with enough working radio links, but that communication path is not necessarily the most-direct path. Network designers can use diagnostic tools to see how devices are communicating, but WirelessHART has no means to direct which devices talk to which others. If less-than-optimal paths form, the mechanism to create new paths requires placing other devices in the network to allow the network to form better paths. Adding

More ANSWERS

**KEYWORDS:**
**WirelessHART, ISA100.11a**

**The self-organization** capabilities of a WirelessHART network

**Implementing a ISA100.11a** wireless instrumentation network

**WirelessHART** and ISA100.11a wireless network capabilities.

**CONSIDER THIS: Which type** of wireless network would be the most beneficial to implement with a particular application?

**ONLINE:**

**Read more online** about industrial wireless networks at www.controleng.com.

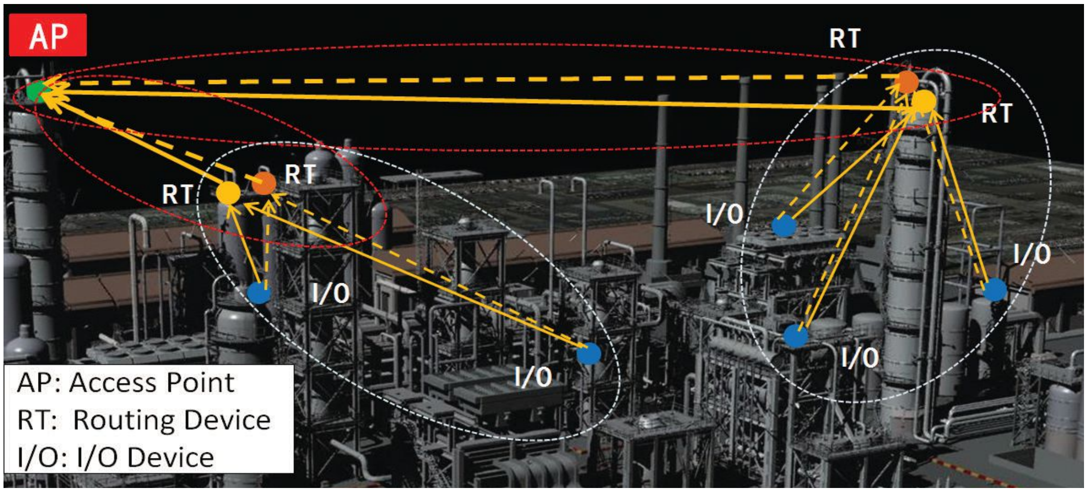


**Figure 1: Routers placed between the individual instruments and the gateway help manage data traffic and minimize dependence on meshing. All graphics courtesy: Yokogawa**

> **Software can identify where pinch points have formed** and can be set to warn human operators of their existence.

more devices does not necessarily clear up bottlenecks or reduce the number of hops a signal has to make to reach a gateway.

- The network's capability to adjust itself as needed provides an attack surface for cyber invaders to try and exploit. For example, the "wormhole" attack aims specifically at ad-hoc networks, and it can disrupt normal communication paths even if the attacker has not compromised any hosts or broken any encryption. There are defensive techniques and successfully carrying off an attack is not easy, but networks depending on mesh communication have this critical weakness.

- The physical layout of a network can cause it to create communication paths which tend to depend on a small number of strategically placed nodes, with data from a large number of devices passing through these nodes. These "pinch points" can place a heavy burden on those strategic nodes such that if one is lost due to battery failure or some other disruption to the path, major parts of the network may be cut off.

The patent for WirelessHART acknowledges the potential for these pinch points and their likely effects:

> "First, the wireless devices that have to communicate through the pinch point may have decreased communication reliability. Second, bandwidth for the wireless devices that have to communicate through the pinch point may be limited, and network performance may be adversely affected. Third, a wireless device that is a pinch point will consume additional power to transmit the increased message load. This is especially significant in battery-powered devices (resulting in decreased battery life) or devices dependent on energy scavenging (e.g. a solar-powered device).
>
> "Pinch points occur due to a variety of circumstances. For example, pinch points can be the result of poor network design or installation, of a constantly changing RF environment, changes in the physical space in which the network is located (which impacts the RF environment), and of wireless devices being taken out of service."

WirelessHART network analysis tools can monitor communication paths along with the status of the member devices, such as battery condition. The software can identify where pinch points have formed and can be set to warn human operators of their existence. Unfortunately, the network can't do anything about correcting the situation because the solution invariably involves adding or moving devices to establish more favorable communication paths. Somebody has to rearrange things until the network can find its own solution or add another gateway in a different location and possibly subdivide the network.

## Managed versus self-organizing

The ISA100 standards committee was formed to prepare a family of standards for wireless communication used in industrial automation applications. ISA100 Working Group 3 was responsible for the development of ISA100.11a, and products have been shipping under the ISA100 Wireless brand since 2013.

The larger standard writing effort started with the notion that networks supporting complex manufacturing environments had to cover more than just field devices and instrumentation. The standard's creators also believed that obtaining maximum performance and security should outweigh oversimplification. Some network planning and management would be necessary to deliver the performance and control desired by serious users. This would have to be accomplished without the usability problems that hampered fieldbus adoption.

An ISA100.11a wireless instrumentation network can be set up to use self-organizing mesh networking much like WirelessHART, but it is not the only option. There are more tools and techniques available, and a user can choose the best approach for a given application and plant environment.

Simple planning and thought during the design phase of implementing ISA100.11a will go a long way to improving all the radio links the network depends on. Understanding basic signal propagation should guide device and antenna placement, avoiding the difficulties common to complex plant installations full of steel tanks and structures, and avoiding the downsides of mesh networking.

Rather than setting up large groups of devices all trying to reach the same gateway directly, ISA100.11a can use routers as relay points (Figure 1), and these collect data from individual wireless instruments, and then data goes to the gateway. Routers are simply wireless transmitters, such as a temperature transmitter, configured to communicate positively with the gateway.

This avoids sending signals among multiple field devices, which slows down data movement and increases power consumption for each device. By implementing ISA100.11a this way, meshing is used only when needed as a means to solve network disruptions, rather than constantly for every device's communications.

Since meshing is not happening constantly, a field instrument with a very slow refresh rate, such as a level indicator on a large tank, can sleep for long periods of time. This will conserve power rather than being constantly active and communicating with other devices. If significant network disruptions break the link between a field instrument and its primary router, the device will automatically contact a secondary router.

## Wireless network implementation

The most effective practice places routers in high positions where there is a clear line of sight to the gateway, coupled with the ability to look down to the individual devices (Figure 2). While most wireless field instruments have integrally-mounted antennas, if there is no clear line of sight to the router, the antenna may have to be moved clear of the obstructions. Moreover, since the individual instrument is trying to reach a specific point, directional antennas can be used to increase signal strength substantially.

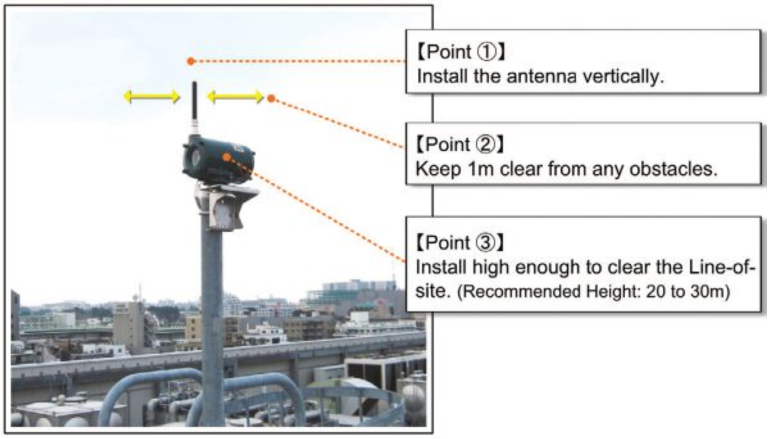


**Figure 2: Effective router placement can make communication on both ends of the network more reliable.**

Engineers and technicians working with network management tools establish these communication links, which once established, generally remain static over time since the equipment itself stays in one place. There can be disruptions, such as a truck blocking a radio link, but networks normally do not require constant readjustment. A well-deployed ISA100.11a network using these methods can remain stable for years. A weak device may need its antenna moved, which isn't difficult to do.

The ISA100 family of wireless standards was built on concepts suited for process plant environments. From the ground up, it was made to work in refineries, chemical plants and other challenging situations. It also covered many forms of wireless communication beyond instrumentation.

WirelessHART, on the other hand, chose to pursue a much shorter development effort by adopting and adapting existing technology. While avoiding "reinventing the wheel" is often a sensible approach, in this case, a technology designed to form ad-hoc networks under constantly changing conditions presents challenges in some situations.

Choosing which wireless network to implement into a facility is critical, and the better choice for a given situation will depend on many variables. **ce**

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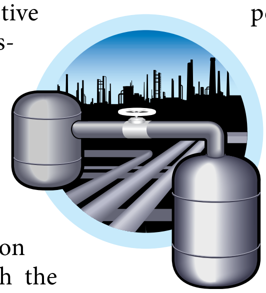
**Robbie Peoples,** Cross Co.

# Four guidelines for successful skid integration of batching operations

Successful skid integration for batch manufacturing operations can be challenging. Following best practices, such as standardized communications and defining status feedback, can make the process a much smoother one.

New processes, or the expansion of existing processes, typically include original equipment manufacturer (OEM) skids. Skid mounted equipment can provide a faster implementation time versus conventional process system building from scratch.

Skid equipment can provide fast deployment with a high-quality cost-effective solution for utility and main processing functions. The integration of skid equipment can be simplified if there is minimal interaction with the overall processing system. In this case, only data collection or minimal interaction are required to work with the main distributed control system (DCS) or supervisory control and data acquisition (SCADA) system. However, seamless integration of the skid equipment into an overall process can be challenging. Tight integration of skid equipment into processing activities such as batching operations requires a much deeper level of cohesive interaction to achieve a high level of process efficiency.



## Skid integration for batch

The primary challenge of integrating a third-party system into a process is that upstream and downstream operations must be coordinated and share a cohesive operating philosophy. Typically, utility system equipment skids simply provide the desired functions at a designed capacity, on demand. On the other hand, OEM skid equipment that is chained together or act as a puzzle piece in a much larger process requires additional coordination of the upstream and downstream units to achieve efficient equipment utilization.

Most skid equipment comes complete with its own dedicated processor, input/output (I/O), and are generally designed to operate independently. Meaning, they operate without anticipation of upstream feeds or downstream demands. Often, the operation of the overall process is forced to work around the OEM functional characteristics. In many circumstances, the operating attributes of the OEM skids are a direct result of the system programming and not a limitation of the equipment capabilities. Meaning, OEM skid equipment is not built to act as a true slave or servant to the overall process coordinator or master controller.

The independent operating philosophy of OEM skids is generally a result of commodity selling of the canned packages. Changes to an existing operating function represent a risk to the supplier and they are generally reluctant to augment system functions upon request. Integration of skid packages into a true batching system is inherently difficult because most skid packages are not programmed using the ISA S88.01: Batch Control standards.

Most skid programs are comprised of ladder logic that was originally built to provide multiple processing options. This allows one system software application to cover a multitude of processing options. Ladder logic can be designed to follow programming standards but it does require some additional effort to do so. Not using industry stan-

More ANSWERS

**KEYWORDS: batching operations, equipment manufacturer (OEM) skids**

**Operating modes** of remote equipment can be tricky if boundaries are not clearly defined.

**Standardizing** operating states allows for a mechanism to handle the difficult part of a batch, which is the exception condition.

**Status feedback** is an essential part of efficient operations between two different systems.

**Communications** between systems can be achieved in a very efficient manner by using single integer value designations.

**CONSIDER THIS**

**Are original** equipment manufacturer (OEM) skids successfully integrated into your operations?

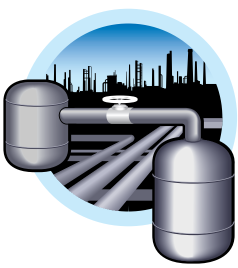
dard programming practices, over-complicating the application with multiple processing functions that are not being used, and a risk-averse supplier can make it very difficult to seamlessly integrate the system into an overall batching solution.

### Integration for batching operations

The integrating of OEM skid equipment into an overall batch management system requires a clearly defined level of coordination between the slave and master (DCS or SCADA) systems. Simple commands to the slave system do not provide the operator with a visual representation of the system. If everything works perfectly, a simple master command to the slave system will suffice. But when an exception condition happens, it will be very difficult to detect and/or troubleshoot without having to go out to the equipment's local human-machine interface (HMI) to determine the issue.

This creates delays in operation, increasing the batch cycle time, reduction in equipment utilization, and reducing the overall operating efficiency. A slave OEM system can be tightly integrated into an overall master processing system by following four simple guidelines:

- Allocate the operating modes
- Follow the standard operating states
- Define status feedback
- Standardize communications.



> "**Operating modes** of remote equipment can be tricky if boundaries are not clearly defined."

The design should synchronize two pieces of equipment by defining an agreed upon method of interactions. A flexible batch architecture includes a respective isolation between different functions, which standardizes how they interface with other functions. This type of definition allows for the equipment entities to operate independently and promotes the reuse of a base code of functions. The reuse of code reduces overall engineering time as well as minimizes the possibilities of human error.

## 1. Allocate the operating modes

Operating modes of remote equipment can be tricky if boundaries are not clearly defined. Can an operator make changes to the equipment locally if the control variables have been commanded remotely from an overall recipe? Should the recipe go to a hold state when a specific operating status changes? These are just a few questions that should be considered when integrating remote equipment. The interface rules and operating philosophy between the master and slave system should be clearly defined to provide a continuous and uniform interface between the two systems.

## 2. Follow the standard operating states

Standardizing operating states allows for a mechanism to handle the difficult part of a batch, which is the exception condition. An exception condition can be defined as an event that occurs outside of the normal or desired behavior of the process. Handling, processing, and recovering from these types of conditions is a critical element of batch production. Not only is exception handling important for process safety, but it is essential for product quality and critical to achieving a high level of operating efficiency. Programming exceptions can represent up to 70% of the programming effort and must be considered a goal in the batch design process.

## 3. Define status feedback

Status feedback is an essential part of efficient operations between two systems. This information should be structured and defined for modes, operating states, and error conditions as well. The representation of the standard modes and states should be common across all equipment but the error conditions should be specific to each piece of equipment. Specific error feedback from a slave or remote system can provide operations a visual indication of the current condition. Error states also can be used to detect preventive actions to increase equipment utilization and boost the overall operating efficiency of the system.

## 4. Standardize communications

Communications between systems can be achieved in a very efficient manner by using single integer value designations. The communications can be very simplistic, using one word for commands to the slave system and providing a status word coming from the slave system. The general command status can be common to follow the operating mode and states.

However, additional parameters or system variables may need to be written down to the slave programmable logic controller (PLC) as a result of an overall recipe setting in the main system. Standardizing on the communication types for remote or third-party equipment make the control system more easily maintained and expanded over the lifecycle. Development of the communication standards for remote interfaces must be designed broad enough to fit application types, but specific enough have value.

## The solution: Standards

The integration of slave or remote systems can be challenging, but standardized interfaces make the process more easily managed. Two out of the four guidelines identified above are clearly defined within the ISA S88.01 standards. The status feedback and packaging of the communication data between the systems can be defined to cover all third-party solutions. A common interface design promotes a consistent coordinated effort across the system that allows for easy maintenance and expansion.

The common interfaces should be documented in a design deliverable provided as a user requirement specification (URS) to OEM vendors to meet the standards. This will ensure the remote system programming complies with the expected operations. Standardizing the interactions to include exception conditions shall provide a system that is more easily operated and maintained to achieve a high level of operating efficiency. **ce**

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**Allan Kern,** APC Performance LLC

# Pros and cons of autotuning—the big story

Autotuning is still not a one-size-fits-all solution.

The historic challenges of single-loop tuning, the limited success of autotuning, and the modern difficulties of model-based control share the same root cause. *Control Engineering* published a two-part series on autotuning: "Pros and cons of autotuning control: Part 1" in the June 2018 issue and "Pros and cons of autotuning control: Part 2" in the August 2018 issue. These are excellent and informative articles, and while they make the correct conclusions, they miss one of the main implications. The story of autotuning reveals this lesson.

As the articles rightly conclude, autotuning is "still no panacea," and as they rightly suspect, "Perhaps the most significant challenge is an unpredictable or nonlinear process." An unpredictable process is one where the actual process response differs from the pre-identified response upon which the tuning or model is based. This turns out to be true for most processes, which is why autotuning has achieved limited success despite a number of industry attempts. Where the actual process response varies poses a fundamental conundrum for tuning and modeling.

This explains why single-loop tuning and multivariable control modeling, which in theory should be one-time engineering tasks, are more like recurring maintenance in practice. That is the long-held reality of loop tuning, and has now emerged as the reality of model-based control, too.

Two common solutions, unfortunately, promise not to solve these problems. One is the idea of an average model or average tuning. While this is probably the best strategy, it obviously has not solved the problem beyond where we are today. The second idea is autotuning or adaptive modeling, which are potentially more problematic than averaging, because they basically tune for today, which may or may not be appropriate tomorrow.

In the vernacular, process gains change. Many, if not most, gains change frequently or even dynamically due to everyday disturbances and changes in process conditions. That retuning and remodeling remain as commonplace as they do, plus the limited success of autotuning, testify to this. It also is common sense to people who have spent years troubleshooting process control performance. Ultimately, autotuning cannot solve this problem. Users should look at the emergence of adaptive modeling, which is attempting to do the same thing on a much larger scale, with a critical eye.

Modern computer-based tools did not solve this dilemma, as we expected, but confirmed it, as we should have known. Going forward, tuning and modeling need to re-orient themselves to the idea that fixed models are the exception, not the rule. Model averaging remains the best practice along with reliable feedback control, conservative tuning, and very selective use of feedforward—only where necessary to avoid hard constraints, or warranted to capture large earnings—because every feedforward model comes with a reliability and maintenance cost. This is the best strategy going forward for both single-loop and multivariable control. ce

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## More ANSWERS

**KEYWORDS:** **Advanced process control, autotuning**

**Single-loop tuning,** autotuning, and model-based control share the same root cause.

**Single-loop tuning** and multivariable control modeling are more like recurring maintenance because there are too many unpredictable variables.

**Model averaging** remains the best practice along with reliable feedback control, conservative tuning, and very selective use of feedforward.

**CONSIDER THIS**

**Are model averaging,** reliable feedback control, conservative tuning, and very selective use of feedforward best practices in your plant?


**The analogy of a passenger plane changing altitude illustrates why operational performance criteria is more appropriate for industrial process operation than traditional error minimization. Courtesy: APC Performance LLC**


## Multi-loop controller has a touchcreen

Future Design Controls' MCT4 is a ¼ DIN multi-loop controller with a 4.3-in. color touch screen user interface. The MCT4, which can be used for up to three proportional-integral-derivative (PID) loops, also features a paperless recorder, trend and data file viewer, email/text messaging on alarm, remote access, Modbus serial and TCP/IP communication, and file transfer via USB. The MCT4 is designed to provide control for applications in various industries including semiconductor, automotive, heat treating, packaging, food and beverage, chemical, and others where control, monitoring, and/or data logging is required.

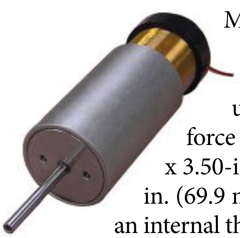
**Future Design Controls, www.futuredesigncontrols.com** Input #200 at www.controleng.com/information

## Shape memory alloy positive displacement piston pump

Kinitics Automation's KPP05 Piston Pump is a shape memory alloy-based positive displacement pump that uses proprietary technology to deliver a precision stroke. Driven by the company's KLA05 Linear Actuator, the product requires only ac or dc electrical power to operate and allows for displacement or pressure control when additional sensors are used. The KPP05 Piston Pump is compatible with a wide range of fluids and provides a high pressure-to-size ratio. The KPP05 Piston Pump may also be configured with alternate bore sizes when higher pressures or displacements are required. Applications for the KPP05 include acting as a master cylinder for brake and clutch control, a hydraulic pump for grippers and clamps, and as a precision metering pump.

**Kinitics Automation, www.kiniticsautomation.com** Input #201 at www.controleng.com/information

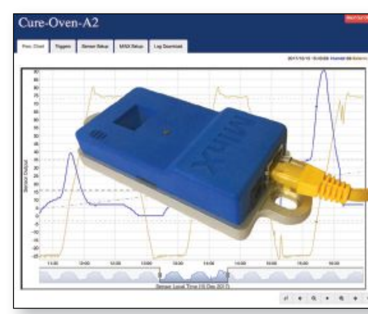
## Linear voice coil motor, high force-to-size ratio



Moticont's GVCM-051-089-05S06 Linear Voice Coil Motor has a high force-to-size ratio with 5.5 lb (24.6 N) continuous force and 17.5 lb (77.7 N) of peak force with a housing measuring just 2-in. dia. x 3.50-in. long. The stroke of the motor is 2.75-in. (69.9 mm) and the precision ground shaft has an internal thread. The housing has threaded mounting holes for easy integration into current and future applications. This brushless actuator is ideal for applications such as assembly equipment, work holding and clamping, laser machining and drilling, scanners, and laser beam steering and filtering. The Moticont's GVCM-051-089-05S06 linear voice coil motor can also be ordered as a complete plug-and-play system including a controller.

**Moticont, www.moticont.com**
Input #202 at www.controleng.com/information

## Plug-and-play sensor includes software




ExpressSense's MINX sensor system is a plug-and-play sensor featuring sensors and software to automatically generate control charts for display in any web browser. Five built-in sensors support the most common preventive maintenance, process control, and automation tasks: optical event counting; shock or vibration limit detection and event counting; ambient temperature measurement; ambient humidity measurement; remote temperature measurement; and limit detection or event counting. It also allows the user to connect a user-supplied sensor to the 5V analog input. Programmable triggers generate e-mail or text alerts when thresholds are reached, or can control equipment with the external output.

**ExpressSense, www.expresssense.com**
Input #203 at www.controleng.com/information


## Modbus flow totalizer, configurable for volume and time settings

SignalFire's ModQ Sentry is a Modbus flow totalizer that interfaces with pulse-type inductive turbine and other flowmeters to provide instantaneous flow rates, accumulated totals, and status information. Units are configurable for volume and time settings and offer options to configure the K factor to match the turbine. Powered by an internal lithium battery for standalone operations or an external 6 to 36 Vdc power source, the ModQ Sentry provides a local display along with a Modbus RS485 data port to integrate with PLC/SCADA and distributed control systems (DCSs). The ModQ Sentry maintains an internal 30-day log of daily flow totals for historical analysis or backup storage. The ModQ is ideal for data management of turbine flowmeters in new and retrofit installations for a variety of industrial applications such as oil and gas, metals and mining, water and wastewater, chemical, power, food and beverage, pulp and paper, aerospace, and pharmaceutical.

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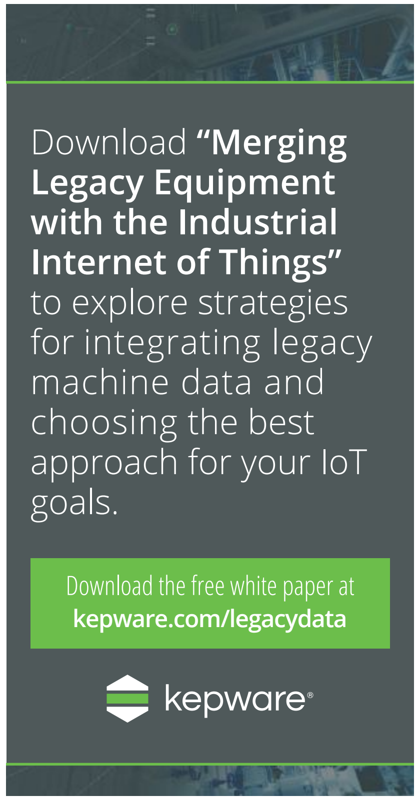


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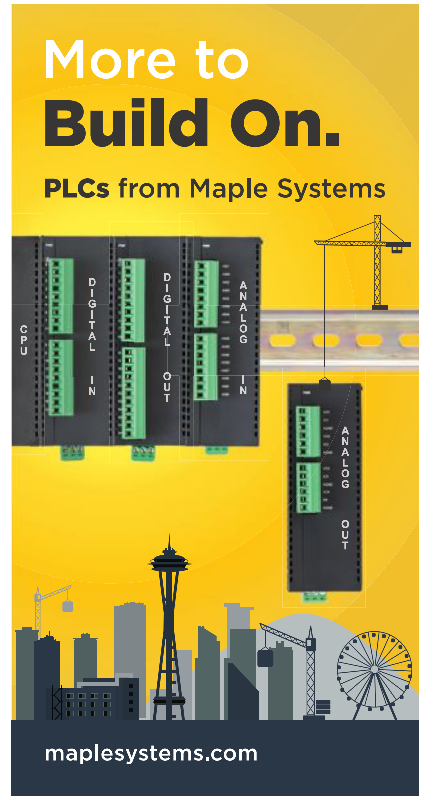


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## Digital dc/dc controllers have pulse width modulation


Renesas Electronics' ISL68300 and 68301 digital dc/dc controllers are designed to provide single output point-of-load (POL) conversions for field programmable gate arrays (FPGAs), network processors, general purpose system rails, and more. The ISL68300 has integrated MOSFET drivers and the ISL68301 has pulse width modulation (PWM) output. Both are designed to simplify designing power supplies for data center, wired and wireless communications, and factory automation equipment. The ISL68300 can drive discrete external MOSFETs directly while the ISL68301 pairs with smart power stages. Both controllers implement Renesas' digital ChargeMode control modulation.

**Renesas Electronics, www.renesas.com** Input #205 at www.controleng.com/information

## Linear motion drives

Nanotec's LGA28 and LGA42 series of captive linear actuators measure 28mm and 42mm, respectively, and are designed to be suitable particularly for use in small installation spaces that demand exact positioning. They offer very low backlash as well as high thrust and tensile force. The integrated linear guide with movable polygon profile makes high-precision feeding possible without additional mechanical components. Both series can be ordered in various lengths, with different windings, and optionally with an encoder. The electrical connection is made using an integrated connector.

**Nanotec, www.nanotec.com**

Input #206 at www.controleng.com/information

## Motorized lead screw actuator

Thomson Industries expanded its line of stepper motor linear actuators with a motorized lead screw actuator (MLA). It provides companies with high-precision, shorter-stroke applications relief from the cost, time, and maintenance worries related to designing and building externally guided systems. The line eliminates the need for external guidance by surrounding the shaft with an aluminum cover tube with molded internal splines that lock onto the nut to keep it from turning. It has an integrated bushing to withstand small radial and moment loads. It is best-suited for space-constrained, force-sensitive applications requiring shorter strokes that must be repeated with high precision.

**Thomson Industries Inc. www.thomsonlinear.com**

Input #207 at www.controleng.com/information

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**Frank Lamb,** Automation Consulting LLC

# Ladder logic simulation

Using simulation for ladder logic allows users to test advanced situations that otherwise wouldn't be possible, reducing potential costs and hazards for users.

In a basic programmable logic controller (PLC) training class, pushbuttons and pilot lights built into a trainer are used to complete exercises, usually to illustrate the use of different instructions on the PLC software platform. Advanced classes concentrate more on the techniques used in programming such as auto sequences, part tracking, and other system functions.

Making all elements of a properly organized program operate together can be a daunting task. Different types of routines relate to each other. Contacts that represent the state of a machine or sequence are easy enough to test. Internal memory bits indicate things like auto/manual mode, autocycle, and even faults.

Inputs and outputs, however, are a different story. In a larger machine or system, they represent a lot of different types of sensors or output devices. With the trainers that are often used in training classes, there are not enough buttons, switches, and pilot lights to substitute for real-world devices. Also, input devices such as buttons, switches, and potentiometers don't react automatically in real-time to sequences and output commands.

Here, a simulation routine can be useful. With the appropriate output logic the inputs and outputs are "aliased" to memory bits rather than real-world input/output (I/O).

If the Z-Axis_Lower_SV output is activated in a real machine, the Z Axis Lowered sensor usually would be activated automatically. Since this is not a real solenoid valve driving an air cylinder with a sensor on it, we need to simulate the sensor being made.

## More INNOVATIONS

**KEYWORDS: Ladder logic, simulation**

**Using simulation** in ladder logic can allow programmers and users to test inputs and outputs before they're implemented.

**Simulation also** allows programmers to test some of the more critical code before deploying it on a machine.

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**Which applications** would benefit most from ladder logic simulation?

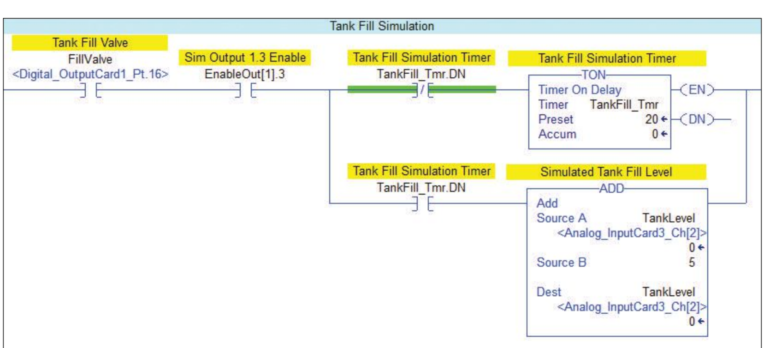


**Figure: Both the timer value and the tank level addend can be adjusted to achieve the desired result.**

## Timer circuit, memory bit

This timer circuit does the job nicely. Notice that a memory bit needs to be used to simulate the input. Input memory bits also can be used in the auto sequence to step from one sequence state to the next. The EnableOut bit is used in case a fault needs to be simulated. If the bit is disabled, it is as if the output activated but the input was never detected. The fault timer will time out and latch a fault condition.

Also notice that a "latch" or "set" bit is used for the input. This is especially important for solenoid valves that are turned off when the sequence proceeds to the next step. When the output goes off, the simulated sensor will stay active.

It is best to put all of the simulation rungs in a separate routine. If the program is designed for training and a real machine, the simulation routine can be removed or disabled later. Simulated I/O also can be replaced later with the real stuff.

With analog values, a timer is used for the simulation. In this case, the tank level will increment by five every 20 ms. Both the timer value and the tank level addend can be adjusted to achieve the desired result. There is more conditioning that should be done to simulate a real tank, but the Figure shows the general idea. To drain the tank, use a subtract instruction. This also can be used to test proportional-integral-derivative (PID) instructions.

Real equipment often is not available during the design phase of a project. Simulation allows programmers to test some of the more critical code before deploying it on a machine. With a human-machine interface (HMI), programmers even can visualize the process via animated objects. **ce**

*__Frank Lamb__ is the founder of Automation Consulting LLC, and is on the* Control Engineering *Editorial Advisory Board. This article originally appeared on Automation Primer's blog. Automation Primer is a CFE Media content partner. Edited by Chris Vavra, production editor,* Control Engineering, *cvavra@cfemedia.com.*


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