MODERN HMIs:
The Backbone of Your Smart Connected Factory

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Not Your Father's HMI

What do you think of when you hear the term HMI - Human Machine Interface? Do you envision a graphic screen used by plant floor operators to run a piece of equipment? Are you smiling, because you know that now there is one screen that has replaced dozens of industrial push-buttons, pilot lights, and 16-position selector switches marked with unrecognizable abbreviations? Do you believe that the HMI is the view into machine's Programmable Logic Controller's soul?

This is what many people's mental picture of an HMI is; a screen that enables right-brained engineers the flexibility to create functional art that beautifully depicts a machines operation. The operator of the machine can switch screens to command machine operation, supervise it's performance in widgets per hour or view it's health via maintenance screens. The HMI is the human interface with the machine or more correctly stated, the PLC that it is connected to. Plant floor information from the HMI and PLC is sent to a SCADA system for plant supervisors to generate summary reports at the end of the week.

HMIs have successfully been employed for decades as a key instrument used by the plant floor operator to run, supervise and maintain skidded equipment. They have saved manufacturers money by replacing dozens of 30 mm push buttons, pilot lights and selector switches that previously needed to be wired to the PLC's I/O modules. HMIs have become an exciting way to operate machines on the plant floor, tank farm, engine room, packaging area and many other applications.

Times are changing. In the smart connected world, manufacturers empower their workers with knowledge to make decisions based on business related data and its analysis. The plant floor operators of yesterday are now the technical users. These people need to have status information about equipment to the east and west of their production line; they need the tools to predict what will be the raw material status at mid shift and end of shift. They need to know the overall equipment effectiveness compared to the machine's designed specifications, compared to last night's shift or from twin plants in Europe and Asia, all in real time. Employers have found that providing business information to their staff enables them to make better decisions at all job functions and thus increase optimal manufacturing performance.

Companies that employ Industrial Internet of Things (IIoT) tools have been enjoying the many business benefits that come along with it. The data collected via the Cloud allows headquarter staff to view data about any plant, production line, or machine in their business enterprises. However, if the data is static and remains at HQ only to be reported out the end of the week, the opportunity to make dynamically integrated corrections or enhancements could be lost. Plant floor operators need live, current data in their hands to make real time decisions. Companies with IIoT systems quickly realize that the benefit is not the data; it's that their staff has the tools to make well-informed decisions.

Advanced HMIs are Essential for a Smart Connected World

The IT and OT worlds have converged. IIoT-enabled business systems are closely integrated with the operations at the plant floor. Data is no longer just northbound. Business systems are supplied

with near real time data from production floors across the enterprise. Critical data on supply chain materials and movements can be pushed down to the plants in order to harmonize production and supply. This allows staff at all levels to have the same view into data that is necessary to optimize performance.

HMIs can also play dual roles. They are, of course, used in the traditional way to operate and monitor machines. They are also the instrument on the plant floor that relays collected data to the connected worker about current and predictive manufacturing events. The data can be visualized in dashboards via trend graphs, gauges or geomaps. The connected worker can interface with the data by setting up their own metric and using ad-hoc queries to get to the relevant information they need.

HMIs for the IT/OT Connected World

Most controls engineers agree that PLCs and Edge controllers are optimized for deterministic sequential control. The IEC 61131 standard offers users multiple languages for machine control such as Ladder Diagram, structured text and function charts. These tools have been the proven workhorses of the control world for decades. They continue to be relevant today, as they have evolved into effective methods of machine regulation.

As IT moves closer to the machine level, engineers need new tools tackle plant floor data management, visualization and network security application challenges. To meet these needs, the control industry is leveraging the benefits of Linux as an operating system for automation controllers. The openness and flexibility of Linux enables engineers to develop the applications they need. In many cases, designers can leverage open applications to help them meet their needs with a packaged application. Grafana is an example of open Linux visualization and analytics platform that can be used within an HMI to effectively display complex metrics.

Today, HMIs need the ability to be multitasking: providing industrial control as well as analytic and visualization tools. To meet these challenges, HMIs are equipped with traditional sequential control-based runtimes that operate on a Linux operating system. Controls engineers now have the best of the OT world for machine control and the IT world for data analytics in a single device.

HMIs with IIoT Connection

Empowering connected people with information is paramount in this globally competitive industry. In order to transport data between IIoT Cloud-based systems, plant floor HMIs and other control devices are necessities for smart manufacturing.

IIoT Cloud systems have multiple data formats for the dynamic exchange of data. However, despite these alternatives, Ethernet-based MQTT and OPC UA protocols continue to be widely used. These protocols provide engineers the ability to transmit complex data in a very efficient and familiar format. HMIs for the IIoT connected world will need to be designed to easily and securely exchange information with Cloud based applications using standard protocols such as these.

Integrated HMI and PLC

As you know with any electric device, advances in technology continue to add features and reduce costs of the devices we use today. This is also true for HMIs. Industrial control manufacturers

leverage evolving technology to enhance features, decrease electronic componentry space requirements and increase processor power all while reducing costs.

Today, integrating your HMI and PLC into one device makes sense. The basic HMI of the past did a great job replacing physical switches wired to a PLC, saving hardware and wiring costs. Advanced HMIs of today are going a step further by taking on the functions of the PLC, helping reduce duplication. Cost savings can be gained by having one device do the job of multiple. Engineers can use one software tool to develop both control logic and HMI graphic screens. There is no need to spend time importing and exporting tag databases between different applications nor spending time storing and maintaining two sets of application files. The all-in-one HMI and PLC helps reduce the cost of ownership of any machine.

Modern HMIs

The HMIs of today are not your father's HMIs. Modern HMIs need to have the power, openness and flexibility demanded by the complex applications of the smart, connected world. End users continue to look for ways to empower their staff with real time information, while reducing system cost of ownership. At the same time, engineers are demanding HMIs that can manage their traditional industrial control and run data analytics in parallel.

So the next time you hear "HMI," think about a device that's far more than a simple screen; think of a device that resides at the very backbone of the smart connected world.

HMI Is Not All About Flashing Lights, Bells and Whistles

There is no one perfect way to design HMI screens. But it's important to present information in a logical manner without gratuitous flash.

By Stephen Fischer

Most customers will never care about your design logic with its perfect structure, adherence to precise standards, or excellent comments and description. Nor will they be aware of that magnificent script running oh-so-silently in the background and keeping their operations from falling into disarray. But they will see the human-machine interface (HMI) screens. Every person walking through that plant will see the HMI, whether they're in the grade school tour group or the curious execs visiting from corporate.

HMI is not all about flashing lights, bells and whistles. There's a plethora of information a programmer can display on an HMI screen. But just because a programmers can display information, it doesn't mean they should. The goal of an HMI screen should always be to present information in a logical and orderly manner, where the most important information or severe issue displays up front and grabs the operator's attention.

There is no one perfect approach to designing HMI screens. There is, however, one basic, never-to-be ignored rule: Get operator input right from the beginning. The system operators will be the people interfacing with the system every day, and it's critical to consult with them early in the design and review process.

Wise engineers adapt to individual customers and present their information in the best way for their particular needs, displaying only necessary information. A bad screen will be busy and disorganized, might ignore standards, or be overly animated or distracting. Yes, alarms should alarm and animation can direct the user to important information, but they should never be there for their own sake, no matter how tempting that might be. Remember also that good HMI design involves more than simply displaying information. Careful designers will also consider process flow, which will impact how they organize and position data on screen and ensure maximum usability.

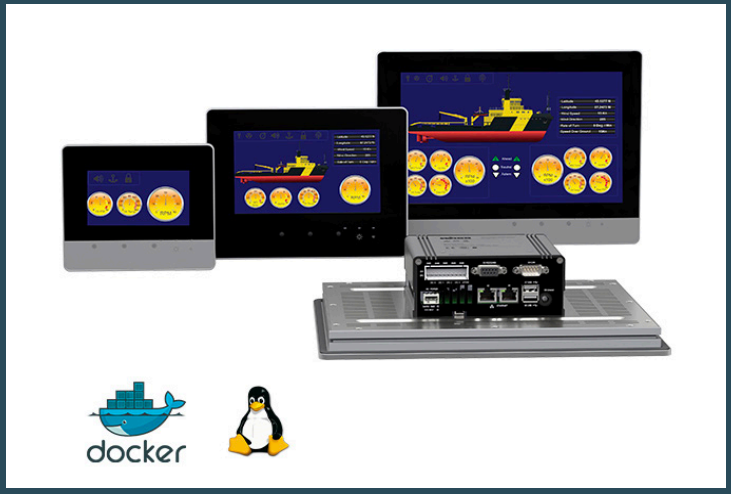
HMI design provides us right-brain engineering types with a rare opportunity to let loose that left cranial occupant and create actual art—functional art that will possibly exist for years (or until that next obsolescence project comes around, but that's a whole other blog topic). Generations of operators will tell stories about the Michelangelo of HMI Screen Design and the masterpieces that came from that artist's keyboard and mouse.

Well…OK. Not really. But you get the idea. If you do your job

right, you will open a world of true process understanding and interaction for your operators—a world where the information is presented in such a clear, concise and usable manner that training is a breeze; a world where onlookers near and far can identify when there is an alarm that needs immediate attention; a world where operators become more productive simply by using your design.

Let loose those creative juices and make HMI screen design the art of concise presentation of useful information. Visualize the process! Learn more about how Avanceon employs accepted standards in its designs.

High-Performance Controller with High Quality Visualizations



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Why is Linux Trending?

Without a lot of fanfare, the use of Linux in automation has been gaining significant ground due to its openness and flexibility. Its common IT programming languages add to its appeal as IT and OT grow closer and new engineering teams emerge on the scene.

By David Greenfield

There have been a number of highly visible, fast-moving trends in industrial automation technology over the past few years. The most notable of these has been the Internet of Things and its related mobile and remote applications. Other high-profile trends include the rise of augmented and virtual reality and the proliferation of industrial cybersecurity companies.

Somewhat under the radar, another trend has been developing: The increasing use of Linux as a leading operating system (OS) for automation controllers.

A major factor behind industry's interest in Linux has always been the technology's openness. Industry's desire to have its technologies be less proprietary and more open—thereby allowing companies to select and exchange their technologies more easily—is, of course, nothing new. The most aggressive industry push for open automation technologies can be seen in the activities of the Open Process Automation Forum.

But in years past, technologies powered by Linux have mostly been niche products offered to appeal to a small segment of the industrial market with the willingness and expertise to buck the more widely used systems. More recently, however, it's become rare for me to attend meetings with technology suppliers who are not loudly touting their support for Linux with an array of products.

To find out what is driving this surge in Linux-powered products, I spoke with GE Automation & Controls, Opto 22, Wago and Wind River.

Behind the trend

The primary driver of the Linux trend is "the desire for flexibility to develop anything the engineer or developer can dream of in an industrially hardened, standards-compliant computing platform at a price point suitable for widespread deployments, and with headroom to expand and grow," said Benson Hougland of Opto 22.

Adding to Hougland's headroom comment, Charlie Norz, Wago product manager, said Linux OS's future proof factor appeals to "a new generation of programmers who have been trained to develop Linux-based languages like C++ and Python." He also pointed out that the amount of programs for Linux has "increased ten-fold and people are responding to that. No one wants to be restricted into one way of doing things, so having the flexibility to customize is increasingly attractive."

Vibhoosh Gupta of GE Automation & Controls concurs with Norz's viewpoint on the new generation of programmers, as well as Hougland's points about Linux's edge for innovation. Overall, he sees three key aspects behind the Linux trend across industry:

Millennials want to have the ability to optimize their processes using the latest programming languages, such as Python or C/C++ rather than being grounded to traditional IEC languages. The IEC1131 languages have their place, but optimization and analytic algorithms are usually better served by the languages like Python and Matlab.

Having the capability, at the edge, to run and write machine learning algorithms to optimize processes on a whole different level than has ever been done before is definitely driving the Linux trend.

Industries race to differentiate and innovate faster. OEMs want to differentiate their offerings and innovate at today's pace. Remember that the mobile industry is just 15 to 20 years old, and we are already deploying 5G—that's the kind of pace of innovation we would want on the industrial side as well. Consumer productivity has outpaced industrial productivity significantly in the past ten years.

With these drivers in mind, I wondered what it was that users liked about Linux beyond its flexibility.

"Linux has been around for a while, so it is robust, scalable and offers high levels of reliability proven through various use cases across multiple market segments," noted Michel Genard, general manager of Wind River's operating system business (Editor's note: Intel sold Wind River to TPG private equity on April 3, 2018, while this article was being developed). "Additionally, Linux inherently offers reasonable licensing terms, a large community of developers and various avenues for support that promote confidence. Plus, companies with a track record in industrial automation are providing the services and support that make Linux commercially viable. This includes software update capabilities in development and post-deployment, continuous security monitoring and vulnerability protection, IP and export compliance artifacts, and an unparalleled range of high-quality board-support packages across a variety of architectures. This ensures that the total cost of ownership [for systems built on Linux] remains predictable."

"With a Linux OS, users can run applications in parallel that provide specific value to their business needs," said Norz. "These types of applications used to have to run in a PC that collected field data from a PLC. Now, it can all be run in one device—saving time and money as well as reducing data latency. Our Linux PLC users can use other applications like SQLite or MySQL to log and analyze data onboard the PLC. This also allows users to choose the security programs they feel comfortable with. It's an intuitive, all-in-one solution."

Products and purchasers

Considering all the upsides to the use of Linux in industrial control systems, what kinds of automation products are available to OEMs and end users that leverage the OS?

Opto 22's support for Linux can be found in its groov EPIC edge programmable industrial controller and groov Edge Appliance. Hougland said purchases of these devices come from a wide range of industries—from oil and gas, to water and wastewater, and OEM machinery.

"Each of these purchasers use the products in ways that make

sense for their specific applications," he said. "For example, end-user companies will likely use EPIC and the Edge Appliance with the installed suite of software, which provides control programming, connectivity and HMI. These end users will not necessarily take advantage of the system's Linux operating system. But they know it's there to expand upon if needed. And they recognize the lower total cost of ownership benefit that embedded Linux systems offer."

For OEMs, however, it's a different story. "OEMs and advanced system integrators recognize the power and openness an embedded, industrial Linux-based system can deliver in protecting their software intellectual property. They also like the ability to use standard development tools like C, C++, Python and Java for their control programs; and the ability to access computing and file systems through secure shell access," Hougland said.

Norz noted that Wago offers Linux in its PFC series of controllers and in its 750 XTR controller series for extreme and hazardous location environments.

According to Gupta, GE Automation & Controls' PACSystems Rx3i CPL400 uses "Type 1 hypervisor technology to run a real-time OS (such as VxWorks) running traditional control loops alongside our PACEdge technology operating on Linux." GE's PACsystems CPE400 controller uses the same technology as CPL400, but "runs our Field Agent technology on Linux to run Predix-based Edge applications and provide secure connectivity to the Predix Asset Performance Management applications," he said.

"OEMs and system integrators are the ones who seem to be most excited about this [Linux] concept," said Gupta, "as it allows them to securely and cooperatively run their differentiated content and analytics—their IP— closer to the asset."

Genard said Wind River's use of Linux extends across its Wind River Linux and Titanium Control products. "Wind River Linux is our embedded Linux offering that enables OEM customers to reduce development risk and time-to-market when building and deploying Linux-based devices. For end users and OEMs, Wind River Titanium Control is our on-premise cloud infrastructure platform for industrial IoT that uses open-source components, including Linux, which Wind River hardened for an industrial-grade environment. It delivers the uptime and performance needed for industrial applications and control services at any scale."

Though Linux clearly has a strong appeal for OEMs, interest from end users is also strong, according to Genard. "OEMs tend to purchase Wind River Linux subscriptions because of the value that they provide in enabling faster time to market, stronger security and lower development risk resulting in a lower cost of total ownership," he said. "When looking for open source software-based solutions, end-user companies prefer solutions built on Wind River Linux because of their confidence in the security, support and maintenance throughout the entire solution lifecycle."

Interest in Linux is also widespread across the globe based on the interviews conducted for this article. "We see similar market strength for Linux in EMEA [Europe, Middle East and Africa], North America and Japan, and we're growing business in APAC [Asia-Pacific], specifically China," said Genard.

"We see high interest in Linux all around the world," added Norz. "Probably because saving time, increasing efficiency and lowering the bottom line is a popular idea for any business anywhere."

What does it mean for industry?

"This trend is just getting started," said Hougland, "and it is largely fueled by incoming engineers and developers who are trained and qualified on these technologies and unwilling to settle for doing things the way they've always been done. These are the engineers and developers who will build our next-generation control systems."

Norz sees it as "a sort of technological awakening. The industrial world is in the process of catching up to the rest of the technological world and implementation of this technology is accelerating across all industries. We've seen the early adopters, and now we're at the brink of this becoming common practice. Education is what's going to push us past the tipping point and further accelerate this phenomenon."

The potential staying power of Linux in manufacturing and processing is underscored by industrial product lifecycle expectations, said Genard. "We see a renewed focus on the commercialization aspects of Linux—things like security, support and maintenance—throughout the lifecycle of a solution that has been built from the ground up for the industrial environment. This becomes particularly pronounced in the case of industrial companies where the product lifecycles are much longer than in the standard IT environment."

Gupta said Linux's openness, as it pertains to its ease of use, customizability and secure nature, make it "more appealing to many who tend to think of the resulting product as more of an appliance." But he also cautioned against any expectation, at this point, that Linux will necessarily become the dominant OS of choice for industry. "We fully expect Windows to catch up. We see Windows IOT as another choice of OS, apart from Linux," he said. "We chose Linux as our first OS for all the reasons I noted, but we are exploring other variants, including Windows."

Have Questions About the Industrial Internet of Things (IIoT)? We've Got Answers

Wago regularly receives questions from customers about a variety of technology topics, which have ramped up with the advance of IIoT and the onset of COVID-19. Here are answers to some of the questions we've seen most often.

By Charlie Norz, WAGO Corporation

Q: How has the pandemic affected the IIoT world overall and specifically Wago?

A: Many manufacturing and process facilities have been evaluating the business advantages of using IIoT-based solutions. For some of these companies, they have accelerated their IIoT projects as more employees are now working remotely. Using cloud-based applications to monitor, control, and optimize plant floor manufacturing can be done from anywhere in the world.

Q: Do you see these effects being permanent? Why or why not?

A: IIoT is a long-term and permanent solution for the future of manufacturing. Companies that started with small test IIoT projects are now enjoying the business benefits from the technology. Most companies we work with plan to expand their IIoT application to multiple applications in the future. We offer great opportunities and solutions for every company. While there is no such thing as an all-in-one solution, smart products, methods, and partners will help advance digitalization in your business in ways that benefit all involved. Digitalization is something that we will see ramp up significantly over the course of the next two to five years.

Q: Why is it important that companies start moving forward towards digitalization now if they already haven't?

A: It is all about data! In the past, the technical data from the field made it through to the control levels at best. That's changed now. Thanks to modern information technology, the most important information from production is no longer restricted to the clas-

sical automation pyramid, but is now available at any time and place. However, the technical conditions must be right for this.

As the world becomes smaller, it becomes necessary to move to digitalization to increase production productivity while increasing quality and having flexibility to meet the changing demands of the market. IIoT is a key technology to enable manufactures to meet these business needs.

Q: What are some trends you see ahead for IIoT over the next year?

A: Cloud-based IIoT can be used for hundreds of different applications including machine learning, predictive maintenance, data mining, digital twins, OEE calculations, line comparison, dashboards, and many more. There are also many different ways to engineer these applications. For some, using tools from cloud service vendors are the way to go. However, this takes deep knowledge in specific algorithms. The other option is take advantage of pre-built solutions for these applications. In the next several years, companies will begin to utilize these prebuilt tools.

Q: What are some contributions Wago is making to IIoT?

A: At Wago, we provide PFC200 controllers with tools to seamlessly connect to popular IIoT and SCADA systems via MQTT, Sparkplug, and OPC UA. For example, these tools can help connect to Microsoft Azure, Amazon Web Services, IBM Cloud, and the SAP Cloud to name a few. Our new PFC200 features the ability to exchange data with two different clouds in parallel. For example, in applications where manufacturing data goes to one cloud and

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maintenance info to the other, the information can be aggregated and used for analysis. These capabilities create true added value for your company—whether for increasing the efficiency of in-house production, implementing energy management, or developing additional end-customer services.

In the coming year, we will be adding new IIoT related devices that include edge computers and edge controllers to our product line. These devices operate at the edge of the network for local control and data pre-processing and aggregation before it is sent to the cloud.

Also, a new on-machine IP67 platform—like Wago's I/O System Field—with industrial fieldbus protocols and OPC UA for direct device-to-cloud connection will be released. These high performance modules are designed for Time-Sensitive Networking and are unshakeable in the harshest environmental conditions. Modern, decentralized production facilities require automation solutions that ensure the highest level of connectivity, which is what our I/O System Field provides.

Q: What do you see for the future of IIoT?

A: IIoT is the future and is here to stay. It will be a big part of industrial automation moving forward and we at Wago offer solutions specifically for this and look forward to helping companies with all of their digitalization needs.

A New Kind of Connected Factory

As a pandemic forces social distancing, manufacturers are using technology to stay connected, creating a new vision for how data is aggregated, shared, and acted upon to unite factories and people.

By Stephanie Neil

Until about 10 months ago, Hugh Roddy, the vice president of global engineering and project management at Chobani, spent much of his time on the road traveling between the company's plants in New York and Idaho, as well as periodically heading overseas to check in on the Australian factory. But his road warrior ways have been curbed by COVID-19, and now—like many of his manufacturing peers—he has to manage the projects and operations remotely.

As a result, Roddy has been turning to technology, including HMI (human machine interface) and SCADA (supervisory control and data acquisition) systems, the Industrial Internet of Things (IIoT), and augmented reality (AR) to remotely manage assets and troubleshoot machines. But he also needs visibility into how each plant is operating overall. A few years ago, that may have been a problem. But since Chobani's adoption of Inductive Automation's Ignition platform, which he describes as a modern day OT (operations technology) operating system, he's been able to develop many different applications and dashboards, giving him and his team the ability to manage new projects, assist with the operations of current production lines, and gain an eagle's eye view of individual plants from the enterprise level.

"When I log into our Ignition system I can see New York, Twin Falls (Idaho), and Australia at any given moment in time," Roddy says. "The plants are more connected to what is happening downstream and upstream…and at the enterprise level it allows plants to be highly integrated from the plant floor to the executive level and back down."

While Chobani adopted the Ignition platform years ago, other companies are just now starting their digital development journey—a process that has been put on fast-forward due to COVID-19. Now, every business, regardless of the industry segment, is finding new ways to stay connected.

People and processes

"The pandemic is accelerating the movement to digital and smart factories to keep operations running as efficiently as possible and to share [information] across cells in a plant, lines in a plant, or plants in a network," says Paul Wellener, a vice chairman at Deloitte LLP and the leader of the company's U.S. Industrial Products and Construction practice.

Deloitte, together with the Manufacturer's Alliance for Productivity and Innovation (MAPI), recently published a report called "Accelerating Smart Manufacturing: The Value of an Ecosystem Approach," which indicates that long-term partnerships in the

form of an ecosystem can accelerate digital initiatives and drive results. According to the report, while the manufacturing industry was already on a digital transformation journey, it has historically been complicated by the complexity of digitally connecting assets that, in some cases, are more than 50 years old.

The disruption and economic hardship caused by the ongoing pandemic have increased the urgency to accelerate smart manufacturing initiatives for future competitiveness. In a recent MAPI CEO poll, 85% of leaders agreed or strongly agreed that investments in smart factories will rise by June 2021. And, while economists predict that overall business investments could be low for the next three cycles, respondents in the study indicated they are directing a greater share of their factory investments toward smart manufacturing initiatives.

So, while it may have taken a global pandemic to push organizations to find new ways to work virtually, the folks living in this new normal say the real revelation here is not how technology can create a connected factory, but how people use the technology and how it can standardize processes.

"It's not so much about digitization or IIoT devices," Roddy says. "The transformational component is an organizational design that empowers the technology user. Connecting factories is about allowing people to see what is going on."

Indeed, industry experts agree that people and processes are the key to the connected factory.

"Technology was never the barrier. It was always the people or the processes or the metrics in the organization that were the inhibitors or barriers to getting the benefits they were looking for," Wellener says.

Because technology is the catalyst to connectivity, much of the work of getting plants connected in a practical fashion has to do with the data gathered and what operators do with it. And as cloud, analytics, and artificial intelligence technologies evolve, so do the way manufacturers work.

P&G's Tim Rogers, chief architect for manufacturing services, and Beth Scheid, associate director of information technology, global business services, discuss a move to GE Digital's Manufacturing Data Cloud.

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P&G's progress

When manufacturers first think about connecting factories, a typical starting place is the manufacturing execution system (MES). That's exactly where Procter & Gamble (P&G) went as it embarked upon its own digital transformation, finding that, of its 101 plants, 94 sites are using GE Digital's Proficy MES, while those using other, homegrown system are actively transitioning to Proficy.

P&G has more than 2,000 manufacturing lines and 45,000 operators, and according to Tim Rogers, P&G's chief architect for manufacturing services, the company is currently trying to figure out how to deal with more than 100 plants, each of which has its own unique applications.

"They tend to be big, they are local, and people want the data, so we looked at what we could do differently," Rogers said during a presentation at GE Digital's user conference in October. "We have a lot of infrastructure at the facilities [and we thought] let's get it out of the facilities. [Because] if we leave it there it will ultimately drive increased cost to maintain and support it."

That resulted in a pilot program with GE Digital to test its Predix Manufacturing Data Cloud (MDC), as a way to move manufacturing data to the cloud and apply analytics.

According to GE Digital, Predix MDC enables the consolidation of three data sets required for process optimization and analytical applications: asset data, ERP data, and manufacturing data. In addition, the cloud structure is secure-by-design and managed 24/7. It ingests incremental data automatically without having to rely on human intervention and its edge technology includes monitoring and remote configuration.

Bringing data to the cloud resulted in an 80% reduction of onsite infrastructure at P&G, which also increased performance because there was less data for applications to wade through. "At the same time, we have so many people accessing this information and they are starting to do more advanced analytics or prognostics or predictions of what might be happening in our plants, or what we could do differently," Rogers said. "And now that this information can be used centrally across the plants, it can be correlated with other information in the company to do more machine learning and advanced analytics as well."

P&G's Tim Rogers, chief architect for manufacturing services, and Beth Scheid, associate director of information technology, global business services, discuss a move to GE Digital's Manufacturing Data Cloud.

To that end, GE Digital is positioning its product portfolio around three areas: the connected worker, enterprise scale and visibility, and lean continuous improvement. "[Technologies] like MDC allow enterprise scale visibility and the ability to aggregate actionable data at new levels," says Richard Kenedi, general man-

ager of GE Digital's digital plant business.

GE Digital's Predix MDC consolidates data sets for process optimization and analytical applications.

GE Digital's Predix MDC consolidates data sets for process optimization and analytical applications.

Testing grounds

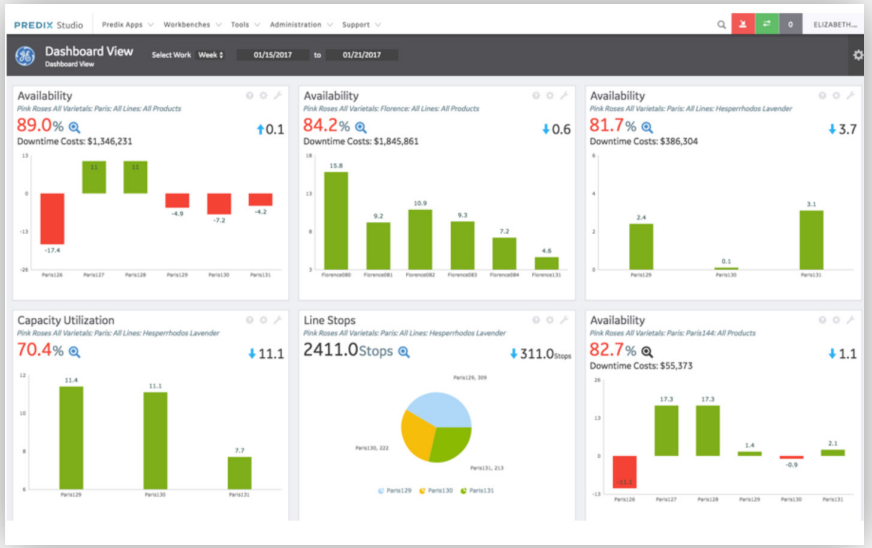
While GE Digital is working closely with customers like P&G, others—including Deloitte, Rockwell Automation, and Schneider Electric—are building their own proof-of-concept smart factories.

In September, Deloitte launched The Smart Factory @ Wichita, located at Wichita State University (WSU). Deloitte and WSU are constructing a new 60,000 square foot facility that will include a full-scale production line, dedicated space for select ecosystem sponsors, and experiential labs for exploring smart factory capabilities using AI, IoT, and robotics to manufacture products. The purpose of the facility, which will be open to the industry in 2021, is to create a dialogue about how companies can accelerate their journey toward scalable and sustainable capabilities.

Rockwell Automation embarked on its own internal digital transformation, which led to numerous lessons learned and the launch of its Connected Enterprise consulting organization. This organization includes the acquisition of Kalypso, a firm specializing in digital transformation. Based on its own experience, "we created a new and thoughtful approach, thinking not just about technology, but also about the process and first and foremost about people and the organizational dynamic," says Bob Murphy, senior vice president of enterprise change management at Rockwell Automation. "We found [people] to be the most essential ingredient in making something happen in terms of connected factories."

Similarly, about three years ago, Schneider Electric launched a smart factory in the U.S. in Lexington, Ky., a build-out that took place in a brownfield factory that had been around for 60 years. The goal was to create a standardized smart factory program integrated with lean manufacturing practices.

"MES was the first investment, but there's been a couple of investments since then in different technologies," says Luke Durcan, Schneider Electric's EcoStruxure director. "We've got multiple automation solutions, robots, drives, recipe management, and we've also invested in novel technology around augmented reality." The company developed AR for wearable devices that connects to a PLC or the electrical infrastructure of a



GE Digital's Predix MDC consolidates data sets for process optimization and analytical applications.

machine, giving users a number of potential recourses when a failure occurs and walking them through the steps required to execute a repair.

Chobani's Roddy is also a big fan of AR, especially since the start of the pandemic, as it has allowed the company to continue to lean on technology suppliers and machine builders for virtual support while empowering operators to solve problems. "A maintenance person with AR goggles can show someone thousands of miles away what is going. That in itself allows us to be more connected," he says.

Inductive Automation's Ignition Perspective can be accessed from mobile devices and as well as centralized computers.

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Understanding the data

Collecting data to connect factories is one thing. Understanding what the data means is another. That's where companies like TrendMiner and Sight Machine come in.

TrendMiner works with time series process and asset data coming from machine sensors that is typically stored in historians, as well as quality, maintenance, and batch records from other business applications. Typically, historians are slow to search and analyze data. But TrendMiner's pattern recognition and search tools can access multiple years of historian data to search for patterns within a split second.

"Just like Google provides search on the web, we have indexed the data so there's that same value proposition," says TrendMiner product manager Rob Azevedo. "TrendMiner works like Google in

the way that we provide a cache on top of all that data to make it searchable and available for analysis in seconds. And just like Google, where you have one entry point where you can launch your data search and it searches every website from there, the same happens in TrendMiner. You have our single application that caches all of your data sources and provides the tools and search capabilities to analyze all of your data, regardless of where it comes from."

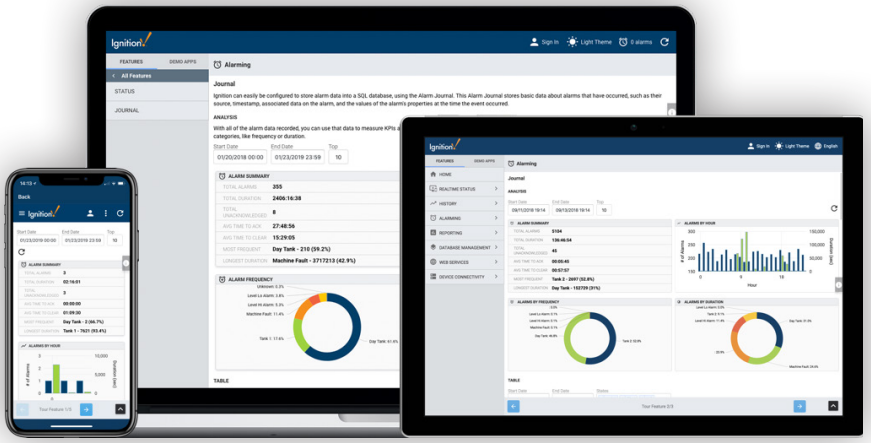
In addition, since it's available as a cloud-based software-as-a-service, TrendMiner can access different time series sources from different factories around the world to generate insights from a central level while sharing with the people onsite, Azevedo says. "The key differentiator is that we analyze time series data, but we also bring in the contextual universe and link to that data. This allows the subject matter experts to analyze what has happened, quickly find the root cause, and monitor to avoid certain behavior in the future."

Manufacturing analytics software provider Sight Machine is also focused on turning data blended from multiple sources into useful information. The company's unique data modeling capability can take dozens of incompatible data types generated by factory equipment and manufacturing software and generate a digital representation of the entire production process, including production lines, downtime, and defects. "We stream data as it's generated, restructuring it from whatever schema it's in and organizing it around generalized concepts like unit of work by a machine," says Sudhir Arni, Sight Machine's senior vice president of business outcomes. "Everything is associated with a part or a piece of material as it's moving through production."

In addition, the company's Dynamic Recipes feature continuously and automatically updates machine settings to produce optimal performance based on a combination of conditions related to raw materials, the environment, and output. "This is the ability to set a recipe every time you do a production run based on current conditions," says Sight Machine CEO Jon Sobel. "That level of precision and flexibility has been the domain of expert judgement, never quantified or repeatable." But now it is, he says, and it can be extended across manufacturing assets, plants, and possibly even entire supply chains. "If we can compare two plants in the same company, why not get everyone in the supply chain connected."

The key to connectivity

For technology to be adopted it has to be accessible, easy-to-use, and accepted by the user. Roddy calls Inductive Automation's Ignition software an OT operating system for the manufacturing



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floor because it is providing many applications beyond traditional HMI and SCADA systems. “It has given us the ability to, at any given moment, see what is going on in the plants from the HMI control standpoint or plant dashboard,” Roddy says. “And that data can be delivered to whoever needs it at any given time.”

But when it comes to getting more, useful data into the hands of whoever needs it, Ignition offers a very useful option—an unlimited licensing model. “Connectivity is key, and from the beginning, the one thing we’ve tried to do is have a different licensing model,” says Travis Cox, co-director of sales engineering at Inductive Automation. “If you have an unlimited approach, it opens more doors of innovation.”

The company also spent a lot of time building out its mobile module called Ignition Perspective, which is a web-based HTML5 visualization tool that provides monitoring and control of processes directly from a mobile device, desktop, or touch panel.

With this tool, users can visualize data in a way that they’re familiar with. “If you make it hard [to access] and have to license it [individually], then it won’t be as effective,” Cox says. Everyone’s lives are hectic and therefore they want data at their fingertips—which is what they are used to. And, now, especially with people working from home, data has to come to them easily. “For us, Perspective is critical to getting data to the different people who need it. The more connected people are, the more they work together.”

So, while there’s a lot of discussion around the “connected factory” these days, the truly transformational aspect of digitalization is the ability to connect people securely and seamlessly.