Automation World® TACTICAL BRIEF

Defining IoT Physical Infrastructure

Providing Visibility into What is Connected

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How the Internet of Things Makes Manufacturers Smart and Connected

The continuous intelligence that can be delivered to manufacturers about their products via the Internet of Things has put OEMs in a position to take advantage of new market opportunities.

By Terri Hiskey, Vice President of Product Marketing, Epicor

Until recently, manufacturers only had to worry about designing, manufacturing, selling and servicing their products. But we are living in a different time now, and wise manufacturers know they need to change to keep up.

It is not enough to only be a manufacturer—customers want more out of their key relationships, and they want the ability to optimize and maximize the performance of whatever product they purchase. These customers are looking to manufacturers to provide an added level of technology, enabled by the Internet of Things (IoT), that enables users to track and analyze usage, whether the product is a tire, an air conditioner or refrigerator.

This means that manufacturers not only have to worry about having to design such capabilities into their products; they also need to consider how IoT technology can help improve and optimize their own manufacturing processes.

As prices of communication equipment and sensors continue to drop, smart manufacturers will be able to gather information from a wide range of devices. With connectivity enabled via IoT, these devices will be able to send valuable information back to the seller or manufacturer. For example, a refrigerator could send a signal to the manufacturer indicating a detected malfunction. With this data, the manufacturer would be able to put in measures to prevent the problem in other products in the line. In another example, an air conditioner might be able to detect when it needs maintenance and send a message to the manufacturer, which can then initiate remote maintenance service. As a result, the customer will be happier and the manufacturer can save on the cost of doing business.

Manufacturers that can extract full value from data gathered via IoT can position themselves to take advantage of new market opportunities. The data collected by billions of things and devices can be used to deliver new services or drive innovation that can help organizations differentiate themselves from the competition. In addition, manufacturers can also connect their supply chain systems to smart devices so they can gain better visibility and control over their extended manufacturing operations.

Customer experience is something that most manufacturers struggle with, but smart manufacturers understand that intelligent devices can reveal vital information, enabling them to drastically improve their customer service. Customers are also increasingly seeking personalized experiences with their manufacturers and suppliers. Mod-

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How the Internet of Things Makes Manufacturers Smart and Connected

ern manufacturing enterprise resource planning (ERP) systems, integrated with IoT, can often provide insight to deliver that personalized experience. IoT offers manufacturers a huge opportunity to improve their customer service and lower the cost of production, driving higher margins.

In IDC FutureScape: Worldwide Manufacturing 2017 Predictions, IDC states: "Manufacturers are trying to accelerate the speed at which they operate, without adding risks to their ability to serve their customers and maintain corporate standards, including product quality. With the proliferation of sensors and IoT throughout operations and in connected products, manufacturers can achieve visibility with greater ease and affordability than ever before."

Manufacturers' use of IoT has gone beyond the "nice to have" phase, and is squarely in the "must have" phase. A comprehensive IoT strategy needs to be in place in order to survive.

Turning Out the Lights on the Factory Floor

Though true lights-out production is still rare, more processes are running with limited human interaction. Variability, complexity, dexterity and danger shape decisions.

By Jeanne Schweder, *Automation World* Contributing Writer

Will the factory of the future be completely automated, with only the proverbial man and a dog—the man to feed the dog and the dog to keep the man from touching anything? It's hard to tell at this stage in technology development, but it's absolutely true that more and more production processes, if not entire factories, are running with limited human interaction.

The evolution to more automated processes has been years in the making. Although many of the technologies needed to automate manufacturing work behind the scenes—such as programmable logic controllers (PLCs), software and vision systems—robots have become the most visible symbols of lights-out manufacturing.

"Robots are uniquely suited to any manufacturing task that is dirty, dangerous or dull," says Douglas Peterson, general manager for the Americas at collaborative robots maker Universal Robots. "If the process doesn't require human dexterity, mental agility or problem-solving skills, then it can be done by a robot."

One of the most widely known examples of a completely lights-out factory is a Fanuc plant in Japan where robots make new robots without human intervention. It's easy to see why a maker of robots would want to demonstrate the lights-out concept, but many manufacturers are exploring the possibilities of using this approach for at least some of their production processes.

Although true lights-out factories are still rare, the use of collaborative robots is growing rapidly, particularly in third-shift operations. "You have to specifically design a factory floor for lights-out operation, which requires a significant capital expenditure," Peterson says. "But collaborative robots can be easily integrated into the existing factory layout because they're designed to work safely alongside humans. They can also function without human supervision."

There are a number of reasons why companies might consider lights-out processes. For some, the goal is better product quality and throughput rates. Others want to reduce workplace injuries, particularly in hazardous environments like paint shops, where high temperatures and noxious gases can pose human dangers. Another factor is the difficulty in finding workers, with an estimated 2 million manufacturing jobs going unfilled today.

Attracting skilled employees is particularly difficult for the small and medium-sized companies that make up the bulk of the country's manufacturing base. According to the National Association of Manufacturers, of the 252,000 manufacturing companies in the U.S., only 3,700 had more than 500 workers. The vast majority of these companies employ fewer than 20 people.

Though machines cannot replace human workers in many production processes, even the smallest companies are finding collaborative robots (co-bots) an easy-to-deploy solution for this worker shortage. Ironically, co-bots may also have a role to play in reindustrializing America and making it possible to create new manufacturing jobs.

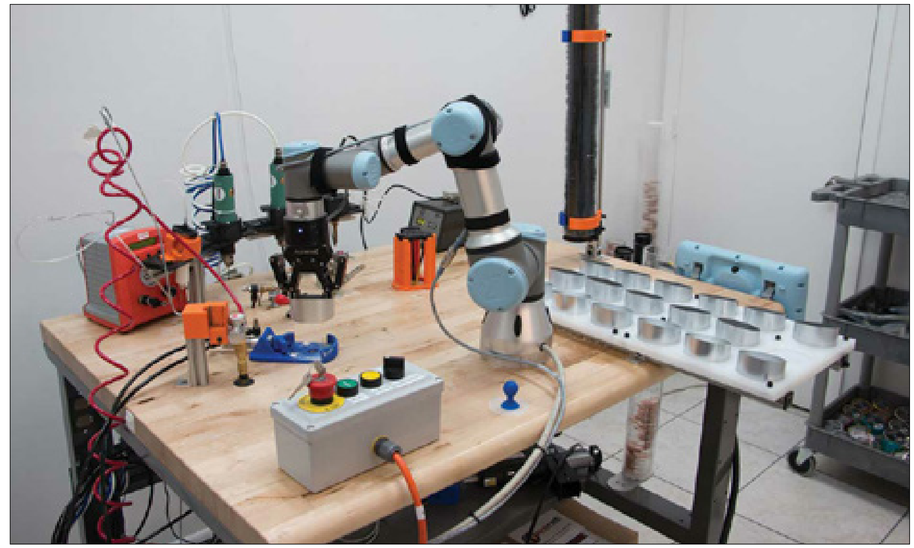
Robots as partners

Consider the experience at Creating Revolutions, a startup making a customer service paging system for the restaurant industry. Customers activate the device using their smartphones, cueing busy waitstaff when service is needed. The system also records data points like response times, helping restaurants better manage their employee resources to improve customer satisfaction and turnover.

Creating Revolutions was experiencing double-digit product rejection rates because of faulty assembly. It was also unable to find skilled workers. Seeking an alternative solution for these production problems, founder Einar Rosenberg turned to Hirebotics, another startup that offered to rent a collaborative robot by the hour. Renting from Hirebotics eliminated the capital expense barriers for new technology faced by nearly every startup. Using the robot also reduced product rejection rates to nearly zero. Perhaps the most surprising result, the company was able to add manufacturing jobs.

"We wouldn't have been able to afford to make our products in the U.S. without the robot," Rosenberg explains. "We've even added jobs to keep up with the increased production the robot generates."

The company can also make changes to its manufacturing processes and products on the fly, a common need at startups that would have been impossible to achieve with offshore manufacturing.



A collaborative robot at Creating Revolutions works side by side with humans during the day and in lights-out mode at night.

In addition to functioning side by side with human workers during the day, the robot continues to perform for hours after workers go home at night, preparing parts for assembly the next day. Creating Revolutions expects to add three more co-bots in 2017 to keep up with demand.

The machines-as-a-service business model used by Hirebotics is becoming more common for machine builders and automation suppliers in the face of ongoing customer resistance to capital expenditures. Hirebotics purchases its collaborative robots from Universal Robots and uses the cloud to program and monitor their performance for customers, as well as to provide ongoing technical support. Performance data is streamed from the robot as events occur and can be monitored by Hirebotics with a mobile app. Web cameras show what's happening on the production line, allowing customers as well as Hirebotics to monitor activities at all times.

"We see our job as helping manufacturers in the U.S. succeed," says Matt Bush, Hirebotics COO and co-founder. "Most companies are years away from lights-out manufacturing because it's so capital-

Customized grippers on this Universal Robots unit let Whippany Actuation Systems run two unattended shifts to meet increased production demand.

intensive. But by renting robots by the hour and only paying for the hours they actually work, companies of all sizes can afford to automate more of their processes."

Bush adds, "While robots work more slowly than human workers, they also work more consistently, without disruptions or distractions, and for more hours, so 10-20 percent increases in productivity are common. Robots can take over the boring, repetitive tasks, freeing human workers for more interesting jobs. People who use them are beginning to see robots as their partners, not their competitors."

Keeping things moving

Although robots have been tending CNC machines, loading and unloading parts, without human intervention for years, customers today want greater flexibility and mobility. WhenWhippany Actuation Systems, a maker of specialized electromechanical actuation systems for the aerospace and defense industries, needed to increase production quickly, it looked for an alternative to sinking a large expenditure into a new CNC machine. The solution was a robot from Universal Robots that could tend its CNC machine overnight. It's able to handle parts of different sizes, using customized adaptive grippers, and communicate with both grippers and the CNC machine.

"We wanted a solution that could be implemented and programmed easily and didn't require traditional guarding and safety," explains Phil DeMauro, Whippany's manager of manufacturing engineering. "The ability to move the robot from one cell to another, just by popping a couple of locating pins in the floor to get up and running, was also a huge consideration."

With Whippany's CNC machines now running two additional, unattended shifts, the company has met its goal of increased production capacity and DeMauro expects to achieve ROI on the robot in less than a year. "Overall, it helps the business from a cost, productivity and capacity standpoint, and we expect it to improve our margins."

Another mobile solution—one that can actually move anywhere on the factory floor unattended—is the MiR100 mobile autonomous robot from Mobile Industrial Robots, a Danish company that entered the U.S. market early in 2016.

"A mobile platform is the single most important recent development in robotics for material handling," says Ed Mullen, vice president of sales for North America at Mobile Industrial Robots. "Traditional automated guided vehicles (AGVs) require fixed tracks or sensors installed in a factory floor, making them expensive and inflexible, as well as unable to avoid obstacles in their path."

Upon installation, a mobile robot is taught the layout of a factory and the paths around it, so it always has a context within which to work. Once programmed, the robot can find its waypoints without human interaction. The operator interface is handled through a wireless web interface. Additional modules can be installed on top of the robot to meet various application needs, such as a 24-inch conveyor to move goods without human assistance from one production station to the next. Other module options for lights-out operation include a lift, a towing hook or even a mounted collaborative robot arm.

Elos Medtech, a Danish maker of medical devices and components, uses its MiR robot to move materials around the factory. Before the robot, staff used to walk an average of 7.5 km a day, pushing goods on a cart between departments. That added up to 1,650 km and many hours every year. Now workers are assured a faster, steadier flow of materials throughout the production process, helping eliminate downtime and latency.

Where does lights out work?

There are many processes within a factory that fit the criteria for a lights-out approach as long as the system is set up properly, according to Will Aja, vice president of customer operations at Panacea Technologies, a member of the Control System Integrators Association (CSIA).

"We've done a few projects in the pharmaceutical industry where eliminating human errors is a big concern," Aja says. "Fully automated storage and warehouse facilities are becoming common for distribution companies like Fed-Ex or UPS. Factories that make products like flour, where there's a great risk to humans from explosions, are also using increased automation. In addition, we're seeing hybrid approaches for inspection and quality control that are directed by software but where a human has to take an action."

Although cost is a major barrier to lights-out manufacturing, Aja sees machines performing an increasing number of tasks in factories around the world. “No matter in what country a product is being made, it’s hard to make things cost-effectively with a lot of workers,” he says. “How far you can go is heavily process-driven. It varies by industry and there’s a range of decisions that have to be made.”

Companies making commodity products might not have the cost structure to support it, Aja adds. “If your brand is based on a level of quality that sets it apart, you may not want to automate. On the other hand, if you’re using expensive raw materials, then the cost of throwing away products ruined by human errors is a big consideration.”

Product variability and environmental conditions are two other critical factors to consider. “Automation often breaks down when you’re making bakery goods or confections, such as when buns aren’t separated enough,” says Mark Noschang, robotics applications engineering lead for Omron. “Produce handling is another difficult area, since no two apples are ever the same. Applications like these often require some manual intervention.”

Packaging can also be tricky to automate. “Plastic clamshells for lettuce or spinach are a particular challenge, since leaves often stick out and prevent the package from closing properly,” Noschang says. “Cold, moist environments that can warp cardboard boxes are likely to need human supervision. It’s difficult for a robot to deal with variations. Even if it can sense a problem, a robot often isn’t capable of correcting it.”

Noschang predicts that industries like solar, automotive, medical devices and electronics will soon automate large portions of their manufacturing processes. “Another trend is the development of autonomous intelligent vehicles (AIVs) for material handling, with built-in safety and navigation features. These will increasingly replace traditional AGVs that require tracks, wires, sensors and magnets.”

Self-driven mobile robots, such as this one from Mobile Industrial Robots, can avoid obstacles and change paths as they carry goods through a factory.

As technology changes what’s possible, it will also change business economics, predicts Beth Parkinson, market development director for Connected Enterprise at Rockwell Automation. “Many processes lend themselves to the lights-out approach, such as those involving high temperatures, toxic gases or high payloads, and applications like furnace and paint line management or carbon fiber cutting, which pose potential harm for humans."

Parkinson cautions, however, that pushing lights out too soon can actually cost more than what a company is paying for labor. "It will be important to prioritize areas that pose dangers to humans, where new workers don't have the needed skills or don't want to do repetitive tasks," she says.

Parkinson adds, "With the increased connectivity of the Industrial Internet of Things, manufacturers will find they need to attract a new kind of worker—one more interested in improving manufacturing technology or managing those processes than in doing manual labor."

What's next for robot tech?

As robot technology advances, so will its increased use on the factory floor. "By the year 2020, an expected 150,000 robots will be sold every year," says Jim Lawton, chief product and marketing officer for Rethink Robotics, one of the early developers of collaborative robots.

"Think of today's robots as PCs with arms," Lawton says. "Our goal was to make them more useful and easier to use, as well as more robust and reliable. Software has become more important than hardware, allowing robots to handle a wider variety of tasks. By leveraging technologies that weren't available 10 years ago, we're turning robots into teachable machines that respond more like a human."

Lawton adds, "People are good at dealing with variability, but not as good at looking at large amounts of noisy data that are separated by time and space. Machine analytics are much better at seeing patterns and connecting different, disparate data sets. Robots will be able to learn at the workcell level and make changes to adjust their performance."

Lawton predicts that the future automated factory will be continuously learning, self-configuring and self-healing. "We're taking small steps toward that future with robots, software and artificial intelligence. Timing is the biggest question now."

The New PLM: Highly Connected, a Little Disruptive

The arrival of smart products is forcing manufacturers to reevaluate how they manage the product lifecycle from idea to end of life, while factoring suppliers and customers into the equation.

By Stephanie Neil, *Automation World* Senior Editor

When you are buying a luxury car, you want it to come fully loaded with all the amenities like navigation, in-vehicle infotainment, intelligent park assist, collision avoidance, etc. These bells and whistles make for a comfortable customer experience. But for the manufacturers and OEMs that are making these software-driven vehicles with upwards of 100 million lines of code, product development is a challenge.

And it's not just automobiles that are morphing into complex electronic systems. Many of the smart things saturating our everyday lives as part of the Internet of Things (IoT) are engineered with mechanical, electrical, software and firmware components, all of which amount to connected chaos when it comes to managing configurations, revisions and quality control as part of the product lifecycle management (PLM) system.

Here's why: PLM traditionally has been a way for manufacturers to bring new products to market faster by reducing development and production time, cutting costs and maintaining product quality. And it all starts with the computer-aided design (CAD) tools to create mechanical diagrams of materials, processes, tolerances and dimensions using 2D vector-based drafting systems and 3D solid and surface models.

In the past, PLM was very much rooted in design and providing a way to manage the lifecycle of a product from inception through engineering and manufacturing and, ultimately, end-of-life product disposal. It was based on a collaborative framework for organizing, connecting and tracking product documents, including CAD and computer-aided manufacturing (CAM) files. More recently, there's been a push to close the loop between engineering, production and enterprise software—like manufacturing execution systems (MES) and enterprise resource planning (ERP)—to create synchronicity and visibility between design, manufacturing, and order and inventory.

Now the industry has entered a new stage in which suppliers and customers are also an important part of the product lifecycle. Suppliers, in some ways, are becoming design partners and customers are leveraging social networks to provide feedback on product functionality. In addition, the "connected products" that make up the IoT are creating a convergence of electronics and software, so there is a need for more integrated simulation models.

Collectively, these factors are feeding into the next generation of PLM, which industry experts are calling the product innovation platform. It is the ability to tie the traditional engineering workgroup into upstream front end of innovation—including understanding customer needs—with downstream manufacturing processes to head off any quality issues. This unified cross-functional architecture also factors in which suppliers to work with and what materials to use.

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The New PLM: Highly Connected, a Little Disruptive

"It is no longer PLM and CAD tools for a few guys in an engineering workgroup," says Jeff Hojlo, program director of product innovation strategies at analyst firm IDC, noting that the existing setup focuses exclusively on R&D. "PLM [now] encompasses suppliers and non-engineers on the manufacturing side so that changes can be made quickly, quality issues can be serviced quickly, and adjustments can be made [based on] product demand."

As a result, the PLM providers have been making some unconventional acquisitions that bring an array of expertise together into a unified lifecycle management platform for the digital enterprise.

A few examples include:

- Autodesk, which made a handful of acquisitions that enhance its AutoCAD design and Inventor modeling/simulation products. In the past few years, the company has bought: Delcam, a provider of CAM software; Netfabb, a developer of industrial additive design software; CadSoft, the maker of Eagle printed circuit board design; and Magestic Systems, a maker of manufacturing software for CNC cutting applications.
- Dassault Systèmes added manufacturing operations management to its 3D design portfolio with the acquisition of Apriso in 2013, and more recently bought Computer Simulation Technology (CST), a maker of electromagnetic and electronics simulation. It also acquired Next Limit Dynamics, a developer of simulation for highly dynamic fluid flow; and Quintiq, a provider of on-premise and on-cloud supply chain and operations planning software.
- PTC, known for its Creo CAD software and Windchill PLM software, bought: Kepware Technologies, a maker of manufacturing connectivity tools; ThingWorx, which offers an ecosystem of IoT development tools; Axeda, another IoT company; ColdLight, which has machine learning and predictive analytics; Vuforia, which adds augmented reality into the mix; and Servigistics, a service parts management tool.
- Siemens PLM brought UGS into the fold way back in 2007 as it outlined its vision to blend virtual and real worlds. In 2012, the company acquired LMS International for its test and mechatronic simulation software. Last year, the company picked up CD-adapco, a simulation company covering a range of engineering disciplines, including fluid dynamics, solid mechanics, heat transfer and electrochemistry. Siemens also added Mentor Graphics to its portfolio for its design automation software, including for automotive integrated circuits and system-on-chip devices.

Though it might seem that PLM providers are on a random buying spree, they are all on the same path to move away from a lot of disparate data and toward a more collaborative visualization effort between engineering, manufacturing, the supply chain and the customer.

"The future opportunity is to use the information around connected products [as it relates to] usage and performance in order to make better products," Hojlo says.

The New PLM: Highly Connected, a Little Disruptive

Disruptive designs

The digital world changes everything. Think about cars. Once all mechanical, automobiles more recently have begun to look like rolling computers. Now the automotive industry must evolve with its products.

"The automotive industry is becoming the mobility industry," says Tom Maurer, senior director of strategy at Siemens PLM. "It's not about selling automobiles, but about mobility in transportation."

Such shifts also open the door for selling products as a service. Maurer points to Konecranes, a maker of heavy-lifting equipment. The company is not just selling cranes anymore, but rather selling lifting as a service. To do that, they've worked with Siemens to equip the cranes with sensors that report information back to the manufacturer, which then applies analytics and knows when it needs to be serviced. This new business model allows the customer to buy an operational service rather than capital equipment.

These examples also mean the design of the products must be different. The Siemens PLM investments are supporting the digital twin concept—not just for the product—but across the entire lifecycle. "Now we can simulate all of the physics in a product and also its performance," Maurer says.

The idea that a manufacturer can monitor and track a product's performance is a major gain that comes from a new type of digital thread sewn into every asset, whether it is mechanical, electrical or software. And PLM is providing that single source of truth throughout the entire organization.

"For years, we've been in the CAD world designing digital prototypes. But as an engineer, the design is based upon assumptions in the requirements," says Paul Sagar, vice president of product management at PTC, noting that in the past the only kind of feedback engineers received came from an irate customer calling to say a product is broken. "With IoT, I know how those products are behaving and can not only monitor them, but understand usage scenarios to optimize designs going forward."

To that end, PTC is adding more IoT capability into its Creo software to connect with physical products in the field and feed that information back into the CAD system. The program, called Design for Connectivity, takes information from sensors on products in the field and feeds it through ThingWorx, which connects back to Creo to provide a real representation of forces and constraints on the model. "When you connect the digital and the physical, it gives traceability throughout design," Sagar says.

The third platform and PLM

Of course, when it comes to collaboration, analytics and mobility, discussions about the third-platform technologies like the cloud and Big Data always come up. And it is no different for PLM, which IDC's Hojlo sees as a growth area over the next five years for quality and service planning. "There is a need for speed when it comes to executing on service and delivery, and if there is a quality issue, you want to react quickly to that," he says.

The adoption of cloud-based PLM is on the rise, agrees Chuck Cimalore, CTO of Omnify Software. The PLM provider offers both on-premise and hosted systems, and for the past two years, it's been a 50/50 split for new customers. For folks opting for the hosted model, the biggest concern has been intellectual property security and accessibility to design data. But customers are becoming more comfortable with the due diligence of cloud suppliers around encryption and blocking unwanted visitors. As a result, Cimalore expects to see Omnify's cloud instances outgrow on-premise deployments and represent 70-80 percent of the installations over the next five years.

IoT is a big motivation for moving to the cloud because companies will want their smart devices to talk directly to the PLM system. To support that, Omnify's latest release of its Empower PLM product is built on a representational state transfer (REST) service platform to enhance the integration framework for third-party systems, providing a standard way for devices to communicate. "IoT will present more opportunities to provide synchronized solutions that tie the product record to the device in the field," Cimalore says.

Arena Solutions, a pioneer of cloud-based software-as-a-service (SaaS) PLM, also sees the product record as a key enabler to next-generation PLM. Arena's PLM platform includes a quality management system (QMS), application lifecycle management (ALM) and supply chain collaboration in one holistic platform. A new product, Arena Verify, adds requirements and defect management. All these systems are tied to the same product records, allowing all teams—engineering, electrical, mechanical and software—to work together across the supply chain. In addition, a partnership with cloud-based quality control supplier 1factory adds the ability to identify non-conformance to specifications early in the design and manufacturing process to accelerate the necessary corrective action.

Indeed, the ability to keep track of all the moving parts in a unified way is the biggest benefit of PLM.

GFS, which makes natural gas conversion systems for high-horse-power diesel engines, uses Arena for creating bills of material (BOMs) and managing technical documents and quality control processes to ensure the company builds a consistent and reliable product. The company's products allow mining trucks, oil drilling rigs, power generators and other industrial applications to run on a combination of liquefied natural gas (LNG) and diesel fuel as a way to save money and improve emissions. The conversion systems include a comprehensive list of sensors, hardware, wiring harnesses and electronic controls.

Prior to the adoption of Arena in 2013, the company was operating in product development mode without a formal PLM system. BOMs were created and tracked using conventional spreadsheets, which proved increasingly difficult to manage as the products matured.

In the future, GFS plans to more fully utilize PLM to optimize the design of the conversion systems, but for now the company is leveraging Arena as a unified platform that allows its procurement, production and engineering teams to access a common set of BOMs using strict document control and tracking.

"The move to Arena allowed us to make an efficient transition from a product developer to a manufacturing company," says Kerry Hackney, chief marketing and communication officer at GFS.

An open, additive approach

As more complexity is introduced into the design and lifecycle management process, it's important to keep an open mind—and open infrastructure—to be able to scale and evolve with the changing product requirements.

The GFS EVO-MT System for mine haul trucks provides an integrated, onboard LNG fuel storage system. The product BOM and design document control are managed by Arena PLM.

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The New PLM: Highly Connected, a Little Disruptive

The PLM systems of the past were rooted in a rigid architecture that managed CAD first and dealt with the enterprise later, which was a clunky approach. Today's PLM should embrace an open architecture, even when customers are using legacy systems or different CAD tools.

To help with this, Rockwell will soon introduce a new release of its design tool, Studio 5000 Architect, that includes new data exchange interfaces with adapters for different electrical CAD software. These interfaces will be used to close the loop between electrical and automation systems.

Also on the flexibility path is Aras, which built its PLM on an open data model that can work with other PLM offerings and still manage configurations across different points in the lifecycle. For example, GE Aviation uses Siemens PLM Teamcenter to manage the engineering BOM, but can be transitioned seamlessly, using Aras, to a manufacturing BOM (MBOM) that is released into ERP for procurement.

A new product from Aras called the Manufacturing Process Planning (MPP) application adds the ability to manage the manufacturing process plan, work instructions and the MBOM, making them interdependent and automatically synchronized as changes occur.

"The ability to manage configurations at different points in the lifecycle is one of our differentiators," says Doug Macdonald, product marketing director at Aras.

An open approach will prove very useful as manufacturers adopt 3D printing. It's a very different way to make parts, and therefore requires a very different way of designing, simulating and configuring. It is for these reasons Autodesk acquired Netfabb, which enables the analysis of a design in advance to show where the challenges will be.

No matter what crosses the PLM path—be it IoT, analytics or additive manufacturing—all vendors understand that manufacturers require repeatability of the design and the manufacturing processes. And that's what they aim to give them.

The Continuing Push for Hardware Standardization

Project costs have for years been getting out of control in the oil and gas industry, even before low oil prices made projects cost-prohibitive. Standardization is the way forward to save costs and schedules.

By Aaron Hand, *Automation World* Executive Editor

If you've been to even one of the process-focused conferences or user group meetings held over the past several years—Emerson Exchange, Schneider Electric's Connect, Siemens Oil & Gas, Honeywell Users Group, ARC Industry Forum, you name it—you can't have failed to hear the directive coming repeatedly and forcefully from ExxonMobil: Standardize and simplify automation in the oil field; make commissioning easier, faster and cheaper.

Sandy Vasser, now retired facilities instrumentation and electrical manager for ExxonMobil Development Co., has long been on a mission to bring automation suppliers around to his list of demands. And those demands have been a huge factor behind the development of more standardized systems from all of the automation suppliers—suppliers that want a piece of the ExxonMobil action, that is.

Vasser was a key driving force behind several developments to come from automation suppliers over the past few years. Smart configurable I/O, remote I/O and virtualization, to name a few, will enable a more standardized approach to project execution. These technologies not only simplify the commissioning process, but also allow engineers to take automation off the critical path.

"All those things are technologies that allowed the contracting engineer that's doing the work for ExxonMobil to continue changing their designs and still allow us to build a control system," says Chris Lyden, senior vice president for process automation at Schneider Electric.

The problem

That's been the problem with project execution thus far. Not only has the typical project been overrun with hundreds of custom-engineered junction boxes and miles of wire and cable from the field, but work on automation often has to be done and redone as changes are made to facility plans.

"Invariably, an automation engineer makes all this progress, and then a process engineer or a machinery engineer makes one little change, and we have to go back to the beginning and redo many of the drawings," Vasser explained at last year's ARC Forum. "This doesn't just happen one time. It happens over and over and over again. Right up until startup, we're making changes."

The work must be done in parallel to compress the schedule, but those dependencies only add to the fact that projects in general are getting larger and more complex. With the lower cost of oil since 2014, lower returns make these projects that much more daunting. "The problem today is we can't make projects economic," Vasser says. "So we've got to come up with a different approach."

Off the critical path

That's the reasoning behind what's called "taking automation off the critical path"—allowing designs to be changed without making the automation team scrap their work over and over again. Smart configurable I/O (or universal I/O), placed in standard cabinets and/or field junction boxes, is a big part of this.

Whether called universal I/O, intelligent marshalling, soft marshalling, electronic marshalling, etc., all the key automation providers have introduced some form of this, enabling more flexibility for I/O changes even as projects near completion.

Other key technology pursuits, as outlined by Vasser, include:

- Virtualization, to a broader extent than is being done already.
- DICED I/O (auto-detect, auto-interrogate, auto-configure, auto-document) so that systems can be automatically commissioned without the need for human interaction.
- SIS logic solver directly programmed using translated cause and effect. This product has actually been out for many years, Vasser says, but people weren't buying it.
- Seamless integration between automation and electrical systems.
- Use of smart I/O to replace control wiring for motor control centers (MCCs). This is an evolution of smart I/O that would eliminate most of the hard wiring.
- Standard assembly to convert multiple discrete signals to a single analog signal (a need borne out of expanded use of smart I/O).
- Simplified package interfaces.
- Wireless field instruments.
- Increased use of DC power to eliminate many of the inverters.

Overall the idea is to reduce customization, reduce complexity, reduce a lot of the dependencies, either reduce documentation or automatically generate it, manage risk, and develop and enable trust with suppliers.

With the Foxboro Evo FBM248, Schneider Electric introduced redundancy capabilities to its Intelligent Marshalling, its form of universal I/O.

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The Continuing Push for Hardware Standardization

All of these changes outlined by ExxonMobil Development are focused on upstream oil and gas operations. But on the downstream side, Don Bartusiak has led a similar charge for ExxonMobil's refineries and chemical operations. It's the same essential business problem—how to take costs out of the projects needed to deliver process control systems—and many of the demands are the same. But the perspective is somewhat different.

While upstream is focused on getting equipment up and running quickly, a chemical plant or refinery is more concerned with keeping things running for decades to come, points out Alex Johnson, system architect for next-generation systems in Schneider Electric's Process Automation group. "So he's thinking: What can I do to minimize obsolescence without compromising production? How do we incorporate new ideas quickly and easily, and avoid the cost of bulldozing? What are you going to do to make that possible?"

ExxonMobil's downstream operations are facing the need to replace a significant percentage of its regulatory control equipment over the next 10 years, notes Bartusiak, chief engineer of process control for ExxonMobil Research & Engineering. It's critical to not only lower the cost of upgrading or replacing a DCS, but also to derive more value from that system.

"We're not getting enough value from the control system," Bartusiak said at the ARC Forum last year. "Over the last 20 years or so, the majority of plus-value applications for us have been deployed at the level of the computing stack above the DCS. It's an unequivocal fact."

Much of the concern downstream is around oil and gas producers being stuck with products and services from a single vendor, so the standardization drive centers around an open system that lets them effortlessly integrate best-in-class components, regardless of provider. It would also preserve the asset owner's application software, significantly lower the cost of future replacement, and employ an adaptive intrinsic security model.

ExxonMobil caused a stir in the industry early last year when it named Lockheed Martin as system integrator in the early-stage development of a next-generation open and secure automation system for process industries. This move had largely to do with Lockheed's experience with The Open Group's Future Airborne Capability Environment (FACE) Consortium, which had the kind of experience in the avionics industry that ExxonMobil was hoping to achieve in oil and gas.

ExxonMobil approached The Open Group to develop a similar consortium in process automation, and the Open Process Automation Forum recently kicked off (see "The Work of the Open Process Automation Forum").

Broader standardization push

Beyond ExxonMobil's specific drive for rethinking process automation, there's been a general push in all industries to standardize technology at various levels. It's been from industries outside of process, in fact, that ExxonMobil has drawn its inspiration, particularly telecom and avionics.

"The push for standardization comes from every stakeholder in the business because, put simply, standardization is proven to lower overall project costs and schedules," says Steve Royston, principal engineer at ABB. "Almost every industry—from pulp and paper to metals, minerals and mining—can and has supported standardization for many years now, and the oil and gas industry should be no exception."

Nearly every element of a project in the oil and gas industry can be standardized—from procedures and documentation on through to the human-machine interface (HMI). The major oil companies are uniting further and further on this point, says Dan Overly, vice president, global head of products for ABB Oil, Gas and Chemical. "They need to because it affects the EPCs as well, since they will have to change the ways projects are procured and designed," he adds.

The NORSOK standards, developed by the Norwegian petroleum industry, are a good example of the oil and gas industry recognizing the value of standardization, Royston points out. The intention is to replace specifications from individual oil companies as much as possible, helping to ensure safety as well as cost-effectiveness.

Out-of-control project costs

The need for standardization and other changes in project design and execution is based on a problem felt by all the major oil players—huge project cost overruns.

At the 2015 Emerson Exchange, Jim Nyquist, president of Emerson's Systems and Solution business, painted a clear picture of the need to bring project budgets under control. "We have a project crisis in this industry," he said, detailing how more than 65 percent of projects greater than $1 billion fail. They're at least 25 percent over budget or 50 percent over schedule. Some 35 percent of projects with smaller budgets are failing as well.

The plunging price of oil beginning in 2014 certainly has played its part in convincing oil producers they need to take a different approach, but it's been a longer time coming than that.

Select I/O and standardized cabinets allow ABB to further decouple hardware and software to make late project changes and decisions.

"Losing major money on poor projects hurts no matter the oil price," Overly says. The original proprietary nature of the industry came from protection of IP and the belief that unique approaches brought a competitive advantage, he says. "In some parts of the industry, that is still true. But on the commodity parts for the industry, that belief is going away."

The industry can't keep doing things the same way, Nyquist said in 2015. "The lower oil price might be the wakeup call that we get, but the way we operate needs to fundamentally change."

Regardless of industry segment, Johnson says, producers have seen the need to reduce the cost of a new project. "Whether greenfield or brownfield expansion, they've got to drive cost out of that," he says. "It's not easily achieved by looking at individual pieces of a project."

Vasser has said as much in his talks. Improving individual pieces of what the industry has already been doing will bring only incremental improvement. And that's just not enough.

Looking only at cost is also not enough. The push comes from the need to reduce risk and improve quality as well, Overly notes. "Less customization allows for mass production of standardized hardware and even software," he says. "This means more predictable performance in the final solution."

Standardization also removes the engineering effort required in designing, building and testing, which in turn lowers project costs and schedules. "Standardization de-risks projects and allows every stakeholder to reduce risk mitigation contingencies in their cost estimates," Royston says. "Standardization not only reduces the factory (capex) costs, it also reduces the total cost of ownership (opex). Standardization reduces the effort required by site-based engineers and operational staff to familiarize themselves with project-specific requirements and solutions."

The entire initiative is likely to create considerable disruption for the business models of automation suppliers. But Bartusiak thinks

The Work of the Open Process Automation Forum

ExxonMobil's Don Bartusiak, Steve Bitar and others were back at the ARC Industry Forum this year to get more support for ExxonMobil's Open Process Automation initiative. In large part, that means rounding up more partners—end users, suppliers and system integrators—to participate in the newly launched Open Process Automation Forum.

Schneider Electric's Alex Johnson, who co-chairs the technical working group with ExxonMobil's Bitar, calls the Open Process Automation Forum the "biggest thing going on in the process world." Most of the major DCS vendors (minus, notably, Rockwell Automation) are part of the forum, along with end users like ExxonMobil, Aramco Services, BASF, Dow, Shell, Merck, Praxair and Koch Industries.

Who's not represented yet are the engineering, procurement and construction providers (EPCs), Johnson notes, but they're working on that. These are matters that profoundly impact both the supplier and end user, so it makes sense for EPCs to be involved as well. "There's got to be an impact on the guy in the middle," he says.

Bitar, R&D program manager for ExxonMobil Research & Engineering and the program lead for ExxonMobil's open architecture initiative, pointed out how the Future Airborne Capability Environment (FACE) Consortium—the model for this latest endeavor—went from zero to 90 members in only four years. "We're going to have to do something similar," he said at last year's ARC Forum. "That kind of pace is remarkable, and it sets the bar for us."

As of late January, there were 20 member organizations in the Open Process Automation Forum.

"We have to be able to demonstrate that we can do things with the new architecture that were very challenging with the old architecture," Bitar says. "And I think we have to do it collectively as a community, as an industry, working together."

The goal of the forum is to develop an open standard framework and reference architecture that should benefit any manufacturer in a continuous or batch process industry. In addition, the forum will create business models that will benefit the entire ecosystem.

Continued
The Continuing Push for Hardware Standardization

that, despite the challenges, suppliers could benefit from reduced systematic costs, increased margins by focusing on differentiating advantages, and a pro-competitive expansion of market opportunities.

"Accepting a standard means change on both sides—users and vendors," says Jörg Schubert, PACT technology account manager for ABB. But the forum's approach is in line with ABB's product strategy for its 800xA DCS, he adds. "ABB is quite active in different technology standardizations with the goal to guarantee interoperability of ABB products with different vendors' products to provide fully integrated solutions that meet the customers' needs best at an optimized cost."

As oil producers push for ways to drive costs down, the automation suppliers themselves have to find more ways to get their own costs down. As oil prices dipped, pressure increased for lower automation prices. As the price of oil comes back up, those automation prices are not coming along for the ride. Instead, they just have to get ready for the next crash.

"If they want to do the projects at the lower cost of oil, the justification becomes harder and harder," Lyden says. "What they're really looking for is productivity from their suppliers. So they push the suppliers to do things more cost-effectively. We have to be in this continual state of finding ways to do things more cost-effectively."

Modernizing the Industrial Ethernet Network with Increased Visibility

By Michael Vermeer, Product Line Manager, Panduit July 2016

The Internet of Things (IoT) and smart manufacturing have become two of the hottest concepts in today's industrial automation world. Together, they are paving the way for the arrival of a new era in manufacturing – dubbed "Industrial IoT" or "Industry 4.0" – a world where sensors, devices, and machines will all be connected by the Internet, operate without human interaction, and offer massive amounts of data that can be used for powerful new insight and intelligence.

Core to the Industrial IoT is the phenomenon of a highly automated "smart factory," powered by connected devices, smart technologies, and seamless processes. This is the next big advancement in modern manufacturing that promises to make room for major operational efficiencies, unparalleled flexibility, productivity gains, and increased profit margins.

Despite these benefits, the factory of the future may seem like a daunting and expensive path to take for many of today's industrial facilities, which are constrained with hefty investments in legacy equipment, implemented the same way they were decades ago at a time when proprietary communications protocols did not need to talk to each other. Before now, there were only a few nodes to connect, control, and monitor, allowing automation engineers, controls engineers and technicians to effectively manage and troubleshoot their networks using programming software tied to the automation system. While this made deployment more complex at the time, it was inherently less risky since it created inherent network segmentation of different parts of the system.

With the connected world in manufacturing gathering pace, the reality of the smart factory is not a far-fetched vision of the future, but manufacturing companies must begin to adapt and innovate now, or risk being left in the dark.

Considering just 10 years ago, small- to mid-sized manufacturing facilities were effectively managing 10-12 Ethernet devices at each of their plants and are now running upwards of 300 devices, this is an extraordinary growth. Moreover, executives in the manufacturing industry anticipate that 95% of companies will take advantage of Industrial Internet of Things (IIoT) technology within three years, aiming to further automate their manufacturing processes by employing smart manufacturing and IIoT concepts and technology on their plant floors. This will radically increase the number of connected industrial devices on the plant floor in the future. As it stands now, numerous components on the plant floor are interconnected, including I/O devices, PLC controllers, human-machine interfaces (HMIs), drives, process instruments, and IP cameras.

With the IoT expected to add an astonishing 50-100 billion connected devices to the network in a short few years, manufacturing facilities are faced with the almost unfathomable task of overcoming a number of significant hurdles before realizing the advantages of the

Industrial IoT. But, by adhering to the following three steps, manufacturing facilities can successfully unlock the many benefits the Industrial IoT promises to offer; some of which can be reaped in a mere six months:

1. Modernize the Industrial Ethernet Network
2. Adopt a proactive and preemptive approach to maintenance
3. Gain complete plant-level awareness and visibility

To better understand how manufacturing facilities can transition into the Industrial IoT and achieve complete plant-level awareness and visibility, let's first briefly look back at the backbone of manufacturing - the Ethernet Network; why it became the popular network choice in manufacturing, and how it compares to Industrial Ethernet.

Industrial Ethernet vs. Enterprise Ethernet

If you were a fish, knowing the difference between salt water and fresh water would be vitally important. Likewise, you would not wear a hard hat in an office setting, nor would it be a wise choice to wear flip-flop sandals on a factory floor with potentially hazardous equipment. Similarly, there are many subtle differences between Industrial Ethernet and enterprise Ethernet, each with their own benefits to be gained (or disadvantages) for the plant floor and office environments.

Decades ago, Ethernet became the popular network standard communication for enterprise office settings, given its cost-effectiveness, reliability, and overall high performance. For similar reasons, Ethernet made its way onto factory floor networks in the form of Industrial Ethernet, which uses the same standard-based networking protocols as enterprise Ethernet, but is uniquely designed to work in the harsh and rugged industrial environments of a plant floor. Such factors include extreme temperatures, humidity, vibrations, and other disturbances with manufacturing equipment that far exceed the ranges (and requirements) for IT equipment, which work just fine in their controlled office environments.

Manufacturing Network Fabric Maturity Model

A well-designed and reliable physical layer, known as the "network fabric", serves as a critical foundation and strategic business advantage for manufacturers seeking to differentiate themselves from the competition. This white paper discusses the importance of the network fabric in today's information-enabled manufacturing environments, outlines the steps that proactive manufacturers can take to capture its full value for years to come and describes a four-stage methodology for improving an existing network to a higher maturity level.

While enterprise networks tend to be bandwidth-limited, manufacturing facilities are more concerned with timing and collisions of traffic on the network than bandwidth. Using standard Ethernet protocols along with the high speed needed for manufacturing environments, Industrial Ethernet on the plant floor quickly became standardized; replacing its fieldbus networks predecessors in the factory. As a result, Industrial Ethernet networks have since become the universal preferred choice for manufacturing and automation systems and business systems. It simply provides a baseline for all manufacturers to work together, offering a consistent and robust system to easily connect computers, networks, data centers, machines, and a variety of automated devices.

Shifting toward a Proactive Approach with Increased Visibility

Now, with the vast number of connected devices entering the plant floor, Industrial Ethernet Networks are reaching the point of no return. Homegrown flat networks can no longer bear the requirements being placed on them by new applications. This, combined with the lack of visibility into these networked automated devices, which are fundamentally responsible for a facility's overall production output, is making detection, diagnosis and problem resolution a costly, time-consuming and a highly complex and painful undertaking. This too will all change as a byproduct of the Industrial IoT, including the way the plant floor works at many facilities, as automation and controls engineers need to integrate older propriety and serial industrial networks, with new networked systems based on an IT infrastructure. Essentially, for the first time ever, the technology gap between information technology (IT) and operational technology (OT) is closing.

Meanwhile, several manufacturing companies are falling into bad habits of looking the other way (whether deliberate or not) to apparent issues throughout their automation system, knowingly awaiting the impending problems that will follow and only continue to rise. When we monetize the cost of ignoring disruptions in the manufacturing world, over time an entire company could either go under, or pay a hefty price. For many companies, an outage could mean losing revenue at a rate of $2.50 to as much as $350/second.

For example, a major grocery retailer recognized widely disruptive Ethernet connectivity issues across almost their entire plant network. Specifically, devices on the plant automation network would inexplicably cease communications. One of their dairy farms, which produces 120,000 gallons of milk each day, experienced a network disruption so dire, they suffered from nearly a full day of downtime.

They were encountering data interruptions arising from certain programmable logic controllers (PLCs). Using IntraVUE™ application software, which provides visibility, diagnostics and analytics, the plant's team uncovered several PLCs with duplicate IP addresses, which were causing the network to act erratically. The IT team used

IntraVUE software to isolate various devices on the network, locating an undocumented, non-industrial device that was mounted above a false ceiling, and removed it, which resolved the issue.

This grocery retailer has since standardized with IntraVUE software across all 33 plants primarily using it as an analysis tool for when problems occur as well as using its' alerting features to inform of any sudden changes in network behavior.

Unlike the above example, nearly 80% of companies have insufficient or ineffective preventive maintenance programs. There is a need not being met—and the demand for a reliable plant network infrastructure has never been higher. To evolve, manufacturing companies must shift away from the current reactive response approach (i.e., responding only when a disruption occurs) to a mindset of pro-activeness. This is the only way manufacturing facilities will greatly improve both the up-time and performance of these critical, real-time networks while also better ensuring valuable time and cost savings; an especially critical component to realizing the true benefits of the Industrial IoT.

Achieving Full Plant-Level Awareness of the Industrial Network

The bread and butter to the IoT are actionable intelligence and insight, which allows industrial controls professionals to make better-informed decisions. For the Industrial IoT, having the ability to know which devices and systems are connected where—and pinpointing what is creating specific disruptions that force downtime – will be critical. With real-time visibility, monitoring and insightful analytics into and from the entire network, those responsible for plant output can assure network uptime and quickly address risks as they appear, before they become an actual problem.

With a tool like IntraVUE software, automation and controls engineers have at their fingertips access to real-time information on how their automation system infrastructure is performing. They can use key performance indicators (KPIs) and analytics capabilities to monitor performance and quickly resolve issues as they occur, such as duplicate IP addresses (e.g., as in the example above), device failures, intermittent connection problems, switch resetting, and large file transfers between devices.

Achieving full plant-level awareness ultimately empowers industrial controls professionals with visibility into the growing complexity of their plant's entire automation system. And, with the Industrial Ethernet connectivity landscape that narrows the scope of where connectivity issues are occurring, plant technicians can get to the root of the problem faster. IntraVUE software allows a complete view into the industrial network, provides actionable insight, improves overall uptime, and reduces network support costs and response times by more than 50%.

Continued
Modernizing the Industrial Ethernet Network with Increased Visibility

The Industrial Internet of Things (Industry 4.0)

The plant of the future requires more automated communication throughout the supply chain that only a modernized, well-architected and managed Industrial Ethernet Network can provide. While each manufacturing company has its own unique challenges, the influx of connected devices expected from the Industrial IoT will inevitably increase the possibility of disruptions, making the need to rapidly detect those disruptions even more important.

Implementing a comprehensive tool that can reduce the potential for intermittent communication disruptions, enable continuous real-time monitoring, and provide remote support, can offer valuable time and cost savings to manufacturing facilities of all sizes today, and in the years to come. With full awareness and real-time visibility into the entire Industrial Ethernet device architecture of levels of devices and connectivity, operational field technicians can efficiently communicate with IT resources, who are also confidently armed with vital information to allow a shift from a reactive response approach to one that is proactive and comprehensive. This, with access to real-time insight and actionable intelligence to enable better-informed decisions are the keys to successfully unlocking all the benefits of the Industrial IoT.