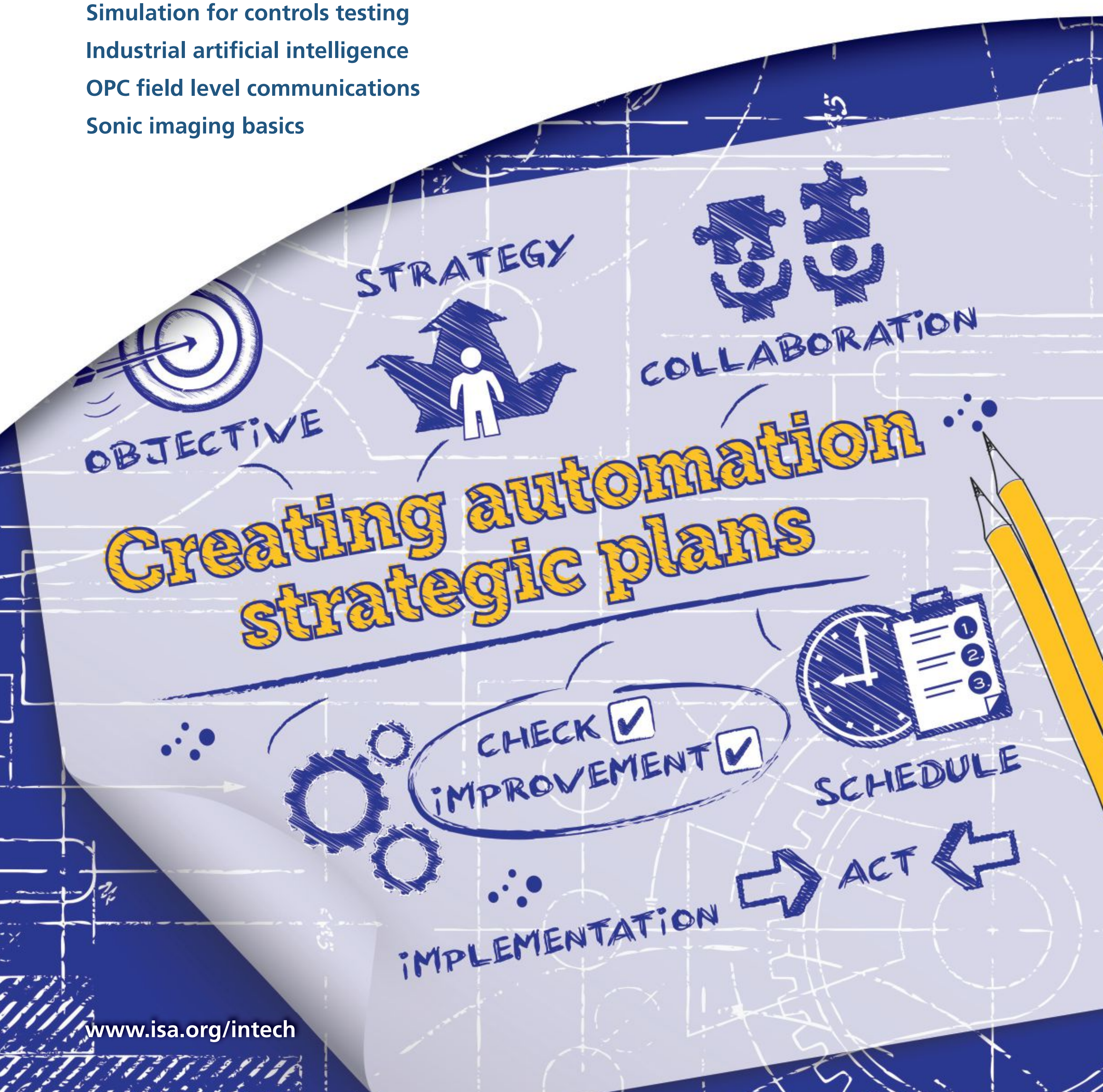
July/August 2020

InTech

OFFICIAL PUBLICATION OF THE INTERNATIONAL SOCIETY OF AUTOMATION

- Edge analytics for optimization
- Simulation for controls testing
- Industrial artificial intelligence
- OPC field level communications
- Sonic imaging basics



Creating automation strategic plans

www.isa.org/intech

100%

of **Reference Standards traceable** to Nationally Recognized Standards.

Ensure compliance and increase process uptime with optimized services

- Lab and field accredited calibrations (A2LA) and verification capabilities for flow, pressure and temperature instruments
- Patented, industry-expert methods to optimize your calibration plan
- We are a leading manufacturer of process instrumentation – uniquely qualified to verify and calibrate
- Our global, harmonized calibration standards provide consistent service quality

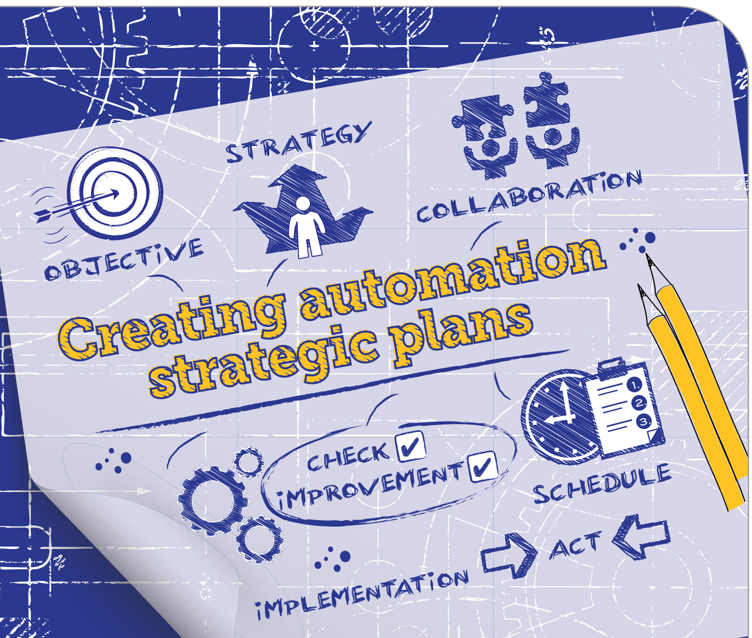
Do you want to learn more?
www.us.endress.com/calibration-usa

Endress+Hauser
People for Process Automation

July/August 2020 | Vol. 67, Issue 4

www.isa.org

InTech



www.isa.org/InTech

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

ISSN 0192-303X

***InTech*, USPS # 0192-303X, is published bimonthly in Research Triangle Park, NC by the International Society of Automation (ISA), 67 T.W. Alexander Drive, P.O. Box 12277, Research Triangle Park, NC 27709. Vol. 67, Issue 4.**

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

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

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

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

Printed in the U.S.A.

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

For permission to make copies of articles beyond that permitted by Sections 107 and 108 of U.S. Copyright Law, contact Copyright Clearance Center at www.copyright.com. For permission to copy articles in quantity or for use in other publications, contact ISA. Articles published before 1980 may be copied for a per-copy fee of $2.50.

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

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

InTech magazine incorporates *Industrial Computing*® magazine.

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


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

The art and science of removing friction

By Renee Bassett, *InTech* Chief Editor

Automating. Optimizing. Problem-solving. What is it that automation engineers are doing exactly?

While compiling information to honor ISA's 75 years of service to the world of industrial automation and instrumentation, I've combed resources covering the history of computer programming. It turns out that whether you're creating systems for banking, breadmaking, or bantering over the Internet, the activities are similar and the milestones are the same.

In the introduction to an article on *Slate* called "The Lines of Code That Changed Everything," Clive Thompson writes, "The most consequential code often creates new behaviors by removing friction. When software makes it easier to do something, we do more of it."

Slate editors polled computer scientists, software developers, historians, and others to create a list of 36 pieces of code that influenced what came next. Many entries show how the history of programming is the history of automation and control, starting, for example, with the invention of the punch card—in 1725.

"Binary programming long predates what we think of as computers," writes Elena Botella of *Slate*. She says Basile Bouchon is believed to be the first person to punch holes into paper and use them to control a machine: A punched-hole "one" and nonpunched "zero" controlled the weaving pattern of a loom. "As much as things have changed since then, the essential building block of code has not," she says.

The Electrical Numerical Integrator and Computer (ENIAC) was the first programmable electronic computer. Built in 1945, it was configured for each new problem by wiring connections between its many components, says Thomas Haigh, co-author of *ENIAC in Action: Making and Remaking the Modern Computer*. The completion of one task, such as a subtraction or addition, triggered a pulse that started the next task. "But a few years later, Klára Dán von Neumann and Los Alamos scientist Nicholas Metropolis wired ENIAC to run the first modern code: hundreds of numerical instructions executed from an addressable read-only memory—ENIAC's function table switches.

Grace Hopper, a programmer in the U.S. Naval Reserve during World War II, knew that her superiors in the military struggled to understand the binary code she was fluent in. She reasoned that if programming languages could be based on human language, they could be more accessible to people without a PhD in mathematics. So, in 1952 she created a set of instructions that could convert English language code into the lower-level binary code processed by a machine. With this compiler, she and her lab developed FLOW-MATIC, the first programming language to incorporate human-readable words.

So, what were Basile, Klára, Nicholas, and Grace doing? The same thing programmers and engineers around the world have been doing since: making it easier to do something in order for that something to be repeated faster, easier, and more reliably.

It takes a special person to do that well. As Thompson describes in his book, *Coders: The Making of a New Tribe and the Remaking of the World*, such friction-removers have "the distinctive psychology of this vocation, which combines a love of logic, an obsession with efficiency, the joy of puzzle-solving, and a superhuman tolerance for mind-bending frustration."

Sound like you? Send a story about your early years in automation to 75in2020@isa.org, and it might make it into our commemorative issue. You can also reach out to me at rbassett@isa.org or www.linkedin.com/in/rrbassett. ■

ISA *INTECH* STAFF

CHIEF EDITOR
Renee Bassett
rbassett@isa.org

CONTRIBUTING EDITOR
Bill Lydon
blydon@isa.org

CONTRIBUTING EDITOR
Charley Robinson
crobinson@isa.org

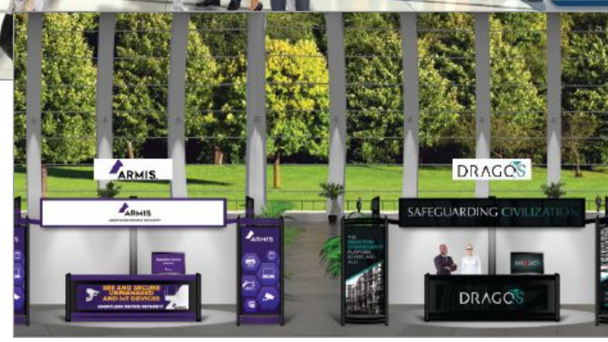
PUBLISHER
Rick Zabel
rzabel@isa.org

PRODUCTION EDITOR
Lynne Franke
lfranke@isa.org

ART DIRECTOR
Lisa Starck
lstarck@isa.org

GRAPHIC DESIGNER
Bonnie Walker
bwalker@isa.org

Virtual Cybersecurity Standards Implementation Conference debuts



No simple recipe exists for how to secure an industrial automation and control system (IACS). Every IACS presents a different risk to its organization depending on the threats it is exposed to, the likelihood of those threats arising, the inherent vulnerabilities in the system, and the consequences if the system were to be compromised. That is why multiple perspectives and experiences must be considered when implementing cybersecurity safeguards. ISA gathered those perspectives and resources in one place—despite a global pandemic and associated travel restrictions—to present its first Cybersecurity Standards Implementation Conference (CSIC) in a virtual format.

The virtual CSIC brought together industrial cybersecurity experts from multiple industries and geographies for a one-day event in July that users could attend from the convenience of their desk or phone. The eight presentations, which varied in format from PowerPoint presentations with audio voiceovers to live video, focused on IACS cybersecurity awareness and solutions based on ISA/IEC 62443, a consensus-based series of industrial cybersecurity standards. The event included chat-based questions and answers after each session, and a separate "show floor" presenting virtual booths and downloadable resources from vendors including PAS, ARMIS, and Dragos.

ISA's unique role in supporting IACS cybersecurity was evident by booths and resources from its departments and supported organizations: the ISA Cybersecurity Alliance (ISAGCA); ISA Security Compliance Institute (ISA Secure), provider of IEC 62443 certifications; ISA training, offering a range of ISA/IEC 62443 courses; and ISA publications.

Those who could not attend the live event can still benefit. The presentations were recorded, and registered attendees received access to session webinars on demand for 30 days following the event. ISA's virtual events program team also plans CSIC+, scheduled for Tuesday, 25 August 2020 at 9:00 AM – 1:00 PM CDT. Multiple webinars on that day will cover additional IACS topics, including the future of cybersecurity from a hacker's perspective and how to hunt ransomware. Find out more at https://isaautomation.isa.org/virtual-events-program-cybersecurity. ■

M12 connector standard established

Eight manufacturers known for making M12 connectors—Phoenix Contact, HARTING, Molex, Murrelektronik, Binder, CONEC, ESCHA, and Weidmüller—have come together to establish a standard for the locking mechanism. The goal of ensuring compatibility across manufacturers has been met by IEC 61076-2-010, a standard that describes both external and internal locking utilizing the push-pull mechanism. The vote on the standard was approved with 92.9 percent in favor. ■

OPC Foundation adds Google Cloud as member

The OPC Foundation welcomed Google Cloud as the latest addition to its 773-member community. Google Cloud provides enterprise-grade cloud solutions that use Google's technology with interoperability, infrastructure, platform capabilities, and industry. In line with its Industry 4.0 effort, Google Cloud will use the OPC UA open standard to incorporate machine data into analytics and artificial intelligence solutions.

OPC UA is an industrial, protocol-agnostic framework for the IIoT and Industry 4.0 that contains mechanisms for secure, reliable, manufacturer- and platform-independent information exchange. It scales from the sensor to the MES/ERP level and into the cloud, and includes a built-in cybersecurity mechanism. ■

Report: USB threat risk to industrials doubles over past 12 months

In a new report based on cybersecurity threat data collected from hundreds of industrial facilities globally, the severity of threats detected to operational technology (OT) systems has risen significantly in a 12-month period. An important vector of vulnerability is USB removable media.

The findings of the *Honeywell Industrial USB Threat Report,* released in July, show that the amount of threat posed by USB removable media to industrial process control networks remains consistently high, with 45 percent of locations detecting at least one inbound threat. Over the same time period, the number of threats specifically targeting OT systems nearly doubled from 16 to 28 percent, while the number of threats capable of causing a loss of view or other major disruption to OT systems more than doubled, from 26 to 59 percent.

"USB-borne malware continues to be a major risk for industrial operators," said Eric Knapp, director of cybersecurity research and engineering fellow, Honeywell Connected Enterprise, Cybersecurity. "What's surprising is that we're seeing a much higher density of significant threats that are more targeted and more dangerous. This isn't a case of accidental exposure to viruses through USB—it's a trend of using removable media as part of more deliberate and coordinated attacks."

As the second most prevalent attack vector into industrial control and automation systems, USB devices play an important role in attacks that target OT systems. The report shows that one in five of all threats was designed specifically to leverage USB removable media as an attack vector. In recent years, such attacks have included Disttrack, Duqu, Ekans, Flame, Havex, Industroyer, and USBCulprit.

More than half the threats were designed to open backdoors, establish persistent remote access, or download additional malicious payloads. These findings are indicative of more coordinated attacks, likely attempting to target air-gapped systems used in most industrial control environments and critical infrastructure, said Knapp.

The Honeywell *Industrial USB Threat Report* examines data collected from Honeywell's Secure Media Exchange (SMX) technology, which is designed to scan and control removable media, including USB drives. ■

NATO, Siemens deepen collaboration on power grid cybersecurity

Siemens Smart Infrastructure and the NATO Cooperative Cyber Defence Centre of Excellence (CCD COE) have signed a memorandum of understanding to continue to cooperate on cybersecurity for critical infrastructure worldwide and advance their existing cooperation on cybersecurity training related to power grids.

NATO CCD COE, located in Tallinn, Estonia, was established in 2008. It engages in research in four core areas: technology, strategy, operations, and law. The CCD COE annually organizes a high-level cyberdefense exercise called Locked Shields to build up defense capabilities.

Locked Shields is designed to train cybersecurity response teams to defend against massive cyberattacks. Siemens has teamed up with NATO CCD COE since 2017 to include complex power grid scenarios for Locked Shields that use Siemens Spectrum Power grid control software and Sicam A8000 remote terminal units.

In the exercise, the defenders have to set the defense lines of a complex infrastructure, including various systems and applications that should withstand massive cyberattacks executed by a large group of hackers. Keeping the lights on while performing threat hunting, reporting attacks, and recovering the system are some of the challenging tasks the cybersecurity experts learn to deal with.

Colonel Jaak Tarien, director of the NATO CCD COE said, "With the aim to reinforce the interaction amongst different cyberdefense stakeholders, to deepen cooperation and exchange of best practices, this agreement takes our cooperation to a new level. Our societies rely on strong and resilient critical infrastructure. Accordingly, there is a real value in our partnership to advance cybersecurity together with the key industry partners."

The way grids are operated and managed has changed fundamentally in the last years with the integration of more renewable and decentralized energy sources, according to Siemens. The need for network optimization, interaction between "prosumers," and the number of new market participants have all significantly increased. ■

Innovation comes to the temperature transmitter market

By P. Vidya

ABOUT THE AUTHOR

P. Vidya, ARC analyst, is based in ARC Advisory Group's offices in Bangalore, India. Her research spans industrial instrumentation and automation. Before ARC, Prasad worked as an analyst at Capgemini, Infiniti Research, Ltd., and Lucintel. She earned an MBA degree from the Bhilai Institute of Technology.

While in the past temperature transmitters were widely viewed as commodity products, recent ARC market research (www.arcweb.com/market-studies/temperature-transmitters) indicates that digital technology and Industrial Internet of Things (IIoT) connectivity are driving innovation in this previously "sleepy" product area. Suppliers offer a broad range of devices appropriate for a wide range of process conditions. Their devices have sophisticated designs and advanced functions, including digital signal processing, multisensing technology, and self-diagnostics, plus wireless and other connectivity.

Within the overall industrial temperature measurement space, ARC has been observing a gradual shift from thermocouples (TCs) to resistance temperature detectors (RTDs) for selected applications, particularly to lower-cost thin-film RTDs. Although thermocouples are generally better than RTDs in terms of cost, ruggedness, measurement speed, and temperature ranges, RTDs are more accurate and have better repeatability. In addition, RTD sensors are relatively easy to calibrate.

Another trend is the growing use of integrated assemblies for process temperature measurement. An integrated assembly provides a thermowell, RTD, transmitter, and local LCD display with a single model number. This reduces costs for both suppliers and users by simplifying order processing and reducing installation costs. With an integrated assembly, the user gets a fully tested system, calibrated to match the sensor.

Low-cost IIoT-connected sensors and analytics software support industrial monitoring and asset management applications.

The adoption of wireless field devices will continue to affect the dynamics of the market for temperature transmitters and other field devices. Although wireless temperature transmitters still represent a very small portion of the overall temperature transmitter market, the wireless market is poised for strong growth in the long run. Wireless technology allows users to install field devices in measurement points that previously were not feasible due to the high cost of wiring. This is particularly true for hazardous or inaccessible areas. Encryption and mesh networking technologies have largely addressed user concerns about the security and reliability of wireless transmission of process data. This is particularly true for monitoring applications. However, battery life remains an issue for wireless transmitters mounted in areas that do not have ready access to line power.

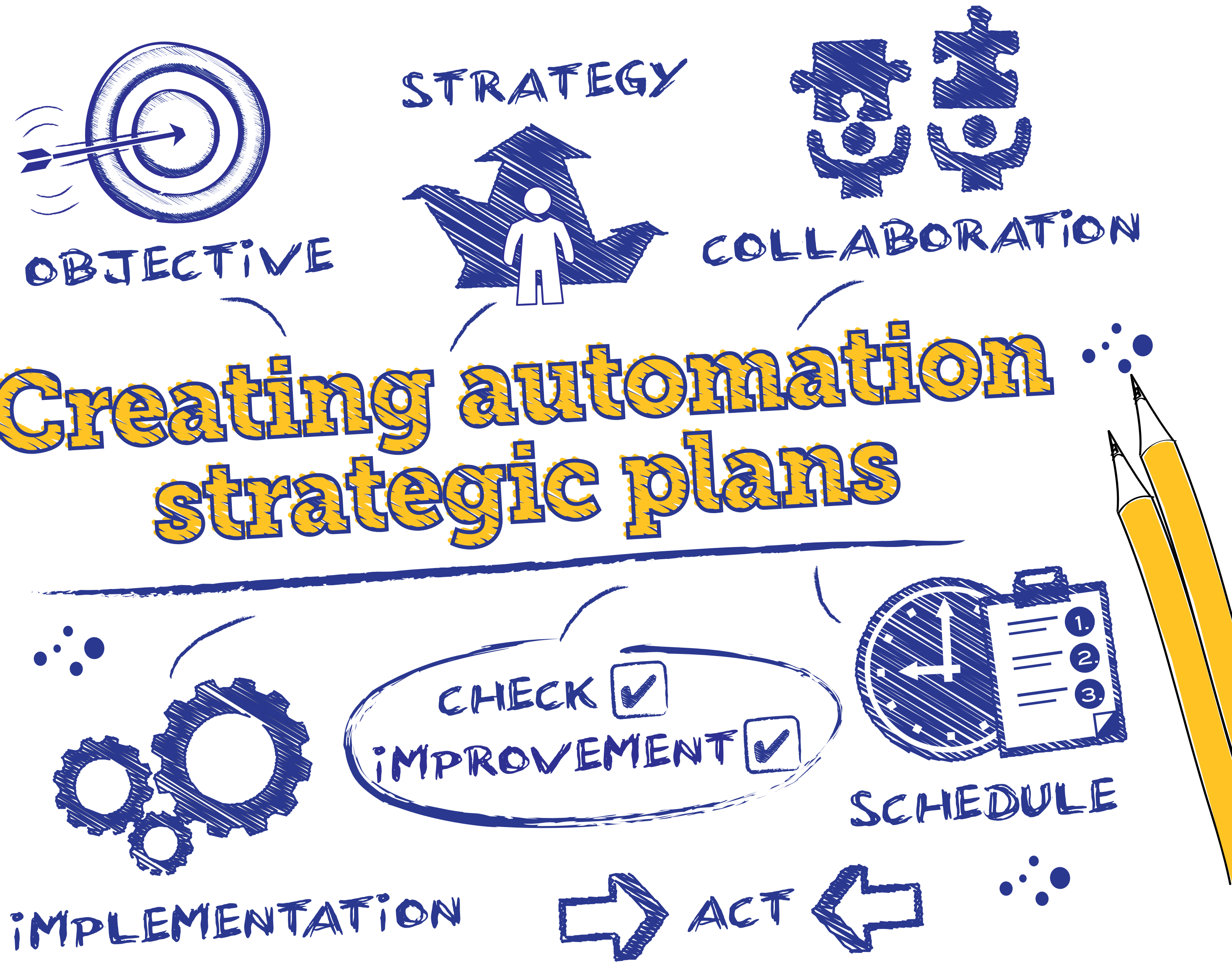
Today's increased emphasis on plant asset management (PAM) supports the proliferation of smart, microprocessor-based temperature transmitters that have digital output and bidirectional communication of diagnostic and process information. For the foreseeable future at least, the vast majority of process variables will continue to be communicated (wired or wirelessly) to industrial controllers and data acquisition devices via either conventional analog signals or industrial digital protocols. However, low-cost IIoT-connected sensors and analytics software are now also being used to support industrial monitoring and asset management applications. These include predictive analytics that can help identify asset- or process-related issues so these can be resolved before they negatively impact plant performance, safety, or environmental compliance.

Forward-looking automation and instrumentation suppliers are investing to bring IIoT to the field device level in the temperature transmitter market. IIoT-enabled capabilities, such as remote monitoring and remote services, can help establish a more collaborative relationship between end users and suppliers. IIoT solutions are now available to help increase horizontal integration along the value-creation chain, from planning to operations and maintenance, and for vertical integration from the field to the control level and beyond.

End users can also leverage the expertise of suppliers to help manage and improve the performance and availability of plant assets across their entire life cycle.

To succeed, suppliers must provide IIoT-ready edge devices, gateways to log and capture data from multiple sources, and cloud capabilities to store and analyze data. Delivering meaningful and actionable results to customers and developing appropriate cybersecurity mechanisms will help end users embrace the new technology. Technology end user organizations, in turn, need a well-thought-out digital transformation strategy and appropriate executive support to reap benefits. ■

Creating automation strategic plans



The fundamentals of evaluating control systems, analyzing the gaps, and plotting a successful course

By Joao Miguel Bassa

The main purpose of an automation strategic plan is to improve our ability to manufacture and sell products by a better utilization of people, equipment, raw materials, and facilities. Three key objectives for improvement are quality, productivity, and responsiveness.

The consistent manufacture of quality products satisfies customer requirements and maintains their confidence. Increased physical plant productivity comes by providing information and tools to the people who manage and operate the facility. Production of quality products in an efficient manner is responsive to the external environment: giving customers products they need, with necessary information about these products, while effectively addressing changes in the marketplace, changes in customers' requirements, and changes in technology.

A good automation plan comes out of a structured assessment to identify the real status of the production process, as well as the needs, opportunities, and benefits of automation. This article will show you how to perform such an assessment.

The control pyramid

To achieve the objectives, you first need to understand the integrated controls systems hierarchy (figure 1). It shows four layers of controls, with each layer addressing a corresponding decision-making level.

Reflexive controls establish the base layer of the regulatory and sequential controls that directly handle the process inputs and outputs. Reflexive controls maintain the process variables in the specified operation range. Classically, reflexive controls comprise sensors, valves, and the hardware to develop feedback controls, sequential or safety interlocks, indications, and records of the running process. From the old pneumatic instruments to the modern distributed control system (DCS), the main purpose of this layer has not changed; however, the use of the modern smart transmitter in fieldbus arrangements and online analyzers can provide the infrastructure for highest-level (strategic) control-function development and application.

Reactive controls, level two of the pyramid, are intended to improve the reflexive controls. The basic idea is to recognize the variables that can influence each other and create some links, building a complex control loop that can compensate its cyclic interaction (multivariable controls). After the control strategy implementation and again using the data from this first approach about the process model, it is possible to make improvements to automatically change the constraint parameters. In addition, the relational gain between loops can have dynamic changes (nonconventional controls) to obtain the instantaneous best possible relation.

Equally, the same knowledge about the process can be used to develop databases that the operators will use to detect and solve operational problems, like process deviations (specialist advice systems), and the process status recognition can be used to show the operator only the consistent or important alarms related to the actual situation (alarm management systems) of the process.

In the next layer, tactical controls, the local process technical and administrative management is done. In this layer the goal, after the process dynamic model development, is to identify the optimal point to operate the unit concerning the constraints of safety, quality, profitability, and operability. In other words, the objective is to be able to adjust the "set point" for a parameters ensemble, instead of setting the individual variables, which will be set in an optimum correspondence and correlation providing optimization plus operability management (coherent operation survey).

The amount of knowledge about the process and its "behavior," established at this layer, allows the database improvements developed in the previous layers. This information, allied to the online data from the process, can be used to check, in an "anticipatory" way, the unit operational and safety conditions (statistical process control). Functional diagnostics about the equipment (predictive maintenance interface) can also be produced.

FAST FORWARD

- Understand the integrated controls systems hierarchy represented by the control pyramid.
- Evaluate automation application development areas, as well as the status of current equipment and technology.
- Combining all this control systems information, plot a graph that can lead to an automation plan.

The last step, strategic controls, is intended to provide the link between the process control system and business automation. The goal is to automatically establish the "production set point" (online scheduling) compatible and optimized with the market demand, customer specifications, inventory capacity, business profitability, or some other related data (management information system).

Cost versus benefits across the pyramid

To analyze the pyramid's different implementation costs, we will split the cost into two different types: hardware-plus-software and engineering. Usually, the main hardware investment will be expended at the beginning of development, to provide installations with the minimum requirements to develop the reflexive controls. This means installing the sensors, valves, and controllers. The hardware investment in the next steps will probably be relatively less expensive, because the development of subsequent steps can take

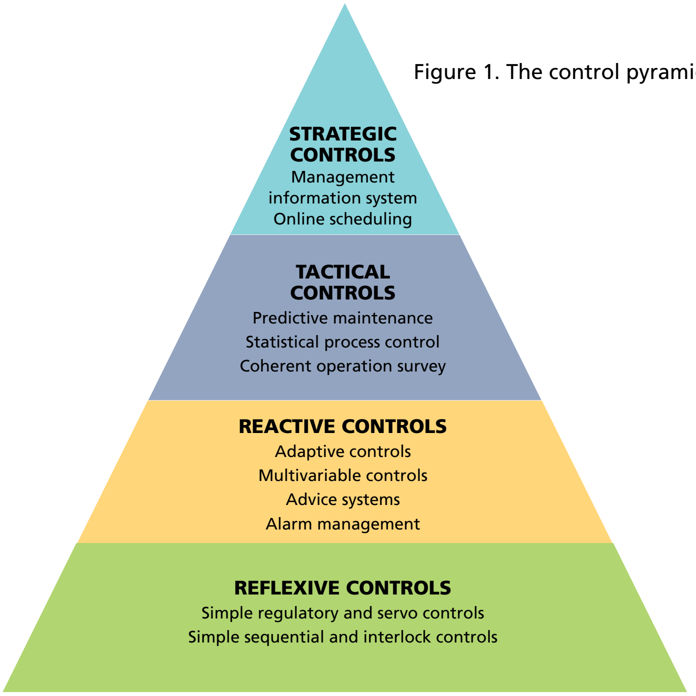


Figure 1. The control pyramid

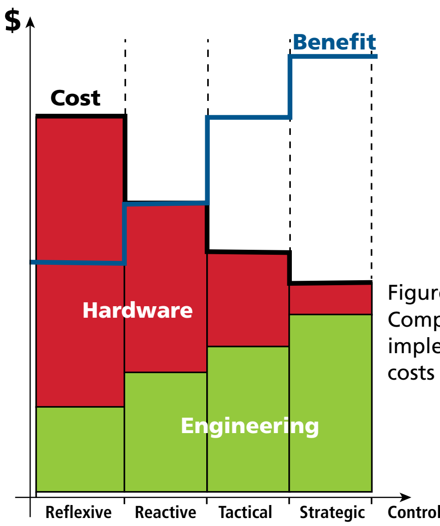


Figure 2. Comparing implementation costs and benefits

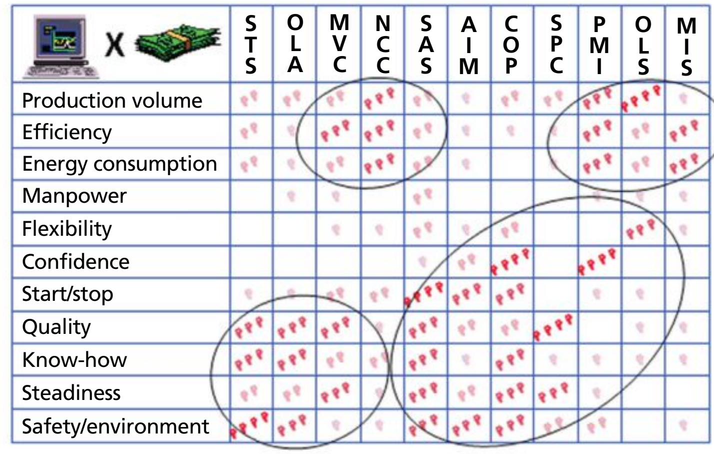


Figure 3. The expected benefit versus cost matrix

advantage of the control and management system installed potential. In a reciprocal relationship, the engineering costs tend to rise as we advance to the strategic controls, because the process identification and modeling are primarily "man-hour" applications.

The main benefits of automation will appear at the last stages. This is because, generally, at the beginning steps, we do only what we can also do with conventional instrumentation. Of course, we need to consider factors such as reliability and maintenance costs, which start to be effective after the initial implementation. However, the key benefits, such as optimization and integrated management, which can provide competitive advantage, will appear as we achieve the pyramid upper layer.

Applications and the potential gain

The expected benefit versus cost matrix (figure 3) is a broad overview of control process applications ("costs") and their relative importance to key business objectives (business "benefits" to be achieved). The potential benefits expected from any of the automation initiatives are listed down the left side of the matrix. Across the top, from left to right, are listed acronyms representing the 11 common automation initiatives that organizations can invest in to deliver those benefits. They include the following:

- **Measurement**: Smart transmitters/sensors (STS) and online analysis (OLA)
- **Control**: Multivariable control (MVC) and nonconventional control (NCC)
- **Operation support**: Specialist advice systems (SAS), alarm information management (AIM), coherent operation survey (COP), and statistical process control (SPC)
- **Process interaction**: Predictive maintenance interface (PMI), online scheduling (OLS), and management information system (MIS)

The "grades" in the matrix, represented by the number and color intensity of the dots, are based on general data. Using the matrix, it is possible to identify four main improvement areas, shown by the circles in the illustration, which can come out of process control techniques and specific automation initiatives.

Improvement area one is on the lower left side. Techniques including smart transmitters/sensors, online analysis, and multivariable control provide the gains initially expected: improvements to know-how, quality, and safety.

Improvement area two is shown in the upper middle/left, where implementing multivariable control and nonconventional control makes it possible to reach the first material gains represented by improvements in production, efficiency, and energy consumption.

The operational support techniques of specialist advice systems, alarm information management, coherent operation survey, and statistical process control will increase knowledge and consolidate the process steadiness, as indicated by the lower middle circle.

Finally, the last stage of improvement (upper-right circle) will be based on the knowledge developed from earlier stages. Taking advantage of process interaction techniques, such as predictive maintenance interface, online scheduling, and management information systems, delivers efficiency improvements and

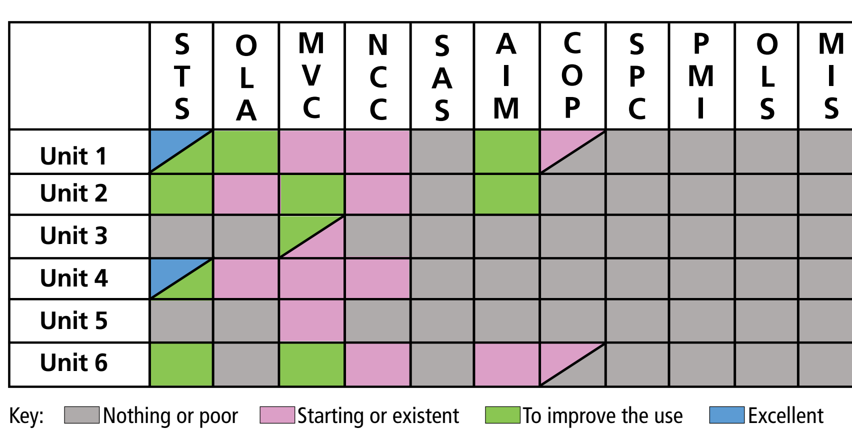


Figure 4. Multi-unit status matrix

increased production volume with less energy consumption.

Assessing the installation's status

Often, assessment plans need to consider many plant units all together when creating an automation strategic plan. Therefore, a comparison of the status of these units needs to be established. The multi-unit status matrix (figure 4) shows the state of the common automation initiatives from figure 3 in each unit. The conclusion in this example is that we have good reflexive control implementations, plus some reactive and a few tactical control developments. However, much more application and development using the different techniques is needed.

The advantage of having some basic stages developed is that the dynamic models or the related variables can be known, and some applications can be developed.

The general picture shows that, considering only the theoretical side, we have enough basis to improve the reactive controls by consolidating the use of MVC and NCC (except for units 3 and 5 due to the lack of STS and OLA). In addition, the implementation of SAS that can be developed for all units and SPC will produce significant benefits at a relatively low investment (just as an assessment for this specific example).

Hardware evaluation

To avoid an evaluation based only on subjective feelings, you can use six criteria and a weighted formula to classify an installation based on its hardware. Figure 5 shows a hardware evaluation table that uses the six criteria to calculate a hardware technical gap score. In the figure, a 4.0 in the hardware technical gap column indicates the worst technology gap. A 0.0 means up-to-date hardware.

The following attributes are used to build a hardware technical gap score for each installation. The weight of the criteria is shown as a percentage, and a number is associated with each level or type within the criteria. Choose the appropriate number for all criteria for each unit, and then calculate the hardware technical gap using the formula that follows.

- **Technology** (weight = 5%): 0 – pneumatic, 1 – electronic analog, 2 – hybrid electronic analog/digital, 3 – digital first generation, 4 – digital contemporary
- **Obsolescence** (weight = 20%): 0 – out of the market, 1 – maintenance still possible, 2 – old/still in the market, 3 – discontinued/supported, 4 – still on the market
- **General status** (weight = 20%): 0 – old and degenerated, 1 – old and degenerating, 2 – can run, 3 – preserved, 4 – excellent
- **Useful life** (weight = 30%): 0 – fewer than 3 years, 1 – 3 years to 6 years, 2 – 6 years to 9 years, 3 – 9 years to 12 years, 4 – more than 12 years
- **Connectivity** (weight =15%): 0 – cannot be connected, 1 – needs communication

Hardware evaluation 	Technology	Obsolescence	General Status	Useful Life	Connectivity	Complexity	Hardware Technical Gap
Unit 1	3	3	3	3	2	2	1.3
Unit 2	2	3	2	1	2	3	2.0
Unit 3	0	0	2	1	1	0	3.2
Unit 4	0	2	3	2	0	1	2.3
Unit 5	0	2	3	1	0	1	2.6
Unit 6	3	1	2	2	1	1	2.4

Figure 5. Hardware evaluation table. In this example table, a 4.0 in the hardware technical gap column means the worst technology gap; 0.0 means up-to-date hardware.

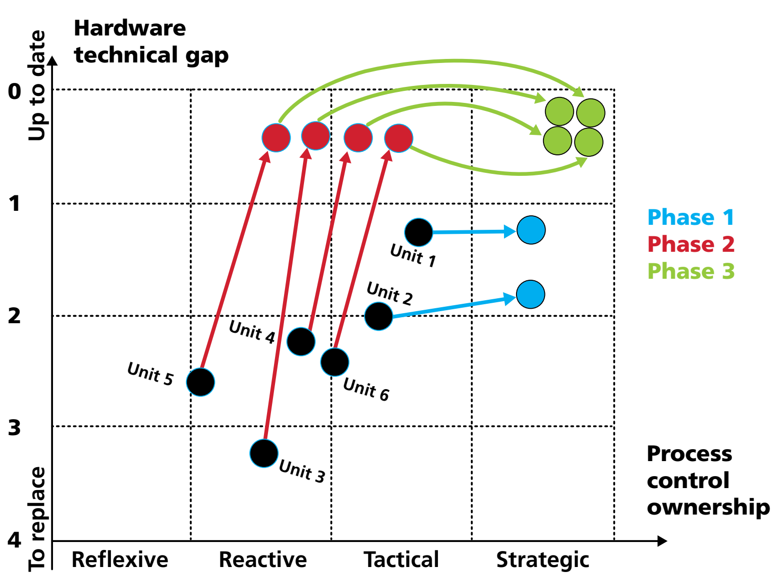


Figure 6. An automation plan

interface, 2 – proprietary LAN, 3 – Open LAN, 4 – open system network

- **Complexity** (weight = 10%): 0 – fewer than 50 loops, 1 – 50 to 100 loops, 2 – 100 to 200 loops, 3 – 200 to 300 loops, 4 – more than 300 loops.

The formula used to calculate the hardware technical gap is:

$$\sum_{i=1}^{6} (4 - \textit{attribute } i) * \textit{weight } i$$

Where we are and where we need to go

Putting together all the above control systems information, it is possible to create an automation strategic plan. You do that by plotting a graph with two dimensions, relating the hardware technical gap score on the vertical axis with the type of controls listed in the control pyramid (figure 6). Different hardware needs levels for each unit, shown as black dots, reflect the actual control systems of today. The more efficient and profitable region of the graph is the upper-right side, representing the most strategic and up-to-date systems.

The purpose of an automation plan is to present the steps needed to reach that upper-right quadrant in the most cost-effective way possible. Figure 6 shows actual control systems (black dots) that are positioned mainly in the graph's lower-left side. The following creates a plan that divides actions into three phases of improvement.

Phase 1: Let's take advantage of the units that have a lower hardware technical gap (that means the almost modern instrumentation) and promote actions to improve the control system in the strategic controls direction. This will allow organizations to develop knowledge in these applications at a reasonably low cost, because the hardware investment will be reduced.

Phase 2: Once the know-how and benefits of the strategic controls are known, let's start to modernize the units with the main hardware technical gaps. Of course, these actions will imply bigger investments, but once the final benefits are proved in phase 1, it will be easier to propose and support these investments.

Phase 3: After the units have been modernized and the operation becomes familiar with the new technologies, it is time to again move these units to the strategic controls area.

A good automation plan comes out of a structured assessment to identify the real status and determine the needs, opportunities, and benefits of modernization. An automation plan cannot be proposed just because somebody thinks the control system is old or because there are many people saying that if you do not come to Industry 4.0 you will fail and be out of the market. ■

ABOUT THE AUTHOR

Joao Miguel Bassa, MSc. (Joao.Bassa@MAHAM.Eng.Br), senior consultant – MAHAM Serviços de Engenharia Consultiva, Brazil, has 40 years of international industrial experience in automation and process controls. He is a professor at Mauá Technology Institute, a member of the *InTech* editorial advisory board, ISA District 4 (Brazil) Standards & Practices chairman, and ISA Publications VP elect.

View the online version at www.isa.org/intech/20200801.


The Plant Floor in Your Pocket
Get an overview of your process at a glance.
Control your SCADA with a swipe.
Ignition
Perspective
See the live demo now.
Scan this QR code with your phone
or visit demo.ia.io/tech

Edge analytics speed optimization cycle times

By Kyle Hable

Practical data-driven IIoT methods and analytics can speed up operational improvement cycle times

Most discrete part manufacturers are continually questing for ways to improve productivity. While some may follow an approach based on gut feel and instinct, it is more constructive to base operational improvement efforts on hard facts. Attainment of this goal is often hindered, however, by a lack of timely data sourced from field instruments, machines, and automation systems.

By the time a report reaches the C-suite, and a downturn in production or an increase in energy consumption is noted, it can be hard to trace the root cause. For some operations, the process of a continuous improvement cycle may operate on an annual or biannual basis, if at all, and proceed as a time-consuming top-down investigation. But what if these same operational teams had the tools needed to facilitate a more scientific approach?

The right automation hardware and software can support these efforts by taking advantage of Industrial Internet of Things (IIoT) devices and communication to support analytics at the edge or a centralized location. This article explores how edge automation concepts and digital transformation processes support the collection and analysis of data, enabling users to gain the insight necessary to reduce the cycle time of monitoring, analyzing, and improving discrete part manufacturing operations.

FAST FORWARD

- Manufacturing process optimization requires analytics based on edge-sourced data.
- The scientific method offers an optimal approach for implementing data gathering and analysis to deliver tangible improvements.
- Breaking the problem down by gathering important "little data" and then integrating it to create a big data solution is often the best way to obtain quick and quantifiable results.

Figure 1. Optimizing industrial system operations calls for iterative cycles of specific tasks, which are enabled and sped up by the digital transformation process.

A scientific method

Production plants commonly consist of many different types of machinery, equipment, and supporting utilities. At a high level, operations personnel want to:

- improve throughput
- maintain quality
- reduce waste
- maximize uptime
- minimize power consumption.

Sometimes these actions are performed at a relatively microscale portion of machines or equipment. Other times they have a broader scope as part of a macroscale business optimization cycle.

These optimizations are made possible by following a procedural process of continuous improvement in an iterative fashion. An effective optimization process model, based on the digital transformation of industrial systems (figure 1), requires organizations to:

- gather data
- connect it within an architecture
- analyze it
- deploy solutions
- repeat!

Some readers may notice that the cycle of continuous improvement has many similarities to the scientific method of research and learning. Typical principles of the scientific method are expressed as:

- observe and question
- research and hypothesize
- experiment and obtain data
- analyze
- draw conclusions and report
- repeat!

The scientific method is readily adapted to provide a complete framework for applying digital transformation methods and optimizing manufacturing operations. As an improvement cycle is executed successfully, improvements to the manufacturing process are applied, with the methodology and procedures used also enhanced.

Digital transformation is an integral part of this improvement cycle, as it is part of an ongoing journey to digitalize the data needed to efficiently support these efforts.

Many "little data" sources

The information needed to assess these characteristics may flow through large enterprise software environments, including supervisory control and data acquisition (SCADA), manufacturing execution systems (MESs), and enterprise resource plan-

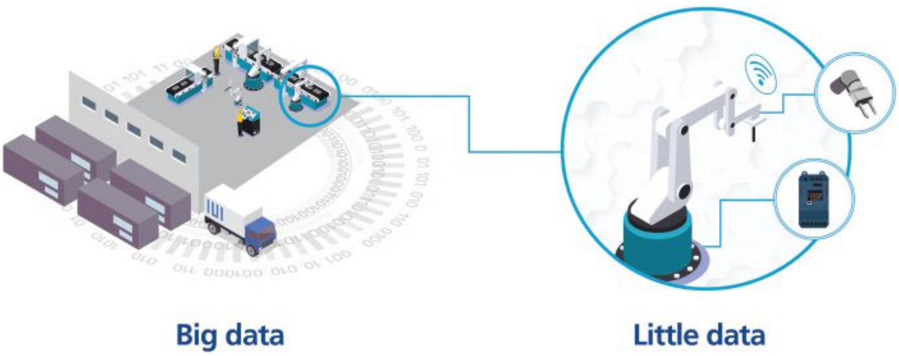


Figure 2. "Little data" is available from a wide range of edge-located sensors, devices, and equipment, and must be gathered so it can be aggregated into "big data" useful for analytics.

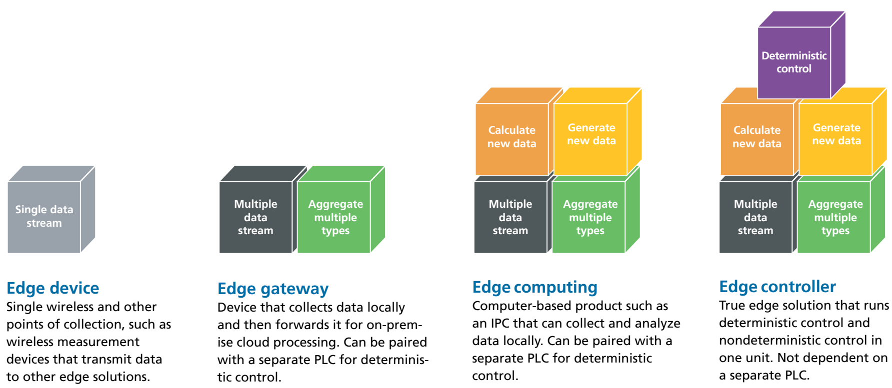


Figure 3. IIoT methods and products help users get the little data needed to support edge analytics.

ning (ERP) systems. Some of the data may arrive in a very manual format handwritten on forms or entered via spreadsheets.

Much of the interesting data comes from programmable logic controllers (PLCs) in the operational technology (OT) domain, including production-related values such as operating rates, part counts, and temperatures. Some data may be facilities information sourced over site information technology (IT) systems. Still more data is associated with asset management, such as wireless vibration readings and other parameters. Many times an out-of-the-box asset performance platform is used to consolidate, contextualize, and visualize such information. This can be useful for both machinery operators and entire manufacturing plants.

Such a large variety of "little data" sources complicates the format and timeliness of data availability. Users must consolidate the information, analyze it for useful results, and then apply changes. Then they repeat the cycle, as often and as quickly as practical, in a process of continuous improvement. As we will see, IIoT-based devices and methods can offer a way to streamline much of the procedure by creating a system where information flows more efficiently to speed up the overall improvement cycle.

Starting the cycle

A logical beginning is to define the objective of process improvement by asking, "how do we optimize operations" and hypothesizing "by tuning and adjusting our equipment and manufacturing processes." To set the improvement cycle in motion, it is necessary to gather all the relevant "little data" so it can be aggregated into "big data," and then analyzed (figure 2).

To be sure, the task can be overwhelming due to the large number of potential data points. Many implementers find that a valuable preliminary step is to perform an asset criticality analysis. Users evaluate the reliability, detectability, and consequences of equipment performance and failure in an unbiased way to identify the greatest pain points and determine which equipment should be addressed first. Essentially, this ensures that the "low hanging fruit" of optimization efforts are harvested first, leading to early savings and building organization enthusiasm for ongoing projects.

With the most critical assets identified, users drill down into the target asset types with a consistent approach to gather the necessary data. This may be:

- production rates or failure indications from the control platform
- other sensed or analytical values
- equipment health indications, such as vibration or bearing temperatures.

Because of the many standalone automation platforms in most industrial plants and facilities—encompassing legacy systems and communication protocols—it is common for implementations to stumble over specialized approaches for obtaining little data. Sometimes on the first pass it is only possible to use whatever data is already easily available.

Targeted approach

Modern IIoT methods and products (figure 3) can help users get data out of isolated platforms in many ways:

- Edge devices: single points of data collection, often wireless, transmitting data to other edge solutions.
- Edge gateways: collect and forward OT, facilities, and asset management system data streams.
- Edge computing: computer-based products able to act as a gateway and perform additional storage and analytical tasks.
- Edge controller: combines deterministic control like a PLC with general-purpose edge computing capabilities.

Edge devices, gateways, computing, and controllers can be added to existing systems as the need and budgets allow. New systems can be designed around edge computing and edge controllers from the beginning, so they are already positioned to obtain and process OT data and make the results available to higher-level systems.

The activity of identifying and connecting with little data at the edge is rarely a one-time event. Indeed, at each iteration of the improvement cycle, users should evaluate any new needed data. This iteration process is necessary to continually build up the data models in support of deeper analysis.

From little data to big data

As the little data becomes available from all types of sources and edge devices, the next question is how to consolidate it, configure it into useful information, and make it available to the OT and IT sides of the business so users can easily access and work with it.

Edge gateways usually provide unidirectional flow of data up to supervisory systems, but they can support bidirectional data flow. Edge computing certainly supports bidirectional data flow but requires users to implement their own security provisions, such as firewalls to make PLCs less vulnerable to attack.

Edge controllers are the most comprehensive solution, suitable for integrating OT data with IT systems, and vice versa (figure 4). Because edge controllers combine deterministic control with general-purpose computing on one device with a built-in firewalled security layer, they have many advantages for edge analytics:

- directly access low-latency source data
- preprocess the data to remove undesirable characteristics
- perform any amount of edge analytics
- transport the data to IT systems using efficient and secure protocols
- native firewall for security between the general-purpose computing and the deterministic control
- locally loop results back into deterministic control.

With IIoT tools at their disposal, users can aggregate all of the little data into their own big data, hosted on site or in the cloud. Big data in the form of time-based historians and record-based databases is the foundation for detailed analytics.

Complete, and repeat, the cycle

With meaningful contextualized data in hand, and with analysis performed at edge controllers or in a central computing or cloud-based system, users can make informed decisions to improve their manufacturing processes. Trials can be run with varied inputs, and users can see results quickly. Based on this more complete information, they can identify new data points that may help with the analysis and build up of operational models. At this point, they can decide whether to manually optimize their equipment based on the results or automatically apply optimizations.

Figure 4. Edge controllers are built for field installation, and are an ideal platform for integrating OT data with IT analytical computing close to the data sources.

After achieving initial success, the team will have proved a methodology they can repeat over and over, with increasing efficiency and speed, for applying the scientific method to process improvement.

Breaking it down

Large software projects bring to mind huge initiatives with significant spending over many years, frequently accompanied by cost and schedule overruns. However, there are improved ways to find success.

In the software development world, agile frameworks such as Scrum break down tasks into smaller modules or "sprints," and then execute each in an iterative manner to achieve success. This is a way to reach a larger goal by executing many smaller and more easily achievable steps.

Similar concepts can be applied to industrial improvement efforts founded on digital transformation. In this case, IT/OT integration projects are broken down to approachable little data tasks and built up into a big data integration solution. Each little data task can be evaluated and validated locally and economically before committing it to the greater big data role.

IIoT and analytics, implemented using edge automation products and practices, are an evolutionary way of performing common business optimization undertakings. Using a data-driven approach when undertaking manufacturing process improvement steps is similar to traditional methods but is much faster and more efficient. ■

ABOUT THE AUTHOR

Kyle Hable is a product manager responsible for integrating and advancing IIoT and edge technology across Emerson's machine automation solutions product portfolio. He has spent his entire career connecting data and embedded things to Ethernet networks, working hands on with both IT and OT customers implementing custom and standard solutions across a variety of technologies and industries. Please send questions and comments to Jeremy Bustin (Jeremy.Bustin@emerson.com).

View the online version at www.isa.org/intech/20200802.

RESOURCES

"Better performance begins at the edge"
www.isa.org/intech/20200203

"Path to OT success on the plant floor as described by users"
www.isa.org/intech/201902channel

"Six steps to improving equipment availability for OEM machine builders"
www.isa.org/intech/20170405

Automation system simulation and virtual controls testing—what you may be missing

By Ian McGregor

Virtual analysis of dynamic digital twins reduces automation system design risks

Industrial simulation and emulation are powerful but still underemployed techniques for designing, developing, and testing better automation solutions and machines. When used as a central part of a project's workflow, they can significantly shorten the project development and commissioning time, reduce overall costs, and provide numerical justification for design decisions. The ongoing emergence of many Industrial Internet of Things (IIoT) technologies has enhanced their appeal and effectiveness by creating much excitement about the opportunities offered by digital twins, but also generated some degree of confusion around their application and areas of impact.

Challenge of making the right design choices

We take it for granted today that systems used in manufacturing and distribution must be automated for them to be competitive. Automation is how we eliminate manufacturing errors, reduce delivery times, keep retail outlets stocked, and ensure that orders placed on a website arrive at their destination just a few hours later. The physical side of automation is familiar to us—conveyors, autonomous vehicles, robots, and so on. Even outside of industry, these items are recognized and are often employed as icons of contemporary life.

This visible face of automation masks the complexity of the system, however. It is the advances made in control systems that have enabled the growth in automation we benefit from today. Until recently, advances were evolutionary rather than revolutionary, but now we are faced with a range of opportunities promising a step change made possible by the concurrent emergence of several complementary technologies. IIoT brings together practically unlimited computing power, cheaper sensors and data storage, big data, and better standards, among other things. But how does an automation system design team choose from the wide range of material handling solutions, control, and management systems available, and how do they demonstrate they have made the right decisions?

Using dynamic digital twins to develop better solutions, faster

Work done on improving operational technology through the intelligent use of real-time data to create digital twins currently gets much indus-

try attention, as does the ability to diagnose and maintain operating machines using remotely supported technicians equipped with augmented reality systems. However, current technology also offers many important opportunities in the design, analysis, and commissioning phases of an automation project, prior to ramp up and operation. Like quality, the best automation solutions are designed in from the start. The correct use of technology not only leads to robust and flexible systems, but also stays within budget. Engineers use dynamic models to create virtual representations of proposed systems in order to understand, improve, and demonstrate future operations in a repeatable manner.

To create the big picture, first answer all the small questions

The creation of a fully operating system model is a demanding discipline in itself, as it requires answers to all the operational questions before the model can be completed and run. As a robust design process, the creation of a dynamic digital twin is second to none and results in an intuitive, interactive, and understandable representation of the physical and logical objective. The model represents the current state of the project, accessible to all team members, and becomes the trusted reference. Suggested changes should be tested against the core model

FAST FORWARD

- User-specific simulation models enhance operational understanding and guide solution choices.
- Fully tested systems can be delivered on time and on budget with offline digital twin controls verification.
- Virtual reality remote solution demonstrations and operator training are both safer and cheaper than face-to-face meetings.

Understanding complex load flow and how incidents arise becomes straightforward by observing an accelerated simulation model.

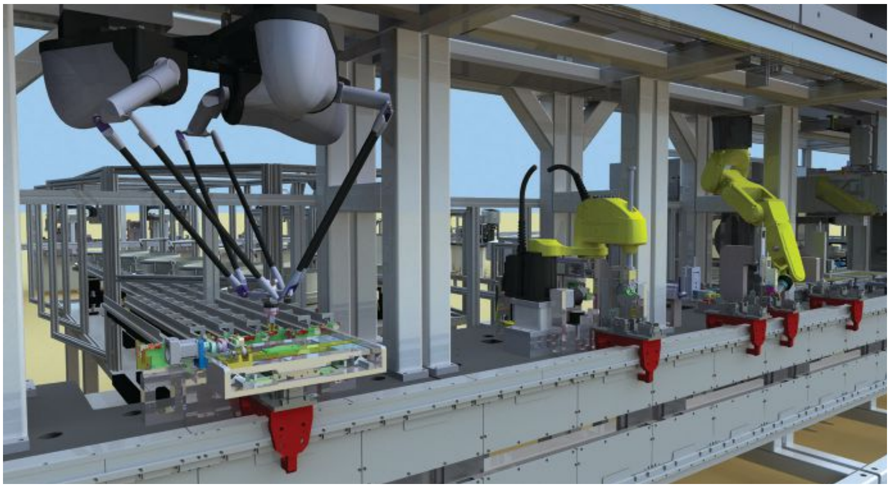
in order to understand any related consequences and the overall impact the changes might have on operation and throughput. By providing repeatable and robust statistical results, these models help project stakeholders reduce the risk associated with their investment, and therefore increase the likelihood of the implementation of further successful automation.

How simulation shortens the design cycle and leads to better outcomes

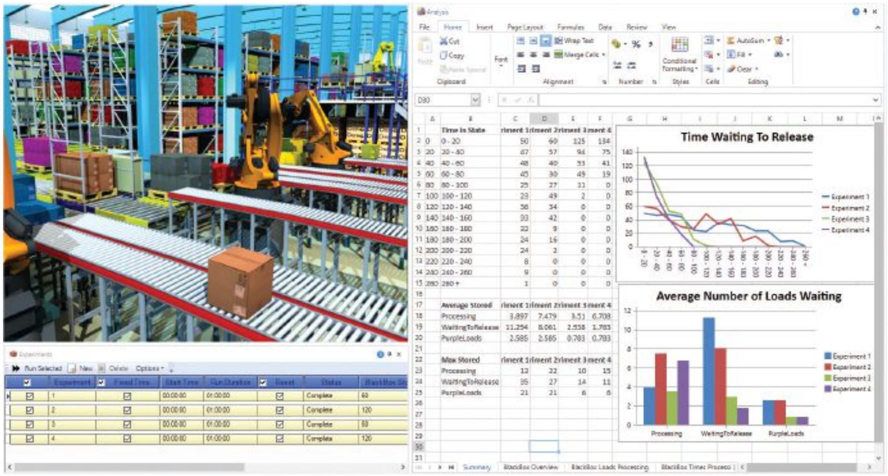
The engineering starting point for any automation system is an operational specification of some sort, including a definition of required throughput. The path from there to the finished system is a series of decisions, each of which must have a justification and set of reasons behind it. The decisions may be about material handling technology choices, or storage options, or how best to batch and route similar orders, but each outcome has consequences and costs associated with it. For simpler decisions, logic or a spreadsheet calculation is often all that is required. But many industrial systems are highly complex, incorporating many concurrently changing and interconnected subsystems that do not lend themselves conveniently to spreadsheet analysis or easy explanation, and this is where dynamic simulation is invaluable.

Discrete event simulation is a powerful tool for industrial analyses of this type—it facilitates the breaking down of a large problem into a data-driven model of many smaller systems, each of which is able to be tested and verified in a repeatable way. Models are event driven, in the same way that much of the real world operates—when orders arrive at an e-commerce center, for example, they are entered into the control system, which initiates a cascade of actions that eventually lead to the orders being delivered.

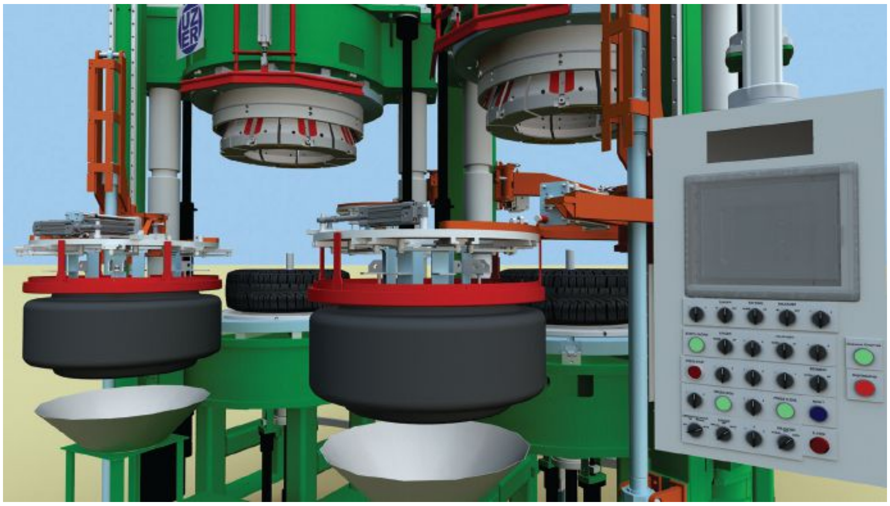
The model focus is invariably on product or load flow and its consequences—throughput, storage, queues, resource use, and so on. The actions taken follow the business rules of the facility, which must be accurately represented in the model. Models are used



Models can be used to understand overall flow or test the cycle time of each robot cell, as in this Rockwell Automation contacter assembly line.



Simulations generate repeatable results to statistically reinforce decisions and clearly illustrate complex operations.



This Emulate3D model tests and verifies the move synchronization on an Uzer Makina tire curing press. The panel on the right is connected to a running Allen Bradley controller, and the buttons are interactive, so operation and test sequences can be run.

to test different ways of dealing with orders to determine which provides the best outcome. Even complex models run considerably faster than they would in real time, and experimental runs can be distributed across many computers or run in parallel in the cloud to get useful results faster.

Demonstrate, experiment, understand, improve

Simulation models of this type serve several purposes. Initially, they are an accurate functional representation of each part that makes up the complete system. Models contains cycle times and decisional logic in order to demonstrate the operation, and as they run, they help stakeholders understand the parts and the whole, often accelerating development.

They also serve as an impartial judge between experience and opinion. Through guided experimentation they help to eliminate fruitless discussion about which is the best of several options by the generation of repeatable results. Their purpose is to develop and dimension the "best" solution to reach agreement on layout, capacity, and so on. From this point, validated models are a means of understanding the system response under any number of data sets representing peak throughput, error conditions, or efficient normal operation, for example. Not only are they used for testing product mix and resource allocation, but the study of their operation can lead to definitions of best practice, degraded performance under various conditions, and recovery from shutdowns.

Test performance of higher-level control software against the simulation model

Simulation models are data-driven, dynamic digital twins of the mechanical and logical system being developed, and they are a reliable way to understand how the various elements constituting the real system will interact. Models can be connected to higher-level order management, manufacturing, or stock controllers to test their performance against the digital twin under a range of foreseeable operating conditions and increasing confidence in the technology application.

Value of simulation for flexible automated system design

The benefits of using simulation to create a flexible dynamic digital twin are many and varied—ranging from material handling equipment selection, queue dimensioning, resource allocation, and operational decisions to recovery procedures and system management selection. In short, any throughput test that would be useful to carry out on the real system can be carried out at lower cost and without disruption or danger on the dynamic digital twin.

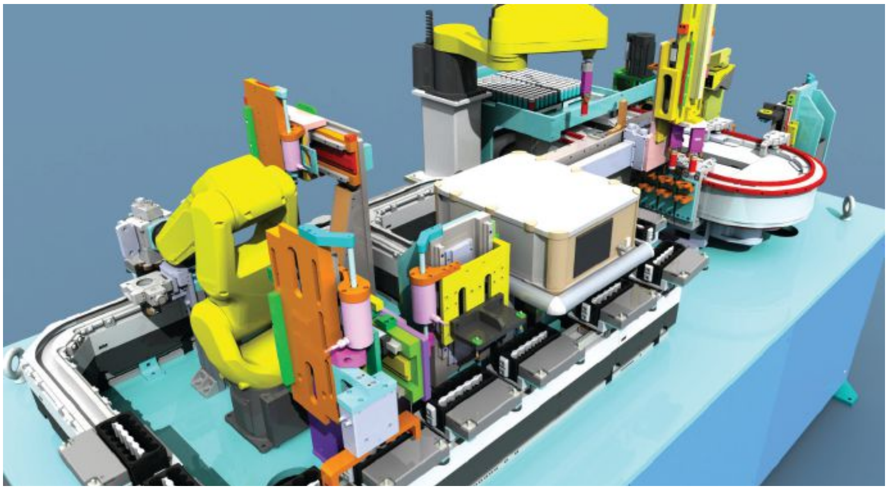
Simulation and emulation differences, and why it matters

Simulation models are mathematical representations of complex industrial systems designed to help understand and improve the real thing. They can be connected to external data sources, such as order management or stock control systems. So why complicate things by introducing the word "emulation" (rather than "simulation") when the system is connected to an external logic controller?

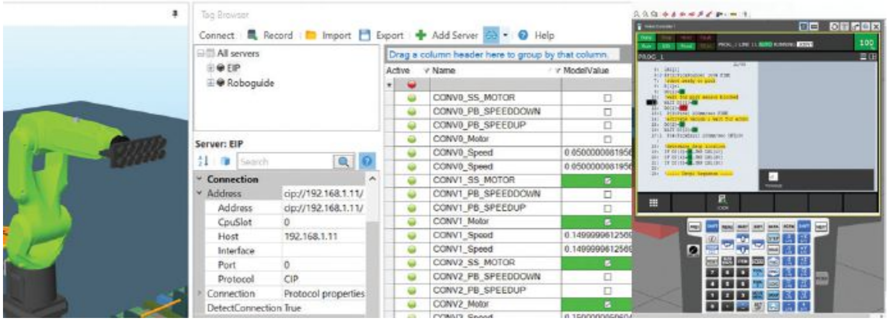
First and foremost, simulation and emulation models have different objectives, and this fundamental difference brings with it implications for the whole structure of the model. Simulation models are used to experiment with different scenarios, often involving changes to many physical and logical parameters such as layout, business rules, and order profiles. Simulation models need to execute quickly if they are to be useful, and they take a "load-centric" view of the world, where each load follows decisional logic to traverse the system. The load is the active element that drives the simulation model forward.

Whilst this is appropriate for the understanding of product flows and resource use in a complex system, it is not how automation systems work. Emulation models are used to test and debug high- and low-level control systems, with the aim of taking the task off the project's critical path and carrying it out virtually, and in parallel with the system build. To do this, emulation models must be able to connect to control systems and respond to them as they run in the same way real equipment does. Emulation model elements need to be functionally close to their real counterparts, including sensors and motors—they are true digital twins in that respect.

Loads move in an emulation model as a result of their presence being detected by sensors and the control system executing logic, which is designed to operate equipment and machines to process or move them. Whereas in a simulation model the logic and business rules are approximated and completely contained within the model, an emulation model is connected



This Emulate3D model of an Eagletech machine generates the Rockwell Magnemotion control code and tests interactions with the FANUC robots by connecting to their ROBOGUIDE soft controllers.



Emulate3D's open framework approach enables users to connect different types of controllers to their models, such as FANUC ROBOGUIDE for virtual commissioning.

to and driven by the real control system. As a result, emulation models run in real time to ensure accurate responses. Even in the rare case of a control system not containing timers, it is still unadvisable to run the model faster than real time, as this may create unrealistic responses.

While simulation models are load-centric, emulation models are equipment-centric. The focus of an emulation model is much more precisely defined, and the movement of modeled loads is the consequence of virtual equipment being activated or deactivated, in a close parallel to the real world.

How does the IIoT benefit simulation and emulation?

Industrial model building requires data, and the better the data, the better the outcome of the model. The IIoT has prompted an awakening to the value of an accurate digital representation of physical assets, as well as enabling access to better and more cost-effectively stored data collected by cheaper sensors. This serves the requirements of both simulation and emulation. Simulation models are massively data driven, which applies at several levels:

- Initial model build, where the physical layout plays a central role in product movement and therefore throughput, and where each model element may require not only product or action-specific cycle time data but also changeover times
- Resource availability, such as shift and break schedules, breakdown rates, repair times, and maintenance patterns
- Order schedules, pick lists, manufacturing, or assembly schedules.

The IIoT offers opportunities to aggregate real data anonymously, whether for specific machines or generic processes, and this is central to building more accurate models. Simulation experiments can generate a large quantity of data that is traditionally hard to absorb and comprehend; being able to extract correlations and deduce causation is something that big data analysis techniques are very good at, and can do quickly. The results of multiple simulation runs can be stored and analyzed further using machine learning techniques to identify situations that could have been better resolved by modifying the control system in some way.

Real opportunities offered by virtual and augmented reality

The augmented or virtual reality headset (often referred to as XR for convenience) has become a familiar symbol for all things concerning the digital thread and IIoT, and while it is not as central to the successful application of this new technology as its prominence in related publications suggests, it certainly is a useful tool in many circumstances. The first of these is clearly the communication of complex ideas, as demonstrated by a running model. It is valid to ask how a model viewed using an XR headset is better or more effective than watching the same model on a monitor. The answer is perhaps self-explanatory to anyone who has had first-hand experience of it, but for those who have not, it can be summed up as immediacy. Assuming that the person in the headset is not among the small percentage of users who feel nauseous under those circumstances, their first experience is generally one of agreeable surprise, if not astonishment. The environment is unreal yet convincing, and the feeling of "being there" is compelling, informative, and useful.

Multiple users can experience the same model simultaneously and see and communicate with each other within it. They can be in different offices, states, or countries, and meet virtually within it to inspect the current state of development and then decide next steps. A mixture of green screen and XR enables real operators to demonstrate the complete operation of virtual prototype semiautomatic machines, with viewers able to check cycle times and even change position to verify clearances whilst discussing the task with the operator.

The operator within the XR model can move around within the model by teleporting, and can be teleported by another user. Both can interact with controls and products using the handheld controllers, and they see each other as avatars within the model.

This model can be used to demonstrate the operation of a proposed semiautomatic assembly machine, testing the controls, or for training operators safely and without disrupting existing production.

This approach reduces development time and costs—no more need to find a mutually convenient day to take a flight and stay a night in a hotel just to sign off on the next phase after a meeting, which could have been held virtually and sooner, and maybe lasted only twenty minutes.

XR offline training – Safer and more comprehensive

No XR headset is complete without controllers, which allow users to navigate around inside the model, operate controls through browser-based human-machine interfaces (HMIs) and control panels, and interact with products. At this point, the model becomes a functional training tool that is safer and less disruptive to ongoing production than the real thing. Recovery procedures from malfunctions, which may be costly or even dangerous to operators and equipment in the real world, can be carried out without consequence in the virtual world.

Achieve better automation systems using simulation modeling and emulation

Making simulation and emulation a central part of the design and testing workflow introduces a productive discipline to the creation of automation systems. This framework requires all relevant elements and ensures they work together—highlighting weaknesses yet to be resolved and focusing stakeholders on the current state of the project. From initial ideas to a fully investigated solution, simulation accelerates the process and makes sure the chosen result is robust and verifiable. Controls testing using an emulation model enables increased control over the project timeline and a more thoroughly tested system, delivered on time. Beyond the design and development phase, both models remain valuable for operator training and to evaluate and develop any future modifications.

As the project manager of a large pharmaceutical company put it, "An emulation model is the first place the two truths of an automation system meet—the mechanical truth is the CAD, and the logical truth is in the form of the control system." By bringing them together to test in a virtual environment early in the design cycle, you can eliminate the need for later alterations in the real world and be ready for ramp-up and production.

The near-term future will unite IIoT and existing product architectures more closely to the benefit of users; the direction of development is dictated by the dual goal of a more user-specific experience and a more fully featured and robust framework to facilitate this. The objective for all is a fuller deployment of client-matched solutions that help generate cost-effective and robust automation solutions, on time and on budget. ■

ABOUT THE AUTHOR

Ian McGregor (ian.mcgregor@ra.rockwell.com) is Global Emulate3D business development manager with Rockwell Automation. He specializes in the application of dynamic digital twins to offline controls testing and throughput simulation in manufacturing, material, and baggage handling. He has more than 30 years of industrial simulation and emulation experience. He has a BSc Hons degree in mechanical, aeronautical, and production engineering from Kingston Polytechnic, U.K., a Diplome d'Ingenieur in applied computing from the Universite de Technologie de Compiegne, France, and a master's degree in computer integrated manufacturing from the Cranfield Institute of Technology in the U.K. In 2005 he cofounded Emulate3D, which was acquired in 2019 by Rockwell Automation to reinforce its digital solutions offering.

View the online version at www.isa.org/intech/20200803.

OPC Field Level Communications:

A controller-to-controller specification within reach

By Peter Lutz

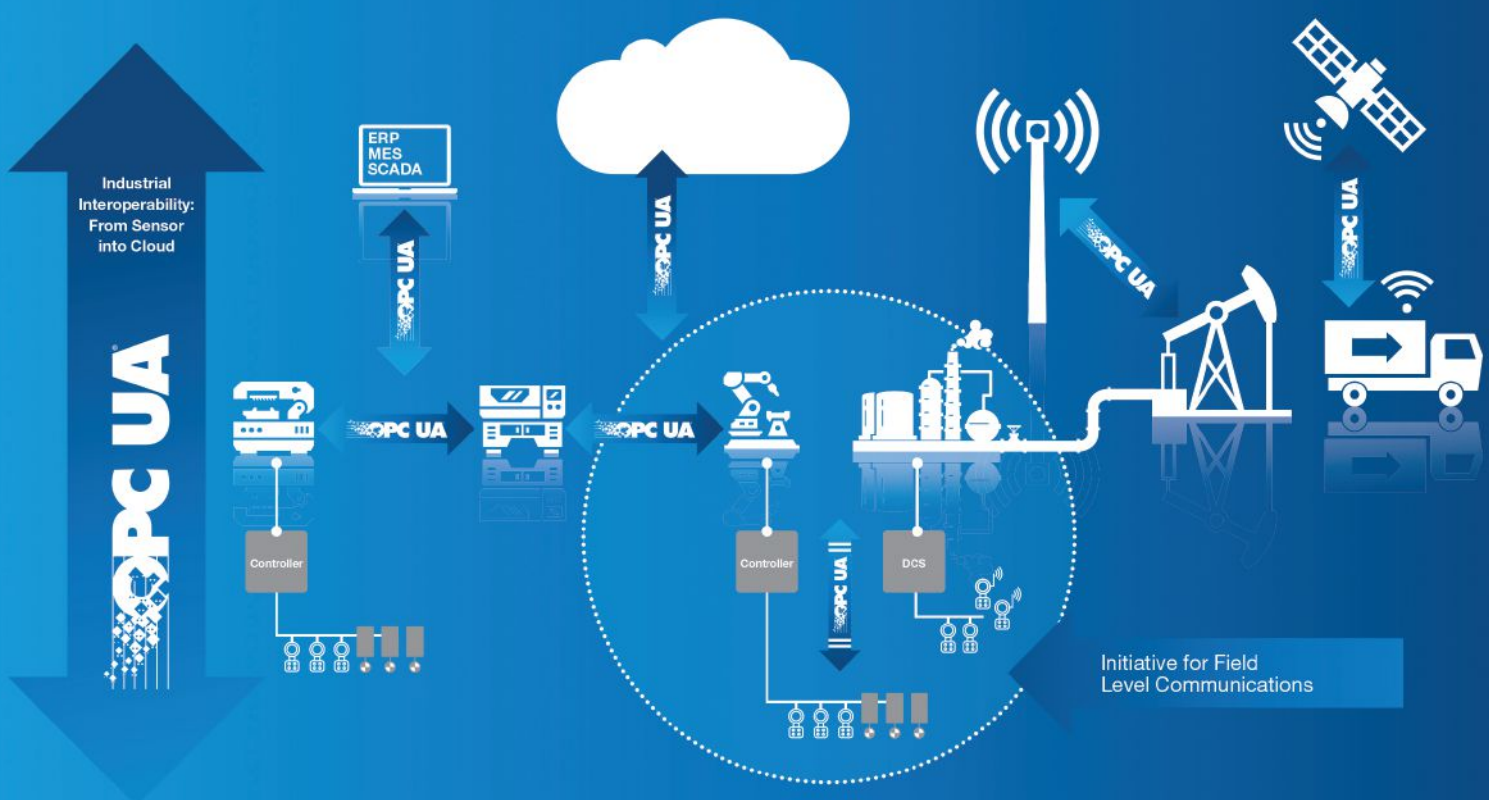


Figure 1. Field Level Communications initiative of the OPC Foundation

Essential for the convergence of IT and OT, FLC is also important for upgrading legacy systems

FAST FORWARD

- OPC UA is an industrial, protocol-agnostic framework for the IIoT and Industry 4.0.
- OPC UA contains mechanisms for secure and reliable manufacturer- and platform-independent information exchange.
- Work on the first specification version has made good progress in recent months, despite Covid-19.

Because of its versatility and manufacturer independence, OPC UA is already used today in many different industrial applications. However, OPC UA is much more than just a transport protocol in its traditional sense. Instead, OPC UA is an industrial, protocol-agnostic framework for the Industrial Internet of Things (IIoT) and Industry 4.0 that contains mechanisms for secure and reliable manufacturer- and platform-independent information exchange, as well as options for semantic information modeling and self-description of devices. OPC UA scales from the sensor across all levels to MES/ERP and also into the cloud. It includes cybersecurity mechanisms built in from the start.

To meet all requirements for use cases from end users, suppliers, and integrators from process automation to factory automation, in November 2018 the OPC Foundation established the Field Level Communications (FLC) initiative, supported by an impressive list of major automation suppliers. The scope of this initiative (figure 1) is to jointly specify and standardize the semantics, protocol, and physical interface of controllers and field devices from different manufacturers.

The main use cases covered by FLC are controller-to-controller and controller-to-device, including support for IIoT connectivity for both controllers and field devices. The FLC-related technical work includes the following topics:

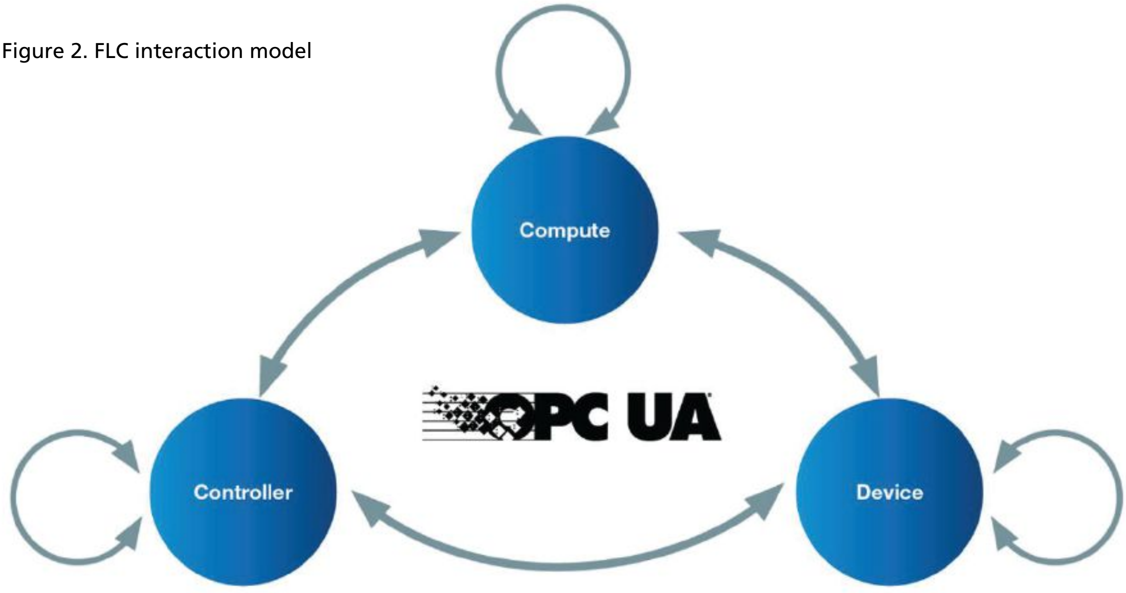
- definition of an "automation component" with functions, interfaces, and behaviors that are common to the different FLC-conformant controllers and devices used in various applications in process and factory automation
- definition of system behaviors and sequences for common functionalities (e.g., bootstrapping and connection establishment)
- harmonization and standardization of application profiles like I/O, motion control, functional safety, and system redundancy
- standardization of OPC UA information models for field level devices in online and offline scenarios (e.g., device description and diagnostics)
- mapping to subordinate communication protocols and transmission physics, such as TCP, UDP, Ethernet APL/SPE, deterministic Ethernet (TSN) with future mapping to 5G and Wi-Fi 6
- guaranteeing the best integration of OPC UA companion specifications like FDI, FDT, PA-DIM, Analyzer Device Integration (ADI), Module Type Package (MTP), and MDIS (oil and gas), VDMA pumps, UMATI, and Spectaris.

FLC interaction model

To generalize from the specific and diverse application scenarios in the broad field of process and factory automation applications, FLC is using an abstract interaction model (figure 2), with the various "abstract" OPC UA use cases.

A controller represents a function typically implemented in a programmable automation controller, programmable logic controller, or distributed control system. Today, automation

Figure 2. FLC interaction model



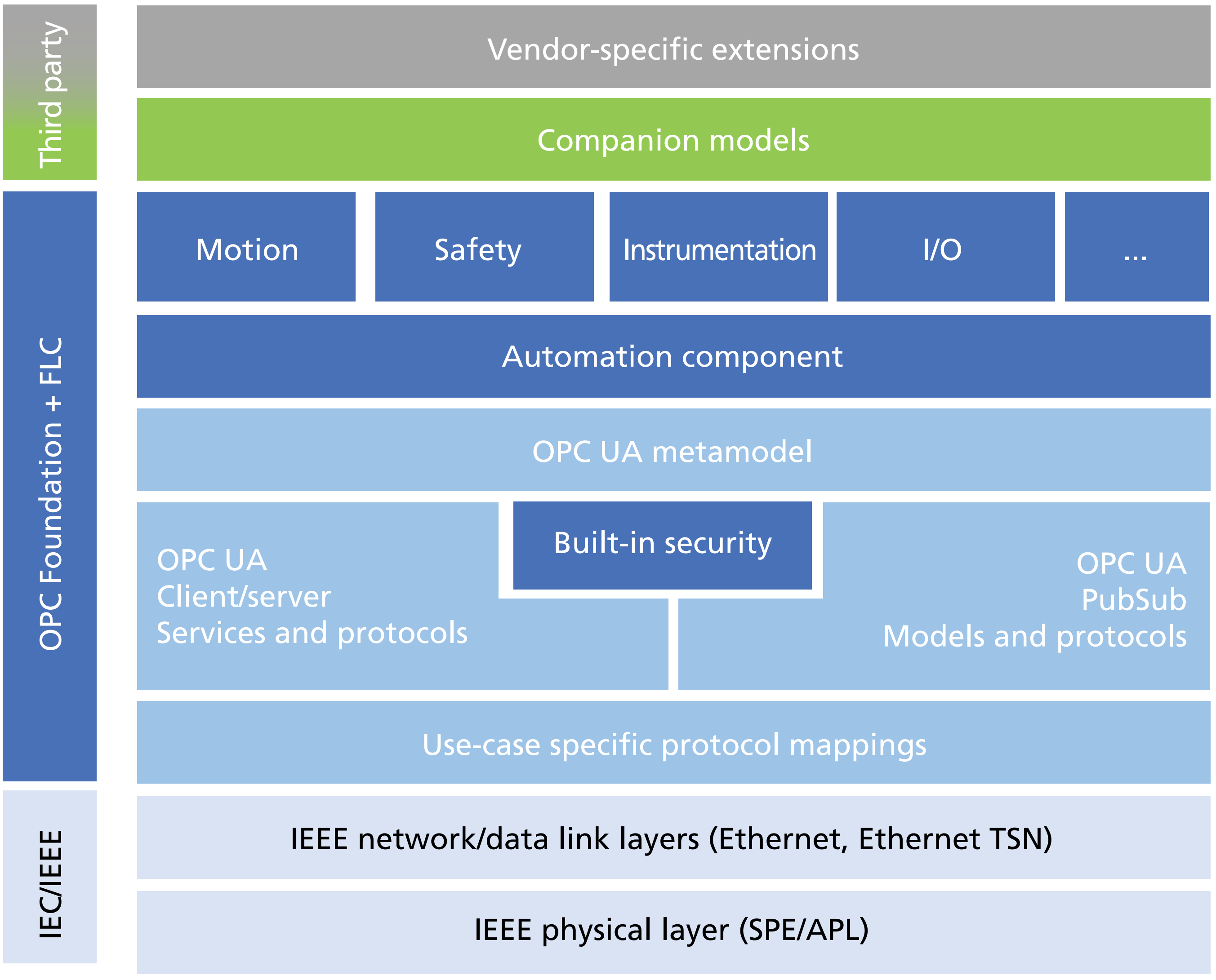


Figure 3. OPC UA FLC system architecture

devices are typically connected to controllers and can be as simple as an inductive proximity switch or as complex as a Coriolis flowmeter or servo drive. Compute's hardware aspect scales from a Raspberry Pi–based data gateway to a blade server in the cloud, but more important are the software applications running on these. Controllers and devices have many attributes in common—the term "automation component" is used where functions apply to both.

Controller-to-Compute. Software running on Compute platforms is a major area of innovation today, whether it is management information in dashboards, long-term process optimization, predictive device level diagnostics, or digital twins. These all require information to be extracted from controllers. OPC UA is dominant today, and almost every major controller supplier offers OPC UA directly on its controller or device.

Controller-to-controller. Plant owners and system integrators are assembling complex operations using machinery purchased from different machine/skid builders. They may find that each is fitted with a controller from a different vendor. This causes a need for an easy way to set up controller-to-controller communications across multiple vendors. The industrial automation industry has not yet effectively solved this problem, and the FLC controller-to-controller solution will be the first to deliver an interoperable real-time solution covering both standards and safety communications for all types of automation applications.

Controller-to-device. The traditional fieldbus approach of having a controller communicate with a subnet of I/O modules, drives, servos, instruments, and other smart automation components is well understood in the industrial automation community. However, it comes with constraints on network architecture and topology when a converged IT/OT solution is deployed, or when different industrial automation technologies share the network. The FLC initiative will have controller-to-device communications that meet or exceed the capabilities of existing solutions, and will add capabilities that are incompletely delivered by the IEC 61784 profiles.

Device-to-device. In bringing together best practices for multiple shop-floor technologies and by harmonizing the application profiles used in end devices, applications such as load sharing of inflexible loads across multiple servo drives will become far easier to deploy in an interoperable manner.

Device-to-Compute. Controllers often serve as a proxy for devices, add valuable context to the information provided by these devices, and in some cases control access to that information. However, as devices become increasingly complex with an ever-growing number of useful variables and internal and external measurements, the use of a controller as a proxy becomes increasingly impractical. For example, routing 4,000 variables from each device through a controller is no longer scalable. FLC will define the necessary semantics and metadata to contextualize the information from devices for use in diverse Compute-based software applications in an open architecture without the controller acting as a bottleneck.

Compute-to-Compute. These applications include gateways to IT systems, cloud-cloud connectivity, interoperable manufacturing operations management, and many more. The Field Level Communications initiative will use and build on the services, information modeling, and interoperability that have driven the success of OPC UA in Compute-to-Compute applications over the past decade. No need for the further development of capabilities to support Compute-to-Compute applications is expected within the FLC initiative, but these applications will inherit and benefit from the increased harmonization at the field level.

FLC system architecture

The FLC system architecture is based on the OPC UA framework (IEC 62541), which enables secure, reliable, and manufacturer- and platform-independent information exchange (figure 3). FLC controllers and devices support the connection-oriented client/server communication model on the one hand, and the publish/subscribe (PubSub) extensions on the other. OPC UA PubSub is essential for communication at the field level due to the corresponding requirements for flexibility, efficiency, and determinism. FLC also uses the security mechanisms specified in OPC UA, which among other things support authentication, signing, and encryption of the data to be transported and can be used for client-server as well as PubSub communication relationships.

The central element for the extensions specified by FLC is the metamodel of OPC UA (figure 3). This is used to specify corresponding information models for FLC automation components and to make the modeled information accessible via standardized OPC UA services.

Because all FLC automation components (controllers and devices) are based on OPC UA, uniform, integrated communication is available across all automation levels supporting a broad range of use cases that open up completely new possibilities, especially with regard to the different Industry 4.0 application scenarios and IT/OT convergence.

Offline engineering

Offline engineering is an important element for the development, operation, and maintenance of an automation system. When the user has the ability to understand the operation of the automation system before deploying the system in physical hardware, the user will know that the system will perform the control function reliably and correctly once the physical system is in place. The user will be able to simulate changes and updates to the automation system before making changes to the physical system and be assured the changes will perform up to the expectation of the user and improve the performance of the system. With the help of product and configuration descriptors, the device descriptions are made accessible to the corresponding configuration tools. However, the specification work does not start "from scratch," but the corresponding preparatory work and experience of the supporting automation manufacturers and fieldbus organizations serve as the basis.

FLC-related modeling

A key element of the FLC-related work is the modeling of functions by means of so-called OPC UA Facets. OPC UA Profiles represent a collection of Facets that can be atomically tested. Full Profiles represent the complete functionality of a device.

The FLC base facet describes basic functions that are common to the various types of automation components (controllers and field devices), such as device identification, basic diagnosis, and connection management. Device- or function-specific facets are built upon the base facet, such as for functional safety, motion, I/O, and instrumentation.

Safety and motion

Functional safety requirements are covered by OPC UA Safety. For this purpose, the first OPC UA safety specification has already been adopted, which is based on client-server mechanisms and has emerged from a joint working group with the Profibus user organization (PNO). There will also be an extension shortly that describes the mapping to PubSub and the parameterization of safety devices. The special feature of the safety concept for OPC UA is, among other things, that safe participants can be integrated into the communication even during ongoing operation, which is not possible with conventional safety protocols.

The Motion Facet includes the specification of motion control functions for various types of motion devices, such as controls, standard drives, frequency converters, and servo drives. The FLC initiative has determined CIP Motion™ and Sercos to be ideal solutions on which to base OPC UA Motion. The CIP Motion and Sercos specifications will be used and may be changed or extended for adaptation to the FLC system architecture, to support innovation to cover Industry 4.0 and digitalization use cases, and to facilitate modern concepts of data modeling and real-time requirements.

The facets that are specified and standardized by OPC can be complemented by OPC UA companion models like FDI, FDT, PA-DIM, Analyzer Device Integration (ADI), Module Type Package (MTP), MDIS (oil and gas), VDMA pumps, UMATI, Spectaris, and so forth. In addition, vendor-specific models can be integrated.

Communication

An important aspect of FLC is to support different underlying transport protocols and physical layers for the broad range of use cases in factory and process automation. To achieve this, the concept of quality of service (QoS) modeling is introduced, which has the possibility of flexibly mapping services to lower-level communication protocols.

In a first step, FLC supports a layer 3 mapping via UDP and a direct layer 2 mapping to Ethernet TSN, both combinable with SPE/APL physical layer. However, the QoS modeling also allows an easy expansion to other subordinate transmission standards, including wireless data exchange, such as 5G or Wi-Fi 6.

The combination of OPC UA with a direct mapping to Ethernet TSN is of particular importance. Only then is deterministic data transmission via OPC UA possible. A working group headed by the FLC steering committee is currently working out which TSN substandards for the FLC end devices and infrastructure components shall be mandatory to meet the specified requirements for performance, flexibility, and ease of use.

On the part of the OPC Foundation there is a clear commitment to the TSN-IA profile, which is being developed in the IEC/IEEE 60802 working group. It has the goal that different protocols and traffic types can be transmitted via a common network infrastructure. This coexistence is not only essential for the convergence of IT and OT, it is also an important aspect when migrating existing brownfield solutions based on conventional fieldbus protocols. In the end, users should be able to freely decide how quickly they want to replace old systems or system components with new ones.

Road map

Work on the first specification version has made good progress in recent months, despite Covid-19 and its limitations. The basic concepts have largely been adopted and have been incorporated into the first draft specifications. The release candidate of the first specification version is within reach. According to current planning, it should be ready in the third quarter. Prototyping has started to verify the draft specifications.

A first specification release can be expected by the end of 2020. At the same time, a working group is also set up to generate the corresponding test specifications, which are then converted into corresponding test cases for the OPC UA Certification Tool (CTT) in a second step. Work has already started on concepts for the controller-to-device use case, which will be included in the second specification version. ■

About the OPC Foundation

Automation.com is hosting OPC expert interviews, a series of discussions taking a deep dive into open platform communications and related technology. International experts discuss the new Field Level Communications group, OPC and OPC UA, protocol binding, security, and more. Find it at www.automation.com/en-us/news-by-company/opc-foundation-news-articles.

Since 1996, the OPC Foundation has facilitated the development and adoption of the OPC information exchange standards. The Foundation serves more than 750 members worldwide. Its mission is to provide the best specifications, technology, process, and certification to achieve multivendor, multiplatform, secure, and reliable interoperability for moving data and information from the embedded world to the enterprise cloud.

ABOUT THE AUTHOR

Peter Lutz is director field level communications of the OPC Foundation. He has more than 25 years of experience in open control systems, industrial automation, and real-time communications. He has been engaged in several national and international standardization committees, including IEC SC65C (digital communication), IEC SC22G (adjustable speed electric drive systems), and IEC/IEEE 60802 WG (TSN Profile for industrial automation). Since April 2019, he has been managing the OPC Foundation's FLC initiative with the goal of establishing OPC UA as a globally accepted standard for field level communications in the factory and process industries.

View the online version at www.isa.org/intech/20200804.

An introduction to industrial artifi

By David Immerman

There is no escaping the term artificial intelligence (AI) today. It perpetuates the media, pop culture, and industry.

We broadly define AI as a discipline that uses computer science and statistics to create systems that perceive, understand, and act in a manner similar to human intelligence. The field of AI covers a variety of technologies leveraging a multitude of data science techniques capable of "learning" to enable this intelligence. In this article we will cover several types of AI, dispel common misconceptions, and dive into more specific real-world industrial applications with future guidance.

The evolving era of AI in all its forms is driving industrial transformation today

ANI versus AGI

At the highest level, there are two forms of AI: artificial narrow intelligence (ANI) and artificial general intelligence (AGI).

Artificial narrow intelligence (also known as specialized AI or weak AI) refers to systems programmed to do a single task, whether it is playing chess, identifying early stages of a disease on MRI scans, or autonomously driving through an environment. Although these tasks differ significantly in complexity and in the level of advancement of their AI techniques, they still fall under specific operational domains.

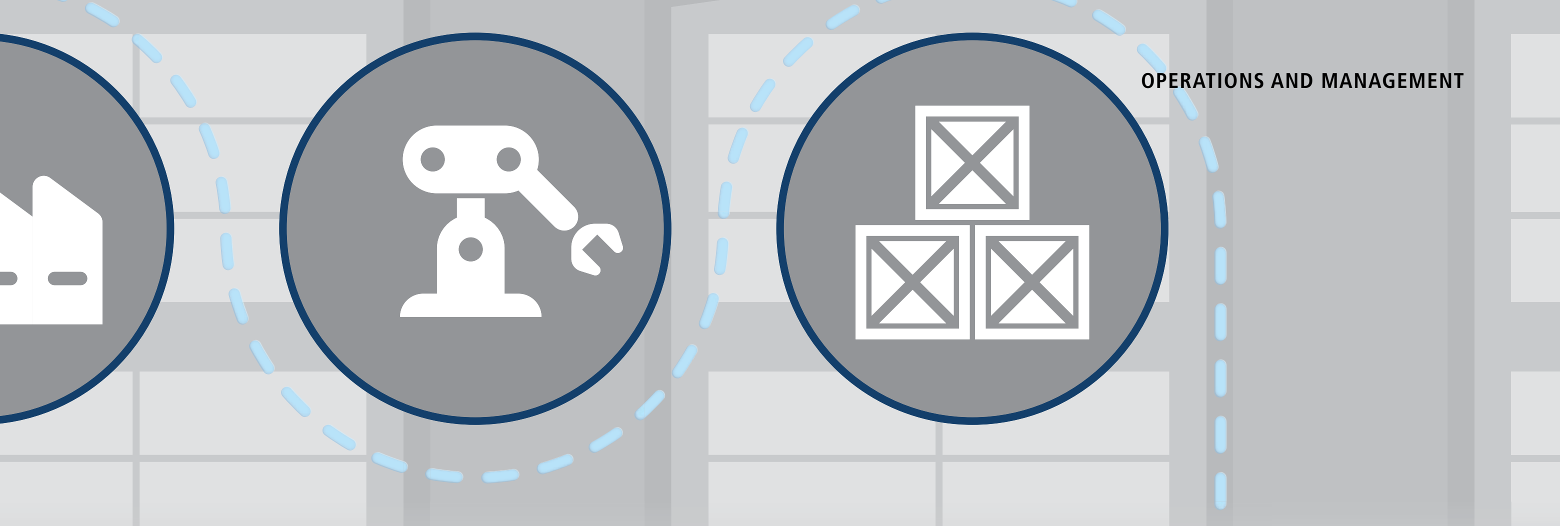
Artificial general intelligence (also known as strong AI) is the machine equivalent of human intelligence where the AI appears to be conscious and sentient. This is typically the popular sci-fi representation of AI such as shown in *Ex Machina, Her, iRobot,* and *Westworld*.

When presented with a novel task, the AGI can use prior knowledge and apply previously learned skills, similar to how a human would solve problems. There are more speculative levels of AI, such as artificial super intelligence, where the robot outperforms human intelligence in multiple domains and tasks, such as autonomously driving to a hospital to detect patient diseases and later defeating a human in chess.

Dispelling AI misconceptions

Due to this pop culture representation of AGI, there are several common misconceptions and misleading connotations with the technology.

Myth: Artificial general intelligence will be here tomorrow. While much of pop culture enjoys running with the AGI utopian narrative, it does not yet exist. Research has progressed immensely in the past few years with technological advancements in high-performance computing and development techniques like neural networks, among others. However, we are still in unchartered waters. Researchers estimate an AGI breakthrough could be anywhere from 10 to more than 100 years away.



cial intelligence

Myth: Using artificial intelligence for automation will soon replace all jobs. The market confusion around automation lies with whether AI is capable of replacing a job's task versus the job itself. As we know with ANI, a single task can be automated, but people underestimate how many different and constantly changing tasks a typical worker performs. McKinsey estimates that fewer than 5 percent of jobs consist of activities that are 100 percent automatable. Even with increasingly autonomous machines entering industrial environments, 72 percent of factory tasks are still performed by humans.

However, there may be some workforce displacement in areas where the strengths of AI and automation align. These include tasks that involve repetition and precision, require heavy lifting, or are executed in hazardous environments. This will create some workforce reskilling and a shift in labor resources.

Assemblers and fabricators, who may be affected by automation disruption (–11 percent job growth for 2018–2028), can transfer to roles that service machines, such as general maintenance and repair workers (+6 percent) or mobile equipment service technicians (+4 percent). Organizations facing worker shortage and skills gaps will recognize that managing worker "displacement" through skills development programs is more cost effective than worker "replacement" by only using autonomous machines or recruiting new employees.

Myth: AI is a silver-bullet technology to solve all business needs. Artificial intelligence is a means to an end for businesses; it cannot be simply thrown at a pressing problem and resolve it. AI is another tool in the digital transformation toolbox that organizations use for enterprise-wide initiatives.

About 30 percent of industrial companies are evaluating or leveraging AI as part of their digital transformation initiative, and AI in manufacturing is anticipated to grow from $1 billion in 2019 to $17 billion by 2025. AI will have a massive impact in the industrial sector, but only when tied to strategically aligned and value-oriented digital transformation programs.

FAST FORWARD

- AI is transcending work as we know it, creating a growing opportunity to revolutionize industrial enterprises and drive unprecedented financial and operational gains.
- Breaking down different forms of AI, dispelling common misconceptions, and connecting to strategic guidance will provide a basis for industrial companies to develop AI use cases today.
- Deep dives into popular industrial artificial intelligence applications and use cases will bring this buzzword to life for industrial companies looking for a place to start creating meaningful business value.

Types of ANI

Under the artificial narrow intelligence umbrella there are two primary classifications: machine learning and deep learning.

Machine learning (ML) is a branch of AI, specific to systems, models, and algorithms that can learn without explicit programming and can recognize patterns to predict outcomes. ML cuts out a lot of time that would be required for strenuous human preprocessing of massive datasets before analysis. The user can more simply build and calibrate models with desired inputs, outputs, and other variables (data labels) for the model to process and gain insights. For example, ML can use input data from Internet of Things (IoT) sensors (e.g., temperature, vibrations) to provide an output for the asset's estimated remaining useful life or when it will fail.

Deep learning (DL) is a subset of ML but is more purpose-built for applications based on insights from unstructured data, such as images or audio files. DL uses interconnected artificial neurons that form neural networks, mimicking activity in the human brain. These networks can consist of millions of layers of neurons, which are essentially calculations and algorithms trained to recognize a specific feature or pattern within the data input to generate an output. Autonomous vehicles rely on DL to train massive neural networks and create inferenced models that can determine the difference between trees, stop signs, and pedestrians in real time.

Both of these types of learning require different forms of training data to feed the AI model, which could be anything from customer orders to machine telemetry to images. Once trained, an inferenced model is used in practice for AI-driven applications.

AI applications for the industrial enterprise

AI is increasingly integrating with and creating innovative industrial applications to improve key Industry 4.0–related financial metrics. AI can improve a range of industrial-oriented key performance indicators (KPIs), including asset efficiency, throughput, quality, new product introductions, and worker productivity.

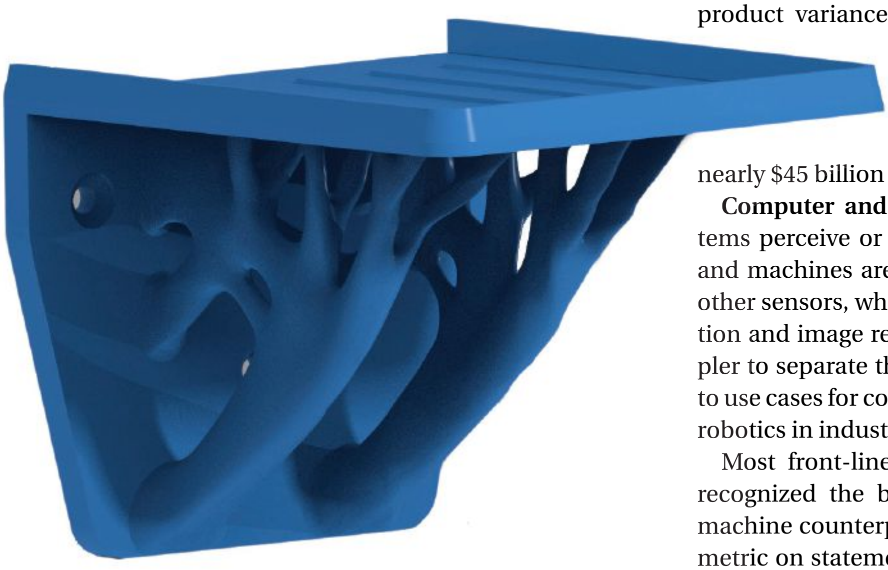
Predictive maintenance is a form of condition-based monitoring that tracks and analyzes an asset's performance, status, and health in real time using a variety of technologies. Even incremental predictability improvements of heavy industrial assets can drastically reduce downtime, which can cost an average of $260,000 per hour or even millions for some mission-critical machines.

There are myriad data sources relevant to effective predictive maintenance, including the asset's configurations, historical systems of record, and increasingly real-time industrial IoT data. ML can aggregate these disparate and massive datasets across fleets of assets and products to create inferenced models that can further predict the asset or product's future state. More accurate predictions into future failures across an asset's life cycle improve not only its uptime but can also better optimize service interventions and generate performance efficiencies, improving its useful life. Nearly 50 percent of manufacturers who use ML today use it or plan to implement it for predictive maintenance use cases.

Demand forecasting estimates optimal supply rates for fluctuating future customer and supply chain demands, and inventory optimization aims to have the optimal stocking to meet service level targets. They are both tools manufacturers and service teams use to lessen unpredictability from shifting market conditions, gain flexibility and agility within their operations, and improve customer satisfaction.

ML provides additional predictability into these applications to lessen intermittent demand across operations. ML identifies real-time patterns from causal (oil prices, market fluctuations, etc.), connected (IoT-enabled assets), and other business system and supply chain data. Of manufacturers with AI strategies, 55 percent are using or plan to use ML for intelligent inventory monitoring and/or supply demand forecasting.

Generative design autonomously creates an optimal design from a set of system requirements and engineer-driven goals. Generative design enables faster product development rates and higher engineering productivity. It creates lower cost, yet high-quality and innovative products. AI is increasingly embedded throughout this development process by presenting design alternatives for consideration and linking in preferred materials, purchasing decisions, manufacturing capacity, product variances, and supply-chain status, among other possible inputs. Additive manufacturing's flexible manufacturing framework will bring many of these generative design-optimized products to life, becoming a nearly $45 billion market in 2030.



Using generative design, the displayed bracket was developed with a set of system requirements and engineer-driven goals.

Computer and machine vision cover how artificial systems perceive or "see" the world around them. Computers and machines are increasingly equipped with cameras and other sensors, which are being embedded with object detection and image recognition deep learning models. It is simpler to separate these two "vision" segments as they pertain to use cases for connected workers and intelligent machines/robotics in industrial enterprises.

Most front-line workers in industrial settings have not recognized the benefits of digital technologies that their machine counterparts have, yet worker productivity is a key metric on statements of operations. Augmented reality (AR) is enabling powerful connected worker applications, and AI plays a major role within industrial use cases. AI is enabling

Using augmented reality, one type of computer and machine vision, a front-line worker can reference safety instructions in real time while conducting maintenance on a machine.

computer vision in AR through perception via native sensors (camera, GPS) on the hardware itself and software interpreting the user's movements (hand gesturing, eye tracking) in the context of the surrounding environment.

For example, consider how unique and complex a typical industrial environment is. There are innumerable dated, newer, and constantly changing items, parts, products, machines, and processes spanning operations. The computer-aided design (CAD) data or digital definition of these different objects, consisting of unique parameters and configurations, can feed into neural networks to train AI models. The deep learning inferenced model could then automatically recognize the object in the real world and its real-time characteristics. A service technician could recognize a machine in his or her field-of-view, trigger the unique object's work instructions in AR to service it, and even order new parts for repairs.

Intelligent machines similarly leverage computer vision for perception, but it is primarily used for repetitive and precision-oriented tasks such as welding. While AI plays an important role in an industrial robot's orientation and movements, we will focus on the machine vision aspect. Intelligent machines can use computer vision–based AI to inform their actions as well as evaluate results. By feeding deep learning models training data for what a product "should" look like, machines can quickly recognize anomalies on a production line.

Machines can quickly inspect the quality of products and check for nuanced defects that the human eye might not perceive. This can be extremely valuable when there are large volumes of different and quickly moving supplies, materials, and components, such as with a process manufacturer's batch production line. With machine vision, manufacturers can spot a defect among these thousands of many different moving parts on the line, some that look nearly identical. Sixty-four percent of manufacturers leveraging machine learning cite using or planning to use it for quality assurance use cases.

These are a few among several forms of AI applications that will interface with the industrial enterprise. The initial form, application, and use case that AI will be used for will be unique to each industrial company and its strategic goals.

AI strategic guidance

The endless possibilities of AI are exciting. It will continue to alter the world and the many factories within it. But industrial companies are facing disruptive forces today and need to leverage technologies for operational efficiencies, strategic differentiation, and competitive advantages. Below are a few key considerations to forming an AI strategy to capitalize on these global headwinds.

1. **Define the breadth of use cases across the company.** Artificial intelligence can create tremendous value across the organizational hierarchy and functions within the company. Use cases across the value chain can span from AI enabling a new smart, connected product to optimizing intelligence across a factory. Understanding the universe of opportunities will excite internal stakeholders, provide scope for current and future initiatives, and help align with technology partners for this transformation.
2. **Prioritize use cases that will drive business value.** For any digital transformation initiative, it is critical to align strategic business goals with use cases. Prioritizing a few targeted, high-value, AI-driven use cases that can quickly produce meaningful wins is more advisable than attempting to simultaneously roll out dozens. Weighing which AI use cases to pick will be subject to a few unique parameters,

such as the internal skill set required to create and expand the use case and the project's scope for future investment. Sourcing and analyzing both internal and external data to train and create inferenced models will also be key components of most artificial intelligence strategies.

3. **Measure success to propel future growth.** Measuring what worked through targeted key performance indicators and metrics will validate the use case's success and provide lessons learned for future transformation involving additional stakeholders. Successful artificial intelligence projects have predetermined the importance of establishing these metrics while the remaining adopters are quickly recognizing the need to: 46 percent of organizations with an AI strategy have defined KPIs to measure success, while 42 percent plan on determining them in the next year.

The inaugural industrial artificial intelligence use case will be unique to each company in form and in how it propels growth. AI could be the centerpiece or a single component in a broader industrial digital transformation; whichever brings the greatest business value to your organization should be prioritized.

Final thoughts for the near future

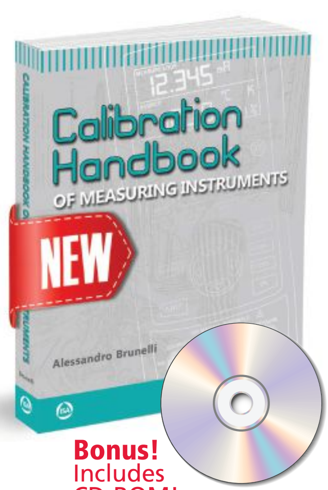
The time is prime for AI, with increasingly ubiquitous computing and growing investment from industry, university, and government entities. Coupled with the growing prevalence of open-source software and powerful AI development tools, this is providing realistic jumping off points for industrial enterprises.

The growth of the cloud and constantly improving AI hardware are providing the infrastructure and compute power to quickly build lower-cost and innovative AI applications. Investments from industry and governmental organizations are spurring research activities, including the next wave of collegiate talent to foster AI growth. Open-source AI software platforms, annotated datasets, and prebuilt digital solutions will lower barriers to AI entry for many industrial incumbents. With this converging ecosystem, all signs point to forming an AI strategy today to drive industrial transformation tomorrow. ■

ABOUT THE AUTHOR

David Immerman (dimmerman@ptc.com) is a senior research analyst for PTC, providing thought leadership and market research on industrial technologies, trends, markets, and other topics. Previously Immerman was an industry analyst in 451 Research's Internet of Things channel, primarily covering smart transportation and automotive technology, including fleet telematics, connected cars, and autonomous vehicles. Prior to 451 Research, Immerman conducted market research at IDC.

View the online version at www.isa.org/intech/20200805.



Seeing air system leaks with sonic imagers

An array of tiny supersensitive microphones on a sonic imager detects sounds outside the range of human hearing.

By Javier Irazola

An estimated 30 percent of compressed air is lost to unrepaired leaks. That means a loss in air pressure, which can lead to reduced productivity from underperforming pneumatic tools, faulty air handling units, and other industrial equipment. Neglected leaks can, over time, lead to unplanned downtime. To repair compressed air system leaks, you need to detect the leaks, prioritize the leaks based on their ability to impact production, and quantify the costs of each leak to determine savings.

Sonic imaging technology combines acoustics and imaging to create a visual representation of the sound of air leaking, so leaks can be easily found and quickly fixed.

Detecting the leaks

Part of the reason air leaks are a big issue is because they are hard to find. Air leaks can occur anywhere within a compressed air, gas, or vacuum system, including in couplings, hoses, fittings, pipe joints, quick disconnects, condensate traps, and valves. Even when found and fixed, new leaks keep popping up—a fact of life due to the wear and tear on equipment over time.

Because it can be so difficult to find air leaks, most facilities just accept them as a cost of doing business. And while it may not be possible to eliminate all leaks, it is possible to substantially reduce their number.

That is where a sonic industrial imager provides its greatest value, and where the future of leak detection is headed. Traditional leak detection methods still work, but they come with challenges and deficiencies. None of these methods is foolproof, and most require downtime, which means lost time and money.

- Sound: Hissing indicates a sizeable leak, since a decibel level of greater than 60 is audible without equipment. Because most plants are noisy and often require worker ear protection, listening for leaks must occur during downtime—between shifts, on weekends, or during scheduled maintenance.
- Sound and soap: Technicians spray soapy water on areas of audible leaks, and where bubbles appear is the leak spot. The method is protracted, far from precise, and requires cleanup, since soapy water overspray creates a slipping hazard.
- Ultrasonic acoustic detection: During downtime, technicians wearing earphones scan potential leak spots with a parabolic dish or cone-shaped accessory. When a leak-indicating noise is detected, the technician switches to a wand-shaped device that must be held a couple of inches from the leak to pinpoint the exact location.
- Using outside experts: Engineers or other experts are engaged, usually once a year to save money and disruption. They use one or all of the traditional techniques, and in-house technicians handle repairs and checks.

Today, a leak detection technology called sonic imaging has radically altered the leak detection process. Technicians can now see their leaks. This technology, introduced in 2019, is in a handheld sonic industrial imager that uses an array of tiny supersensitive microphones to detect sounds both in the human hearing range and in the ultrasonic range. The output is a visual representation of sound. Most users can get up to speed with the easy point-and-shoot imager in about 10 minutes, regardless of how little experience they have with leak detection.

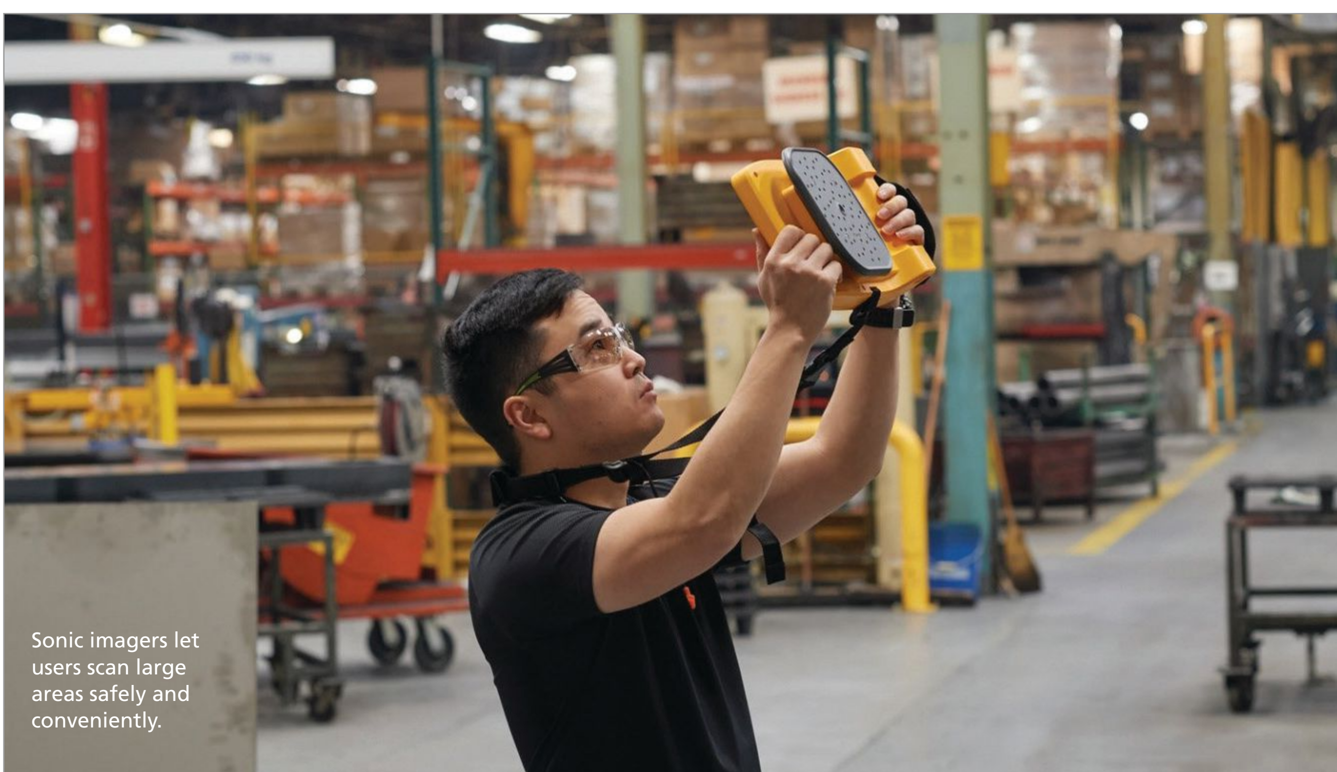
Users simply scan the area of interest, and the imager applies proprietary algorithms to the identified sounds. The result is an instant, visual map of the leak. The map is layered over a visible light image of the area, so users can quickly pinpoint the location of the leak and tag it or repair it on the spot. After repairing the leak, the technician can use the sonic imager to instantly verify the repair. Scans can be saved as images or video to be a reference for future discussions with colleagues or supervisors.

The sonic imager can visually scan large areas from more than 10 m (33 ft) in heavy noise conditions and detect leaks from up to 100 m in low-noise conditions. This allows technicians to work very quickly and from a safe distance while equipment is running. It also makes it easier to find leaks in hard-to-reach areas, like behind equipment or in overhead pipes, and to distinguish between multiple leaks in the same area. The captured images eliminate the need to climb a ladder to tag the leak, because the location of the leak is clearly identified on the image.

Prioritizing the leaks

Depending on the size of your compressed air system, you could have anywhere from tens to thousands of leaks at any given time. Just like with other assets, leaks should be prioritized for fixes based on their ability to affect the bottom line.

A criticality analysis would likely classify your compressed air system as a "star athlete." This means that the compressed air system directly determines the company's



Sonic imagers let users scan large areas safely and conveniently.

ability to win, and by how much. Beyond simple uptime and downtime, there is a direct relationship between each percentage of incremental performance and the incremental revenue of the company. This is where maintenance must be at its peak.

To prioritize leaks, then, you need to know how big they are. How much air is leaking depends on the size of the hole the air is coming from, as well as a few other factors, such as compressor pressure and backpressure.

Sonic industrial imagers come with LeakQ technology that allows the user to estimate the size of detected leaks. Although there is no mathematical way to obtain a flow rate out of its sound signature, the LeakQ flow estimator might provide the best guidance. The way LeakQ estimates is mostly empirical, based on average sound generated by average leaks. Many leak types were measured at different flow rates and at different pressures, then a regression model was created to estimate the flow rate out of a decibel measurement.

In LeakQ mode, you position the leak within the circle on the screen. You will see the distance you are from the leak and the severity scale of the leak. It is very easy and straightforward. In this mode, you can also add notes, tags, and more for sharing with others. With this information in hand, you are now able to prioritize which leaks should be fixed first.

Quantifying the costs of the leaks

For production companies that start using the sonic imager, early results validate energy savings. One plant saw a near 26 percent recovery in compressed air capacity and close to $49,000 in annual electrical energy savings—based on their total installed capacity of air compressors equaling 330 horsepower. Before using the sonic imager to inspect for air leaks, the plant ran four compressors close to full capacity. After a one-day inspection, the technicians found and repaired more than 130 leaks. Now the facility can handle most of its compressed air needs with just three compressors.

How do you identify the cost savings? You can develop a detailed report to estimate your total cost savings, should you repair identified leaks. To create such a report, you simply upload the LeakQ images from the sonic industrial imager into the reporting tool and add some information about your system, such as:

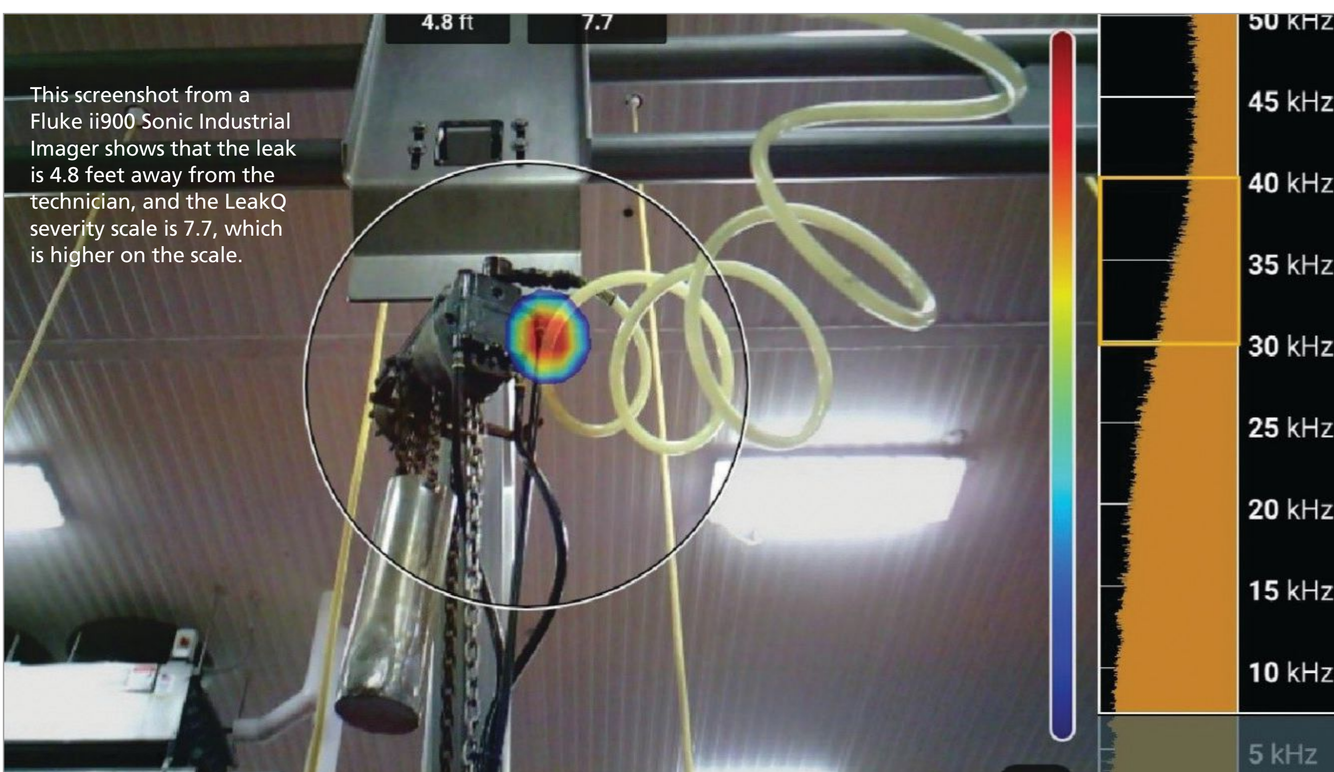
- gas type
- pressure in pounds per square inch (psi)
- cost of gas per standard cubic feet (SCF)
- cost of electricity per kWh
- ratio of power to flow rate in kW per 100 cubic feet per minute (CFM)
- operating hours per year.

With this information, you can generate a report that will include detailed information about the leak costs as a whole and individual leak costs.

Why is this information important? One reason is that it provides a solid return on investment argument for the purchase and use of the sonic industrial imager. Another is that it can be used to show successful efforts made toward meeting plant efficiency and cost-savings goals. ■

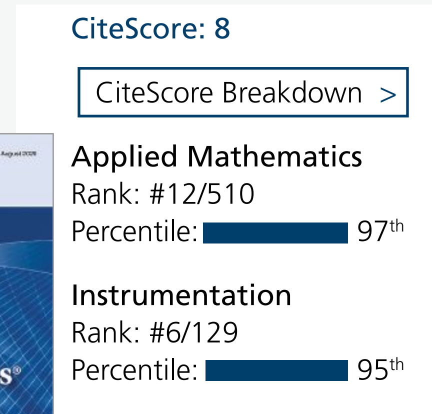
ABOUT THE AUTHOR

Javier Irazola, global product manager for the Industrial Imaging group at Fluke Corporation, led the recent launch of acoustic imaging solutions. He has eight years of previous experience in engineering and project management for utility projects in the U.S. and E.U. and three years working for the product innovation department of Fluke Industrial Group.



This screenshot from a Fluke ii900 Sonic Industrial Imager shows that the leak is 4.8 feet away from the technician, and the LeakQ severity scale is 7.7, which is higher on the scale.

ISA Transactions earns high scores for citations



ISA's monthly scientific journal, *ISA Transactions*, has earned a 2019 CiteScore of 8.0. The CiteScore was calculated by Scopus on 6 May 2020 and made available by ScienceDirect.com, both divisions of Elsevier, a global information analytics company specializing in science and health.

ISA Transactions covers state-of-the-art developments in the science and engineering of measurement and automation. Its intended audience is research and development personnel from academe and industry in the fields of control systems, process instrumentation, systems, and automation.

ISA Transactions "seeks to bridge the theory and practice gap. This balance of interests requires simplicity of technique, credible demonstration, fundamental grounding, and connectivity to the state of the art in both theory and practice," said *ISA Transactions* editor in chief A.B. (Ahmad) Rad, who is with Simon Fraser University School of Mechatronic Systems Engineering in British Columbia, Canada. He has headed *ISA Transactions* for the past nine years. "*ISA Transactions* has significantly evolved in the last decade and is now among the top international scientific journals," Rad said.

Peer reviewed, peer cited

First published in 1962, *ISA Transactions* is the flagship academic journal of ISA. It is currently published by Elsevier 12 times per year. In 2019, the journal received 2,450 submissions from all over the world and published 330 papers.

ScienceDirect.com is a platform for peer-reviewed literature used by 25 million researchers a month, published by Elsevier. Scopus is the largest abstract and citation database of peer-reviewed literature, including scientific journals, books, and conference proceedings. Elsevier launched CiteScore in 2016 to provide a comprehensive metric to rate and rank scientific journals.

Source: *International Society of Automation Annual Report 2019*

Scopus metrics track the number of citations that peer-reviewed journal articles receive each year, then creates a CiteScore rating so journals can be compared to others in the same topical category. CiteScore measures the average citations received per document published in a particular issue. CiteScore values are based on citation counts in a given year (e.g., 2018) to documents published in three previous calendar years (e.g., 2015–17), divided by the number of documents in these three previous years (e.g., 2015–17).

Contributing to its overall CiteScore, *ISA Transactions* ranked 12th out of 510 (97th percentile) on the topic of applied mathematics and sixth out of 129 (95th percentile) on the topic of instrumentation. *ISA Transactions* also earned an impact factor of 4.343. The impact factor measures the average number of citations received in a particular year by papers published in the journal during the two preceding years.

The journal is one of 15 that Scopus has grouped into the signal processing and control category. *Automatica* (CiteScore: 2.4) and *Mechanical Systems and Signal Processing* (10.6) were the top journals in the category, while *Flow Measurement and Instrumentation* (3.4) and *European Journal of Control* (3.3) were at the bottom.

A sample of recent topics cited include:

- "A novel deep learning based fault diagnosis approach for chemical process with extended deep belief network" (Wang, Pan, Yuan, Yang, and Gui, 2020)
- "An experimental setup of multi-intelligent control system (MICS) of water management using the Internet of Things (IoT)" (Hadipour, Derakhshandeh, and Shiran, 2020)
- "Performance estimation of three-phase induction motors from no-load startup test without speed acquisition" (Pereira, Perin, Pereira, Ruthes, Mattos de Sousa, and Peres de Oliveira, 2020)

Visit www.sciencedirect.com/journal/isa-transactions for more information about *ISA Transactions*' 2019 scores. ■

CSIC virtual conference showcases ISA industrial cybersecurity expertise

With pandemic concerns disrupting business travel and face-to-face interactions, ISA staff have been working overtime to develop new ways to further the association's mission to advance technical competence by connecting the automation community. The result: the successful debut of the Cybersecurity Standards Implementation Conference (CSIC) in a virtual (digital only) format.

The Virtual CSIC, held on 16 July 2020 for six hours, gathered expert speakers and attendees in a virtual meeting space complete with an auditorium for presentations; chat rooms for questions, answers, and peer-to-peer networking; and a "show floor" with "booths" to visit for solutions, education, and technical information. The focus of all was industrial automation and control system (IACS) cybersecurity awareness, solutions, and action plans related to the ISA/IEC 62443 series of standards.

Through the virtual show floor, ISA showcased its unique role in furthering global education and collaboration around the topic of industrial cybersecurity. ISA's Global Cybersecurity Alliance (isa.org/ISAGCA) had a booth filled with resources and information about advancing cybersecurity readiness and awareness in manufacturing and critical-infrastructure facilities and processes.

Through a wholly owned subsidiary, ISA bridges the gap between standards and their implementation with the ISA Security Compliance Institute (isasecure.org) and the ISA Wireless Compliance Institute (isa100wci.org). The Automation Federation (automationfederation.org), an association of nonprofit organizations serving as "The Voice of Automation" (of which ISA is a founding sponsor), also had a booth. ISA-owned Automation.com was also in a booth, showcasing its news website, emailed newsletters, digital magazines, and other publications filled with automation-related content. Automation.com publishes *InTech* magazine in print and digital formats for ISA.

The next conference on cybersecurity topics is CSIC+ on 25 August 2020 from 9:00 AM – 1:00 PM CDT. Find out more at https://isaautomation.isa.org/virtual-events-program-cybersecurity. ■

Megatrends: Forces impacting automation professionals

Discussing ISA's 75th anniversary year activities recently, ISA president Eric Cosman said, "Our plan is to [use the anniversary to] raise awareness of the profession. We will be highlighting major technical advances in automation throughout our first 75 years and looking to how automation will impact our lives in the future."

To fulfill that goal, ISA is kicking off a new megatrends initiative—an ongoing look at the forces affecting automation professionals around the world. Megatrends coverage will appear prominently in the anniversary issue of *InTech* magazine, due out in October, and will continue into 2021. Megatrends articles and insights are also accessible online at https://isaautomation.isa.org/isa-megatrends.

The initiative seeks to provide insight and spark discussion around the trends shaping the future of automation. It will present articles, reports, and other resources on trends in four broad categories. These megatrends are:

- Workforce of the future: Our work is changing, and our skills must evolve.
- Environmental safety and security evolutions: Engineering design and operations processes will shift, reflecting societal pressures and business drivers.
- Manufacturing technology transformation: New tools will enable rapid and consistent connection, collaboration, and technology development.

- Standards under pressure: Global operations require global standards, but resistance and power struggles could be barriers to success.

ISA is also gathering your thoughts and ideas on how trends within each of these categories will impact your industry and your professional life in the coming years. The website has a link to a survey, and results will be published in a future report.

Join conversations about these topics on ISA's social channels or in its upcoming online community, ISA Connect, launching later this year. ■

Professional Development

ISA Certified Automation Professional (CAP) program

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

CAP question

Which statement BEST describes the rationale for an MES?

A. Enterprise resource planning (ERP) must have information from plant floor controllers.
B. To compete in a global economy, there must be the capability to conduct business using online means.
C. Equipment control cannot function unless it is integrated with ERP.
D. Automation effectiveness is not based solely on equipment control capability.

CAP answer

The answer is *D,* "Automation effectiveness is not based solely on equipment control capability." Automation effectiveness must encompass not only the effectiveness of equipment control, but also the effectiveness of the use of raw materials, plant production capacity, product storage and transfer capacity, operations resource planning, and production cost factors, to name a few. The technical resources to coordinate these components of automation effectiveness cannot be found at the equipment control level.

To optimize these activities, a manufacturing execution system (MES) should be considered that is configured to specifically coordinate these activities in the plant. A well-performing equipment control function is critical to the supply and receipt of data from higher-level coordinating applications, such as MES.

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

ISA Certified Control Systems Technician (CCST) program

CCSTs calibrate, document, troubleshoot, and repair/replace instrumentation for systems that measure and control level, temperature, pressure, flow, and other process variables.

CCST question

The purpose of the plug within the control valve is to:

A. send a signal to the control valve to maintain the set point.
B. create a flow area that modifies the flow rate.
C. measure the upstream pressure of the property.
D. allow the valve to rotate without any linear motion.

CCST answer

The correct answer is *B,* "create a flow area that modifies the flow rate." The plug in a control valve is the part that is positioned inside the valve by movement of the valve stem in response to a change in the control output. The plug is typically tapered or conical in shape and seats or fits into an orifice hole in the body of the valve. As the plug moves and changes position in relation to the orifice, a proportionately greater or smaller flow area is created.

When the plug is fully mated to the seat ring, the orifice is plugged and the valve is fully closed, and no flow can pass. As the plug is positioned away from the seat ring, a larger and larger annular area is exposed around the plug and through the orifice, allowing a greater flow rate to be developed through the valve.

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

New CAPs and CCSTs

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

Certified Control System Technicians

Name	Company	Location
Level 1		
Autumn Hansen	None	U.S.
Brandon Hiler,	None	U.S.
Eric Lara	None	U.S.
Jorge Vega	None	U.S.
Jeffrey Hubbard	Eagle Eye Electric	U.S.
Brian Oravsky	None	U.S.
Nicolas Van Kooten	None	U.S.
Justin Nava	None	U.S.
Jaren Bowers	None	U.S.
Jordan Houston	Akorn	U.S.
Jacob Norton	None	Canada
Jason Vormbaum	City of San Luis Obispo	U.S.
David Faust	None	U.S.
Mark Seliga	None	U.S.
Adrien Sanchez	None	U.S.
Roberto Ramirez	None	U.S.
Husam Khaleel	None	Saudi Arabia
Kolter Knapp	TM Process & Controls	U.S.
Justin Torok	Aaron Associates	U.S.
Level 2		
Jack Johnson	None	U.S.
Justin Critchlow	Alyeska Pipeline Service Co.	U.S.
Christopher Fitka	Alyeska Pipeline Service Co.	U.S.
Juston Freeman	None	U.S.
Robert Jeffries	None	U.S.
Nathan Morris	Alyeska Pipeline Service Co.	U.S.
David Moravek	None	U.S.
Manuel Hernandez	None	U.S.
Gliserio Chavez	None	U.S.
Reagan Vatzlavick	None	U.S.
Level 3		
Rasel Ahmed	None	U.S.
Herman Wuebkers	None	U.S.

Certified Automation Professionals

Name	Company	Location
Lamidi Kolawole	KHS Machines	Nigeria
Trinh Van Huan	Petro Vietnam Gas Corporation	Vietnam
Srinivas Gunasekaran	Black Cat Consulting & Engineering WLL	Qatar
Victor Taveras	ACS	U.S.
Muhammad Inayat	None	Saudi Arabia
Patrick Kneisley	HRSD	U.S.
Giang Vuong	None	Vietnam
Armaghan Yusuf	None	Canada
Jim Delillo	None	U.S.
James Wilbourn	None	U.S.

Open-loop, closed-loop heating methods

By Jason Sanders and Connor Wegner

Manufacturers today face many hurdles in their manufacturing applications. Process parameters can range from one application to the next. While some applications require very little precision and control system manipulation, others can be more complex and require further feedback for a more precise and repeatable process. In situations where temperature regulation is required, industrial heating requirements follow a similar path to other process controls. In temperature regulation, there are two types of systems: open loop and closed loop. Deciding which methodology to choose depends on the requirements of the process.

Open-loop heating

Open-loop heating uses manual manipulation to regulate temperature. There is very limited feedback or control features for temperature control. Open-loop heating regulation is achieved by either voltage manipulation to the heater, increasing or decreasing the amount of airflow, or utilization of an onboard potentiometer, if available. This method relies upon manual intervention by the operator to control the system at any point during the process.

The open-loop heating system has some advantages, including design simplicity and ease of maintenance. With only voltage applied to a heat source, this method does not require an elaborate control system to manipulate the temperature, which makes it easier for the user to implement the necessary components into the system. It also simplifies troubleshooting for maintenance purposes when necessary. There are also disadvantages to this method. Some of the disadvantages are inaccuracy of the system itself and no opportunities for automatic adjustments. Since there are no means for feedback to a temperature controller or programmable logic controller (PLC), the system does not have a way to make the necessary adjustments to optimize the process.

Closed-loop heating

Closed-loop heating is a method to accurately control and maintain temperature during the process. This method contains a feedback loop in which a control system receives feedback from the process and develops a response to achieve stability. It can be used for many heating applications and is an effective control method in process heating due to its ability to provide a stable and accurate temperature. A closed-loop heating system comprises a heat source, means for temperature feedback (i.e., thermocouple), and controller. In a closed-loop heating system, the controller—usually a PLC or a temperature controller—receives a signal from a temperature sensor, thermocouple, or infrared thermometer. This signal is a measurement of the temperature at a designated location in the system. This signal is then returned to the controller, where it will adjust the power given to the heater to maintain a temperature set point.

The closed-loop heating system has some advantages, such as overall system accuracy and ease of integration. Because this method can account for unexpected changes in the process, such as variations in ambient temperature or pressure, shifts in supplied voltage, or wind and air flow shifts, it gives the system the ability to manipulate the process automatically from an external controller.

Even though closed-loop heating systems can be an efficient method for a variety of industrial processes, they do have some drawbacks. This method requires a more complex control scheme and is costlier to implement and maintain. Since closed-loop heating relies upon various components for precision feedback and optimized control, the system can incur additional hardware/software costs versus an open-loop system, which can vary depending on the intricacy of the controls. In addition to increased equipment costs, more frequent maintenance activities, such as routine checks for the proper system operation, can increase.

Many variables

There are many variables to consider when deciding between an open-loop or closed-loop heating control system for an industrial application. Both methods offer great benefits, but choosing which is better suited for the process will depend upon the requirements of the end user and the application. Having a good understanding of the requirements can help companies design and implement a heating system that is both reliable and safe for end users. To help navigate system requirement and equipment options, end users should rely upon experienced consultants to find suitable solutions for their applications. ■

ABOUT THE AUTHORS

Jason Sanders (Jason.sanders@leister.com) is both the product specialist and manager for the Industrial Heat division at Leister Technologies LLC, a plastic welding and hot-air technologies company based in Itasca, Ill. Sanders earned an AAS in computer-aided design, a BA in business management and leadership, and an MBA.

Connor Wegner (connor.wegner@leister.com) is a technical sales and support associate for the process heating division at Leister Technologies. After receiving his BS in chemical engineering in 2017 from Illinois Institute of Technology, he joined Leister Technologies as an associate product specialist for process heating products.

Leister Technologies is a member of the Control System Integrators Association (CSIA), founded in 1994 as not-for-profit professional association of over 500-member companies in 40 countries advancing the industry of control system integration (www.controlsys.org).

Pandemic pushes human adaptability to new heights

By Jose Rivera

ABOUT THE AUTHOR
Jose Rivera is the CEO of the Control System Integrators Association (CSIA), www.controlsys.org

After more than three months of COVID-19, I feel exhausted. I am looking forward to a return to the "old normal," which may never happen. I'm sure that I am not the only one feeling this way. Why are we all so exhausted?

It may be related to the dramatic effort required by all of us to cope with the change imposed by months of the pandemic, economic upheaval, and societal protests. We were already challenged trying to keep up with technological change in our personal and professional lives. Industrial companies of all types are navigating "digital transformations" being pushed by the new technologies of Industry 4.0. The people who work for and with those companies have been adapting to and encouraging technological changes with varying success and support. Then along comes a new coronavirus and its demands.

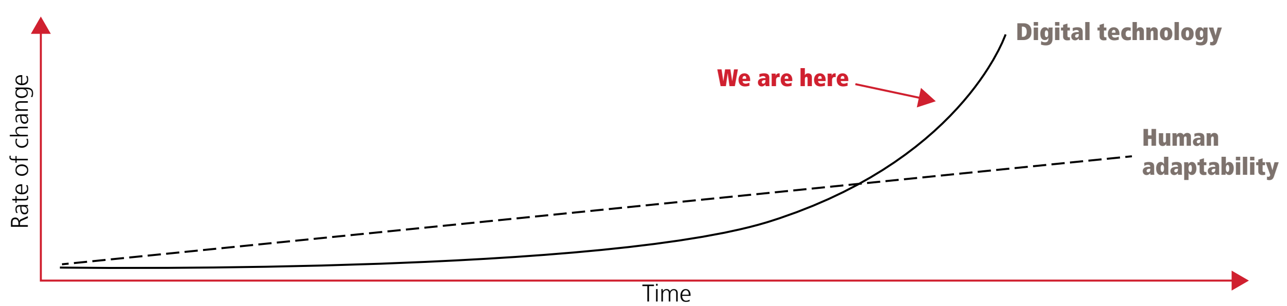
These coronavirus times, as governor of New York state Andrew Cuomo said on 5 June 2020, "will go down in history as one of the great transformational moments of society." The pandemic has pushed us to the next level. In a truly short period of time, we all have had to redefine fundamental aspects of our lives: the way we work, learn, conduct business, entertain, socialize, and relax. The lockdown has melted the workplace, the training center, the school, the university, and the home into a single entity. By working (adults) and learning (kids and adults) from home, we have blurred the lines between work and home, and between worker and parent/teacher roles. We have eliminated the healthy separations and breaks we had in the past (e.g., commute to and from work), as all has blended.

Every small decision we are faced with seems to have become a complex one. In our regular lives we simplify many small decisions by following what we have done in the past or following some heuristics. The pandemic has challenged this approach. Every decision demands energy, brainpower, and, in many cases, debates. Truly important decisions need to be made in consideration of various possible scenarios, as everything can change over a short period of time.

And still the technology marches on. In 2016, Thomas Friedman summarized in his book, *Thank you for Being Late,* the thought of Eric "Astro" Teller, the CEO of Google's X research and development lab: "Even though human beings and societies have steadily adapted to change, on average, the rate of technological change is now accelerating so fast that it has risen above the average rate at which most people can absorb all these changes." Teller represented this thought as shown in the chart below.

Human adaptability is being tested. The economic uncertainty caused by the response to the pandemic has created an environment where many fear for their jobs and main source of income. Those currently unemployed worry even more. Altogether, societal upheaval has taken a serious emotional toll, leading to issues like anxiety and substance abuse. It has also added fuel to the fires of social injustice protests, causing many to call for even more change and faster transformation. The nationwide uproar and protests over the killing of George Floyd by a Minneapolis police officer ignited calls for justice that quickly expanded internationally and hopefully will lead to important reforms.

I encourage the engineering and automation community to reflect on these personal and societal transformations and find concrete actions you can take in your community and your workplace. Diversity and inclusion are not mere buzzwords. Transformation is not just a technological imperative. In addition to being the morally right thing to do, it can make individuals and companies stronger and more resilient. ■



Standards update: SCADA, IDM, and enterprise-control system integration

ISA112 releases draft SCADA life cycle

The ISA112, SCADA Systems, standards committee is developing a comprehensive standard covering best practices design, implementation, and long-term management of supervisory control and data acquisition (SCADA) systems. These fundamental systems can be found controlling and monitoring a wide range of industrial applications, including pipeline operations, electric transmission systems, rail and road systems, municipal water/wastewater infrastructure, and canals, tunnels, and bridges. Because of this range, the roles and usage of SCADA technology can vary considerably across industries and geographic areas.

For this reason, a major focus of ISA112 has been to develop a set of standardized terminology that can be used for specifying, designing, implementing, and managing SCADA systems. The committee has also worked hard to develop an easily applicable ISA112 SCADA life cycle that can be applied to both large and small SCADA systems, regardless of industry.

ISA112 has now released interim drafts of its SCADA life-cycle diagram and reference model architecture as it moves toward an expected first release of a standard by late 2022. That standard will be followed by additional guidance documents such as technical reports. The draft life cycle and reference-model architecture may be downloaded at www.isa.org/isa112. Please send review comments and suggestions to graham.nasby@grahamnasby.com.

ISA112 brings together more than 150 members from a variety of backgrounds, roles, and industries, spanning end users, operating companies, engineering firms, suppliers, distributors, and system integrators across such sectors as municipal water, pipeline, electric power, chemical, mining, environmental, and oil and gas. The committee co-chairs are Graham Nasby and Ian Verhappen. As in all ISA standards committees, membership is open to any interested individuals. For more information on ISA112, please contact Charley Robinson, crobinson@isa.org. ■

Intelligent device management revisions

ISA-TR108.1, *Intelligent Device Management Part 1: Concepts and Terminology*, first published in 2015, describes concepts and terminology necessary to understand and communicate effectively about intelligent device management (IDM). It provides overviews of the basic concepts of how intelligent devices can be managed and how such device management plays a larger role in the overall objectives of a facility throughout its life cycle. The document also explains the relationship between IDM and other existing asset management standards.

An updated version of the technical report, revised in a collaboration between ISA108 and IEC SC65E WG10 to reflect improvements in the understanding of the associated technology, has now been published with the designation ISA-TR 63082-1:2020. The new technical report presents a more comprehensive description of the concepts and terminology associated with IDM.

It is the intent of the ISA108 committee to move ahead in its joint work with IEC SC65E WG10 to develop Part 2 of the ISA/IEC 63082 series, which will be a standard based on this Part 1 technical report. Subsequent technical reports and recommended practices are also planned by ISA108, all based on this Part 1 technical report and the anticipated Part 2 standard.

The ISA108 committee co-chairs are Kouji Demachi of Yokogawa Electric Corp. and Herman Storey of Herman Storey Consulting, LLC. The ISA108 managing director is Ian Verhappen of CIMA. For more information about ISA108, contact crobinson@isa.org. For information on obtaining the new technical report, please visit www.isa.org/findstandards. ■

New standard in the ISA-95 enterprise-control system series

The widely used ISA-95 standards define the integration of control systems with enterprises. A newly published document in the series defines the subset of the standards used for a set of message exchanges for a specific industry or use case.

ISA-95.00.08, *Enterprise/Control System Integration Part 8: Information Exchange Profiles*, aids in implementations of ISA-95 for application integration. The information exchange profile's intended business usage is within a defined scope for activities, functions, and tasks of ISA-95 Level 3 manufacturing operations management and their exchanges between Level 3 and 4 applications. The information exchange profile references the ISA-95 models, concepts, and terminology defined in ISA-95 Parts 1 through 7.

The new Part 8 provides a coordinated method to apply all parts of the ISA-95 series to reduce the effort associated with implementing new product offerings. The goal is to have manufacturing operations management systems that interoperate and easily integrate, regardless of the degree of automation.

ISA95 is chaired by Chris Monchinski, who also serves as the 2019–20 vice president of the ISA Standards & Practices Department. For more information about ISA95, contact crobinson@isa.org. For information on viewing or obtaining the new standard or other ISA standards, visit www.isa.org/findstandards. ■

Have an idea for an ISA standard, book, training course, conference topic, or other product or service? Send it to: crobinson@isa.org.

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

1945 ISA 2020

The Sep/Oct 2020 issue of *InTech* will include the 75th Anniversary Commemorative Supplement. Show your support for the organization that supports your people, products, and customers. Contact your sales rep for details.

Contact *InTech* today:

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

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

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

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

Reprints

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

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

Sample of Jobs Available at Jobs.isa.org

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

Cybersecurity SME

Foxhole Technology: The cybersecurity subject-matter expert in Arlington, Va., will provide specialized technical expertise to the Department of Homeland Security to support the technical application of existing and future continuous diagnostic and mitigation (CDM) tools, analysis of requirements and design specifications, development of CDM capability requirements, and consultation with recommended solutions. The position requires a bachelor's degree in software engineering, computer science, or IT management (graduate degree preferred), at least five years of experience in system design or system architecture, and expertise with cloud, mobile, identity and access management, data protection, network defense, digital forensics, and risk compliance . . . see more at Jobs.isa.org.

Manufacturing process engineer

Factory Fix: The engineer in Lithia Springs, Ga., will identify and develop processes and equipment needed to produce specific products, design and implement manufacturing processes, identify deficiencies in process or equipment to advise on improvements, develop quality assurance procedures, and handle mechanical management of the production line. The position requires a BS in engineering, experience in a production management environment, and at least five years of experience in a similar position. The successful applicant should be proficient in lean manufacturing, value stream mapping, blueprint reading, and custom machine design . . . see more at Jobs.isa.org.

Instrumentation and control technician

The Metropolitan Water District of Southern California: The technician will work at Parker Dam to assist journey-level technicians on projects, special assignments, and equipment and system modifications. He or she will assist in routine maintenance, installing complex digital and analog control systems, repairing and modifying electronic instrumentation and control systems, and performing technical electronic, laboratory, and field analysis. A high school diploma, completion of 40 semester units in electronics, and two years of relevant experience is required, as well as a valid California Class C driver's license, and certificates in forklift, manlift, and ISA's Control Systems Technician Association Recognition program . . . see more at Jobs.isa.org.

Senior packaging engineer

Pfizer: The engineer in Kalamazoo, Mich., will provide support for the design, qualification, approval, and implementation of new and revised packaging materials and packaging bills of materials for Pfizer products and affiliated products, serve as a key contact for packaging technical support, and be accountable for all aspects of package development, anticipating and recognizing risks, analyzing data, identifying root causes, and drawing conclusions to deliver viable packaging solutions that solve problems. A BS in package engineering or a related engineering discipline, at least five years of experience directly in pharmaceutical packaging operations support, and a minimum of five years of experience directly with package material qualification or test method validation is required . . . see more at Jobs.isa.org.

datafile

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

Digital twin – Macro closed-loop control

By Bill Lydon

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

Creating a digital twin has become a major goal for digitalization, and it is easy to get intimidated by all the buzzwords. The digital twin concept is really about creating a macro control loop with many subloops covering the entire manufacturing and production operations. The digital twin uses a wide range of inputs and models in real time to control and optimize an entire manufacturing and production plant. Conceptually this is analogous to cascaded proportional, integral, derivative (PID) controls, along with multivariable control, optimization, and predictive algorithms, but with the addition of much more information for sensing and feedback.

The digital twin is a powerful concept to constantly benchmark manufacturing and production operations against ideal operational models to optimize all factors to achieve greater quality, responsiveness, productivity, and profits. The feasibility of creating effective digital twins is becoming possible with the major growth of computing power at lower-cost, high-speed plant data networks, open controller communications, and lower-cost sensors.

The fundamental idea of the digital twin is to have a virtual model of the ideal manufacturing operations and processes, which is used to dynamically benchmark the actual production metrics in real time. Out of bounds operations are automatically adjusted in real time, or the appropriate people are given immediate advisories with actionable information for decision making. The broadest implementation models include all the factors that affect efficiency and profitability of production, including machines, processes, labor, incoming material quality, order flow, and economic factors. This provides a wealth of information to optimize production in a holistic way to maximize quality, efficiency, and productivity.

The digital twin is a powerful concept to constantly benchmark manufacturing and production operations against ideal operational models.

In addition, leveraging optimization, expert, and artificial intelligence systems can help companies predict bottlenecks and problems before they disrupt efficient production. This gives staff information to take actions and avoid lost efficiency and downtime.

The digital twin is a prominent example of practical macro-level, closed-loop control that is now feasible with the advanced hardware, software, sensors, network communication, and systems technology available.

Automation professionals essential

Automation professionals are essential for creating meaningful digital twins to implement digitalization with an understanding of the processes, interactions, and critical information that needs to be captured to improve operations and detect issues. Important tasks performed by automation professionals are design, sensor selection, implementation, and system integration to capture required real-time information that is the bedrock of implementing productive digital twins.

Digitalization is a holistic integration of manufacturing and production organizations requiring automation professionals to broaden their scope to effectively collaborate with operations and business information people in this new environment for companies to remain competitive. It may be uncomfortable at first, but this is the process of breaking down the silos and creating new working relationships and cooperation for success. ■

RESOURCES

"Why bother with a digital twin?"
www.isa.org/intech/20190803

"Digitalization delivers value"
www.isa.org/intech/20190603

"Scale and scope: The driving force of Industry 4.0"
www.isa.org/intech/20181005

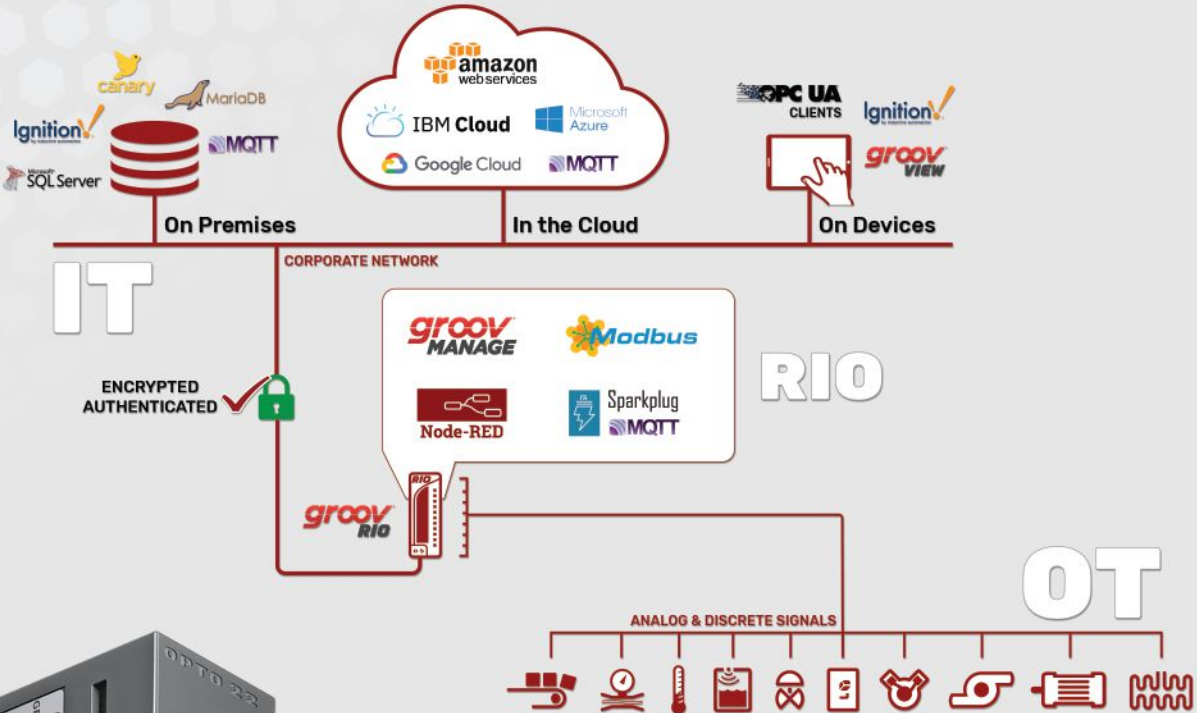
"Blurring the boundaries between design and automation"
www.isa.org/intech/20200401

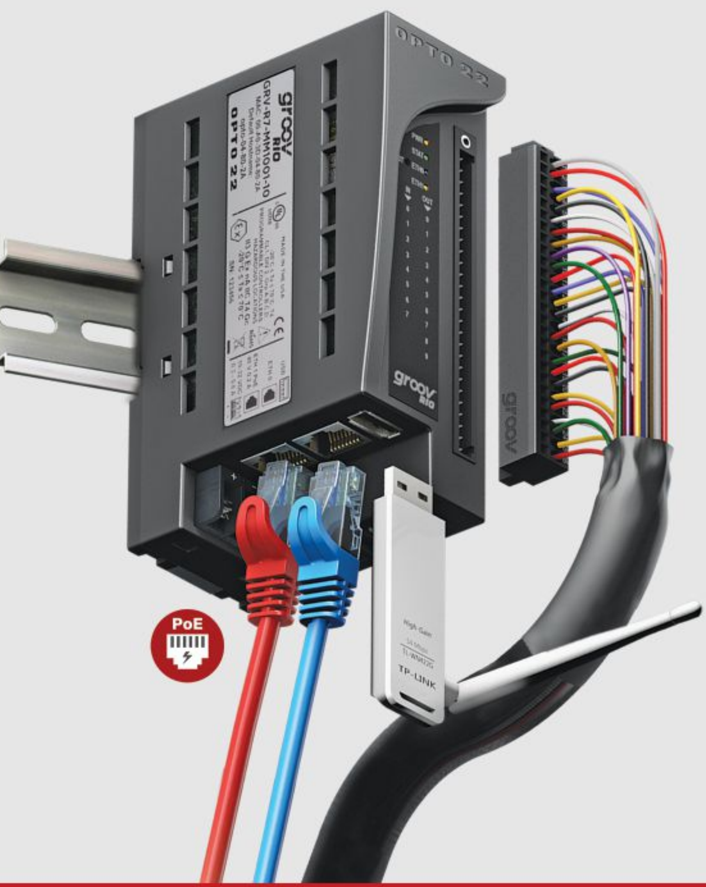
"Optimizing related process variables to improve profitability"
www.isa.org/intech/20180602

"What has industry learned about model-based multivariable control?"
www.isa.org/intech/20191002

groov RIO

I/O for the IIoT™





Need field device data on premises or in the cloud? You've got it!

Collect and securely publish I/O data—no PLC or PC needed—to multiple destinations, simultaneously:

- Cloud services
- Ignition® SCADA
- MQTT brokers
- SQL databases
- USB mass storage
- Local power-fail-safe disk

This is *not* your father's remote I/O.

***groov* RIO** is a standalone, industrial, PoE-powered Ethernet I/O module that supports nearly 60,000 unique signal combinations from a single unit, including all necessary software to democratize your OT data.

Learn more about *groov* RIO: **info.opto22.com/introducingRIO**

MADE IN THE USA

Made and supported in the U.S.A.
Call us toll-free at **800-321-6786** or visit **www.opto22.com**

OPTO 22
The Future of Automation.


Ignition 8
by inductive automation
The Unlimited SCADA Platform of the Future is Here
Download the free trial today at
inductiveautomation.com
14:13
Back
Ignition
Start Date
End Date
Top
01/23/2019 00:00
01/23/2019 23:59
10
ALARM SUMMARY
TOTAL ALARMS 3
TOTAL DURATION 02:16:01
TOTAL UNACKNOWLEDGED 3
AVG TIME TO ACK 00:00:00
AVG TIME TO CLEAR 01:09:30
MOST FREQUENT Day Tank - 2 (66.7%)
LONGEST DURATION Tank 1 - 7621 (93.4%)
ALARMS BY HOUR
# of Alarms
Duration (sec)
Tour Feature 1/5